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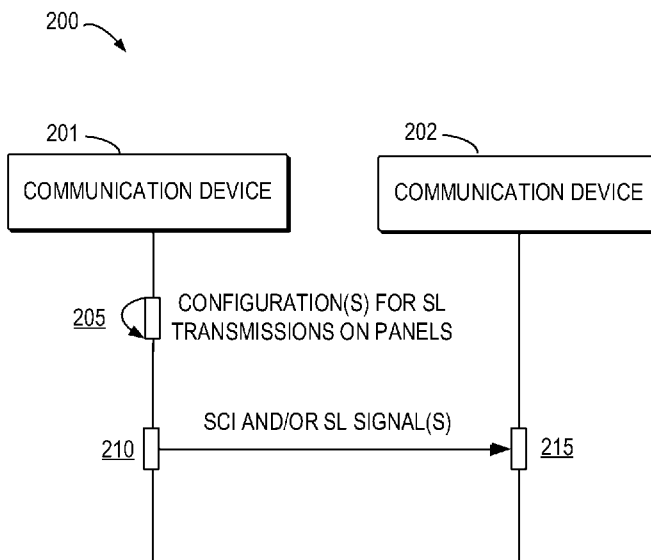


FIG. 2

(57) Abstract: Embodiments of the present disclosure provide a solution for multi-panel based sidelink (SL) transmissions. A communication device determines at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels. The communication device transmits, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.

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DEVICE AND METHOD FOR COMMUNICATION

FIELDS

[0001] Example embodiments of the present disclosure generally relate to the field of communication techniques and in particular, to a device, method and computer storage medium for multi-panel based sidelink (SL) transmissions.

BACKGROUND

[0002] A sidelink (SL) refers to a communication mode in which a direct link is established between communication devices, e.g., terminal devices, and data or information is directly exchanged between terminal devices without going through a network device. In sidelink communications, a SL signal may be communicated between communication devices for various applications. For example, a communication device (e.g., a terminal device) may be configured to determine its own position and/or the position of other communication devices based on sidelink positioning reference signals (SL-PRSs) exchanged with the other communication devices. Generally, resource allocation may be dynamically allocated or configured for SL signal communication as well as associated information for the SL signal communication.

SUMMARY

[0003] In general, embodiments of the present disclosure provide a device, method and computer storage medium for multi-panel based sidelink (SL) transmissions.

[0004] In a first aspect, there is provided a communication device comprising: a processor configured to cause the communication device to: determine at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and transmit, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.

[0005] In a second aspect, there is provided a communication method. The method

comprises: determining, by a communication device, at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and transmitting, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.

[0006] In a third 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 second aspect.

[0007] Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] 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:

[0009] FIG. 1 illustrates an example communication environment in which example embodiments of the present disclosure can be implemented;

[0010] FIG. 2 illustrates a signaling flow of communication in accordance with some example embodiments of the present disclosure;

[0011] FIG. 3 illustrates an example comb-based multiplexing of SL signals in accordance with some example embodiments of the present disclosure;

[0012] FIGS. 4A-4C illustrate schematic diagrams of example sidelink control information (SCI) scheduling in accordance with some example embodiments of the present disclosure;

[0013] FIGS. 5A-5C illustrate schematic diagrams of example SCI scheduling in accordance with some further example embodiments of the present disclosure;

[0014] FIGS. 6A-6B illustrate schematic diagrams of example SCI scheduling in accordance with some yet further example embodiments of the present disclosure;

[0015] FIG. 7 illustrates a flowchart of a method implemented at a communication device according to some example embodiments of the present disclosure; and

[0016] FIG. 8 illustrates a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure.

[0017] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0018] 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 limitations as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] The terminal or the network device may work on several frequency ranges, e.g., FR1 (410 MHz to 7125 MHz), FR2 (24.25GHz to 71GHz), frequency band larger than 100GHz 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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 the time domain, a resource in the 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.

[0028] Embodiments of the present disclosure provide a solution for configuration in multi-panel based SL transmissions. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0029] It is noted that any section/subsection headings provided herein are not intended to be limiting. Embodiments are described throughout this document, and any type of embodiment may be included under any section/subsection. Furthermore, embodiments disclosed in any section/subsection may be combined with any other embodiments described in the same section/subsection and/or a different section/subsection in any manner.

[0030] FIG. 1 illustrates a schematic diagram of an example communication environment 100 in which example embodiments of the present disclosure can be implemented.

[0031] The communication environment 100 includes a plurality of communication devices 110-1, 110-2, 110-3, 110-4, and 120. In FIG. 1, the communication devices 110-1, 110-2, 110-3, and 110-4 (collectively or individually referred to as communication devices 110) are illustrated as terminal devices. The communication device 120 is illustrated as a network device which provides a serving area 102 called a cell.

[0032] It is to be understood that the number of devices and their connections in FIG. 1 are given for the purpose of illustration without suggesting any limitations to the present disclosure. The communication environment 100 may include any suitable number of network devices and/or terminal devices adapted for implementations of the present disclosure.

[0033] 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.

[0034] In some embodiments, a communication device 110 and a communication device 120 may communicate with each other via a channel such as a wireless communication channel on an air interface (e.g., Uu interface). The communication device 110 capable of communicating with the communication device 120 may be in coverage of the serving area

102 of the communication device 120. In the illustrated example of FIG. 1, the communication devices 110-1 and 110-2 may communicate with the communication device 120. 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. In the specific example of communication environment 100, a link from the communication device 110 to the communication device 120 is referred to as uplink, while a link from the communication device 120 to the communication device 110 is referred to as a downlink.

[0035] In some embodiments, the communication devices 110 may communicate with each other via a sidelink (SL) connection. A sidelink is a communication mode that allows communications between two or more terminal devices without the communications going through the network device. In sidelink, a communication device which performs a transmission to another communication device may be referred to as a transmitting device, a sidelink transmitting device, a sidelink transmitter, a TX device, or the like, and the other communication device which receives the transmission may be referred to as a receiving device, a sidelink receiving device, a sidelink receiver, a RX device, or the like.

[0036] Sidelink communications may be carried out on a wireless interface, e.g., PC5 interface. sidelink communications may be unicast, groupcast, or broadcast, and may be used for device-to-device (D2D) communications, vehicle-to-everything (V2X) communications, emergency rescue applications, etc.

[0037] Depending on whether covered within a serving area of a network device or not, sidelink communication scenarios may include in-coverage (InC), partial-coverage, and out-of-coverage (OOC). For example, in the illustrated example of FIG. 1, sidelink communications between the communication devices 110-1 and 110-2 are in-coverage of the communication device 120; sidelink communications between the communication devices 110-3 and 110-4 are out-of-coverage. Partial-coverage may involve a scenario where a communication device 110 is within the network coverage area while the other communication device is outside the network coverage. For example, in FIG. 1, sidelink communications between one of the communication devices 110-1 and 110-2 and one of the communication devices 110-3 and 110-4 may be considered as in partial-coverage.

[0038] In some cases, a network device (e.g., the communication device 120) facilitates the scheduling of resources for sidelink communications between the communication devices 110. In other cases, sidelink communications are carried out between the communication devices 110 without the involvement of a network device (e.g., the communication device 120). The configuration information for sidelink communication may be conveyed via one of: signaling from a network device, system information block from a network device or the other UE, sidelink control information from the other UE, PC5 signaling from the other UE, medium access control element (MAC CE) from the other UE and pre-configuration information.

[0039] SL resource allocation schemes may be applied to allocate resources in a SL resource pool for sidelink communications. There may be two SL resource allocation schemes. In a first SL resource allocation scheme (referred to as Mode 1 or Scheme 1 of SL resource allocation), the network device may schedule SL resources via the communication interface with the communication devices 110. The resource allocation may include dynamic grant, for example, by downlink control information (DCI), or configured grant (e.g., Type 1 or Type 2 configured grant). In a second SL resource allocation scheme (referred to as Mode 2 or Scheme 2 of SL resource allocation), the resources for sidelink communications may be autonomously selected by the communication devices 110 based on a contention scheme through resource sensing or random selection.

[0040] In some embodiments, one or more types of resource pools, such as one or more dedicated resource pools (DRPs) and/or one or more shared resource pools (SRPs) including the time-frequency resources may be configured for sidelink communications. As used herein, a “resource pool” may also be referred to as a resource block (RB) set, a resource set, and/or the like. A resource pool may occupy a certain frequency band and may occur in time domain according to certain timing configuration. A resource pool may thus comprise time-frequency resources for use.

[0041] The available time-frequency resources within a resource pool may be defined at least at a slot level in the time domain, for example, through a bitmap indication to indicate which slot(s) are available for this resource pool. The available time-frequency resources within a resource pool may be further defined at a symbol level per bandwidth part (BWP), for example, through some parameters indicating a starting symbol (e.g., *sl-StartSymbol*) and a length of the symbols (e.g., *sl-LengthSymbols*). At the symbol level, a SL signal may span a number of Orthogonal Frequency-Division Multiplexing (OFDM) symbols. The available

time domain resource for a resource pool may be further defined at a slot level per bandwidth part, for example, through parameter indicating the bitmap of the resource pool (e.g., *sl-TimeResource*), which is defined by repeating the bitmap with a periodicity during a cell system frame number (SFN) or direct frame number (DFN) cycle. In some embodiments, there may be consecutive physical resource blocks (PRBs) in the frequency domain. The PRBs may be configured, for example, according to a start RB of the resource block (e.g., *sl-StartRB-Sub-channel*) which indicates the lowest RB of the resource pool, and a total number of RBs of the resource pool (e.g., *sl-RB-Number*). In some embodiments, a sub-channel may be a frequency resource unit in a resource pool, and each sub-channel may contain a consecutive RBs. The size of a sub-channel (e.g., *Sub-channelSize*) may be configurable, for example, as 10, 12, 15, 20, 25, 50, 75, 100 RBs or the like.

