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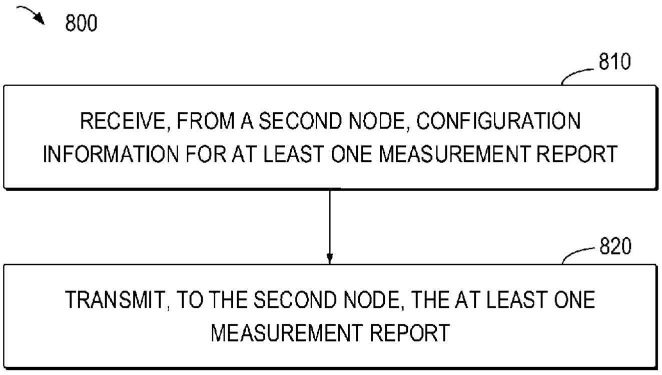

FIG.8

(57) Abstract: Embodiments of the present disclosure provide a solution for configuring and transmitting channel information. In a solution, a first node receives, from a second node, configuration information for at least one measurement report; and transmits, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

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DEVICES AND METHODS FOR COMMUNICATION

FIELDS

[0001] Example embodiments of the present disclosure generally relate to the field of communication techniques and in particular, to devices and methods for configuring and transmitting channel information.

BACKGROUND

[0002] Technology of multiple input multiple output (MIMO) has been widely used in current wireless communication system, where a large number of antenna elements are used by a network device for communicating with a terminal device for both sub-6GHz and over-6GHz frequency bands.

[0003] Further, technology of orthogonal time frequency space (OTFS) may be introduced in the future communication, especially for the scenario of integrated sensing and communication (ISAC), such that a richer reporting may be achieved. However, the richer reporting also brings an increasing signalling overhead. Thus, how to report OTFS-related channel information with a reduced signalling overhead is desirable to be further discussed.

SUMMARY

[0004] In general, embodiments of the present disclosure provide a solution for configurating and transmitting channel information.

[0005] In a first aspect, there is provided a first node comprising: a processor configured to cause the first node to: receive, from a second node, configuration information for at least one measurement report; and transmit, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0006] In a second aspect, there is provided a second node comprising: a processor configured to cause the second node to: transmit, to a first node, configuration information for at least one measurement report; and receive, from the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0007] In a third aspect, there is provided a communication method performed by a first node. The method comprises: receiving, from a second node, configuration information for at least one measurement report; and transmitting, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0008] In a fourth aspect, there is provided a communication method performed by a second node. The method comprises: transmitting, to a first node, configuration information for at least one measurement report; and receiving, from the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0009] In a fifth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to carry out the method according to the third, or fourth aspect.

[0010] Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Through the more detailed description of some example embodiments of the present disclosure in the accompanying drawings, the above and other objects, features and advantages of the present disclosure will become more apparent, wherein:

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

[0013] FIG. 2 illustrates a signaling flow of communication in accordance with some embodiments of the present disclosure;

[0014] FIG. 3A and 3B illustrate examples of the reporting information;

[0015] FIG. 4A and 4B illustrate examples of the reporting information;

[0016] FIG. 5 illustrates an example of the reporting information;

[0017] FIG. 6 illustrates an example of the reporting information;

[0018] FIG. 7 illustrates an example of the reporting information;

[0019] FIG. 8 illustrates a flowchart of a method implemented at a first node according to some example embodiments of the present disclosure;

[0020] FIG. 9 illustrates a flowchart of a method implemented at a second node according to some example embodiments of the present disclosure; and

[0021] FIG. 10 illustrates a simplified block diagram of an apparatus that is suitable for implementing example embodiments of the present disclosure.

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

DETAILED DESCRIPTION

[0023] Principle of the present disclosure will now be described with reference to some 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.

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

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

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

[0027] The terminal device or the network device may have Artificial intelligence (AI) or Machine learning capability. It generally includes a model which has been trained from numerous collected data for a specific function, and can be used to predict some information.

[0028] The terminal or the network device may work on several frequency ranges, e.g., FR1 (e.g., 450 MHz to 6000 MHz), FR2 (e.g., 24.25GHz to 52.6GHz), frequency band larger than 100A GHz as well as Tera Hertz (THz). It can further work on licensed/unlicensed/shared spectrum. The terminal device may have more than one connection with the network devices under Multi-Radio Dual Connectivity (MR-DC) application scenario. The terminal device or the network device can work on full duplex, flexible duplex and cross division duplex modes.

[0029] The embodiments of the present disclosure may be performed in test equipment, e.g., signal generator, signal analyzer, spectrum analyzer, network analyzer, test terminal device, test network device, channel emulator. In some embodiments, the terminal device may be connected with a first network device and a second network device. One of the first network device and the second network device may be a master node and the other one may be a secondary node. The first network device and the second network device may use different radio access technologies (RATs). In some embodiments, the first network device may be a first RAT device and the second network device may be a second RAT device. In some embodiments, the first RAT device is eNB and the second RAT device is gNB. Information related with different RATs may be transmitted to the terminal device from at least one of the first network device or the second network device. In some embodiments, first information may be transmitted to the terminal device from the first network device and second information may be transmitted to the terminal device from the second network device directly or via the first network device. In some embodiments, information related with configuration for the terminal device configured by the second network device may be transmitted from the second network device via the first network device. Information related with reconfiguration for the terminal device configured by the second network device may be transmitted to the terminal device from the second network device directly or via the first network device.

[0030] As used herein, the singular forms ‘a’, ‘an’ and ‘the’ are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term ‘includes’ and its variants are to be read as open terms that mean ‘includes, but is not limited to.’ The term ‘based on’ is to be read as ‘at least in part based on.’ The term ‘one embodiment’ and ‘an embodiment’ are to be read as ‘at least one embodiment.’ The term ‘another embodiment’ is to be read as ‘at least one other embodiment.’ The terms ‘first,’ ‘second,’ and the like may refer to different or same objects. Other definitions, explicit and implicit, may be included below.

[0031] In some examples, values, procedures, or apparatus are referred to as 'best,' 'lowest,' 'highest,' 'minimum,' 'maximum,' or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0032] As used herein, the term "resource," "transmission resource," "uplink resource," or "downlink resource" may refer to any resource for performing a communication, 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 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.

[0033] As discussed above, technology of OTFS may be introduced in the future communication, especially for the scenario of ISAC. However, the richer reporting also brings an increasing signalling overhead. Thus, how to report OTFS-related channel information with a reduced signalling overhead is desirable to be further discussed. So far, there is no details on how to report OTFS-based channel information.

[0034] It has been noted that in case of the large bandwidth, the resolution of delay is fine, while the candidate values needed to be considered of delay are usually concentrated within a smaller range. Similarly, if the total number of candidate values of doppler domain is larger, the resolution of doppler will be fine, but the candidate values of doppler needed to be considered are usually concentrated within a smaller range.

[0035] Further, it also has been noted that as for sensing, reporting of multiple number of doppler/delay pairs is useful, while for communication (such as, precoding), there may be no need of so many doppler/delays or no need of amplitude/phase coefficients for all reported doppler/delay pairs.

[0036] In view of this, it is possible to reduce the overhead by reducing the reporting of unnecessary information.

[0037] According to the present disclosure, a solution for configuring and transmitting channel information is proposed. In this solution, the first node (such as, a terminal device) receives configuration information for at least one measurement report from a second node (such as, a network device). Based on the first configuration information, the first node transmits the at least one measurement report to the second node. The at least one measurement report may indicate a first set of pairs of delay information and doppler information and a second set of pairs of delay information and doppler information. In particular, the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0038] By reporting two different and correlated sets of pairs of delay information and doppler information, the unnecessary information for sensing and communication may be reduced. As a result, the singling overhead is reduced.

[0039] As used herein, the terms “UE expects”, “UE does not expect, “terminal device expects”, “terminal device does not expect” may imply restrictions on a configuration of a network device. The terms “UE is not expected to” and “terminal device is not expected to” may imply a terminal implementation, also referred to as UE implementation. In some embodiments, the terms “UE does not expect” and “UE is not expected to” may be used equally.

[0040] As used herein, terms “signaling”, “message”, “configuration”, “request”, “response”, “information” and “signal”, “packet” may be used interchangeably.

[0041] As used herein, the terms “element of indication field”, “parameter” and “indication” may be used interchangeably.

[0042] As used herein, the terms “index”, “indicator”, “indication”, “field”, “bit field” and “bitmap” may be used interchangeably.

[0043] As used herein, the terms “associated with”, “corresponding to”, “correspond to” and “comprise” may be used interchangeably.

[0044] As used herein, a function entity may be a 5G core (5GC) feature/function, including but are not limited to an AMF, ISMF, SF, LMF and any suitable 5GC feature/function.

[0045] As used herein, the terms “node”, “device”, “apparatus” “function” and “function entity” may be used interchangeably.

[0046] As used herein, the terms “vector”, “vectors”, “bases” and “basis” may be used interchangeably.

[0047] As used herein, the terms "precoder", "precoding", "precoding matrix", "beam", "beamforming", "vector", "basis", "codebook", "UL codebook", "spatial domain-related information", "SD-related information", "spatial relation information", "spatial relation info", "precoding information", "precoding information and number of layers", "precoding matrix indicator (PMI)", "precoding matrix indicator", "transmission precoding matrix indication", "precoding matrix indication", "transmission configuration indication state (TCI state)", "UL TCI state", "joint TCI state", "transmission configuration indicator", "quasi co-location (QCL)", "quasi-co-location", "QCL parameter", "QCL assumption", "QCL relationship" and "spatial relation" may be used interchangeably.

[0048] In the context of the present application, the terms "third vector", "a channel state information reference signal (CSI-RS) port", "a reference signal port", "an antenna port", "beam", "third bases", "third basis vector", "spatial domain/SD basis vector", "spatial domain/SD vectors", "spatial domain/SD basis", "an azimuth angle of departure", "an angle of departure", "AoD", "a zenith angle of departure", "ZoD", "an angle of a directional angle", "an azimuth angle of arrival", "an angle of arrival", "AoA", "a zenith angle of departure", "ZoA" and "spatial domain/SD bases" can be used interchangeably. In the context of the present application, the terms "vector", "bases" and "basis" can be used interchangeably.

[0049] In the context of the present application, the terms "first vector", "first basis", "frequency domain/FD basis vector", "frequency domain/FD vector", "frequency domain/FD basis", "frequency domain/FD bases", "first bases", "index of first domain", "index of delay domain", "first domain index", "delay domain index", "first domain element", "delay domain element", "value in first domain", "value in delay domain", "value of first domain", "value of delay domain", "first domain value", "delay domain value", "first domain information", "first information", "delay information" and "delay domain information" can be used interchangeably.

[0050] In the context of the present application, the terms "second vector", "second basis", "doppler domain/DD basis vector", "doppler domain/DD vector", "doppler domain/DD basis", "doppler domain/DD bases", "second bases", "index of second domain", "index of doppler domain", "second domain index", "doppler domain index", "second domain element", "doppler domain element", "value in second domain", "value in doppler domain", "value of second domain", "value of doppler domain", "second domain value", "doppler domain value", "second domain information", "second information", "doppler information" and "doppler domain information" can be used interchangeably.

[0051] In the context of the present application, the terms "first domain", "frequency domain" and "delay domain" can be used interchangeably. In the context of the present application, the terms "second domain", "time domain" and "doppler domain" can be used interchangeably. In the context of the present application, the terms "index", "value", "information" and "element" can be used interchangeably.

[0052] As used herein, the terms "an SRS port", "a CSI-RS port", "an RS port", "an SRS resource", "a CSI-RS resource", "an RS resource", "an antenna port", "third beam", "beam", "third bases", "third basis vector", "spatial domain/SD basis vector", "spatial domain/SD vectors", "spatial domain/SD basis", "spatial domain/SD bases", "spatial domain/SD basis vectors corresponding to a TRP index", "spatial domain/SD vectors corresponding to a TRP index", "spatial domain/SD basis corresponding to a TRP index", "spatial domain/SD bases corresponding to a TRP index", "third basis corresponding to a TRP index", "spatial domain-related information", "SD-related information", "spatial relation information", "spatial relation info", "an azimuth angle of departure", "an angle of departure", "AoD", "a zenith angle of departure", "ZoD", "an angle of a directional angle", "an azimuth angle of arrival", "an angle of arrival", "AoA", "a zenith angle of departure", "ZoA" and "third basis" may be used interchangeably.

[0053] As used herein, the terms "bit size", "size of bits", "number of bits", "size of field", "bitwidth" and "field size" may be used interchangeably.

[0054] For ease of discussion, some parameters used in the following description are listed as below:

- M refers to the total number of values in delay domain. In some embodiments, M may be a first parameter used for a first transform (e.g., zak transform, ISFFT and/or SFFT), M may be a positive integer. For example, 1<= M <= 4096 or $M \in$ {2048, 4096}. For another example, M may be defined as a default value (e.g. M=2048 or 1200 or 1024 or 4096 or 3300). For another example, M may be configured by the second node (e.g. network device) or reported by the first node (e.g. terminal device);

- N refers to the total number of values in doppler domain. In some embodiments, N may be a second parameter used for the first transform (e.g., zak transform, ISFFT and/or SFFT), N may be a positive integer. For example, 1<= N <= 128. In some embodiments , N may be defined as a default value (e.g., $N = 16\ or\ 32\ or\ 64$). In some embodiments, N may be configured by the second node (e.g. network device) or reported by the first node (e.g. terminal device);

- Δf refers to the value of subcarrier spacing. In some embodiments, Δf may be at least one of {15, 30, 60, 120, 240, 480 960, 1920, 3840}kHz;

- T refers to a time duration corresponding to one symbol. For example, $T = 1/\Delta f$;

- N_{fft} refers to parameter for performing a second transform. For example, the second transform comprises at least one of the following: a transform to generate a transmitting symbol or an orthogonal frequency division multiplexing (OFDM) symbol, fast fourier transform (FFT) or inverse FFT (IFFT). In some embodiments, N_{fft} may refer to the size of the second transform and used for generating the transmitting symbol. In some embodiments, N_{fft} may be positive integer. For example, $64 \le N_{fft} \le 8192$. For another example, $N_{fft} \in \{1024\ 2048, 3300, 4096, 8192\}$. In some embodiments, N_{fft} may be equal to and/or larger than M, $N_{fft} \ge M$. In some embodiments, the value of N_{fft} may be correlated to or corresponding to the value of M. In some embodiments, $N_{fft} = 2048$ may correspond to $M = 2048$ or $M = 1024$ or $M = 1200$. In some embodiments, $N_{fft} = 4096$ may correspond to $M = 4096$ or $M = 2048$ or $M = 3300$;

- M_1 refers to the total number of candidate values in delay domain, corresponding to the first set of pairs of delay information and doppler information. In some embodiments, M_1 may be a positive integer. For example, 1<= M_1<= M. For another example, 1<= M_1<=128. For another example, the value of M_1 may be larger than 1;

