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(54) **Title:** RADIO LINK AND BEAM FAILURE MANAGEMENT

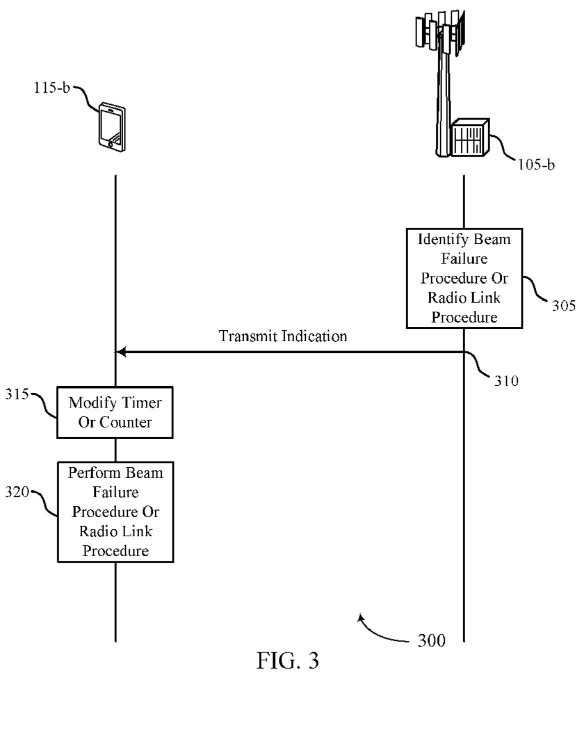

FIG. 3

(57) Abstract: Methods, systems, and devices for wireless communications are described in which a device in a wireless communications system (e.g., a user equipment (UE)) performs a beam failure detection (BFD) procedure or a radio link management (RLM) procedure. For example, a network node (e.g., a base station) may indicate to the UE to perform one or both of BFD or RLM. The base station may signal this information to the UE via control signaling and in some cases, this information may be signaled in response to a request from the UE. If beam failure is detected during a BFD procedure, the UE may perform a beam failure recovery (BFR) procedure or an RLM procedure. If RLM is stopped (e.g., upon detection of a number of in-sync indications), the UE will keep the RLM configuration and reset or freeze related timers or counters.

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RADIO LINK AND BEAM FAILURE MANAGEMENT

CROSS REFERENCE

[0001] The present Application for Patent claims priority to International Patent Application No. PCT/CN2018/109316 to CHENG et.al., titled "RADIO LINK AND BEAM FAILURE MANAGEMENT", filed October 8, 2018, assigned to the assignee hereof, which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The following relates generally to wireless communications, and more specifically to radio link and beam failure management.

[0003] Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include fourth generation (4G) systems such as Long Term Evolution (LTE) systems, LTE-Advanced (LTE-A) systems, or LTE-A Pro systems, and fifth generation (5G) systems which may be referred to as New Radio (NR) systems. These systems may employ technologies such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), or discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM). A wireless multiple-access communications system may include a number of base stations or network access nodes, each simultaneously supporting communication for multiple communication devices, which may be otherwise known as user equipment (UE).

[0004] Some wireless communications systems may implement radio link management techniques to manage radio link quality between devices. For example, a device (e.g., a UE or a base station) may measure reference signals for a given radio link, and based on the measured signal quality of the reference signal, the device may determine an overall quality of the radio link. If the quality of the radio link is determined to be poor, the device may initiate a radio link failure mechanism, which may initiate a timer for a reestablishment procedure. At the expiration of the timer, the device may transmit a request for reestablishment of the radio link to a receiving device.

[0005] Some systems implementing radio link management techniques may also implement beam failure recovery techniques. For instance, a device may measure reference signals over a set of directional beams received at the device. Based on the measurements of the reference signals, the device may detect a beam failure for one or more of the directional beams and may initiate a beam failure recovery mechanism.

[0006] Systems that implement both radio link management techniques and beam failure recovery techniques may implement these techniques separately. In some cases, however, these techniques may be related in that a failure of one technique may result in a failure in the other. Because these are implemented separately, in such scenarios, the device performing the techniques may utilize additional resources and have increased overhead in order to manage the processes.

SUMMARY

[0007] The described techniques relate to improved methods, systems, devices, and apparatuses that support radio link and beam failure management. Generally, the described techniques provide for a device in a wireless communications system (e.g., a user equipment (UE)) performs a beam failure detection (BFD) procedure or a radio link management (RLM) procedure. For example, a network node (e.g., a base station) may indicate to the UE to perform one or both of BFD or RLM. The base station may signal this information to the UE via radio resource control (RRC) signaling or a media access control control element (MAC-CE). In some cases, whether a UE is to perform BFD or RLM may be signaled in response to a request from the UE. For instance, a UE may determine whether BFD or RLM is sufficient (e.g., based on configured reference signals for BFD and RLM or based on previous BFD and RLM results) and the UE may transmit a request to perform only one of BFD or RLM to the base station.

[0008] Based on the indication from the base station, the UE may perform RLM or BFD. In some cases, BFD may be performed initially (e.g., as a baseline) and if beam failure is detected during a BFD procedure, the UE may trigger a beam failure recovery (BFR) procedure or an RLM procedure. If RLM is stopped (e.g., upon detection of a number of in-sync indications), the UE will keep the RLM configuration and reset or freeze related timers or counters.

[0009] A method of wireless communications is described. The method may include receiving, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modifying a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and performing at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0010] An apparatus for wireless communications is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0011] Another apparatus for wireless communications is described. The apparatus may include means for receiving, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modifying a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and performing at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0012] A non-transitory computer-readable medium storing code for wireless communications is described. The code may include instructions executable by a processor to receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0013] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, receiving the indication may include operations, features, means, or instructions for receiving the indication via RRC signaling or a MAC-CE.

[0014] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, modifying the radio link timer may include operations, features, means, or instructions for freezing or resetting the radio link timer after receiving the indication from the base station.

[0015] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, modifying the sync indication counter may include operations, features, means, or instructions for freezing or resetting the sync indication counter after receiving the indication from the base station.

[0016] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, performing at least one of the beam failure procedure or the radio link procedure may include operations, features, means, or instructions for performing one of the beam failure procedure or the radio link procedure indicated by the indication received from the base station.

[0017] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, performing the beam failure procedure may include operations, features, means, or instructions for performing a beam failure detection procedure, determining that beam failure may be detected, transmitting a recovery request to the base station based on determining that beam failure may be detected and monitoring for a response to the recovery request from the base station.

[0018] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for performing a beam failure recovery procedure based on receipt of the response to the recovery request, where the recovery request indicates a candidate beam for the beam failure recovery procedure.

[0019] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining one of the beam failure procedure or the radio link procedure, transmitting a request to perform one of the beam failure procedure or the radio link procedure based on the determining and receiving the indication to perform a beam failure procedure, a radio link procedure, or any combination thereof based on the request.

[0020] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the request may include operations, features, means, or instructions for transmitting the request to the base station via a random access control channel (RACH) or an uplink control channel.

[0021] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the request includes a one bit request message.

[0022] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining one of the beam failure procedure or the radio link procedure may include operations, features, means, or instructions for determining one of the beam failure procedure or the radio link procedure based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure.

[0023] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining one of the beam failure procedure or the radio link procedure may include operations, features, means, or instructions for determining the beam failure procedure, the radio link procedure, or any combination thereof based on results of previous beam failure procedures or radio link procedures over a time period.

[0024] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for performing a beam failure detection procedure based on the indication, determining that beam failure may be detected and triggering a beam failure recovery process and a radio link management process based on determining that beam failure may be detected.

[0025] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for performing the radio link management process based on the triggering, pausing the radio link timer for a pause duration, identifying a set of in-sync indications during the pause duration and stopping the radio link management process based on a number of the set of in-sync indications identified during the pause duration exceeding a threshold number of in-sync indications.

[0026] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for performing the beam failure recovery process based on the triggering, determining that the beam failure recovery process was successful and stopping the radio link management process based on determining that the beam failure recovery process was successful.

[0027] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for freezing or resetting information associated with the radio link timer or the sync indication counter.

[0028] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving a keep configuration from the base station, where the keep configuration indicates freeze or reset information associated with the radio link timer or the sync indication counter.

[0029] A method of wireless communications is described. The method may include identifying a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmitting, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0030] An apparatus for wireless communications is described. The apparatus may include a processor, memory in electronic communication with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0031] Another apparatus for wireless communications is described. The apparatus may include means for identifying a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmitting, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0032] A non-transitory computer-readable medium storing code for wireless communications is described. The code may include instructions executable by a processor to identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0033] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, transmitting the indication may include operations, features, means, or instructions for transmitting the indication via RRC signaling or a MAC-CE.

[0034] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining the beam failure procedure, the radio link procedure, or any combination thereof based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure.

[0035] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining the beam failure procedure, the radio link procedure, or any combination thereof based on previous beam failure procedures or radio link procedures.

[0036] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the beam failure procedure, the radio link procedure, or any combination thereof may be determined based on results of previous beam failure procedures or radio link procedures over a time period.

[0037] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving, from the UE, a request to perform one of the beam failure procedure or the radio link procedure and determining the beam failure procedure, the radio link procedure, or any combination thereof based on the request.

[0038] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, determining the beam failure procedure, the radio link procedure, or any combination thereof may include operations, features, means, or instructions for determining one of the beam failure procedure or the radio link procedure as indicated in the request from the UE.

[0039] In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the request may be received via a RACH or a physical uplink control channel (PUCCH).

[0040] Some examples of the method, apparatuses, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting a keep configuration to the UE, where the keep configuration indicates freeze or reset information associated with a radio link timer or a sync indication counter of the UE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] FIG. 1 illustrates an example of a wireless communications system that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0042] FIG. 2 illustrates an example of a wireless communications system that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0043] FIGs. 3–5 illustrate example process flows that support radio link and beam failure management in accordance with aspects of the present disclosure.

[0044] FIGs. 6 and 7 show block diagrams of devices that support radio link and beam failure management in accordance with aspects of the present disclosure.

[0045] FIG. 8 shows a block diagram of a communications manager that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0046] FIG. 9 shows a diagram of a system including a device that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0047] FIGs. 10 and 11 show block diagrams of devices that support radio link and beam failure management in accordance with aspects of the present disclosure.

[0048] FIG. 12 shows a block diagram of a communications manager that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0049] FIG. 13 shows a diagram of a system including a device that supports radio link and beam failure management in accordance with aspects of the present disclosure.

[0050] FIGs. 14 through 20 show flowcharts illustrating methods that support radio link and beam failure management in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0051] Some wireless communications systems may employ Radio Link Management (RLM) techniques to monitor link quality conditions within the system. A user equipment (UE) in such a system may be configured to monitor a set of resources (e.g., RLM reference signal resources) for one or more reference signals to measure. The UE may measure reference signals received and may determine a quality of the radio link based on the measurements. If the quality of the radio link falls below a threshold, the UE may initiate a radio link procedure (e.g., a radio link failure (RLF) mechanism), where the UE may initiate an RLF timer. Once the timer expires, the UE may transmit a reestablishment request to a base station to improve radio link conditions.

[0052] Some wireless communications systems may also employ beam failure recovery (BFR) techniques. A UE may receive at least one directional beam from another device. The UE may also receive reference signals corresponding to a directional beam. The UE may measure reference signals received and may determine a quality of the directional beam based on the measurements. If the quality of the directional beam falls below a threshold, the UE may initiate a BFR procedure. The BFR procedure may be used to improve beam quality conditions.

[0053] In some cases, an RLF procedure may overlap in time with a BFR procedure for a device. In these cases, if the BFR procedure is successful, the reconfigured or newly identified beams may also improve radio link conditions for a radio link corresponding to the RLF procedure. Performing both a radio link procedure and a beam failure procedure may increase overhead and waste resources at the UE. Thus, according to some aspects, a network node such as a base station may determine that the UE is to perform only one of a beam failure detection (BFD) procedure or an RLM procedure, or both. The base station may transmit an indication of whether to perform BFD or RLM to the UE and the UE may perform at least one of the BFD or RLM according to the indication.

[0054] Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects are then described with respect to process flows. Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to radio link and beam failure management.

[0055] **FIG. 1** illustrates an example of a wireless communications system 100 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The wireless communications system 100 includes base stations 105, UEs 115, and a core network 130. In some examples, the wireless communications system 100 may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an LTE-A Pro network, or a New Radio (NR) network. In some cases, wireless communications system 100 may support enhanced broadband communications, ultra-reliable (e.g., mission critical) communications, low latency communications, or communications with low-cost and low-complexity devices.

[0056] Base stations 105 may wirelessly communicate with UEs 115 via one or more base station antennas. Base stations 105 described herein may include or may be referred to by those skilled in the art as a base transceiver station, a radio base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation Node B or giga-nodeB (either of which may be referred to as a gNB), a Home NodeB, a Home eNodeB, or some other suitable terminology. Wireless communications system 100 may include base stations 105 of different types (e.g., macro or small cell base stations). The UEs 115 described herein may be able to communicate with various types of base stations 105 and network equipment including macro eNBs, small cell eNBs, gNBs, relay base stations, and the like.

[0057] Each base station 105 may be associated with a particular geographic coverage area 110 in which communications with various UEs 115 is supported. Each base station 105 may provide communication coverage for a respective geographic coverage area 110 via communication links 125, and communication links 125 between a base station 105 and a UE 115 may utilize one or more carriers. Communication links 125 shown in wireless communications system 100 may include uplink transmissions from a UE 115 to a base station 105, or downlink transmissions from a base station 105 to a UE 115. Downlink transmissions may also be called forward link transmissions while uplink transmissions may also be called reverse link transmissions.

[0058] The geographic coverage area 110 for a base station 105 may be divided into sectors making up only a portion of the geographic coverage area 110, and each sector may be associated with a cell. For example, each base station 105 may provide communication coverage for a macro cell, a small cell, a hot spot, or other types of cells, or various combinations thereof. In some examples, a base station 105 may be movable and therefore provide communication coverage for a moving geographic coverage area 110. In some examples, different geographic coverage areas 110 associated with different technologies may overlap, and overlapping geographic coverage areas 110 associated with different technologies may be supported by the same base station 105 or by different base stations 105. The wireless communications system 100 may include, for example, a heterogeneous LTE/LTE-A/LTE-A Pro or NR network in which different types of base stations 105 provide coverage for various geographic coverage areas 110.

[0059] The term “cell” refers to a logical communication entity used for communication with a base station 105 (e.g., over a carrier), and may be associated with an identifier for distinguishing neighboring cells (e.g., a physical cell identifier (PCID), a virtual cell identifier (VCID)) operating via the same or a different carrier. In some examples, a carrier may support multiple cells, and different cells may be configured according to different protocol types (e.g., machine-type communication (MTC), narrowband Internet-of-Things (NB-IoT), enhanced mobile broadband (eMBB), or others) that may provide access for different types of devices. In some cases, the term “cell” may refer to a portion of a geographic coverage area 110 (e.g., a sector) over which the logical entity operates.

[0060] UEs 115 may be dispersed throughout the wireless communications system 100, and each UE 115 may be stationary or mobile. A UE 115 may also be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, where the “device” may also be referred to as a unit, a station, a terminal, or a client. A UE 115 may also be a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE 115 may also refer to a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or an MTC device, or the like, which may be implemented in various articles such as appliances, vehicles, meters, or the like.

[0061] Some UEs 115, such as MTC or IoT devices, may be low cost or low complexity devices, and may provide for automated communication between machines (e.g., via

Machine-to-Machine (M2M) communication). M2M communication or MTC may refer to data communication technologies that allow devices to communicate with one another or a base station 105 without human intervention. In some examples, M2M communication or MTC may include communications from devices that integrate sensors or meters to measure or capture information and relay that information to a central server or application program that can make use of the information or present the information to humans interacting with the program or application. Some UEs 115 may be designed to collect information or enable automated behavior of machines. Examples of applications for MTC devices include smart metering, inventory monitoring, water level monitoring, equipment monitoring, healthcare monitoring, wildlife monitoring, weather and geological event monitoring, fleet management and tracking, remote security sensing, physical access control, and transaction-based business charging.

[0062] Some UEs 115 may be configured to employ operating modes that reduce power consumption, such as half-duplex communications (e.g., a mode that supports one-way communication via transmission or reception, but not transmission and reception simultaneously). In some examples half-duplex communications may be performed at a reduced peak rate. Other power conservation techniques for UEs 115 include entering a power saving “deep sleep” mode when not engaging in active communications, or operating over a limited bandwidth (e.g., according to narrowband communications). In some cases, UEs 115 may be designed to support critical functions (e.g., mission critical functions), and a wireless communications system 100 may be configured to provide ultra-reliable communications for these functions.

[0063] In some cases, a UE 115 may also be able to communicate directly with other UEs 115 (e.g., using a peer-to-peer (P2P) or device-to-device (D2D) protocol). One or more of a group of UEs 115 utilizing D2D communications may be within the geographic coverage area 110 of a base station 105. Other UEs 115 in such a group may be outside the geographic coverage area 110 of a base station 105, or be otherwise unable to receive transmissions from a base station 105. In some cases, groups of UEs 115 communicating via D2D communications may utilize a one-to-many (1:M) system in which each UE 115 transmits to every other UE 115 in the group. In some cases, a base station 105 facilitates the scheduling of resources for D2D communications. In other cases, D2D communications are carried out between UEs 115 without the involvement of a base station 105.

[0064] Base stations 105 may communicate with the core network 130 and with one another. For example, base stations 105 may interface with the core network 130 through backhaul links 132 (e.g., via an S1, N2, N3, or other interface). Base stations 105 may communicate with one another over backhaul links 134 (e.g., via an X2, Xn, or other interface) either directly (e.g., directly between base stations 105) or indirectly (e.g., via core network 130).

[0065] The core network 130 may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network 130 may be an evolved packet core (EPC), which may include at least one mobility management entity (MME), at least one serving gateway (S-GW), and at least one Packet Data Network (PDN) gateway (P-GW). The MME may manage non-access stratum (e.g., control plane) functions such as mobility, authentication, and bearer management for UEs 115 served by base stations 105 associated with the EPC. User IP packets may be transferred through the S-GW, which itself may be connected to the P-GW. The P-GW may provide IP address allocation as well as other functions. The P-GW may be connected to the network operators IP services. The operators IP services may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched (PS) Streaming Service.

[0066] At least some of the network devices, such as a base station 105, may include subcomponents such as an access network entity, which may be an example of an access node controller (ANC). Each access network entity may communicate with UEs 115 through a number of other access network transmission entities, which may be referred to as a radio head, a smart radio head, or a transmission/reception point (TRP). In some configurations, various functions of each access network entity or base station 105 may be distributed across various network devices (e.g., radio heads and access network controllers) or consolidated into a single network device (e.g., a base station 105).

[0067] Wireless communications system 100 may operate using one or more frequency bands, typically in the range of 300 MHz to 300 GHz. Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band, since the wavelengths range from approximately one decimeter to one meter in length. UHF waves may be blocked or redirected by buildings and environmental features. However, the waves may penetrate structures sufficiently for a macro cell to provide service to UEs 115 located indoors. Transmission of UHF waves may be associated with smaller antennas and shorter range (e.g., less than 100 km) compared to transmission using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

[0068] Wireless communications system 100 may also operate in a super high frequency (SHF) region using frequency bands from 3 GHz to 30 GHz, also known as the centimeter band. The SHF region includes bands such as the 5 GHz industrial, scientific, and medical (ISM) bands, which may be used opportunistically by devices that can tolerate interference from other users.

[0069] Wireless communications system 100 may also operate in an extremely high frequency (EHF) region of the spectrum (e.g., from 30 GHz to 300 GHz), also known as the millimeter band. In some examples, wireless communications system 100 may support millimeter wave (mmW) communications between UEs 115 and base stations 105, and EHF antennas of the respective devices may be even smaller and more closely spaced than UHF antennas. In some cases, this may facilitate use of antenna arrays within a UE 115. However, the propagation of EHF transmissions may be subject to even greater atmospheric attenuation and shorter range than SHF or UHF transmissions. Techniques disclosed herein may be employed across transmissions that use one or more different frequency regions, and designated use of bands across these frequency regions may differ by country or regulating body.

