

Source: Johns Hopkins University APL
Title: Discussion on Channel Access Mechanisms
Agenda item: 9.4.1.1
Document for: Discussion and Decision

1. Background

Objective 2 of the Work Item Description (WID) on NR sidelink evolution [1] is to study and specify support for sidelink operation in the unlicensed bands with focus on the FR1 unlicensed bands, n46 and n96/n102. The agreements reached at the previous RAN WG1 meetings that are relevant to this discussion are listed in the respective sections. The specific topics addressed here are on multi-channel access, UE-to-UE COT sharing, cyclic prefix extension (CPE) and Type 1 LBT blocking issue.

2. Discussion

2.1 Multi-Channel Access for Sidelink Transmissions

The following agreement was reached in RAN1 #112bis-e [2]:

Agreement

For dynamic channel access mode with multi-channel case in SL-U, both NR-U DL Type A and Type B multi-channel access procedure are supported for multiple PSFCH transmissions on multiple channels.

- FFS: It is up to UE implementation to perform either Type A or Type B multi-channel access procedure.
- FFS: whether this can initiate a shared COT
- FFS: whether there is any special handling needed for transmission in a shared COT on one or more of the channels

The first FFS deals with whether a UE performing a PSFCH transmission on multiple channels should perform an NR-U DL Type A channel access procedure, an NR-U DL Type B channel access procedure, or whether the decision is left up to the UE implementation. Not listed as an option in the FFS would be to make the decision a configurable parameter.

The multi-channel access procedure for PSFCH is the NR-U DL procedure so transmissions can occur on any channel to which access is gained. This is unlike the NR-U UL procedure which features an ‘all-or-nothing’ rule where access must be gained to every channel in the channel set if any transmission is to occur [3].

Type A requires a Type 1 channel access procedure on every channel in the channel set. Type B requires a Type 1 channel access procedure on only one channel in the channel set while the other channels sense the channel for 25 μ s immediately before the Type 1 channel gains access.

Due to their different access approaches, Type A and Type B have distinct advantages. The Type B procedure will, on average, gain access to more channels since all but one of the channels have to sense the channel idle for only 25 μ s. The single Type 1 channel may be in use, however, delaying transmission on the entire set of channels until it becomes clear. For Type A, one channel being busy would not prevent the remaining channels from completing their independent Type 1 channel access procedures. The transmissions on the idle channels are not delayed by the access procedure on the busy channel. Because of this, using the Type A procedure will, on average, result in quicker access to at least some sub-set of the channels.

The number of channels accessed and the transmission delay both depend on the actual traffic patterns on the channels which, in turn, depend on the traffic statistics of each channel. The choice between Type A and Type B depends on preferring the possibility of transmitting on fewer channels with less delay or more channels with more delay. The preferred access procedure depends on the UE's specific connections and the current channel loading. Since neither of these is known beforehand, the most prudent course of action is to give UEs the freedom to decide which approach to use. Therefore, we propose to let the choice between the Type A and Type B channel access procedures be an implementation choice.

Proposal 1: For PSFCH transmissions, the decision to perform a Type A or Type B multi-channel access procedure is an implementation choice.

The next FFS topic is on whether a PSFCH can initiate a COT. The PSFCH transmissions in a COT is in response to PSSCH/PSCCH transmissions that occurred prior to the start of the current COT. From a regulatory perspective, the ETSI standard [4] does not preclude the PSFCH initiating a COT as long as the Type 1 procedure is used to access at least one of the channels. Also, because the PSFCH and PSSCH/PSCCH transmit at different positions in the slot, these transmissions will not block each other when initiating a COT.

Proposal 2: Support initiating a shared COT with a PSFCH transmission.