- $M_{offset1}$ refers to the offset value in delay domain for a first range, corresponding to the first set of pairs of delay information and doppler information or corresponding to the set of delay information. In some embodiments, $M_{offset1}$ may be an integer; For example, 0<= $M_{offset1}$<= M-1;

- N_1 refers to the total number of candidate values in doppler domain, corresponding to the first set of pairs of delay information and doppler information. In some embodiments, N_1 may be a positive integer. For example, $1 <= N_1 <= N$. For another example, $1<=N_1<=64$. For another example, the value of N_1 may be larger than 1;

- $N_{offset1}$ refers to the offset value in doppler domain for a first range, corresponding to the first set of pairs of delay information and doppler information or corresponding to the set of doppler information. In some embodiments, $N_{offset1}$ may be an integer; For example, $0<= N_{offset1}<= N-1$;

- M_2 refers to a parameter corresponding to the delay domain. In some embodiments, M_2 may be the number of indexes in a group of delay domain indexes. In some embodiments, M_2 may be the number of delay domain indexes in a group of pairs of delay information and doppler information. In some embodiments, M_2 may be positive integer. For example, $1<= M_2 <=M-1$. For example, $1<= M_2 <=M_1-1$;

- $M_{offset2}$ refers to the offset value in delay domain for a second range. In some embodiments, $M_{offset2}$ may be the offset value corresponding to the at least one group of delay domain indexes or corresponding to the at least one group of pairs of delay information and doppler information. In some embodiments, $M_{offset2}$ may be positive integer. For example, $1<= M_{offset2} <=M-1$;

- N_2 refers to a parameter corresponding to the doppler domain. In some embodiments, N_2 may be the number of indexes in a group of doppler domain indexes. In some embodiments, N_2 may be the number of doppler domain indexes in the group of pairs of delay information and doppler information. In some embodiments, N_2 may be positive integer. For example, $1<= N_2 <=N-1$. For example, $1<= N_2 <=N_1-1$;

- $N_{offset2}$ refers to the offset value in doppler domain for a second range. In some embodiments, $N_{offset2}$ may be the offset value corresponding to the at least one group of doppler domain indexes or corresponding to the at least one group of pairs of delay information and doppler information. In some embodiments, $N_{offset2}$ may be positive integer. For example, $1<= N_{offset2} <=N-1$;

- P_1 refers to the number of pairs in the first set of pairs of delay information and doppler information;

- P_2 refers to the number of pairs in the second set of pairs of delay information and doppler information;

- G_1 refers to the number of the at least one group of pairs corresponding to the first set of pairs of delay information and doppler information; or

- G_2 refers to the number of the at least one group of pairs corresponding to the second set of pairs of delay information and doppler information.

[0055] In some embodiments, the first transform (e.g. ISFFT) may be represented as $X[n,m] = \frac{1}{\sqrt{NM}}\sum_{k=0}^{N-1}\sum_{l=0}^{M-1} x[k,l]e^{j*2\pi(\frac{nk}{N}-\frac{ml}{M})}$, wherein $n = 0,1, \ldots N-1$, $m = 0,1, \ldots M-1$. In some embodiments, the first transform (e.g. SFFT) may be represented as $y[k,l] = \frac{1}{\sqrt{NM}}\sum_{n=0}^{N-1}\sum_{m=0}^{M-1} Y[n,m]e^{-j*2\pi(\frac{nk}{N}-\frac{ml}{M})}$, wherein $k = 0,1, \ldots N-1$, $l = 0,1, \ldots M-1$.

[0056] It is to be understood that the scenario of ISAC would be especially benefit from the example embodiments of the present disclosure. However, it does not mean that the example embodiments of the present disclosure can be implemented only for this specific scenario. Actually, the example embodiments of the present disclosure may be implemented in any scenario where at least one measurements report is associated with at least two different functionalities. The present disclosure is not limited in this regard.

[0057] It should be understood that in the context of the present disclosure, the terminal device and the network device are used as example as the first node and the second node for illustrative purpose only. Actually, the first node may be a terminal device or a network device, while the second node may be a terminal device, a network device or a function entity in core network.

[0058] It should be understood that in the context of the present disclosure, the delay domain and the doppler domain are used as example as the first domain and the second domain for illustrative purpose only.

[0059] Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

Example environment

[0060] FIG. 1 illustrates an example communication environment 100A in which example embodiments of the present disclosure can be implemented. The communication environment 100 includes a first node 110 and a second node 120.

[0061] In some example embodiments, the first node 110 may be comprised in a terminal device/apparatus and the second node 120 may be comprised in a network device/apparatus serving the terminal device/apparatus.

[0062] In the following, for the purpose of illustration, some example embodiments are described with the first node 110 operating as a terminal device and the second node 120 operating as a network device. However, in some example embodiments, operations described in connection with a terminal node may be implemented at a network node or other node, and operations described in connection with a network node may be implemented at a terminal node or other node.

[0063] In some example embodiments, if the first node 110 is a terminal node and the second node 120 is a network node, a link from the second node 120 to the first node 110 is referred to as a downlink (DL), while a link from the first node 110 to the second node 120 is referred to as an uplink (UL). In DL, the second node 120 is a transmitting (TX) apparatus (or a transmitter) and the first node 110 is a receiving (RX) apparatus (or a receiver). In UL, the first node 110 is a TX apparatus (or a transmitter) and the second node 120 is a RX apparatus (or a receiver).

[0064] Further, MIMO is supported by at least one of the first node 110 and the second node 120. As illustrated in FIG. 1, the first node 110 may use at least one of: beams 150-1, 150-2, 150-3 (individually or collectively referred to as a beam 150) and beams 170-1, 170-2, 170-3 (individually or collectively referred to as a beam 170) to communicate with the second node 120. Accordingly, 1, the second node 120 may use at least one of: beams 140-1, 140-2, 140-3 (individually or collectively referred to as a beam 140) and beams 160-1, 160-2, 160-3 (individually or collectively referred to as a beam 160) to communicate with the first node 110.

[0065] Further, the communication environment 100A comprises objects 130-1 and 130-2, collectively referred to as object(s) 130 or individually referred to as a first object 130-1 and a second object 130-2. According to the example embodiments of the present disclosure, the object(s) 130 may be sensed by the first node 110 and/or the second node 120.

[0066] In some embodiments, the first node 110 may transmit measurement report(s) to the second node 120. By communicating the measurement report(s), ISAC may be achieved in the communication environment 100.

[0067] Further, OTFS-related measurement report maybe supported in the FIG. 1. As a result, zak transform, the symplectic finite fourier transform (SFFT) and inverse SFFT (ISFFT) may be supported. Specifically, with SFFT, the time-frequency domain may be transformed to the delay-doppler domain, and with ISFFT, the delay-doppler domain may be transformed to the time-frequency domain.

[0068] In some embodiments, the first node 110 and the second node 120 may communicate with each other via a channel such as a wireless communication channel on an air interface (e.g., Uu interface). The wireless communication channel may comprise a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH), a physical random-access channel (PRACH), a physical downlink control channel (PDCCH), a physical downlink shared channel (PDSCH) and a physical broadcast channel (PBCH). Of course, any other suitable channels are also feasible.

[0069] The communications in the communication environment 100 may conform to any suitable standards including, but not limited to, Global System for Mobile Communications (GSM), Long Term Evolution (LTE), LTE-Evolution, LTE-Advanced (LTE-A), New Radio (NR), Wideband Code Division Multiple Access (WCDMA), Code Division Multiple Access (CDMA), GSM EDGE Radio Access Network (GERAN), Machine Type Communication (MTC) and the like. The embodiments of the present disclosure may be performed according to any generation communication protocols either currently known or to be developed in the future. Examples of the communication protocols include, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, 5.5G, 5G-Advanced networks, or the sixth generation (6G) networks.

<u>Example processes</u>

[0070] Reference is made to FIG. 2, which illustrates a signaling flow 200 of communication in accordance with some embodiments of the present disclosure. For the purposes of discussion, the signaling flow 200 will be discussed with reference to FIG. 1, for example, by using the first node 110 and the second node 120.

[0071] It is to be understood that the operations at the first node 110 and the second node 120 should be coordinated. In other words, the second node 120 and the first node 110 should have common understanding about configurations, parameters and so on. Such common understanding may be implemented by any suitable interactions between the second node 120 and the first node 110 or both the second node 120 and the first node 110 applying the same rule/policy. In the following, although some operations are described from a perspective of the first node 110, it is to be understood that the corresponding operations should be performed by the second node 120. Similarly, although some operations are described from a perspective of the second node 120, it is to be understood that the corresponding operations should be performed by the first node 110. Merely for brevity, some of the same or similar contents are omitted here.

[0072] In addition, in the following description, some interactions are performed among the first node 110 and the second node 120 (such as, exchanging configuration(s) and so on). It is to be understood that the interactions may be implemented either in one single signaling/message/configuration or multiple signaling/messages/configurations, including system information, radio resource control (RRC) message, downlink control information (DCI) message, uplink control information (UCI) message, media access control (MAC) control element (CE) and so on. The present disclosure is not limited in this regard.

[0073] In some embodiments, the first node 110 may be operated as a terminal device and the second node 120 may be operated as a network device. Alternatively, in some embodiments, the first node 110 may be operated as a network device and the second node 120 may be operated as a terminal device.

[0074] In operation, the first node may receive 210 configuration information for at least one measurement report from the second node 120. In some embodiments, the at least one measurement report may be OTFS-related measurement report.

[0075] The first node 110 may transmit 220 the at least one measurement report to the second node 120. In the present disclosure, the at least one measurement report may indicate a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information. In particular, the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0076] In some embodiments, in addition to the first and second sets of pairs of delay information and doppler information, more information may be indicated in the measurement report(s). Example information indicated by the measurement report incudes but is not limited to,

➢ a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, such as, corresponding to the P_2 delay/doppler pairs based on second sets of pairs (For example, the first amplitude coefficient may correspond to finer quantization. For another example, the indication for first amplitude coefficient may comprise more bits),

➢ a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, such as, corresponding to the P_2 delay/doppler pairs based on second sets of pairs (For example, the first phase coefficient may correspond to finer quantization. For another example, the indication for the first phase coefficient may comprise more bits),

➢ a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, such as, corresponding to the P_1-P_2 delay/doppler pairs (For example, the P_1-P_2 delay/doppler pairs may be based on first sets of pairs and excluding those pairs based on the second sets of pairs) (For example, the second amplitude coefficient may correspond to coarse quantization. For another example, the indication for second amplitude coefficient may comprise less bits than the indication of the first amplitude coefficient),

➢ a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, such as, corresponding to the P_1-P_2 delay/doppler pairs (For example, the P_1-P_2 delay/doppler pairs may be based on first sets of pairs and excluding those pairs based on the second sets of pairs) (For example, the second phase coefficient may correspond to coarse quantization. For another example, the indication for second phase coefficient may comprise less bits than the indication of the first phase coefficient),

➢ at least one parameter M_1 indicating a first delay range corresponding to the delay domain or corresponding to the delay domain and the doppler domain.. In some embodiments, the parameter M_1 may identify the range of delay/doppler pair. In some embodiments, M_1 may be positive integer. For example, $1<M_1<M$. For another example, $1<M_1<M\_interval$. In some embodiments, the parameter $M_{offset1}$ may identify the location of the delay indexes or the first range corresponding to the delay domain. In some embodiments, $M_{offset1}$ may be an integer. For example, $0<= M_{offset1}<=M-1$. In some embodiments, the first set of pairs of delay information and doppler information may be within the first range corresponding to the delay domain and/or within the first range corresponding to the doppler domain or the first range corresponding to the delay domain and the doppler domain,

➢ at least one parameter N_1 indicating a first doppler range corresponding to the doppler domain or corresponding to the delay domain and the doppler domain. In some embodiments, the parameter N_1 may identify the range of delay/doppler pair. In some embodiments, N_1 may be positive integer. For example, $1<N_1<N$. For another example, $1<N_1<N\_interval$. In some embodiments, the parameter $N_{offset1}$ may identify the location of the doppler indexes or the first range corresponding to the doppler domain. In some embodiments, $N_{offset1}$ may be an integer. For example, $0<= M_{offset1}<=M-1$. In some embodiments, the first set of pairs of delay information and doppler information may be within the first range corresponding to the delay domain and/or within the first range corresponding to the doppler domain or the first range corresponding to the delay domain and the doppler domain.at least one parameter M_2 indicating a group of pairs of delay information and doppler information or indicating a number of delay domain indexes in a group of delay domain indexes or indicating a number of delay domain indexes in the group of pairs of delay information and doppler information. In some embodiments, M_2 may be a positive integer. For example, $1<=M_2<=M$. For another example, $1<=M_2<=32$. For another example, $1<=M_2<=16$. For another example, $M_2 \in \{2,4,6,8,12,14,16,32\}$,

➢ at least one parameter N_2 indicating a group of pairs of delay information and doppler information or indicating a number of doppler domain indexes in a group of doppler domain indexes or indicating a number of doppler domain indexes in the group of pairs of delay information and doppler information. In some embodiments, N_2 may be a positive integer. For example, $1<=N_2<=N$. For another example, 1<=N_2<=32. For another example, 1<=N_2<=16. For another example, 1<=N_2<=8. For another example, 1<=N_2<=14. For another example, $N_2 \in \{2,4,6,8,12,14,16,32\}$,

➢ at least one parameter M_2 and N_2 for indicating a size of a group of pairs or identifying the unit of one group of pairs,

➢ a reference pair of delay information and doppler information,

➢ a receiving power corresponding to the reference pair. For example, the reference pair may be the strongest delay/doppler pair or the pair with largest value of first amplitude coefficient or with largest value of second amplitude coefficient,

➢ the number of reported pairs of delay information and doppler information or the number of groups of pairs (For example, P_1 pairs or G_1 groups) corresponding to the first set of pairs of delay information and doppler information,

➢ the number of reported pairs of delay information and doppler information or the number of groups of pairs (For example, P_2 pairs or G_2 groups) corresponding to the second set of pairs of delay information and doppler information,

➢ first value X, which may be the second amplitude coefficient or a threshold for amplitude corresponding to the P_1-P_2 delay/doppler pairs, or

➢ at least one spatial domain (SD)-related indication or at least one third vector indication.

[0077] In some embodiments, the number of the at least one spatial domain indication or the number of the at least one third vector in the measurement report may be represented as L. In some embodiments, L may be positive integer. For example, $1 \leq L \leq 16$. For another example, $L \in \{1, 2, 3, 4, 6\}$.

[0078] In some embodiments, one third vector of the at least one third vector may be represented as $v_{l,m}$. In some embodiments, $v_{l,m} = \left[u_m, u_m * e^{j\frac{2\pi l}{O_1 R_1}}, \ldots, u_m * e^{j\frac{2\pi l*(R_1-1)}{O_1 R_1}}\right]^T$. In some embodiments, $u_m = \begin{cases} \left[1, e^{j\frac{2\pi m}{O_2 R_2}}, \ldots, e^{j\frac{2\pi m(R_2-1)}{O_2 R_2}}\right] & R_2 > 1 \\ 1 & R_2 = 1 \end{cases}$. In some embodiments, $l \in \{0, 1, \ldots O_1 R_1 - 1\}$. In some embodiments, $m \in \{0, 1, \ldots O_2 R_2 - 1\}$. In some embodiments, $= O_1 n_1 + q_1$, $m = O_2 n_2 + q_2$.

