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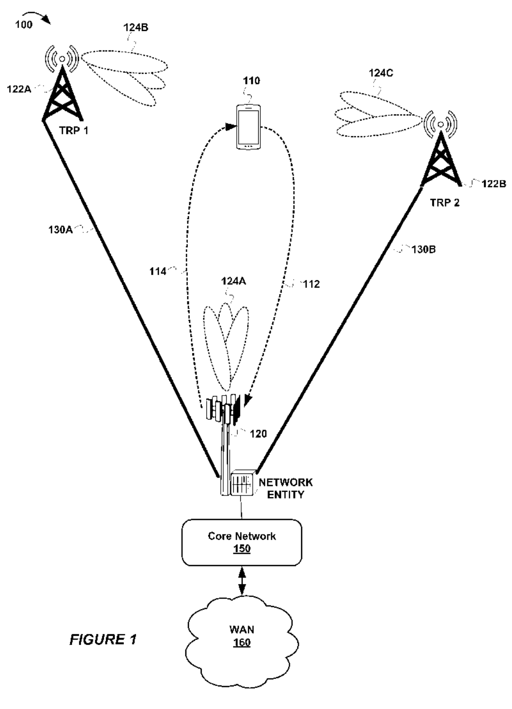

FIGURE 1

(57) Abstract: Systems, methods and apparatuses perform UE initiated beam switching. A UE (110) receives (304), from a network entity (120), a UE initiated beam switching configuration indicating a plurality of reference signals (RSs) associated with a plurality of beams. The UE receives (308), from the network entity, one or more RSs associated with one or more beams. The UE transmits (312), to the network entity, an indication to switch from communicating via at least one first beam to communicating via at least one second beam based on the one or more RSs. The UE and the network entity communicate (318) with one another via the at least one second beam.

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UE INITIATED BEAM SWITCHING

TECHNICAL FIELD

[0001] Aspects of the present disclosure relate generally to wireless communication and techniques for UE initiated beam switching.

BACKGROUND

[0002] Beamforming is a technique that can enhance the signal quality between a network entity and a UE thereby improving data rates, reducing latency, and increasing overall network performance. In beamforming, the transmitter directs radio frequency (RF) transmission towards a specific direction (e.g., towards an intended receiver), creating a "beam" of focused energy, rather than radiating the signal in all directions equally.

BRIEF SUMMARY

[0003] The systems, methods, and devices of this disclosure each have several innovative aspects, no single one of which is solely responsible for the desirable attributes disclosed herein.

[0004] One innovative aspect of the subject matter described in this disclosure can be implemented as a method for wireless communications by a user equipment. The method may include receiving, from a network entity, a UE initiated beam switching configuration indicating a plurality of reference signals (RSs) associated with a plurality of beams. The method may further include receiving, from the network entity, one or more RSs associated with one or more beams. The method may further include transmitting, to the network entity, an indication to switch from communicating via at least one first beam to communicating via at least one second beam based on the one or more RSs. The method may further include communicating with the network entity via the at least one second beam.

[0005] Another innovative aspect of the subject matter described in this disclosure can be implemented as a method for wireless communications by a network entity. The method may include transmitting, to a user equipment (UE), a UE initiated beam switching configuration indicating a plurality of reference signals (RSs) associated with a plurality of beams. The method may further include transmitting, to the UE, one or more RSs associated with one or more beams. The method may further include receiving, from the UE, an indication to switch from communicating via at least one first beam to communicating via at least one second beam. The method may further include communicating with the UE via the at least one second beam.

[0006] Details of one or more implementations of the subject matter described in this disclosure are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Note that the relative dimensions of the following figures may not be drawn to scale. Like reference numbers and designations in the various drawings indicate like elements. To easily identify the discussion of any particular element or act, the most significant digit or digits in a reference number refer to the figure number in which that element is first introduced.

[0008] **Figure 1** is a conceptual diagram illustrating an example wireless system including a user equipment communicating with a network entity.

[0009] **Figure 2** is a block diagram illustrating example configurations of a network entity and a user equipment.

[0010] **Figure 3** is a sequence diagram illustrating example operations of a communications process for UE initiated beam switching.

[0011] **Figure 4** is a flow chart diagram illustrating example UE operations of a method for UE initiated beam switching.

[0012] **Figure 5** is a flow chart diagram illustrating example network entity operations of a method for UE initiated beam switching.

[0013] **Figure 6** is a flow chart diagram illustrating example network entity operations of a method for detecting a beam switching request event.

[0014] **Figure 7A** is a diagram illustrating an example of beam switching based on an indicated TCI state.

[0015] **Figure 7B** is a diagram illustrating an example of beam switching based on multiple indicated TCI states.

[0016] **Figure 7C** is a diagram illustrating an example of UE initiated joint uplink and downlink beam switching.

[0017] **Figure 7D** is a diagram illustrating an example of UE initiated separate uplink and downlink beam switching.

[0018] **Figure 8A** is a diagram illustrating an example of joint uplink and downlink beam switching in a response to a UE initiated beam switch.

[0019] **Figure 8B** is a diagram illustrating an example of separate uplink and downlink beam switching in a response to a UE initiated beam switch.

[0020] **Figure 9** is a diagram illustrating an example timeline for additional TRS sets based on QCL parameter identification.

[0021] **Figure 10** is a diagram illustrating an example timeline for an additional TRS with dynamic QCL update based QCL parameter identification.

[0022] **Figure 11** is a diagram illustrating an example timeline including a scheduling restriction after beam switching.

DETAILED DESCRIPTION

[0023] The following description is directed to certain implementations for the purpose of describing the innovative aspects of this disclosure. However, a person having ordinary skill in the art will readily recognize that the teachings herein can be applied in a multitude of different ways. Some of the examples in this disclosure are based on wireless communication according to the 3rd Generation Partnership Project (3GPP) wireless standards, such as the 4th generation (4G) Long Term Evolution (LTE) and 5th generation (5G) New Radio (NR) standards. However, the described implementations can be implemented in any device, system, or network that is capable of transmitting and receiving radio frequency signals according to any of the wireless communication standards, including any of the Institute of Electrical and Electronics Engineers (IEEE) 802.11, 802.15, or 802.16 wireless standards, or other known signals that are used to communicate within a wireless, cellular, or internet of things (IOT) network, such as a system utilizing 3G, 4G, 5G, WiFi or future radio technology.

[0024] As discussed above, beamforming is a technique that can enhance the signal quality between a network entity and a UE thereby improving data rates, reducing latency, and increasing overall network performance. In beamforming, the transmitter directs radio frequency (RF) transmission towards a specific direction (e.g., towards an intended receiver), creating a "beam" of focused energy, rather than radiating the signal in all directions equally.

[0025] A problem when using beamforming is that there can be undesirable latency when switching from a first beam to a second beam. In existing systems, the network entity may initiate beam switching based on signal quality information received from the UE. The network entity may initiate beam switching based on the beam quality indicators. For example, the UE may measure beam quality using reference signals such as channel state information reference signals (CSI-RSs) or synchronization signal blocks (SSBs), and transmit beam quality indicators to the network entity. For example, the UE may measure the CSI-RS in a transmission configuration indicator (TCI) state or the synchronization signal block (SSB) with which the CSI-RS is quasi-co-located before the UE applies a corresponding active TCI state. The UE may measure the CSI-RS or SSB once for time and frequency offset tracking. The UE may also measure the SSB multiple times, e.g., eight times, for UE beam sweeping. In one example, such TCI activation delay could be 20ms or 160ms given an SSB periodicity of 20ms. If the UE is configured with discontinuous reception (DRX), the activation delay may be 160ms. Additional latency may be introduced based on the exchange of message between the network entity and the UE. Network initiated beam switching may involve the exchange of four messages (two round trips) between the network entity and the UE. Each message may introduce additional latency when beam switching occurs.

[0026] The above-described latency may affect network performance, leading to user dissatisfaction. Additionally, the network entity may initiate beam switching too frequently, thereby increasing overhead on the UE to process the beam switching. Additionally, the network entity may fail to detect network conditions that would favor beam switching, thereby leading to reduced network performance.

[0027] According to aspects of the disclosure, different techniques may be used by a UE and network entity to facilitate a UE initiating beam switching. The network entity can transmit the CSI-RSs or SSBs, and the UE can measure beam quality using the CSI-RSs or SSBs. The UE can then initiate beam switching if the difference between a measured beam quality for a current beam and a measured quality for a candidate new beam exceeds a threshold difference. In some aspects, the UE may initiate beam switching by transmitting a beam switching request to the network entity. In some other aspects, the UE can initiate beam switching by indicating a beam switching request in a beam report. A technical advantage of the techniques disclosed herein is that the disclosed UE initiated beam switching can be accomplished using fewer transmissions than in existing systems, thereby reducing the latency involved in beam switching.

[0028] **Figure 1** is a conceptual diagram illustrating an example wireless system including a user equipment communicating with a network entity. In the example shown in Figure 1, wireless communication system 100 includes a UE 110 that wirelessly communicates with a network entity 120. The UE may communicate directly with the network entity 120 or via one or more transmit/receive points (TRPs) (e.g., TRPs 122A or 122B). Network entity 120 may be coupled to TRPs 122A and 122B via respective fronthaul networks 130A and 130B. For example, fronthaul networks 130A and 130B may be high performance networks such as fiber optic networks.

[0029] Although illustrated as a smartphone in Figure 1, the UE 110 may be implemented as any suitable computing or electronic device, such as a mobile communication device, a modem, cellular phone, gaming device, navigation device, media device, laptop computer, desktop computer, tablet computer, smart appliance, vehicle-based communication system, an Internet-of-things (IoT) device (e.g., sensor node, controller/actuator node, combination thereof), and the like. Network entity 120 (e.g., base station, an Evolved Universal Terrestrial Radio Access Network Node B (E-UTRAN Node B), evolved Node B, eNodeB, eNB, Next Generation Node B, gNode B, gNB, ng-eNB, access point, radio head or the like) may be implemented in a macrocell, microcell, small cell, picocell, or the like, or any combination thereof. The network entity 120 may be configured to use multiple-input and multiple-output (MIMO) communication to exchange wireless signals with UE 110. Additionally, network entity 120 may use beamforming when communicating with UE 110. For example, network entity 120 may configure beams 124A to communicate with UE 110. In some aspects, UE 110 may communicate with network entity 120 via multiple TRPs (e.g., TRPs 122A and 122B) associated with the network entity 120. In such aspects, TRPs 122A and 122B may be configured with beams 124B and 124C, respectively, for use in communicating with UE 110.

[0030] In some aspects, the functionality, and thus the hardware components, of the network entity 120 may be distributed across multiple network nodes or devices and may be distributed in a manner to perform the functions described herein. As one example, the functionality of network entity 120 may be distributed across a radio unit (RU), distributed unit (DU), or central unit (CU).

[0031] The UE 110 may communicate with network entity 120 and TRPs 122A and 122B using wireless links (not shown in Fig. 1), which may be implemented as any suitable type of wireless link. The wireless links may include one or more wireless links (e.g., radio links) or bearers implemented using any suitable communication protocol or standard, or combination of communication protocols or standards, such as 3rd Generation Partnership Project Long-Term Evolution (3GPP LTE), Fifth Generation New Radio (5G NR), and so forth. Multiple wireless links may be aggregated in a carrier aggregation to provide a higher data rate for the UE 110.

[0032] The network entity 120 and TRPs 122A and 122B support wireless communication with one or more UEs, such as UE 110, via radio frequency (RF) signaling using one or more applicable radio access technologies (RATs) as specified by one or more communications protocols or standards. The network entity 120 and the TRPs 122A and 122B may employ any of a variety of RATs, such as operating as a NodeB (or base transceiver station (BTS)) for a Universal Mobile Telecommunications System (UMTS) RAT (also known as "3G"), operating as an enhanced NodeB ("eNB") for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) RAT, operating as a 5G node B ("gNB") for a 3GPP Fifth Generation (5G) New Radio (NR) RAT, and the like.

[0033] The network entity 120 and TRPs 122A and 122B may be part of a radio access network (RAN), for example, an Evolved Universal Terrestrial Radio Access Network, E-UTRAN, 5G NR RAN, or NR RAN. The network entity 120 may be connected to a core network 150. For example, the network entity 120 may connect to the core network 150 through an NG2 interface for control-plane signaling and using an NG3 interface for user-plane data communications when connecting to a 5G core network, or using an Si interface for control-plane signaling and user-plane data communications when connecting to an Evolved Packet Core (EPC) network. The network entity 120 may communicate using an Xn Application Protocol (XnAP) through an Xn interface or using an X2 Application Protocol (X2AP) through an X2 interface to exchange user-plane and control-plane data. The UE 110 may connect, via the core network 150, to one or more wide area networks (WANs) 160 or other packet data networks (PDNs), such as the Internet.

[0034] Communications between network entity 120 and UE 110 utilize an uplink (UL) transmission path 112 for RF transmissions from the UE 110 to the network entity 120 and a downlink (DL) transmission path 114 for RF transmissions from the network entity 120 to the UE 110. As such, in the context of the UL transmission path 112, the UE 110 serves as the data sending device and the network entity 120 serves as the data receiving device, whereas in the context of the DL transmission path 114, the network entity 120 serves as the data sending device and the UE 110 serves as the data receiving device. UL transmission path 112 and DL transmission path 114 may utilize multiple communications channels for signal transmission. The multiple channels may each have different purposes.

[0035] UL transmission path 112 may include a Physical Uplink Shared Channel (PUSCH), a Physical Uplink Control Channel (PUCCH), and a Physical Random Access Channel (PRACH). The PUSCH is used for the transmission of user data, such as voice data, video data, or text message data from UE 110 to network entity 120. Additionally, the PUSCH may be used to transmit control information (e.g., uplink control information (UCI)). The PUSCH may be shared by multiple UEs. The PUCCH is used for transmitting control information (e.g., UCI) from the UE to the network, such as channel quality feedback, scheduling requests, and acknowledgments. The PRACH is used for random access in the uplink direction, enabling the UE to access the system.

[0036] DL transmission path 114 may include one or more of a Physical Downlink Shared Channel (PDSCH), a Physical Downlink Control Channel (PDCCH), a Physical Broadcast Channel (PBCH), or a paging channel. The PDSCH is used for transmission of user data from the network entity to the UE. The PDSCH may be shared by multiple UEs. As with the PUSCH, the data may be any type of information, such as voice data, video data, or text message data. The paging channel is used to notify the UE 110 that there is incoming traffic for it from the network entity 120.

[0037] During operation, the UE 110 may measure the quality of beams 124A, 124B and/or 124C. In response to the beam quality measurements, the UE may detect that one or more of the current beams in use should be replaced with other beams having better beam quality. The UE can initiate a beam switch by indicating the beam switch to the network entity 120 via beam report or a beam request. The network entity 120 can respond to the UE initiated beam switch indicating an action time for the beam switch. Following the action time, the UE 110 and network entity may use the new beam for uplink and/or downlink communications. The disclosed techniques may improve communications performance by reducing the latency involved with beam switching when compared to existing systems.

[0038] In the example shown in Figure 1, two TRPs 122A and 122B are illustrated. However, a wireless communications system may include more than two TRPs.

[0039] Further details of various techniques and aspects of disclosure are provided below with respect to Figures 2-11.

[0040] **Figure 2** is a block diagram illustrating example configurations of a network entity and a user equipment. Note that the depicted hardware configurations represent the processing components and communication components related to HARQ process management by a network entity 120 and UE 110. The depicted hardware configurations may omit certain components well-understood to be frequently implemented in such electronic devices, such as displays, peripherals, power supplies, and the like.

[0041] The UE 110 includes antennas 202, a radio frequency front end (RF front end) 204, and radio-frequency transceivers (e.g., an LTE transceiver 206 and a 5G NR transceiver 208) for communicating with network entity 120 and/or one or more TRPs (e.g., TRPs 122A and 122B of Figure 1).

[0042] The RF front end 204 includes one or more modems configured for the corresponding RAT(s) employed (for example, 3GPP 5G NR), one or more analog-to-digital converters (ADCs), one or more digital-to-analog converters (DACs), signal processors, and the like. In the example illustrated in Figure 2, the RF front end 204 of the UE 110 may couple or connect the LTE transceiver 206, and the 5G NR transceiver 208 to the antennas 202 to facilitate various types of wireless communication. The RF front end 204 operates, in effect, as a physical (PHY) transceiver interface to conduct and process signaling between the one or more processors 214 and the antennas 202 so as to facilitate various types of wireless communication.

[0043] The antennas 202 of the UE 110 may include an array of multiple antennas that may be tuned to one or more frequency bands associated with a corresponding RAT. The antennas 202 and the RF front end 204 may be tuned to, and/or be tunable to, one or more frequency bands defined by the 3GPP LTE and 5G NR communication standards and implemented by the LTE transceiver 206, and/or the 5G NR transceiver 208. Additionally, the antennas 202, the RF front end 204, the LTE transceiver 206, and/or the 5G NR transceiver 208 may be configured to support beamforming for the transmission and reception of communications with the network entity 120 and/or with one or more TRPs (e.g., TRPs 122A and 122B of Figure 1). By way of example and not limitation, the antennas 202 and the RF front end 204 may be implemented for operation in sub-gigahertz bands, sub-6 GHz bands, and/or above 6 GHz bands that are defined by the 3GPP LTE and 5G NR communication standards.

[0044] The UE 110 also includes processor(s) 214 and computer-readable storage media (CRM) 216. The processor(s) 214 may include, for example, one or more central processing units, graphics processing units (GPUs), or other application-specific integrated circuits (ASIC), and the like. To illustrate, the processor(s) 214 may include an application processor (AP) utilized by the UE 110 to execute an operating system and various user-level software applications, as well as one or more processors utilized by modems or a baseband processor of the RF front end 204.

[0045] CRM 216 may include any suitable memory or storage device such as random-access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), non-volatile RAM (NVRAM), read-only memory (ROM), Flash memory, solid-state drive (SSD) or other mass-storage devices, and the like useable to store one or more sets of executable software instructions and associated data that manipulate the one or more processors 214 and other components of the UE 110 to perform the various functions described herein and attributed to the UE 110. The sets of executable software instructions include, for example, an operating system (OS) and various drivers (not shown), and various software applications (not shown), which are executable by processor(s) 214 to enable user-plane communication, control-plane signaling, and user interaction with the UE 110. The data 218 stored in the CRM 216 represents, for example, user data, multimedia data, beamforming codebooks, software application configuration information, and the like.

[0046] Data 218 may include beam report configuration 219 and beam quality measurements 220. Beam report configuration 219 includes information the UE 110 may use to perform UE initiated beam detection. UE 110 may receive the beam report configuration from network entity 120. Further details on such configuration information will be discussed below with reference to Figures 3-11. Beam quality measurements 220 may include various parameters measured by the UE 110 that indicate the quality of beams used to communicate between UE 110 and network entity 120. The UE 110 may provide the beam quality measurements 220 to the network entity 120 in a beam report (e.g., one of beam reports 261).

[0047] CRM 216 also includes a communications controller 222. Alternately or additionally, the communications controller 222 may be implemented in whole or part as hardware logic or circuitry integrated with or separate from other components of the UE 110. In some aspects, communications controller 222 configures the RF front end 204, the LTE transceiver 206, and/or the 5G NR transceiver 208 to implement the techniques described herein for UE initiated beam switching.

