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(54) **Title:** A METHOD OF SIDELINK BEAM-BASED RLF DETECTION

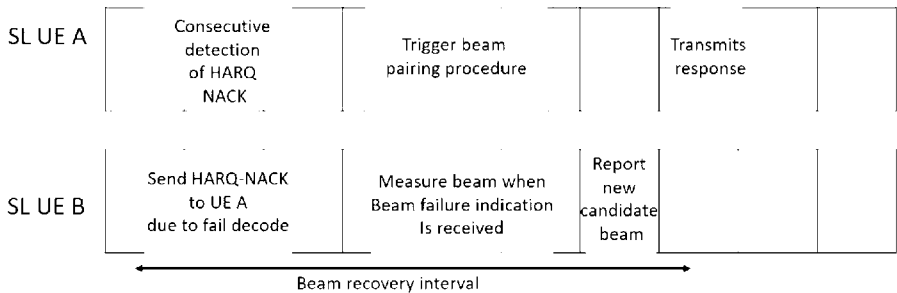


Figure 1

(57) **Abstract:** This disclosure describes a sidelink beam failure detection and beam failure recovery.

A METHOD OF SIDELINK BEAM-BASED RLF DETECTION

Field

The present disclosure relates a sidelink beam failure detection and radio link failure detection.

BACKGROUND

5 This design document targets to propose operation methods for SL devices to perform beamformed transmission. To improve SL throughput for commercial usecase (e.g., file droppings between smartphone, XR tethering between smartphone and wearable XR glasses), FR2 frequency band is preferable with large transmission bandwidth and short transmission latency. Beamformed transmission/reception on FR2 frequency band is necessary to overcome pathloss, reduce
10 interference and improve coverage. With beam paired transmission link, a sidelink(SL) beam failure recovery procedure is required to recover a potential beam failure.

SUMMARY

The following presents a simplified summary of one or more aspects in order to provide a
15 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.

20 In an aspect of the disclosure, a method of SL beam failure detection and beam failure recovery is described. The SL UE detects beam failure instance and report to MAC. The SL UE triggers beam failure recovery procedure when the number of beam failure instance reach a (pre-)configured number. The SL UE triggers beam pairing procedure to identify new candidate beam(s). The SL UE report new candidate beam(s) and UE identifier to the peer SL UE. The SL
25 UE monitor a response from the peer SL UE. A relationship between SL radio link failure detection and SL beam failure detection/recovery is described.

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 drawings set forth in detail certain illustrative features of the one or
30 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

35 FIG. 1 illustrates an example timeline of SL UE beam failure recovery.

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.

Beam failure detection of sidelink is described in the following paragraph. It is supposed that a SL link is established between two SL UEs, a UE and its peer UE. The steps of beam failure detection are described as following:

Step 1: UE ‘s PHY layer provides a beam failure instance to its MAC layer when one or multiple condition(s) is met

1. UE receives HARQ-NACK from the peer UE after a PSCCH/PSSCH is sent
2. UE doesn’t receive any HARQ-ACK and HARQ-NACK from the peer UE after a PSCCH/PSSCH is sent during a (pre-)configured monitoring window, e.g., HARQ DTX
3. The PSCCH/PSSCH’s RSRP received from the peer UE is lower than a (pre-)configured threshold
4. The PSCCH/PSSCH’s BLER received from the peer UE is higher than a (pre-)configured threshold
5. The SL periodic CSI-RS’s RSRP received from the peer UE is lower than a (pre-)configured threshold
6. The SL aperiodic CSI-RS’s RSRP received from the peer UE is lower than a (pre-)configured threshold
7. The SL semi-persistence CSI-RS’s RSRP received from the peer UE is lower than a (pre-)configured threshold

8. If SL SSB(S-SSB) carries UE identifier, the S-SSB's RSRP received from the peer UE is lower than a (pre-)configured threshold.

The MAC layer counts the beam failure instances if a (pre-)configured timer is not expired and declares beam failure when the beam failure instance counter reaches a (pre-)configured maximum number. The maximum number is (pre-)configured differently when different or mix condition(s) are used on PHY layer to provide a beam failure instance. Once a beam failure is declared, the UE triggers a beam failure recovery procedure.

Beam failure recovery of sidelink is described in the following paragraph.

During beam failure recovery procedure, the UE needs to first identify the new candidate beam(s).

