(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
18 January 2024 (18.01.2024)

WIPO | PCT

(10) **International Publication Number**
WO 2024/011589 A1

(51) **International Patent Classification:**
H04L 5/00 (2006.01)

(21) **International Application Number:**
PCT/CN2022/105988

(22) **International Filing Date:**
15 July 2022 (15.07.2022)

(25) **Filing Language:** English

(26) **Publication Language:** English

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

(54) **Title:** METHOD, DEVICE AND COMPUTER READABLE MEDIUM FOR COMMUNICATIONS

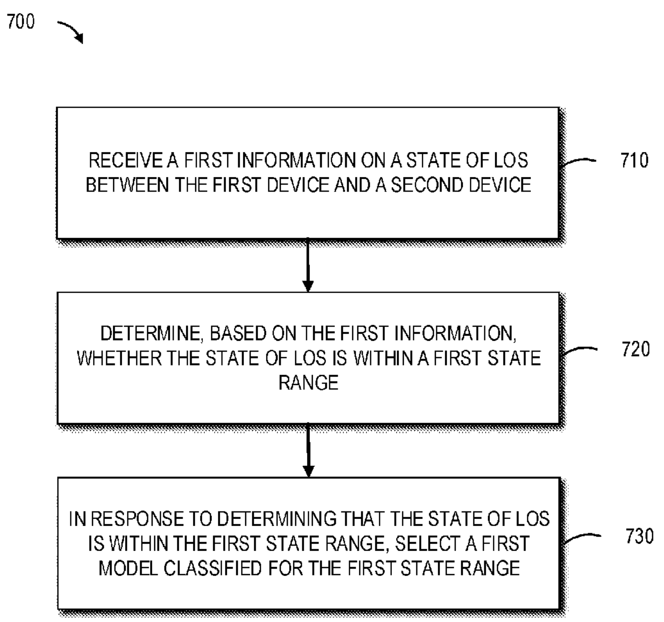

FIG. 7

(57) **Abstract:** Embodiments of the present disclosure relate to methods, devices and computer readable media for communications. According to embodiments of the present disclosure, a first device receives first information on a state of Line-of-Sight (LOS) between the first device and a second device. The first device determines whether the state of LOS is within a first state range based on the first information. Then, the first device selects a first model classified for the first state range in response to determining that the state of LOS is within the first state range.

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GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

METHOD, DEVICE AND COMPUTER READABLE MEDIUM FOR COMMUNICATIONS

FIELD

[0001] Embodiments of the present disclosure generally relate to the field of communications, and in particular, to a method, device and computer readable medium for Artificial Intelligence (AI) or Machine Learning (ML) model assisted communication.

BACKGROUND

[0002] With the development of communication technology, multi-antenna transmission has been introduced. In the multi-antenna transmission, by carefully adjusting the phase, and possibly also the amplitude, of each antenna element, multiple antennas at the transmitter side can be used to provide directivity, that is, to focus the overall transmitted power in a certain direction (beam forming) or, in the more general case, to specific locations in space. Such directivity can increase the achievable data rates and communication range due to higher power reaching the target receiver. In this case, the determination of preferred beams, channels or radio paths for data transmission between devices is a precondition of making full use of the multi-antenna transmission technology. In one solution, a Channel State Information (CSI) measurement is performed between a terminal device and a network device, and the network device may schedule a preferred beam, channel or radio path for the terminal device based on a CSI report from the terminal device. In another solution, a Beam Management (BM) procedure is performed between the terminal device and the network device, and the network device may update the preferred beam based on a beam report received from the terminal device.

[0003] In some situations, AI or ML technology is used for enhancing communication performance, especially for enhancing the communication performance under multi-constraints. The selection of AI or ML model is a key aspect of utilizing the AI or ML technology.

SUMMARY

[0004] In general, example embodiments of the present disclosure relate to methods, devices and computer readable media for the AI or ML model assisted communication.

[0005] In a first aspect, there is provided a communication method. In the method, a first device receives a first information on a state of Line-of-Sight (LOS) between the first device and a second device. The first device determines whether the state of LOS is within a first state range based on the first information. Then, the first device selects a first model classified for the first state range in response to determining that the state of LOS is within the first state range.

[0006] In a second aspect, there is provided a communication method. In the method, a second device receives a first CSI report comprising a number of compressed bits. The second device receives a first information on a state of Line-of-Sight (LOS) between the first device and a second device. The second device determines whether the state of LOS is within a first state range based on the first information. Then, the second device selects a first model for de-compressing the first CSI report, the first model being classified for the first state range in response to determining that the state of LOS is within the first state range.

[0007] In a third aspect, there is provided a terminal device. The terminal device comprises a processor and a memory coupled to the processor and storing instructions thereon, the instructions, when executed by the processor, causing the terminal device to perform the method of the first aspect.

[0008] In a fourth aspect, there is provided a network device. The network device comprises a processor and a memory coupled to the processor and storing instructions thereon, the instructions, when executed by the processor, causing the network device to perform the method of any one of the first aspect to the second aspect.

[0009] In a fifth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to perform the method of any one of the first aspect to the second aspect.

[0010] It is to be understood that the summary section is not intended to identify key or essential features of example embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Some example embodiments will now be described with reference to the accompanying drawings, where:

[0012] FIG. 1 illustrates an example environment in which some embodiments of the present disclosure can be implemented;

[0013] FIG. 2 illustrates a signaling process of a CSI report according to some embodiments of the present disclosure;

[0014] FIGs. 3A to 3D illustrates examples of input data and output data according to some embodiments of the present disclosure;

[0015] FIG. 3E illustrates an example of a AI or ML model according to some embodiments of the present disclosure;

[0016] FIGs. 4A to 4D illustrate signaling processes of the BM according to some embodiments of the present disclosure;

[0017] FIGs. 5A to 5B illustrate example beam patterns according to some embodiments of the present disclosure;

[0018] FIGS. 6A to 6C illustrate example historic measurement instances as input for a model according to some embodiments of the present disclosure;

[0019] FIG. 7 illustrates a flowchart of an example method implemented at a first device according to some embodiments of the present disclosure;

[0020] FIG. 8 illustrates a flowchart of an example method implemented at a second device according to some embodiments of the present disclosure; and

[0021] FIG. 9 illustrates a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure.

[0022] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0023] Principle of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitations as to the scope of the disclosure.

The disclosure described herein can be implemented in various manners other than the ones described below.

[0024] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0025] As used herein, the term ‘terminal device’ refers to any device having wireless or wired communication capabilities. Examples of the terminal device include, but not limited to, user equipment (UE), personal computers, desktops, mobile phones, cellular phones, smart phones, personal digital assistants (PDAs), portable computers, tablets, wearable devices, internet of things (IoT) devices, Ultra-reliable and Low Latency Communications (URLLC) devices, Internet of Everything (IoE) devices, machine type communication (MTC) devices, device on vehicle for V2X communication where X means pedestrian, vehicle, or infrastructure/network, devices for Integrated Access and Backhaul (IAB), Small Data Transmission (SDT), mobility, Multicast and Broadcast Services (MBS), positioning, dynamic/flexible duplex in commercial networks, reduced capability (RedCap), Space borne vehicles or Air borne vehicles in Non-terrestrial networks (NTN) including Satellites and High Altitude Platforms (HAPs) encompassing Unmanned Aircraft Systems (UAS), eXtended Reality (XR) devices including different types of realities such as Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR), the unmanned aerial vehicle (UAV) commonly known as a drone which is an aircraft without any human pilot, devices on high speed train (HST), or image capture devices such as digital cameras, sensors, gaming devices, music storage and playback appliances, or Internet appliances enabling wireless or wired Internet access and browsing and the like. The ‘terminal device’ can further has ‘multicast/broadcast’ feature, to support public safety and mission critical, V2X applications, transparent IPv4/IPv6 multicast delivery, IPTV, smart TV, radio services, software delivery over wireless, group communications and IoT applications. It may be also incorporated one or multiple Subscriber Identity Module (SIM) as known as Multi-SIM. The term “terminal device” can be used interchangeably with a UE, a mobile station, a subscriber station, a mobile terminal, a user terminal or a wireless device.

[0026] As used herein, the term “network device” refers to a device which is capable of providing or hosting a cell or coverage where terminal devices can communicate. Examples of a network device include, but not limited to, a Node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a next generation NodeB (gNB), a transmission reception point (TRP), a remote radio unit (RRU), a radio head (RH), a remote radio head (RRH), an IAB node, a low power node such as a femto node, a pico node, a reconfigurable intelligent surface (RIS), Network-controlled Repeaters, and the like.

[0027] The terminal device or the network device may have Artificial intelligence (AI) or Machine learning capability. It generally includes a model which has been trained from numerous collected data for a specific function, and can be used to predict some information. The terminal or the network device may work on several frequency ranges, e.g. FR1 (410 MHz – 7125 MHz), FR2 (24.25 GHz to 71 GHz), 71 GHz to 114 GHz, and frequency band larger than 100 GHz as well as Tera Hertz (THz). It can further work on licensed/unlicensed/shared spectrum. The terminal device may have more than one connection with the network devices under Multi-Radio Dual Connectivity (MR-DC) application scenario. The terminal device or the network device can work on full duplex, flexible duplex and cross division duplex modes.

[0028] The network device may have the function of network energy saving, Self-Organizing Networks (SON)/ Minimization of Drive Tests (MDT). The terminal may have the function of power saving.

[0029] The embodiments of the present disclosure may be performed in test equipment, e.g. signal generator, signal analyzer, spectrum analyzer, network analyzer, test terminal device, test network device, channel emulator.

[0030] The embodiments of the present disclosure may be performed according to any generation communication protocols either currently known or to be developed in the future. Examples of the communication protocols include, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, 5.5G, 5G-Advanced networks, or the sixth generation (6G) networks.

[0031] In one embodiment, the terminal device may be connected with a first network device and a second network device. One of the first network device and the second network device may be a master node and the other one may be a secondary node. The first network device and the second network device may use different radio access technologies (RATs). In one embodiment, the first network device may be a first RAT device and the second network device may be a second RAT device. In one embodiment, the first RAT device is eNB and the second RAT device is gNB. Information related with different RATs may be transmitted to the terminal device from at least one of the first network device and the second network device. In one embodiment, first information may be transmitted to the terminal device from the first network device and second information may be transmitted to the terminal device from the second network device directly or via the first network device. In one embodiment, information related with configuration for the terminal device configured by the second network device may be transmitted from the second network device via the first network device. Information related with reconfiguration for the terminal device configured by the second network device may be transmitted to the terminal device from the second network device directly or via the first network device.

[0032] As used herein, the singular forms ‘a’, ‘an’ and ‘the’ are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term ‘includes’ and its variants are to be read as open terms that mean ‘includes, but is not limited to.’ The term ‘based on’ is to be read as ‘at least in part based on.’ The term ‘one embodiment’ and ‘an embodiment’ are to be read as ‘at least one embodiment.’ The term ‘another embodiment’ is to be read as ‘at least one other embodiment.’ The terms ‘first,’ ‘second,’ and the like may refer to different or same objects. Other definitions, explicit and implicit, may be included below.

[0033] In some examples, values, procedures, or apparatus are referred to as ‘best,’ ‘lowest,’ ‘highest,’ ‘minimum,’ ‘maximum,’ or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0034] In this disclosure, the terms “beam” can be represented by “beam pair” , “beam pair link”, “Tx beam”, “Rx beam”, “resource” , “resource set” or “resource setting” , “resource configuration”. The terms “beam quality” used herein refers to “RSRP”, “SINR” , “RSSI” or “RSRQ” measured or on the corresponding resource or measured via the corresponding beam. The terms “precoder”, “precoding”, “precoding matrix”, “beam”, “spatial relation information”, “spatial domain transmission filter”, “spatial domain filter”, “spatial parameter”, “spatial relation information”, “spatial relation info”, “TPMI”, “precoding information”, “precoding information and number of layers”, “precoding matrix indicator (PMI)”, “precoding matrix indicator”, “transmission precoding matrix indication”, “precoding matrix indication”, “TCI state”, “transmission configuration indicator”, “quasi co-location (QCL)", "quasi-co-location", "QCL parameter" and "spatial relation" can be used interchangeably. The terms "SRI", "SRS resource set index", "UL TCI", "UL spatial domain filter", "UL beam", "joint TCI" can be used interchangeably. The terms "candidate", "predicted", "target" and "potential" can be used interchangeably. The terms "group", "subset" and "set" may be used interchangeably. The terms "relationship", "mapping" and "correspondence" may be used interchangeably. The terms "recovery", "decode", "reconstruction" and "decompress" may be used interchangeably, and the term "encode" and "compress" may be used interchangeably. The terms "compressed CSI", "compressed PMI" and "compressed CSI/PMI" may be used interchangeably.

In this disclosure, The terms "CSI" or "CSI report" may comprises at least one of the following:

- Channel Quality Indicator (CQI), precoding matrix indicator (PMI), CSI-RS resource indicator (CRI), SS/PBCH Block Resource indicator (SSBRI), layer indicator (LI), rank indicator (RI), Capability[Set]Index, panel index, wideband/subband PMI, wideband/subband CQI, wideband/subband amplitude/phase, wideband/subband co-phasing, index or linear combination of spatial/frequency/time-domain discrete Fourier transform (DFT)/discrete Cosine transform (DCT) basis;
- Signal to Noise Ratio (SNR), Reference Signal Received Power (RSRP), Signal to Interference plus Noise Ratio (SINR), Received Signal Strength Indicator (RSSI), Reference Signal Receiving Quality (RSRQ), supported modulation scheme, supported coding rate, supported efficiency;
- type I single panel codebook, type I multi-panel codebook, type II codebook, type II port selection codebook, enhanced type II codebook, enhanced type II port selection codebook, and further enhanced type II port selection codebook;
- channel matrix or transform-domain of channel matrix, including spatial-frequency domain, time-frequency domain, angular-delay domain, and so on.

[0035] The term "circuitry" used herein may refer to hardware circuits and/or combinations of hardware circuits and software. For example, the circuitry may be a combination of analog and/or digital hardware circuits with software/firmware. As a further example, the circuitry may be any portions of hardware processors with software including digital signal processor(s), software, and memory (ies) that work together to cause an apparatus, such as a terminal device or a network device, to perform various functions. In a still further example, the circuitry may be hardware circuits and or processors, such as a microprocessor or a portion of a microprocessor, that requires software/firmware for operation, but the software may not be present when it is not needed for operation. As used herein, the term circuitry also covers an implementation of merely a hardware circuit or processor(s) or a portion of a hardware circuit or processor(s) and its (or their) accompanying software and/or firmware.

[0036] As mentioned above, in some situations, the AI or ML model has been introduced to enhance communication performance, especially under multi-constrains, for example, Multi-antenna processing or Multiple Input Multiple Output (MIMO) processing. In this case, the selection of AI or ML model should be further considered. For example, for different channel characteristics, AI or ML models trained with different data samples may achieve different communication performances. In general, a state of Line-of-Sight (LOS) between communication counterparts is an importance factor affecting the channel characteristics.

[0037] The example embodiments of this disclosure propose a mechanism for the AI or ML model assisted communication. In the mechanism, a first device receives a first information on a state of Line-of-Sight (LOS) between the first device and a second device. The first device determines whether the state of LOS is within a first state range based on the first information. Then, the first device selects a first model classified for the first state range in response to determining that the state of LOS is within the first state range.

[0038] In this way, the first device (for example, a terminal device or a network device) for communication determines an AI or ML model for assisting communication based on the state of LOS. As such, the AI or ML model may be trained purposefully and efficiently, and the selected AI or ML model is more adaptive. In addition, the size, type or time span of the input and output data may depend on the selected AI or ML model.

[0039] FIG. 1 illustrates an example environment 100 in which example embodiments of the present disclosure can be implemented.

[0040] The environment 100, which may be a part of a communication network, comprises a terminal device 110, a network device 120 and a location server 130. Without any limitation, the terminal device and network device in FIG. 1 are capable of performing data transmission in different spatial directions based on multi-beams capability.

[0041] In some embodiments, the location server 130 may comprise the Location Management Server (LMF). The location server 130 may provide first information on the state of LOS between the terminal device 110 and the network device 120 for the terminal device 110 and the network device 120. In addition or alternatively, the location server 130 may also provide the first information for the AI or ML model in the terminal device 110 and another AI or ML model in the network device 120. In addition or alternatively, a MI or ML model for positioning in the location server may also provide the first information for the terminal device 110 and the network device 120, or for the AI or ML model in the terminal device 110 and the other AI or ML model in the network device 120. In addition or alternatively, the first information on the state of LOS may be also exchanged between the terminal device 110 and the network device 120 directly, and this is discussed in the following embodiments.