[0042] For a SRP, a SL-PRS resource refers to a time-frequency resource within a slot that is used for SL-PRS transmission. Characteristics associated with a SL-PRS resource in a slot of a shared resource pool include at least: SL-PRS resource ID, SL-PRS comb offset and associated SL-PRS comb size (N), SL-PRS starting symbol and number of SL-PRS symbols (M), and SL-PRS frequency domain allocation where SL-PRS frequency domain allocation is not used to identify a unique SL-PRS resource ID. A SL-PRS resource is identified by a combination of SL-PRS resource ID and a SL-PRS frequency domain allocation. This combination is unique within a slot of a shared resource pool. A SL-PRS resource refers to a time-frequency resource within a slot of a dedicated SL-PRS resource pool that is used for SL-PRS transmission.

[0043] According to some time-frequency definitions, a slot may comprise one or more automatic gain control (AGC) symbols, one or more physical sidelink control channels (PSCCH) for carrying control information, one or more physical sidelink shared channels (PSSCH) for carrying traffic data, one or more gap protect (GP) symbols, and one or more physical sidelink feedback channels (PSFCH) for carrying feedback information. A resource for the PSFCH may comprises a resource block (RB) and/or a symbol. In some examples, PSFCH may be at a last available sidelink symbol before GP. In some examples, the PSFCH may be configured as RBs in a resource pool, indicated by a bitmap.

[0044] In some sidelink communication scenarios, one or more SL signals may be exchanged between two or among a group of communication devices 110. The SL signals may carry SL traffic, or may include a SL-RS. A SL-RS or a RS may be a signal sequence that is generally known to both a transmitting device and a receiving device. There may be

various SL-RSs designed for different purpose.

[0045] As an example, in the case of SL positioning, one or more sidelink positioning reference signals (SL-PRSs) may be communicated. A positioning procedure may involve a target device to be positioned and further involve at least one anchor device according to different PRS-based positioning techniques. An anchor device may comprise any communication device that supports positioning of the target device. One or more SL-PRSs may be communicated between the target device and the anchor device(s) along with the assistance information for absolute positioning or relative positioning, respectively. In some embodiments, the target device may act as a TX device to transmit a SL-PRS to the anchor device(s). In some embodiments, one or more anchor device(s) may act as a TX device(s) to transmit a SL-PRS to the target device and/or other anchor device(s).

[0046] In some embodiments, multiple LTE Positioning Protocol (LPP) transactions may be in progress simultaneously between the same target and server nodes, to improve flexibility and efficiency. In some embodiments, no more than one LPP procedure between a particular pair of target and server nodes to obtain location information shall be in progress at any time for the same positioning method. Parallel transactions are permitted (i.e. a new LPP transaction may be initiated, while another one is outstanding). A LLP procedure may include a server sending a request to the target for positioning measurements, the target sending a request for particular assistance data, the server returning the assistance data requested, and the target obtains and returns the location information (e.g., positioning method measurements) requested. In some embodiments, LPP procedures are not required to occur in any fixed order, in order to provide greater flexibility in positioning.

[0047] In addition to the positioning, a SL-RS may be communicated to enable channel status determination of a sidelink, communication scheme determination, and/or for other purposes. In addition to the SL-PRS, a SL-RS may also include, for example, a channel status information reference signal (CSI RS), a sounding reference signal (SRS), or any other reference signals that need to be transmitted in sidelink communications.

[0048] In SL-RS communications, a RX device may transmit a measurement report about the SL-RS to the TX device. In addition to the measurement report, in some cases, it is also beneficial to transmit feedback information corresponding to the SL-RS reception, for example, to achieve reliable SL-PRS reception with low latency and improve energy efficiency of SL-RS transmission. For example, if a RX device fails to receive a SL-RS or

the quality of the received SL-RS does not meet the requirement, it is supported that the RX device sends a feedback to the TX device so that the TX device can retransmit the SL-RS. In some embodiments, the retransmission of the SL-RS may be performed in the case of a positive Hybrid Automatic Repeat reQuest (HARQ) feedback (ACK) and/or the absence of negative HARQ feedback (NACK). That is, the feedback mechanism may be defined as ACK/NACK-based or NACK-only based.

[0049] During associated communication of SL-RS, both a TX device and a RX device need to determine a resource(s) configured for communicating a SL-RS and the feedback information (as well as a measurement report). A TX device determines the configured resource(s) so that it can know where to transmit the SL-RS and receive the feedback information (as well as the measurement report). A RX device determines the configured resource(s) in a similar way so that it can know where to detect the SL-RS and transmit the feedback information (as well as the measurement report). Therefore, some operations for the communication devices involved in the associated communications of SL-RS are similar.

[0050] In some embodiments, it is proposed to support a wide bandwidth for SL communications. For example, it is proposed to support for SL PRS bandwidths of up to 100 MHz, e.g., at least in FR1 spectrum. In SL-RS communication, signalling and associated device behavior may be performed via unicast, groupcast (not including many to one) and broadcast.

[0051] In some embodiments, a SL communication device may be equipped with one or more panels for SL communications. A panel may also be referred to as an antenna panel with a group of antenna elements characterized by the geometry and the properties of the array elements. The geometry of the array elements can be either linear or non-linear to meet the system requirements. For example, a vehicle may have two antenna panels, on front and back bumper separately, and each panel may use wide beam to cover about 180 degrees of area. In another example, a vehicle may be equipped with front-side, back-side, left-side, and right-side panels, each covering about 90 degrees of area. In some embodiments, each panel may be equipped with one or more antenna arrays, and can be independently configured for transmission and reception at certain of bands.

[0052] Multiple panels may be used for different functions in the different manners, e.g. for SL positioning with multiple LPPs in parallel, or for a single LPP with enhanced

performance on accuracy, power and/or latency. Correspondingly, the related designs, such as resource allocation, SL-RS generation, and scheduling methods, should be studied.

[0053] Example embodiments of the present disclosure provide improved solutions to multi-panel based SL transmissions. A SL communication device, which is equipped with a plurality of panels, determines at least one configuration for SL transmissions on a plurality of panels, including a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels. The communication device transmits, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels. Through these solutions, resource pool configuration, SL signal transmission, and/or SCI transmission are supported for the multi-panel based SL transmissions.

[0054] Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0055] Reference is made to FIG. 2, which illustrates a signaling flow 200 of communication in accordance with some example embodiments of the present disclosure. The signal flow 200 involves a plurality of communication devices, including a communication device 201 and a communication device 202, that support sidelink communication with each other. The communication devices 201, 202 may be any of the communication devices 110 in FIG. 1 or other sidelink communication device. Although two communication devices are illustrated, there may be more communication devices involved in the SL communication which may apply similar operations as discussed below.

[0056] In the signaling flow 200, it is assumed that the communication device 201 may establish sidelink connections with the communication device 202, for example, via a PC5 interface. One or more sidelink SL signals and their associated control information are to be communicated between the communication device 201 and the communication device 202 using SL resources within a resource pool. A resource pool may include time-frequency resources to be allocated for SL transmissions. As used herein, a “time-frequency resource” refers to any resource for performing communication, which can be determined at least based on a time location in the time domain and a frequency location in the frequency domain.

[0057] For the purpose of discussion, it is assumed that in FIG. 2, the communication device 201 is a source communication device which transmits one or more SL signals to one or more communication devices including the communication device 202; the communication device 202 is a destination communication device which receives one or more SL signals from one or more communication devices including the communication device 202. There may be more than one communication device to which the communication device 201 may transmit the SL signal(s) (including SL-RS and/or SL data).

[0058] For example, in a positioning-related scenario, according to the principle of different SL-PRS positioning approaches, a positioning procedure may involve a target device and at least two anchor devices or nodes, along with the necessary assisted information for absolute positioning or relative positioning, respectively. Each anchor device or node may transmit or receive SL-PRS through omnidirectional or directional beams from one or multiple panels, and a directional SL-PRS beam corresponds to a certain spatial direction and coverage. The target device may establish separate sidelink (e.g., PC5) connection(s) with one or multiple anchor nodes, the signaling, SL-PRS (pre)configuration and positioning related information, such as shared and/or dedicated resource pool configuration, SL PRS resource configuration and measurement report configuration, may be transmitted via the PC5 interface. In the SL traffic scenario, a SL device may transmit SL traffic to more than two other SL devices in groupcast or broadcast manners.

[0059] In the signaling flow 200, the communication device 201 determines (205) at least one configuration for SL transmissions on a plurality of panels, including a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, and/or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels.

[0060] In some cases, the plurality of panels may be arranged separately on the communication device 201, and thus the arrangement conditions and channel conditions of the plurality of panels may be varied. For example, a vehicle may be equipped with front-side, back-side, left-side, and right-side panels, each faced with different channel conditions. Further, the communication capabilities of the plurality of panels, such as the beamforming capabilities, may be varied. In such cases, per-channel configuration, including a configuration for the types of resource pools applied to multi-panel based SL transmissions,

resource-level allocation, SL-RS design and allocation, and SCI scheduling configuration, may be needed, to achieve high communication performance and efficiency and high resource usage.

