
Agenda Item: 7.2.4.1
Source: TCL Communications
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

Agreements :

RAN1 AH1901

- 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

If SL is deployed on a dedicated carrier it is sufficient to configure resource pools on a slot-based granularity.

Proposal 1: On a dedicated sidelink carrier the resource pool time-domain granularity is slot-level.

In a shared carrier, only uplink symbols may be used for sidelink transmissions. If a slot is configured to contain only flexible and UL symbols it is desirable to utilize the UL symbols for sidelink transmission. However, it seems complicated to specify the resource pools based on symbol-level granularity. Thus, we prefer slot-level granularity for shared carriers.

Proposal 2: On a shared sidelink carrier the resource pool time-domain granularity is slot-level.

It is possible that a shared TDD carrier is configured with a significant number of flexible slots which reduces the number of available resources for sidelink transmission. Therefore, it would be beneficial if flexible slots can be made available for sidelink transmission.

Observation 1: On shared TDD carrier, it is beneficial to allow sidelink transmission on flexible slots.

Concerning frequency allocation, non-contiguous PRB allocation has the following advantages (+) and disadvantages (–):

- + higher flexibility for resource allocation (if resources are fragmented)
- + exploit frequency diversity
- severe in-band emission interference
- increased signaling overhead and specification effort

Thus, we think that contiguous frequency allocation is sufficient.

Proposal 3: Sidelink resource pools always consist of contiguous PRBs, i.e. support Option 1.

3 Physical Sidelink Shared Channel (PSSCH)

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

3.1 DMRS Design

The following agreements on reference symbol design for PSSCH have been reached:

- 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

DMRS pattern selection based on sub-carrier spacing: Increasing SCS shortens the OFDM symbol duration. Therefore, given the same time-domain properties of the channel, fewer DMRS symbols are required per TTI.

Proposal 4: DMRS time-domain density for PSSCH should depend on the sub-carrier spacing.

Single or multiple DMRS pattern(s) per resource pool: A resource pool can be shared between multiple UEs with different traffic patterns (unicast, groupcast or broadcast) where each transmission can experience different channel conditions. Hence, it is beneficial to allow multiple DMRS patterns per resource pool to adapt to the various SL channels and traffic patterns.

Proposal 5: A sidelink resource pool supports multiple DMRS patterns.

Tx-Rx alignment of DMRS pattern: Given the particularities of V2V channel, e.g. rapid transitions between LOS and NLOS channel propagation conditions, the SL needs to be able to quickly adapt its transmission parameters. Thus, dynamically signaling the DMRS pattern as part of the SCI should be considered.

Proposal 6: The PSSCH DMRS pattern configuration should be signaled in the associated control information (SCI).

Mapping of time-domain DMRS patterns: A similar approach as in Uu can be utilized, where front-loaded DMRS are present and the number of additional DMRS symbols is configured semi-statically or dynamically. Due to high mobility environments more than 3 additional DMRS symbols can be considered. The PDSCH single-symbol DMRS positions can serve as a starting point. The exact placement of the additional DMRS symbols depends on the slot structure, in particular AGC and Tx-Rx switching symbols.

DMRS patterns in frequency domain: 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 7: Support PDSCH single-symbol DMRS type 1 for PSSCH.

3.2 Channel Coding and Modulation

Agreements :

RAN1 #96b

- LDPC codes used for Rel-15 NR DL-SCH is applied to a transport block delivered by PSSCH.

Similarly, the same modulation and coding schemes as in NR UL/DL can be adopted for NR SL, including 256QAM for unicast.

Proposal 8: Support NR Uu modulation and coding schemes for PSSCH.

3.3 Transmission schemes

Working Assumption :

RAN1 #96b

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

For unicast transmission it is desirable to use multiple antenna ports for spatial multiplexing. However, short-term channel feedback is likely unreliable because of the aperiodic feedback and dynamic propagation environment. Therefore, transmission schemes that are robust to errors in the channel state information at the transmitter should be considered in a first instance, e.g. transmit diversity schemes or open-loop spatial multiplexing schemes. Specific scenarios, e.g. platooning, may allow for closed-loop spatial multiplexing since channel conditions are more stable.

Proposal 9: For PSSCH, consider transmission schemes that are robust to errors in channel state information at the transmitter.

4 Physical Sidelink Control Channel (PSCCH)

This section discusses the design of the sidelink control channel.

Agreements :

RAN1 #94b

- 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.
 - NDI, if defined, is a part of SCI.

