

LINKING OF FUNCTIONALITY MONITORING RESOURCES TO FUNCTIONALITY RESOURCES

FIELDS

[0001] The present application claims priority from, and the benefit of, GB Application No. 2318463.3, filed December 4, 2023, the contents of which are hereby incorporated by reference in their entirety.

FIELDS

[0002] Various example embodiments of the present disclosure generally relate to the field of telecommunication and in particular, to methods, devices, apparatuses and computer readable storage medium for a linking of functionality monitoring resources to functionality resources.

BACKGROUND

[0003] Due to the great success of artificial intelligence (AI)/machine learning (ML) technologies, the AI/ML study item, which may refer to UE-sided model and network (NW) sided model, has been discussed in 3GPP.

SUMMARY

[0004] In a first aspect of the present disclosure, there is provided an apparatus. The apparatus comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: receive, from a network node, at least one channel state information (CSI) reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; obtain linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a

linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus; and determine the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.

[0005] In a second aspect of the present disclosure, there is provided an apparatus. The apparatus comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to: transmit, to a terminal device, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and provide, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

[0006] In a third aspect of the present disclosure, there is provided a method. The method comprises: receiving, from a network node, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; obtaining linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus; and determining the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.

[0007] In a fourth aspect of the present disclosure, there is provided a method. The method comprises: transmitting, to a terminal device, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first

resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and providing, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

[0008] In a fifth aspect of the present disclosure, there is provided an apparatus. The apparatus comprises means for receiving, from a network node, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; means for obtaining linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus; and means for determining the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.

[0009] In a sixth aspect of the present disclosure, there is provided an apparatus. The apparatus comprises means for transmitting, to a terminal device, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and means for providing, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

[0010] In a seventh aspect of the present disclosure, there is provided a computer readable medium. The computer readable medium comprises instructions stored thereon for causing an apparatus to perform at least the method according to the third aspect.

[0011] In an eighth aspect of the present disclosure, there is provided a computer

readable medium. The computer readable medium comprises instructions stored thereon for causing an apparatus to perform at least the method according to the fourth aspect.

[0012] It is to be understood that the Summary section is not intended to identify key or essential features of 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

[0013] Some example embodiments will now be described with reference to the accompanying drawings, where:

[0014] FIG. 1 illustrates an example communication environment in which example embodiments of the present disclosure can be implemented;

[0015] FIG. 2 illustrates a signaling chart illustrating an example of process according to some example embodiments of the present disclosure;

[0016] FIG. 3 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure;

[0017] FIG. 4 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure;

[0018] FIG. 5 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure;

[0019] FIG. 6 illustrates a flowchart of a method implemented at an apparatus according to some example embodiments of the present disclosure;

[0020] FIG. 7 illustrates a flowchart of a method implemented at an apparatus according to some example embodiments of the present disclosure;

[0021] FIG. 8 illustrates a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure; and

[0022] FIG. 9 illustrates a block diagram of an example computer readable medium in accordance with some example embodiments of the present disclosure.

[0023] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0024] Principle of the present disclosure will now be described with reference to some example 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 limitation as to the scope of the disclosure. Embodiments described herein can be implemented in various manners other than the ones described below.

[0025] 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.

[0026] References in the present disclosure to “one embodiment,” “an embodiment,” “an example embodiment,” and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0027] It shall be understood that although the terms “first,” “second,” ..., etc. in front of noun(s) and the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another and they do not limit the order of the noun(s). For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0028] As used herein, “at least one of the following: <a list of two or more elements>” and “at least one of <a list of two or more elements>” and similar wording, where the list of two or more elements are joined by “and” or “or”, mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

[0029] As used herein, unless stated explicitly, performing a step “in response to A” does not indicate that the step is performed immediately after “A” occurs and one or more intervening steps may be included.

[0030] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. 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. It will be further understood that the terms “comprises”, “comprising”, “has”, “having”, “includes” and/or “including”, when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0031] As used in this application, the term “circuitry” may refer to one or more or all of the following:

- (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and
- (b) combinations of hardware circuits and software, such as (as applicable):
 - (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and
 - (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and
- (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0032] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0033] As used herein, the term “communication network” refers to a network following any suitable communication standards, such as New Radio (NR), Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Narrow Band Internet of Things (NB-IoT) and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, 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), the sixth generation (6G) communication protocols, and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0034] As used herein, the term “network device” refers to a node in a communication network via which a terminal device accesses the network and receives services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), an NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, an Integrated Access and Backhaul (IAB) node, a low power node such as a femto, a pico, a non-terrestrial network (NTN) or non-ground network device such as a satellite network device, a low earth orbit (LEO) satellite and a geosynchronous earth orbit (GEO) satellite, an aircraft network device, and so forth, depending on the applied terminology and technology. In some example embodiments, radio access network (RAN)

split architecture comprises a Centralized Unit (CU) and a Distributed Unit (DU) at an IAB donor node. An IAB node comprises a Mobile Terminal (IAB-MT) part that behaves like a UE toward the parent node, and a DU part of an IAB node behaves like a base station toward the next-hop IAB node.

[0035] The term “terminal device” refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a communication device, user equipment (UE), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VoIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of Things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. The terminal device may also correspond to a Mobile Termination (MT) part of an IAB node (e.g., a relay node). In the following description, the terms “terminal device”, “communication device”, “terminal”, “user equipment” and “UE” may be used interchangeably.

[0036] As used herein, the term “resource,” “transmission resource,” “resource block,” “physical resource block” (PRB), “uplink resource,” or “downlink resource” may refer to any resource for performing a communication, for example, a communication between a terminal device and a network device, such as a resource in time domain, a resource in frequency domain, a resource in space domain, a resource in code domain, or any other combination of the time, frequency, space and/or code domain resource enabling a communication, and the like. In the following, unless explicitly stated, a resource in both frequency domain and time domain will be used as an example of a transmission resource for describing some example embodiments of the present disclosure. It is noted that

example embodiments of the present disclosure are equally applicable to other resources in other domains.

[0037] During the discussion on AI/ML study item on 3GPP, two different ML-related identification types are agreed, namely a functionality identification and a model-identification, where the model identification was assumed to use a “model-ID” in the identification process and functionality identification was assumed to use a “functionality” in the identification process. The descriptions of the two ML-related identification type are listed as below:

- Model identification: A process/method of identifying an AI/ML model for the common understanding between the NW and the UE.

Note: The process/method of model identification may or may not be applicable.

Note: Information regarding the AI/ML model may be shared during model identification.

- Functionality identification: A process/method of identifying an AI/ML functionality for the common understanding between the NW and the UE.

Note: Information regarding the AI/ML functionality may be shared during functionality identification.

[0038] Some agreements related to functionality-life cycle management (LCM) and model-ID-based LCM are listed as below:

For UE-side models and UE-part of two-sided models:

- For AI/ML functionality identification:
 - Reuse legacy 3GPP framework of Features as a starting point for discussion.
 - UE indicates supported functionalities/functionality for a given sub-use-case.
 - UE capability reporting is taken as starting point.
- For AI/ML model identification:
 - Models are identified by model ID at the Network. UE indicates supported AI/ML models.
- In functionality-based LCM:
 - Network indicates activation/deactivation/fallback/switching of AI/ML functionality via 3GPP signaling (e.g., RRC, MAC-CE, DCI).
 - Models may not be identified at the Network, and UE may perform model-level LCM.
 - Study whether and how much awareness/interaction NW should

have about model-level LCM.