[0042] It is to be understood that the number of terminal devices and network device is shown in the environment 100 only for the purpose of illustration, without suggesting any limitation to the scope of the present disclosure. In some embodiments, the environment 100 may comprise a further terminal device to communicate information with a further network device. In some embodiments, the environment 100 may further comprise an AI or ML server. The AI or ML server may provide AI or ML capabilities for the terminal device 110, the network device 120 and the location server 130. The AI or ML capabilities may comprise: AI or ML model download, AI or ML model upload, AI or ML model update, AI or ML model training and AI or ML model inference. The provided AI or ML model may be provided with first information on the state of LOS. In addition or alternatively, the provided AI or ML model may also provide the first information on the state of LOS.

[0043] The communications in the environment 100 may follow any suitable communication standards or protocols, which are already in existence or to be developed in the future, such as Universal Mobile Telecommunications System (UMTS), long term evolution (LTE), LTE-Advanced (LTE-A), the fifth generation (5G) New Radio (NR), Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMAX) standards, and employs any suitable communication technologies, including, for example, Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiplexing (OFDM), time division multiplexing (TDM), frequency division multiplexing (FDM), code division multiplexing (CDM), Bluetooth, ZigBee, and machine type communication (MTC), enhanced mobile broadband (eMBB), massive machine type communication (mMTC), ultra-reliable low latency communication (URLLC), Carrier Aggregation (CA), Dual Connection (DC), and New Radio Unlicensed (NR-U) technologies.

[0044] The AI or ML model may be adopted in the CSI report procedure and the BM procedure, the AI or ML model for the CSI report is discussed with reference to FIG. 2.

[0045] FIG.2 illustrates a signaling process 200 of a CSI report according to some embodiments of the present disclosure. For purpose of discussion, the process 200 will be described with reference to FIG. 1.

[0046] Generally, in the CSI report procedure, the network device 120 transmits Downlink (DL) Beam Reference Signal (RS) for the terminal device 110 measuring the CSI information. The DL RS may comprise at least one of CSI-RS, Synchronization Signal and Physical Broadcast Channel block (SSB), Demodulation Reference Signal (DMRS). After measuring the CSI information, the terminal device 110 transmits a CSI measurement report to the network device 120. The CSI measurement report comprises an indication that is indicative of preferred beam for the terminal device 110, for example, an indication of DL RS which is quasi-collocated with the preferred beam. Specifically, as mentioned above, the CSI measurement report may comprise CQI, PMI, CRI, SSB Resource Indicator (SSBRI), Layer Indicator (LI), Rank Indicator (RI), L1-RSRP, L1-SINR or Capability (Set) Index. The network device 120 may schedule the communication resources for the terminal device 110 based on the CSI measurement report.

[0047] In this disclosure, the terminal device 110 selects an AI or ML model for encoding/compressing the CSI measurement report based on the state of LOS between the terminal device 110 and the network device 120. The network device 120 selects, based on the state of LOS, another AI or ML model for decoding/decompressing the CSI measurement report from the terminal device 110. The details are discussed as below. In some embodiments, the compression or encoding may be used for the whole CSI report or a part of CSI report to obtain the compressed bits. For example, one or more of the following are compressed or encoded: CQI, PMI, CRI, SSBRI, LI, RI, L1-RSRP, L1-SINR or Capability (Set) Index. Especially, the compression or the encoding is applied to the PMI in the CSI report to obtain the number of compressed bits.

[0048] At 201, the terminal device 110 and network device 120 may exchange capability information. The capability information indicates whether the terminal device 110 or the network device 120 supports the selection of AI or ML model based on the state of LOS. For example, the network device 120 may inform whether the network device 120 supports the selection of AI or ML model by RRC configuration. The terminal device 110 may inform whether the terminal device 120 supports the selection of AI or ML model by UE capability reporting. In addition or alternatively, the configuration or UE capability reporting may further indicate to start/end/request-to-start/request-to-end AI/ML model selection based on LOS/NLOS information. In some embodiments, the LOS or NLOS information is provided to the entity which supports the selection of the AI or ML model or which deployed with AI or ML model.

[0049] At 203, the terminal device 110 receives first information on the state of LOS between the terminal device 110 and the network device 120. In addition or alternatively, the network device 110 also receives the first information. In this disclosure, a first device may refer to the terminal device 110 or the network device 120, and then a second device may refer to the network device or the terminal device accordingly. For example, the first device receiving the first information on the state of LOS between the first device and the second device may refer to:

- the terminal device 110 receiving the first information on the state of LOS between the terminal device 110 and the network device 120; or
- the network device 120 receiving the first information on the state of LOS between the network device 120 and the terminal device 110.

[0050] In some embodiments, the first information on the state of LOS is received from the location server 130. In some embodiments, the terminal device 110 may receive the first information from the network device 120. In addition or alternatively, the network device 120 may receive the first information from the terminal device 110. In addition or alternatively, the terminal device 110 and the network device 120 may receive the first information from the location server 130. In addition or alternatively, the terminal device 110 and the network device 120 may also provide the first information to the location server 130 for UE positioning. For discussion clarity, the first information on the LOS or Non-LOS (NLOS) and the exchange of the first information is further discussed with reference to FIGs. 3A-3E. With the received first information, the first device (the terminal device 110 or the network device 120) may select a corresponding AI/ML model.

In some embodiments, the AI or ML model server may also provide the first information to the terminal device 110, the network device 120 and the location server 130. In addition or alternatively, the first information may be provided from the any of the terminal device 110, the network device 120 and the location server 130 to the AI or ML model server.

[0051] The state of LOS indicates a channel condition between the first device and the second device. For example, the state of LOS having a first value (for example, “1”) indicates that the radio path between the first device and the second device is “Line-of-Sight” within a certain radio frequency range. In addition, the state of LOS having a second value (for example, “0”) indicates that the radio path between the first device and the second device is “Non-Line-of-Sight” within the certain radio frequency range. In some embodiments, the state of LOS indicating “Line-of-Sight” crosses a first state range and the other state of LOS indicating “Non-Line-of-Sight” crosses a second state range which is at least partially different from the first state range. In addition or alternatively, the state of LOS is expressed by a probability value or a likelihood, for example, scaled value as 0, 0.1, 0.2, …, 1. In addition or alternatively, the state of LOS may be indicated by Multipath information, for example, number of paths, number of dominant paths, ratio of strongest path and second strongest path, and so on.

[0052] At 205, the terminal device 110 may perform CSI or channel measurement on DL RS received from the network device 120.

[0053] At 207, the terminal device 110 determines whether the state of LOS is within a first state range based on the first information. Then, in response to determining that the first state range is within the first state range, the terminal device 110 selects a first model classified for the first state range, in order to encode/compress the CSI measurement report. In some embodiments, the first information may be the hard value, for example, 0 or 1, indicating the LOS or NLOS as discussed above. In addition or alternatively, the first information may be soft value, such as a probability or likelihood value. In addition or alternatively, the first information may be also a number of multi-paths, or other parameters as discussed above. In some other embodiments, the first information may be other parameters associated with the channel condition.

[0054] At 208, the network device 120 determines whether the state of LOS is within a first state range based on the first information. Then, in response to determining that the first state range is within the first state range, the network device 120 selects another first model classified for the first state range, in order to decode/decompress the CSI measurement report.

[0055] In some embodiments, the first device (the terminal device 110 or the network device 120) may select the model from at least two models that comprise the first model and a second model classified for a second state range. The second state range is at least partially different from the first state range. In some embodiments, the first state range is specific to a LOS communication environment and the second state range is specific to a Non-LOS (NLOS) communication environment. In addition or alternatively, if the state of LOS is within the second state range, the first device may select the second model classified for the second state range. In addition or alternatively, the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment. In some embodiments, the third state range is not overlap with the first state range and the second state range or the state range is partially overlap with the first state range or the second state range, if the state of LOS is not within the first state range and the second state range, the first device may select the third model classified for the third state range. The third state range may be specific to a predefined default communication environment. In some embodiments, the first device may select the first model by activating the first model, or by de-activating respective other AI/ML models. In addition or alternatively, the first device may change model status (for example, from "on" to "off" or "off" to "on") of the AI/ML model. In addition or alternatively, if multiple AI/ML models configured for LOS/NLOS, a further model index information can be provided.

[0056] In some embodiments, the first model may be an AI or ML model for the CSI compression or the CSI decompression. For example, the first device as the terminal device 110 may select the AI or ML model for the CSI compression and the first device as the network device 120 may select the AI or ML model for the CSI decompression. In addition or alternatively, the first model may be a Bayesian model, a clustering model, a SVM model or any other statistical model.

[0057] The selection of the first model based on the first information on the state of LOS may comprise selecting an Identification (ID) of the first model to be applied; determining the type and size of the input data for the first model; determining historical data as the input for the first model; and determining the output of the first model. The output of the first model may comprise the type of output, the size of the output, the valid timing of the output. In some embodiments, the models classified for different state ranges of LOS are adapted to different channel conditions, and the input, output, training data, algorithms, model type or other parameters for the models are different accordingly. In addition, the selection of model may be occurred in multiple phases in a lifecycle of the models, for example, the selection of model may occurred in training of the model, the validation of the model, the testing of the model and/or the inference of the model.

[0058] In an example, the available AI/ML models are categorized or classified into “to be used in LOS environment or the first state range” and “to be used in NLOS environment or the second state range”. In addition or alternatively, the available AI/ML models can be classified depending on different values/ranges of the LOS/NLOS likelihood or number of paths, and so on. Different AI/ML models may be featured in different types (CNN, RNN, Transformer, Inception, and so on), number of layers, branches, real valued or complex valued parameters, number of compressed bits, input/output sizes, and so on. The difference between the AI or ML models may be also manifest in other parameters and hyper-parameters for describing the AI or ML mode ((or, for aligning encoder/decoder)). The other parameters and hyper-parameters comprise a number or a maximum number of layers, a number or a maximum number of hidden layers, layer types, layer shapes (i.e., filter size, a number of channels/filters), a number and a maximum number of neurons per each layer, a number and a maximum number of neurons, and connections between layers, learning rate, loss function, cost function, activation function, mini-batch size, number of training iterations, momentum, number of hidden units, weight decay, activation sparsity, nonlinearity, weight initialization, regularization constant, number of epochs, number of branches in a decision tree, number of clusters in a clustering algorithm and any other hyper-parameters.

[0059] In addition, the number of compressed bits output by the first model selected by the first device serving as the terminal device 110 may be different in different state ranges of the LOS. For example, for the LOS condition, the channel characteristics may be simpler than that of the NLOS condition, such that less payload of the CSI report may sufficiently indicate the LOS channel. In this way, a less number of compressed bits may be adopted in order to reduce the overhead. In an example, fewer or less bits are needed in LOS scenario. In addition or alternatively, a CSI report format with less payload or overhead can be used for sending compressed bits to the first device serving as the network device 120 or the second device. In this disclosure, the compression or encoding may be used for the whole CSI report or a part of CSI report to obtain the compressed bits. For example, one or more of the following are compressed or encoded: CQI, PMI, CRI, SSBRI, LI, RI, L1-RSRP, L1-SINR or Capability (Set) Index. Especially, the compression or the encoding is applied to the PMI in the CSI report to obtain the number of compressed bits.

[0060] In addition or alternatively, the report includes information of whether the compressed bits are obtained by a LOS or a NLOS AI model. In some embodiments, the first device may transmit a CSI report to the second device. The CSI report (which may be also referred to as a first CSI report) may comprise the first number of compressed bits if the first device selects a model classified for the LOS communication environment. In addition or alternatively, the CSI report (which may be also referred to as a second CSI report) may comprise the second number of compressed bits if the first device selects a model classified for the NLOS communication environment. As mentioned above, the first number of compressed bits may be less than the second number of compressed bits. In addition, the first CSI report may comprise a first indication, and the first indication is indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment. In addition or alternatively, the second CSI report may comprise a second indication, and the second indication is indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

[0061] Further, in one solution, the compressed bit is calculated by the following equation:

$$\text{The number of compressed bits}=2*Nt*Ns*\alpha*Q \quad (1)$$

where the N_t is the number of ports, Ns is the number of sub-bands, α is the compression ratio, and Q is quantization bits.

[0062] In some embodiments, the compression ratio of a model classified for different state ranges is different. In an example, higher ratio can be used in LOS scenario (for example, LOS: 1/16; NLOS: 1/4). In another example, in LOS situation, higher ratio to compress PMI with less rank, rank can be fixed as 1 or 2.

[0063] In addition or alternatively, a first input type for the first model classified for the LOS communication is different from a second input type for the second model classified for the LOS communication. For example, the first input may comprise angular-delay domain channel matrix since the multipath component can be removed without degrading the compression performance. Correspondingly, the second input type may comprise spatial-frequency domain channel matrix.

[0064] In addition or alternatively, the first input type may further comprise eigenvector of (raw) channel matrix, channel information (e.g., matrix, eigenvectors, Pre-coder Matrix Indication, PMIs) and PMI. The second input type may further comprise (raw) channel matrix, profile of the received reference signal (for example, PDP, amplitude, phase and so on).

[0065] In addition or alternatively, a first input size for the first model classified for the LOS communication is different from a second input size for the second model classified for the LOS communication. In an example, the first input size is less or smaller than the second input size. Specifically, the first input size or the second input size may be any one of: a number of sub-bands, a number of rows or columns of a channel matrix, a bandwidth of a subband, a number of beams, a number of Discrete Fourier Transform (DFT) vectors, a number of eigenvalues or eigenvectors and a value of rank for a channel.

[0066] In addition or alternatively, the historical channel information as the input for the first model may be also different from that for the second model. In general, the channel characteristics in NLOS situation may be changed rapidly. Less historic channel information can be used for the second model classified for the NLOS communication environment. More historic channel information can be used for the first model classified for the LOS communication environment. In an example, the input for the first model may comprise M1 latest measurement instances, for example, M1 channel matrix. The input for the second model may comprise M2 latest measurement instances, for example, M2 channel matrix, and M1 is greater than M2. In addition or alternatively, M1 is equal to or smaller than M2, but the first interval between the adjacent measurement instances for the first model is larger than the second interval between the adjacent measurement instance for the second model, such that M1*first interval is greater than M2*second interval. The input domain parameter may be further referred to FIGs. 6A to 6C. In general, LOS channel condition requires less information in time-domain, frequency- domain, beam/angular-domain, delay-domain for inference.

[0067] In addition, the data processing for different models may be also different. The data processing at least includes clean the raw data samples, normalizing/truncating the input/output size. The data samples for training the models (for example, the first and second model) are labeled with LOS or NLOS information when the data samples are collected. For the first model classified for the LOS communication environment, the first model is trained based on data samples labeled with LOS. In addition or alternatively, the input of inference for the first device needs to remove data samples labeled with "NLOS". For the second model classified for the LOS communication environment, the second model is trained based on data samples labeled with NLOS. In addition or alternatively, the input of inference for the first device needs to remove data samples labeled with "LOS". In addition or alternatively, for AI/ML model trained for a specific LOS likelihood (value or range), the input of inference for the AL/ML model only include data samples in the specific range.

[0068] Further, as to the input or output of the model for the CSI measurement report decompression at the network device 120 (or the first device serving as the network device 120 or the second device as mentioned above), the input size of the model serving as the decode is based on the compressed bits reported, i.e., the output of the encoder (for example, the first number or second number of compressed bits as mentioned above). In addition, the output size of the decoder is also based on the input type/size of encoder.

[0069] In addition, some other parameters for the first model and the second model may be also different. In some embodiments, the quantization parameter is different. The quantization parameter may comprise quantization types (for example, uniform quantization or vector quantization), quantization step (for example, larger if LOS communication environment), quantization bits (for example, smaller if LOS communication environment). In some embodiments, time-related parameter is different, for example, periodicity of reporting the CSI measurement (for example, larger if LOS communication environment). In some embodiments, computation related parameter is different, and the computation related parameter comprises complexity, time (for example, less if LOS communication environment). In some embodiments, the loss function or convergence condition is different. For example, a first criterion for a first loss function of the first model is looser than a second criterion for a second loss function of the second model. In another example, a first constraint condition for the first model is looser than a second constraint condition for the second model.

[0070] In addition or alternatively, if LOS/NLOS information is not provided, or a special status of LOS/NLOS is provide, a default AI/ML model can be adopted. In some embodiments, a default or a predefined value of aforementioned parameters is applied. In addition or alternatively, a default configuration may be the configuration for non-AI-based CSI feedback.

[0071] In some embodiments, the terminal device 110 and the network device 120 are provided with an association between at least one of a model or a parameter associated with the model and a state range of the LOS. The first device may select the first model by determining, based on the first information and the association, at least one of a first ID for the first model, a number of compressed bit a compression ratio, an input data size, a pattern of a beam set for a beam measurement, a number of predicted beams or a payload size of a beam report. For example, the first device (the terminal device 110 or the network device 120) may select the first model or second model based on the association. In some embodiments, the provided association is predefined. In addition or alternatively, the provided association is configured by the first device serving as the network device 120. In addition or alternatively, the provided association is received by the terminal device 110 in response to a request for the association transmitted by the terminal device 110 to the network device 120. In some embodiments, the association may be expressed as the following table 1.

