5G-NR Rel-16 2019-03

NR V2X Summary Report (RAN1#96)

[NR Sidelink V2X]

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Keywords

3GPP, 5G, NR, NR V2X, NR Sidelink, Sidelink Unicast, Sidelink Groupcast, Sidelink Broadcast, Uu-based Sidelink

Highlights from RAN plenary

There are a lot of study items that need to be completed by March 2019. It was clearly stated that offline discussions are only for structuring the online session and not necessarily for reaching agreements. Decisions are always made online. Delegates who missed (parts of) the offline sessions have the opportunity to comment on offline session outcome in the online session. The offline sessions should be no more than 4 hours. The feature leads objective is to better structure the discussions. The study items that need to be completed are listed below:

1. Power Saving
2. eURLLC
3. NR V2X

RAN1 target completion date should be 3 months ahead of RAN2 and RAN4 core requirements. RAN1 CRs and required RRC parameters shall be formally approved at the RAN1 freezing milestone (Dec/2019 for Rel-16). It is proposed to plan the Release-17 package approval for December 2019 (RAN#86).

Incoming LSs

//General NR

R1-1901484 LS on FR1 range RAN, Qualcomm

Discuss further offline whether there is any action necessary from RAN1 perspective – Peter (Qualcomm)

R1-1903801 (38.213, CR0032)

R1-1903808 Response LS on FR1 range Qualcomm

LS is approved (to attach x3801 in the LS) with final LS R1-1903816

//NR-U

R1-1903329 Invitation to a Coexistence Workshop in Vienna, Austria July 2019 IEEE 802.11 WG

//UE-feature

R1-1901485 LS on RAN1 NR UE features RAN, NTT DOCOMO

//Power control

R1-1901487 LS on PHR procedure in dual-connectivity RAN2, Qualcomm

R1-1902965 Discussion of RAN2 LS on PHR Procedure in Dual-Connectivity Qualcomm Incorporated

R1-1902966 Draft Response LS on PHR Procedure in Dual-Connectivity Qualcomm Incorporated

//BWP

R1-1901488 LS on BWP ID interpretation for DCI code point RAN2, Intel

// V2X

R1-1903333 LS on 2Rx Antennas for NR V2X Sidelink 5GAA WG4, General Motors

R1-1903787 LS on Conclusion of NR V2X and Agreed TP for TR 38.885 RAN3, LGE

//Power saving

R1-1903765 LS to RAN1 on power saving RAN2, vivo

//NR Positioning

R1-1903802 LS on RAN2 conclusion for NR positioning SI RAN3, Intel

1. NR V2X Overall Summary

1.1. Sidelink Design

1.1.1 Physical Layer Structure

Including waveform, RS, control/data mux, resource pool, etc.

Highlights

The design of a physical SL control channel (PSCCH), a physical SL shared channel (PSSCH), a physical SL feedback channel (PSFCH) [insert others later…], and other matters related to physical layer structures are studied. For design of the physical SL broadcast channel (PSBCH).

A single waveform is used for all the SL channels in a carrier. The waveform supported in the study is only CP-OFDM.

In FR1, 15 kHz, 30 kHz and 60 kHz SCS are supported with normal CP, and 60 kHz SCS with extended CP. In FR2, 60kHz and 120 kHz SCS are supported with normal CP, and 60 kHz SCS with extended CP. In a given carrier, a UE is not required to receive simultaneously SL transmissions with more than one combination of SCS and CP, nor transmit simultaneously SL transmissions with more than one combination of SCS and CP. The numerology configuration is part of the SL BWP configuration.

The channel coding defined for data and control in NR Uu are respectively the starting points for data and control on the NR SL.

BWP is defined for SL, and the same SL BWP is used for transmission and reception. In specification terms, in a licensed carrier, SL BWP would be defined separately, and have separate configuration signalling, from Uu BWP. One SL BWP is (pre-)configured for RRC IDLE and out-of-coverage NR V2X UEs in a carrier. For UEs in RRC_CONNECTED mode, one SL BWP is active in a carrier. No signalling is exchanged over SL for the activation or deactivation of a SL BWP.

Only one SL BWP is configured in a carrier for a UE, and a UE is not expected to use different numerologies in the SL BWP than an active UL BWP.

A resource pool is a set of time-frequency resources that can be used for SL transmission and/or reception. From the UE point of view, a resource pool is inside the UE's bandwidth, within a SL BWP and has a single numerology. Time domain resources in a resource pool can be non-contiguous. Multiple resource pools can be (pre-)configured to a UE in a carrier.

NR V2X may be deployed in a carrier dedicated to ITS services, or a carrier shared with cellular services. Therefore, resource arrangements where all the symbols in a slot are available for SL, and where only a subset of consecutive symbols in a slot (which are not dynamically indicated) are available for SL are supported. The latter case is not intended for use in ITS spectrum, if normative specification work does not find a forward compatibility issue.

Resource allocation for PSSCH is based on the concept of sub-channels in the frequency domain and a UE performs either transmission or reception in a slot on a carrier. Blind retransmissions of a TB are supported, and resource allocation Mode 2 supports reservation of sidelink (SL) resourcesat least for such blind retransmission. PSFCH supports at least a format which uses the last symbol(s) available for SL in a slot. DM-RS associated with PSSCH are transmitted in one of several possible patterns in the time domain. In FR2, a PT-RS for PSSCH is also supported.

Other candidate reference signals are: CSI-RS, SRS, and AGC training signal.

Work Item Phase

NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

- Sidelink signals, channels, bandwidth parts, and resource pools for the work item phase.

R1-1901438 Feature lead summary for agenda item 7.2.4.1.1 Physical layer structure LGE

1.1.1.1 Physical channels

A sidelink physical channel corresponds to a set of resource elements carrying information originating from higher layers. The following sidelink physical channels are defined:

- PSCCH
- PSSCH
- PSBCH

1.1.1.2 Reference signals

- DM-RS: DM-RS defined in Rel-15 NR Uu is the starting point.
  - Multiple DMRS patterns in time domain are supported for PSSCH
    - FFS: Whether a DMRS pattern is selected based on the subcarrier spacing
    - FFS: Single or multiple DMRS pattern(s) per a resource pool
    - FFS: How TX UE and RX UE can be aligned in terms of the DMRS pattern used for PSSCH
    - FFS: RE mapping, sequence generation
  - Continue to study DMRS pattern in frequency domain for PSSCH
    - E.g. Whether multiple patterns are supported, whether PDSCH/PUSCH DMRS configuration 1 or 2 is reused.
- PT-RS for PSSCH for FR2

<u>DMRS design issues</u>

Issue 2-1: DMRS pattern for PSSCH

- Company's proposal: Multiple DMRS pattern in time is supported for PSSCH (9 companies)
  - Rationale:
    - Considering various scenario regarding doppler spread
    - Rel. 15 NR DMRS structure can be reused **Error! Reference source not found.**
  - Company's proposal: Fixed DMRS pattern in time is supported for PSSCH (1 company)
    - Rationale:
      - Optimized DMRS pattern can be used to reduce overhead
  - Company's proposal: Multiple DMRS pattern in frequency is supported for PSSCH (2 companies)
    - Rationale:
      - UE can adaptively improve resource utilization or performance according to the situation
      - Reduce frequency domain density to increase time domain density when needed without extra overhead
  - Company's proposal: Fixed DMRS pattern in frequency is supported for PSSCH (2 companies)
    - Rationale:
      - Optimized DMRS pattern can be used to reduce overhead **Error! Reference source not found.**

Issue 2-2: DMRS pattern for PSCCH

- Company's proposal: Fixed DMRS pattern is supported for PSCCH (6 companies)
  - Rationale:
    - Blind decoding complexity

        - Throughput is rather low and reliability is the most important criterion
- Company's proposal: DMRS structure of NR PDCCH is baseline (4 companies)
    - Rationale:
        - Small specification effort
        - Sufficient detection performance Issue 2-3: Others
- Company's proposal
    - 15kHz SCS should not be considered for ultra high-speed scenarios for NR V2X FR1.
- Company's proposal **Error! Reference source not found.**
    - Consider to support up to 8 antenna ports from system perspective to support reception of multiple interfering transmissions as well as spatial multiplexing
    - Design DMRS patterns to optimally support 64-QAM at least till 120 km/h relative speed and 16-QAM till 240 km/h
    - NR V2X PSCCH sidelink physical structure and DMRS take into account benefits of multiple decoding attempts for PSCCH transmissions collided on the same resource
- Company's proposal
    - At least a DMRS pattern specific for CP-OFDM is supported
    - Better PSCCH demodulation performance can be achieved by removing DMRS symbols in PSCCH and using PSSCH DMRS to demodulate PSCCH.
- Company's proposal
    - Physical layer ID is used for randomization of scrambling code and DMRS generation.
- Company's proposal
    - Common design for PSCCH DMRS and PSSCH DMRS should be further studied
- Company's proposal
    - Discuss the support for orthogonal DM-RS signals for potential colliding UEs.
    - Discuss the solution to mitigate the impact of aperiodic packets on the sidelink channel measurement and UE resource selection. S-RSSI measurement based on DMRS could be considered.

Observation

- Majority companies support multiple DMRS patterns in time-domain for PSSCH.

1.1.1.3 Synchronization signals

The SL primary synchronization signal (S-PSS) and SL secondary synchronization signal (S-SSS) design is based on the following:

- The sequence type for S-PSS is the same type as the M-sequence used for NR-PSS
- The sequence type for S-SSS is the same type as the Gold sequence for NR-SSS

1.1.1.4 S-SSB

- The study of NR V2X synchronization includes synchronization based on S-SSB
- The study also includes use of other sidelink signals/channels (e.g., other RSs in the SL, using PSSCH, using PSCCH, etc.) for the sidelink synchronization

The frequency location for S-SSB is based on:

- The frequency location for S-SSB is (pre-) configured
    - Note: it implies that there is no intended hypothses detection in frequency location of S-SSB performed by the UE for a carrier in a given band
    - Note: the potential frequency locations for the (pre-)configured frequency location may be restricted, up to RAN4

1.1.1.5 Sidelink Numerology

- For PSCCH/PSSCH in FR1, NR V2X supports normal CP for 15kHz, 30kHz, 60kHz, and extended CP for 60kHz.
    - For PSCCH/PSSCH in FR2, NR V2X supports normal CP for 60kHz and 120kHz, and extended CP for 60kHz

- Only one combination of CP length and SCS is used in a carrier at a given time for NR V2X UEs communicating with each other using SL

1.1.1.6 Sidelink Waveform

More companies support CP-OFDM is the only waveform for NR sidelink.

It is observed that DFT-S-OFDM provides better link budget in some simulation results while some companies argue that such link budget gain is not necessary in NR V2X. Meanwhile, to support DFT-S-OFDM, several companies mentioned that there are issues on UE complexity and specification effort.

The agreements are the following:

- CP-OFDM is only supported for Rel-16
- No consensus in supporting DFT-S-OFD

1.1.1.7 BWP

Issue 3-1: The number of configured SL BWP for RRC connected NR V2X UE (regarding WA)

- Company's proposal: Confirm the working assumption (only one SL BWP is configured in a carrier for a NR V2X UE)
  - Rationale:
    1) UE would miss some message due to SL BWP switching because there is no signalling in SL for SL BWP activation/deactivation
    2) Using resource pool can be an alternative
    3) Dynamic SL BWP switching cause switching latency and make SL BWP operation more complex

Issue 3-2: Relationship between SL and Uu BWP

- Company's proposal: SL BWP and Uu BWP are independently configured.
  - Rationale:
    1) gNB can configure UL BWP and SL BWP to ensure the UL BWP and resource pool(s) or SL BWP are within UE's RF bandwidth
    2) All UEs with potentially different active Uu BWP needs to have the same active SL BWP
- Company's proposal: Further study is necessary in terms of handling switching latency (if exists) between Uu BWP(s) and SL BWP.
- Company's proposal: It could be beneficial to restrict UE RF BW covering Uu BWP(s) and SL BWP, and align numerology of Uu BWP(s) and SL BWP in terms of reducing switching latency among them.

Observation

- Companies discussed switching delay and numerology alignment between SL BWP and Uu BWP where Uu BWP can include DL BWP, UL BWP, and the initial BWP.

Proposal for conclusion:

- RAN1 to discuss further switching latency and numerology alignment between SL BWP and Uu BWP in the WI phase.

1.1.1.8 Resource Pool

Issue 4-1: How resource pool in time-domain is defined

- Company's proposal: Support symbol-level resource pool consisting of contiguous or non-contiguous symbols
  - Rationale:
    - Shared carrier between Uu and NR sidelink [2][15][18]

Issue 4-2: How resource pool in frequency-domain is defined

- Company's proposal: Support resource pool consisting of contiguous RBs

        - Rationale:
            - Simple configuration of resource pool [18]
    - Company's proposal: Introduce the concept of sub-channel consisting of contiguous RBs to express resource pool in frequency domain
        - Rationale:
            - Reduced blind decoding complexity for PSCCH [15]
            - Reduced overhead to indicate PSSCH allocation [2]

Issue 4-3: Others
- Company's proposal
    - Both common resource pools (for broadcast) and UE-dedicated resource pools can be configured
- Company's proposal
    - Dedicated resource pools for control and data respectively should be supported for NR sidelink.
- Company's proposal
    - Study the configuration of resource pools based on different defined criteria
- Company's proposal
    - A common sidelink resource pool configuration scheme should be defined for both PSCCH/PSSCH multiplexing option 1b and option 3
    - Multiple resource pools can be configured within a BWP
- Company's proposal
    - Discuss whether logical or physical slot indexing is used in NR V2X sidelink
    - A SL BWP configured in a carrier always occupies whole bandwidth of the carrier
    - Resource pool configuration method of LTE V2X is baseline (time domain by bitmap, frequency domain by contiguous PRBs)
- Company's proposal
    - Although multiple resource pools can be configured to a single UE, the UE choose one TX pool within which it performs resource selection

Observation
- Companies discussed the time domain granularity of the resource pool and the contiguity in the frequency domain.
- The feature lead is of the opinion that the time domain granularity can have important impact on the physical channel design while the frequency domain issue is more related to the high layer signalling issue.

Proposal for conclusion (discussed but no consensus):
- For the operation regarding PSSCH, a UE performs either transmission or reception in a slot.
- NR sidelink supports a case where all the symbols in a slot are available for sidelink.
- NR sidelink should also support a case where only a subset of symbols in a slot is available for sidelink.
    - FFS the supported slot configuration(s)
    - FFS whether this support is limited to mode 1
    - FFS whether/how to operate it in partial coverage scenarios

1.1.1.9 PSCCH/PSSCH multiplexing
Note that Option 3 is already made as working assumption for PSCCH/PSSCH multiplexing.

Issue 5-1: Whether one of options covers the other options
- Company's proposal:
    - Option 3 can be transformed into a structure like option 1 & 2
    - Option 1a is a special case of option 3
    - Discuss further how to realize option 1a based on option 3
    - Time resource allocation based on option 3 can be used to realize option 1b

Issue 5-2: Options to be supported

- Option 1A (Support: / Not support:
  - Pros
    - Cross- and multiple-slot scheduling is possible
    - Small latency **Error! Reference source not found.**
    - Small size of indication for PSSCH allocation in frequency domain
  - Cons
    - Scheduling restriction on PSSCH allocation
    - Variable SA frequency resource is challengeable for blind detection
    - Sensing complexity increases [15]
- Option 1B (Support: Mitsubishi / Not support:
  - Pros
    - common design for cross slot scheduling between PSCCH and PSSCH
    - Facilitate short-term sensing
    - Coverage enhancement
    - Simpler or reuse design of front-loaded DMRS in PSSCH
    - No need to same number of layer/rank and MIMO scheme between PSCCH/PSSCH
    - No power sharing issue
  - Cons
    - Transient period between PSCCH and PSSCH is needed
- Option 2 (Support: [18]/ Not support:
  - Pros
    - High coverage and higher reliability of PSCCH
  - Cons
    - Large latency
    - Constraints on PSCCH precoding/antenna virtualization

Issue 5-3: Others

- Company's proposal
  - The duration of PSCCH can be set to all OFDM symbols
  - PSCCH decoding starts from the symbol immediately following the AGC symbol
  - PSCCH decoding starts from the lowest RB index of a subchannel
- Company's proposal
  - The frequency location of PSCCH can be associated with the frequency location of the associated PSSCH.
- Company's proposal
  - Option 3 is limited to rank 1 for both PSCCH and PSSCH. Option 1B supports spatial multiplexing for PSSCH while PSCCH is limited to rank 1 as well.
- Company's proposal
  - For option 3, PSCCH and PSSCH should start on the first symbol assigned for sidelink within a slot.
  - In PSCCH/PSSCH multiplexing option 3, the RB's of PSCCH is contained inside RB's of PSSCH.
    - Case 1: The starting RB indices of the both channels have to be the same.
    - Case 2: The starting RB indices of the both channels can be different.
  - For option 1B, PSCCH should be multiplexed with PSSCH on different symbols within one slot.
  - Confirm the WA: no transient period is in need between symbols containing PSCCH and symbols not containing PSCCH of option 3.

Observation

- Majority companies do not support Option 1A. Next, it seems that majority companies support Option 1B. However, some companies argue that transient period may be necessary between PSCCH and PSSCH. Regarding Option 2, limited support was observed and there was a comment regarding the necessity of coverage enhancement at the expense of large latency.

Proposal for agreement (discussed but no consensus reached):

- For PSCCH/PSSCH multiplexing
  - Working assumption: Option 1B is supported.
    - Option 1B design will not assume transient period between PSCCH and PSSCH symbols. Confirmation of this working assumption will be based on the RAN4 LS regarding the need of transient period between PSCCH and PSSCH symbols.

1.1.1.10 PSCCH

Issue 6-1: SCI format

- Company's proposal: multiple SCI formats are carried by PSCCH **Error! Reference source not found. Error! Reference source not found.** [AT&T, 6] [LG Electronics, 7] [OPPO, 14] [Nokia, Nokia Shanghai Bell, 19] [InterDigital, Inc., 20] [Spreadtrum Communications, 24] [Ericsson, 29] (9 companies)
  - Rationale:
    1. To enable flexible and efficient sidelink transmission **Error! Reference source not found.** [AT&T, 6] [LG Electronics, 7] [Nokia, Nokia Shanghai Bell, 19] [InterDigital, Inc., 20] [Spreadtrum Communications, 24]
    2. The large discrepancy in terms of bit size (e.g., to support of transmission with or without feedback) **Error! Reference source not found.** [Ericsson, 29]

Observation

- Majority companies supported multiple SCI formats, so it can be the basis in further PSCCH design.

Proposal for agreement:

- For SCI design, consider following options:
  - Option 1: Single SCI format size per a resource pool, but SCI format size can be different across resource pools
    - FFS: Single or multiple SCI format with different set of fields
  - Option 2: Multiple SCI format sizes per a resource pool
    - FFS: How to utilize different SCI format size in a resource pool (e.g. 2-step SCI, multiplexing sidelink transmission with different characteristics such as MIMO scheme, HARQ-ACK feedback scheme, etc.)
  - For down-selection, following aspects are investigated:
    - Blind decoding complexity
    - Detection performance of SCI

Issue 6-2: Blind decoding number and location

- Company's proposal: Fixed or (pre-)configured size (time/frequency) and/or location **Error! Reference source not found.** [LG Electronics, 7] [ZTE, Sanechips, 10] [OPPO, 14] (4 companies)
  - Rationale:
    1) To reduce blind decode complexity **Error! Reference source not found.** [LG Electronics, 7] [ZTE, Sanechips, 10] [OPPO, 14]
- Company's proposal: Support 2-stage SCI; one for anonymous UE(s), and the other for dedicated UE **Error! Reference source not found.** [Fraunhofer HHI, Fraunhofer IIS, 5] [Lenovo, Motorola Mobility, 11] [Panasonic, 12] [InterDigital, Inc., 20] [Spreadtrum Communications, 24] [Ericsson, 29] (7 companies)
  - Rationale:
    1) To support multiple SCI format with different size with acceptable BD complexity **Error! Reference source not found. Error! Reference source not found.** [InterDigital, Inc., 20] [Ericsson, 29]
    2) Pre-emptive reservation, announcement of resource pool by group leader, coexistence between in- and out-of-coverage UE [Fraunhofer HHI, Fraunhofer IIS, 5]
    3) Contents of SCI related to data decoding part of unicast and groupcast data need not be decoded by other UEs [Lenovo, Motorola Mobility, 11]
    4) Considering compromised solution for combining option 1B and option 3 [Panasonic, 12]
    5) High coverage requirement can be fulfilled using 2 stage SCI design [Ericsson, 29]

Observation
- Several companies supported "2-stage SCI" and this has an impact on the PSCCH design.

Proposal for agreement (discussed but no consensus reached):
- It is supported that a UE decodes a single SCI to receive a PSSCH.
  - FFS whether to support the case where a UE decodes two SCI to receive a PSSCH.

View check during offline regarding two SCI in addition to single SCI:
- Yes: IDC, MediaTek, FH, Panasonic, Ericsson, Intel, Huawei, HiSi, Nokia, DOCOMO, Lenovo, Hepta, Fujitsu (13)
- No: vivo, QC, CATT, LGE, ZTE, Sanchips, OPPO, Samsung, AT&T (9)

Issue 6-3: Which information is conveyed on PSCCH other than SCI for PSSCH reception
- Company's proposal:
  - Information related to reserved resources **Error! Reference source not found.** [Intel Corporation, 16]
  - Resource allocation for transmission of another UE [AT&T, 6]

Issue 6-4: Transmission scheme for PSCCH
- Company's proposal: single-port transmission with transparent TxD scheme [Samsung, 13] [Intel Corporation, 16] [Qualcomm Incorporated, 28] (3 companies)
  - Rationale:
    - Consider NR PDCCH as baseline [Samsung, 13] [Intel Corporation, 16] [Qualcomm Incorporated, 28]
- Company's proposal: multi-port transmission **Error! Reference source not found.** (1 company)
  - Rationale:
    - Better link budget performance **Error! Reference source not found.**

Observation
- More companies support single-port transmission for PSCCH by taking NR PDCCH as the baseline.

Proposal for agreement:
- Support single-port transmission with transparent TxD for PSCCH considering NR PDCCH as baseline

1.1.1.11 Feedback channel

Issue 7-1: PSFCH format structure for HARQ feedback
- Company's proposal: Reuse sequence-based HARQ feedback (NR PUCCH format 0/1) [LG Electronics, 7] [Fujitsu, 8] [CATT, 9] [Samsung, 13] [OPPO, 14] [Nokia, Nokia Shanghai Bell, 19] [Spreadtrum Communications, 24] [ITL, 26] [Ericsson, 29] (9 companies)
  - Rationale:
    - Sequences are good enough to be orthogonal [CATT, 9]
    - Small specification effort [LG Electronics, 7][Spreadtrum Communications, 24] [ITL, 26]
    - Reduce UE/gNB processing time [Samsung, 13]
    - To increase spectral efficiency [Nokia, Nokia Shanghai Bell, 19]
    - Reduced overhead and complexity [LG Electronics, 7][8][Ericsson, 29]

Observation
- Most companies seem to support reusing sequence-based HARQ feedback as in NR PUCCH format 0/1.

Proposal for agreement:
- NR sidelink supports sequence-based HARQ feedback similar to NR PUCCH format 0/1 for PSFCH format structure.

Issue 7-2: Time resource for PSFCH for HARQ feedback

- Using last symbol(s) of slot (Support: [Huawei, HiSilicon, 1] [MediaTek Inc., 3] [LG Electronics, 7] [Fujitsu, 8] [Samsung, 13] [Intel Corporation, 16] [InterDigital, Inc., 20] [Spreadtrum Communications, 24] [NTT DOCOMO, INC., 25] (9 companies))
  - Pros
    - To allow a fast feedback [Huawei, HiSilicon, 1] [MediaTek Inc., 3] [LG Electronics, 7]
- Using all symbols of slot (Support: [Huawei, HiSilicon, 1] [Fujitsu, 8] [Intel Corporation, 16] [Nokia, Nokia Shanghai Bell, 19] [InterDigital, Inc., 20] [Spreadtrum Communications, 24] (6 companies / Not support [LG Electronics, 7] [OPPO, 14] [Samsung, 30] (3 companies))
  - Pros
    - better resource utilization efficiency [Huawei, HiSilicon, 1]
    - AGC impact [Nokia, Nokia Shanghai Bell, 19]
  - Cons
    - As long as PSFCH coverage is comparable to PSCCH, there is no strong motivation to introduce long PSFCH at all. long PSFCH uses more symbols than short PSFCH and it will make half-duplexing problem in NR V2X severer [Samsung, 30]

Observation

- Most companies seem to support PSFCH format using the last symbol(s) in a slot for HARQ feedback. There are companies also supporting a format using all the symbols of a slot but several companies questioned its necessity.

Proposal for agreement:

- For sidelink HARQ feedback, NR sidelink supports at least a PSFCH format which uses last symbol(s) of slot.
  - This PSFCH format uses less than [4] symbols.

Issue 7-3: Others

- Company's proposal [LG Electronics, 7]
  - At least for unicast, feedback information other than SL HARQ (e.g., long-term channel quality measurement) is conveyed via PSSCH.
  - If SL transmission with PSFCH and SL transmission without PSFCH are allowed to be multiplexed in the same pool, at least the following issues need to be further studied.
    - How to reduce additional AGC during PSSCH reception
    - Collision avoidance between PSSCH and PSFCH
- Company's proposal [Fujitsu, 8]
  - PSFCH alignment within a slot can be considered to alleviate the potential AGC impact from PSFCH
- Company's proposal [CATT, 9]
  - PSFCH for HARQ feedback should be transmitted at the end of a slot.
- Company's proposal [OPPO, 14]
  - SL feedback with larger payload, such as CSI etc, can be conveyed via PSSCH.
- Company's proposal [NTT DOCOMO, INC., 25]
  - If flexible PSFCH resource indication is supported for transmission mode 1 (e.g. the resource is indicated by SCI), and/or if SL-CSI can be reported on PSFCH, both short and long PSFCH formats are supported; otherwise only short PSFCH format is supported.
    - For PSFCH formats, PUCCH formats in NR-Uu are starting point with some modification to support only CP-OFDM
- Company's proposal [ITL, 26]
  - SL CSI can be sent via PSSCH rather than PSFCH
- Company's proposal [ASUSTEK COMPUTER (SHANGHAI), 27]
  - RAN1 study the impact on multiplexing between PSCCH/PSSCH and PSFCH when determining time domain resource for PSFCH.
- Company's proposal [Ericsson, 29]
  - NR SL supports sequence-based HARQ feedback, for both TB-based and CBG-based cases.
  - PSFCH is transmitted at the end of a slot

- FFS: PSFCH format for other feedback contents (if supported)

1.1.1.12 AGC/switching period handling

Issue 8-1: Whether to support AGC training signal

- Company's proposal: Support AGC training signal (2 company)
  - Rationale:
    - Reduced AGC settling time
    - In higher SCS, the duration of symbol becomes shorter and one OFDM symbol length might not be enough for AGC training
    - Could be used for AGC training, channel tracking, along with DMRS for channel estimation, and CSI acquisition
    - Channel clearance detection for LBT
- Company's proposal: No support AGC training signal (4 companies)
  - Rationale:
    - The same principle as LTE-V can be used
    - AGC retraining is not always needed
    - High required density of DMRS and presence of AGC and guard period

Issue 8-1: Others

- Company's proposal
  - CSI-RS symbols can be placed at the beginning of a slot and also serve as AGC training signals.
- Company's proposal
  - Comb-like resource mapping on the first and last OFDM symbol can be supported in NR-V2X.
- Company's proposal
  - Use the first half OFDM symbol for tx/rx switching and the second half OFDM symbol for AGC adaptation in a slot for 15 and 30 kHz SCS
  - Use the last OFDM symbol for tx/rx switching and the first OFDM symbol for AGC adaptation for 60 kHz SCS
  - Transmit PSCCH on at least the first three symbols or transmit training signal in the first symbol considering the performance degradation of PSCCH due to AGC impact
- Company's proposal
  - The guard period and AGC protection can be integrated in a single symbol to reduce the overhead.
- Company's proposal
  - It can be considered to adopt merging AGC/Tx-Rx switching in one OFDM symbol or LTE-V2X-like way

Observation

- Handing of AGC still needs RAN4 feedback and the details can be discussed based on it.

Proposal for agreement:

- For AGC symbol, consider following options for data and/or RS mapping based on RAN4 LS on the AGC time.
  - Option 1: NR sidelink channels are mapped without consideration of AGC symbol
  - Option 2: Comb-like resource mapping is applied
    - Option 2-1: For PSCCH/PSSCH, data is mapped on AGC symbol
    - Option 2-2: For PSCCH/PSSCH, DMRS is mapped on AGC symbol
  - Option 3: NR sidelink channels are not mapped
    - Option 3-1: Preamble is mapped on AGC symbol
    - Option 3-2: RS other than DMRS is mapped on AGC symbol

1.1.1.13 DMRS design

Issue 9-1: DMRS pattern in time domain for PSSCH

- FFS: Whether a DMRS pattern is selected based on the subcarrier spacing
  - Views supporting DMRS pattern selection based on subcarrier spacing
    - DMRS pattern should be selected based on the subcarrier spacing (UE speed for unicast and groupcast) [CATT, 9]
    - larger SCS may prefer a lower DMRS density in time domain [Ericsson, 29]
- FFS: Single or multiple DMRS pattern(s) per a resource pool
  - Views supporting multiple DMRS pattern in a resource pool
    - multiple DMRS patterns are configured for a resource pool [vivo, 2]
    - Support multiple time-domain DM-RS patterns for each subcarrier spacing and resource pool. [Mitsubishi Electric RCE, 4]
    - Multiple DMRS patterns should be supported in one resource pool [NEC, 22]
      - Select the appropriate DMRS pattern dynamically according to instant channel status
    - multiple DMRS time patterns are supported for the resource pool, the dynamic indication of DMRS time pattern by SCI [Nokia, Nokia Shanghai Bell, 19]
    - Multiple DMRS pattern should be allowed per resource pool. UEs can select optimal DMRS pattern based on
      - UE speed, communication types and operation frequency range [Sony, 17]
      - UE speed and MCS [Qualcomm Incorporated, 28]
      - UE speed and subcarrier spacing [CATT, 9]
- FFS: How TX UE and RX UE can be aligned in terms of the DMRS pattern used for PSSCH
  - Company views
    - DMRS pattern of PSSCH can be indicated in PSCCH/SCI [Mitsubishi Electric RCE, 4] [LG Electronics, 7] [OPPO, 14][Nokia, Nokia Shanghai Bell, 19][InterDigital, Inc., 20] [NEC, 22]
- FFS: RE mapping, sequence generation
  - Company views
    - Physical layer ID is used for randomization of scrambling code and DMRS generation [Samsung, 13]

Observation

- Majority company support allowing multiple time patterns for PSSCH DMRS in a resource pool and the selected pattern is indicated in SCI.