In model-ID-based LCM, models are identified at the Network, and Network/UE may activate/deactivate/select/switch individual AI/ML models via model ID.

- AI/ML-enabled Feature refers to a Feature where AI/ML may be used.
- For functionality identification, there may be either one or more than one Functionalities defined within an AI/ML-enabled feature.

[0039] Furthermore, further agreements related to functionality-LCM and model-ID-based LCM are listed as below:

- For AI/ML functionality identification and functionality-based LCM of UE-side models and/or UE-part of two-sided models:
 - Functionality refers to an AI/ML-enabled Feature/FG enabled by configuration(s), where configuration(s) is(are) supported based on conditions indicated by UE capability.
 - Correspondingly, functionality-based LCM operates based on, at least, one configuration of AI/ML-enabled Feature/FG or specific configurations of an AI/ML-enabled Feature/FG.
 - FFS: Signaling to support functionality-based LCM operations, e.g., to activate/deactivate/fallback/switch AI/ML functionalities.
 - FFS: Whether/how to address additional conditions (e.g., scenarios, sites, and datasets) to aid UE-side transparent model operations (without model identification) at the Functionality level.
 - FFS: Other aspects that may constitute Functionality.
 - FFS: which aspects should be specified as conditions of a Feature/FG available for functionality will be discussed in each sub-use-case agenda.
- For AI/ML model identification and model-ID-based LCM of UE-side models and/or UE-part of two-sided models:
 - model-ID-based LCM operates based on identified models, where a model may be associated with specific configurations/conditions associated with UE capability of an AI/ML-enabled Feature/FG and additional conditions (e.g., scenarios, sites, and datasets) as determined/identified between UE-side and NW-side.
 - FFS: Which aspects should be considered as additional conditions, and how to include them into model description information during model identification will be discussed in each sub-use-case agenda.

- FFS: Relationship between functionality and model, e.g., whether a model may be identified referring to functionality(s).
 - FFS: relationship between functionality-based LCM and model-ID-based LCM.
- Note: Applicability of functionality-based LCM and model-ID-based LCM is a separate discussion.

[0040] For AI/ML enhancements related to beam management (BM), two sub-use cases have been identified, namely beam prediction in the spatial domain (BM-Case1) and beam prediction in the time domain (BM-Case2). The primary motivation is to support a reduced overhead and lower beam measurements and reporting latency.

[0041] Some agreements related to the AI/ML for BM and related agreements for the present disclosure are listed as below:

For AI/ML-based beam management, support BM-Case1 and BM-Case2 for characterization and baseline performance evaluations:

- BM-Case1: Spatial-domain DL beam prediction for Set A of beams based on measurement results of Set B of beams.
- BM-Case2: Temporal DL beam prediction for Set A of beams based on the historic measurement results of Set B of beams.

For the sub use case BM-Case1 and BM-Case2, further study the following alternatives for the predicted beams:

- Alt.1: DL Tx beam prediction.
- Alt.2: DL Rx beam prediction.
- Alt.3: Beam pair prediction (a beam pair consists of a DL Tx beam and a corresponding DL Rx beam).
- Note1: DL Rx beam prediction may or may not have spec impact.

In order to facilitate the AI/ML model inference, study the following aspects as a starting point:

- Enhanced or new configurations/UE reporting/UE measurement, e.g., Enhanced or new beam measurement and/or beam reporting.
- Enhanced or new signaling for measurement configuration/triggering.
- Signaling of assistance information (if applicable).
- Other aspect(s) is not precluded.

[0042] For BM-Case1 and BM-Case2 with a UE-side AI/ML model, study potential

specification impact of AI model inference from the following additional aspects on top of previous agreements:

- Indication of the associated Set A from network to UE, e.g., association/mapping of beams within Set A and beams within Set B if applicable
- Beam indication from network for UE reception
- Note: The second bullet may or may not have additional specification impact (e.g., legacy mechanism may be reused).

[0043] Based on the agreement and discussion, the AI/ML for BM may be supported by single-sided models and consider supporting the necessary/recommended LCM components for selected sub use cases.

[0044] For AI-based beam management, the following recommendations are made:

- BM-Case1 refers to spatial-domain DL beam prediction for Set A of beams based on measurement results of Set B of beams; and BM-Case2 refers to temporal DL beam prediction for Set A of beams based on the historic measurement results of Set B of beams;
- DL Tx beam prediction may be used for both UE-sided model and NW-sided model;
- Necessary signaling/mechanism(s) to facilitate data collection, model inference, and performance monitoring for both UE-sided model and NW-sided model;
- Signaling/mechanism(s) to facilitate necessary LCM operations via 3GPP signaling for UE-sided model.

[0045] For data collection, model inference and performance monitoring, the signaling aspects include the indication of the associated Set A from the network to the UE, e.g., the association/mapping of beams within Set A and beams within Set B, in addition to the indication of beams from the network for UE reception. These aspects may cover both BM-Case1 and BM-Case2 with a UE-side AI/ML model. The aim is to investigate the potential specification impact of AI model inference.

[0046] For an ML-based beam prediction applied at the UE, it is possible to use the ML model to predict the best Tx beam or Tx-Rx beam pair(s) by using a subset of measurements at the input of the ML model and reporting the predicted Top-K best beam to the NW.

[0047] The CSI framework includes the procedure of a particular CSI-reference signal (RS) indicated to be measured by the NW and related feedback information from the UE.

The current specification allows to define the use of two CSI resource configurations, namely one for channel measurements and the other for interference measurements. The CSI-RS configuration of type non-zero-power (NZP)-CSI-RS enables resources dedicated for channel measurements (known as channel measurement resources (CMR)), whereas the CSI-RS configuration of the type zero-power (ZP)-CSI-RS enables resources dedicated for interference measurements (known as information measurement (IM)).

[0048] Nevertheless, for the inference operation of UE-sided AI/ML beam prediction, the NW and UE shall have common understanding on what is assumed as the prediction beam set, which is neither included in the NZP-CSI-RSs for channel measurements, nor in the ZP-CSI-RSs for interference measurements.

[0049] Therefore, in the scenario of using CSI report configuration for UE-sided beam prediction (i.e., functionality of beam prediction may be supported by CSI-ReportConfig), the NW may indicate the UE which prediction resources (or resource set) from the current CSI-RS resources (resource set) for measurements should be used when reporting the CSI resource indicators (CRIs)/ Synchronization Signal Block resource indicators (SSBRIs) corresponding to the predicted beams. In summary, during the AI/ML model inference, the UE derives the prediction resources (or resource set) from the current CSI-RS resources (resource set) configuration received from the NW and the UE uses the prediction resources when reporting the CRIs/ SSBRIs and corresponding other CSI quantities in the CSI report. In addition, the UE determines the dimensioning of the CRI or SSBRI of the prediction resources.

[0050] For beam prediction functionality with UE-side models, the NW may configure the functionality for reporting predicted beams. Necessary signaling mechanism(s) has been discussed to facilitate performance monitoring for AI/ML functionality such as beam prediction running at the UE side. The AI/ML functionality monitoring may be requested by the UE to verify that the ML model performing the functionality is working properly, or alternatively to find the best performing model for a functionality or to perform any other operation with the ML model transparent to the NW.