[0048] In some aspects, UE 110 may include an inference engine 224. Inference engine 224 may use a model 221 to predict future beam quality based on current or past beam quality measurements 220. For example, model 221 may be a machine-learning model trained to predict beam quality.

[0049] Turning to the hardware configuration of the network entity 120, it is noted that although Figure 2 illustrates an implementation of the network entity 120 as a single network node (for example, a 5G NR Node B, or "gNB"), the functionality, and thus the hardware components, of the network entity 120 instead may be distributed across multiple network nodes or devices and may be distributed in a manner to perform the functions described herein. As one example, the functionality of network entity 120 may be distributed across a radio unit (RU), distributed unit (DU), or central unit (CU).

[0050] The network entity 120 includes antennas 252, a radio frequency front end (RF front end) 254, one or more LTE transceivers 256, and/or one or more 5G NR transceivers 258 for communicating with the UE 110. The RF front end 254 of the network entity 120 may couple or connect the LTE transceivers 256 and the 5G NR transceivers 258 to the antennas 252 to facilitate various types of wireless communication. Similar to RF front end 204, the RF front end 254 includes one or more modems, one or more ADCs, one or more DACs, and the like. RF front end 254 receives the one or more RF signals, for example, RF signals from UE 110, and pre-processes the one or more RF signals to generate data from the RF signals that is provided as input to processes and/or applications executing on network entity 120. This pre-processing may include, for example, power amplification, conversion of band-pass signaling to baseband signaling, initial analog-to-digital conversion, and the like.

[0051] The antennas 252 of the network entity 120 may be configured individually and/or as one or more arrays of multiple antennas. The antennas 252 and the RF front end 254 may be tuned to, and/or be tunable to, one or more frequency band defined by the 2GPP LTE and 5G NR communication standards, and implemented by the LTE transceivers 256, and/or the 5G NR transceivers 258. Additionally, the antennas 252, the RF front end 254, the LTE transceivers 256, and/or the 5G NR transceivers 258 may be configured to support beamforming, such as Massive-MIMO, for the transmission and reception of communications with the UE 110.

[0052] The network entity 120 also includes processor(s) 260 and computer-readable storage media (CRM) 262. The processor 260 may include, for example, one or more central processing units, graphics processing units (GPUs), or other application-specific integrated circuits (ASIC), and the like. To illustrate, the processors 260 may include an application processor (AP) utilized by the network entity 120 to execute an operating system and various user-level software applications, as well as one or more processors utilized by modems or a baseband processor of the RF front end 254 to enable communication with the UE 110.

[0053] CRM 262 may include any suitable memory or storage device such as random-access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), non-volatile RAM (NVRAM), read-only memory (ROM), or Flash memory useable to store device data of the network entity 120. The device data may include data 264, which includes network scheduling data, radio resource management data, beamforming codebooks, software application configuration information, UE transmitter power levels, and/or TRP configuration data and the like.

[0054] Data 264 may further include beam report(s) 261 and UE capability information 263. UE capability information includes data regarding the UE 110's ability to perform UE initiated beam switching. Further details on such data are provided below with respect to Figures 3-11. Beam report(s) 261 includes data regarding beam quality of beams used to communicate information between UE 110 and network entity 120. A beam report 261 may include beam quality measurements 220 or information derived from beam quality measurements 220.

[0055] CRM 262 additionally includes a communications controller 271. Alternately or additionally, the communications controller 271 may be implemented in whole or part as hardware logic or circuitry integrated with or separate from other components of the network entity 120. Like communications controller 222 of UE 110, communications controller 271 configures the RF front end 254, the LTE transceiver 256, and/or the 5G NR transceiver 258 to implement the techniques described herein for UE initiated beam switching.

[0056] CRM 262 also includes an RF resource manager 265. In some aspects, the RF resource manager 265 of the network entity 120 is implemented to perform various functions associated with allocating physical access (for example, resource blocks) or communication resources for the air interface of the network entity 120. The air interface of the network entity 120, may be partitioned or divided into various units (for example, frames, subframes, or slots) of one or more of bandwidth, time, symbols, or spatial layers. For example, within a framework of a 5G NR protocol, the RF resource manager 265 may allocate bandwidth and time intervals of access in resource blocks, each of which may be allocated in whole, or in part, to one or more channels for communicating with the UE 110. The channels may include one or more of a PRACH, a PUCCH, a PUSCH, a PDCCH, a PDSCH, a PBCH, or a paging channel. The resource blocks may include multiple subcarriers that each span a portion of a frequency domain of the resource blocks. The subcarriers may be further divided into resource elements, or orthogonal frequency-division multiplexing (OFDM) symbols, that each span a portion of a time domain of the subcarriers. Consequently, a resource block includes multiple OFDM symbols that may be grouped into subcarriers with other OFDM symbols having a common frequency bandwidth. In some aspects, the OFDM symbols may be Discrete Fourier Transform-spread-Orthogonal Frequency Division

Multiplexing (DFT-s-OFDM) symbols. In some other aspects, the OFDM symbols may be Cyclic Prefix-Orthogonal Frequency Division Multiplexing (CP-OFDM) symbols.

[0057] CRM 262 further includes network entity manager 266. Alternately or additionally, the network entity manager 266 may be implemented in whole or part as hardware logic or circuitry integrated with or separate from other components of the network entity 120. In at least some aspects, the network entity manager 266 configures the LTE transceivers 256 and the 5G NR transceivers 258 for communication with the UE 110, communication with TRPs (e.g., TRPs 122A and 122B of Figure 1) via fronthaul interface 267, as well as communication with a core network 150 (Figure 1).

[0058] In some aspects, the network entity 120 includes an inter-network entity station interface 268, such as an Xn and/or X2 interface, which the network entity manager 266 configures to exchange user-plane and control-plane data between another network entity, to manage the communication of the network entity 120 with the UE 110. The network entity 120 includes a core network interface 270 that the network entity manager 266 configures to exchange user-plane and control-plane data with core network functions and entities.

[0059] Figures 3-6, 7A-7D, 8A, 8B, and 9-11 and the accompanying description below describe various techniques for UE initiated beam switching. In some examples that follow, the operations may be described as utilizing radio resource control (RRC) signaling. Unless specified otherwise, RRC signaling may indicate a RRC reconfiguration message from the network entity to the UE, or a system information block (SIB), where the SIB may be an existing SIB (e.g., SIB1) or a new SIB (e.g., SIB *J*, where *J* is an integer above 21) transmitted by the network entity.

[0060] **Figure 3** is a sequence diagram illustrating example operations of a communications process 300 for UE initiated beam switching. In the discussion that follows, a "current beam" is a beam that is currently being used for communication between UE 110 and network entity 120 prior to beam switching. A "new" beam is a beam that the UE indicates for beam switching for future communications between UE 110 and network entity 120. Further, in the discussion that follows, the UE may initiate beam switching via information included in a beam report transmitted to the network entity, which may be referred to a "report-based beam switching." Further, the UE may initiate beam switching via information in a specific request transmitted to the network entity, which may be referred to as "request-based beam switching." Although not illustrated for the sake of illustration clarity, various acknowledgements for messages illustrated in Figure 3 may be implemented to ensure reliable operations for UE initiated beam switching.

[0061] At operation 302, the UE 110 may transmit or report to network entity 120 the UE's capability(s) for supporting UE initiated beam switching. In some aspects, UE 110 may transmit UE capability information to the network entity 120 during an initial communication session setup process between the UE 110 and the network entity 120. The UE capability information may include supported frequency bands, radio access technologies, maximum transmission power, maximum data rates, and network protocols. In some aspects, the UE 110 may transmit UE capability information indicating whether the UE supports UE initiated beam switching, and if supported, the type of UE initiated beam switching supported by the UE 110. For example, the UE 110 may indicate that the UE supports initiating beam switching utilizing a UE request to switch beams (request-based beam switching), an indication in a beam switch report to switch beams (report-based beam switching), or both request-based and report-based UE initiated beam switching.

[0062] In some aspects, the UE capability information may include one or more of the following:

- An indicator indicating whether the UE supports beam report-based beam switching.
- An indicator indicating whether the UE supports UE request-based beam switching. (in some aspects, the indicator may comprise two indicators depending on whether a new beam indicated by the UE may be from a set of activated beams or not.)
- A maximum number of SSB or CSI-RS resources in a set for beam measurement for UE report based or request-based beam switching.
- A maximum number of SSB or CSI-RS resources sets for beam measurement for UE report based or request-based beam switching.
- A maximum number of reported beams in a beam report.
- A maximum number of requested beams in a UE request.
- An indicator indicating whether the UE supports reporting beam quality in addition to an SSB resource indicator (SSBRI) or CRI report.
- An indicator indicating whether the UE supports reporting predicted beam quality.
- An indicator indicating whether the UE supports report/request beam(s) for beam switching with beam prediction.
- A minimum action delay for UE report based or request-based beam switching.
- A maximum action delay for UE report based or request-based beam switching.

[0063] In the example of Figure 3, the UE 110 transmits UE capability information to network entity 120. In some implementations, the network entity may receive the UE capability from a core network (e.g., from an access and mobility management function (AMF) of the core network 150 of Figure 1). In some other implementations, the network entity receives the UE capability from another network entity (e.g., a gNB or eNB).

[0064] At operation 304, the network entity 120 may, depending on the UE capability information received at operation 302, configure the UE for UE initiated beam switching. In some aspects, the network entity 120 may configure the UE 110 via RRC signaling, for example, a *CSI-ReportConfig*. In some other aspects, the network entity 120 may configure the UE 110 via *RRCReconfiguration*.

[0065] The network entity may supply one or more of the following parameters for a UE initiated beam switching configuration:

- A first set of SSBs or CSI-RSs for beam measurement.
- A first set of TCI states for beam measurement and/or quasi-co-location (QCL) and/or power control parameter identification.
- A beam switching scheme, e.g., whether to indicate common or separate beam(s) for beam switching for uplink and downlink channels. (In some examples, this RRC parameter follows an RRC parameter for a type of unified TCI state (e.g., *unifiedTCI-StateType*). In some examples, the network entity 120 may not configure this RRC parameter, and whether to indicate common or separate beam(s) for beam switching for uplink and downlink channels may follow an RRC parameter for a type of unified TCI state (e.g., *unifiedTCI-StateType*.)
- Target or applicable uplink and/or downlink channels or RSs for beam switching.
- A second set of CSI-RS for tracking (referred to as a tracking reference signal (TRS)) for QCL-TypeA parameters identification after the beam switching procedure.
- A set of uplink power control parameters for uplink power control after the beam switching procedure.

[0066] In some aspects, for multiple transmission and reception points (mTRP) operation, the network entity 120 may configure more than one set of SSBs or CSI-RSs or more than one set of TCIs or TCI states for beam measurement, where each set corresponds to a TRP or is associated with a *CORESETPoolIndex* value associated with a TRP.

[0067] In some aspect, some of the parameters above may be predefined. In one example, the number of reported SSBRIs, CSI reference signal resource indicators (CRIs), TCIs may be one (1) or equal to a number of sets of SSBs, CSI-RSs, or TCIs for beam measurement. In other aspects, the report quantity may indicate that the UE 110 is to report SSBRIs, CRIs, or TCI indexes only. In still other aspects, the target or applicable uplink and/or downlink channels or RSs for report-based beam switching may be predefined, e.g., channels or RSs that share an indicated unified TCI state. In further aspects, the target or applicable uplink and/or downlink channels or RSs for report-based beam switching may not be the target or applicable uplink and/or downlink channels or RSs for an indicated unified TCI state, and vice versa. Table 1 below illustrates one example of target channels for beam switching, where the search space types are defined in 3GPP Technical Specification (TS) 38.213. In some aspects, the beam report scheme may be predefined. For example, if separate uplink and downlink TCI states are configured by network entity 120, the UE 110 may report separate SSBRIs or CRIs for uplink and downlink channels. Otherwise, the UE 110 may report common SSBRI(s) or CRI(s) for uplink and downlink channels.

Predefined target/applicable channels/RSs	A first type of PDCCH in a control resource set (CORESET) associated with only Type3 common search space (CSS) and UE-specific search space (USS), PDSCH scheduled by the first type of PDCCH, PUSCH, PUCCH
Configurable target/applicable channels/RSs (whether the channels/RSs are target/applicable channels/RSs is configured by the network entity)	A second type of PDCCH in a CORESET associated with at least one search space other than Type3 CSS and USS, PDSCH scheduled by the second type of PDCCH, aperiodic CSI-RS, sounding reference signal (SRS) for codebook/non-codebook/antenna switching
Channels other than the target/applicable channel/RS	Periodic/semi-persistent CSI-RS, SSB, PRACH, SRS for beam management

Table 1

[0068] In some implementations, some of the above RRC parameters may be the same or inferred from RRC parameters for beam failure recovery (BFR), for example, an RS set of candidate beam identification. In some aspects, the RRC parameters may be different or be separate RRC parameters from those used for BFR.

[0069] In some aspects, the network entity 120 may configure the UE to measure the beam quality based on a set of SSBs or CSI-RSs. In some other implementations, the network entity 120 may configure the UE 110 to measure the beam quality based on downlink reference signals configured in TCI states. In some aspects, the network entity 120 may configure one SSB or CSI-RS in a TCI state for beam measurement. In some other aspects, the UE 110 may measure beam quality based on the SSB or CSI-RS used for QCL indication. If there are more than one SSB or CSI-RS used for QCL indication in the TCI state, the UE 110 may select the SSB or CSI-RS based on an indicated QCL type, e.g., QCL-TypeD (spatial receiving parameters). In some other aspects, the UE 110 may measure beam quality based on the SSB which is quasi-co-located with the CSI-RS used for QCL indication in the TCI state. In some other aspects, the UE may measure beam quality based on the SSB which is used for QCL indication in the TCI state. As used herein, a TCI state may indicate a joint TCI state, downlink TCI state, uplink TCI state or spatial relation info.

[0070] In some other aspects, the network entity 120 may configure both a first set of one or more SSBs or CSI-RSs for beam measurement and a first set of TCI states. The network entity 120 may configure an association between each configured SSB or CSI-RS and TCI state. In some aspects, the configured SSBs or CSI-RSs and TCI states may be one-to-one associated. The UE 110 may measure beam quality based on the configured SSBs or CSI-RSs, and if the UE 110 selects one SSB or CSI-RS is for beam switching, the UE 110 may identify QCL and/or power control parameters based on the TCI state associated with the selected SSB or CSI-RS.

[0071] In some aspects, the network entity 120 may configure a first set of one or more SSBs or CSI-RSs in the same serving cell. In some aspects, the network entity 120 may configure a first set of one or more SSBs or CSI-RSs in another serving cell in the same serving cell list to which the serving cell belongs. As an example, the network entity 120 may configure the serving cell index for the serving cell list.

[0072] To configure report-based beam switching, the network entity 120 may provide one or more of the following additional parameters:

- An indicator indicating whether the beam report is for beam switching or not.
- A number of reported SSBRIs, CRIs, or TCI states.
- An uplink resource for beam report, e.g., physical uplink control channel (PUCCH) resource or a configured-grant based physical uplink shared channel (PUSCH).
- A report quantity for the beam report. The report quantity may indicate whether the UE 110 is to report SSBRIs, CRIs, and/or TCI indexes only, or to report beam quality in addition to SSBRIs, CRIs, and/or TCI indexes.
- An action delay for the beam switching, which indicates the delay between the last symbol of the beam report or the response to the beam report until the first symbol to apply the reported beam(s) for the target uplink and/or downlink channels.

[0073] To configure request-based beam switching, the network entity 120 may provide one or more of the following additional parameters:

- A number of requested SSBRIs, CRIs, or TCIs.
- A first threshold to identify the new beam.
- A second threshold to determine the beam quality for current beam.
- A number of beam switching request events to transmit the beam switching request.
- An interval for beam switching request event detection.
- A request quantity for the UE request for beam switching. The request quantity may indicate whether the UE 110 includes SSBRI and/or CRI only or to beam

quality in addition to SSBRI and/or CRI in a UE initiated request to perform beam switching.

- An uplink resource to transmit the beam switching request (e.g., PUCCH resource.)
- A scheduling request (SR) to request the uplink grant for beam switching request transmission.
- A maximum number of retransmissions of beam switching requests.
- A counter for counting (re)transmissions of beam switching requests.
- A monitoring window during for the response to the beam switching request.
- An action delay for the beam switching, which indicates the delay between the last symbol of the beam report or the response to the beam report until the first symbol to apply the reported beam(s) for the target uplink and/or downlink channels.

[0074] In some aspects, the network entity 120 may configure a common resource for a beam switching request for both uplink and downlink beam switching. In some other aspects, the network entity 120 may configure one resource for a beam switching request for uplink channel(s) and another resource for a beam switching request for downlink channel(s).

[0075] In some aspects where the UE 110 is configured for report-based UE initiated beam switching, at operation 306 the network entity 120 may optionally trigger a beam report for beam switching. For example, the network entity 120 may transmit a medium access control (MAC) control element (CE) or downlink control information (DCI) triggering the beam report. In some aspects, the network entity 120 may transmit a MAC CE activating or deactivating a semi-persistent beam report for beam switching. In some other aspects, the network entity 120 may transmit a DCI triggering an aperiodic beam report for beam switching. In some aspects, the MAC CE or DCI may indicate one or more of the UE initiated beam switching configuration parameters discussed above when activating or triggering a beam report for beam switching.

[0076] At operation 308, the network entity 120 transmits a set of one or more SSBs or CSI-RSs for beam measurement.

[0077] At operation 310, the UE 110 detects a beam switch event. A beam switch event may be detected based on one or more of the following criteria being satisfied:

- In some aspects, the difference in beam quality, e.g., the difference between a layer 1 reference signal received power (L1-RSRP), layer 1 signal-to-interference plus noise ratio (L1-SINR), hypothetical block error ratio (BLER), channel quality indicator (CQI), or spectrum efficiency (SE) for a current bean and a candidate new beam is above a first threshold with respect to any of the current beams. In some other aspects, the difference in beam quality may be with respect to the current beam having the best beam quality among all of the current beams.

- In some aspects, the beam quality (e.g., L1-RSRP, L1-SINR, CQI, or SE) for one or any of the current beams is below a second threshold, or the BLER for one or any of the current beams is above a third threshold. In some other aspects, the beam quality for the beam with the best beam quality among the current beams compared with the second or third threshold.

[0078] **Figure 6** is a flow chart diagram illustrating example UE operations of a method 600 for detecting a beam switching request event. The example operations of method 600 may be performed, for example, by UE 110 of Figures 1-3. The example operations of method 600 may be performed once per event detection interval. The UE 110 may determine the event detection interval based on the minimum or maximum periodicity of the SSBs or CSI-RSs for beam measurement, and/or a predefined or configured maximum or minimum detection interval. In some aspects, the network entity 120 configures the detection interval, for example, as described at Figure 3, operation 304.

[0079] In some aspects, for mTRP operation, e.g., when the network entity configures more than one set of SSBs or CSI-RSs for beam measurement, the UE 110 may perform the operations of method 600 on a per TRP basis (e.g., per SSB or CSI-RS set) or across TRPs (e.g., across all the configured SSB or CSI-RS sets).

