

Description

Title of Invention: COMMUNICATION APPARATUSES AND COMMUNICATION METHODS FOR CONGESTION CONTROL OF SIDELINK SIGNAL

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TECHNICAL FIELD

[1] The present disclosure relates to communication apparatuses and communication methods. In particular, it may relate to communication apparatuses and communication methods for congestion control of sidelink signal.

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BACKGROUND

[2] In the 3rd Generation Partnership Project (3GPP) Release (Rel.) 18 Expanded and Improved NR Positioning as described in WID RP-223549, congestion control mechanisms are specified using the existing congestion control mechanisms as a starting point for Scheme 2 sidelink positioning reference signal (SL-PRS) resource allocation. One or more of the following are studied for potential changes over existing congestion control mechanisms: Channel Busy Ratio (CBR) and Channel Occupancy Ratio (CR) definition for SL-PRS; parameters of a SL-PRS configuration that could be impacted by the congestion control mechanism, the mapping between congestion measurements, SL-PRS priority and SL-PRS parameters; CR and CBR measurement time window; congestion control processing time; number of CBR ranges; and whether any proposed changes could be applicable to shared resource pools in addition to a dedicated resource pool.

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[3] However, there has been no discussion on how detailed congestion control mechanisms for sidelink signal may be specified.

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[4] Thus, there is a need to provide communication apparatuses and methods for congestion control of sidelink signal that resolve above problems.

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SUMMARY

[5] Non-limiting and exemplary embodiments facilitate providing communication apparatuses and methods for congestion control of sidelink signal.

5 [6] According to a first embodiment of the present disclosure, there is provided a communication apparatus comprising: circuitry, which in operation, determines a configuration from a set of two or more configurations; and a transmitter, which in operation, transmits a sidelink signal based on the determined configuration.

10 [7] According to a second embodiment of the present disclosure, there is provided a base station comprising: circuitry, which in operation, determines a set of configurations from one or more sets of configurations, each of the one or more sets comprising two or more configurations; and a transmitter, which in operation, transmits a signaling indicating the determined set of configurations to the communication apparatus.

15 [8] According to a third embodiment of the present disclosure, there is provided a communication method comprising: determining a configuration from a set of two or more configurations; and transmitting a sidelink signal based on the determined configuration.

20 [9] According to a fourth embodiment of the present disclosure, there is provided a communication method comprising: determining a set of configurations from one or more sets of configurations, each of the one or more sets comprising two or more configurations; and transmitting a signaling indicating the determined
25 set of configurations to the communication apparatus.

[10] It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof.

30 [11] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain
35 one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[12] Embodiments of the disclosure will be better understood and readily apparent to one of ordinary skilled in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

5 [13] Fig. 1 shows an exemplary 3GPP NR radio access network (NR-RAN) architecture to which exemplary embodiments of the present disclosure can be applied.

10 [14] Fig. 2 depicts a schematic drawing which shows functional split between NG-RAN and 5G Core Network (5GC) to which exemplary embodiments of the present disclosure may be applied.

15 [15] Fig. 3 depicts a sequence diagram for RRC (radio resource control) connection setup/reconfiguration procedures to which exemplary embodiments of the present disclosure may be applied.

20 [16] Fig. 4 depicts a schematic drawing showing usage scenarios of Enhanced mobile broadband (eMBB), Massive Machine Type Communications (mMTC) and Ultra Reliable and Low Latency Communications (URLLC) to which exemplary embodiments of the present disclosure may be applied.

25 [17] Fig. 5 shows a block diagram showing an exemplary 5G system architecture for vehicle to everything (V2X) communication in a non-roaming scenario to which exemplary embodiments of the present disclosure may be applied.

[18] Fig. 6 shows an exemplary flowchart for switching of a configuration according to various embodiments of the present disclosure.

30 [19] Fig. 7 shows an exemplary flowchart for switching of a configuration when a fallback mechanism according to various embodiments of the present disclosure.

35 [20] Fig. 8 shows an exemplary flowchart for user equipment (UE) behaviour for power control with 2 configurations according to various embodiments of the present disclosure.

[21] Fig. 9 shows an exemplary flowchart for UE behaviour for deferment and dropping of a sidelink signal transmission for according to various embodiments of the present disclosure.

5 [22] Fig. 10 shows a flow chart illustrating a communication method for a UE according to various embodiments of the present disclosure.

[23] Fig. 11 shows a flow chart illustrating a communication method for a base station (gNB) according to various embodiments of the present disclosure.

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[24] Fig. 12 shows a schematic block diagram of an exemplary communication apparatus in accordance with a single antenna with various embodiments of the present disclosure.

15 [25] Fig. 13 shows a schematic block diagram of an exemplary communication apparatus with multiple antennas in accordance with various embodiments of the present disclosure.

[26] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the dimensions of some of the elements in the illustrations, block diagrams or flowcharts may be exaggerated in respect to other elements to help to improve understanding of the present embodiments.

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DETAILED DESCRIPTION

[27] Some embodiments of the present disclosure will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[28] Among other things, the overall system architecture assumes an NG-RAN (Next Generation – Radio Access Network) that comprises gNBs, providing the NG-radio access user plane (SDAP/PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the user equipment (UE). The gNBs are interconnected with each other by means of the Xn interface. The gNBs are also connected by means of the Next Generation (NG) interface to the NGC (Next Generation Core), more specifically to the AMF (Access and Mobility Management

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Function) (e.g., a particular core entity performing the AMF) by means of the NG-C interface and to the UPF (User Plane Function) (e.g., a particular core entity performing the UPF) by means of the NG-U interface. The NG-RAN architecture 100 is illustrated in Fig. 1 (see e.g., 3GPP TS 38.300 v16.3.0, section 4).

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[29] The user plane protocol stack for NR (see e.g., 3GPP TS 38.300, section 4.4.1) comprises the PDCP (Packet Data Convergence Protocol, see section 6.4 of TS 38.300), RLC (Radio Link Control, see section 6.3 of TS 38.300) and MAC (Medium Access Control, see section 6.2 of TS 38.300) sublayers, which are terminated in the gNB on the network side. Additionally, a new access stratum (AS) sublayer (SDAP, Service Data Adaptation Protocol) is introduced above PDCP (see e.g., sub-clause 6.5 of 3GPP TS 38.300). A control plane protocol stack is also defined for NR (see for instance TS 38.300, section 4.4.2). An overview of the Layer 2 functions is given in sub-clause 6 of TS 38.300. The functions of the PDCP, RLC and MAC sublayers are listed respectively in sections 6.4, 6.3, and 6.2 of TS 38.300. The functions of the RRC layer are listed in sub-clause 7 of TS 38.300. Further, sidelink (SL) communications is introduced in 3GPP TS 38.300 v16.3.0. Sidelink supports UE-to-UE direct communication using the sidelink resource allocation modes, physical-layer signals/channels, and physical layer procedures (see for instance section 5.7 of TS 38.300).

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[30] For instance, the Medium-Access-Control layer handles logical-channel multiplexing, and scheduling and scheduling-related functions, including handling of different numerologies.

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[31] The physical layer (PHY) is for example responsible for coding, PHY HARQ processing, modulation, multi-antenna processing, and mapping of the signal to the appropriate physical time-frequency resources. It also handles mapping of transport channels to physical channels. The physical layer provides services to the MAC layer in the form of transport channels. A physical channel corresponds to the set of time-frequency resources used for transmission of a particular transport channel, and each transport channel is mapped to a corresponding physical channel. For instance, the physical channels are Physical Random Access Channel (PRACH), Physical Uplink Shared Channel (PUSCH) and Physical Uplink Control Channel (PUCCH) for uplink and Physical Downlink Shared Channel (PDSCH), Physical Downlink Control Channel (PDCCH) and Physical Broadcast Channel (PBCH) for downlink. Further, physical sidelink

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channels include Physical Sidelink Control Channel (PSCCH), Physical Sidelink Shared Channel (PSSCH), Physical Sidelink Feedback Channel (PSFCH) and Physical Sidelink Broadcast Channel (PSBCH).