[0070] In some cases, wireless communications system 100 may utilize both licensed and unlicensed radio frequency spectrum bands. For example, wireless communications system 100 may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) radio access technology, or NR technology in an unlicensed band such as the 5 GHz ISM band. When operating in unlicensed radio frequency spectrum bands, wireless devices such as base stations 105 and UEs 115 may employ listen-before-talk (LBT) procedures to ensure a frequency channel is clear before transmitting data. In some cases, operations in unlicensed bands may be based on a CA configuration in conjunction with CCs operating in a licensed band (e.g., LAA). Operations in unlicensed spectrum may include downlink transmissions, uplink transmissions, peer-to-peer transmissions, or a combination of these. Duplexing in unlicensed spectrum may be based on frequency division duplexing (FDD), time division duplexing (TDD), or a combination of both.

[0071] In some examples, base station 105 or UE 115 may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. For example, wireless communications system 100 may use a transmission scheme between a transmitting device (e.g., a base station 105) and a receiving device (e.g., a UE 115), where the transmitting device is equipped with multiple antennas and the receiving devices are equipped with one or more antennas. MIMO communications may employ multipath signal propagation to increase the spectral efficiency by transmitting or receiving multiple signals via different spatial layers, which may be referred to as spatial multiplexing. The multiple signals may, for example, be transmitted by the transmitting device via different antennas or different combinations of antennas. Likewise, the multiple signals may be received by the receiving device via different antennas or different combinations of antennas. Each of the multiple signals may be referred to as a separate spatial stream, and may carry bits associated with the same data stream (e.g., the same codeword) or different data streams. Different spatial layers may be associated with different antenna ports used for channel measurement and reporting. MIMO techniques include single-user MIMO (SU-MIMO) where multiple spatial layers are transmitted to the same receiving device, and multiple-user MIMO (MU-MIMO) where multiple spatial layers are transmitted to multiple devices.

[0072] Beamforming, which may also be referred to as spatial filtering, directional transmission, or directional reception, is a signal processing technique that may be used at a transmitting device or a receiving device (e.g., a base station 105 or a UE 115) to shape or steer an antenna beam (e.g., a transmit beam or receive beam) along a spatial path between the transmitting device and the receiving device. Beamforming may be achieved by combining the signals communicated via antenna elements of an antenna array such that signals propagating at particular orientations with respect to an antenna array experience constructive interference while others experience destructive interference. The adjustment of signals communicated via the antenna elements may include a transmitting device or a receiving device applying certain amplitude and phase offsets to signals carried via each of the antenna elements associated with the device. The adjustments associated with each of the antenna elements may be defined by a beamforming weight set associated with a particular orientation (e.g., with respect to the antenna array of the transmitting device or receiving device, or with respect to some other orientation).

[0073] In one example, a base station 105 may use multiple antennas or antenna arrays to conduct beamforming operations for directional communications with a UE 115. For instance, some signals (e.g., synchronization signals, reference signals, beam selection signals, or other control signals) may be transmitted by a base station 105 multiple times in different directions, which may include a signal being transmitted according to different beamforming weight sets associated with different directions of transmission. Transmissions in different beam directions may be used to identify (e.g., by the base station 105 or a receiving device, such as a UE 115) a beam direction for subsequent transmission and/or reception by the base station 105. Some signals, such as data signals associated with a particular receiving device, may be transmitted by a base station 105 in a single beam direction (e.g., a direction associated with the receiving device, such as a UE 115). In some examples, the beam direction associated with transmissions along a single beam direction may be determined based at least in in part on a signal that was transmitted in different beam directions. For example, a UE 115 may receive one or more of the signals transmitted by the base station 105 in different directions, and the UE 115 may report to the base station 105 an indication of the signal it received with a highest signal quality, or an otherwise acceptable signal quality. Although these techniques are described with reference to signals transmitted in one or more directions by a base station 105, a UE 115 may employ similar techniques for transmitting signals multiple times in different directions (e.g., for identifying a beam direction for subsequent transmission or reception by the UE 115), or transmitting a signal in a single direction (e.g., for transmitting data to a receiving device).

[0074] A receiving device (e.g., a UE 115, which may be an example of a mmW receiving device) may try multiple receive beams when receiving various signals from the base station 105, such as synchronization signals, reference signals, beam selection signals, or other control signals. For example, a receiving device may try multiple receive directions by receiving via different antenna subarrays, by processing received signals according to different antenna subarrays, by receiving according to different receive beamforming weight sets applied to signals received at a plurality of antenna elements of an antenna array, or by processing received signals according to different receive beamforming weight sets applied to signals received at a plurality of antenna elements of an antenna array, any of which may be referred to as "listening" according to different receive beams or receive directions. In some examples a receiving device may use a single receive beam to receive along a single beam direction (e.g., when receiving a data signal). The single receive beam may be aligned in a beam direction determined based at least in part on listening according to different receive beam directions (e.g., a beam direction determined to have a highest signal strength, highest signal-to-noise ratio, or otherwise acceptable signal quality based at least in part on listening according to multiple beam directions).

[0075] In some cases, the antennas of a base station 105 or UE 115 may be located within one or more antenna arrays, which may support MIMO operations, or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some cases, antennas or antenna arrays associated with a base station 105 may be located in diverse geographic locations. A base station 105 may have an antenna array with a number of rows and columns of antenna ports that the base station 105 may use to support beamforming of communications with a UE 115. Likewise, a UE 115 may have one or more antenna arrays that may support various MIMO or beamforming operations.

[0076] In some cases, wireless communications system 100 may be a packet-based network that operate according to a layered protocol stack. In the user plane, communications at the bearer or Packet Data Convergence Protocol (PDCP) layer may be IP-based. A Radio Link Control (RLC) layer may in some cases perform packet segmentation and reassembly to communicate over logical channels. A Medium Access Control (MAC) layer may perform priority handling and multiplexing of logical channels into transport channels. The MAC layer may also use hybrid automatic repeat request (HARQ) to provide retransmission at the MAC layer to improve link efficiency. In the control plane, the Radio Resource Control (RRC) protocol layer may provide establishment, configuration, and maintenance of an RRC connection between a UE 115 and a base station 105 or core network 130 supporting radio bearers for user plane data. At the Physical (PHY) layer, transport channels may be mapped to physical channels.

[0077] In some cases, UEs 115 and base stations 105 may support retransmissions of data to increase the likelihood that data is received successfully. HARQ feedback is one technique of increasing the likelihood that data is received correctly over a communication link 125.

HARQ may include a combination of error detection (e.g., using a cyclic redundancy check (CRC)), forward error correction (FEC), and retransmission (e.g., automatic repeat request (ARQ)). HARQ may improve throughput at the MAC layer in poor radio conditions (e.g., signal-to-noise conditions). In some cases, a wireless device may support same-slot HARQ feedback, where the device may provide HARQ feedback in a specific slot for data received in a previous symbol in the slot. In other cases, the device may provide HARQ feedback in a subsequent slot, or according to some other time interval.

[0078] Time intervals in LTE or NR may be expressed in multiples of a basic time unit, which may, for example, refer to a sampling period of $T_s = 1/30{,}720{,}000$ seconds. Time intervals of a communications resource may be organized according to radio frames each having a duration of 10 milliseconds (ms), where the frame period may be expressed as $T_f = 307{,}200\ T_s$. The radio frames may be identified by a system frame number (SFN) ranging from 0 to 1023. Each frame may include 10 subframes numbered from 0 to 9, and each subframe may have a duration of 1 ms. A subframe may be further divided into 2 slots each having a duration of 0.5 ms, and each slot may contain 6 or 7 modulation symbol periods (e.g., depending on the length of the cyclic prefix prepended to each symbol period). Excluding the cyclic prefix, each symbol period may contain 2048 sampling periods. In some cases, a subframe may be the smallest scheduling unit of the wireless communications system 100, and may be referred to as a transmission time interval (TTI). In other cases, a smallest scheduling unit of the wireless communications system 100 may be shorter than a subframe or may be dynamically selected (e.g., in bursts of shortened TTIs (sTTIs) or in selected component carriers using sTTIs).

[0079] In some wireless communications systems, a slot may further be divided into multiple mini-slots containing one or more symbols. In some instances, a symbol of a mini-slot or a mini-slot may be the smallest unit of scheduling. Each symbol may vary in duration depending on the subcarrier spacing or frequency band of operation, for example. Further, some wireless communications systems may implement slot aggregation in which multiple slots or mini-slots are aggregated together and used for communication between a UE 115 and a base station 105.

[0080] The term “carrier” refers to a set of radio frequency spectrum resources having a defined physical layer structure for supporting communications over a communication link

125. For example, a carrier of a communication link 125 may include a portion of a radio frequency spectrum band that is operated according to physical layer channels for a given radio access technology. Each physical layer channel may carry user data, control information, or other signaling. A carrier may be associated with a pre-defined frequency channel (e.g., an evolved universal mobile telecommunication system terrestrial radio access (E-UTRA) absolute radio frequency channel number (EARFCN)), and may be positioned according to a channel raster for discovery by UEs 115. Carriers may be downlink or uplink (e.g., in an FDD mode), or be configured to carry downlink and uplink communications (e.g., in a TDD mode). In some examples, signal waveforms transmitted over a carrier may be made up of multiple sub-carriers (e.g., using multi-carrier modulation (MCM) techniques such as orthogonal frequency division multiplexing (OFDM) or discrete Fourier transform spread OFDM (DFT-S-OFDM)).

[0081] The organizational structure of the carriers may be different for different radio access technologies (e.g., LTE, LTE-A, LTE-A Pro, NR, etc.). For example, communications over a carrier may be organized according to TTIs or slots, each of which may include user data as well as control information or signaling to support decoding the user data. A carrier may also include dedicated acquisition signaling (e.g., synchronization signals or system information, etc.) and control signaling that coordinates operation for the carrier. In some examples (e.g., in a carrier aggregation configuration), a carrier may also have acquisition signaling or control signaling that coordinates operations for other carriers.

[0082] Physical channels may be multiplexed on a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed on a downlink carrier, for example, using time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. In some examples, control information transmitted in a physical control channel may be distributed between different control regions in a cascaded manner (e.g., between a common control region or common search space and one or more UE-specific control regions or UE-specific search spaces).

[0083] A carrier may be associated with a particular bandwidth of the radio frequency spectrum, and in some examples the carrier bandwidth may be referred to as a “system bandwidth” of the carrier or the wireless communications system 100. For example, the carrier bandwidth may be one of a number of predetermined bandwidths for carriers of a particular radio access technology (e.g., 1.4, 3, 5, 10, 15, 20, 40, or 80 MHz). In some examples, each served UE 115 may be configured for operating over portions or all of the carrier bandwidth. In other examples, some UEs 115 may be configured for operation using a narrowband protocol type that is associated with a predefined portion or range (e.g., set of subcarriers or RBs) within a carrier (e.g., "in-band" deployment of a narrowband protocol type).

[0084] In a system employing MCM techniques, a resource element may consist of one symbol period (e.g., a duration of one modulation symbol) and one subcarrier, where the symbol period and subcarrier spacing are inversely related. The number of bits carried by each resource element may depend on the modulation scheme (e.g., the order of the modulation scheme). Thus, the more resource elements that a UE 115 receives and the higher the order of the modulation scheme, the higher the data rate may be for the UE 115. In MIMO systems, a wireless communications resource may refer to a combination of a radio frequency spectrum resource, a time resource, and a spatial resource (e.g., spatial layers), and the use of multiple spatial layers may further increase the data rate for communications with a UE 115.

[0085] Devices of the wireless communications system 100 (e.g., base stations 105 or UEs 115) may have a hardware configuration that supports communications over a particular carrier bandwidth, or may be configurable to support communications over one of a set of carrier bandwidths. In some examples, the wireless communications system 100 may include base stations 105 and/or UEs 115 that can support simultaneous communications via carriers associated with more than one different carrier bandwidth.

[0086] Wireless communications system 100 may support communication with a UE 115 on multiple cells or carriers, a feature which may be referred to as carrier aggregation (CA) or multi-carrier operation. A UE 115 may be configured with multiple downlink CCs and one or more uplink CCs according to a carrier aggregation configuration. Carrier aggregation may be used with both FDD and TDD component carriers.

[0087] In some cases, wireless communications system 100 may utilize enhanced component carriers (eCCs). An eCC may be characterized by one or more features including wider carrier or frequency channel bandwidth, shorter symbol duration, shorter TTI duration, or modified control channel configuration. In some cases, an eCC may be associated with a carrier aggregation configuration or a dual connectivity configuration (e.g., when multiple serving cells have a suboptimal or non-ideal backhaul link). An eCC may also be configured for use in unlicensed spectrum or shared spectrum (e.g., where more than one operator is allowed to use the spectrum). An eCC characterized by wide carrier bandwidth may include one or more segments that may be utilized by UEs 115 that are not capable of monitoring the whole carrier bandwidth or are otherwise configured to use a limited carrier bandwidth (e.g., to conserve power).

[0088] In some cases, an eCC may utilize a different symbol duration than other CCs, which may include use of a reduced symbol duration as compared with symbol durations of the other CCs. A shorter symbol duration may be associated with increased spacing between adjacent subcarriers. A device, such as a UE 115 or base station 105, utilizing eCCs may transmit wideband signals (e.g., according to frequency channel or carrier bandwidths of 20, 40, 60, 80 MHz, etc.) at reduced symbol durations (e.g., 16.67 microseconds). A TTI in eCC may consist of one or multiple symbol periods. In some cases, the TTI duration (that is, the number of symbol periods in a TTI) may be variable.

[0089] Wireless communications systems such as an NR system may utilize any combination of licensed, shared, and unlicensed spectrum bands, among others. The flexibility of eCC symbol duration and subcarrier spacing may allow for the use of eCC across multiple spectrums. In some examples, NR shared spectrum may increase spectrum utilization and spectral efficiency, specifically through dynamic vertical (e.g., across the frequency domain) and horizontal (e.g., across the time domain) sharing of resources.

[0090] According to some aspects, a UE 115 may perform one or more of a BFD procedure or an RLM procedure. The determination of which procedure to perform may be based on signaling received from a base station 105. For example, a base station 105 may decide that only one of BFD or RLM may be sufficient in order to restore or reestablish communication with the UE 115. This decision may be based on the set of monitoring reference signals configured for BFD and RLM being the same or the base station 105 may observe BFD and RLM results from the UE 115 (e.g., previous results from the UE 115) and if the results are similar, the base station 105 may make a decision on whether the UE 115 is to perform BFD, RLM, or both. In some cases, a UE 115 may identify that only BFD or only

RLM may be sufficient (e.g., based on similar factors) and may transmit a request to the base station 105 indicating which of BFD or RLM the UE 115 wishes to perform. The base station 105 may also consider this request in making a decision and may indicate to the UE 115 to perform one or both of BFD or RLM according to the request or if the base station 105 determines that a procedure different than that which was identified in the request from the UE 115, the base station 105 may indicate this to the UE 115.

[0091] In some examples, this indication may be transmitted via RRC signaling or a MAC control element (MAC-CE). The UE 115 may then performed BFD or RLM as indicated by the base station 105. If beam failure is detected during a BFD procedure, the UE 115 may perform a BFR procedure or an RLM procedure. During RLM, if RLM is stopped (e.g., upon detection of a number of in-sync indications), the UE 115 will keep the current or previous RLM configuration and reset or freeze related timers (e.g., a T310 timer) or counters (e.g., a sync counter).

[0092] **FIG. 2** illustrates an example of a wireless communications system 200 that supports radio link and beam failure management in accordance with aspects of the present disclosure. In some examples, wireless communications system 200 may implement aspects of wireless communications system 100. Wireless communications system 200 may include a base station 105-a and a UE 115-a, which may be examples of base station 105 and UE 115, respectively. Base station 105-a may transmit directional beams 210-a through 210-d to UE 115-a. Some of the directional beams (e.g., directional beams 210-a and 210-b) may carry a radio link to the UE 115-a. Additionally or alternatively, the UE 115-a may receive only a subset of the directional beams (e.g., directional beams 210-a through 210-c).

[0093] Wireless communications system 200 may employ RLM techniques to monitor link quality conditions within the system. UE 115-a may be configured to monitor a set of resources (e.g., RLM reference signal resources) for one or more reference signals (e.g., synchronization signals, channel state information reference signals (CSI-RSs), or a combination thereof) to measure. The number of resources to monitor may be based on the frequency range the UE 115-a operates. For example, if the frequency range is below 3 GHz, the UE may be configured to monitor 2 resources for reference signals. Alternatively, if the frequency range is between 3 GHz and 6 GHz, the UE 115-a may be configured to monitor 4 resources for reference signals. Alternatively, if the frequency range is above 6 GHz, the UE 115-a may be configured to monitor 8 resources for reference signals.

[0094] The UE 115-a may measure reference signals received and may determine a quality of the radio link based on the measurements. For example, a UE 115-a may determine that a radio link is a periodic in-sync (IS) mode if an estimated link quality is above a predefined threshold. A periodic IS mode may be determined based on at least one measured reference signal received in the set of monitored resources. In another example, a UE 115-a may determine that a radio link is in a periodic out-of-sync (OOS) mode if an estimated link quality is below a predefined threshold. A periodic OOS mode may be determined based on a set of measured reference signal received across the set of monitored resources. Additionally, the estimated link quality for periodic IS and periodic OSS modes may be based at least in part on a hypothetical channel block error rate (BLER) (e.g., a physical downlink control channel (PDCCH) BLER), a signal to interference plus noise ratio (SINR), or a combination thereof, determined from the measured reference signal(s).

[0095] A radio link failure (RLF) procedure may be implemented based on OOS conditions present for a radio link. For example, a UE 115-a may determine that an OOS mode is present for a radio link based on measured RLM reference signals as discussed above. The UE 115-a may continue to measure RLM reference signals for the radio link after determining the presence of the OOS mode. The UE 115-a may, in some cases, determine an OOS mode is present for the radio link a predefined number of consecutive times (e.g., N310 consecutive periodic OOS mode determinations). The UE may then initiate a RLF timer (e.g., T310) based on the set of consecutive OOS determinations. The RLF timer may in turn, upon expiration, initiate a radio link reestablishment procedure for the radio link. For example, UE 115-a may transmit a reestablishment request 210 to the base station 105-a.

[0096] Wireless communication system 200 may also employ BFR mechanisms. UE 115-a may monitor for reference signals corresponding to directional beams received by the UE 115-a (e.g., directional beams 205-a through 205-d). The reference signals may be received over the corresponding directional beams in some cases. The reference signals may include synchronization signals, CSI-RS, or a combination thereof.

[0097] UE 115-a may measure the received reference signals to determine quality conditions for corresponding beams. In some cases, the UE 115-a may measure a hypothetical BLER rate, a SINR, or a combination thereof, corresponding to a directional beam based on received reference signals corresponding to the directional beam. The UE 115-a may determine that the measured beam quality falls below a predefined threshold. In such a case, the UE may determine that a BFD occurred for the corresponding beam. In some cases, the UE 115-a may make this determination after a successive number of beam quality measurements fall below a predefined threshold. Additionally or alternatively, the UE 115-a may make this determination based on beam quality measurements across all received beams at the UE 115-a fall below a predefined threshold. In some cases, the reference signals received for monitoring beam quality conditions may also be monitored for radio link conditions. For example, UE 115-a may receive reference signals over beam 205-a, where directional beam 205-a may also be a portion of a radio link for UE 115-a.

[0098] Once the UE 115-a determines a BFD has occurred, the UE 115-a may transmit to the base station 105-a a beam failure recovery request (BFRQ). The BFRQ transmission may be a part of a BFR mechanism for the UE 115-a. In some cases, the BFRQ may be transmitted over a random access channel (RACH). In response to the BFRQ, the base station 105-a may transmit to the UE 115-a a set of beam candidate identifiers for the UE 115-a monitor for. In some cases, the beam candidate identifiers may correspond to reconfigured directional beams, where the directional beams are reconfigured by the base station 105-a based on the received BFRQ. In other cases, the beam candidate identifiers may correspond to other directional beams the UE 115-a was not monitoring prior to transmission of the BFRQ.