Table 1

LOS/NLOS information					Model selection details				
LOS/NLOS	Likelihood	Number of paths	Ratio of $1^{st}/2^{nd}$ strongest path	Other representation of LOS/NLOS	Applied Model ID selection	Compressed bits	Compression ratio	Input size selection	…
First value (e.g., LOS as 1)	First range (e.g., 0.8-1)	First value/range (e.g., 1)	First range (e.g., >=10)	…	First ID(s), e.g., ID 1	First number of bits, e.g., N1 bits	First ratio, e.g., 1/16	First Nc, e.g., 8 First Ns, e.g., 8	
Second value (e.g., NLOS as 0)	Second range (e.g., 0-0.2)	Second value/range (e.g., 2)	Second range (e.g., <=3)	…	Second ID(s), e.g., ID 2	Second number of bits, e.g., N2 bits	Second ratio, e.g., ¼	Second Nc, e.g., 32, second Ns, e.g., 32	
Not provided	Other ranges or	Other or not	Other or not	….	Other model	Other number of	Other or default (if	Other or default	

	not provided	provided …	provided …		ID or default (if not provided)	bits or default (if not provided)	not provided)	(if not provided)	

[0072] There may be more parameters for selecting the first or second model which may be defined in the association. Without any limitation, the table 1 only lists a part of these parameters. In addition, the other model listed in the above table is a general AI or ML model which may be trained based on both data samples labeled with LOS and the data samples labeled with NLOS.

[0073] In addition or alternatively, the first device selects the first model by determining at least a part of the above parameters based on the first information and a scaled value. In an example, a scaled value can be used based on the LOS likelihood. In some embodiments, the scaling function is N = f(LOS likelihood) * N_basic, if LOS likelihood is 0.5, N_basic = N1 is the number of compressed bits configured for LOS=1, f(x) is a function of likelihood = 1/x, then N = 2*N1. The first device may determine at least one of the following parameters based on the scaled value: a number of compressed bit a compression ratio, an input data size, a number of beams for a beam measurement, a number of predicted beams or a payload size of a beam report.

[0074] At 209, the terminal device 110 compresses or encodes the CSI report by means of embodiments as mentioned above. For example, the terminal device 110 compresses or encodes the channel matrix or the precoding matrix. At 211, the terminal device 110 transmits the compressed/encoded CSI measurement report to the network device 120. For example, the terminal device 110 transmits the CSI measurement report via Uplink Control Information (UCI or via a Physical Uplink Shared Channel (PUSCH) in compressed bits manner. At 212, the network device 120 decompresses or decodes the CSI measurement report as mentioned above. For example, the network device 120 recovers the channel matrix/precoding matrix from compressed bits. Then, the network device 120 may schedule the communication resource for the terminal device 110 and perform data transmission accordingly.

[0075] As mentioned above, the models may be selectively used for the CSI report based on the first information on the state of LOS. In this way, the CSI prediction accuracy may be enhanced accordingly and the payload of the CSI measurement report may be reduced significantly.

[0076] As mentioned above, the first information may be obtained or provided in various manners. This is discussed with reference to FIGs. 3A to 3D.

[0077] FIGs. 3A to 3D illustrate examples of input data and output data according to some embodiments of the present disclosure.

[0078] In some embodiments, the LOS/NLOS information may be exchanged between the terminal device 110 and the network device 120. In addition or alternatively, the LOS/NLOS information may be also exchanged between different AI/ML models. In addition or alternatively, the LOS/NLOS information is associated with each data sample used for AI/ML model collected for model training/validation/testing/inference.

[0079] In some embodiments, LOS/NLOS information can be exchanged between network device and terminal device explicitly or implicitly, for example, it can be represented as hard value (for example, 0 and 1) or soft value (for example, l a probability or a likelihood - a scaled value as 0, 0.1, 0.2, …, 1). The LOS/NLOS information can be also expressed as Multipath information, for example, number of paths, number of dominant paths, ratio of strongest path and second strongest path, and so on.

[0080] In addition, the terminal device 110 may provide the LOS/NLOS information to the network device 120 via a Radio Resource Control (RRC) signaling, a Medium Access Control (MAC) Control Element (CE), a UCI, a CSI report, a beam report and so on. In some embodiments, the LOS/NLOS information may be provided per at least one of: a transmission path, a beam, an antenna, a path, a resource set, a CSI-Reference Signal (RS) Resource Indicator (CRI), a Transmit-Receive-Point (TRP), a cell, a BandWidth Part (BWP) and a spectrum band. Further, the LOS/NLOS information may be provided per DL Reference Signal time difference (RSTD), DL Reference Signal Received Power (RSRP), and UE Rx-Tx time difference. In addition, the LOS/NLOS information may be provided per AI/ML model, including report LOS/NLOS information together with each (or a set of) data sample(s) collected for model training/validation/testing/inference. The LOS/NLOS information may be also provided by the network device 120 in the same way.

[0081] In turn, the network device 120 may transmit the LOS/NLOS information to the terminal device 110 via a RRC signaling, a MAC CE or a DCI. Further, the LOS/NLOS information may be configured per AI/ML model, including configured LOS/NLOS information together with each (or a set of) data sample(s) collected for model training/validation/testing/inference. In addition or alternatively, the first device (the terminal device 110 or network device 120) can send/request resource to send update information when LOS/NLOS condition changes or the change is beyond a threshold.

[0082] As shown in FIG. 3A, the AI/ML model for CSI or BM (which will be discussed in the following) can also provide LOS/NLOS information as part of the output of the AI/ML model. Further, as shown in FIG. 3B, LOS/NLOS information can be used as a part of the input of the AI/ML model for CSI/BM.

[0083] In some further embodiments, as shown in FIGs. 3D to 3E, location server 130 may provide LOS/NLOS information to source. Location server 130 may provide LOS/NLOS information to the terminal device 110 or to the network device 120. Location server 130 may be provided with LOS/NLOS information from the terminal device 110 or from network device 120. AI/ML model server can provide LOS/NLOS information terminal device 110 or to network device 120. AI/ML model server may be provided with LOS/NLOS information from the terminal device 110 or from the network device 120. AI/ML model for positioning can provide LOS/NLOS information to AI/ML model for CSI/BM. AI/ML model for CSI/BM can provide LOS/NLOS information to AI/ML model for positioning. The provided LOS/NLOS information can be per path, per beam, per panel, per resource, per resource set, per CRI, per TRP, per cell, per BWP, per band, per DL RSTD, DL RSRP, and UE Rx-Tx time difference, per AI/ML model, and so on.

[0084] In some yet embodiments, the LOS/NLOS indicator can also be another environment indicator (for example, indicating the propagation scenario like indoor/outdoor, urban/rural, micro/macro, dry air, foliage, fog, rain, cloud, temperature and so on.), position indicator (cell-edge, cell-center), mobility indicator (UE-NW relative moving speed/moving direction), UE class/type, BS class/type. This may be further discussed as below.

[0085] As mentioned above, the first information on the state of LOS (or the LOS/NLOS information) may be exchanged between any two of the terminal device, network device and the location server and AI or ML models integrated therein. In this way, the first device and network device may obtain LOS/NLOS information for further use (e.g., model selection, model training, model inference). Further, the first device and network device may update LOS/NLOS information if channel condition changes.

[0086] FIG. 3E illustrates an example of a AI or ML model according to some embodiments of the present disclosure.

[0087] As shown in FIG. 3E, the AI or ML model adopted in the disclosure may be also expressed as below:

Data Collection is a function that provides input data to Model training and Model inference functions. AI/ML algorithm specific data preparation (e.g., data pre-processing and cleaning, formatting, and transformation) is not carried out in the Data Collection function.

Examples of input data may include measurements from UEs or different network entities, feedback from Actor, output from an AI/ML model.

Training Data: Data needed as input for the AI/ML Model Training function.

Inference Data: Data needed as input for the AI/ML Model Inference function.

Model Training is a function that performs the ML model training, validation, and testing which may generate model performance metrics as part of the model testing procedure. The Model Training function is also responsible for data preparation (e.g. data pre-processing and cleaning, formatting, and transformation) based on Training Data delivered by a Data Collection function, if required.

Model Deployment/Update: Used to initially deploy a trained, validated, and tested AI/ML model to the Model Inference function or to deliver an updated model to the Model Inference function.

Model Inference is a function that provides AI/ML model inference output (e.g. predictions or decisions) . It may provide model performance feedback to Model Training function. The Model inference function is also responsible for data preparation (e.g. data pre-processing and cleaning, formatting, and transformation) based on Inference Data delivered by a Data Collection function, if required.

Output: The inference output of the AI/ML model produced by a Model Inference function.

Note: Details of inference output are use case specific.

Model Performance Feedback: Applied if certain information derived from Model

Inference function is suitable for improvement of the AI/ML model trained in Model Training function. Feedback from Actor or other network entities (via Data Collection function) may be needed at Model Inference function to create Model Performance Feedback.

Actor is a function that receives the output from the Model inference function and triggers or performs corresponding actions. The Actor may trigger actions directed to other entities or to itself.

Feedback: Information that may be needed to derive training or inference data or performance feedback.

[0088] As mentioned above, in addition to the CSI report, the first model may be selected for a Beam Management (BM) procedure, the first model for BM may be different from the first model for CSI report, and the so called "first" model is just used for referring to the selected model by the first device based on the state of LOS for different purposes without any limitation. The selection of first model for the BM procedure is discussed with reference to FIGs. 4 to 6C.

[0089] FIGs. 4A to 4D illustrate signaling processes 400A, 400B, 400C and 400D of the BM according to some embodiments of the present disclosure.

[0090] Compared with the CSI report which may require selecting the first model at both sides of the terminal device and the network device, the first model may be only selected by one side in the BM procedure. For example, the first model may be at the terminal device 110 side or at the network device 120 side.

[0091] As shown in FIG. 4A, the first model is selected by the network device 120 for predicting/inferencing at least one beam in a set of beams for the beam prediction. In other words, the first model is at the network device side in FIG. 4A.

[0092] In the signaling process 400A, at 401, the terminal device 110 and the network device 120 exchange their capability or configuration of the selection of AI or ML model. In some embodiments, the terminal device 110 may exchange the capability or receiving the configuration from the network device 120 in the same way as the CSI report.

[0093] At 403, the terminal device 110 and network device 120 receive or provide the first information on the state of LOS. In some embodiments, the terminal device 110 and network device 120 may receive or provide the first information in the same way as discussed in the above embodiments. At 405, the network device 120 transmits a set of beam RSs to the first device 110 for measuring the beam quality. The beam RS may be transmitted periodically, semi-persistently or aperiodic.

[0094] At 407, the terminal device 110 determines a set of beams for measuring (which may be also referred to as a set B of beams). For different states of LOS, the set B of beams may be determined differently. For the first model classified for the first state range or the LOS communication environment, the terminal device 110 may determine a first set of beams for measuring. For the second model classified for the second state range or the NLOS communication environment, the terminal device 110 may determine a second set of beams for measuring. The first model and second model may be selected based on the first information by the first device serving as network device 120 in the same way as the embodiments discussed above. In some embodiments, the network device 120 may select the first model by activating the first model, or by de-activating respective other AI/ML models. In addition or alternatively, the first device may change model status (for example, from "on" to "off" or "off" to "on") of the AI/ML model. In addition or alternatively, if multiple AI/ML models configured for LOS/NLOS, a further model index information can be provided. In some embodiments, a second number of beams in the second set of beams is greater than a first number of beams in the first set of beams. In an example, less number of beams are measured and report in the LOS communication environment. In turn, more number of beams are measured and report in the NLOS communication environment.

[0095] In addition or alternatively, a first beam pattern of the first set of beams for the first model is different from a second beam pattern of the second set of beams for the second model. In this disclosure, the beam pattern refers to a distribution of the beams in a grid of beams. For example, the beams in the first set of beams are distributed as a plurality of neighboring beams, and wherein the beams in the second set of beams are distributed randomly or uniformly in a spatial domain. For discussion clarity, the difference of beam patterns is discussed with reference to FIGs. 5A to 5B.

[0096] FIGs. 5A to 5B illustrate example beam patterns 500A and 500B according to some embodiments of the present disclosure.

[0097] The beam pattern 500A is an example of the first beam pattern. As shown in FIG.

5A, the beams is distributed in the grid of beams by a relative focusing manner. The pattern 500B is an example of the second beam pattern. As shown in FIG. 5B, the beams is distributed in the grid of beams by a randomly manner or a uniformly manner (for example, equally spacing beams). In addition or alternatively, the first set of beams may have a fixed pattern and the second set of beams may have a random pattern.

[0098] Referring back to FIG. 4A, in addition or alternatively, the first set of beams may be a subset of a third set of beams, and the second set of beams is different from a fourth set of beams. The third set of beams and fourth set of beams are a set of beams for a beam prediction. The third set of beams is associated with the first model classified for the LOS communication environment; the fourth set of beams is associated with the second model classified for the NLOS communication environment. In turn, the first model may predict a preferred beam for the terminal device 110 from the third set of beams. The second model may predict a preferred beam for the terminal device 110 from the fourth set of beams.

[0099] In addition or alternatively, a beam of the first set of beams is narrower than another beam of the second set of beams. In turn, the second set of beams may have a relative wider beam. In addition or alternatively, beam selection criteria/requirements associated with the first or second set of beams are different with each other. For example, the RSRP threshold for a beam in first set of beams may be higher than that for a beam in the second set of beams.

[00100] At 409, the terminal device 110 transmits a BM report to the network device 120. In some embodiments, the terminal device 110 may transmit a first BM report associated with the first set of beams to the network device 120, if the state of LOS is determined as LOS communication environment. The terminal device 110 may determine the first BM report by determining the following reported information: a first beam ID for a beam in the first set of beams determined as above and the first RSRP for the beam, or a second beam ID for a receive beam in the first set of beams.

[00101] In some embodiments, the terminal device 110 may transmit a second BM report associated with the second set of beams to the network device 120, if the state of LOS is determined as NLOS communication environment. The information indicated by the second BM report may be different from that indicated by the first BM report. For example, the second reported information in the second BM report may comprise at least one of: a third beam ID for a beam in the second set of beams, the second RSRP and a beam orientation of the beam, the third beam ID and a Signal to Interference plus Noise Ratio (SINR) associated with the beam and a fourth beam ID for a transmit beam in the second set of beams.

[00102] In addition or alternatively, the time domain parameters for the first set of beams and the second set of beams are also different. For discussion clarity, the time domain parameters for the first set of beams and the second set of beams may be discussed with reference to FIGs. 6A to 6C.

[00103] FIGS. 6A to 6C illustrate example historic measurement instances 600A, 600B and 600C as input for a model according to some embodiments of the present disclosure.

[00104] In some embodiments, the input for the second model may comprise M2 latest beam measurement results, as shown by 610 in FIG. 6A. The input for the first model may comprise M1 beam measurement results, for example, as shown by 620 in FIG. 6A, and M1 is greater than M2. In addition or alternatively, the first interval between the adjacent beam measurement results (as shown by 650 in FIG. 6C) for the first model is larger than the second interval (as shown by 630 in FIG. 6C) between the adjacent beam measurement results for the second model.

[00105] Referring back to FIG. 4A, at 409, the selected first model or second model at the network device 120 may predict or inference the beams from the third set of beams based on the BM report (for example, the first BM report) or predict or inference the beams from the fourth set of beams (for example, the second BM report). In some embodiments, the first model may output a first number of predictions for a first number of future time instances and each of the first number of predictions beams corresponds to a respective future time instances in the first number of future time instances. In turn, the second model may output a second number of predictions for a second number of future time instances and each of the second number of predictions corresponds to a respective future time instances in the second number of future time instances. In addition, one of the predictions may at least one predicted beam. In some embodiments, the first number of predictions is greater than the second number of predictions. For example, there may be F1 numbers predictions for F1 future time instances in LOS communication environment and F2 numbers predictions for F2 future time instances in NLOS communication environment. F1 is greater than F2.

[00106] In addition or alternatively, a third time interval between adjacent time instances in the first number of future time instances is greater than a fourth time interval between adjacent time instances in the second number of future time instances. In addition or alternatively, a first lifetime for the first number of predictions is greater than a second lifetime of the second number of predictions.

[00107] In some other embodiments, if AI/ML model is at network device 120, the BM report content and format depends on the input type/size. Alternatively, if AI/ML model is at terminal device 110, the BM report content and format depends on the output type/size. In addition or alternatively, the BM report includes information of whether the beam report is obtained by/for an AI model for a LOS or a NLOS.

[00108] In some embodiments, the data processing for different models may be also different. The data processing at least includes clean the raw data samples, normalizing/truncating the input/output size. The data samples for training the models (for example, the first and second model) are labeled with LOS or NLOS information when the data samples are collected. For the first model classified for the LOS communication environment, the first model is trained based on data samples labeled with LOS. In addition or alternatively, the input of inference for the first device needs to remove data samples labeled with "NLOS". For the second model classified for the LOS communication environment, the second model is trained based on data samples labeled with NLOS. In addition or alternatively, the input of inference for the first device needs to remove data samples labeled with "LOS". In addition or alternatively, for AI/ML model trained for a specific LOS likelihood (value or range), the input of inference for the AL/ML model only include data samples in the specific range.