[0079] In some embodiments, q_1 and q_2 may be rotations of the plurality of rotations for the at least one third vector. In some embodiments, $q_1 \in \{0, 1, \dots O_1 - 1\}$. In some embodiments, $q_2 \in \{0, 1, \dots O_2 - 1\}$.

[0080] In some embodiments, a value of the first parameter of antenna port configuration may be represented as R_1. For example, R_1 may be a positive integer. For example, R_1 may be one of {2, 3, 4, 6, 8, 12, 16}. In some embodiments, a value of the second parameter of antenna port configuration may be represented as R_2. For example, R_2 may be a positive integer. For example, R_2 may be one of {1, 2, 3, 4}. In some embodiments, the first parameter of antenna port configuration and the second parameter of antenna port configuration may be configured in one higher layer parameter.

[0081] In some embodiments, the number of antenna ports for each CSI-RS resource in the at least one CSI-RS resource may be determined based on the first parameter of antenna port configuration and a second parameter of antenna port configuration. In some embodiments, the number of antenna ports for the CSI-RS resource may be $P = R_1 \cdot R_2 \cdot 2$.

[0082] In some embodiments, there may be a parameter "O_1", and "O_1" may represent a first discrete fourier transform (DFT) oversampling in the first dimension. For example, "O_1" may be one of {1, 2, 4}. For another example, "O_1" may be 2 or 4. In some embodiments, there may be a parameter "O_2", and "O_2" may represent a second DFT oversampling in the second dimension. For example, "O_2" may be one of {1, 2, 4}. For another example, "O_2" may be 2 or 4.

[0083] In some embodiments, the first node 110 (e.g., terminal device) may receive at least one configuration for channel measurement/report (i.e., configuration information) from the second node 120 (e.g., network device), and the first node 110 may determine and/or transmit at least one of the following in the measurement report(s):

- at least one first indication (e.g., indicating a first set of pairs of delay information and doppler information) corresponding to a first domain (e.g., delay domain) and a second domain (e.g., doppler domain),

- at least one second indication (e.g., indicating a second set of pairs of delay information and doppler information) corresponding to the first domain (e.g., delay domain) and the second domain (e.g., doppler domain),

- a set of first amplitude coefficients (one or more coefficients) corresponding to the at least one second indication, or

➢ a set of first phase coefficients (one or more coefficients) corresponding to the at least one second indication.

[0084] In some embodiments, the at least one second indication may be based on the at least one first indication. In some embodiments, the second set of pairs of delay information and doppler information may be selected from or a subset of the first set of pairs of delay information and doppler information. . In some embodiments, the at least one first indication may be based on the at least one second indication. In some embodiments, the first set of pairs of delay information and doppler information may be selected from or a subset of the second set of pairs of delay information and doppler information.

[0085] In some embodiments, the first set of pairs of delay information and doppler information and/or the second set of pairs of delay information and doppler information may be limited in a first range. In some embodiments, the candidate value in delay domain corresponding to the first set of pairs of delay information and doppler information and/or the second set of pairs of delay information and doppler information may be limited within [$M_{offset1}$, $M_{offset1}$+M_1-1] (For example, as illustrated in FIG. 3A, which illustrated an example of the reporting information 300A), or [$M_{offset1}$, ($M_{offset1}$+M_1-1) mod M] (For example, as illustrated in FIG. 4A, which illustrated an example of the reporting information 400A). In some embodiments, the candidate value in doppler domain corresponding to the first set of pairs of delay information and doppler information and/or the second set of pairs of delay information and doppler information may be limited within [$N_{offset1}$, $N_{offset1}$+N_1-1] (For example, as illustrated in FIG. 3A and FIG. 4A) or [$N_{offset1}$, ($N_{offset1}$+N_1-1) mod N].

[0086] In some embodiments, the at least one group of pairs of delay information and doppler information (For example, G_1 or G_2) may be limited in a second range. In some embodiments, the candidate value in delay domain corresponding to the at least one group of pairs of delay information and doppler information may be limited within [$M_{offset2}$, $M_{offset2}$+ M_1/M_2-1], or [$M_{offset2}$, ($M_{offset2}$+ M_1/M_2-1) mod (M/M_2)]. In some embodiments, the candidate value in doppler domain corresponding to the at least one group of pairs of delay information and doppler information may be limited within [$N_{offset2}$, $N_{offset2}$+ N_1/N_2-1] or [$N_{offset2}$, ($N_{offset2}$+ N_1/N_2-1) mod (N/N_2)].

[0087] In some embodiments, the second delay range may be the same as or different from the first delay range. In some embodiments, the second doppler range may be the same as or different from the first doppler range.

[0088] The first set of pairs of delay information and doppler information may be indicated in many suitable manners as discussed below.

[0089] Merely for a better understanding, in one specific embodiment, the first set may be: pair #a, pair #b, pair #c, pair #d.

[0090] In some embodiments, the first set of pairs of delay information and doppler information may be indicated by a set of first indicators and a set of second indicators, where each first indicator may indicate a first value in delay domain and each second indicator may indicate a second value in doppler domain. In some embodiments, the set of first indicators, the set of second indicators are corresponding to the first set of pairs of delay information and doppler information. In the above specific embodiment, the set of first indicators may be: first indicator #a, first indicator #b, first indicator #c, first indicator #d, while the set of second indicators may be: second indicator #a, second indicator #b, second indicator #c, second indicator #d.

[0091] In some embodiments, the measurement report(s) may comprise at least one first indication (e.g., indicating the first set of pairs of delay information and doppler information), and the at least one first indication may comprise at least one first indicator indicating at least one first value (e.g., represented as m1. In some embodiments, m1 may be an integer. For example, 0<=m1<=M_1-1), and each first value m1 may be within a first range corresponding to the first domain. In some embodiments, the at least one first indication may also comprise at least one second indicator indicating at least one second value (e.g., represented as n1. In some embodiments, n1 may be an integer. For example, 0<=n1<=N_1-1), and each second value n1 may be within a first range corresponding to the second domain.

[0092] In some embodiments, the first set of pairs of delay information and doppler information may be indicated by a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator. In some embodiments, the set of third indicators is corresponding to the first set of pairs of delay information and doppler information. In the above specific embodiment, the set of third indicators may be {first indicator #a, second indicator #a}, {first indicator #b, second indicator #b}, {first indicator #c, second indicator #c}, {first indicator #d, second indicator #d}.

[0093] In some embodiments, the at least one first indication (e.g., indicating a pair of delay information and doppler information) may comprise a third indicator corresponding to the first domain and the second domain. In some embodiments, the third indicator may comprise or may correspond to at least one pair of first value and second value. In some embodiments, the third indicator may comprise one value corresponding to one pair of first value and second value.

[0094] In some embodiments, the first value indicated by the first indicator may be within a first delay range (e.g., [$M_{offset1}$, $M_{offset1}$+M_1-1] or [$M_{offset1}$, ($M_{offset1}$+M_1-1) mod M]). In some embodiments, the first delay range may be determined based on a first offset in delay domain (e.g., represented as $M_{offset1}$) and a first length of the first delay range (e.g., represented as M_1). In some embodiments, the second value indicated by the second indicator may be within a first doppler range (e.g., [$N_{offset1}$, $N_{offset1}$+N_1-1] or [$N_{offset1}$, ($N_{offset1}$+N_1-1) mod N]). In some embodiments, the first doppler range may be determined based on a first offset in doppler domain (e.g., represented as $N_{offset1}$) and a first length of the first doppler range (e.g., represented as N_1).

[0095] In some embodiments, the first set of pairs of delay information and doppler information may be indicated by a first indication or a third indicator indicating a first bitmap of the first set of pairs of delay information and doppler information, each bit in the first bitmap corresponding to a pair of delay information and doppler information. In some embodiments, the first indication or the first bitmap may be a bitmap with a size M_1* N_1. For example, in the first bitmap, each of the bits corresponding to the pair #a, pair #b, pair #c, pair #d is set to "1".

[0096] In some embodiments, the at least one first indication (e.g., indicating a pair of delay information and doppler information) may comprise the third indicator corresponding to the first domain and the second domain, where the third indicator may be a first bitmap. In some embodiments, the size of the first bitmap may be M_1* N_1, and each bit in the first bitmap may correspond to one pair of first domain index and second domain index (or one pair of delay and doppler), within the first range corresponding to the first domain and the first range corresponding to the second domain.

[0097] In some embodiments, the at least one first indication may comprise at least one first indicator and at least one second indicator, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain.

[0098] In some embodiments, the at least one first indication may comprise at least one third indicator, each third indicator indicating a pair of values of a first indicator and a second indicator or each third indicator indicating a value corresponding to a pair of first domain index and second domain index.

[0099] In some embodiments, the at least one second indication may comprise at least one fourth indictor and at least one fifth indicator, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain.

[0100] In some embodiments, the at least one second indication may comprise at least one sixth indicator, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator or each sixth indicator indicating a value corresponding to a pair of first domain index and second domain index. Similar with the first set of pairs of delay information and doppler information, the second set of pairs of delay information and doppler information also may be indicated in many suitable manners as discussed below.

[0101] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by a set of fourth indicators and a set of fifth indicators, where each fourth indicator may indicate a third value in delay domain and each fifth indicator may indicate a fourth value in doppler domain. In some embodiments, the set of fourth indicators, the set of fifth indicators are corresponding to the second set of pairs of delay information and doppler information.

[0102] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator. In some embodiments, the set of sixth indicators is corresponding to the second set of pairs of delay information and doppler information.

[0103] In some embodiments, the sixth indicator may be a second bitmap. In some embodiments, the size of the second bitmap may be $M_1 * N_1/(M_2 * N_2)$, and each bit in the second bitmap may correspond to one pair of first domain index and second domain index (or one pair of delay and doppler), within the first range or second range corresponding to the first domain and the first range or second range corresponding to the second domain.

[0104] In some embodiments, the third value indicated by the fourth indicator may be within the first delay range or within a second delay range (e.g., $[M_{offset2}, M_{offset2} + M_1/M_2 - 1]$, or $[M_{offset2}, (M_{offset2} + M_1/M_2 - 1) \bmod (M/M_2)]$). In some embodiments, the second delay range may be determined based on a second offset in delay domain (e.g., represented as $M_{offset2}$) and/or M_2.

[0105] In some embodiments, the fourth value indicated by the fifth indicator may be within the first doppler range or within a second doppler range (e.g. $[N_{offset2}, N_{offset2}+ N_1/N_2-1]$ or $[N_{offset2}, (N_{offset2}+ N_1/N_2-1) \bmod (N/N_2)]$) . In some embodiments, the second doppler range may be determined based on a second offset in doppler domain (e.g., represented as $N_{offset2}$) and/or N_2.

[0106] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by a second indication indicating a second bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information. In some embodiments, the second indication or the second bitmap may be a bitmap with a size of $(M_1* N_1)/(M_2* N_2)$. For example, in this bitmap, each of the bits corresponding to the second set of pairs of delay information and doppler information is set to "1".

[0107] In this way, by allowing the larger M and/or N, the delay and/or doppler resolution may be designed to be fine and the accurate measurement maybe obtained thereby. Further, as the delay/doppler pairs are sparse and the maximum value of delay and/or doppler and the delay/doppler pairs are within a range, the reporting overhead may be reduced by limiting the reported information to the first/second range.

[0108] In some embodiments, in order to further save signaling, the pairs of delay information and doppler information may be divided into multiple groups of pairs of delay information and doppler information, such as, each group may comprise $M_2* N_2$ pairs of delay information and doppler information. In some embodiments, M_2 may refer to the number of elements or indexes in delay domain. In some embodiments,N_2 may refer to the number of elements or indexes in doppler domain.

[0109] In some embodiments, the second set of pairs of delay information and doppler information may comprise at least one group of pairs of delay information and doppler information (G_2 groups), where each group may comprise a plurality of pairs of delay information and doppler information ($M_2* N_2$ pairs of delay information and doppler information). In some embodiments, the at least one group comprised in the second set of pairs of delay information and doppler information may be based on the first set of pairs of delay information and doppler information. In some embodiments, the first set of pairs of delay information and doppler information may be based on the at least one group comprised in the second set of pairs of delay information and doppler information.

[0110] In this event, the second set of pairs may be indicated by at least group identity corresponding to the at least one group, or a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

[0111] In some embodiments, the first set of pairs of delay information and doppler information may indicated by: at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

[0112] As discussed above, the first set and the second set of pairs of delay information and doppler information are correlated with each other. In some embodiments, the second set of pairs of delay information and doppler information may be a subset of the first set of pairs of delay information and doppler information. In some embodiments, the first set of pairs of delay information and doppler information may be a subset of the second set of pairs of delay information and doppler information.

[0113] In some embodiments, the second set of pairs of delay information and doppler information may be selected based on the first set of pairs of delay information and doppler information. In some embodiments, the first set of pairs of delay information and doppler information may be selected based on the second set of pairs of delay information and doppler information.

[0114] More details about the correlation between the first and second sets of pairs of delay information and doppler information will are discussed as below.

[0115] In some embodiments, the number of pairs in the first set of pairs of delay information and doppler information may be represented as P_1. In some embodiments, P_1 may be positive integer, e.g., $1 <= P_1 <= M_1 * N_1$. In some embodiments, the number of pairs in the second set of pairs of delay information and doppler information may be represented as P_2. In some embodiments,, P_2 may be positive integer, e.g., $1 <= P_2 <= P_1$.

[0116] In some embodiments, the second set of pairs of delay information and doppler information may be a subset of the first set of pairs of delay information and doppler information. Reference is now made to FIG. 3B, which illustrated an example of the reporting information 300B. In FIG. 3B, the second set of pairs of delay information and doppler information may be selected based on the first set of pairs of delay information and doppler information.

[0117] In this way, there may be no need to indicate fine quantize amplitude and/or phase or first amplitude coefficient or first phase coefficient for all delay/doppler pairs based on first indication, with further second indication, the overhead may be reduced.

[0118] As the second set of pairs of delay information and doppler information is selected from the first set of pairs of delay information and doppler information, the second set of pairs of delay information and doppler information also may be indicated based on the first set. In some embodiments, the second set of pairs of delay information and doppler information also may be indicated based on the first set. Specifically, as discussed above, the at least one first indication (used for indicating the first set of pairs of delay information and doppler information) may comprise at least one first value corresponding to the first domain and at least one second value corresponding to the second domain. In this event, the measurement report(s) may comprise at least one second indication (i.e., indicating the second pairs of delay information and doppler information), and the at least one second indication may comprise at least one third value selected from the at least one first values, and at least one fourth value selected from the at least one second values.

[0119] In some embodiments, the first set of pairs of first value and second value may indicated by at least one pair of first value and second value, and thus the measurement report(s) may comprise a set of sixth indicators comprise at least one pair of fourth value and fifth value, where the at least one pair of fourth value and fifth value is selected from the at least one pair of first value and second value.