[0051] The additional resources required for measurements in the functionality performance monitoring can significantly increase the CSI-RS transmissions at the NW, especially if the functionality monitoring is requested by the UE frequently. In addition, the UE may have multiple functionalities enabled and running at the same time. For

instance, the UE may have one functionality dedicated to beam prediction in the spatial domain (BMCase1) and another functionality dedicated to beam prediction in time domain (BMCase2). Multiple functionalities may relate to different AI/ML use cases, such as one functionality dedicated to beam prediction and another functionality dedicated to CSI prediction, etc.

[0052] A fundamental issue will be that each functionality may require a different functionality monitoring, and therefore a specific CSI-RS resource set associated to a full set of beams to be measured in order to calculate the relevant KPIs for monitoring the functionality. The resources configured by the NW for measurements may increase further when considering multiple functionalities running in parallel at the UE side.

[0053] Therefore, in the scenario where a CSI report configuration is used for functionality monitoring at the UE side (the functionality of beam prediction may be also supported by at least one different *CSI-ReportConfig*), the UE may request a specific CSI-RS resource set assumed for the functionality monitoring in addition to another set of resources assumed for the functionality.

[0054] This method is proposed to enable the indication to the UE of the link between resources used for the functionality and resources used for functionality monitoring and this method is proposed for the NW to configure resources for functionality monitoring that partially or fully overlap with the resources dedicated to the functionality, or another set of resources dedicated to other functionalities that can be re-used for the functionality monitoring, either.

[0055] Furthermore, the UE may request data collection for a functionality. Therefore, the NW may configure an additional set of resources that enable data collection. It is unknown whether the resources that are used for data collection and are configured with a separate CSI report can be associated to the one used for the functionality. It is unclear whether the resources used for performance monitoring can be associated to the resources used for the functionality if they are configured with a separate CSI report.

[0056] Therefore, solutions for linking resources dedicated to the functionality and resources that are dedicated for the functionality monitoring will be discussed with reference to embodiments of the present disclosure.

[0057] The present disclosure proposes a mechanism for a linking of functionality

monitoring resources to functionality resources. In this solution, the terminal device receives at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device. The at least one first functionality may be associated to a first resource configuration and the functionality monitoring may be associated to a functionality monitoring resource configuration. The terminal device obtains linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device. At least based on the linking information and the functionality monitoring resource configuration, the terminal device determines the functionality monitoring resource set used for monitoring the at least one first functionality.

[0058] Example embodiments of the present disclosure will be described in detail below with reference to the accompanying drawings.

[0059] FIG. 1 shows an example communication network 100 in which embodiments of the present disclosure may be implemented. As shown in FIG. 1, the communication network 100 may include a terminal device 110. Hereinafter the terminal device 110 may also be referred to as a UE.

[0060] The communication network 100 may further include a network node 120. Hereinafter the network node 120 may also be referred to as a gNB or an eNB, respectively. The terminal device 110 may communicate with the network node 120 within a coverage of a cell 102 managed by the network node 120.

[0061] It is to be understood that the number of network nodes and terminal devices shown in FIG. 1 is given for the purpose of illustration without suggesting any limitations. The communication network 100 may include any suitable number of network nodes and terminal devices.

[0062] In some example embodiments, links from the network node 120 to the terminal device 110 may be referred to as a downlink (DL), while links from the terminal device 110 to the network node 120 may be referred to as an uplink (UL). In DL, the network node 120 is a transmitting (TX) device (or a transmitter) and the terminal device 110 is a receiving (RX) device (or receiver). In UL, the terminal device 110 is a TX device (or transmitter) and the network node 120 is a RX device (or a receiver).

[0063] Communications in the communication environment 100 may be implemented according to any proper communication protocol(s), comprising, but not limited to, cellular communication protocols of the first generation (1G), the second generation (2G), the third generation (3G), the fourth generation (4G), the fifth generation (5G), the sixth generation (6G), and the like, wireless local network communication protocols such as Institute for Electrical and Electronics Engineers (IEEE) 802.11 and the like, and/or any other protocols currently known or to be developed in the future. Moreover, the communication may utilize any proper wireless communication technology, comprising but not limited to: Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Frequency Division Duplex (FDD), Time Division Duplex (TDD), Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiple (OFDM), Discrete Fourier Transform spread OFDM (DFT-s-OFDM) and/or any other technologies currently known or to be developed in the future.

[0064] Reference is now made to FIG. 2, which shows a signaling chart 200 for communication according to some example embodiments of the present disclosure. As shown in FIG. 2, the signaling chart 200 involves the terminal device 110 and the network device 120. For the purpose of discussion, reference is made to FIG. 1 to describe the signaling chart 200.

[0065] As described above, the terminal device 110 may be capable of functionalities, e.g., AI/ML functionalities. The terminal device 110 may inform the network node 120 about the functionalities supported by the terminal device 110. Thus, the terminal device 110 may transmit (202) a capability report to the network device 120 containing information for the AI/ML functionality.

[0066] Then the network node 120 may configure (204) the terminal device 110 with at least one CSI reporting configuration associated with at least one functionality of the terminal device 110 (hereinafter may also be referred to as at least one first functionality of the terminal device 110). The at least one CSI reporting configuration associated with at least one functionality may be associated to a first resource configuration. Based on the first resource configuration, the terminal device 110 may derive a set of resources (hereinafter may also be referred to a second set of resource) to perform measurements required by the at least one first functionality. For example, the second set of resources may correspond to a set of beams (which may also be referred to as “Set B beam” or a

second set of beams hereinafter).

[0067] For example, the terminal device 110 perform measurements required by the at least one first functionality based on a CSI-RS resource set indicated in the at least one CSI reporting configuration (which may also be referred to the CSI report setting #1 hereinafter) and may use the measurements as input of a UE-sided model used by the terminal device 110 for the at least one first functionality.

[0068] As described above, performance monitoring for AI/ML functionality may also be requested by the terminal device, for example, to verify that the ML model performing the functionality is working properly and find the best performing ML model for a functionality, etc. Thus, in some embodiments, the terminal device 110 may transmit (206) to the network node 120, a request for monitoring performance of the at least one first functionality. In some other embodiments, the performance monitoring of the at least one first functionality of the terminal device 110 may be requested by the network node 120.

[0069] For both cases, the network node 120 may determine resources for performance monitoring of the at least one first functionality of the terminal device 110. As shown in FIG. 2, the network node 120 transmit (210) to the terminal device 110, at least one CSI reporting configuration associated with a functionality monitoring of the at least one first functionality of the terminal device 110. The at least one CSI reporting configuration associated with a functionality monitoring may be associated to a functionality monitoring resource configuration. For example, by the functionality monitoring resource configuration, the terminal device 110 may be configured with a set of resources (hereinafter may also be referred to a first set of resource) corresponding to a first set of beams (which may also be referred to as “Set A-B beams”) referring to transmitted beams by the network node 120. The first set of beams (e.g., “Set A-B beams”) may be not included in a second set of beams (e.g., “Set B beam”) that are corresponding to the second set of resources configured by the first resource configuration associated with the at least one first functionality.

[0070] In addition to the at least one CSI reporting configuration associated with a functionality monitoring of the at least one first functionality, the terminal device 110 may receive linking information. The linking information may comprise one or more linking identifiers and may relate the functionality monitoring resource configuration associated with a functionality monitoring of the at least one functionality to other

resource configuration associated with at least one functionality.

[0071] As a first option, the linking information may comprise a first linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring of the at least one first functionality and a second linking identifier corresponding to the at least one CSI reporting configuration associated with the at least one first functionality. That is, in this case, the linking may be considered as a CSI reporting configuration level linking.

