3GPP TSG RAN WG1 Meeting #100-e **R1-2000428**
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Agenda Item:	7.2.4.1
Source:	TCL Communication
Title:	Physical Layer Structure for Sidelink
Document for:	Discussion and Decision

1 Introduction

Based on the results of the V2X SI [1], the corresponding WI [2] has been approved in RAN Plenary #83. In the following we discuss the physical layer aspects and solutions to enable sidelink unicast, groupcast and broadcast transmission for V2X services.

2 Resource Pool

The following agreements have been reached:

Agreements: **RAN1 #98b**

- A slot is the time-domain granularity for resource pool configuration.
  - To down-select:
    - Alt 1. Slots for a resource pool is (pre-)configured with bitmap, which is applied with periodicity
    - Alt 2. Slots for a resource pool is (pre-)configured, where the slots are applied with periodicity.
  - FFS: signaling details
  - FFS: how to apply the above bitmap signaling, e.g., to all slots or only to a set of slots
  - FFS: symbols for sidelink in the slot, how to indicate for the case when not all symbols are for SL

2.1 Time-domain Granularity of Resource Pool Configuration

Concerning the configuration of the time-domain resources, we prefer Alt. 1 where SL slots are selected via a bitmap which has a certain periodicity. This bitmap should be applied to all available physical slots. Moreover, given the guidelines, it is preferable to only select full slots for SL, i.e. all symbols within the slot are available for SL. Mechanism on how to use and signal partial slots can be considered in a future release.

Proposal 1: Support Alt.1 where slots for a resource pool are (pre-)configured with a bitmap, which is applied with periodicity.

Proposal 2: Only use slots where all symbols are available for SL.

3 Physical Sidelink Shared Channel (PSSCH)

In this section we discuss the design of the SL data channel.

3.1 DMRS Pattern in Frequency Domain

The following agreement on reference symbol design for PSSCH has been reached in the last meetings:

Working Assumption: **RAN1 #97**

- Rel-15 PDSCH DMRS Configuration type 1 and/or type 2 are reused for frequency-domain pattern of PSSCH DMRS.
  - FFS whether to support either one or both types
  - FFS details on multiplexing of different ports for PSSCH DMRS

Agreements: **RAN1 #99**

- NR PUSCH DMRS for CP-OFDM sequence is the baseline for PSSCH DMRS sequence at least with the following modification.

- n_SCID is fixed as 0.
- n_ID^{N_SCID} is determined by the 16-bit LSB of CRC of the corresponding 1st SCI.

The WI [2] considers that *multi-rank PSSCH transmission is supported with up to two antenna ports*. Therefore, single-symbol DMRS type 1 is sufficient to support spatial multiplexing for sidelink of up to 2 layers. Adapting the frequency density to increase resource efficiency requires accurate sidelink channel information at the transmitter which, given the dynamic propagation environment and aperiodic traffic, seems difficult to obtain and exploit. Moreover, a single pattern in frequency domain reduces the signaling overhead, which is particularly important if the DMRS pattern is signaled dynamically in the SCI.

Proposal 3: Only support PDSCH single-symbol DMRS type 1 for PSSCH.

3.2 Channel Coding and Modulation

Working Assumption: **RAN1 #96b**

- Transmission of 1 TB with up to 2 layers in a PSSCH is supported.

Agreements: **RAN1 #98b**

- 256QAM is supported for SL.
  - Support of 256QAM by a UE is FFS between mandatory vs. based on UE capability from the Rx perspective
  - Support of 256QAM is based on UE capability from the Tx perspective
  - 64QAM is mandatory

Agreements: **RAN1 #98b**

- Three MCS tables supported in Rel-15 NR Uu CP-OFDM are also used for SL.
  - Support of the the low-spectral efficiency 64QAM MCS table is an optional UE feature in SL as in the Uu link
- For each resource pool, at least one MCS table is (pre)-configured
  - FFS whether or not to introduce a case where the MCS table can be overwritten by PC5 RRC or indicated in SCI
- Each resource pool is only configured with one 1st stage SCI PSCCH format

In our view, it is better to transmit 1 TB with up to two layers. This is in line with Uu and will avoid signaling overhead in both control and feedback channel.

Proposal 4: Confirm working assumption to support 1 TB per PSSCH.

4 Physical Sidelink Control Channel (PSCCH)

This section discusses the design of the sidelink control channel.