[0099] The UE 115-a may monitor for the directional beams corresponding to the candidate beam identifiers. The UE 115-a may receive and measure reference signals corresponding to the new directional beams. In some cases, the measured beam quality conditions may yet fall below a predefined threshold. In these cases, the UE 115-a may determine the BFR mechanism has failed. Additionally, the UE 115-a may determine that the corresponding RACH has failed. If the UE 115-a was also concurrently executing a RLF mechanism when the UE 115-a determines the RACH failure, the UE 115-a may also determine a RLF failure due to the RACH failure. Alternatively, the measured beam quality conditions may be above a predefined threshold. In these cases, the UE 115-a may determine the BFR mechanism has succeeded.

[0100] In some examples, a UE 115 may perform both BFD and RLM in scenarios where BFD and RLM are strongly coupled (e.g., the failure of one may lead to the failure of the other or the success of one may lead to the success of the other). For example, in an OOS case, the failure of BFR (triggered after a beam failure is detected) may trigger RLF (e.g., failure after an RLM process). Further, when performing both BFD and RLM, UE 115 may maintain multiple tracking loops for each configured reference signal to be monitored, which may result in power consumption and increased overhead and complexity. This may result in a waste of resources (e.g., time, power) at UE 115.

[0101] According to some aspects, a network node (e.g., a base station 105) may identify whether a UE 115 is to perform BFD or RLM (or both). The base station 105 may signal which procedure to perform via radio RRC signaling or a MAC-CE. The UE 115 may performed BFD or RLM according to the signaling from the base station 105, which may prevent the UE 115 from performing both BFD (and a subsequent BFR procedure) as well as RLM simultaneously. This may result in power saving at UE 115.

[0102] **FIG. 3** illustrates an example of a process flow 300 that supports radio link and beam failure management in accordance with aspects of the present disclosure. In some examples, process flow 300 may be implemented by aspects of wireless communications systems 100 or 200. As shown, process flow 300 may be implemented by a base station 105-b and a UE 115-b, which may be examples of the corresponding devices described herein.

[0103] At 305, base station 105-b identifies whether UE 115-b is to perform a beam failure process (e.g., BFD) or a radio link procedure (e.g., RLM), or both. In some examples, base station 105-b may determine a BFD or RLM procedure based on the set of monitoring reference signals configured for BFD and RLM. For instance, base station 105-b may determine that the set of reference signals configured for BFD are the same as the set of reference signals configured for RLM (e.g., the reference signals used for BFD and RLM are configured as a single reference signal (RS) pool (e.g., *RadioLinkMonitoringRS*), and each reference signal may be configured to perform one or both of BFD or RLM). Based on this determination, base station 105-b may decide that only BFD or only RLM is to be performed. In some cases, base station 105-b may decide that both BFD and RLM are to be performed.

[0104] Additionally or alternatively, base station 105-b may observe BFD results and RLM results from previous procedure performed by UE 115-b. If the results of BFD and RLM are similar (e.g., over a time period), base station 105-b may decide that only BFD or only RLM is to be performed. In some cases, base station 105-b may decide that both BFD and RLM are to be performed.

[0105] At 310, base station 105-b may transmit, and the UE 115-b may receive, an indication based on the identification of BFD or RLM by the base station 105-b at 305. The indication may be transmitted via RRC signaling or a MAC-CE. In some examples, for the case of MAC-CE, such signaling may be supported by low latency devices. For instance, UE 115-b may be a low latency device associated with a low latency service (e.g., URLLC) and the base station 105-b may transmit the indication to UE 115-b via MAC-CE.

[0106] After UE 115-b receives the indication from base station 105-b at 310, the UE 115-b may modify a timer or a counter for the BFD or RLM procedure at 315. For instance, the UE 115-b may freeze or reset a radio link timer associated with RLM (e.g., a T310 timer). The UE 115-b may reset or freeze a sync indication counter associated with RLM (e.g., an OOS or IS indication counter). In some examples, the UE 115-b may keep the configuration of the disabled BFD or RLM procedure and reset or freeze all related timers or counters. Keeping the configuration may be based on freeze or reset information indicated by the base station 105-b (e.g., via a keep configuration).

[0107] At 320, the UE 115-b performs a beam failure procedure (e.g., BFD) or radio link procedure (e.g., RLM) as indicated by the base station 105-b at 310. In some cases, an RLM procedure may be performed in frequency bands below 6 GHz. In some examples, a successful BFR procedure after a beam failure is detected (e.g., based on a BFD procedure) may imply that a radio link may be recoverable.

[0108] **FIG. 4** illustrates an example of a process flow 400 that supports radio link and beam failure management in accordance with aspects of the present disclosure. In some examples, process flow 400 may implement aspects of wireless communications systems 100 or 200. As shown, process flow 400 may be implemented by a base station 105-c and a UE 115-c, which may be examples of the corresponding devices described herein.

[0109] At 405, UE 115-c determines whether a beam failure process (e.g., BFD) or a radio link procedure (e.g., RLM), or both may be sufficient. In some examples, UE 115-c may determine a BFD or RLM procedure based on the set of monitoring reference signals configured for BFD and RLM. For instance, UE 115-c may determine that the set of reference signals configured for BFD are the same as the set of reference signals configured for RLM (e.g., the reference signals used for BFD and RLM are configured as a single RS pool (e.g., *RadioLinkMonitoringRS*), and each reference signal may be configured to perform one or both of BFD or RLM). Based on this determination, UE 115-c may decide that only BFD or only RLM is to be performed.

[0110] Additionally or alternatively, UE 115-c may observe BFD results and RLM results from previous procedure performed by UE 115-c. If the results of BFD and RLM are similar (e.g., over a time period), UE 115-c may decide that only BFD or only RLM is to be performed.

[0111] At 410, UE 115-c may transmit a request to perform one of BFD or RLM based on the determination at 405. The request may be transmitted to base station 105-c via a physical uplink control channel (PUCCH) or a RACH message. In some examples, the request may be a 1-bit request. The request may include information on whether the UE 115-c wishes to perform BFD or RLM.

[0112] At 415, base station 105-c identifies whether UE 115-c is to perform a beam failure process (e.g., BFD) or a radio link procedure (e.g., RLM), or both. In some cases, base station 105-c may identify either BFD or RLM based on the request from the UE 115-c received at 410. For instance, the base station 105-c may determine BFD if BFD was indicated in the request received at 410, or the base station 105-c may determine RLM if RLM was indicated in the request received at 410.

[0113] The base station 105-c may also consider other factors. For instance, base station 105-c may determine a BFD or RLM procedure based on the set of monitoring reference signals configured for BFD and RLM. For instance, base station 105-c may determine that the set of reference signals configured for BFD are the same as the set of reference signals configured for RLM (e.g., the reference signals used for BFD and RLM are configured as a single RS pool (e.g., *RadioLinkMonitoringRS*), and each reference signal may be configured to perform one or both of BFD or RLM). Based on this determination, base station 105-c may decide that only BFD or only RLM is to be performed. In some cases, base station 105-c may decide that both BFD and RLM are to be performed.

[0114] Additionally or alternatively, base station 105-c may observe BFD results and RLM results from previous procedure performed by UE 115-c. If the results of BFD and RLM are similar (e.g., over a time period), base station 105-c may decide that only BFD or only RLM is to be performed. In some cases, base station 105-c may decide that both BFD and RLM are to be performed.

[0115] In some aspects, the base station 105-c may decide whether to use the information in the request received from UE 115-c at 410. For example, the base station 105-c may decide that the UE 115-c is to perform a procedure different than the procedure indicated in the request received from the UE 115-c at 410.

[0116] At 420, base station 105-c may transmit, and the UE 115-c may receive, an indication based on the identification of BFD or RLM by the base station 105-c at 415. The indication may be transmitted via RRC signaling or a MAC-CE. In some examples, for the case of MAC-CE, such signaling may be supported by low latency devices. For instance, UE 115-c may be a low latency device associated with a low latency service (e.g., URLLC) and the base station 105-b may transmit the indication to UE 115-c via MAC-CE.

[0117] After UE 115-c receives the indication from base station 105-c at 415, the UE 115-b may modify a timer or a counter for the BFD or RLM procedure at 425. For instance, the UE 115-c may freeze or reset a radio link timer associated with RLM (e.g., a T310 timer). The UE 115-c may reset or freeze a sync indication counter associated with RLM (e.g., an OOS or IS indication counter). In some examples, the UE 115-c may keep the configuration of the disabled BFD or RLM procedure and reset or freeze all related timers or counters. Keeping the configuration may be based on freeze or reset information indicated by the base station 105-c (e.g., via a keep configuration).

[0118] At 430, the UE 115-c performs a beam failure procedure (e.g., BFD) or radio link procedure (e.g., RLM) as indicated by the base station 105-c at 420. In some cases, an RLM procedure may be performed in frequency bands below 6 GHz. In some examples, a successful BFR procedure after a beam failure is detected (e.g., based on a BFD procedure) may imply that a radio link may be recoverable.

[0119] **FIG. 5** illustrates an example of a process flow 500 that supports radio link and beam failure management in accordance with aspects of the present disclosure. In some examples, process flow 500 may implement aspects of wireless communications systems 100 or 200. As shown, process flow 500 may be implemented by a base station 105-d and a UE 115-d, which may be examples of the corresponding devices described herein.

[0120] At 505, base station 105-d identifies whether UE 115-d is to perform a beam failure process (e.g., BFD) as a baseline procedure prior to or without performing RLM.

[0121] At 510, base station 105-d may transmit, and the UE 115-d may receive, an indication based on the identification of BFD as baseline by the base station 105-d at 505. The indication may be transmitted via RRC signaling or a MAC-CE. In some examples, for the case of MAC-CE, such signaling may be supported by low latency devices. For instance, UE 115-d may be a low latency device associated with a low latency service (e.g., URLLC) and the base station 105-d may transmit the indication to UE 115-d via MAC-CE.

[0122] After UE 115-d receives the indication from base station 105-d at 510, the UE 115-d may modify a timer or a counter for the RLM procedure at 515. For instance, the UE 115-d may freeze or reset a radio link timer associated with RLM (e.g., a T310 timer). The UE 115-d may reset or freeze a sync indication counter associated with RLM (e.g., an OOS or IS indication counter). In some examples, the UE 115-d may keep the configuration of the disabled RLM procedure and reset or freeze all related timers or counters. Keeping the configuration may be based on freeze or reset information indicated by the base station 105-d (e.g., via a keep configuration).

[0123] At 520, the UE 115-d performs a beam failure procedure (e.g., BFD) as indicated by the base station 105-d at 410. In some examples, the BFD may not trigger BFR (e.g., if beam failure is not detected). In other cases, beam failure may be detected (e.g., when all beams in monitored BFD set failed). This may trigger a BFR procedure and/or a RLM procedure at 525. In some examples, BFR and RLM may be performed independently and it may be possible that BFR is successful but RLM may trigger a RLF.

[0124] At 530, the RLM procedure may optionally be stopped by UE 115-d based on one or more conditions. For example, UE 115-d may stop RLM if a radio link timer (e.g., T310) is reset due to a number of periodic IS indications received during a specified time period. In other examples, UE 115-d may stop RLM if both a radio link timer (e.g., T310) is reset due to a number periodic IS indications received during a specified time period and the triggered BFR at 525 is successful. In some cases, after RLM is stopped, UE 115-d may keep the configuration of RLM and reset/freeze all related timer(s) or counter(s) (e.g., T310 and OOS/IS counter), and performs only BFD until next BFR is triggered by a BFD.

[0125] **FIG. 6** shows a block diagram 600 of a device 605 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 605 may be an example of aspects of a UE as described herein. The device 605 may include a receiver 610, a communications manager 615, and a transmitter 620. The device 605 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0126] The receiver 610 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to radio link and beam failure management, etc.). Information may be passed on to other components of the device 605. The receiver 610 may be an example of aspects of the transceiver 920 described with reference to FIG. 9. The receiver 610 may utilize a single antenna or a set of antennas.

[0127] The communications manager 615 may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0128] The communications manager 615 as described herein may be implemented to realize one or more potential advantages. One implementation may allow the device 605 to save power and increase battery life by communicating with a base station 105 (as shown in FIG. 1) more efficiently. For example, the device 605 may improve conditions of beam quality and a radio link with a base station 105, as the device 605 may be able to initiate a BFR or a radio link procedure to reestablish or improve communications with the base station 105. Another implementation may promote low latency communications at the device 605, as a number of resources allocated to signaling overhead may be reduced. The communications manager 615 may be an example of aspects of the communications manager 910 described herein.

[0129] The communications manager 615, or its sub-components, may be implemented in hardware, code (e.g., software or firmware) executed by a processor, or any combination thereof. If implemented in code executed by a processor, the functions of the communications manager 615, or its sub-components may be executed by a general-purpose processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described in the present disclosure.

[0130] The communications manager 615, or its sub-components, may be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations by one or more physical components. In some examples, the communications manager 615, or its sub-components, may be a separate and distinct component in accordance with various aspects of the present disclosure. In some examples, the communications manager 615, or its sub-components, may be combined with one or more other hardware components, including but not limited to an input/output (I/O) component, a transceiver, a network server, another computing device, one or more other components described in the present disclosure, or a combination thereof in accordance with various aspects of the present disclosure.

[0131] The transmitter 620 may transmit signals generated by other components of the device 605. In some examples, the transmitter 620 may be collocated with a receiver 610 in a transceiver module. For example, the transmitter 620 may be an example of aspects of the transceiver 920 described with reference to FIG. 9. The transmitter 620 may utilize a single antenna or a set of antennas.

[0132] **FIG. 7** shows a block diagram 700 of a device 705 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 705 may be an example of aspects of a device 605, or a UE as described herein. The device 705 may include a receiver 710, a communications manager 715, and a transmitter 735. The device 705 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0133] The receiver 710 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to radio link and beam failure management, etc.). Information may be passed on to other components of the device 705. The receiver 710 may be an example of aspects of the transceiver 920 described with reference to FIG. 9. The receiver 710 may utilize a single antenna or a set of antennas.

[0134] The communications manager 715 may be an example of aspects of the communications manager 615 as described herein. The communications manager 715 may include an indication receiver 720, a modification component 725, and a procedure manager 730. The communications manager 715 may be an example of aspects of the communications manager 910 described herein.

[0135] The indication receiver 720 may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof.

[0136] The modification component 725 may modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station.

[0137] The procedure manager 730 may perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0138] The transmitter 735 may transmit signals generated by other components of the device 705. In some examples, the transmitter 735 may be collocated with a receiver 710 in a transceiver module. For example, the transmitter 735 may be an example of aspects of the transceiver 920 described with reference to FIG. 9. The transmitter 735 may utilize a single antenna or a set of antennas.

[0139] **FIG. 8** shows a block diagram 800 of a communications manager 805 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The communications manager 805 may be an example of aspects of a communications manager 615, a communications manager 715, or a communications manager 910 described herein. The communications manager 805 may include an indication receiver 810, a modification component 815, a procedure manager 820, a beam failure component 825, a request manager 830, a monitoring component 835, a recovery component 840, a trigger component 845, a radio link manager 850, an in-sync component 855, and a configuration receiver 860. Each of these modules may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0140] The indication receiver 810 may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof. In some examples, the indication receiver 810 may receive the indication via RRC signaling or a MAC-CE. In some cases, the indication receiver 810 may receive the indication to perform a beam failure procedure, a radio link procedure, or any combination thereof based on the request.

[0141] The modification component 815 may modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station. In some examples, the modification component 815 may freeze or resetting the radio link timer after receiving the indication from the base station. In some cases, the modification component 815 may freeze or resetting the sync indication counter after receiving the indication from the base station. In some instances, the modification component 815 may pause the radio link timer for a pause duration. In some aspects, the modification component 815 may freeze or resetting information associated with the radio link timer or the sync indication counter.

[0142] The procedure manager 820 may perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station. In some examples, the procedure manager 820 may perform one of the beam failure procedure or the radio link procedure indicated by the indication received from the base station. In some cases, the procedure manager 820 may determine one of the beam failure procedure or the radio link procedure. In some aspects, the procedure manager 820 may determine one of the beam failure procedure or the radio link procedure based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure. In some instances, the procedure manager 820 may determine the beam failure procedure, the radio link procedure, or any combination thereof based on results of previous beam failure procedures or radio link procedures over a time period.

[0143] The beam failure component 825 may perform a beam failure detection procedure. In some examples, the beam failure component 825 may determine that beam failure is detected. In some cases, the beam failure component 825 may perform a beam failure detection procedure based on the indication. In some aspects, the beam failure component 825 may perform the beam failure recovery process based on the triggering. In some instances, the beam failure component 825 may determine that the beam failure recovery process was successful.

[0144] The request manager 830 may transmit a recovery request to the base station based on determining that beam failure is detected. In some examples, the request manager 830 may transmit a request to perform one of the beam failure procedure or the radio link procedure based on the determining. In some cases, the request manager 830 may transmit the request to the base station via a RACH or an uplink control channel. In some aspects, the request includes a one bit request message.

[0145] The monitoring component 835 may monitor for a response to the recovery request from the base station.

[0146] The recovery component 840 may perform a beam failure recovery procedure based on receipt of the response to the recovery request, where the recovery request indicates a candidate beam for the beam failure recovery procedure.

[0147] The trigger component 845 may trigger a beam failure recovery process and a radio link management process based on determining that beam failure is detected.

[0148] The radio link manager 850 may perform the radio link management process based on the triggering. In some examples, the radio link manager 850 may stop the radio link management process based on a number of the set of in-sync indications identified during the pause duration exceeding a threshold number of in-sync indications. In some cases, the radio link manager 850 may stop the radio link management process based on determining that the beam failure recovery process was successful.

[0149] The in-sync component 855 may identify a set of in-sync indications during the pause duration.

[0150] The configuration receiver 860 may receive a keep configuration from the base station, where the keep configuration indicates freeze or reset information associated with the radio link timer or the sync indication counter.

[0151] **FIG. 9** shows a diagram of a system 900 including a device 905 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 905 may be an example of or include the components of device 605, device 705, or a UE 115 as described herein. The device 905 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager 910, an I/O controller 915, a transceiver 920, an antenna 925, memory 930, and a processor 940. These components may be in electronic communication via one or more buses (e.g., bus 945).

[0152] The communications manager 910 may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof, modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station, and perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station.

[0153] The I/O controller 915 may manage input and output signals for the device 905. The I/O controller 915 may also manage peripherals not integrated into the device 905. In some cases, the I/O controller 915 may represent a physical connection or port to an external peripheral. In some cases, the I/O controller 915 may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In other cases, the I/O controller 915 may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller 915 may be implemented as part of a processor. In some cases, a user may interact with the device 905 via the I/O controller 915 or via hardware components controlled by the I/O controller 915.

[0154] The transceiver 920 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 920 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 920 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0155] In some cases, the device 905 may include a single antenna 925. However, in some cases the device 905 may have more than one antenna 925, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0156] The memory 930 may include random-access memory (RAM) and read-only memory (ROM). The memory 930 may store computer-readable, computer-executable code 935 including instructions that, when executed, cause the processor to perform various functions described herein. In some cases, the memory 930 may contain, among other things, a basic input/output system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0157] The processor 940 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a central processing unit (CPU), a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, the processor 940 may be configured to operate a memory array using a memory controller. In other cases, a memory controller may be integrated into the processor 940. The processor 940 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 930) to cause the device 905 to perform various functions (e.g., functions or tasks supporting radio link and beam failure management).

[0158] The processor 940 of the device 905 (e.g., controlling the receiver 610, the transmitter 620, or the transceiver 920) may reduce power consumption and increase transmission reliability based on performing a BFD procedure, or an RLM procedure, or both. In some examples, the processor 940 of the device 905 may reconfigure parameters for transmitting over the radio link or the beam. For example, the processor 940 of the device 905 may turn on one or more processing units for performing the BFD or RLM procedure, increase a processing clock, or a similar mechanism within the device 905. As such, when subsequent radio link reconfigurations are required, the processor 940 may be ready to respond more efficiently through the reduction of a ramp up in processing power. The improvements in power saving and transmission reliability may further increase battery life at the device 905 (for example, by reducing or eliminating unnecessary or failed transmissions, etc.).