[00109] In some embodiments, some other parameters (for example, quantization types, quantization step, quantization bits, time-related parameter, computation related parameter, and the loss function or convergence condition) is also different as discussed with reference to CSI report.

[00110] In addition or alternatively, if LOS/NLOS information is not provided, or a special status of LOS/NLOS is provide, a default AI/ML model can be adopted. In some embodiments, a default or a predefined value of aforementioned parameters is applied. In addition or alternatively, a default configuration may be the configuration for non-AI-based CSI feedback.

[00111] In some embodiments, similarly, an association between at least one of a model selected for BM procedure or a parameter associated with the model and a state range of the LOS is provided. In some embodiments, the provided association is predefined. In addition or alternatively, the provided association is configured by the first device serving as the network device 120. In addition or alternatively, the provided association is received by the terminal device 110 in response to a request for the association transmitted by the terminal device 110 to the network device 120. In some embodiments, the association may be expressed as the following table 2.

Table 2

LOS/NLOS information					Model selection details				
LOS/NLOS	Likelihood	Number of paths	Ratio of 1st/2nd strongest path	Other representation	Applied Model ID selection	Input size/type, or, Set B size/pattern	Output size/type	Beam report	…
First value (e.g., LOS as 1)	First range (e.g., 0.8-1)	First value/range (e.g., 1)	First range (e.g., >=10)	…	First ID(s), e.g., ID 1	First set B, e.g., 8 neighbor beams	First number of predicted beams, e.g., 1	First set B, e.g., 8; First number of best beams, e.g., 1;	
Second value (e.g., NLOS as 0)	Second range (e.g., 0-0.2)	Second value/range (e.g., 2)	Second range (e.g., <=3)	…	Second ID(s), e.g., ID 2	Second set B, e.g., uniformly distributed 16 beam	Second number of predicted beams, e.g., 4	First set B, e.g., 16; First number of best beams, e.g., 4;	
Not provided	Other ranges or not provided	Other or not provided …	Other or not provided …	….	Other or default (if not provided)	Other or default (if not provided)	Other or default (if not provided)	Other or default (if not provided)	

[00112] There may be more parameters for selecting the first or second model which may be defined in the association. Without any limitation, the table 2 only lists a part of these parameters. In addition, the other model listed in the above table is a general AI or ML model which may be trained based on both data samples labeled with LOS and the data samples labeled with NLOS.

[00113] In addition or alternatively, the first device selects the first model by determining at least a part of the above parameters based on the first information and a scaled value in the same way as the CSI report.

[00114] After obtaining the predictions, the network device 120 may update the beam for the terminal device 110. For example, the update of the applied beam may be depend on the network device 120 or may be depend on trigger/request a further beam search and so on, and no limitation is enforced in this case.

[00115] In addition to the BM RS transmitted by the network device 120, the BM RS may be also transmitted by the terminal device 110.

[00116] As shown in FIG. 4B, at 413 the terminal device 110 may determine the set of beams for beam measurements in the same way as FIG. 4A. At 415, the terminal device 110 transmits Uplink (UL) BM RS on the set of beams determined for the beam measurement. At 409, based on the state of LOS, the first or second model at the network device 120 may predict or inference the beams based on measuring the UL BM RS. Then, the network device 120 may update the beam applied for the terminal device 110 as discussed above.

[00117] In addition to the network device 120 selecting the first model for the BM procedure and performing inference or prediction, the selection of first or second model may be also at the terminal device 110.

[00118] FIGs. 4C to 4D illustrate signaling processes 400C and 400D of the BM in which the first model is at terminal device according to some embodiments of the present disclosure.

[00119] In signaling process 400C, the steps 401, 403, 405 and 407 may be the same as discussed above. At 421, based on the state of LOS, the first model or second model at the terminal device 110 may inference or predict the beams to be applied. Then, at 423, the terminal device 110 may transmit a BM report associated with the predicted beams. In some embodiments, if the first information indicates the LOS communication environment, the terminal device 110 may transmit a third BM report to the network device 120, the third BM report indicates a third number of beams predicted by the first model in the third set of beams and reported information associated with the third number of beams. The reported information may be the information as similar as the first reported information as discussed above. In addition or alternatively, if the first information indicates the NLOS communication environment, the terminal device 110 may transmit a fourth BM report to the network device 120, the third BM report indicates a third number of beams predicted by the first model in the third set of beams and reported information associated with the third number of beams. The reported information may be the information as similar as the second reported information as discussed above.

[00120] With the third or fourth BM report, the network device 120 may update the beam applied to the terminal device 110 in the same way as discussed above.

[00121] In signaling process 400D, the steps 401, 403, 405, 407 and 423 may be the same as discussed above. In this process, as similar as process 400B, at 427, the BM RSs are transmitted from the terminal device 110 to the network device 120. In turn, at 429, the network device 120 performs measurements on the UL BM RSs on a set B of beams from the terminal device 110, and transmits the measurement results to the terminal device 110. At 431, based on the state of LOS information, the terminal device 110 obtains the predictions. Then, with the beam report, the network device 120 update the beam applied to the terminal device 110 in the same way as discussed above.

[00122] In this way, the BM prediction accuracy may be enhanced accordingly and the payload of the BM report may be reduced significantly.

[00123] In addition, as discussed above, the LOS/NLOS indicator can also be another environment indicator. For example, the impact of LOS/NLOS indicator can be similar to the impact of other indicators, (environment, mobility, UE class, etc.), the methods in case 0/1 can be valid by replacing LOS/NLOS indicator with other indicators, for example:

- LOS communication environment → UE moving at low speed; NLOS communication environment → UE moving at high speed; LOS likelihood value/range → moving speed value/range;
- LOS communication environment → Outdoor/rural environment; NLOS communication environment → Indoor/dense urban environment;
- LOS communication environment → energy saving mode; NLOS communication

environment → regular mode; and

- LOS communication environment → UE with reduced capability; NLOS communication environment → normal UE.

[00124] In addition, LOS/NLOS information can be applied to improve the CSI feed back/BM/positioning/mobility/handover/load balancing/scheduling/resource allocation/en ergy saving without AI/ML models, e.g., determining CSI/beam report content and f ormat based on LOS/NLOS information.

[00125] In addition, the LOS/NLOS information may be also used for selecting data samples for the AI or ML model. For example, the LOS/NLOS information may be used to determine the size of date samples collected for model training/validation/testing/inference, for example, Number of data samples (measurements/measurement results/reports/resources/resource sets) needed for training respective AI/ML model(s), for example, for model training, L1 data samples are needed if LOS, L2 data samples are needed if NLOS, L2>L1. In addition, L2 = f(LOS likelihood) * L1, f(LOS likelihood) = 1/LOS likelihood. In addition, the LOS/NLOS information may be used to determine input/output size/type for data samples collected in model training/validation/testing/inference phase, respectively. In addition, the methods may be applied to AI/ML models for other purposes, for example, for positioning, mobility, handover, load balancing, scheduling, resource allocation, energy saving.

[00126] In this way, data collection (e.g., measurements, calculations, reports) overhead may be reduced.

[00127] FIG. 7 illustrates a flowchart of a method 700 of communication implemented at a first device in accordance with some embodiments of the present disclosure. The method 700 can be implemented at the terminal device or network device shown in FIG. 1. For the purpose of discussion, the method 700 will be described with reference to FIG. 1. It is to be understood that the method 700 may include additional acts not shown and/or may omit some shown acts, and the scope of the present disclosure is not limited in this regard.

[00128] At 710, the first device receives first information on a state of Line-of-Sight (LOS) between the first device and a second device.

[00129] At 720, the first device determines, based on the first information, whether the state of LOS is within a first state range.

[00130] At 730, in response to determining that the state of LOS is within the first state range, the first device selects a first model classified for the first state range.

[00131] In some embodiments, selecting the first model comprises: selecting the first model from at least two models that comprise the first model and a second model classified for a second state range, the second state range being at least partially different from the first state range.

[00132] In some embodiments, one of the at least two models comprises at least one of: a first Artificial Intelligence (AI) or Machine Learning (ML) model for a Channel State Information (CSI) compression; a second AI or ML model for a Beam Management (BM).

[00133] In some embodiments, the first model is different from the second model in at least one of: a type of an AI or ML model; a number of layers of an AI or ML model; a branch of an AI or ML model; a real valued parameter of an AI or ML model; a complex valued parameter of an AI or ML model; a number of compressed bits for an AI or ML model; an input data size of an AI or ML model; an output data size of an AI or ML model; an input type of an AI or ML model; or an output type of an AI or ML model.

[00134] In some embodiments, the first state range is specific to a LOS communication environment and wherein the second state range is specific to a Non-LOS (NLOS) communication environment, and wherein the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment.

[00135] In some embodiments, in case of the first model and the second model are used for a CSI compression, a first number of compressed bits output by the first model is less than a second number of compressed bits output by the second model.

[00136] In some embodiments, the method further comprising: transmitting a CSI report to the second device, the CSI report comprising at least one of the first number of compressed bits or the second number of compressed bits.

[00137] In some embodiments, wherein at least one of: a first CSI report comprising the first number of compressed bits further comprises a first indication, the first indication being indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment; or a second CSI report comprising the second number of compressed bits further comprises a second indication, the second indication being indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

[00138] In some embodiments, a first size of a first input for the first model is less than a second size of a second input for the second model.

[00139] In some embodiments, one of the first size or the second size comprises at least one of: a number of sub-bands; a number of rows or columns of a channel matrix; a bandwidth of a subband; a number of beams; a number of Discrete Fourier Transform (DFT) vectors; a number of eigenvalues or eigenvectors; or a value of rank for a channel.

[00140] In some embodiments, a first group of historic channel information as an input for the first model crosses a longer time period than a second group of historic channel information as an input for the second model.

[00141] In some embodiments, the first group of historic channel information comprises a first number of latest measurement instances, the second group of historic channel information comprises a second number of latest measurement instances, wherein at least one of: the first number of latest measurement instances is greater than the second number of latest measurement instances; or a first time interval between adjacent measurement instances in the first group is greater than a second time interval between adjacent measurement instances in the second group.

[00142] In some embodiments, the first model is trained based on a first data sample labeled with the LOS communication environment, and wherein the second model is trained based a second data sample labeled with the NLOS communication environment.

[00143] In some embodiments, at least one of: a first quantization step for the first model is greater than a second quantization step for the second model; or a second quantization bit number for the second model is greater than a first quantization bit number for the first model.

[00144] In some embodiments, at least one of: a first criterion for a first loss function of the first model is looser than a second criterion for a second loss function of the second model; or a first constraint condition for the first model is looser than a second constraint condition for the second model.

[00145] In some embodiments, at least one of: an association between at least one of a model or a parameter associated with the model and a state range of the LOS is predefined; the association is received from the second device; or the association is received in response to a request for the association transmitted by the first device.

[00146] In some embodiments, selecting the first model comprises determining, based on the first information and the association, at least one of: a first ID for the first model; a number of compressed bit; a compression ratio; an input data size; a pattern of a beam set for a beam measurement; a number of predicted beams; or a payload size of a beam report.

[00147] In some embodiments, selecting the first model comprises determining, based on the first information and a scaled value, at least one of: a number of compressed bit; a compression ratio; an input data size; a pattern of a beam set for a beam measurement; a number of predicted beams; or a payload size of a beam report.

[00148] In some embodiments, the method further comprising: in case of the first model and the second model are used for a BM, determining a first set of beams for the first model and a second set of beams for the second model, the first set of beams and the second set of beams being used for a beam measurement.

[00149] In some embodiments, a second number of beams in the second set of beams is greater than a first number of beams in the first set of beams.

[00150] In some embodiments, the beams in the first set of beams are distributed as a plurality of neighboring beams, and wherein the beams in the second set of beams are distributed randomly or uniformly in a spatial domain.

[00151] In some embodiments, the first set of beams is a subset of a third set of beams and wherein the second set of beams is different from a fourth set of beams, the third set of beams being a set of beams for a beam prediction, the fourth set of beams being another set of beams for a beam prediction.

[00152] In some embodiments, a first Reference Signal Received Power (RSRP) threshold for the first set of beams is greater than a second RSRP for the second set of beams.

[00153] In some embodiments, the first model outputs a first number of predictions for a first number of future time instances and each of the first number of predictions corresponds to a respective future time instances in the first number of future time instances, wherein the second model outputs a second number of predictions for a second number of future time instances and each of the second number of predictions corresponds to a respective future time instances in the second number of future time instances, one of the predictions comprising at least one predicted beam, and wherein at least one of: the first number of predictions is greater than the second number of predictions; a third time interval between adjacent time instances in the first number of future time instances is greater than a fourth time interval between adjacent time instances in the second number of future time instances; or a first lifetime for the first number of predictions is greater than a second lifetime of the second number of predictions.

[00154] In some embodiments, the method further comprising determining a first reported information for the first set of beams, the first reported information comprising at least one of: a first beam ID for a beam in the first set of beams and the first RSRP; or a second beam ID for a receive beam in the first set of beams.

[00155] In some embodiments, the method further comprising determining a second reported information for the second set of beams, the second reported information comprising at least one of: a third beam ID for a beam in the second set of beams, the second RSRP and a beam orientation of the beam; the third beam ID and a Signal to Interference plus Noise Ratio (SINR) associated with the beam; or a fourth beam ID for a transmit beam in the second set of beams.

[00156] In some embodiments, the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of: transmitting a first BM report to the second device, the first BM report comprising the first reported information; or transmitting a second BM report to the second device, the second BM report comprising the second reported information.

[00157] In some embodiments, the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of: transmitting a third BM report to the second device, the third BM report indicating a third number of beams predicted by the first model in the third set of beams and reported information associated with the third number of beams, and transmitting a fourth BM report to the second device, the fourth BM report indicating a fourth number of beams predicted by the second model in the fourth set of beams and reported information associated with the fourth number of beams, the fourth number being greater than the third number.

[00158] In some embodiments, receiving the first information from at least one of: the second device; a location server; or an AI or ML model.

[00159] In some embodiments, the method further comprises transmitting the first information to at least one of: the second device; a location server; or an AI or ML model.

[00160] In some embodiments, transmitting the first information comprises transmitting the first information per at least one of a transmission path, a beam, an antenna path, a resource set, a CSI-Reference Signal (RS) Resource Indicator (CSI), a Transmit-Receive-Point (TRP), a cell, a BandWidth Part (BWP) and a spectrum band.

[00161] In some embodiments, the first information further indicates at least one of: a location of the first device; a velocity of the first device; or a trajectory of the first device.

[00162] In some embodiments, the first information is used as an input data for the first model.

[00163] In some embodiments, where the first device comprises at least one of a terminal device or a network device.

[00164] FIG. 8 illustrates a flowchart of a method 800 of communication implemented at a second device in accordance with some embodiments of the present disclosure. The method 800 can be implemented at the network device 120 shown in FIG. 1. For the purpose of discussion, the method 800 will be described with reference to FIG. 1. It is to be understood that the method 800 may include additional acts not shown and/or may omit some shown acts, and the scope of the present disclosure is not limited in this regard.

[00165] At 810, the second device receives a first Channel State Information (CSI) report comprising a number of compressed bits.

[00166] At 820, the second device receives a first information on a state of Line-of-Sight (LOS) between the first device and a second device.

[00167] At 830, the second device determines, based on the first information, whether the state of LOS is within a first state range.

[00168] At 840, in response to determining that the state of LOS is within the first state range, the second device selects a first model for de-compressing the first CSI report, the first model being classified for the first state range.

[00169] In some embodiments, wherein one of the at least two models comprises at least one of: an Artificial Intelligence (AI) or Machine Learning (ML) model for a Channel State Information (CSI) de-compression.

[00170] In some embodiments, wherein receiving the first information by receiving the first CSI report.

[00171] In some embodiments, selecting the first model comprises: selecting the first model from at least two models that comprise the first model and a second model classified for a second state range, the second state range being at least partially different from the first state range.

[00172] In some embodiments, the first state range is specific to a LOS communication environment and wherein the second state range is specific to a Non-LOS (NLOS) communication environment, and wherein the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment.

[00173] In some embodiments, a first number of compressed bits for the first model is less than a second number of compressed bits output for the second model.

[00174] In some embodiments, the first CSI report comprising the first number of compressed bits further comprises a first indication, the first indication being indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment.

[00175] In some embodiments, a second CSI report comprising the second number of compressed bits further comprises a second indication, the second indication being indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

[00176] In some embodiments, receiving the first information from at least one of: the first device; a location server; or an AI or ML model.

[00177] In some embodiments, further comprising transmitting the first information to at least one of: the first device; a location server; or an AI or ML model.

[00178] In some embodiments, the first information further indicates at least one of: a location of the first device; a velocity of the first device; or a trajectory of the first device.

[00179] In some embodiments, the second device comprises a network device or a terminal device.