[0072] In this situation, the linking information may be carried by the at least one CSI reporting configuration associated with the functionality monitoring and/or the at least one CSI reporting configuration associated with the at least one first functionality. For example, the first linking identifier may be carried by the at least one CSI reporting configuration associated with the functionality monitoring and the second linking identifier may be carried by the at least one CSI reporting configuration associated with the at least one first functionality.

[0073] It is also possible that the linking information may be obtained from a separate signaling/message including but not limited to a radio resource control (RRC) signal, a medium access control (MAC) control element (CE) command, etc.

[0074] If the terminal device 110 determines that the first linking identifier matches the second linking identifier, for example, the first linking identifier and the second linking identifier are same, the terminal device 110 may be aware of an association between the functionality monitoring resource configuration associated with a functionality monitoring of the at least one functionality and a first resource configuration associated with the at least one functionality. Then the terminal device 110 may derive (212) the functionality monitoring resource set used for monitoring the at least one first functionality based on the functionality monitoring resource configuration and the first resource configuration.

[0075] FIG. 3 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure. As shown in FIG. 3, the at least one CSI reporting configuration associated with the at least one first functionality corresponds to the CSI report setting #1 310 and the at least one CSI reporting configuration associated with the functionality monitoring of the at least one first functionality corresponds to the CSI report setting #2

320.

[0076] In this case, when at least one CSI reporting configuration (e.g., the CSI report setting #1 310) associated with the at least one first functionality is having at least one channel measurement resource (CMR) (e.g., “CMR 1”) of the first resource configuration (e.g., CSI-RS based resource setting #1 311) and at least one CSI reporting configuration associated with the at least one first functionality is associated with a resource set (e.g., CSI-RS resource set 1 312) for the at least one first functionality (e.g., corresponding to Set B beams), the terminal device 110 may derive the first set of resources (e.g., CSI-RS resource set 1 322) for functionality monitoring (e.g., corresponding to Set A-B beams) from the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #2 321) based on the linking identifier.

[0077] Similarly, when at least one CSI reporting configuration (e.g., the CSI report setting #1 320) associated with the functionality monitoring is having at least one CMR (e.g., “CMR 2”) of the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #2 321) and at least one CSI reporting configuration associated with the functionality monitoring is associated with the second set of resources (e.g., CSI-RS resource set 1 322) for the functionality monitoring (e.g., corresponding to e.g., corresponding to Set A-B beams), the terminal device 110 may derive a resource set (e.g., CSI-RS resource set 1 312) for the at least one first functionality (e.g., corresponding to Set B beams) from the first resource configuration (e.g., CSI-RS based resource setting #1 311) based on the linking identifier.

[0078] The resource set for monitoring the at least one first functionality may have periodic or semi-persistent time domain behaviors (with periodicity larger than the one set for the resource set associated to the at least one first functionality) or alternatively the resource set for monitoring the at least one first functionality may be configured aperiodically via a MAC-CE command.

[0079] Specifically, the terminal device 110 may determine the first set of resources for measuring a first set of beams (e.g., “Set A-B beams”) from the functionality monitoring resource configuration and the second set of resources for measuring a second set of beams (e.g., “Set B beams”) from the first resource configuration, both first and second sets of resources may be used for the terminal device 110 to determine performance monitoring results of the at least one first functionality. That is, the terminal device 110 may derive

(212) the functionality monitoring resource set used for monitoring the at least one first functionality by combining the first and second sets of resources.

[0080] As a second option, the terminal device 110 may also support at least one second functionality, which may be different from the at least one first functionality configured at the terminal device 110 by the network node 120. For example, the at least one second functionality may refer to one or more AI/ML based functionality or to one or more non-AI/ML based functionality.

[0081] As an example, the at least one first functionality may correspond to one ML model providing spatial beam prediction in which Set A is different than Set B beams (e.g., to predict Set A “refined” beams given Set B “wide” beams measurements). The at least one second functionality may correspond to another ML model providing temporal beam prediction in which Set A is the subset of the Set B beams (e.g., to predict Set A “refined” beams given Set B “refined” beams measurements).

[0082] For the at least one second functionality, the network node 120 may configure (208) at least one CSI reporting configuration associated with the at least one second functionality, which may be associated to a second resource configuration. The second resource configuration may configure a third set of resources for the at least one second functionality (e.g., corresponding to refined Set B beams).

[0083] In this case, in addition to the at least one CSI reporting configuration associated with a functionality monitoring of the at least one first functionality, the terminal device 110 may receive a linking identifier, as the linking information, corresponding to the at least one CSI reporting configuration associated with a functionality monitoring. For example, the linking identifier may be carried by the at least one CSI reporting configuration associated with the functionality monitoring. It is also possible that the linking identifier may be obtained from a separate signaling/message including but not limited to a radio resource control (RRC) signal, a medium access control (MAC) control element (CE) command, etc.

[0084] If the terminal device 110 determines that the received linking identifier relates the functionality monitoring resource configuration to the second resource configuration, the terminal device 110 may derive (212) the functionality monitoring resource set used for monitoring the at least one first functionality based on the second resource configuration and the functionality monitoring resource configuration.

[0085] For monitoring the at least one first functionality, the terminal device 110 may expect a configuration for measuring the full Set A of “refined” beams. The terminal device 110 may determine, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams (e.g., “refined Set A-B beams”) and determine, from the second resource configuration, the third set of resources measuring a second set of beams (e.g., “refined Set B beams”). Both first and third sets of resources may be used for the terminal device 110 to determine performance monitoring results of the at least one first functionality. That is, the terminal device 110 may derive (212) the functionality monitoring resource set used for monitoring the at least one first functionality by combining the first and third sets of resources.

[0086] FIG. 4 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure. As shown in FIG. 4, the at least one CSI reporting configuration associated with the at least one first functionality corresponds to the CSI report setting #1 410, the at least one CSI reporting configuration associated with the at least one second functionality corresponds to the CSI report setting #2 420, and the at least one CSI reporting configuration associated with the functionality monitoring of the at least one first functionality corresponds to the CSI report setting #3 430.

[0087] The linking identifier corresponding to the at least one CSI reporting configuration (e.g., the CSI report setting #3 430) associated with a functionality monitoring may relate the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #3 431) to the second resource configuration (e.g., CSI-RS based resource setting #2 421), the terminal device 110 may derive the first set of resources (e.g., CSI-RS resource set 1 432) corresponding to the first set of beams (e.g., “refined Set A-B beams”) from the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #3 431) and the third set of resources (e.g., CSI-RS resource set 1 422) corresponding to the second set of beams (e.g., “refined Set A-B beams”) from the second resource configuration (e.g., CSI-RS based resource setting #2 421). Then both first and third sets of resources (e.g., CSI-RS resource set 1 432 and CSI-RS resource set 1 422) may be used for the terminal device 110 to determine performance monitoring results of the at least one first functionality.