[0159] The code 935 may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The code 935 may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some cases, the code 935 may not be directly executable by the processor 940 but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0160] **FIG. 10** shows a block diagram 1000 of a device 1005 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 1005 may be an example of aspects of a base station 105 as described herein. The device 1005 may include a receiver 1010, a communications manager 1015, and a transmitter 1020. The device 1005 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0161] The receiver 1010 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to radio link and beam failure management, etc.). Information may be passed on to other components of the device 1005. The receiver 1010 may be an example of aspects of the transceiver 1320 described with reference to FIG. 13. The receiver 1010 may utilize a single antenna or a set of antennas.

[0162] The communications manager 1015 may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. The communications manager 1015 as described herein may be implemented to realize one or more potential advantages. One implementation may allow the device 1005 to save power by communicating with a UE 115 (as shown in FIG. 1) more efficiently. For example, the device 1005 may reduce signaling overhead in communications with a UE 115, as the device 1005 may be able to signal the UE 115 to perform only one of a BFD procedure, or an RLM procedure, or both. The communications manager 1015 may be an example of aspects of the communications manager 1310 described herein.

[0163] The communications manager 1015, or its sub-components, may be implemented in hardware, code (e.g., software or firmware) executed by a processor, or any combination thereof. If implemented in code executed by a processor, the functions of the communications manager 1015, or its sub-components may be executed by a general-purpose processor, a DSP, an ASIC, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described in the present disclosure.

[0164] The communications manager 1015, or its sub-components, may be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations by one or more physical components. In some examples, the communications manager 1015, or its sub-components, may be a separate and distinct component in accordance with various aspects of the present disclosure. In some examples, the communications manager 1015, or its sub-components, may be combined with one or more other hardware components, including but not limited to an input/output (I/O) component, a transceiver, a network server, another computing device, one or more other components described in the present disclosure, or a combination thereof in accordance with various aspects of the present disclosure.

[0165] The transmitter 1020 may transmit signals generated by other components of the device 1005. In some examples, the transmitter 1020 may be collocated with a receiver 1010 in a transceiver module. For example, the transmitter 1020 may be an example of aspects of the transceiver 1320 described with reference to FIG. 13. The transmitter 1020 may utilize a single antenna or a set of antennas.

[0166] **FIG. 11** shows a block diagram 1100 of a device 1105 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 1105 may be an example of aspects of a device 1005, or a base station 105 as described herein. The device 1105 may include a receiver 1110, a communications manager 1115, and a transmitter 1130. The device 1105 may also include a processor. Each of these components may be in communication with one another (e.g., via one or more buses).

[0167] The receiver 1110 may receive information such as packets, user data, or control information associated with various information channels (e.g., control channels, data channels, and information related to radio link and beam failure management, etc.). Information may be passed on to other components of the device 1105. The receiver 1110 may be an example of aspects of the transceiver 1320 described with reference to FIG. 13. The receiver 1110 may utilize a single antenna or a set of antennas.

[0168] The communications manager 1115 may be an example of aspects of the communications manager 1015 as described herein. The communications manager 1115 may include a procedure identifier 1120 and an indication transmitter 1125. The communications manager 1115 may be an example of aspects of the communications manager 1310 described herein.

[0169] The procedure identifier 1120 may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE.

[0170] The indication transmitter 1125 may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0171] The transmitter 1130 may transmit signals generated by other components of the device 1105. In some examples, the transmitter 1130 may be collocated with a receiver 1110 in a transceiver module. For example, the transmitter 1130 may be an example of aspects of the transceiver 1320 described with reference to FIG. 13. The transmitter 1130 may utilize a single antenna or a set of antennas.

[0172] **FIG. 12** shows a block diagram 1200 of a communications manager 1205 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The communications manager 1205 may be an example of aspects of a communications manager 1015, a communications manager 1115, or a communications manager 1310 described herein. The communications manager 1205 may include a procedure identifier 1210, an indication transmitter 1215, a request receiver 1220, and a configuration transmitter 1225. Each of these modules may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0173] The procedure identifier 1210 may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE. In some examples, the procedure identifier 1210 may determine the beam failure procedure, the radio link procedure, or any combination thereof based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure. In some cases, the procedure identifier 1210 may determine the beam failure procedure, the radio link procedure, or any combination thereof based on previous beam failure procedures or radio link procedures. In some aspects, the procedure identifier 1210 may determine the beam failure procedure, the radio link procedure, or any combination thereof based on the request. In some instances, the procedure identifier 1210 may determine one of the beam failure procedure or the radio link procedure as indicated in the request from the UE.

[0174] In some cases, the beam failure procedure, the radio link procedure, or any combination thereof is determined based on results of previous beam failure procedures or radio link procedures over a time period. In some examples, the request is received via a RACH or a PUCCH.

[0175] The indication transmitter 1215 may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. In some examples, the indication transmitter 1215 may transmit the indication via RRC signaling or a MAC-CE.

[0176] The request receiver 1220 may receive, from the UE, a request to perform one of the beam failure procedure or the radio link procedure.

[0177] The configuration transmitter 1225 may transmit a keep configuration to the UE, where the keep configuration indicates freeze or reset information associated with a radio link timer or a sync indication counter of the UE.

[0178] **FIG. 13** shows a diagram of a system 1300 including a device 1305 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The device 1305 may be an example of or include the components of device 1005, device 1105, or a base station 105 as described herein. The device 1305 may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager 1310, a network communications manager 1315, a transceiver 1320, an antenna 1325, memory 1330, a processor 1340, and an inter-station communications manager 1345. These components may be in electronic communication via one or more buses (e.g., bus 1350).

[0179] The communications manager 1310 may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE and transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

[0180] The network communications manager 1315 may manage communications with the core network (e.g., via one or more wired backhaul links). For example, the network communications manager 1315 may manage the transfer of data communications for client devices, such as one or more UEs 115.

[0181] The transceiver 1320 may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver 1320 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 1320 may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

[0182] In some cases, the device 1305 may include a single antenna 1325. However, in some cases the device 1305 may have more than one antenna 1325, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

[0183] The memory 1330 may include RAM, ROM, or a combination thereof. The memory 1330 may store computer-readable code 1335 including instructions that, when executed by a processor (e.g., the processor 1340) cause the device to perform various functions described herein. In some cases, the memory 1330 may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0184] The processor 1340 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some cases, the processor 1340 may be configured to operate a memory array using a memory controller. In some cases, a memory controller may be integrated into processor 1340. The processor 1340 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 1330) to cause the device 1305 to perform various functions (e.g., functions or tasks supporting radio link and beam failure management).

[0185] The inter-station communications manager 1345 may manage communications with other base station 105, and may include a controller or scheduler for controlling communications with UEs 115 in cooperation with other base stations 105. For example, the inter-station communications manager 1345 may coordinate scheduling for transmissions to UEs 115 for various interference mitigation techniques such as beamforming or joint transmission. In some examples, the inter-station communications manager 1345 may provide an X2 interface within an LTE/LTE-A wireless communication network technology to provide communication between base stations 105.

[0186] The code 1335 may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The code 1335 may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some cases, the code 1335 may not be directly executable by the processor 1340 but may cause a computer (e.g., when compiled and executed) to perform functions described herein.

[0187] **FIG. 14** shows a flowchart illustrating a method 1400 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1400 may be implemented by a UE 115 or its components as described herein. For example, the operations of method 1400 may be performed by a communications manager as described with reference to FIGs. 6 through 9. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

[0188] At 1405, the UE may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof. The operations of 1405 may be performed according to the methods described herein. In some examples, aspects of the operations of 1405 may be performed by an indication receiver as described with reference to FIGs. 6 through 9.

[0189] At 1410, the UE may modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station. The operations of 1410 may be performed according to the methods described herein. In some examples, aspects of the operations of 1410 may be performed by a modification component as described with reference to FIGs. 6 through 9.

[0190] At 1415, the UE may perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station. The operations of 1415 may be performed according to the methods described herein. In some examples, aspects of the operations of 1415 may be performed by a procedure manager as described with reference to FIGs. 6 through 9.

[0191] **FIG. 15** shows a flowchart illustrating a method 1500 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1500 may be implemented by a UE 115 or its components as described herein. For example, the operations of method 1500 may be performed by a communications manager as described with reference to FIGs. 6 through 9. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

[0192] At 1505, the UE may determine one of the beam failure procedure or the radio link procedure. The operations of 1505 may be performed according to the methods described herein. In some examples, aspects of the operations of 1505 may be performed by a procedure manager as described with reference to FIGs. 6 through 9.

[0193] At 1510, the UE may transmit a request to perform one of the beam failure procedure or the radio link procedure based on the determining. The operations of 1510 may be performed according to the methods described herein. In some examples, aspects of the operations of 1510 may be performed by a request manager as described with reference to FIGs. 6 through 9.

[0194] At 1515, the UE may receive the indication to perform a beam failure procedure, a radio link procedure, or any combination thereof based on the request. The operations of 1515 may be performed according to the methods described herein. In some examples, aspects of the operations of 1515 may be performed by an indication receiver as described with reference to FIGs. 6 through 9.

[0195] At 1520, the UE may modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station. The operations of 1520 may be performed according to the methods described herein. In some examples, aspects of the operations of 1520 may be performed by a modification component as described with reference to FIGs. 6 through 9.

[0196] At 1525, the UE may perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station. The operations of 1525 may be performed according to the methods described herein. In some examples, aspects of the operations of 1525 may be performed by a procedure manager as described with reference to FIGs. 6 through 9.

[0197] **FIG. 16** shows a flowchart illustrating a method 1600 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1600 may be implemented by a UE 115 or its components as described herein. For example, the operations of method 1600 may be performed by a communications manager as described with reference to FIGs. 6 through 9. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

[0198] At 1605, the UE may receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof. The operations of 1605 may be performed according to the methods described herein. In some examples, aspects of the operations of 1605 may be performed by an indication receiver as described with reference to FIGs. 6 through 9.

[0199] At 1610, the UE may modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station. The operations of 1610 may be performed according to the methods described herein. In some examples, aspects of the operations of 1610 may be performed by a modification component as described with reference to FIGs. 6 through 9.

[0200] At 1615, the UE may perform a beam failure detection procedure based on the indication. The operations of 1615 may be performed according to the methods described herein. In some examples, aspects of the operations of 1615 may be performed by a beam failure component as described with reference to FIGs. 6 through 9.

[0201] At 1620, the UE may determine that beam failure is detected. The operations of 1620 may be performed according to the methods described herein. In some examples, aspects of the operations of 1620 may be performed by a beam failure component as described with reference to FIGs. 6 through 9.

[0202] At 1625, the UE may trigger a beam failure recovery process and a radio link management process based on determining that beam failure is detected. The operations of 1625 may be performed according to the methods described herein. In some examples, aspects of the operations of 1625 may be performed by a trigger component as described with reference to FIGs. 6 through 9.

[0203] **FIG. 17** shows a flowchart illustrating a method 1700 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1700 may be implemented by a base station 105 or its components as described herein. For example, the operations of method 1700 may be performed by a communications manager as described with reference to FIGs. 10 through 13. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

[0204] At 1705, the base station may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE. The operations of 1705 may be performed according to the methods described herein. In some examples, aspects of the operations of 1705 may be performed by a procedure identifier as described with reference to FIGs. 10 through 13.

[0205] At 1710, the base station may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. The operations of 1710 may be performed according to the methods described herein. In some examples, aspects of the operations of 1710 may be performed by an indication transmitter as described with reference to FIGs. 10 through 13.

[0206] **FIG. 18** shows a flowchart illustrating a method 1800 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1800 may be implemented by a base station 105 or its components as described herein. For example, the operations of method 1800 may be performed by a communications manager as described with reference to FIGs. 10 through 13. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

[0207] At 1805, the base station may determine a beam failure procedure, a radio link procedure, or any combination thereof for a UE based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure. The operations of 1805 may be performed according to the methods described herein. In some examples, aspects of the operations of 1805 may be performed by a procedure identifier as described with reference to FIGs. 10 through 13.

[0208] At 1810, the base station may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. The operations of 1810 may be performed according to the methods described herein. In some examples, aspects of the operations of 1810 may be performed by an indication transmitter as described with reference to FIGs. 10 through 13.

[0209] **FIG. 19** shows a flowchart illustrating a method 1900 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 1900 may be implemented by a base station 105 or its components as described herein. For example, the operations of method 1900 may be performed by a communications manager as described with reference to FIGs. 10 through 13. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

[0210] At 1905, the base station may determine a beam failure procedure, a radio link procedure, or any combination thereof for a UE based on previous beam failure procedures or radio link procedures. The operations of 1905 may be performed according to the methods described herein. In some examples, aspects of the operations of 1905 may be performed by a procedure identifier as described with reference to FIGs. 10 through 13.

[0211] At 1910, the base station may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. The operations of 1910 may be performed according to the methods described herein. In some examples, aspects of the operations of 1910 may be performed by an indication transmitter as described with reference to FIGs. 10 through 13.

[0212] **FIG. 20** shows a flowchart illustrating a method 2000 that supports radio link and beam failure management in accordance with aspects of the present disclosure. The operations of method 2000 may be implemented by a base station 105 or its components as described herein. For example, the operations of method 2000 may be performed by a communications manager as described with reference to FIGs. 10 through 13. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

[0213] At 2005, the base station may identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE. The operations of 2005 may be performed according to the methods described herein. In some examples, aspects of the operations of 2005 may be performed by a procedure identifier as described with reference to FIGs. 10 through 13.

[0214] At 2010, the base station may transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE. The operations of 2010 may be performed according to the methods described herein. In some examples, aspects of the operations of 2010 may be performed by an indication transmitter as described with reference to FIGs. 10 through 13.

[0215] At 2015, the base station may transmit a keep configuration to the UE, where the keep configuration indicates freeze or reset information associated with a radio link timer or a sync indication counter of the UE. The operations of 2015 may be performed according to the methods described herein. In some examples, aspects of the operations of 2015 may be performed by a configuration transmitter as described with reference to FIGs. 10 through 13.

[0216] It should be noted that the methods described herein describe possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0217] Techniques described herein may be used for various wireless communications systems such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), and other systems. A CDMA system may implement a radio technology such as CDMA2000, Universal Terrestrial Radio Access (UTRA), etc. CDMA2000 covers IS-2000, IS-95, and IS-856 standards. IS-2000 Releases may be commonly referred to as CDMA2000 1X, 1X, etc.

IS-856 (TIA-856) is commonly referred to as CDMA2000 1xEV-DO, High Rate Packet Data (HRPD), etc. UTRA includes Wideband CDMA (WCDMA) and other variants of CDMA. A TDMA system may implement a radio technology such as Global System for Mobile Communications (GSM).

[0218] An OFDMA system may implement a radio technology such as Ultra Mobile Broadband (UMB), E-UTRA, Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunications System (UMTS). LTE, LTE-A, and LTE-A Pro are releases of UMTS that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A, LTE-A Pro, NR, and GSM are described in documents from the organization named “3rd Generation Partnership Project” (3GPP). CDMA2000 and UMB are described in documents from an organization named “3rd Generation Partnership Project 2” (3GPP2). The techniques described herein may be used for the systems and radio technologies mentioned herein as well as other systems and radio technologies. While aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE, LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR applications.

[0219] A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs 115 with service subscriptions with the network provider. A small cell may be associated with a lower-powered base station 105, as compared with a macro cell, and a small cell may operate in the same or different (e.g., licensed, unlicensed, etc.) frequency bands as macro cells. Small cells may include pico cells, femto cells, and micro cells according to various examples. A pico cell, for example, may cover a small geographic area and may allow unrestricted access by UEs 115 with service subscriptions with the network provider. A femto cell may also cover a small geographic area (e.g., a home) and may provide restricted access by UEs 115 having an association with the femto cell (e.g., UEs 115 in a closed subscriber group (CSG), UEs 115 for users in the home, and the like). An eNB for a macro cell may be referred to as a macro eNB. An eNB for a small cell may be referred to as a small cell eNB, a pico eNB, a femto eNB, or a home eNB. An eNB may support one or multiple (e.g., two, three, four, and the like) cells, and may also support communications using one or multiple component carriers.

[0220] The wireless communications system 100 or systems described herein may support synchronous or asynchronous operation. For synchronous operation, the base stations 105 may have similar frame timing, and transmissions from different base stations 105 may be approximately aligned in time. For asynchronous operation, the base stations 105 may have different frame timing, and transmissions from different base stations 105 may not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.

[0221] Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0222] The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0223] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0224] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

[0225] As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an exemplary step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on."

[0226] In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label, or other subsequent reference label.

[0227] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term “exemplary” used herein means “serving as an example, instance, or illustration,” and not “preferred” or “advantageous over other examples.” The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0228] The description herein is provided to enable a person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein, but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A method for wireless communications, comprising:

receiving, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof;

modifying a radio link timer, a sync indication counter, or any combination thereof based at least in part on the indication received from the base station; and

performing at least one of the beam failure procedure or the radio link procedure based at least in part on the indication received from the base station.

2. The method of claim 1, wherein receiving the indication comprises:

receiving the indication via radio resource control (RRC) signaling or a media access control control element (MAC-CE).

3. The method of claim 1, wherein modifying the radio link timer comprises:

freezing or resetting the radio link timer after receiving the indication from the base station.

4. The method of claim 1, wherein modifying the sync indication counter comprises:

freezing or resetting the sync indication counter after receiving the indication from the base station.

5. The method of claim 1, wherein performing at least one of the beam failure procedure or the radio link procedure comprises:

performing one of the beam failure procedure or the radio link procedure indicated by the indication received from the base station.

6. The method of claim 5, wherein performing the beam failure procedure comprises:

performing a beam failure detection procedure;

determining that beam failure is detected;

transmitting a recovery request to the base station based at least in part on determining that beam failure is detected; and

monitoring for a response to the recovery request from the base station.

7. The method of claim 6, further comprising:

performing a beam failure recovery procedure based at least in part on receipt of the response to the recovery request, wherein the recovery request indicates a candidate beam for the beam failure recovery procedure.

8. The method of claim 1, further comprising:

determining one of the beam failure procedure or the radio link procedure;

transmitting a request to perform one of the beam failure procedure or the radio link procedure based at least in part on the determining; and

receiving the indication to perform a beam failure procedure, a radio link procedure, or any combination thereof based at least in part on the request.

9. The method of claim 8, wherein transmitting the request comprises:

transmitting the request to the base station via a random access control channel (RACH) or an uplink control channel.

10. The method of claim 9, wherein the request comprises a one bit request message.

11. The method of claim 8, wherein determining one of the beam failure procedure or the radio link procedure comprises:

determining one of the beam failure procedure or the radio link procedure based at least in part on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure.

12. The method of claim 8, wherein determining one of the beam failure procedure or the radio link procedure comprises:

determining the beam failure procedure, the radio link procedure, or any combination thereof based at least in part on results of previous beam failure procedures or radio link procedures over a time period.

13. The method of claim 1, further comprising:

performing a beam failure detection procedure based at least in part on the indication;

determining that beam failure is detected; and

triggering a beam failure recovery process and a radio link management process based at least in part on determining that beam failure is detected.

14. The method of claim 13, further comprising:

performing the radio link management process based at least in part on the triggering;

pausing the radio link timer for a pause duration;

identifying a set of in-sync indications during the pause duration; and

stopping the radio link management process based at least in part on a number of the set of in-sync indications identified during the pause duration exceeding a threshold number of in-sync indications.

15. The method of claim 14, further comprising:

performing the beam failure recovery process based at least in part on the triggering;

determining that the beam failure recovery process was successful; and

stopping the radio link management process based at least in part on determining that the beam failure recovery process was successful.

16. The method of claim 13, further comprising:

freezing or resetting information associated with the radio link timer or the sync indication counter.

17. The method of claim 1, further comprising:

receiving a keep configuration from the base station, wherein the keep configuration indicates freeze or reset information associated with the radio link timer or the sync indication counter.