When beam failure recovery is triggered by UE, UE identifies new candidate beam(s) of the peer UE by one or multiple solution(s):

(A) If a periodic SL CSI-RS is (pre-)configured to be transmitted by the peer UE during a (pre-)configured SL beam recovery interval, UE measures SL CSI-RS resources and identifies new candidate beam(s) with best RSRP(s)

(B) If an aperiodic/semi-persistence SL CSI-RS is transmitted by the peer UE during a (pre-)configured SL beam recovery interval, UE measures SL CSI-RS resources and identifies new candidate beam(s) with best RSRP(s)

(C) If SL SSB(S-SSB) carries UE identifier and S-SSB is transmitted by the peer UE during a (pre-)configured SL beam recovery interval, UE measures S-SSB and identifies new candidate beam(s) with best RSRP(s)

(D) UE triggers beam pairing procedure during a (pre-)configured SL beam recovery interval.

1. Step 1: UE transmits beam measuring reference resources with beam sweeping. The beam failure detection result (e.g., failure beam ID, RSRP) and/or the peer UE's identifier are carried through SCI and/or MAC CE

2. Step 2: the peer UE detects beam pairing requirement and reference resources from UE. The peer UE measures reference resources from the UE and identify new candidate beam(s).

3. Note: The beam pairing procedure's methodology is same as SL initial beam pairing procedure. The contents carried for initial beam pairing (e.g., DCR message) is replaced by beam failure information.

After UE identifies new candidate beam(s), the UE informs the peer UE with new candidate beam(s) and/or its own UE identifier (e.g., SL beam failure recovery request (BFRQ)).

1. UE reports new candidate beam(s) and/or its identifier through SCI to the peer UE with new paired best beam(s)

2. UE reports new candidate beam(s) and/or its identifier through MAC CE to the peer UE with new paired best beam(s)
3. UE informs its peer UE the new candidate beam(s) and its own identifier through PSFCH corresponding to the PSSCH carrying reference resources transmitted by the peer UE.

Once the UE informs the peer UE with new candidate beam(s) and/or its identifier (e.g., BFRQ), the UE will monitor for a response from the peer UE (e.g., SL beam failure recovery response (BFRR)) during a (pre-)configured monitoring interval. The response from the peer UE is sent through SCI or MAC CE or PSFCH corresponding to the PSSCH that carried SL BFRQ.

Based on the design procedures, several embodiments are described as below. The timeline of case 1 is illustrated in Figure 1:

- Case 1: UE A and UE B are paired with unicast transmission. UE A transmits packet to UE B. The periodic SL CSI-RS resource is not configured.

- Step 1 : UE A sends a beam failure instance(s) to MAC layer when a HARQ-NACK is received from UE B

- Step 2 : MAC layer starts a beam failure counter and timer. Before the expiration of timer, MAC layer counts the beam failure instance into the counter

- Step 3 : Once the counter reaches the maximum value that is preconfigured corresponding to HARQ-NACK beam failure instance condition, UE A's MAC layer triggers beam failure instance recovery procedure

- Step 4 : UE A triggers beam pairing procedure during beam recovery timing window and transmits reference resource(s) with multiple beams. The beam pairing procedure is the same as SL initial beam pairing procedure. The beam failure indication and UE B's identifier are carried in the transmitted resource(s) replacing DCR message.

- Step 5 : UE B upon receiving the beam failure indication, start to measure for new candidate beam(s) by the beam pairing procedure triggered by UE A

- Step 6 : UE B reports new candidate beam(s) in the same container of SL initial beam pairing procedure.

- Step 7 : UE A transmits response to UE B in the same container of SL initial beam pairing procedure.

In legacy SL without beam-based operation, RLF is detected with one of the following triggering conditions:

1. the maximum number of retransmissions for a specific destination has been reached
2. T400 expiry for a specific destination
3. the maximum number of consecutive HARQ DTX for a specific destination has been reached
4. the integrity check failure is indicated from SL PDCP entity.

When SL operated with beam-based transmission, the maximum number of consecutive HARQ DTX and the maximum number of retransmissions for a peer UE to detect RLF may be affected by beam failure. A UE may maintain multiple beams and beam pairs for a single radio link with its peer UE. It implies that before triggering RLF event, the device might have triggered BFR several times and tried to identify a suitable beam. From previous paragraph that describes BFI triggering methodology, The BFI is possible to be triggered by one or multiple condition(s) as following

1. Receiving of HARQ DTX from the peer UE
2. Receiving of HARQ-NACK from the peer UE
3. Receiving of PSCCH/PSSCH's BLER from the peer UE
4. Measuring reference signal's RSRP from the peer UE.