Agreements: **98b-NR-15**

- When reservation of a sidelink resource for an initial transmission of a TB at least by an SCI associated with a different TB is disabled, N_{MAX} is 3
  - SCI signaling is designed to allow to indicate 1 or 2 or 3 resources at least of the same number of sub-channels with full flexibility in time and frequency position in a window W of a resource pool
    - FFS: if full flexibility is limited in some cases
  - Value 2 or 3 is (pre-)configured per resource pool
  - FFS size of window W

Agreements: **RAN1 #99**

- 1st SCI includes at least

- Priority (QoS value),
- PSSCH resource assignment (frequency/time resource for PSSCH),
- Resource reservation period (if enabled),
- PSSCH DMRS pattern (if more than one patterns are (pre-)configured),
- 2nd SCI format (e.g. information on the size of 2nd SCI),
- [2]-bit information on amount of resources for 2nd SCI (e.g. beta offset or aggregation level)
- Number of PSSCH DMRS port(s)
- 5-bit MCS

4.1 Design of 1st-stage SCI

First stage SCI can occupy a fraction of the PRBs in a sub-channel. To fulfill different QoS requirements in different channel conditions, multiple sizes for the transmission of 1st stage SCI should be supported. Each resource pool is configured with the suitable size for the 1st stage SCI to avoid any blind decodes.

Proposal 5: Multiple sizes for the transmission of 1st stage SCI are supported. A resource pool is configured with the 1st stage SCI size to be used in this resource pool.

It would be interesting to investigate the pros and cons of configuring more than one size for the 1st stage SCI transmissions. On the downside, it increases the blind decoding complexity. On the upside, it improves resource and power efficiency by combining the knowledge of QoS and link conditions.

4.2 Compact 2nd Stage SCI for Transmissions with Prior Reservations

It has been agreed that at least an SCI in Mode 2 can indicate up to 3 resources, one current resource and two future reservations. Each 2nd stage SCI in the first transmission and subsequent transmissions, reserved earlier, will have the same source ID and destination ID. As the source ID and the destination ID are at least known to the destination, in case of HARQ enabled SL transmissions, they can be removed from the transmissions which were reserved in the prior transmissions, thus reducing the SCI overhead without impacting the sensing operation of neighbouring SL devices. This

significant advantage can be easily obtained by having a 2nd stage SCI format without the source and destination IDs.

Proposal 6: When the sidelink control information associated to a sidelink transmission carries the indication of resource reservation for a future transmission, the source ID and the destination ID in the 2nd stage SCI of reserved transmission are not transmitted.

5 Physical Sidelink Feedback Channel (PSFCH)

This section discussed the sidelink feedback channel.

Agreements: **RAN1 #97**

- A sequence-based PSFCH format with one symbol (not including AGC training period) is supported.
  - This is applicable for unicast and groupcast including options 1/2.
  - Sequence of PUCCH format 0 is the starting point.
  - FFS: 1 PRB or multiple PRBs is/are used for this PSFCH format
  - FFS: feasible number of HARQ-ACK bits, mapping of HARQ-ACK bit
- FFS whether to support the following formats
  - X-symbol PSFCH format with a repetition of the one-symbol PSFCH format (not including AGC training period).
    - E.g. $X = 2$
  - A PSFCH format based on PUCCH format 2
  - A PSFCH format spanning all available symbols for sidelink in a slot

Agreements: **98b-NR-09**

- For the agreed sequence-based PSFCH format with onesymbol (not including AGC training period),
  - 1 PRB is used.

- Only 1 bit can be carried for the case of $N = 1$, where N denotes the periodof slot having PSFCH resource in a resource pool,
- FFS: for the case of $N = 2, 4$

Note: Each company is encouraged to discuss on howto handle AGC issue for the agreed sequence-based PSFCH format with onesymbol (not including AGC training period) to decide whether/how to support 2-symbol PSFCH format.