[0120] In some embodiments, the measurement report(s) may comprise a third bitmap, wherein the size of the third bitmap may be P_1, and each bit in the third bitmap may correspond to one pair of first domain index and second domain index (or one pair of delay and doppler).

[0121] In some embodiments, the pairs of delay information and doppler information may be divided into multiple groups of pairs of delay information and doppler information. In some embodiments, each group may comprise M_2*N_2 pairs of delay information and doppler information. In some embodiments, M_2 may refer to the number of elements or indexes in delay domain. In some embodiments, N_2 may refer to the number of elements or indexes in doppler domain. For example, the second set of pairs of delay information and doppler information may be a group-based indication as discussed below.

[0122] In some embodiments, if the second set of pairs of delay information and doppler information comprises G_2 groups of pairs, the measurement report(s) may indicate G_2 groups of pairs of first domain indexes and second domain indexes. In some embodiments, G_2 may be positive integer. For example, $1<= G_2<=P_1$. For another example, $1<= G_2<=M_1*N_1 /(M_2*N_2)$.

[0123] In some embodiments, each group of pairs may comprise M_2*N_2 pairs of first domain indexes and second domain indexes, or M_2 first domain indexes, N_2 second domain indexes. In some embodiments, M_2 and N_2 may be positive integers. For example, $1< M_2<=32$. For example, $1< N_2<=16$. For example, the two dimensional range M_1*N_1 may be divided into a plurality of groups. e.g., $M_1*N_1/(M_2*N_2)$. In some embodiments, the two dimensional range M*N may be divided into a plurality of groups, e.g., $M*N/(M_2*N_2)$).

[0124] For a better understanding, reference is now made to FIG. 5, which illustrates an example of the reporting information 500. In FIG. 5, the second set of pairs of delay information and doppler information is selected from the first set of pairs of delay information and doppler information, while the second set of pairs of delay information and doppler information corresponds to G_2 group of pairs.

[0125] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by at least one third value (e.g., represented as m2. In some embodiments, m2 may be an integer. For example, $0<=m2<=M_1/M_2-1$), at least one fourth value (e.g., represented as n2. In some embodiments, n2 may be an integer. For example, $0<=n2<=N_1/N_2-1$). In some embodiments, the at least one third value may correspond to a group of first domain indexes, and each third value m2 may be within a second range corresponding to the first domain (e.g., $[M_{offset2}, M_{offset2}+M_1/M_2-1]$ or $[M_{offset2}, (M_{offset2}+M_1/M2-1) \bmod (M/M_2)]$). In some embodiments, the at least one fourth value may correspond to a group of second domain indexes, and each second value n2 may be within a second range corresponding to the second domain (e.g. $[N_{offset2}, N_{offset2}+N_1/N_2-1]$ or $[N_{offset2}, (N_{offset2}+N_1/N_2-1) \bmod (N/N_2)]$).

[0126] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by at least one pair of third value and fourth value.

[0127] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by a fourth bitmap, wherein the size of the second bitmap may be $M_1*N_1/(M_2*N_2)$, and each bit in the fourth bitmap may correspond to one group of pairs of first domain indexes and second domain indexes, within the first or second range corresponding to the first domain and the second domain.

[0128] In some embodiments, the first set of pairs of delay information and doppler information may be G_1 groups of pairs. In this event, the G_2 groups of pairs may be selected from the G_1 groups of pairs and indicated by a bitmap with a size of G_1.

[0129] In some embodiments, $G_2 = G_1$. In this case, there is no need to indicate the second set of pairs of delay information and doppler information, because the G_2 groups of pairs may be determined based on the P_1 pairs (or G_1 groups of pairs) and the value of P and Q.

[0130] In some embodiments, the first set of pairs of delay information and doppler information may be determined from the second set of pairs of delay information and doppler information may be determined, as discussed below.

[0131] In some embodiments, the second set of pairs of delay information and doppler information comprises G_2 groups of pairs of first domain indexes and second domain indexes. G_2 may be positive integer. For example, $1<= G_2<=M_1*N_1/(M_2*N_2)$. For another example, $1<= G_2<=M*N/(M_2*N_2)$.

[0132] FIG. 6 illustrates an example of the reporting information 600. As illustrated in FIG. 6, the first set of delay information and doppler information (i.e., P_1) may be determined based on the G_2 groups. In FIG. 6, P_1 may be positive integer, e.g., $G_2<=P_1<= G_2* M_2*N_2$.

[0133] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by at least one third value (e.g., represented as m2), at least one fourth value (e.g., represented as n2). In some embodiments, each third value may correspond to a group of first domain indexes, and each third value m2 may be within a second range corresponding to the first domain (e.g., $[M_{offset2}, M_{offset2}+M_1/M_2-1]$ or $[M_{offset2}, (M_{offset2}+M_1/M_2-1) \bmod (M/M_2)]$). In some embodiments, each fourth value may correspond to a group of second domain indexes, and each second value n2 may be within a second range corresponding to the second domain (e.g. $[N_{offset2}, N_{offset2}+N_1/N_2-1]$ or $[N_{offset2}, (N_{offset2}+N_1/N_2-1) \bmod (N/N_2)]$).

[0134] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by at least one pair of third value and fourth value.

[0135] In some embodiments, the second set of pairs of delay information and doppler information may be indicated by a fourth bitmap, wherein the size of the fourth bitmap may be $M_1*N_1/(M_2*N_2)$, and each bit in the fourth bitmap may correspond to one group of pairs of first domain indexes and second domain indexes, within the first or second range corresponding to the first domain and the second domain.

[0136] As the first set of pairs of delay information and doppler information is determine based on the G_2 groups of pairs, and the first set of pairs also may be indicated based on the G_2 groups of pairs. In some embodiments, the measurement report(s) may comprise first information corresponding to the first domain and second information corresponding to the second domain, wherein the first information may comprise at least one fifth value (e.g., represented as m3. In some embodiments, m3 may be an integer. For example, $0<=m3<= M_1$), wherein each fifth value may correspond to one first domain index within a group, and each fifth value m3 may be within a third range corresponding to the first domain (e.g. $[0, M_2-1]$, the second information corresponding to the second domain may comprise at least one sixth value (e.g., represented as n3. In some embodiments, n3 may be an integer. For example, $0<=n3<= N_1$), wherein each sixth value may correspond to one second domain index, and each sixth value n3 may be within a third range corresponding to the second domain (e.g. $[0, N_2-1]$).

[0137] In some embodiments, the measurement report(s) may comprise third information comprise at least one pair of fifth value and sixth value.

[0138] In some embodiments, the measurement report(s) may comprise at least fifth bitmap, where each fifth bitmap may be of a size of M_2*N_2, and each bit in the fifth bitmap may correspond to one pair of first domain index and second domain index. In some embodiments, the size of the at least fifth bitmap may be $G_2* M_2*N_2$.

[0139] In the following, the other information (rather than the first and second sets of pairs) comprised in the measurement report is discussed as below.

[0140] In some embodiments, the measurement report(s) may comprise an indication of $M_{offset1}$. For example, $M-M_1<= M_{offset1} <=M$.

[0141] In some embodiments, the measurement report(s) may further comprise an indication of received power (e.g., reference signal receiving power, RSRP). In some embodiments, the received power may correspond to one pair of delay/doppler indexes (e.g., a reference pair, for example the pair with largest power or largest amplitude coefficient). In some embodiments, the quantization of the received power may reuse RSRP. In some embodiments, the pair of delay/doppler indexes may also be comprised in the measurement report(s).

[0142] In some embodiments, the P_2 pairs or G_2 groups of pairs of first domain indexes and second domain indexes may be associated with one set of first amplitude coefficients and/or one set of first phase coefficients, where each first amplitude coefficient corresponds to a pair of the P_2 pairs or a group of G_2 groups of pairs may be indicated based on B1 bits. In some embodiments, B1 may be a positive integer. For example, B1 may be 2 or 3 or 4.

[0143] In some embodiments, the first amplitude coefficient may be at least one of $\{\left(\frac{1}{32768}\right)^{1/4}, \frac{1}{\sqrt{128}}, \left(\frac{1}{8192}\right)^{1/4}, \frac{1}{8}, \left(\frac{1}{2048}\right)^{1/4}, \frac{1}{2\sqrt{8}}, \left(\frac{1}{512}\right)^{1/4}, \frac{1}{4}, \left(\frac{1}{128}\right)^{1/4}, \frac{1}{\sqrt{8}}, \left(\frac{1}{32}\right)^{1/4}, \frac{1}{2}, \left(\frac{1}{8}\right)^{1/4}, \frac{1}{\sqrt{2}}, \left(\frac{1}{2}\right)^{1/4}, 1\}$. In some embodiments, the power corresponding to one delay/doppler pair may be based on the first amplitude coefficient corresponding to the delay/doppler pair and the indication of the received power.

[0144] In some embodiments, one pair of the P_1-P_2 remaining pairs or one group of the G_1-G_2 groups of pairs of first domain indexes and second domain indexes may not be associated with one amplitude coefficient and/or one phase coefficient and/or one first amplitude coefficient and/or one first phase coefficient. In some embodiments, the amplitude corresponding to the pair or the group may be assumed to be a first value X or less than X or no larger than X. In some embodiments, X may be $\left(\frac{1}{32768}\right)^{1/4}$ or $\frac{1}{\sqrt{128}}$ or 1/8 or 1/16.

[0145] In some embodiments, one pair of the P_1-P_2 remaining pairs or one group of the G_1-G_2 groups of pairs of first domain indexes and second domain indexes may be associated with one second amplitude coefficient and/or one second phase coefficient. In some embodiments, each second amplitude coefficient corresponding to the P_1-P_2 remaining pairs or one group of the G_1-G_2 groups may be indicated based on B2 bits. In some embodiments, e.g., B2<=B1. In some embodiments, B2 may be at least one of {1,2,3,4}. In some embodiments, the amplitude corresponding to the pair or the group may be based on the second amplitude coefficient and/or the first value X. In some embodiments, the amplitude corresponding to the pair or the group may be second amplitude coefficient multiplies the first value X. In some embodiments, the second amplitude coefficient may be at least one of $\{\frac{1}{\sqrt{8}}, \frac{1}{2}, \frac{1}{\sqrt{2}}, 1\}$. In some embodiments, the second amplitude coefficient may be at least one of $\{\frac{1}{4}, \left(\frac{1}{128}\right)^{1/4}, \frac{1}{\sqrt{8}}, \left(\frac{1}{32}\right)^{1/4}, \frac{1}{2}, \left(\frac{1}{8}\right)^{1/4}, \frac{1}{\sqrt{2}}, \left(\frac{1}{2}\right)^{1/4}, 1\}$.

[0146] In some embodiments, the measurement report may further comprise the indication of the first value X, and the first value may be applied to the P_1-P_2 pairs or the G_1-G_2 groups of pairs.

[0147] In this way, the power of the remaining pairs is small, considering the overhead, no need of report amplitude and/or phase, the delay/doppler pair can be further measured with other configuration.

[0148] In some embodiments, within the first range corresponding to the first domain and/or the second domain, the maximum (allowed) reported number of pairs or groups of first domain indexes and second domain indexes may be Pair_max1, where Pair_max1 may be positive integer. For example, 1<= Pair_max1<= M_1*N_1. In some embodiments, the value of Pair_max1 may be configured by the second device or predetermined based on the value of M_1 and/or N_1. In some embodiments, P_1<=Pair_max1.

[0149] In some embodiments, within the first range corresponding to the first domain and/or the second domain, the maximum (allowed) reported number of first amplitude coefficients and/or first phase coefficients (e.g., corresponding to a second maximum number of pairs or groups of first domain indexes and second domain indexes) may be Pair_max2, where Pair_max2 may be positive integer. For example, 1<= Pair_max2<= M_1*N_1. In some embodiments, the value of Pair_max2 may be configured by the second device or predetermined based on the value of M_1 and/or N_1. In some embodiments,, P_2 <=Pair_max2. In some embodiments, the value of Pair_max2 may be no larger than the value of Pair_max1.

[0150] In some embodiments, the measurement report may further comprise at least one third basis or at least one phase information corresponding to P ports of at least one CSI-RS resource, and one pair of first domain index and second domain index may be associated with the at least one third basis or a subset (one or more) of the at least one third basis, e.g., for a first type of report. For example, all the P ports may correspond to same first indication and same second indication. In some embodiments, P may be positive integer. For example, 1<=P<=256. For another example, $P \in \{1, 2, 4, 6, 8, 12, 16, 24, 32, 64, 96, 128, 256, 512\}$.

[0151] In some embodiments, the measurement report may further comprise at least one port of the P ports, and one pair of first domain index and second domain index may be associated with the at least one port or a subset (one or more) of the at least one port, e.g., for a second type of report, such as (port selection report), wherein each port may be at least one beam or at least one pair of beam and delay. For example, each one of the at least one port of the P ports may correspond to one first indication and one second indication.

[0152] In some embodiments, the second node 120 may indicate a range of two dimensional elements to the first node 110 for the report (e.g., value of M_1 and/or value of N_1), and the first node 110 may report the first set of pairs of delay information and doppler information within the range and/or at least one first amplitude coefficient (or at least one second amplitude coefficient) and at least one first phase coefficient (or at least one second phase coefficient) corresponding to the first set of pairs of delay information and doppler information to the second node 120.

[0153] In some embodiments, the P ports of the at least one reference signal may be multiplexed based on the first domain and/or multiplexed based on the second domain, wherein each port may be mapped within a range of M_1*N_1 elements of the first domain and the second domain, as illustrated in FIG. 7, which illustrates an example of the reporting information 700.

[0154] In some embodiments, group may be represented as a range of [M_interval*AP1_i, M_interval*AP1_i+M_1-1] in the first domain, and a range of [N_interval*AP2_i, N_interval*AP2_i+N_1-1], wherein AP1_i may be the index of the AP1 ports multiplexed in the first domain, and AP2_i may be the index of the AP2 ports multiplexed in the second domain. In some embodiments, AP1 may be positive integer. For example, 1<=AP1<=32. For another example, AP1∈{1,2,3,4,6,8,16,32}. In some embodiments, AP2 may be positive integer. For example, 1<=AP2<=32. For another example, AP2 ∈ {1,2,3,4,6,8,16,32}. For example, AP1*AP2=P. For example, 0<=AP1_i<=AP1-1. For example, 0<=AP2_i<=AP2-1.

[0155] In some embodiments, each port may comprise a sequence of L1 values in the first domain and/or a sequence of L2 values in the second domain. In some embodiments, L1 may be positive integer. For example, 1<=L1<=M., In some embodiments, L2 may be positive integer. For example, 1<=L2<=N_1. In some embodiments, M_interval may be a positive integer, e.g., M_interval >= M_1 or M_interval >=M_1+L1. In some embodiments, N_interval may be a positive integer, e.g., N_interval >=N_1, N_interval >=N_1+L1. In some embodiments, N_interval may be fixed, e.g., fixed as 0 or N/2 for all the P ports.