Proposal for agreement:

- NR sidelink allows multiple time patterns for PSSCH DMRS in a resource pool. The pattern selected for a certain PSSCH transmission is indicated in SCI.
  - FFS how the selection is made.

Issue 9-2: DMRS pattern in frequency domain for PSSCH

- Whether multiple patterns are supported
  - Company's proposal: Multiple DMRS pattern in frequency is supported for PSSCH [vivo, 2] [Mitsubishi Electric RCE, 4] [CATT, 9] (3 companies)
    - Rationale:
      - UE can adaptively improve resource utilization or performance according to the situation [vivo, 2] [CATT, 9]
      - RB-combing for frequency-domain reduced density patterns [Mitsubishi Electric RCE, 4]
  - Company's proposal: Fixed DMRS pattern in frequency is supported for PSSCH [LG Electronics, 7] [OPPO, 14] [Intel Corporation, 16] (3 companies)
    - Rationale:
      - Optimized DMRS pattern can be used to reduce overhead [Intel Corporation, 16]
- Whether PDSCH/PUSCH DMRS configuration 1 or 2 is reused
  - Company's proposal: Support DMRS configuration 1 [LG Electronics, 7] [Nokia, Nokia Shanghai Bell, 19] [InterDigital, Inc., 20] [Ericsson, 29] (4 companies)
    - Rationale:

        - Number of antenna ports will be limited (e.g. up to 2) and MU-MIMO is not a main target [LG Electronics, 7] [Ericsson, 29]
        - Better performance over Type 2 [InterDigital, Inc., 20]
        - accurate channel estimation especially for the channels/scenarios with relatively large channel delay [Nokia, Nokia Shanghai Bell, 19]
        - enough DMRS elements are needed to enable sufficient performance in the low SNR regime [Nokia, Nokia Shanghai Bell, 19]
    - Company's proposal: Support DMRS configuration 2 [Mitsubishi Electric RCE, 4] [NEC, 22] (2 companies)
        - Rationale:
            - Lower overhead [Mitsubishi Electric RCE, 4] [NEC, 22]
    - Company's proposal: Support both DMRS configurations [Huawei, HiSilicon, 1] (1 company)
        - Rationale:
            - Type-1 DMRS is configured at least for 60 kHz / Type-2 DMRS is configured at least for 15kHz and 30kHz [Huawei, HiSilicon, 1]

Observation

- No majority view was observed regarding the frequency domain PSSCH DMRS pattern.

- Issue 9-3: Others
    - Company's proposal [Huawei, HiSilicon, 1]
        - The PSFCH DMRS is based on the design of DMRS in NR Uu PDCCH, with consideration of some simplifications and modifications.
    - Company's proposal [Mitsubishi Electric RCE, 4]
        - For PSSCH DM-RS, support time domain patterns with 1, 2, 3 and 4 DM-RS per slot
            - FFS maximum number of DM-RS for each slot length
            - FFS exact positions
            - FFS potential further restrictions based on SCS and/or MCS.
    - Company's proposal [OPPO, 14]
        - DMRS pattern of PSCCH can be numerology or resource pool specific
    - Company's proposal [Intel Corporation, 16]
        - NR V2X PSSCH/PSCCH sidelink physical structure and DMRS take into account benefits of multiple decoding attempts for sidelink transmissions collided on the same resources:
            - DMRS patterns should avoid collisions with control or data transmissions
            - PSSCH DMRS sequence generation is randomized based on SCI payload/content (e.g. source and/or destination ID, resource allocation information or other fields) can be used for DMRS sequence randomization
                - FFS if dedicated fields are introduced to SCI to randomize DMRS sequence generation or selection of DMRS parameters
            - Use of UE location information to generate sidelink DMRS
    - Company's proposal [Nokia, Nokia Shanghai Bell, 19]
        - Support multiple orthogonal DMRS patterns in frequency to suppress the potential colliding interference.
        - Discuss the solution to mitigate the impact of aperiodic packets on the sidelink channel measurement and UE resource selection. S-RSSI measurement based on DMRS could be considered.
    - Company's proposal [NEC, 22]
        - In Option 3, DMRS for PSSCH part with mapping type A and PSSCH part mapping type B should be inserted separately.
    - Company's proposal [Xiaomi Communications, 23]
        - The density of DMRS in time domain and frequency domain could be dynamic or semi-static configured according to different carrier frequency, numerology and channel status between transmitter and receiver(s).
        - Better PSCCH demodulation performance can be achieved by removing DMRS symbols in PSCCH and using PSSCH DMRS to demodulate PSCCH.
    - Company's proposal [ITL, 26]

- Common design for PSCCH DMRS and PSSCH DMRS should be further studied

1.1.1.14 Measurement RS

Issue 10-1: Whether to support CSI-RS

- Company's proposal: Support CSI-RS [Huawei, HiSilicon, 1] [Fujitsu, 8] [OPPO, 14] [HEPTA 7291, 21] [NTT DOCOMO, INC., 25] [Qualcomm Incorporated, 28] [Ericsson, 29] (7 companies)
  - Rationale:
    - Channel estimation to provide better spectrum efficiency [Huawei, HiSilicon, 1] [Fujitsu, 8] [OPPO, 14] [HEPTA 7291, 21] [NTT DOCOMO, INC., 25] [Qualcomm Incorporated, 28] [Ericsson, 29]
- Company's proposal: No support CSI-RS [Intel Corporation, 16] (1 company)
  - Rationale:
    - Sufficient performance can be achieved using DMRS [Intel Corporation, 16]

Observation

- Majority companies support CSI-RS for NR sidelink.

Proposal for agreement:

- Decide whether to support CSI-RS based on the progress in 7.2.4.1.2

Issue 10-2: Whether to support PT-RS in FR1

- Company's proposal: Support PT-RS in FR1 [InterDigital, Inc., 20]
  - Rationale:
    - For Doppler frequency estimation
- Company's proposal: Not support PT-RS in FR1 [Huawei, HiSilicon, 1]
  - Rationale:
    - high density in both time domain and frequency domain and TRS can also be configured in FR1

1.1.1.15 Meeting Agreements

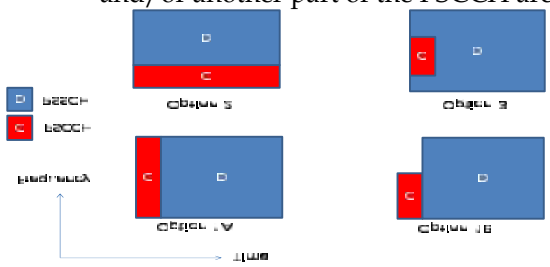
This section provides all the meeting agreements during the NR V2X study item phase for physical layer structure.

In RAN1 #94, the following agreements were made for physical layer design:

Agreement for physical layer design:

- At least PSCCH and PSSCH are defined for NR V2X. PSCCH at least carries information necessary to decode PSSCH.
  - Note: PSBCH will be discussed in the synchronization agenda.
- RAN1 continues study on the necessity of other channels.
- Further study on
  - Whether/which sidelink feedback information is carried by PSCCH or by another channel/signal.
  - Whether/which information to assist resource allocation and/or schedule UE's transmission resource(s) is carried by PSCCH or by another channel/signal.
  - PSCCH format(s) and content(s) for unicast, groupcast, and broadcast
- RAN1 continues study on the necessity, benefits and relationship between bandwidth part and resource pool.
- RAN1 to continue study on the physical channel considering at least the following aspects:
- Waveform
  - Candidates: CP-OFDM, DFT-s-OFDM
    - Proposals from companies:
      - CP-OFDM only
      - Support both
  - Consideration points:
    - Different channel can have different waveform?
    - Benefit and impact of supporting only one waveform and supporting both waveforms

- Subcarrier spacing
  - Candidates for further study are:
    - FR1: 15 kHz, 30 kHz, 60 kHz, 120 kHz
    - FR2: 30 kHz, 60 kHz, 120 kHz, 240 kHz
- Companies are encouraged to consider the potential issues and benefit of introducing new subcarrier spacing.
- CP length
- RS design
  - Candidates are:
    - DM-RS: DM-RS defined in Rel-15 NR Uu is the starting point.
    - PT-RS
    - CSI-RS
    - SRS
    - AGC training signal
- Channel coding
  - For data, channel coding defined for data in Rel-15 NR Uu is the starting point.
  - For control, channel coding defined for control in Rel-15 NR Uu is the starting point.
- Modulation
- RE mapping and rate-matching
- Scrambling
- RAN1 to continue study on multiplexing physical channels considering at least the above aspects:
- Multiplexing of PSCCH and the associated PSSCH (here, the "associated" means that the PSCCH at least carries information necessary to decode the PSSCH).
- Study further the following options:
  - **Option 1:** PSCCH and the associated PSSCH are transmitted using non-overlapping time resources.
  - **Option 1A:** The frequency resources used by the two channels are the same.
  - **Option 1B:** The frequency resources used by the two channels can be different.
  - **Option 2:** PSCCH and the associated PSSCH are transmitted using non-overlapping frequency resources in the all the time resources used for transmission. The time resources used by the two channels are the same.
  - **Option 3:** A part of PSCCH and the associated PSSCH are transmitted using overlapping time resources in non-overlapping frequency resources, but another part of the associated PSSCH and/or another part of the PSCCH are transmitted using non-overlapping time resources.



In RAN1 #94bis, the following agreements were made for physical layer design:

Agreement for physical layer design:

- NR sidelink supports the SCSs supported by Uu in a given frequency range, i.e., {15, 30, 60 kHz} in FR1 and {60, 120 kHz} in FR2.
  - **FFS the supported CP length**
  - Baseline is that a UE is not required to receive sidelink transmissions using different SCSs simultaneously in a given carrier.
    - **FFS if this applies to sidelink synchronization signals/channels**
  - Baseline is that a UE is not required to transmit sidelink transmissions using different SCSs simultaneously in a given carrier.
    - **FFS if this applies to sidelink synchronization signals/channels**
- Continue discussion on the **waveform (only CP-OFDM or both CP-OFDM and DFT-S-OFDM)** till next meeting – companies are encouraged to perform more analysis/evaluations.

- For PSCCH and associated PSSCH multiplexing
  - At least one of Option 1A, 1B, and 3 is supported.
    - **FFS whether some options require transient period between PSCCH and PSSCH.**
  - **FFS whether to support Option 2**
- Sidelink control information (SCI) is defined.
  - SCI is transmitted in PSCCH.
  - SCI includes at least one SCI format which includes the information necessary to decode the corresponding PSSCH.
    - **New data indicator (NDI), if defined, is a part of SCI**
- Sidelink feedback control information (SFCI) is defined.
  - SFCI includes at least one SFCI format which includes HARQ-ACK for the corresponding PSSCH.
    - **FFS whether a solution will use only one of "ACK," "NACK," "DTX," or use a combination of them.**
  - **FFS how to include other feedback information (if supported) in SFCI.**
  - **FFS how to convey SFCI on sidelink in PSCCH, and/or PSSCH, and/or a new physical sidelink channel**
- **FFS in the context of Mode 1:**
  - Whether/how to convey information for SCI on downlink
  - Whether/how to convey information of SFCI on uplink
- At least resource pool is supported for NR sidelink
  - Resource pool is a set of time and frequency resources that can be used for sidelink transmission and/or reception.
    - **FFS whether a resource pool consists of contiguous resources in time and/or frequency.**
    - A resource pool is inside the RF bandwidth of the UE.
    - **FFS how gNB and other UEs know the RF bandwidth of the UE**
  - **FFS if BWP (if defined) can be used to in defining at least part of resource pool**
  - **FFS if the numerology of a resource pool is indicated as a part of (pre-)configuration for resource pool, carrier, band, or BWP (if defined)**
  - UE assumes a single numerology in using a resource pool.
  - Multiple resource pools can be configured to a single UE in a given carrier.
    - **FFS how to use multiple resource pools when (pre-)configured.**
- **FFS BWP is supported for NR sidelink**
  - **FFS whether RAN1 can assume that at most one BWP is configured in a carrier from the system perspective.**
  - It is RAN1 understanding that, in some cases, the entire system bandwidth is covered by a single BWP.
  - **FFS the details of BWP configurations, including the possibility of restricting the number of BWPs**
  - **FFS whether BWP for TX and RX is separated or a common BWP applied to both TX and RX**
  - There is at most one activated sidelink BWP for a UE in a given carrier as in the Uu case
    - Further study the feasibility, benefit, and impact of sidelink BWP switching
  - Aim to conclude in RAN1#95
    - **Companies are encouraged to provide more analysis, including checking current Rel-15 specification regarding BWP related text**

In RAN1 #95, the following agreements were made for physical layer design:

Agreement for physical layer design:

- At least CP-OFDM is supported.
- Continue study on whether to support DFT-S-OFDM including the potential issues and the following potential benefit:
  - Synchronization coverage enhancement
  - PSCCH coverage enhancement, e.g., with Option 2 of PSCCH/PSSCH multiplexing with the restriction that PSCCH and PSSCH use adjacent frequency resources
  - Feedback channel coverage enhancement

- A single waveform is used in all the sidelink channels in a carrier.
  - Note: A sequence based channel can be supported in any waveform.
  - (Pre-)configuration will be used to determine the used waveform if the specification supports multiple waveforms.

- For PSCCH/PSSCH in FR1, NR V2X supports normal CP for 15kHz, 30kHz, 60kHz, and extended CP for 60kHz.
  - FFS extended CP for 30 kHz in FR1.
- FFS CP for PSCCH/PSSCH in FR2
  - E.g., NR V2X supports normal CP for 60kHz and 120kHz, and extended CP for 60kHz
    - FFS extended CP for 120 kHz in FR2.
- Only one combination of CP length and SCS is used in a carrier at a given time for NR V2X UEs communicating with each other using SL

- BWP is defined for NR sidelink.
  - In a licensed carrier, SL BWP is defined separately from BWP for Uu from the specification perspective.
    - FFS the relation with Uu BWP.
  - The same SL BWP is used for both Tx and Rx.
  - Each resource pool is (pre)configured within a SL BWP.
  - Only one SL BWP is (pre)configured for RRC idle or out of coverage NR V2X UEs in a carrier.
  - For RRC connected UEs, only one SL BWP is active in a carrier. No signalling is exchanged in sidelink for activation and deactivation of SL BWP.
    - Working assumption: only one SL BWP is configured in a carrier for a NR V2X UE
      - Revisit in the next meeting if significant issues are found
  - Numerology is a part of SL BWP configuration.

Note: This does not intend to make restriction in designing the sidelink aspects related to SL BWP.
Note: This does not preclude the possibility where a NR V2X UE uses a Tx RF bandwidth the same as or different than the SL BWP.

Working assumption:
- Regarding PSCCH / PSSCH multiplexing, at least option 3 is supported for CP-OFDM.
  - RAN1 assumes that transient period is not needed between symbols containing PSCCH and symbols not containing PSCCH in the supported design of option 3.
  - FFS how to determine the starting symbol of PSCCH and the associated PSSCH
  - FFS for other options. e.g. whether some of them are supported to increase PSCCH coverage.

Working assumption:
- For RAN1 evaluation purpose only, until RAN4 response on AGC and switching time, it is assumed that one symbol is used for AGC and another one symbol is used for TX/RX switching.

Note: TX/RX switching includes transition in the power amplifier.

In RAN1 #AH_1901, the following agreements were made for physical layer design:
Agreement for physical layer design:
R1-1901322 Feature lead summary for agenda item 7.2.4.1.1 Physical layer structure LG Electronics
R1-1901438
Proposals**:**
- No consensus in supporting DFT-S-OFDM for NR SL in Rel-16

To conclude in RAN1#96

Conclusion:
- No extended CP is supported for 30 kHz in FR1 in Rel-16
- No extended CP is supported for 120 kHz in FR2 in Rel-16

Agreements:

- Confirm the working assumption
  - Working assumption: only one SL BWP is configured in a carrier for a NR V2X UE

Agreements:
- Configuration for SL BWP is separated from Uu BWP configuration signalling.
  - UE is not expected to use different numerology in the configured SL BWP and active UL BWP in the same carrier at a given time.
    - FFS the time scale
    - FFS relation to DL BWP including initial Uu BWP
    - FFS relation in terms of frequency location and bandwidth

Agreements:
- For time domain resources of a resource pool for PSSCH,
  - Support the case where the resource pool consists of non-contiguous time resources
    - FFS details including granularity
- For frequency domain resources of a resource pool for PSSCH,
  - Down select following options:
    - Option 1: The resource pool always consists of contiguous PRBs
    - Option 2: The resource pool can consist of non-contiguous PRBs

Agreements:
- Multiple DMRS patterns in time domain are supported for PSSCH
  - FFS: Whether a DMRS pattern is selected based on the subcarrier spacing
  - FFS: Single or multiple DMRS pattern(s) per a resource pool
  - FFS: How TX UE and RX UE can be aligned in terms of the DMRS pattern used for PSSCH
  - FFS: RE mapping, sequence generation
- Continue to study DMRS pattern in frequency domain for PSSCH
  - E.g. Whether multiple patterns are supported, whether PDSCH/PUSCH DMRS configuration 1 or 2 is reused.

Agreements:
- Support PT-RS for PSSCH for FR2

Conclusion:
- RAN1 to conclude on the need of physical channel for discovery in RAN1#96.

In RAN1 #96, the following agreements were made for physical layer design:

Agreement for physical layer design:
- Rel-16 NR sidelink supports CP-OFDM only.

Agreements:
- For PSCCH/PSSCH in FR2, NR V2X supports normal CP for 60 kHz, 120 kHz, and extended CP for 60 kHz.
- Note: it is understood that PSFCH follows the same CP as PSCCH/PSSCH

Agreements:
- For the operation regarding PSSCH, a UE performs either transmission or reception in a slot on a carrier.
- NR sidelink supports for a UE:
  - A case where all the symbols in a slot are available for sidelink.
  - Another case where only a subset of consecutive symbols in a slot is available for sidelink
    - Note: this case is not intended to be used for the ITS spectra, if there is no forward-compatibility issue. Finalize in the WI phase whether there is such an issue or not
    - The subset is NOT dynamically indicated to the UE
    - FFS the supported slot configuration(s)
    - FFS whether/how to operate it in partial coverage scenarios

Proposal for agreement (discussed but no consensus reached):
- It is supported that a UE decodes a single SCI to receive a PSSCH.
  - FFS whether to support the case where a UE decodes two SCI to receive a PSSCH.

Discuss further offline – especially regarding the details of 2-stage, applicability to different transmissions (unicast/broadcast/groupcast), etc.

Agreements:

- At least for sidelink HARQ feedback, NR sidelink supports at least a PSFCH format which uses last symbol(s) available for sidelink in a slot.

Agreements:

- RAN1 concludes that no additional physical channel needs to be defined for the purpose of discovery in Rel-16.

1.1.2 Physical Layer Procedure

Including HARQ feedback, CSI acquisition, etc.

Highlights

Multiplexing of physical channels

- A PSSCH is said to be "associated" to a PSCCH when the PSCCH carries at least the SL control information (SCI) necessary to decode the PSSCH. The following option for multiplexing of a PSCCH and associated PSSCH is supported:
  - Option 3: Part of PSCCH and the associated PSSCH are transmitted using overlapping time resources in non-overlapping frequency resources, but another part of the associated PSSCH and/or another part of the PSCCH are transmitted using non-overlapping time resources.

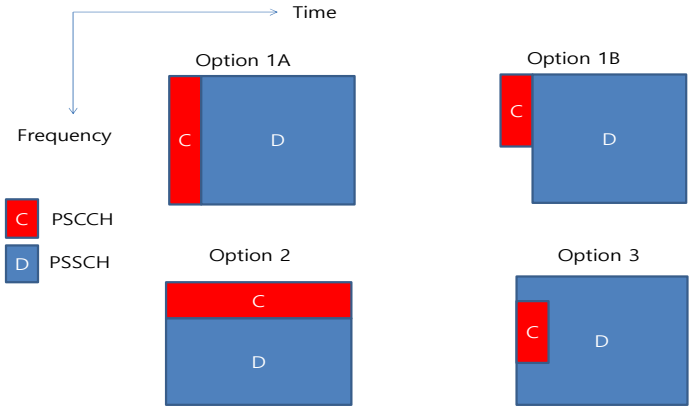


Figure 1: Illustration of multiplexing options for PSCCH and associated PSSCH.

HARQ procedures

- General HARQ procedures
  - For SL unicast and groupcast, HARQ feedback and HARQ combining in the physical layer are supported. HARQ-ACK feedback for a PSSCH is carried in SL feedback control information (SFCI) format(s) via PSFCH in resource allocation Modes 1 and 2.
  - When SL HARQ feedback is enabled for unicast, in the case of non-CBG operation the receiver UE generates HARQ-ACK if it successfully decodes the corresponding TB. It generates HARQ-NACK if it does not successfully decode the corresponding TB after decoding the associated PSCCH targeted to the receiver UE.
  - When SL HARQ feedback is enabled for groupcast, it supported to use TX-RX distance and/or RSRP in deciding whether to send HARQ feedback. In the case of non-CBG operation, two options are supported: (Editor's note: This is a RAN1 working assumption)
    - Option 1: Receiver UE transmits HARQ-NACK on PSFCH if it fails to decode the corresponding TB after decoding the associated PSCCH. It transmits no signal on PSFCH otherwise.
    - Option 2: Receiver UE transmits HARQ-ACK on PSFCH if it successfully decodes the corresponding TB. It transmits HARQ-NACK on PSFCH if it does not successfully decode the corresponding TB after decoding the associated PSCCH which targets the receiver UE.

- HARQ procedure details for Mode 1 resource allocation
  - The time between PSSCH and sending HARQ feedback on PSFCH is (pre-)configured. For unicast, if retransmission is needed on the SL, this can be indicated to the gNB by an in-coverage UE using PUCCH. It is supported that the transmitter UE sends the indication to its serving gNB in the form of SR/BSR, etc. (but not in the form of HARQ ACK/NACK). Two options are studied in this section:
    - Option 1: The receiver UE sends the indication to its serving gNB, as HARQ ACK/NACK, and there is no inter-BS.
    - Option 2: The transmitter UE sends the indication to gNB.
  - We agreed to select option 1.
  - SL re-transmission resources can also be scheduled by the gNB without receiving such an indication.
- HARQ procedure details for Mode 2 resource allocation
  - The time between PSSCH and sending HARQ feedback on PSFCH is (pre-) configured.

CSI acquisition
  - The usefulness, when it is available, of information representing the channel between the transmitter and receiver, and of information representing the interference at the receiver is studied. Examples of CSI information for V2X are CQI, PMI, RI, RSRP, RSRQ, pathgain/pathloss, SRI, CRI, interference condition, vehicle motion. For unicast communication, CQI, RI and PMI, or a subset among them, are supported with non-subband-based aperiodic CSI reports assuming no more than 4 antenna ports. The CSI procedure does not rely on a 'standalone' RS. CSI reporting can be enabled and disabled by configuration.

Power control
- Open-loop power control (OLPC) procedures are supported for SL. When the transmitting UE is in-coverage, gNB can enable OLPC for a unicast, groupcast or broadcast transmission based on the pathloss between the transmitting UE and its serving gNB. This is in order to mitigate interference to the gNB's UL reception. Additionally, at least for unicast, (pre-)configuration can enable also using the pathloss between the transmitting and receiving UE, in which case the receiving UE reports SL RSRP to the transmitting UE, which derives a pathloss estimation.
- To support OLPC, long-term measurements, i.e. with L3 filtering, on SL are supported, at least for unicast. The SL does not support TPC commands.

Beam management
- RAN1 conducted a limited study on beam management, and concluded that it is beneficial for the SL. In FR1, it is feasible to support V2X use cases without SL beam management. In FR2, it is feasible to support some V2X use cases without SL beam management in some scenarios. To improve communication range in FR2, panel selection is necessary.

Multi antenna scheme
- Whether/how to support multi-antenna transmission scheme at least for the purpose of supporting high data rate and reliability in sidelink operation?
  - Summary of company's view:
    - Open-loop MIMO scheme (e.g., SFBC, pre-coder cycling)
      - Supported by [Huawei][vivo][MediaTek][ZTE, Sanechips][OPPO] [Nokia,NSB][HEPTA 7291][NEC] (8 companies)
    - Closed-loop MIMO scheme
      - Supported by [Huawei][vivo][ZTE, Sanechips][Samsung][Nokia,NSB][HEPTA 7291][NEC][Ericsson] (8 companies)
    - Note that support of closed-loop MIMO scheme depends on whether to introduce the sidelink short-term channel quality measurement/feedback
    - MU-MIMO scheme

- Supported by [Samsung]

Observation

- Majority companies supports open-loop MIMO and closed-loop MIMO to improve spectral efficiency and to mitigate interference to other UEs.
- This issue is to be discussed with section 5.

Work Item Phase

NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

- Sidelink procedures for the above, including those identified in TR 38.885 for the work item phase.

R1-1901323 Feature lead summary for agenda item 7.2.4.1.2 Physical layer procedures, LGE

1.1.2.1 Highlights

This is the issues list related to the physical layer procedures.

1.1.2.2 Necessary information in physical layer

Issue 2-1: Whether mechanism to handle collision in layer-1 ID is supported or not? In detail, company's view and its rationale are as follows:

- Supported by [LG,6][CATT,8][Samsung,14][Sharp,22]
  - Rationale:
    - To avoid wrong HARQ combining [LG,6][CATT,8][Samsung,14]
    - To ensure unintended PSSCH transmissions can be filtered out [Sharp,22]

Issue 2-2: How to derive Layer-1 ID? In detail, company's view and its rationale are as follows:

- Layer-1 ID is derived by upper layer ID
  - Supported by [Huawei,1][vivo,2][LG,6][CATT,8][Sharp,22][ITL,29] [Qualcomm,30][Ericsson,32] (8 companies)
  - Rationale:
    - SA2 agreed that the source and destination L2 IDs are provided by V2X layer to AS layer
  - Comments from [Ericsson,32]
    - Discuss the size and determination of Layer-1 IDs during the WI and based on RAN2 progress.
  - Comments from [Lenovo, Motorola,11]
    - Layer-1 destination ID is derived by upper layer destination ID
- Layer-1 source ID is a temporary ID
  - Supported by [Lenovo,Motorola,11]
  - Rationale:
    - Reduced SCI field size
- Layer-1 source ID is designated by Rx UE
  - Supported by [NEC,24]
  - Rationale:
    - Collision avoidance in Layer-1 source ID

Observation

- The issue of Layer-1 ID collision was raised by several companies. It was the majority view that Layer-1 ID is derived by upper layer ID.

Issue 2-3: Whether some of SCI fields such as Layer-1 ID, HPN, NDI, RV are not present? In detail,

company's view and its rationale are as follows:

- Summary of supporting company's view/preference as follows:
  - For broadcast or unicast/groupcast without HARQ feedback, SCI indicates both initial transmission resources and retransmission resources, and Layer-1 ID, HPN, NDI, and RV may not be present in SCI [CATT,8][InterDigital,21]
  - For unicast/groupcast with HARQ feedback, Layer-1 ID, HPN, NDI, and RV are present in SCI [CATT,8]
  - L1 destination ID is always present, HARQ process ID, RV, NDI and L1 source ID are only present for unicast/groupcast [ZTE, Sanechips,10]
  - No layer-1 destination ID for broadcast [Sony,12][Samsung,14][Sharp,22]
  - Full Layer-1 source and destination ID should be included in SCI [OPPO,16]
  - Comments from [LG,6][CATT,8][Samsung,14]
    - For asynchronous HARQ, Layer-1 ID, HPN, NDI, and RV are present in SCI for TB identification [LG,6][CATT,8]
    - For broadcast, Layer-1 destination ID could be useful in that UE can distinguish interest broadcast services [LG,6]

Observation

- Companies have divergent views on whether Layer-1 destination ID, HPN, NDI, and/or RV are present in SCI for sidelink transmission without HARQ feedback. Meanwhile, it is straightforward at least for asynchronous HARQ operation, these SCI fields need to be present for TB identification for soft HARQ combining.

1.1.2.3 Sidelink HARQ Feedback

Issue 3-1: How to determine the time gap between PSSCH and the associated PSFCH? In detail, company's view and its rationale are as follows:

- For Mode 1,
  - the time gap is indicated by SCI
    - Supported by [vivo,2][Sony,12][Samsung,14][OPPO,16][NTT,28] (5 companies)
    - Rationale:
      - To reduce the slot containing PSFCH considering small number of Rx-Tx switching and coexistence between sidelink and Uu link [vivo,2]
      - Different types of services and different categories of UEs [vivo,2]
      - gNB can manage resources in the sidelink [Sony,12][Samsung,14]
  - the time gap is (pre-)configured
    - Supported by [Huawei,1][LG,6][CATT,8][ZTE,Sanechips,10][OPPO,16][InterDigital,21][HEPTA 7291,23][NTT,28][Qualcomm,30][Ericsson,32] (10 companies)
    - Rationale:
      - Beneficial in sensing operation considering resource pool shared by Mode 1 and Mode 2 operation
- For Mode 2, (pre)configuration indicates the time gap
  - Supported by [Huawei,1][LG,6][CATT,8][ZTE,Sanechips,10][InterDigital,21]
    - Rationale:
      - Consider UE's decoding capability and the latency requirement

Observation

- Majority companies support the time gap between PSFCH and the associated PSSCH is not indicated in SCI considering potential resource sharing between Mode 1 and Mode 2 operation.
- Proposals for the flexible time gap between PSFCH and the associated PSSCH need to consider the

case where resource pool shared by Mode 1 and Mode 2 operation.

Issue 3-2: How to determine the frequency/code resource of PSFCH? In detail, company's view and its rationale are as follows:

- The resource is indicated by SCI
  - Supported by [vivo,2][Fujitsu,7][CATT,8][Intel,19][NTT,28][ITL,29] (6 companies)
  - Rationale:
    - Different types of services and different categories of UEs [vivo,2]
    - Consider PUCCH resource determination in NR Uu link as a baseline [Fujitsu,7]
    - Consider multiple PSSCHs are associated with the same PSFCH slot [Intel,19]
    - Efficient resource utilization [ITL,29]
- The resource is implicitly given by the associated PSSCH resource
  - Supported by [LG,6][CATT,8][Sony,12][Panasonic,13][ASUSTEK,18][NTT,28] (6 companies)
  - Rationale:
    - Efficient collision handling [LG,6]
    - Simple PSFCH resource allocation without sensing operation [LG,6][ASUSTEK,18]
    - Save SCI overhead [Panasonic,13]
- The resource is determined by Rx UE
  - Supported by [Fujitsu,7][OPPO,16] (2 companies)
  - Rationale:
    - Collision/interference avoidance
  - Comments from [Fujitsu,7][OPPO,16][ITRI,17]
    - Conveying source ID and/or destination ID in PSFCH is needed to identify the relationship between PSFCH and the associated PSSCH.
  - Comments from [Sony,12]
    - PSFCH resources should be allocated by Tx UE to transmit PSFCH with no sensing operation and to ensure Tx UE identifies which UE transmit PSFCH.