[0061] In some embodiments, the at least one configuration for SL transmissions may be determined by the communication device 201 based on pre-configuration information, and/or may be configured or indicated by other SL communication device(s) or the network device and then notified to the communication device 201.

[0062] In some embodiments, the at least one SL signal may comprise SL traffic or data to be conveyed from the communication device 201 to one or more other communication devices. In some embodiments, the at least one SL signal may comprise one or more SL-RSs to be transmitted for various purposes. In some examples, the one or more SL-RSs may comprise one or more SL-PRSs for positioning of the communication device 201 or other communication device. In some embodiments, the SCI may include control information that are associated with the SL transmissions, such as the control information for the SL traffic, or the SL-RS (e.g., SL-PRS).

[0063] Further, the communication device 201 transmits (210), based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels. Depending on the configurations for the respective panels, those panels can be configured accordingly to transmit SCI and/or SL signal(s). At the destination side, the communication device 202 receives (215) the SCI and/or the at least one SL signal transmitted from the communication device 201, e.g., via the sidelink connection between the two communication devices. The communication device 202 may be equipped with one or more panels for the reception of the SCI and/or the at least one SL signal.

[0064] In the following, some example embodiments related to the configurations for the plurality of panels of the communication device 201 will be discussed in more details below.

[0065] Before discussing those embodiments, it is first introduced that in some embodiments, some information and/or configuration are proposed to support the proposed features herein, example of which may include the resource allocation that are used to determine the resource pool(s) and/or the time-frequency resources within the resource pool(s). In some embodiments, the above-mentioned information and/or configuration may be carried in SL control information (SCI).

[0066] In some embodiments, some introductions or enhancements may be proposed to

legacy SCI with the information proposed herein. There may be two kinds of implementation approaches to indicate the corresponding information dynamically (may or may not in combination with the resource (pre)configuration). In a first kind of implementations, one or more new fields with the additional information may be inserted to a legacy SCI format (such as SCI format 1-A, SCI format 1-B, SCI format 2-A, SCI format 2-B, SCI format 2-C) in sidelink, or replacing the corresponding field(s) by redefined or enhanced information (with the same or different size). In a second kind of implementations, one or more new SCI format(s) (such as SCI format 1-X and/or SCI format 2-D) or media access control-control element (MAC CE) may be introduced to convey the enhanced SCI information for the intended SL transmissions (e.g., SL signal configuration, indication, or transmission) on one or multiple resource pools. The new SCI format may also include the same information as that of legacy SCI format.

[0067] In some embodiments, the SL signal (including the SL-RS or SL-PRS) resource related parameters may include the subcarrier spacing (SCS) or cyclic prefix (CP) for a SL-RS resource, a SL-RS resource set (resource pool) configuration identity, a SL-RS resource configuration identity, a SL-RS resource periodicity, the number of SL-RS resource repetitions, the offset between two repeated instances of a SL-RS resource, a starting slot/symbol of SL-RS resource, a comb size of a SL-RS resource, a RE offset of a comb-based SL-RS resource, the number of symbols in SL-RS resource and the PSFCH resource corresponding to at least one SL-PRS and so on. On the SL-RS resource selection in embodiments of the present disclosure, the determination of these parameters may rely on both the (pre)configuration (which may be conveyed in assistance data transfer) and the sensed/indicated/randomly selected applicable resource(s) by DCI/SCI/MAC-CE. For the latter, there may have several methods to determine/indicate one or more SL-PRS parameter(s). In a first method, the association between the SL-RS parameter(s) and applicable resource(s) may be (pre)defined. In a second method, the parameter(s) may be indicated to the communication device(s) along with the time-frequency resource indication, which may be as additional indication/information to legacy frequency resource allocation indication value (FRIV) and time resource allocation indication value (TRIV), or as information within one of fields in a new DCI format/SCI format/MAC-CE. It is noted that the above methods may be feasible to the embodiments discussed herein.

[0068] In some embodiments, the scheme 2 resource allocation in legacy SL communication may be applied for positioning related resource allocation especially in OOC

scenarios. A communication device may autonomously determine (by sensed-based method and/or random selecting based method) the resource used in intended positioning procedure, especially for the resource in the dedicated resource pool for SL-PRS transmission. The proposed methods/designs/mechanisms in the embodiments discussed herein may be applied separately or jointly (at least two designs may be used jointly).

[0069] As mentioned above, in some embodiments, the communication device 201 equipped with a plurality of panels may determine a resource pool configuration for multi-panel based SL transmission, i.e., the first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels. That is, the first configuration may indicate an association between the panels of the communication device 201 and the resource pools. Different types or combination of resource pools can be considered for the panels of the communication device 201. In some embodiments, the type(s) of resource pool configured for the respective panels may be determined by the communication device 201 based on pre-configuration information, or may be determined based on configuration information received from other device. A panel of the communication device 201 may be allocated with time-frequency resources within the configured type of resource pool for a SL transmission on that panel.

[0070] There may be a plurality of types of resource pools for SL transmissions. In some embodiments, the plurality of types of resource pools may comprise a type of dedicated resource pool (DRP) which is configured for a certain SL service, and a type of shared resource pool (SRP) which is configured for communication of both SL traffic and other information such as SL-RSs (or even SL-PRSs). In some embodiments, a DRP may be configured for a SL positioning service, and resources in the DRP may be allocated for transmissions of SL-PRSs and in some cases, may be further configured for transmissions of associated information for the SL positioning service. In some embodiments, for a same type of resource pool, there may be more than one resource pool may be available for the SL transmissions on the plurality of panels.

[0071] In some embodiments, the first configuration (i.e., the type(s) of resource pool configured for the respective panels) may be determined based on respective operating frequency bands associated with the plurality of panels. The plurality of panels may be configured to operate at different frequency bands depending on their arrangement conditions. For example, one or more panels may operate at Frequency Range 1 (FR1) while one or more other panels may operate at Frequency Range 2 (FR2). According to the working frequency

band (such as within FR1 or FR2) associated with each panel and resource pool(s), the resource pool(s) with the same or different types (SRP or DRP) may be configured or selected for each panel. Alternatively, or in addition, the first configuration (i.e., the type(s) of resource pool configured for the respective panels) may be determined based on respective operating frequency bands associated with a plurality of types of resource pools. Different types of resource pools may occupy different frequency bands, and thus may be suitable for use by different panels.

[0072] Alternatively, or in addition, the first configuration (i.e., the type(s) of resource pool configured for the respective panels) may be determined based on respective serving functions of the plurality of panels. For example, one or more panels may support a positioning function, while one or more panels may support environment sensing function. Different types of resource pools may be suitable for different serving functions. For example, a DRP may be configured to be dedicated for the positioning function, while a SRP may be used for communication of SL traffic in the environment sensing function. The communication device 201 may autonomously and dynamically select the resource pool from available resource pools with different types according to different serving functions and objects for the respective panels.

[0073] In some embodiments, the communication device 201 may indicate the related information to the other communication devices in a communication group (e.g., in a SL positioning group) as assistant information before the SL transmissions. The related information may indicate the type of resource pools applied to the panels. For example, the related information may be as assistant information via LPP/SLPP in advance.

[0074] In some embodiments, the first configuration indicates a type of resource pool for the SL transmissions on the plurality of panels. The same type of resource pool may be used for SL transmissions through all the panels. In the SL positioning case, the same type of resource pool may be used for SL PRS transmission through all the panels in SL positioning.

[0075] In some embodiments, if a type of resource pool is selected for the SL transmissions on the plurality of panels, this type of resource pool may comprise the type of SRP, and thus only one or more available SRPs may be configured for the plurality of panels. As an example, if all the panels are working in FR1 with the omnidirectional beam or wider beamwidth (weak directivity beam), then the type of SRP may be configured for those panels.

[0076] In some embodiments, if a type of resource pool is selected for the SL

transmissions on the plurality of panels, this type of resource pool may comprise the type of DRP, and thus only one or more available DRPs may be configured for the plurality of panels. In some embodiments, if the SL transmissions comprises SL-RS transmissions, SL data associated with the SL-RS transmissions such as SL measurement reports may need to be received by the panels after the SL-RS(s) is transmitted. If the DRP(s) comprises no resources for the transmission and/or reception of the SL data, then the first configuration may further indicate at least one SRP for transmission and/or reception of SL data associated with the SL-RS transmissions on at least one of the plurality of panels. In an example, only one SRP corresponding to a panel is configured for the transmission and/or reception of SL data related to all SL-RS transmissions on the plurality of panels. Alternatively, at least one SRP corresponding to each panel is configured for the transmission and/or reception of SL data related to at least one SL-RS transmission.

[0077] In some embodiments, the first configuration indicates a plurality of different types of resource pools for the SL transmissions on the plurality of panels. That is, different types of resource pools may be used or configured for the plurality of panels in SL transmissions. In some embodiments, each panel associated with a certain type of resource pool may be used for the overall functionality of SL transmission, e.g. SL PRS resources, SCI resources, measurement report resources. Accordingly, the first configuration indicates a third type of resource pool for a plurality of types of SL transmissions on a third panel of the plurality of panels. In some embodiments, each panel associated with a certain type of resource pool may be used for separate functionality related to SL transmissions. Accordingly, the first configuration may indicate a first type of resource pool for a first type of SL transmission on a first panel of the plurality of panels, and a second type of resource pool for a second type of SL transmission on a second panel of the plurality of panels. For example, one panel may be associated with a DRP for SL PRS transmission, and another panel may be associated with a SRP for measurement report.