[00180] Fig. 9 is a simplified block diagram of a device 900 that is suitable for implementing some embodiments of the present disclosure. The device 900 can be considered as a further example embodiment of the network devices 130 and 140 as shown in FIG. 1, or terminal devices 110 and 120 as shown in FIG. 1. Accordingly, the device 900 can be implemented at or as at least a part of the above network devices or terminal devices.

[00181] As shown, the device 900 includes a processor 910, a memory 920 coupled to the processor 910, a suitable transmitter (TX) and receiver (RX) 940 coupled to the processor 910, and a communication interface coupled to the TX/RX 940. The memory 920 stores at least a part of a program 930. The TX/RX 940 is for bidirectional communications. The TX/RX 940 has at least one antenna to facilitate communication, though in practice an Access Node mentioned in this application may have several ones. The communication interface may represent any interface that is necessary for communication with other network elements, such as X2 interface for bidirectional communications between gNBs or eNBs, S1 interface for communication between a Mobility Management Entity (MME)/Serving Gateway (S-GW) and the gNB or eNB, Un interface for communication between the gNB or eNB and a relay node (RN), or Uu interface for communication between the gNB or eNB and a terminal device.

[00182] The program 930 is assumed to include program instructions that, when executed by the associated processor 910, enable the device 900 to operate in accordance with the embodiments of the present disclosure, as discussed herein with reference to FIGs. 2-8. The embodiments herein may be implemented by computer software executable by the processor 1910 of the device 900, or by hardware, or by a combination of software and hardware. The processor 910 may be configured to implement various embodiments of the present disclosure. Furthermore, a combination of the processor 910 and memory 920 may form processing means 950 adapted to implement various embodiments of the present disclosure.

[00183] The memory 920 may be of any type suitable to the local technical network and may be implemented using any suitable data storage technology, such as a non-transitory computer readable storage medium, semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one memory 920 is shown in the device 900, there may be several physically distinct memory modules in the device 900. The processor 1210 may be of any type suitable to the local technical network, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 900 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00184] In some embodiments, a terminal device comprises circuitry configured to perform method 600.

[00185] In some embodiments, a network device comprises circuitry configured to perform method 700 and/or 800.

[00186] The components included in the apparatuses and/or devices of the present disclosure may be implemented in various manners, including software, hardware, firmware, or any combination thereof. In one embodiment, one or more units may be implemented using software and/or firmware, for example, machine-executable instructions stored on the storage medium. In addition to or instead of machine-executable instructions, parts or all of the units in the apparatuses and/or devices may be implemented, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (ASICs), Application-specific Standard Products (ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), and the like.

[00187] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it will be appreciated that the blocks, apparatus, systems, technique terminal devices or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00188] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the process or method as described above with reference to any of Figs. 3 to 11. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00189] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[00190] The above program code may be embodied on a machine readable medium, which may be any tangible medium that may contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. A machine readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the machine readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[00191] Further, while operations are depicted 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. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific embodiment details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[00192] Although the present disclosure has been described in language specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

[00193] In summary, embodiments of the present disclosure may provide the following solutions.

[00194] A method of communication, comprising: receiving first information on a state of Line-of-Sight (LOS) between the first device and a second device; determining, based on the first information, whether the state of LOS is within a first state range; in response to determining that the state of LOS is within the first state range, selecting a first model classified for the first state range.

[00195] In one embodiment, selecting the first model comprises: selecting the first model from at least two models that comprise the first model and a second model classified for a second state range, the second state range being at least partially different from the first state range.

[00196] In one embodiment, one of the at least two models comprises at least one of: a first Artificial Intelligence (AI) or Machine Learning (ML) model for a Channel State Information (CSI) compression; a second AI or ML model for a Beam Management (BM).

[00197] In one embodiment, the first model is different from the second model in at least one of: a type of an AI or ML model; a number of layers of an AI or ML model; a branch of an AI or ML model; a real valued parameter of an AI or ML model; a complex valued parameter of an AI or ML model; a number of compressed bits for an AI or ML model; an input data size of an AI or ML model; an output data size of an AI or ML model; an input type of an AI or ML model; or an output type of an AI or ML model.

[00198] In one embodiment, the first state range is specific to a LOS communication environment and wherein the second state range is specific to a Non-LOS (NLOS) communication environment, and wherein the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment.

[00199] In one embodiment, in case of the first model and the second model are used for a CSI compression, a first number of compressed bits output by the first model is less than a second number of compressed bits output by the second model.

[00200] In one embodiment, the method further comprising: transmitting a CSI report to the second device, the CSI report comprising at least one of the first number of compressed bits or the second number of compressed bits.

[00201] In one embodiment, wherein at least one of: a first CSI report comprising the first number of compressed bits further comprises a first indication, the first indication being indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment; or a second CSI report comprising the second number of compressed bits further comprises a second indication, the second indication being indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

[00202] In one embodiment, a first size of a first input for the first model is less than a second size of a second input for the second model.

[00203] In one embodiment, one of the first size or the second size comprises at least one of: a number of sub-bands; a number of rows or columns of a channel matrix; a bandwidth of a subband; a number of beams; a number of Discrete Fourier Transform (DFT) vectors; a number of eigenvalues or eigenvectors; or a value of rank for a channel.

[00204] In some embodiments, a first group of historic channel information as an input for the first model crosses a longer time period than a second group of historic channel information as an input for the second model.

[00205] In one embodiment, the first group of historic channel information comprises a first number of latest measurement instances, the second group of historic channel information comprises a second number of latest measurement instances, wherein at least one of: the first number of latest measurement instances is greater than the second number of latest measurement instances; or a first time interval between adjacent measurement instances in the first group is greater than a second time interval between adjacent measurement instances in the second group.

[00206] In one embodiment, the first model is trained based on a first data sample labeled with the LOS communication environment, and wherein the second model is trained based a second data sample labeled with the NLOS communication environment.

[00207] In one embodiment, at least one of: a first quantization step for the first model is greater than a second quantization step for the second model; or a second quantization bit number for the second model is greater than a first quantization bit number for the first model.

[00208] In one embodiment, at least one of: a first criterion for a first loss function of the first model is looser than a second criterion for a second loss function of the second model; or a first constraint condition for the first model is looser than a second constraint condition for the second model.

[00209] In one embodiment, wherein at least one of: an association between at least one of a model or a parameter associated with the model and a state range of the LOS is predefined; the association is received from the second device; or the association is received in response to a request for the association transmitted by the first device.

[00210] In one embodiment, selecting the first model comprises determining, based on the first information and the association, at least one of: a first ID for the first model; a number of compressed bit; a compression ratio; an input data size; a pattern of a beam set for a beam measurement; a number of predicted beams; or a payload size of a beam report.

[00211] In one embodiment, selecting the first model comprises determining, based on the first information and a scaled value, at least one of: a number of compressed bit; a compression ratio; an input data size; a pattern of a beam set for a beam measurement; a number of predicted beams; or a payload size of a beam report.

[00212] In one embodiment, the method further comprising: in case of the first model and the second model are used for a BM, determining a first set of beams for the first model and a second set of beams for the second model, the first set of beams and the second set of beams being used for a beam measurement.

[00213] In one embodiment, a second number of beams in the second set of beams is greater than a first number of beams in the first set of beams.

[00214] In one embodiment, the beams in the first set of beams are distributed as a plurality of neighboring beams, and wherein the beams in the second set of beams are distributed randomly or uniformly in a spatial domain.

[00215] In one embodiment, the first set of beams is a subset of a third set of beams and wherein the second set of beams is different from a fourth set of beams, the third set of beams being a set of beams for a beam prediction, the fourth set of beams being another set of beams for a beam prediction.

[00216] In one embodiment, a first Reference Signal Received Power (RSRP) threshold for the first set of beams is greater than a second RSRP for the second set of beams.

[00217] In one embodiment, the first model outputs a first number of predictions for a first number of future time instances and each of the first number of predictions corresponds to a respective future time instances in the first number of future time instances, wherein the second model outputs a second number of predictions for a second number of future time instances and each of the second number of predictions corresponds to a respective future time instances in the second number of future time instances, one of the predictions comprising at least one predicted beam, and wherein at least one of: the first number of predictions is greater than the second number of predictions; a third time interval between adjacent time instances in the first number of future time instances is greater than a fourth time interval between adjacent time instances in the second number of future time instances; or a first lifetime for the first number of predictions is greater than a second lifetime of the second number of predictions.

[00218] In one embodiment, the method further comprising determining a first reported information for the first set of beams, the first reported information comprising at least one of: a first beam ID for a beam in the first set of beams and the first RSRP; or a second beam ID for a receive beam in the first set of beams.

[00219] In one embodiment, the method further comprising determining a second reported information for the second set of beams, the second reported information comprising at least one of: a third beam ID for a beam in the second set of beams, the second RSRP and a beam orientation of the beam; the third beam ID and a Signal to Interference plus Noise Ratio (SINR) associated with the beam; or a fourth beam ID for a transmit beam in the second set of beams.

[00220] In one embodiment, the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of: transmitting a first BM report to the second device, the first BM report comprising the first reported information; or transmitting a second BM report to the second device, the second BM report comprising the second reported information.

[00221] In one embodiment, the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of: transmitting a third BM report to the second device, the third BM report indicating a third number of beams predicted by the first model in the third set of beams and reported information associated with the third number of beams, and transmitting a fourth BM report to the second device, the fourth BM report indicating a fourth number of beams predicted by the second model in the fourth set of beams and reported information associated with the fourth number of beams, the fourth number being greater than the third number.

[00222] In one embodiment, receiving the first information from at least one of: the second device; a location server; or an AI or ML model.

[00223] In one embodiment, the method further comprises transmitting the first information to at least one of: the second device; a location server; or an AI or ML model.

[00224] In one embodiment, transmitting the first information comprises transmitting the first information per at least one of a transmission path, a beam, an antenna path, a resource set, a CSI-Reference Signal (RS) Resource Indicator (CSI), a Transmit-Receive-Point (TRP), a cell, a BandWidth Part (BWP) and a spectrum band.

[00225] In one embodiment, the first information further indicates at least one of: a location of the first device; a velocity of the first device; or a trajectory of the first device.

[00226] In one embodiment, the first information is used as an input data for the first model.

[00227] In one embodiment, where the first device comprises at least one of a terminal device or a network device.

[00228] A method of communication comprising: receiving, at a second device from a first device, a first Channel State Information (CSI) report comprising a number of compressed bits; receiving a first information on a state of Line-of-Sight (LOS) between the first device and a second device; determining, based on the first information, whether the state of LOS is within a first state range; and in response to determining that the state of LOS is within the first state range, selecting a first model for de-compressing the first CSI report, the first model being classified for the first state range.

[00229] In one embodiment, wherein one of the at least two models comprises at least one of: an Artificial Intelligence (AI) or Machine Learning (ML) model for a Channel State Information (CSI) de-compression.

[00230] In one embodiment, wherein receiving the first information by receiving the first CSI report.

[00231] In one embodiment, selecting the first model comprises: selecting the first model from at least two models that comprise the first model and a second model classified for a second state range, the second state range being at least partially different from the first state range.

[00232] In one embodiment, the first state range is specific to a LOS communication environment and wherein the second state range is specific to a Non-LOS (NLOS) communication environment, and wherein the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment.

[00233] In one embodiment, a first number of compressed bits for the first model is less than a second number of compressed bits output for the second model.

[00234] In one embodiment, the first CSI report comprising the first number of compressed bits further comprises a first indication, the first indication being indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment.

[00235] In one embodiment, a second CSI report comprising the second number of compressed bits further comprises a second indication, the second indication being indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

[00236] In one embodiment, receiving the first information from at least one of: the first device; a location server; or an AI or ML model.

[00237] In one embodiment, further comprising transmitting the first information to at least one of: the first device; a location server; or an AI or ML model.

[00238] In one embodiment, the first information further indicates at least one of: a location of the first device; a velocity of the first device; or a trajectory of the first device.

[00239] In one embodiment, the second device comprises a network device or a terminal device.

[00240] A terminal device comprising: a processor; and a memory coupled to the processor and storing instructions thereon, the instructions, when executed by the processor, causing the terminal device to perform the method according to above methods of communication.

[00241] A network device comprising: a processor; and a memory coupled to the processor and storing instructions thereon, the instructions, when executed by the processor, causing the network device to perform the method according to above methods of communication.

[00242] A computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to perform the method according to above methods of communication.

[00243] Without any limitation, terminologies and the corresponding descriptions related with this disclosure are listed as below in Table 3.

TABLE 3

Terminology	Description
Data collection	A process of collecting data by the network nodes, management entity, or UE for the purpose of AI/ML model training, data analytics and inference
AI/ML Model	A data driven algorithm that applies AI/ML techniques to generate a set of outputs based on a set of inputs.
AI/ML model training	A process to train an AI/ML Model [by learning the input/output relationship] in a data driven manner and obtain the trained AI/ML Model for inference
AI/ML model Inference	A process of using a trained AI/ML model to produce a set of outputs based on a set of inputs
AI/ML model validation	A subprocess of training, to evaluate the quality of an AI/ML model using a dataset different from one used for model training, that helps selecting model parameters that generalize beyond the dataset used for model training.
AI/ML model testing	A subprocess of training, to evaluate the performance of a final AI/ML model using a dataset different from one used for model training and validation. Differently from AI/ML model validation, testing does not assume subsequent tuning of the model.
UE-side (AI/ML) model	An AI/ML Model whose inference is performed entirely at the UE
Network-side (AI/ML) model	An AI/ML Model whose inference is performed entirely at the network
One-sided (AI/ML) model	A UE-side (AI/ML) model or a Network-side (AI/ML) model
Two-sided (AI/ML) model	A paired AI/ML Model(s) over which joint inference is performed, where joint inference comprises AI/ML Inference whose inference is performed jointly across the UE and the network, i.e, the first part of inference is firstly performed by UE and then the remaining part is performed by gNB, or vice versa.
AI/ML model transfer	Delivery of an AI/ML model over the air interface, either parameters of a model structure known at the

	receiving end or a new model with parameters. Delivery may contain a full model or a partial model.
Model download	Model transfer from the network to UE
Model upload	Model transfer from UE to the network
Federated learning / federated training	A machine learning technique that trains an AI/ML model across multiple decentralized edge nodes (e.g., UEs, gNBs) each performing local model training using local data samples. The technique requires multiple interactions of the model, but no exchange of local data samples.
Offline field data	The data collected from field and used for offline training of the AI/ML model
Online field data	The data collected from field and used for online training of the AI/ML model
Model monitoring	A procedure that monitors the inference performance of the AI/ML model
Supervised learning	A process of training a model from input and its corresponding labels.
Unsupervised learning	A process of training a model without labelled data.
Semi-supervised learning	A process of training a model with a mix of labelled data and un-labelled data
Reinforcement Learning (RL)	A process of training an AI/ML model from input (a.k.a. state) and a feedback signal (a.k.a. reward) resulting from the model's output (a.k.a. action) in an environment the model is interacting with.
Model activation	enable an AI/ML model for a specific function
Model deactivation	disable an AI/ML model for a specific function
Model switching	Deactivating a currently active AI/ML model and activating a different AI/ML model for a specific function

WHAT IS CLAIMED IS:

1. A method of communication, comprising:

receiving, at a first device, a first information on a state of Line-of-Sight (LOS) between the first device and a second device;

determining, based on the first information, whether the state of LOS is within a first state range; and

in response to determining that the state of LOS is within the first state range, selecting a first model classified for the first state range.

2. The method of claim 1, wherein selecting the first model comprises:

selecting the first model from at least two models that comprise the first model and a second model classified for a second state range, the second state range being at least partially different from the first state range.

3. The method of claim 2, wherein one of the at least two models comprises at least one of:

a first Artificial Intelligence (AI) or Machine Learning (ML) model for a Channel State Information (CSI) compression;

a second AI or ML model for a Beam Management (BM).

4. The method of claim 2, wherein the first model is different from the second model in at least one of:

a type of an AI or ML model;

a number of layers of an AI or ML model;

a branch of an AI or ML model;

a real valued parameter of an AI or ML model;

a complex valued parameter of an AI or ML model;

a number of compressed bits for an AI or ML model;

an input data size of an AI or ML model;

an output data size of an AI or ML model;

an input type of an AI or ML model; or

an output type of an AI or ML model.

5. The method of claim 2, wherein the first state range is specific to a LOS communication environment and wherein the second state range is specific to a Non-LOS (NLOS) communication environment, and

wherein the at least two models further comprises a third model classified for a third state range, the third state range being specific to a predefined default communication environment.

6. The method of claim 5, wherein in case of the first model and the second model are used for a CSI compression, a first number of compressed bits output by the first model is less than a second number of compressed bits output by the second mode.

7. The method of claim 6, further comprising:

transmitting a CSI report to the second device, the CSI report comprising at least one of the first number of compressed bits or the second number of compressed bits.