[0156] In some embodiments, the configuration information may further comprise the value of M_interval and/or the value of N_interval.

[0157] In some embodiments, the measurement report (such as, the at least one first indication and/or the at least one second indication) may need to exclude the part of M_interval and N_interval.

[0158] In some embodiments, the two dimensional elements M*N of first domain and second domain (delay/doppler domain) may be transformed into M*N of time/frequency domain with M indexes in frequency domain and N indexes in time domain, and the M indexes may be mapped to a range of M*comb frequency elements with an interval of comb elements (e.g. interleaved frequency domain multiplexing IFDMA), comb may be a positive integer. For example, 1<=comb<=8. For another example, comb∈ {1, 2, 4, 8, 12}. In some embodiments, different ports of the reference signal may be multiplexed with different values of comb offset, the comb offset values may be [0, 1, ..., comb-1].

[0159] In some embodiments, the configuration information may indicate related parameters/information to be used for the measurement report. Example related parameters/information includes but are not limited to:

- at least one reference signal (RS) for the at least one measurement report,
- at least one parameter for performing a first transform. For example, the first transform comprises at least one of the following: a transform corresponding to OTFS, zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT),
- at least one parameter for performing a second transform. For example, the second transform comprises at least one of the following: a transform to generate OFDM symbol or transmitting symbol, fast fourier transform (FFT) or inverse FFT (IFFT),
- a resolution of the delay domain,
- a resolution of the doppler domain,
- at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, or
- at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

[0160] In some embodiment, the configuration information may indicate at least one reference signal for channel measurement/report, wherein the at least one reference signal may be mapped on a range of two dimensional elements, wherein the range of two dimensional elements may comprise M elements in the first domain and N elements in the second domain. In some embodiment, M and N may be the parameters for a first transform (e.g., zak transform, ISFFT and SFFT) and M and N are positive integer. For example, 1<=M <= 4096 or M∈ {2048, 4096}. For example, 1<= N <= 128. For another example, M may be defined as a default value (e.g. M=2048 or 1200 or 1024 or 4096 or 3300). For another example, M may be configured by the second node (e.g., a network device) or reported by the first node (e.g., a terminal device). In some embodiments , N may be defined as a default value (e.g., $N = 16$ or 32 or 64). In some embodiments, N may be configured by the second node (e.g., network device) or reported by the first node (e.g., terminal device).In some embodiments, the parameter M and/or parameter N may be pre-defined. As one example, the parameter M and/or parameter N may be pre-defined by the communication organization (such as 3GPP), or pre-defined by the network operator or service provider. In this way, no additional signaling is needed.

[0161] In some embodiments, the parameter M and/or parameter N may be dynamically or semi-statically configured. For example, either the first node 110 or the second node 120 may determine the at least one rule and then inform at least one rule to the other node. Further, the parameter M and/or parameter N may be predetermined, e.g., based on at least one of value of frequency range, value of bandwidth and value of subcarrier spacing.

[0162] In some embodiments, the at least one reference signal may comprise P ports, where P∈ {1, 2, 4, 8, 12, 16, 24, 32, 64, 96, 128, 256, 512}.

[0163] In some embodiment, the configuration information may indicate at least one parameter (e.g., represented as N_{fft}) for performing a second transform, wherein the second transform comprises at least one of the following: a transform to generate OFDM symbol or transmitting symbol, FFT or IFFT. In some embodiments. N_{fft} may be positive integer, e.g., $64 \leq N_{fft} \leq 4096$. For another example, $N_{fft} \in \{1024, 2048, 3300, 4096\}$.

[0164] In some embodiment, $N_{fft} \geq M$, e.g., N_{fft} may be the same as M or $N_{fft} = 2M$. For example, when $N_{fft} = 2048$, M = 1024 or 1200. For another example, when $N_{fft} = 4096$, M = 3300 or 2048.

[0165] In some embodiment, there may be a resolution of the delay domain or a unit of first domain, which may be T/M, ${}^{1}/_{(\Delta f * M)}$, ${}^{1}/_{(\Delta f * N_{fft})}$ or T/N_{fft}. In some embodiments, Δf may be the value of subcarrier spacing, e.g. Δf may be at least one of {15, 30, 60, 120, 240, 480 960, 1920, 3840} kHz. In some embodiments, $T = 1/\Delta f$. In some embodiments, the resolution of the delay domain or the unit of the first domain may be comprised in or may be determined based on the configuration information.

[0166] In some embodiment, there may be a resolution of the doppler domain or a unit of second domain, which may be ${}^{1}/_{(T * N)}$, $\Delta f/N$ $e^{j \cdot 2\pi * 1/(N*T)}$. In some embodiments, the resolution of the doppler domain or the unit of the second domain may be comprised in or may be determined based on the configuration information.

[0167] In some embodiment, the configuration information may indicate the value of M_1 (i.e., at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information) and/or N_1 (i.e., at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information).

[0168] In some embodiments, the parameter M_1 and/or the parameter N_1 may be pre-defined. As one example, the parameter M_1 and/or the parameter N_1 may be pre-defined by the communication organization (such as 3GPP), or pre-defined by the network operator or service provider. In this way, no additional signaling is needed. For example, $1< M_1<= M$ (e.g., $1< M_1<=128$). For example, $1< N_1<= N$ (e.g., $1<N_1<=64$).

[0169] In some embodiments, related parameters/information used for reporting the measurement report may be either configured by the second node 120 or reported by the first node 110. Example related parameters/information includes but are not limited to:

- the supported maximum number of pairs or maximum number of groups of pairs corresponding to the first set of pairs of delay information and doppler information,
- the supported maximum number of pairs corresponding to the second set of pairs of delay information and doppler information, or
- the supported maximum number of groups of pairs corresponding to the second set of pairs of delay information and doppler information.

<u>Example methods</u>

[0170] FIG. 8 illustrates a flowchart of a communication method 800 implemented at a first node in accordance with some embodiments of the present disclosure. For the purpose of discussion, the method 800 will be described from the perspective of the first node 110 in FIG. 1.

[0171] At block 810, the first node may receive, from a second node, configuration information for at least one measurement report.

[0172] At block 820, the first node may transmit, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0173] In some example embodiments, the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

[0174] In some example embodiments, the first set of pairs of delay information and doppler information is indicated by one of the following: a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain, a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

[0175] In some example embodiments, the second set of pairs of delay information and doppler information is indicated by one of the following: a set of fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain, a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

[0176] In some example embodiments, the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

[0177] In some example embodiments, the second set of pairs of delay information and doppler information is indicated by at least one of the following: at least group identity corresponding to the at least one group, or a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

[0178] In some example embodiments, the first set of pairs of delay information and doppler information is indicated by: at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

[0179] In some example embodiments, the at least one group is based on the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is based on the at least one group.

[0180] In some example embodiments, the at least one measurement report further indicates at least one of the following: a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a size of a group of pairs, a reference pair of delay information and doppler information, a receiving power corresponding to the reference pair, the number of reported pairs of delay information and doppler information corresponding to the first set of pairs of delay information and doppler information, the number of reported pairs of delay information and doppler information or the number of groups of pairs corresponding to the second set of pairs of delay information and doppler information, or at least one spatial domain (SD)-related indication.

[0181] In some example embodiments, the configuration information indicates at least one of the following: at least one reference signal (RS) for the at least one measurement report, at least one parameter for performing a first transform, wherein the first transform comprises at least one of the following: zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT), at least one parameter for performing a second transform, wherein the second transform comprises at least one of the following: fast fourier transform (FFT) or inverse FFT (IFFT), a resolution of the delay domain, a resolution of the doppler domain, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

[0182] In some example embodiments, at least one of the following is configured by the second node or reported by the first node: the supported maximum number of pairs corresponding to the first set of pairs of delay information and doppler information, the supported maximum number of pairs corresponding to the second set of pairs of delay information and doppler information, or the supported maximum number of groups of pairs corresponding to the second set of pairs of delay information and doppler information.

[0183] In some example embodiments, the first value indicated by the first indicator is within a first delay range, the first delay range is determined based on a first offset in delay domain and a first length of the first delay range, the second value indicated by the second indicator is within a first doppler range, the first doppler range is determined based on a first offset in doppler domain and a first length of the first doppler range, the third value indicated by the fourth indicator is within a second delay range, the second delay range is determined based on a second offset in delay domain and a second length of the second delay range, the fourth value indicated by the fifth indicator is within a second doppler range, the second doppler range is determined based on a second offset in doppler domain and a second length of the second doppler range, wherein the second delay range is the same as or different from the first delay range, and the second doppler range is the same as or different from the first doppler range.

[0184] In some example embodiments, the first node is a terminal device and the second node is a network device.

[0185] FIG. 9 illustrates a flowchart of a communication method 900 implemented at a second node in accordance with some embodiments of the present disclosure. For the purpose of discussion, the method 900 will be described from the perspective of the second node 120 in FIG. 1.

[0186] At block 910, the second node may transmit, to a first node, configuration information for at least one measurement report.

[0187] At block 920, the second node may receive, from the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0188] In some example embodiments, the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

[0189] In some example embodiments, the first set of pairs of delay information and doppler information is indicated by one of the following: a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain, a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

[0190] In some example embodiments, the second set of pairs of delay information and doppler information is indicated by one of the following: a second set of t fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain, a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

[0191] In some example embodiments, the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

[0192] In some example embodiments, the second set of pairs of delay information and doppler information is indicated by at least one of the following: at least group identity corresponding to the at least one group, or a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

[0193] In some example embodiments, the first set of pairs of delay information and doppler information is indicated by: at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

[0194] In some example embodiments, the at least one group is based on the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is based on the at least one group.

[0195] In some example embodiments, the at least one measurement report further indicates at least one of the following: a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a size of a group of pairs, a reference pair of delay information and doppler information, a receiving power corresponding to the reference pair, the number of reported pairs of delay information and doppler information corresponding to the first set of pairs of delay information and doppler information, the number of reported pairs of delay information and doppler information or the number of groups of pairs corresponding to the second set of pairs of delay information and doppler information, or at least one spatial domain (SD)-related indication.

[0196] In some example embodiments, the configuration information indicates at least one of the following: at least one reference signal (RS) for the at least one measurement report, at least one parameter for performing a first transform, wherein the first transform comprises at least one of the following: zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT), at least one parameter for performing a second transform, wherein the second transform comprises at least one of the following: fast fourier transform (FFT) or inverse FFT (IFFT), a resolution of the delay domain, a resolution of the doppler domain, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

[0197] In some example embodiments, at least one of the following is configured by the second node or reported by the first node: the supported maximum number of pairs corresponding to the first set of pairs of delay information and doppler information, the supported maximum number of pairs corresponding to the second pairs of delay information and doppler information, or the supported maximum number of groups of pairs corresponding to the second pairs of delay information and doppler information.

[0198] In some example embodiments, the first value indicated by the first indicator is within a first delay range, the first delay range is determined based on a first offset in delay domain and a first length of the first delay range, the second value indicated by the second indicator is within a first doppler range, the first doppler range is determined based on a first offset in doppler domain and a first length of the first doppler range, the third value indicated by the fourth indicator is within a second delay range, the second delay range is determined based on a second offset in delay domain and a second length of the second delay range, the fourth value indicated by the fifth indicator is within a second doppler range, the second doppler range is determined based on a second offset in doppler domain and a second length of the second doppler range, wherein the second delay range is the same as or different from the first delay range, and the second doppler range is the same as or different from the first doppler range.

[0199] In some example embodiments, the first node is a terminal device and the second node is a network device.

Example devices and apparatuses

[0200] FIG. 10 is a simplified block diagram of a device 1000 that is suitable for implementing embodiments of the present disclosure. The device 1000 can be considered as a further example implementation of any of the devices as shown in FIG. 1. Accordingly, the device 1000 can be implemented at or as at least a part of the first node 110 and the second node 120.

[0201] As shown, the device 1000 includes a processor 1010, a memory 1020 coupled to the processor 1010, a suitable transceiver 1040 coupled to the processor 1010, and a communication interface coupled to the transceiver 1040. The memory 1020 stores at least a part of a program 1030. The transceiver 1040 may be for bidirectional communications or a unidirectional communication based on requirements. The transceiver 1040 may include at least one of a transmitter 1042 and a receiver 1044. The transmitter 1042 and the receiver 1044 may be functional modules or physical entities. The transceiver 1040 has at least one antenna to facilitate communication, though in practice an Access Node mentioned in this application may have several ones. The communication interface may represent any interface that is necessary for communication with other network elements, such as X2/Xn interface for bidirectional communications between eNBs/gNBs, S1/NG interface for communication between a Mobility Management Entity (MME)/Access and Mobility Management Function (AMF)/SGW/UPF and the eNB/gNB, Un interface for communication between the eNB/gNB and a relay node (RN), or Uu interface for communication between the eNB/gNB and a terminal device.

[0202] The program 1030 is assumed to include program instructions that, when executed by the associated processor 1010, enable the device 1000 to operate in accordance with the embodiments of the present disclosure, as discussed herein with reference to FIGS. 1 to 10. The embodiments herein may be implemented by computer software executable by the processor 1010 of the device 1000, or by hardware, or by a combination of software and hardware. The processor 1010 may be configured to implement various embodiments of the present disclosure. Furthermore, a combination of the processor 1010 and memory 1020 may form processing means 1050 adapted to implement various embodiments of the present disclosure.

[0203] The memory 1020 may be of any type suitable to the local technical network and may be implemented using any suitable data storage technology, such as a non-transitory computer readable storage medium, semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one memory 1020 is shown in the device 1000, there may be several physically distinct memory modules in the device 1000. The processor 1010 may be of any type suitable to the local technical network, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 1000 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.

[0204] According to embodiments of the present disclosure, a first node comprising a circuitry is provided. The circuitry is configured to: receive, from a second node, configuration information for at least one measurement report; and transmit, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other. According to embodiments of the present disclosure, the circuitry may be configured to perform any method implemented by the first node as discussed above.

[0205] According to embodiments of the present disclosure, a second node comprising a circuitry is provided. The circuitry is configured to: transmit, to a first node, configuration information for at least one measurement report; and receive, from the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other. According to embodiments of the present disclosure, the circuitry may be configured to perform any method implemented by the second node as discussed above.

[0206] The term "circuitry" used herein may refer to hardware circuits and/or combinations of hardware circuits and software. For example, the circuitry may be a combination of analog and/or digital hardware circuits with software/firmware. As a further example, the circuitry may be any portions of hardware processors with software including digital signal processor(s), software, and memory(ies) that work together to cause an apparatus, such as a terminal device or a network device, to perform various functions. In a still further example, the circuitry may be hardware circuits and or processors, such as a microprocessor or a portion of a microprocessor, that requires software/firmware for operation, but the software may not be present when it is not needed for operation. As used herein, the term circuitry also covers an implementation of merely a hardware circuit or processor(s) or a portion of a hardware circuit or processor(s) and its (or their) accompanying software and/or firmware.