Observation

- No clear majority view was observed regarding PSFCH resource allocation in frequency/code domain.
- The decision for PSFCH resource allocation needs to consider how many PSSCH can be associated with the same PSFCH slot.
- Companies are encouraged to continue discussion together with considering how slot containing PSFCH resource is (pre-)configured and PSFCH design.

Issue 3-3: For groupcast HARQ feedback, whether the working assumption is confirmed or not? In detail, company's view and its rationale are as follows: (i.e., Option 1: Receiver UE transmits only HARQ NACK, Option 2: Receiver UE transmits HARQ ACK/NACK)

- Support only Option 1
  - Supported by [LG,6][Kyocera,9][ZTE,Sanechips,10][Panasonic,13] (4 companies)
  - Rationale:
    - To minimize SL HARQ feedback reporting/resource overhead (e.g., by sharing the same feedback resource among the group members) [LG,6][Kyocera,9][Panasonic,13]
    - Feasible for both connection-less and connection-oriented groupcast [LG,6][ZTE,Sanechips,10]
    - No need to handle DTX issue and destructive channel sum effect [Qualcomm,30]
    - DTX issue is alleviated by using energy detection for PSCCH RS [LG,6]
    - Destructive channel sum effect is alleviated by using randomized sequence selection per receiver UE [LG,6]

- Comments from [Samsung,14]
  - The error rate of PSSCH in groupcast transmission would be low-bounded by the error rate of PSCCH

- Support only Option 2
  - Supported by [Huawei,1][OPPO,16] (2 companies)
  - Rationale:
    - Option 2 has no DTX problem and has no destructive sum effect if dedicated PSFCH resource for each UE is supported [Huawei,1]
  - Comments from [LG,6][ZTE,Sanechips,10]
    - How to allocate dedicated PSFCH resources needs to be defined
    - It is not feasible for connection-less groupcast
  - Comments from [OPPO,16]
    - For connection-less groupcast, feedback can be disabled and N re-transmissions can be applied by TX UE.
- Confirm the working assumption which support both Option 1 and Option 2
  - Supported by [vivo,2][MediaTek,3][Lenovo,Motorola,11][Sony,12][ITRI,17] [InterDigital,21][HEPTA 7291,23][NEC,24][Xiaomi,25][Spreadtrum,26][NTT,28][ITL,29] [Qualcomm,30][Ericsson,32] (14 companies)
  - Comments from [Xiaomi,25]
    - Within a group associated with the same groupcast, some portion of UEs use Option 1 while others use Option 2.
- Comments from [Nokia,NSB,20]
  - Support HARQ feedback mechanism to alleviate PSFCH resource overhead together with handling DTX issue

Observation

- Majority companies propose to confirm the working assumption that support both Option 1 and Option 2 for groupcast.

Issue 3-4: Whether/how to support TX-RX distance based SL HARQ feedback? In detail, company's view and its rationale are as follows:

- Supported by [LG,6][HEPTA 7291,23][Qualcomm,30] (3 companies)
  - Rationale:
    - For certain advanced use cases, UEs in certain range of a transmitter UE are required to receive messages more reliably than UEs which are far away from the transmitter UE
    - SA2 found that in addition to 5QI metrics, minimum communication rage is an important metric to be considered in NR V2X scenarios (TR 23.786)
    - Connection-less groupcast
  - Comments from [Qualcomm,30]
    - System-level evaluation results shows that distance-based NACK feedback performs better than RSRP based retransmission for all UEs in the system
    - The following was agreed in SA2 regarding the range:

> This solution follows the below principles when NR PC5 is the selected RAT:
> - V2X Layer informs the Access Stratum (AS) Layer of the Destination L2 ID for the group communication transmission, based on group identifier provided by Application Layer;
> - V2X Layer informs the Access Stratum (AS) Layer of the Source L2 ID (self-assigned by the UE) for the group communication transmission;
> - V2X Layer informs the Access Stratum Layer of the communication type, and QoS parameters (including 5QI) and Range for the group communication traffic;
> - NOTE 1: Range may also be provided to AS Layer for the dynamic group communication operations, depending on RAN decisions.

- V2X Layer informs the Access Stratum Layer of the Destination L2 ID for the group communication reception;
- When V2X Layer receives no group information from Application Layer, it should then use the default mapping, e.g. derive destination L2 ID and QoS parameters (e.g. VQI) and Range based on PSID/ITS-AID mapping, and use those for the operation;
- V2X Layer coverts the Group Identifier provided by Application Layer into the Destination L2 ID, using a mechanism defined by stage 3.
- NOTE 2: Different Destination L2 IDs may be used for different QoS levels.
- NOTE 3: Stage 3 needs to standardize the mechanism to be used by both transmitting and receiving UE, e.g. a specific hash function.

- Not supported by [Huawei,1][Kyocera,9] (2 companies)
  - Rationale:
    - Range may be used as a factor to determine a group at application layer [Huawei,1]
    - The receiving UEs will not need to track their positions, zone ID, etc. relative to the transmitting UEs [Kyocera,9]
- Commented from [Huawei,1]
  - When no sidelink group information is provided by Application Layer, assume the service is provided using sidelink broadcast in the radio layers [Huawei,1]
    - Rationale:
      - A unified design for resource allocation of unicast, groupcast and broadcast transmissions can simplify both the specification and implementation.

Observation

- No consensus was observed regarding supporting TX-RX distance based SL HARQ feedback, e.g., considering the 5QI metrics defined in SA2.
- Companies have different views on how to progress based on SA2 agreement, i.e., whether radio layer needs to support features optimized for groupcast (e.g., HARQ feedback) when the application layer does not form the receiver group or the receiver group formed by the application layer includes UEs outside the minimum required communication range.

Issue 3-5: How to report the indication of the need of SL retransmission to gNB via UL in Mode 1? In detail, company's view and its rationale are as follows:

- Which UE sends SL retransmission indication to gNB via UL?
  - Transmitter UE
    - Supported by [Huawei,1][Fraunhofer,4][LG,6][Fujitsu,7][CATT,8][ZTE,Sanechips,10][Samsung,14][CMCC,15][OPPO,16][ASUSTEK,18][Intel,19][Nokia,NSB,20][InterDigital,21][Sharp,22][NEC,24][Xiaomi,25][NTT,28][ITL,29][Ericsson,32] (19 companies)
      - Rationale:
        - It has no limitation on the location and status of receiver UE (e.g., idle/inactive state, out of coverage) [Huawei,1][LG,6][ZTE,Sanechips,10][OPPO,16][ASUSTEK,18][Intel,19][Nokia,NSB,20][InterDigital,21][Xiaomi,25][Ericsson,32]
        - Transferring sidelink feedback from the receiver UE over Uu link(s) and Xn interface is complicated [Huawei,1][LG,6]
        - Reduce control signaling for Rx UE to transmit PUCCH [ZTE,Sanechips,10][Ericsson,32]
        - Potential misalignment on the number of HARQ-ACK bits between gNB and receiver UE [Fraunhofer,4]
        - PUCCH resource determination mechanism in Uu link can be reused [LG,6][ZTE,Sanechips,10][Samsung,14][CMCC,15][ASUSTEK,18]
        - Simple procedure for groupcast [Huawei,1][Fujitsu,7][Samsung,14]
  - Receiver UE

- ❖ Note that this approach may be beneficial only if both the transmitter UE and the receiver UE are served by the same gNB, and the receiver UE is in RRC-CONNECTED.
- ❖ supported by [vivo,2][MediaTek,3][Fujitsu,7][CATT,8][Samsung,14][CMCC,15][OPPO,16] [Sharp,22][NEC,24][NTT,28][ITL,29][Convida,31] (12 companies)
  - Rationale:
  - Low scheduling delay [vivo,2][MediaTek,3][Fujitsu,7][CATT,8][CMCC,15] [OPPO,16][Convida,31]
  - Rx UE does not need to transmit SL HARQ feedback in the sidelink [vivo,2][Fujitsu,7][CMCC,15]
  - Typical scenario of Mode 1 is that both Tx UE and Rx Ue are within the coverage of the same cell [MediaTek,3]

- Which information to send
  - HARQ ACK/NACK
    - ❖ Supported by [Huawei,1][Fujitsu,7][CMCC,15][Sharp,22][Xiaomi,25][ITL,29] (6 companies)
  - CSI information
    - ❖ Supported by [Huawei,1][NTT,28]
  - Information for close loop power control
    - ❖ Supported by [LG,6]
  - SR and/or BSR for SL transmission
    - ❖ Supported by [Intel,19]
    - ❖ Comments from [Huawei,1]
      - SR does not help gNB to know the precise status of the sidelink transmissions
  - The number of required number of resources for retransmission
    - ❖ Supported by [Fraunhofer,4]
- PUSCH can used to convey the indication
  - Supported by [Fujitsu,7][Xiaomi,25][ITL,29]

Observation

- Majority companies support Tx UE sends an indication to gNB to indicate the need for retransmission.
- It is common understanding that the retransmission indication is sent by Tx UE at least for following cases
  - Tx UE and Rx UE are not served by the same gNB, or
  - Rx UE is not in RRC_CONNECTED mode, or
  - Groupcast

Issue 3-6: Whether or not to support additional condition to disable SL HARQ feedback when (pre-)configuration enables SL HARQ feedback. In detail, company's view and its rationale are as follows:

- Summary of supporting company's view/preference as follows:
  - Congestion level [LG,6][Sony,12][Intel,19][InterDigital,21][Sharp,22][NEC,24][Qualcomm,30] (7 companies)
    - ❖ Rationale:
      - since feedback itself may consume resources, it may be disabled in some cases to improve system performance
  - QoS parameter [LG,6][CATT,8][Sony,12][Samsung,14][Intel,19] [InterDigital,21] (6 companies)
    - ❖ Rationale:
      - Traffic types or services may be realized by mapping particular QoS attribute combinations to enabling/disabling HARQ

- ❖ Comments from [LG,6]
  - RAN1 can send an LS to RAN2 to ask them to consider the possibility of supporting TX-RX distance based SL HARQ feedback using the physical layer procedure which decides the transmission of SL HARQ feedback based on Layer-1 ID(s) included in SCI.
- RSRP/CQI level [MediaTek,3][Kyocera,9]
- Packet type [Samsung,14]
- Group size for groupcast [InterDigital,21]

- Not supported by [Huawei,1][vivo,2]
  - Rationale
    - ❖ Changes in HARQ operation are handled by re-configuration [Huawei,1][vivo,2]

Observation

- Majority companies support additional condition to disable SL HARQ feedback when (pre-)configuration enables SL HARQ feedback based on congestion level and/or QoS parameters.

Issue 3-7: Whether to support SL HARQ feedback per CBG? In detail, company's view and its rationale are as follows:

- Supported by [vivo,2][Fraunhofer,4][Fujitsu,7][Samsung,14][InterDigital,21][Ericsson,32] (6 companies)
  - Rationale:
    - ❖ Useful for very large TB size [vivo,2][Ericsson,32]
    - ❖ Different CBG may experience different interferences due to the high time selectivity [Fraunhofer,4][Fujitsu,7][Ericsson,32]
    - ❖ Resource efficiency for retransmission [Samsung,14][InterDigital,21]
- Not supported by [CATT,8][Panasonic,13] (2 companies)
  - Rationale:
    - ❖ CBG based feedback will make the retransmission very complicated as each Rx UE may have different feedback situation for transmitted CBGs due to different radio link [Panasonic,13]
    - ❖ For groupcast, gain of CBG-based HARQ operation is not clear comparing with TB-based HARQ feedback [CATT,8]
    - ❖ Large feedback overhead [Panasonic,13]

Observation

- Majority companies support CBG-based HARQ feedback and retransmission at least for unicast.
- For groupcast, no clear majority is observed that whether support CBG-based HARQ feedback and retransmission.
- CBG-based operation may have impact on SCI design and PSFCH design. Also the design needs to firstly consider the solution to be used for non-CGB-based case.
- Companies are encouraged to consider CBG-based operation aspects for SCI design and PSFCH design.

Issue 3-8: How to handle PSFCH resource in resource pool? In detail, company's view and its rationale are as follows:

- Summary of company's view/preference as follows:
  - Further study is necessary on the following cases in terms of managing resource pool for PSFCH [LG,6]
    - ❖ Option 1: Pool separation between PSFCH-enabled and -disabled pool
    - ❖ Option 2: SL transmission with PSFCH and SL transmission without PSFCH are

multiplexed in the same pool

- System-wise PSFCH resource management [Kyocera,9][Sony,12][Intel,19][Qualcomm,30] (4 companies)
  - Rationale:
    - To save resource reserved for PSFCH transmission and to mitigate half-duplex constraint [Sony,12][Intel,19][Qualcomm,30]
    - Different QoS requirement [Kyocera,9]
- Presence of PSFCH in a slot is signalled in the SCI associated with the corresponding data transmission [Ericsson,32]
  - Rationale:
    - Resources reserved for PSFCH can be used for PSSCH transmission to increase resource efficiency.

Observation

- Companies discussed how to manage PSFCH slot/resource in the perspective of network resource utilization.
- Companies are encouraged to continue to discuss how network manage PSFCH slot/resource in a resource pool considering coexistence between PSFCH-enabled and PSFCH-disabled operations, and network resource utilization efficiency.

1.1.2.4 Sidelink CSI Acquisition

Issue 5-1: How to design long-term measurement of sidelink signal. In detail, company's view and its rationale are as follows:

- Note that long-term measurement means a measurement with L3 filtering.
- The purpose of this measurement on top of the open-loop power control
  - Link management
    - Supported by [LG,6]
  - QoS prediction
    - Supported by [LG,6]
  - Initial Tx parameter setting
    - Supported by [LG,6]
- Which metric is used for this measurement
  - RSRP
    - Supported by [vivo,2][LG,6][ZTE,Sanechips,10][Samsung,14][InterDigital,21][HEPTA 7291,23]
  - RSSI
    - Supported by [vivo,2]
  - RSRQ
    - Supported by [LG,6]

Observation

- Companies discussed further details on long-term measurement such as the purpose of the measurement, and the measurement metric.
- Majority companies support RSRP for long-term measurement.
- Companies are encourage to continue to discuss the purpose of the long-term measurement on top of open-loop power control and how to measure/report it.

Issue 5-2: Whether or how to design short-term measurement of sidelink signal where L3 filtering is not applied. In detail, company's view and its rationale are as follows:

- Not supported by [LG,6][Qualcomm,30]

- Rationale:
  - Unclear benefits of having short-term channel quality measurement
- Comments from [CATT,8]
  - The co-channel interference for NR V2X is dynamic and varies in time. It is very challenged to be estimated accurately.

- Supported by [Huawei,1][vivo,2][CATT,8][ZTE,Sanechips,10][Samsung,14][InterDigital,21][Spreadtrum,26][Ericsson,32]
  - Rationale:
    - Improved spectral efficiency [Huawei,1][vivo,2][ZTE,Sanechips,10][Samsung,14][Spreadtrum,26][Ericsson,32]
    - Fluctuation on pathloss due to Tx UE and Rx in motion [CATT,8]
  - Comments from [Huawei,1]
    - Link level evaluation results show that the appropriate channel estimation accuracy/throughput can be achieved by adjusting the CSI feedback periodicity and close-loop MIMO with feedback can outperform open-loop MIMO in terms of throughput
    - System level evaluation results assuming resource allocation mode 1 where interference level is stabilized by gNB show that closed-loop MIMO can outperform open-loop MIMO in terms of PRR, throughput, and PIR in modified periodic/aperiodic traffic model.
  - Comments from [Ericsson,32]
    - Link level evaluation results show that using RI, wideband PMI and CQI reports, joint CL-MIMO and LA scheme provides clear throughput gain compared to open-loop RPS schemes in LOS scenarios.
  - The purpose of this measurement
    - Closed-loop MIMO operation
      - Supported by [Huawei,1][vivo,2][Samsung,14][Ericsson,32]
    - Adaptation on modulation and coding scheme
      - Supported by [Huawei,1][vivo,2][Samsung,14][Ericsson,32]
    - Beam management
      - Supported by [Huawei,1][vivo,2][ZTE,Sanechips,10][InterDigital,21][HEPTA 7291,23][Spreadtrum,26]
      - Comments from [AT&T,5][OPPO,16]
        - A wide beam antenna panel can work well in the range of 300meters for V2X communication
    - Open-loop power control
      - Supported by [CATT,8]
  - Which RS is used for this measurement
    - Dedicated RS for this measurement
      - Supported by [vivo,2][AT&T,5][CATT,8]
    - DMRS of PSCCH and/or PSSCH
      - Supported by [Intel,19]
      - Comments from [Intel,19]
        - Link-level evaluation results shows that throughput performance of DMRS-based measurement is comparable with ideal case.
  - Which metric is used for this measurement
    - CQI
      - Supported by [Huawei,1][vivo,2][Samsung,14][InterDigital,21]
    - RI, PMI
      - Supported by [Huawei,1][vivo,2][Samsung,14][InterDigital,21]
    - CRI/SRI

        - Supported by [Huawei,1][Samsung,14][InterDigital,21][HEPTA 7291,23]
    - L1-RSRP
        - Supported by [Huawei,1][vivo,2][CATT,8][Samsung,14][Spreadtrum,26]
    - Doppler spread and delay spread
        - Supported by [Huawei,1]
    - Interference condition

Supported by [MediaTek,3]

Observation

- Majority companies support short-term measurement which does not apply L3 filtering for open/closed-loop MIMO and adaptive modulation and coding scheme.
    - No clear majority is observed for other purposes such as beam management.
- It is commented that it is challenging to estimate the interference accurately since interference can be dynamically fluctuated in V2X environment.
- Evaluation results show that short-term measurement is beneficial under the condition where no interference model is emulated (link-level evaluation) or interference is relatively stabilized (Mode 1 operation). In addition, for system-level evaluation, periodic/aperiodic traffic profile used for the evaluation is modified to be more challenging compared to the agreed evaluation assumption.

1.1.2.5 Sidelink Power Control

- Issue 4-1: How to support SL pathloss-based open-loop power control? In detail, company's view and its rationale are as follows:
    - How to derive SL pathloss
        - Tx UE estimate the pathloss based on RSRP reported by Rx UE [Huawei,1][LG,6][Samsung,14][Intel,19][Ericsson,32] (5 companies)
            - Rationale:
                - Tx UE already knows the transmit power of RS used for RSRP measurement without signaling
        - Tx UE estimate the pathloss based on RSRP measured by Tx UE and the configured or indicated transmit power of RS used for RSRP measurement [LG,6] [ZTE,Sanechips,10][Samsung,14][Ericsson,32] (4 companies)
            - Rationale:
                - Reuse the same principle of Uu link
            - Comment from [LG,6][ZTE,Sanechips,10][Samsung,14]
                - The Tx power of the signal used for SL pathlosss estimation needs to be signaled in the sidelink.
        - Rx UE estimate the pathloss based on RSRP measured by Rx UE and Rx UE reports the derived pathloss [Spreadtrum,26]
    - SL pathloss-based open-loop power control is applicable to groupcast
        - Supported by [Huawei,1][vivo,2][LG,6][Samsung,14][InterDigital,21][HEPTA 7291,23][NEC,24] [Convida,31][Ericsson,32] (9 companies)
            - Rationale:
                - Efficient power usage and reduce interference to the sidelink
    - SL pathloss-based open-loop power control is applicable to broadcast
        - Supported by [Samsung,14]
            - Rationale:
                - Efficient power usage and reduce interference to the sidelink
    - How to inter-work between SL pathloss-based open-loop power control and DL pathloss-based open-loop power control when both pathloss are enabled
        - Take into account both DL pathloss and SL pathloss simultaneously for open-loop power

control [LG,6][Convida,31] (2 companies)
    - Rationale:
        - Optimize SL Tx power together with interference reduction
- Whether DL pathloss or SL pathloss is used for open-loop power control is configurable [OPPO,16]
    - Rationale:
        - Either UL reception or V2x service is protected based on the selected opne-loop power control.

Observation
- Majority companies supports open-loop power control based on the pathloss between Tx UE and Rx UE for groupcast.
- Companies discussed how to derive the pathloss between Tx UE and Rx UE.
- When both DL pathloss and SL pathloss are enabled, which pathloss is used for open-loop power control is discussed.
- Companies are encouraged to continue to discuss whether SL pathloss-based open-loop power control is supported for groupcast considering how the SL pahtloss is derived in unicast.
- Companies are encouraged to continue to discuss how to perform open-loop power control when both the open-loop power control based on the pathloss between TX UE and gNB and the open-loop power control based on the pathloss between TX UE and RX UE are enabled.

Proposal for agreement (offline consensus):
- For sidelink power pathloss used for sidelink power control,
    - RS used for the estimation of the sidelink pathloss
        - Option 1: Transmitted by TX UE
        - Option 2: Transmitted by RX UE

Issue 4-2: Whether or not to support SL closed-loop power control based on dynamic indication to change transmit power? In detail, company's view and its rationale are as follows:
- Supported by [vivo,2][Fraunhofer,4][ASUSTEK,18][InterDigital,21][HEPTA 7291,23][NTT,28] (6 companies)
    - Rationale:
        - Interference mitigation [vivo,2][InterDigital,21]
        - Improved spectral efficiency and robustness of SL communications [Fraunhofer,4][ASUSTEK,18][InterDigital,21][HEPTA 7291,23]
    - Comments from [vivo,2]
        - In [vivo,2] evaluation result, close-loop power control with L1 TPC feedback outperforms than without power control in terms of PRR. (i.e., a receiver UE suffering severe interference would inform the aggressor via a TPC-like L1 feedback)
- Not supported by [Samsung,14][Intel,19] (2 companies)
    - Rationale:
        - To keep consistent resource selection decisions [Samsung,14]
        - Inaccurate closed-loop power control due to the fast-changing and dynamic interference environment in V2X communication [Intel,19]

Observation
- More companies support closed-loop power control based dynamic indication to change transmit power, e.g. TPC for improved spectral efficiency and interference mitigation. But it seems necessary to clarify which entity can control transmit power of which channel.
- It is commented that dynamic power change can have impact on sensing operation.

- Companies are encouraged to continue to discuss whether or not to support closed-loop power control considering the impact on sensing operation.

Proposal for conclusion

- For closed power control, the following options are further discussed:
  - Option 1: gNB sends transmit power command
  - Option 2: Data Tx UE sends transmit power command (e.g., for power control of PSFCH)
  - Option 3: Data Rx UE sends transmit power command (e.g., for power control of PSCCH/PSSCH)

1.1.2.6 Sidelink multi-antenna transmission scheme

Issue 6-1: Whether/how to support multi-antenna transmission scheme at least for the purpose of supporting high data rate and reliability in sidelink operation?

- Summary of company's view:
  - Open-loop MIMO scheme (e.g., SFBC, pre-coder cycling)
    - Supported by [Huawei,1][vivo,2][MediaTek,3][ZTE,Sanechips,10][OPPO,16] [Nokia,NSB,20][HEPTA 7291,23][NEC,24] (8 companies)
    - Comments from [MediaTek,3]
      - Link-level evaluation results show that pre-coder cycling with smaller DMRS overhead outperforms SFBC.
  - Closed-loop MIMO scheme
    - Supported by [Huawei,1][vivo,2][ZTE,Sanechips,10][Samsung,14][Nokia,NSB,20][HEPTA 7291,23][NEC,24][Ericsson,32] (8 companies)
      - Note that support of closed-loop MIMO scheme depends on whether to introduce the sidelink short-term channel quality measurement/feedback
  - MU-MIMO scheme
    - Supported by [Samsung,14]

Observation

- Majority companies supports open-loop MIMO and closed-loop MIMO to improve spectral efficiency and to mitigate interference to other UEs.

1.1.2.7 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for physical layer procedure.

In RAN1 #94, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Proposal 1: RAN1 assumes that higher layer decides if a certain data has to be transmitted in a unicast, groupcast, or broadcast manner and inform the physical layer of the decision. For a transmission for unicast or groupcast, RAN1 assumes that the UE has established the session to which the transmission belongs to. Note that RAN1 has not made agreement about the difference among transmissions in unicast, groupcast, and broadcast manner.

- Proposal 2: RAN1 assumes that the physical layer knows the following information for a certain transmission belonging to a unicast or groupcast session. Note RAN1 has not made agreement about the usage of this information.
  - ID
    - Groupcast: destination group ID, FFS: source ID
    - Unicast: destination ID, FFS: source ID
    - HARQ process ID (FFS for groupcast)

- RAN1 can continue discussion on other information

- Proposal 3: Send LS to RAN2 and SA2 to inform Proposal 1 and 2 if agreed.

Companies discussed SL enhancements for unicast and/or groupcast. The following topics were discussed:

- Proposal 4: RAN1 to study the following topics for the SL enhancement for unicast and/or groupcast. Other topics are not precluded.
  - HARQ feedback
  - CSI acquisition
  - Open loop and/or closed loop power control
  - Link adaptation
  - Multi-antenna transmission scheme

In RAN1 #94bis, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Layer-1 destination ID is conveyed via PSCCH
  - **FFS how many bits are conveyed.**
  - **FFS details for each of the unicast/groupcast/broadcast cases**
- Additional Layer-1 ID(s) is conveyed via PSCCH at least for the purpose of identifying which transmissions can be combined in reception when HARQ feedback is in use.
  - **FFS whether this ID can be used for other HARQ feedback related operation.**
  - **FFS other purpose**
  - **FFS how many bits are conveyed**
- **FFS details including how to convey the ID(s), e.g., whether the ID(s) is conveyed in the SCI or used for CRC scrambling.**
- For unicast, sidelink HARQ feedback and HARQ combining in the physical layer are supported.
  - **FFS details, including the possibility of disabling HARQ in some scenarios**
- For groupcast, sidelink HARQ feedback and HARQ combining in the physical layer are supported.
  - **FFS details, including the possibility of disabling HARQ in some scenarios**
- **Conclusion:** To update the TR 37.885 by replacing "multicast" by "groupcast"
- In the context of sidelink CSI, RAN1 to study further which of the following information is useful in sidelink operation when it is available at the transmitter.
  - Information representing the channel between the transmitter and receiver
  - Information representing the interference at receiver
  - Examples for this information are:
    - CQI, PMI, RI, RSRP, RSRQ, pathgain/pathloss, SRI, CRI, interference condition, vehicle motion
  - **FFS including:**
    - **Such information can be acquired using reciprocity or feedback**
    - **Time scale of the information**
    - **Which information is useful in which operation and scenario**

In RAN1 #95, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

- Physical sidelink feedback channel (PSFCH) is defined and it is supported to convey SFCI for unicast and groupcast via PSFCH.

- When SL HARQ feedback is enabled for unicast, the following operation is supported for the non-CBG case:

- Receiver UE generates HARQ-ACK if it successfully decodes the corresponding TB. It generates HARQ-NACK if it does not successfully decode the corresponding TB after decoding the associated PSCCH which targets the receiver UE.
- FFS whether to support SL HARQ feedback per CBG

- When SL HARQ feedback is enabled for groupcast, the following operations are further studied for the non-CBG case:
  - Option 1: Receiver UE transmits HARQ-NACK on PSFCH if it fails to decode the corresponding TB after decoding the associated PSCCH. It transmits no signal on PSFCH otherwise. Details are FFS including the following:
    - Whether to introduce an additional criterion in deciding HARQ-NACK transmission
    - Whether/how to handle DTX issue (i.e., transmitter UE cannot recognize the case that a receiver UE misses PSCCH scheduling PSSCH)
    - Issues when multiple receiver UEs transmit HARQ-NACK on the same resource
      - How to determine the presence of HARQ-NACK transmissions from receiver UEs
      - Whether/how to handle destructive channel sum effect of HARQ-NACK transmissions from multiple receiver UEs if the same signal is used
  - Option 2: Receiver UE transmits HARQ-ACK on PSFCH if it successfully decodes the corresponding TB. It transmits HARQ-NACK on PSFCH if it does not successfully decode the corresponding TB after decoding the associated PSCCH which targets the receiver UE. Details are FFS including the following:
    - Whether to introduce an additional criterion in deciding HARQ-ACK/NACK transmission
    - How to determine the PSFCH resource used by each receiver UE
  - FFS whether to support SL HARQ feedback per CBG
  - Other options are not precluded

- It is supported to enable and disable SL HARQ feedback in unicast and groupcast.
  - FFS when HARQ feedback is enabled and disabled.

- Study further whether to support UE sending to gNB information which may trigger scheduling retransmission resource in mode 1. FFS including
  - Which information to send
  - Which UE to send to gNB
  - Which channel to use
  - Which resource to use

In RAN1 #AH_1901, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:

R1-1901323 Feature lead summary for agenda item 7.2.4.1.2 Physical layer procedures LG Electronics

Agreements:

- Layer-1 destination ID can be explicitly included in SCI
  - FFS how to determine Layer-1 destination ID
  - FFS size of Layer-1 destination ID
- The following additional information can be included in SCI
  - Layer-1 source ID
    - FFS how to determine Layer-1 source ID
    - FFS size of Layer-1 source ID
  - HARQ process ID

- NDI
- RV

- FFS whether some of the above information may not be present etc. in some operations (e.g., depending on whether they are used for unicast, groupcast, broadcast)

Agreements:

- For determining the resource of PSFCH containing HARQ feedback, support that the time gap between PSSCH and the associated PSFCH is not signaled via PSCCH at least for modes 2(a)(c)(d) (if respectively supported)
  - FFS whether or not to additionally support other mechanism(s) for modes 2(a)(c)(d)
  - FFS for mode 1

Proposals:

- When HARQ feedback is enabled for groupcast, support (options as identified in RAN1#95):
  - Option 1: Receiver UE transmits only HARQ NACK
  - Option 2: Receiver UE transmits HARQ ACK/NACK
- FFS applicability of option 1 and option 2

Supported by: vivo, MTK, Intel, LGE, QC, IDC, E///, HEPTA, Nokia, NSB, CATT, Xiaomi, ITL, SONY, Lenovo, MotM, ATT, Panasonic, Apple, Convida, SS, DCM, NEC
Objected by: HW, HiSi

Working assumption:

- When HARQ feedback is enabled for groupcast, support (options as identified in RAN1#95):
  - Option 1: Receiver UE transmits only HARQ NACK
  - Option 2: Receiver UE transmits HARQ ACK/NACK
- FFS applicability of option 1 and option 2 – this part is particulary relevant to confirm (or not) the working assumption

Agreements:

- It is supported that in mode 1 for unicast, the in-coverage UE sends an indication to gNB to indicate the need for retransmission
  - At least PUCCH is used to report the information
    - If feasible, RAN1 reuses PUCCH defined in Rel-15
  - The gNB can also schedule re-transmission resource
  - FFS transmitter UE and/or receiver UE
    - If receiver UE, the indication is in the form of HARQ ACK/NAK
    - If transmitter UE, FFS

Check beam management procedure needed for FR2 or not – companies are encouraged to check R1-1900446

- Discuss further offline regarding potential TP based on the measurement results in R1-1900466 – to check later

R1-1901411 – revisit on Friday
R1-1901463

R1-1901439
Agreements:

- (Pre-)configuration indicates whether SL HARQ feedback is enabled or disabled in unicast and/or groupcast.
  - When (pre-)configuration enables SL HARQ feedback, FFS whether SL HARQ feedback is always used or there is additional condition of actually using SL HARQ feedback

Agreements:

- SL open-loop power control is supported.
  - For unicast, groupcast, broadcast, it is supported that the open-loop power control is based on the pathloss between TX UE and gNB (if TX UE is in-coverage).