18. A method for wireless communications, comprising:

identifying a beam failure procedure, a radio link procedure, or any combination thereof for a user equipment (UE); and

transmitting, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

19. The method of claim 18, wherein transmitting the indication comprises:

transmitting the indication via radio resource control (RRC) signaling or a media access control control element (MAC-CE).

20. The method of claim 18, further comprising:

determining the beam failure procedure, the radio link procedure, or any combination thereof based at least in part on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure.

21. The method of claim 18, further comprising:

determining the beam failure procedure, the radio link procedure, or any combination thereof based at least in part on previous beam failure procedures or radio link procedures.

22. The method of claim 21, wherein the beam failure procedure, the radio link procedure, or any combination thereof is determined based on results of previous beam failure procedures or radio link procedures over a time period.

23. The method of claim 18, further comprising:

receiving, from the UE, a request to perform one of the beam failure procedure or the radio link procedure; and

determining the beam failure procedure, the radio link procedure, or any combination thereof based at least in part on the request.

24. The method of claim 23, wherein determining the beam failure procedure, the radio link procedure, or any combination thereof comprises:

determining one of the beam failure procedure or the radio link procedure as indicated in the request from the UE.

25. The method of claim 23, wherein the request is received via a random access channel (RACH) or a physical uplink control channel (PUCCH).

26. The method of claim 18, further comprising:

transmitting a keep configuration to the UE, wherein the keep configuration indicates freeze or reset information associated with a radio link timer or a sync indication counter of the UE.

27. An apparatus for wireless communications, comprising:

a processor,

memory in electronic communication with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof;

modify a radio link timer, a sync indication counter, or any combination thereof based at least in part on the indication received from the base station; and

perform at least one of the beam failure procedure or the radio link procedure based at least in part on the indication received from the base station.

28. The apparatus of claim 27, wherein the instructions are further executable by the processor to cause the apparatus to:

receive the indication via radio resource control (RRC) signaling or a media access control control element (MAC-CE).

29. An apparatus for wireless communications, comprising:

a processor,

memory in electronic communication with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

identify a beam failure procedure, a radio link procedure, or any combination thereof for a user equipment (UE); and transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE.

30. The apparatus of claim 29, wherein the instructions are further executable by the processor to cause the apparatus to:

transmit the indication via radio resource control (RRC) signaling or a media access control control element (MAC-CE).

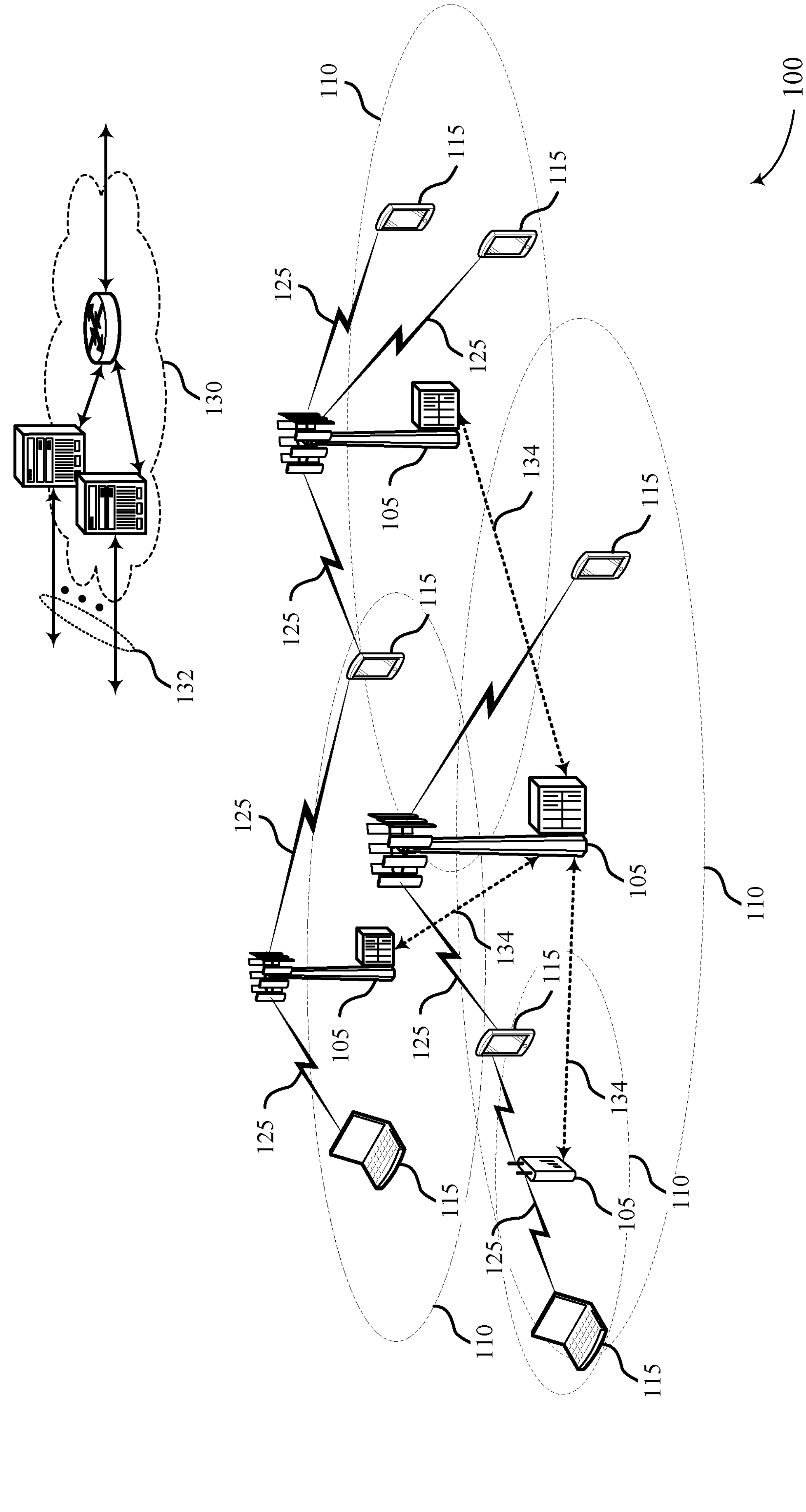

FIG. 1

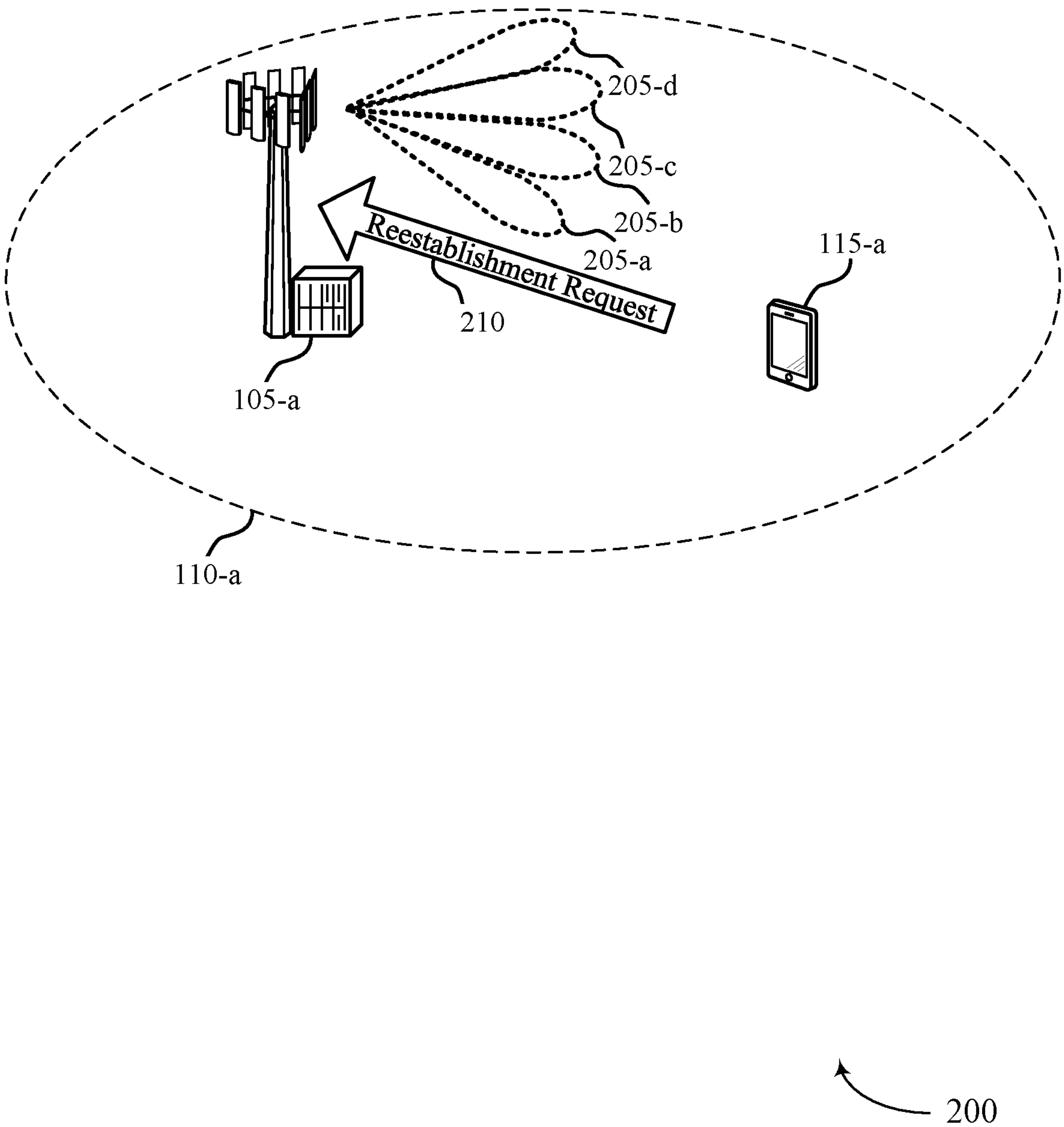
205-d
205-c
205-b
205-a
115-a
Reestablishment Request
210
105-a
110-a
200

FIG. 2

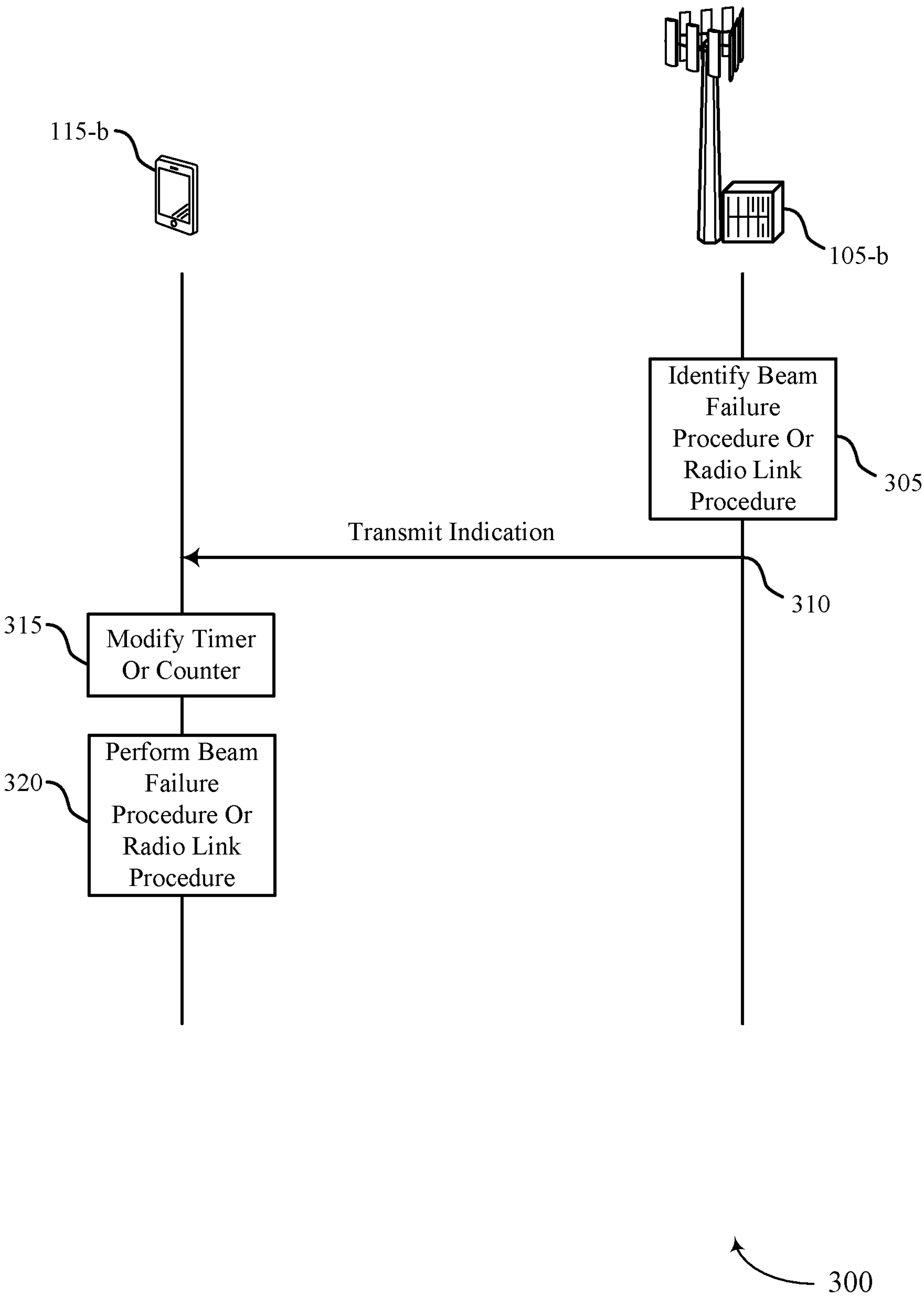
115-b
105-b
Identify Beam Failure Procedure Or Radio Link Procedure
305
Transmit Indication
310
315
Modify Timer Or Counter
Perform Beam Failure Procedure Or Radio Link Procedure
320
300

FIG. 3

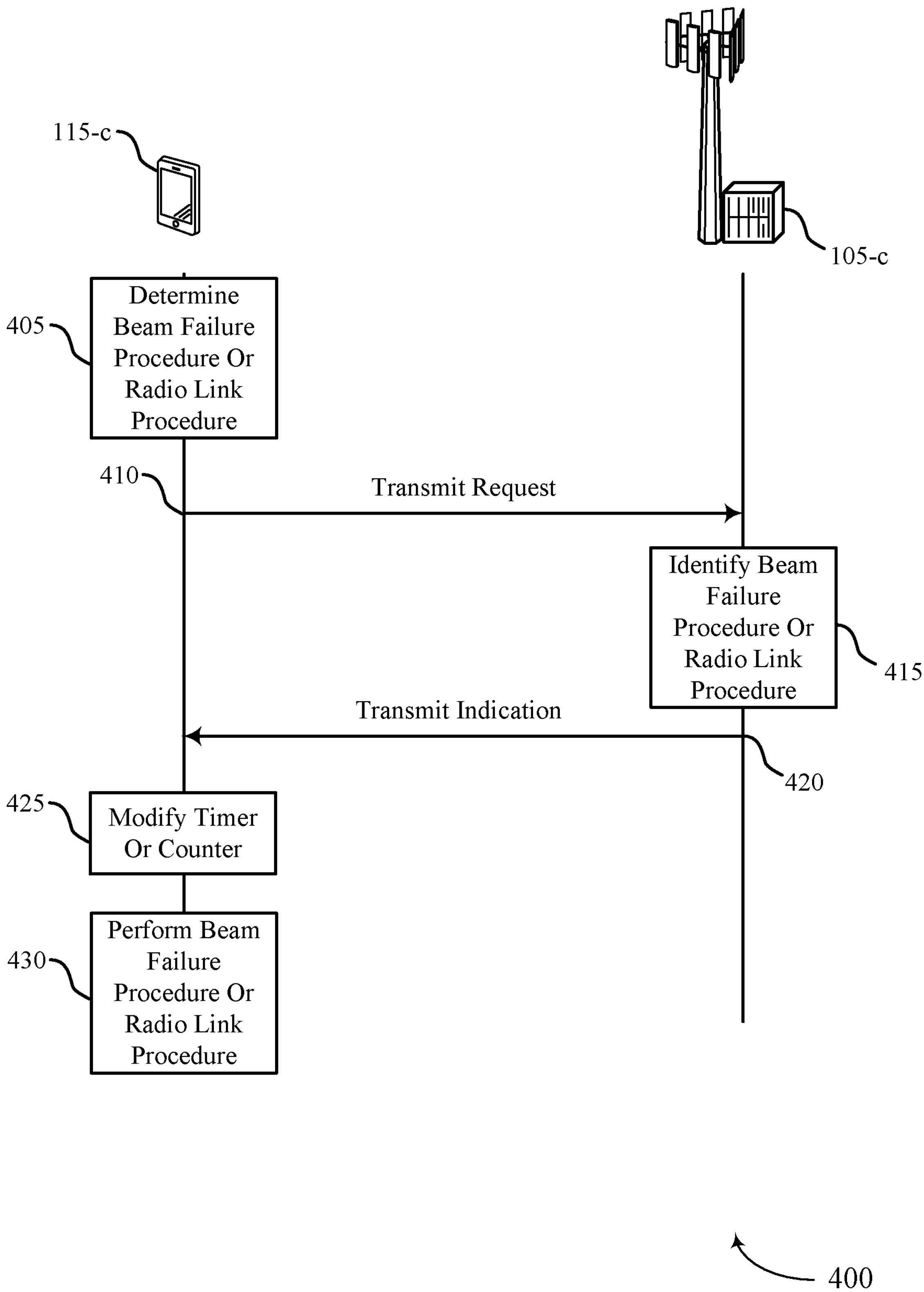
115-c
105-c
405
Determine Beam Failure Procedure Or Radio Link Procedure
410
Transmit Request
Identify Beam Failure Procedure Or Radio Link Procedure
415
Transmit Indication
420
425
Modify Timer Or Counter
430
Perform Beam Failure Procedure Or Radio Link Procedure
400