[0207] According to embodiments of the present disclosure, a first node is provided. The first node comprises means for receiving, from a second node, configuration information for at least one measurement report; and means for transmitting, to the second node, the at least one measurement report indicating the following: means for a first set of pairs of delay information and doppler information, and means for a second set of pairs of delay information and doppler information, means for wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other. In some embodiments, the first apparatus may comprise means for performing the respective operations of the method 800. In some example embodiments, the first apparatus may further comprise means for performing other operations in some example embodiments of the method 800. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[0208] According to embodiments of the present disclosure, a second node is provided. The second node comprises means for transmitting, to a first node, configuration information for at least one measurement report; and means for receiving, from the second node, the at least one measurement report indicating the following: means for a first set of pairs of delay information and doppler information, and means for a second set of pairs of delay information and doppler information, means for wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other. In some embodiments, the second apparatus may comprise means for performing the respective operations of the method 900. In some example embodiments, the second apparatus may further comprise means for performing other operations in some example embodiments of the method 900. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[0209] In summary, embodiments of the present disclosure provide the following aspects.

[0210] In an aspect, it is proposed a first node comprising: a processor configured to cause the first node to: receive, from a second node, configuration information for at least one measurement report; and transmit, to the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0211] In some embodiments, the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

[0212] In some embodiments, the first set of pairs of delay information and doppler information is indicated by one of the following: a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain, a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

[0213] In some embodiments, the second set of pairs of delay information and doppler information is indicated by one of the following: a set of fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain, a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

[0214] In some embodiments, the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

[0215] In some embodiments, the second set of pairs of delay information and doppler information is indicated by at least one of the following: at least group identity corresponding to the at least one group, or a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

[0216] In some embodiments, the first set of pairs of delay information and doppler information is indicated by: at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

[0217] In some embodiments, the at least one group is based on the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is based on the at least one group.

[0218] In some embodiments, the at least one measurement report further indicates at least one of the following: a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a size of a group of pairs, a reference pair of delay information and doppler information, a receiving power corresponding to the reference pair, the number of reported pairs of delay information and doppler information corresponding to the first set of pairs of delay information and doppler information, the number of reported pairs of delay information and doppler information or the number of groups of pairs corresponding to the second set of pairs of delay information and doppler information, or at least one spatial domain (SD)-related indication.

[0219] In some embodiments, the configuration information indicates at least one of the following: at least one reference signal (RS) for the at least one measurement report, at least one parameter for performing a first transform, wherein the first transform comprises at least one of the following: zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT), at least one parameter for performing a second transform, wherein the second transform comprises at least one of the following: fast fourier transform (FFT) or inverse FFT (IFFT), a resolution of the delay domain, a resolution of the doppler domain, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

[0220] In some embodiments, at least one of the following is configured by the second node or reported by the first node: the supported maximum number of pairs corresponding to the first set of pairs of delay information and doppler information, the supported maximum number of pairs corresponding to the second set of pairs of delay information and doppler information, or the supported maximum number of groups of pairs corresponding to the second set of pairs of delay information and doppler information.

[0221] In some embodiments, the first value indicated by the first indicator is within a first delay range, the first delay range is determined based on a first offset in delay domain and a first length of the first delay range, the second value indicated by the second indicator is within a first doppler range, the first doppler range is determined based on a first offset in doppler domain and a first length of the first doppler range, the third value indicated by the fourth indicator is within a second delay range, the second delay range is determined based on a second offset in delay domain and a second length of the second delay range, the fourth value indicated by the fifth indicator is within a second doppler range, the second doppler range is determined based on a second offset in doppler domain and a second length of the second doppler range, wherein the second delay range is the same as or different from the first delay range, and the second doppler range is the same as or different from the first doppler range.

[0222] In some embodiments, the first node is a terminal device and the second node is a network device.

[0223] In an aspect, it is proposed a second node comprising: a processor configured to cause the second node to: transmit, to a first node, configuration information for at least one measurement report; and receive, from the second node, the at least one measurement report indicating the following: a first set of pairs of delay information and doppler information, and a second set of pairs of delay information and doppler information, wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

[0224] In some embodiments, the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

[0225] In some embodiments, the first set of pairs of delay information and doppler information is indicated by one of the following: a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain, a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

[0226] In some embodiments, the second set of pairs of delay information and doppler information is indicated by one of the following: a second set of t fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain, a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

[0227] In some embodiments, the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

[0228] In some embodiments, the second set of pairs of delay information and doppler information is indicated by at least one of the following: at least group identity corresponding to the at least one group, or a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

[0229] In some embodiments, the first set of pairs of delay information and doppler information is indicated by: at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

[0230] In some embodiments, the at least one group is based on the first set of pairs of delay information and doppler information, or the first set of pairs of delay information and doppler information is based on the at least one group.

[0231] In some embodiments, the at least one measurement report further indicates at least one of the following: a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs, a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a second doppler range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a size of a group of pairs, a reference pair of delay information and doppler information, a receiving power corresponding to the reference pair, the number of reported pairs of delay information and doppler information corresponding to the first set of pairs of delay information and doppler information, the number of reported pairs of delay information and doppler information or the number of groups of pairs corresponding to the second set of pairs of delay information and doppler information, or at least one spatial domain (SD)-related indication.

[0232] In some embodiments, the configuration information indicates at least one of the following: at least one reference signal (RS) for the at least one measurement report, at least one parameter for performing a first transform, wherein the first transform comprises at least one of the following: zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT), at least one parameter for performing a second transform, wherein the second transform comprises at least one of the following: fast fourier transform (FFT) or inverse FFT (IFFT), a resolution of the delay domain, a resolution of the doppler domain, at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

[0233] In some embodiments, at least one of the following is configured by the second node or reported by the first node: the supported maximum number of pairs corresponding to the first set of pairs of delay information and doppler information, the supported maximum number of pairs corresponding to the second pairs of delay information and doppler information, or the supported maximum number of groups of pairs corresponding to the second pairs of delay information and doppler information.

[0234] In some embodiments, the first value indicated by the first indicator is within a first delay range, the first delay range is determined based on a first offset in delay domain and a first length of the first delay range, the second value indicated by the second indicator is within a first doppler range, the first doppler range is determined based on a first offset in doppler domain and a first length of the first doppler range, the third value indicated by the fourth indicator is within a second delay range, the second delay range is determined based on a second offset in delay domain and a second length of the second delay range, the fourth value indicated by the fifth indicator is within a second doppler range, the second doppler range is determined based on a second offset in doppler domain and a second length of the second doppler range, wherein the second delay range is the same as or different from the first delay range, and the second doppler range is the same as or different from the first doppler range.

[0235] In some embodiments, the first node is a terminal device and the second node is a network device.

[0236] In an aspect, a first node comprises: at least one processor; and at least one memory coupled to the at least one processor and storing instructions thereon, the instructions, when executed by the at least one processor, causing the device to perform the method implemented by the first node discussed above.

[0237] In an aspect, a second node comprises: at least one processor; and at least one memory coupled to the at least one processor and storing instructions thereon, the instructions, when executed by the at least one processor, causing the device to perform the method implemented by the second node discussed above.

[0238] In an aspect, a computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to perform the method implemented by the first node discussed above.

[0239] In an aspect, a computer readable medium having instructions stored thereon, the instructions, when executed on at least one processor, causing the at least one processor to perform the method implemented by the second node discussed above.

[0240] In an aspect, a computer program comprising instructions, the instructions, when executed on at least one processor, causing the at least one processor to perform the method implemented by the first node discussed above.

[0241] In an aspect, a computer program comprising instructions, the instructions, when executed on at least one processor, causing the at least one processor to perform the method implemented by the second node discussed above.

[0242] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it will be appreciated that the blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0243] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the process or method as described above with reference to FIGS. 1 to 10. 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.

[0244] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[0245] The above program code may be embodied on a machine readable medium, which may be any tangible medium that may contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. A machine readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the machine readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or

Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[0246] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific 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. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[0247] Although the present disclosure has been described in language specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

CLAIMS

1. A first node comprising:

a processor configured to cause the first node to:

receive, from a second node, configuration information for at least one measurement report; and

transmit, to the second node, the at least one measurement report indicating the following:

a first set of pairs of delay information and doppler information, and

a second set of pairs of delay information and doppler information,

wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

2. The first node of claim 1, wherein,

the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or

the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

3. The first node of claim 1, wherein the first set of pairs of delay information and doppler information is indicated by one of the following:

a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain,

a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or

a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and

wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

4. The first node of claim 3, wherein the second set of pairs of delay information and

doppler information is indicated by one of the following:

a set of fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain,

a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or

a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information,

and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

5. The first node of claim 1, wherein the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

6. The first node of claim 5, wherein the second set of pairs of delay information and doppler information is indicated by at least one of the following:

at least group identity corresponding to the at least one group, or

a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

7. The first node of claim 5, wherein the first set of pairs of delay information and doppler information is indicated by:

at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

8. The first node of claim 1, wherein,

the at least one group is based on the first set of pairs of delay information and doppler information, or

the first set of pairs of delay information and doppler information is based on the at least one group.

9. The first node of claim 1, wherein the at least one measurement report further indicates at least one of the following:

a set of first amplitude coefficients associated with the second set of pairs of delay information and doppler information, each first amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs,

a set of first phase coefficients associated with the second set of pairs of delay information and doppler information, each first phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs,

a set of second amplitude coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second amplitude coefficient corresponding to a pair of delay information and doppler information or a group of pairs,

a set of second phase coefficients associated with pairs included in the first set of pairs of delay information and not included in the second set of pairs of delay information and doppler information, each second phase coefficient corresponding to a pair of delay information and doppler information or a group of pairs,

at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information,

at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information,

at least one parameter used for indicating a second delay range corresponding to the first set of pairs of delay information and doppler information,

at least one parameter used for indicating a second doppler range corresponding to the first set of pairs of delay information and doppler information,

at least one parameter used for indicating a size of a group of pairs,

a reference pair of delay information and doppler information,

a receiving power corresponding to the reference pair,

the number of reported pairs of delay information and doppler information corresponding to the first set of pairs of delay information and doppler information,

the number of reported pairs of delay information and doppler information or the number of groups of pairs corresponding to the second set of pairs of delay information and doppler information, or

at least one spatial domain (SD)-related indication.

10. The first node of claim 1, wherein the configuration information indicates at least one of the following:

at least one reference signal (RS) for the at least one measurement report,

at least one parameter for performing a first transform, wherein the first transform comprises at least one of the following: zak transform, symplectic finite fourier transform (SFFT) or inverse SFFT (ISFFT),

at least one parameter for performing a second transform, wherein the second transform comprises at least one of the following: fast fourier transform (FFT) or inverse FFT (IFFT),

a resolution of the delay domain,

a resolution of the doppler domain,

at least one parameter used for indicating a first delay range corresponding to the first set of pairs of delay information and doppler information, or

at least one parameter used for indicating a first doppler range corresponding to the first set of pairs of delay information and doppler information.

11. The first node of claim 1, wherein at least one of the following is configured by the second node or reported by the first node:

the supported maximum number of pairs corresponding to the first set of pairs of delay information and doppler information,

the supported maximum number of pairs corresponding to the second set of pairs of delay information and doppler information, or

the supported maximum number of groups of pairs corresponding to the second set of pairs of delay information and doppler information.

12. The first node of claim 4, wherein,

the first value indicated by the first indicator is within a first delay range, the first delay range is determined based on a first offset in delay domain and a first length of the first delay range,

the second value indicated by the second indicator is within a first doppler range, the first doppler range is determined based on a first offset in doppler domain and a first length of the first doppler range,

the third value indicated by the fourth indicator is within a second delay range, the second delay range is determined based on a second offset in delay domain and a second length of the second delay range, the fourth value indicated by the fifth indicator is within a second doppler range, the second doppler range is determined based on a second offset in doppler domain and a second length of the second doppler range,

wherein the second delay range is the same as or different from the first delay range, and the second doppler range is the same as or different from the first doppler range.

13. The first node of claim 1, wherein the first node is a terminal device and the second node is a network device.

14. A second node comprising:

a processor configured to cause the second node to:

transmit, to a first node, configuration information for at least one measurement report; and

receive, from the second node, the at least one measurement report indicating the following:

a first set of pairs of delay information and doppler information, and

a second set of pairs of delay information and doppler information,

wherein the first set and the second set of pairs of delay information and doppler information are correlated with each other.

15. The second node of claim 14, wherein,

the second set of pairs of delay information and doppler information is a subset of the first set of pairs of delay information and doppler information, or

the first set of pairs of delay information and doppler information is a subset of the second set of pairs of delay information and doppler information.

16. The second node of claim 14, wherein the first set of pairs of delay information and doppler information is indicated by one of the following:

a set of first indicators and a set of second indicators, each first indicator indicating a first value in delay domain and each second indicator indicating a second value in doppler domain,

a set of third indicators, each third indicator indicating a pair of values of a first indicator and a second indicator, or

a first indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information, and

wherein the set of first indicators, the set of second indicators, the set of third indicators and the first indicator are corresponding to the first set of pairs of delay information and doppler information.

17. The second node of claim 16, wherein the second set of pairs of delay information and doppler information is indicated by one of the following:

a set of fourth indicators and a set of fifth indicators, each fourth indicator indicating a third value in delay domain and each fifth indicator indicating a fourth value in doppler domain,

a set of sixth indicators, each sixth indicator indicating a pair of values of a fourth indicator and a fifth indicator, or

a second indication indicating a bitmap of the first set of pairs of delay information and doppler information, each bit corresponding to a pair of delay information and doppler information,

and wherein the set of fourth indicators, the set of fifth indicators, the set of sixth indicators and the second indicator are corresponding to the second set of pairs of delay information and doppler information.

18. The second node of claim 14, wherein the second set of pairs of delay information and doppler information comprises at least one group of pairs of delay information and doppler information, each group comprising a plurality of pairs of delay information and doppler information.

19. The second node of claim 18, wherein the second set of pairs of delay information and doppler information is indicated by at least one of the following:

at least group identity corresponding to the at least one group, or

a third indication indicating a bitmap of the at least one group, each bit corresponding to a group of pairs of delay information and doppler information.

20. The second node of claim 18, wherein the first set of pairs of delay information and doppler information is indicated by:

at least one fourth indication, each fourth indication indicating a bitmap of a group of pairs, each bit corresponding to a pair of delay information and doppler information.