        - This is at least to mitigate interference to UL reception at gNB.
        - Rel-14 LTE sidelink open-loop power control is the baseline.
        - gNB should be able to enable/disable this power control.
    - At least for unicast, it is supported that the open-loop power control is also based on the pathloss between TX UE and RX UE.
        - (Pre-)configuration should be able to enable/disable this power control.
        - FFS whether this is applicable to groupcast
        - FFS whether this requires information signaling in the sidelink.
    - Further study its potential impact, e.g., on resource allocation.
- FFS whether closed-loop power control is additionally needed

Agreements:
- Long-term measurement of sidelink signal is supported at least for unicast.
    - Long-term measurement here means a measurement with L3 filtering.
    - This measurement is used at least for the open-loop power control.
        - FFS for other purpose
    - FFS: measurement metric
    - FFS: which signal is used
    - FFS: whether feedback of this measurement is needed
    - FFS whether this is applicable to groupcast

In RAN1 #96, the following agreements were made for unicast, groupcast and broadcast:

Agreement for unicast, groupcast and broadcast:
- (Pre-)configuration indicates the time gap between PSFCH and the associated PSSCH for Mode 1 and Mode 2.

Agreements:
- In mode 1 for unicast and groupcast, it is supported for the transmitter UE via Uu link to report an indication to gNB to indicate the need for retransmission of a TB transmitted by the transmitter UE.
    - FFS the format of the indication, e.g., in the form of HARQ ACK/NACK, or in the form of SR/BSR, etc.
- RAN1 continues discussion on whether to support report from the receiver UE
    - No inter-BS communication will be considered.

To discuss aspects related to 1st sub-bullet & 2nd bullet during this week -revisit later

Agreements:
- Sidelink HARQ ACK/NACK report from UE to gNB is not supported in Rel-16.

Agreements:
- For unicast RX UEs, SL-RSRP is reported to TX UE
- For sidelink open loop power control for unicast for the TX UE, TX UE derives pathloss estimation
    - Revisit during the WI phase w.r.t. whether or not there is a need regarding how to handle pathloss estimation for OLPC before SL-RSRP is available for a RX UE

Agreements:
- TPC commands for SL PC are not supported

Agreements:
- For sidelink groupcast, it is supported to use TX-RX distance and/or RSRP in deciding whether to send HARQ feedback.
    - Details to be discussed during WI phase, including whether the information on TX-RX distance is explicitly signaled or implicitly derived, whether/how this operation is related to resource allocation, accuracy of distance and/or RSRP, the aspects related to "and/or", etc.

- This feature can be disabled/enabled

Working assumption:

- For unicast, the following CSI reporting is supported based on non-subband-based aperiodic CSI reporting mechanism assuming no more than 4-port:
  - CQI
  - RI
  - PMI
- CSI reporting can be enabled and disabled by configuration.
  - It is supported to configure a subset of the above metric for CSI reporting.
- There is no standalone RS transmission dedicated to CSI reporting in Rel-16
- NR sidelink CSI strives to reuse the CSI framework for NR Uu.
  - Discuss details during WI phase

Agreements:

- RAN1 concludes the following regarding beam management:
  - Beam management is beneficial
  - RAN1 has conducted limited study on the beam management.
  - In FR1, it is feasible to support V2X use cases without beam management.
  - In FR2, it is feasible to support some V2X use cases without beam management in some scenarios.
    - Panel selection is necessary to improve the communication range in FR2.

Conclusion:

- There is no consensus in supporting beam management for normative work for NR V2X in Rel-16.

1.1.3 Synchronization

Highlights

The synchronization procedure was discussed for UE to maintain the synchronization when UE has been synchronized with gGNSS and temperately out-of-sync from GNSS. The non-SLSS based synchronization, such as DM RS, could be used in additional to SLSS based synchronization.

NR V2X supports using a sidelink RS for synchronization purpose

- Applicable only on unlicensed (ITS) carrier with no network deployment on this carrier
- This RS is not a standalone RS and not part of SLSS.
- This RS will not appear in the synchronization procedure for the selection of sync sources.
- RS used for the synchronization purpose would not impact any sidelink RS design
- FFS: Whether this RS is DM RS or other RS
- FFS: Whether this could be achieved by UE implementation
- FFS: Specification impact

The V2X SL synchronization includes the following:

- SL synchronization signals: SL primary synchronization signal (S-PSS), SL secondary synchronization signal (S-SSS)
- Physical SL broadcast channel (PSBCH)
- SL synchronization sources and procedures

The use of other SL signals and channels for SL synchronization, such as reference signals and PSCCH/PSSCH is also studied.

- S-PSS, S-SSS and PSBCH are structured in a block format (S-SSB) which supports periodic transmission. The S-SSB has the same numerology (i.e. SCS and CP length) as PSCCH/PSSCH in a carrier, transmission bandwidth is within the (pre-)configured SL BWP, and its frequency location is (pre-)configured. This leads to no need for the UE to perform hypothesis detection in

frequency to find S-SSB in a carrier.

- The sequence for S-PSS is an m-sequence, and the sequence for S-SSS is a Gold sequence. Note that these are respectively the same types of sequence as PSS and SSS.

SL synchronization sources are GNSS, gNB, eNB, NR UE, each associated with a synchronization priority, as shown in Table 1.

Table 1: Synchronization source priority

Priority level	GNSS-based synchronization	gNB/eNB-based synchronization
P0	GNSS	gNB/eNB
P1	All UEs directly synchronized to GNSS	All UEs directly synchronized to gNB/eNB
P2	All UEs indirectly synchronized to GNSS	All UEs indirectly synchronized to gNB/eNB
P3	Any other UE	GNSS
P4	N/A	All UEs directly synchronized to GNSS
P5	N/A	All UEs indirectly synchronized to GNSS
P6	N/A	Any other UE

Whether GNSS- or gNB/eNB-based synchronization is used is (pre-)configured. In single-carrier operation, UE derives its transmission timing from the available synchronization reference with the highest priority. An eNB can be a synchronization source only for NR UEs which support LTE Uu/PC5 or LTE Uu.

Operation when the NR SL is synchronized with an LTE SL, and where the NR SL and LTE SL synchronization procedures operate independently are relevant to normative specification work.

On an unlicensed (ITS) carrier where no cellular network is present, it is also supported to use a SL RS for the purpose of synchronization. Such an RS is neither a part of S-PSS/S-SSS nor is it transmitted or designed specifically for this purpose.

Work Item Phase

NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

- Synchronization mechanism for the work item phase.

R1-1901377 Summary of AI 7.2.4.1.3 NR V2X synchronization, CATT

1.1.3.1 Sidelink Synchronization Signals

In RAN1 AH#1901, the design target of NR S-PSS/S-SSS was agreed as follows,

Agreements in RAN1 AH#1901**:**

- Design Target for NR S-PSS/S-SSS:
  - At least for 15 kHz SCS NR S-PSS/S-SSS, same or better coverage to that of LTE under the same Tx/Rx configuration
    - Coverage: measured in terms of coupling loss
      - MCL = P_Tx – (NF + N_floor + SINR)
        - N_floor = -174 +10 log (BW)
        - P_Tx = 23 dBm
        - NF = 9 dB
        - SINR = -6 dB for LTE as the reference

Companies to report detailed assumptions e.g. the detection method / probability / etc. for the target SINR The detection performance at -6dB from companies had been summarized in the aforementioned table. The detection performance of the proposed NR S-PSS/S-SSS sequences had shown the comparable detection performance to that of LTE.

Proposal 1: The detection performance of the proposed SLSS sequences is comparable to detection performance of sidelink synchronization sequences in LTE.

- One company has concerns on the current evaluation results that no consideration of the power back off caused by PAPR in the NR Uu M-sequence.

No consensus in the offline discussion

The number of NR V2X SSID to be supported in NR S-SSB design is

- Alt1: 672
- Alt2: 336

Most companies proposed that the number of NR V2X SSID needs to be expanded to support the capacity enhancement of synchronization source identification, in-coverage/out-of-coverage, and distinguish between NR Uu and NR V2X sidelink in [2,Huawei, HiSilicon] [3,vivo] [7,CATT] [9,Samsung] [15,InterDigital] [16,HEPTA 7291] [21,NTT DOCOMO] [23,ITL] [25,Qualcomm]. Two alternatives (336 or 168) for number of SSSS/S-SSS sequences is proposed in [13,Intel]. And [21,NTT DOCOMO] proposed that the number of SL-SSID will be decided in WI phase. [25,Qualcomm] proposed that RAN1 specifies new sequences for S-PSS and S-PSS has one hypothesis.

Number of NR SL-SSID	Supporting Companies
672	[2,Huawei, HiSilicon] [3,vivo] [7,CATT] [9,Samsung] [15,InterDigital] [16,HEPTA 7291]
336	[25,Qualcomm]

Proposal 2: The number of NR V2X SSID to be supported in NR S-SSB design is 672 as the working assumption.

- The working assumption could be re-visited if some issues, such as complexity, miss-detection performance at the SINR equivalent to LTE = -6 dB, functionality of SSID, are found.

1.1.3.2 Waveform for S-SSB

Two candidates of S-SSB waveform are the DFT-s-OFDM and CP-OFDM. Two companies indicated their only support of CP-OFDM waveform for the S-SSB in [3, vivo] [4,MediaTek]. Two companies proposed DFT-s-OFDM waveform for the S-SSB in [6, CATT] [16,ZTE]. One company claimed that NR V2X should support only single waveform for the sidelink SSB [12,ETRI]. The summary of Pros and Cons of CP-OFDM and DFT-s-OFDM waveforms for the S-SSB is as follows:

Candidate schemes	CP-OFDM for the waveform of S-SSB	DFT-s-OFDM for the waveform of S-SSB
Supporting companies	[4,MediaTek]	[6,CATT] [16,ZTE]
Pros	• Support flexible resource allocation mechanism • Higher spectrum efficiency	• lower PAPR • Higher coverage area
Cons	• Higher PAPR • Reduced coverage area	• Restrictions in terms of multiplexing of data and DMRS in the same OFDM symbol • Lower spectrum efficiency
Performance evaluation	[6,CATT]: CP-OFDM can only provide a little better BLER performance (less than 1dB) than DFT-s-OFDM, but DFT-s-OFDM can provide about 2.7dB CM performance gain for QPSK compared to CP-OFDM.	
Comments	[6,CATT] provides the comparison of performance between CP-OFDM and DFT-s-OFDM.	

Proposal 4: Both DFT-s-OFDM and CP-OFDM should be considered in the design of S-SSB structure.

1.1.3.3 Synchronization numerology

Most Companies support a default SCS and CP length for S-SSB for a given band/carrier. [4,MediaTek], [6,CATT], [14,Spreadtrum]

Proposal 5:
A SCS is pre-configured for SLSS/PSBCH transmission for a given band

The proposals from companies are as follows,

- The adoption of the numerology for S-SSB should take into account the coverage restricted by the CP length. [4,MediaTek]
- Extended CP is not supported for S-SSB. [22,Samsung]

Proposal 6:
A SCS is pre-configured for SLSS/PSBCH transmission for a given band/carrier.

1.1.3.4 Synchronization bandwidth

Offline Agreements

The S-SSB bandwidth for further evaluation should be determined together with the design of V2X S-SSB from the following alternatives,

- Alt 1: 20RB
- Alt2: 24RB
- Alt3: 12RB

The proposed number of RBs for S-SSB are 12, 20 and 24 in [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] [12,ETRI] [19,Qualcomm]. [24,Nokia, NSB] proposed that the bandwidth of S-SSB should be restricted. The performance results of SLSS sequence are provided by [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] with the summary of Pros and Cons shown in the table blow,

Candidate schemes	12 RB	20RB	24RB
Supporting companies		[3,vivo]	[6,CATT]
Pros	• Less minimum bandwidth than 20RB and 24RB	• Less minimum bandwidth than 24RB	• Better BLER performance than 12RB and 20RB • Support length-255 SLSS • Support waveform-independent S-SSB pattern
Cons	• Worse performance than 20RB and 24RB • Cannot support length-255 SLSS • Need more PSBCH symbols	• Worse performance than 24RB • Cannot support length-255 SLSS	• Need more minimum bandwidth than 12 RB and 20RB
PSBCH BLER @-6dB SNR	[2,Huawei, HiSilicon]: 1.5%	[2,Huawei, HiSilicon]: 0.3% [3,vivo]: 25% [6,CATT]: 0.9% [10,LG]: 6.8%	[6,CATT]: 0.4% [10,LG]: 7.2%
Key simulation assumptions	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 250Kmph [3,vivo]: TDL-A channel, 30KHz SCS, 240Kmph [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 240Kmph, @-8dB SNR [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 250Kmph		

Notes: the above table only includes the analysis with the evaluation results.

Offline Agreements
The frequency location for S-SSB should be (pre-) configured.

The proposals of S-SSB frequency location are as follows,

- The frequency location for S-SSB should be (pre-) configured or network indicated. [9,Intel] [10,LG] [11,NEC] [16,ZTE]
- The center frequency of S-SSB can be different from the center frequency of the NR sidelink carrier. [9,Intel]
- The frequency location of S-SSB should be fixed or same on one carrier for all UEs. [11,NEC] [16,ZTE]

The proposals of S-SSB Sync raster are as follows,

- Sync raster of NR SSB should be reused as the starting point. [16,ZTE]
- Coarser or low sync raster could be predefined to reduce the UE synchronization complexity as well as latency. [21,Xiaomi] [24,Nokia,Nokia Shanghai Bell]
- RAN1 shall send an LS to RAN4 to inquire the synchronization raster and channel raster for sidelink. [22,Samsung]

1.1.3.5 S-SSB Structure

Several companies had proposals in the S-SSB structure design [3,vivo] [4,MediaTek] [6,CATT] [8,ITRI] [9,Intel] [10,LG] [11,NEC] [13,Sequans] [14,Spreadtrum] [17,InterDigital] [22,Samsung] [23,ITL] [24,Nokia,Nokia Shanghai Bell]. In [13,Sequans] [17,InterDigital] [23,ITL], NR SSB structure is proposed as the starting point of NR V2X S-SSB for minimizing standardization effort and NR V2X UE detection complexity. In [3,vivo] [17,InterDigital] [22,Samsung], a unified S-SSB pattern should be considered for both FR1 and FR2.

There are proposals to have S-SSB design with low correlation to the NR SSB and to be distinguished in the manner of FDM, TDM, GSCN, S-SSB pattern, SS sequence, cyclic shifts or muting [2,Huawei, HiSilicon] [5,OPPO] [10,LG] [12,ETRI] [13,Sequans],

Two alternatives of the number of S-PSS and S-SSS symbols in a S-SSB were proposed as follows,

- Alt1: Single-symbol SLSS with S-PSS and S-SSS only occupy one symbol – [3,vivo] [5,OPPO] [6,CATT] [27,Ericsson],
  - The simulation results showed that implementation methods can improve the detection performance without additional SLSS symbol in an S-SSB [3,vivo] [6,CATT]. The method of multiple searchers in [3, vivo] and multiple hypotheses [6, CATT] were proposed and evaluated for the high speed scenarios.
- Alt2: Multi-symbol SLSS with S-PSS and/or S-SSS occupy at least two symbols - [2,Huawei, HiSilicon] [4,MediaTek] [10,LG] [14,Spreadtrum] [19,Qualcomm] [24,Nokia, NSB].
  - The simulation results showed better detection performance of multiple SLSS symbols in a S-SSB comparing with that of one SLSS symbols within one S-SSB [2,Huawei, HiSilicon] [10 LG].

Detection Performance of NR SLSS

The performance evaluation results of the designed SLSS sequence from [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] are shown in the table below,

Candidate schemes	Single-symbol SLSS	Multi-symbols SLSS
Supporting companies	[3,vivo] [6,CATT]	[2,Huawei, HiSilicon] [10,LG]
Pros	• Lower overhead than multiple-symbols SLSS. • Similar performance can be obtained with implementation methods to improve the performance	• Better detection performance than one-symbol SLSS without using implementation methods to improve the performance • Reduce the complexity of detection
Cons	• The complexity of detection will increase after using the implementation methods, but can be controlled in a reasonable way	• Higher overhead than one-symbol SLSS
Performance @-6dB SNR	[3,vivo]: 82% [6,CATT]: 83%	[2,Huawei, HiSilicon]: 97.5% [10,LG]: 39%
Key simulation assumptions	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 3Kmph, IFO(Initial Frequency Offset) = ±5ppm [3,vivo]: TDL-A channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 6Kmph, IFO = ±5ppm	

	[10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 3Kmph, IFO unknown

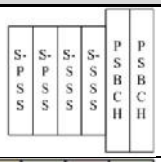
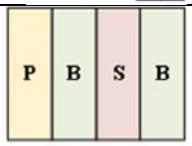
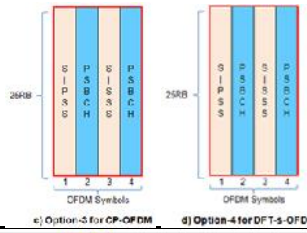
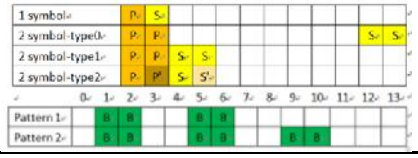
Notes: the above table only includes the opinions of companies which provide the simulation results.

Offline agreements

For the design of S-SSB structure, the number of symbols for S-PSS/S-SSS should be determined for design of S-SSB pattern

- Option 1: Each of S-PSS and S-SSS could use two or three symbols in a S-SSB.
- Option 2: Single symbol for S-PSS/S-SSS in a S-SSB.

S-SSB patterns were proposed by[2,Huawei, HiSilicon] [3,vivo] [4,MediaTek] [5,OPPO] [6,CATT] [10,LG] [14,Spreadtrum] [16,ZTE] [24,Nokia,Nokia Shanghai Bell] [27,Ericsson].
The simulation results of the design S-SSB pattern from [2,Huawei, HiSilicon] [3,vivo] [6,CATT] [10,LG] are shown in the table below,

Supporting Companies	S-SSB patterns	Sequence length of SLSS	Bandwidth of PSBCH	Detection Probability of SLSS@-6dB SNR	BLER of PSBCH@-6dB SNR
[2,Huawei, HiSilicon]		127	20RB	97.5%	0.3%
[3,vivo]		127	20RB	82%	25%
[6,CATT]		255	24RB	83%	0.4%
[10,LG]		127	20RB	39%	6.8%
Key simulation assumptions for SLSS	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 3Kmph, IFO(Initial Frequency Offset) = ±5ppm [3,vivo]: TDL-A channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 6Kmph, IFO = ±5ppm [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 3Kmph, IFO unknown				
Key simulation assumptions for PSBCH	[2,Huawei, HiSilicon]: CDL-C channel, 60KHz SCS, 250Kmph [3,vivo]: TDL-A channel, 30KHz SCS, 240Kmph [6,CATT]: V2X CDL Urban-LOS channel, 30KHz SCS, 240Kmph, @-8dB [10,LG]: V2X CDL Urban-NLOS channel, 30KHz SCS, 250Kmph				

AGC and TX/RX switching periods should be taken into account for the design of S-SSB [3,vivo] [6,CATT] [9,Intel] [10,LG] with the options list below:

Options	AGC solutions	Supporting company
Option 1	Using the PSBCH before S-PSS to do AGC tuning	[3,vivo]

Option 2	One symbol of AGC training sequence should be added in front of each S-SSB	[6,CATT]
Option 3	SLSS (or any other known signal) transmission at the first symbol of slot as an AGC training symbol	[9,Intel]

Proposal 10: AGC and TX/RX switching periods should be taken into account in design S-SSB

- ***Option 1: PSBCH before S-PSS is used for AGC tuning***
- ***Option 2: One symbol of AGC training sequence is added in front of each S-SSB.***
- ***Option 3: SLSS (or any other known signal) transmission at the first symbol of slot as an AGC training symbol***

The proposals of supporting more than one S-SSB per slot/period are as follows

- Supported multiple S-SSB transmission in one period. [2,Huawei, HiSilicon] [6,CATT] [11,NEC] [16,ZTE] [20,NTT DOCOMO] [23,ITL]
- Whether one or multiple S-SSB is transmitted within a period depends on whether beamforming is supported. [5,OPPO].
- At least two S-SSBs per Slot for beam sweeping of 64 S-SSBs. [6,CATT]

Proposal 11:
More than one S-SSB in a slot/period is supported.

There were discussions on the support of multi-beam operation in NR sidelink as follows,

- S-SSB beam sweeping or repetition should be supported to enlarge the coverage range of S-SSB. [6,CATT] [12,ETRI] [21,Xiaomi] [17,InterDigital]
- Beam sweeping and beam identification of S-SSB is not considered at least in FR1. [10,LG]

Proposal 12: The design of S-SSB structure and resource mapping should support S-SSB sweeping
It was proposed that more than one S-SSB periodicity should be supported and with the periodicity configured by the network [3,vivo] [20,NTT DOCOMO] [21,Xiaomi]. The details should the S-SSB periodicity should be further study.

1.1.3.6 PSBCH Contents

PSBCH contents were discussed in [4,MediaTek] [7,CATT] [8,ZTE,Sanechips] [10,OPPO] [11,ITRI] [16,HEPTA 7291] [19,Spreadtrum] [21,NTT DOCOMO] as follows,

- TDD UL/DL configuration or SFI information should be included in PSBCH with reasonable overhead. [7,CATT] [10,OPPO] [16,HEPTA 7291] [21,NTT DOCOMO]
- TDD UL/DL configuration can be carried by SL-SIB or PC5-RRC channel, instead of PSBCH, due to the limited PSBCH payload. [19,Spreadtrum] [8,ZTE,Sanechips]
- PSBCH carries the information to derive frame timing, such as slot number information, SFN/DFN, and direct synchronization indicator. [4,MediaTek] [8,ZTE,Sanechips]
- PSBCH indicate the location and bandwidth of the initial SL BWP. [4,MediaTek] [19,Spreadtrum]
- InCoverage indicator can be carried in PSBCH-DMRS rather than PSBCH payload to avoid unnecessary decoding for priority group identification. [4,MediaTek] [19,Spreadtrum]

Proposal 13: PSBCH for NR V2X should include as least the SFI. The following parameters are FFS

- DirectFrameNumber
- The location and bandwidth of the initial SL BWP
- Slot number information
- InCoverage Indicator
- S-SSB time index

The following PSBCH content should be considered in which a total 48 bits for the PSBCH content are supported. [2,Huawei, HiSilicon]

MasterInformationBlock-NR-V2X	bits	Notes
sl-Bandwidth	4	
tdd-ConfigSL	[10]	
directFrameNumber	10	
S-SSB time index	3	*L*_v2x=8
inCoverage	2	In coverage for eNB coverage or gNB coverage, or out of coverage
reserved	19	
Total	48	

Proposal 13: PSBCH for NR V2X should include SFI information with the following parameters FFS

- DirectFrameNumber
- The location and bandwidth of the initial SL BWP
- Slot number information
- InCoverage Indicator
- S-SSB time index

The payload size and the coding rate of PSBCH were discussed in [2,Huawei, HiSilicon] [4,MediaTek] [7,CATT] [9,Samsung] with the list of summary in the following:

Supporting Companies	The payload size of PSBCH	Rationale
[2,Huawei, HiSilicon] [4,MediaTek] [7,CATT]	56 bits	NR V2X PSBCH channel coding can reuse the channel coding of NR PBCH, in order to reduce the standardization effort.
[9,Samsung]	Coding rate shall target for around 0.02 to 0.03.	NR V2X shall target for one-shot decoding of PSBCH.

Proposal 14: The payload size of NR V2X PSBCH is no more than 56 bits to reuse the channel coding of NR PBCH, which includes the following,

- Polar code
- CRC length
- Payload interleaver pattern

1.1.3.7 Synchronization Procedures

Most companies proposed to have same priority of the gNB and eNB as the synchronization source [2,Huawei, HiSilicon] [3,vivo] [4,MediaTek] [6,CATT] [9,Intel] [25,HEPTA 7291]. There are proposals to have RSU and UE-in-platoon as a new type of synchronization sources [9,Intel] [13,Sequans]. Whether LTE UE as the NR V2X synchronization source were also discussed synchronization source with the summary in the table below,

Options	Supporting Companies	Rationale
Option 1: Supporting LTE UE as the NR V2X synchronization source	[6,CATT] [21,Xiaomi] [24,Nokia,Nokia Shanghai Bell]	• To expand the coverage range • Being beneficial on interference control • Use case is NR sidelink UE cannot receive any GNSS signals
Option 2: Do not supporting LTE UE as the NR V2X synchronization source	[4,MediaTek] [9,Intel] [20,NTT DOCOMO] [22,Samsung] [27,Ericsson]	• Mandate the inter-module tunnel between NR-V2X module and LTE-V2X module with high complexity and cost. • To reduce amount of work and standardization efforts • Don't find any practical use case

In [10,LG] [24,Nokia,Nokia Shanghai Bell], SLSS of a specific UE can have a higher priority in unicast and groupcast in the synchronization procedure.

A lot of companies discussed the issue of Priority and selection of the synchronization sources as follows,

- LTE V2X synchronization source selection mechanism can be a starting point for NR V2X. [3,vivo] [8,ITRI] [10,LG] [11,NEC] [22,Samsung] [23,ITL]
- Priority rules for sidelink sync source selection are based on type of original synchronization source / reference, number of hops and stationary of sync source. [2,Huawei, HiSilicon] [4,MediaTek] [9,Intel] [10,LG] [17,InterDigital] [20,NTT DOCOMO]
- Indication of the synchronization source type or number of hops through the S-SSB and/or PSBCH. [2,Huawei, HiSilicon] [20,NTT DOCOMO] [17,InterDigital]

Proposal 15: LTE V2X synchronization procedure and source selection priority could be reused for that of V2X procedure as in the following table as a starting point for the rule of NR V2X synchronization source selection.

GNSS-based synchronization	gNB/eNB-based synchronization

• P0: GNSS
• P1: the following UE has the same priority:
  • UE directly synchronized to GNSS
• P2: the following UE has the same priority:
  • UE indirectly synchronized to GNSS
• P3: the remaining UEs have the lowest priority.
	• P0: gNB/eNB
	• P1': UE directly synchronized to gNB/eNB
	• P2': UE indirectly synchronized to gNB/eNB
	• P3': GNSS
	• P4': UE directly synchronized to GNSS
	• P5': UE indirectly synchronized to GNSS
	• P6': the remaining UEs have the lowest priority.

The following details of the synchronization sources and source selection would be discussed in the WI

- gNB/eNB - gNB/eNB as the synchronization source and could directly/indirectly provide the required sidelink configuration information
- The timing offset from the sync source in relation to the NR sidelink frame number needs to be provided for the NR sidelink operation

The synchronization procedure was discussed for UE to maintain the synchronization when UE has been synchronized with gNSS and temperately out-of-sync from gNSS. The non-SLSS based synchronization, such as DM RS, could be used in additional to SLSS based synchronization

Proposal:

- NR V2X supports using sidelink DM RS for synchronization purpose
  - Applicable only on unlicensed (ITS) carrier with no network deployment on this carrier
  - FFS: whether this could be achieved by UE implementation
  - FFS: specification impact

1.1.3.8 Resource Configuration for S-SSB transmission

There were discussions in time and frequency resource configuration or triggering for S-SSB transmission [2,Huawei, HiSilicon] [5,OPPO] [9,Intel] [16,ZTE] [23,ITL] [25,HEPTA 7291] [26,Convida Wireless] [27,Ericsson],.

- The same synchronization resource configuration as LTE-V2X can be applied to NR-V2X. [5,OPPO]
- S-SSB transmission can be network configured or UE triggered. [2,Huawei, HiSilicon] [9,Intel] [25,HEPTA 7291] [27,Ericsson]

- Both TDM and FDM for S-SSB transmissions from different source types can be considered. [9,Intel] [16,ZTE] [23,ITL]

1.1.3.9 Synchronization Enhancements

There were proposals on synchronization enhancement schemes [5,AT&T] [6,LG] [13,Intel] [20,Apple] [25,Qualcomm] [27,Ericsson].

The non-SLSS based synchronization was proposed in [6,LG] [13,Intel] [25,Qualcomm]. The motivation is to consider the case when the UE has lost synchronization but has not drifted significantly from the previous sync source reference. In this case, UE can perform synchronized search based on other reference UE's DMRS and GNSS coverage status information. [6,LG] [13,Intel] [25,Qualcomm] [27,Ericsson] discussed the non-SLSS based synchronization as follows:

Options	Supporting Companies	Rationale
Option 1: Supporting Non-SLSS based synchronization operation or Data-aided synchronization	[6,LG] [13,Intel] [25,Qualcomm]	- Reduce the complexity of synchronization. - Simplify the sidelink synchronization procedure. - Being supplement to SLSS-based synchronization.
Option 2: Do not supporting Data aided synchronization (i.e. non-SLSS)	[27,Ericsson]	- S-SSB is dedicated signaling for this purpose. - It identifies the synchronization reference used by the transmitter. - It comes at regular intervals.

Other proposed synchronization enhancement schemes includes:

- Local manager (scheduling UE) to broadcast a special SSB to identify itself to neighbour UEs.[5,AT&T]
- Multi-cluster synchronization signal searching / tracking. A location based resource pool selection method. A method of utilizing FR1 timing to FR2 can be considered [6,LG]
- Sidelink operation needs to be supported in asynchronous cell deployment. [6,LG]
- Synchronization group/source dynamic merging and consolidation. [20,Apple]
- Synchronous-SLSS only based synchronization enhancements (perform the SLSS search only on a restricted window) [25,Qualcomm]
- UEs with multiple clocks to enable communication among UEs synchronized to different references with equal priority. [27,Ericsson]

1.1.3.10 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for synchronization.