- 5 [32] Use cases / deployment scenarios for NR could include enhanced mobile broadband (eMBB), ultra-reliable low-latency communications (URLLC), massive machine type communication (mMTC), which have diverse requirements in terms of data rates, latency, and coverage. For example, eMBB is expected to support peak data rates (20Gbps for downlink and 10Gbps for uplink) and user-experienced data rates in the order of three times what is offered by IMT-Advanced. On the other hand, in case of URLLC, the tighter requirements are put on ultra-low latency (0.5ms for UL and DL each for user plane latency) and high reliability ($1-10^{-5}$ within 1ms). Finally, mMTC may preferably require high connection density (1,000,000 devices/km² in an urban environment), large coverage in harsh environments, and extremely long-life battery for low cost devices (15 years).

- [33] Therefore, the Orthogonal Frequency Division Multiplexing (OFDM) numerology (e.g., subcarrier spacing, OFDM symbol duration, cyclic prefix (CP) duration, number of symbols per scheduling interval) that is suitable for one use case might not work well for another. For example, low-latency services may preferably require a shorter symbol duration (and thus larger subcarrier spacing) and/or fewer symbols per scheduling interval (aka, TTI) than a mMTC service. Furthermore, deployment scenarios with large channel delay spreads may preferably require a longer CP duration than scenarios with short delay spreads. The subcarrier spacing should be optimized accordingly to retain the similar CP overhead. NR may support more than one value of subcarrier spacing. Correspondingly, subcarrier spacing of 15kHz, 30kHz, 60 kHz... are being considered at the moment. The symbol duration T_u and the subcarrier spacing Δf are directly related through the formula $\Delta f = 1 / T_u$. In a similar manner as in LTE systems, the term “resource element” can be used to denote a minimum resource unit being composed of one subcarrier for the length of one OFDM/SC-FDMA symbol.

- 35 [34] In the new radio system 5G-NR for each numerology and carrier a resource grid of subcarriers and OFDM symbols is defined respectively for uplink and downlink. Each element in the resource grid is called a resource element and is

identified based on the frequency index in the frequency domain and the symbol position in the time domain (see 3GPP TS 38.211 v16.3.0).

[35] Schematic drawing 200 of Fig. 2 illustrates functional split between NG-RAN and 5GC. NG-RAN logical node is a gNB or ng-eNB. The 5GC has logical nodes Access and Mobility Management Function (AMF), User Plane Function (UPF) and Session Management Function (SMF).

[36] In particular, the gNB and ng-eNB host the following main functions:

- 10 – Functions for Radio Resource Management such as Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling);
- IP header compression, encryption and integrity protection of data;
- Selection of an AMF at UE attachment when no routing to an AMF can be
15 determined from the information provided by the UE;
- Routing of User Plane data towards UPF(s);
- Routing of Control Plane information towards AMF;
- Connection setup and release;
- Scheduling and transmission of paging messages;
- 20 – Scheduling and transmission of system broadcast information (originated from the AMF or OAM);
- Measurement and measurement reporting configuration for mobility and scheduling;
- Transport level packet marking in the uplink;
- 25 – Session Management;
- Support of Network Slicing;
- QoS Flow management and mapping to data radio bearers;

- Support of UEs in RRC_INACTIVE state;
 - Distribution function for NAS messages;
 - Radio access network sharing;
 - Dual Connectivity;
- 5 – Tight interworking between NR and E-UTRA.

[37] The Access and Mobility Management Function (AMF) hosts the following main functions:

- Non-Access Stratum, NAS, signaling termination;
- 10 – NAS signaling security;
- Access Stratum, AS, Security control;
 - Inter Core Network, CN, node signaling for mobility between 3GPP access networks;
- 15 – Idle mode UE Reachability (including control and execution of paging retransmission);
- Registration Area management;
 - Support of intra-system and inter-system mobility;
 - Access Authentication;
 - Access Authorization including check of roaming rights;
- 20 – Mobility management control (subscription and policies);
- Support of Network Slicing;
 - Session Management Function, SMF, selection.

[38] Furthermore, the User Plane Function, UPF, hosts the following main functions:

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- Anchor point for Intra-/Inter-RAT mobility (when applicable);
- External PDU session point of interconnect to Data Network;
- Packet routing & forwarding;
- Packet inspection and User plane part of Policy rule enforcement;
- 5 – Traffic usage reporting;
- Uplink classifier to support routing traffic flows to a data network;
- Branching point to support multi-homed PDU session;
- QoS handling for user plane, e.g. packet filtering, gating, UL/DL rate enforcement;
- 10 – Uplink Traffic verification (SDF to QoS flow mapping);
- Downlink packet buffering and downlink data notification triggering.

[39] Finally, the Session Management function, SMF, hosts the following main functions:

- 15 – Session Management;
- UE IP address allocation and management;
- Selection and control of UP function;
- Configures traffic steering at User Plane Function, UPF, to route traffic to proper destination;
- 20 – Control part of policy enforcement and QoS;
- Downlink Data Notification.

[40] Sequence diagram 300 in Fig. 3 illustrates some interactions between a UE, gNB, and AMF (an 5GC entity) in the context of a transition of the UE from RRC_IDLE to RRC_CONNECTED for the NAS part (see TS 38.300 v16.3.0). The transition steps are as follows:

1. The UE requests to setup a new connection from RRC_IDLE.

2/2a. The gNB completes the RRC setup procedure.

NOTE: The scenario where the gNB rejects the request is described below.

5 3. The first NAS message from the UE, piggybacked in *RRCSetupComplete*, is sent to AMF.

4/4a/5/5a. Additional NAS messages may be exchanged between UE and AMF, see TS 23.502 reference [22] (3GPP TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station in idle mode").

10 6. The AMF prepares the UE context data (including PDU session context, the Security Key, UE Radio Capability and UE Security Capabilities, etc.) and sends it to the gNB.

7/7a. The gNB activates the AS security with the UE.

8/8a. The gNB performs the reconfiguration to setup SRB2 and DRBs.

15 9. The gNB informs the AMF that the setup procedure is completed.

[41] RRC is a higher layer signalling (protocol) used for UE and gNB configuration. In particular, this transition involves that the AMF prepares the UE context data (including e.g., PDU session context, the Security Key, UE Radio Capability and UE Security Capabilities, etc.) and sends it to the gNB with the
20 INITIAL CONTEXT SETUP REQUEST. Then, the gNB activates the AS security with the UE, which is performed by the gNB transmitting to the UE a SecurityModeCommand message and by the UE responding to the gNB with the SecurityModeComplete message. Afterwards, the gNB performs the reconfiguration to setup the Signaling Radio Bearer 2, SRB2, and Data Radio
25 Bearer(s), DRB(s) by means of transmitting to the UE the RRCReconfiguration message and, in response, receiving by the gNB the RRCReconfigurationComplete from the UE. For a signaling-only connection, the steps relating to the RRCReconfiguration are skipped since SRB2 and DRBs are not setup. Finally, the gNB informs the AMF that the setup procedure is completed
30 with the INITIAL CONTEXT SETUP RESPONSE.

[42] Schematic drawing 400 in Fig. 4 illustrates some use cases for 5G NR. In third generation partnership project new radio (3GPP NR), three use cases are being considered that have been envisaged to support a wide variety of services and applications by IMT-2020. The technical specification (TS) for the phase 1 of enhanced mobile-broadband (eMBB) has been concluded. In addition to further extending the eMBB support, the current and future work would involve the standardization for ultra-reliable and low-latency communications (URLLC) and massive machine-type communications (mMTC). Fig. 4 illustrates some examples of envisioned usage scenarios for IMT for 2020 and beyond (see e.g., ITU-R M.2083 Fig.2).

[43] The URLLC use case has stringent requirements for capabilities such as throughput, latency and availability and has been envisioned as one of the enablers for future vertical applications such as wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid, transportation safety, etc. Ultra-reliability for URLLC is to be supported by identifying the techniques to meet the requirements set by TR 38.913. For NR URLLC in Release 15, key requirements include a target user plane latency of 0.5 ms for UL (uplink) and 0.5 ms for DL (downlink). The general URLLC requirement for one transmission of a packet is a BLER (block error rate) of $1E-5$ for a packet size of 32 bytes with a user plane latency of 1ms.