FIG. 4

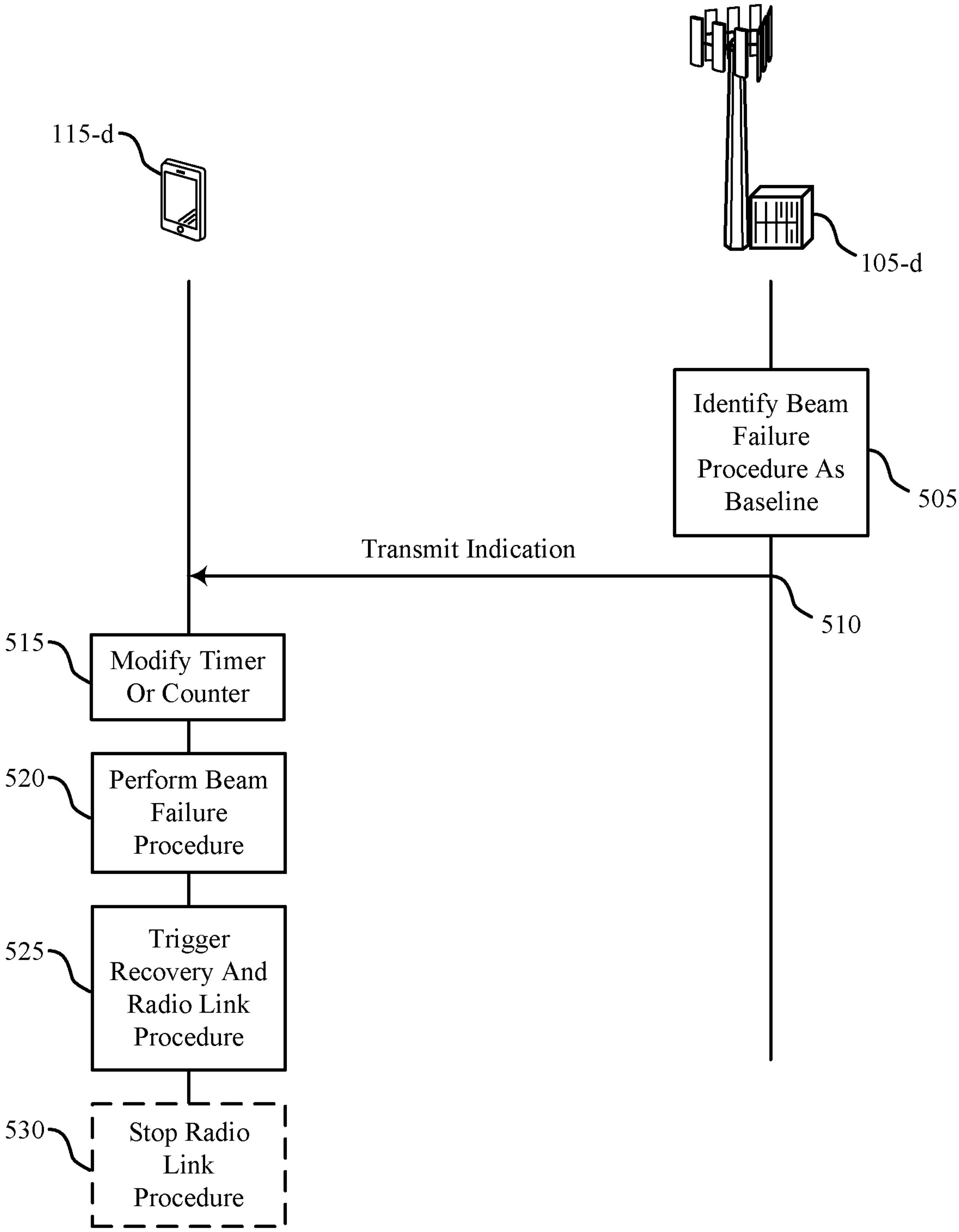
115-d
105-d
Identify Beam Failure Procedure As Baseline
505
Transmit Indication
510
515
Modify Timer Or Counter
520
Perform Beam Failure Procedure
525
Trigger Recovery And Radio Link Procedure
530
Stop Radio Link Procedure
500

FIG. 5

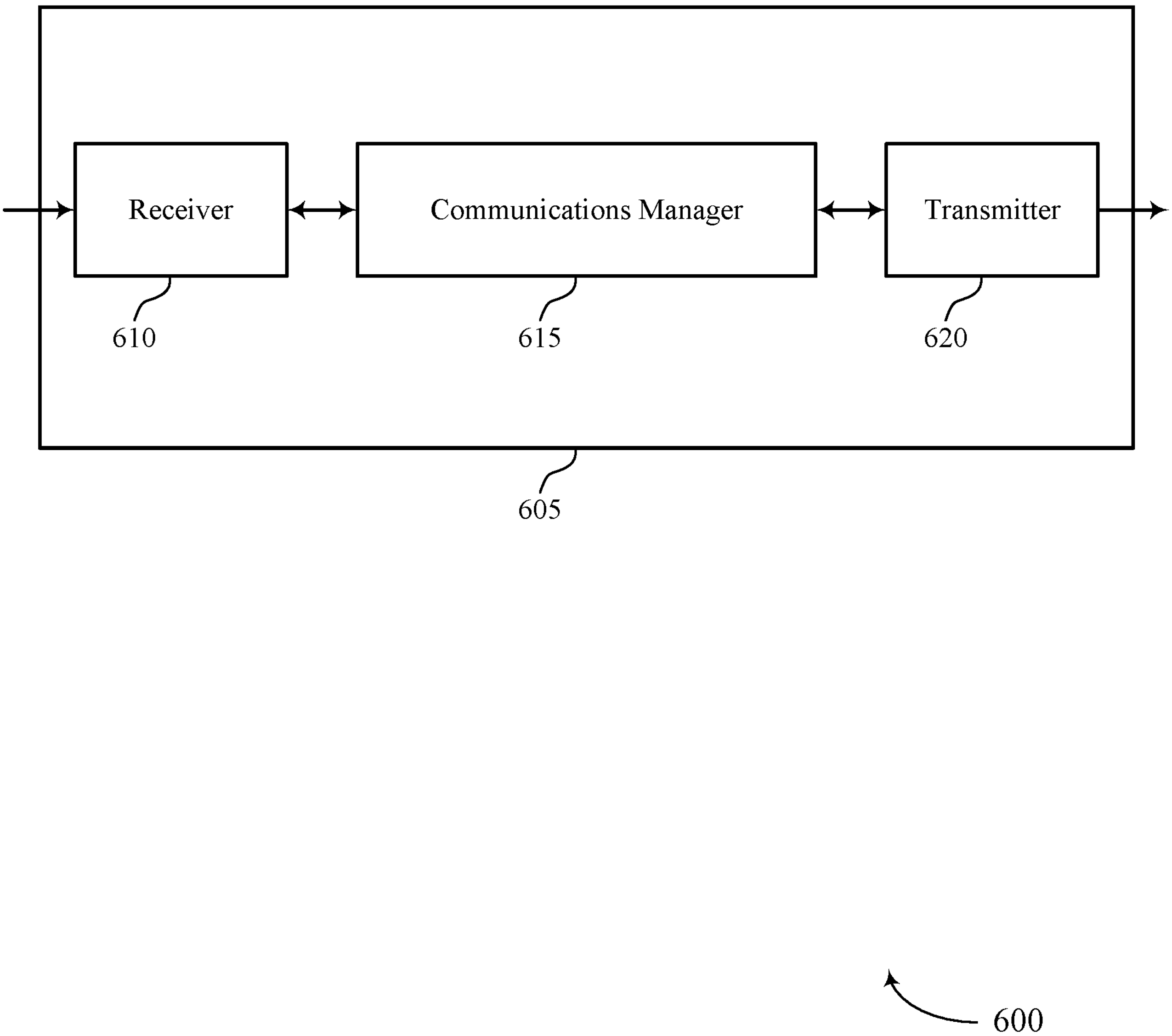
Receiver
Communications Manager
Transmitter
610
615
620
605
600

FIG. 6

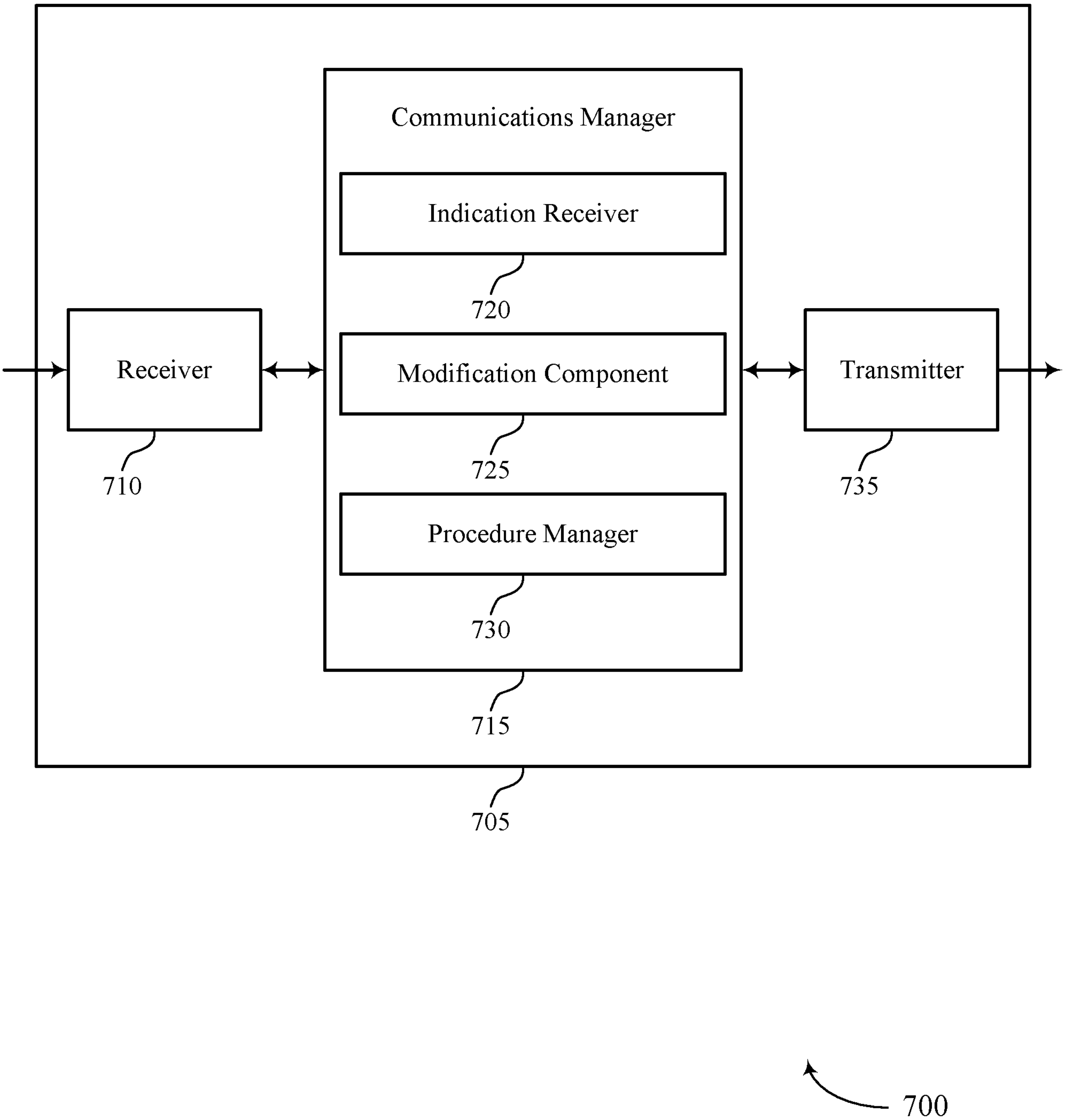
Communications Manager
Indication Receiver
720
Receiver
Modification Component
Transmitter
710
725
735
Procedure Manager
730
715
705
700

FIG. 7

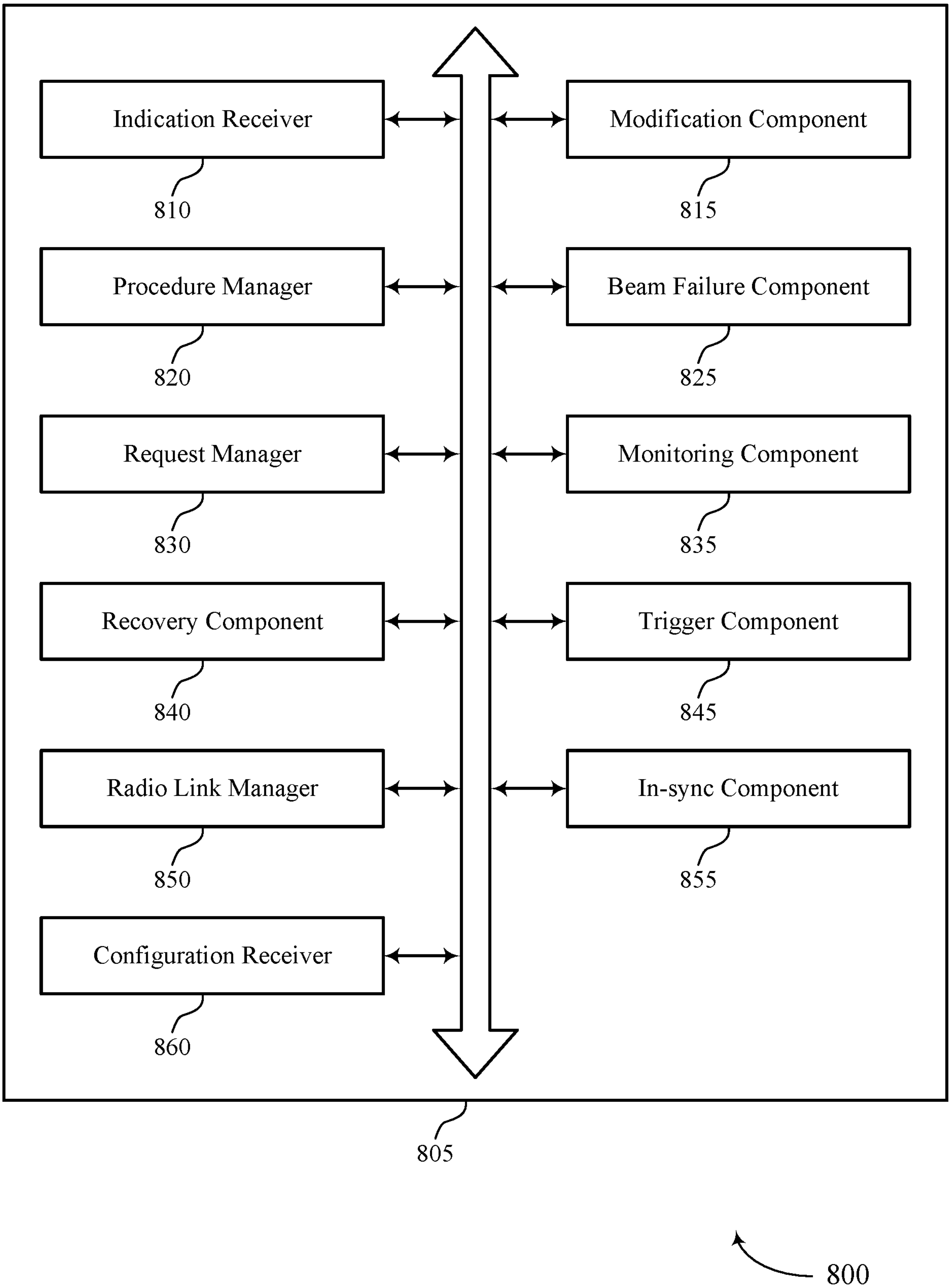
Indication Receiver
810
Modification Component
815
Procedure Manager
820
Beam Failure Component
825
Request Manager
830
Monitoring Component
835
Recovery Component
840
Trigger Component
845
Radio Link Manager
850
In-sync Component
855
Configuration Receiver
860
805
800

FIG. 8

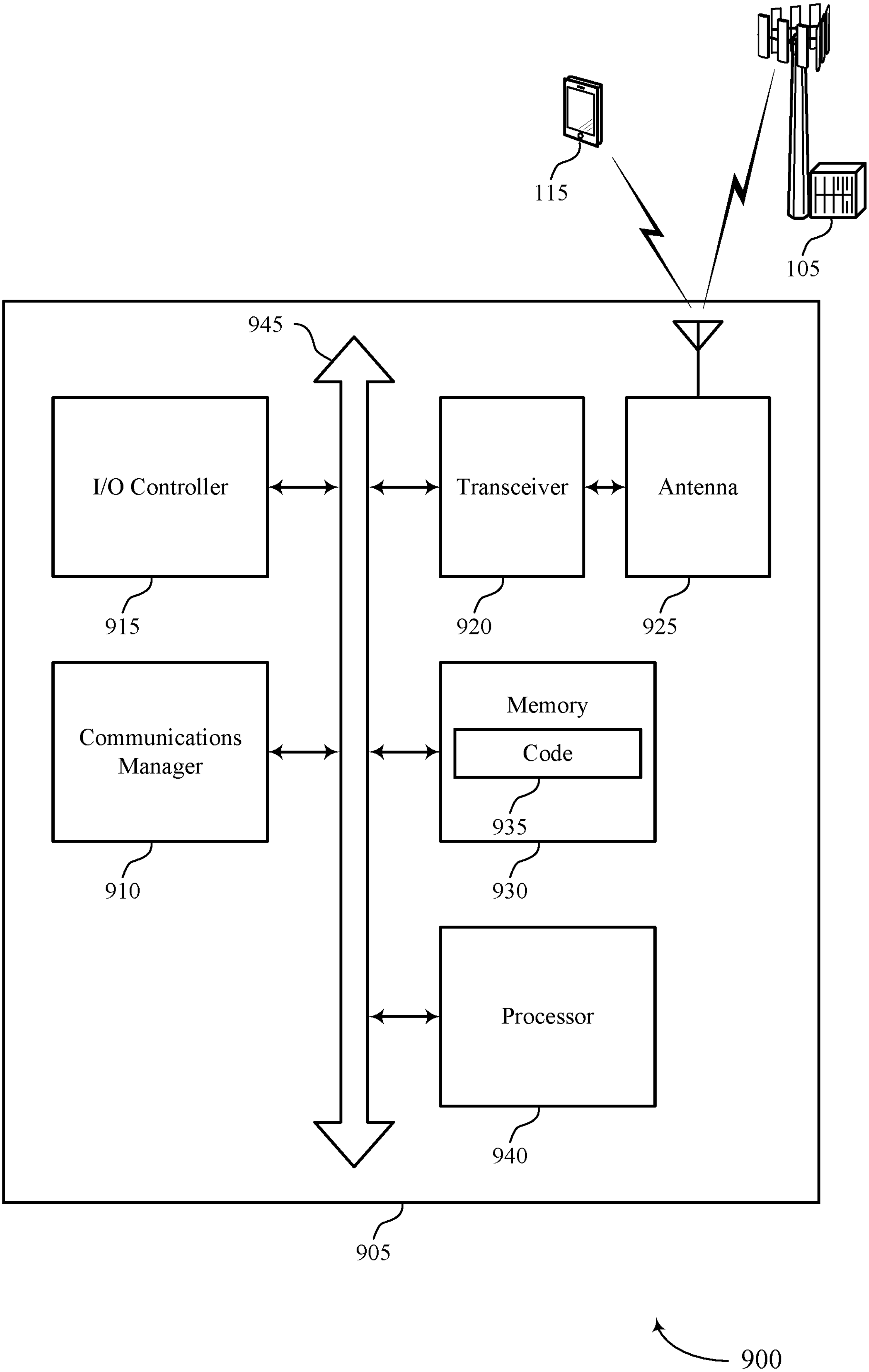
115
105
945
I/O Controller
Transceiver
Antenna
915
920
925
Communications Manager
Memory
Code
935
910
930
Processor
940
905
900

FIG. 9

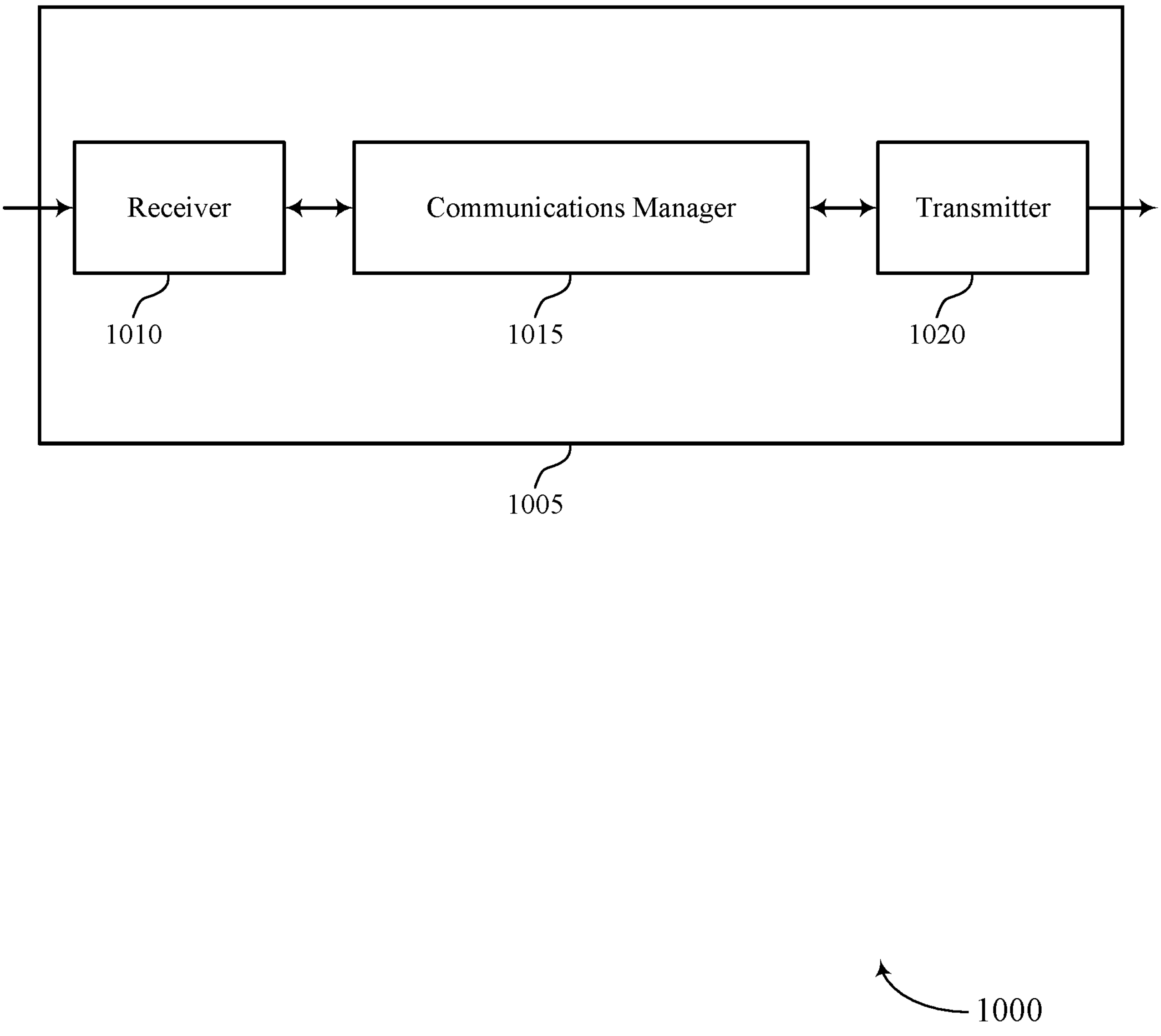
Receiver
Communications Manager
Transmitter
1010
1015
1020
1005
1000