It has been agreed to reuse the single-symbol PUCCH Format 0 for PSFCH with 1 bit payload. The technical specification TS 38.211 defines the cyclic shift computation as depicted in Figure 1.

$$\alpha_l = \frac{2\pi}{N_{\mathrm{sc}}^{\mathrm{RB}}}\left(\left(m_0 + m_{\mathrm{cs}} + n_{\mathrm{cs}}(n_{\mathrm{s,f}}^{\mu}, l + l')\right) \bmod N_{\mathrm{sc}}^{\mathrm{RB}}\right)$$

where

- $n_{\mathrm{s,f}}^{\mu}$ is the slot number in the radio frame
- l is the OFDM symbol number in the PUCCH transmission where $l = 0$ corresponds to the first OFDM symbol of the PUCCH transmission,
- l' is the index of the OFDM symbol in the slot that corresponds to the first OFDM symbol of the PUCCH transmission in the slot given by [5, TS 38.213]
- m_0 is given by [5, TS 38.213] for PUCCH format 0 and 1 while for PUCCH format 3 and 4 is defined in subclause 6.4.1.3.3.1
- $m_{\mathrm{cs}} = 0$ except for PUCCH format 0 when it depends on the information to be transmitted according to subclause 9.2 of [5, TS 38.213].

Figure 1: Cyclic shift computation for PUCCH format 0 [3, Section 6.3.2.2.2]. For PSFCH, $l = 0$ and $N_{SC}^{RB} = 12$.

If cyclic shift hopping $n_{cs}(\dots)$ is used has not been agreed yet. The shift m_{CS} depends on the payload. For a single-bit payload it is given by

Table 9.2.3-3: Mapping of values for one HARQ-ACK information bit to sequences for PUCCH format 0

HARQ-ACK Value	0	1
Sequence cyclic shift	$m_{\mathrm{cs}} = 0$	$m_{\mathrm{cs}} = 6$

Figure 2: Cyclic shift m_{CS} for PUCCH format 0 and 1 bit payload [4, Table 9.2.3-3].

It remains to define the initial cyclic shifts m_0. Since Y is fixed per resource pool, a corresponding sequence of initial cyclic shifts can be (pre-)configured together with the

resource pool. For instance, if $Y = 3$ cyclic shift pairs are configured, a sequence of $m_0 = \{0, 2, 4\}$ may be configured. However, this fixed sequence is sub-optimal for groupcast option 2 because the group size X may vary and not all cyclic shifts are used. In case only 2 code dimensions are used for example, any of the pairs in $m_0 = \{0, 2, 4\}$ results in sub-optimal detection because the corresponding ACK/NACK points are spaced closer than with e.g. $m_0 = \{0, 3\}$. Therefore, at least for groupcast option 2, we propose to specify a table (or multiple tables) of initial cyclic shifts as a function of Y. Depending on its size, the group may choose an appropriate sequence from this table to maximize PSFCH detection performance.

Proposal 7: Sequences of initial cyclic shifts m_0 are defined depending on the number of cyclic shift pairs Y.

6 Conclusion

In this contribution the following proposals and observations have been made:

Proposal 1: Support Alt.1 where slots for a resource pool are (pre-)configured with a bitmap, which is applied with periodicity.

Proposal 2: Only use slots where all symbols are available for SL.

Proposal 3: Only support PDSCH single-symbol DMRS type 1 for PSSCH.

Proposal 4: Confirm working assumption to support 1 TB per PSSCH.

Proposal 5: Multiple sizes for the transmission of 1st stage SCI are supported. A resource pool is configured with the 1st stage SCI size to be used in this resource pool.

Proposal 6: When the sidelink control information associated to a sidelink transmission carries the indication of resource reservation for a future transmission, the source ID and the destination ID in the 2nd stage SCI of reserved transmission are not transmitted.

Proposal 7: Sequences of initial cyclic shifts m_0 are defined depending on the number of cyclic shift pairs Y.

References

[1] TSG RAN, "Study on NR Vehicle-to-Everything (V2X)," 3GPP TR 38.885 V2.0.0, Tech. Rep., Mar. 2019.

[2] ——, "Revised WID on 5G V2X with NR sidelink," 3GPP RP-190984, Tech. Rep., Jun. 2019.

[3] 3rd Generation Partnership Project, "Physical Channels and Modulation," 3GPP TS 38.211 V15.3.0, Tech. Rep., Oct. 2018.

[4] ——, "Physical Layer Procedures for Control," 3GPP TS 38.213 V16.0.0, Tech. Rep., Dec. 2019.

[5] SA2, "Reply LS on Sidelink HARQ Feedback for Groupcast," 3GPP TSG RAN1 #98b, Tech. Rep. R1-1911676, Oct. 2019.