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## Cell-less wireless network


### Abstract

A radio access network (RAN) may comprise at least one transmission-reception point (TRP) configured to provide wireless connections to one or more User Equipment devices (UEs) in an area. The area is not predefined by a cell boundary. The RAN may be configured to: broadcast Scheduling and Synchronization Relation (SSR) information to a UE; and establish with the UE a transmission mode for the TRP.



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## Background/Summary

BACKGROUND INFORMATION

(1) A cellular network operates based on omnidirectional signal coverage of geographical areas. A cell is an area covered by signals from a transmission point or a reception point and has a boundary defined based on signal attenuation.

## Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** illustrates an example network environment in which systems and methods described herein may be implemented;
(2) FIG. **2**A illustrates exemplary dual connectivity (DC) according to an implementation;
(3) FIG. **2**B illustrates exemplary carrier aggregation (CA) according to an implementation;
(4) FIG. **2**C illustrates exemplary multiple transmission-reception points (multi-TRPs) according to an implementation;
(5) FIG. **3** shows an exemplary framework for an access network according to an implementation;
(6) FIG. **4** depicts exemplary components of an access network, according to an implementation;
(7) FIGS. **5**A and **5**B illustrate exemplary communication paths through a transmission timing group (TTG), synchronization groups (SG), and different TRPs, according to an implementation.
(8) FIG. **6** is a flow diagram of an example process that is associated with a cell-less wireless network, according to an implementation; and
(9) FIG. **7** depicts components of an example network device, according to an implementation.

## DETAILED DESCRIPTION OF EMBODIMENTS

(10) The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

(11) The systems and methods described herein relate to cell-less wireless networks. Currently, User Equipment devices (UEs) may use one or more technologies to wirelessly connect to a cellular network. For example, a UE may attach to a Fifth Generation (5G) base station (e.g., next generation Node B or gNB) and an evolved Node B (eNB) using Dual-Connectivity (DC) technology, Carrier Aggregation (CA), and/or multiple Transmission and Reception points (TRPs) that provide either non-coherent joint transmissions and multiple Downlink Control Information blocks (DCIs) or coherent joint transmissions and a single DCI. Various aspects of DC, CA and multi-TRP may be configured through Radio Resource Control (RRC). Adopting these connectivity technologies individually incurs significant implementation and operational costs and increases the complexity of the cellular network. The cell-less wireless network as described herein allows UEs to connect to a wireless network using a single framework that unifies significant features of DC, CA, and multi-TRPs with minimal technological overlaps.

(12) In addition, today's radio access networks (RANs) are transitioning from distributed RAN (D-RAN) architectures to virtual Radio Access Network (V-RAN) or cloud RAN (C-RAN) architectures. D-RAN architectures impose limitations on network operation and its adaptability, thus slowing the growth of wireless network ecosystems. V-RAN and C-RAN virtualize and centralize the network resources (e.g., processing capabilities and scheduling control) into pools that may be dynamically shared among network elements for increased efficiency and for improved ecosystem growths. However, current V-RAN and C-RAN technological improvements are focused mostly on network requirements and have yet to significantly impact the radio interfaces and provide further improvements in overall network efficiency. Cell-less wireless network implementations provide mechanisms to optimize the operation of air-links of the V-RANs and/or C-RANs by removing the legacy barriers (e.g., assignment of cells to base stations) and by treating connections as pools of resources that can be dynamically shared by wireless stations and UEs.

(13) In implementations described herein, a cell-less wireless network operates without cells (e.g., bounded areas that are assigned to particular base stations for communication services). That is, a base station that belongs to the wireless network may manage UEs in an area that is not within a boundary of a typical cell (e.g., an area not predefined or defined by a cell boundary). Once a UE accesses the wireless network, the UE is serviced by beams from different TRPs selected from a pool of activated TRPs. Each pool of such TRPs can be operated for a particular RAN architecture, such as V-RAN or C-RAN architecture. The TRPs may be adaptively maintained through different activation and deactivation processes.

(14) In the implementations described herein, DC, CA, multi-TRPs with array antennas or legacy discrete antennas are aggregated or unified into a single framework that focuses on network synchronization and scheduling characteristics, such as backhaul data synchronization and/or transmission timing.

(15) The implementations described herein streamline and thus reduce wireless network operational complexity, reduce cost, and set paths to further evolution of the wireless network. In addition, the implementations may improve user experience by reducing latency, UE operational complexity, and power consumption. Furthermore, the implementations are well-suited to be adapted for C-RAN and/or V-RAN architectures—akin to air link advantages inherent in C-RAN and/or V-RAN networks. Additionally, the implementations provide interfaces to beam-based controls in C-band and millimeter wave (mmWave) band operations.