[0080] At block 602, the UE 110 sets a detection counter for the current event detection interval to zero (0). In some aspects, a detection counter is maintained for per serving cell or per bandwidth part (BWP). The detection counter may be set to zero upon the occurrence of one or more of the following:

- The UE 110 activates the serving cell (e.g., a secondary cell (SCell)).
- The UE 110 switches to another BWP for a serving cell.
- The UE 110 adds the serving cell as a primary secondary cell (PSCell) with UE request-based beam switching configured.
- The UE 110 failed to detect a beam switching event within a beam switching request event detection interval.

[0081] At block 604, the UE 110 may receive a set of one or more SSBs or CSI-RSs for beam measurement within the current detection interval (e.g., Figure 3, operation 308).

[0082] At decision block 606, the UE 110 may determine if beam switch event criteria (discussed above) have been met.

[0083] If the beam switch event criteria has not been met ("NO" branch of block 606), the UE 110 resets the detection counter to zero (0), and returns to block 604 to await reception of the next SSB or CSI-RS for beam measurement.

[0084] If the beam switch criteria has been met within the current detection interval ("YES" branch of block 606), then at block 610, the UE 110 increments the detection counter.

[0085] At decision block 612, the UE 110 determines if the detection counter is equal to a threshold number of detection events. In some aspects, the detection counter may determine if N consecutive detection events have occurred, where N may be predefined or configured by the network entity 120. In some aspects, if N is not defined of configured, then N may be set to one (1) and the UE transmits a beam switching event upon the occurrence of one beam switching event.

[0086] If the threshold number of detection events has been reached ("YES" branch of block 612), then the UE 110 triggers a UE initiated beam switch from a current beam to a new beam, and resets the event detection counter to zero (0).

[0087] If the threshold number of detection events has not been reached ("NO" branch of block 612), then the UE 110 returns to block 604 to await reception of the next SSB or CSI-RS for beam measurement.

[0088] Returning to Figure 3, after detecting a beam switching event, at operation 312, the UE 110 transmits, to the network entity 120, an indication to perform beam switching from one or more current beams to one or more new beams. In some aspects, the UE 110 may transmit a beam report for beam switching identifying one or more new beams. In some other aspects, the UE 110 may transmit a request to perform beam switching. In some aspects, the indication to perform beam switching may include an indicator identifying the requested new beam. As an example, the UE 110 may transmit in the report or the request one or more indexes from the configured first set of SSBs, CSI-RSs or TCIs that are associated with the new beam(s). In some aspects, the indication to perform beam switching may include an indicator identifying the new beam(s). In some aspects, the UE 110 may indicate at least one SSB resource indicator (SSBRI) or CSI-RS resource indicator (CRI) or TCI index indicating the new beam(s).

[0089] The indication to perform beam switching may include one or more of the following parameters:

- A serving cell index or a serving cell list index indicating the target serving cell index or serving cell index to apply the new beam(s).
- A number of reported SSBRIs, CRIs, TCI indexes.
- One or more SSBRIs, CRI, or TCI indexes selected from the configured first set of SSB, or CSI-RS, or TCI indicating the new beam(s).

- A beam quality for the reported SSBRI(s), CRI(s), TCI(s) (e.g., L1-RSRP, L1-SINR, hypothetical BLER, CQI, or SE).
- A first indicator indicating whether the UE has obtained the best UE beam for each or all SSBs, CRIs, or TCIs indicated by the reported SSBRI, CRI, or TCI index (may be used indicate whether additional delay for UE beam sweeping for the SSB, CRI, or TCI may occur).
- A second indicator indicating whether the UE has obtained the QCL parameters for each or all SSBs, CRIs, or TCIs indicated by the reported SSBRI, CRI, or TCI index (may be used to indicate whether additional delay for time and frequency offset tracking for the SSB, CRI, or TCI may occur).
- A third indicator indicating whether the UE has obtained the layer 3 RSRP (L3-RSRP) for SSBs, CRIs, or TCIs indicated by the reported SSBRIs, CRIs, or TCI indexes (may indicate whether additional delay for pathloss reference signal (PL-RS) measurement for the SSB, CRI, or TCI may occur).
- A beam quality for a current beam (e.g., L1-RSRP, L1-SINR, hypothetical BLER, CQI, or SE).
- A fourth indicator indicating whether the beam quality is based on actual beam measurement or predicted beam measurement at the configured or reported action time.
- A preferred action delay or action time for switching to the new beam(s).
- Target channels for the new beam(s).
- A fifth indicator indicating which of the reported SSBRI(s), CRI(s), or TCI(s) are for beam switching.

[0090] In some aspects, the UE 110 may indicate beam switching by MAC CE or uplink control information (UCI) on PUSCH. For UE request-based beam switching, the UE may transmit an SR if the UE 110 did not receive an uplink grant for PUSCH transmission. If the SR is not configured, the UE 110 may transmit PRACH to request an uplink grant for the beam switching request. In some other aspects, the UE may transmit PRACH for the beam switching request directly. In some other aspects, the UE 110 may transmit the indication for beam switching by PUCCH, where the PUCCH resource may be configured by the network entity 120.

[0091] The UE 110 may transmit an indication for beam switching by UCI on PUSCH or long PUCCH (e.g., a PUCCH with more than 4 symbols). In some aspects, the UE 110 may transmit the information for the indication for beam switching in CSI part 1. In some other aspects, the UE 110 may transmit the information for indication for beam switching by CSI part 2. In further other aspects, the UE 110 may transmit some of the information for the indication for beam switching by CSI part 1 (e.g., the number of reported SSBRI(s) or CRI(s)), and other information for the indication for beam switching by CSI part 2. The CSI part 1 and CSI part 2 are defined in 3GPP TS 38.212.

[0092] In some aspects, the UE 110 may indicate a preferred action time for the beam switching by indicating a preferred slot index, subframe index and/or frame index for the reported SSBRI(s) or CRI(s). In some aspects, the UE may indicate a preferred action time for the beam switching by indicating a row or logical index mapping to rows in a table listing candidate action times. In some other aspects, the UE 110 may report an action delay for the reported SSBRI(s), CRI(s), or TCI(s). In such aspects, the UE 110 may apply the reported SSBRI(s), CRI(s), or TCI(s) after the action delay with respect to the last symbol of the indication for beam switching or after a response to the indication for beam switching received from the network entity 120.

[0093] Some or all of the information above may be predefined. In some aspects, the UE 110 may identify the best UE beam for each reported SSBRI, CRI, or TCI before the UE transmits the indication for beam switching. Thus, no additional delay for UE beam sweeping may be needed before the UE 110 switches to the corresponding SSBRI, CRI, or TCI. In such aspects, the UE 110 may not need to report the first indicator indicating whether the UE has obtained the best UE beam for any or all of the SSBs, CRIs, or TCIs indicated by the reported SSBRI, CRI, or TCI index. In another aspect, the UE 110 may identify the QCL parameters for each reported SSBRI, CRI, or TCI before the UE transmits the indication for beam switching. Thus, no additional delay for time and frequency offset tracking may be needed before the UE 110 switches to the corresponding SSBRI, CRI, or TCI. In such aspects, the UE may not need to report the second indicator indicating whether the UE has obtained the QCL parameters for any or all of the SSBs, CRIs, or TCIs indicated by the reported SSBRI, CRI, or TCI index. In still another aspect, the UE 110 may identify the L3-RSRP for each reported SSBRI, CRI, or TCI before the UE transmits the indication for beam switching. Thus, no additional delay for pathloss measurement may be needed before the UE 110 switches to the corresponding SSBRI, CRI, or TCI. In such aspects, the UE may not need to report the third indicator indicating whether the UE has obtained the L3-RSRP for SSBs, CRIs, or TCIs indicated by the reported SSBRIs, CRIs or TCI indexes.

[0094] In some aspects the UE 110 may indicate one or more target or applicable channels for new beam(s) by indicating whether the new beam(s) are for uplink or downlink channels. In some other aspects, some target channels may be predefined, and the UE 110 may indicate the additional target channels as shown below in Table 2. In still other aspects, the UE 110 may report a replaced indicated unified TCI state index. The target channel may indicate the channels with the indicated unified TCI state applied. If the network entity 120 indicates one unified TCI state, the UE 110 may not report the replaced indicated unified TCI state index. The target channels may be the channels with the indicated unified TCI state applied. If the network entity indicates more than one unified TCI states (e.g., W (W>1) TCI states), the UE 110 may indicate the replaced unified TCI state indexes based on the W indicated TCI states. Figure 7A discussed below illustrates one example for a UE initiated indication for beam switching for one of the indicated TCI states. Figure 7b discussed below illustrates one example for a UE initiated indication for beam switching for multiple indicated TCI states.

Predefined target or applicable channels and/or RSs	A first type of PDCCH in a control resource set (CORESET) associated with only a Type3 common search space (CSS) and UE-specific search space (USS), PDSCH scheduled by the first type of PDCCH, PUSCH, PUCCH
UE report target or applicable channels and/or RSs (whether the channels or RSs are target or applicable channels or RSs is reported by the UE)	A second type of PDCCH in a CORESET associated with at least one search space other than Type3 CSS and USS, PDSCH scheduled by the second type of PDCCH, aperiodic CSI-RS, SRS for codebook/non-codebook/antenna switching
Channels other than the target or applicable channels or RSs	Periodic/semi-persistent CSI-RS, SSB, PRACH, SRS for beam management

Table 2

[0095] In some aspects, for UE request-based beam switching, after X slots or symbols after the UE 110 transmits the first or last symbol of the request, the UE may start to monitor for a network entity's response to the request. X may be predefined (e.g., X=0 or X=4) or configured by the network entity 120 via RRC signaling. The UE 110 may start or reset a monitoring timer. If the UE 110 detects a response to the request, the UE may stop or reset the monitoring timer. After the monitoring timer expires, the UE may retransmit the request if the number of retransmissions of the request is smaller than a maximum number of retransmissions of the request.

[0096] In some aspects, at operation 314, the network entity may transmit a response to the indication to perform beam switching. The response may indicate an acknowledgement of the indication to perform beam switching that was transmitted at operation 312. The network entity 120 may transmit the response as a PDCCH associated with a dedicated radio network temporary identifier (RNTI), as a PDCCH in a dedicated search space (SS) or control resource set (CORESET). The RNTI may be predefined or configured by the network entity 120. Similarly, the SS or CORESET may be configured by the network entity 120. In some aspects, the network entity 120 may transmit the PDCCH as an uplink grant scheduling a new transmission for the same Hybrid Automatic Repeat reQuest (HARQ) process as was used for a PUSCH transmission including the indication to perform beam switching transmitted by the UE 110.

[0097] In some implementations, the network entity 120 may further transmit at least one or more of the following parameters in response to the indication to perform beam switching:

- An action delay or action time for the UE reported/requested beam(s);
- Selected SSBRI(s), CRI(s), and/or TCI(s) from the reported SSBRIs, CRIs, and/or TCI(s) for joint or separate uplink and downlink beam switching;
- An indication whether to apply the new beam(s) for uplink and/or downlink communication (e.g., uplink and/or downlink channel(s) that share an indicated unified TCI state).
- An indication whether to apply the new beam(s) to additional uplink and/or downlink channel(s) (e.g., uplink and/or downlink channel(s) that do not share the indicated unified TCI state).

[0098] The network entity 120 may transmit the additional information above by DCI or MAC CE. Figure 8A discussed below illustrates one example for the SSBRI, CRI, or TCI selection for joint uplink and downlink beam switching in a response to a UE initiated indication for beam switching. Figure 8B discussed below illustrates one example for the SSBRI, CRI, or TCI selection for separate uplink and downlink beam switching in the response to a UE initiated indication for beam switching.

[0099] At operation 316, the UE 110 may calculate one or more QCL parameters and/or uplink power control parameters for a channel associated with the one or more new beams. In some aspects, the UE 110 may identify the QCL parameters for the downlink channel(s) associated with the new beam(s) and the uplink power control parameters for the uplink channel(s) associated with the new beam(s).

[0100] In some aspects, the network entity 120 may configure a second set of TRS for QCL-TypeA parameters identification (e.g., Doppler shift, Doppler spread, average delay, delay spread), where each SSB or CSI-RS in the first set may be associated with one of the TRS in the second set. In some aspects, the network entity 120 may configure the associated TRS for each SSB or CSI-RS in the first set. In some other aspects, the TRS and the SSB or CSI-RS in both sets are one-to-one associated. In such aspects, the UE 110 may determine the QCL parameters based on the associated TRS when one SSB or CSI-RS is determined or selected for beam switching. In still other aspects, the network entity 120 may configure a second set of TRS for QCL-TypeA parameter identification in a configured first set of TCI states, where the network entity 120 may configure the TRS as the source reference signal for QCL-TypeA indication. Figure 9 discussed below illustrates one example for the additional TRS sets based QCL parameter identification.

[0101] In some aspects, the network entity 120 may configure a second set of TRS for QCL-TypeA parameter identification, where each TRS may be associated with a reported or selected

SSBRI or CRI. After receiving the UE initiated indication for beam switching or after transmitting a response to such an indication, the network entity 120 may dynamically update the beam for the TRS based on the reported or selected SSBRI(s) or CRI(s).

[0102] In some aspects, the network entity 120 may update the beam for the TRS based on the TRS resource set index, and/or an order or index of the reported or selected SSBRI or CRI. In one example, the network entity 120 may transmit a first TRS (TRS with lowest resource set index) based on the beam for the first reported or selected SSBRI or CRI. In some other examples, the network entity 120 may indicate the beam for each TRS by MAC CE or DCI based on the reported or selected SSBRI or CRI.

[0103] In some aspects, the UE may constrain or restrict scheduling a PDSCH after UE initiated beam switching. In some examples, if the UE 110 has no TRS for QCL-TypeA parameter identification, the network entity 120 may refrain from scheduling the PDSCH based on a modulation and coding scheme (MCS) equal to or higher than a threshold after the UE 110 switches to the new beam and before the UE applies a newly indicated TCI state. The threshold may be predefined (e.g., MCS corresponding to the 16QAM with smallest coding rate) or may be reported by the UE 110 via UE capability information.

[0104] In some other aspects, the network entity 120 may refrain from scheduling the PDSCH with number of layers equal to or higher than a threshold after the UE 110 switches to the new beam and before the UE applies a newly indicated TCI state. The threshold may be predefined (e.g., 2) or may be reported by the UE via UE capability information.

[0105] In still other aspects, the UE 110 may use the same QCL-TypeA parameters from a previously used joint/DL TCI state before it applies a newly indicated TCI state.

[0106] Figure 11 discussed below illustrates one example for the scheduling restriction after beam switching and before TCI indication.

[0107] In addition to the QCL parameter identification discussed above, the UE 110 may identify power control parameters. In some aspects, the network entity 120 may configure a list of power control parameter sets for power control parameter identification, where each SSB or CSI-RS in the first set is associated with one of the power control parameters sets in the list. In some aspects, the network entity 120 may configure the associated power control parameter set for each SSB or CSI-RS in the first set. In some other aspects, the power control parameter set in the list and the SSB or CSI-RS in the first set are one-to-one associated. In still other aspects, the network entity 120 configures some of or all the power control parameters in a configured first set of TCI states. The UE 110 may determine the uplink power control parameters when one SSB or CSI-RS is indicated for beam switching. The power control parameters configured in each set may include at least one of P0, alpha, path loss reference signal (PL-RS), and closed loop index (CLI).

[0108] In some other aspects, the UE 110 may determine the PL-RS based on the indicated SSBRI or CRI. The SSB or CSI-RS indicated by the SSBRI/CRI may be used as the PL-RS.

[0109] In some implementations, the network entity 120 may configure a common P0 and alpha for the indicated SSBRIs or CRIs. In some other implementations, the network entity 120 may configure separate P0 and alpha for the indicated SSBRIs or CRIs corresponding to different sets of SSBs or CSI-RSs for beam measurement.

[0110] In some aspects, the network entity 120 may configure a common CLI for the indicated SSBRIs or CRIs. In some other implementations, the network entity 120 may configure a separate CLI for the SSBRIs or CRIs corresponding to different sets of SSBs or CSI-RSs for beam measurement. In still other aspects, the network entity 120 may configure the CLI for each of the indicated SSBRIs or CRIs by RRC signaling, MAC CE, or DCI (e.g., in a response to the UE initiated indication for beam switching).

[0111] At operation 318, the UE 110 and network entity communicate using the new beam(s) specified by the UE initiated indication for beam switching. The UE 110 may communicate with the network entity 120 based on the QCL parameters and/or the uplink power control parameters for the corresponding channels calculated at operation 316. In some cases, the UE may not identify the QCL parameters for the downlink channel(s) associated with the new beam(s) and/or the uplink power control parameters for the uplink channel(s) associated with the new beam(s). In such cases, the UE may use a default set of QCL parameters and/or a default set of uplink power control parameters.

[0112] **Figure 4** is a flow chart diagram illustrating example UE operations of a method 400 for UE initiated beam switching. The example operations of method 400 may be performed, for example, by UE 110 of Figures 1-3.

[0113] At block 402, and as described above with respect to Figure 3, operation 302, the UE may transmit UE capability information to a network entity. In some aspects, the UE may transmit UE capability information indicating whether the UE supports UE initiated beam switching, and if supported, the type of UE initiated beam switching supported by the UE 110. For example, the UE 110 may indicate that the UE supports initiating beam switching utilizing a UE request to switch beams (request-based beam switching), an indication in a beam switch report to switch beams (report-based beam switching), or both request-based and report-based UE initiated beam switching. The UE capability information may also include: a maximum number of SSB or CSI-RS resources in a set for beam measurement for UE report-based or request-based beam switching; a maximum number of SSB or CSI-RS resources sets for beam measurement for UE report based or request-based beam switching; a maximum number of reported beams in a beam report; or a maximum number of requested beams in a UE request.

[0114] At block 404, and as described above with respect to Figure 3, operation 304, the UE may receive a configuration for UE initiated beam switching. In some aspects, the configuration information may include: a first set of SSBs or CSI-RSs for beam measurement; a first set of TCI states for beam measurement and/or QCL and/or power control parameter identification; or a beam switching scheme (e.g., whether to indicate common or separate beam(s) for beam switching for uplink and downlink channels).

[0115] For report-based beam switching, the configuration information may further include: an indicator indicating whether the beam report is for beam switching or not; a number of reported SSBRIs, CRIs, or TCI states; or an uplink resource for beam report (e.g., PUCCH resource or a configured-grant based PUSCH (CG-PUSCH)).

[0116] For request-based beam switching, the configuration for UE initiated beam switching may include: a number of requested SSBRIs, CRIs, or TCIs; a first threshold to identify the new beam; a second threshold to determine the beam quality for current beam; a number of beam switching request events to transmit the beam switching request; or an interval for beam switching request event detection.

[0117] At block 406, and as described above with respect to Figure 3, operation 306, if the UE is configured for report-based beam switching, the UE may receive, from the network entity, a trigger for a beam report for beam switching. For example, the UE may receive a MAC CE or DCI triggering the beam report. In some aspects, the UE may receive a MAC CE activating or deactivating a semi-persistent beam report for beam switching. In some other aspects, the UE may receive a DCI triggering an aperiodic beam report for beam switching. In some aspects, the MAC CE or DCI may indicate one or more of the UE initiated beam switching configuration parameters discussed above when activating or triggering a beam report for beam switching.