2.2 UE-to-UE COT Sharing

Agreement at RAN1#111 meeting [2]:

Agreement

For UE-to-UE COT sharing,

- When performing S-SSB transmission(s), a responding UE can utilize a COT shared by a COT initiating UE (using type 1 channel access) when the responding UE is intended to transmit S-SSB within RB set(s) corresponding to the shared COT. When performing PSFCH transmission(s), a responding UE can utilize a COT shared by a COT initiating UE at least when at least one of the responding UE's PSFCH transmissions in a symbol/slot within RB set(s) corresponding to the shared COT is intended for the COT initiating UE.
 - FFS: whether a responding UE can transmit PSFCH(s) to UE(s) other than the initiator
- When performing PSSCH/PSCCH transmission(s), a responding UE can utilize a COT shared by a COT initiating UE at least when the responding UE's PSSCH/PSCCH transmission(s) within RB set(s) corresponding to the shared COT is intended for the COT initiating UE.
 - FFS whether to support the case if a responding UE transmits PSSCH/PSCCH to destination ID other than the source ID of the COT initiating transmission, where the destination ID of the responding UE's PSSCH/PSCCH transmission(s) can be different from the source/destination IDs of COT initiating UE's PSSCH/PSCCH transmission when sharing the COT information.
 - FFS: how to determine / what are the restrictions to the destination ID of the responding UE's PSSCH/PSCCH transmission(s) to utilize the COT shared by the initiating UE.
 - FFS whether the responding UE can utilize the COT when at least the responding UE's PSCCH transmission in the reserved resources within the shared COT or MCSt is intended for the COT initiating UE and what are the restrictions (e.g., priority, etc.) and indication to the responding UE.
- FFS: UE forwarding/relaying information about a COT initiated by another UE.

Agreement at RAN1#112 meeting [2]:

Agreement

- A responding UE over a shared COT can be:
 - a receiving UE, which is the target of a PSCCH/PSSCH transmission of a COT initiator
 - In the case of unicast from the COT initiator, within the same COT when the source and destination IDs contained in the COT initiator's SCI match to the corresponding destination and source IDs relating to the same unicast at the receiving UE
 - In the case of groupcast and broadcast, when the destination ID contained in the COT initiator's SCI match to a destination ID known at the receiving UE
 - a UE identified by ID(s), if additional IDs are supported in the COT sharing information (in addition to the source and destination IDs of the PSCCH/PSSCH transmission), when additional IDs are included in the COT sharing information from the COT initiator
 - FFS Limitations on what additional IDs may be included and how they may be indicated

Agreement at RAN1#112 meeting [2]:

Agreement

A responding UE's PSSCH/PSCCH transmission(s) within RB set(s) corresponding to a shared COT is intended for the COT initiating UE when,

- In the case of unicast from the responding UE, when the source and destination IDs contained in the responding UE's PSCCH/PSSCH match to the destination and source IDs from a COT initiator's unicast transmission that included COT sharing information, or match to the additional ID(s) included in the COT sharing information (if supported)
- In the case of groupcast or broadcast from the responding UE, when the destination ID contained in the responding UE's PSCCH/PSSCH matches to the destination ID from a COT initiator's groupcast or broadcast transmission that included COT sharing information, or matches to the additional ID(s) included in the COT sharing information (if supported)
- FFS: all other details and additional restrictions

2.2.1 ETSI Requirements

Because concerns about compliance of some proposals with regulatory constraints were raised at the previous RAN1 meeting, in this subsection the relevant requirements from the ETSI standard are discussed. In the unlicensed bands, UE-to-UE COT sharing is supported using a regulatory framework established in the ETSI EN 301 893 [4] standard.

ETSI EN 301 893 [4] defines the roles of *Initiating* and *Responding Devices* with respect to meeting the regulatory requirements in the EU in these unlicensed bands. The clause (clause 4.2.7.3.2.7) relevant to the UE-to-UE COT sharing is listed below with the emphasis added to the original text.

4.2.7.3.2.7 Responding Device Channel Access Mechanism

Clause 4.2.7.3.2.6, step 6) b) describes the possibility whereby an *Initiating Device* grants an authorization to one or more associated *Responding Devices* to transmit on the current *Operating Channel*. A *Responding Device* that receives such a grant shall follow the procedure described in step 1) to step 3):

1) A *Responding Device* that received a transmission grant from an associated *Initiating Device* may proceed with transmissions on the current *Operating Channel*.

....