[0088] As a third option, the terminal device 110 may be configured with a mapping of functionality resources and functionality monitoring resources, which may be represented

as a look up table. An example of the look up table is shown as below:

Set A dimen- sion	Set B dimen- sion	CSI-RS Resource Set 1 for AI/ML functionality	Corresponding beams indices (Set B)	CSI-RS Resource Set 2 for AI/ML functionality monitoring	Associated beams indices (Set A-Set B)
32	4	CSI-RS #0, CSI-RS #1, CSI-RS #2, CSI-RS #3	2, 6, 10, 14	CSI-RS #4, CSI-RS #5, CSI-RS #6, CSI- RS #7, CSI-RS #8, CSI-RS #9, CSI-RS #10, CSI-RS #11, CSI-RS #12, CSI-RS #13, CSI-RS #14, CSI-RS #15, CSI-RS #16, CSI-RS #17, CSI-RS #18, CSI-RS #19, CSI-RS #20, CSI-RS #21, CSI-RS #22, CSI-RS #23, CSI-RS #24, CSI-RS #25, CSI-RS #26, CSI-RS #27, CSI-RS #28, CSI-RS #29, CSI-RS #30, CSI-RS #31	0, 1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31
32	8	CSI-RS #0, CSI-RS #1, CSI-RS #2, CSI-RS #3, CSI-RS #4, CSI-RS #5, CSI-RS #6, CSI-RS #7	0, 4, 9, 13, 18, 22, 27, 31	CSI-RS #8, CSI-RS #9, CSI-RS #10, CSI- RS #11, CSI-RS #12, CSI-RS #13, CSI-RS #14, CSI-RS #15, CSI-RS #16, CSI-RS #17, CSI-RS #18, CSI-RS #19, CSI-RS	1, 2, 3, 5, 6, 7, 8, 11, 12, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 26, 28, 29, 30

				#20, CSI-RS #21, CSI-RS #22, CSI-RS #23, CSI-RS #24, CSI-RS #25, CSI-RS #26, CSI-RS #27, CSI-RS #28, CSI-RS #29, CSI-RS #30, CSI-RS #31	
32	16	CSI-RS #0, CSI-RS #1, CSI-RS #2, CSI-RS #3, CSI-RS #4, CSI-RS #5, CSI-RS #6, CSI-RS #7, CSI-RS #8, CSI-RS #9, CSI-RS #10, CSI-RS #11, CSI-RS #12, CSI-RS #13, CSI-RS #14, CSI-RS #15	0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30	CSI-RS #16, CSI-RS #17, CSI-RS #18, CSI-RS #19, CSI-RS #20, CSI-RS #21, CSI-RS #22, CSI-RS #23, CSI-RS #24, CSI-RS #25, CSI-RS #26, CSI-RS #27, CSI-RS #28, CSI-RS #29, CSI-RS #30, CSI-RS #31	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31

[0089] Both the terminal device 110 and the network node 120 may be aware of this mapping. In some embodiments, the terminal device 110 may obtain this mapping from the network node 120. In some other embodiments, this mapping may be pre-configured.

[0090] In this case, the terminal device 110 may receive a linking identifier, as the linking information, that relates to the functionality monitoring resource configuration, associated with at least one CSI reporting configuration associated with a functionality monitoring of the at least one first functionality. Based on the mapping, for example, by looking up the table based on the received linking identifier, the functionality monitoring

resource configuration may be related to the first resource configuration associated with the at least one CSI reporting configuration associated with at least one functionality. Similar with the first option, the terminal device 110 may derive (212) the functionality monitoring resource set used for monitoring the at least one first functionality based on the functionality monitoring resource configuration and the first resource configuration.

[0091] For example, the linking identifier may be carried by the at least one CSI reporting configuration associated with the functionality monitoring. It is also possible that the linking identifier may be obtained from a separate signaling/message including but not limited to a radio resource control (RRC) signal, a medium access control (MAC) control element (CE) command, etc.

[0092] FIG. 5 illustrates a diagram of an example of linking functionality monitoring resources to functionality resources according to some example embodiments of the present disclosure. As shown in FIG. 5, the at least one CSI reporting configuration associated with the at least one first functionality corresponds to the CSI report setting #1 510.

[0093] The linking identifier corresponding to the at least one CSI reporting configuration associated with a functionality monitoring may relate the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #2 530) to the first resource configuration (e.g., CSI-RS based resource setting #1 520), the terminal device 110 may derive the first set of resources (e.g., CSI-RS resource set 2 531) corresponding to the first set of beams (e.g., "Set A-B beams") from the functionality monitoring resource configuration (e.g., CSI-RS based resource setting #2 530) and the second set of resources (e.g., CSI-RS resource set 1 521) corresponding to the second set of beams (e.g., "Set B beams") from the first resource configuration (e.g., CSI-RS based resource setting #1 520). Then both first and third sets of resources (e.g., CSI-RS resource set 1 521 and CSI-RS resource set 2 531) may be used for the terminal device 110 to determine performance monitoring results of the at least one first functionality.

[0094] After deriving the functionality monitoring resource set used for monitoring the at least one first functionality, as an option, the terminal device 110 may determine functionality monitoring results based on a functionality monitoring performed on the determined functionality monitoring resource set and provide the functionality monitoring results to the network node 120.

[0095] It is also possible that the terminal device 110 may determine functionality monitoring measurements based on the determined functionality monitoring resource set and provide the functionality monitoring measurements to the network node.

[0096] It is to be understood that the resources included in the first, second and third set of resources may be referred to one or more CSI-RS resource and/or one or more SSB resources.

[0097] In addition to the functionality monitoring resource configuration, the measurement configuration during data collection may also need to be discussed. The network node may configure at least one dedicated CSI report for data collection. In addition, the network node may configure at least one further CSI report that enables the monitoring functionality.

[0098] As an example, a link may be defined between the at least one dedicated CSI report for data collection and at least one further CSI report for functionality monitoring, to indicate that the at least one dedicated CSI report is related to data collection of functionality supported by the at least one further CSI report for functionality monitoring. When the network node needs to collect data for a particular functionality, if Set A is already configured for monitoring, the same measurement configuration can be indicated to be used for the data collection aspects.

[0099] At the same time, for the case when Set A excludes Set B (i.e., Set A-Set B) is configured for monitoring, the functionality monitoring resource configuration would be indicated for Set A-Set B measurement, then this measurement configuration could be used for data collection.

[0100] While defining the CSI report for functionality monitoring, including the linking to the dedicated CSI report for data collection, the report quantities may be needed to indicate which resource set is applicable for reporting quantities, depending on where the monitoring and data collection happens. There are options for reporting quantities. In Option 1, for data collection/performance monitoring at terminal device, the reporting quantities set to none, meaning that none of the measurements performed at the UE device are required to be reported to the NW. In Option 2, for data collection/performance monitoring at network node based on beam IDs, the reporting quantities set to CRI/SSBRI, meaning that the CRI/SSBRI related to the Top-N strongest beams determined based on the measurements performed at the UE device are required to be reported to the NW. In

Option 3, for data collection/performance monitoring at network node based on beam IDs and/or layer 1 Reference Signal Received Powers (L1-RSRPs), the reporting quantities set to CRI plus L1RSRP, meaning that the CRI/SSBRI and corresponding L1-RSRPs related to the Top-N strongest beams determined based on the measurements performed at the UE device are required to be reported to the NW.

[0101] In some other embodiments, another possibility is for the network node to provide the terminal device the configuration with other signalling such as the RRC measurement configuration, containing the measurement object (MO), reporting configurations, quantity configurations such as link quality related to RSRP, Reference Signal Received Quality (RSRQ) and Signal to Interference plus Noise Ratio (SINR), etc. More than one reporting configuration can be associated with one MO.