[0118] At block 408, and as described above with respect to Figure 3, operation 308, the UE receives, from the network entity, a set of one or more SSBs or CSI-RSs for beam measurement.

[0119] At block 410, and as described above with respect to Figure 3, operation 310, the UE detects a beam switch event. As discussed above, the beam switch event may be detected based on one or more of the following criteria being satisfied: (A) a difference in beam quality (e.g., the difference between an L1-RSRP, L1-SINR, BLER, CQI, or SE) for a current bean and a candidate new beam is above a first threshold with respect to any of the current beams. In some other aspects, the difference in beam quality may be with respect to the current beam having the best beam quality among all of the current beams or (B) the beam quality (e.g., L1-RSRP, L1-SINR, CQI, or SE) for one or any of the current beams is below a second threshold, or the BLER for one or any of the current beams is above a third threshold. In some other aspects, the beam quality for the beam with the best beam quality among the current beams compared with the second or third threshold.

[0120] In some aspects and as described with reference to Figure 6, the UE may be configured to detect N consecutive beams switch events during a detection interval before initiating a beam switch.

[0121] At block 412, and as described above with respect to Figure 3, operation 312, the UE transmits, to the network entity 120, an indication to perform beam switching from one or more current beams to one or more new beams. In some aspects, the UE may transmit a beam report for beam switching identifying one or more new beams. In some other aspects, the UE may transmit a request to perform beam switching. In some aspects, the indication to perform beam switching may include an indicator identifying the requested new beam. As an example, the UE 110 may transmit in the report or the request one or more indexes from a configured first set of SSBs, CSI-RSs, or TCIs that are associated with the new beam(s). In some aspects, the indication to perform beam switching may include an indicator identifying the new beam(s). In some aspects, the UE 110 may indicate at least one SSBRI or CRI or TCI index indicating the new beam(s).

[0122] At block 414, and as described above with respect to Figure 3, operation 314, the UE may receive, from the network entity, a response to the indication to perform beam switching. The response may indicate an acknowledgement of the indication to perform beam switching that was transmitted at block 412. In some aspects, the UE may receive an action delay or action time for the UE reported/requested beam(s) and/or selected SSBRI(s), CRI(s), and/or TCI(s) from the reported SSBRIs, CRIs, and/or TCI(s) for joint or separate uplink and downlink beam switching.

[0123] At block 416, and as described above with respect to Figure 3, operation 316, the UE may calculate one or more QCL parameters and/or uplink power control parameters for a channel associated with the one or more new beams. In some aspects, the UE may identify the QCL parameters for the downlink channel(s) associated with the new beam(s) and the uplink power control parameters for the uplink channel(s) associated with the new beam(s).

[0124] At block 418, and as described above with respect to Figure 3, operation 318, the UE communicates with the network entity using the new beam(s) specified by UE initiated indication for beam switching. The UE may communicate with the network entity 120 based on the QCL parameters and/or the uplink power control parameters for the corresponding channels calculated at block 416.

[0125] **Figure 5** is a flow chart diagram illustrating example network entity operations of a method 500 for UE initiated beam switching. The example operations of method 500 may be performed, for example, by UE 110 of Figures 1-3.

[0126] At block 502, and as described above with respect to Figure 3, operation 302, the network entity may receive UE capability information from a UE. In some aspects, the network entity may receive UE capability information indicating whether the UE supports UE initiated beam switching, and if supported, the type of UE initiated beam switching supported by the UE 110. For example, the UE 110 may indicate that the UE supports request-based beam switching, report-based beam switching, or both request-based and report-based beam switching. In some aspects, the network entity may receive UE capability information including similar UE capabilities as described with respect to Figure 4, block 402.

[0127] At block 504, and as described above with respect to Figure 3, operation 304, the network entity may transmit a configuration for UE initiated beam switching. In some aspects, the configuration information may include: a first set of SSBs or CSI-RSs for beam measurement; a first set of TCI states for beam measurement and/or QCL and/or power control parameter identification; or a beam switching scheme (e.g., whether to indicate common or separate beam(s) for beam switching for uplink and downlink channels).

[0128] For report-based beam switching, the configuration information may further include: an indicator indicating whether the beam report is for beam switching or not; a number of reported SSBRIs, CRIs, or TCI states; or an uplink resource for beam report (e.g., PUCCH resource or a CG-PUSCH).

[0129] For request-based beam switching, the configuration for UE initiated beam switching may include: a number of requested SSBRIs, CRIs, or TCIs; a first threshold to identify the new beam; a second threshold to determine the beam quality for current beam; a number of beam switching request events to transmit the beam switching request; or an interval for beam switching request event detection.

[0130] At block 506, and as described above with respect to Figure 3, operation 306, if the UE is configured for report-based beam switching, the network entity may transmit, to the UE, a trigger for a beam report for beam switching. For example, the network entity may transmit a MAC CE or DCI triggering the beam report. In some aspects, the network entity may transmit a MAC CE activating or deactivating a semi-persistent beam report for beam switching. In some other aspects, the network entity may transmit a DCI triggering an aperiodic beam report for beam switching. In some aspects, the MAC CE or DCI may indicate one or more of the UE initiated beam switching configuration parameters for beam switching.

[0131] At block 508, and as described above with respect to Figure 3, operation 308, the network entity transmits, to the UE, a set of one or more SSBs or CSI-RSs for beam measurement.

[0132] At block 512, and as described above with respect to Figure 3, operation 312, the network entity receives, from the UE, an indication to perform beam switching from one or more current beams to one or more new beams. In some aspects, the network entity may receive a beam report for beam switching identifying one or more new beams. In some other aspects, the network entity may receive a request to perform beam switching. In some aspects, the indication to perform beam switching may include an indicator identifying the requested new beam. As an example, the network entity may receive in the report or the request one or more indexes from a configured first set of SSBs, CSI-RSs or TCIs that are associated with the new beam(s). As discussed above, in some aspects, the indication to perform beam switching may include an indicator identifying the new beam(s). In some aspects, the indication to perform beam switching may indicate at least one SSBRI or CRI or TCI index identifying the new beam(s).

[0133] At block 514, and as described above with respect to Figure 3, operation 314, the network entity may transmit, to the UE, a response to the indication to perform beam switching. The response may indicate an acknowledgement of the indication to perform beam switching that was received at block 512. As discussed above, in some aspects, the network entity may transmit an action delay or action time for the UE reported/requested beam(s) and/or selected SSBRI(s), CRI(s), and/or TCI(s) from the reported SSBRIs, CRIs, and/or TCI(s) for joint or separate uplink and downlink beam switching.

[0134] At block 518, and as described above with respect to Figure 3, operation 318, the network entity communicates with the UE using the new beam(s) specified by UE initiated indication for beam switching.

[0135] **Figures 7A-7D, 8A, 8B, and 9-11** are conceptual diagrams illustrating various examples of the aspects of the disclosure described above. Figures 7A-7D, 8A, 8B, and 9-11 include timelines illustrating relative timings of various operations performed during UE initiated beam switching. The timelines may not be drawn to scale, and the time durations between the various operations may differ from that shown in the Figures. The example conception graphs shown in Figures 7A-7D, 8A, and 8B represent thirty-two beams, and are shown with respect to Azimuth angle Of Departure (AoD) and Zenith angle Of Departure (ZoD). In these examples, the thirty two beams (labeled 0-31) are represented in grids, where the beams are located in the grids based on AoD (X axis) and ZoD (Y-axis).

[0136] **Figure 7A** is a diagram illustrating an example of beam switching based on an indicated TCI state. In the example shown in Figure 7A, grid 700 represents a state of the beams prior to beam switching. Grid 705 represents the state of the beams after beam switching. Timeline 710 represents timing of various operations prior to, and after beam switching.

[0137] In this example, beams 18 and 11 are beams currently used for communication between a UE and a network entity. At time T_0 the TCI indications are shown as TCI state 11 being associated with SSB or CSI-RS 11 and TCI state 18 being associated with SSB or CSI-RS 18. At time T_1 through T_2, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_3, the UE initiates a beam switch, indicating that beam 28 is to replace beam 18. For example, the UE may indicate that a target channel for the first reported SSBRI, CRI, or TCI (e.g., SSB, CSI-RS, or TCI 28) should replace the a first indicated TCI state (TCI state 18). In the example shown in Figure 7A, the action time for the beam switch is T_4. This action time may be indicated by the network entity, perhaps based on an action time requested by the UE. Grid 705 illustrates the state of the beams following the beam switch at time T_4.

[0138] **Figure 7B** is a diagram illustrating an example of beam switching based on multiple indicated TCI states. In the example shown in Figure 7B, grid 720 represents a state of the beams prior to beam switching. Grid 725 represents the state of the beams after beam switching. Timeline 730 represents timing of various operations prior to, and after beam switching.

[0139] In this example, beams 18 and 11 are beams currently used for communication between the UE and a network entity. At time T_0 the TCI indications are shown as TCI state 11 being associated with SSB or CSI-RS 11 and TCI state 18 being associated with SSB or CSI-RS 18. At time T_1 through T_2, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_3, the UE initiates a beam switch using multiple (two) TCI states, indicating that beam 28 is to replace beam 11, and that beam 21 is to replace beam 18. For example, the UE may indicate that a target channel for the first reported SSBRI, CRI, or TCI (e.g., SSB, CSI-RS, or TCI 28) should replace the a first indicated TCI state (TCI state 11), and that a target channel for the second reported SSBRI, CRI, or TCI (e.g., SSB, CSI-RS, or TCI 21) should replace the a second indicated TCI state (TCI state 18). In the example shown in Figure 7B, the action time for the beam switch is T_4. This action time may be indicated by the network entity, perhaps based on an action time requested by the UE. Grid 725 illustrates the state of the beams following the beam switch at time T_4.

[0140] **Figure 7C** is a diagram illustrating an example of UE initiated joint uplink and downlink beam switching. In the example shown in Figure 7C, grid 740 represents a state of the beams prior to beam switching. Grid 745 represents the state of the beams after beam switching. Timeline 750 represents timing of various operations prior to, and after beam switching.

[0141] As discussed above, a UE may report beam quality for N beams, and may indicate that M beams of the N beams are for beam switching. Thus, M beams are used for beam switching and N-M beams are used for a normal beam report. In this example, prior to beam switching, beam 9 is currently used for downlink and uplink beam indication. At time T_0 through T_1, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2, the UE initiates a beam switch via a beam report.

At time T_3 the UE transmits a beam report indicates the quality of beams 11, 12, 18, and 28, and indicates that beam 28 is to replace beam 9 for uplink and downlink beam indications. Thus, in this example, N=4 and M=1. Grid 745 illustrates that beam 28 has replaced beam 9 following the beam switch at time T_4.

[0142] **Figure 7D** is a diagram illustrating an example of UE initiated separate uplink and downlink beam switching. In the example shown in Figure 7D, grid 760 represents a state of the beams prior to beam switching. Grid 765 represents the state of the beams after beam switching. Timeline 770 represents timing of various operations prior to, and after beam switching.

[0143] This example is similar to the example shown in Figure 7C, with the exception that instead of the UE providing joint uplink and downlink beam indications in a beam report, the UE provides separate uplink and downlink beam indications. In this example, prior to beam switching, beam 9 is currently used for downlink indications and beam 2 is used for uplink beam indications. At time T_0 through T_1, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_3, the UE initiates a beam switch via a beam report. The beam report indicates the quality of beams 11, 12, 18, and 28, indicates that beam 28 is to replace beam 2 for downlink beam indications and indicates that beam 12 is to replace beam 9 for uplink beam indications. Grid 765 illustrates that beam 28 has replaced beam 2 and beam 12 has replaced beam 9 following the beam switch at time T_4.

[0144] **Figure 8A** is a diagram illustrating an example of joint uplink and downlink beam switching in a response to a UE initiated beam switch. In the example shown in Figure 8A, grid 800 represents a state of the beams prior to beam switching. Grid 805 represents the state of the beams after beam switching. Timeline 810 represents timing of various operations prior to, and after beam switching.

[0145] As discussed above, a UE may report beam quality for N beams, and may indicate that M beams of the N beams are for beam switching. In this example, prior to beam switching, beam 9 is currently used for downlink and uplink beam indication. At time T_0 through T_1, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2, the UE initiates a beam switch via a beam report. The report indicates the quality of beams 11, 12, 18, and 28, and indicates that beam 28 is to replace beam 9 for uplink and downlink beam indications. At time T_3 the network entity transmits a response to the beam report. The response indicates that as requested, beam 28 is to replace beam 9 for uplink and downlink beam indications at the action time. Grid 805 illustrates that beam 28 has replaced beam 9 following the beam switch at time T_4.

[0146] **Figure 8B** is a diagram illustrating an example of separate uplink and downlink beam switching in a response to a UE initiated beam switch. In the example shown in Figure 8B, grid

820 represents a state of the beams prior to beam switching. Grid 825 represents the state of the beams after beam switching. Timeline 830 represents timing of various operations prior to, and after beam switching.

[0147] This example is similar to the example shown in Figure 8A, with the exception that instead of the network response to UE initiated beam switching indicating joint uplink and downlink beam indications in a beam report, the network entity indicates separate uplink and downlink beam indications in the response. In this example, prior to beam switching, beam 9 is currently used for downlink indications and beam 2 is used for uplink beam indications. At time T_0 through T_1, the UE performs beam measurement operations to measure beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2, the UE initiates a beam switch via a beam report. The beam report indicates the quality of beams 11, 12, 18, and 28, indicates that beam 28 is to replace beam 2 for uplink beam indications and indicates that beam 12 is to replace beam 9 for downlink beam indications. At time T_3 the network entity transmits a response to the beam report. The response indicates that as requested, beam 28 is to replace beam 2 for uplink beam indications and indicates that beam 12 is to replace beam 9 for downlink beam indications at the action time. Grid 765 illustrates that beam 28 has replaced beam 2 and beam 12 has replaced beam 9 following the beam switch at time T_4.

[0148] **Figure 9** is a diagram illustrating an example timeline 900 for additional TRS sets based on QCL parameter identification. In this example, at time T_0 through T_1, the UE measures beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2, the UE initiates report-based beam switching or request-based beam switching via a transmission to the network entity. The report or request indicates that a new beam associated with SSBRI 12 or CRI 12 is to replace a current beam. In response to the beam switch, the network entity configures the UE to use TRS 12 for QCL parameter identification for the new beam associated with SSBRI 12 or CRI 12. At times T_3-T_5, the UE may use TRS 0, …, TRS 12, …, and TRS 31 for QCL parameter identification for their associated beams.

[0149] **Figure 10** is a diagram illustrating an example timeline 1000 for an additional TRS with dynamic QCL update based QCL parameter identification. In this example, at time T_0 through T_1, the UE measures beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2 and T_3, the network entity transmits a TRS 0 and TRS 1 respectively associated with a first current beam and a second current beam. At time T_4, the UE initiates report-based beam switching or request-based beam switching via a transmission to the network entity. The report or request indicates that a beam associated with SSBRI 8 or CRI 8 is to replace the first current beam, and that a beam associated with SSBRI 12 or CRI 12 is to replace the second current beam. In response to the beam switch, at time T_5 the network entity configures the UE to use TRS

0 for QCL parameter identification for the new beam associated with SSBRI 8 or CRI 8. At time T_6, the network entity configures the UE to use TRS 1 for QCL parameter identification for the new beam associated with SSBRI 12 or CRI 12.

[0150] **Figure 11** is a diagram illustrating an example timeline 1100 including a scheduling restriction after beam switching. In the example shown in Figure 11, at time T_0 through T_1, the UE measures beam quality based on SSB or CSI-RS 0, SSB or CSI-RS 1, …, SSB or CSI-RS 31. At time T_2, the UE initiates a beam switch via a beam report. The beam report indicates a new beam associated with SSBRI 8 or CRI 8 to replace a current beam, and indicates an action time of T_3. In this example, the network entity does not transmit a TCI indication until time T_4. Therefore, the network entity indicates an action time later than T_4 (e.g., T_5).

[0151] It is noted that throughout this disclosure, an expression of "X/Y" may include meaning of "X or Y". It is noted that throughout this disclosure, an expression of "X/Y" may include meaning of "X and Y". It is noted that throughout this disclosure, an expression of "X/Y" may include meaning of "X and/or Y". It is noted that throughout this disclosure, an expression of "(A) B" or "B (A)" may include concept of "only B". It is noted that throughout this disclosure, an expression of "(A) B" or "B (A)" may include concept of "A+B" or "B+A".

[0152] It is noted that some or all of the foregoing or the following implementations can be jointly combined or formed to be a new or another one implementation.

[0153] It is noted that the foregoing or the following techniques can be used to solve at least (but not limited to) the issue(s) or scenario(s) mentioned in this disclosure.

[0154] The following additional considerations may apply to the foregoing and the following discussions.

[0155] It is noted that any two or more than two of the foregoing or the following paragraphs, (sub)-bullets, points, actions, or claims described in each method/technique/implementation may be combined logically, reasonably, and properly to form a specific method.

[0156] It is noted that any sentence, paragraph, (sub)-bullet, point, action, or claim described in each of the foregoing or the following technique(s)/implementation(s)/concept(s) may be implemented independently and separately to form a specific method. Dependency, such as "based on", "more specifically", "where" or etc., in technique(s)/implementation(s)/concept(s) mentioned in this disclosure is just one possible implementation which would not restrict the specific method.

[0157] Certain techniques are described in this disclosure as including logic or a number of components or modules. Modules may be software modules (such as code stored on non-transitory machine-readable medium) or hardware modules. A hardware module is a tangible unit capable of performing certain operations and may be configured or arranged in a certain manner. A hardware module can comprise dedicated circuitry or logic that is permanently configured (such as a special-purpose processor, such as a field programmable gate array (FPGA) or an application-specific integrated circuit (ASIC)) to perform certain operations. A hardware module may also comprise programmable logic or circuitry (for example, as encompassed within a general-purpose processor or other programmable processor) that is temporarily configured by software to perform certain operations. The decision to implement a hardware module in dedicated and permanently configured circuitry, or in temporarily configured circuitry (for example, configured by software) may be driven by cost and time considerations.

[0158] Figures 1-6, 7A-7D, 8A, 8B, and 9-11 and the operations described herein are examples meant to aid in understanding example implementations and should not be used to limit the potential implementations or limit the scope of the claims. Some implementations might include additional operations, fewer operations, operations in parallel or in a different order, and some operations differently.

[0159] As used herein, the terms “component” and “module” are intended to be broadly construed as hardware, firmware, or a combination of hardware and software. As used herein, a processor is implemented in hardware, firmware, or a combination of hardware and software. As used herein, the phrase “based on” is intended to be broadly construed to mean “based at least in part on.”

[0160] Some aspects are described herein in connection with thresholds. As used herein, satisfying a threshold may refer to a value being greater than the threshold, greater than or equal to the threshold, less than the threshold, less than or equal to the threshold, equal to the threshold, not equal to the threshold, or the like.

[0161] As used herein, a phrase referring to “at least one of” or “one or more of” a list of items refers to any combination of those items, including single members. For example, “at least one of: a, b, or c” is intended to cover the possibilities of: a only, b only, c only, a combination of a and b, a combination of a and c, a combination of b and c, and a combination of a and b and c.

[0162] In this disclosure, the term "can" indicates a capability, or alternatively indicates a possible implementation option. The term "may" indicates a permission or a possible implementation option.