[44] From the physical layer perspective, reliability can be improved in a number of possible ways. The current scope for improving the reliability involves defining separate CQI tables for URLLC, more compact DCI formats, repetition of PDCCH, etc. However, the scope may widen for achieving ultra-reliability as the NR becomes more stable and developed (for NR URLLC key requirements). Particular use cases of NR URLLC in Rel. 15 include Augmented Reality/Virtual Reality (AR/VR), e-health, e-safety, and mission-critical applications.

[45] Moreover, technology enhancements targeted by NR URLLC aim at latency improvement and reliability improvement. Technology enhancements for latency improvement include configurable numerology, mini-slot-based scheduling with flexible mapping, grant free (configured grant) uplink, mini-slot-level repetition for data channels, and downlink pre-emption. Pre-emption means that a transmission for which resources have already been allocated is stopped, and the already allocated resources are used for another transmission that has been requested

later, but has lower latency / higher priority requirements. Accordingly, the already granted transmission is pre-empted by a later transmission. Pre-emption is applicable independent of the particular service type. For example, a transmission for a service-type A (URLLC) may be pre-empted by a transmission for a service type B (such as eMBB). Technology enhancements with respect to reliability improvement include dedicated Channel Quality Indicator/Modulation and Coding Scheme (CQI/MCS) tables for the target BLER of $1E-5$.

[46] The use case of mMTC (massive machine-type communication) is characterized by a very large number of connected devices typically transmitting a relatively low volume of non-delay sensitive data. Devices are required to be low cost and to have a very long battery life. From NR perspective, utilizing very narrow bandwidth parts is one possible solution to have power saving from UE perspective and enable long battery life.

[47] As mentioned above, it is expected that the scope of reliability in NR becomes wider. One key requirement to all the cases, and especially necessary for URLLC and mMTC, is high reliability or ultra-reliability. Several mechanisms can be considered to improve the reliability from radio perspective and network perspective. In general, there are a few key potential areas that can help improve the reliability. Among these areas are compact control channel information, data/control channel repetition, and diversity with respect to frequency, time and/or the spatial domain. These areas are applicable to reliability in general, regardless of particular communication scenarios.

[48] For NR URLLC, further use cases with tighter requirements have been identified such as factory automation, transport industry and electrical power distribution, including factory automation, transport industry, and electrical power distribution. The tighter requirements are higher reliability (up to 10^{-6} level), higher availability, packet sizes of up to 256 bytes, time synchronization down to the order of a few μs where the value can be one or a few μs depending on frequency range and short latency in the order of 0.5 to 1 ms in particular a target user plane latency of 0.5 ms, depending on the use cases.

[49] Moreover, for NR URLLC, several technology enhancements from the physical layer perspective have been identified. Among these are PDCCH (Physical Downlink Control Channel) enhancements related to compact DCI,

PDCCH repetition, increased PDCCH monitoring. Moreover, UCI (Uplink Control Information) enhancements are related to enhanced HARQ (Hybrid Automatic Repeat Request) and channel state information (CSI) feedback enhancements. Also PUSCH enhancements related to mini-slot level hopping and retransmission/repetition enhancements have been identified. The term “mini-slot” refers to a Transmission Time Interval (TTI) including a smaller number of symbols than a slot (a slot comprising fourteen symbols).

[50] The 5G QoS (Quality of Service) model is based on QoS flows and supports both QoS flows that require guaranteed flow bit rate (GBR QoS flows) and QoS flows that do not require guaranteed flow bit rate (non-GBR QoS Flows). At NAS level, the QoS flow is thus the finest granularity of QoS differentiation in a PDU session. A QoS flow is identified within a PDU session by a QoS flow ID (QFI) carried in an encapsulation header over NG-U interface.

[51] For each UE, 5GC establishes one or more PDU Sessions. For each UE, the NG-RAN establishes at least one Data Radio Bearers (DRB) together with the PDU Session, and additional DRB(s) for QoS flow(s) of that PDU session can be subsequently configured (it is up to NG-RAN when to do so), e.g., as shown above with reference to Fig. 3. The NG-RAN maps packets belonging to different PDU sessions to different DRBs. NAS level packet filters in the UE and in the 5GC associate UL and DL packets with QoS Flows, whereas AS-level mapping rules in the UE and in the NG-RAN associate UL and DL QoS Flows with DRBs.

[52] Block diagram 500 in Fig. 5 illustrates a 5G NR non-roaming reference architecture (see TS 23.287 v16.4.0, section 4.2.1.1). An Application Function (AF), e.g., an external application server hosting 5G services, exemplarily described in Fig. 4, interacts with the 3GPP Core Network in order to provide services, for example to support application influence on traffic routing, accessing Network Exposure Function (NEF) or interacting with the Policy framework for policy control (see Policy Control Function, PCF), e.g., QoS control. Based on operator deployment, Application Functions considered to be trusted by the operator can be allowed to interact directly with relevant Network Functions. Application Functions not allowed by the operator to access directly the Network Functions use the external exposure framework via the NEF to interact with relevant Network Functions.

[53] Fig. 5 shows further functional units of the 5G architecture for V2X communication, namely, Unified Data Management (UDM), Policy Control Function (PCF), Network Exposure Function (NEF), Application Function (AF), Unified Data Repository (UDR), Access and Mobility Management Function (AMF), Session Management Function (SMF), and User Plane Function (UPF) in the 5GC, as well as with V2X Application Server (V2AS) and Data Network (DN), e.g. operator services, Internet access or third party services. All of or a part of the core network functions and the application services may be deployed and running on cloud computing environments.

[54] The work item of sidelink positioning is newly introduced into 3GPP in Release (Rel.) 18 to support sidelink ranging and positioning with sidelink positioning reference signal (SL-PRS). In Rel.16, the congestion control for SL transmission is only specified for CR (channel occupancy ratio) and CBR (channel busy ratio) definitions in RAN1, and the remaining behaviours are up to user equipment (UE) implementation.

[55] However, as different UEs may implement different behaviours to accommodate congestion control (e.g., transmitting (Tx) power, priority, dropping, etc.), system performance (resource utilization, power consumption, etc.) may fluctuate severely, and may even further exacerbate the congestion situation.

[56] Therefore, in the present disclosure, detailed congestion control mechanisms are specified for SL-PRS and also other SL signals and channels to overcome the above issues. A UE may be configured with one or more sets of configurations, where each set may comprise at least two configurations. A configuration may be determined by the UE. The configuration may be determined based on a signaling, the UE's default / initial setting, a congestion situation of the UE, or other similar factors. The UE (and/or gNB) may be configured to measure or counts certain parameters or criteria (e.g., to understand the congestion situation and) to determine which configuration the UE is in, and switch to another configuration (if necessary) based on the determination. Further, one or more behaviors (e.g., behaviours for congestion control such as adjustment of Tx power, priority, dropping/deferring a sidelink signal transmission, resource utilization, power consumption, and other similar behaviors) of a UE and/or a gNB may be specified for each configuration.

[57] In a proposed solution, a specified solution for SL congestion control is implemented, instead of leaving it up to UE implementation after CBR/CR measurement. Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.

[58] A SL UE (e.g., UE-A) may be configured with at least one set of configurations. Each set may comprise at least two configurations, and each configuration specifies its own UE behaviors for congestion control. For example, a set may comprise 2 configurations (a first configuration for a non-congested situation, and a second configuration for a congested situation). A UE having this setting may be configured to receive the first and second configurations by a higher layer signaling. In another example, the UE may be configured with a set comprising 3 configurations: a first configuration for a low-congested situation, a second configuration for a mid-congested situation, and a third configuration for a high-congested situation. A UE having this setting may be configured to receive the first, second and third configurations by a higher layer signaling.

[59] In either example, the UE may be configured to switch between the configurations. The UE may be configured to switch from one configuration to another configuration based on a signaling (e.g., from a gNB, another UE, or an internal signaling within the UE), a congestion situation of the UE (e.g., based on a value relating to a congestion situation), an initial or default configuration of the UE (e.g., when implementing a fallback mechanism to fall back to the initial or default configuration) or other similar factors. The signaling may be physical or higher layer signaling(s). In an implementation, the signaling may be from another UE and indicate certain parameters that may be used by the UE to determine a configuration to be in. For example, the signaling may indicate a priority level of a transmission, a request to switch configurations, a pre-emption for a higher priority transmission (e.g., from the another UE), or other similar parameters. In another example, the signaling may be transmitted from another UE and indicate a configuration which the another UE is in, and the UE may be configured to determine a configuration based on this information. For instance, the UE may switch to a configuration that is same as that of the another UE, or to a similar one based on a further check of other parameters. In an implementation, a value relating to a congestion situation (e.g., CBR, CR, or other similar parameter) may be measured and compared against a threshold value, and a configuration may

be switched based on the comparison. For example, a UE may be configured to switch to a first configuration when a value relating to a congestion situation is less than a threshold, and switch to a second configuration when the value relating to the congestion situation is equal to or larger than the threshold. It will be appreciated that more than one thresholds may be implemented along with a third or more configurations.

[60] The UE may be configured to transmit a sidelink signal based on the configuration. It will be appreciated that a sidelink signal may be a PSCCH, PSSCH, PSFCH SL-PRS, or other similar sidelink transmission including sidelink channels and signals. Furthermore, the UE may also be configured with more than one sets of configurations, such that the UE may switch from one set of configurations to another set. The switch between different sets of configurations may be based on a signaling (e.g., from a gNB, another UE, or an internal signaling within the UE) specified by standardization bodies, or configured by regulators, UE vendors, operators, base stations, etc. The signaling may be physical or higher layer signaling(s).

[61] In an implementation, for a set of at least two configurations, one configuration may be set as a default configuration of a UE. For example, when a set comprises 2 configurations with a first configuration for a non-congested situation and a second configuration for a congested situation, a configuration for a non-congested situation may be set as a default for a UE that is typically in a non-congested situation, while a configuration for a congested situation may be set as a default for a UE that is typically in a congested situation.

[62] Further, each configuration may be linked to different use cases or scenarios. For example, for a geo-location based configuration, when a UE is located in an area that is typically associated with a high load (e.g., having a high network traffic with large numbers of SL transmission and reception), the UE may be configured to switch to a configuration that is associated with a congested situation. Examples of areas with a high load may include areas prone to traffic jams such road junctions, or multilayer interchanges, or other similar areas. In another example, for a UE type configuration, a UE that is associated with cars or sedans may be set to a configuration associated with a non-congested situation, while UEs associated with road-side units (RSU) or emergency vehicles may be set to a configuration associated with a congested situation.

[63] In an implementation, a gNB may be configured to transmit a signaling indicating at least one set of configurations to the UE, and the UE may be configured to implement the at least one set of configurations.

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[64] In another example, for a cell-wise configuration, a gNB may be configured to broadcast in a cell to configure all UEs within the cell to a configuration associated with a certain congestion situation when triggered by a threshold based on measurement of a parameter associated with the cell, a signaling or historical data. It will be appreciated that the above examples are not exhaustive and other categorizations are also possible. The at least one set of configurations, at least two configurations, default congestion situation, and categorizations discussed above may be specified by standardization bodies, or configured by regulators, UE vendors, operators, base stations, and other similar entities.

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[65] In an implementation, a UE and/or gNB may be configured to check certain conditions (e.g., parameter, criteria, signaling, and other similar condition) to determine what congestion situation it is in, and may then be configured to switch to another configuration based on the determination. Among at least two configurations, a UE may be configured to switch from a first configuration (for example, a default configuration) to a second configuration based on certain triggering conditions. Fig. 6 shows an exemplary flowchart 600 for switching of a configuration based on a triggering condition. At step 602, a UE may be in a configuration associated with a non-congested situation. At step 604, the UE or a gNB may be configured to check for a triggering condition associated with a congested situation. At step 606, it is determined whether the triggering condition is met. If it is met, the process proceeds to step 608 in which the UE may be configured to switch to a configuration associated with a congested situation. If the triggering condition is not met, the process proceeds instead to step 610 in which the UE remains in the configuration associated with a non-congested situation.

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[66] The triggering condition may be referred as whether a value relating to a congested situation is less than a threshold. For example, if a value relating to a congested situation is less than a threshold, the UE may be configured to switch to a configuration associated with a congested situation. If the value relating to a congested situation is equal to or large than the threshold, the UE may remain in the configuration associated with a non-congested situation.

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[67] In another example, a fallback mechanism may be designed for a UE to switch back to a configuration associated with a default or initial congestion situation e.g., based on an expiration timer, counter, or other similar mechanisms that result in the UE switching back to the default or initial configuration. Fig. 7 shows an exemplary flowchart 700 for switching of a configuration based on a fallback mechanism. At step 702, a UE is initialized with a configuration associated with a non-congested situation. At step 704, the UE or a gNB may check for a triggering condition associated with a congested situation. At step 706, it is determined whether the triggering condition is met. If it is determined that the triggering condition is not met, the process proceeds to step 714 in which the UE remains in the same configuration e.g., the configuration associated with the non-congested situation. If it is determined that the triggering condition is met, the process proceeds instead to step 708 where the UE switches to a configuration associated with a congested situation. At step 710, the UE or gNB may check for a fallback condition (e.g., an expiration timer, counter, or other similar mechanisms that result in the UE switching back to the initial condition). At step 712, it is determined whether the fallback condition is fulfilled. If it is determined that the fallback condition is fulfilled, the process proceeds to step 714 in which the UE switches back to the configuration associated with the initial non-congestion situation. Otherwise, the process proceeds back to step 708 instead, in which the UE remains in the same configuration. It will be appreciated that the initial configuration may also be one that is associated with a congestion situation depending on the circumstances.

[68] Implementation of a fallback mechanism and/or triggering condition advantageously enables a UE to adaptively and automatically switch to another configuration.

[69] There are various conditions that may be checked by a UE or gNB to determine a congestion situation or a configuration. CBR or CR may be checked such that, upon the CBR or CR reaching above a certain threshold value, a UE may be configured to switch to a configuration associated with a (pre-)configured congestion situation that corresponds to the threshold value. For example, the CBR or CR value may be divided to ranges of values in which each range may correspond to a congestion situation (e.g., low congestion, mid congestion, high congestion, not congested, or other similar situations). The measuring window

(e.g., a duration of time during which a UE or gNB checks the value of CBR or CR) for checking CBR or CR may be configured to be different for different congestion situations (e.g., depending on a location where a UE is currently in). In an implementation, a UE may be configured to be in a configuration depending on a value relating to a congestion situation. The value may be that of a CBR, CR, or other similar parameters. For example, a UE may be in a first configuration when the value is less than a threshold, or in a second configuration when the value is equal to or larger than the threshold. This advantageously enables a UE to adaptively switch to a suitable configuration according to the value to improve performance of the UE.

[70] A priority associated with data transmission may be checked as a condition for switching configurations. For example, a UE with a higher SL priority data (e.g., priority value of 0-3) to be transmitted may be configured to be in a configuration associated with a congested situation, while a UE with a lower SL priority data (e.g., priority value of 4-7) to be transmitted may be configured to be in a configuration associated with a non-congested situation.

[71] A cast-type of a transmission may also be checked. For example, a UE with SL unicast to be transmitted may be configured to be in a configuration associated with a non-congested situation, UE with SL groupcast or broadcast may be configured to be in a configuration associated with a congested situation. A UE may also be configured to switch from a configuration associated with a non-congested situation to one associated with a congested situation when being pre-empted by a higher priority transmission from other UE(s). It will be appreciated that a UE may also be pre-empted by a lower priority transmission from other UE(s) to switch to another configuration.

[72] UE signalings may be checked as a condition for switching configurations as well. For example, a first UE may switch to a configuration associated with a congested situation if a second UE indicated that it is in a configuration associated with a congested situation. This is beneficial for Tx only UEs to improve the chances of a successful transmission especially in congested situations. In another example, when a first UE's request to a second UE to transmit a sidelink signal, the second UE may be in a configuration associated with a congested situation by default. Further, gNB signaling may be checked as a condition for a

UE to switch to a configuration associated with a certain congestion situation based on the gNB's determination.

[73] Furthermore, periodicity of sidelink signal transmissions, number of occupied subchannels of sidelink signal (e.g., for shared resource pool), number of sidelink signal resources in a slot, number of OFDM symbols of a sidelink signal resource in a slot, and other similar conditions may also be used to determine the congestion situation of a UE and whether the UE should switch to another configuration.

[74] UE behaviour may be configured to change according to a configuration that the UE is in. In an implementation, upon being (pre-)configured or switched to a configuration associated with a certain congestion situation, certain actions may be taken by a UE solely or jointly, according to Scheme 1 or 2 (e.g., where Scheme 1 corresponds to a network-centric sidelink signal resource allocation and Scheme 2 corresponds to a UE autonomous sidelink signal resource allocation [RAN1]) with or without higher layer management. The actions may be (pre-)configured according to different congestion situation within the UE itself, or signaled by a gNB, other UE(s), or other similar entities. For scheme 1 and 2, the signaling for a UE behavior may be different (e.g., self signaling or gNB signaling in PHY/MAC/RRC layers). Advantageously, it is possible to attain a unified and organized behavior for each UE in a system for an improved system performance.

[75] For example, a different maximum sidelink signal transmission power may be configured for different congestion situations (e.g., a different maximum power may be configured for each of a configuration associated with a low congestion situation, a mid congestion situation, a high congestion situation, or other variations of congestion situations). Based on the configuration that a UE switches to, Tx power for sidelink signal may be increased or decreased accordingly (e.g., an offset for Tx power may be scaled up or down).

[76] Fig. 8 shows an exemplary flowchart 800 for UE behaviour for power control with 2 configurations according to various embodiments of the present disclosure. At step 802, a UE may be initialized with a configuration associated with a non-congested situation with a maximum Tx power of $P_{\text{cmax_non-congested}}$. At step 804, a determination and switching of a configuration of the UE may be performed. At step 806, it is determined whether the UE is switched to a configuration

associated with a congested situation. If it is determined that the UE is not switched to a configuration associated with a congested situation, the process proceeds to step 812 in which the maximum Tx power remains the same e.g., at $P_{\text{max_non-congested}}$. Otherwise, the process proceeds to step 808 in which the maximum Tx power of the UE is switched to one that is set for a congested situation e.g., $P_{\text{max_congested}}$. At step 810, the UE then adjusts the Tx power actually used to transmit the sidelink signal accordingly to satisfy the new maximum Tx power. Advantageously, such configuration of different maximum Tx power can reduce noise and interference in the system.

[77] In an example, it is also possible to configure different maximum bandwidth (BW) for different congestion situations (e.g., full, half, 1/3 BW of a resource pool for configurations associated with high, mid, and low-congestion situations respectively). Accordingly, BW of a to-be-transmitted SL signal (e.g., SL-PRS) may be limited or increased to satisfy the configured maximum BW. A gNB may also be configured to determine a sequence for BW changing according to different congestion situations. Configuration of different maximum bandwidth advantageously enables better resource utilization and a lower chance of over-the-air collisions. Further, a resource pool utilized by a UE for sidelink signal transmission may be switched according to different congestion situations. For example, in a configuration associated with a high/low congestion situation, the UE may be configured to switch to another resource pool with a higher/lower BW or more/less resource candidates respectively. This advantageously enables a more efficient resource utilization.

[78] In an implementation, transmission periodicity may be adjusted according to different congestion situations. For example, a maximum duration of 80ms, 40ms and 20ms between each transmission may be set for configurations associated with a high, mid, and low-congestion situation respectively. In an implementation, a UE may be configured to drop or defer a future SL transmission (e.g., SL-PRS) depending on difference congestion situations. For example, a duration of deferment of a future SL transmission may be different for different congestion situations. A threshold timer or counter may also be set to determine whether to drop a packet if a certain number of deferments is exceeded.

[79] One example is shown in illustration 900 of Fig. 9 for a combined deferment and drop mechanism with a single counter for 2 congestion situations (e.g., a first

configuration associated with a non-congested situation and a second configuration associated with a congested situation). At step 902, a UE may be initialized with a configuration associated with a non-congested situation with a SL signal (e.g., SL-PRS) to be transmitted. At step 904, a determination and switching of a configuration of the UE may be performed. At step 906, it is determined whether the UE has switched to a configuration associated with a congested situation. If it is determined that the UE has not switched to a configuration associated with a congested situation, the process proceeds to step 914 in which the UE transmits any sidelink signal without any change. If it is determined that the UE has switched to a configuration associated with a congested situation, the process proceeds to step 908 instead, in which a counter for dropping a sidelink signal transmission is initialized. For example, the counter may be set to a value of zero, and then incremented by a set value (e.g., by a value of one) whenever a sidelink signal transmission is deferred. At step 910, it is determined whether the counter is within a threshold value. If it is determined that the counter is still within the threshold value, the process proceeds to step 912 in which the UE defers the transmission of the sidelink signal by a set duration (e.g., X milliseconds) and increases the counter by the set value, and then proceeds back to step 910. On the other hand, if it is determined at step 910 that the counter has exceeded the threshold value, the process proceeds to step 916 in which the UE drops the transmission of the sidelink signal. Dropping or deferring a future sidelink signal transmission depending on difference congestion situations advantageously enables better resource utilization and a lower chance of over-the-air collisions. While illustration 900 depicts a combined deferment and drop mechanism, it will be appreciated that a UE may also be configured to perform either a standalone deferment mechanism or a standalone drop mechanism.

[80] In an implementation, essential sidelink signal Tx UE (e.g., UEs associated with RSU, emergency vehicles, and other similar entities) may be configured to pre-empt a resource to be utilized for a SL signal (e.g., SL-PRS) transmission by broadcasting with certain sidelink control information (SCI) information bits. Rx UEs may then be required to perform an operation (e.g., lower Tx power, drop future periodic/aperiodic transmissions, or other similar operations) upon receiving PSCCH with the certain SCI information bits.

[81] A minimum set of parameters that may be required for congestion control of a SL signal (e.g., SL-PRS) may comprise a set of two configurations (e.g., each

configuration associated with a congestion situation) and a triggering condition to determine a congestion situation. A Tx parameter may then be adjusted for congestion control according to the congestion situation e.g., according to a configuration associated with the congestion situation. The solutions as discussed

5 in the present disclosure may be applied for either sidelink positioning Scheme 1 (gNB centric) or Scheme 2 (UE autonomous), with or without higher layer management, with a dedicated or shared resource pool, and may also be applied to other SL services such as device-to-device (D2D), V2X, or other similar services.

10 [82] The congestion control settings and situations in the present disclosure may be applied to all or a portion of SL resources. In an implementation, the congestion control settings and situations may be applied to a designated spectrum of a SL resource pool. The entire SL resources may be separated into a

15 plurality of portions for different services (e.g., D2D, LTE-V2X, NR-V2X, SL-PRS, and other similar services), and each portion may have different congestion control settings and situations. For example, congestion control may be implemented over V2X resource usage but the amount of positioning related resources used need to be informed. There may be other interactions between congestion control of

20 sidelink positioning and other different services at PHY or higher layers that the allocated resource, quality or service (QoS), latency, etc. are having different requirements.

[83] In an implementation, higher layer reporting and management may be

25 implemented to inform a UE or gNB how often a location of a neighboring UE/vehicle is obtained, a speed of a UE, and other similar factors. For example, in a case where UE speed is considered, a periodicity of the higher layer reporting may not be reduced for higher speed UEs. For slower speed UEs, a longer periodicity may not have impact on safety operations that need to use positioning

30 services. The UE's configuration can then be determined accordingly by the UE or gNB based on the higher layer reporting.

[84] In another implementation, signaling for switching and/or actions for sidelink signal congestion control may be explicit or implicit. For example, an

35 explicit signaling may be a PHY or higher layer signaling from gNB, other UE, self-generated by a UE, or other similar entities. Further, implicit signaling means that sidelink signal triggering may be inferred by other non-explicit signaling (e.g., a

specific sequence for a reference signal (RS) or PSFCH, a specific time or frequency resource allocation for PSCCH/PSSCH/PSFCH, synchronization ID, or other similar signaling.

5 [85] In an implementation, a UE may receive a signaling (e.g., from a gNB, other UE, or other similar entities) for determining a configuration, and further be configured to determine a congestion situation (e.g., based on a value related to the congestion situation) or other similar factors that may be used for determining a configuration. The UE may then be configured to determine a configuration
10 based on either the signaling or the determined congestion situation (or other similar factors), depending on which one takes precedence. For example, it may be configured (e.g., by the gNB, or internally set in the UE, or other similar ways) that a signaling will override the determined congestion situation (or similar factors) such that the UE will determine the configuration based on the signaling instead of
15 the determined situation, or vice versa.

[86] Fig. 10 shows a flow chart 1000 illustrating a communication method for a UE according to various embodiments of the present disclosure. At step 1002, a configuration may be determined from a set of two or more configurations. At step
20 1004, a sidelink signal may be transmitted based on the determined configuration.

[87] Fig. 11 shows a flow chart 1100 illustrating a communication method for a base station according to various embodiments of the present disclosure. At step 1102, a set of configurations may be determined from one or more sets of
25 configurations, each of the one or more sets comprising two or more configurations. At step 1104, a signaling indicating the determined set of configurations may be transmitted to a communication apparatus.

[88] Fig. 12 shows a schematic, partially sectioned view of the communication
30 apparatus 1200 that can be implemented for in accordance with various embodiments and examples as shown in Figs. 1 to 11. The communication apparatus 1200 may be implemented as a UE or base station according to various embodiments.

35 [89] Various functions and operations of the communication apparatus 1200 are arranged into layers in accordance with a hierarchical model. In the model, lower layers report to higher layers and receive instructions therefrom in accordance with

3GPP technical specifications. For the sake of simplicity, details of the hierarchical model are not discussed in the present disclosure.

[90] As shown in Fig. 12, the communication apparatus 1200 may include
5 circuitry 1214, at least one radio transmit (Tx) chain 1202 (also referred to herein as transmitter 1202), at least one radio receive (Rx) chain 1204 (also referred to herein as receiver 1204), and at least one antenna 1212 (for the sake of simplicity, only one antenna is depicted in Fig. 12 for illustration purposes). The circuitry 1214 may include at least one controller 1206 for use in software and hardware aided
10 execution of tasks that the at least one controller 1206 is designed to perform, including control of communications with one or more other communication apparatuses in a wireless network. The circuitry 1214 may furthermore include at least one transmission signal generator 1208 and at least one receive signal processor 1210. The at least one controller 1206 may control the at least one
15 transmission signal generator 1208 for generating signals to be sent through the at least one radio transmitter 1202 to one or more other communication apparatuses and the at least one receive signal processor 1210 for processing signals received through the at least one radio receiver 1204 from the one or more other communication apparatuses under the control of the at least one controller
20 1206. The at least one transmission signal generator 1208 and the at least one receive signal processor 1210 may be stand-alone modules of the communication apparatus 1200 that communicate with the at least one controller 1206 for the above-mentioned functions as shown in Figs. 1-11. Alternatively, the at least one transmission signal generator 1208 and the at least one receive signal processor
25 1210 may be included in the at least one controller 1206. It is appreciable to those skilled in the art that the arrangement of these functional modules is flexible and may vary depending on the practical needs and/or requirements. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. In various embodiments, when in
30 operation, the at least one radio transmitter 1202, at least one radio receiver 1204, and at least one antenna 1212 may be controlled by the at least one controller 1206. It will be appreciated that the communication apparatus 1200 may include a plurality of antennas, for example as shown in communication apparatus 1300 of Fig. 13 which includes a plurality of antennas 1312. Each of the plurality of
35 antennas 1312 can be connected to a corresponding Tx chain 1302 and Rx chain 1304 through a switcher or switch point. Alternatively, each of the plurality of antennas 1312 can be connected to a corresponding Tx chain or Rx chain.

[91] The communication apparatus 1200, when in operation, provides functions required for congestion control of sidelink signal. For example, the communication apparatus 1200 may be a UE, and the circuitry 1214 may, in operation, determine
 5 a configuration from a set of two or more configurations. The transmitter 1202 may, in operation, transmit a sidelink signal based on the determined configuration.

[92] The circuitry 1214 may be configured to determine the configuration based on a signaling from a base station or another communication apparatus. The
 10 signaling may indicate a priority level of a transmission, a request to switch configurations, or a pre-emption for a higher priority transmission and the circuitry is configured to determine the configuration based on the signaling. The signaling from the another communication apparatus indicates a configuration which the another communication apparatus is in, and the circuitry is configured to determine
 15 the configuration based on the signaling. The determined configuration may be the same configuration as the another communication apparatus.

[93] At least a first configuration and a second configuration of the two or more configurations may be indicated by a higher layer signaling. The circuitry 1214 may
 20 determine a first configuration of the two or more configurations when a value relating to the congestion situation is less than a threshold, and determine a second configuration of the two or more configurations when the value relating to the congestion situation is equal to or larger than the threshold. The circuitry may be configured to determine the configuration based on a priority level of the sidelink
 25 signal, a request to switch configurations, cast type of the sidelink signal, a pre-emption for a higher priority transmission, a higher layer signaling, or downlink/sidelink control indication.

[94] The communication apparatus may be further configured with another set
 30 of two or more configurations, and the circuitry 1214 may be further configured to switch to the another set for two or more configurations based on a signaling. A first configuration of the two or more configurations may be a default configuration for the communication apparatus, and the circuitry 1214 may be configured to switch from the first configuration to a second configuration of the two or more
 35 configurations based on the congestion situation of the communication apparatus. The transmitter 1202 may be further configured to determine the configuration based on a priority level associated with the sidelink signal to be transmitted. The

circuitry 1214 may be configured to determine the configuration based on whether the sidelink signal is a unicast, broadcast or groupcast transmission. The circuitry 1214 may be configured to adjust one or more of a sidelink signal transmission power, bandwidth or transmission periodicity based on the determined configuration, and the transmitter 1202 may be configured to transmit the sidelink signal with the adjusted sidelink signal transmission power, bandwidth or transmission periodicity. The circuitry 1214 may be configured to select a resource pool based on the determined configuration, and the transmitter 1202 may be configured to transmit the sidelink signal with the selected resource pool. The circuitry 1214 may be configured to drop or defer a future sidelink signal based on the determined configuration. The circuitry 1214 may be further configured to determine the configuration based on a location of the communication apparatus, a user equipment type associated with the communication apparatus, or a cell-wise configuration of the communication apparatus.

[95] The communication apparatus 1200 may be a base station, and the circuitry 1214 may, in operation, determine a set of configurations from one or more sets of configurations, each of the one or more sets comprising two or more configurations. The transmitter 1202 may, in operation, transmit a signaling indicating the determined set of configurations to a communication apparatus. The circuitry 1214 may be further configured to determine a configuration from the determined set of configurations, and the signaling further indicates the determined configuration.

[96] The mapping may further be between a preamble of the one or more preambles, a RO group of the one or more RO groups, and (1) a channel state information reference signal (CSI-RS) index based on a number of CSI-RSs and the index associated with the one or more multiple PRACH transmissions, or (2) a synchronization signal block (SSB) index based on a number of SSBs and the index associated with the one or more multiple PRACH transmissions.

(Control Signals)

[97] In the present disclosure, the downlink control signal (information) related to the present disclosure may be a signal (information) transmitted through PDCCH of the physical layer or may be a signal (information) transmitted through a MAC Control Element (CE) of the higher layer or the RRC. The downlink control signal may be a pre-defined signal (information).

[98] The uplink control signal (information) related to the present disclosure may be a signal (information) transmitted through PUCCH of the physical layer or may be a signal (information) transmitted through a MAC CE of the higher layer or the RRC. Further, the uplink control signal may be a pre-defined signal (information).
 5 The uplink control signal may be replaced with uplink control information (UCI), the first stage sidelink control information (SCI) or the second stage SCI.

(Base Station)

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[99] In the present disclosure, the base station may be a Transmission Reception Point (TRP), a cluster head, an access point, a Remote Radio Head (RRH), an eNodeB (eNB), a gNodeB (gNB), a Base Station (BS), a Base Transceiver Station (BTS), a base unit or a gateway, for example. Further, in
 15 sidelink communication, a terminal may be adopted instead of a base station. The base station may be a relay apparatus that relays communication between a higher node and a terminal. The base station may be a roadside unit as well.

(Uplink/Downlink/Sidelink)

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[100] The present disclosure may be applied to any of uplink, downlink and sidelink.

[101] The present disclosure may be applied to, for example, uplink channels, such as PUSCH, PUCCH, and PRACH, downlink channels, such as PDSCH, PDCCH, and PBCH, and side link channels, such as Physical Sidelink Shared Channel (PSSCH), Physical Sidelink Control Channel (PSCCH), and Physical Sidelink Broadcast Channel (PSBCH).
 25

[102] PDCCH, PDSCH, PUSCH, and PUCCH are examples of a downlink control channel, a downlink data channel, an uplink data channel, and an uplink control channel, respectively. PSCCH and PSSCH are examples of a sidelink control channel and a sidelink data channel, respectively. PBCH and PSBCH are examples of broadcast channels, respectively, and PRACH is an example of a
 30 random access channel.
 35

(Data Channels/Control Channels)

[103] The present disclosure may be applied to any of data channels and control channels. The channels in the present disclosure may be replaced with data channels including PDSCH, PUSCH and PSSCH and/or control channels including PDCCH, PUCCH, PBCH, PSCCH, and PSBCH.

(Reference Signals)

[104] In the present disclosure, the reference signals are signals known to both a base station and a mobile station and each reference signal may be referred to as a Reference Signal (RS) or sometimes a pilot signal. The reference signal may be any of a DMRS, a Channel State Information – Reference Signal (CSI-RS), a Tracking Reference Signal (TRS), a Phase Tracking Reference Signal (PTRS), a Cell-specific Reference Signal (CRS), and a Sounding Reference Signal (SRS).

(Time Intervals)

[105] In the present disclosure, time resource units are not limited to one or a combination of slots and symbols, and may be time resource units, such as frames, superframes, subframes, slots, time slot subslots, minislots, or time resource units, such as symbols, Orthogonal Frequency Division Multiplexing (OFDM) symbols, Single Carrier-Frequency Division Multiplexing Access (SC-FDMA) symbols, or other time resource units. The number of symbols included in one slot is not limited to any number of symbols exemplified in the embodiment(s) described above, and may be other numbers of symbols.

(Frequency Bands)

[106] The present disclosure may be applied to any of a licensed band and an unlicensed band.

(Communication)

[107] The present disclosure may be applied to any of communication between a base station and a terminal (Uu-link communication), communication between a terminal and a terminal (Sidelink communication), and Vehicle to Everything (V2X) communication. The channels in the present disclosure may be replaced with

PSCCH, PSSCH, Physical Sidelink Feedback Channel (PSFCH), PSBCH, PDCCH, PUCCH, PDSCH, PUSCH, and PBCH.

[108] In addition, the present disclosure may be applied to any of a terrestrial network or a network other than a terrestrial network (NTN: Non-Terrestrial Network) using a satellite or a High Altitude Pseudo Satellite (HAPS). In addition, the present disclosure may be applied to a network having a large cell size, and a terrestrial network with a large delay compared with a symbol length or a slot length, such as an ultra-wideband transmission network.

(Antenna Ports)

[109] An antenna port refers to a logical antenna (antenna group) formed of one or more physical antenna(s). That is, the antenna port does not necessarily refer to one physical antenna and sometimes refers to an array antenna formed of multiple antennas or the like. For example, it is not defined how many physical antennas form the antenna port, and instead, the antenna port is defined as the minimum unit through which a terminal is allowed to transmit a reference signal. The antenna port may also be defined as the minimum unit for multiplication of a precoding vector weighting.

[110] As described above, the embodiments of the present disclosure provide an advanced communication system, communication methods and communication apparatuses that advantageously perform congestion control of sidelink signal.

[111] The present disclosure can be realized by software, hardware, or software in cooperation with hardware. Each functional block used in the description of each embodiment described above can be partly or entirely realized by an LSI such as an integrated circuit, and each process described in each embodiment may be controlled partly or entirely by the same LSI or a combination of LSIs. The LSI may be individually formed as chips, or one chip may be formed so as to include a part or all of the functional blocks. The LSI may include a data input and output coupled thereto. The LSI here may be referred to as an IC, a system LSI, a super LSI, or an ultra LSI depending on a difference in the degree of integration. However, the technique of implementing an integrated circuit is not limited to the LSI and may be realized by using a dedicated circuit, a general-purpose processor, or a special-purpose processor. In addition, a FPGA (Field Programmable Gate Array) that can

be programmed after the manufacture of the LSI or a reconfigurable processor in which the connections and the settings of circuit cells disposed inside the LSI can be reconfigured may be used. The present disclosure can be realized as digital processing or analogue processing. If future integrated circuit technology replaces
5 LSIs as a result of the advancement of semiconductor technology or other derivative technology, the functional blocks could be integrated using the future integrated circuit technology. Biotechnology can also be applied.

[112] The present disclosure can be realized by any kind of apparatus, device or
10 system having a function of communication, which is referred as a communication apparatus.

[113] Some non-limiting examples of such communication apparatus include a phone (e.g., cellular (cell) phone, smart phone), a tablet, a personal computer (PC)
15 (e.g., laptop, desktop, netbook), a camera (e.g., digital still/video camera), a digital player (e.g., digital audio/video player), a wearable device (e.g., wearable camera, smart watch, tracking device), a game console, a digital book reader, a telehealth/telemedicine (e.g., remote health and medicine) device, and a vehicle providing communication functionality (e.g., automotive, airplane, ship), and
20 various combinations thereof.

[114] The communication apparatus is not limited to be portable or movable, and may also include any kind of apparatus, device or system being non-portable or stationary, such as a smart home device (e.g., an appliance, lighting, smart meter,
25 control panel), a vending machine, and any other “things” in a network of an “Internet of Things (IoT)”.

[115] The communication may include exchanging data through, for example, a cellular system, a wireless LAN system, a satellite system, etc., and various
30 combinations thereof.

[116] The communication apparatus may comprise a device such as a controller or a sensor which is coupled to a communication device performing a function of communication described in the present disclosure. For example, the
35 communication apparatus may comprise a controller or a sensor that generates control signals or data signals which are used by a communication device performing a communication function of the communication apparatus.

[117] The communication apparatus also may include an infrastructure facility, such as a base station, an access point, and any other apparatus, device or system that communicates with or controls apparatuses such as those in the above non-
5 limiting examples.

[118] It will be understood that while some properties of the various embodiments have been described with reference to a device, corresponding properties also apply to the methods of various embodiments, and vice versa.

10

[119] The present disclosure may refer to the following statements:

Statement 1. A communication apparatus comprising: circuitry, which in operation, determines a configuration from a set of two or more configurations; and
15 a transmitter, which in operation, transmits a sidelink signal based on the determined configuration.

(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)
20

Statement 2. The communication apparatus of Statement 1, wherein the circuitry is configured to determine the configuration based on a signaling from a base station or another communication apparatus.

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(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)

30 Statement 3. The communication apparatus of Statement 1, wherein at least a first configuration and a second configuration of the two or more configurations are indicated by a higher layer signaling.

(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)
35

Statement 4. The communication apparatus of Statement 1, wherein the circuitry determines a first configuration of the two or more configurations when a value relating to the congestion situation is less than a threshold, and determines a second configuration of the two or more configurations when the value relating to the congestion situation is equal to or larger than the threshold.

(This advantageously enables a UE to adaptively switch to a suitable configuration according to the value to improve performance of the UE)

Statement 5. The communication apparatus of Statement 1, wherein the circuitry is configured to determine the configuration based on a priority level of the sidelink signal, a request to switch configurations, cast type of the sidelink signal, a pre-emption for a higher priority transmission, a higher layer signaling, or downlink/sidelink control indication.

(Implementation of a triggering condition advantageously enables a UE to adaptively and automatically switch to another configuration)

Statement 6. The communication apparatus of Statement 2, wherein the signaling indicates a priority level of a transmission, a request to switch configurations, or a pre-emption for a higher priority transmission and the circuitry is configured to determine the configuration based on the signaling.

(Implementation of a triggering condition advantageously enables a UE to adaptively and automatically switch to another configuration)

Statement 7. The communication apparatus of Statement 2, wherein the signaling from the another communication apparatus indicates a configuration which the another communication apparatus is in, and the circuitry is configured to determine the configuration based on the signaling.

(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)

Statement 8. The communication apparatus of Statement 7, wherein the determined configuration is the same configuration as the another communication apparatus.

- 5 (Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)

Statement 9. The communication apparatus of Statement 1, wherein the
10 communication apparatus is further configured with another set of two or more configurations, and the circuitry is further configured to switch to the another set for two or more configurations based on a signaling.

- (Advantageously, this provides a unified and organized solution for sidelink signal
15 congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)

Statement 10. The communication apparatus of Statement 1, wherein a first
20 configuration of the two or more configurations is a default configuration for the communication apparatus, and the circuitry is configured to switch from the first configuration to a second configuration of the two or more configurations based on a congestion situation of the communication apparatus.

- (Implementation of a triggering condition advantageously enables a UE to
25 adaptively and automatically switch to another configuration)

Statement 11. The communication apparatus of Statement 1, wherein the
transmitter is further configured to determine the configuration based on a priority
level associated with the sidelink signal to be transmitted.

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- (Implementation of a triggering condition advantageously enables a UE to
adaptively and automatically switch to another configuration)

Statement 12. The communication apparatus of Statement 1, wherein the circuitry
35 is configured to determine the configuration based on whether the sidelink signal is a unicast, broadcast or groupcast transmission.

(Implementation of a triggering condition advantageously enables a UE to adaptively and automatically switch to another configuration)

Statement 13. The communication apparatus of Statement 1, wherein the circuitry
 5 is configured to adjust one or more of a sidelink signal transmission power, bandwidth or transmission periodicity based on the determined configuration, and the transmitter is configured to transmit the sidelink signal with the adjusted sidelink signal transmission power, bandwidth or transmission periodicity.

10 (Advantageously, this can reduce noise and interference in the system)

Statement 14. The communication apparatus of Statement 1, wherein the circuitry
 is configured to select a resource pool based on the determined configuration, and the transmitter is configured to transmit the sidelink signal with the selected
 15 resource pool.

(This advantageously enables a more efficient resource utilization.)

Statement 15. The communication apparatus of Statement 1, wherein the circuitry
 20 is configured to drop or defer a future sidelink signal based on the determined configuration.

(Dropping or deferring a future sidelink signal transmission depending on difference congestion situations advantageously enables better resource
 25 utilization and a lower chance of over-the-air collisions)

Statement 16. The communication apparatus of Statement 1, wherein the circuitry
 is further configured to determine the configuration based on a location of the communication apparatus, a user equipment type associated with the
 30 communication apparatus, or a cell-wise configuration of the communication apparatus.

(This advantageously enables a UE to adaptively switch to a suitable configuration to improve performance of the UE)

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Statement 17. A base station comprising: circuitry, which in operation, determines a set of configurations from one or more sets of configurations based on a

congestion situation of a communication apparatus, each of the one or more sets comprising two or more configurations; and a transmitter, which in operation, transmits a signaling indicating the determined set of configurations to the a communication apparatus.

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(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency, power saving, etc. from a system level prospective.)

10 Statement 18. The base station of Statement 17, wherein the circuitry is further configured to determine a configuration from the determined set of configurations based on the congestion situation of the communication apparatus, and the signaling further indicates the determined configuration.

15 (This advantageously enables a UE to adaptively switch to a suitable configuration to improve performance of the UE)

Statement 19. A communication method comprising: determining a configuration from a set of two or more configurations based on a congestion situation of a
20 communication apparatus; and transmitting a sidelink signal based on the determined configuration.

(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency,
25 power saving, etc. from a system level prospective.)

Statement 20. A communication method comprising: determining a set of configurations from one or more sets of configurations based on a congestion situation of a communication apparatus, each of the one or more sets comprising
30 two or more configurations; and transmitting a signaling indicating the determined set of configurations to the a communication apparatus.

(Advantageously, this provides a unified and organized solution for sidelink signal congestion control with performance improvement on overall resource efficiency,
35 power saving, etc. from a system level prospective.)

Statement 21. The communication apparatus of Statement 10, wherein the circuitry is configured to switch back to the first configuration based on value related to a congestion situation.

- 5 (Implementation of a fallback mechanism advantageously enables a UE to adaptively and automatically switch to another configuration)

- 10 [120] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present disclosure as shown in the specific embodiments without departing from the spirit or scope of the disclosure as broadly described. The present embodiments are, therefore, to be considered in all respects illustrative and not restrictive.

CLAIMS

1. A communication apparatus comprising:
circuitry, which in operation, determines a configuration from a set of two
5 or more configurations; and
a transmitter, which in operation, transmits a sidelink signal based on the
determined configuration.
- 10 2. The communication apparatus of claim 1, wherein the circuitry is
configured to determine the configuration based on a signaling from a
base station or another communication apparatus.
- 15 3. The communication apparatus of claim 1, wherein at least a first
configuration and a second configuration of the two or more
configurations are indicated by a higher layer signaling.
- 20 4. The communication apparatus of claim 1, wherein the circuitry
determines a first configuration of the two or more configurations when
a value relating to the congestion situation is less than a threshold, and
determines a second configuration of the two or more configurations
when the value relating to the congestion situation is equal to or larger
than the threshold.
- 25 5. The communication apparatus of claim 1, wherein the circuitry is
configured to determine the configuration based on a priority level of the
sidelink signal, a request to switch configurations, cast type of the
sidelink signal, a pre-emption for a higher priority transmission, a higher
layer signaling, or downlink/sidelink control indication.
- 30 6. The communication apparatus of claim 2, wherein the signaling indicates
a priority level of a transmission, a request to switch configurations, or a
pre-emption for a higher priority transmission and the circuitry is
configured to determine the configuration based on the signaling.
- 35 7. The communication apparatus of claim 2, wherein the signaling from the
another communication apparatus indicates a configuration which the

another communication apparatus is in, and the circuitry is configured to determine the configuration based on the signaling.

5 8. The communication apparatus of claim 7, wherein the determined configuration is the same configuration as the another communication apparatus.

10 9. The communication apparatus of claim 1, wherein the communication apparatus is further configured with another set of two or more configurations, and the circuitry is further configured to switch to the another set for two or more configurations based on a signaling.

15 10. The communication apparatus of claim 1, wherein a first configuration of the two or more configurations is a default configuration for the communication apparatus, and the circuitry is configured to switch from the first configuration to a second configuration of the two or more configurations based on the congestion situation of the communication apparatus.

20 11. The communication apparatus of claim 1, wherein the transmitter is further configured to determine the configuration based on a priority level associated with the sidelink signal to be transmitted.

25 12. A base station comprising:
circuitry, which in operation, determines a set of configurations from one or more sets of configurations, each of the one or more sets comprising two or more configurations; and
a transmitter, which in operation, transmits a signaling indicating the determined set of configurations to a communication apparatus.

30 13. The base station of claim 12, wherein the circuitry is further configured to determine a configuration from the determined set of configurations, and the signaling further indicates the determined configuration.

35 14. A communication method comprising:
determining a configuration from a set of two or more configurations; and
transmitting a sidelink signal based on the determined configuration.

15. A communication method comprising:

determining a set of configurations from one or more sets of configurations, each of the one or more sets comprising two or more configurations; and

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transmitting a signaling indicating the determined set of configurations to a communication apparatus.