[0078] In some cases, the SL transmissions on the plurality of panels may comprise SL-RS transmissions, including SL-PRS transmission. As mentioned above, the communication device 201 equipped with a plurality of panels may determine SL-RS design and allocation related to the plurality of panels, i.e., the second configuration indicating at least one SL signal to be transmitted on the plurality of panels. Regarding SL-RS configuration or generation related to the plurality of panels, in some embodiments, the SL-PRSs for the plurality of panels may be determined according to different SL positioning methods or

procedures applied for SL positioning.

[0079] In some embodiments, the second configuration may indicate related information for generating a SL-RS to be transmitted on the plurality of panels. That is, the same SL-RS may be used for the plurality of panels for SL transmissions, for example, the same SL PRS used for all panels in SL positioning. The related information may include one or more parameters that define the generation of a SL-RS. In some embodiments, an identical SL-RS may be used for the plurality of panels, for simple diversity transmission to enhance SL-RS coverage. In some embodiments, the second configuration may indicate a plurality of redundancy versions of the SL-RS to be transmitted on the plurality of panels, respectively. By configuring different redundancy versions of a SL-RS to different panels, joint reception of the different redundancy versions at the side of the receiving communication device can improve SL PRS decoding performance.

[0080] In some embodiments, the second configuration may indicate related information for generating a plurality of SL-RSs to be transmitted on the plurality of panels, respectively. That is, different SL-RSs may be used for the plurality of panels for SL transmissions, for example, different SL-PRSs may be used for the respective panels in SL positioning. The related information may include one or more parameters that define the generation of a SL-RS.

[0081] In some embodiments, if the plurality of SL-RSs are a plurality of SL-PRSs, those SL-PRSs may be related to a same ongoing SL positioning procedure (SLPP). For example, a plurality of SL-PRSs with different directions may be configured for a same positioning method, e.g., the angle of departure (AOD) based positioning method, or the angle of arrival (AOA) based positioning method. In some embodiments, the plurality of SL-PRSs may be respectively related to a plurality of ongoing SLPPs which are performed in parallel. For example, each SL-PRS may correspond to a separate SLPP and may be transmitted through one of the plurality of panels.

[0082] As discussed above, the same SL-RS or different SL-RSs may be configured to be transmitted on the plurality of panels of the communication device 201. In some embodiments, the panel ID or index may or may not be involved in the generation of the SL-RS or the different SL-RSs.

[0083] In some embodiments, the communication device 201 may determine the resource allocation for multi-panel based SL transmissions. The resource allocation may be

configured to allow efficient resource utilization. Regarding the SL resource allocation related to the plurality of panels, in some embodiment, the SL resource configuration or allocation may vary with the applications of the different panels.

[0084] In some embodiments, the communication device 201 may further determine a fourth configuration which indicates a plurality of beam directions for the plurality of panels, and/or a plurality of beam shapes for the plurality of panels. The fourth configuration may indicate beam-based resource allocation related to the plurality of panels for SL transmissions.

[0085] In some embodiments, the fourth configuration may indicate time-frequency resources allocated for the plurality of beam directions. In some embodiments, the time-frequency resources allocated for the plurality of beam directions may be overlapped or partially overlapped. For example, (partial) overlapping time-frequency resources may be allocated for SL-PRS transmission through the respective panels with different beam directions due to panel-based beamforming. In some embodiments, the time-frequency resources allocated for the plurality of beam directions may be non-overlapped. For example, non-overlapped time-frequency resources may be allocated for SL-PRS transmissions through the respective panels with different beam directions. In some embodiments, alternatively, or in addition, the fourth configuration may indicate beams with different beam shapes associated with different panels. The beam shapes may include beams with intense directivity (narrower beamwidth) or beams with mild directivity (wider beamwidth, such as an omnidirectional beam or a quasi-omnidirectional beam).

[0086] In some embodiments, the communication device 201 may further determine a fifth configuration for frequency-division multiplexed (FDM-ed) based SL resource allocation related to the panels for SL transmissions. The fifth configuration may indicate a plurality of sub-channel sets in a resource pool allocated for the plurality of panels, or a plurality of comb-based patterns in a resource pool allocated for the plurality of panels. That is, the fifth configuration may indicate sub-channel-based FDM-ed multiplexing of SL resources within a resource pool for SL transmissions through all the panels in parallel or comb-based FDM-ed multiplexing of SL resources within a resource pool for SL transmissions through all the panels in parallel. In some embodiments, for the comb-based FDM-ed multiplexing, the comb patterns may including full staggering or partial staggering SL resource pattern.

[0087] FIG. 3 illustrates an example comb-based multiplexing 300 of three SL signals in accordance with some example embodiments of the present disclosure. In this example, the

start symbol is 2, the length of a SL-RS is 12 symbols, the comb size of the SL-RS is 4 symbols, and the offset is 3 symbols.

[0088] In some embodiments, the communication device 201 may further determine a sixth configuration which indicate time-frequency resources in a plurality of resource pools allocated for the plurality of panels. The communication device 201 may determine resource pool based SL resource allocation for SL transmissions through the plurality of panels in parallel.

[0089] Some example embodiments related to the SL resource allocated for the multiple panels have been discussed above. It would be appreciated that the panel ID or index may or may not be involved in the SL resource definition or configuration.

[0090] As mentioned above, in some embodiments, the communication device 201 equipped with a plurality of panels may determine SCI information design and resource allocation for the multi-panel based SL transmissions, i.e., the third configuration indicating a transmission scheme for SCI associated with the SL transmissions on the plurality of panels. Usually, SCI may be transmitted together with a SL signal. Regarding scheduling information transmission related to multiple panels, the configuration of SCI scheduling SL PRS resource may also vary with different considerations, to allow the SCI transmission configuration related to the SL signal transmissions in parallel.

[0091] In some embodiments, a SCI may be transmitted to schedule all SL transmissions (for example, the SL-PRS transmissions) and this SCI may be transmitted through a certain panel.

[0092] In some embodiments, the third configuration may indicate a first transmission scheme in which a first SCI is to be transmitted through one of the plurality of panels, the first SCI being used for scheduling the SL transmissions on the plurality of panels. In some examples, a single SCI with a new enhanced format may be transmitted through a certain panel. The single SCI may include all scheduling information related to the SL-RS transmissions and SL data transmissions through the plurality of panels, such as in a manner of multiple TRIVs and FRIVs correspond to each SL-RS resource and SL data jointly or separately. In some embodiments, the certain panel used for transmitting the single SCI may be (pre)configured or dynamically selected by the communication device 201 and indicated to the other communication device(s) which receive the SCI as assistant information at least.

[0093] FIGS. 4A-4C illustrate schematic diagrams of example sidelink control

information (SCI) scheduling in accordance with some example embodiments of the present disclosure. In the example 410 of FIG. 4A, it is assumed that the communication device 201 include two panels, Panel 1 and Panel 2. A SCI is configured to be transmitted through Panel 1, and may be transmitted together with a SL signal (e.g., a SL-PRS) through Panel 1. This SCI conveys scheduling information related to transmissions of SL traffic and/or SL-RSs on both Panel 1 and Panel 2. FIG. 4B and FIG. 4C show two example arrangements of different types of scheduling information within the single SCI. In the example 420 of FIG. 4B, from the top to the bottom, there are a TRIV and a FRIV for scheduling a transmission on Panel 1, and then a further TRIV and a further FRIV for scheduling a transmission on Panel 2. In the example 430 of FIG. 4C, from the top to the bottom, there are two TRIVs for scheduling transmissions on Panel 1 and Panel 2, respectively, and then two FRIVs for scheduling transmissions on Panel 1 and Panel 2, respectively.

[0094] It would be appreciated that the examples in FIGS. 4A-4C are provided as examples. There may be many other examples of transmission schemes for the single SCI, and parameter arrangements in the single SCI. The scope of the present disclosure is not limited in this regard.

[0095] In some embodiments, the third configuration may indicate a second transmission scheme in which a plurality of SCIs are to be transmitted through one of the plurality of panels, the plurality of SCIs being used for scheduling the SL transmissions on the plurality of panels, respectively. That is, multiple SCIs scheduling multiple SL PRS transmissions respectively may be transmitted through a certain panel. The multiple SCIs may be transmitted in a time-division multiplexed (TDM-ed) or FDM-ed (for example, sub-channel based, comb-based, or resource pool based) manner. In some embodiments, the certain panel used for transmitting the multiple SCIs may be (pre)configured or dynamically selected by the communication device 201 and indicated to the other communication device(s) which receive the SCI as assistant information at least.

[0096] FIGS. 5A-5C illustrate schematic diagrams of example SCI scheduling in accordance with some further example embodiments of the present disclosure. In the example 510 of FIG. 5A, it is assumed that the communication device 201 include two panels, Panel 1 and Panel 2. A first SCI (SCI 1) for scheduling conveys scheduling information related to SL transmissions on Panel 1 and a second SCI (SCI 2) for scheduling conveys scheduling information related to SL transmissions on Panel 2 are both transmitted through Panel 1.

[0097] FIG. 5B shows an example 520 of TDM-ed based SCI transmission. As shown, SCI 1 and SCI 2 both occupy X1 symbols in the time domain, SCI 1 occupies Y1 sub-channels, and SCI 2 occupies Y3 sub-channels. There may be a gap of Y2 sub-channels in the frequency domain between SCI 1 and SCI 2. FIG. 5C shows an example 530 of FDM-ed based SCI transmission. As shown, SCI 1 and SCI 2 both occupy at least Y4 sub-channels in the frequency domain, and each of SCI 1 and SCI 2 occupies X2 symbols in the time domain.