Among the triggering condition(s), the receiving of HARQ DTX/NACK and receiving of PSCCH/PSSCH's BLER from the peer UE could be repetitive counted for SL BFR and RLF procedures. In order to prevent SL RLF triggering before UE attempts any BFR procedure, one or multiple limitation(s) or condition(s) may be provided for the relationship between beam failure and radio link failure as following:

1. The maximum number of consecutive HARQ DTX for triggering SL RLF should be equal or larger than the maximum number of consecutive HAR DTX for triggering SL BFR
2. The maximum number of consecutive HARQ DTX for triggering SL RLF should be equal or larger than the maximum number of consecutive HAR NACK for triggering SL BFR
3. The maximum number of retransmissions for triggering SL RLF should be equal or larger than the maximum number of retransmissions for triggering SL BFR
4. The maximum value of transmission failure ratio for triggering SL RLF should be equal or larger than the PSSCH/PSCCH's BLER for triggering SL BFR

5. When UE is configured with multiple transmission/reception beams, a beam set for RLF detection may be (pre-)configured or implemented by UE. If all of the candidate beams in the beam set fails to recover beam pairing, the RLF can be triggered.

5 6. If UE fails on a (pre-)configured or UE-implemented number of [consecutive] BFR to get new beam pair for serving link, the RLF can be triggered.

Feasibility of DL-UL-DL case for COT initiating UE to resume COT.

10 The NR-U DL-UL-DL case for gNB to resume transmission on its COT defines following constraints:

- gNB shared the COT with a UE that transmits a transmission with type 2 UL channel access procedure
- gNB transmits a transmission within its COT that follows the UE's transmission
- Any gap between any 2 transmissions in the shared COT is at most 25us.

15 For SL-U, a COT sharing case that can fulfill these constraints for COT initiating UE to resume its transmission is shown below:

DLULDL

COT initiating UE transmits PSCCH/PSSCH responding UE transmits PSFCH with CPE that time gap <25us COT initiating UE transmits PSCCH/PSSCH with CPE that time gap <25us.

20 The COT initiator UE may assign the responding UE to transmit on PSFCH with a PSFCH-like signal or HARQ-ACK/NACK feedback with CPE time gap less than 25us in order to resume its transmission within its COT. For this case, we have following proposal:

25 Proposal 9: NR-U DL-UL-DL should be supported, for COT initiating UE to transmit within the same channel occupancy that follows a COT responding UE's SL transmission(s), at least when responding UE's SL transmission is on PSFCH with CPE of time gap less than 25us.

30 In an aspect of the disclosure, a SL operation on unlicensed band is described. multiple consecutive slot transmission within its COT is described. Assuming UE reserves multiple consecutive resource for transmission, within the multiple consecutive PSCCH/PSSCH resources slots, a PSFCH is (pre-)configured. The UE first initiates type 1 channel access procedure to obtain channel occupancy (COT) for its transmission on unlicensed band. For the COT sharing information, the UE indicates one or multiple responding UE(s). The UE transmits on the first part of consecutive reserved/selected resources in its COT. Then the PSFCH occasion occurs. The UE configured a responding UE to transmit on the PSFCH occasion with cyclic prefix starting position
35 (CPE starting position) that allows transmission gap less than 25us. The responding UE transmits

on the PSFCH occasion with its PSFCH feedback toward the COT initiating UE or a PSFCH-like signal toward the COT initiating UE. After transmission of the responding UE, the COT initiating UE resumes its transmission by a CPE starting position that allows transmission gap less than 25us. In this case, NR-U's DL channel access procedures in a shared channel occupancy is re-used.