8. The method of claim 6, wherein at least one of:

a first CSI report comprising the first number of compressed bits further comprises a first indication, the first indication being indicative of the first number of compressed bits is determined by a model classified for the LOS communication environment; or

a second CSI report comprising the second number of compressed bits further comprises a second indication, the second indication being indicative of the second number of compressed bits is determined by a model classified for the NLOS communication environment.

9. The method of claim 5, wherein a first size of a first input for the first model is less than a second size of a second input for the second model.

10. The method of claim 5, wherein a first group of historic channel information as an input for the first model crosses a longer time period than a second group of historic channel information as an input for the second model.

11. The method of claim 10, wherein the first group of historic channel information comprises a first number of latest measurement instances, the second group of historic channel information comprises a second number of latest measurement instances, wherein at least one of:

the first number of latest measurement instances is greater than the second number of latest measurement instances; or

a first time interval between adjacent measurement instances in the first group is greater than a second time interval between adjacent measurement instances in the second group.

12. The method of claim 5, wherein at least one of:

an association between at least one of a model or a parameter associated with the model and a state range of the LOS is predefined;

the association is received from the second device; or

the association is received in response to a request for the association transmitted by the first device.

13. The method of claim 5, further comprising:

in case of the first model and the second model are used for a BM, determining a first set of beams for the first model and a second set of beams for the second model, the first set of beams and the second set of beams being used for a beam measurement.

14. The method of claim 13, wherein a second number of beams in the second set of beams is greater than a first number of beams in the first set of beams.

15. The method of claim 13, wherein the beams in the first set of beams are distributed as a plurality of neighboring beams, and wherein the beams in the second set of beams are distributed randomly or uniformly in a spatial domain.

16. The method of claim 13, wherein the first set of beams is a subset of a third set of beams and wherein the second set of beams is different from a fourth set of beams, the third set of beams being a set of beams for a beam prediction, the fourth set of beams being another set of beams for a beam prediction.

17. The method of claim 13, wherein the first model outputs a first number of predictions for a first number of future time instances and each of the first number of predictions corresponds to a respective future time instances in the first number of future time instances, wherein the second model outputs a second number of predictions for a second number of future time instances and each of the second number of predictions corresponds to a respective future time instances in the second number of future time instances, one of the predictions comprising at least one predicted beam, and wherein at least one of:

the first number of predictions is greater than the second number of predictions;

a third time interval between adjacent time instances in the first number of future time instances is greater than a fourth time interval between adjacent time instances in the second number of future time instances; or

a first lifetime for the first number of predictions is greater than a second lifetime of the second number of predictions.

18. The method of claim 17, further comprising determining a first reported information for the first set of beams, the first reported information comprising at least one of:

a first beam ID for a beam in the first set of beams and the first RSRP; or

a second beam ID for a receive beam in the first set of beams.

19. The method of claim 18, further comprising determining a second reported information for the second set of beams, the second reported information comprising at least one of:

a third beam ID for a beam in the second set of beams, the second RSRP and a beam orientation of the beam;

the third beam ID and a Signal to Interference plus Noise Ratio (SINR) associated with the beam; or

a fourth beam ID for a transmit beam in the second set of beams.

20. The method of claim 19, wherein the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of:

transmitting a first BM report to the second device, the first BM report comprising the first reported information; or

transmitting a second BM report to the second device, the second BM report comprising the second reported information.

21. The method of claim 17, wherein the first device is a terminal device and the second device is a network device, and wherein the method further comprises at least one of:

transmitting a third BM report to the second device, the third BM report indicating a third number of beams predicted by the first model in the third set of beams and reported information associated with the third number of beams, and

transmitting a fourth BM report to the second device, the fourth BM report indicating a fourth number of beams predicted by the second model in the fourth set of beams and reported information associated with the fourth number of beams, the fourth number being greater than the third number.

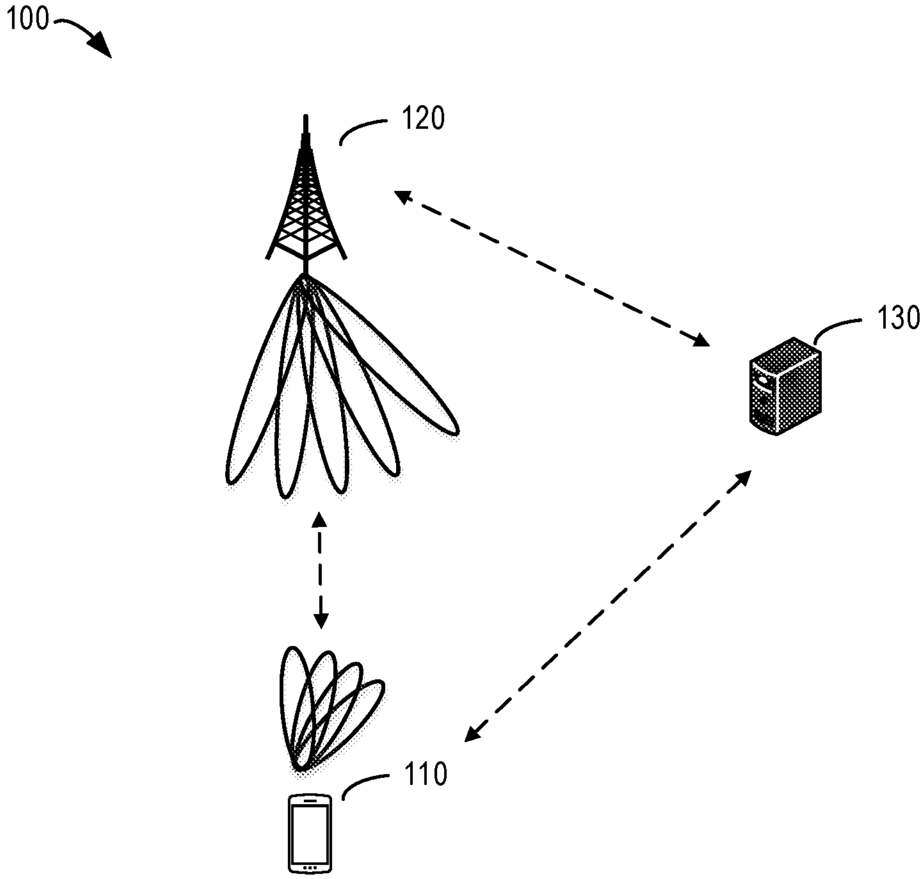

FIG. 1

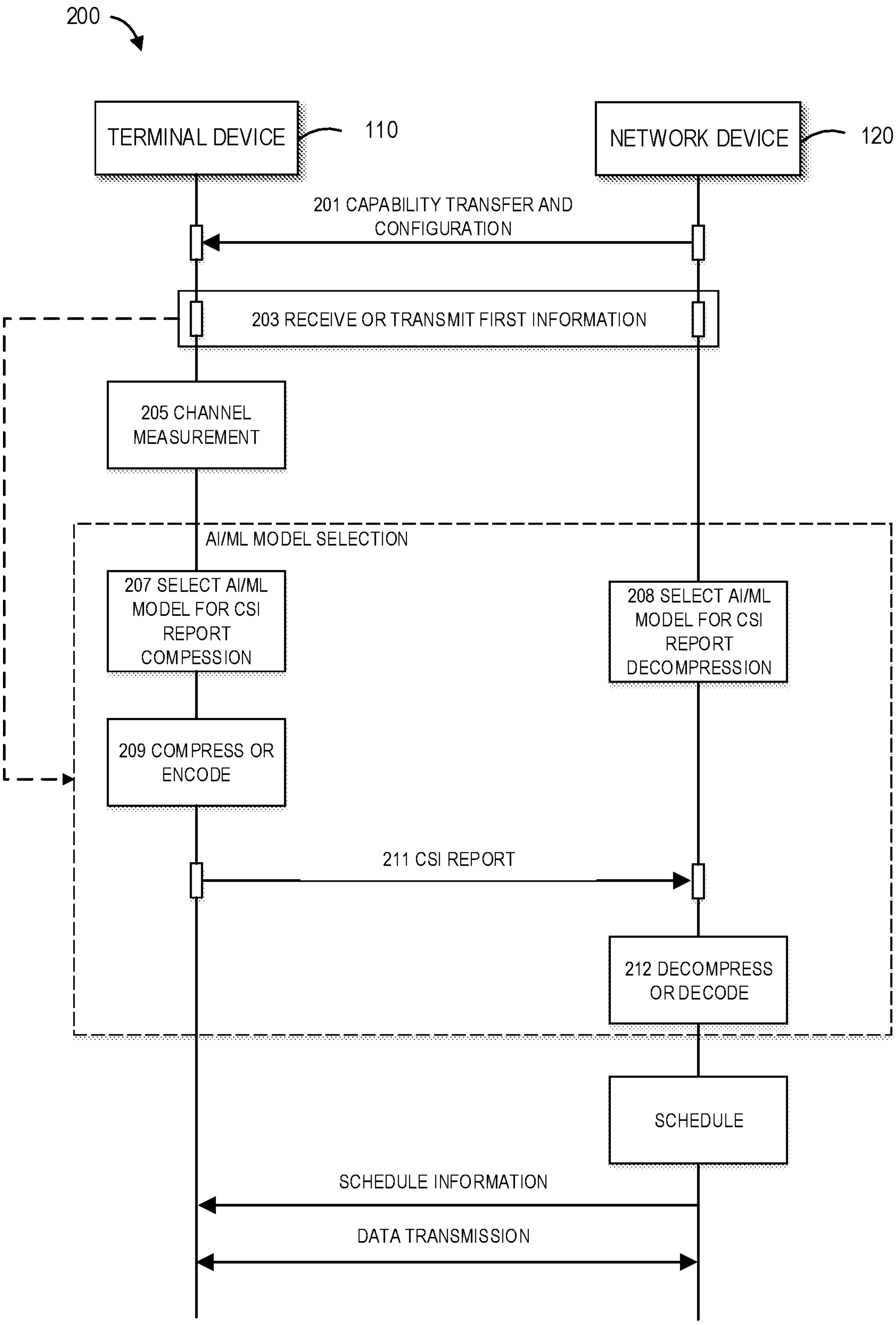
200
TERMINAL DEVICE
110
NETWORK DEVICE
120
201 CAPABILITY TRANSFER AND CONFIGURATION
203 RECEIVE OR TRANSMIT FIRST INFORMATION
205 CHANNEL MEASUREMENT
AI/ML MODEL SELECTION
207 SELECT AI/ML MODEL FOR CSI REPORT COMPESSION
208 SELECT AI/ML MODEL FOR CSI REPORT DECOMPRESSION
209 COMPRESS OR ENCODE
211 CSI REPORT
212 DECOMPRESS OR DECODE
SCHEDULE
SCHEDULE INFORMATION
DATA TRANSMISSION

FIG. 2

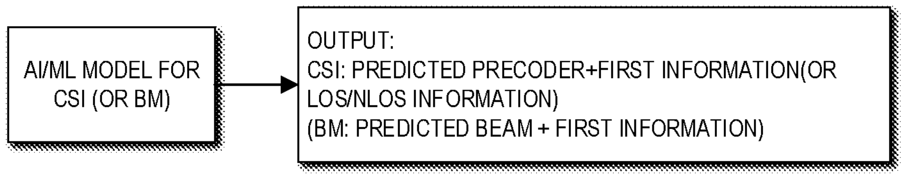

FIG. 3A

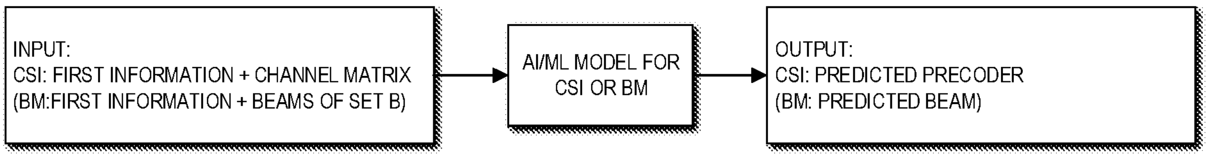

FIG. 3B

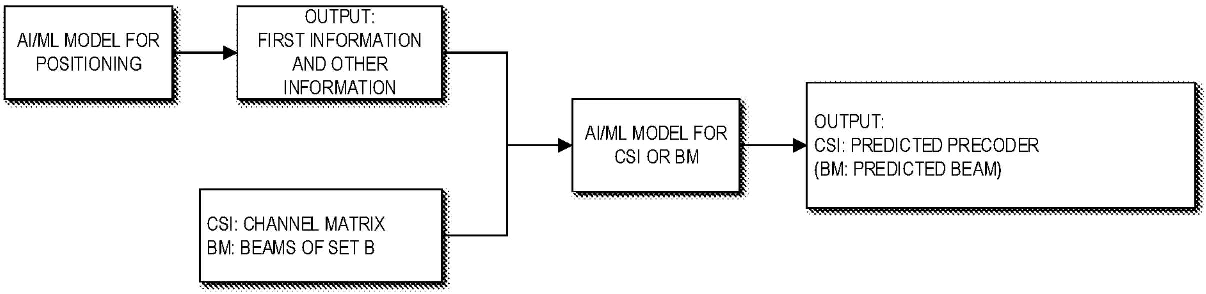

FIG. 3C

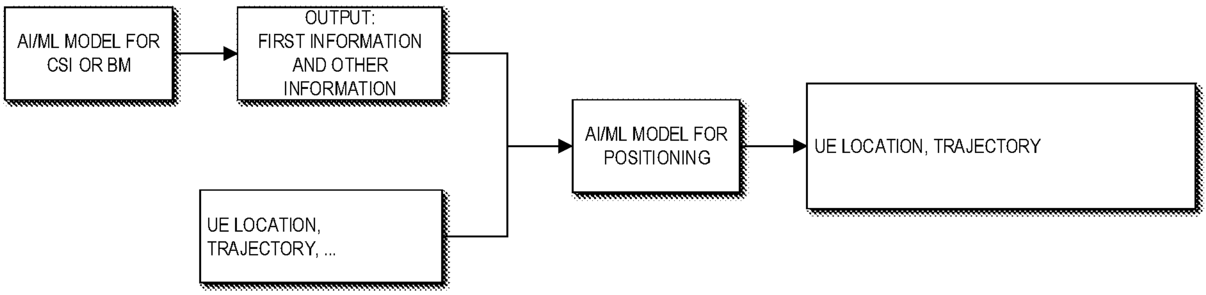

FIG. 3D

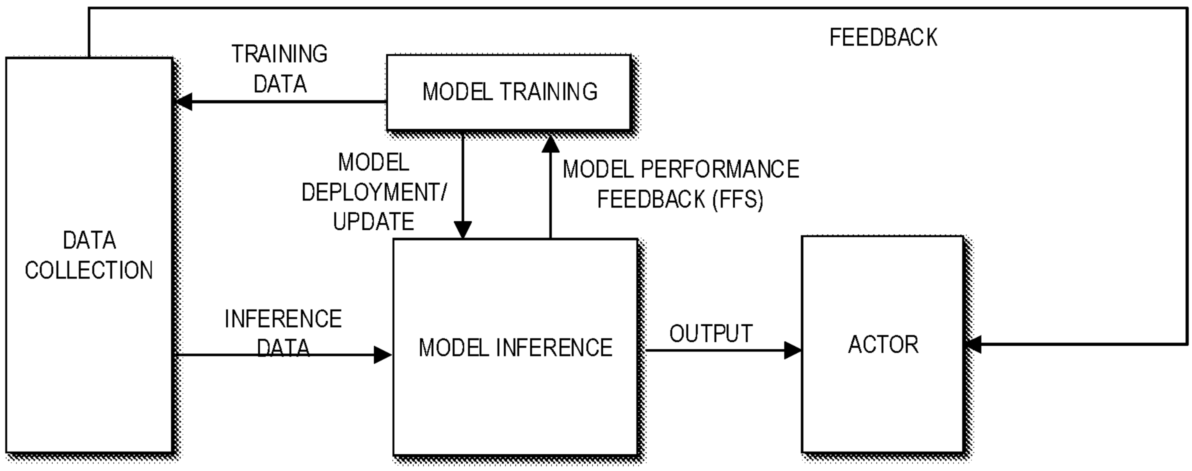
FEEDBACK
TRAINING DATA
MODEL TRAINING
DATA COLLECTION
MODEL DEPLOYMENT/ UPDATE
MODEL PERFORMANCE FEEDBACK (FFS)
INFERENCE DATA
MODEL INFERENCE
OUTPUT
ACTOR