(16) FIG. **1** illustrates an example network environment **100** according to an implementation. As shown, network environment **100** may include UEs **102** (individually and generically referred to as UE **102** and collectively as UEs **102**), an access network **104**, a core network **106**, and a data network **108**. UE **102** may include, for example, a wireless communication device, a mobile

terminal, or a fixed wireless access (FWA) device. Examples of UE **102** include: a smart phone; a tablet device; a wearable computer device (e.g., a smart watch, smart glasses); a laptop computer; an autonomous vehicle with communication capabilities; a portable gaming system; an Internet-of-Thing (IoT) device and/or other devices with processing and communication capabilities.

(17) In some implementations, UE **102** may correspond to a wireless Machine-Type-Communication (MTC) device that communicates with other devices over a machine-to-machine (M2M) interface, such as Long-Term-Evolution for Machines (LTE-M) or Category M1 (CAT-M1) devices and Narrow Band (NB)-IoT devices. UE **102** may send packets to or over access network **104**. UE **102** may have the capability to connect to different Radio Access Technology (RAT) access devices, such as LTE or 5G base stations.

(18) UE **102** may include components to support multiple transmission (TRX) chains. Depending on the implementation, UE **102** may have varying degrees of transmission and reception processing capabilities, such as capabilities to perform: packet timing, physical signal timing (e.g., modify timing advance parameters), multi-input multi-output (MIMO) multi-layer communications using multiple frequency layers, and joint processing of multiple streams. UE **102** may select and/or control its transmission mode based on information about channels to each of the transmission points (e.g., a base station, a radio unit, etc.) in access network **104**. For example, UE **102** may determine a transmission mode that maximizes a particular parameter. For example, UE **102** may identify one or more channels (e.g., different beams and/or frequency bands) with the maximum power, maximum throughput, minimum latency, minimum noise/interference, signal-to-interference and noise-ratio (SINR), etc.

(19) Access network **104** may allow UE **102** to access core network **106**. To do so, access network **104** may establish and maintain, with participation from UE **102**, an over-the-air channel with UE **102**; and maintain backhaul channels (not shown) with core network **106**. Access network **104** may convey information through these channels, from UE **102** to core network **106** and vice versa.

(20) Access network **104** may include an LTE radio access network, a Next Generation (NG) radio access network (e.g., a 5G radio access network) and/or another advanced radio network. These radio networks may operate in many frequency ranges, including millimeter wave (mmWave) frequencies, sub 6 GHz frequencies, and/or other frequencies. Access network **104** may include many wireless stations, Central Units (CUs), Distributed Units (DUs), and Radio Units (RUs). The wireless stations, CUs, DUs, and/or RUs nodes may establish and maintain over-the-air channels with UEs **102** and backhaul channels with core network **106**. In FIG. **1**, the wireless stations, CUs, DUs, and RUs are collectively depicted as wireless station **110**.

(21) Wireless station **110** may include a 5G, 4G, or another type of wireless station (e.g., evolved Node B (eNB), next generation Node B (gNB), etc.), CUs, DUs, and RUs. Wireless station **110** (also referred to as base station **110**) may provide or support one or more of the following: 4 Tx functions (e.g., 4 transceiver antenna function); carrier aggregation functions; advanced or massive multiple-input and multiple-output (MIMO) antenna functions (e.g., 8×8 antenna functions, 16×16 antenna functions, 256×256 antenna functions, etc.); cooperative MIMO (CO-MIMO) functions; relay stations; Heterogeneous Network (HetNets) of overlapping small cell-related functions; macrocell-related functions; Machine-Type Communications (MTC)-related functions, such as 1.4 MHz wide enhanced MTC (eMTC) channel-related functions (i.e., Cat-M1), Low Power Wide Area (LPWA)-related functions such as Narrow Band (NB) Internet-of-Thing (IoT) (NB-IoT) technology-related functions, and/or other types of MTC technology-related functions; DC, and other types of LTE-Advanced (LTE-A) and/or 5G-related functions. In some implementations, wireless station **110** may be part of an evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Network (eUTRAN). Wireless station **110** may include Remote Electronic Tilt (RET) capability for beam steering or beam shaping.