[0098] In some embodiments, the third configuration may indicate a third transmission scheme in which a plurality of SCIs are to be transmitted through the plurality of panels, respectively. That is, the multiple SCIs scheduling the SL transmissions are transmitted through the plurality of panels.

[0099] In some embodiments, each of the plurality of SCIs may be used for scheduling a SL transmission on one of the plurality of panels. Each SCI scheduling a SL transmission (e.g., a SL-PRS transmission) may be transmitted along with the scheduled SL signal (e.g., the SL-PRS) through the same panel, respectively. Namely, the third configuration may indicate per-panel SCI transmission. FIG. 6A illustrates such an example 610, where SCI 1 is transmitted through Panel 1 and used for scheduling the SL transmission on Panel 1, and SCI 2 is transmitted through Panel 2 and used for scheduling the SL transmission on Panel 2.

[0100] In some embodiments, each of the plurality of SCIs may be used for scheduling the SL transmissions on the plurality of panels. Each SCI scheduling all the SL transmissions is transmitted along with each SL signal through each panel. FIG. 6B illustrates such an example 620. As shown, SCI 1 is transmitted through Panel 1 and is used for scheduling the SL transmissions on both Panel 1 and Panel 2. SCI 2 is transmitted through Panel 2 and is also used for scheduling the SL transmission on both Panel 1 and Panel 2. In some embodiments, each SCI may include all scheduling information related to all SL-RS transmissions and SL data transmissions through the multiple panels. In some embodiments, the multiple SCIs transmitted through different panels may be the same redundancy version or different redundancy versions of a SCI.

[0101] Some example embodiments related to the SCI transmissions for multi-panel SL transmissions have been discussed above. It would be appreciated that the panel ID or index may or may not be involved in the SCI content with a new format or enhanced legacy format.

[0102] According to the embodiments of the present disclosure, with less impact on the

existing specifications/standards of SL and positioning, the enhancements and methods for multi-panel based SL transmissions are proposed to facilitate the related applications, such as resource pool configuration, SL-RS design, resource configuration/allocation for SL signal transmissions, and SL-RS scheduling information transmission.

[0103] FIG. 7 illustrates a flowchart of a communication method 700 implemented at a communication device in accordance with some embodiments of the present disclosure. For the purpose of discussion, the method 700 will be described from the perspective of the communication device 201 in FIG. 2 (which may be any of the communication devices 110 in FIG. 1).

[0104] At block 710, the communication device 201 determines at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels.

[0105] At block 720, the communication device 201 transmits, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.

[0106] In some example embodiments, the first configuration is determined based on at least one of the following: respective operating frequency bands associated with the plurality of panels, respective operating frequency bands associated with a plurality of types of resource pools, or respective serving functions of the plurality of panels.

[0107] In some example embodiments, the first configuration indicates a type of resource pool for the SL transmissions on the plurality of panels.

[0108] In some example embodiments, the type of resource pool comprises at least one shared resource pool.

[0109] In some example embodiments, the type of resource pool comprises at least one dedicated resource pool, and wherein the SL transmissions comprises SL reference signal (SL-RS) transmissions, and the first configuration further indicates at least one shared resource pool for reception of SL data associated with the SL-RS transmissions on at least one of the plurality of panels.

[0110] In some example embodiments, the first configuration indicates a plurality of different types of resource pools for the SL transmissions on the plurality of panels.

[0111] In some example embodiments, the first configuration indicates a first type of resource pool for a first type of SL transmission on a first panel of the plurality of panels, and a second type of resource pool for a second type of SL transmission on a second panel of the plurality of panels, and/or wherein the first configuration indicates a third type of resource pool for a plurality of types of SL transmissions on a third panel of the plurality of panels.

[0112] In some example embodiments, the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a SL-RS to be transmitted on the plurality of panels.

[0113] In some example embodiments, the second configuration indicates a plurality of redundancy versions of the SL-RS to be transmitted on the plurality of panels, respectively.

[0114] In some example embodiments, the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a plurality of SL-RSs to be transmitted on the plurality of panels, respectively.

[0115] In some example embodiments, the plurality of SL-RSs comprises a plurality of SL positioning reference signals (SL-PRSs), and wherein the plurality of SL-PRSs are related to a SL positioning procedure (SLPP), or the plurality of SL-PRSs are related to a plurality of SLPPs, respectively.

[0116] In some example embodiments, the at least one configuration further comprises a fourth configuration indicating at least one of the following: a plurality of beam directions for the plurality of panels, or a plurality of beam shapes for the plurality of panels.

[0117] In some example embodiments, the fourth configuration further indicates time-frequency resources allocated for the plurality of beam directions, and wherein the time-frequency resources allocated for the plurality of beam directions are non-overlapped, or are at least partially overlapped.

[0118] In some example embodiments, the at least one configuration further comprises a fifth configuration indicating a plurality of sub-channel sets in a resource pool allocated for the plurality of panels, or a plurality of comb-based patterns in a resource pool allocated for the plurality of panels.

[0119] In some example embodiments, the at least one configuration further comprises a

sixth configuration indicates time-frequency resources in a plurality of resource pools allocated for the plurality of panels.

[0120] In some example embodiments, the third configuration indicates a first transmission scheme in which a first SCI is to be transmitted through one of the plurality of panels, the first SCI being used for scheduling the SL transmissions on the plurality of panels.

[0121] In some example embodiments, the third configuration indicates a second transmission scheme in which a plurality of SCIs are to be transmitted through one of the plurality of panels, the plurality of SCIs being used for scheduling the SL transmissions on the plurality of panels, respectively.

[0122] In some example embodiments, the third configuration indicates a third transmission scheme in which a plurality of SCIs are to be transmitted through the plurality of panels, respectively, and wherein each of the plurality of SCIs is used for scheduling a SL transmission on one of the plurality of panels, or each of the plurality of SCIs is used for scheduling the SL transmissions on the plurality of panels.

[0123] In some example embodiments, the at least one SL signal comprises at least one sidelink positioning reference signal (SL-PRS), or wherein the at least one SL signal comprises SL traffic.

[0124] FIG. 8 is a simplified block diagram of a device 800 that is suitable for implementing embodiments of the present disclosure. The device 800 can be considered as a further example implementation of any of the communication devices 110 and 120 as shown in FIG. 1 or any of the first, second, and third communication devices 201, 202, and 203 as shown in FIG. 2. Accordingly, the device 800 can be implemented at or as at least a part of a terminal device or a network device.

[0125] As shown, the device 800 includes a processor 810, a memory 820 coupled to the processor 810, a suitable transceiver 840 coupled to the processor 810, and a communication interface coupled to the transceiver 840. The memory 810 stores at least a part of a program 830. The transceiver 840 may be for bidirectional communications or a unidirectional communication based on requirements. The transceiver 840 may include at least one of a transmitter 842 and a receiver 844. The transmitter 842 and the receiver 844 may be functional modules or physical entities. The transceiver 840 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.

[0126] The program 830 is assumed to include program instructions that, when executed by the associated processor 810, enable the device 800 to operate in accordance with the embodiments of the present disclosure, as discussed herein with reference to FIGS. 1 to 7. The embodiments herein may be implemented by computer software executable by the processor 810 of the device 800, or by hardware, or by a combination of software and hardware. The processor 810 may be configured to implement various embodiments of the present disclosure. Furthermore, a combination of the processor 810 and memory 820 may form processing means 850 adapted to implement various embodiments of the present disclosure.

[0127] The memory 820 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 820 is shown in the device 800, there may be several physically distinct memory modules in the device 800. The processor 810 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 800 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[0128] According to embodiments of the present disclosure, the circuitry may be configured to perform any method implemented by the communication device as discussed above.

[0129] According to embodiments of the present disclosure, a communication device comprising a circuitry is provided. The circuitry is configured to: determine at least one

configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and transmit, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels. According to embodiments of the present disclosure, the circuitry may be configured to perform any method implemented by the communication device as discussed above.

[0130] 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.

[0131] According to embodiments of the present disclosure, a communication apparatus is provided. The communication apparatus comprises means for determining at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: means for a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, means for a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or means for a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and means for transmitting, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels. In some example embodiments, the first apparatus may comprise means for performing the

respective operations of the method 700. In some example embodiments, the first apparatus may further comprise means for performing other operations in some example embodiments of the method 700. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[0132] In summary, embodiments of the present disclosure provide the following aspects.

[0133] In an aspect, it is proposed a communication device comprising: a processor configured to cause the communication device to: determine at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following: a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels, a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and transmit, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.

[0134] In some embodiments, the first configuration is determined based on at least one of the following: respective operating frequency bands associated with the plurality of panels, respective operating frequency bands associated with a plurality of types of resource pools, or respective serving functions of the plurality of panels.

[0135] In some embodiments, the first configuration indicates a type of resource pool for the SL transmissions on the plurality of panels.

[0136] In some embodiments, the type of resource pool comprises at least one shared resource pool.

[0137] In some embodiments, the type of resource pool comprises at least one dedicated resource pool, and wherein the SL transmissions comprises SL reference signal (SL-RS) transmissions, and the first configuration further indicates at least one shared resource pool for reception of SL data associated with the SL-RS transmissions on at least one of the plurality of panels.

[0138] In some embodiments, the first configuration indicates a plurality of different types of resource pools for the SL transmissions on the plurality of panels.

[0139] In some embodiments, the first configuration indicates a first type of resource pool

for a first type of SL transmission on a first panel of the plurality of panels, and a second type of resource pool for a second type of SL transmission on a second panel of the plurality of panels, and/or wherein the first configuration indicates a third type of resource pool for a plurality of types of SL transmissions on a third panel of the plurality of panels.