[0102] In one variant, the network node could add a separate relation to identify which CSI-RS resources are related to which other CSI-RS resource configuration, to provide the linkage between measurement for functionality and measurements for the functionality monitoring. Similarly, to the cases provided above for CSI reporting configuration, in this case of RRC measurement configuration, the relationship between functionality and functionality monitoring may be defined by linking a particular reporting configuration (defined for the functionality) to another reporting configuration (defined for functionality monitoring), wherein the reporting configurations may be included in the same or in a different MO.

[0103] According to different options as discussed above, the linking between resources dedicated to the functionality and resources that are dedicated for the functionality monitoring may be established and indicated to the terminal device, which may enhance the efficiency of the functionality monitoring and further improve the performance of the functionality.

[0104] FIG. 6 shows a flowchart of an example method 600 implemented at an apparatus in accordance with some example embodiments of the present disclosure. For the purpose of discussion, the method 600 will be described from the perspective of the terminal device 110 in FIG. 1.

[0105] At block 610, the terminal device 110 receives, from a network node, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated

to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration.

[0106] At block 620, the terminal device 110 obtains linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus.

[0107] At block 630, the terminal device 110 determines the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.

[0108] In some example embodiments, the method 600 further comprises: receiving, from the network node, at least one further CSI reporting configuration associated with the at least one first functionality that is associated with the first resource configuration.

[0109] In some example embodiments, the method 600 further comprises: in accordance with a determination that the second linking identifier is same with the first linking identifier, deriving the functionality monitoring resource set used for monitoring the at least one first functionality based on the first resource configuration and the functionality monitoring resource configuration.

[0110] In some example embodiments, the method 600 further comprises: determining, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams referring to transmitted beams by the network node; determining, from the first resource configuration, a second set of resources for measuring a second set of beams, and deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0111] In some example embodiments, the method 600 further comprises: receiving, from the network node, at least one another CSI reporting configuration configuring the at least one second functionality of the apparatus that is associated to the second resource configuration.

[0112] In some example embodiments, the method 600 further comprises: in accordance with a determination that the linking identifier relates the functionality monitoring resource configuration to the second resource configuration, deriving the functionality

monitoring resource set used for monitoring the at least one first functionality based on the second resource configuration and the functionality monitoring resource configuration.

[0113] In some example embodiments, the method 600 further comprises: determining, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams; determining, from the second resource configuration, a second set of resources for measuring a second set of beams, and deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0114] In some example embodiments, the method 600 further comprises: determining, based on the linking identifier and a mapping between functionality resources and functionality monitoring resources, the linking between the functionality monitoring resource configuration and the first resource set; and deriving the functionality monitoring resource set used for monitoring the at least one first functionality based on the first resource configuration and the functionality monitoring resource configuration.

[0115] In some example embodiments, the method 600 further comprises: determining, based on the linking identifier and a mapping, a first set of resources of the functionality monitoring resource configuration for measuring a first set of beams; determining, from the first resource configuration, a second set of resources for measuring a second set of beams, and deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0116] In some example embodiments, the mapping is pre-configured or obtained from the network node.

[0117] In some example embodiments, the linking information is obtained by at least one of the following: a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, a reception of the at least one further CSI reporting configuration associated with the at least one first functionality, a radio resource control, RRC, signaling, or a medium access control, MAC, control element, CE, command.

[0118] In some example embodiments, the method 600 further comprises: transmitting, to the network node, a request for monitoring performance of the at least one first functionality.

[0119] In some example embodiments, the method 600 further comprises: determining functionality monitoring results based on a functionality monitoring performed on the determined functionality monitoring resource set; and providing the functionality monitoring results to the network node.

[0120] In some example embodiments, the method 600 further comprises: determining functionality monitoring measurements based on the determined functionality monitoring resource set; and providing the functionality monitoring measurements to the network node.

[0121] In some example embodiments, each of the first resource configuration, the second resource configuration and the functionality monitoring resource configuration indicates at least one of: one or more CSI-RS resources, or one or more SSB resources.

[0122] In some example embodiments, the at least one first functionality comprises at least one artificial intelligence, AI/machine learning, ML-based functionality.

[0123] FIG. 7 shows a flowchart of an example method 700 implemented at an apparatus in accordance with some example embodiments of the present disclosure. For the purpose of discussion, the method 700 will be described from the perspective of the network node 120 in FIG. 1.

[0124] At block 710, the network node 120 transmits, to a terminal device, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and

[0125] At block 720, the network node 120 provides, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

[0126] In some example embodiments, the method 700 further comprises: transmitting, to a terminal device, at least one further CSI reporting configuration associated with the at least one first functionality that is associated with the first resource configuration.

[0127] In some example embodiments, the link information comprises a first linking

identifier associated with the first CSI reporting configuration and a second linking identifier associated with the second CSI reporting configuration.

[0128] In some example embodiments, the method 700 further comprises: transmitting, to a terminal device, at least one another CSI reporting configuration configuring the at least one second functionality of the terminal device that is associated to the second resource configuration.

[0129] In some example embodiments, the link information comprises a linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring, and the linking identifier relates the functionality monitoring resource configuration to the second resource configuration.

[0130] In some example embodiments, the link information comprises a linking identifier relates to the functionality monitoring resource configuration.

[0131] In some example embodiments, the method 700 further comprises: transmitting, to a terminal device, a mapping between functionality resources and functionality monitoring resources.

[0132] In some example embodiments, the method 700 further comprises: providing the link information to the terminal device by at least one of the following: a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, a reception of the at least one further CSI reporting configuration associated with the at least one first functionality, a radio resource control, RRC, signaling, or a medium access control, MAC, control element, CE, command.

[0133] In some example embodiments, the method 700 further comprises: receiving, from the terminal device, at least one of: functionality monitoring results for the at least one first functionality; or functionality monitoring measurements for the at least one first functionality.

[0134] In some example embodiments, the method 700 further comprises: receiving, from the terminal device, a request for monitoring performance of the at least one first functionality.

[0135] In some example embodiments, each of the first resource configuration, the second resource configuration and the functionality monitoring resource configuration

indicates at least one of: one or more CSI-RS resources, or one or more SSB resources.

[0136] In some example embodiments, the at least one first functionality comprises at least one artificial intelligence, AI/machine learning, ML-based functionality.

[0137] In some example embodiments, an apparatus capable of performing any of the method 600 (for example, the terminal device 110 in FIG. 1) may comprise means for performing the respective operations of the method 600. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module. The apparatus may be implemented as or included in the terminal device 110 in FIG. 1.

[0138] In some example embodiments, the apparatus comprises means for receiving, from a network node, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; means for obtaining linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus; and means for determining the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.

[0139] In some example embodiments, the apparatus further comprises: means for receiving, from the network node, at least one further CSI reporting configuration associated with the at least one first functionality that is associated with the first resource configuration.

[0140] In some example embodiments, the link information comprises a first linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring and a second linking identifier corresponding to the at least one further CSI reporting configuration associated with the at least one first functionality, and wherein the apparatus further comprises: means for in accordance with a determination that the second linking identifier is same with the first linking identifier, deriving the functionality monitoring resource set used for monitoring the at least one first

functionality based on the first resource configuration and the functionality monitoring resource configuration.

[0141] In some example embodiments, the apparatus further comprises: means for determining, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams referring to transmitted beams by the network node; means for determining, from the first resource configuration, a second set of resources for measuring a second set of beams, and means for deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0142] In some example embodiments, the apparatus further comprises: means for receiving, from the network node, at least one another CSI reporting configuration configuring the at least one second functionality of the apparatus that is associated to the second resource configuration.