FIG. 3E

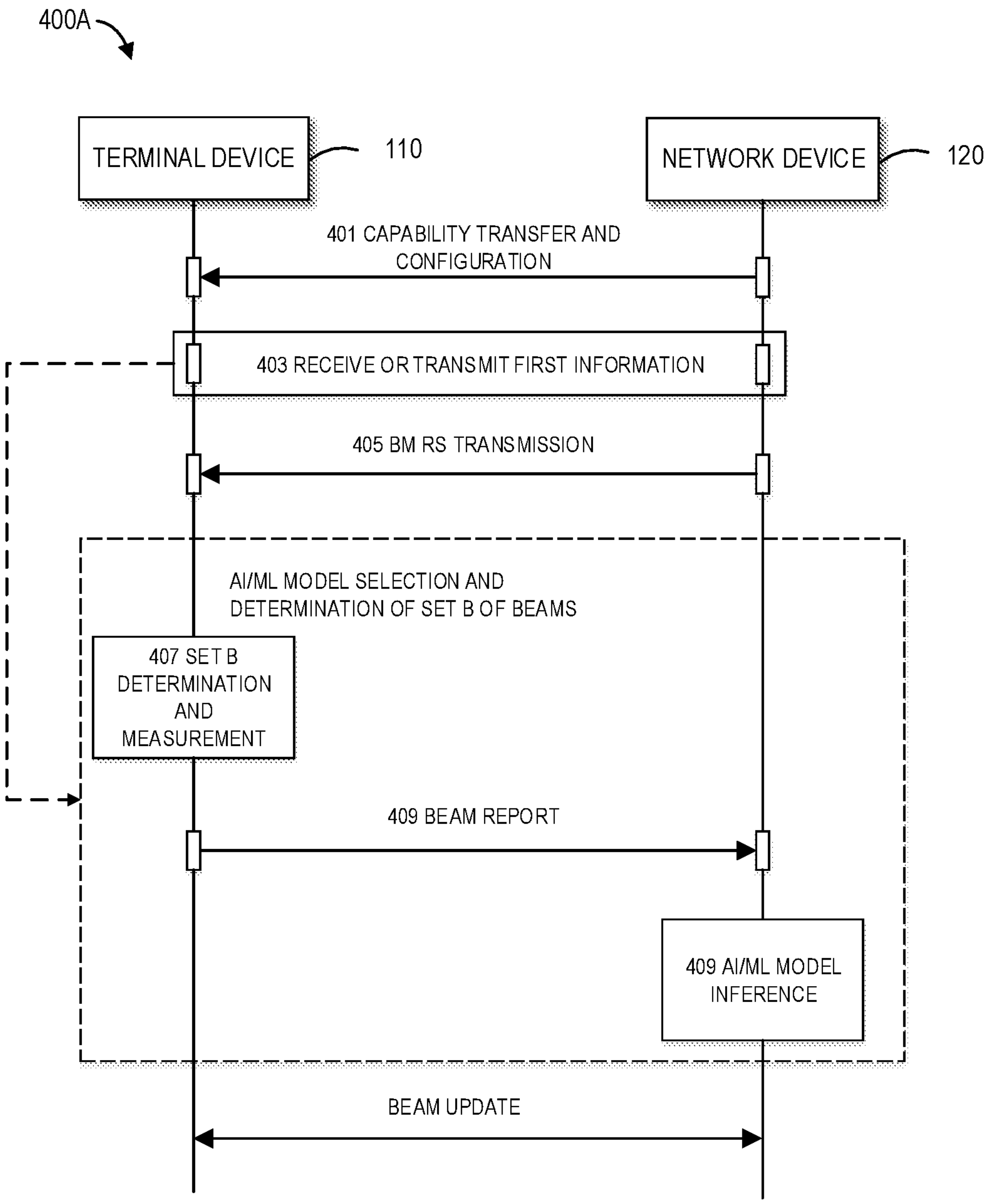
400A
TERMINAL DEVICE
110
NETWORK DEVICE
120
401 CAPABILITY TRANSFER AND CONFIGURATION
403 RECEIVE OR TRANSMIT FIRST INFORMATION
405 BM RS TRANSMISSION
AI/ML MODEL SELECTION AND DETERMINATION OF SET B OF BEAMS
407 SET B DETERMINATION AND MEASUREMENT
409 BEAM REPORT
409 AI/ML MODEL INFERENCE
BEAM UPDATE

FIG. 4A

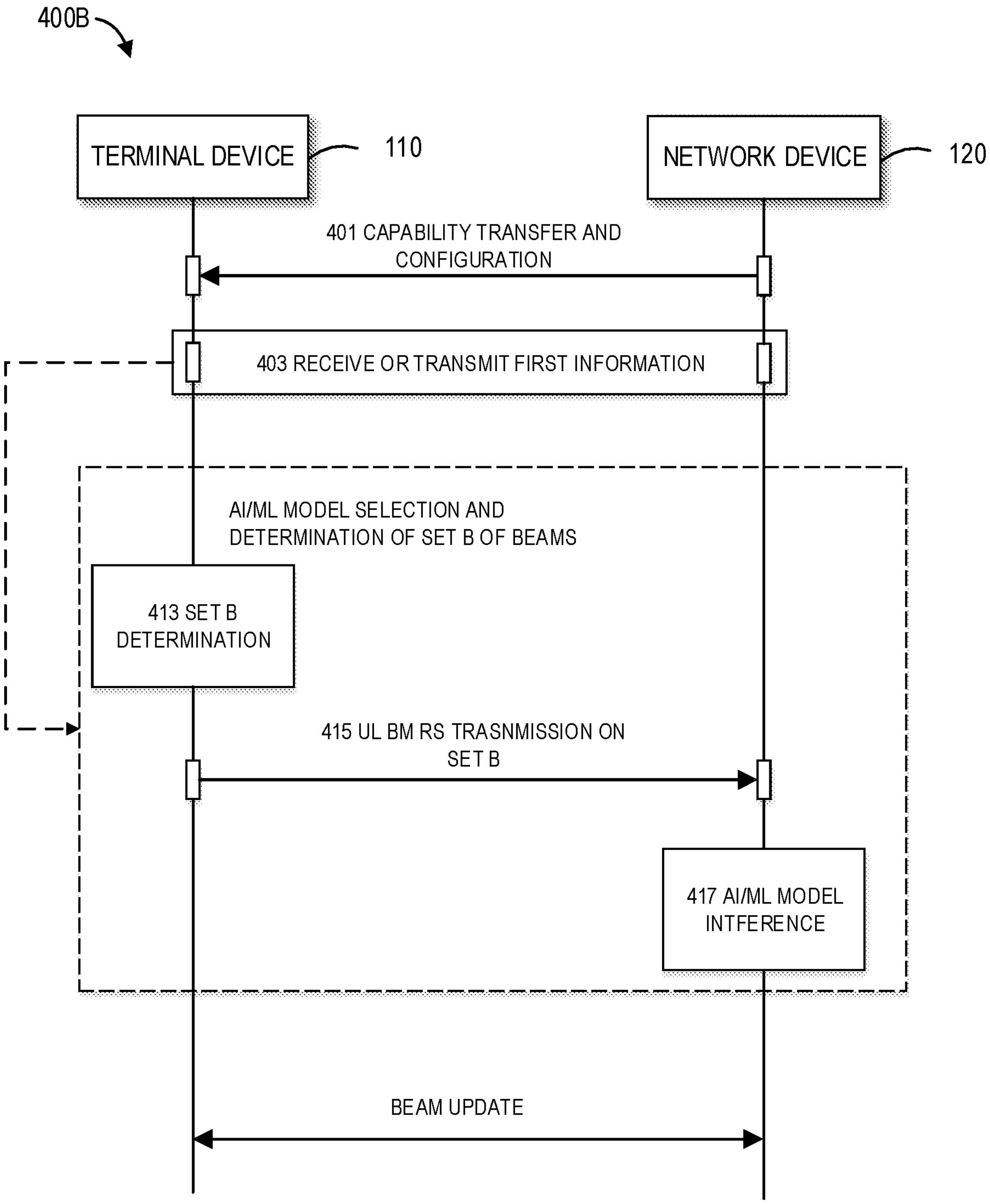
400B
TERMINAL DEVICE
110
NETWORK DEVICE
120
401 CAPABILITY TRANSFER AND CONFIGURATION
403 RECEIVE OR TRANSMIT FIRST INFORMATION
AI/ML MODEL SELECTION AND DETERMINATION OF SET B OF BEAMS
413 SET B DETERMINATION
415 UL BM RS TRASNMISSION ON SET B
417 AI/ML MODEL INTFERENCE
BEAM UPDATE

FIG. 4B

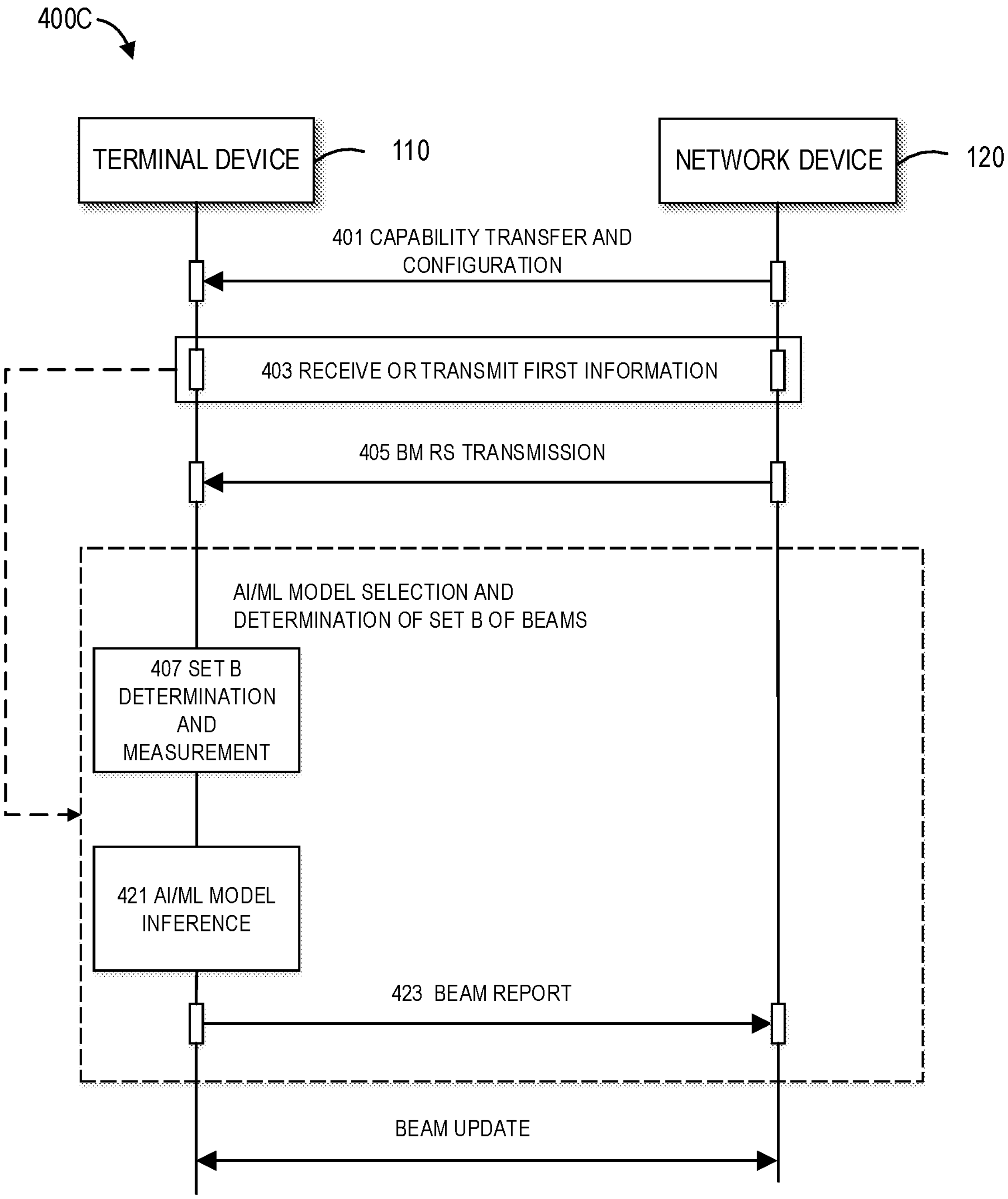
400C
TERMINAL DEVICE
110
NETWORK DEVICE
120
401 CAPABILITY TRANSFER AND CONFIGURATION
403 RECEIVE OR TRANSMIT FIRST INFORMATION
405 BM RS TRANSMISSION
AI/ML MODEL SELECTION AND DETERMINATION OF SET B OF BEAMS
407 SET B DETERMINATION AND MEASUREMENT
421 AI/ML MODEL INFERENCE
423 BEAM REPORT
BEAM UPDATE

FIG. 4C

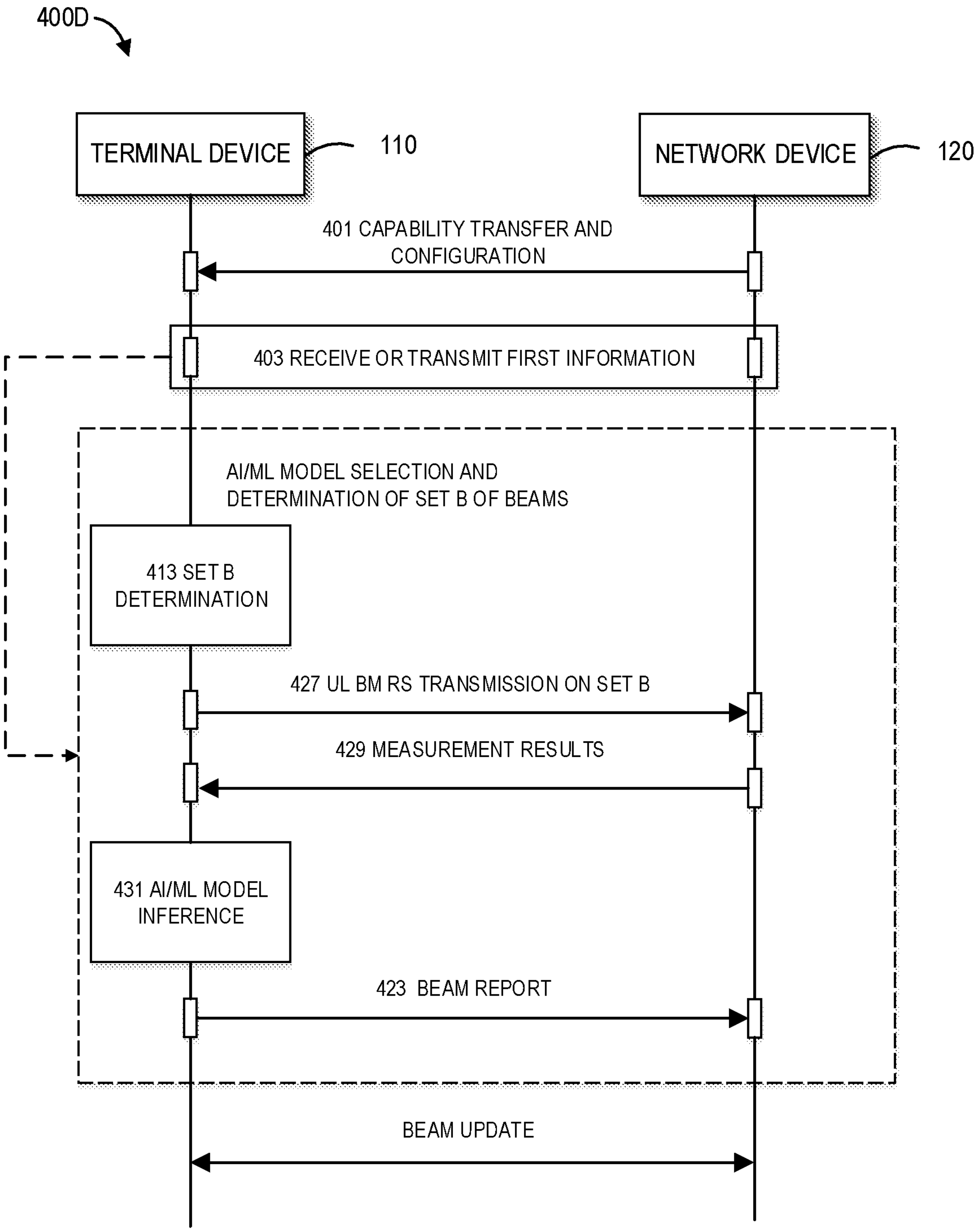
400D
TERMINAL DEVICE
110
NETWORK DEVICE
120
401 CAPABILITY TRANSFER AND CONFIGURATION
403 RECEIVE OR TRANSMIT FIRST INFORMATION
AI/ML MODEL SELECTION AND DETERMINATION OF SET B OF BEAMS
413 SET B DETERMINATION
427 UL BM RS TRANSMISSION ON SET B
429 MEASUREMENT RESULTS
431 AI/ML MODEL INFERENCE
423 BEAM REPORT
BEAM UPDATE