In RAN1 #94, the following agreements were made for synchronization:

Agreement for synchronization:

- NR V2X Sidelink Synchronization includes at least the following
  - Sidelink synchronization signal(s)
  - PSBCH
  - Sidelink synchronization sources and procedure(s)
    - Study potential synchronization sources –GNSS, gNB, eNB, UE, LTE UE
      - Note: this doesn't mean all of them are to be supported

In RAN1 #94bis, the following agreements were made for synchronization:

Agreement for synchronization:

- At least GNSS, gNB, NR UE, and eNB are supported as the synchronization source for NR V2X.
  - eNB as a synchronization source for NR V2X UEs supporting LTE Uu/PC5 or Uu only (no change to the eNB behaviour)
  - **Whether a source is supported is for further NR V2X UE capability consideration**
- NR V2X sidelink operation includes the following cases:
  - NR V2X sidelink is synchronized with LTE V2X sidelink
  - NR V2X sidelink synchronization procedure operates independently to the LTE V2X sidelink synchronization procedure
- The design of NR V2X sidelink synchronization signals and PSBCH uses NR SSB structure as the starting point with the following properties:
  - NR V2X synchronization signals include sidelink PSS (S-PSS) and sidelink SSS (S-SSS) and are structured with PSBCH in a block format (S-SSB)
- Periodic transmission of S-SSB in NR V2X is supported
  - **FFS: whether one/more S-SSB is transmitted in a period**
- **Working Assumption:** For the purpose of evaluation, the initial frequency error should be within ±[5] ppm with the assumption of uniform distribution [-5, 5] for NR V2X sidelink synchronization.
  - Note: This is the error of the local oscillator for the Tx and Rx with respect to the absolute carrier frequency.

In RAN1 #95, the following agreements were made for synchronization:

Agreement for synchronization:

- Confirm the working assumption that initial frequency error before synchronized to any synchronization source should be within ±5 ppm for the purpose of evaluation.

- S-SSB has the same numerology, which includes SCS and CP length, as that of control and data channels for a given carrier

- The transmission bandwidth for S-SSB is within the BW of the (pre)-configured SL-BWP.
  - FFS: The actual transmission BW for S-SSB and sync raster

- For evaluation of V2X S-SSB, the transmission bandwidth of S-SSB is in proportion to the SCS for the design of V2X S-SSB.
  - Alt1: 24 PRBs
  - Alt2: 20 PRBs
  - Other values are not precluded

- For the evaluation of S-PSS/S-SSS, the sequences and/or polynomials used in NR Uu PSS/SSS are used as the starting point of the NR V2X S-PSS/S-SSS design.
  - Others are not precluded.

- The aspects of synchronization sequence for NR V2X to be considered for the evaluation include,
  - The length of S-PSS and S-SSS sequences
  - If and how to distinguish from NR Uu PSS and SSS sequences
  - The number of NR SL-SSID targeted in the design of NR V2X S-PSS/S-SSS
    - Use cases of NR SL-SSID should be addressed

- Using the below table as a starting point for evaluation assumptions for sidelink synchronization LLS.

- Detection probability of S-PSS/S-SSS
- Decoding BLER of PSBCH
- Check further offline regarding UE speeds (absolute vs. relative, including current channel model assumptions in the TR) → on Friday, confirmed to be relative speed and thus, the speeds in the table below need to be doubled
- Discuss further offline payload size of PSBCH → to revisit in the next RAN1 meeting. Companies to report the assumed payload size of PSBCH in their evaluations

	Below 6GHz	Above 6GHz
Carrier Frequency	6 GHz	30 GHz
Channel Model	CDL channel models	
Subcarrier Spacing(s)	15, 30, 60 kHz	60, 120 kHz
SNR Range	> -6 dB	> -6 dB
UE Speed	3 km/h, 120 km/h (mandatory) 30km/h, 250 km/h (optional)	3 km/hr, 120 km/h (mandatory)
Interference model	Scenario 1: no interference Scenario 2: effect of interference includes in the model	Scenario 1: no interference
Initial Frequency Offset	TX: Uniform distribution within [-5, 5] ppm of nominal carrier frequency RX: Uniform distribution within [-5, 5] ppm of nominal carrier frequency	

Agreements:

- The study of NR V2X synchronization includes synchronization based on S-SSB
- The study also includes use of other sidelink signals/channels (e.g., other RSs in the SL, using PSSCH, using PSCCH, etc.) for the sidelink synchronization

In RAN1 #AH_1901, the following agreements were made for synchronization:

Agreement for synchronization:

R1-1901326 Summary of AI 7.2.4.1.3 NR V2X synchronization CATT

R1-1901377

Agreements**:**

- For NR SLSS, as the baseline:
  - The sequence type for S-PSS is the same type as the M-sequence used for NR-PSS
  - The sequence type for S-SSS is the same type as the Gold sequence for NR-SSS

Agreements:

- The frequency location for S-SSB is (pre-) configured
  - Note: it implies that there is no intended hypothses detection in frequency location of S-SSB performed by the UE for a carrier in a given band
  - Note: the potential frequency locations for the (pre-)configured frequency location may be restricted, up to RAN4

Further discussion offline to identify several potential options for SL-SSB in terms of combinations of # of RBs and # of symbols for S-PSS/S-SSS, for additional more focused evaluations

R1-1901448

Agreements**:**

- Combination 1:
  - Time domain: 2 symbol of length-127 S-PSS, 2 symbol of length-127 S-SSS
  - Frequency domain:11 or 12 RBs
  - BW containing S-SSB:
    - 2.5 MHz for 15 kHz SCS
    - 5 MHz for 30 kHz SCS
    - 10 MHz for 60 kHz SCS
    - 20 MHz for 120 kHz SCS
- Combination 2:
  - Time domain: 2 symbol of length-127 S-PSS, 2 symbol of length-127 S-SSS
  - Frequency domain: 20 RBs
  - BW containing S-SSB:
    - 5 MHz for 15 kHz SCS
    - 10 MHz for 30 kHz SCS
    - 20 MHz for 60 kHz SCS
    - 40 MHz for 120 kHz SCS
- Combination 3:
  - Time domain: 1 symbol of length-127 S-PSS, 1 symbol of length-127 S-SSS
  - Frequency domain: 20 RBs
  - BW containing S-SSB:
    - 5 MHz for 15 kHz SCS
    - 10 MHz for 30 kHz SCS
    - 20 MHz for 60 kHz SCS
    - 40 MHz for 120 kHz SCS
- Combination 4:
  - Time domain: 1 symbol of length-255 S-PSS, 1 symbol of length-255 S-SSS
  - Frequency domain: 24 RBs
  - BW containing S-SSB:
    - 5 MHz for 15 kHz SCS
    - 10 MHz for 30 kHz SCS
    - 20 MHz for 60 kHz SCS
    - 40 MHz for 120 kHz SCS
- Other combinations are not precluded.
- Note: Company should specify the assumptions, such as total energy per SSB, when the performance results are compared between different combinations.

R1-1901414

Agreements**:**

- Design Target for NR S-PSS/S-SSS:
  - At least for 15 kHz SCS NR S-PSS/S-SSS, same or better coverage to that of LTE under the same Tx/Rx configuration
    - Coverage: measured in terms of coupling loss
      - MCL = P_Tx – (NF + N_floor + SINR)
        - N_floor = -174 +10 log (BW)
        - P_Tx = 23 dBm
        - NF = 9 dB
        - SINR = -6 dB for LTE as the reference
    - Companies to report detailed assumptions e.g. the detection method/probability/etc. for the target SINR

Agreements**:**

For the evaluation at next meeting, sequence length of S-PSS/S-SSS for all evaluated SCS is assumed the same as that of S-PSS/S-SSS with 15 kHz SCS

- Other sequence lengths are not precluded

Agreements:

- At least for single-carrier operation:
  - For the SL synchronization procedure, each type of synchronization reference has a respective sync priority
    - FFS the priority between eNB and gNB (if necessary)
  - For the SL synchronization procedure, among the available references, a UE selects the synchronization reference with the highest priority as the reference to derive its transmission timing
    - FFS other potential usage
    - FFS how to handle the case when there are two or more references of a same priority to be selected as the highest priority

In RAN1 #96, the following agreements were made for synchronization:

Agreement for synchronization:

- Whether GNSS-based synchronization or gNB/eNB-based synchronization is used is (pre)-configured.
  - The following table is a working assumption

GNSS-based synchronization	gNB/eNB-based synchronization

• P0: GNSS
• P1: the following UE has the same priority:
  • UE directly synchronized to GNSS
• P2: the following UE has the same priority:
  • UE indirectly synchronized to GNSS
• P3: the remaining UEs have the lowest priority.
	• P0: gNB/eNB
	• P1': UE directly synchronized to gNB/eNB
	• P2': UE indirectly synchronized to gNB/eNB
	• P3': GNSS
	• P4': UE directly synchronized to GNSS
	• P5': UE indirectly synchronized to GNSS
	• P6': the remaining UEs have the lowest priority.

Agreements:

- NR V2X supports using a sidelink RS for synchronization purpose
  - Applicable only on unlicensed (ITS) carrier with no network deployment on this carrier
  - This RS is not a standalone RS and not part of SLSS.
  - This RS will not appear in the synchronization procedure for the selection of sync sources.
  - RS used for the synchronization purpose would not impact any sidelink RS design
  - FFS: Whether this RS is DM RS or other RS
  - FFS: Whether this could be achieved by UE implementation
  - FFS: Specification impact

1.1.4 Resource Allocation

Highlights

The following are the two SL resource allocation modes:

- Mode 1: BS schedules SL resource(s) to be used by UE for SL transmission(s).
- Mode 2: UE determines, i.e. BS does not schedule, SL transmission resource(s) within SL resources configured by BS/network or pre-configured SL resources.

The definition of SL resource allocation Mode 2 covers:

a) UE autonomously selects SL resource for transmission
b) UE assists SL resource selection for # of other UE(s), a functionality which can be part of a), c), d)
c) UE is configured with NR configured grant (Type-1 like) for SL transmission
d) UE schedules SL transmissions of other UEs

Resource allocation Mode 2 supports reservation of SL resources at least for blind retransmission.

Sensing and resource (re-)selection

- Sensing and resource (re-)selection-related procedures are supported for resource allocation Mode 2.
- The sensing procedure considered is defined as decoding SCI(s) from other UEs and/or SL measurements. Decoding SCI(s) in this procedure provides at least information on SL resources indicated by the UE transmitting the SCI. The sensing procedure uses a L1 SL RSRP measurement based on SL DMRS when the corresponding SCI is decoded.
- The resource (re-)selection procedure considered uses the results of the sensing procedure to determine resource(s) for SL transmission.

- Mode 2(a)
  - The study considers SL sensing and resource selection procedures for Mode 2(a), in the context of a semi-persistent scheme where resource(s) are selected for multiple transmissions of different TBs and a dynamic scheme where resource(s) are selected for each TB transmission.
  - The following techniques are studied to identify occupied SL resources:
    - Decoding of SL control channel transmissions
    - SL measurements
    - Detection of SL transmissions
  - The following aspects are studied for SL resource selection
    - How a UE selects resource for PSCCH and PSSCH transmission (and other SL physical channel/signals that are defined)
    - Which information is used by UE for resource selection procedure
- Mode 2 (c)
  - For out-of-coverage operation, Mode 2(c) assumes a (pre-)configuration of single or multiple SL transmission patterns, defined on each SL resource pool. For in-coverage operation, Mode 2(c) assumes that gNB configuration indicates single or multiple SL transmission patterns, defined on each SL resource pool. If there is a single pattern configured to a transmitting UE, there is no sensing procedure executed by UE, while if multiple patterns are configured, there is a possibility of a sensing procedure.
  - A 'pattern' is defined by the size and position(s) of the resource in time and frequency, and the number of resources.

Mode 2(d)

- In the context of group-based SL communication, it supported for UE-A to inform its serving gNB about members UE-B, UE-C, and so on of a group, and for the gNB to provide individual resource pool configurations and/or individual resource configurations to each group member through UE-A. UE-A cannot modify the configurations, and there is no direct connection between any member UE and the gNB. Higher-layer only signalling is used to provide the configurations. Such functionality is up to UE capability(ies

Work Item Phase

NR sidelink: Specify NR sidelink solutions necessary to support sidelink unicast, sidelink groupcast, and sidelink broadcast for V2X services, considering in-network coverage, out-of-network coverage, and partial network coverage.

- Resource allocation
  - Mode 1
    - NR sidelink scheduling by NR Uu and LTE Uu as identified in TR 38.885
  - Mode 2
    - Including sidelink configuration by NR Uu and LTE Uu as identified in TR 38.885
  - Support for simultaneous configuration of Mode 1 and Mode 2

1.1.4.1 Sidelink Resource Allocation Mode 1, Mode-2 and the Sub-Modes

The following are a list of open issues that was identified:

- Sidelink resource allocation Mode-2 and sub-modes

- Sidelink channel access and collision avoidance aspects for sidelink transmissions (control and shared channel) in case of unicast, groupcast and broadcast sidelink transmissions for periodic and aperiodic traffic

❖ UE behavior to select sidelink resource for PSCCH/PSSCH transmission or any new sidelink physical channel(s) / signal(s) if proposed

➢ Note: There is a potential overlap with another agenda item "7.2.4.1.2 Physical layer structures and procedure(s))"

- Sidelink resource configuration and resource pools
  - Configuration of sidelink resource pools and pool attributes

❖ Note: There is a potential overlap with another agenda item "7.2.4.1.2 Physical layer structures and procedure(s)"

- Mode-1/Mode-2 sidelink resource sharing and mode switching
  - Sidelink resource sharing between gNB-controlled and UE-autonomous resource allocation modes
  - Switching aspects between gNB-controlled and UE-autonomous resource allocation modes
  - Note: There is a potential overlap with another agenda item "7.2.4.3.1 Enhancements of LTE Uu and NR Uu to control NR sidelink"

1.1.4.1.1 Mode-2(a) open issues

1.1.4.1.1.1 Dynamic and semi-persistent resource selection for Mode-2

The following scheme(s) were discussed with respect to sidelink resource selection

- Alt. 1: Dynamic and semi-persistent resource selection schemes
  - Dynamic scheme: sidelink resource(s) are selected for each TB transmission
  - Semi-persistent scheme: sidelink resource(s) are selected for multiple periodic transmissions of different TBs
    - Supported by Ericsson, Nokia, Mediatek, CATT, Sony, NEC, HEPTA 7291, Samsung, Interdigital
- Alt. 2: Only dynamic resource selection scheme: sidelink resource(s) are selected for each TB transmission
  - Dynamic scheme: sidelink resource(s) are selected for each TB transmission
    - Supported by Qualcomm

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- NR V2X Mode-2 supports the following scheme(s) for sidelink resource selection
  - Dynamic scheme: sidelink PSCCH/PSSCH resource(s) are selected for single TB transmission
  - Semi-persistent scheme: sidelink PSCCH/PSSCH resource(s) are selected for multiple transmissions of different TBs

Topics with discussion:

- NR V2X Mode-2 supports the following scheme(s) for sidelink resource selection
  - Dynamic scheme: sidelink PSSCH resource(s) are selected for transmission of one TB [or two TBs if supported by MIMO scheme]
  - Semi-persistent scheme: sidelink PSSCH resource(s) are selected for transmission of multiple TBs
  - Note: that this does not imply how signaling for resource allocation is done

Candidate options

- The following options are identified for further analysis:
  - Option 1: Initial transmission and retransmission(s) use dynamic scheme for resource selection
  - Option 2: Initial transmission and retransmission(s) use semi-persistent scheme for resource selection

- Option 3: Initial transmission uses semi-persistent scheme and retransmission uses dynamic scheme for resource selection
- Option 4: Initial transmission uses dynamic scheme and retransmission uses semi-persistent scheme for resource selection

1.1.4.1.1.2 Reservation for sidelink transmission

Two main options were discussed with respect to sidelink resource reservation mechanism. The first option is when dedicated reservation signal is sent a priori of initial transmission of a TB and reserves resources for initial transmission and retransmissions. On top of that the subsequent control channel transmission can also reserve resources for retransmissions. In the second option, there is no resource reservation for initial transmission of a TB, while initial transmission itself reserves resources for retransmissions.

- Alt.1 NR V2X supports reservation of sidelink resources for initial transmission and (re)-transmissions of a TB
  - Supported by Ericsson, Nokia, Interdigital, vivo, Kyocera, CATT
- Alt.2 NR V2X supports reservation of sidelink resources only for retransmissions of a given TB
  - Supported by Qualcomm

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- NR V2X Mode-2 supports reservation of sidelink resources for initial transmission and retransmissions of a TB
  - FFS in which cases reservation is signaled for initial transmission of a TB
- NR V2X Mode-2 supports reservation of sidelink resources for retransmissions of a TB

Topics with discussion:

- Blind retransmissions of a TB are supported by NR-V2X
  - FFS details

- NR V2X Mode-2 supports reservation of sidelink resources at least for blind retransmission of a TB
  - Whether reservation is supported for initial transmission of a TB is to be discussed if/when it is specified
  - FFS whether reservation is supported for potential retransmissions based on HARQ feedback

1.1.4.1.1.3 Sensing and resource selection windows

Companies discuss terms of sensing and resource selection windows:

- Define sensing window as a time interval where UE is expected to monitor medium before resource (re)-selection trigger (Intel)
- Sensing window duration is configurable (Intel)
- Resource selection window is defined as a time interval starting from resource (re)-selection trigger and bounded by min(packet delay budget , configurable resource selection window duration)
- For resource selection procedure latency is used (e.g., for selection window setting and redundant transmission) (LGE)
- The latency QoS attribute is supported for setting the resource selection windows (HEPTA 7291)
- Prior to selection of resources, the UE shall sense the channel during a window of length equal to the longest reservation that can be signalled in the SCI (Ericsson)

Based on review of submitted contributions, we have the following proposal to trigger discussion:

Topics not discussed due to lack of time:

- Sensing window is defined

- FFS details, including whether it is configurable and/or a function of e.g. maximum resource reservation interval
- Resource selection window is defined
  - The resource selection window is bounded by packet delay budget
  - FFS other details

1.1.4.1.1.4 Information extracted from SCI for sensing procedure

The following proposals are discussed in submitted contributions with respect to information extracted from SCI decoding for Mode-2 sensing procedure:

- L1 source and destination IDs (Intel)
- Priority and resource allocation (vivo, Sony, Intel, LGE)
- Slot aggregation (vivo, Qualcomm)
- Distance, e.g. zone ID (Qualcomm)
- Resource reservation information (e.g. reservation period for SPS services) (ZTE, OPPO, Sony, Interdigital, Nokia, Ericsson, LGE(scheduling));
- Time interval between SCI and the reserved resources for dynamic resource selection (ZTE)
- QoS parameters for given sidelink transmission (Ericsson, Intel)
- PSSCH sub-channels for initial transmission and retransmission (OPPO)
- Request for HARQ feedback and pre-emption messages (Ericsson)

Based on review of submitted contributions, we have following proposal for initial discussion:

Topics not discussed due to lack of time:

- Mode-2 sensing procedure extracts the following information from SCI decoding for the purpose of resource selection
  - Used and reserved resources for sidelink transmission
  - QoS related parameters for sidelink transmission associated with the decoded SCI which include:
    - Priority of transmission, FFS other QoS parameters
  - L1 source and destination IDs, if provided

1.1.4.1.1.5 Sidelink measurements for sensing procedure

The following proposals are discussed in submitted contributions with respect to sidelink measurement for Mode-2 sensing procedure:

- SL-RSRP, SL-RSSI (LGE)
- Sidelink measurements. One sidelink measurement that would be useful for Mode 2 operation and should continue to be supported for NR-V2X is PSSCH-RSRP (OPPO)
- Energy/power measurements of resources (e.g., radio resources, DMRS sequences, etc.) based on decoding information is supported (Ericsson)
- Both SA SCI decoding and L1 measurement based sensing should be studied for Mode 2 (a) (Convida Wireless)
  - Energy/power measurements of resources (e.g., radio resources, DMRS sequences, etc.) based on decoding information is supported (Ericsson)
- To alleviate IBE problem, two nearby UEs' resources can be allocated adjacently. One weighting function can be introduced to resource selection procedure to indicate RSRP difference between UE and occupied resource (Mediatek)
- SFCI including HARQ-ACK, CSI, RSRP and RSRQ is utilized for the sensing and resource selection procedure in NR V2X (Samsung)
- SL-RSRP and SL-RSSI measurements are introduced for sensing and resource selection procedure (Intel)
- For Mode-2 sensing procedure S-RSRP measurements should be supported. SL-RSRP should be defined for PSCCH and PSSCH sidelink channels. (HEPTA 7291)

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- Mode-2 sensing procedure utilizes the following sidelink measurements
  - L1 SL-RSRP based on sidelink DMRS when the corresponding SCI is decoded
    - FFS whether/which measurement is used if the corresponding SCI is not decoded e.g. SL-RSRP after blind DMRS detection, SL-RSSI

1.1.4.1.1.6 Sidelink resource (re)-selection procedure

The following major steps of sidelink resource selection procedure are discussed by companies:

- Resource exclusion based on SCI decoding and sidelink measurements
- Construction of a candidate resource set(s) for sidelink PSCCH and PSSCH transmission
- Selection of a resource for sidelink PSCCH and PSSCH transmission from the candidate resources set

Based on review of submitted contributions, we have the following proposal for discussion:

Topics not discussed due to lack of time:

- Resources (re)-selection procedure includes
  - Candidate resource set formation by resource exclusion procedure from the resource selection window
    - FFS details of resource exclusion procedure
  - Actual resource selection from the candidate resource set
    - FFS scheme for actual resource selection from the candidate resource set (e.g. backoff / counter based or any other randomization mechanism)

1.1.4.1.1.7 Resource exclusion procedure (part of resource (re)-selection)

In the context of resource selection and candidate resource set formation, the resource exclusion procedures are discussed.

Based on review of submitted contributions, we have the following proposal for discussion:

Topics not discussed due to lack of time:

- Mode-2 resource exclusion procedure is based on processing of decoded SCI transmissions to exclude occupied/reserved PSSCH resources based on at least SL-RSRP measurements
  - FFS whether / how distance based control exclusion is supported
  - FFS whether and how QoS attributes (e.g. priority, reliability, latency) are taken into account
  - FFS other measurements

1.1.4.1.1.8 Granularity of sensing and resource selection

Granularity of sensing and resource selection procedure is discussed. In frequency domain, the sub-channels are considered by most of the companies. In time domain, the proposals range from one OFDM symbol to several slots (as part of TFRPs).

Based on review of submitted contributions, we suggest to continue discussion once more progress is made on sidelink physical structure and procedures.

1.1.4.1.1.9 Assistance information for UE resource (re)-selection

In terms of assistance information used in resource selection procedure mainly three options are being discussed: 1) utilization of geographical location information; 2) utilization of measurement/sensing reports; 3) utilization of feedback information 4) gNB assistance signalling. In particular, the following proposals were made:

- Support the zone-based resource allocation principle (LGE)

- Each UE broadcasts its geographic information, for the purposes of group forming, communication range based ACK/NACK feedback, and so forth (Fujitsu)
- UEs can be divided into different groups based on geo-information. Each group will decide the group header by some information. The group header selection mechanism will be FFS. (ITRI)
- Feedback based resource reselection triggering should be introduced. FFS on feedback information (Sony)
- UE assistance information based on sensing results, i.e., in the form of sensing results reporting. HARQ feedback, collision detection reports by the other UE and reselection requests (HEPTA 7291)
- Sidelink measurement for NR V2X mode 2 resource sensing and selection procedure may be important. The measurement report may receive from the base station (i.e. gNB) or the other UEs. P5: The measurement report may include the UE location, traffic specific configuration (i.e. periodic and aperiodic traffic) or else. (ITRI)
- The following types of assistance information for resource selection are supported: feedback from target receivers and geo-location information (Intel)
- SFCI including HARQ-ACK, CSI, RSRP and RSRQ is utilized for the sensing and resource selection procedure in NR V2X (Samsung)
- For Mode 2a, the assistance from receiving side on collision avoidance and high interference indication should be supported, at least for unicast/groupcast (Xiaomi)
- RSRP based control exclusion and distance based control exclusion are both supported in NR V2X (Qualcomm)

Based on review of submitted contributions, we have following proposal to trigger discussion:

Topics not discussed due to lack of time:

- RAN1 continues analysis of the benefits from the following assistance information and whether / how UE reselecting resource in Mode-2 takes it into account
  - Location information of transmitting UEs
  - Feedback and measurement reports from target receiver UEs including resource restriction or resource recommendation information
  - gNB assistance signaling

1.1.4.1.1.10 Pre-emption Mechanism

Many contributions have mentioned that NR-V2X should support pre-emption mechanisms mainly targeting support of different transmission priorities and reliability levels/QoS targets.

Topics not discussed due to lack of time:

- NR-V2X Mode-2 supports resource pre-emption mechanism
  - FFS details of pre-emption mechanisms and its impact on sidelink resource selection and UE transmission behavior

1.1.4.1.2 Mode-2(c)

Based on review of submitted contributions, we have the following proposal for discussion:

Topics with discussion:

- NR-V2X Mode-2(c) is not supported as a standalone mode for sidelink resource allocation
  - FFS if time frequency repetition patterns are introduced as a part of Mode-2 sensing and resource selection procedures

Mode-2 does not support configuration of pool of patterns for sidelink transmission
Mode-2 support configuration of resource pools for sidelink transmission

1.1.4.1.3 Mode-2(d)

Based on review of submitted contributions, it is clear that there is no consensus on Mode-2(d) support, therefore RAN1 need to continue discussion on whether/how to support Mode-2(d) with S-UE configuring sidelink transmission resources to other group member UE using higher layer signaling.

Topics with discussion:

- **In the context of Mode-2(d), NR V2X supports the following functionality:**
  - **A UE informs gNB about group members and gNB provides individual resource pool configuration and/or individual resource configuration through the same UE to each group member UE within the same group. It does not require connection between member UE and gNB**
    - **The UE cannot modify the configuration provided by gNB**
    - **Higher layer signaling is to be used to provide the configuration. No physical layer signaling is used**
  - **FFS if one or both options are supported (i.e. resource pool configuration(s) or resource configuration)**
  - **FFS which functionality defined as a part of Mode-2 is applicable for this feature**
  - **This functionality is UE capability(ies)**

1.1.4.1.4 Selection of scheduling UE (S-UE) in Mode-2(d)

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- RAN1 assumes that the scheduling UE is assigned by higher layers or by pre-configuration

1.1.4.1.5 Selection of resources for group members by S-UE in Mode-2(d)

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- Set of sidelink resources a scheduling UE can use to configure resources for other UEs is semi-statically configured or pre-configured

1.1.4.1.6 Potential Mode-2(d) procedures out of RAN1 scope

Based on review of submitted contributions, we have following proposal for discussion:

Topics with discussion:

- RAN1 confirms that the following potential radio-layer procedures for Mode-2(d) support are out of RAN1 scope:
  - Procedures to become/serve as a scheduling UE for in-coverage and out-of-coverage scenarios
  - UE behavior to (re)-select scheduling UE(s)
  - UE behavior to associate to scheduling UE(s)
  - UE behavior when scheduling UE stop scheduling
  - Relationship between scheduling UE and UE groups from upper layer perspective

1.1.4.1.7 Other Aspects

Other aspects mentioned in contributions are:

- Multi-slot scheduling for large packets [vivo, LGE, Qualcomm]
- Cross-slot scheduling [vivo]
- IBE in resource selection – weighting function based on RSRP [MediaTek]
- Multiple PSCCH transmissions are associated with PSSCH [OPPO]
- Feedback as a trigger to reselect resources [Sony]
- Assistance information and sharing of sensing information [CMCC, Convida Wireless, HEPTA 7291]

- Dedicated resource pools for periodic and aperiodic traffics [ITRI, Panasonic **Error! Reference source not found.**]
- SFCI for sensing + association of PSCCH/PSSCH and PSFCH resources [Panasonic]
- Impact of distributed antenna on resource allocation [LGE]
- Adaptation of the reporting and CDRX configuration based on UE speed [Apple]
- Mode-1 / Mode-2 resource pool sharing [Intel]
- QoS is mapped to pool (CATT)
- Coexistence mechanism of NR V2X and LTE V2X should be considered in resource allocation (CATT)
- Half-duplex in the context of carrier aggregation (CATT)
- Sidelink resources used before association to scheduling UE and switching to Mode-2(d) from other sub-modes (Sony)
- Use of exceptional pool for sub-mode switching (Spreadtrum)
- UE association to scheduling UE by higher layers (NTT DOCOMO)

1.1.4.1.8 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for resource allocation.