2) The *Responding Device* may perform transmissions on the current *Operating Channel* for the remaining *Channel Occupancy Time*. The *Responding Device* may have multiple transmissions on this *Operating Channel* provided that the gap in between such transmissions does not exceed 16 μ s. When the transmissions by the *Responding Device* are completed the *Responding Device* shall proceed with step 3).

To comply with this ETSI standard, the key relevant requirements on the *Responding Devices* are as follows:

Observation 1: The *Initiating Device* can grant authorization to one or more *Responding Devices* to use its channel occupancy time.

Observation 2: The *Responding Device* is allowed multiple transmissions to *Responding/Initiating Devices* within this channel occupancy time.

2.2.2 Approaches for COT Sharing

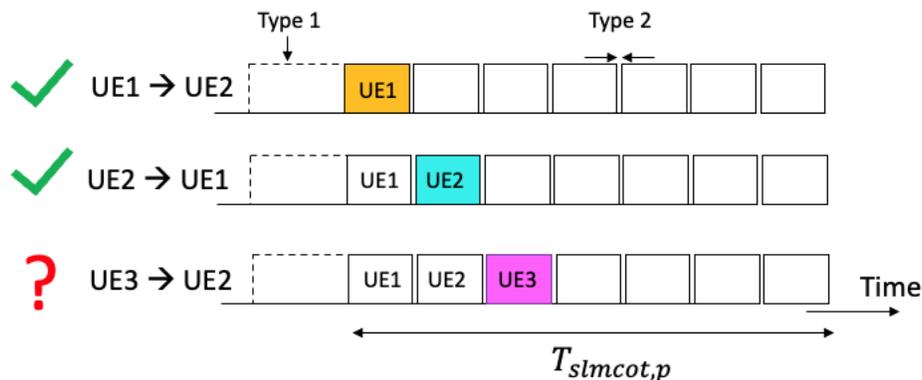


Figure 1. Illustrative COT sharing scenario: UE1, COT initiator, sharing its COT with UE2 and UE3.

Figure 1 shows an illustrative scenario where UE1 is the COT initiator and it is desired to support UE2, UE3 and other UEs in UE1's COT which is of duration $T_{slmcot,p}$. From a regulatory perspective, as per Observations A and B in the preceding subsection, UE2 and UE3 can use UE1's COT once they receive transmission grants from UE1. Additionally, there are no restrictions on UE2 and UE3 to send their transmissions only to UE1. In this figure, after gaining access to the channel, UE1 sends its PSSCH/PSCCH to UE2 in the first slot. According to RAN1#112 agreements, UE2 is now a responding UE so it can send its transmission to UE1. In the third slot, UE3 desires to send its PSSCH/PSCCH transmission to UE2. According to RAN1#112 agreements this transmission is allowed only when additional IDs are supported in the COT initiator's transmission. From a regulatory perspective, transmission of

additional IDs by the COT initiator can be construed as granting an authorization for the UEs with such IDs to share the COT.

As per RAN1#112 agreements, when the ID of UE3 is included as an additional ID in the COT sharing information, UE3 is considered as a responding UE over the COT share. Also, when the ID of UE2 is included as an additional ID in the COT sharing information, a transmission to UE2 is considered as that is intended for the COT initiating UE. Therefore, the PSSCH/PSCCH transmission from UE3 to UE2 can be supported by including the IDs of UE2 and UE3 in the COT share information

Proposal 3: Support inclusion of additional IDs in the COT sharing information. The set of additional IDs should include the IDs of all responding UEs in the COT share and the IDs of the UEs that these responding UEs intend to send their PSSCH/PSCCH transmissions.

To support ultra-reliable, low-latency communications applications in sidelink and for the efficient use of the COT share, it is desirable to send the responding UE's PSFCH transmission directly to the corresponding UE without requiring it to be sent to the COT initiator. To authorize this transmission, it is necessary to include the ID of the UE that is sending the PSFCH transmission in the COT share information. Similar to a PSSCH/PSCCH transmission, a transmission from a responding UE is intended for the COT initiator when the source and destination IDs contained in the PSFCH transmission match to the additional ID(s) included in the COT share information.