(22) In one implementation, access network **104** may include the framework in which network components for DC, CA, and multi-TRPs (with array antennas or legacy discrete antennas) are

aggregated or unified. The framework provides network synchronization and scheduling characteristics, such as backhaul data synchronization and/or transmission timing. One example of such a framework is described below with reference to FIG. **3**.
(23) Core network **106** may include a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), an optical network, a cable television network, a satellite network, a wireless network (e.g., a Code Division Multiple Access (CDMA) network, a general packet radio service (GPRS) network, an LTE network (e.g., a 4G network), a 5G network, an ad hoc network, a telephone network (e.g., the Public Switched Telephone Network (PSTN), an intranet, a public land mobile network (PLMN), or a combination of networks. Core network **106** may allow the delivery of Internet Protocol (IP) services to UE **102** and may interface with other networks, such as data network **108**.
(24) Depending on the implementation, core network **106** may include 4G core network components (e.g., a Serving Gateway (SGW), a Packet data network Gateway (PGW), a Mobility Management Entity (MME), a Home Subscriber Server (HSS), an Authentication Authorization and Accounting (AAA) server, a Policy and Charging Rules Function (PCRF), etc.) and/or 5G core network components. The 5G core network components may include, for example, a Unified Data Management (UDM), an Access and Mobility Management Function (AMF), an Authentication Server Function (AUSF), a Unified Data Repository (UDR), a Policy Control Function (PCF), a Session Management Function (SMF), a User Plane Function (UPF), etc.
(25) Data network **108** may include networks that are external to core network **106**. In some implementations, data network **108** may include packet data networks, such as an Internet Protocol (IP) network. In another implementation, data network **108** may be part of core network **106**. Data network **108** may provide particular network services, such as, for example, Voice-over-IP (VoIP) services, messaging services, video services, etc.
(26) For simplicity, FIG. **1** does not show all components that may be included in network environment **100** (e.g., routers, bridges, wireless access points, additional networks, additional UEs **102**, wireless stations, CUs, DUs, RUs, etc.). These components and the components described above may be connected to one another by either wireless links or physical links. Also, depending on the implementation, network environment **100** may include additional, fewer, different, or a different arrangement of components than those illustrated in FIG. **1**.
(27) As indicated above, access network **104** may include the framework with components for and/or components that aggregate technologies for DC, CA, and multi-TRPs with array antennas or legacy discrete antennas). FIGS. **2**A-**2**C illustrate DC, CA, and multi-TRPs according to different implementations.
(28) FIG. **2**A illustrates Dual Connectivity (DC), with two base stations **110-1** and **110-2**. Base station **110-1**, which is attached to core network **106** through a backhaul **202**, is herein referred to as a master base station or a master cell group (e.g., a Master gNB (MgNB), a Master eNB (MeNB), etc.). Base station **110-2**, herein referred to as a secondary base station or a secondary cell group (e.g., a Secondary gNB (SgNB), a Secondary eNB (SeNB), etc.), is linked to master base station **110-1**. In this scheme, UE **102** may wirelessly connect to both of stations **110-1** and **110-2** through different RF links **204** and **206**.
(29) Depending on the implementation, establishment and maintenance of link **204** and link **206** may entail use of different Radio Access Technologies (RATs) or the same RAT (e.g., NG Radio or LTE RAT). For example, base station **110-1** may be implemented as a master gNB (MgNB) or a master eNB (MeNB). In either case, base station **110-1** may coordinate transmission of data at base stations **110-1** and **110-2**, to achieve optimum data throughput or to provide link redundancy. That is, base station **110-1** synchronizes data that is to be transmitted from/received at base station **110-1** to/from UE **102** and data that is to be transmitted from/received at base station **110-2** to/from UE **102**.
(30) FIG. **2**B illustrates Carrier Aggregation (CA), with base station **110-3** connected to core

network **106** via backhaul **212**. UE **102** establishes a link with a primary carrier component (PCC) **208** and a secondary carrier component (SCC) **210**. To send downlink (DL) data to UE **102**, base station **110-3** schedules the data for transmission at a Media Access Control (MAC) layer. Furthermore, base station **110-3** assembles data received from UE **102** at the MAC layer. That is, any data synchronization is performed at the MAC layer. In contrast, for DC, data separation/synchronization is performed at the master base station **110-1**, at a communication layer that is above the MAC layer (e.g., at Packet Data Convergence Protocol (PDCP) layer).

(31) FIG. **2**C illustrates multiple transmission-reception points (multi-TRPs). In FIG. **2**C, base station **110** includes a base station portion **214** and transceivers **212-1** through **212-4**. Each transceiver **212** may transmit a signal to UE **102**. Depending on the implementation, transceivers **212** may act as a coordinated multipoint (CoMP) to provide coherent joint transmission (CJT) that shape the overall beam to UE **102**. Such a coherent beam may provide signal spatial diversity. If the signals are non-coherent (i.e., non-coherent joint transmission (NCJT)), each of the signals may follow/provide different signal paths to UE **102**. Providing path redundancy.