[0140] In some embodiments, the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a SL-RS to be transmitted on the plurality of panels.

[0141] In some embodiments, the second configuration indicates a plurality of redundancy versions of the SL-RS to be transmitted on the plurality of panels, respectively.

[0142] In some embodiments, the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a plurality of SL-RSs to be transmitted on the plurality of panels, respectively.

[0143] In some embodiments, the plurality of SL-RSs comprises a plurality of SL positioning reference signals (SL-PRSs), and wherein the plurality of SL-PRSs are related to a SL positioning procedure (SLPP), or the plurality of SL-PRSs are related to a plurality of SLPPs, respectively.

[0144] In some embodiments, the at least one configuration further comprises a fourth configuration indicating at least one of the following: a plurality of beam directions for the plurality of panels, or a plurality of beam shapes for the plurality of panels.

[0145] In some embodiments, the fourth configuration further indicates time-frequency resources allocated for the plurality of beam directions, and wherein the time-frequency resources allocated for the plurality of beam directions are non-overlapped, or are at least partially overlapped.

[0146] In some embodiments, the at least one configuration further comprises a fifth configuration indicating a plurality of sub-channel sets in a resource pool allocated for the plurality of panels, or a plurality of comb-based patterns in a resource pool allocated for the plurality of panels.

[0147] In some embodiments, the at least one configuration further comprises a sixth configuration indicates time-frequency resources in a plurality of resource pools allocated for the plurality of panels.

[0148] In some embodiments, the third configuration indicates a first transmission scheme

in which a first SCI is to be transmitted through one of the plurality of panels, the first SCI being used for scheduling the SL transmissions on the plurality of panels.

[0149] In some embodiments, the third configuration indicates a second transmission scheme in which a plurality of SCIs are to be transmitted through one of the plurality of panels, the plurality of SCIs being used for scheduling the SL transmissions on the plurality of panels, respectively.

[0150] In some embodiments, the third configuration indicates a third transmission scheme in which a plurality of SCIs are to be transmitted through the plurality of panels, respectively, and wherein each of the plurality of SCIs is used for scheduling a SL transmission on one of the plurality of panels, or each of the plurality of SCIs is used for scheduling the SL transmissions on the plurality of panels.

[0151] In some embodiments, the at least one SL signal comprises at least one sidelink positioning reference signal (SL-PRS), or wherein the at least one SL signal comprises SL traffic.

[0152] In an aspect, a communication device 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 communication device discussed above.

[0153] 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 communication device discussed above.

[0154] 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 communication device discussed above.

[0155] 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.

[0156] 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 8. 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.

[0157] 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.

[0158] 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.

[0159] 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.

[0160] 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.

WHAT IS CLAIMED IS:

1. A communication device comprising:
a processor configured to cause the communication device to:
 - determine at least one configuration for sidelink (SL) transmissions on a plurality of panels, the at least one configuration comprising at least one of the following:
 - a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels,
 - a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or
 - a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and
 - transmit, based on the at least one configuration, the SCI and/or the at least one SL signal through at least one of the plurality of panels.
2. The device of claim 1, wherein the first configuration is determined based on at least one of the following:
 - respective operating frequency bands associated with the plurality of panels,
 - respective operating frequency bands associated with a plurality of types of resource pools, or
 - respective serving functions of the plurality of panels.
3. The device of claim 1, wherein the first configuration indicates a type of resource pool for the SL transmissions on the plurality of panels.
4. The device of claim 3, wherein the type of resource pool comprises at least one shared resource pool.
5. The device of claim 3, wherein the type of resource pool comprises at least one dedicated resource pool, and
 - wherein the SL transmissions comprises SL reference signal (SL-RS) transmissions, and the first configuration further indicates at least one shared resource pool for reception of

SL data associated with the SL-RS transmissions on at least one of the plurality of panels.

6. The device of claim 1, wherein the first configuration indicates a plurality of different types of resource pools for the SL transmissions on the plurality of panels.

7. The device of claim 6, wherein the first configuration indicates a first type of resource pool for a first type of SL transmission on a first panel of the plurality of panels, and a second type of resource pool for a second type of SL transmission on a second panel of the plurality of panels, and/or

wherein the first configuration indicates a third type of resource pool for a plurality of types of SL transmissions on a third panel of the plurality of panels.

8. The device of claim 1, wherein the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a SL-RS to be transmitted on the plurality of panels.

9. The device of claim 8, wherein the second configuration indicates a plurality of redundancy versions of the SL-RS to be transmitted on the plurality of panels, respectively.

10. The device of claim 1, wherein the SL transmissions comprise SL reference signal (SL-RS) transmissions, and the second configuration indicates related information for generating a plurality of SL-RSs to be transmitted on the plurality of panels, respectively.

11. The device of claim 10, wherein the plurality of SL-RSs comprises a plurality of SL positioning reference signals (SL-PRSs), and

wherein the plurality of SL-PRSs are related to a SL positioning procedure (SLPP), or the plurality of SL-PRSs are related to a plurality of SLPPs, respectively.

12. The device of claim 1, wherein the at least one configuration further comprises a fourth configuration indicating at least one of the following: a plurality of beam directions for the plurality of panels, or a plurality of beam shapes for the plurality of panels.

13. The device of claim 12, wherein the fourth configuration further indicates time-frequency resources allocated for the plurality of beam directions, and

wherein the time-frequency resources allocated for the plurality of beam directions are non-overlapped, or are at least partially overlapped.

14. The device of claim 1, wherein the at least one configuration further comprises a fifth configuration indicating a plurality of sub-channel sets in a resource pool allocated for the plurality of panels, or a plurality of comb-based patterns in a resource pool allocated for the plurality of panels.

15. The device of claim 1, wherein the at least one configuration further comprises a sixth configuration indicates time-frequency resources in a plurality of resource pools allocated for the plurality of panels.

16. The device of claim 1, wherein the third configuration indicates a first transmission scheme in which a first SCI is to be transmitted through one of the plurality of panels, the first SCI being used for scheduling the SL transmissions on the plurality of panels.

17. The device of claim 1, wherein the third configuration indicates a second transmission scheme in which a plurality of SCIs are to be transmitted through one of the plurality of panels, the plurality of SCIs being used for scheduling the SL transmissions on the plurality of panels, respectively.

18. The device of claim 1, wherein the third configuration indicates a third transmission scheme in which a plurality of SCIs are to be transmitted through the plurality of panels, respectively, and

wherein each of the plurality of SCIs is used for scheduling a SL transmission on one of the plurality of panels, or each of the plurality of SCIs is used for scheduling the SL transmissions on the plurality of panels.

19. The device of any of claims 1-15, wherein the at least one SL signal comprises at least one sidelink positioning reference signal (SL-PRS), or

wherein the at least one SL signal comprises SL traffic.

20. A communication method comprising:

determining, by a communication device, at least one configuration for sidelink (SL)

transmissions on a plurality of panels, the at least one configuration comprising at least one of the following:

- a first configuration indicating at least one of a plurality of types of resource pools for the SL transmissions on the plurality of panels,

- a second configuration indicating at least one SL signal to be transmitted on the plurality of panels, or

- a third configuration indicating a transmission scheme for SL control information (SCI) associated with the SL transmissions on the plurality of panels; and transmitting, based on the at least one configuration, of the SCI and/or the at least one SL signal through at least one of the plurality of panels.