Also, the PSFCH transmissions may have to be sent in the current COT interval in response for the PSSCH/PSCCH transmissions that occurred in the previous COT intervals. To support such PSFCH transmissions, the IDs of UEs that have scheduled PSFCH transmissions in the current COT share have to be included in the COT share information.

Proposal 4: Responding UEs can send PSFCH transmissions in the COT share to UE(s) other than the COT initiator.

Proposal 5: A responding UE's PSFCH transmission(s) within RB set(s) corresponding to a shared COT is intended for the COT initiating UE when the source and destination IDs contained in the responding UE's PSFCH match to the additional ID(s) included in the COT sharing information.

2.3 CP Extension (CPE)

The CPEs of a UE when initiating a COT and sharing the COT were discussed at the previous RAN1 meeting. The discussion in this subsection is on the effects of using different CPE lengths when sharing a COT.

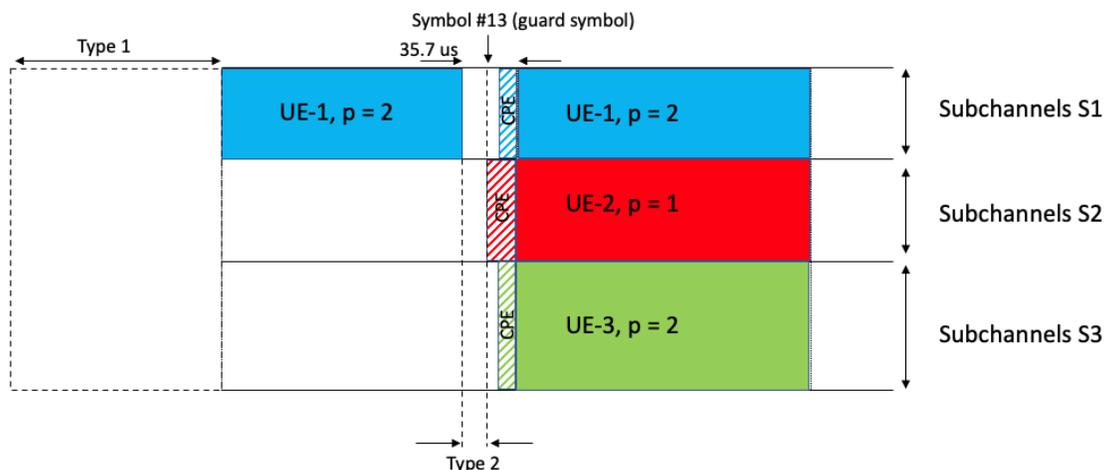


Figure 2. CPE for COT sharing. Using a longer CPE with higher priority traffic UE, UE-1.

Figure 2 shows the UEs with two priorities sharing UE-1's COT. UE-2 has higher priority ($p=1$) traffic and all UEs have reservations scheduled in the slot shown in this figure. For accessing the COT it is reasonable to use a longer CPE with the higher priority traffic. However, using a longer CPE within the COT will block UE-1 and UE-2 accessing the COT, even though they occur in separate frequency resources. Because of this the CPE length should be such that the start time of the transmissions are the same in all subchannels.

Proposal 6: The CPE used by a UE for COT sharing should be such that the start time of transmissions is the same across all RBs in the RB set.

2.4 Type LBT Blocking Issue

Agreement at RAN1#112bis-e meeting [2]:

Agreement

To resolve the Type 1 LBT blocking issue, where one UE performing a Type 1 LBT procedure for using its own selected/reserved resource(s) is blocked by another UE's SL transmission at least in a slot preceding to the selected/reserved resource and causing the LBT to fail, further study the following options in a future meeting.