[0163] The various illustrative components, logic, logical blocks, modules, circuits, operations and algorithm processes described in connection with the implementations disclosed herein may be implemented as electronic hardware, firmware, software, or combinations of hardware, firmware or software, including the structures disclosed in this specification and the structural equivalents thereof. The interchangeability of hardware, firmware and software has been described generally, in terms of functionality, and illustrated in the various illustrative components, blocks, modules, circuits and processes described above. Whether such functionality is implemented in hardware, firmware or software depends upon the particular application and design constraints imposed on the overall system.

[0164] The hardware and data processing apparatus used to implement the various illustrative components, logics, logical blocks, modules and circuits described in connection with the aspects disclosed herein may be implemented or performed with a general purpose single- or multi-chip processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device (PLD), 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, or any conventional processor, controller, microcontroller, or state machine. A processor also may be implemented as a combination of computing devices, for example, 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. In some implementations, particular processes, operations and methods may be performed by circuitry that is specific to a given function.

[0165] As described above, in some aspects implementations of the subject matter described in this specification can be implemented as software. For example, various functions of components disclosed herein, or various blocks or steps of a method, operation, process or algorithm disclosed herein can be implemented as one or more modules of one or more computer programs. Such computer programs can include non-transitory processor- or computer-executable instructions encoded on one or more tangible processor- or computer-readable storage media for execution by, or to control the operation of, data processing apparatus including the components of the devices described herein. By way of example, and not limitation, such storage media may include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that may be used to store program code in the form of instructions or data structures. Combinations of the above should also be included within the scope of storage media. When implemented in software, the techniques can be provided as part of the operating system, a library used by multiple applications, a particular software application, etc. The software can be executed by one or more general-purpose processors or one or more special-purpose processors.

[0166] As used herein, the terms "user device", "user equipment" (for example, UE 110), "wireless communication device", "mobile communication device", "communication device", or "mobile device" refer to any one or all of cellular telephones, smartphones, portable computing devices, personal or mobile multi-media players, laptop computers, tablet computers, smartbooks, Internet-of-Things (IoT) devices, palm-top computers, wireless electronic mail receivers, multimedia Internet enabled cellular telephones, wireless gaming controllers, display sub-systems, driver assistance systems, vehicle controllers, vehicle system controllers, vehicle communication system, infotainment systems, vehicle telematics systems or subsystems, vehicle display systems or subsystems, vehicle data controllers, point-of-sale (POS) terminals, health monitoring devices, drones, cameras, media-streaming dongles or another personal media devices, wearable devices such as smartwatches, wireless hotspots, femtocells, broadband routers or other types of routers, and similar electronic devices which include a programmable processor and memory and circuitry configured to perform operations as described herein. Further, the user device in some cases may be embedded in an electronic system such as the head unit of a vehicle or an advanced driver assistance system (ADAS). Still further, a mobile-internet device (MID). Depending on the type, the user device can include one or more general-purpose processors, a computer-readable memory, a user interface, one or more network interfaces, one or more sensors, etc.

[0167] Various modifications to the implementations described in this disclosure may be readily apparent to persons having ordinary skill in the art, and the generic principles defined herein may be applied to other implementations without departing from the spirit or scope of this disclosure. Thus, the claims are not intended to be limited to the implementations shown herein but are to be accorded the widest scope consistent with this disclosure, the principles and the novel features disclosed herein.

[0168] Additionally, various features that are described in this specification in the context of separate implementations also can be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation also can be implemented in multiple implementations separately or in any suitable subcombination. As such, although features may be described above as acting in particular combinations, and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

[0169] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. Further, the drawings may schematically depict one or more example processes in the form of a flowchart or flow diagram. However, other operations that are not depicted can be incorporated in the example processes that are schematically illustrated. For example, one or more additional operations can be performed before, after, simultaneously, or between any of the illustrated operations. In some circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the implementations described above should not be understood as requiring such separation in all implementations, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products. Additionally, other implementations are within the scope of the following claims. In some cases, the actions recited in the claims can be performed in a different order and still achieve desirable results.

[0170] The foregoing disclosure provides illustration and description but is not intended to be exhaustive or to limit the aspects to the precise form disclosed. Modifications and variations may be made in light of the above disclosure or may be acquired from practice of the aspects. While the aspects of the disclosure have been described in terms of various examples, any combination of aspects from any of the examples is also within the scope of the disclosure. The examples in this disclosure are provided for pedagogical purposes.

CLAIMS

What is claimed is:

1. A method for wireless communications by a user equipment (UE) (110), comprising:
   receiving (304), from a network entity (120), a UE initiated beam switching configuration indicating a plurality of reference signals (RSs) associated with a plurality of beams;
   receiving (308), from the network entity, one or more RSs associated with one or more beams;
   transmitting (312), to the network entity, an indication to switch from communicating via at least one first beam to communicating via at least one second beam based on the one or more RSs; and
   communicating (318) with the network entity via the at least one second beam.

2. The method of claim 1, wherein the UE initiated beam switching configuration includes one of more of:
   an indicator indicating whether a beam report is for beam switching;
   a number of reported synchronization signal block (SSB) resource indicators (SSBRIs), channel state information reference signal (CSI-RS) resource indicators (CRIs), or transmission configuration indicator (TCI) indexes;
   a first uplink resource for a beam report for beam switching;
   a report quantity for the beam report for beam switching;
   target uplink channels or downlink channels for beam switching;
   a first set of one or more SSBs or CSI-RSs for beam measurement;
   a second set of CSI-RSs for tracking reference signals (TRSs) for quasi-colocation (QCL) TypeA parameter identification;
   an action delay for the beam switching;
   a set of uplink power control parameters for uplink power control after the beam switching;
   a number of requested SSBRIs, CRIs, or TCI indexes;
   a first threshold to identify the at least one second beam;
   a second threshold to determine a beam quality for the at least one first beam;
   a number of beam switching request events to trigger a beam switching request;
   a detection interval for beam switching event detection;

an indicator indicating whether to include a beam quality indicator with a SSBRI, CRI, or TCI index associated with a beam;

a second uplink resource to transmit a beam switching request;

a scheduling request (SR) to request an uplink grant for a beam switching request transmission;

a maximum number of retransmissions of beam switching request; or

a monitoring window for a response to the beam switching request.

3. The method of claim 1 or 2, further comprising detecting (310), by the UE, at least one beam switching event based on the one or more RSs; wherein the transmitting the indication to switch is in response to the detecting the at least one beam switching event.

4. The method of claims 3, further comprising:

calculating one or more beam quality measurements associated with one or more beams of the plurality of beams, the one or more beam quality measurements including at least one first beam quality measurement associated with the at least one first beam and at least one second beam quality measurement associated with the at least one second beam; and

wherein the detecting the at least one beam switching event comprises at least one of:

determining that a difference between the at least one first beam quality measurement and the at least one second beam quality measurement exceeds a first threshold difference; or

determining that the at least one first beam quality measurement is below a second threshold.

5. The method of claim 4, wherein the at least one first beam quality measurement and the at least one second beam quality measurement comprises one or more of:

a layer 1 reference signal received power (L1-RSRP);

a layer 1 signal-to-interference plus noise ratio (L1-SINR);

a channel quality indicator (CQI);

a hypothetical block error rate (BLER); or

a spectrum efficiency (SE).

6. The method of claim 4, wherein the calculating the one or more beam quality measurements comprises one or more of:

calculating the one or more beam quality measurements based on the one or more RSs;

calculating the one or more beam quality measurements based on downlink reference signals configured in one or more TCI states;

calculating the one or more beam quality measurements based on a TRS used for QCL indication;

calculating the one or more beam quality measurements based on a first SSB that is quasi-co-located with a CSI-RS used for QCL indication in a first TCI state; or

calculating the one or more beam quality measurements based on a second SSB that is used for QCL indication in a second TCI state.

7. The method of any of claims 1-6, further comprising transmitting, to the network entity, UE capability information indicating whether the UE supports UE initiated beam switching.

8. The method of any of claims 1-7, further comprising one or more of:

identifying, in the indication to switch, a best UE beam for each SSBRI, CRI, or TCI index;

identifying, in the indication to switch, QCL parameters for each SSBRI, CRI, or TCI index; or

identifying, in the indication to switch, a layer 3 reference signal received power (L3-RSRP) for each SSBRI, CRI, or TCI index.

9. The method of any of claims 1-8, further comprising detecting a predetermined or configurable number of beam switching events within a predetermined or configurable detection interval.

10. The method of any of claims 1-9, wherein the RSs comprise at least one of synchronization signal blocks (SSBs) or channel state information reference signals (CSI-RSs).

11. The method of any of claims 1-10, wherein the indication to switch comprises at least one of a SSB resource indicator (SSBRI) associated with the at least one second beam, a CSI-RS resource indicator (CRI) associated with the at least one second beam, or a transmission configuration indicator (TCI) index associated with the at least one second beam.

12. The method of claim 11, further comprising:
    determining quasi-co-location (QCL) parameters based on one or more of:
        a tracking reference signal (TRS) indicated by the SSBRI, the CRI, or the TCI index, or
        a configured TRS; and
    applying the QCL parameters for the communicating with the network entity via the at least one second beam.

13. The method of any of claims 1-12, wherein the transmitting the indication to switch comprises transmitting, to the network entity, the indication in a beam report.

14. The method of any of claims 1-12, wherein the transmitting the indication to switch comprises transmitting, to the network entity, the indication in a request to switch from the at least one first beam to the at least one second beam.

15. A method for wireless communications by a network entity (120), comprising:
    transmitting (304), to a user equipment (UE) (110), a UE initiated beam switching configuration indicating a plurality of reference signals (RSs) associated with a plurality of beams;
    transmitting (308), to the UE, one or more RSs associated with one or more beams;
    receiving (312), from the UE, an indication to switch from communicating via at least one first beam to communicating via at least one second beam; and
    communicating (318) with the UE via the at least one second beam.

16. The method of claim 15, further comprising transmitting, to the UE, a response to the receiving the indication to switch, the response including one or more of:
    an action delay or an action time for the switching to communicating via the at least one second beam;
    one or more synchronization signal block (SSB) resource indicators (SSBRIs), channel state information reference signal (CSI-RS) resource indicators (CRIs), or one or more transmission configuration indicator (TCI) indexes received from the UE in the indication to switch; or

another indication of target uplink or downlink channels associated with the at least one second beam.

17. The method of claims 15 or 16, wherein the UE initiated beam switching configuration includes one of more of:

an indicator indicating whether a beam report is for beam switching;

a number of reported synchronization signal block (SSB) resource indicators (SSBRIs), channel state information reference signal (CSI-RS) resource indicators (CRIs), or transmission configuration indicator (TCI) indexes;

a first uplink resource for a beam report for beam switching;

a report quantity for the beam report for beam switching;

target uplink channels or downlink channels for beam switching;

a first set of one or more SSBs or CSI-RSs for beam measurement;

a second set of CSI-RSs for tracking reference signals (TRSs) for quasi-colocation (QCL) TypeA parameter identification;

an action delay for the beam switching;

a set of uplink power control parameters for uplink power control after the beam switching;

a number of requested SSBRIs, CRIs, or TCI indexes;

a first threshold to identify the at least one second beam;

a second threshold to determine a beam quality for the at least one first beam;

a number of beam switching request events to trigger a beam switching request;

a detection interval for beam switching event detection;

an indicator indicating whether to include a beam quality indicator with a SSBRI, CRI, or TCI index associated with a beam;

a second uplink resource to transmit a beam switching request;

a scheduling request (SR) to request an uplink grant for a beam switching request transmission;

a maximum number of retransmissions of beam switching request; or

a monitoring window for a response to the beam switching request.

18. An apparatus, comprising:

a communication unit; and

a processing system configured to control the communication unit to implement any one of the methods of claims 1-17.

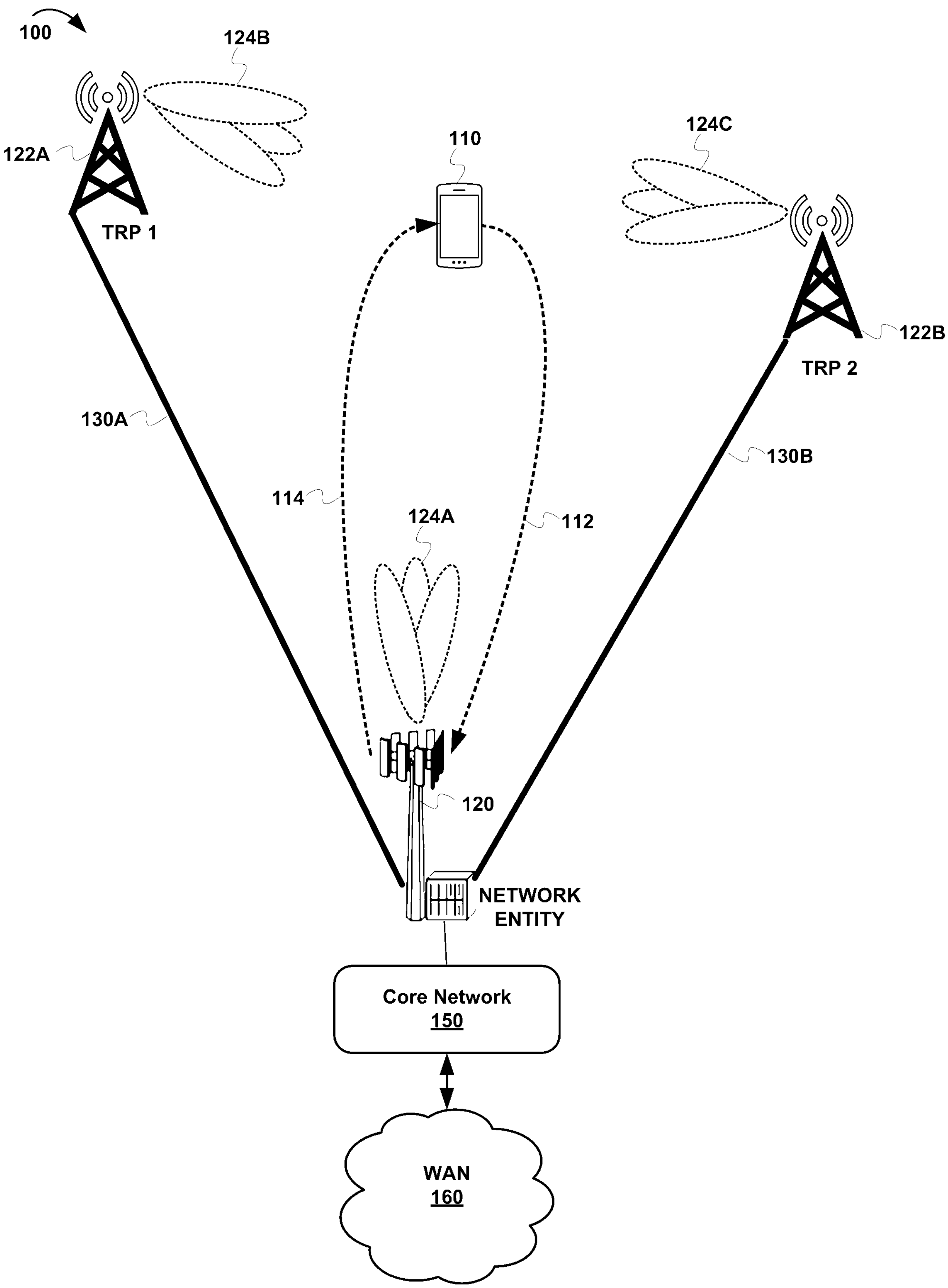
100
124B
122A
TRP 1
110
124C
122B
TRP 2
130A
130B
114
124A
112
120
NETWORK ENTITY
Core Network
150
WAN
160

FIGURE 1

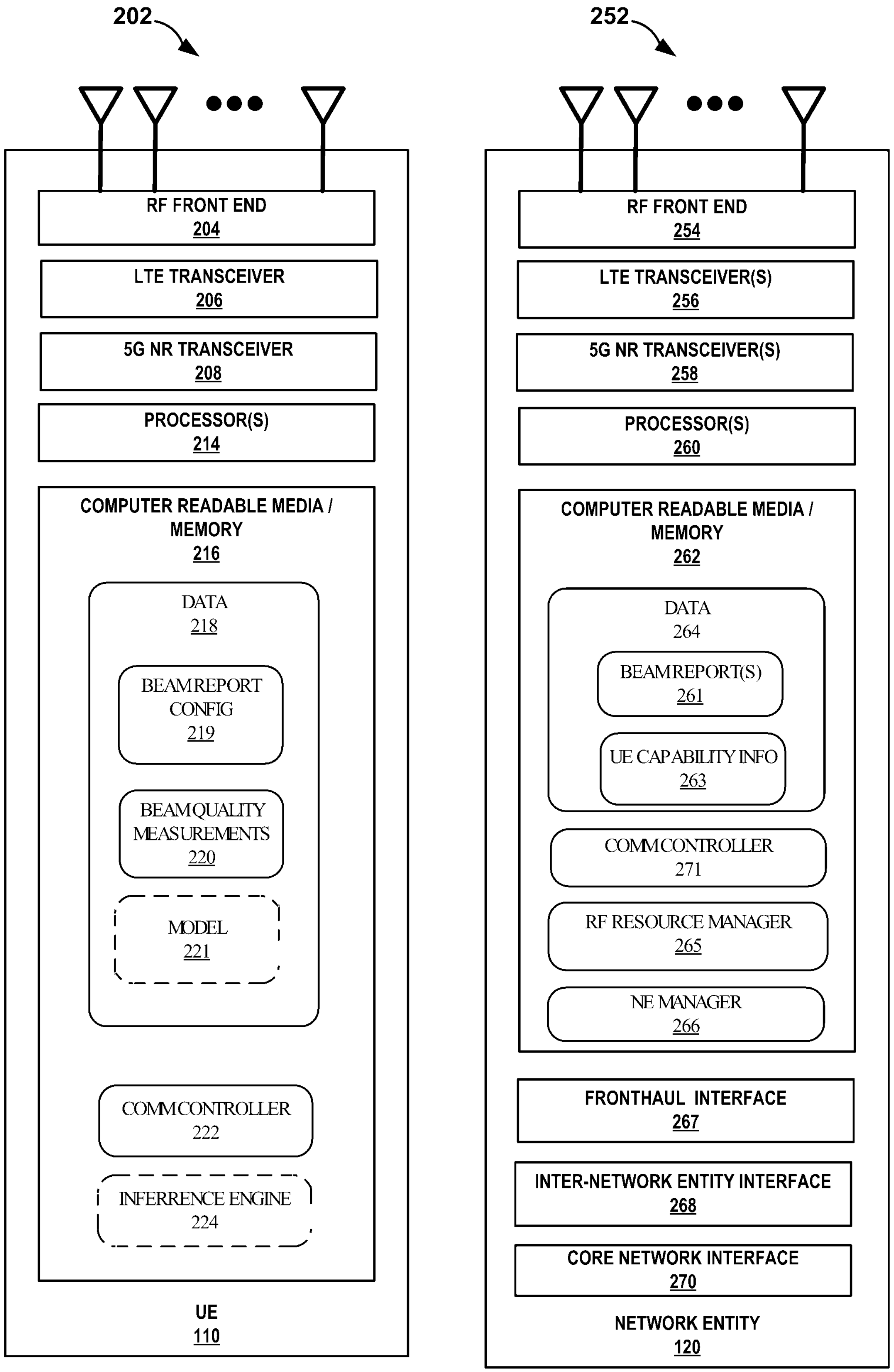
202
RF FRONT END
204
LTE TRANSCEIVER
206
5G NR TRANSCEIVER
208
PROCESSOR(S)
214
COMPUTER READABLE MEDIA / MEMORY
216
DATA
218
BEAMREPORT CONFIG
219
BEAMQUALITY MEASUREMENTS
220
MODEL
221
COMMCONTROLLER
222
INFERRENCE ENGINE
224
UE
110
252
RF FRONT END
254
LTE TRANSCEIVER(S)
256
5G NR TRANSCEIVER(S)
258
PROCESSOR(S)
260
COMPUTER READABLE MEDIA / MEMORY
262
DATA
264
BEAMREPORT(S)
261
UE CAPABILITY INFO
263
COMMCONTROLLER
271
RF RESOURCE MANAGER
265
NE MANAGER
266
FRONTHAUL INTERFACE
267
INTER-NETWORK ENTITY INTERFACE
268
CORE NETWORK INTERFACE
270
NETWORK ENTITY
120