Agreements :

RAN1 #96b

- For the purpose of evaluation of PSCCH design, RAN1 assumes 60 bits, 90 bits, 120 bits as the total SCI sizes including 24 bits CRC.
 - Other sizes are not precluded.

Agreements:

RAN1 #96b

- QPSK is used for PSCCH.

SCI Formats: NR sidelink supports different transmissions (broad, uni, group-cast) with different requirements. For instance, a broadcast transmission has by definition no dedicated target receiver. Therefore, the associated SCI does not contain signaling related to HARQ for example and is thus significantly smaller than an SCI scheduling a unicast transmission. Another case can be made for SCI not associated to a PSSCH, e.g. for resource reservation requests, CSI report request or other short messages.

Proposal 10: SL supports multiple SCI formats.

A two-stage SCI approach can be a flexible solution. The 1. SCI is decodable by all UEs and can hence be utilized to schedule a broadcast transmission. If not used for broadcast then it can also indicate the resources for the 2. SCI. This 2.SCI is UE or group-specific and contains all the information required to decode the associated PSSCH.

Observation 2: Two-stage SCI can be utilized for flexible scheduling of different transmissions.

4.1 Channel Coding and Modulation

Agreements:

RAN1 #96b

- Polar code adopted for Rel-15 NR DCI is applied to PSCCH.

4.2 Transmission schemes

Broadcast transmission requires that all UEs are capable of decoding the PSCCH. To keep the number of blind decoding attempts low, only receiver-transparent single-antenna port transmission should be considered.

Proposal 11: Only consider receiver transparent single-antenna port transmission schemes for PSCCH.

4.3 Resource allocation

Agreements :

RAN1 #96b

- The starting symbol and the number of symbols for a PSCCH are assumed to be known to the receiving UE before decoding the PSCCH.

It should be allowed that the PSCCH occupies all symbols in a slot to carry SCI that is not associated to a PSSCH. This resource allocation is more robust to AGC impairments.

Proposal 12: A PSCCH resource allocation can comprise all symbols in a slot.

5 Physical Sidelink Feedback Channel (PSFCH)

This section discussed the sidelink feedback channel.

Agreements :

RAN1 #95

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

Agreements :

RAN1 #96

- 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.

Work Item Description :

[2]

- In sidelink, CSI is delivered using PSSCH (including PSSCH containing CSI only) using the resource allocation procedure for data transmission.

The PSFCH is agreed to carry at least HARQ feedback. To this end, the NR PUCCH can be reused. Since it is agreed that at least the last symbols in a slot can be used for PSFCH, PUCCH format 0 is a good starting point. To increase coverage also PUCCH format 1 can be supported.

Proposal 13: Consider sequence-based HARQ feedback for PSFCH, e.g. PUCCH formats 0/1

6 Conclusion

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

Proposal 1: On a dedicated sidelink carrier the resource pool time-domain granularity is slot-level.

Proposal 2: On a shared sidelink carrier the resource pool time-domain granularity is slot-level.

Observation 1: On shared TDD carrier, it is beneficial to allow sidelink transmission on flexible slots.

Proposal 3: Sidelink resource pools always consist of contiguous PRBs, i.e. support Option 1.

Proposal 4: DMRS time-domain density for PSSCH should depend on the sub-carrier spacing.

Proposal 5: A sidelink resource pool supports multiple DMRS patterns.

Proposal 6: The PSSCH DMRS pattern configuration should be signaled in the associated control information (SCI).

Proposal 7: Support PDSCH single-symbol DMRS type 1 for PSSCH.

Proposal 8: Support NR Uu modulation and coding schemes for PSSCH.

Proposal 9: For PSSCH, consider transmission schemes that are robust to errors in channel state information at the transmitter.

Proposal 10: SL supports multiple SCI formats.

Observation 2: Two-stage SCI can be utilized for flexible scheduling of different transmissions.

Proposal 11: Only consider receiver transparent single-antenna port transmission schemes for PSCCH.

Proposal 12: A PSCCH resource allocation can comprise all symbols in a slot.

Proposal 13: Consider sequence-based HARQ feedback for PSFCH, e.g. PUCCH formats 0/1

References

- [1] TSG RAN, “Study on NR Vehicle-to-Everything (V2X),” 3GPP TR 38.885 V2.0.0, Tech. Rep., Mar. 2019.
- [2] —, “New WID on 5G V2X with NR Sidelink,” 3GPP RP-190766, Tech. Rep., Mar. 2019.