In RAN1 #94, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- At least two sidelink resource allocation modes are defined for NR-V2X sidelink communication
  - Mode 1: Base station schedules sidelink resource(s) to be used by UE for sidelink transmission(s)
  - Mode 2: UE determines (i.e. base station does not schedule) sidelink transmission resource(s) within sidelink resources configured by base station/network or pre-configured sidelink resources
- Note:
  - eNB control of NR sidelink and gNB control of LTE sidelink resources will be separately considered in corresponding agenda items.
  - Mode-2 definition covers potential sidelink radio-layer functionality or resource allocation sub-modes (subject to further refinement including merging of some or all of them) where
    - a) UE autonomously selects sidelink resource for transmission
    - b) UE assists sidelink resource selection for other UE(s)
    - c) UE is configured with NR configured grant (type-1 like) for sidelink transmission
    - d) UE schedules sidelink transmissions of other UEs
- RAN1 to continue study details of resource allocation modes for NR-V2X sidelink communication

In RAN1 #94bis, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- Sidelink sensing and resource selection procedures are studied for Mode-2(a)
  - The following techniques are studied to identify occupied sidelink resources
    - decoding of sidelink control channel transmissions
    - sidelink measurements
    - detection of sidelink transmissions
    - other options are not precluded, including combination of the above options
  - The following aspects are studied for sidelink resource selection
    - how a UE selects resource for PSCCH and PSSCH transmission (or other sidelink physical channel/signal, if it is introduced)
    - which information is used by UE for resource selection procedure
- The following aspects about assistance information are studied for Mode 2(b)
  - Which assistance information is used and how it is acquired
  - Which UE sends assistance information

- How to deliver assistance information, including physical channel and UE behavior
- How assistance information is taken into account in determination of sidelink resource for transmission

- RAN1 to further study whether some or all of Mode-2(b) functionality is a part of Mode-2(a)(c)(d)
- The following aspects are studied for Mode 2(c)
  - How to assign resource(s) for UE sidelink transmission to mitigate collisions and half-duplex impacts
  - Whether any sensing or resource selection procedure is used on top of configured grant(s)
  - Whether and how to use any granted but unused resources
  - How to adapt to traffic variation
  - How it is different from Mode-1 operation for in-coverage scenario
  - How it is different from Mode-2(a), when Mode-2(a) uses dedicated resource pool with dedicated sidelink resource pool configuration
  - Whether and how this mode operates out of network coverage
- RAN1 to further study whether some or all of Mode-2(c) functionality is a part of Mode-2(a)(b)(d)
- The following aspects are studied for Mode 2(d)
  - In which use cases/scenarios this mode is applicable
  - What is the overall architecture for Mode-2(d) operation
  - How to decide which UE schedules which other UE(s) and how to maintain this relationship
  - What is the procedure of UE(s) when the scheduling UE disappears
  - What is the scheduling UE behavior and signaling mechanism to schedule sidelink resources for transmission/reception for other UEs
  - Which resources can be used to schedule other UEs
  - Inter- and intra-UE collision handling and sidelink resource allocation mechanisms across groups
- RAN1 to further study whether or not some or all of the above aspects are applicable to 2(b)

In RAN1 #95, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

- Sensing procedure is defined as SCI decoding from other UEs and/or sidelink measurements
  - FFS information extracted from SCI decoding
  - FFS sidelink measurements used
  - FFS UE behavior and timescale of sensing procedure
  - Note: It is up to further discussion whether SFCI is to be used in sensing procedure
  - Note: Sensing procedure can be discussed in the context of other modes
- Resource (re)-selection procedure uses results of sensing procedure to determine resource(s) for sidelink transmission
  - FFS timescale and conditions for resource selection or re-selection
  - FFS resource selection / re-selection details for PSCCH and PSSCH transmissions
  - FFS details for PSFCH (e.g. whether resource (re)-selection procedure based on sensing is used or there is a dependency/association b/w PSCCH/PSSCH and PSFCH resource)
  - FFS impact of sidelink QoS attributes on resource selection / re-selection procedure
- For Mode-2(a), the following schemes for resource selection are evaluated, including
  - Semi-persistent scheme: resource(s) are selected for multiple transmissions of different TBs
  - Dynamic scheme: resource(s) are selected for each TB transmission

- Mode-2(b) to be studied as a functionality that can be a part of Mode-2(a)(c)(d) operation, when one UE assists sidelink resource selection for other UE(s)
- Note: Mode-2(b) is not supported/studied as a standalone sidelink resource allocation mode
- For out of coverage operation, Mode-2(c) assumes (pre)-configuration of single or multiple sidelink transmission patterns (patterns are defined on each sidelink resource pool).

- For in-coverage operation, Mode-2(c) assumes that gNB configuration indicates single or multiple sidelink transmission patterns (patterns are defined on each sidelink resource pool)
- FFS pattern design in time and frequency for periodic and aperiodic traffic
- If single pattern is configured to transmitting UE there is no sensing procedure executed by UE
- If multiple patterns are configured to transmitting UE there is a possibility of sensing procedure executed by UE
- Pattern is defined as follows
    - Size of the resource in time and frequency
    - Position(s) of the resource in time and frequency
    - Number of resources
- FFS pattern selection procedure by UE

- For Mode-2(d) operation, further study the following potential radio-layer procedures including at least the following
    - Procedures to become/serve as a scheduling UE for in-coverage and out-of-coverage scenarios
        - The following options are identified for further study:
            - Scheduling UE is configured by gNB
            - Application layer or pre-configuration selects scheduling UE
            - Receiver UE schedules transmissions of the transmitter UE during the session
            - Scheduling UE is decided by multiple UEs including the one that is finally selected
                - UE may autonomously decide to serve as a scheduling UE (self-nomination) / offer scheduling UE functions

- Initialization of Mode-2(d) operation is FFS
- For Mode-2(d) operation, further study the following potential radio-layer procedures including at least the following
    - Procedure to determine a set of sidelink resources a scheduling UE can use for scheduling of other UEs
        - The following options are identified:
            - Based on sensing procedure by scheduling UE
            - Configured by gNB if scheduling UE is in-coverage
            - Pre-configured if scheduling UE is out of coverage
            - Transmitting UE provides information about sidelink resources to scheduling UE
    - FFS behavior/algorithm of scheduling UE
    - Behavior of scheduling UE to signal scheduling decisions for transmission/reception of other UEs
        - The following options are identified:
            - Physical layer signaling
            - Higher layer signaling
    - UE behavior to (re)-select scheduling UE(s)
    - UE behavior to associate to scheduling UE(s)
    - UE behavior when scheduling UE stop scheduling
    - Resource management to address collision/interference and half-duplex issues b/w UEs scheduled by different scheduling UEs
    - Relationship between scheduling UE and UE groups from upper layer perspective
        - Whether UEs from the same upper layer group are served by the same scheduling UE
    - Resources used for communication before UE is associated with a scheduling UE
- Procedures to switch between Mode-2(d) from/to other submodes

In RAN1 #AH_1901, the following agreements were made for resource allocation mechanism:

Agreement for resource allocation mechanism:

R1-1901375

Agreements:
Mode-2 supports the sensing and resource (re)-selection procedures according to the previously agreed definitions.

- FFS resource granularity for sensing & resource (re)-selection, e.g., PRB(s), slots, resource patterns (when applicable), etc.
- FFS detailed conditions when these procedures can apply

Agreements:

- For the purpose of performance evaluation for Mode-2(c), the following Mode-2(c) transmission pattern selection is used when a UE is configured with a pool of patterns:
  - Sensing based pattern selection (e.g. UE selects unused pattern based on sensing results)
    - Additional information to assist pattern selection is not precluded, e.g., by using UE geographical location information

Agreements:

- Sub-channel based resource allocation is supported for PSSCH
  - FFS details for sub-channels
  - FFS other use cases for sub-channel (e.g., measurement, interaction with PSCCH, etc.)

R1-1901462
Agreements**:**

- SCI decoding applied during sensing procedure provides at least information on sidelink resources indicated by the UE transmitting the SCI

Agreements:
At least for the purpose of evaluation, in Mode-2(d), at least for group operation, a member UE transmits on resources configured by another UE (S-UE) within the same group

- High layer signaling is assumed between S-UE and a member UE

In RAN1 #96, the following agreements were made for resource allocation mechanism:
Agreement for resource allocation mechanism:

- Blind retransmissions of a TB are supported for SL by NR-V2X
  - Details are for the WI phase

Agreements:

- NR V2X Mode-2 supports reservation of sidelink resources at least for blind retransmission of a TB
  - Whether reservation is supported for initial transmission of a TB is to be discussed in the WI phase
  - Whether reservation is supported for potential retransmissions based on HARQ feedback is for the WI phase

Agreements:

- Mode-2 sensing procedure utilizes the following sidelink measurement
  - L1 SL-RSRP based on sidelink DMRS when the corresponding SCI is decoded
    - FFS whether/which measurement is used if the corresponding SCI is not decoded e.g. SL-RSRP after blind DMRS detection, SL-RSSI

Agreements:
In the context of Mode-2(d), NR V2X supports the following functionality:

- A UE informs gNB about group members and gNB provides individual resource pool configuration and/or individual resource configuration through the same UE to each group member UE within the same group. It does not require connection between member UE and gNB
  - The UE cannot modify the configuration provided by gNB

- Higher layer signaling is to be used to provide the configuration. No physical layer signaling is used
- FFS if one or both options are supported (i.e. resource pool configuration(s) or resource configuration)
- FFS which functionality defined as a part of Mode-2 is applicable for this feature
- This functionality is up to UE capability(ies)

1.2 Evaluation of Uu for advanced V2X use cases

No additions included

Highlights

NR supports having multiple active UL configured grants in a given bandwidth part (BWP) in a given cell, of which not more than one is used simultaneously for transmission by UE. Downlink control information (DCI) is used to identify the type-2 UL configured grant (Tpye 2: Based on RRC configuration and L1 signaling for activation/deactivation) to be activated or deactivated.

The UE can report assistance information to the gNB consisting of at least UE-related geographic information such as position and, at least for periodic traffic, reports of Uu and SL V2X traffic periodicity, timing offset, and message size.

Rel-15 NR does not support multicast/broadcast over the Uu interface. There are two technologies for Uu multicast/broadcast in 3GPP previously: multimedia broadcast single frequency network (MBSFN) and single-cell point-to-multipoint (SC-PTM), both supported in LTE. NR Uu multicast/broadcast are beneficial at least in terms of resource utilization for V2X use cases in some scenarios.

Work Item Phase

NR Uu enhancement: Specify NR Uu enhancements identified necessary during the related study

- Multiple activated configured grants for UL for the work item phase.

1.2.1 Evaluation of Uu for V2X Issues

This section provides all the meeting agreements during the NR V2X study item phase for Uu for advanced V2X use cases.

1.2.1.1 Support for multiple uplink configured grants

In previous meetings, the following agreements and conclusions were made:

Agreements:
- For Uu for advanced V2X use cases, NR supports having multiple active UL configured grants in a given BWP in a given cell.
  - Details FFS

Agreements:
- DCI is used to identify the type-2 UL configured grant to be activated or released.
  - FFS Single DCI for multiple type-2 UL configured grants.

Conclusion:
- For type 2 configured grant, discuss signalling details and whether single DCI can activate/release multiple configured grants during WI (if included in the WI).

Agreements:
- A UE is not expected to transmit simultaneously according to more than one UL grant (e.g., dynamic or CG) in a given BWP.

A few contributions discuss signalling details for type-2 UL configured grants: R1-1901813 (MediaTek), R1-1902485 (Intel), R1-1902998 (Qualcomm). Given the conclusion from RAN1#AH-1901 reproduced above, it seems that no further discussion on the issue is necessary in the SI.

Similarly, R1-1901543 (Huawei, HiSilicon) discusses signalling details on type-1 as well type-2 configured grants. Again, given the conclusion from RAN1#AH-1901, it seems that no further discussion on type-2 is necessary. Also, it seems reasonable to postpone the discussion on signalling details for type-1 configured grant to the WI too.

Proposed Conclusion (offline consensus):

- **For type 1 configured grant, discuss signalling details during WI (if included in the WI).**

Other contributions discuss different aspects of UL configured grants but there are no commonalities between them. R1-1900200 (MediaTek) discusses the maximum number of type-2 configurations, proposing to limit it to at most 8 CGs. CATT describes a problem regarding HARQ process ID collisions for UL configured grants, indicating that further study is necessary but without any technical proposal. ZTE, Sanechips propose to introduce HARQ ACK/NACK for UL configured grants to allow for quick detection of transmissions that are not detected by the gNB as well as having retransmissions for multiple type-1 UL configured grants. Finally, Ericsson discusses the possibility of supporting UL SPS confirmation but defers the discussion to the follow-up WI.

1.2.1.2 Support for UE reports

In the past, it was agreed to support UE reports of assistance information to the gNB.

Agreements:
- NR supports that UE reports assistance information to the gNB, consisting of at least (with details FFS):
  - UE-related geographic information (e.g., position).
  - Reports of Uu V2X traffic-related information (at least for periodic traffic).

Agreements:
- From RAN1 perspective, NR UE reporting on Uu that include at least traffic periodicity, timing offset, and message size is beneficial at least for the purpose of managing multiple UL configured grants.

Agreements:
- NR supports UE reporting over Uu of sidelink traffic-related information.
  - FFS contents.

Multiple contributions list possible reports but in general there is little technical discussion. The following reports are proposed by different companies:

- Traffic periodicity (OPPO)
- Timing offset (OPPO)
- Message size (OPPO, Interdigital)
- Latency (OPPO)
- CBR per resource pool (OPPO)
- Information about the utilization of the PC5 pool (OPPO)
- QoS requirement (Qualcomm, CATT)
- Communication range (Qualcomm)
- Speed and direction (Interdigital)

At least one contribution (R1-1901687, vivo) proposes to leave the discussion on the contents of the reports to the WI.

The first three reports listed above, although mentioned in an existing agreement, are not explicitly supported yet. Moreover, their usefulness was already confirmed for LTE V2X so there is no need to repeat the discussion here.

Proposed agreement: (offline consensus)

- **UE reports of assistance information to the gNB include, at least: traffic periodicity, timing offset, and message size for Uu V2X and sidelink V2X traffic (at least for periodic traffic).**

Given the lack of discussion in the papers and the nature of the topic, we propose to leave the discussion of QoS requirements reports to RAN2 Reporting of QoS requirements, if necessary, to RAN2.

1.2.1.3 Other enhancements

Multiple contributions discuss broadcast/multicast for NR Uu.

Vivo proposes not to study BC/MC for Uu in the SI. MediaTek argues that design of BC/MC for Uu is not in scope of the SI. At the same time, it proposes to study several candidate designs, without any further proposal in this direction. CATT proposes not to treat the standardization of BC/MC for Uu in this SI. Intel observes that, while NR V2X services may benefit from support of MBMS/SC-PTM features, the scope and inter-WG dependency level demands a separate SI/WI on the topic. Similarly, OPPO recommends that the support of V2X services using broadcast / multicast over NR Uu interface in the downlink be discussed in a separate RAN SI/WI.

Samsung proposes to study SC-PTM-like group communications and associated HARQ and CSI feedback over NR Uu. Interdigital simply proposes to support BC/MC for NR Uu.
Given that this is the last meeting in the study item, the limited study so far, and the guidance from RAN1 chair during RAN1#AH-0119, it is unclear which goal the above proposals can realistically attain. A few contributions have a more constructive approach and propose to capture some statement in TR 38.885 regarding the benefits or need of supporting broadcast and multicast transmissions. These include:

- Huawei, HiSilicon, discussing the benefits of Uu MC in terms of resource utilization and latency, which are not restricted to V2X UCs. The contribution proposes to take SC-PTM as the baseline for NR Uu MC.
- Samsung, proposing to capture the necessity of groupcast via Uu link to support NR V2X use cases.
- Nokia, proposing to capture the need for Uu broadcast/multicast to support V2X over Uu in a resource-efficient way.

The following proposal aims at summarizing the key points in the different proposals.

Proposed conclusion: (offline consensus)

- **Capture in TR 38.885 that NR Uu broadcast/multicast are beneficial at least in terms of resource utilization for V2X use cases in some scenarios.**

Proposed conclusion: (offline consensus)

- **RAN1 to prepare a TP on broadcast/multicast for the body (not conclusions) of TR.**

Two contributions (OPPO, Ericsson) propose supporting multiple active DL SPS configurations. ON this topic, Ericsson discusses other aspects such as periodicities and skipping HARQ feedback. The issue has not been discussed in RAN1 so far. Given that only two companies mention the feature, it seems that more discussion is necessary in RAN1.

In addition, the following enhancements are presented in a single contribution:

- UL mobility measurements (R1-1900027, Huawei, HiSilicon).
- Mapping rule between LTE QoS and NR QoS (R1-1900325, CATT)

1.2.2 Summary of discussion of LTE feasibility and enhancements

Regarding potential enhancements for LTE, one contribution (Huawei, HiSilicon) discusses feasibility and possible enhancements with different degrees of specification impact, proposing to focus on those with no/little impact. Discussion on the topic is needed.

In addition, given that only one contribution has treated this topic, it should not be controversial to focus on enhancements with no or minor specification impact, if any.

Proposed conclusion for TR conclusion section (offline consensus):

- **In terms of supporting advanced V2X uses cases over the LTE Uu interface, some possible enhancements were studied but none are recommended.**

1.2.3 Observations and conclusions in the TR

Since RAN plenary agreed on allocating the remote driving discussion to the eURLLC SI, there will be a mismatch between the use cases and objectives in the SID and the contents of the TR. For this reason, two contributions (R1-1901934, LGE and R1-1903169, Ericsson) suggest having a link to the eURLLC TR in the V2X TR.

Proposed agreement: (offline consensus)

- Add a reference in TR 38.885 stating that the remote driving use case is handled in TR 38.824.

Two contributions (R1-1901934, LGE and R1-1903169, Ericsson) propose to capture in TR 38.885 a recommendation for specifying the two features agreed so far (multiple active UL configured grants and reports of UE assistance information to the gNB).

Proposed agreement:

- Recommend the inclusion of the following enhancements to the Uu interface in the technical solution list of WI:
  - Multiple active UL configured grants
  - UE assistance information reporting to gNB

Several contributions propose to capture observations in TR 38.885 regarding BC/MC (see discussion and proposals in Section 2.2). Finally, in R1-1903169, Ericsson proposes to capture in TR 38.885 a positive statement on the feasibility of NR Uu for supporting V2X use cases.

Proposed conclusion:

- RAN1 to continue discussing the conclusions in the TR.

1.2.4 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for Uu for advanced V2X use cases.

In RAN1#94, the following agreements has been made on Uu for advanced V2X use cases:

Agreements on Uu for advanced V2X use cases:

- No agreements were made.

In RAN1#94bis, the following agreements has been made on Uu for advanced V2X use cases:

Agreement on Uu for advanced V2X use cases:

- **NR supports that UE reports assistance information to the gNB, consisting of at least (with details FFS):**
  - UE-related geographic information (e.g., position).
  - Reports of Uu V2X traffic-related information (at least for periodic traffic)
- For Uu for advanced V2X use cases, NR supports having multiple active UL configured grants in a given BWP in a given cell.
  - **Open discussions on details**
  - LS sent to RAN2 on this agreement.

In RAN1#AH_1901, the following agreements has been made on Uu for advanced V2X use cases:

Agreement on Uu for advanced V2X use cases:

R1-1901383 Feature lead summary on Evaluation of Uu for advanced V2X use cases Ericsson

Conclusion:

- For type 2 configured grant, discuss signalling details and whether single DCI can activate/release multiple configured grants during WI (if included in the WI).

Agreements:

- A UE is not expected to transmit simultaneously according to more than one UL grant (e.g., dynamic or CG) in a given BWP.

In RAN1#96, the following agreements has been made on Uu for advanced V2X use cases:

Agreement on Uu for advanced V2X use cases:

- UE reports of assistance information to the gNB include, at least: traffic periodicity, timing offset, and message size for Uu V2X and sidelink V2X traffic (at least for periodic traffic).

Conclusion:

- For type 1 configured grant, discuss signalling details during WI (if included in the WI).
- Capture in TR 38.885 that NR Uu broadcast/multicast are beneficial at least in terms of resource utilization for V2X use cases in some scenarios.
- To include for TR conclusion section:
  - In terms of supporting advanced V2X uses cases over the LTE Uu interface, some possible enhancements were studied but none are recommended.
- Add a reference in TR 38.885 stating that the remote driving use case is handled in TR 38.824.

1.3 Uu-based sidelink resource allocation/configuration

Including LTE/NR controlling NR sidelink & NR Uu controlling LTE sidelink

Highlights for LTE Uu and NR sidelink

LTE Uu can provide the necessary semi-static configurations (i.e. through RRC) for NR SL resource allocation Mode 1 and Mode 2.

- For Mode 1, the configuration is of a Type 1 configured grant with configuration limited to time-frequency resources and periodicity, without additional functions or procedures on the LTE Uu interface.

Highlights for NR Uu and LTE sidelink

The study considers how NR Uu can assign NR SL resources for the cases of (i) a licensed carrier shared between NR Uu and NR SL; and (ii) a carrier dedicated to NR SL. The following techniques are supported for resource allocation Mode 1:

- Dynamic resource allocation
  - Dynamic (i.e. through a DCI)
- Configured grant Type 1 and Type 2
  - For a PUSCH (re)transmission configured by higher layer parameter ConfiguredGrantConfig
  - Type 1: Only based on RRC configuration without any L1 signaling
  - Tpye 2: Based on RRC configuration and L1 signaling for activation/deactivation

Work Item Phase

It is feasible to support LTE Uu managing NR SL in resource allocation Modes 1 and 2.

- Specification of the enhancements described to the respective Uu interfaces is recommended.

It is feasible to support NR Uu managing LTE SL in Modes 3 and 4.

- Specification of the enhancements described to the respective Uu interfaces is recommended.

Specify support for NR Uu to control LTE sidelink as identified in TR 38.885 for the work item phase.

1.3.1 LTE Uu enhancements to controls NR sidelink

1.3.1.1 LTE Uu schedules NR sidelink Mode 1

For LTE Uu controlling NR sidelink mode 1, some issues were raised. The issues include:

- NR mode 1 HARQ-ACK feedback (R1-1901814, R1-1901879)
- NR mode 1 SL numerology (R1-1901879)
- Congestion report of NR mode 1 to eNB is beneficial (R1-1901935)
- Multiple type 1 configured grants (R1-1901544)
- Continuous use of NR SL type-1 configured grant in case of RRC interruption (R1-1901544)

1.3.1.1.1 NR Mode 1 HARQ-ACK feedback

One source (R1-1901814) proposes NR mode 1 sidelink HARQ-ACK feedback should be supported through PSFCH when controlled by LTE Uu and the SL HARQ feedback can be enabled/disabled by eNB in a higher layer signal. Another source [18] pointed out that to support NR sidelink unicast and groupcast, the type 1 configured grant configuration via LTE Uu interface should include the time/frequency resources and periodicity for sidelink feedback.

One source (R1-1901879) proposes that for LTE Uu controlling NR mode 1, HARQ feedback in SL is not supported in order to not introduce additional function/procedure to LTE Uu.

It is understood that HARQ feedback in SL through PSFCH does not introduce additional function/procedure to LTE Uu. It has been also agreed that the HARQ-ACK feedback can be enabled/disabled. How to implement the enabled/disabled function can be left to WI.

1.3.1.1.2 NR Mode 1 SL numerology

One source (R1-1901879) proposes that for LTE Uu controlling NR mode 1, the SCS of the configured resource pool/BWP is restricted to 15 kHz.

It is understood that restricting to 15 kHz is not necessary nor expected given the benefits of NR SL supporting advanced V2X services potentially by using other numerologies than 15 kHz.

1.3.1.1.3 Congestion report

One source (R1-1901935) raises an observation that for the case of LTE Uu to schedule NR sidelink mode 1, if congestion level reporting procedure of NR sidelink mode 1 UE is introduced for LTE Uu, it could be beneficial at least in terms of NR sidelink mode 1 pool management / resource allocation (e.g., especially when NR sidelink mode 1 and 2 use the shared pool).

Reporting congestion level of NR sidelink mode 1 is deemed additional function/procedure introduced to LTE Uu though it could be beneficial.

1.3.1.1.4 Multiple Type 1 configured grants and continuous use of NR SL Type-1 configured grant

One source (R1-1901544) proposes that multiple type 1 configured grants are supported for NR SL mode 1 when controlled by LTE Uu so as to adapt to different loads, latency, reliability and traffic types. It also proposes that NR UE can start or continue using a NR SL type-1 configured grant which was provided by

the eNB when it experiences RRC connection interruption, following procedures defined for the NR Uu interface.

The proposals follow the agreement but just involve the configurations itself. The configurations when provided by LTE can be left in WI and follow the procedures defined for the NR Uu interface.

1.3.1.2 LTE Uu provides configuration for NR sidelink Mode 2

One source (R1-1902603) states LTE V2X supports the sidelink configurations of neighboring frequencies (e.g., the IE *v2x-InterfreqInfoList*) and a similar approach could be extended for configuring NR V2X sidelink. The configuration could be sent over common configurations, e.g., a new LTE SIB. The dedicated configurations for NR V2X sidelink may need to be further studied. It proposes that LTE Uu at least supports the resource pool configuration for NR mode 2 UE sidelink transmission.

One source (R1-1902999) proposes SIB26 is enhanced to contain semi-static configuration in Rel-16 for NR V2X sidelink mode 2.

One source (R1-1901879) states that for mode 2 communication without eNB scheduling, the SCSs other than 15 kHz could be used, and unicast/groupcast transmission with HARQ feedback is also become feasible and proposes that for LTE Uu controlling NR mode 2, same functionality as NR Uu controlled NR mode 2 is assumed.

Suggested offline proposal 1: When LTE Uu provides configuration for NR sidelink mode 2,

- **It is necessary that LTE Uu existing higher layer signalling (e.g., SIB) is enhanced to included semi-static configuration for NR sidelink mode 2. Details up to RAN2**

1.3.2 NR Uu enhancements to enable NR sidelink Mode 1

All submitted tdocs discussed this aspect.

In RAN1 AdHoc #1901, it was agreed that:

- When NR Uu schedules NR SL mode 1, both type 1 and type 2 configured grants are supported for NR SL

1.3.2.1 NR SL resource allocation

The proposals are related to DCI and SR design for NR SL mode 1. Eight companies propose new DCI format for NR SL mode 1. [Seven companies propose to have resource allocation information in the DCI including PSSCH, PSCCH, and PSFCH. Transmission type (uni-/group-/broadcast) is also proposed to be included by 3 companies. Two companies further propose to have indicators related to inter-RAT and resource pools. One company considers also having Rx UE information in DCI. Regarding SR, two companies propose a new framework, while 3 companies propose adding extra information to existing BSR.

Differentiation of SL SR from UL SR is also proposed by two companies.

Suggested offline proposal 2:

- **RAN1 to design new DCI format(s), and modify SR and BSR to support mode-1 for V2X**

1.3.2.2 NR SL configured grant resource allocation

Repetition of the configured grants is proposed in three contributions, whereas one company further proposes the use of TFRPs for both type-1 and type-2 configured grants with continuity under Uu connection interruptions. Furthermore, four companies propose to have multiple configured grants for NR SL mode 1.

Suggested offline proposal 3:

- **Further study the details of the exact configuration of grants, including time/frequency resources used (e.g., TFRPs), repetition, and duration of the grants**

Suggested offline proposal 4:

- **Multiple configured grants per UE are supported**

1.3.2.3 UE assistance for NR SL mode 1 resource allocation

It was agreed in RAN1 AdHoc #1901 that:

- It is supported that in mode 1 for unicast, the in-coverage UE sends an indication to gNB to indicate the need for retransmission
  - At least PUCCH is used to report the information
    - If feasible, RAN1 reuses PUCCH defined in Rel-15
  - The gNB can also schedule re-transmission resource
  - FFS transmitter UE and/or receiver UE
    - If receiver UE, the indication is in the form of HARQ ACK/NAK
    - If transmitter UE, FFS
- For determining the resource of PSFCH containing HARQ feedback, support that the time gap between PSSCH and the associated PSFCH is not signaled via PSCCH at least for modes 2(a)(c)(d) (if respectively supported)
  - FFS whether or not to additionally support other mechanism(s) for modes 2(a)(c)(d)
  - FFS for mode 1

Note that, in RAN-1 #95, the following was already agreed:

"Physical sidelink feedback channel (PSFCH) is defined and it is supported to convey SFCI for unicast and groupcast via PSFCH.

Study further whether to support UE sending to gNB information which may trigger scheduling retransmission resource in mode 1. FFS including

- Which information to send
- Which UE to send to gNB
- Which channel to use
- Which resource to use"

Related to RAN-1 #95 agreement above, in RAN-2 #104 it was agreed that:

"The UE assistance reporting mechanism for LTE V2X sidelink communication is taken as the baseline."

At RAN1#94bis, there was a related agreement on reporting geographic information:

"NR supports that UE reports assistance information to the gNB, consisting of at least (with details FFS):

- UE-related geographic information (e.g., position)."

15 companies proposed UE assistance for SL mode 1 resource allocation, whether in terms of HARQ feedback, reporting SL measurements, or additional information to the gNB by the UE.

Different HARQ mechanisms are proposed in 7 contributions. Two companies propose that HARQ includes ACK, NACK and/or DTX. Furthermore, two other companies propose to include SCI information (PMI, RI, beam information, etc.) in the HARQ mechanism. Two companies propose that the destination UE sends the HARQ feedback, and 7 companies have proposals on which channel/resource should be used for the feedback.

10 companies proposed reporting measurements and other information to gNB. CSI of SL resources is proposed to be reported by 4 companies, including RSRP, RSSI, CR, CBR of the (preferred) SL resources, or

the SL resource index. Three companies propose to report the information regarding UE mobility. Moreover, to help scheduling of NR SL mode 1 communications, the following proposals for UE reporting to gNB are made:

- To report message size,
- To report information for modifying SL grants,
- To send a request for reserving SL resources.

Three companies discuss which UE to report the information to the gNB.

Suggested offline proposal 5:

- **Support HARQ feedback to the gNB. When designing feedback, consider the following:**
  - **Which information to be sent (ACK/NACK/DTX, CSI, etc.)**
  - **Whether the source or the destination UE sends it**
  - **Which resources to use to send the feedback**

Suggested offline proposal 6:

- **Reporting SL related information to the gNB is supported. At least information about the following is reported to the gNB:**
  - **Measurements (FFS details, e.g., CSI, RSRP, CR, CBR, etc.)**
  - **Used resources**

1.3.2.4 Inter-operation of NR SL Mode 1 with Mode 2

RAN-2 #104 agreed that a UE can simultaneously operate NR SL mode 1 and mode 2:

> "RAN2 will support the case a UE can be configured to perform both mode-1 and mode-2 at the same time assuming RAN1 does not have concern on it."

Related to the agreement, five companies proposed to support or study shared resource pools between NR SL mode 1 and mode 2. For co-existence of both modes, companies have several proposals regarding the configuration and usage of the associated resources. One company considers configuring NR SL mode 2 resources associated with a validity area (i.e., across cells). Uu control on switching NR SL modes, and control of associated resources are proposed by 4 companies. One company proposes prioritization of mode 1 SL transmissions over other SL receptions, whereas another company proposes seperation of resources for two modes in time when operated simultaneously by a UE.

Suggested offline proposal 7:

- **Study mechanisms for inter-operation of mode-1 and mode-2, including**
  - **NR Uu control on NR SL mode switching**
  - **Resource configuration (e.g., pool sharing, validity area, etc.)**

1.3.2.5 Shared NR Uu/NR SL carrier

Eight companies propose that NR Uu carrier be shared with NR SL mode 1. Seven companies propose that at least UL symbols are shared, whereas [4] proposes to introduce dedicated slot format for SL, and adopting NR flexible slot format also for NR SL in a shared carrier.

Suggested offline proposal 8:

- **At least UL symbols can be shared between UL and SL**

1.3.3 NR Uu enhancements to control LTE sidelink

13 of 22 submitted tdocs discussed NR Uu controls LTE sidelink mode 1. The latest agreement on this topic reads as follows:

Agreements:

- In continuing evaluating NR Uu scheduling of LTE sidelink mode-3, consider at least:
  - What will be required on the UE side to support such feature
  - DCI design (e.g., whether DCI 5A can be reused)
  - Deployment scenarios where it is beneficial

The following issues were raised:

- Separate signalling for LTE sidelink and NR sidelink, e.g., SIB, DCI formats (R1-1901814, R1-1901997, R1-1901879, R1-1902999, R1-1902289, R1-1902603)
- Different numerologies for LTE sidelink and NR Uu and timing (R1-1903170, R1-1902486, R1-1901544, R1-1902388)
- UE implementation, e.g., processing time (R1-1903170)
- UE reporting assistance information (R1-1902486, R1-1902999)
- Resources configured for LTE sidelink mode 3 (R1-1902289)
- NR Uu provides configuration for LTE sidelink mode 4 (R1-1902999)

Two sources (R1-1902331, R1-1901544) showed some scenarios where NR Uu controls LTE sidelink mode 3 is beneficial/needed. They also observed that the specification impact of NR Uu scheduling LTE sidelink was quite similar with that of NR Uu scheduling NR sidelink. The source (R1-1902331) proposes to support NR Uu scheduling of LTE sidelink mode 3.