5 Another embodiment given for the multiple consecutive slots transmission (MCSt) is described as following: Assuming UE reserves multiple consecutive resource for transmission, the UE first initiates type 1 channel access procedure to obtain channel occupancy (COT) for its transmission on unlicensed band. For the COT sharing information, the UE indicates one or multiple responding UE(s). the UE dynamically indicates a PSFCH occasion within the multiple
10 consecutive PSCCH/PSSCH resources slots. The UE transmits on the first part of consecutive reserved/selected resources in its COT. Then the PSFCH occasion occurs. All of the responding UE(s) transmit on the PSFCH occasion with cyclic prefix starting position (CPE starting position) that allows transmission gap less than 25us. The responding UE(s) transmit on the PSFCH occasion with its PSFCH feedback toward the COT initiating UE or a PSFCH-like signal toward
15 the COT initiating UE. After transmission of the responding UE(s), the COT initiating UE resumes its transmission by a CPE starting position that allows transmission gap less than 25us. In this case, NR-U's DL channel access procedures in a shared channel occupancy is re-used.

It is understood that the specific order or hierarchy of blocks in the processes / flowcharts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is
20 understood that the specific order or hierarchy of blocks in the processes / flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

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."
25 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"
30 include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or
35

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,” “device,” 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.”

CLAIMS

1. A method of SL UE to perform beam failure recovery, comprising:
detecting beam failure instance by condition(s) and reporting beam failure instance to MAC;
triggering beam failure recovery procedure when a (pre-)configured maximum number of
5 beam failure instances are counted;
identifying new candidate beam(s) from the peer UE;
reporting new candidate beam(s) and/or UE identifier to the peer UE;
monitoring response from the peer UE.

10 2. The method of claim1, wherein the condition of beam failure instance is the HARQ-NACK receiving.

3. The method of claim1, wherein the condition of beam failure instance is the measured RSRP from SL CSI-RS lower than a threshold.

4. The method of claim1, wherein the (pre-)configured number of maximum beam failure instance is different when different or mix condition(s) are used for beam failure instance detection.

15 5. The method of claim1, wherein the UE triggers beam pairing procedure toward the peer UE when the beam failure recovery procedure is triggered.

6. The method of claim1, wherein the peer UE identifies new candidate beam(s) of the UE by the beam pairing procedure.

20 7. The method of claim1, wherein the peer UE reports new candidate beam(s) to the UE through SCI.

8. The method of claim1, wherein the UE send a response to the peer UE on PSFCH corresponding to the peer UE's PSCCH/PSSCH.

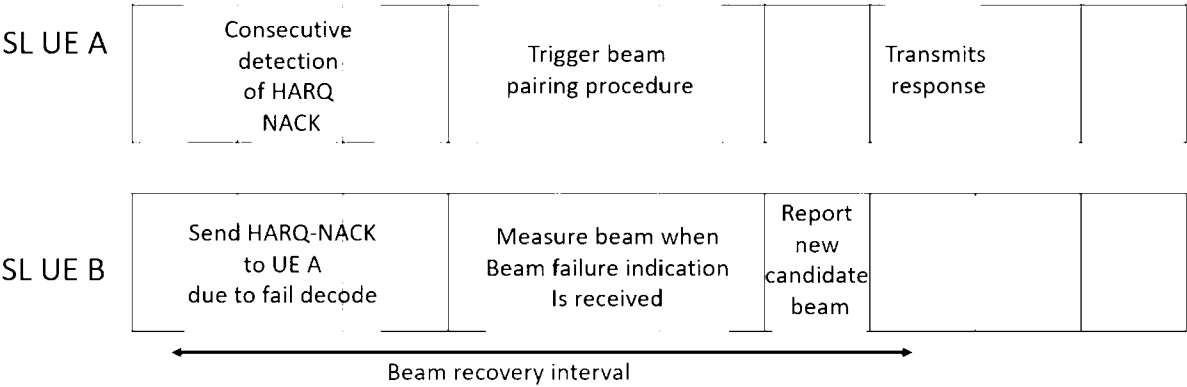


Figure 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/112721

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/04(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04W,H04Q

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

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

3GPP,CNTEXT,DWPI,ENTXTC: beam,candidate,MAC,resume,RLF,sidelink,SL,UE,fail+, count+, failure recovery, BFR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MODERATOR(APPLE). "FL summary #1 for AI 9.4.3 Enhanced sidelink operation on FR2 licensed spectrum" 3GPP TSG RAN WG1 #112 R1- 2301843, 03 March 2023 (2023-03-03), section 3.3	1-8
A	WO 2022206845 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 06 October 2022 (2022-10-06) the whole document	1-8
A	US 2023088597 A1 (IDAC HOLDINGS, INC.) 23 March 2023 (2023-03-23) the whole document	1-8



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

02 April 2024

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10 April 2024

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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				BR	112023020148	A2	28 November 2023
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