[0143] In some example embodiments, the linking information comprises a linking identifier corresponding to the at least one CSI reporting configuration associated with a functionality monitoring, and wherein the apparatus further comprises: means for in accordance with a determination that the linking identifier relates the functionality monitoring resource configuration to the second resource configuration, deriving the functionality monitoring resource set used for monitoring the at least one first functionality based on the second resource configuration and the functionality monitoring resource configuration.

[0144] In some example embodiments, the apparatus further comprises: means for determining, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams; means for determining, from the second resource configuration, a second set of resources for measuring a second set of beams, and means for deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0145] In some example embodiments, the apparatus further comprises: receive the linking information comprises a linking identifier that relates to the functionality monitoring resource configuration; means for determining, based on the linking identifier and a mapping between functionality resources and functionality monitoring resources, the linking between the functionality monitoring resource configuration and the first

resource set; and means for deriving the functionality monitoring resource set used for monitoring the at least one first functionality based on the first resource configuration and the functionality monitoring resource configuration.

[0146] In some example embodiments, the apparatus further comprises: means for determining, based on the linking identifier and a mapping, a first set of resources of the functionality monitoring resource configuration for measuring a first set of beams; means for determining, from the first resource configuration, a second set of resources for measuring a second set of beams, and means for deriving the functionality monitoring resource set by combining the first set of resources and the second set of resources.

[0147] In some example embodiments, the mapping is pre-configured or obtained from the network node.

[0148] In some example embodiments, the linking information is obtained by at least one of the following: a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, a reception of the at least one further CSI reporting configuration associated with the at least one first functionality, a radio resource control, RRC, signaling, or means for a medium access control, MAC, control element, CE, command.

[0149] In some example embodiments, the apparatus further comprises: means for transmitting, to the network node, a request for monitoring performance of the at least one first functionality.

[0150] In some example embodiments, the apparatus further comprises: means for determining functionality monitoring results based on a functionality monitoring performed on the determined functionality monitoring resource set; and means for providing the functionality monitoring results to the network node.

[0151] In some example embodiments, the apparatus further comprises: means for determining functionality monitoring measurements based on the determined functionality monitoring resource set; and means for providing the functionality monitoring measurements to the network node.

[0152] In some example embodiments, each of the first resource configuration, the second resource configuration and the functionality monitoring resource configuration indicates at least one of: one or more a CSI-RS resources, or one or more SSB resources.

[0153] In some example embodiments, the at least one first functionality comprises at least one artificial intelligence, AI/machine learning, ML-based functionality.

[0154] In some example embodiments, the apparatus further comprises means for performing other operations in some example embodiments of the method 600 or the terminal device 110. In some example embodiments, the means comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the performance of the apparatus.

[0155] In some example embodiments, an apparatus capable of performing any of the method 700 (for example, the network node 120 in FIG) may comprise means for performing the respective operations of the method 700. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module. The apparatus may be implemented as or included in the network node 120 in FIG. 1.

[0156] In some example embodiments, the apparatus comprises means for transmitting, to a terminal device, at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and means for providing, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

[0157] In some example embodiments, the apparatus further comprises: means for transmitting, to a terminal device, at least one further CSI reporting configuration associated with the at least one first functionality that is associated with the first resource configuration.

[0158] In some example embodiments, the link information comprises a first linking identifier associated with the first CSI reporting configuration and a second linking identifier associated with the second CSI reporting configuration.

[0159] In some example embodiments, the apparatus further comprises: means for

transmitting, to a terminal device, at least one another CSI reporting configuration configuring the at least one second functionality of the terminal device that is associated to the second resource configuration.

[0160] In some example embodiments, the link information comprises a linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring, and the linking identifier relates the functionality monitoring resource configuration to the second resource configuration.

[0161] In some example embodiments, the link information comprises a linking identifier relates to the functionality monitoring resource configuration.

[0162] In some example embodiments, the apparatus further comprises: means for transmitting, to a terminal device, a mapping between functionality resources and functionality monitoring resources.

[0163] In some example embodiments, the apparatus further comprises: means for providing the link information to the terminal device by at least one of the following: a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, a reception of the at least one further CSI reporting configuration associated with the at least one first functionality, a radio resource control, RRC, signaling, or means for a medium access control, MAC, control element, CE, command.

[0164] In some example embodiments, the apparatus further comprises: means for receiving, from the terminal device, at least one of: means for functionality monitoring results for the at least one first functionality; or means for functionality monitoring measurements for the at least one first functionality.

[0165] In some example embodiments, the apparatus further comprises: means for receiving, from the terminal device, a request for monitoring performance of the at least one first functionality.

[0166] In some example embodiments, each of the first resource configuration, the second resource configuration and the functionality monitoring resource configuration indicates at least one of: one or more a CSI-RS resources, or one or more SSB resources.

[0167] In some example embodiments, the at least one first functionality comprises at least one artificial intelligence, AI/machine learning, ML-based functionality.

[0168] In some example embodiments, the apparatus further comprises means for performing other operations in some example embodiments of the method 700 or the network node 120. In some example embodiments, the means comprises at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the performance of the apparatus.

[0169] FIG. 8 is a simplified block diagram of a device 800 that is suitable for implementing example embodiments of the present disclosure. The device 800 may be provided to implement a communication device, for example, the terminal device 110 or the network node 120 as shown in FIG. 1. As shown, the device 800 includes one or more processors 810, one or more memories 820 coupled to the processor 810, and one or more communication modules 840 coupled to the processor 810.

[0170] The communication module 840 is for bidirectional communications. The communication module 840 has one or more communication interfaces to facilitate communication with one or more other modules or devices. The communication interfaces may represent any interface that is necessary for communication with other network elements. In some example embodiments, the communication module 840 may include at least one antenna.

[0171] The processor 810 may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 800 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.

[0172] The memory 820 may include one or more non-volatile memories and one or more volatile memories. Examples of the non-volatile memories include, but are not limited to, a Read Only Memory (ROM) 824, an electrically programmable read only memory (EPROM), a flash memory, a hard disk, a compact disc (CD), a digital video disk (DVD), an optical disk, a laser disk, and other magnetic storage and/or optical storage. Examples of the volatile memories include, but are not limited to, a random access memory (RAM) 822 and other volatile memories that will not last in the power-down duration.

[0173] A computer program 830 includes computer executable instructions that are

executed by the associated processor 810. The instructions of the program 830 may include instructions for performing operations/acts of some example embodiments of the present disclosure. The program 830 may be stored in the memory, e.g., the ROM 824. The processor 810 may perform any suitable actions and processing by loading the program 830 into the RAM 822.

[0174] The example embodiments of the present disclosure may be implemented by means of the program 830 so that the device 800 may perform any process of the disclosure as discussed with reference to FIG. 2 to FIG. 7. The example embodiments of the present disclosure may also be implemented by hardware or by a combination of software and hardware.

[0175] In some example embodiments, the program 830 may be tangibly contained in a computer readable medium which may be included in the device 800 (such as in the memory 820) or other storage devices that are accessible by the device 800. The device 800 may load the program 830 from the computer readable medium to the RAM 822 for execution. In some example embodiments, the computer readable medium may include any types of non-transitory storage medium, such as ROM, EPROM, a flash memory, a hard disk, CD, DVD, and the like. The term “non-transitory,” as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[0176] FIG. 9 shows an example of the computer readable medium 900 which may be in form of CD, DVD or other optical storage disk. The computer readable medium 900 has the program 830 stored thereon.