FIGURE 2

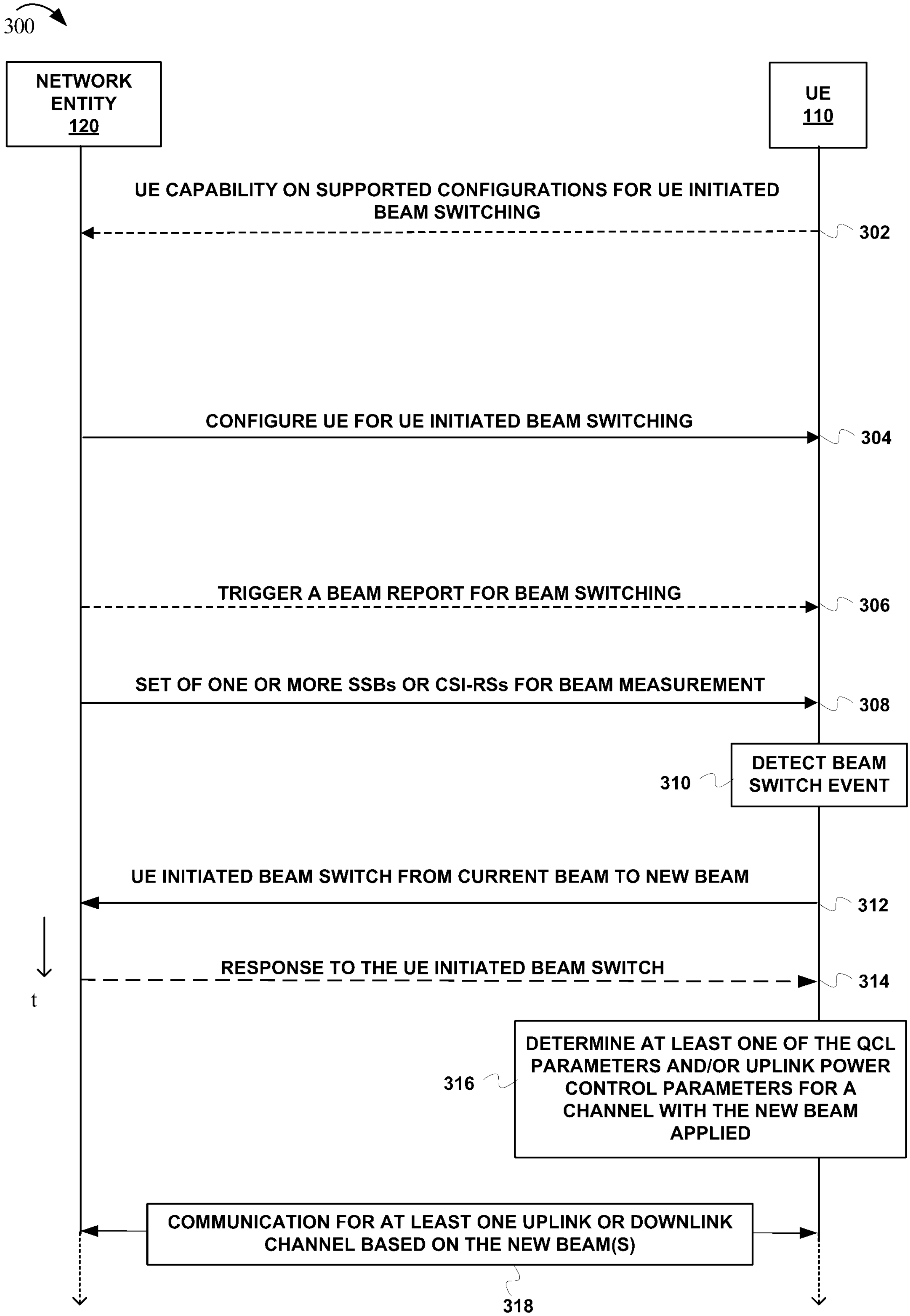
300
NETWORK ENTITY 120
UE 110
UE CAPABILITY ON SUPPORTED CONFIGURATIONS FOR UE INITIATED BEAM SWITCHING
302
CONFIGURE UE FOR UE INITIATED BEAM SWITCHING
304
TRIGGER A BEAM REPORT FOR BEAM SWITCHING
306
SET OF ONE OR MORE SSBs OR CSI-RSs FOR BEAM MEASUREMENT
308
DETECT BEAM SWITCH EVENT
310
UE INITIATED BEAM SWITCH FROM CURRENT BEAM TO NEW BEAM
312
RESPONSE TO THE UE INITIATED BEAM SWITCH
314
t
DETERMINE AT LEAST ONE OF THE QCL PARAMETERS AND/OR UPLINK POWER CONTROL PARAMETERS FOR A CHANNEL WITH THE NEW BEAM APPLIED
316
COMMUNICATION FOR AT LEAST ONE UPLINK OR DOWNLINK CHANNEL BASED ON THE NEW BEAM(S)
318

FIGURE 3

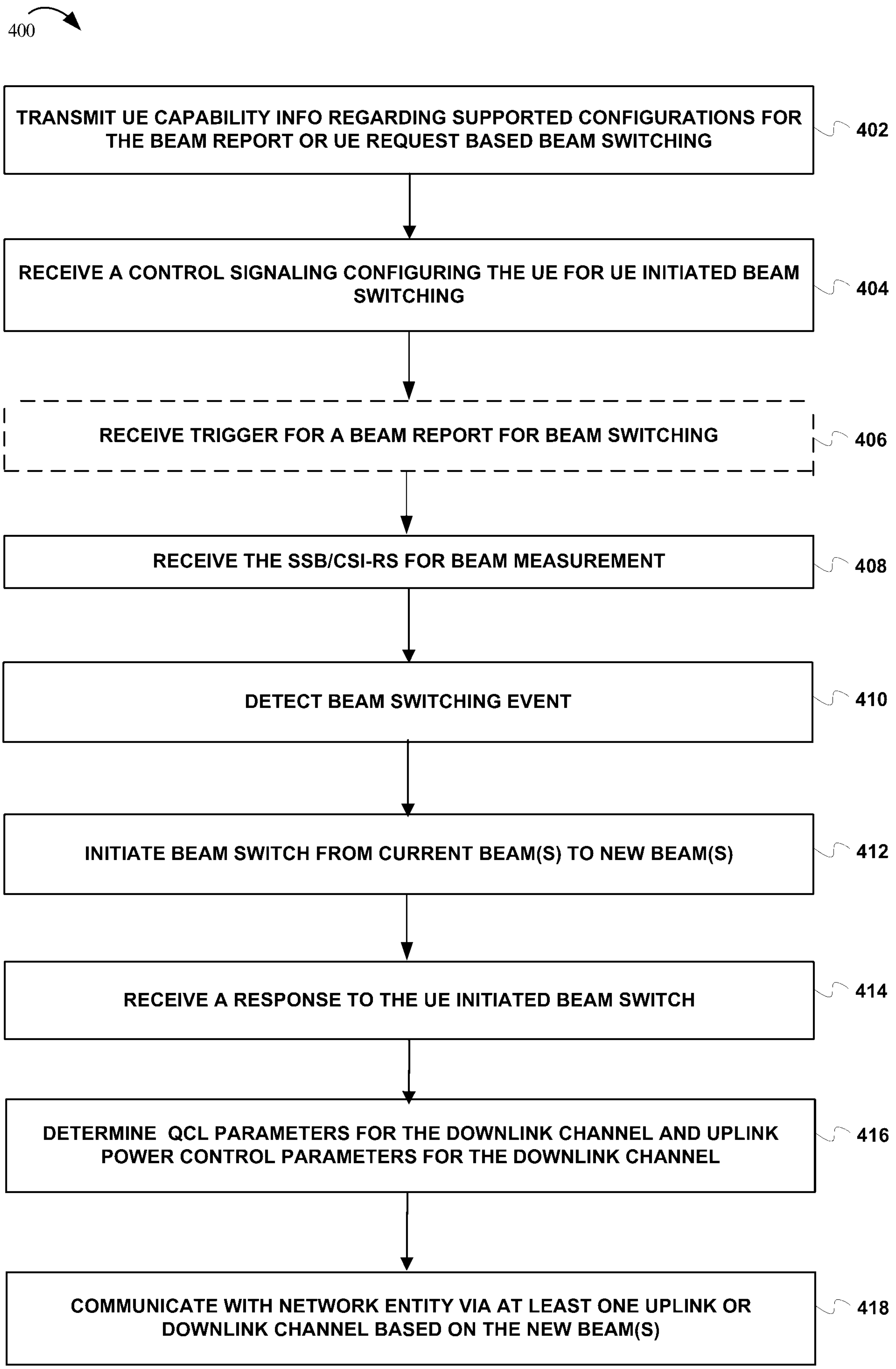
400
TRANSMIT UE CAPABILITY INFO REGARDING SUPPORTED CONFIGURATIONS FOR THE BEAM REPORT OR UE REQUEST BASED BEAM SWITCHING
402
RECEIVE A CONTROL SIGNALING CONFIGURING THE UE FOR UE INITIATED BEAM SWITCHING
404
RECEIVE TRIGGER FOR A BEAM REPORT FOR BEAM SWITCHING
406
RECEIVE THE SSB/CSI-RS FOR BEAM MEASUREMENT
408
DETECT BEAM SWITCHING EVENT
410
INITIATE BEAM SWITCH FROM CURRENT BEAM(S) TO NEW BEAM(S)
412
RECEIVE A RESPONSE TO THE UE INITIATED BEAM SWITCH
414
DETERMINE QCL PARAMETERS FOR THE DOWNLINK CHANNEL AND UPLINK POWER CONTROL PARAMETERS FOR THE DOWNLINK CHANNEL
416
COMMUNICATE WITH NETWORK ENTITY VIA AT LEAST ONE UPLINK OR DOWNLINK CHANNEL BASED ON THE NEW BEAM(S)
418

FIGURE 4

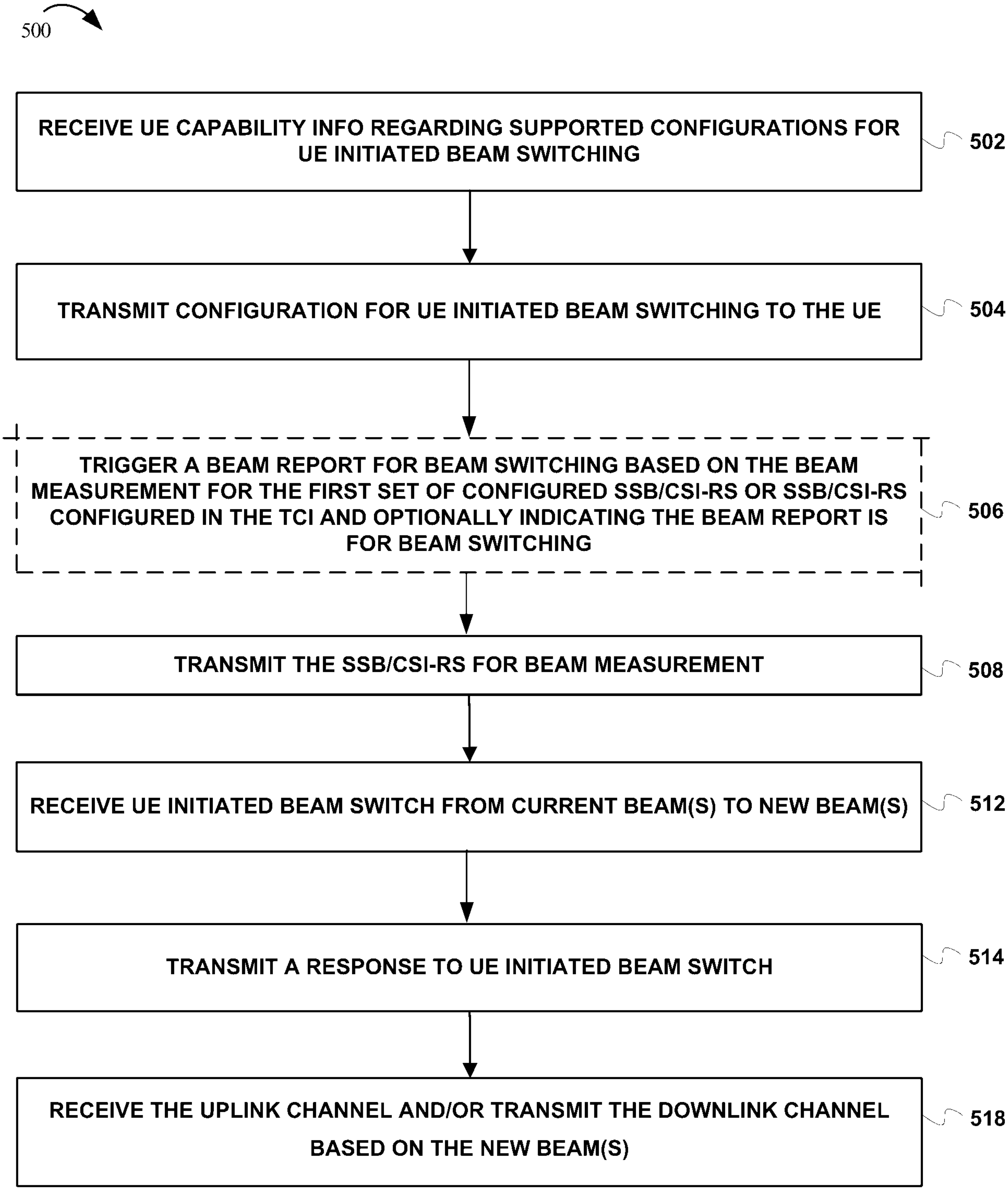
500
RECEIVE UE CAPABILITY INFO REGARDING SUPPORTED CONFIGURATIONS FOR UE INITIATED BEAM SWITCHING
502
TRANSMIT CONFIGURATION FOR UE INITIATED BEAM SWITCHING TO THE UE
504
TRIGGER A BEAM REPORT FOR BEAM SWITCHING BASED ON THE BEAM MEASUREMENT FOR THE FIRST SET OF CONFIGURED SSB/CSI-RS OR SSB/CSI-RS CONFIGURED IN THE TCI AND OPTIONALLY INDICATING THE BEAM REPORT IS FOR BEAM SWITCHING
506
TRANSMIT THE SSB/CSI-RS FOR BEAM MEASUREMENT
508
RECEIVE UE INITIATED BEAM SWITCH FROM CURRENT BEAM(S) TO NEW BEAM(S)
512
TRANSMIT A RESPONSE TO UE INITIATED BEAM SWITCH
514
RECEIVE THE UPLINK CHANNEL AND/OR TRANSMIT THE DOWNLINK CHANNEL BASED ON THE NEW BEAM(S)
518

FIGURE 5

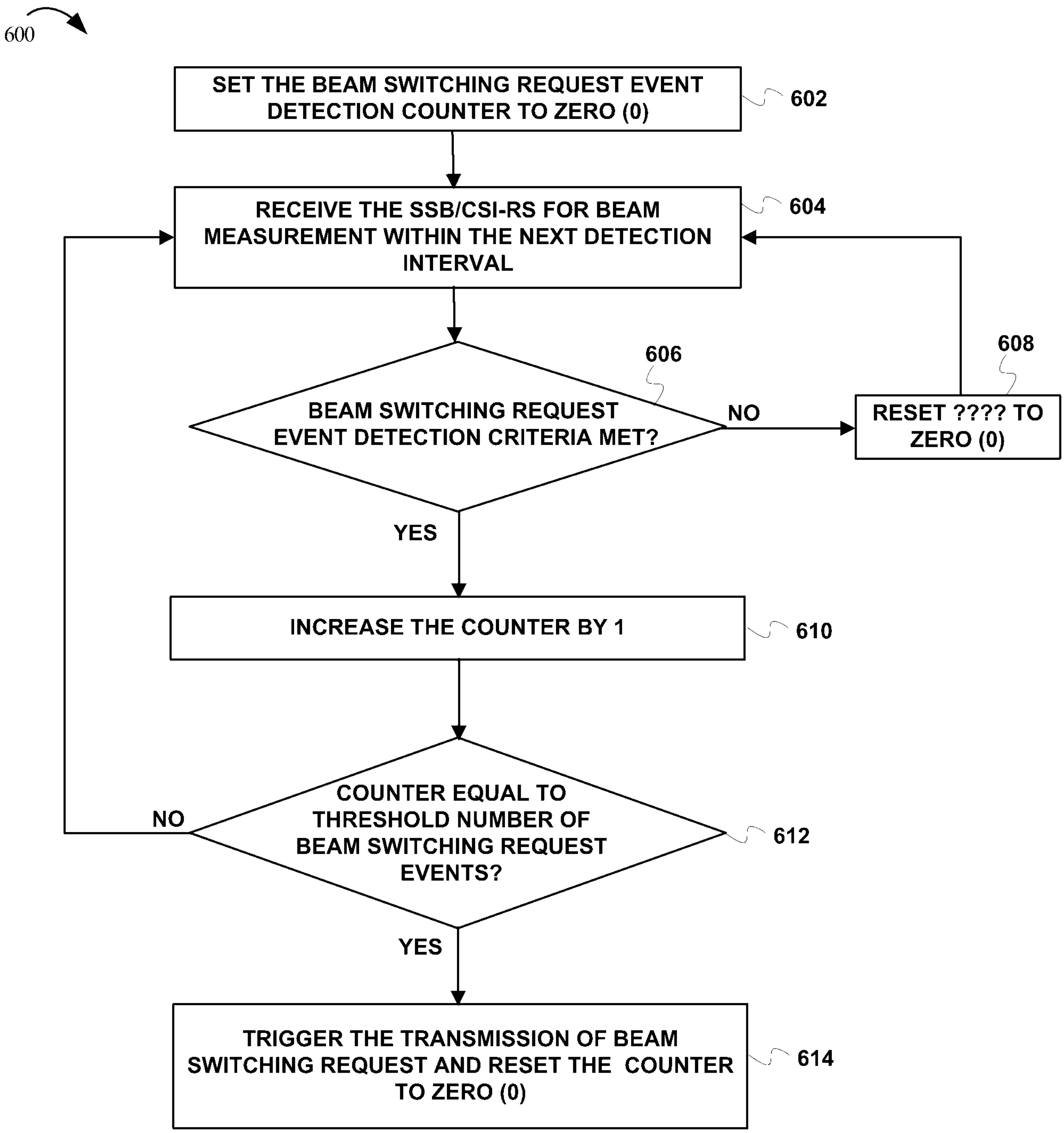
600
SET THE BEAM SWITCHING REQUEST EVENT DETECTION COUNTER TO ZERO (0)
602
RECEIVE THE SSB/CSI-RS FOR BEAM MEASUREMENT WITHIN THE NEXT DETECTION INTERVAL
604
BEAM SWITCHING REQUEST EVENT DETECTION CRITERIA MET?
606
NO
RESET ???? TO ZERO (0)
608
YES
INCREASE THE COUNTER BY 1
610
COUNTER EQUAL TO THRESHOLD NUMBER OF BEAM SWITCHING REQUEST EVENTS?
612
NO
YES
TRIGGER THE TRANSMISSION OF BEAM SWITCHING REQUEST AND RESET THE COUNTER TO ZERO (0)
614