FIG. 10

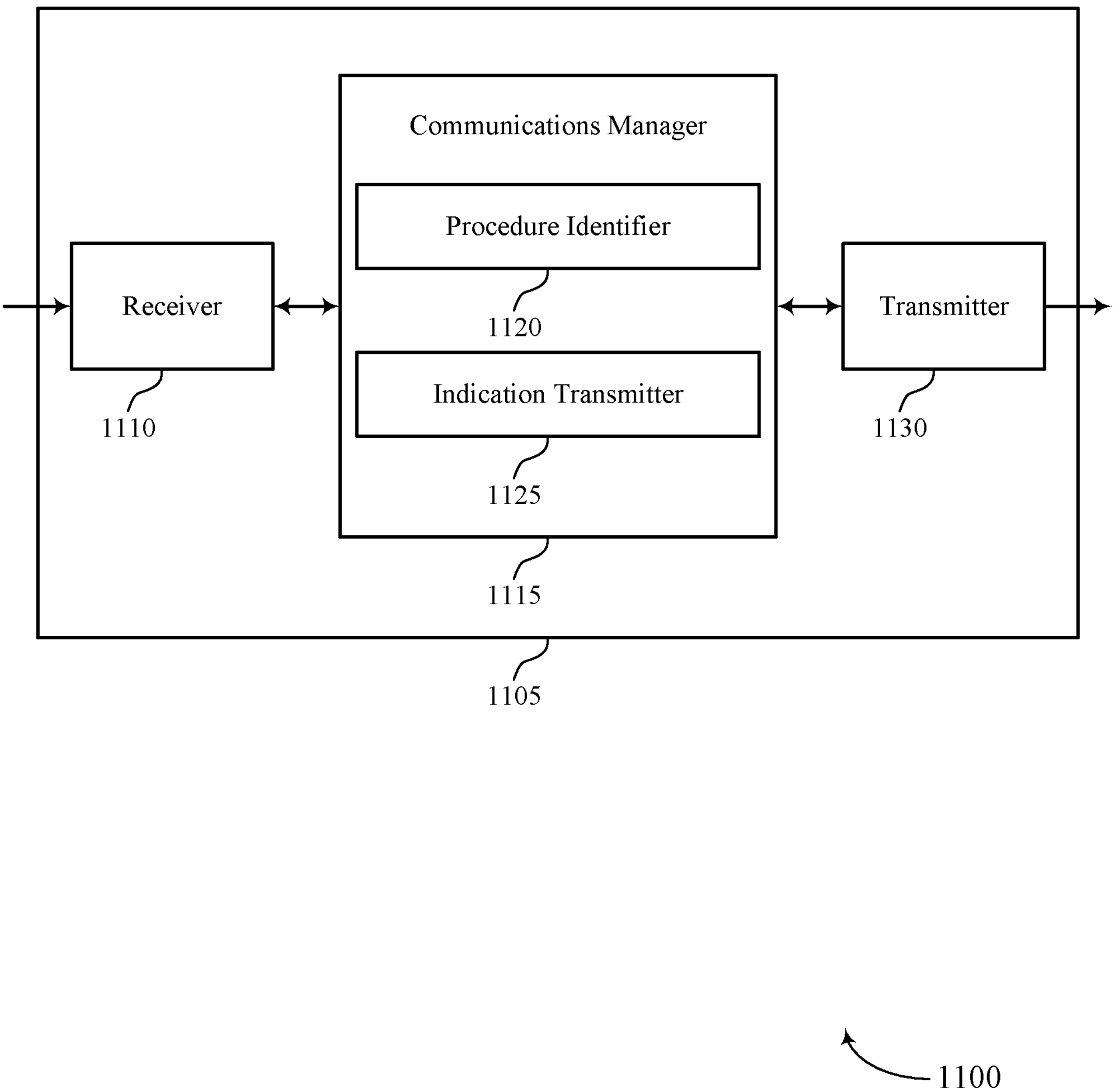
Communications Manager
Procedure Identifier
1120
Receiver
Transmitter
Indication Transmitter
1110
1130
1125
1115
1105
1100

FIG. 11

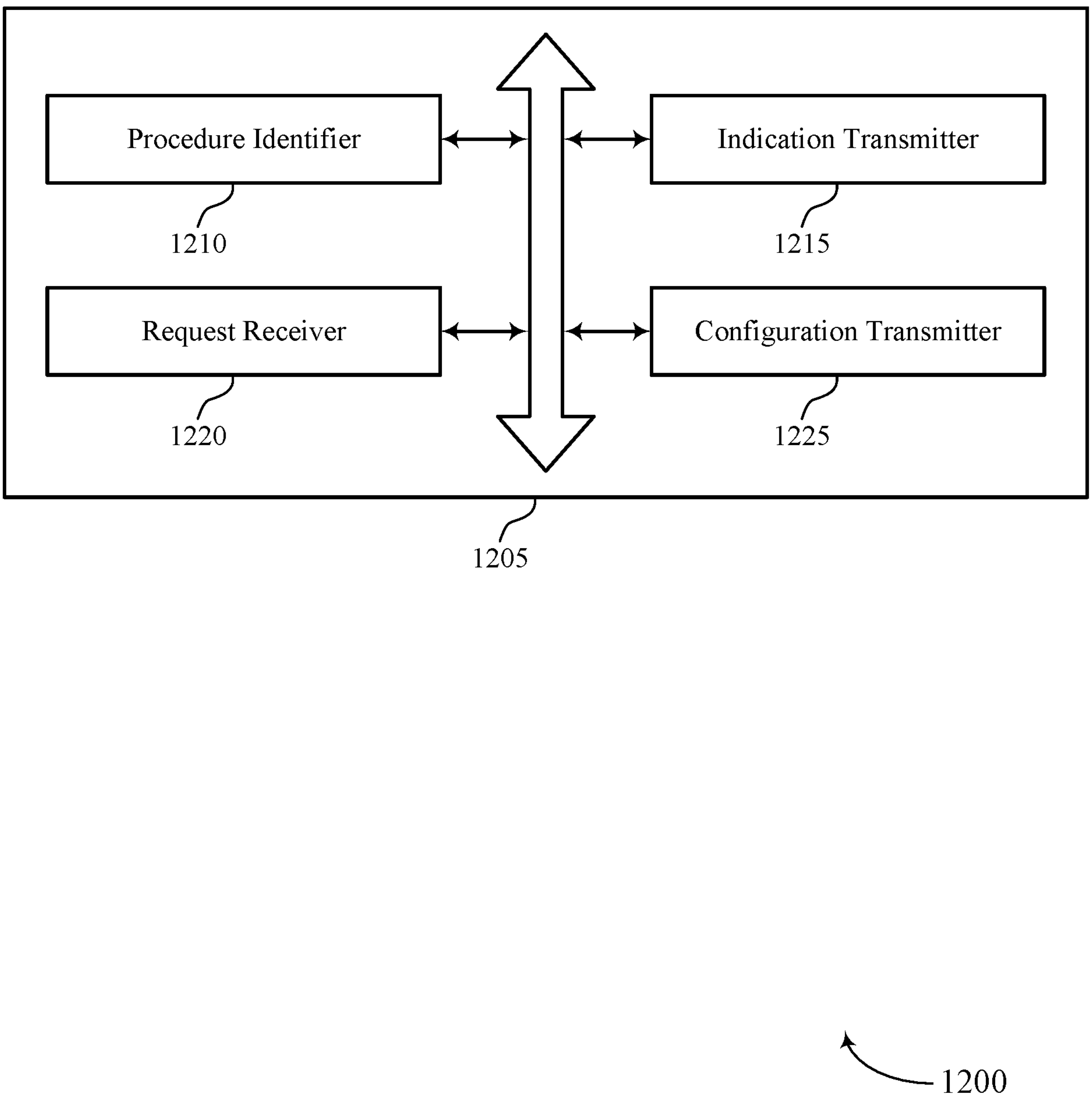
Procedure Identifier
1210
Indication Transmitter
1215
Request Receiver
1220
Configuration Transmitter
1225
1205
1200

FIG. 12

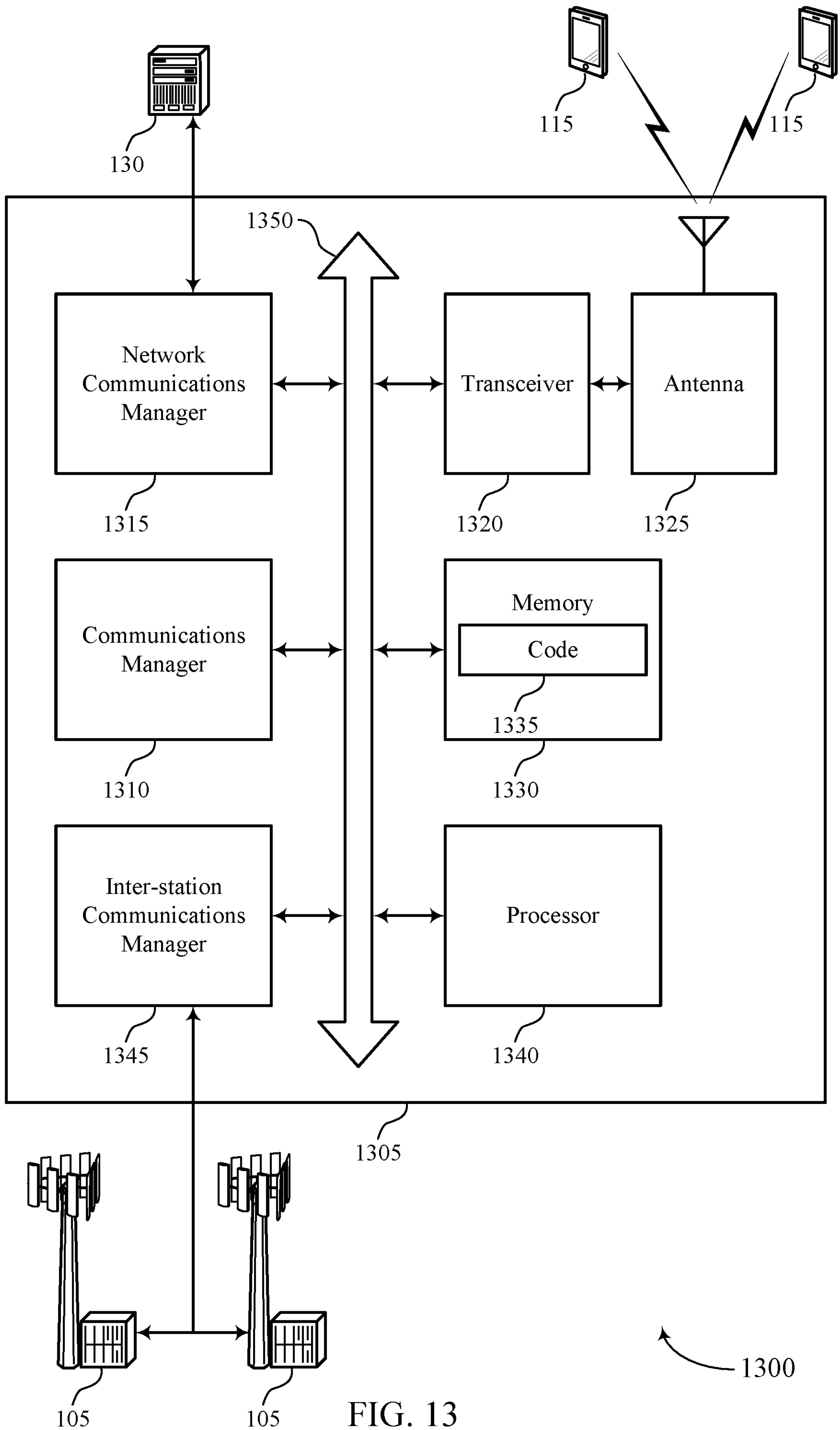
130
115
115
1350
Network Communications Manager
Transceiver
Antenna
1315
1320
1325
Communications Manager
Memory
Code
1335
1310
1330
Inter-station Communications Manager
Processor
1345
1340
1305
1300
105
105

FIG. 13

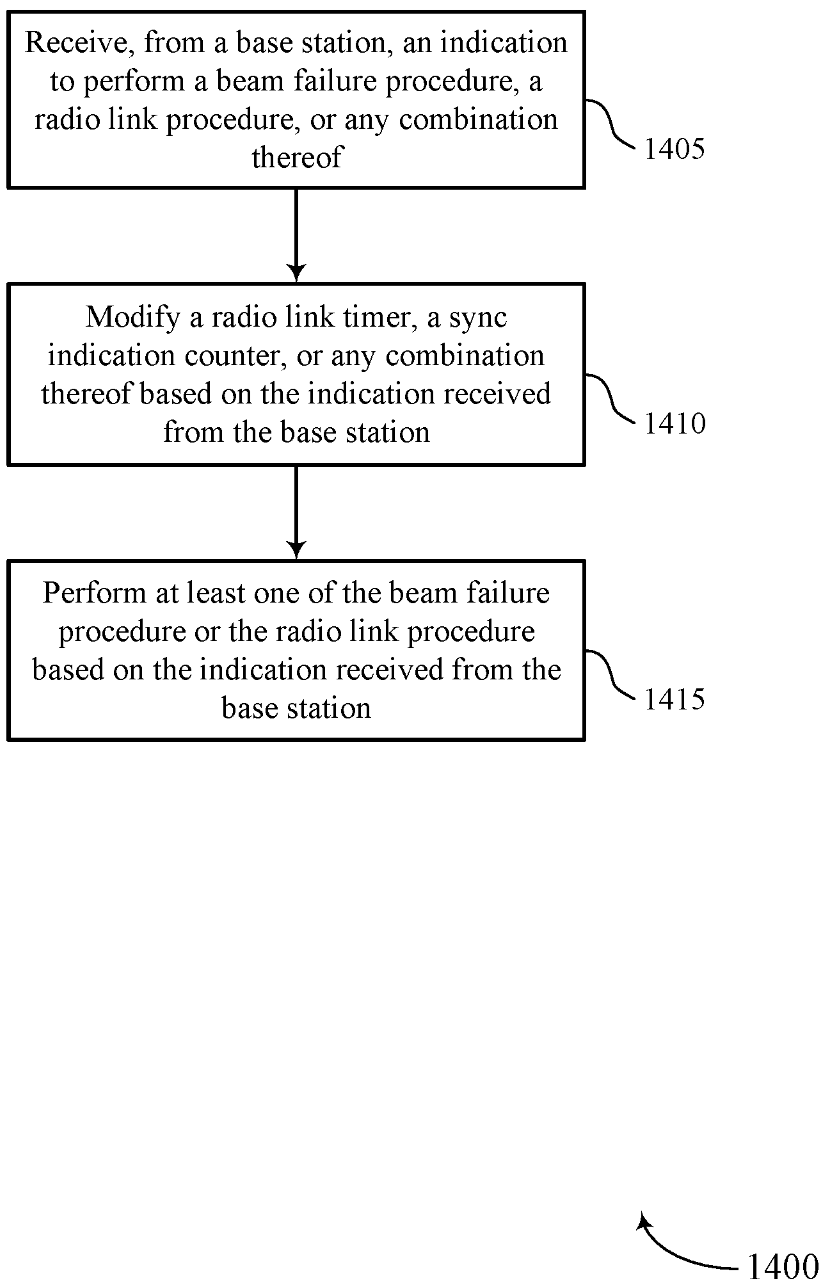
Receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof
1405
Modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station
1410
Perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station
1415
1400

FIG. 14

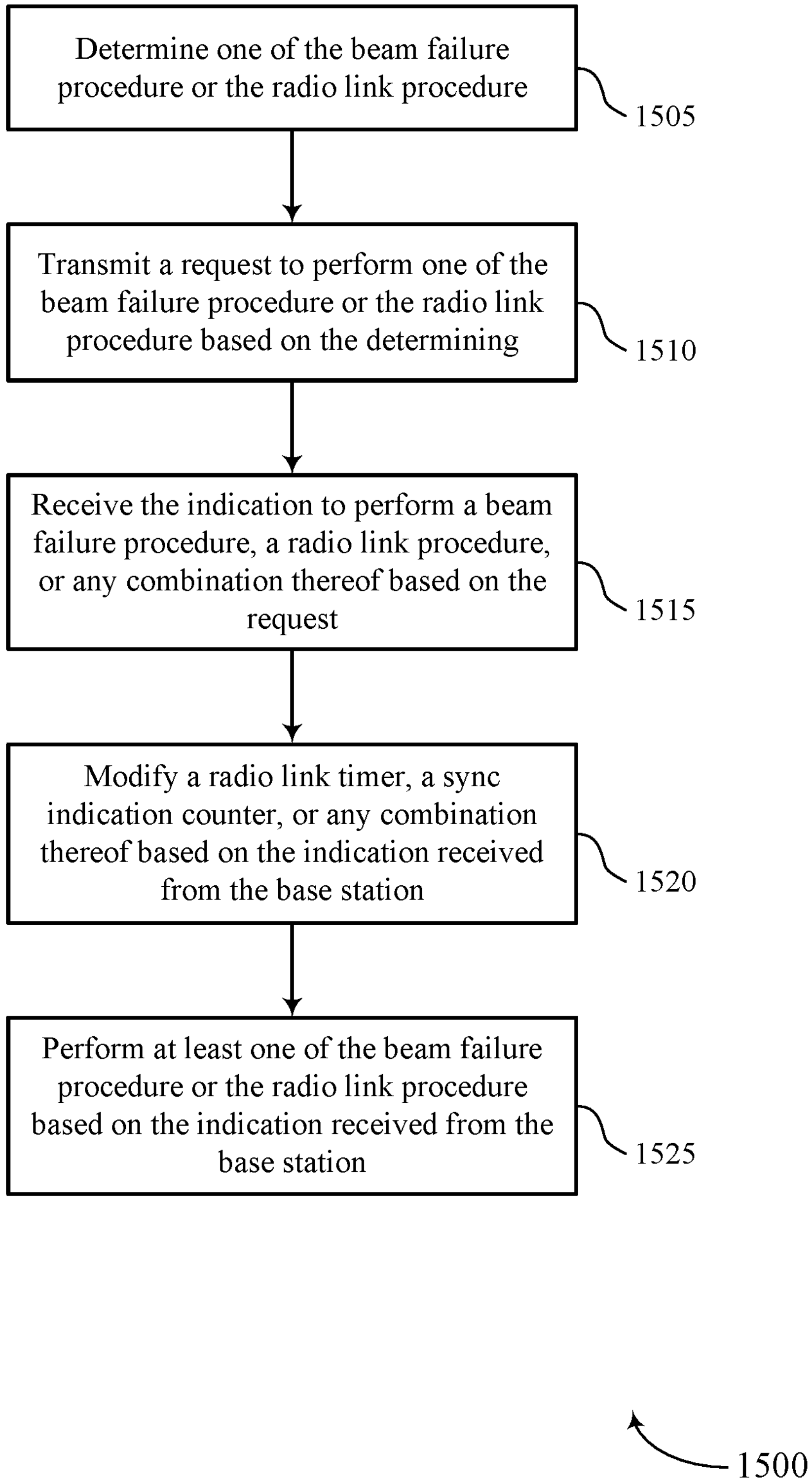
Determine one of the beam failure procedure or the radio link procedure
1505
Transmit a request to perform one of the beam failure procedure or the radio link procedure based on the determining
1510
Receive the indication to perform a beam failure procedure, a radio link procedure, or any combination thereof based on the request
1515
Modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station
1520
Perform at least one of the beam failure procedure or the radio link procedure based on the indication received from the base station
1525
1500