[0177] 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, and other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. Although various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method 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.

[0178] Some example embodiments of the present disclosure also provide at least one computer program product tangibly stored on a computer readable medium, such as a non-transitory computer readable medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target physical or virtual processor, to carry out any of the methods as described above. 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.

[0179] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. The program code 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 code, 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.

[0180] In the context of the present disclosure, the computer program code or related data may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer readable medium, and the like.

[0181] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer 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 computer 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.

[0182] Further, although 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, although several specific implementation 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. Unless explicitly stated, certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, unless explicitly stated, various features that are described in the context of a single embodiment may also be implemented in a plurality of embodiments separately or in any suitable sub-combination.

[0183] Although the present disclosure has been described in languages 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.

WHAT IS CLAIMED IS:

1. An apparatus comprising:
at least one processor; and
at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:
receive, from a network node, at least one channel state information, CSI, reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration;
obtain linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the apparatus; and
determine the functionality monitoring resource set used for monitoring the at least one first functionality at least based on the linking information and the functionality monitoring resource configuration.
2. The apparatus of claim 1, wherein the first apparatus is caused to:
receive, from the network node, at least one further CSI reporting configuration associated with the at least one first functionality that is associated with the first resource configuration.
3. The apparatus of claim 2, wherein the link information comprises a first linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring and a second linking identifier corresponding to the at least one further CSI reporting configuration associated with the at least one first functionality, and wherein the first apparatus is caused to:
in accordance with a determination that the second linking identifier is same with the first linking identifier, derive the functionality monitoring resource set used for monitoring the at least one first functionality based on the first resource configuration and the functionality monitoring resource configuration.

4. The apparatus of claim 3, wherein the first apparatus is caused to:
determine, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams referring to transmitted beams by the network node;
determine, from the first resource configuration, a second set of resources for measuring a second set of beams, and
derive the functionality monitoring resource set by combining the first set of resources and the second set of resources.

5. The apparatus of claim 2, wherein the first apparatus is caused to:
receive, from the network node, at least one another CSI reporting configuration configuring the at least one second functionality of the apparatus that is associated to the second resource configuration.

6. The apparatus of claim 5, wherein the linking information comprises a linking identifier corresponding to the at least one CSI reporting configuration associated with a functionality monitoring, and wherein the first apparatus is caused to:
in accordance with a determination that the linking identifier relates the functionality monitoring resource configuration to the second resource configuration, derive the functionality monitoring resource set used for monitoring the at least one first functionality based on the second resource configuration and the functionality monitoring resource configuration.

7. The apparatus of claim 6, wherein the first apparatus is caused to:
determine, from the functionality monitoring resource configuration, a first set of resources for measuring a first set of beams referring to transmitted beams by the network node;
determine, from the second resource configuration, a third set of resources for measuring a second set of beams, and
derive the functionality monitoring resource set by combining the first set of resources and the second set of resources.

8. The apparatus of claim 2, wherein the first apparatus is caused to:

receive the linking information comprises a linking identifier that relates to the functionality monitoring resource configuration;

determine, based on the linking identifier and a mapping between functionality resources and functionality monitoring resources, the linking between the functionality monitoring resource configuration and the first resource set; and

derive the functionality monitoring resource set used for monitoring the at least one first functionality based on the first resource configuration and the functionality monitoring resource configuration.

9. The apparatus of claim 8, wherein the first apparatus is caused to:

determine, based on the linking identifier and a mapping, a first set of resources of the functionality monitoring resource configuration for measuring a first set of beams;

determine, from the first resource configuration, a second set of resources for measuring a second set of beams, and

derive the functionality monitoring resource set by combining the first set of resources and the second set of resources.

10. The apparatus of claim 8 or 9, wherein the mapping is pre-configured or obtained from the network node.

11. The apparatus of any of claims 2-10, wherein the linking information is obtained by at least one of the following:

a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the apparatus,

a reception of the at least one further CSI reporting configuration associated with the at least one first functionality,

a radio resource control, RRC, signaling, or

a medium access control, MAC, control element, CE, command.

12. The apparatus of any of claims 1-13, wherein the apparatus is caused to:

transmit, to the network node, a request for monitoring performance of the at least one first functionality.

13. The apparatus of any of claims 1-12, wherein the apparatus is caused to:

determine functionality monitoring results based on a functionality monitoring performed on the determined functionality monitoring resource set; and
provide the functionality monitoring results to the network node.

14. The apparatus of any of claims 1-12, wherein the apparatus is caused to:
determine functionality monitoring measurements based on the determined functionality monitoring resource set; and
provide the functionality monitoring measurements to the network node.

15. The apparatus of any of claims 1-13, wherein each of the first resource configuration, the second resource configuration and the functionality monitoring resource configuration indicates at least one of:
one or more a CSI-RS resources, or
one or more SSB resources.

16. The apparatus of any of claims 1-13, wherein the at least one first functionality comprises at least one artificial intelligence, AI/machine learning, ML-based functionality.

17. An apparatus comprising:
at least one processor; and
at least one memory storing instructions that, when executed by the at least one processor, cause the apparatus at least to:
transmit, to a terminal device, at least one channel state information, CSI, reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device, wherein the at least one first functionality is associated to a first resource configuration and the functionality monitoring is associated to a functionality monitoring resource configuration; and
provide, to the terminal device, linking information indicating a linking between the functionality monitoring resource configuration and the first resource configuration or a linking between the functionality monitoring resource configuration and a second resource configuration associated with at least one second functionality of the terminal device.

18. The apparatus of claim 17, wherein the apparatus is caused to:
transmit, to a terminal device, at least one further CSI reporting configuration

associated with the at least one first functionality that is associated with the first resource configuration.

19. The apparatus of claim 18, wherein the link information comprises a first linking identifier associated with the first CSI reporting configuration and a second linking identifier associated with the second CSI reporting configuration.

20. The apparatus of claim 18, wherein the apparatus is caused to:
transmit, to a terminal device, at least one another CSI reporting configuration configuring the at least one second functionality of the terminal device that is associated to the second resource configuration.

21. The apparatus of claim 20, wherein the link information comprises a linking identifier corresponding to the at least one CSI reporting configuration associated with the functionality monitoring, and the linking identifier relates the functionality monitoring resource configuration to the second resource configuration.

22. The apparatus of claim 18, wherein the link information comprises a linking identifier relates to the functionality monitoring resource configuration.

23. The apparatus of claim 22, wherein the apparatus is caused to:
transmit, to a terminal device, a mapping between functionality resources and functionality monitoring resources.

24. The apparatus of any of claims 18-23, wherein the apparatus is caused to:
provide the link information to the terminal device by at least one of the following:
a reception of the at least one CSI reporting configuration associated with a functionality monitoring of at least one first functionality of the terminal device,
a reception of the at least one further CSI reporting configuration associated with the at least one first functionality,
a radio resource control, RRC, signaling, or
a medium access control, MAC, control element, CE, command.

25. The apparatus of claim 18, wherein the apparatus is caused to:

receive, from the terminal device, at least one of:

functionality monitoring results for the at least one first functionality;

functionality monitoring measurements for the at least one first functionality; or

a request for monitoring performance of the at least one first functionality.