FIGURE 6

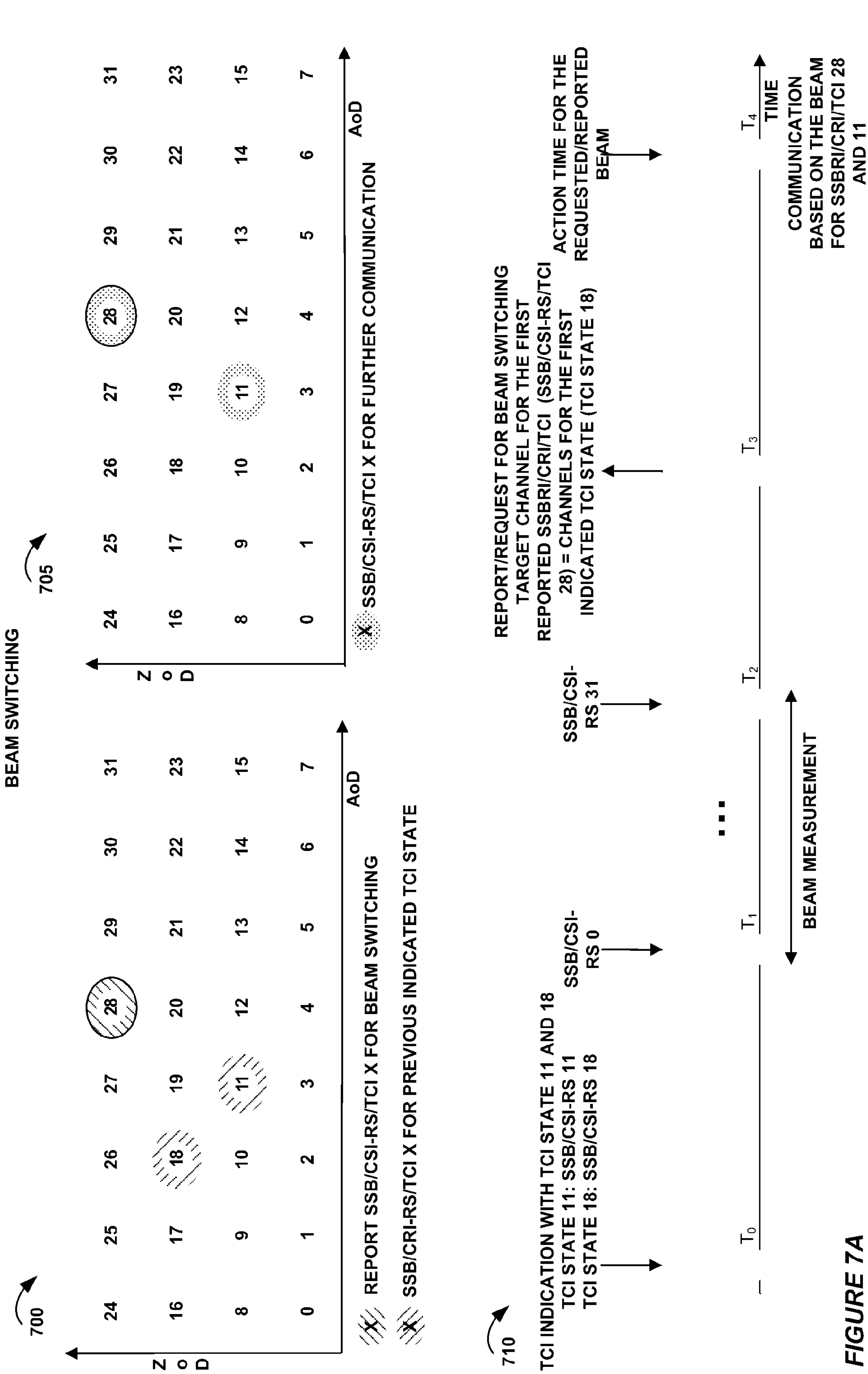
BEAM SWITCHING
700
705
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
X REPORT SSB/CSI-RS/TCI X FOR BEAM SWITCHING
X SSB/CRI-RS/TCI X FOR PREVIOUS INDICATED TCI STATE
X SSB/CSI-RS/TCI X FOR FURTHER COMMUNICATION
710
TCI INDICATION WITH TCI STATE 11 AND 18
TCI STATE 11: SSB/CSI-RS 11
TCI STATE 18: SSB/CSI-RS 18
SSB/CSI-RS 0
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING TARGET CHANNEL FOR THE FIRST REPORTED SSBRI/CRI/TCI (SSB/CSI-RS/TCI 28) = CHANNELS FOR THE FIRST INDICATED TCI STATE (TCI STATE 18)
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
T0
T1
T2
T3
T4
TIME
BEAM MEASUREMENT
COMMUNICATION BASED ON THE BEAM FOR SSBRI/CRI/TCI 28 AND 11

FIGURE 7A

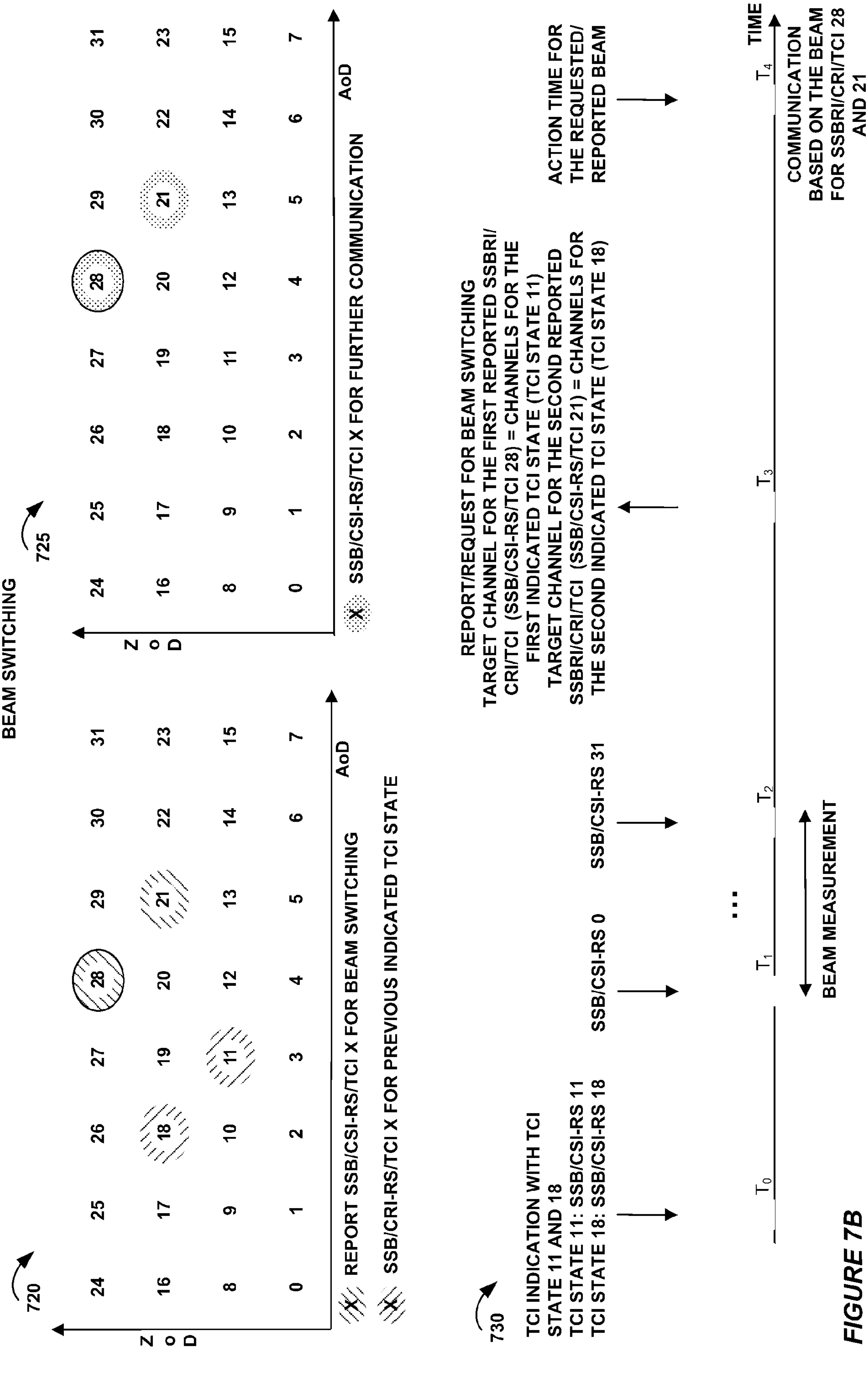
BEAM SWITCHING
720
725
730
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
X REPORT SSB/CSI-RS/TCI X FOR BEAM SWITCHING
X SSB/CRI-RS/TCI X FOR PREVIOUS INDICATED TCI STATE
X SSB/CSI-RS/TCI X FOR FURTHER COMMUNICATION
TCI INDICATION WITH TCI STATE 11 AND 18
TCI STATE 11: SSB/CSI-RS 11
TCI STATE 18: SSB/CSI-RS 18
SSB/CSI-RS 0
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING
TARGET CHANNEL FOR THE FIRST REPORTED SSBRI/CRI/TCI (SSB/CSI-RS/TCI 28) = CHANNELS FOR THE FIRST INDICATED TCI STATE (TCI STATE 11)
TARGET CHANNEL FOR THE SECOND REPORTED SSBRI/CRI/TCI (SSB/CSI-RS/TCI 21) = CHANNELS FOR THE SECOND INDICATED TCI STATE (TCI STATE 18)
ACTION TIME FOR THE REQUESTED/ REPORTED BEAM
...
T0
T1
T2
T3
T4
TIME
BEAM MEASUREMENT
COMMUNICATION BASED ON THE BEAM FOR SSBRI/CRI/TCI 28 AND 21

FIGURE 7B

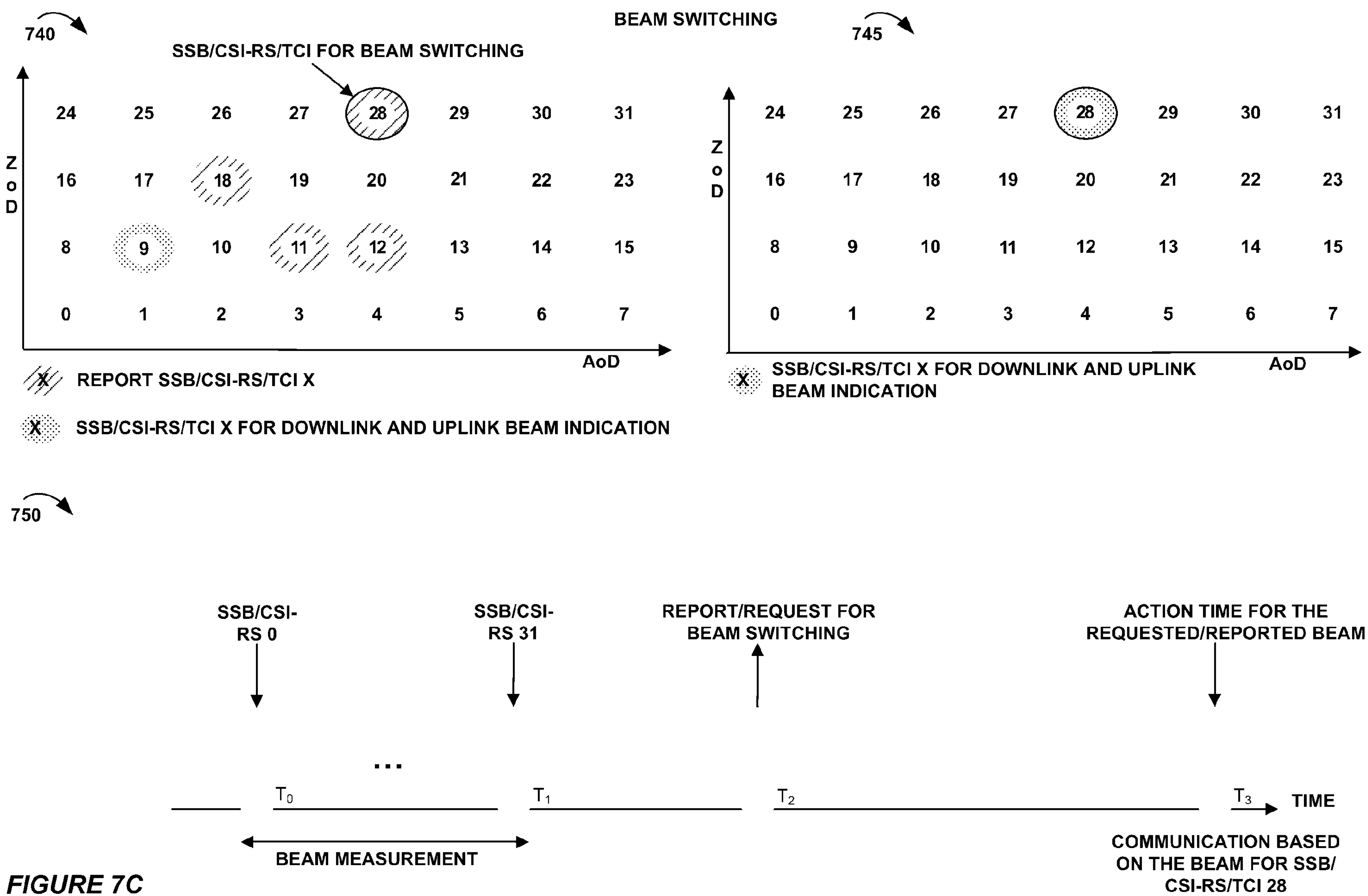
BEAM SWITCHING
740
745
750
SSB/CSI-RS/TCI FOR BEAM SWITCHING
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
X REPORT SSB/CSI-RS/TCI X
X SSB/CSI-RS/TCI X FOR DOWNLINK AND UPLINK BEAM INDICATION
X SSB/CSI-RS/TCI X FOR DOWNLINK AND UPLINK BEAM INDICATION
SSB/CSI-RS 0
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
...
T_0
T_1
T_2
T_3
TIME
BEAM MEASUREMENT
COMMUNICATION BASED ON THE BEAM FOR SSB/CSI-RS/TCI 28

FIGURE 7C

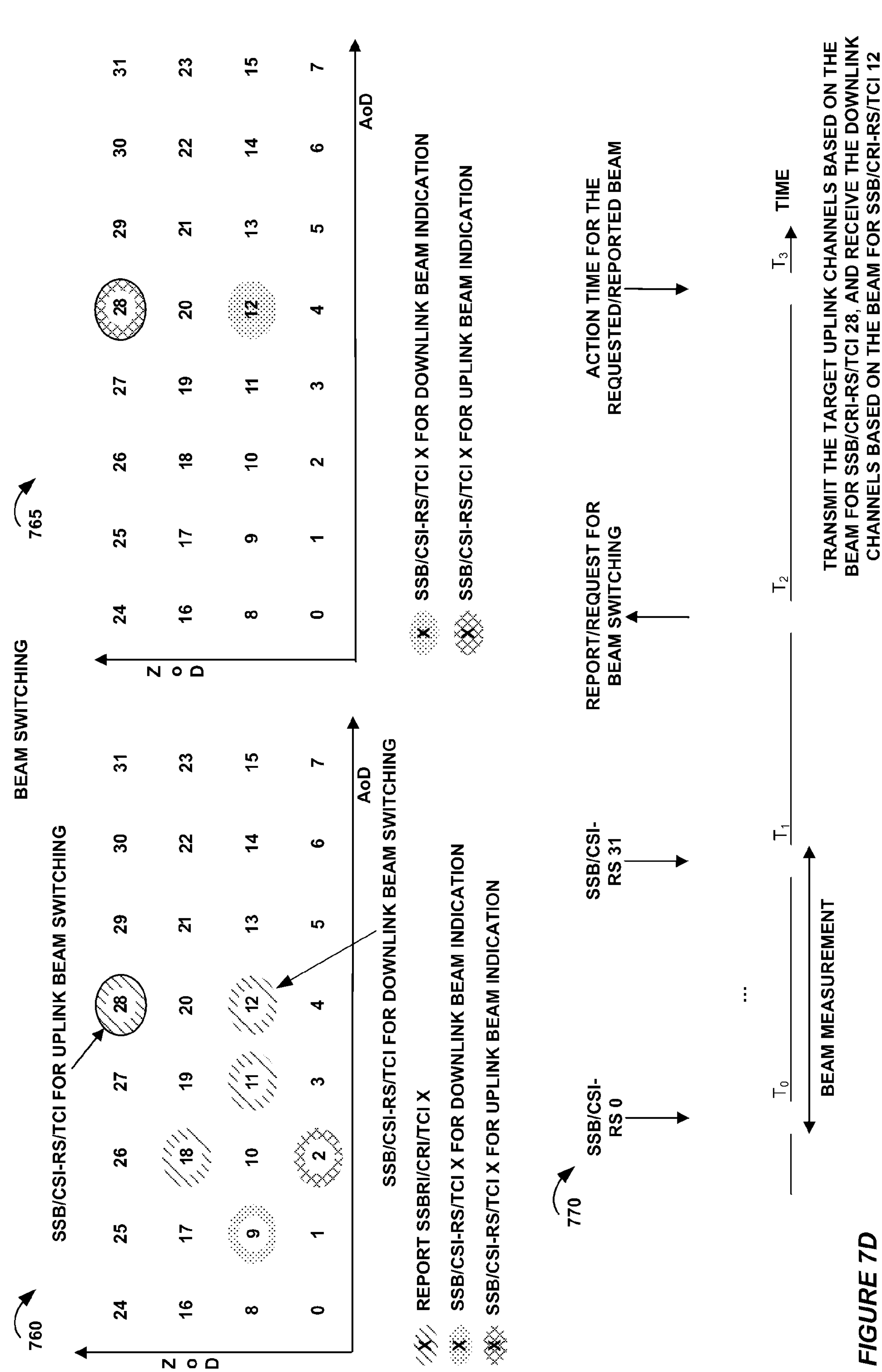
BEAM SWITCHING
760
SSB/CSI-RS/TCI FOR UPLINK BEAM SWITCHING
SSB/CSI-RS/TCI FOR DOWNLINK BEAM SWITCHING
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
REPORT SSBRI/CRI/TCI X
SSB/CSI-RS/TCI X FOR DOWNLINK BEAM INDICATION
SSB/CSI-RS/TCI X FOR UPLINK BEAM INDICATION
765
SSB/CSI-RS/TCI X FOR DOWNLINK BEAM INDICATION
SSB/CSI-RS/TCI X FOR UPLINK BEAM INDICATION
770
SSB/CSI-RS 0
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
...
T0
T1
T2
T3
TIME
BEAM MEASUREMENT
TRANSMIT THE TARGET UPLINK CHANNELS BASED ON THE BEAM FOR SSB/CRI-RS/TCI 28, AND RECEIVE THE DOWNLINK CHANNELS BASED ON THE BEAM FOR SSB/CRI-RS/TCI 12