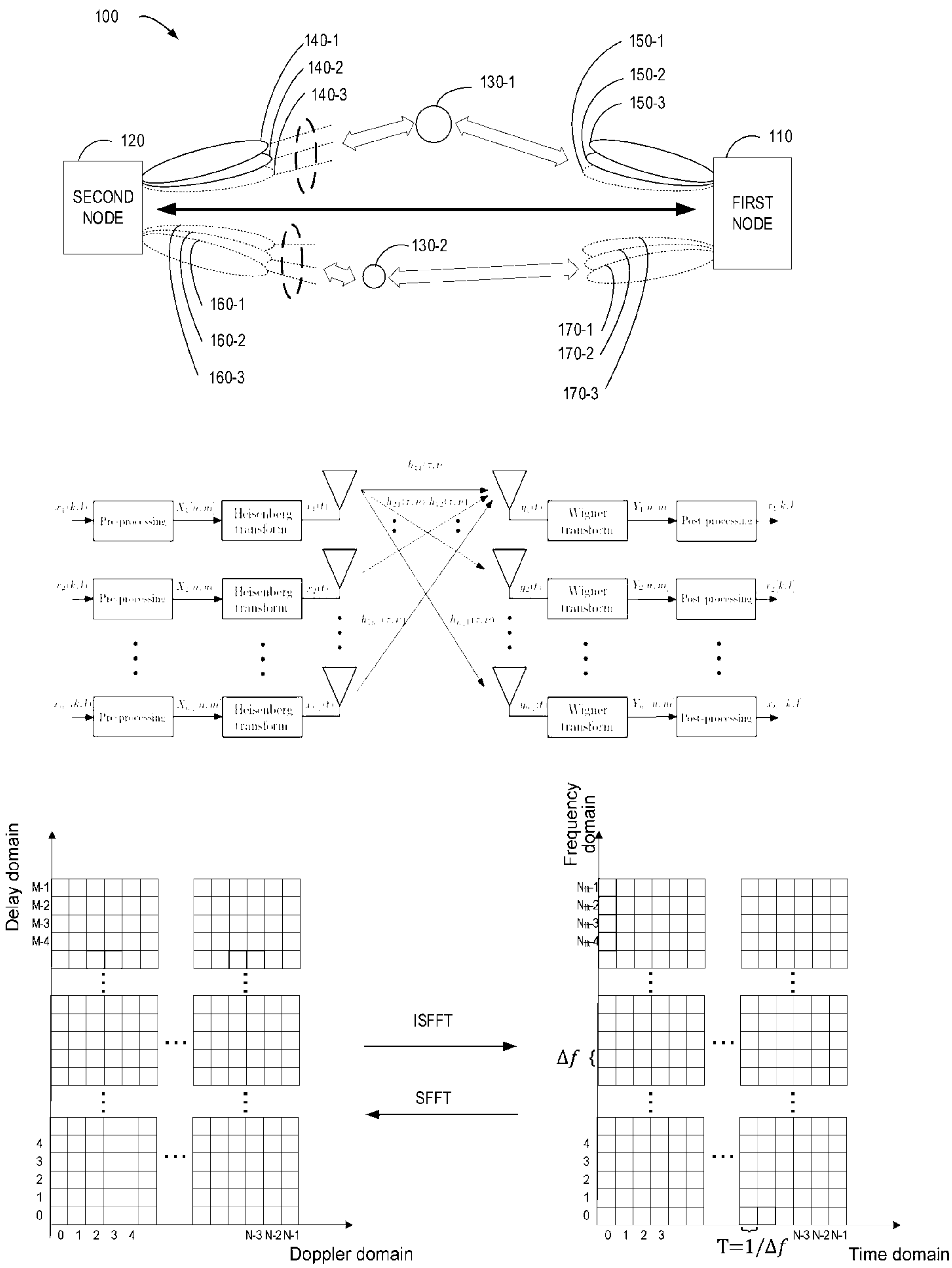
100
140-1
140-2
140-3
130-1
150-1
150-2
150-3
120
110
SECOND NODE
FIRST NODE
130-2
160-1
160-2
160-3
170-1
170-2
170-3
Pre-processing
Heisenberg transform
Wigner transform
Post processing
Post-processing
Delay domain
M-1
M-2
M-3
M-4
4
3
2
1
0
0 1 2 3 4
N-3 N-2 N-1
Doppler domain
ISFFT
SFFT
Frequency domain
Δf
T=1/Δf
Time domain

FIG.1

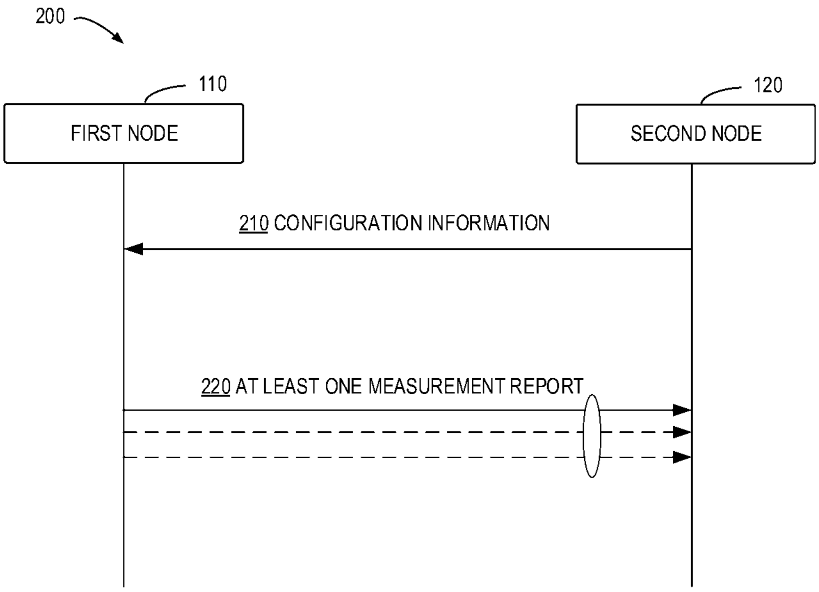
200
110
120
FIRST NODE
SECOND NODE
210 CONFIGURATION INFORMATION
220 AT LEAST ONE MEASUREMENT REPORT

FIG.2

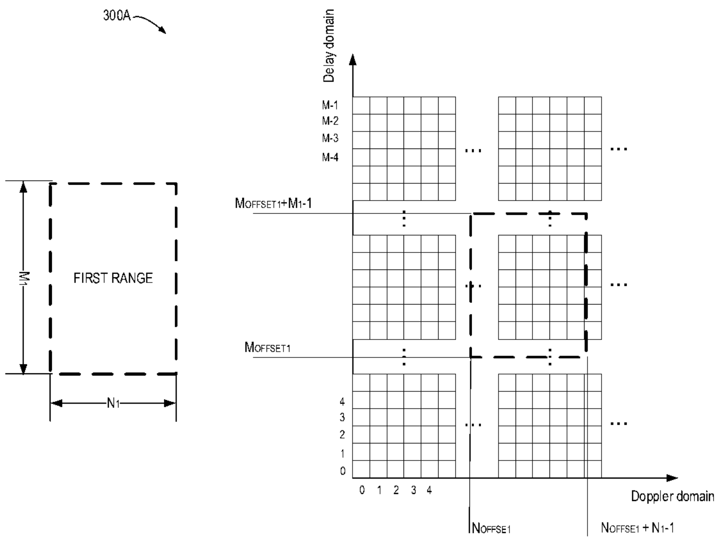
300A
Delay domain
M-1
M-2
M-3
M-4
MOFFSET1+M1-1
MOFFSET1
FIRST RANGE
M1
N1
4
3
2
1
0
0 1 2 3 4
Doppler domain
NOFFSE1
NOFFSE1 + N1-1

FIG.3A

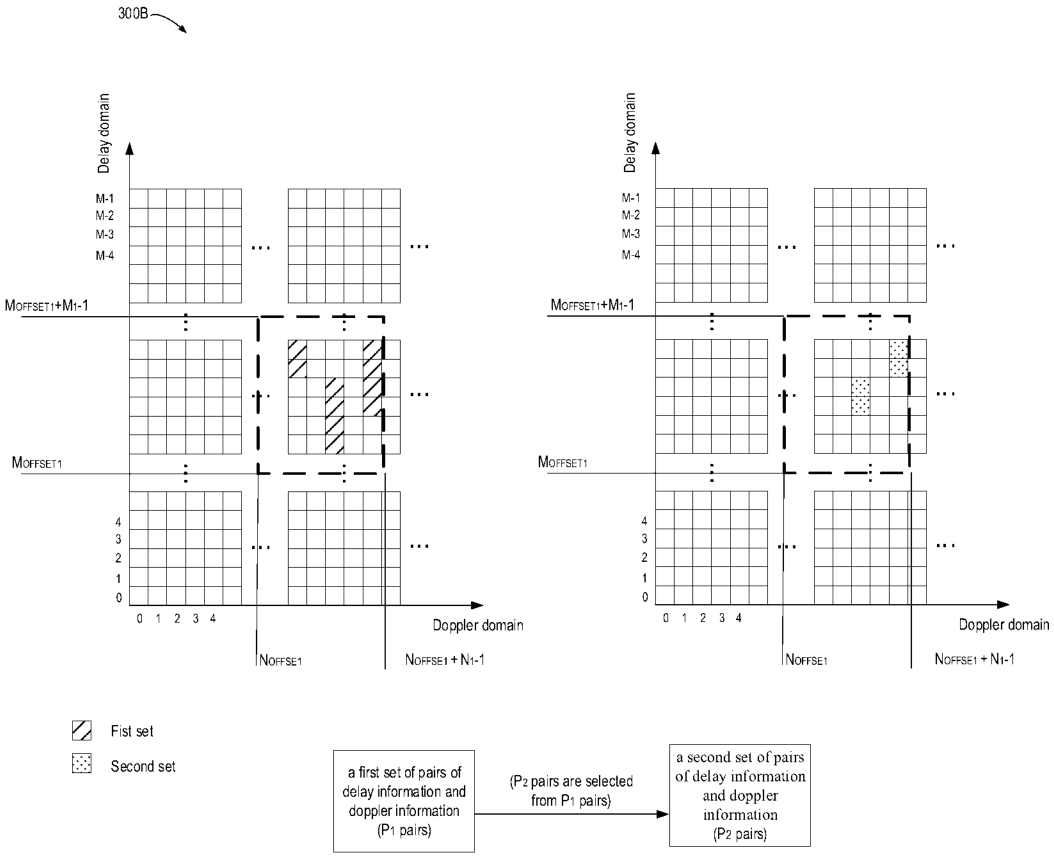
300B
Delay domain
M-1
M-2
M-3
M-4
MOFFSET1+M1-1
MOFFSET1
4
3
2
1
0
0 1 2 3 4
Doppler domain
NOFFSE1
NOFFSE1 + N1-1
Fist set
Second set
a first set of pairs of delay information and doppler information (P1 pairs)
(P2 pairs are selected from P1 pairs)
a second set of pairs of delay information and doppler information (P2 pairs)

FIG.3B

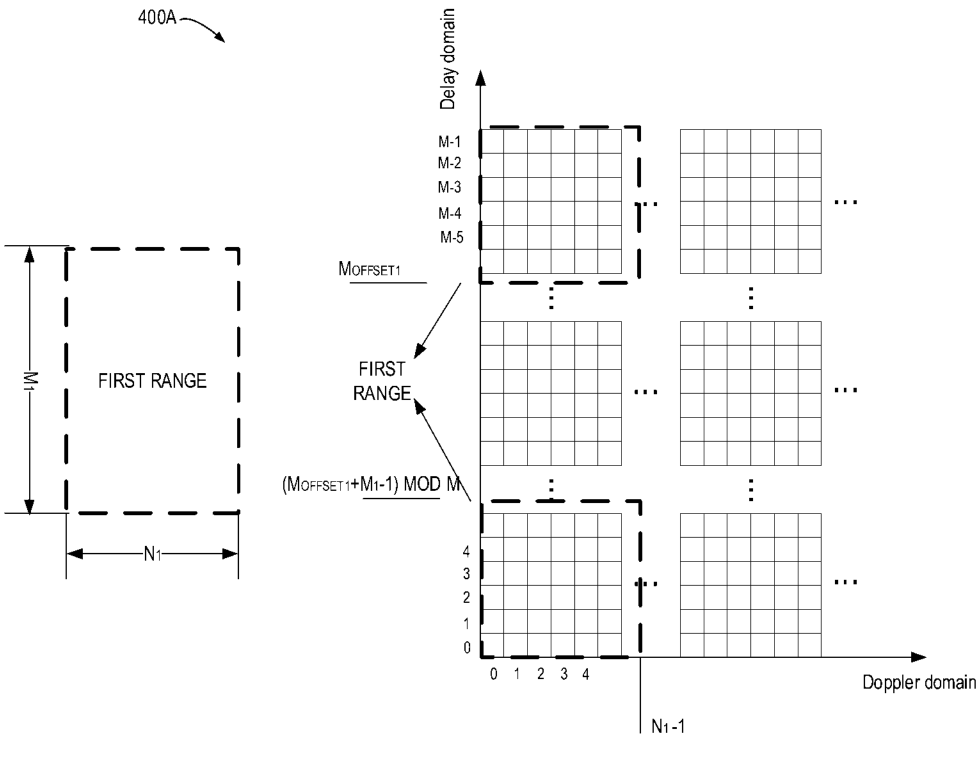
400A
Delay domain
M-1
M-2
M-3
M-4
M-5
MOFFSET1
FIRST RANGE
(MOFFSET1+M1-1) MOD M
M1
N1
4
3
2
1
0
0 1 2 3 4
Doppler domain
N1 -1

FIG.4A

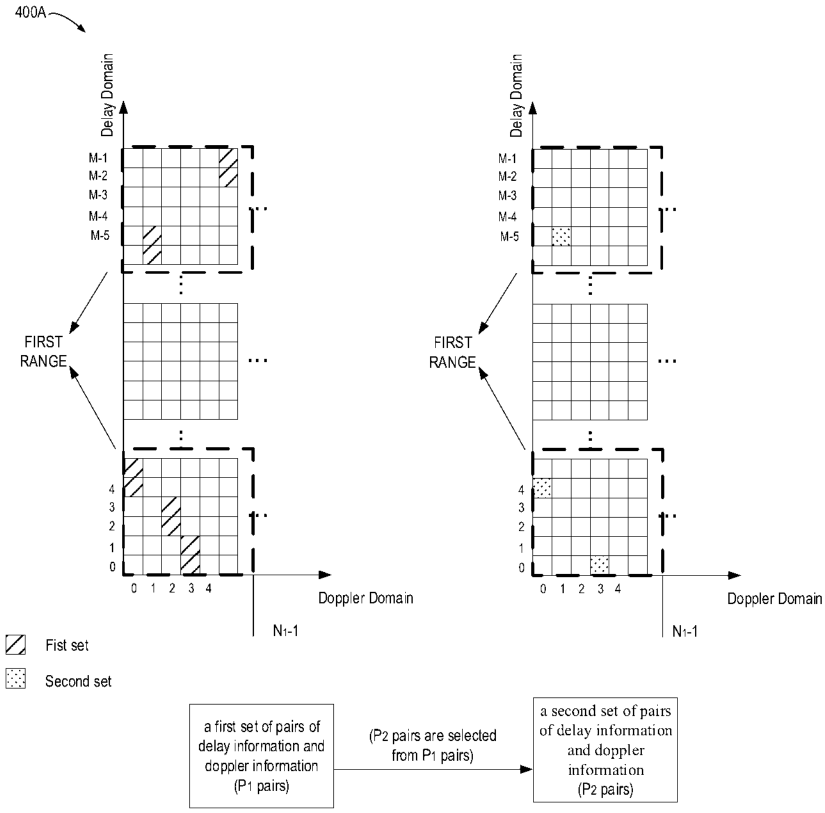
400A
Delay Domain
M-1
M-2
M-3
M-4
M-5
FIRST
RANGE
4
3
2
1
0
0 1 2 3 4
Doppler Domain
N1-1
Fist set
Second set
a first set of pairs of delay information and doppler information (P1 pairs)
(P2 pairs are selected from P1 pairs)
a second set of pairs of delay information and doppler information (P2 pairs)