FIG. 4D

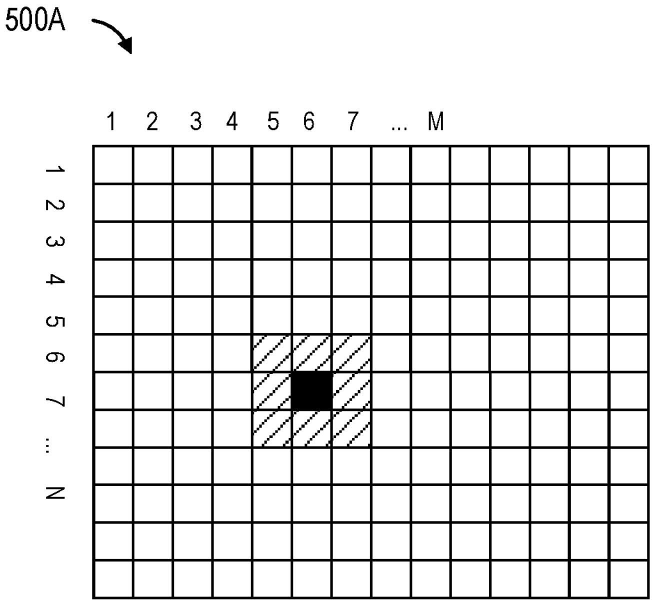

FIG. 5A

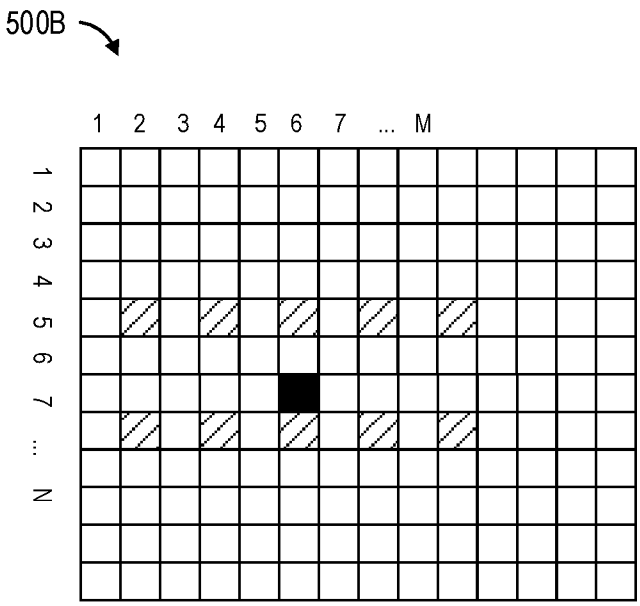

FIG. 5B

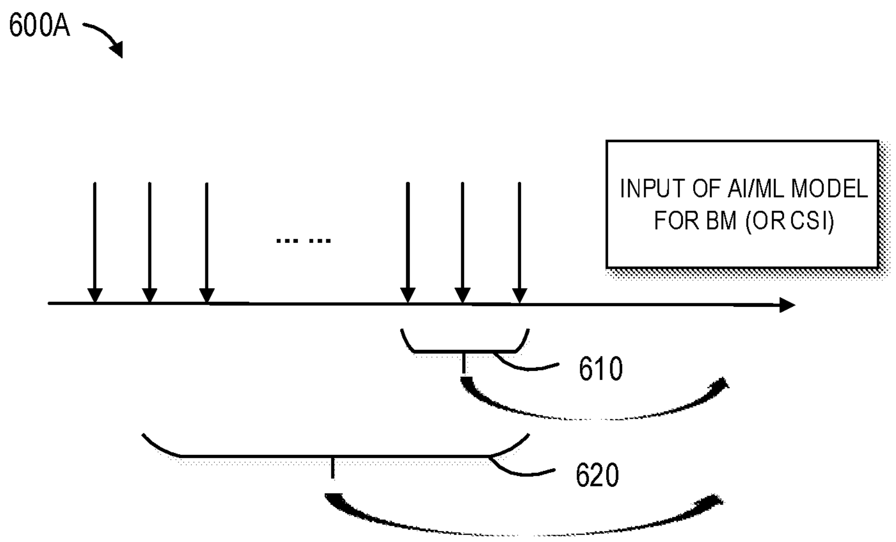

FIG. 6A

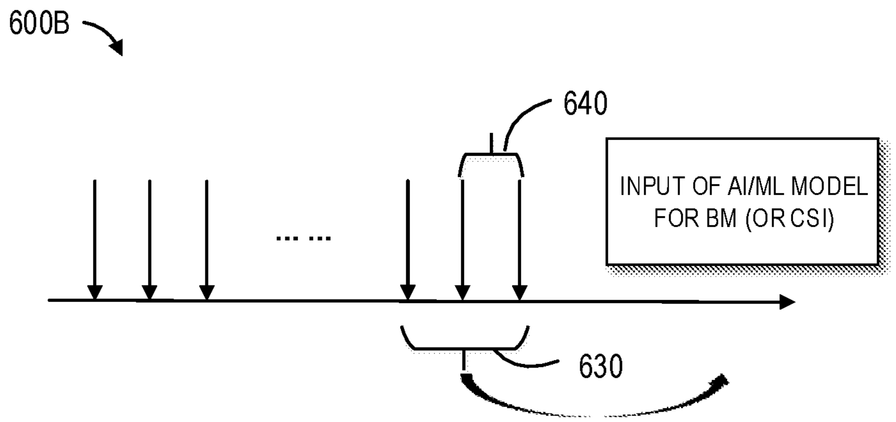

FIG. 6B

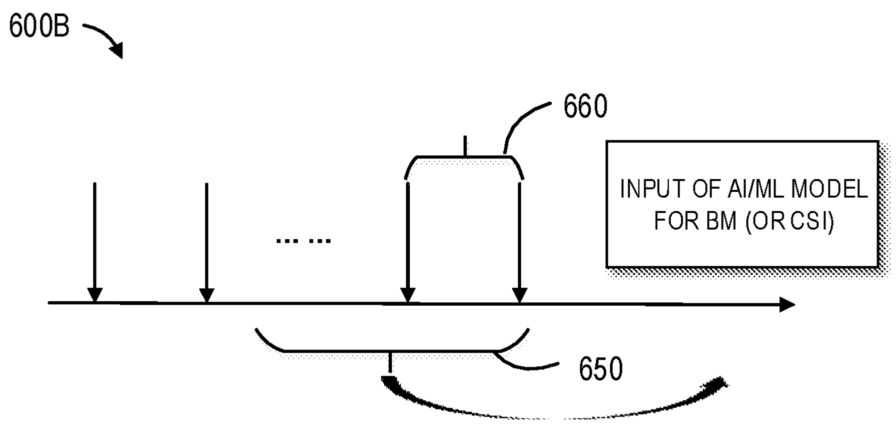

FIG. 6C

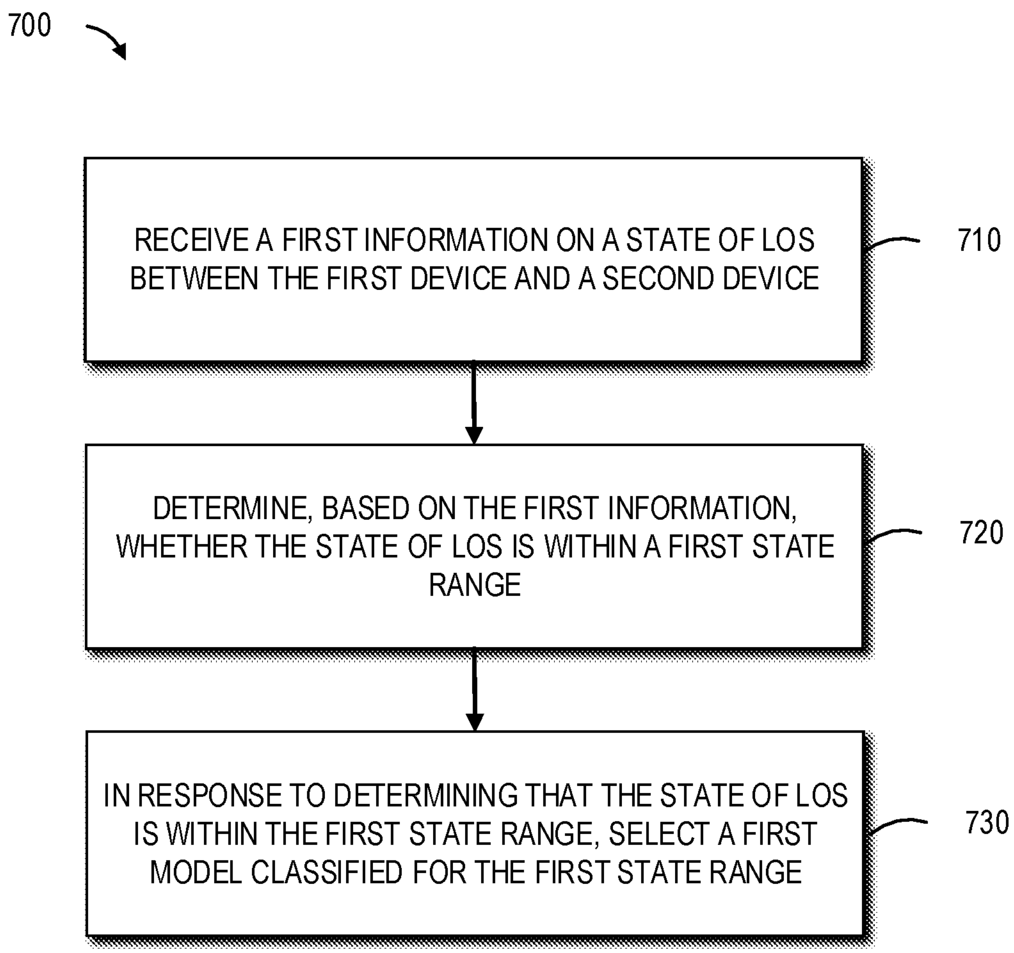
700
RECEIVE A FIRST INFORMATION ON A STATE OF LOS BETWEEN THE FIRST DEVICE AND A SECOND DEVICE
710
DETERMINE, BASED ON THE FIRST INFORMATION, WHETHER THE STATE OF LOS IS WITHIN A FIRST STATE RANGE
720
IN RESPONSE TO DETERMINING THAT THE STATE OF LOS IS WITHIN THE FIRST STATE RANGE, SELECT A FIRST MODEL CLASSIFIED FOR THE FIRST STATE RANGE
730

FIG. 7

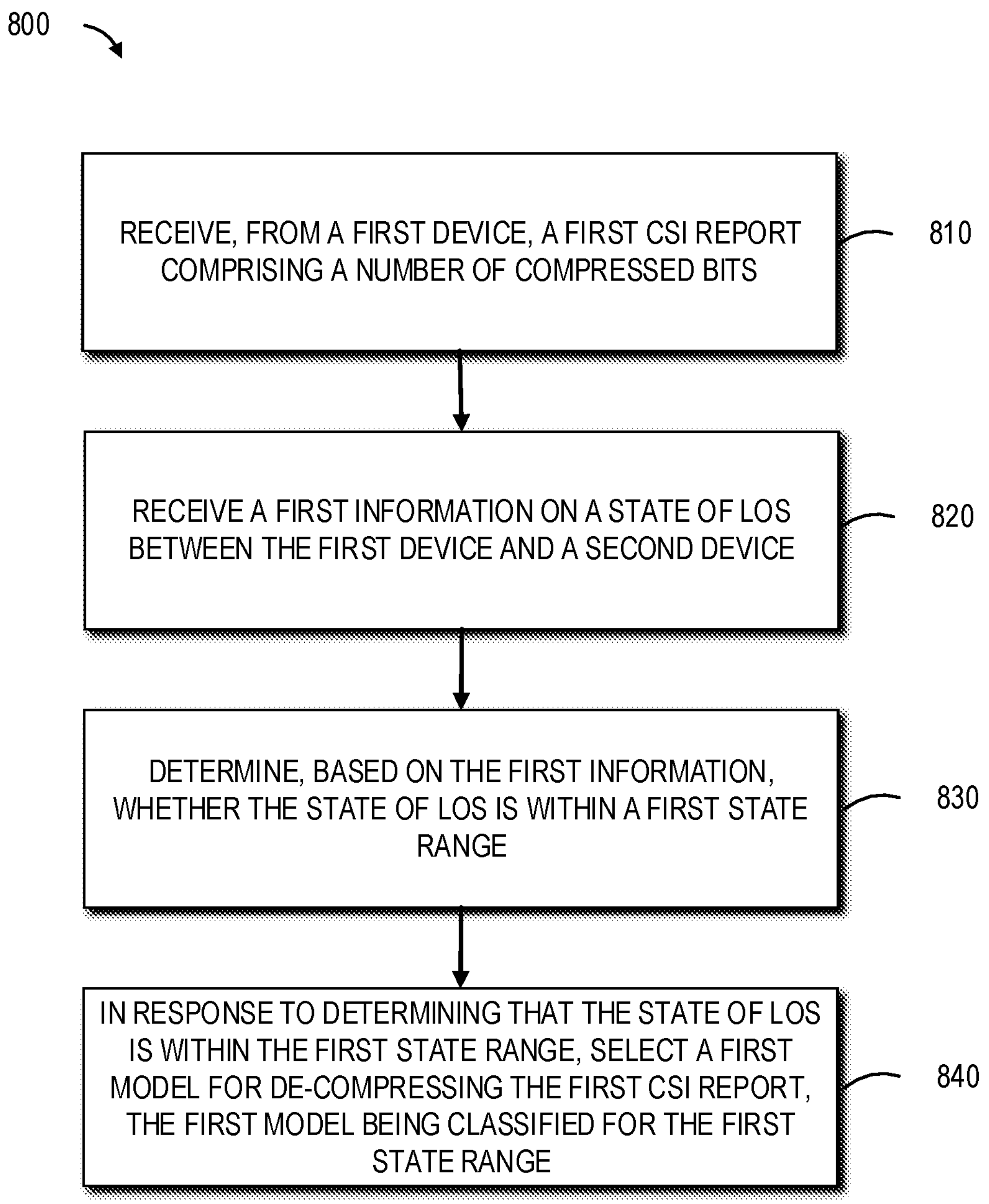
800
RECEIVE, FROM A FIRST DEVICE, A FIRST CSI REPORT COMPRISING A NUMBER OF COMPRESSED BITS
810
RECEIVE A FIRST INFORMATION ON A STATE OF LOS BETWEEN THE FIRST DEVICE AND A SECOND DEVICE
820
DETERMINE, BASED ON THE FIRST INFORMATION, WHETHER THE STATE OF LOS IS WITHIN A FIRST STATE RANGE
830
IN RESPONSE TO DETERMINING THAT THE STATE OF LOS IS WITHIN THE FIRST STATE RANGE, SELECT A FIRST MODEL FOR DE-COMPRESSING THE FIRST CSI REPORT, THE FIRST MODEL BEING CLASSIFIED FOR THE FIRST STATE RANGE
840

FIG. 8

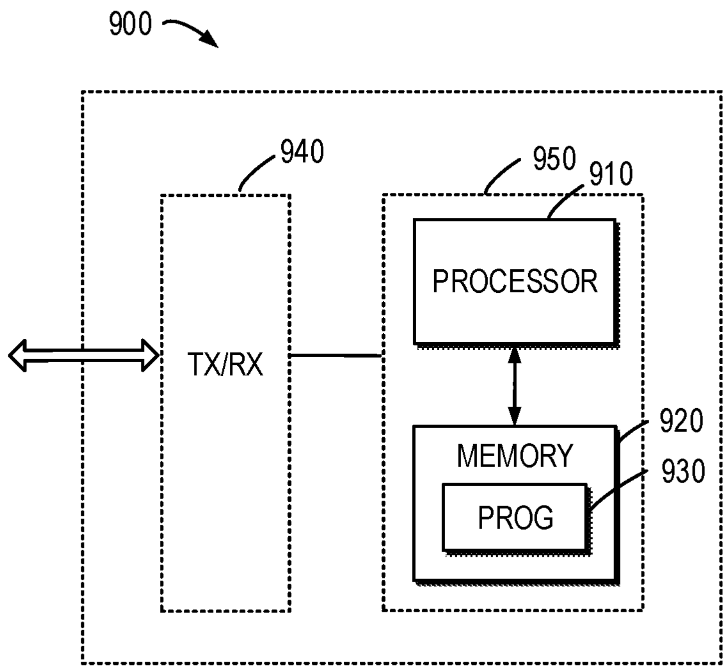

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/105988

A. CLASSIFICATION OF SUBJECT MATTER

H04L 5/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05L H04B 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)

CNPAT, WPI, EPODOC, CNKI, 3GPP:LOS, NLOS, line of sight, value, range, artificial intelligence, AI, ML, machine learning, model, select, choose, determine, CSI, channel state information, beam management, BM

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020177259 A1 (HUAWEI TECHNOLOGIES CO.， LTD.) 04 June 2020 (2020-06-04) description， paragraphs 0006-0026， 0038-0092	1-21
A	CN 114616762 A (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP.， LTD.) 10 June 2022 (2022-06-10) the whole document	1-21
A	CHINA TELECOM. "Study on NR coverage enhancements" *3GPP TSG RAN meeting #90e RP-202359,* 11 December 2020 (2020-12-11), pages 1-3， 23-34	1-21
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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08 December 2022	**20 December 2022**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/105988

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