FIGURE 7D

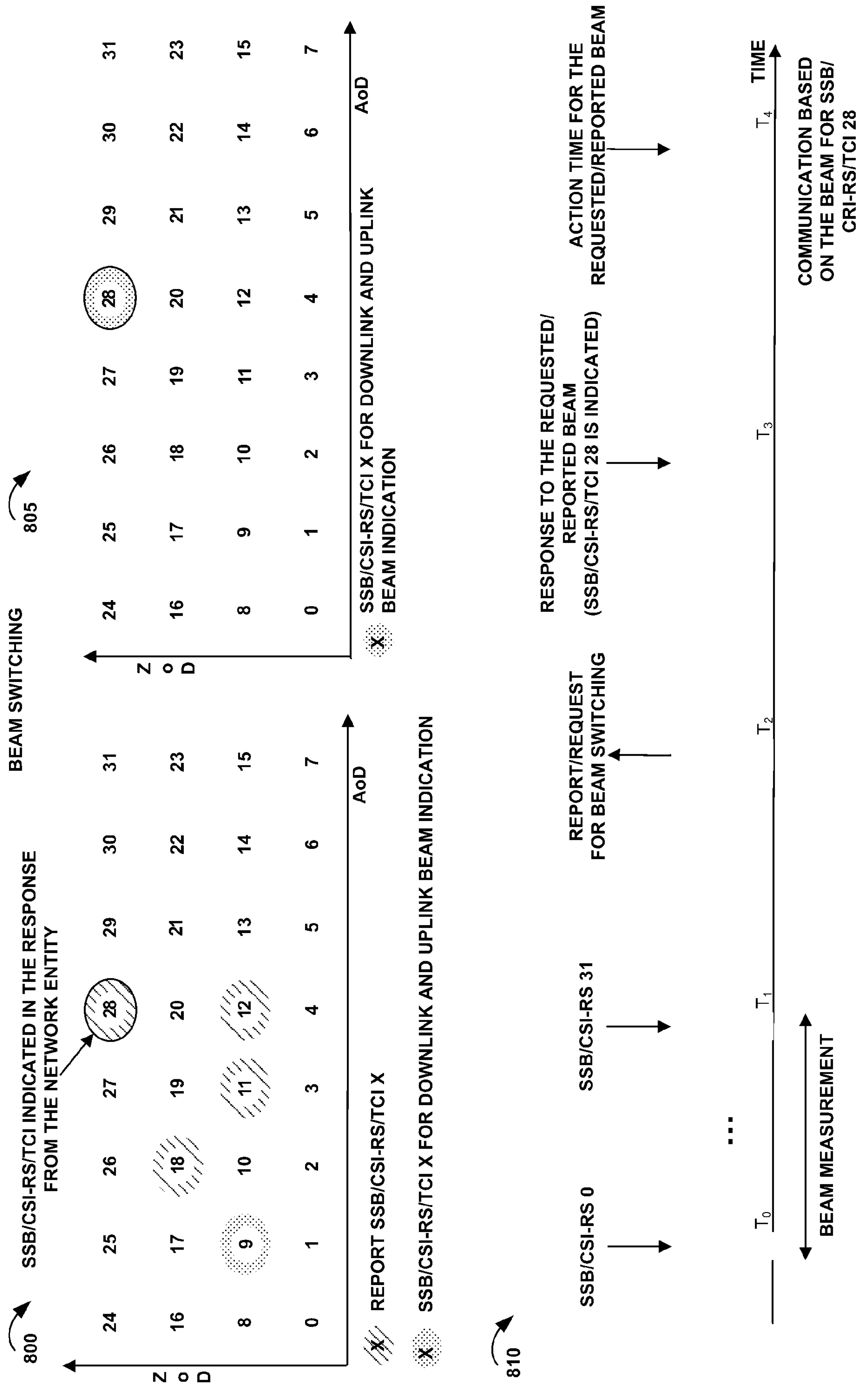
BEAM SWITCHING
800
SSB/CSI-RS/TCI INDICATED IN THE RESPONSE FROM THE NETWORK ENTITY
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
X REPORT SSB/CSI-RS/TCI X
X SSB/CSI-RS/TCI X FOR DOWNLINK AND UPLINK BEAM INDICATION
805
X SSB/CSI-RS/TCI X FOR DOWNLINK AND UPLINK BEAM INDICATION
810
SSB/CSI-RS 0
...
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING
RESPONSE TO THE REQUESTED/ REPORTED BEAM (SSB/CSI-RS/TCI 28 IS INDICATED)
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
T_0
T_1
T_2
T_3
T_4
TIME
BEAM MEASUREMENT
COMMUNICATION BASED ON THE BEAM FOR SSB/ CRI-RS/TCI 28

FIGURE 8A

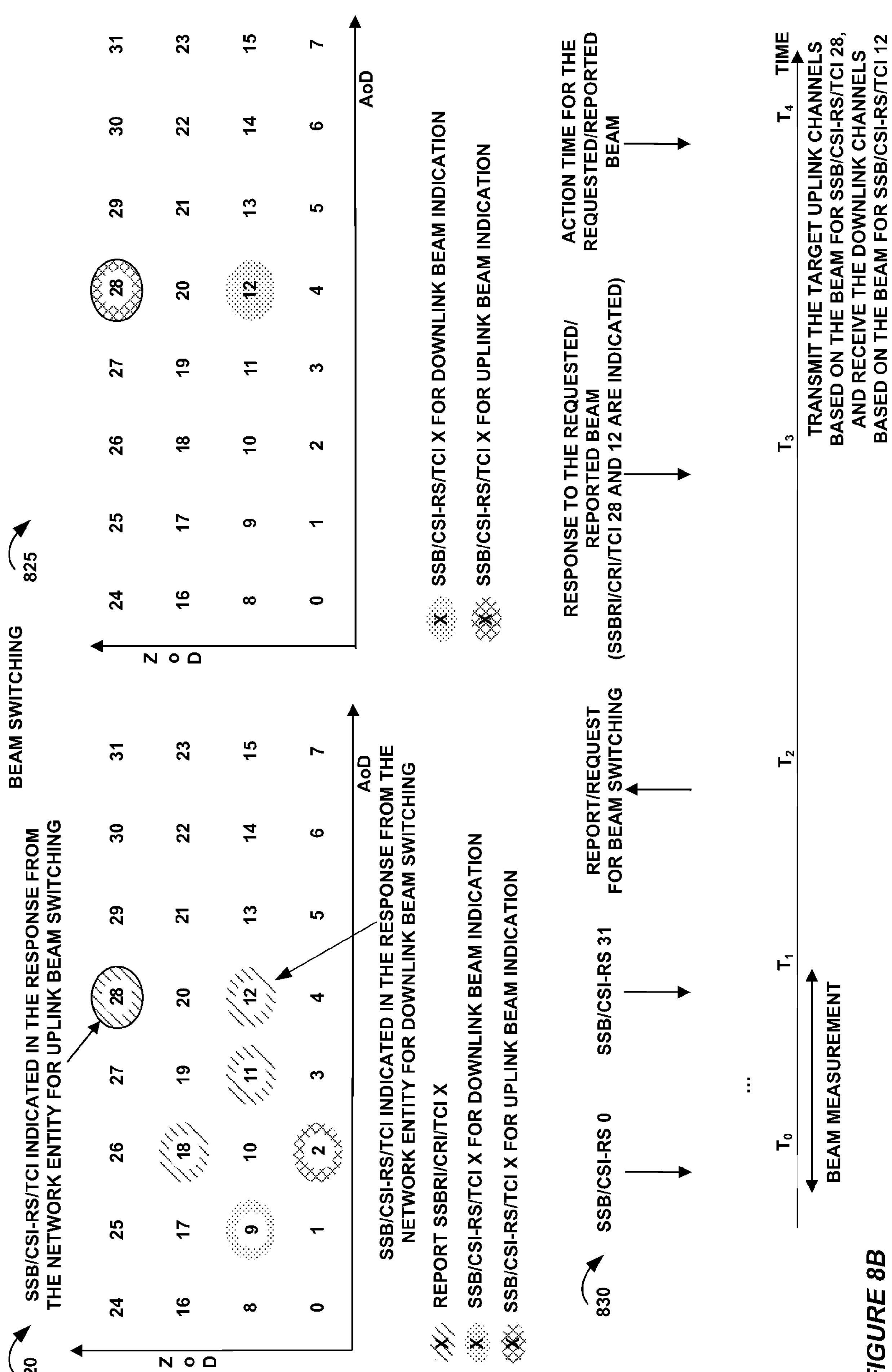
BEAM SWITCHING
820
SSB/CSI-RS/TCI INDICATED IN THE RESPONSE FROM THE NETWORK ENTITY FOR UPLINK BEAM SWITCHING
SSB/CSI-RS/TCI INDICATED IN THE RESPONSE FROM THE NETWORK ENTITY FOR DOWNLINK BEAM SWITCHING
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
REPORT SSBRI/CRI/TCI X
SSB/CSI-RS/TCI X FOR DOWNLINK BEAM INDICATION
SSB/CSI-RS/TCI X FOR UPLINK BEAM INDICATION
825
ZoD
AoD
24 25 26 27 28 29 30 31
16 17 18 19 20 21 22 23
8 9 10 11 12 13 14 15
0 1 2 3 4 5 6 7
SSB/CSI-RS/TCI X FOR DOWNLINK BEAM INDICATION
SSB/CSI-RS/TCI X FOR UPLINK BEAM INDICATION
830
SSB/CSI-RS 0
...
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING
RESPONSE TO THE REQUESTED/ REPORTED BEAM (SSBRI/CRI/TCI 28 AND 12 ARE INDICATED)
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
T_0
T_1
T_2
T_3
T_4
TIME
BEAM MEASUREMENT
TRANSMIT THE TARGET UPLINK CHANNELS BASED ON THE BEAM FOR SSB/CSI-RS/TCI 28, AND RECEIVE THE DOWNLINK CHANNELS BASED ON THE BEAM FOR SSB/CSI-RS/TCI 12

FIGURE 8B

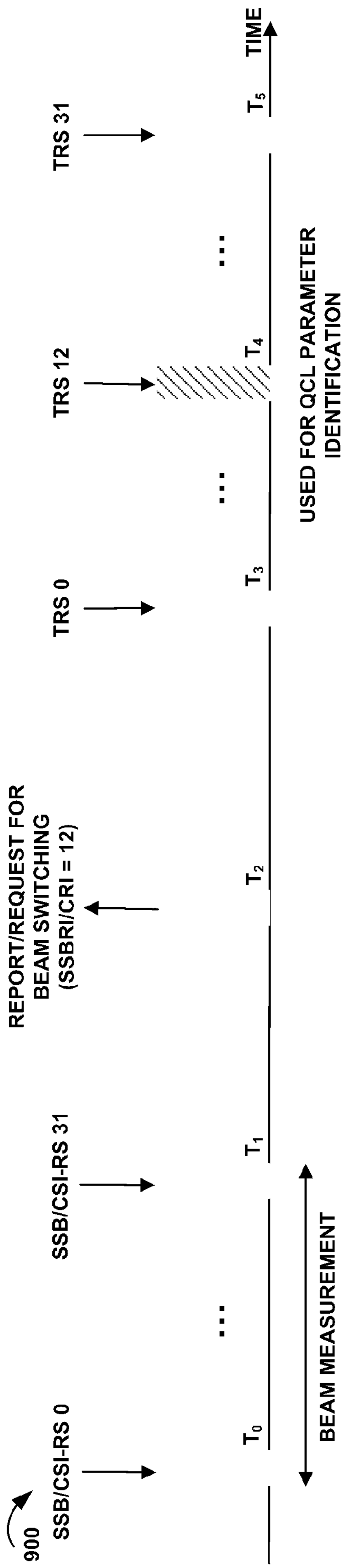

FIGURE 9

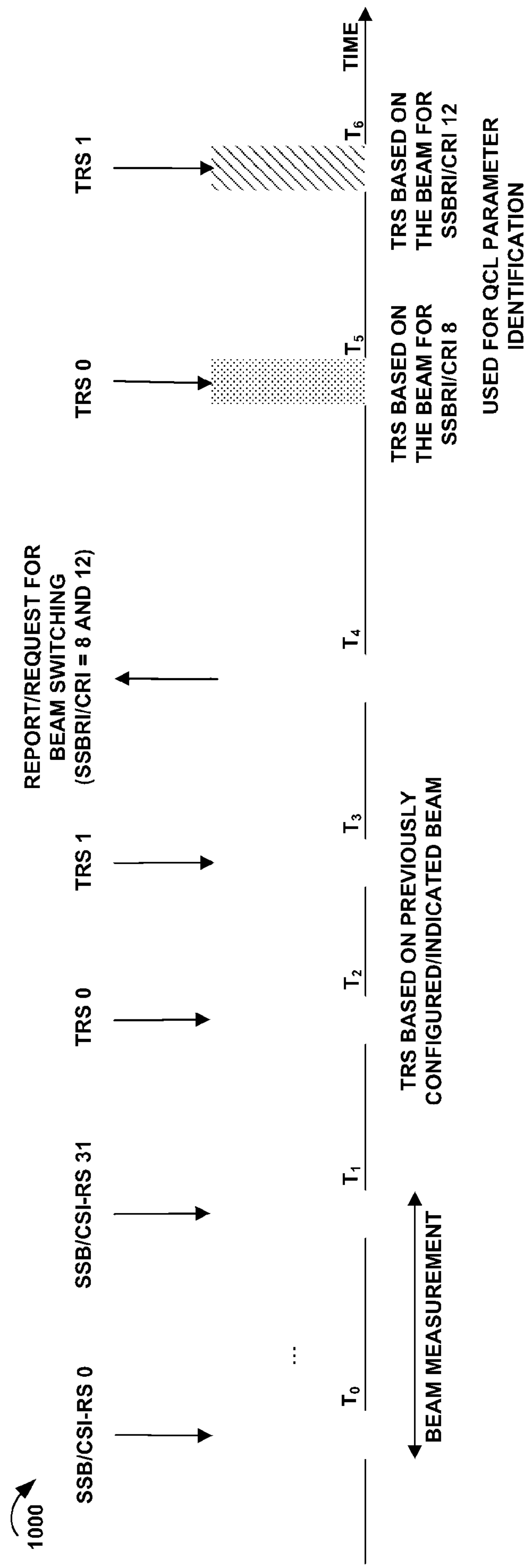

FIGURE 10

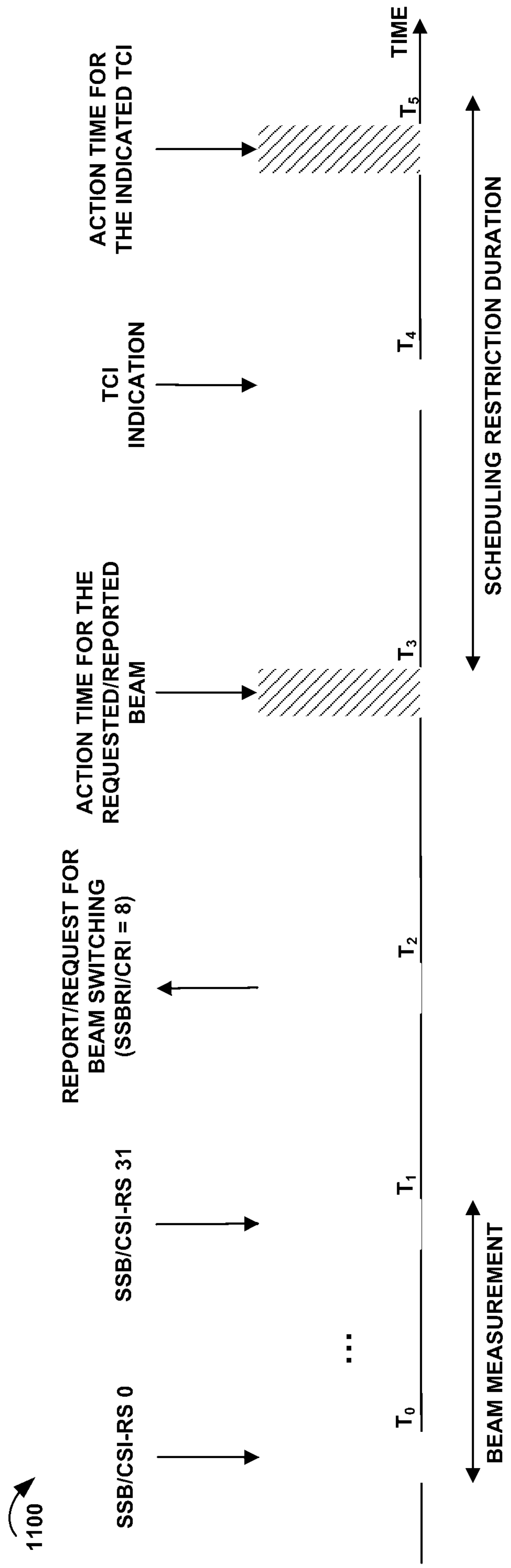
1100
SSB/CSI-RS 0
...
SSB/CSI-RS 31
REPORT/REQUEST FOR BEAM SWITCHING (SSBRI/CRI = 8)
ACTION TIME FOR THE REQUESTED/REPORTED BEAM
TCI INDICATION
ACTION TIME FOR THE INDICATED TCI
TIME
T_0
T_1
T_2
T_3
T_4
T_5
BEAM MEASUREMENT
SCHEDULING RESTRICTION DURATION

FIGURE 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2023/112567

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/06 H04B7/08 H04L5/00 H04W72/044 H04W72/21
H04W72/23
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H04L H04W

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2023/139487 A1 (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD [CN]) 27 July 2023 (2023-07-27) paragraphs [0023] - [0030]; figure 1 -----	1-6, 8-11, 13-18 7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2024	13/02/2024

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

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	OPPO: "Enhancements on Multi-Beam Operation", 3GPP DRAFT; R1-2109038, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. e-Meeting; 20211011 - 20211019 1 October 2021 (2021-10-01), XP052057999, Retrieved from the Internet: URL:https://ftp.3gpp.org/tsg_ran/WG1_RL1/TSGR1_106b-e/Docs/R1-2109038.zip [retrieved on 2021-10-01]	1-6,8-18
Y	Sections 2, 6-8	7
Y	WO 2022/236805 A1 (QUALCOMM INC [US]; WEI CHAO [CN] ET AL.) 17 November 2022 (2022-11-17) paragraph [0080]	7

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Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2023139487	A1	27-07-2023	NONE	
WO 2022236805	A1	17-11-2022	NONE	