- Option 1:
 - UE avoid selection of N consecutive resource(s) before a reserved resource with high priority when the transmitting symbols of the selected resource overlap with Type 1 LBT of the reserved resource.
 - UE avoid selection of N consecutive resource(s) after a reserved resource when the transmitting symbols of the reserved resource overlap with LBT of the selected resource.
 - FFS: the avoidance should be performed by L1 exclusion or L2 MAC selection
 - FFS: whether / how to achieve this in RA mode 1
 - FFS: How to determine value of N
- Option 2:
 - UE prioritizes/selects resource(s) for transmission in slot(s) after a reserved resource when transmission of the selected resource is able to share the initiated COT of the reserved resource (i.e., the selected resource(s) is within the COT duration of the reserved resource and the CAPC value of the selected resource(s) is equal to or higher than that of the reserved resource).
 - UE prioritizes/selects resource(s) for transmission in slot(s) before a reserved resource when transmission of the selected resource is able to share its initiated COT with the reserved resource (i.e., the reserved resource is within the COT duration of the selected resource(s) and the CAPC value of the selected resource(s) is equal to or smaller than that of the reserved resource).
 - FFS whether / how to achieve this in RA mode 1.
- Option 3: UE selects extra / more resources than required for transmitting a TB (i.e., overbooking) to accommodate potential Type 1 LBT failures. FFS how to determine/preconfigure the number of extra selected resources.
- Option 4: The expected LBT duration is determined firstly, then resource selection takes into account of the expected LBT duration is performed.
- Option 5: At MAC layer, selection of resource(s) among the reported set of candidate resources from L1 is up to UE implementation in mode 2 for SL-U, instead of random selection.
- Option 6: UE excludes frequency resources (if any) previously reserved via SCI by other SL UEs in the corresponding slot, when estimating the detected power within a sensing slot duration in Type 1 channel access.
- Option 7: SL UE deems channel busy only if the UE detects transmission other than SL transmission occupying the channel (e.g., exceeding the energy detection threshold), i.e., the energy detection for EDT checking in LBT procedure does not take into account the energy from SL transmissions.
- Option X: No solution is needed. To avoid inter-UE blocking from performing Type 1 LBT can be handled based on UE implementation (e.g., as the start timing to perform LBT sensing is determined by each UE).

Option 1 is not attractive when sharing with multiple RATs because the avoidance of selecting resources before the reserved resources of the higher priority traffic UE may result in other RATs accessing the channel during the time that the higher priority traffic UE is accessing the channel. However, in lightly loaded channels this would be advantageous to the sidelink when COT sharing is not available.

Option 2 is advantageous because COT sharing can be efficiently utilized.

Option 3 adds resiliency to the design so support this option. Although this reduces spectral efficiency, sidelink already uses blind retransmissions of TBs to enhance transmission reliability.

Proposal 7: Because any single option does not have a clear advantage over the other options and most of these techniques can be implemented at the UE without impacting the intended specification, support Option X. Support studying Option 3 as well.

3. Summary of Proposals

Proposal 1: For PSFCH transmissions, the decision to perform a Type A or Type B multi-channel access procedure is an implementation choice.

Proposal 2: Support initiating a shared COT with a PSFCH transmission.

Proposal 3: Support inclusion of additional IDs in the COT sharing information. The set of additional IDs should include the IDs of all responding UEs in the COT share and the IDs of the UEs that these responding UEs intend to send their PSSCH/PSCCH transmissions.

Proposal 4: Responding UEs can send PSFCH transmissions in the COT share to UE(s) other than the COT initiator.

Proposal 5: A responding UE's PSFCH transmission(s) within RB set(s) corresponding to a shared COT is intended for the COT initiating UE when the source and destination IDs contained in the responding UE's PSFCH match to the additional ID(s) included in the COT sharing information.

Proposal 6: The CPE used by a UE for COT sharing should be such that the start time of transmissions is the same across all RBs in the RB set.

Proposal 7: Because any single option does not have a clear advantage over the other options and most of these techniques can be implemented at the UE without impacting the intended specification, support Option X. Support studying Option 3 as well.

4. References

[1] 3GPP RP-230077: "WID revision: NR sidelink evolution." 3GPP TSG RAN Meeting #99, Rotterdam, Netherlands, March 20 – 23, 2023.

[2] OPPO, "FL summary for AI 9.4.1.1: SL-U channel access mechanism (EOM)." 3GPP TSG RAN WG1 #112bis-e. e-Meeting, April 17 – 26, 2023.

[3] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access."

[4] ETSI EN 301 893 V2.1.1 (2017-05): "5 GHz RLAN; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU."