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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2024 (10.10.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/207496 A1

(51) International Patent Classification:
H04W 72/04 (2023.01)

(21) International Application Number:
PCT/CN2023/087068

(22) International Filing Date:
07 April 2023 (07.04.2023)

(25) Filing Language: English

(26) Publication Language: English

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

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

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

(54) Title: METHODS FOR LBT FAILURE INDICATION OF SL-U

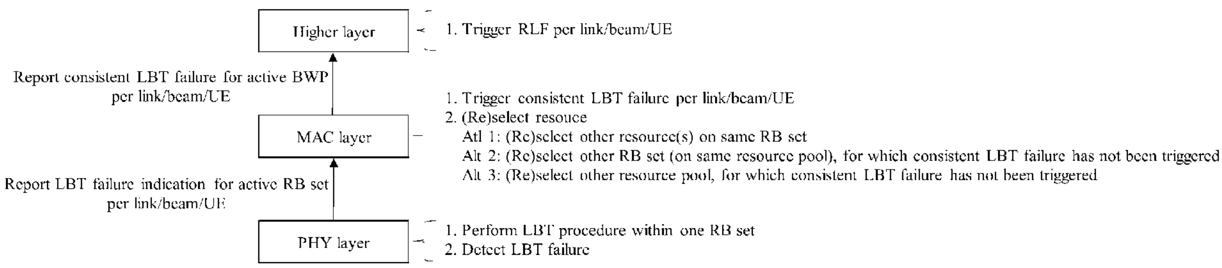

Figure 1

(57) Abstract: This disclosure describes methods for LBT failure indication and corresponding resource (re)selection of SL-U. The LBT failure indication can be counted per link and/or per UE and/or per beam. The corresponding methods to declare RLE failure due to different LBT failure indications are described. Additionally, the impact of LBT failure to the SL resource (re)selection procedure is also discussed in this disclosure.

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METHODS FOR LBT FAILURE INDICATION OF SL-U

FIELD

The invention discussed below relates generally to wireless communication systems, and more particularly, to methods for LBT failure indication of SL-U.

BACKGROUND

In legacy NR-U, if a UE fails to access the channel(s) prior to an intended UL transmission to a gNB, Layer 1 notifies higher layers about the LBT (i.e., channel access) failure. This mechanism is also applicable for SL transmission on unlicensed spectrum (SL-U). Bur different from NR-U that one UE may only communication with one gNB in a duration, in SL-U, a UE may maintain multiple links with different UE. Besides, a UE may perform beam based LBT (i.e., channel access) for the case that transmitted on the spectrum of FR2. In these cases, the LBT failure indication methods should be reconsidered, e.g., the granularity of the LBT failure indication. Additionally, the corresponding RLF failure declaration and the potential resource (re)selection triggered by LBT failure indication should also be redesigned. To this end, the methods related to LBT failure indication of SL-U is described in this disclosure.

For SL transmission on unlicensed spectrum (e.g., SL-U), the potential channel access (e.g., LBT) failure will block the transmission and thus may degrade the system performance. For example, the LBT failure before synchronization signal (e.g., SL S-SSB) will block the normal transmission of S-SSB signal, and further result in synchronization problem of the system. Due to these observations, the methods for synchronization signal transmission of SL-U are disclosed in this patent

SUMMARY

The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

Various aspects of the present disclosure relate to the methods for SL enhancements. In one aspect, the method for LBT failure indication of SL-U is proposed. Specifically, for SL-U, if a UE fails to access the channel(s) prior to an intended SL transmission to another UE, Layer 1 (i.e., physical layer) notifies higher layers about the LBT (i.e., channel access) failure. The granularity of the LBT failure indication can be (pre-)configured and/or indicated. For example, the LBT failure can be per link, and/or per UE, and/or per beam. Besides, from the point of resource granularity of LBT failure indication, if can be (pre-)configured as per RB set, and/or per resource pool. A signaling can be used to indicate the granularity of LBT failure indication when Layer 1 reports the LBT failure indication to MAC layer.

In another aspect of the disclosure, for SL-U, the consistent LBT failure indication can be counted by

MAC layer. The granularity of consistent LBT failure triggered in MAC layer should be aligned with the granularity of LBT failure indication reported from Layer 1. If consistent LBT failure has been triggered in all SL RB sets, MAC layer shall indicate consistent LBT failure to higher layer. In this case, the RLF shall be declared. The granularity of RLF declaration can be (pre-)configured and/or indicated based on the granularity of consistent LBT failure indication triggered in MAC layer. For example, the RLF can be declared per link, and/or per UE, and/or per beam. A signaling can be used to indicate the granularity of consistent LBT failure when MAC layer reports the consistent LBT failure to higher layer.

In another aspect of the disclosure, the resource (re)selection maybe triggered by the UE upon receiving an LBT failure indication from physical layer for a PSSCH transmission. This new resource (re)selection trigger is applicable to single slot transmission and multiple consecutive slot transmission (MCSt). The resource (re)selection can be (pre-)configured within one RB set and/or resource pool, and/or across different RB set and/or resource pool based on some (pre-)configured conditions. The conditions can be, for example, channel busy ratio, whether (consistent) LBT failure is triggered in one RB set.

In another aspect of the disclosure, for frequency grid of SL-U, the methods of interlace index and sub-channel index across different resource pools is proposed.

Another aspect of the present disclosure relates to the methods of S-SSB signal transmission methods of SL-U. Specifically, the methods of additional candidate S-SSB occasion(s) is introduced and the design on the number and location of the additional candidate S-SSB occasion(s) is discussed.

In one aspect of the disclosure, the number of the additional candidate S-SSB occasion(s) can be set as *N* regarding per legacy S-SSB occasion. The value of *N* can be (pre-)configured and/or indicated (e.g., by SIB/(SL-)RRC/MAC-CE/SCI) based on, for example, the channel busy ratio, numerology (e.g., SCS), frequency range (e.g., FR1 or FR2), QCL relation, legacy S-SSB number with a S-SSB period, offset of the 1st legacy S-SSB from the start of S-SSB period, and/or the interval between neighboring legacy S-SSB occasions. The UE behavior on the additional candidate S-SSB occasion(s) can be (pre-)configured. For example, it can be (pre-)configured as that UE only transmit on all or partial of the additional candidate S-SSB occasion(s) only when it fails to transmit on the legacy S-SSB occasion(s), or UE can transmit on all or partial of the additional candidate S-SSB occasion(s) regardless of whether it transmit on the legacy S-SSB occasion(s) or not.

In another aspect of the disclosure, the location of the additional candidate S-SSB can be (pre-)configured and/or indicated (e.g., by SIB). For example, the transmission of legacy S-SSB(s) can additional candidate S-SSB(s) can be (pre-)configured as a S-SSB transmission burst. A S-SSB transmission burst in this disclosure defined as a set of contiguous S-SSB transmissions and/or a set of S-SSB transmissions without any gap greater than a (pre-)configured threshold (e.g., 16us). A UE can transmit S-SSB transmission(s) after a gap within a S-SSN transmission burst without sensing the corresponding channel(s) for availability. Alternatively, the additional candidate S-SSB occasion(s) can be defined by an offset *L* from the corresponding legacy S-SSB occasion. The value of *L* can be (pre-)configured based on for example, channel busy ratio, numerology, frequency range (e.g., FR1 or FR2), QCL relation, legacy S-

SSB number with a S-SSB period, offset of the 1^{st} legacy S-SSB from the start of S-SSB period, and/or the interval between neighboring legacy S-SSB occasions.

Another aspect of the present disclosure relate to the methods of beam management, e.g., initial beam pairing, beam maintenance and etc., in SL FR2 in the wireless communication system. Compared with FR1, the signal of FR2 fades faster during transmission, causing the problem of coverage reduction. In this case, beam management methods can be applied in SL FR2 to achieve further coverage enhancement, including initial beam pairing, beam maintenance and etc.

In an aspect of the disclosure, a beam pairing method for beam management (e.g., initial beam pairing, beam maintenance, beam failure recovery and etc.), with PSSCH and PSFCH association is proposed. The PSSCH and/or PSFCH indicating the corresponding beam quality is transmitted based on the timing with multiple options. For the case of beam measurement report is needed for the beams other than the activated beam, beam maintenance based on the activated beam for measurement report is proposed.

In another aspect of this disclosure, a new CSI-RS resource mapping configuration method is proposed for SL FR2 initial beam pairing before link establishment accomplished. There are 2 options for the configuration methods. For option 1, set an index or bit-string represents for the combination of time and/or frequency location of CSI-RS REs within an RB, starting RB and RB quantity in frequency domain, etc. For option 2, to configure the time and/or frequency location of CSI-RS RE within an RB, starting RB and RB quantity in frequency domain, etc. separately.

In another aspect of this disclosure, a new CSI-RS configuration method is proposed for beam management. A periodic system (pre-)configured CSI-RS and/or a dynamic indicated CSI-RS is proposed. For the case of periodic system (pre-)configured CSI-RS, a new slot structure of standalone CSI-RS and/or a new slot structure of CSI-RS with data may be used. For the case of dynamic indicated CSI-RS, CSI-RS configuration is indicated by SCI.

In another aspect of this disclosure, capabilities of Tx UE need to be informed by Tx UE to Rx UE and/or capabilities of Tx UE and Rx UE need to be exchanged during and/or before initial beam pairing. The capabilities of UE(s) can cover many aspects and the total beam sweeping time and/or beam sweeping pattern/method of Tx UE and/or Rx UE can be determined with the information of capabilities of Tx UE and/or Rx UE.

To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed figures set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 illustrates an exemplary diagram of the disclosed methods for LBT failure indication of SL-U, wherein the interactive information between different layers and the action of each layer is illustrated.

FIG.2 illustrates an exemplary diagram of the disclosed methods for interlace and sub-channel indexing across different resource pools.

FIG.3 illustrates an exemplary diagram of the disclosed synchronization signal transmission method of SL-U, where the legacy S-SSB occasions and additional candidate S-SSB occasions are within one S-SSB transmission burst.

FIG.4 illustrates an exemplary diagram of the disclosed synchronization signal transmission method of SL-U, where the legacy S-SSB occasions and additional candidate S-SSB occasions are within two S-SSB transmission bursts.

FIG.5 illustrates an exemplary diagram of the beam pairing method with PSSCH and PSFCH association, where the PSFCH feedback F1 corresponds to Tx beam B1 and PSFCH feedback F2 corresponds to Tx beam B2.

FIG.6 illustrates an exemplary diagram of the measurement report based on the activated beam, where the beam B2 is the activated beam and the beam B1 is the beam being measured.

DETAILED DESCRIPTION

The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

This invention is motived by, but not limited to, a scenario where SL transmitted on unlicensed spectrum (SL-U). In such scenario, a channel access (e.g., LBT) procedures should be executed before the UE can start transmission on the channel. If a UE fails to access the channel(s) prior to an intended SL transmission to another UE, Layer 1 (i.e., physical layer) notifies higher layers (e.g., MAC layer) about the LBT failure (i.e., channel access failure). The LBT failure can be indicated per UE if no additional (pre-)configuration and/or indication.

Additionally, for the case that a UE maintains multiple links with other UE(s) (e.g., by the way of TDM), the granularity of LBT failure indication can be (pre-)configured and/or indicated per link. For the case that the LBT failure indication is per link, an additional signaling can be added to indicate the link index. For example, the L1 ID (e.g., destination ID) of each link can be indicated together with the corresponding LBT failure indication.

Additionally, for the case that the transmission is beam based, the LBT failure indication can be (pre-)configured and/or indicated per beam. For the case that the LBT failure indication is per beam, an additional signaling can be added to indication the beam index. For example, the beam index/ID, and/or CSI-RS resource indicator of each beam can be indicated together with the corresponding LBT failure indication.

In another aspect of the disclosure, if LBT failure indication has been detected from lower layer, the MAC entity shall start a LBT failure indication counter. The consistent LBT failure is detected per RB set, and/or resource pool, by counting LBT failure indications, for all SL transmissions, from the lower layer to MAC entity. If the counted LBT failure indications meet a (pre-)configured condition, the consistent LBT failure shall be triggered for the active SL RB set. The condition can be, for example, within a (pre-)configured failure detection timer (e.g., 10ms/20ms/40ms/80ms/160ms/320ms), the LBT failure indication counter reaches a (pre-)configured value (e.g., 4/8/16/32/64/128).

In another aspect of the disclosure, if LBT failure indication is detected, and/or consistent LBT failure is triggered, a resource (re)selection and/or resource switching should be triggered by MAC entity. Specifically, the MAC entity can switch the active SL RB set to a SL RB set (or re-select a SL RB set), on a same resource poo and/or on a same BWP, for which consistent LBT failure has not been triggered. Alternatively, the MAC entity can re-select a SL resource (e.g., other slots) within a same RB set. The granularity of the consistent LBT failure triggered by MAC entity should be aligned with the granularity of LBT failure indication from Layer 1.

In this disclosure, the resource (re)selection and/or resource switching can be applicable for both single slot transmission and multiple consecutive slot transmission (MCSt) in this disclosure. The (re)selection can be (pre-)configured as a (re)selection of different slot(s) within the same RB set for which a LBT failure is indicated. Alternatively, it can be a (re)selection of different RB set for which LBT failure has not been indicated. For the case that the (re)selection is used for MCSt, the MAC entity can (re)select other N single-slot resource(s). The value of N depends on number of slot(s) triggering LBT failure indication. Alternatively, For the case that used of MCSt, the MAC entity can (re)select other multi-slot resources, where a multi-slot resource consists of a set of single-slot resources that are consecutive in time. The above procedures in this disclosure can be performed within one RB set and/or resource pool. Alternatively, the above procedure can be performed across different RB sets, and/or resource pools. Foe the later case, the (re)selection of the other RB set(s) and/or resource pool(s) can be based on, for example, channel busy ratio, and/or whether a consistent LBT failure is detected on that RB set and/or resource pool.

In another aspect of the disclosure, if consistent LBT failure has been triggered in all SL RB sets, MAC layer shall indicate consistent LBT failure to higher layer. In this case, the RLF shall be declared by higher layers. The granularity of the RLF declaration should be aligned with the granularity of consistent LBT failure triggered by MAC entity. For example, if the consistent LBT failure is per UE, or per link, or per beam, the RLF should be declared per UE, or per link, or per beam, respectively. Additionally, for the case the RLF is declared per UE, it means all link(s) and/or all beam(s) associated with the corresponding UE are declared as RLF. In this case, an additionally signaling shall be added when MAC entity indicates consistent LBT failure to upper layers. For example, the link index and/or destination ID of each link can be added to indicate which link the consistent LBT failure is detected. Besides, the beam index/ID and/or CSI-RS resource indicator of each beam can be added to indicate which beam the consistent LBT failure is detected. Additionally, regarding the resource granularity of RLF trigger, it can be (pre-)configured per resource pool and/or per SL BWP/carrier.

To illustrate the methods described above, an example is given in Figure 1. As shown in Figure 1, for physical layer, LBT procedure is performed within one RB set. If LBT failure is detected, the LBT failure indication should be reported by physical layer per link/beam/UE and per RB set. For MAC layer, if LBT failure indication has been received from lower layers, it can start or restart a LBT failure detection timer, and increment LBT counter by 1. If the LBT counter greater than a (pre-)configured LBT failure instance max counter, MAC entity shall trigger consistent LBT failure for the active RB set per link/beam/UE. For the case that MAC layer detects LBT failure indication from lower layer, and/or the consistent LBT failure is triggered for the active RB set, MAC layer can (re)select other resource(s) on same RB set. Alternatively, MAC layer can (re)select other RB set (on same resource pool), for which consistent LBT failure has not been triggered. For the case that the consistent LBT failure has been triggered in all SL RB sets on same resource pool, MAC layer can (re)select other resource pool, for which consistent LBT failure has not been triggered. For the case that the consistent LBT failure has been triggered in all resource pools on the same BWP, MAC entity shall indicate consistent LBT failure to upper layers. If all triggered consistent LBT failures are cancelled; or if the LBT failure detection time expires; or if LBT failure detection time or LBT failure instance max count is reconfigured by higher layers, the LBT counter can be set to 0.

Additionally, for higher layers, if consistent LBT failure is reported from lower layers, it can trigger RLF per link/beam/UE. If the RLF is triggered per resource pool, the higher layers can (re)select another resource pool for which consistent LBT failure has not been triggered. If the RLF is triggered per BWP, the higher layer can (re)select another carrier if only one BWP is (pre-)configured in one carrier. Otherwise, higher layer can (re)select another BWP on the same carrier.

In another aspect of the disclosure, the CPE can be used immediately before the transmission. The multiple CPE starting positions can be divided into multiple sub-sets based on the starting position of each CPE. The UE with different packet priority (e.g., CAPC value) can select one sub-set of the CPE starting position based on the packet priority. For example, the UE with higher packet priority (i.e., a smaller CAPC value) can select a sub-set comprised of CPE with earlier starting position(s). Next, the UEs with same packet priority can randomly select one/single CPE starting position from the previously selected sub-set of the CPE starting position.

In another aspect of the disclosure, the methods of interlace and sub-channel index across different RPs is proposed in this disclosure. As an example shown in Figure 2, one SL BWP consists of multiple SL

RPs, and the sub-channel is indexed across multiple RPs. It should be noted that in Figure 2, the terms of logical and physical in the following options are stated from the perspective of logical index and physical location, respectively. Specifically, interlace can be defined within one SL BWP, and logical sub-channel index (i.e., sub-channel #0) can be mapped from physical interlace index (the 1st interlace regarding physical location, i.e., interlace #2 in Option 1). Alternatively, interlace can be defined within one BWP and logical sub-channel index (i.e., sub-channel #0) can be mapped from logical interlace index (i.e., interlace #0 in Option 2). Alternatively, interlace can be defined within one RP and logical sub-channel index (i.e., sub-channel #0) can be mapped from physical interlace index (the 1st interlace regarding physical location, i.e., interlace #0 in Option 1) or logical interlace index (i.e., interlace #0 in Option 3).

In another aspect of the disclosure, for a scenario where SL synchronization signal is transmitted on unlicensed spectrum, the potential channel access failure may block the transmission of S-SSB signal. To this end, the methods for S-SSB signal transmission of SL-U is disclosed regarding to the design on the number and location of the additional candidate S-SSB occasion(s).

In one aspect of the disclosure, additional candidate S-SSB occasion(s) can be (pre-)configured to combat the potential channel access failure before the legacy S-SSB occasion. For example, it can be (pre-)configured that each legacy S-SSB occasion has N corresponding additional candidate S-SSB occasion(s). Alternatively, it can be (pre-)configured that the total number of the legacy S-SSB occasion(s) and additional candidate S-SSB occasion(s) is N, which can be defined by, for example, a RRC parameter sl-NumSSB-WithinPeriod for each numerology.

In another aspect of the disclosure, regarding the location of the additional candidate S-SSB occasion(s), it can be (pre-)configured and/or indicated based on, for example, channel busy ratio, numerology, frequency range (e.g., FR1 or FR2), QCL relation, legacy S-SSB number with a S-SSB period, offset of the 1st legacy S-SSB from the start of S-SSB period, and/or the interval between neighboring legacy S-SSB occasions. The additional candidate S-SSB(s) can be set as a transmission burst together with the corresponding legacy S-SSB. In this manner, the additional candidate S-SSB(s) and the corresponding legacy S-SSB(s) are contiguous or there is no gap greater than a threshold (e.g., 16 us) among the additional candidate S-SSB(s) and the corresponding legacy S-SSB.

Alternatively, the additional candidate S-SSB occasion can be defined by an offset regarding to the corresponding legacy S-SSB occasion. The offset value L can be (pre-)configured and/or indicated.

In this disclosure, the number and location of the additional candidate S-SSB occasion(s) can be (pre-)configured and/or indicated based on a set of parameters. For example, it can be based the channel busy ratio, numerology (e.g., SCS), frequency range (e.g., FR1 or FR2), QCL relation, legacy S-SSB number with a S-SSB period, offset of the 1st legacy S-SSB from the start of S-SSB period, and/or the interval between neighboring legacy S-SSB occasions. The (pre-)configuration and/or indication can be signaled by SIB, (SL-)RRC, MAC-CE, and/or SCI.

In another aspect of the disclosure, for synchronization signal transmitted in FR1, the additional S-SSB occasion(s) are common to legacy S-SSB(s). In this manner, any additional candidate S-SSB occasion can regarded as a duplication/replacement of any legacy S-SSB occasion. For synchronization signal transmitted in FR2, and/or transmitted based on the manner of beam, each legacy S-SSB occasion may be associated with a specific beam and/or CSI-RS and/or direction and/or average gain. In this case, only the additional candidate S-SSB occasion(s) associated with the same beam and/or CSI-RS and/or direction and/or average gain can be regarded as the duplication/replacement of the corresponding legacy S-SSB occasion. In other words, only the additional candidate S-SSB occasion(s) that have QCL (quasi co-location) relation can be regarded as the duplication/replacement of the corresponding QCLed legacy S-SSB occasion.

In order to illustrate the method described above. An example is given in Figure 3. In this example, two legacy S-SSB (e.g., legacy S-SSB index#0 and legacy S-SSB index#1) are (pre-)configured as contiguous. Each legacy S-SSB is (pre-)configured with one (i.e., $N=1$) additional candidate S-SSB (e.g., additional candidate S-SSB index#0 and additional candidate S-SSB index#1). Regarding the location of the additional candidate S-SSB index#0/1, as shown in Figure 3, they are contiguous with the legacy S-SSB index #0/1. The four S-SSB occasion (i.e., legacy S-SSB index#0/1 and additional candidate S-SSB index#0/1) can be regarded as a S-SSB transmission burst. Alternatively, the offset between legacy S-SSB occasion and the corresponding additional candidate S-SSB occasion is 2 slots in this example. As shown in Figure 3, the LBT (i.e., channel access) is failed before two legacy S-SSB occasion(s). Thus there in no synchronization signal transmission on the two legacy S-SSB occasion(s). Next, the LBT is succeed before the first additional candidate S-SSB occasion (i.e., additional candidate S-SSB index#0). Thus there a synchronization signal transmission on the additional candidate S-SSB index#0. Due to additional candidate S-SSB with index#1 and #0 are contiguous (or they are in a S-SSB transmission burst), the synchronization signal can be transmitted on additional candidate S-SSB index#1 without sensing the channel availability. It should be note that the S-SSB transmission burst can be defined as all S-SSB occasion(s) including both S-SSB occasion with LBT failed before that (i.e., the S-SSB occasion without synchronization signal transmission) and the S-SSB occasion with LBT succeed before that (i.e., the S-SSB occasion with synchronization signal transmission).

Another example is shown in Figure 4. In this example, two legacy S-SSB occasion are (pre-)configured as discontinuous with an internal between them. In this case, the additional candidate S-SSB is located contiguously behind the corresponding legacy S-SSB occasion. Alternatively, the offset between the additional candidate S-SSB occasion and the corresponding legacy S-SSB occasion is set a one slot in this example. Total, there are two S-SSB transmission burst in this example.

In this disclosure, the behavior on the additional candidate S-SSB occasion(s) can be (pre)configured. For example, it can be (pre-)configured to transmit or not on the additional candidate S-SSB occasion(s) based on some factors. The factors can be, for example, where the transmission on the legacy S-SSB occasion(s) is successful or not, or the number of succeed transmission on the legacy S-SSB occasion(s).

For the scenario where beam management applied in wireless communication system of SL FR2, high carrier frequency will lead to increasement in signal fading thus degradation of signal coverage. To solve this problem, methods of beam management, including initial beam pairing, beam maintenance and etc., for SL FR2 is proposed in this disclosure. However, the methods of beam management that proposed in this closure may not be limited to SL FR2 only, e.g., SL FR1 and/or SL FR2.

In an aspect of this disclosure, a beam pairing method for beam management (e.g., initial beam pairing, beam maintenance, beam failure recovery and etc.), with PSSCH and PSFCH association is proposed. As is shown is Fig. 5, a Tx UE transmit beams of B1 and B2 of different directions and a Rx UE monitors those beams by measuring beam qualities, PSFCH feedback of Rx UE is at a corresponding time occasion and/or a corresponding resource location, e.g., PSFCH feedback F1 corresponds to Tx beam B1 and PSFCH feedback F2 corresponds to Tx beam B2. A Tx UE transmits beams in different directions which carried by PSSCH and /or PSCCH and a Rx UE monitors those beams by measuring beam qualities. The beam qualities that measured by a Rx UE may be obtained by CSI-RS RSRP and/or DMRS RSRP. The beam qualities that measured by a Rx UE is carried by PSFCH feedback at a corresponding time occasion and/or a corresponding resource location.

For the Rx UE, if the measured RSRP quality is higher than a (pre-)configured threshold and/or good enough for reception (e.g., the associated data is decodable), the PSFCH indicating the corresponding beam quality is transmitted based on the timing with following 2 options.

For Option 1, the PSFCH is transmitted based on the ACK/NACK feedback timing of the existing PSFCH for ACK/NACK mechanism in NR SL. One, two or a set of candidate PSFCH resources for the corresponding beam measurement result and/or quality indication are corresponding to each CSI-RS resource transmitted from the Tx UE. In one aspect, the different candidate PSFCH resources may indicate whether the corresponding CSI-RS transmission from a Tx UE is good enough (e.g., higher than a (pre-)configured threshold, satisfying a (pre-)configured criteria, etc.). In another aspect, the different candidate PSFCH resources may indicate different measured quantity of the corresponding CSI-RS measurement results and/or quality. The mapping between the PSFCH resources and the quantity value (e.g., absolute RSRP value, OK/Good/Excellent quality, etc.) could be (pre-)configured. In another aspect, the different candidate PSFCH resources may indicate whether the measured result/quality of the corresponding CSI-RS transmission is better than the early reported one. For example, if the measured RSRP for the corresponding CSI-RS transmission is higher than a (pre-)configured threshold and/or higher than any early measured RSRP and/or any early reported RSRP corresponding to the previous corresponding CSI-RS transmissions, the Rx UE can transmit PSFCH to indicate the corresponding CSI-RS transmission is the best one so far. Otherwise, there is no PSFCH transmission for reporting.

For Option 2, the timing for PSFCH indicating beam quality is (pre-)configured. Only one PSFCH time resource is reserved for the feedback which is corresponding to multiple CSI-RS resource measurements. The PSFCH will only indicate which beam is the best beam by using the different PSFCH resources corresponding to the different CSI-RS resources and/or beams of different directions. In this case, PSFCH resources for measurement report of beam management may be (pre-)configured separately from the one for ACK/NACK feedback. PSFCH resources for measurement report of beam management may be determined according to the source ID and/or destination ID of the UEs. The PSFCH indicating beam quality can either be transmitted on the activated beam for measurement report, or via the measurement report carried in PSSCH subject to the resource selection. Which one is used can be up to (pre-)configuration.

For the case of beam measurement report of beam management is needed for other beams, i.e., to measure the beams other than the activated beam and report their quality and/or results, beam maintenance based on the activated beam for measurement report is proposed. As shown is Fig. 6, after the Rx UE measured the beams (e.g., B1) other than the activated beam (e.g., B2) from Tx UE, the measurement report (e.g., F1) of the beam is sent to Tx UE either on the activated beam via PSFCH, which extra resource selection procedure is not needed, or on the activated beam via PSSCH (e.g., carried by 2nd stage SCI, carried by data, etc.) if it is not in connected mode, which resource selection procedure is needed.

In another aspect of this disclosure, a new CSI-RS resource mapping configuration method is proposed for SL FR2 initial beam pairing before link establishment accomplished. For the case of initial beam pairing before link establishment accomplished, there is no CSI-RS configurations to do resource mapping, hence a new method of CSI-RS resource mapping configurations is needed. The new method of CSI-RS resource mapping configurations can be described as the following. For SL FR2 beam management, NR SL CSI-RS resource mapping method can be reused and only nrofPorts={p1}, density=1 and cdm-Type={noCDM} will be used. Other than the three fixed parameters above, parameters such as *firstOFDMSymbolInTimeDomain* and *frequencyDomainAllocation* are used for CSI-RS location within an RB, and *startingRB* (only multiples of 4 are allowed) and *nrofRBs* (only multiples of 4 are allowed and has a minimum value of 24) are used for RB locations of CSI-RS in the frequency domain. There are 2 options for the configuration methods containing the parameters above. For option 1, set an index or bit-string represents for the combination of time and/or frequency location of CSI-RS REs within an RB, starting RB and RB quantity in frequency domain, etc. For option 2, to configure the time and/or frequency location of CSI-RS within an RB, starting RB and RB quantity in frequency domain and etc. separately.

Moreover, the one or a set of CSI-RS resources for beam management, especially initial beam pairing, can be (pre-)configured. For the initial beam pairing, UE can indicate the specific CSI-RS resources from a set of (pre-)configured CSI-RS resources for beam measurement via the field in SCI (1st and/or 2nd SCI). Additionally, 1st SCI can be broadcast in a wide beam whereas the 2nd SCI/PSSCH can be transmitted in unicast with a different beam (e.g., narrow beam). Additionally, indicator in SCI may imply whether the current transmission is used for beam management, e.g., with a repetition or beam-sweeping mode. For example, the beam ID and the total number of beams can be indicated in the SCI. The indicator for beam management can be carried in SCI as well. Moreover, the indicator on whether these beams are repeated or beam-sweeped or whether they are the QCLed for the same/different beams can be provided in the (pre-)configuration or indicated in SCI. Based on one or multiple indicators or (pre-)configuration abovementioned, the Rx UE can know whether/how to measure CSI-RS for beam management.

In another aspect of this disclosure, a new CSI-RS configuration method is proposed for beam management. For existing NR SL CSI framework, it can only be configured as aperiodic and it has to be transmitted together with data, i.e., within PSSCH. Either or both of standalone CSI-RS slot structure and CSI-RS with data is needed for SL FR2 initial beam pairing and/or beam maintenance. Refer to NR Uu CSI-RS for beam management, a periodic system (pre-)configured CSI-RS and/or a dynamic indicated CSI-RS is proposed. For the case of periodic system (pre-)configured CSI-RS, a new slot structure of standalone CSI-RS and/or a new slot structure of CSI-RS with data may be used. For the case of dynamic indicated CSI-RS, CSI-RS configuration is indicated by SCI (e.g., 1st stage SCI, 2nd stage SCI, etc.). Furthermore, the new CSI-RS resource mapping configuration method above can be used.

In another aspect of this disclosure, capabilities of Tx UE need to be informed by Tx UE to Rx UE and/or capabilities of Tx UE and Rx UE need to be exchanged during and/or before initial beam pairing. The capabilities of UE(s) can cover many aspects, i.e., the number of (coarse/fine) beams supported by a UE, , the number of panels of the UE, the number of panels that can be enabled at the same time for transmitting and/or receiving for a UE, etc. Furthermore, the total beam sweeping time and/or beam sweeping pattern/method of Tx UE and/or Rx UE can be determined with the information of capabilities of Tx UE and/or Rx UE.

For sidelink mode 1 operation, it is possible that gNB can configure and indicate the CSI-RS resource for beam management in the DCI scheduling SL transmission. DCI can provide the CSI-RS resources in one or multiple symbols of the scheduled one or multiple slots. The UE receiving the DCI can use the indicated CSI-RS resources for CSI-RS transmission with or without any associated PSCCH and/or PSSCH transmission. gNB may schedule multiple UEs for CSI-RS transmissions in FDM/TDM. Indication of CSI-RS resources can be an index associated with one entry (pre-)configuration table, i.e., indicate the one to be used from a set of CSI-RS resource configurations obtained from signaling or pre-configuration.

Considering the different length of the SL symbols, DMRS pattern and PSCCH location, the (pre-)configuration of CSI-RS resources can be configured separately according to these parameters.

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean “one and only one” unless specifically so stated, but rather “one or more.” The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any aspect described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term “some” refers to one or more. Combinations such as “at least one of A, B, or C,” “one or more of A, B, or C,” “at least one of A, B, and C,” “one or more of A, B, and C,” and “A, B, C, or any combination thereof” include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as “at least one of A, B, or C,” “one or more of A, B, or C,” “at least one of A, B, and C,” “one or more of A, B, and C,” and “A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "UE," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

CLAIMS

1. Methods for SL enhancements

2.The method of claim 1, wherein the method of LBT failure indication of SL-U is proposed.

3.The method of claim 2, wherein the LBT failure can be reported from physical layer to MAC layer for the active RB set.

4.The method of claim 2, wherein the LBT failure can be reported from physical layer to MAC layer per link/beam/UE.

5.The method of claim 4, where in an additional signaling can be added together with LBT failure indication to indicate the LBT failure granularity is per link, per beam, or per UE.

6.The method of claim 5, wherein the additional signaling can be L1 ID/destination ID of each link, and/or beam index/ID and/or CSR-RS resource indicator of each beam.

7.The method of claim 2, wherein the consistent LBT failure can be triggered by MAC layer based on the detection of LBT failure indication reported from lower layer.

8.The method of claim 7, wherein a resource (re)selection and/or resource switching can be triggered by MAC layer after consistent LBT failure is triggered.

9.The method of claim 8, wherein the MAC entity can (re)select other resource(s) on same RB set.

10.The method of claim 8, wherein the MAC entity can (re)select other RB set (on same resource pool), for which consistent LBT failure has not been triggered.

11.The method of claim 8, wherein the MAC entity can (re)select other resource pool, for which consistent LBT failure has not been triggered.

12.The method of claim 2, wherein the consistent LBT failure can be reported from MAC layer to higher layer per link/beam/UE.

13.The method of claim 12, wherein in an additional signaling can be added together with consistent LBT failure indication to indicate the consistent LBT failure granularity is per link, per beam, or per UE.

14.The method of claim 13, wherein a RLF shall be declared based on the detection of consistent LBT failure indication from lower layer.

15.The method of claim 14, wherein the RLF shall be declared per link if the consistent LBT failure is per link.

16.The method of claim 14, wherein the RLF shall be declared per beam if the consistent LBT failure is per beam.

17.The method of claim 14, wherein the RLF shall be declared for all links and/or all beams if the consistent LBT failure is per UE.

18.The method of claim 1, wherein the method to select CPE starting position for UEs with various packet priority is proposed.

19.The method of claim 1, wherein the method of interlace indexing and sub-channel indexing across multiple resource pools are proposed.

20.The method of claim 1, wherein the methods of synchronization signal transmission of SL-U is proposed.

21. The method of claim 20, wherein the additional candidate S-SSB occasion(s) can be (pre-)configured and/or indicated.
22. The method of claim 21, wherein the number of the additional candidate S-SSB occasion(s) can be (pre-)configured and/or indicated.
23. The method of claim 21, wherein the location of the additional candidate S-SSB occasion(s) can be (pre-)configured and/or indicated.
24. The method of claim 23, wherein the additional candidate S-SSB occasion(s) can be set as contiguous with each other and/or set as a S-SSB transmission burst including the additional candidate S-SSB occasion(s).
25. The method of claim 23, wherein the additional candidate S-SSB occasion(s) as contiguous with the corresponding legacy S-SSB and/or set as a S-SSB transmission burst including the additional candidate S-SSB occasion(s) and the corresponding legacy S-SSB occasion(s).
26. The method of claim 23, wherein the location of the additional candidate S-SSB occasion(s) can be defined by an offset regarding to the corresponding legacy S-SSB occasion.
27. The method of claim 21 and claim 22, wherein the (pre-)configuration and/or indication can be based on the channel busy ratio, numerology (e.g., SCS), frequency range (e.g., FR1 or FR2), QCL relation, legacy S-SSB number with a S-SSB period, offset of the 1st legacy S-SSB from the start of S-SSB period, and/or the interval between neighboring legacy S-SSB occasions.
28. The method of claim 21, wherein for the synchronization signal transmitted on FR1 and/or without beam-based transmission, any additional candidate S-SSB occasion can be regarded as the duplication/replacement of any legacy S-SSB occasion.
29. The method of claim 21, wherein for the synchronization signal transmitted on FR2 and/or with beam-based transmission, only the additional candidate S-SSB occasion(s) that have QCL relation can be regarded as the duplication/replacement of the corresponding QCLed legacy S-SSB occasion.
30. The method of claim 29, wherein the QCL relation can be (pre-)configured from a set of factors.
31. The method of claim 30, the set of factors can be (pre-)configured to include average gain, time property, frequency property, space property, CSI-RS relation, etc.
32. The method of claim 21, wherein the behavior of the UE on the additional S-SSB occasion(s) can be (pre-)configured and/or indicated.
33. The method of claim 32, wherein the UE attempts to transmit on all or some of additional candidate S-SSB occasion(s) only when it fails to transmit on legacy S-SSB occasion(s).
34. The method of claim 32, wherein the UE attempts to transmit on all additional candidate S-SSB occasion(s) regardless of whether or not it transmitted on legacy S-SSB occasion(s).
35. The method of claim 1, wherein the methods for beam management of SL FR2 is proposed.

36. The method of claim 35, wherein the methods for a beam pairing method for beam management is PSSCH and PSFCH association.
37. The method of claim 36, wherein the beam qualities that measured by a Rx UE may be obtained by CSI-RS RSRP and/or DMRS RSRP.
38. The method of claim 36, wherein the the beam qualities that measured by a Rx UE is carried by PSFCH feedback at a corresponding time occasion and/or a corresponding resource location.
39. The method of claim 38, wherein if the measured RSRP quality is higher than a (pre-)configured threshold and/or good enough for reception, the PSFCH indicating the corresponding beam quality is transmitted based on the timing.
40. The method of claim 39, wherein the PSFCH is transmitted based on the ACK/NACK feedback timing of the existing ACK/NACK mechanism in NR SL.
41. The method of claim 39, wherein the different candidate PSFCH resources may indicate whether the corresponding CSI-RS transmission from a Tx UE is good enough or indicate different measured quantity.
42. The method of claim 39, wherein the different candidate PSFCH resources may indicate whether the measured result/quality of the corresponding CSI-RS transmission is better than the early reported one.
43. The method of claim 37, wherein the timing for PSFCH indicating beam quality is (pre-)configured.
44. The method of claim 43, wherein only one PSFCH time resource is reserved for the feedback which is corresponding to multiple CSI-RS resource measurements.
45. The method of claim 43, wherein the PSFCH resources for measurement report of beam management is (pre-)configured separately from the one for ACK/NACK.
46. The method of claim 37, wherein for the case of beam measurement report is needed for beams other than the activated beam, the activated beam for measurement report is used.
47. The method of claim 43, wherein the PSFCH indicating beam quality can either be transmitted on the activated beam or via the measurement report carried in PSSCH subject to the resource selection.
48. The method of claim 35, wherein the parameter of CSI-RS resource mapping method including nrofPorts={p1}, density=1 ,cdm-Type={noCDM}, *firstOFDMSymbolInTimeDomain* and *frequencyDomainAllocation* for CSI-RS location within an RB, and startingRB and nrofRBs for RB locations of CSI-RS in the frequency domain.
49. The method of claim 35, wherein the new CSI-RS configuration method is periodic system (pre-)configured CSI-RS and/or a dynamic indicated CSI-RS.
50. The method of claim 49, wherein for the case of periodic system (pre-)configured CSI-RS, a new slot structure of standalone CSI-RS and/or a new slot structure of CSI-RS with data may be used.
51. The method of claim 49, wherein for the case of dynamic indicated CSI-RS, CSI-RS configuration is indicated by SCI (e.g., 1st stage SCI, 2nd stage SCI, etc.).
52. The method of claim 35, wherein the capabilities of Tx UE need to be informed by Tx UE to Rx

UE and/or capabilities of Tx UE and Rx UE need to be exchanged during and/or before initial beam pairing.

53. The method of claim 52, wherein the total beam sweeping time and/or beam sweeping pattern/method of Tx UE and/or Rx UE can be determined with the information of capabilities of Tx UE and/or Rx UE.

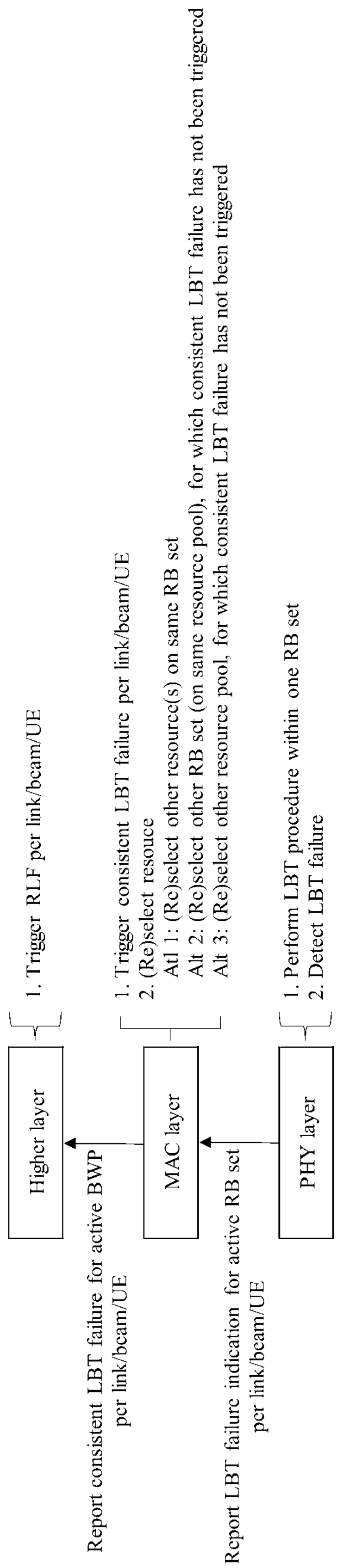
Higher layer
MAC layer
PHY layer
1. Trigger RLF per link/beam/UE
1. Trigger consistent LBT failure per link/beam/UE
2. (Re)select resouce
Atl 1: (Re)select other resource(s) on same RB set
Alt 2: (Re)select other RB set (on same resource pool), for which consistent LBT failure has not been triggered
Alt 3: (Re)select other resource pool, for which consistent LBT failure has not been triggered
1. Perform LBT procedure within one RB set
2. Detect LBT failure
Report consistent LBT failure for active BWP per link/beam/UE
Report LBT failure indication for active RB set per link/beam/UE

Figure 1

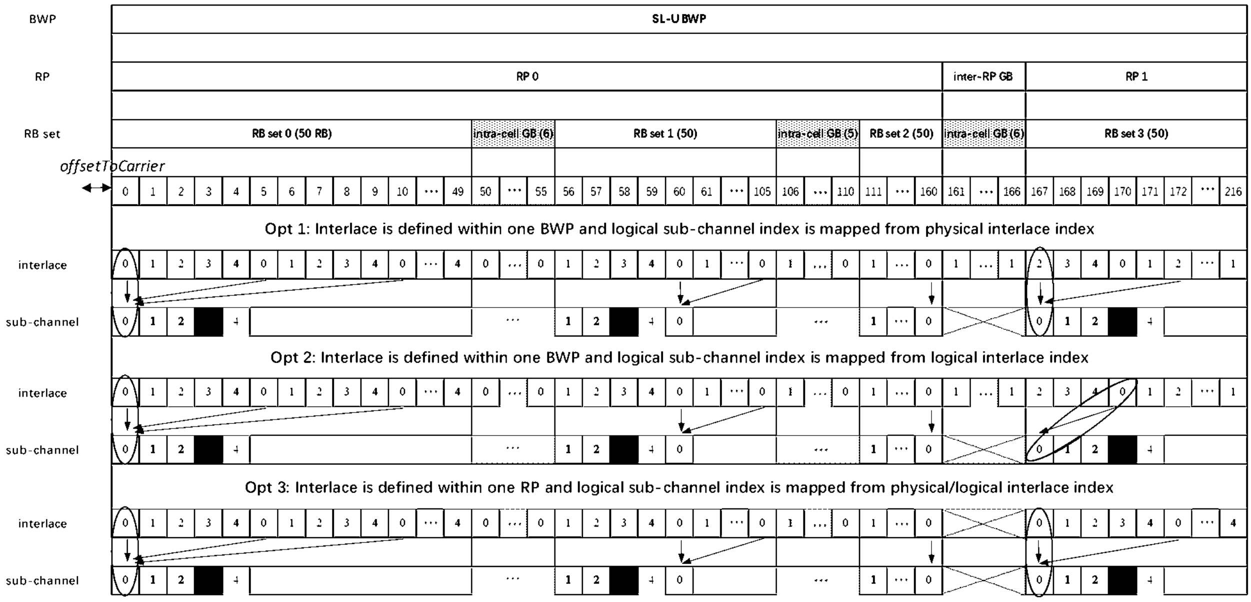

Figure 2

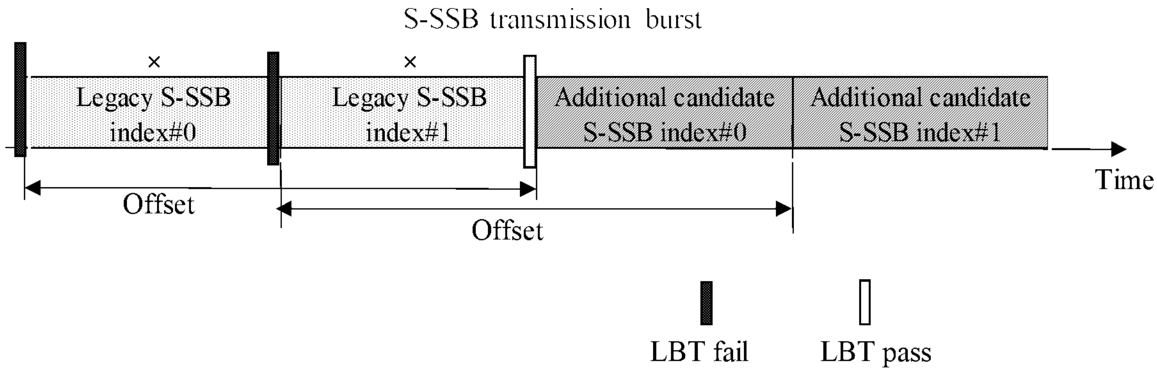

Figure 3

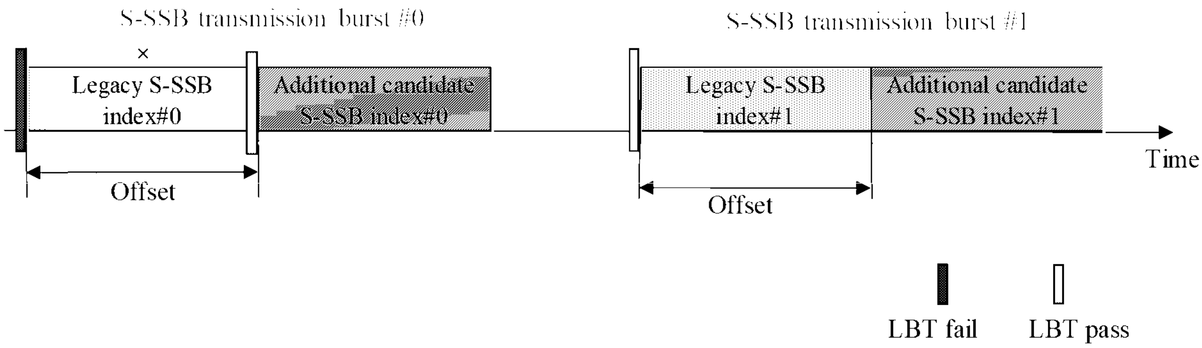

Figure 4

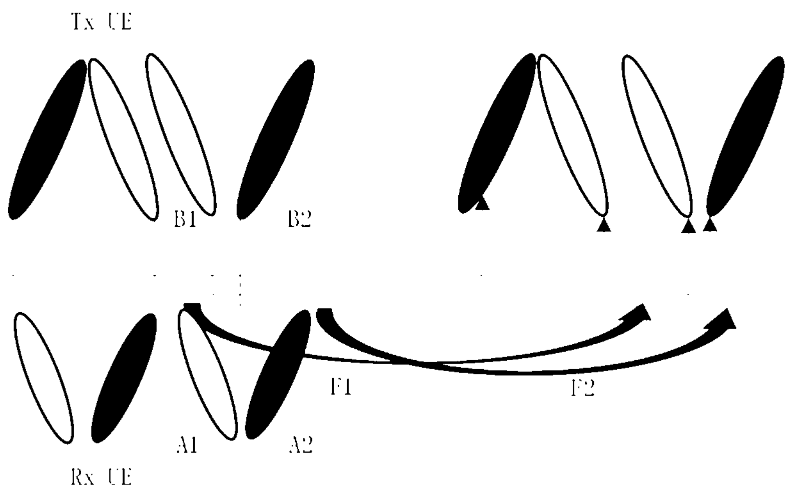

Figure 5

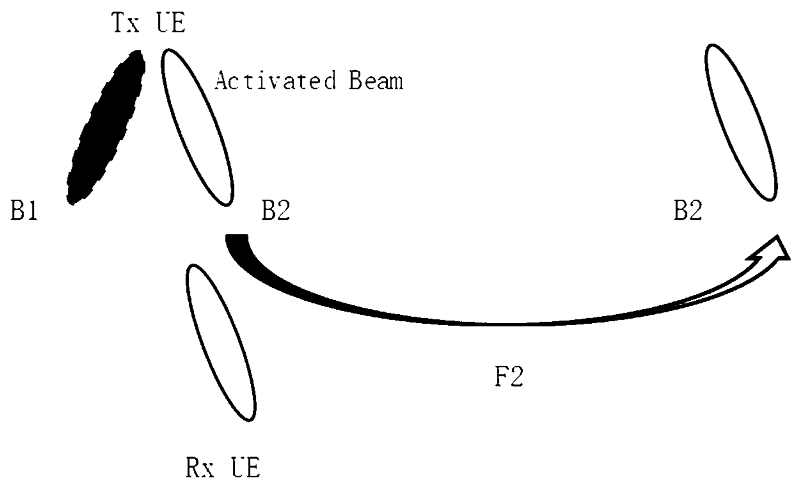

Figure 6

INTERNATIONAL SEARCH REPORT	International application No. PCT/CN2023/087068

A. CLASSIFICATION OF SUBJECT MATTER

H04W72/04(2023.01)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)

CNTXT; ENTXT; DWPI; CNKI; 3GPP: sidelink, sidelink-unlicensed, sidelink-U, SL-U, listen before talk, LBT, failure, physical layer, MAC layer, CPE, CAPC, packet, priority,start position, RP, resource pool, interlace, index, sub-channel, synchronization signal, sidelink synchronization signal block, S-SSB, SL-SSs, additional, number, location, physical sidelink feedback channel, PSFCH, physical sidelink shared channel, PSSCH, FR1, FR2, beam, CSI-RS, RSRP, DMRS, NROFports, Density, CDM-Type, capability

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 115884240 A (ZTE CORPORATION) 31 March 2023 (2023-03-31) description paragraphs 0218-0379	1-17
X	OPPO. "On channel access mechanism and resource allocation for SL-U" *3GPP TSG-RAN WG1 Meeting #112 R1-2300297,* 03 March 2023 (2023-03-03), section 1	1,18
X	US 2023028000 A1 (SAMSUNG ELECTRONICS CO., LTD.) 26 January 2023 (2023-01-26) description paragraphs 0086	1,19
X	NOKIA et al. "Discussion on NR V2X Sidelink Synchronization mechanism" *3GPP TSG-RAN WG1 Meeting #98bis R1-1910515,* 08 October 2019 (2019-10-08), section 3.3	1,20-34
X	US 2022360302 A1 (QUALCOMM INCORPORATED) 10 November 2022 (2022-11-10) description paragraphs 0059,0076,0080	1,35-53

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
08 December 2023	**13 December 2023**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**LIU,QingFeng** Telephone No. **(+86) 010-53961581**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 115280886 A (QUALCOMM INCORPORATED) 01 November 2022 (2022-11-01) the whole document	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/087068

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	115884240	A	31 March 2023	None			
US	2023028000	A1	26 January 2023	WO	2023003221	A1	26 January 2023
US	2022360302	A1	10 November 2022	None			
CN	115280886	A	01 November 2022	US	2021289553	A1	16 September 2021
				EP	4118921	A1	18 January 2023
				WO	2021183806	A1	16 September 2021
				IN	202247042140	A	16 September 2022