DRAWINGS

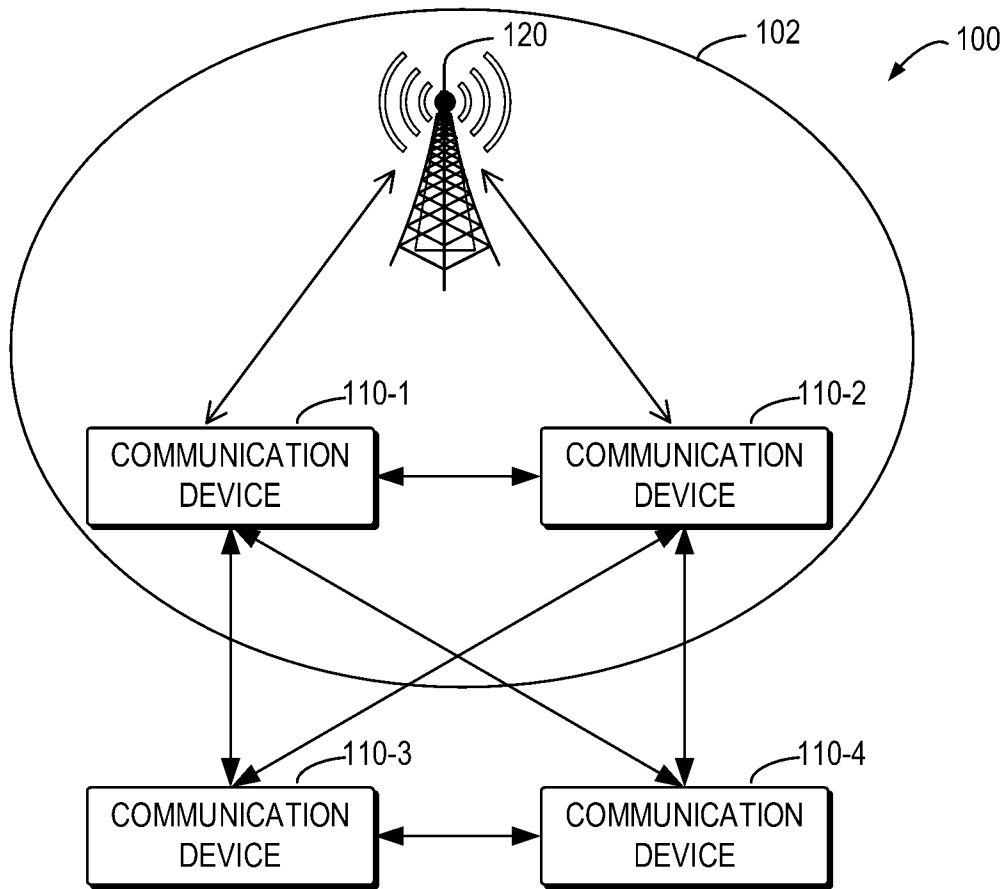


FIG. 1

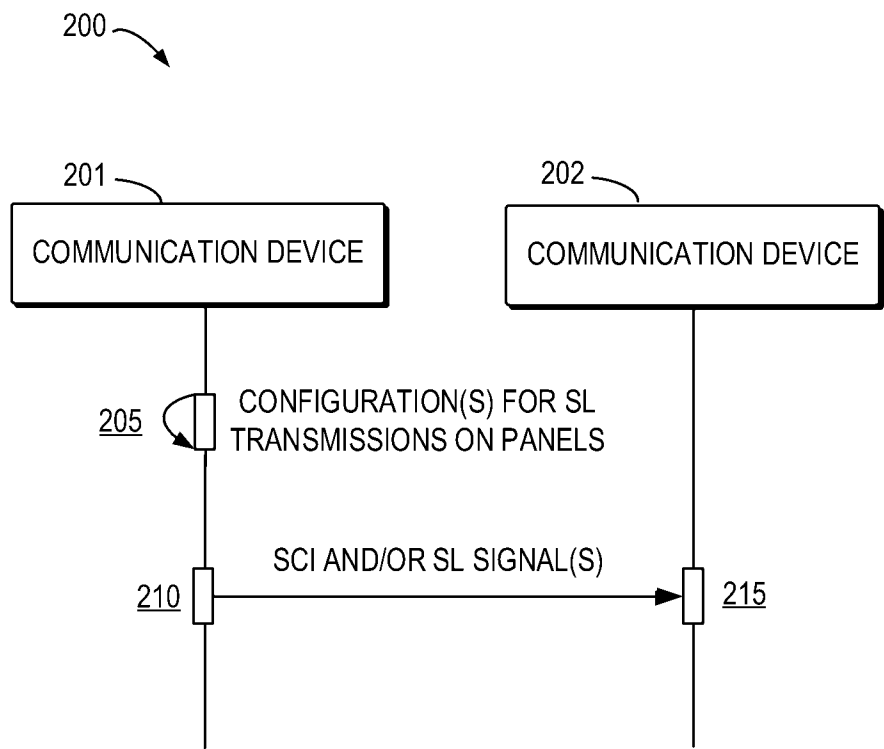


FIG. 2

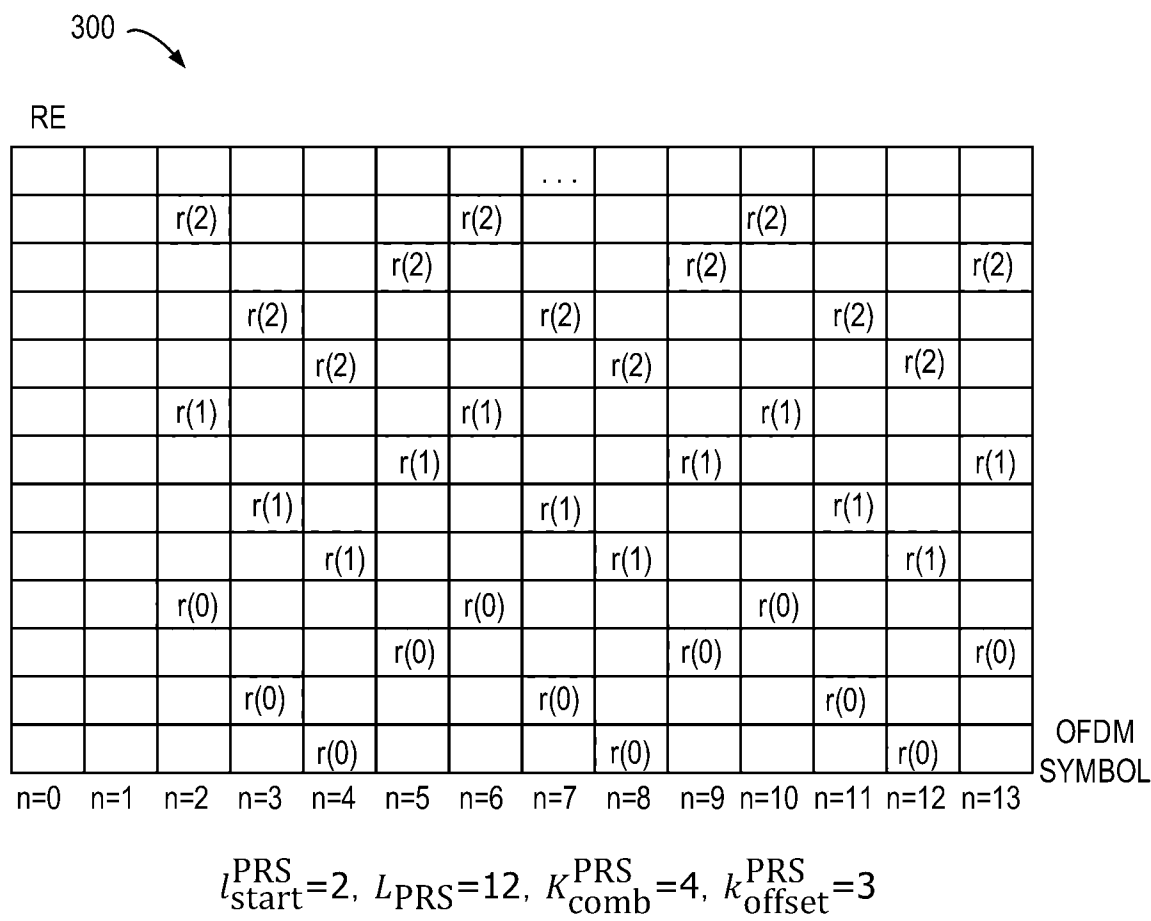


FIG. 3

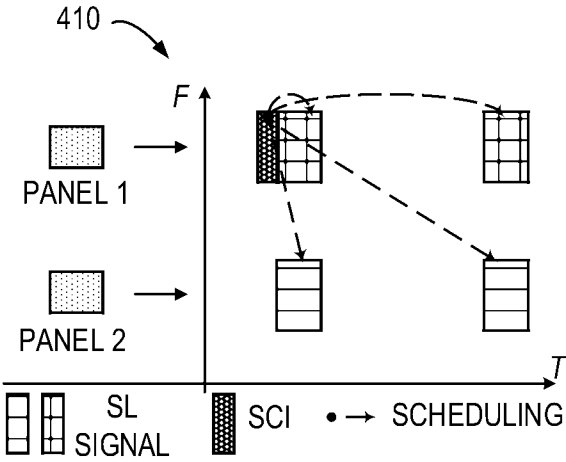


FIG. 4A

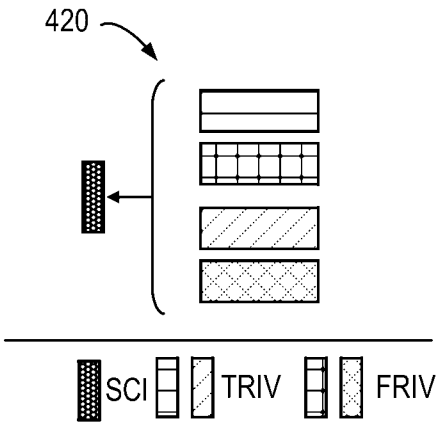


FIG. 4B

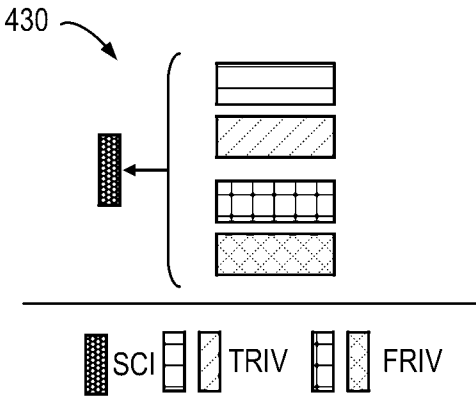


FIG. 4C

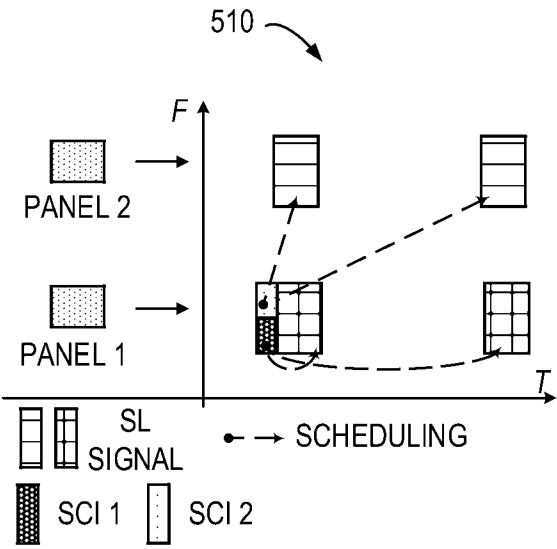


FIG. 5A

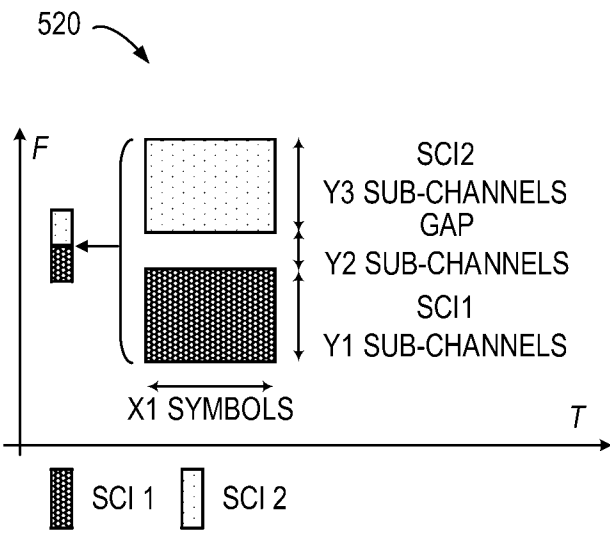


FIG. 5B

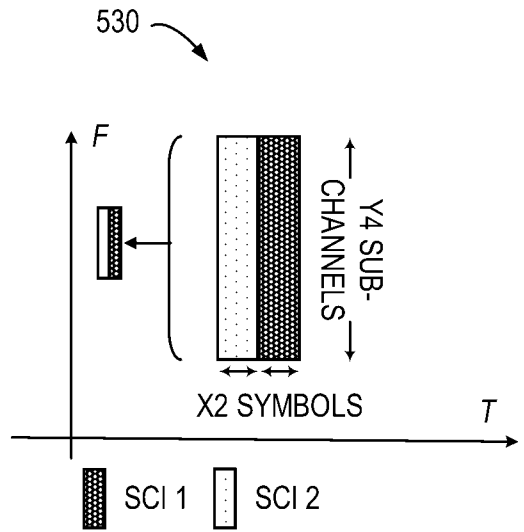


FIG. 5C

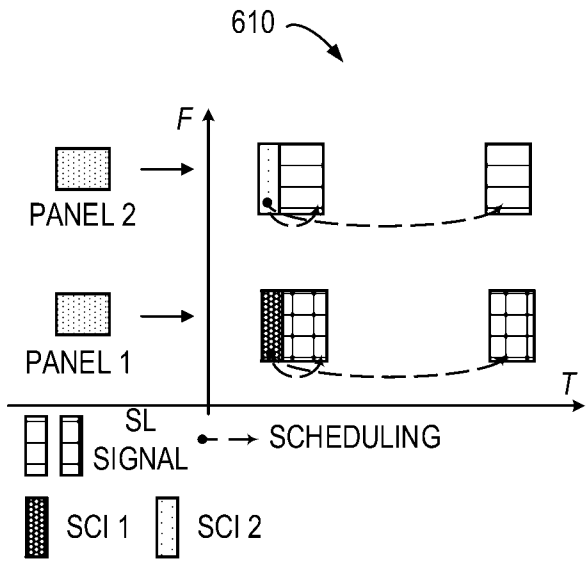


FIG. 6A

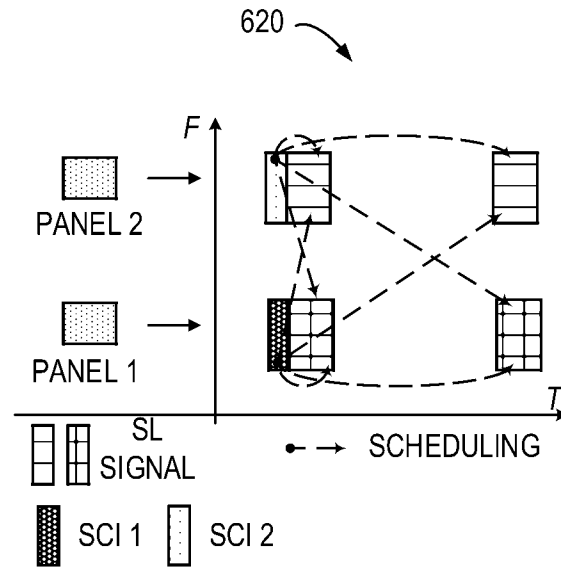


FIG. 6B

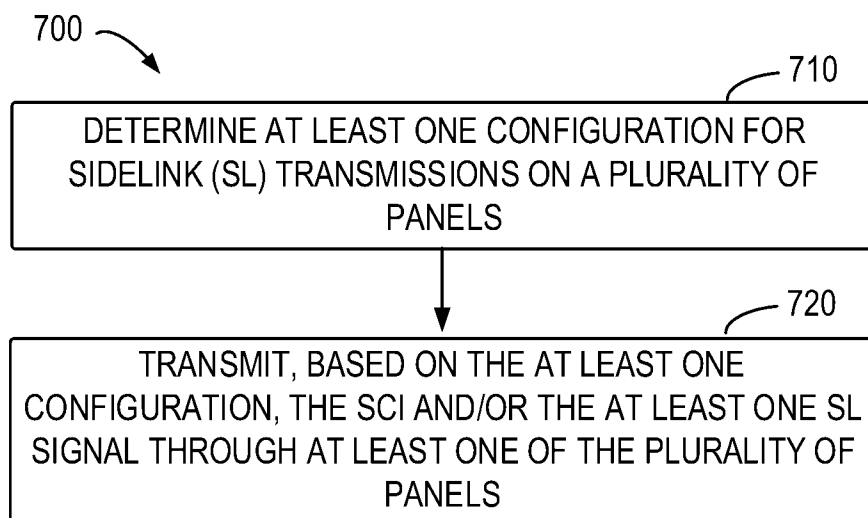


FIG. 7

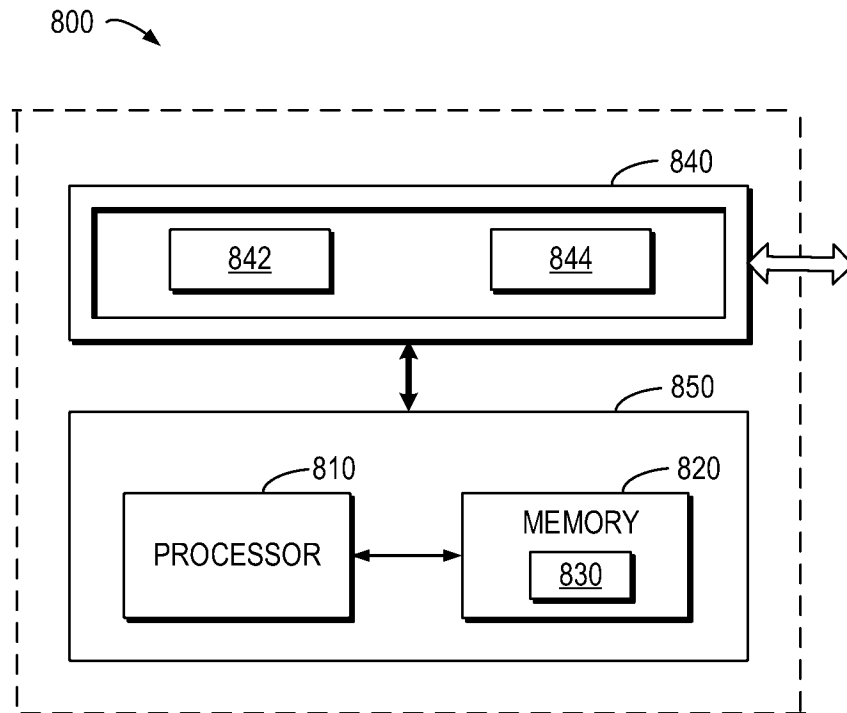


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/100821

A. CLASSIFICATION OF SUBJECT MATTER

H04W72/25(2023.01)i; H04W64/00(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

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,CNXTX,DWPI,ENTXT,ENTXTC,WPABS,WPABSC:panel,pool,resource,RS,SCI,sidelink,SL,configur+,multi+,SL-PRS,type,dedicated,shared,beam