(32) FIG. **3** shows an exemplary framework for an access network **104** according to an implementation. The framework unifies and/or aggregates processes and components for achieving data synchronizations, scheduling, and signal timing in DC, CA and multi-TRP illustrated in FIGS. **2**A-**2**C. As shown, access network **104** may comprise backhaul groups (BHGs) **304-1**, **304-2**, etc. Each BHG **304** corresponds to synchronized or non-synchronized backhauls. Access network **104** may also include transmission timing groups (TTGs) **306**. Each TTG **306** (any of TTG **306-1**, **306-2**, etc.) is capable of being time synchronized, Each TTG may connect to one or more BHGs, and conversely, each BHG may connect to one or more TTGs. Each TTG may be connected to one or more scheduling groups (SGs) **308-1**, **308-2**, etc. Each SG **308** may connect to one or more of TRPs **310-1**, **310-2**, etc. SG **308** jointly may schedule resource elements that are to be transmitted via TRPs **310**, as non-joint coherent transmission or a coherent joint transmission. One or more TRPs **310** may be attached to the same piece of hardware that enables coherent transmission at the TRPs **310**.

(33) In the implementation of FIG. **3**, TTG **306**, SGs **308**, and TRPs **310** are not assigned to a particular a cell (a fixed geographical area in which UEs **102** are serviced by a wireless station). For example, a TRP **310** may provide connections (from access network **104**) to UEs **102** in an area that is not within a boundary of a cell or an area not predefined by a cell or a cell boundary. For example, assume that TRP **310** serves multiple UEs **102**, where one of the UEs **102** is inside an area that is associated with a cell and the other UE **102** is outside the area. In this example, the total area in which TRP **310** serves the UEs **102** is outside of a single cell. In this context, “connections” does not include any temporary connections between UEs **102** and wireless stations during handoffs. For a conventional access network, a wireless station is assigned to a cell and services only those UEs within the cell.

(34) In access network **104** shown in FIG. **3**, a path from a TRP **310** to core network **106** may be identified by a quadruple (i, j, n, m), where m is index of the TRP (i.e., a TRP identifier (TRP ID), n is an index for the SG, j is an identifier the TTG, and i is an identifier for the BHG in access network **104**. For each path that can be identified by a path quadruple, access network **104** may provide various synchronization and/or scheduling states.

(35) For example, given a path quadruple of (1, 3, 2, 7), access network **104** may determine the synchronization scheduling relation information (SSR) of the first BHG **304** in access network **104**, third TTG, second SG **308**, and seventh TRP **310**. One example SSR may indicate: (unsynchronized (non-ideal) backhaul, synchronized transmission timing, and independent scheduling for the SG. Other example SSRs include: Unsynchronized (i.e., “non-ideal”) backhaul, synchronization-capable transmission timing, independent scheduling; synchronized (i.e., “ideal”) backhaul, synchronization-capable transmission timing, independent scheduling; and (synchronized (i.e., “ideal”) backhaul, synchronization-capable transmission timing, joint scheduling.

(36) The SSRs for a path may hold for all frequency layers and may indicate how data over a particular path may be synchronized or behave with respect to scheduling. For example, at a TRP **310**, data over the path quadruple of (1, 1, 3, 2) may be jointly scheduled with the path quadruple of (1, 1, 3, 5). Because each TRP **310** can provide one or more beams to UE **102**, given path quadruples for multiple TRPs, the UE **102** may determine and/or access a pool of beams associated with TRPs identified by the path quadruples. Associations between SSRs and paths may be adapted or modified dynamically, for example, via MAC-Control Element, Downlink Control Information (DCI), or Radio Resource Control (RRC) messages.
(37) For UE **102** to connect with access network **104** and to maintain its connectivity via TRP **310***s*, UE **102** may use SSR and what is typically referred to as Quasi Co-Location (QCL) information to determine the best transmission mode, within its capability, and convey its state to access network **104**. SSR is semi-static and may be broadcast from network **104** to a region that includes UE **102** or unicast to UE **102**. A UE unicast signal may be coded (e.g., scrambled, masked, etc.) by its own identify, a network identify, and a TRP identity. When UE **102** receives SSR, UE **102** may use the received information to determine the feasibility of communications and/or the UE/network communications capability.
(38) QCL information pertains to a common set of values that characterize two or more communication ports or antennas. Two antenna ports are said to be quasi co-located if properties of one channel can be inferred from those of another channel Information that may be used to infer the properties is QCL information. QCL information may include, for example, Doppler Shift, Doppler Spread, average delay, receiver parameters, etc. Thus, QCL can be used to indicate conditions of different antenna ports or antennas.
(39) SSR may provide information on BHG, TTG, SG, and TRPs regarding: packet timing (same or separate processing chain); whether transmission/reception is synchronous or asynchronous (same or separate Fast-Fourier Transform engine); control mapping (e.g., Physical Downlink Control Channel (PDCCH), Physical Uplink Control Channel (PUCCH, data buffering and processing buffered data, etc.); and QCL-based determination of communication capability via the identified TRP, depending on the QCL processing capability of UE **102**. Thus, SSR may be used for objective optimization of various parameters, such as throughput, latency, etc. The optimization process may be dynamic and adaptive changes may be signaled from UE **102** and/or network **104**. For example, BHG, TTG, SG, and TRP-related information in SSR may be used to determine, respectively: network coding scheme (e.g., asynchronous DC-like schemes); synchronous DC-like schemes; CA-like schemes and/or single-DCI/multi-DCI for multi-TRP-like schemes, NCJT; and JCT for multi-TRP.
(40) FIG. **4** depicts exemplary components of access network **104** according to an implementation. In this implementation. as shown, access network **104** may include Central Unit-Control Plane (CU-CP) for forming a BHG. A TTG **306**. comprise a Central Unit-User Plane (CU-UP) **404-1**, and SGs **308** may comprise Distributed Units (DUs) **406-1** through **406-**T. Access network **104** may also comprise TRPs **408**. Depending on the implementation, access network **104** may include fewer, additional, different, or a different arrangement of components than those illustrated in FIG. **4**. Additionally, some of these components may be implemented in access network **104** without being confined to a particular piece of hardware. For example, CU-CP **402** and CU-UP **404** may be implemented in an edge devices, at a data center as part of V-RAN or C-RAN, or as part of a network slice through network function virtualization.
(41) CU-CP **402** may perform control plane signaling associated with managing DU **406** over F1-C interface. CU-CP **402** may signal to DU **406** over a control plane communication protocol stack that includes, for example, F1AP (e.g., the signaling protocol for F1 interface between a CU and a DU). CU-CP **402** may include protocol layers comprising: Radio Resource Control (RRC) layer and a Packet Data Convergence Protocol-Control Plane (PDCP-C). DU **406** may include corresponding stacks to handle/respond to the signaling (not shown).