FIG. 15

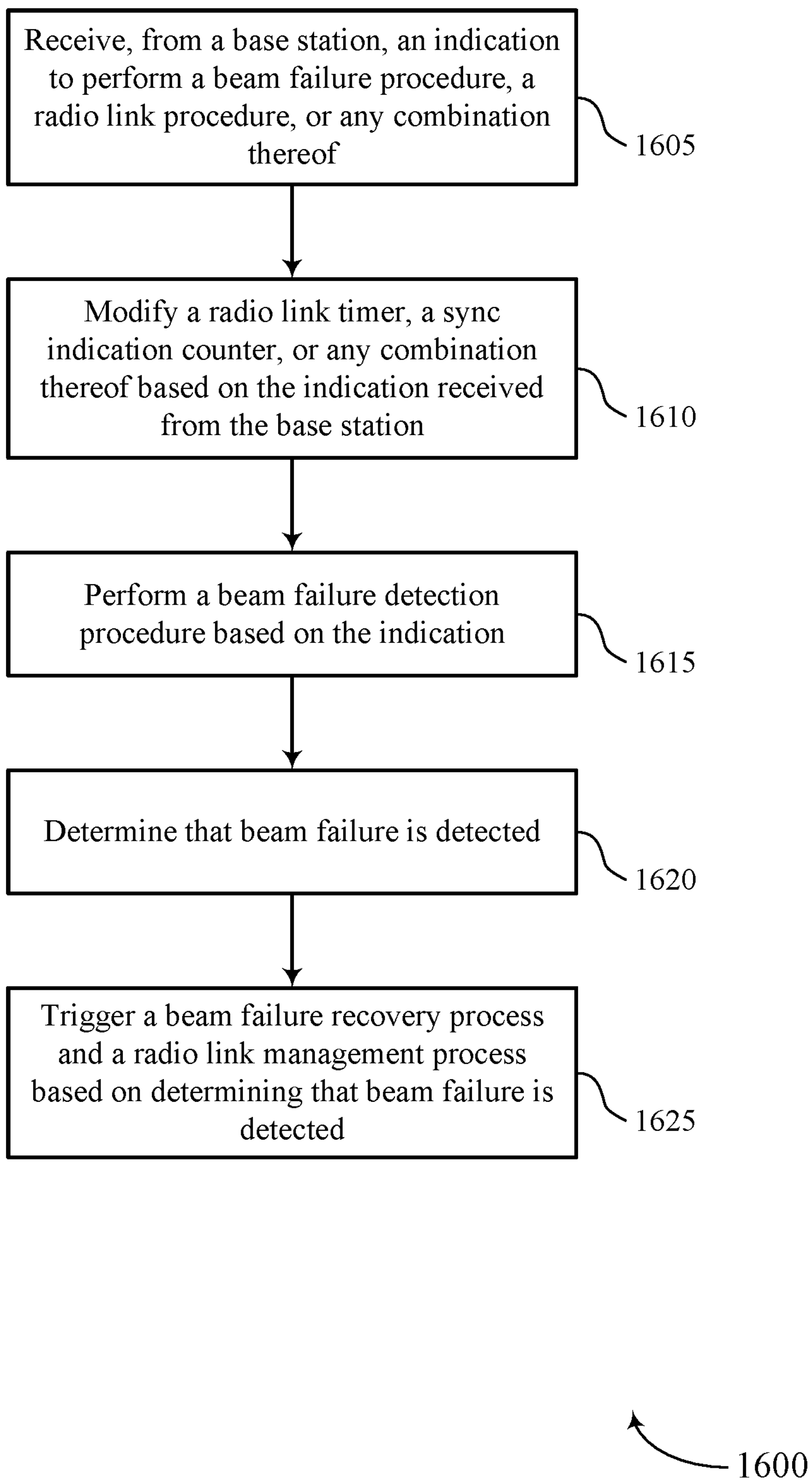
Receive, from a base station, an indication to perform a beam failure procedure, a radio link procedure, or any combination thereof
1605
Modify a radio link timer, a sync indication counter, or any combination thereof based on the indication received from the base station
1610
Perform a beam failure detection procedure based on the indication
1615
Determine that beam failure is detected
1620
Trigger a beam failure recovery process and a radio link management process based on determining that beam failure is detected
1625
1600

FIG. 16

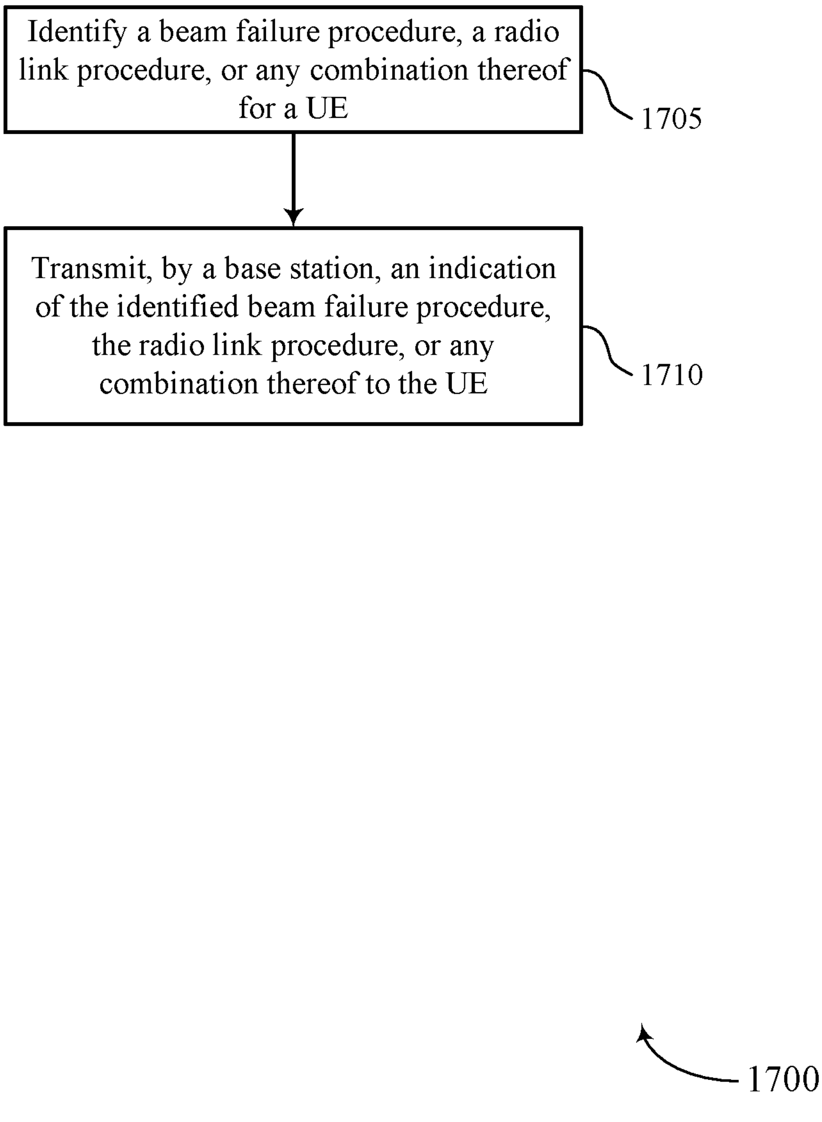
Identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE
1705
Transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE
1710
1700

FIG. 17

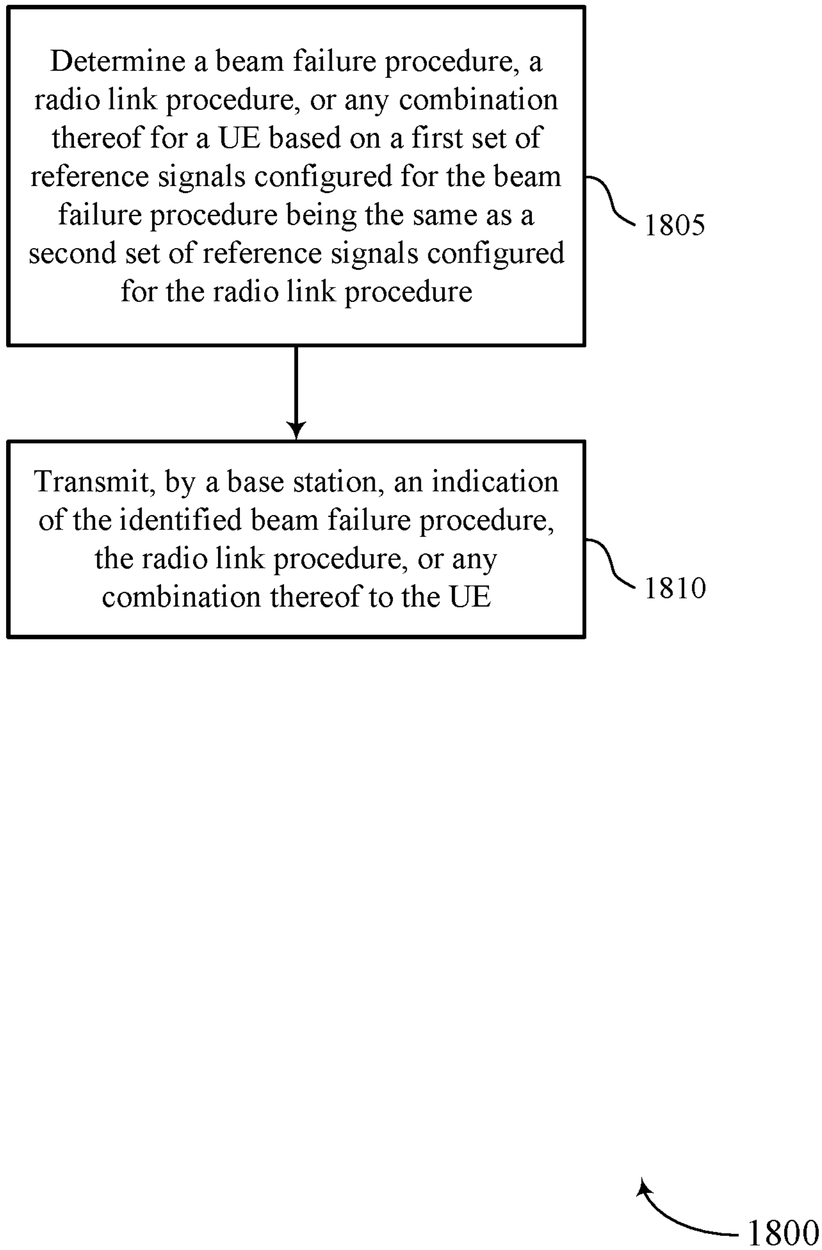
Determine a beam failure procedure, a radio link procedure, or any combination thereof for a UE based on a first set of reference signals configured for the beam failure procedure being the same as a second set of reference signals configured for the radio link procedure
1805
Transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE
1810
1800

FIG. 18

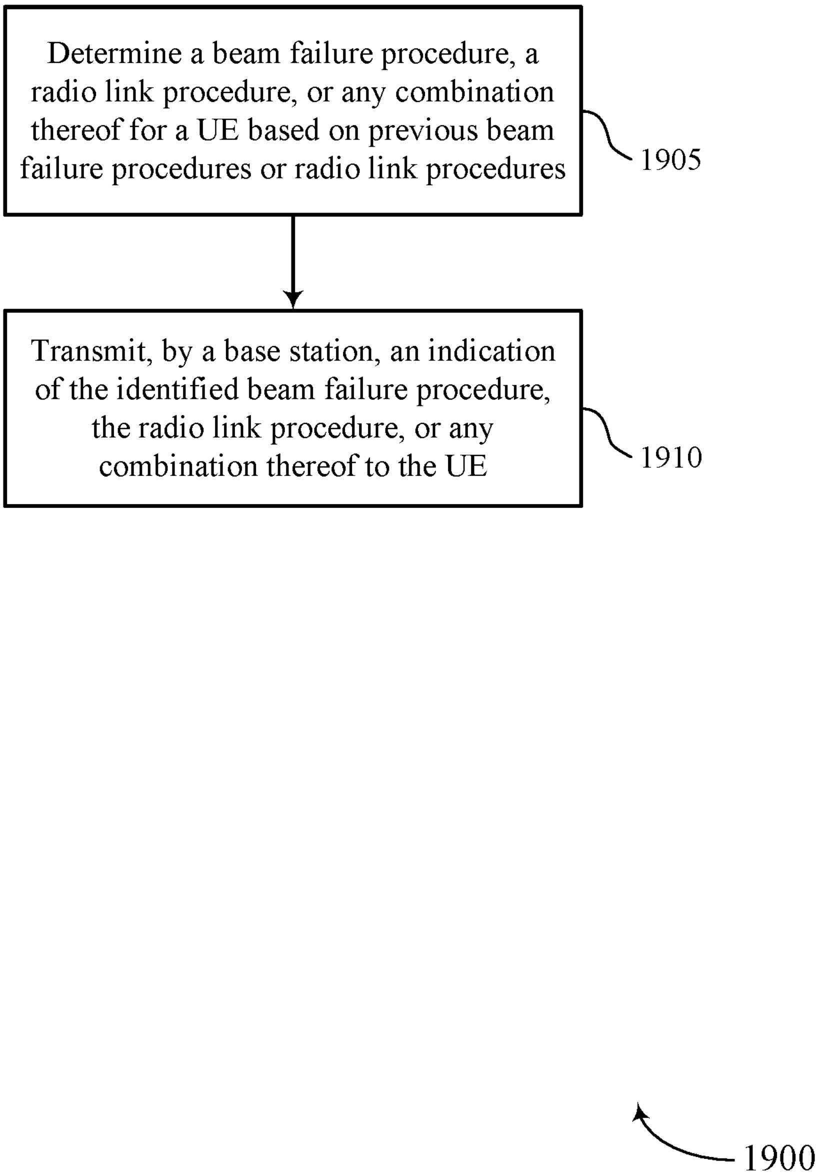
Determine a beam failure procedure, a radio link procedure, or any combination thereof for a UE based on previous beam failure procedures or radio link procedures
1905
Transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE
1910
1900

FIG. 19

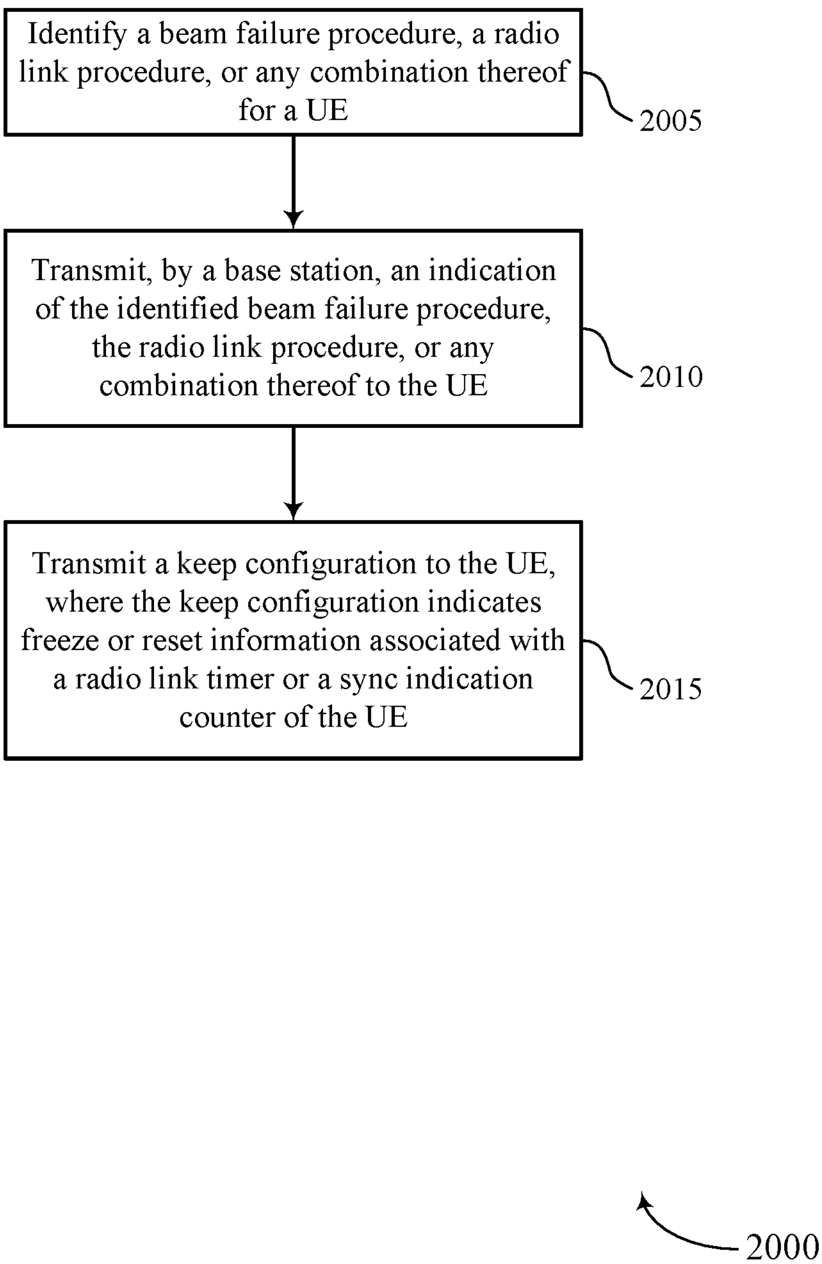
Identify a beam failure procedure, a radio link procedure, or any combination thereof for a UE
2005
Transmit, by a base station, an indication of the identified beam failure procedure, the radio link procedure, or any combination thereof to the UE
2010
Transmit a keep configuration to the UE, where the keep configuration indicates freeze or reset information associated with a radio link timer or a sync indication counter of the UE
2015
2000

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/107414

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04Q

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

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

CNPAT;CNKI;WPI;EPODOC;IEEE;3GPP:beam failure, detect+, recover+, radio link, monitor+, timer, counter, indication, sync+, reset+, restart+, modif+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI et al. "Reset of BFR timers and counters with RLM reconfiguration" *3GPP TSG-RAN WG2 Meeting 102 R2-1808416,* 25 May 2018 (2018-05-25), sections 2-3, 5	1-30
X	CN 108260212 A (ZTE CORPORATION) 06 July 2018 (2018-07-06) paragraphs 144-186 in description	1-30
A	WO 2018141238 A1 (VIVO MOBILE COMMUNICATION CO., LTD.) 09 August 2018 (2018-08-09) the whole document	1-30
A	WO 2018129300 A1 (IDAC HOLDINGS, INC.) 12 July 2018 (2018-07-12) the whole document	1-30

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 November 2019	**27 November 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**YAN,Yue**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961643**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/107414

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 108260212 A	06 July 2018	WO 2019128751 A1	04 July 2019
WO 2018141238 A1	09 August 2018	CN 108401295 A	14 August 2018
WO 2018129300 A1	12 July 2018	None	