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	LG ELECTRONICS. "Discussion on resource allocation for SL positioning reference signal" <i>3GPP TSG RAN WG1 Meeting #112 R1-2301538</i> , 03 March 2023 (2023-03-03), sections 1-2	1-20
Y	WO 2022193314 A1 (LENOVO (BEIJING) LTD.) 22 September 2022 (2022-09-22) description, paragraphs 82-186	1-20
Y	VIVO. "Discussion on potential solutions for sidelink positioning" <i>3GPP TSG RAN WG1 #109-e R1- 2203566</i> , 20 May 2022 (2022-05-20), sections 2-4	1-20
Y	CN 115987470 A (HUAWEI TECHNOLOGIES CO., LTD.) 18 April 2023 (2023-04-18) description, paragraphs 133-207	1-20
Y	WO 2022018688 A1 (LENOVO (SINGAPORE) PTE. LTD.) 27 January 2022 (2022-01-27) description, paragraphs 52-63	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

30 November 2023

Date of mailing of the international search report

06 December 2023

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/100821

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022193314	A1	22 September 2022	None			
CN	115987470	A	18 April 2023	None			
WO	2022018688	A1	27 January 2022	US	2023361955	A1	09 November 2023
				EP	4186174	A1	31 May 2023
				CN	116508266	A	28 July 2023