(42) CU-UP **404** may perform user plane functions associated with managing DU **406** over the F1-U interface. CU-UP **404** may interact with DU **406** over a user plane communication protocol stack that includes, for example, General Packet Radio Service Tunneling Protocol (GTP)-User plane, the User Datagram Protocol (UDP), and/or IP. DU **406** may include corresponding layers to handle/respond to messages from CU-UP **404** (not shown). CP-UP **404** may include processing layers that comprise a Service Data Adaptation Protocol (SDAP) and a PDCP-User Plane (PDCP-U). CU-UP **404** and CU-CP **402** communicate over E1 interface, for example, for exchanging bearer setup messages.
(43) CU-CP **402** and CU-UP **404** (collectively referred to as CU) may communicate with the components of core network **106** through S l/NG interfaces and with other CUs through X2/Xn interfaces.
(44) DU **406** may provide support for scheduling data for one or more radio beams at TRPs **408**. DU **406** may handle UE mobility, from a DU to a DU, gNB to gNB, beam to beam, etc. TRP **408** may perform physical layer functions, such as antenna functions, transmissions of radio beams, etc.
(45) In FIG. **4**, CU-CP **402**, CU-UP **404**, and DU **406** may include, respectively, BHG Control **402**, TTG control **404**, and SG control **406**. The BHG Control **402**, TTG Control **404**, and SG Control **406** may set and monitor values of parameters that are associated with backhauls, TTGs, DUs, and TRPs. For example, the BHG Control **402** may coordinate different CU-UPs **404** to ensure their NG interfaces to core network **106** are synchronized when different portions of UE data arrive through different CU-UPs **404** (e.g., during multi-bearer DC or DC-like communication).
(46) Similarly, TTG Control **404** may manage multiple DUs **406** that send/receive data through radio bearers. The data from/to the radio bearers may be sent to or received synchronously from the data bearer during, for example, a single-data bearer DC or DC-like connectivity with UE **102**. SG Control **406** may coordinate multi-TRPs **408** to perform, for example, joint coherent transmissions (JCT), non-joint coherent transmissions (NJCT).
(47) Each of BHG Control **402**, TTG Control **404**, and SG Control **406** may set and/or monitor values of different operational parameters of, respectively, BHG **304**, TTG **306**, and SG **308**.
(48) The implementation shown in FIG. **4** is exemplary. Depending on the implementation, access network **104** may include different BHG-, TTG-, and/or SG-related components and connectivity configurations. For example, in FIG. **4**, CU-UP **404** may be connected to a particular CU-CP **402**, and each DU **406** may be connected to particular TRPs **310**. In different implementations, BHG and TTGs may be capable of selecting to which BHGs and TTG to connect. Similarly, a SG may transmit/receive via one or more of TRPs **408** that the SG selects.
(49) FIGS. **5**A and **5**B illustrate exemplary communication paths through TTGs **306**, SGs **308**, and TRPs **310** according to different implementations. These implementations are consistent with the implementation shown FIG. **4**. Other implementations are possible, and the example of FIGS. **5**A and **5**B do not limit the implementations described herein.
(50) For the implementation of FIG. **5**A, CU-CP **402** (not shown in FIG. **5**A) may synchronize CU-UP **404-1** and CU-UP **404-2** and set up a DC-like connection with UE **102-1**. In particular, CU-UP **404-1** is linked to DU **406-1** that sends/receives data through TRP **408-1** to/from UE **102-1** over a beam **502-1**; and CU-UP **404-2** is linked to DU **406-2** that sends/receives data through TRP **408-2** to/from UE **102-1** over another beam **502-2**. Each of DUs **406-1** and **406-2** may or may not schedule transmissions independently (i.e., DU **406-1** does not or does directly communication with DU **406-2** to schedule data transmissions to UE **102**). Although different portions of data to/from UE **102** pass through different TTG Controls (i.e., CU-UP **404-1** and CU-UP **404-2**), the data are appropriately organized (synchronized) to reach the correct destination in, for example, data network **108**. Beams **502-1** and **502-2** may or may not be formed via different RATs.
(51) In FIG. **5**B, CU-UP **404-3** may synchronize DU **406-3** and DU **406-4**, to set up DC-like links with UE **102-2**. In contrast to the configuration in FIG. **5**A, in FIG. **5**B, the TTG Control (e.g., CU-UP **404-3**) performs the synchronization. DU **406-3** sends/receives data through TRP **408-3** to/from

UE **102-2** over a beam **502-3**; and DU **406-4** sends/receives data through TRP **408-4** to/from UE **102-2** over another beam **502-4**. Each of DUs **406-3** and **406-4** may schedule transmissions independently. Although different portions of data to/from UE **102** pass through different SG Controls (i.e., DU **406-3** and DU **406-4**), the data are appropriately synchronized at CU-UP **404-3**. Beams **502-3** and **502-4** may or may not be formed via different RATs.

(52) FIG. **6** is a flow diagram of an example process **600** that is associated with a cell-less wireless network according to an implementation. Process **600** may be performed by one or more of the components shown in FIGS. **3**, **4**, **5**A and/or **5**B. As shown, process **600** may include TRPs broadcasting reference signals (e.g., Synchronization Signal Block (SSB)) (block **602**). In response, UE **102** may obtain Synchronization and Scheduling Relation information (SSR) provided via the broadcast signals and the SSBs (block **604**). In some implementations, UE **102** may obtain only part of the SSR from the broadcast and acquire the full SSR after accessing the network **104**, through dedicated signaling such as RRC signaling.

(53) Process **600** may further include UE **102** receiving configuration information for TRPs through the RRC connection (block **606**). After the receipt, UE **102** may measure and report beam quality information for the TRPs **408** (block **608**). In response to the information from UE **102**, access network **104** may determine what TRP beams to activate and/or which TRP beams to deactivate (block **610**). Access network **104** may forward the beam activation/deactivation information (which identifies active beams) to UE **102** (e.g., via MAC-CE) (block **612**). In some implementations, UE **102** may receive additional dynamic information about one or multiple TRP beams in the activated pool via other signals, such as Downlink Control Information (DCI).

(54) Process **600** may further include access network **104** determining a transmission mode (also referred to as transmit mode) for the TRPs (block **614**). A transmission mode may include, for example, asynchronous or synchronous DC-like transmission, a CA-like transmission, multi-DCI/single DCI-based transmission for multi-TRPs (e.g., for non-coherent joint transmission or coherent joint transmission). Determining the optimum transmission mode may include using the SSR associated with the TRPs **408**. Additionally, access network **104** may code the Demodulation Reference Signal (DMRS) to convey the channel condition, from which UE **102** may deduce the transmission mode (block **614**).

(55) Process **600** may further include access network **104** and UE **102** establishing the selected transmission mode for the connection (block **616**). During the establishment of the transmission mode or thereafter, the TRPs may refine beams (block **618**) via, for example, Tracking Reference Signal (TRS)-based refinement; UE **102** may perform beam refinement; or both the TRPs and UE **102** may perform a joint beam refinement. The beam refinement may include, for example, beam reshaping and/or adjusting beam directions. Furthermore, UE **102** may measure the relative strengths of the beams and provide channel state information (CSI) to access network **104** (block **620**), to assist the TRPs **408** in maintaining the optimum beam states.

(56) FIG. **7** depicts example components of an example network device **700**. Network device **700** corresponds to or is included in UE **102** and any of the network components of FIGS. **1-4**, **5**A, and **5**B (e.g., a router, a network switch, servers, gateways, gNB, eNB, CU-CP **402**, CU-UP **404**, DU **406**, BHG **304**, TTG **306**, SG **308**/**406**, TRP **310**/**408**, etc.). As shown, network device **700** includes a processor **702**, memory/storage **704**, input component **706**, output component **708**, network interface **710**, and communication path **712**. In different implementations, network device **700** may include additional, fewer, different, or a different arrangement of components than the ones illustrated in FIG. **7**. For example, network device **700** may include a display, network card, etc.

(57) Processor **702** may include a processor, a microprocessor, an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a programmable logic device, a chipset, an application specific instruction-set processor (ASIP), a system-on-chip (SoC), a central processing unit (CPU) (e.g., one or multiple cores), a microcontroller, and/or another processing logic device (e.g., embedded device) capable of controlling network device **700** and/or executing

programs/instructions.
(58) Memory/storage **704** may include static memory, such as read only memory (ROM), and/or dynamic memory, such as random access memory (RAM), or onboard cache, for storing data and machine-readable instructions (e.g., programs, scripts, etc.).
(59) Memory/storage **704** may also include a CD ROM, CD read/write (R/W) disk, optical disk, magnetic disk, solid state disk, holographic versatile disk (HVD), digital versatile disk (DVD), and/or flash memory, as well as other types of storage device (e.g., Micro-Electromechanical system (MEMS)-based storage medium) for storing data and/or machine-readable instructions (e.g., a program, script, etc.). Memory/storage **704** may be external to and/or removable from network device **700**. Memory/storage **704** may include, for example, a Universal Serial Bus (USB) memory stick, a dongle, a hard disk, off-line storage, a Blu-Ray® disk (BD), etc. Memory/storage **704** may also include devices that can function both as a RAM-like component or persistent storage, such as Intel® Optane memories.
(60) Depending on the context, the term “memory,” “storage,” “storage device,” “storage unit,” and/or “medium” may be used interchangeably. For example, a “computer-readable storage device” or “computer-readable medium” may refer to both a memory and/or storage device.
(61) Input component **706** and output component **708** may provide input and output from/to a user to/from network device **700**. Input and output components **706** and **708** may include, for example, a display screen, a keyboard, a mouse, a speaker, actuators, sensors, gyroscope, accelerometer, a microphone, a camera, a DVD reader, Universal Serial Bus (USB) lines, and/or other types of components for obtaining, from physical events or phenomena, to and/or from signals that pertain to network device **700**.
(62) Network interface **710** may include a transceiver (e.g., a transmitter and a receiver) for network device **700** to communicate with other devices and/or systems. For example, via network interface **710**, network device **700** may communicate with wireless station **110**.
(63) Network interface **710** may include an Ethernet interface to a LAN, and/or an interface/connection for connecting network device **700** to other devices (e.g., a Bluetooth interface). For example, network interface **710** may include a wireless modem for modulation and demodulation. Communication path **712** may enable components of network device **700** to communicate with one another.
(64) Network device **700** may perform the operations described herein in response to processor **702** executing software instructions stored in a non-transient computer-readable medium, such as memory/storage **704**. The software instructions may be read into memory/storage **704** from another computer-readable medium or from another device via network interface **710**. The software instructions stored in memory or storage (e.g., memory/storage **704**, when executed by processor **702**, may cause processor **702** to perform processes that are described herein. For example, UE **102**, CU-CP/BHG Control **402**, CU-UP/TTG Control **404**, DU/SG Control **406**, TRPs **408**, wireless stations **110** and/or other components described with respect to FIGS. **1**-**5**B may each include various programs for performing some of the above-described functions and processes.
(65) In this specification, various preferred embodiments have been described with reference to the accompanying drawings. Modifications may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.
(66) While a series of blocks have been described above with regard to the process illustrated in FIG. **6**, the order of the blocks may be modified in other implementations. In addition, non-dependent blocks may represent blocks that can be performed in parallel.
(67) It will be apparent that aspects described herein may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement aspects does not limit the

invention. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware can be designed to implement the aspects based on the description herein.
(68) Further, certain portions of the implementations have been described as “logic” that performs one or more functions. This logic may include hardware, such as a processor, a microprocessor, an application specific integrated circuit, or a field programmable gate array, software, or a combination of hardware and software.
(69) To the extent the aforementioned embodiments collect, store, or employ personal information provided by individuals, it should be understood that such information shall be collected, stored, and used in accordance with all applicable laws concerning protection of personal information. The collection, storage and use of such information may be subject to consent of the individual to such activity, for example, through well known “opt-in” or “opt-out” processes as may be appropriate for the situation and type of information. Storage and use of personal information may be in an appropriately secure manner reflective of the type of information, for example, through various encryption and anonymization techniques for particularly sensitive information.
(70) No element, block, or instruction used in the present application should be construed as critical or essential to the implementations described herein unless explicitly described as such. Also, as used herein, the articles “a,” “an,” and “the” are intended to include one or more items. Further, the phrase “based on” is intended to mean “based, at least in part, on” unless explicitly stated otherwise.