FIG.4B

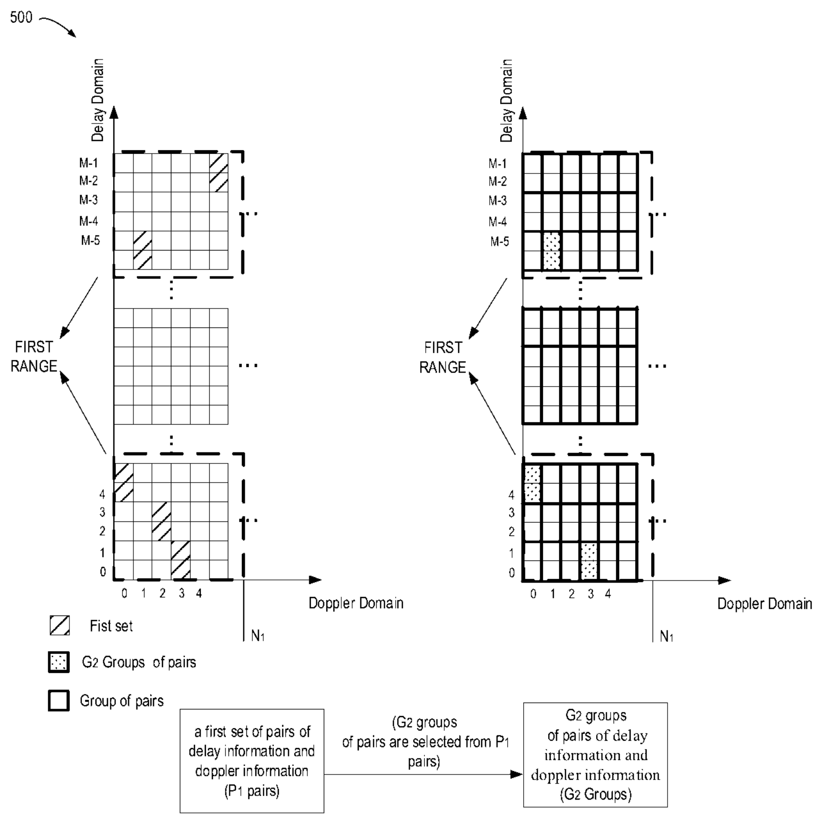
500
Delay Domain
M-1
M-2
M-3
M-4
M-5
FIRST RANGE
4
3
2
1
0
0 1 2 3 4
Doppler Domain
N1
Fist set
G2 Groups of pairs
Group of pairs
a first set of pairs of delay information and doppler information (P1 pairs)
(G2 groups of pairs are selected from P1 pairs)
G2 groups of pairs of delay information and doppler information (G2 Groups)

FIG.5

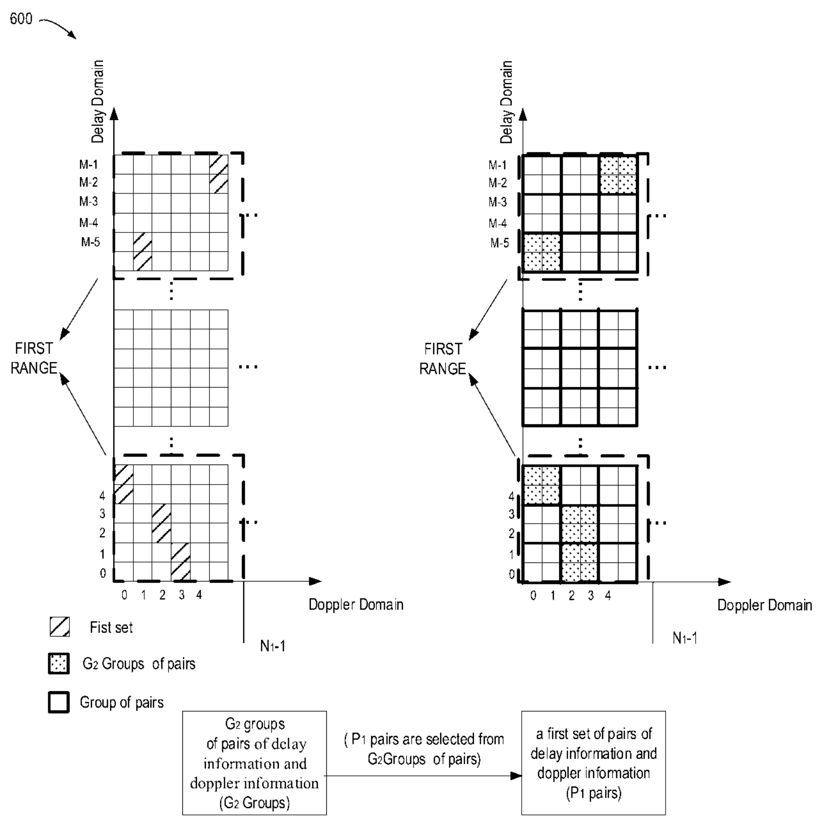
600
Delay Domain
M-1
M-2
M-3
M-4
M-5
FIRST RANGE
4
3
2
1
0
0 1 2 3 4
Doppler Domain
N1-1
Fist set
G2 Groups of pairs
Group of pairs
G2 groups of pairs of delay information and doppler information (G2 Groups)
(P1 pairs are selected from G2Groups of pairs)
a first set of pairs of delay information and doppler information (P1 pairs)

FIG.6

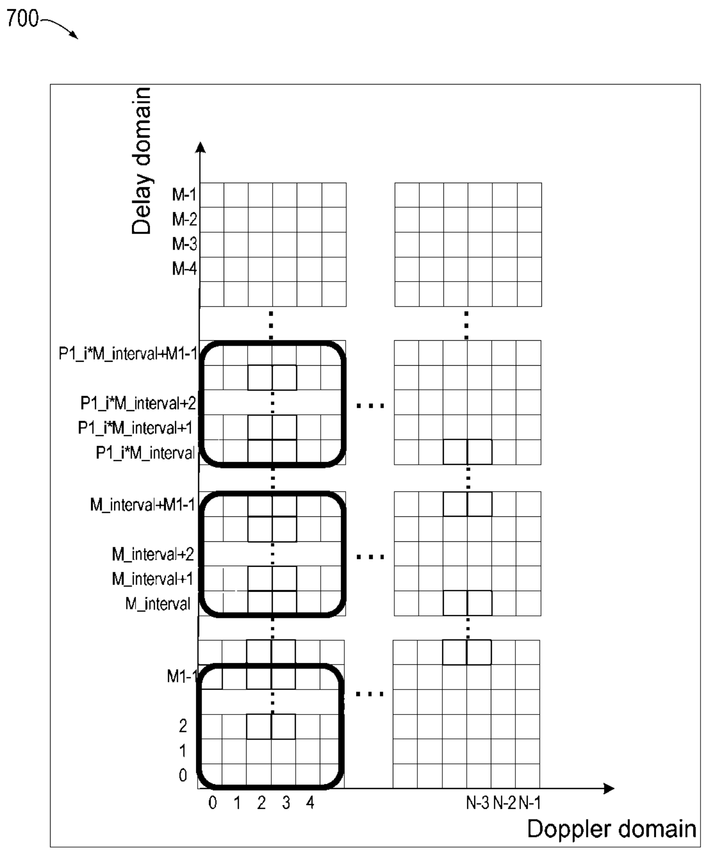
700
Delay domain
M-1
M-2
M-3
M-4
P1_i*M_interval+M1-1
P1_i*M_interval+2
P1_i*M_interval+1
P1_i*M_interval
M_interval+M1-1
M_interval+2
M_interval+1
M_interval
M1-1
2
1
0
0 1 2 3 4
N-3 N-2 N-1
Doppler domain

FIG.7

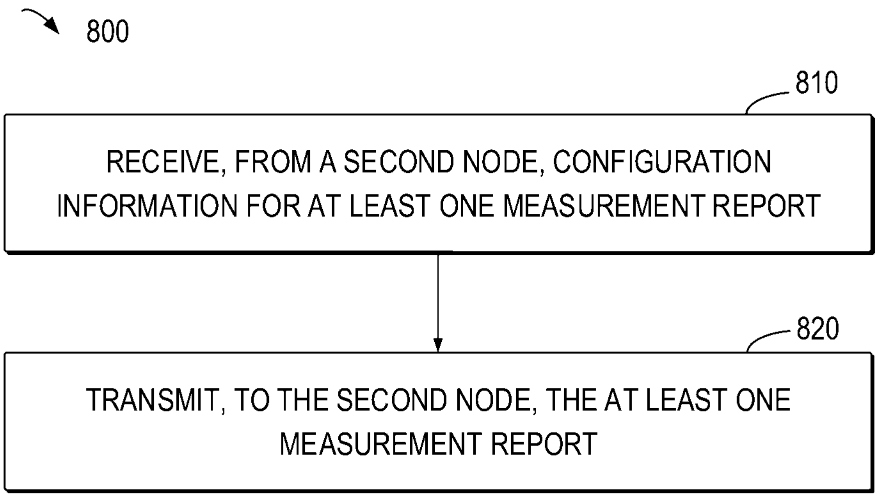
800
810
RECEIVE, FROM A SECOND NODE, CONFIGURATION INFORMATION FOR AT LEAST ONE MEASUREMENT REPORT
820
TRANSMIT, TO THE SECOND NODE, THE AT LEAST ONE MEASUREMENT REPORT

FIG.8

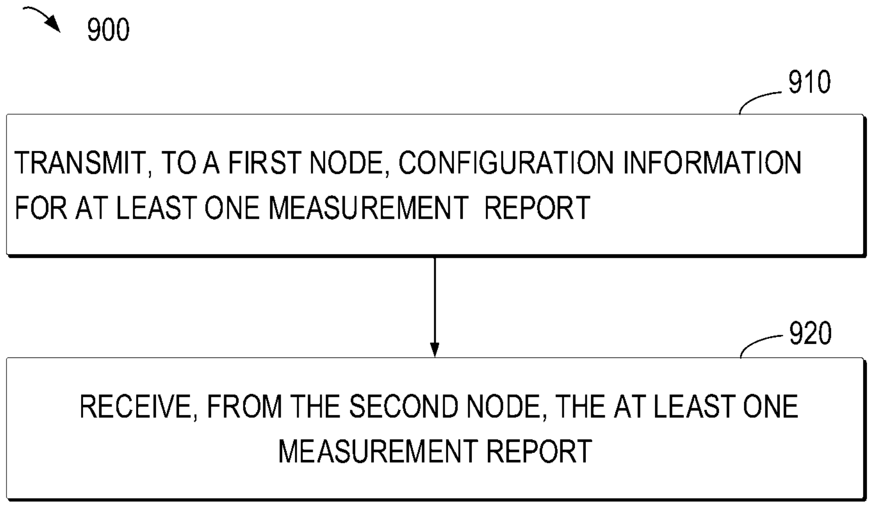
900
910
TRANSMIT, TO A FIRST NODE, CONFIGURATION INFORMATION FOR AT LEAST ONE MEASUREMENT REPORT
920
RECEIVE, FROM THE SECOND NODE, THE AT LEAST ONE MEASUREMENT REPORT

FIG.9

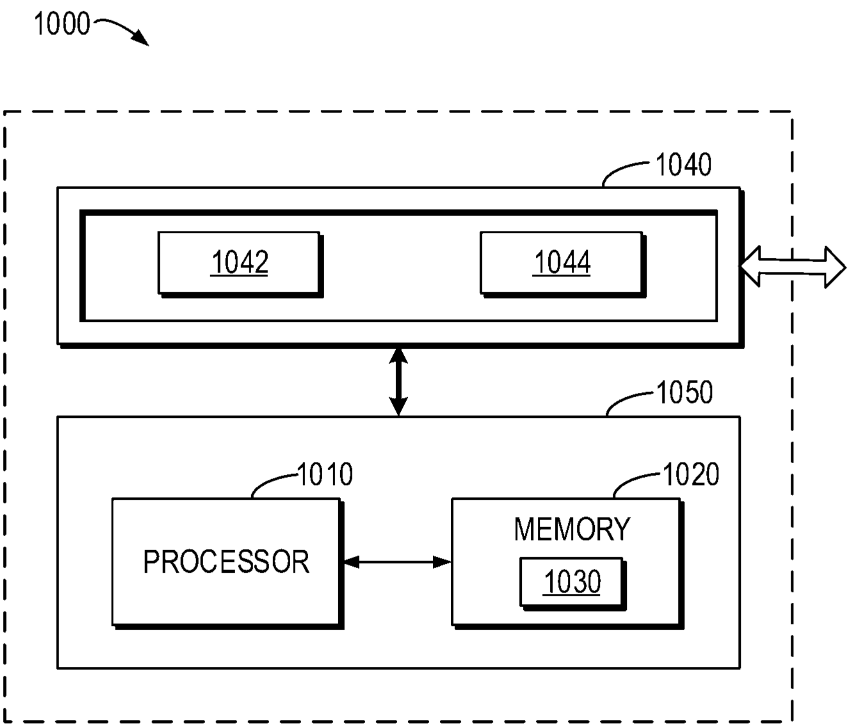
1000
1040
1042
1044
1050
1010
PROCESSOR
1020
MEMORY
1030

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/107996

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/10(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04W,H04L,H04B

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

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

3GPP,VEN,DWPI,ENTXT,CNTXT,ENTXTC:bitmap,domain,doppler,set??,subset??,pair??,group+,report,index,coder,vector,coefficient,matrix

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2022194822 A1 (FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 22 September 2022 (2022-09-22) description,page 9 line 27-page 13 line 5, page 14 line 15-page 30 line 25, page 47 line 10-page 64 line 30	1-20
X	WO 2021028331 A1 (FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 18 February 2021 (2021-02-18) description,page 34 line 5-page 49 line 35	1-20
A	US 2023155761 A1 (QUALCOMM INCORPORATED) 18 May 2023 (2023-05-18) the whole document	1-20
A	QUALCOMM INCORPORATED. "Discussion on QCL" *3GPP TSG RAN WG1 #89 R1-1708601,* 19 May 2017 (2017-05-19), the whole document	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 March 2024	**03 April 2024**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**MENG,WeiZhi** Telephone No. **(+86) 010-53961614**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/107996

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022194822	A1	22 September 2022	KR	20230159494	A	21 November 2023
				EP	4309299	A1	24 January 2024
				CN	117356039	A	05 January 2024
WO	2021028331	A1	18 February 2021	EP	3780410	A1	17 February 2021
				EP	4014340	A1	22 June 2022
US	2023155761	A1	18 May 2023		None		