One source (R1-1901879) explains that there are some potential benefits for fine resource controlling and coexistence if NR Uu scheduling of LTE sidelink mode 3 is supported.

One source (R1-1901997) analyzes that LTE mode 3 controlled by NR Uu can improve the flexibility of resource pool configuration by configuring UE with the resource collectively to adapt to the usage of the resource pools and coordinate the interference between LTE V2X and NR V2X.

One source (R1-1901900) points out that dual connectivity can be considered for NR UU to control LTE sidelink. In particular, LTE or NR sidelink can be considered as a SCG while NR Uu interface is the MCG. In such way, NR UU can control either LTE or NR sidelink just like controlling an access link in dual connectivity framework.

1.3.3.1 Separate signaling for LTE sidelink and NR sidelink e.g., SIB, DCI formats

When LTE sidelink is in the control of NR Uu, the signalling designed for NR Uu controlling NR sidelink may not be compatible with the signalling designed for LTE sidelink in the control of LTE Uu, e.g., SIB for configurations, DCI formats.

The necessary enhancement raised by one source (R1-1901814, R1-1901997, R1-1901879, R1-1902999, R1-1902289, R1-1902603) is that NR base stations use separate signaling for LTE sidelink and NR sidelink (e.g., potentially including a new SIB, a new DCI format, a new SS structure, etc.).

1.3.3.1.1 DCI formats

One source (R1-1901997) proposes a new DCI format for NR can be designed with the same contents as that of LTE DCI 5A for NR Uu managing LTE sidelink mode-3. One source (R1-1902603) states that the new NR DCI format should support both dynamic scheduling and SPS.

Two sources (R1-1901997, R1-1901879) describe one approach where a common DCI format is designed for both NR sidelink mode 1 and NR controlling LTE sidelink mode 3 and with one indication bit in the DCI content to indicate to which sidelink it applies. Another approach could be based on RNTI, i.e., gNB could allocate one RNTI for LTE mode 3 and another RNTI for NR mode 1.

One source (R1-1902999) states that L1 signaling design in NR Uu ePDCCH to control PC5 interface should have a unified design for both LTE and NR sidelink. The sidelink grant formats and how to interpret the contents of the sidelink grant are different for NR sidelink and LTE sidelink. For example, this requires the translation of OFDM numerology from NR to LTE and vice versa (assuming different SCS is used).

One source (R1-1902289) views that DCI format can be transmitted in either common SS (search space) or USS (UE-specific search space). The CRC of that DCI format is scrambled with a RNTI assigned for LTE sidelink transmission.

Suggested offline proposal 9: For NR Uu to schedule LTE sidelink mode 3, it is necessary to select one of the two options:

- **Option 1: a new different DCI format is designed, which has the same/similar contents as that of LTE DCI 5A, or**
- **Option 2: a common/unified DCI format to schedule either NR or LTE SL is designed, FFS how to differentiate scheduling between LTE sidelink and NR sidelink.**

1.3.3.1.2 DCI blind decoding

If a new DCI format is designed when LTE sidelink mode 3 is controlled by NR Uu that is of different size than the DCI format designed for NR Uu controlling NR sidelink mode 1. The blind decoding attempts may increase.

One source (R1-1901997) proposes to solve the blind decoding issue by padding the new DCI format (e.g. DCI 2_0) until the size is the same as the DCI format that used by NR Uu to manage NR sidelink mode-1.

One source (R1-1902603) views to reduce the blind decoding of NR DCI, the payload size of the new NR DCI format should be aligned with some existing NR DCI formats. It is preferred to pad as few zeros as possible for the new NR DCI format to align with the payload size of an existing NR DCI format. This could improve the transmission reliability of the new NR DCI format. Two options for the new NR DCI format payload size could be aligned to DCI format 0_0 or compact DCI format. Propose NR Uu interface supports a new DCI format to schedule (including both dynamic scheduling and SPS) mode 3 UEs in LTE sidelink.

One source (R1-1901544) views that NR has defined mechanisms of managing the number of UE blind decodes, e.g., configuring the search space, aggregation level, candidates, DCI formats that UE needs to monitor, which could be applied in addition to the option of padding to the same size of other formats if UE monitoring DCI 5A' possibly increases the complexity of blind decoding.

No offline proposal is suggested, since the decision is dependent on which option of DCI design is chosen.

1.3.3.2 Different numerologies and timing

LTE sidelink uses the fixed 15kHz subcarrier spacing but NR Uu supports flexible numerologies. When LTE Uu controls LTE sidelink mode 3, the fixed timing between DCI reception and sidelink transmission is not earlier than 4 subframes. NR Uu supports flexible timing between DCI and PUSCH/PDSCH and the timing between DCI and NR sidelink transmission is probably flexible as well.

When NR Uu controls LTE sidelink, 2 contributions (R1-1903170, R1-1902486, R1-1901879) point out that RAN1 WG needs to discuss timing relationship between NR Uu DCI transmission and LTE sidelink PSCCH/PSSCH transmission for all NR Uu numerologies and timing relationships. The source (R1-1901879) proposes a fixed timing should be supported.

One source (R1-1902338) states that when NR Uu controls LTE sidelink mode 3, the NR Uu should be limited to 15 kHz.

One source (R1-1901544) discusses the timing regarding to all NR Uu numerologies and provides two options. Option 1 is to align to LTE SL timing of four subframes at 15 kHz SCS so the timing offset depending on the numerology of NR Uu is $n + 4 \times 2^{\mu}$, where n is the nth slot where DCI 5A' is received and μ^{P} equals to 0, 1, 2 corresponding to 15, 30, and 60 kHz, respectively. Alternatively, option 2 uses a fixed timing offset independent of NR Uu numerology, e.g., $n + 4$. It also points out that if the SL transmission timing is defined as n+4 for each numerology, processing may need to be faster than the 4ms used for LTE.

<u>Suggested offline proposal 10</u>: For NR Uu to schedule LTE sidelink mode 3, it is necessary to define the LTE Uu timing between DCI and SL as:

- $n + 4 \times 2^{\mu}$ **, where n is the slot where DCI 5A' is received and μ^{P} is 0, 1, 2, 3, 4 corresponding to 15, 30, 60, 120, and 240 kHz, respectively.**

1.3.3.2.1 UE implementation, e.g., processing time

In order to support NR Uu scheduling LTE sidelink mode 3, Intel pointed out that at the UE side, a fast inter-RAT interface will be required and may even need to be standardized as a cross-RAT adaptation layer.
One source (R1-1903170) views the inter-RAT signalling as increasing UE complexity, which is not desirable. DCI processing may be faster for NR UEs, especially for larger SCS but processing of the sidelink TB remains unchanged. This separate processing also requires some internal UE interfaces and signalling, adding some further processing time.

<u>Suggested offline proposal 11</u>: For NR Uu to schedule LTE sidelink mode 3, it is necessary to define to define capability signaling for the LTE UE.

1.3.3.2.2 UE reporting assistance information

To facilitate eNB/gNB scheduling the resources for LTE/NR sidelink transmission, the UE may report some assistance information to the eNB/gNB. In LTE-V2X, UE reports traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR. For NR-V2X, it has not been agreed what information the UE would report to the gNB but the reporting could probably additionally include other assistance information. One NR Uu interface will support UE reporting assistance information from LTE sidelink and NR sidelink (R1-1902486, R1-1902999).

One source (R1-1902486) points out that NR Uu will need to implement TX Profile selection concept in order to be able switch between LTE Mode-3 R14 and R15 transmission formats. In addition, R15 Mode-3 UEs support Mode-4 sensing and reporting to assist eNB scheduling. All LTE Mode-3 UE also report traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR which are also required for eNB Mode-3 scheduling decisions. All of these functionalities may need to be duplicated in NR Uu if dynamic scheduling is supported.

One source (R1-1902999) views it is cumbersome to support two different BSR formats in one interface. However, if only one format is defined, how to interpret the BSR has to be added in the specification.

<u>Suggested offline proposal 12</u>: For NR Uu to schedule LTE sidelink mode 3, consider NR Uu enhancements to support UE reporting assistance information similar to what has been specified in LTE.

1.3.3.2.3 Resource configured for LTE sidelink Mode 3

When LTE sidelink mode 3 controls NR Uu, the gNB needs to provide the necessary configurations for sidelink transmission.

One source (R1-1902289) proposes that the NR module needs to use system information (for example RMSI) and RRC signaling to configure the configuration parameters for LTE V2X, similar to the configuration process in LTE.

Suggested offline proposal 13: For NR Uu to schedule LTE sidelink mode 3, consider NR Uu enhancement to provide necessary configuration for LTE sidelink mode 3.

1.3.3.3 NR Uu supports flexible slot formats

NR UE is configured with a reference subcarrier spacing configuration of «$_{SFI}$ and a corresponding slot format and can derive the slot format for the active BWP of subcarrier spacing configuration of « with « | «$_{SFI}$. The slot format issue only exists when LTE mode-3 SL shares the carrier with NR Uu. The issue is whether NR Uu can still be configured flexible slot formats without changing LTE mode-3 SL procedure.

One sources (R1-1900028) provides two direction to solve this issue: one direction is that the slot format configured for NR Uu shall be compatible with LTE TDD configurations, so that from UE operating mode-3 SL perspective it is the legacy procedure for determining the subframe pool without change. Alternatively, NR Uu is free to be configured any of slot formats defined but LTE mode-3 SL UE procedure for determining subframe pool needs change to be able to preclude the DL subframes or subframes with DL/flexible symbols that are not compatible with LTE TDD configurations. Any change to LTE SL procedure is undesirable. Therefore, the first direction is recommended.

In order to support NR Uu scheduling LTE sidelink mode 3, Intel pointed out that at the UE side, afast inter-RAT interface will be required and may even need to be standardized as a cross-RAT adaptation layer.

One source (R1-1901216) views the inter-RAT signalling as increasing UE complexity, which is not desirable. DCI processing may be faster for NR UEs, especially for larger SCS but processing of the sidelink TB remains unchanged. This separate processing also requires some internal UE interfaces and signalling, adding some further processing time.

To facilitate eNB/gNB scheduling the resources for LTE/NR sidelink transmission, the UE may report some assistance information to the eNB/gNB. In LTE-V2X, UE reports traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR. For NR-V2X, it has not been agreed what information the UE would report to the gNB but the reporting could probably additionally include other assistance information. One NR Uu interface will support UE reporting assistance information from LTE sidelink and NR sidelink (R1-1900486, R1-1900889).

One source (R1-1900486) points out that NR Uu will need to implement TX Profile selection concept in order to be able switch between LTE Mode-3 R14 and R15 transmission formats. In addition, R15 Mode-3 UEs support Mode-4 sensing and reporting to assist eNB scheduling. All LTE Mode-3 UE also report traffic assistance information and congestion control related information as well as sidelink scheduling request and BSR which are also required for eNB Mode-3 scheduling decisions. All of these functionalities may need to be duplicated in NR Uu if dynamic scheduling is supported.

One source (R1-1900889) views it is cumbersome to support two different BSR formats in one interface. However, if only one format is defined, how to interpret the BSR has to be added in the specification.

When LTE sidelink mode 3 controls NR Uu, the gNB needs to provide the necessary configurations for sidelink transmission.

One source (R1-1901060) proposes that the NR module needs to use system information (for example RMSI) and RRC signaling to configure the configuration parameters for LTE V2X, similar to the configuration process in LTE.

RAN1 has to decide whether to support NR Uu scheduling LTE sidelink mode 3. Given that some companies have shown scenarios where such a feature would be useful, and that other companies has shown that it would require reasonable standardization work, it is proposed to support the feature.

1.3.4 NR Uu provides configuration for LTE sidelink Mode 4

NR Uu provides necessary semi-static configuration for mode-4 LTE sidelink. From RAN1 perspective, signaling should be similar to LTE in terms of UE-specific or cell-specific, with signaling details up to RAN2. One source (R1-1902999) proposes that the SIB in NR Uu includes resource configuration for both NR sidelink and LTE sidelink, and to reuse semi-static configurations defined for LTE sidelink in SIB21/SIB26 for NR Uu configuration of LTE sidelink.

Suggested offline proposal 14: When NR Uu provides configuration for LTE sidelink mode 4, consider reusing semi-static configurations defined for LTE sidelink in SIB21/SIB26 for NR Uu enhancement. Details up to RAN2.

1.3.5 DCI formats defined in NR

The DCI formats defined in table 7.3.1-1 are supported. As described in TS 38.211. For sidelink the most important DCI formats are DCI format 0_0 and DCI format 0_1.

Table 7.3.1-1: DCI formats

DCI format	Usage
0_0	Scheduling of PUSCH in one cell
0_1	Scheduling of PUSCH in one cell
1_0	Scheduling of PDSCH in one cell
1_1	Scheduling of PDSCH in one cell
2_0	Notifying a group of UEs of the slot format
2_1	Notifying a group of UEs of the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE
2_2	Transmission of TPC commands for PUCCH and PUSCH
2_3	Transmission of a group of TPC commands for SRS transmissions by one or more UEs

The fields defined in the DCI formats below are mapped to the information bits a_0 to a_{A-1} as follows. Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit a_0 and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to a_0.

If the number of information bits in a DCI format is less than 12 bits, zeros shall be appended to the DCI format until the payload size equals 12.

- ConfiguredGrantConfig

The IE *ConfiguredGrantConfig* is used to configure uplink transmission without dynamic grant according to two possible schemes. The actual uplink grant may either be configured via RRC (type1) or provided via the PDCCH (addressed to CS-RNTI) (type2).

ConfiguredGrantConfig information element

```
-- ASN1START
-- TAG-CONFIGUREDGRANTCONFIG-START

ConfiguredGrantConfig ::=           SEQUENCE {
    frequencyHopping                        ENUMERATED {intraSlot, interSlot}
OPTIONAL,   -- Need S,
    cg-DMRS-Configuration               DMRS-UplinkConfig,
    mcs-Table                           ENUMERATED {qam256, qam64LowSE}
OPTIONAL,   -- Need S
    mcs-TableTransformPrecoder          ENUMERATED {qam256, qam64LowSE}
OPTIONAL,   -- Need S
    uci-OnPUSCH                         SetupRelease { CG-UCI-OnPUSCH }
OPTIONAL,   -- Need M
    resourceAllocation                  ENUMERATED { resourceAllocationType0,
resourceAllocationType1, dynamicSwitch },
    rbg-Size                                ENUMERATED {config2}
OPTIONAL,   -- Need S
    powerControlLoopToUse               ENUMERATED {n0, n1},
    p0-PUSCH-Alpha                      P0-PUSCH-AlphaSetId,
    transformPrecoder                   ENUMERATED {enabled, disabled}
OPTIONAL,   -- Need S
    nrofHARQ-Processes                  INTEGER(1..16),
    repK                                    ENUMERATED {n1, n2, n4, n8},
    repK-RV                             ENUMERATED {s1-0231, s2-0303, s3-0000}
OPTIONAL,   -- Need R
    periodicity                         ENUMERATED {
                                            sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14,
sym8x14, sym10x14, sym16x14, sym20x14,
                                            sym32x14, sym40x14, sym64x14, sym80x14, sym128x14,
sym160x14, sym256x14, sym320x14, sym512x14,
                                            sym640x14, sym1024x14, sym1280x14, sym2560x14,
sym5120x14,
                                            sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12,
sym10x12, sym16x12, sym20x12, sym32x12,
                                            sym40x12, sym64x12, sym80x12, sym128x12, sym160x12,
sym256x12, sym320x12, sym512x12, sym640x12,
                                            sym1280x12, sym2560x12
    },
    configuredGrantTimer                INTEGER (1..64)
OPTIONAL,   -- Need R
    rrc-ConfiguredUplinkGrant           SEQUENCE {
        timeDomainOffset                    INTEGER (0..5119),
        timeDomainAllocation                INTEGER  (0..15),
        frequencyDomainAllocation           BIT STRING (SIZE(18)),
        antennaPort                         INTEGER (0..31),
        dmrs-SeqInitialization              INTEGER (0..1)
OPTIONAL,   -- Need R
        precodingAndNumberOfLayers          INTEGER (0..63),
        srs-ResourceIndicator               INTEGER (0..15)
OPTIONAL,   -- Need R
        mcsAndTBS                           INTEGER (0..31),
        frequencyHoppingOffset              INTEGER (1.. maxNrofPhysicalResourceBlocks-1)
OPTIONAL,   -- Need R
        pathlossReferenceIndex              INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1),
        ...
    }
OPTIONAL,       -- Need R
    ...
}

CG-UCI-OnPUSCH ::= CHOICE {
    dynamic                             SEQUENCE (SIZE (1..4)) OF BetaOffsets,
    semiStatic                          BetaOffsets
}

-- TAG-CONFIGUREDGRANTCONFIG-STOP
-- ASN1STOP
```

ConfiguredGrantConfig field descriptions
antennaPort Indicates the antenna port(s) to be used for this configuration, and the maximum bitwidth is 5. See TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1.
cg-DMRS-Configuration DMRS configuration, corresponds to L1 parameter 'UL-TWG-DMRS' (see TS 38.214, section 6.1.2).
configuredGrantTimer Indicates the initial value of the configured grant timer (see TS 38.321,) in number of periodicities.
dmrs-SeqInitialization The network configures this field if transformPrecoder is disabled. Otherwise the field is absent.
frequencyDomainAllocation Indicates the frequency domain resource allocation, see TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1).
mcsAndTBS The modulation order, target code rate and TB size (see TS38.214, section 6.1.2). The NW does not configure the values 28~31 in this version of the specification.
nrofHARQ-Processes The number of HARQ processes configured. It applies for both Type 1 and Type 2. See TS 38.321, section 5.4.1.
p0-PUSCH-Alpha Index of the P0-PUSCH-AlphaSet to be used for this configuration.
…
powerControlLoopToUse Closed control loop to apply. Corresponds to L1 parameter 'PUSCH-closed-loop-index' (see TS 38.213, section 7.7.1).
rbg-Size Selection between configuration 1 and configuration 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. The NW may only set the field to *config2* if *resourceAllocation* is set to *resourceAllocationType0* or *dynamicSwitch.* Note: rbg-Size is used when the transformPrecoder parameter is disabled.
repK-RV The redundancy version (RV) sequence to use. See TS 38.214, section 6.1.2. The network configures this field if repetitions are used, i.e., if repK is set to n2, n4 or n8. Otherwise, the field is absent.
repK The number or repetitions of K.
resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1. For Type 1 UL data transmission without grant, "resourceAllocation" should be resourceAllocationType0 or resourceAllocationType1.
rrc-ConfiguredUplinkGrant Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1). If this field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2). Type 1 configured grant may be configured for UL or SUL, but not for both simultaneously.
srs-ResourceIndicator Indicates the SRS resource to be used.
timeDomainAllocation Indicates a combination of start symbol and length and PUSCH mapping type, see TS 38.214, section 6.1.2 and TS 38.212, section 7.3.1.
timeDomainOffset Offset related to SFN=0, see TS 38.321, section 5.8.2.
transformPrecoder Enables or disables transform precoding for type1 and type2. If the field is absent, the UE enables or disables transform precoding in accordance with the field msg3-transformPrecoder in RACH-ConfigCommon, see 38.214, section 6.1.3.
uci-OnPUSCH Selection between and configuration of dynamic and semi-static beta-offset. For Type 1 UL data transmission without grant, *uci-OnPUSCH* should be set to *semiStatic.*

Type 1 configured grant, the actual uplink grant can be configured via RRC (type1). Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1).

Type 2 configured grant, the actual uplink grant can be provided via the PDCCH (addressed to CS-RNTI) (type2). If the *rrc-ConfiguredUplinkGrant* field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2).

1.3.5 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for QoS management.

In RAN1 #94, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

- NR Uu can assign NR sidelink resources for the following:
  - Shared licensed carrier between Uu and NR sidelink
  - Dedicated NR sidelink carrier
- Study at least the following NR sidelink resource allocation techniques:
  - Dynamic resource allocation
  - Activation/deactivation based
    - E.g., semi-persistent scheduling allocation or NR grant free type-2
  - RRC (pre-)configured
    - E.g., configured NR grant type-1, UE autonomous selection of resource(s) from resources configured by RRC
- RAN1 will study the level of network control, e.g., whether the UE may select other parameters (e.g., MCS) and/or the exact transmission resources, and whether the selection is autonomous or not

In RAN1 #94bis, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

- **Enhancements of LTE Uu and NR Uu to control NR sidelink**
  - It is supported that LTE Uu provides at least necessary semi-static configuration for NR mode-2 SL communications
    - **Open discussions on details**
  - Further study impact and benefits of LTE Uu managing NR model-1 SL communications
  - It is supported that NR Uu provides necessary semi-static configuration for mode-4 LTE SL communications
    - From RAN1 perspective, signalling should be similar to LTE in terms of UE-specific or cell-specific
    - Signalling details up to RAN2
  - **Further study feasibility, benefits (others than ones already identified for LTE) and impact of NR Uu managing LTE mode-3 SL communications**
  - Further study feasibility Send LS to RAN2 informing them of the two agreements:
  - **For the 1st agreements, RAN1 continues working on identifying necessary details, including parameters**
  - For the 2nd agreements, ask RAN2 to work on signalling

In RAN1 #95, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

N/A

In RAN1 #AH_1901, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

- LTE Uu to schedule NR sidelink mode 1 is supported:
  - The support is done based on type 1 configured grant with configuration restricted to time/frequency resources & periodicity, with the condition that no additional function/procedure is to be introduced for LTE Uu
  - Both DCI based scheduling and type 2 configured grant scheduling are not supported for scheduling NR sidelink mode 1

In RAN1 #96, the following agreements were made for LTE Uu and NR Uu to control NR sidelink:

Agreement for LTE Uu and NR Uu to control NR sidelink:

N/A

In RAN1 #94, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- RAN1 will study the level of network control, e.g., whether the UE may select other parameters (e.g., MCS) and/or the exact transmission resources, and whether the selection is autonomous or not

In RAN1 #94bis, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- **Enhancements of NR Uu to control LTE sidelink**
  - Continue studying NR sidelink resource allocation techniques by NR Uu for mode-1:
  - Dynamic resource allocation
  - Semi-persistent scheduling allocation or NR grant type-2 (activation/de-activation by physical layer signaling)
  - Grant free transmission i.e., configured NR grant type-1
  - Study further which resources to use for SL transmission and other network-control sidelink issues (e.g., power control) in the case of shared carrier.

In RAN1 #95, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

The following NR sidelink resource allocation techniques by NR Uu for mode-1 are supported:

- Dynamic resource allocation
- Configured grant.
  - FFS whether type-1 and/or type-2
- In continuing evaluating NR Uu scheduling of LTE sidelink mode-3, consider at least:
  - What will be required on the UE side to support such feature
  - DCI design (e.g., whether DCI 5A can be reused)
  - Deployment scenarios where it is beneficial

In RAN1 #AH_1901, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- When NR Uu schedules NR SL mode 1, both type 1 and type 2 configured grants are supported for NR SL
- Send an LS to RAN2 – Phillipe (HW), **R1-1901410,** which is approved with the final LS in R1-1901445

In RAN1 #96, the following agreements were made for NR Uu to control LTE sidelink:

Agreement for NR Uu to control LTE sidelink:

- Scheduling by gNB using RRC for LTE sidelink scheduled mode is supported from RAN1 perspective under the premise that there is sufficient time for coordination between the NR and LTE modules. No DCI to activate/release
  - RRC message delivers the SPS grant configuration and releases the SPS configuration.
  - Support of this scheduling mode is subject to UE capability (may or may not have capability for both LTE & NR)
  - Note: some specification LTE change is needed to support the reception of a grant through RRC
    - RRC message contains mode 3 grant content and timing
    - Up to the Editor to capture it as mode 3 or new LTE sidelink mode
  - No intention to have additional NR & LTE specification change (other than those described above) for this function in Rel-16
- RAN1 studied the feasibility of SPS scheduling by gNB for LTE sidelink with DCI activation/release, but there is no consensus to support it

1.4 QoS

Including congestion control

Highlights

QoS management is relevant to V2X in the context of its use in resource allocation, congestion control, in-device coexistence, power control and SLRB configuration. Physical layer parameters related to QoS management are the priority, latency, reliability and minimum required communication range (as defined by higher layers) of the traffic being delivered. Data rate requirements are also supported in the AS. A SL congestion metric and, at least in resource allocation mode 2, mechanisms for congestion control are needed. It is beneficial to report the SL congestion metric to gNB.

For SL unicast, groupcast and broadcast, QoS parameters of V2X packets are provided by upper layers to the AS.

Work Item Phase

It is deemed beneficial to report Sidelink Congestion Metrics(s) to a gNB.

- Consequently, it is recommended to specify the corresponding details in the work item phase

Specify support for QoS management for the work item phase.

1.4.1 QoS management Issues

Companies also the detailed of the congestion metric(s) and other QoS parameters.

1.4.1 Issue 1: Minimum Required Communication Range (meters)

Some general guidance on this parameter can be found in SA2's TR 23.786, the most recent version is V1.0.0. The current status appears to be that it is used in groupcast and is provided by the V2X layer to the AS layer along with the QoS parameters (see Solution #21: Group communication enhancement for NR PC5):

- V2X Layer informs the Access Stratum Layer of the communication type, and QoS parameters (including 5QI) and Range for the group communication traffic

The issue to address is if this parameter is relevant for RAN1 studies; and, if the answer is yes, how it might be used. The following proposals were found in the contributions reviewed for this summary:

- Used for power control: R1-1901877, R1-1903171
- Used for control of other sidelink TX parameters, e.g. MCS: R1-1901877
- Used to avoid HARQ feedback by UEs outside target communication range: R1-1901936, R1-1903000
- Used to control the number of retransmissions (e.g. number of blind retransmissions, maximum number of retransmissions for groupcast with HARQ feedback): R1-1901877, R1-1903000, R1-1903171
- Reliability should be interpreted in the condition of minimum required communication range: R1-1902205
- Not necessary in the physical layer: R1-1901545

In addition, some contributions in other agenda items propose uses of minimum required communication range:

- Open loop power control for broadcast transmission: R1-1902274 (Samsung)
- Open loop power control for groupcast transmission: R1-1903164 (Ericsson)
- Link adaptation for groupcast: R1-1903185 (Ericsson)

Furthermore, one contribution pointed out that, if it is decided to use minimum required communication range in the physical layer, then it may need to be studied how to translate minimum required communication range (meters) into the physical layer (R1-1901998).

Assessment: The majority view seems to be that this parameter is relevant for RAN1 studies. However, it seems difficult to progress on this issue in the QoS AI; the proposed uses of the minimum required communication range parameter should be discussed in the appropriate agenda items (e.g. Physical layer procedures), and if any of the uses are agreed then the issue of whether to use the parameter is settled.

Topics with no consensus:

- Discuss the proposed uses of minimum required communication range in the appropriate agenda items.

1.4.2 Issue 2: Sidelink Congestion Metric(s)

In LTE V2X, Channel busy ratio (CBR) was specified as measurement of the resource utilization state of a resource pool. Several companies propose to reuse this metric for the NR sidelink.

The congestion metric(s) options provided are as such:

- CBR (R1-1900029, R1-1900358, R1-1900653, R1-1900704, R1-1900770, R1-1900890, R1-1900967, R1-1901162, R1-1901217)
- New metric in addition to CBR (R1-1900254)

It has been agreed at RAN1#AH_1901 to study details of the congestion metric(s) for NR sidelink in the WI phase (if included in the WI scope).

Several contributions discuss sidelink congestion metric(s). However, given the previous agreement, the discussion shall be continued during the WI (if included in the WI scope).

1.4.3 Issue 3: Sidelink Congestion Control

The LTE V2X sidelink congestion control mechanism uses measurement of channel busy ratio CBR and channel occupancy ratio CR, and, based on current CBR, can require a UE to adapt its TX parameters (MCS, number of PSSCH subchannels, number of ReTX, transmit power) and to limit its CR.
It has been agreed at RAN1#AH_1901 to study details of congestion control for NR sidelink in the WI phase (if included in the WI scope).

Several contributions discuss sidelink congestion control. However, given the previous agreement below, the discussion shall be continued during the WI (if included in the WI scope).

RAN1 concludes that congestion control is supported at least for sidelink mode 2.

- Note: congestion control will be covered in the work item phase, not in this SI.
- Nothing else to do in SI phase

1.4.4 Issue 4: Reporting of Sidelink Congestion Metric(s) to gNB

RAN1 have agreed to introduce at least one congestion metric for NR sidelink. In LTE V2X, the eNB can request UEs to report CBR measurement results.

Several contributions propose that reporting of sidelink congestion metric(s) to the gNB be supported for NR V2X: R1-1901936, R1-1902580, R1-1903171.

Topics not discussed due to lack of time:

Discuss reporting of Sidelink Congestion Metric(s) to gNB during the WI phase (if included in WI scope).

1.4.5 Issue 5: QoS-based Resource Pool Segregation/Prioritization

Rel-12 ProSe sidelink supported resource segregation based on QoS by associating a priority list with each resource pool (priority-based resource pool selection). No such mechanism was defined for the LTE V2X sidelink.

This issue was raised again in two contributions:

- Study resource pool prioritization based on different QoS parameters (R1-1902104)
- Support transmissions with different QoS within the same resource pool (R1-1902604)

Topics not discussed due to lack of time:

Discuss if QoS-based resource pool segregation/prioritization should be supported.

1.4.6 Issue 6: Sidelink preemption

Several contributions (R1-1901877, R1-1901998, R1-1902580, R1-1902715, R1-1903171) proposed under this AI to study or support preemption by a high priority/short latency transmission of one UE of a lower-priority/longer latency transmission of another UE; however, for mode 2, this concept was also proposed under AIs "Physical layer structure" and "Resource allocation mechanism", for mode 1 this concept is also proposed under AI "Uu-based sidelink resource allocation/configuration".

Topics not discussed due to lack of time:

To avoid overlap, discuss sidelink preemption mechanisms in the appropriate other agenda item(s), discuss how and when to use such preemption mechanisms in the QoS Management agenda item.

1.4.7 Issue 7: For sidelink, are QoS-related attributes signaled over the air (e.g., in SCI)?

One of the intended uses of QoS-related attribute "priority" is for resolution of inter-UE contention for resources. In LTE V2X, PPPP was included in SCI format 1 for this purpose (field "Priority"). Note that LTE's PPPP encodes both priority and latency.