## Claims

1. A radio access network (RAN) comprising: at least one transmission-reception point (TRP) configured to provide wireless connections to one or more User Equipment devices (UEs) in an area, wherein the area is not within a cell and is not predefined by a cell boundary, and wherein the RAN is configured to: broadcast Scheduling and Synchronization Relation (SSR) information to a UE, wherein the SSR information includes an identifier that specifies at least a group of backhaul paths from the RAN to a core network; and establish with the UE a transmission mode for the at least one TRP.
2. The RAN of claim 1, further configured to: perform refinement of a beam from the at least one TRP to the UE.
3. The RAN of claim 2, wherein when the RAN performs the beam refinement, the RAN is configured to: receive channel state information (CSI) from the UE.
4. The RAN of claim 1, wherein the RAN comprises at least one of a cloud RAN (C-RAN) or a virtual RAN (V-RAN).
5. The RAN of claim 1, wherein when the at least one TRP is in the transmission mode, a first TRP of the at least one TRP and a second TRP of the at least one TRP provide dual connectivity (DC) from the RAN to the UE over the first TRP and the second TRP, wherein the RAN includes a network component for coordinating transmission to the UE at the first TRP and the second TRP.
6. The RAN of claim 1, wherein when the at least one TRP is in the transmission mode, the at least one TRP is configured to: perform carrier aggregation with the UE.
7. The RAN of claim 1, wherein a first TRP of the at least one TRP and a second TRP of the at least one TRP are configured to perform coherent joint transmission to the UE.
8. The RAN of claim 1 further comprising: a backhaul group (BHG) that includes a transmission timing group (TTG) comprising a scheduling group (SG) that includes the at least one TRP, wherein the SSR information includes information that specifies synchronization and scheduling information for the BHG, the TTG, the SG, and the at least one TRP.
9. The RAN of claim 1, wherein the RAN is further configured to: exchange configuration information for the at least one TRP over a Radio Resource Control (RRC) connection with the UE.

10. The RAN of claim 1, wherein the RAN is further configured to: forward, to the UE, information that describes or identifies one or more beams to be activated between the at least one TRP and the UE.
11. A method comprising: broadcasting Scheduling and Synchronization Relation (SSR) information to a User Equipment device (UE); and establishing with the UE a transmission mode for a transmission-reception point (TRP) included in a Radio Access Network (RAN), wherein the TRP is configured to provide wireless connections to one or more UEs in an area, wherein the area is not within a cell and is not predefined by a cell boundary, and wherein the SSR information includes an identifier that specifies at least a group of backhaul paths from the RAN to a core network.
12. The method of claim 11, further comprising: performing refinement of a beam from the TRP to the UE.
13. The method of claim 12, wherein performing the beam refinement includes: receiving channel state information (CSI) from the UE.
14. The method of claim 11, wherein the RAN comprises at least one of a cloud RAN (C-RAN) or a virtual RAN (V-RAN).
15. The method of claim 11, further comprising: providing dual connectivity (DC) from the RAN to the UE via the TRP and a second TRP, wherein the RAN includes a network component for coordinating data transmission to the UE at the TRP and the second TRP.
16. The method of claim 11, further comprising: performing carrier aggregation with the UE.
17. The method of claim 11, further comprising: performing a coherent joint transmission, at the TRP and a second TRP, to the UE.
18. The method of claim 11, wherein the RAN comprises a backhaul group (BHG) that includes a transmission timing group (TTG) comprising a scheduling group (SG) that includes the TRP, and wherein the SSR information includes information that specifies synchronization and scheduling information for the BHG, the TTG, the SG, and the TRP.
19. The method of claim 11, further comprising: exchanging configuration information for the TRP over a Radio Resource Control (RRC) connection with the UE.
20. A non-transitory computer-readable medium comprising computer-executable instructions, when executed by one or more processors, cause the one or more processors to: broadcast Scheduling and Synchronization Relation (SSR) information to a User Equipment device (UE); and establish with the UE a transmission mode for a transmission-reception point (TRP) included in a Radio Access Network (RAN), wherein the TRP is configured to provide wireless connections from the RAN to one or more UEs in an area, wherein the area is not within a cell and is not predefined by a cell boundary, and wherein the SSR information includes an identifier that specifies at least a group of backhaul paths from the RAN to a core network.