Several contributions proposed that priority be signalled over the air: R1-1901877, R1-1902487, R1-1903000.

If this was to be agreed then it would next need to be discussed if this field in the SCI is a direct copy of the priority QoS parameter, or should be a composite field encoding priority, latency/PDD and/or reliability/PER requirement.

Topics not discussed due to lack of time:

RAN1 to discuss whether to include a "priority" field in the SCI for NR V2X sidelink.

1.4.8 Issue 8: Traffic Characteristics

Intel proposed: Consult with SA2 WG whether upper layers can … provide additional data on transmission rate (e.g. period / packet size or statistical information) for NR–V2X communication.

Alternatives:

- Desirable that it be specified that higher layers provide additional traffic characteristics such as packet size and packet arrival statistics.
- Can be up to UE implementation (similar to e.g. deriving resource reservation interval in LTE V2X).

Topics not discussed due to lack of time:

Discuss if RAN1 needs to liaise with SA2 on providing detailed traffic characteristics.

1.4.9 Issue 9: Special uses of QoS parameters

Several contributions proposed specific uses of QoS parameters in the physical layer:

Priority

- For sensing and resource selection procedures (including preemption operation) R1-1901936
- Used to handle intra and inter UE transmission conflicts R1-1902487
- In channel access and resource selection procedures R1-1902487
- Based on RSRP level, Priority Level of the reserved resource and Priority Level of own packet a UE can decide to occupy reserved resource if no other free resource is available R1-1903000
- Based on Distance, Priority Level of the reserved resource and Priority Level of own packet a UE can decide to occupy reserved resource if no other free resource is available R1-1903000

Latency/PDB

- Setting selection window R1-1901936
- Allowing redundant transmission. R1-1901936
- Used in channel access and resource selection procedures at the transmitter side (e.g. to determine window for resource selection) R1-1902487
- Transmitter UE select transmission and retransmission resources within provided Packet Delay Budget R1-1903000

Reliability/PER

- Transmission parameter adjustment (e.g. MCS, RB size, power control, HARQ retransmission, MIMO scheme selection) R1-1901936
- Packet Error Rate and Minimum Communication Range parameters are used by transmitter to decide required number of blind retransmissions in case of broadcast and maximum number of retransmissions and need for transmission of HARQ feedback in case of groupcast. R1-1903000

Proposals not specific to a single QoS parameter

- QoS to control enabling/disabling HARQ feedback: R1-1901998
- When PSCCH and its associated PSSCH are multiplexed with 'Option 3', the transmission parameters (e.g., number of symbols occupied by the PSCCH) are configured according to the QoS needs (R1-1901545)
- UE can be configured with a mapping between resource allocation mode and PC5 QoS range (R1-1901829)
- A mapping relationship can be built up between HARQ-ACK utilization and QoS requirements. R1-1901998

1.4.2 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for QoS management.

In RAN1#94, the following agreements has been made on QoS Management:

Agreements on QoS:

- From RAN1 perspective, at least the following QoS-related parameters relevant to physical layer studies are considered:
  - Priority
  - latency
  - reliability

In RAN1#94bis, the following agreements has been made on QoS Management:

Agreements on QoS:

- RAN1 studies further how to use:
  - Priority,
  - Latency,

- Reliability,
- **Minimum required communication range (as defined by higher layers) if agreed to use**

- In the physical layer aspects of at least:
  - Resource allocation,
  - Congestion control and
  - Resolution of in-device coexistence issues and
  - Power control

In RAN1#95, the following agreements has been made on QoS Management:

Agreements on QoS:

Conclusion:

- Selection of QoS model (QoS Flow or per-packet QoS) for the NR V2X sidelink is outside the scope of RAN1

In RAN1#AH_1901, the following agreements has been made on QoS Management:

Agreements on QoS:

R1-1901290 Feature Lead Summary for 7.2.4.4 QoS Management Nokia

Agreements:

- Introduce at least one congestion metric for NR sidelink
  - FFS details – to be done in WI phase (if included)

Agreements:

- Congestion control is supported at least for sidelink mode 2
  - Note: details of congestion control can be covered in the work item phase, not in this SI.

In RAN1#96, the following agreements has been made on QoS Management:

Conclusion on QoS:

- It is deemed beneficial to report Sidelink Congestion Metrics(s) to a gNB
  - Consequently, it is recommended to specify the corresponding details in the WI phase

1.5 Coexistence

Including feasibility of coexistence mechanisms & advanced V2X services provided by NR V2X under co-existence

Highlights

From the UE perspective, coexistence between LTE V2X and NR V2X SLs is studied in the scenarios when there are coordinated procedures between LTE and NR, and half-duplex constraints are assumed; and where LTE and NR SL do not have any coordinated procedures.

Solutions based on TDM or FDM between LTE and NR SLs are the focus of the study. TDM solutions are those that involve overlapping or simultaneous NR and LTE V2X SL transmissions. FDM solutions are those that involve simultaneous NR and LTE V2X SL transmissions, and define solutions for sharing the total power between the two.

TDM solutions

In this section, the LTE and NR V2X SLs are assumed to be synchronized to a certain degree. Subframe boundary alignment between the SLs is required, as well as both SLs being aware of the other's time resource index, e.g. DFN on the LTE SL. There can be:

1. Long-term timescale coordination, where potential transmissions in time of LTE and NR V2X are statically/quasi-statically determined; or
2. Short-term timescale coordination, where transmissions in time of LTE and NR V2X are known to each RAT.

For long-term timescale coordination, coexistence is feasible from the physical-layer point of view by (pre-)configuring resource pools which are non-overlapping in the time-domain, with no need to modify LTE specifications. This may have impacts on latency, reliability and data rate requirements for some V2X applications.

For short-term timescale coordination between NR SL and LTE SL with SPS scheduling, when SL transmissions from both RATs overlap, or transmission from one overlaps with reception for the other, one of the RATs is prioritized on each occurrence. This requires information exchange within the UE between the SLs, and is feasible when the traffic load of LTE and NR is at or below an acceptable level. Normative work on prioritization is expected to cover high-level principles of prioritization, with details left to UE implementation.

FDM solutions
For dynamic and semi-static power allocation solutions, for physical layer purposes synchronization is assumed between NR and LTE V2X SLs in intra-band cases.
For inter-band FDM coexistence, static and dynamic power sharing are considered. Wwith static power assignment of Pc, max for each carrier, synchronization between the SLs is not assumed. Under these conditions, inter-band FDM coexistence is feasible when SL transmissions from both RATs overlap. When transmission from one SL overlaps with reception for the other, inter-band FDM coexistence under the above conditions is feasible if the inter-band separation is large enough, but it is not feasible otherwise.

For inter-band and intra-band FDM coexistence with dynamic power sharing, it is assumed that NR and LTE transmissions are fully overlapped in the time domain, i.e. NR transmissions span the entire LTE TTI such that the total power across the transmissions is constant. In addition, it is assumed that there is subframe boundary alignment between LTE and NR SLs and that both SLs are aware of the time resource index, e.g. DFN for LTE, in both carriers. Under these conditions, inter-band and intra-band FDM coexistence is feasible when SL transmissions from both RATs overlap. Normative work on prioritization for dynamic power sharing is expected to cover high-level principles of prioritization, with details left to UE implementation.

For inter-band and intra-band FDM coexistence, coexistence is feasible when SL receptions for both RATs overlap, with normative work expected to cover high-level principles of this case of coexistence, with details left to UE implementation.

Work Item Phase
Based on the study from physical layer specification perspective, in-device coexistence of LTE and NR sidelink is feasible for intra- and inter-band under the respective conditions, and solutions for TX/TX, TX/RX, and RX/RX coexistence have been identified in this TR.

Solutions identified (based on the study) necessary in TR 38.885 for 'not co-channel' in-device coexistence between LTE and NR sidelinks are considered for the work item phase.

1.5.1 Coexistence issues
Companies also discussed the details of the TDM solutions on top of agreements in previous meetings including the information exchanges that may be needed to enable long term or short-term coordination between the two RAT implementation modules. It was considered that short term coordination required a lot of information exchanges between the modes but provided some benefits in managing the coexistence. Issues regarding AGC, managing prioritization between services etc were raised. Long term coordination

was considered to be simpler for implementation but there are concerns on whether latency requirements would be impacted.

1.5.1.1 Issue 1: TDM Solution for NR V2X Coexistence

Most contributions discussed the TDM solution for coexistence with differing levels of support. As a recap, it was already agreed that long term TDM solutions were feasible but could have an impact on the reliability, latency and data rates of the system. For short term TDM solutions, it was agreed that there would be prioritization of one RAT over another in case of Tx/Tx and Tx/Rx overlaps.

Remaining issue is for companies to discuss the feasibility of short term TDM solutions and the impacts on UE implementations. Some companies also commented on the system impacts of long term TDM solutions.

Issue 1-1: short term TDM solutions:

Company views on short term TDM solutions are provided below.

Topics with discussion:

- Short term TDM solution is not feasible due to the following reasons [Huawei]
  - Necessity of fast information exchange between the LTE and NR modules
  - Severe AGC constraints making the LTE-V2X performance poor in urban environments
- Short term TDM solution is feasible if short -term inter module signalling is implemented and potential solutions are [vivo]
  - Joint resource selection to avoid Tx/Tx overlaps
  - Prioritization based on QoS parameters and/or other metrics
- Short term TDM solution with LTE SPS scheduling is feasible with appropriate prioritization [Mediatek]
  - For Tx/Tx overlaps, prioritize LTE SL transmissions
  - For Tx/Rx overlaps, prioritizing Tx over Rx is feasible
    - LTE Rx can be prioritized over NR Tx
- Feasible with appropriate prioritization of Tx and Rx [ZTE]
  - No impact to LTE specifications
  - For Tx/Tx, LTE transmissions are prioritized
  - For Tx/Rx, LTE transmissions are prioritized. For NR Tx, compare prioritization of each RAT.
- Short term TDM solution with LTE SPS scheduling is feasible with appropriate prioritization and it is based on UE capability [LG]
  - LTE SL service/RAT can have higher priority than NR SL service/RAT
- Feasible but there would be impact to latency and reliability [CATT]
  - Joint resource occupation detection and resource selection of NR and LTE sidelink resources to avoid concurrent transmissions
- Short term TDM solutions should be supported [Lenovo]
  - No impact to LTE specifications
  - Inter-module signalling delay needs to be studied
  - Joint resource selection mechanism and priority-based dropping mechanism for coordination between NR sidelink and LTE sidelink
    - Different priority for initial transmission and re-transmission of LTE sidelink
- Feasible to have short term TDM solution with coordinated NR resource selection and priority based selection (from SCI decoding) [Panasonic]
- Feasible if the inter-module signalling can be less than 20ms [OPPO]
  - If SL reservation and allocation information is exchanged only from LTE to NR V2X, there would be no change to LTE specifications.
- At least for semi-persistent resource allocations it should be possible to exchange information across RATs and address in-device coexistence issues [Intel]
  - No impact to Rel-15 LTE specifications

    - Mechanisms based on RAT preemption (from TX perspective / DTX state) can be considered.
- Feasible if simple prioritization rule (e.g. LTE SL is prioritized over NR SL) is used [Nokia]
    - Need to specify common priority definitions between NR SL and LTE SL
- For a UE in NR mode 2, the UE's NR sidelink resource selection procedure should consider the resource reservation in LTE sidelink transmission and reception. [Interdigital]
    - For short time scale TDM solutions, the prioritization between NR sidelink and LTE sidelink should be based on data QoS.
- Solution is considered to be feasible. RAN1 should study a priority-based rule between LTE and NR sidelink packets [NEC]
    - For Tx/Rx overlap, the Rx priority can be a (pre-) configured value
    - Use LTE PPPP value or (pre-) configured value, NR packet latency or NR packet priority as priority of LTE and NR sidelink transmission respectively
- For short-term TDM solutions for in-device coexistence [NTTDCM]
    - For Tx/Tx overlap, one RAT is prioritized over another based on (pre-)configured prioritization rule.
    - For Tx/Rx overlap, one RAT is prioritized over another by UE implementation.
- Short term TDM solutions are considered to be feasible [Qualcomm]
    - For Tx/Tx, if prioritization is known, prioritization rule is pre-configured. Else, it's up to UE implementation.
    - For Tx/Rx overlaps, the UE is configured with a max interruption value (per priority)
- Inter-RAT signalling constraints need to be studied before concluding the feasibility of short-term TDM solution. [Ericsson]
    - Both long-term and short-term coordination solutions are needed
    - RAT prioritization for TDM-based coexistence is only considered by RAN1 once the QoS framework and related priority mapping is developed by RAN2
- No impact to RAN1 LTE specification.

Issue 1-2: long term TDM solutions:
Company views on long term TDM solutions are provided below.

Topics with no consensus:
- For long term time-scale TDM coexistence, the increase in latency could be an issue for some NR applications [Huawei]
- NR V2X latency requirements can be fulfilled for some V2X use cases with long term TDM [Mediatek]
- For the long-term coordination in time domain, there would be adverse impacts on the latency and reliability [CATT]
- Long term TDM solutions are not recommended as it can cause negative impact to Tx latency, reliability and data rate. [OPPO]
- The long time scale TDM coordination has impact on latency requirements [Interdigital]

The following aspects were agreed concerning short term and long term TDM solutions:
- From RAN1 point of view, short term TDM solutions for NR and LTE V2X in-device coexistence is considered to be feasible for a UE when the load for the UE from LTE side and from NR side is at or below an acceptable level
- For each occurrence of Tx/Tx overlap and of Tx/Rx overlap, one RAT is prioritized over another
    - High-level principles of prioritization (e.g., BSM is deemed to have a higher priority, etc.) of LTE/NR can be discussed during the WI phase, while it is expected that detailed solutions may be left for implementation

1.5.1.2 Issue 2: FDM Solution for NR and LTE V2X Coexistence

Most companies also discussed the FDM solution for coexistence with some differing levels of support. In the last RAN1 meeting, the feasibility of inter-band FDM solution with static power assignments was agreed if the band separation was considered by RAN4 to be large enough. In this meeting, the remaining aspects to be discussed are about the feasibility of dynamic power sharing of inter-band FDM solutions as well as solutions for intra-band FDM coexistence. The views of the various companies on these two topics are shown below.

Issue 2-1: Dynamic power sharing solutions for FDM inter-band FDM coexistence:
Companies views on dynamic power sharing solutions in the case of inter-band FDM coexistence are the following:

Topics with discussion:

- Not supported/feasible because of significant burdens on hardware and impact on system performance [1-Huawei]
- Feasible with short-term inter-module signalling. Additionally, subframe boundary alignment between LTE and NR is required. [2-vivo]
  - Power scaling is based on QoS parameters or the RAT type
- Feasible with semi-static EN-DC power control rules assumed as baseline. QoS requirements/priorities of the packet should also factor into power sharing rules [3-Mediatek]
- Feasible with prioritization of LTE transmissions. Only NR Tx power is adjusted [4-ZTE]
- Feasible with appropriate prioritization and is subject to UE capability [5-LG]
  - LTE SL service/RAT can have higher priority than NR SL service/RAT
- For inter-band FDM solutions, harmonic interference and phase discontinuities should be further studied [6-CATT]
  - Not suitable to prioritize LTE transmissions over NR. Need study on mapping of priorities between LTE and NR V2X
  - Need study on how to avoid PSD imbalance between LTE and NR
- Feasible with power sharing rules based on priority [8-Panasonic]
- Feasible based on UE capability [9-Samsung]
  - EN-DC/NE-DC power control/sharing mechanisms as a baseline
- Feasible if the inter-module signalling (from LTE V2X to NR V2X) is less than 20ms and has no impact to LTE specifications. [10-OPPO]
- Feasibility of power sharing needs to be discussed in RAN4 [11-Intel]
- Feasible if appropriate power sharing is specified [12 – Nokia]
  - Power sharing methods specified for dual connectivity are the starting point
  - Both asynchronous and synchronous operation is supported with dynamic power sharing
- RAN1 supports dynamic power sharing between LTE sidelink transmission and NR sidelink transmission. [13-Interdigital]
  - Power allocation on each sidelink depends on data QoS
- FDM solution with dynamic power sharing for V2X in-device co-existence is considered to be feasible [15-NTTDCM]
  - NR Uu EN-DC power sharing can be considered as the baseline solution for FDM solution with dynamic power sharing.
- Dynamic power sharing based FDM solutions are not feasible [16-Qualcomm]
- Rules for power sharing for FDM-based coexistence should utilize QoS parameters, communication range, and congestion levels. [17-Ericsson]
  - The use of QoS parameters is only considered when the QoS framework for NR V2X has been developed.

Issue 2-2: Solutions for intra-band FDM coexistence:
Companies views on feasibility of intra-band FDM coexistence are the following:

Topics with discussion:

- Intra-band FDM coexistence (when band separation is not sufficient) is not feasible due to complexities in Rx/Rx implementation [1-Huawei]
- Feasible if the network can configure LTE and NR resource pools with sufficient guard band [3-Mediatek]
- Feasible with prioritization of LTE transmissions. Only NR Tx power is adjusted [4-ZTE]
- Timing alignment is required for intra-band FDM solutions [6-CATT]
    - Feasibility can be determined after study on PSD, phase discontinuity, half duplex, prioritization etc.
- Feasible if the inter-module signalling (from LTE V2X to NR V2X) is less than 20ms and has no impact to LTE specifications. [10-OPPO]
- FDM solution with dynamic power sharing for V2X in-device co-existence is considered to be feasible [15-NTTDCM]
    - NR Uu EN-DC power sharing can be considered as the baseline solution for FDM solution with dynamic power sharing.
- Dynamic power sharing based FDM solutions are not feasible [16-Qualcomm]
- Rules for power sharing for FDM-based coexistence should utilize QoS parameters, communication range, and congestion levels. [17-Ericsson]
    - The use of QoS parameters is only considered when the QoS framework for NR V2X has been developed

The following aspects were agreed concerning Dynamic power sharing solutions for FDM inter-band FDM coexistence and intra-band FDM coexistence:

- From RAN1 point of view, for both intra-band and inter-band Tx/Tx FDM solutions for in-device coexistence are considered to be feasible, at least if the following conditions are met:
    - For the intra-band case for dynamic power sharing, NR and LTE transmissions are fully overlapped in the time domain, i.e., NR transmissions have to span the entire LTE TTI such that the total power across the transmissions is constant.
- For intra-band and inter-band FDM dynamic power sharing solutions, the following additional conditions apply:
    - Subframe boundary alignment is required between LTE and NR V2X sidelinks
    - Both LTE and NR V2X sidelinks are aware of the time resource index (e.g., DFN for LTE) in both carriers
- For purposes of dynamic power sharing between LTE and NR Tx,
    - High-level principles of prioritization (e.g., BSM is deemed to have a higher priority, etc.) of LTE/NR can be discussed during the WI phase, while it is expected that detailed solutions may be left for implementation

1.5.1.3 Issue 3: Network Involvement in resolving UE Coexistence when in-coverage

Several companies discussed network involvement in coordinating LTE and NR N2X procedures within the UE. A summary of the proposals made regarding network involvement when co-existence is considered are captured below.

Topics with no consensus:

- UEs can inform the network about potential coexistence issues and provide assistance information when in coverage on both RATs. Alternatively, autonomous resource allocation may take into account scheduled resources by eNB/gNB [vivo]
- Base station dynamically or semi-statically configuring UE-specific resources to manage coexistence [CATT]
    - For TDM solutions, degradation of spectrum efficiency can be minimized by dynamic allocation of resource in time domain. There would be adverse impacts on the latency and reliability.
- As UE assistance information, UE reports information on its configured resource pool of LTE sidelink and/or NR sidelink to the eNB and gNB [Samsung]

- UEs inform network on availability of NR/LTE PC5 coordination function, which is subject to UE capability [Intel]
  - Mode-2 UEs in NR and Mode-4 UEs in LTE (i.e. UE operating in autonomous resource allocation mode) can inform network on reserved sidelink resources
- Study benefits of UE providing information on coexistence issues to the network when Uu-based sidelink resource allocation is used [Nokia]
- For a UE in NR mode 1, the network should support a coordinated scheduling scheme such that the simultaneous NR sidelink transmission and LTE sidelink transmission/reception is avoided in TDM solutions. [Interdigital]
  - Further study should be done of the coordination assistance information that UE should report to the network.
- Reporting information on SL resource pool of a RAT to the other RAT NW would be beneficial. [NTTDCM]
  - However, the usage scenarios should be further investigated during WI phase.
- UE reporting in some cases can be beneficial [Qualcomm]
  - For LTE V2X in Mode 3 and NR V2X in mode 2.
    - If LTE V2X detect a future collision of its SPS process and NR reserved resources, no new grant will be requested.
  - For NR V2X in Mode 1 and LTE V2X in Mode 2.
    - If NR V2X detects a future collision of its reserved resource and LTE resource, it will resolve this collision using configured priority resolution rule.
    - In case NR V2X transmission needs to be dropped, a new resource request can be sent to ask for a new grant.

1.5.1.4 Issue 4: Feasibility of Rx/Tx coexistence for intra-band TDM and FDM

Some companies commented on the feasibility of simultaneous reception of LTE and NR V2X when they are on adjacent carriers or intra-band.

Topics with discussion:

The following aspects discussed on the feasibility of simultaneous reception of LTE and NR V2X when they are on adjacent carriers or intra-band:

- AGC issues due to different numerologies of LTE and NR V2X impose implementation complexity and make Rx/Rx coexistence not feasible [Huawei]
- Rx-Rx in-device coexistence is feasible and can be left to device implementation [Mediatek]
- Rx-Rx in-device coexistence is based on UE capability [OPPO]
- The sidelink coexistence of potential LTE V2X reception and NR V2X reception is handled by UE implementation. [Interdigital]
- Rx-Rx in-device coexistence is feasible and up to UE implementation [Qualcomm]

The following aspects were agreed concerning feasibility of Rx/Tx coexistence for intra-band TDM and FDM:

- From RAN1 point of view, for both intra-band and inter-band Tx/Tx FDM solutions for in-device coexistence are considered to be feasible.
- Rx/Rx coexistence are feasible for intra- & inter-band from RAN1 point of view

This means that based on the study from physical layer specification perspective, in-device coexistence of LTE and NR sidelink is feasible for intra- & inter-band under the respective conditions & solutions for TX/TX, TX/RX, & RX/RX.

1.5.1.5 Issue 5: Other Aspects

The following aspects were also considered in some contributions but there was no consensus on these topics.

Topics with no consensus:

- Limited Tx and Rx capabilities need to be considered to resolve coexistence for pedestrian UEs [vivo]
  - Cross-carrier/-sidelink sensing and reservation can be considered for mitigating the limited Tx/Rx capability issues
- In-device coexistence problem b/w NR PC5 and LTE PC5 RATs can be addressed through switching to NR or LTE Uu air-interfaces [Intel]
  - *Discuss prioritization of Uu UL transmissions over NR PC5 SL or LTE PC5 SL*

1.5.2 Meeting Agreements

This section provides all the meeting agreements during the NR V2X study item phase for coexistence.

In RAN1#94, the following agreements has been made on coexistence:

Agreements on co-existence:

- For the study of LTE-V2X and NR-V2X sidelink co-existence, at least the following scenarios are considered from the UEs perspective:
  - LTE sidelink and NR sidelink do not have any coordinated procedures
  - LTE sidelink and NR sidelink have coordinated procedures and half-duplex constraints are assumed
    - RAN1 will focus on this scenario in the SI
- RAN1 focus on at least the following potential solutions for coexistence at least until the next meeting:
  - TDM of LTE V2X and NR V2X sidelink transmissions
  - FDM of LTE V2X and NR V2X sidelink transmissions

In RAN1#94bis, the following agreements has been made on coexistence:

Agreements on co-existence:

- In the context of in-device coexistence between NR and LTE V2X sidelinks (not co-channel, which could include both adjacent channel and channels that are sufficiently far apart.)
  - TDM solutions are those that prevent overlapping or simultaneous NR and LTE V2X sidelink transmissions.
  - FDM solutions are those that involve simultaneous transmissions of NR and LTE V2X sidelink transmissions and defining mechanisms for sharing the total device power between the two.
- For TDM solutions, LTE and NR V2X sidelinks are assumed to be synchronized
  - FFS accuracy of time alignment/synchronization
  - FFS alignment whether slot level and/or direct frame number (DFN) based alignment is needed
- For TDM solutions, the following aspects are studied in RAN1:
  - Long term time-scale coordination
    - Potential transmissions in time of LTE and NR V2X are statically/quasi-statically determined
    - UE behaviour when LTE and NR V2X sidelink transmissions overlap in time is FFS
  - Short time-scale coordination
  - Transmissions in time of LTE and NR V2X are known to each RAT (details FFS)
  - UE behavior when LTE and NR V2X sidelink transmissions overlap in time is FFS
- FFS coordination details
- FFS UE assistance for coordination

In RAN1#95, the following agreements has been made on coexistence:

Agreements on co-existence:

- Consider solutions for sidelink coexistence for the following:
  - Potential LTE V2X Tx and NR V2X Tx
  - Potential LTE V2X Tx and NR V2X Rx
  - Potential LTE V2X Rx and NR V2X Tx

- FFS the case of potential LTE V2X Rx and NR V2X Rx, e.g., whether or not it can be handled implementation

RAN1 will identify both TDM and FDM solutions for coexistence. The specific support for each solution is FFS.
For FDM solutions:

- For both dynamic and semi-static power allocation solutions, RAN1 assumes synchronization between NR and LTE V2X sidelinks, for a NR V2X UE when NR and LTE V2X sidelinks are intra-band
- The case of inter-band is FFS

Note: If the identified solutions can be applied to systems that are not synchronized, then RAN1 may revisit this assumption.

In RAN1#AH_1901, the following agreements has been made on coexistence:
Agreements on co-existence:

R1-1901392
Agreements:
- For TDM solutions for in-device coexistence between LTE and NR V2X:
  - Time Alignment
    - Subframe boundary alignment is required between LTE and NR V2X sidelinks
    - Both LTE and NR V2X sidelinks are aware of the time resource index (e.g., DFN for LTE) in both carriers

R1-1901425
Agreements:
- For long term time scale TDM solutions for in-device coexistence between LTE and NR V2X:
  - For a UE with coexistence impact, non-overlapping (in time domain) resource pools are (pre-)configured for NR V2X and LTE V2X sidelinks
    - No information is exchanged between LTE and NR sidelinks within the UE
- Long term time scale TDM solution is feasible from RAN1 point of view
  - Note: although feasible, it is expected that such a solution may have impact on latency, reliability and data rate requirements for some applications
  - No additional modifications to LTE specifications are needed

Agreements:
Assuming SPS scheduling (mode -3 or mode-4) for LTE V2X, for short time scale TDM solutions for in-device coexistence for V2X,
- For each occurrence of Tx/Tx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE
  - FFS: whether the information exchange between LTE and NR sidelinks can support this requirement
  - FFS: if there is impact to RAN1 LTE specification with this agreement
  - FFS: whether this solution can be up to UE implementation
- For each occurrence of Tx/Rx overlap, one RAT is prioritized over another
  - This requires some information exchange between LTE and NR sidelinks within the UE
  - FFS: if there is impact to RAN1 LTE specification with this agreement
  - FFS: whether this solution can be up to UE implementation
  - FFS: If determination of priority for Rx operation is feasible and whether the information exchange between LTE and NR sidelinks can support this requirement

Agreements:
- Inter-band FDM Solutions for coexistence
  - For static power assignment of Pc,max for each carrier

        - Synchronization is not assumed for inter-band coexistence of NR sidelink and LTE sidelink.
        - This FDM solution is feasible for resolution of Tx/Tx coexistence conflicts
        - If the band separation is large enough (based on RAN4 indication), then this FDM solution for coexistence is feasible for Tx/Rx coexistence
        - If the band separation is NOT large enough, then this FDM solution is not feasible for resolution of Tx/Rx coexistence conflicts
    - For dynamic power sharing between carriers,
        - FFS details of FDM solutions and whether they are feasible

Assuming SPS scheduling (mode -3 or mode-4) for LTE V2X, for short time scale TDM solutions for in-device coexistence for V2X,

- For each occurrence of Tx/Tx overlap, one RAT is prioritized over another
    - This requires some information exchange between LTE and NR sidelinks within the UE
    -
- For each occurrence of Tx/Rx overlap, one RAT is prioritized over another
    - This requires some information exchange between LTE and NR sidelinks within the UE

- Inter-band FDM Solutions for coexistence
    - For dynamic power sharing between carriers,
        - FFS details of FDM solutions and whether they are feasible

In RAN1#96, the following agreements has been made on coexistence:

Agreements on co-existence:

R1-1903594 Summary of Coexistence Aspects in NR-V2X Study Qualcomm

Agreements:

- From RAN1 point of view, short term TDM solutions for NR and LTE V2X in-device coexistence is considered to be feasible for a UE when the load for the UE from LTE side and from NR side is at or below an acceptable level
- For each occurrence of Tx/Tx overlap and of Tx/Rx overlap, one RAT is prioritized over another
    - High-level principles of prioritization (e.g., BSM is deemed to have a higher priority, etc.) of LTE/NR can be discussed during the WI phase, while it is expected that detailed solutions may be left for implementation

GM has concerns over the "e.g." in the agreements above.

Agreements**:**

- From RAN1 point of view, for both intra-band and inter-band Tx/Tx FDM solutions for in-device coexistence are considered to be feasible, at least if the following conditions are met:
    - For the intra-band case for dynamic power sharing, NR and LTE transmissions are fully overlapped in the time domain, i.e., NR transmissions have to span the entire LTE TTI such that the total power across the transmissions is constant.
- For intra-band and inter-band FDM dynamic power sharing solutions, the following additional conditions apply:
    - Subframe boundary alignment is required between LTE and NR V2X sidelinks
    - Both LTE and NR V2X sidelinks are aware of the time resource index (e.g., DFN for LTE) in both carriers
- For purposes of dynamic power sharing between LTE and NR Tx,
    - High-level principles of prioritization (e.g., BSM is deemed to have a higher priority, etc.) of LTE/NR can be discussed during the WI phase, while it is expected that detailed solutions may be left for implementation

Agreements:

- Rx/Rx coexistence are feasible for intra- & inter-band from RAN1 point of view

- High-level principles of Rx/Rx coexistence of LTE/NR can be discussed during the WI phase, while it is expected that detailed solutions may be left for implementation

Agreements:

- Based on the study from physical layer specification perspective, in-device coexistence of LTE and NR sidelink is feasible for intra- & inter-band under the respective conditions & solutions for TX/TX, TX/RX, & RX/RX
  - In the TR, also provides a reference to the respective sections