**3GPP TSG RAN WG1 #110 R1-2207789**

**Toulouse, France, 22 – 26 August, 2022**

**Source: Moderator (OPPO)**

**Title: FL summary #1 for AI 9.4.1.1: SL-U channel access mechanism**

**Agenda item: 9.4.1.1**

**Document for:** **Discussion and Decision**

Introduction

In the last RAN#96 meeting, the [WID](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_96/Docs/RP-221798.zip) for Rel-18 NR sidelink evolution was updated to include a new note on clarifying/restricting gNB’s behavior in unlicensed spectrum for the SL-U objective as followed.

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| 1. Study and specify support of sidelink on unlicensed spectrum for both mode 1 and mode 2 where Uu operation for mode 1 is limited to licensed spectrum only [RAN1, RAN2, RAN4]
* Channel access mechanisms from NR-U shall be reused for sidelink unlicensed operation
	+ Assess the applicability of sidelink resource reservation from Rel-16/Rel-17 to sidelink unlicensed operation within the boundaries of unlicensed channel access mechanism and operation
		- No specific enhancements for Rel-17 resource allocation mechanisms
		- If the existing NR-U channel access framework does not support the required SL-U functionality, WGs will make appropriate recommendations for RAN approval.
* Physical channel design framework: Required changes to NR sidelink physical channel structures and procedures to operate on unlicensed spectrum
	+ The existing NR sidelink and NR-U channel structure shall be reused as the baseline.
* No specific enhancements for existing NR SL feature
* The study should focus on FR1 unlicensed bands (n46 and n96/n102) and is to be completed by RAN#98.
* Note: In sidelink unlicensed operation, the gNB does not perform Type 1 channel access to initiate and share a channel occupancy, neither Type 2 channel access to share an initiated channel occupancy, nor semi-static channel access procedures to access an unlicensed channel.
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This contribution provides a summary of submitted contributions, discussion topics and outcomes that are related to the channel access mechanisms for SL-U (blue text part of objective) during this RAN1 meeting. Note that, all past outcomes including agreements, conclusions and working assumptions reached during this WI are captured in Section 5 (Appendix) of this document.

Collection of all agreements / outcomes of RAN1#110

To be collected once agreement is reached.

Topics for discussion

[109-e-R18-SL-01] Email discussion on channel access mechanism by May 20 – Kevin (OPPO)

* Check points: May 16, May 20

## [ACTIVE] Topic #1: Evaluation methodology for SL-U

**Background**: During the last RAN1#109-e meeting, the work on updating simulation assumptions for evaluating NR sidelink performance in the unlicensed spectrum for both commercial and V2X deployment scenarios was discussed, and RAN1 almost reached an agreement on the updated evaluation methodology due to two small final details on equal number of SL-U and Wi-Fi devices and equivalent load between SL and Wi-Fi traffics.

According to the end of meeting FL summary [2], the latest proposal is captured in the following and it should be used as the start point for concluding the discussion on evaluation methodology update in this meeting.

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| **Proposal 1 (XII) – from RAN1#109-e**The followings, two evaluation scenarios can be used for evaluating performance of SL-U designs, resource allocation schemes, and coexistence study with another RAT ~~(commercial scenario only)~~ in a shared channel.* Scenario 1 (commercial use cases) – recommended:
	+ Evaluation methodology baseline is NR-U from TR 38.889 with the following updates.
	+ Indoor layout
		- Option 1: a pairs topology for SL-U from R1-2205033 – recommended

* + - * a = 20m, b = 60m, c = 20m, d = 80 m
			* There are two operators to model two RATs at a time. The red one is SL-U UE, the blue one is Wi-Fi or NR-U. (Note, one round of simulations targets SL-U vs. Wi-Fi and another one targets SL-U vs. NR-U)
			* ~~For NR-U / Wi-Fi, the same number of UEs / Wi-Fi nodes as the total number of SL-U devices are dropped in the area. The~~ NR-U UE / Wi-Fi nodes are dropped uniformly per gNB/AP per 20 MHz.
			* For evaluation of unicast traffic, the topology of SL-U is pair topology and the SL-U UEs are dropped uniformly at random in the area
				+ For SL-U pairs: 3, 5 or 10 pairs of UEs per 20MHz
			* For evaluation of groupcast traffic, SL-U UEs are dropped uniformly at random in the area, SL-UEs form groupcast UE group based on TX-RX UE distancing, the distance is provided by each company. 6, 10 or 20 UEs per 20MHz is assumed.
			* For evaluation of broadcast traffic, SL-U UEs are dropped uniformly at random in the area. 6, 10 or 20 UEs per 20MHz is assumed.
		- Option 2: SL UE clusters (R1-2203146)

* + - * Indoor layout and UE dropping model with N = 6 or 12 clusters and each with M=5 UEs
			* Each cluster is a circle, with a central point and radius Rmax = 15 or 10m and Rmin = 5 or 1m
			* No overlapping among the N clusters
	+ Channel model follows NR InH Mixed Office model used in NR-U (TR38.889)
	+ Traffic model
		- Option 1: R17 sidelink commercial traffic model with periodic model 3 with packet size reduced by a factor of (high: 1; mid: 5; low: 8)
		- Option 2: FTP model 3 with arrival rate satisfying one of the followings:
			* BO Low load: 10%~25%
			* BO Mid load: 35%~50%
			* BO High load: above 55%
		- Option 3: XR cloud gaming model in TR38.838
		- It is up to each company to use either Option 1 or 2 or Option 3 or mixed of them
	+ Interference model:
		- Layout option 1: Explicit modelling of NR-U / WiFi transmissions (as per TR38.889)
		- Layout option 2: Same as layout option 1, but optional modelling
		- Note, for the interference traffic model:
			* The same or equivalent traffic model setting as SL-U should be used as much as possible to achieve equal load (e.g., SL-U RAT offered load equal the interfering RAT’s offered load).
			* The same number of traffic flows should be used between SL-U and the interfering RAT (e.g., 10 UEs with 10 flows, and 5 STAs with 2 flows each, one for DL and one for UL)
	+ Performance metric: UPT, latency, and PRR which regards the packet whose delay exceeding the remaining PDB as transmission failure. FFS: UE satisfaction/system capacity as section 7.2 in TR 38.838 for XR traffic evaluation
	+ Fair coexistence criterion between SL-U and the interfering RAT (e.g., according to NR-U TR38.889)
* Scenario 2 (V2X use cases):
	+ Evaluation methodology baseline is NR sidelink from TR 37.885.
	+ Layout: Highway (baseline), urban (optional)
	+ Channel model follows NR sidelink TR 37.885
	+ Traffic model baseline is R17 sidelink commercial traffic model
	+ FFS: how to model NR-U and Wi-Fi hotspot interference (including their traffic and channel models) ~~is not modelled for highway and, at least for, urban it is up to companies how to implement the interference model~~
	+ FFS: Performance metric~~: PRR and PIR (V2X)~~
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According to the summary of contributions provided in Section 4.2, based on majority’s preference, FL’s proposal for round 1 discussion based on majority’s preference is as followed. The differences to the above Proposal 1 (XII) are in red font.

**Proposal 1 (I):**

The followings, two evaluation scenarios can be used for evaluating performance of SL-U designs, resource allocation schemes, and coexistence study with another RAT in a shared channel.

* Scenario 1 (commercial use cases) – recommended:
	+ Evaluation methodology baseline is NR-U from TR 38.889 with the following updates.
	+ Indoor layout
		- Option 1: a pairs topology for SL-U from R1-2205033 – recommended



* + - * a = 20m, b = 60m, c = 20m, d = 80 m
			* There are two operators to model two RATs at a time. The red one is SL-U UE, the blue one is Wi-Fi or NR-U. (Note, one round of simulations targets SL-U vs. Wi-Fi and another one targets SL-U vs. NR-U)
			* For NR-U / Wi-Fi, the same number of UEs / Wi-Fi nodes as the total number of SL-U devices are dropped in the area. The NR-U UE / Wi-Fi nodes are dropped uniformly per gNB/AP per 20 MHz.
			* For evaluation of unicast traffic, the topology of SL-U is pair topology and the SL-U UEs are dropped uniformly at random in the area.
				+ 6 SL-U pairs and 4 NR-U UEs / Wi-Fi nodes per gNB/AP per 20 MHz
			* For evaluation of groupcast traffic, SL-U UEs are dropped uniformly at random in the area, SL-UEs form groupcast UE group based on TX-RX UE distancing, the distance is provided by each company.
				+ 12 SL-U UEs and 4 NR-U UEs / Wi-Fi nodes per gNB/AP per 20 MHz
			* For evaluation of broadcast traffic, SL-U UEs are dropped uniformly at random in the area.
				+ 12 SL-U UEs and 4 NR-U UEs / Wi-Fi nodes per gNB/AP per 20 MHz
		- Option 2: SL UE clusters (R1-2203146)

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* + - * Indoor layout and UE dropping model with N = 3 or 6 clusters and each with M=5 UEs
			* Each cluster is a circle, with a central point and radius Rmax = 15 or 10m and Rmin = 5 or 1m
			* No overlapping among the N clusters
			* For coexistence, there are two operators to model two RATs at a time, where the red one is Wi-Fi AP or NR-U gNB. NR-U UE / Wi-Fi nodes are dropped uniformly per gNB/AP.
	+ Channel model follows NR InH Mixed Office model used in NR-U (TR38.889)
	+ Traffic model
		- Option 1: R17 sidelink commercial traffic model with periodic model 3 with packet size reduced by a factor of (high: 1~3; mid: 4~6; low: 7~10)
		- Option 2: FTP model 3 with arrival rate satisfying one of the followings:
			* BO Low load: 10%~25%
			* BO Mid load: 35%~50%
			* BO High load: above 55%
		- Option 3: XR cloud gaming model in TR38.838
		- It is up to each company to use either Option 1 or 2 or Option 3 or mixed of them
	+ Interference model:
		- Layout option 1: Explicit modelling of NR-U / WiFi transmissions (as per TR38.889)
		- Layout option 2: Same as layout option 1, but optional modelling
		- Note, for the interference traffic model:
			* The same or equivalent traffic model setting as SL-U should be used as much as possible to achieve equal load (e.g., SL-U RAT offered load equal the interfering RAT’s offered load).
			* ~~The same number of traffic flows should be used between SL-U and the interfering RAT (e.g., 10 UEs with 10 flows, and 5 STAs with 2 flows each, one for DL and one for UL)~~
	+ Performance metric: UPT, latency, and PRR which regards the packet whose delay exceeding the remaining PDB as transmission failure. ~~FFS: UE satisfaction/system capacity as section 7.2 in TR 38.838 for XR traffic evaluation~~
	+ Fair coexistence criterion between SL-U and the interfering RAT (e.g., according to NR-U TR38.889)
* Scenario 2 (V2X use cases):
	+ Evaluation methodology baseline is NR sidelink from TR 37.885.
	+ Layout: Highway (baseline), urban (optional)
	+ Channel model follows NR sidelink TR 37.885
	+ Traffic model baseline is R17 sidelink commercial traffic model
	+ It is up to companies how to implement NR-U or Wi-Fi interference model
	+ Performance metric: PRR and PIR from TR 37.885

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| **Company** | **Comments** |
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### FL Proposals for round 2

TBD

## [ACTIVE] Topic #2: Channel access mechanisms for SL-U

**Background**:

In the last meeting (RAN1#109-e), the following top-level agreement was reached on the LBE-based channel access mechanisms for SL-U operation with FFS on the details.

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| **Agreement**Type 1 and Type 2 (2A/2B/2C) channel access procedures, transmission gap and LBT sensing idle time requirements specified in TS37.213 for NR-U are taken as baseline for NR sidelink operation in a shared channel.* FFS conditions for the actual channel access type(s) used for each SL channel and signal transmitted, and based on COT sharing conditions (if supported)
* FFS whether UL CAPC or DL CAPC or both should be used as the baseline,
	+ FFS how the channel access priority classes apply to each SL channel and signal
	+ FFS sidelink priority levels (PQI or L1 priority), channel and signal mapping to the 4 channel access priority classes. The discussion may involve other WGs.
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One of them remaining details to be resolved is related to the UL and/or DL CAPC should be used as the baseline. Based on review of submitted contributions to this meeting, some of the main reasons for supporting either UL or DL CAPC table are:

* DL CAPC table from NR-U:
	+ Applications with anchor-node UE to consistently share longer duration COTs.
	+ Acting as a supervising role in Mode 2 IUC
* UL CAPC table from NR-U:
	+ In ultra-dense networks, a wider range of CWs offers more chances to back off if collisions occur.
	+ A larger CWmax allows more channel access opportunities if one fails.
	+ Acting as a supervised role in Mode 1
	+ Unified scheme to access the channel between UL and SL transmissions for a UE.

As summarised in Section 4.3, some think both tables can be support for either different applications or different role that the SL UE is involved. Considering what was used in NR-U, it is proposed to support both tables depending on the role of the SL UE.

For the topic on the contention window (CW) adjustment, while there are quite divergent views from the contribution submitted this time on how the CW should be updated/adjusted, one of the simplest ways is to reuse the NR-U scheme as the baseline when both ACK and NACK reports are enabled. When SL-HARQ feedback is disabled, the CW can be kept constant/unchanged from the initial transmission. As for the case of NACK-only feedback, it is yet unclear the benefits and drawbacks of each proposed scheme. Further discussion and study on the scheme would be necessary. Some even proposed not to support groupcast option 1 for SL-U.

 Proposal details for CAPC and CW adjustment from FL is captured in Proposal 2-1 below.

On the applicable transmission(s) / channel types and transmission gap that is allowed for each of the agreed Type 2A/2B/2C channel access scheme, there seemed to be some misalignment on the interpretation or understanding of the NR-U spec from reviewing contributions. It is in FL’s view that it is important to align our understanding now on this issue, as this will impact on the remaining channel access procedure work and details for CPE. Please find FL’s proposal in Proposal 2-2 below.

In the last meeting, the support for FBE-based semi-static channel access procedure was first time discussed. From reviewing the contributions submitted to this meeting, there is a significant preference to support this feature for SL-U operation. FL proposal to support this feature is captured in Proposal 2-3 below, with a same constraint on its usage applied in NR-U.

**Proposal 2-1 (I):**

* Type 1 channel access procedure
	+ CAPC
		- The UL CAPC table from NR-U (Table 4.2.1-1 of TS37.213) is used when SL UE operates in Mode 1 RA, as the UE is considered a supervised role.
			* The mapping of L1 priority levels in SCI or PQI to the 4 CAPC levels is up to RAN2 or SA2
			* FFS any necessary update (including the applicability of NOTE 1 and NOTE 2).
		- The DL CAPC table from NR-U (Table 4.1.1-1 of TS37.213) is used when SL UE operates in Mode 2 RA, as the UE is considered a supervising role.
			* The mapping of L1 priority levels in SCI or PQI to the 4 CAPC levels is up to RAN2 or SA2
			* FFS any necessary update
	+ CW adjustment
		- NR-U CW adjustment mechanism is used as the baseline for SL-U when SL-HARQ feedback is enabled in SCI for unicast and groupcast option 2
			* FFS any necessary update for SL-U operation
		- CW size remains the same when SL-HARQ feedback is disabled in SCI
		- FFS the case of groupcast option 1 (NACK-only)

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| **Company** | **Comments** |
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**Proposal 2-2 (I):**

* Type 2A/2B/2C SL channel access procedures
	+ Type 2A channel access procedure is applicable to the following transmission by a UE:
		- Transmission(s) by a UE following transmission(s) by another UE for a gap ≥ 25μs in a shared channel occupancy
		- FFS any other transmission by a UE
	+ Type 2B channel access procedure is applicable to the following transmission by a UE:
		- Transmission(s) by a UE following transmission(s) by another UE when 25μs > gap ≥ 16μs in a shared channel occupancy
		- FFS any other transmission by a UE
	+ Type 2C channel access procedure is applicable to the following transmission by a UE:
		- Transmission(s) by a UE following transmission(s) by another UE for a gap < 16μs in a shared channel occupancy
		- FFS any other transmission by a UE

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| **Company** | **Comments** |
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**Proposal 2-3 (I):**

* FBE-based semi-static channel access for SL-U is supported
	+ Channel access procedures based on semi-static channel occupancy are intended for environments where the absence of other technologies is guaranteed e.g., by level of regulations, private premises policies, etc.
	+ NR-U channel access procedures for semi-static channel occupancy are to be taken as the baseline / starting point.
	+ FFS any necessary updates or enhancement for SL-U operation

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| **Company** | **Comments** |
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### Proposal for round 2

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## [ACTIVE] Topic #3: Sharing of channel occupancy time (COT)

**Background**:

In the last meeting (RAN1#109-e), the following top-level agreement was reached on UE-to-UE COT sharing for SL-U operation with FFS on the remaining details. Note that, FL feels that any treatment on the CPE topic should be after further progress has been made on the channel access schemes for SL channels (e.g., S-SSB, PSFCH) and multi-consecutive slots transmission.

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| **Agreement*** UE-to-UE COT sharing is supported in NR sidelink operation in a shared channel (SL-U).
	+ FFS applicable SL channels and signals (e.g., PSCCH/PSSCH, PSFCH, S-SSB) for shared COT access and any restrictions (e.g. whether the COT can be shared with a single UE or multiple UEs)
	+ FFS all other details in compliance with the regulatory requirements
* CP extension (CPE) is supported for NR sidelink operation in a shared channel.
	+ FFS all remaining details including applicable scenarios, usage, PHY structure, etc.
 |

On UE-to-UE COT sharing, there is a wide range of proposals brought to this meeting in the contributions. Applicable scenarios for the COT sharing range from a very tight restriction of unicast only (only one target receiver UE), a somewhat limited target UEs based on transmission relationship, to a very broad coverage of every UE that have received a shared COT.

According to the COT sharing principle adopted in NR-U, although the Uu communication is mostly based on unicast communication (hence the COT sharing is mostly between gNB and just one UE), but it is allowed for the gNB to use a shared COT from a UE for DL broadcast transmission when the COT sharing/initiating UE is also a target receiver. Then based on this principle, FL proposes the following operation for UE-to-UE COT sharing in Proposal 3 below. Furthermore, the FL also propose to include some of COT sharing information that are widely mentioned in the contributions to be agreed in this meeting (FFS on others and also the container(s) for carrying COT sharing information).

Lastly, in the last RAN#96 meeting, a new note was added to the SL-U objective in the WID on the LBT behaviour for gNB in SL Mode 1 RA. But it still leaves the door open as to whether in Mode 1 RA a gNB can share/forward a COT to a SL UE that was received from another SL UE (even when the two UEs are engaged in unicast with one another). In some contributions, it is brought up that if a UE can already receive SL transmission from another UE, the COT sharing can be done directly from one UE to the another UE directly using UE-to-UE COT sharing. It is unnecessary to sharing a COT via an intermediate node (gNB). Therefore, the FL also propose that gNB relaying/forwarding a UE initiated COT to another UE is not supported.

**Proposal 3 (I):**

* UE-to-UE COT sharing
	+ A responding SL UE(s) can utilize a shared COT when its transmission(s) has an equal or higher CAPC level than the CAPC level indicated in a shared COT and the responding SL UE(s) is a target receiver determined by the destination ID of the shared COT.
	+ When a responding UE uses a shared COT for its transmission(s), the COT initiation/sharing UE is a target receiver of the transmission(s).
		- In unicast, the destination ID in SCI for the transmission(s) shall be the source ID in SCI of the shared COT
		- In groupcast and broadcast, the destination ID in SCI for the transmission(s) shall be same as the destination ID in SCI of the shared COT
	+ Contents of COT sharing information includes the followings.
		- Destination ID
		- CAPC level
		- Remaining COT duration (in number of SL slots)
		- FFS any others (e.g., information on time and frequency resources)
	+ FFS the container(s) for the COT sharing information (e.g., 1st SCI, 2nd SCI, MAC CE)
* gNB relaying/forwarding a UE initiated COT to another UE is not supported in Rel-18
	+ FFS whether a Mode 1 UE can report a COT to gNB for aiding Mode 1 RA

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| **Company** | **Comments** |
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### Proposal for round 2

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## [ACTIVE] Topic #4: Short control signalling transmission - SCSt

**Background**:

In the last RAN1#109-e meeting, the short control signalling transmission (SCSt) mechanism was first time discussed for SL-U. According to European regulation (ETSI EN 301 893), the SCSt, which does not require a UE to perform a CCA procedure to detect transmission in a shared carrier, is allowed to be performed by a device when the SCSt complies with a duty cycle and total duration requirements within an observation period of 50ms. A summary of the regulation for SCSt is copied below.

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| * **Short control signalling transmission (SCSt)**
	+ According to European regulation (ETSI EN 301 893), following limitations apply
		- within an observation period of 50 ms, the number of Short Control Signalling Transmissions by the equipment shall be equal to or less than 50; and
		- the total duration of the equipment's Short Control Signalling Transmissions shall be less than 2500 µs within said observation period.
 |

The SCSt mechanism is adopted in NR-U for discovery burst transmissions (SSB) from the gNB since it satisfies the European requirement. But in NR-U as specified the UE is still required to perform a Type 2A channel access procedure to ensure the channel is idle before transmitting the discovery bust. It is understood to be extra friendly to the transmissions of other RATs that coexist in the same shared spectrum.

For SL-U, the SCSt has been considered for S-SSB and PSFCH transmissions by several companies. The main benefit of supporting SCSt for these two SL transmission types is the simplification of the standardisation effort to complete the work for SL-U since it is allowed by the regulation. That is, we potentially do not need to introduce/specify additional transmission occasions, new procedures and new format(s) since these channels can be always transmitted (i.e., no LBT failure). Also, since the transmission duration for S-SSB and PSFCH is short (a few symbols, less than one slot), impact to the performance of other RATs is expected to be small.

While there are some benefits of supporting the SCSt for S-SSB and PSFCH, others expressed their support to adopt the same transmission mechanism used in NR-U (i.e., Type 2A) for these channels or performing a full Type 1 LBT procedure when the transmission is not within an applicable COT. Subsequently, the chance of not transmitting PSFCH will be quite high since the allowable time gap from the received PSSCH to perform Type 1 LBT is very limited. Nevertheless, the 3 common options for each S-SSB and PSFCH are listed below in Proposal 4 for discussion and down-selection.

**Proposal 4 (I):**

* Channel access mechanism for S-SSB, down-select to one of the followings
	+ Option 1: UE does not sense the channel before a S-SSB transmission when the transmission meets the European regulation (ETSI EN 301 893) for SCSt.
	+ Option 2: UE performs Type 2A channel access procedure before each S-SSB transmission regardless of a shared channel occupancy.
	+ Option 3: UE performs Type 1 channel access procedure with p=1 for a S-SSB transmission without a shared channel occupancy and Type 2 channel access procedure in a shared channel occupancy.
* Channel access mechanism for PSFCH, down-select to one of the followings
	+ Option 1: UE does not sense the channel before a PSFCH transmission when the transmission meets the European regulation (ETSI EN 301 893) for SCSt.
	+ Option 2: UE performs Type 2A channel access procedure before each PSFCH transmission regardless of a shared channel occupancy.
	+ Option 3: UE performs Type 1 channel access procedure for a PSFCH transmission without a shared channel occupancy and Type 2 channel access procedure in a shared channel occupancy.
		- FFS the CAPC level for PSFCH (e.g., same as the corresponding PSSCH, p=1, etc)

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| **Company** | **Comments** |
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### Proposal for round 2

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## [ACTIVE] Topic #5: Multi-channel access

**Background:**

In the last meeting, it was agreed to support channel access procedure for transmission on multiple channels in a shared carrier as followed.

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| **Agreement**Channel access procedures for transmission(s) on multiple channels are supported for NR sidelink operation as defined by TS37.213 for NR-U (wherever applicable)* FFS whether the downlink, uplink and/or semi-static multiple channel access procedure(s) (if supported) from NR-U should be used as a baseline and whether/how they are applied in SL mode 1 and mode 2 operation
 |

According to the access procedures for multiple channels defined in NR-U, the DL multiple channel access procedure(s) requires UE to perform LBT sensing independently on each unlicensed channel (RB\_set) for which the UE is intended to transmit. The UE transmit on the channel(s) where the channel access procedure is a success. On the other hand, the UL multiple channel access procedure requires UE to perform LBT sensing all the unlicensed channels (RB\_sets) for which the UE is intended to transmit. And only if the channel access procedures are successful for all the channels are successful, then the UE can transmit. Otherwise, the UE does not transmit on any channel (i.e., “all-or-nothing” access).

According to the contribution summary in Section 4.5, although the UL channel access procedures from NR-U has more supports than the DL counterpart, but many have expressed that both should be supported for different transmission scenarios. For example, when UE has a wideband transmission (large packet) that requires frequency resources from more than one RB\_set, the UE would select and encode data for transmission over multiple channels. In this case, if channel access procedure for one of the channels is successful but others have failed, the UE would not want to transmit only on just one channel. Hence, the UL channel access procedure makes sense. On the other hand, when UE is transmitting different data on each channel, even if LBT sensing on one of the channels is failed, it makes sense for the UE to transmit on other channels where LBT sensing is a success. Hence the use of the DL multiple channel access procedure(s).

Therefore, the FL propose to support both DL and UL multiple channel access procedures from NR-U for SL-U operation.

**Proposal 5 (I):** Multi-channel access

* Both DL (Type A and Type B) and UL multiple channel access procedures from NR-U are to be used as the baseline for SL-U
	+ FFS whether Type A and/or Type B DL channel access procedures from NR-U should be supported for SL-U
	+ FFS their applicable transmission scenarios and any necessary enhancement and update for SL-U operation

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| **Company** | **Comments** |
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### Proposal for round 2

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## [ACTIVE] Topic #6: Multi-consecutive slots transmission (MCSt)

**Background:**

Motivations to support multi-consecutive slots transmission (MCSt) / sidelink burst transmission (SBt) cited in the submitted contributions are mainly to reduce the need/frequency of UE performing LBT to access the channel once it has acquired a COT, to retain the COT to transmit UE’s data as much as possible and to be able to transmit UE’s data as soon as possible in the following slot. From reviewing the contributions (summary in Section 4.8), there is a large interest to support this feature in SL-U while some expressed concerns on the potential standardization workload. Therefore, the FL proposes to support this feature for SL-U operation in Rel-18 but strongly urge to keep the details / mechanism to be as simple as possible while still achieving the main intention. That is, strive to reuse existing SL designs as much as possible.

**Proposal 6 (I):**

* Multi-consecutive slots transmission (MCSt) is support for Mode 1 and Mode 2 resource allocation in SL-U.
	+ Strive to reuse existing NR sidelink designs wherever possible to minimize specification impact.
	+ FFS details

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| **Company** | **Comments** |
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### Proposal for round 2

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Contribution summary for channel access mechanism

## Regulation aspects

* **Short control signalling transmission (SCSt)**
	+ According to European regulation (ETSI EN 301 893), following limitations apply
		- within an observation period of 50 ms, the number of Short Control Signalling Transmissions by the equipment shall be equal to or less than 50; and
		- the total duration of the equipment's Short Control Signalling Transmissions shall be less than 2 500 µs within said observation period.

## Evaluation methodology

* **Proposal (XII) as the starting point for evaluation methodology discussion**
	+ [4/Nokia, NSB], [6/HW, HiSi], [8/vivo], [12/OPPO], [9/ZTE, SC], [13/CATT, GH], [20/China Telecom], [28/QC], [34/BOSCH]
* **Updates of Scenario 1 (commercial use cases):**
	+ [6/HW, HiSi]:
		- ***Option 2: SL UE clusters (R1-2203146)***

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* + - * ***Indoor layout and UE dropping model with N = 3 or 6 clusters and each with M=5 UEs***
			* ***Each cluster is a circle, with a central point and radius Rmax = 15 or 10m and Rmin = 5 or 1m***
			* ***No overlapping among the N clusters***
			* ***For coexistence, there are two operators to model two RATs at a time, where the red one is Wi-Fi or NR-U gNB. NR-U UE / Wi-Fi nodes are dropped uniformly per gNB/AP.***
		- ***Simulation bandwidth: 80MHz***
	+ [8/vivo]:
		- PRR is not supported in the evaluation for commercial use case
		- The metric of UPT should be updated considering that the file transmission time includes the time gap between two reserved resource.
	+ [9/ZTE, SC]:
		- For unicast, a RX user is re-dropped when the received power between TX-RX UEs is less than - 82 dBm.
		- In the evaluation for groupcast, it should be guaranteed that received power of the RX UE is not less than - 82 dBm and TX-RX UE distancing is not larger than X meters in the groupcast UE group.
		- For evaluation of broadcast traffic, only RX UEs with received power not less than - 82 dBm are considered for performance statistics.
	+ [12/OPPO]:
		- Option 1: R17 sidelink commercial traffic model with periodic model 3 with packet size reduced by a factor of (high: 1-3; mid:4-6; low:7-10)
	+ [13/CATT, GH]:
		- For UE dropping: For NR-U / Wi-Fi, the same number of UEs / Wi-Fi nodes as the total number of SL-U devices are dropped in the area.
		- For interference modelling: the following equal load interference traffic model is recommended for evaluation.
	+ [28/QC]:
		- To drop a sidelink pair in Scenario 1 – Option 1, the first UE should be dropped uniformly at random. The second UE is dropped uniformly at random, then the RSRP to the first UE is computed. The second UE is retained if the RSRP is above a threshold, otherwise it is dropped again. The set of RSRP association thresholds {-72, -62, -52} dBm can be considered.
		- Introduce the sildelink star topology as a new Scenario 1 – Option 1b. The dropping technique is derived from the sidelink pairs dropping technique, starting from the center UE, and dropping each other UE to form a pair with the center UE.



* + - We propose to down-select two drop cases for Scenario 1 – Option 1 with SL-U pairs, namely a low density drop, and a high density drop. Assuming 3 APs the following cases can be considered: a) 3 SL-U pairs and 2 STAs per AP, b) 6 SL-U pairs and 4 STAs per AP, c) 9 SL-U pairs and 6 STAs per AP, d) 12 SL-U pairs and 8 STAs per AP.
		- We propose to down-select two drop cases for Scenario 1 – Option 1 with SL-U stars, namely a low density drop, and a high density drop. Assuming 3 APs and 3 SL-U stars, the following cases can be considered: a) 2 UEs per anchor UE and 2 STAs per AP, b) 4 UEs per anchor UE and 4 STAs per AP, c) 6 UEs per anchor UE and 6 STAs per AP, d) 8 UEs per anchor UE and 8 STAs per AP.
	+ [35/E///]:
		- For SL-U evaluations the indoor mixed office model sub-7 GHz is used as the baseline:
			* 5 SL-U UE pairs (10 UEs in total) in the scenario. Each pair is separated by Uniform [10, 25] m
				+ For unicast: communication between UEs in the pair
				+ For groupcast: communication between a UE and its 4 closest neighbors
				+ For broadcast: communication between a UE and all other UEs.
			* 10 interfering devices, with the same drop distribution as the UEs.
			* D2D channel model is InH office pathloss model with proper d\_3D with indoor mixed office LOS probability
		- The Periodic 3 and Aperiodic 2 models in TR 37.885 are the baseline for SL-U evaluations. In addition to the parameters in TR 37.885 a low-load version is defined
			* Periodic 3 with low load has packet size reduced by a factor of 5.
			* Aperiodic 2 with low load has packet size reduced by a factor of 5
* **Updates of Scenario 2 (V2X use cases):**
	+ [6/HW, HiSi]:
		- *~~FFS: how to model~~ Modelling of NR-U and Wi-Fi hotspot interference (including their traffic and channel models)*
		- *~~FFS:~~ Performance metric: PRR and PIR(V2X)*
	+ [8/vivo]:
		- PRR can be selected in the V2X use case
		- RAN1 should define deployment method for WIFI node and WIFI UE, e.g., the WIFI node is modelled as RSU and WIFI UE is modelled as pedestrian UE.
	+ [12/OPPO]:
		- Use PRR and PIR defined in TR37.885 as performance metric for Scenario 2.
	+ [28/QC]:
		- For Scenario 2 (if supported), a) evaluate only unicast transmissions, b) use UPT as the KPI, and c) model other-RAT interference.
	+ [34/BOSCH]:
		- It is up to companies how to implement the interference model for highway and urban
* **Channel access mechanism**
	+ Type 1 and Type 2A/2B/2C: [4/Nokia, NSB]
* **Resource allocation granularity:**
	+ [9/ZTE, SC]: baseline: interleaving, optional: non interleaving
* **SCS and bandwidth:**
	+ [6/HW, HiSi]: 80MHz recommended
	+ [9/ZTE, SC]: 30KHz is assumed for 80MHz, Note that 15 kHz SCS is not supported for the channel bandwidth above 50MHz in NR-U.
	+ [35/E///]: A single 20 MHz unlicensed channel is baseline for evaluations in Rel-18
* **Performance evaluation on coexistence**
	+ Not required: [4/Nokia, NSB], [6/HW, HiSi]
* **Others (27/CableLabs)**

Table 1. Propagation Evaluation Parameters, sub 7GHz indoor

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Comments |
| Carrier Frequency | 6 GHz (mandatory), 6405-6425 MHz, 5 GHz is optional | Channel 6405-6425MHz is the upper EU 6GHz channel and bordering US/ISED U-NII 6 |
| Carrier Channel Bandwidth | 20MHz baseline, 80MHz optional | 6405-6425MHz |
| Number of carriers | 1 |  |
| Number of users per operator | 5 UEs associated with each gNB per 20MHz |  |
| SCS | 30kHz |  |
| Channel Model | NR InH Mixed Office model |  |
| BS/AP Tx Power | 23dBm (total across all TX antennas) |  |
| UE/STA Tx Power | 18dBm (total across all TX antennas) |  |
| BS/AP Antenna gain | 0dBi  |  |
| UE/STA Antenna gain | 0dBi |  |
| BS/AP Noise Figure | 5dB |  |
| UE/STA Receiver Noise Figure | 9dB |  |
| Minimum received power from serving cell for UE dropping | -82dBm |  |
| UE receiver | MMSE-IRC as the baseline receiver |  |
| BS/AP antenna Array configuration | (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1), dH = dV = 0.5 λ | TR38.901, section #7.3 |
| UE/STA antenna Array configuration | Baseline Tx/Rx: (M, N, P, Mg, Ng) = (1, 1, 2, 1, 1), dH = dV = 0.5 λ | TR38.901, section #7.3 |
| Traffic model | Table A.1.1, TR36.889 | Specific SL-U traffic needs could be discussed. |
| UE/STA to UE/STA link pathloss model | * Indoor Office (Table 7.2-2),
* InH-Office propagation model
 | TR38.901 |
| gNB to gNB link pathloss model | * Indoor Office (Table 7.2-2),
* InH-Office propagation model
 | TR38.901 |

Table 2. Propagation Evaluation Parameters, sub 7GHz outdoor

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Comments |
| Carrier Frequency | 6 GHz (mandatory), 6405-6425 MHz, 5 GHz is optional | Channel 6405-6425MHz is the upper EU 6GHz channel and bordering US/ISED U-NII 6 |
| Carrier Channel Bandwidth | 20MHz baseline , 80MHz optional | 6405-6425MHz |
| Number of carriers | 1 |  |
| Number of users per operator | 5 UEs associated with each gNB per 20MHz |  |
| SCS | 30kHz |  |
| Channel Model | NR UMi street canyon | TR38.901 |
| BS/AP Tx Power | 36dBm per beam | 6dB beam separation considered |
| UE/STA Tx Power | 23dBm (total across all TX antennas) |  |
| BS/AP Antenna gain | 0 dBi  |  |
| UE/STA Antenna gain | 0 dBi |  |
| BS/AP Noise Figure | 5dB |  |
| UE/STA Receiver Noise Figure | 9dB |  |
| Minimum received power from serving cell for UE dropping | -82dBm |  |
| UE receiver | MMSE-IRC as the baseline receiver |  |
| BS/AP antenna Array configuration | (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1), dH = dV = 0.5 λ | TR38.901 |
| UE/STA antenna Array configuration | (M, N, P, Mg, Ng) = (1, 1, 2, 1, 1), dH = dV = 0.5 λ | TR38.901 |
| Traffic model | Table A.1.1, TR36.889 | Specific SL-U traffic needs could be discussed. |
| UE/STA to UE/STA link pathloss model | UMi street canyon pathloss model | TR38.901 |
| gNB to gNB link pathloss model | UMi street canyon pathloss model | TR38.901 |

Table 3. SL-U/Wi-Fi Coexistence Parameters (sub 7GHz)

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Comments** |
| **Common Assumptions** |
| TDD DL/UL ratio | 50/50 |  |
| Primary LBT | Cat-4 LBT (exponential back-off) |  |
| MCOT duration | 6 ms |  |
| Max Modulation | QAM256 |  |
| CCA ED threshold | -72dBm | Channel BW=20MHz |
| CW{min, max} | DL{15,63} UL{15,1023} |  |
| Max number of air layers | 2 | MIMO rank |
| Slots/Subframe | 2 |  |
| **NR-U/SL-U assumptions** |
| DMRS | 1 symbol | Overhead |
| DRS | Enabled, 1ms |  |
| HARQ ACQ/CQI Feedback | 1 symbol per feedback |  |
| PDCCh | 1 symbol/slot |  |
| PDSCh Mapping | Type B |  |
| PUSCh Mapping | Type A |  |
| Scheduling | Proportional fair |  |
| gNB to UE COT sharing | Enabled |  |
| UE to UE COT sharing | N/A |  |
| **Wi-Fi** |
| RTS/CTS | Disabled |  |
| MPDU size | 1500 bytes |  |
| Wi-Fi guard interval  | Short |  |
| Frame Aggregation | A-MPDU |  |

## Channel access mechanisms

* **FBE-based semi-static channel access**
	+ Support: [4/Nokia, NSB], [6/HW, HiSi], [7/Spreadtrum], [5/LGE], [8/vivo], [15/Lenovo], [12/OPPO], [17/Intel], [21/Samsung], [22/ITL], [33/ASUSTeK], [23/CMCC], [17/Intel], [34/BOSCH], [25/JHU]
	+ FFS/de-prioritized: [16/NEC], [19/Transsion], [20/China Telecom], [35/E///] (limited applicable scenarios)
	+ Issues to be further studied:
		- How to set FFP (fixed frame period) and what is the granularity of configuration for FFP
* **Type 1 channel access procedure (long LBT)**
	+ Baseline channel access mechanism, mainly used for initiating a COT
	+ Applicable SL channels/signals:
		- PSCCH/PSSCH: [5/LGE], [9/ZTE, SC], [10/Sony], [12/OPPO], [16/NEC], [28/QC], [32/DCM], [35/E///]
		- PSFCH: [9/ZTE, SC], [10/Sony, 15/Lenovo, 28/QC, 30/Panasonic] ($p=1$), [16/NEC], [18/Xiaomi], [32/DCM]
		- S-SSB: [10/Sony], [16/NEC], [28/QC], [32/DCM], [4/Nokia, NSB, 10/Sony, 31/Apple] ($p=1$)
	+ [8/vivo]: When UE detects the gap between the end of LBT procedure and the start of the SL transmission resource, the UE apply a 25us deferred LBT before the SL transmission resource.
	+ [13/CATT, GH]:
		- Introduce a *channel occupancy extension* transmission after Type 1 LBT success and before the starting time of the selected transmission resource. The maximum duration of the channel occupancy extension needs to be further studied to avoid unfairness to other RAT access and insufficient resource usage.
		- A (pre-)configured maximum gap should be defined, and UE at least need to sense a sensing slot duration *Tsl* before transmission if the gap between the ending time of Type 1 channel access and the transmission is less than or equal to the maximum gap.
	+ [29/Sharp]: For the case of non-COT-sharing, channel access type and CPE length are determined in the same way in resource allocation Mode 1 and resource allocation Mode 2.
	+ [30/Panasonic]: When UE detects SCI in the slot with PSFCH, UE use Type 2 channel access. Either of longer PSSCH length or CP extension of PSFCH is used to align with Type 2 sensing duration. When UE doesn’t detect SCI in the slot with PSFCH, UE use Type 1 channel access procedure.
* **Type 2 channel access procedure (including 2A/2B/2C)**
	+ Mainly used in COT sharing
	+ Applicable SL channels/signals:
		- PSCCH/PSSCH: [5/LGE], [8/vivo], [9/ZTE, SC], [12/OPPO], [28/QC], [32/DCM]
		- PSFCH: [5/LGE], [8/vivo, 16/NEC, 22/ITL, 23/CMCC, 28/QC] (2A), [9/ZTE, SC, 32/DCM] (2A/2B/2C), [13/CATT, SC], [18/Xiaomi], [35/E///] (2A/2B)
		- S-SSB: [8/vivo, 10/Sony, 13/CATT, SC, 16/NEC, 18/Xiaomi, 21/Samsung, 22/ITL, 23/CMCC, 28/QC, 30/Panasonic, 31/Apple, 32/DCM, 35/E///] (2A), [9/ZTE, SC] (2A/2B)
* **Type 2A channel access procedure**
	+ Within a COT, when the transmission gap between the initiator and the responder UEs ≥ 25μs
		- [28/QC], [21/Samsung], [23/CMCC], [12/OPPO], [14/Fraunhofer], [31/Apple]
	+ For TX with 25 us time gap from the last TX in the same COT
		- [32/DCM]
* **Type 2B channel access procedure**
	+ Within a COT, when the transmission gap between the initiator and the responder UEs is 25 > gap > 16μs
		- [28/QC], [21/Samsung], [12/OPPO], [14/Fraunhofer]
	+ For TX with 16 us time gap from the last TX in the same COT
		- [32/DCM], [23/CMCC]
* **Type 2C channel access procedure**
	+ Within a COT, when the transmission gap between the initiator and the responder UEs is 16 ≥ gap
		- [28/QC], [21/Samsung], [23/CMCC], [12/OPPO], [14/Fraunhofer]
	+ For TX with up to 16 us time gap from the last TX in the same COT
		- [32/DCM]
* **Energy detection (ED) threshold setting**
	+ [9/ZTE, SC]: At least the default maximum energy detection threshold is supported.
	+ [5/LGE]: Energy detection threshold adaptation procedure for UL is considered as baseline.
	+ [17/Intel]: FFS whether any enhancements are needed to the ED threshold defined in TS37.213 to operate in band n102 for VLP (very lower power) operation.
	+ [19/Transsion]: The EDT determination method for NR-U/LAA uplink can be used as a starting point for the study of EDT determination method for sidelink unlicensed access system.
	+ [26/IDC]: Study dynamic Energy Detection threshold adjustment to meet SL-U latency/reliability requirements.
	+ Issues that should be further studied:
		- FFS: COT sharing ED threshold is (pre)configured or PC5-RRC configured
		- FFS: Energy detection threshold for S-SSB transmission
* **CW adjustment**
	+ CW size is reset to a minimum value (follows the same DL Type 1 LBT procedure) when an ACK is received (unicast, groupcast option 2): [5/LGE], [12/OPPO], [17/Intel]
	+ CW size remains the same when SL HARQ feedback disabled: [5/LGE], [12/OPPO], [17/Intel], [31/Apple]
		- Reference duration of UL channel access is reused by replacing PUSCH with PSSCH
	+ [5/LGE] CW adjustment for NACK-only / groupcast option 1 is based on either
		- Alt. 1: If the TX UE does not receive ACK from any RX UE, but receives NACK in response of groupcast PSSCH transmission(s), contention window size for every CAPC is set to the next allowable value.
		- Alt. 2: RX UEs transmit ACK in response of groupcast PSSCH upon decoding success. If the TX UE receives at least one ACK from the groupcast RX UE(s), contention window size for every CAPC is set to the minimum allowable value.
	+ [7/Spreadtrum] When sidelink HARQ feedback is enabled, contention window can be adjusted according to SL HARQ feedback. When sidelink HARQ feedback is disabled, the SL CBR can be considered for contention window adjustment.
	+ [9/ZTE, SC]
		- For unicast sidelink transmission with ACK/NACK enabled, it is suggested to reuse the CW adjustment mechanism in NR-U.
		- For PSCCH/PSSCH transmission with ACK/NACK disabled, further study on the adjustment mechanism of CW based on CBR.
		- For groupcast with type 1/2 HARQ feedback, the adjustment mechanism of CW window needs to be further studied considering a) DRX case for groupcast type 1 and b) part of member UEs feedback ACK while the left member UEs feedback NACK for groupcast type 2.
	+ [16/NEC]
		- in the case that PSFCH is configured, using sidelink A/N feedback for contention window adjustment in SL-U, more details FFS;
		- in the case that PSFCH is not configured, using sidelink CR/CBR for contention window adjustment, more details FFS;
	+ [21/Samsung]: Further study whether and how SL measurement can contribute to contention window size adjustment
	+ [31/Apple]: For unicast transmission and group cast transmission with ACK/NACK feedback, CW is updated per UE per access priority.
	+ [36/WILUS]
		- Similar to CWS adjustment in NR-U, CWS adjustment based on the HARQ-ACK feedback via PSFCH should be used for Type 1 channel access for PSSCH transmission if HARQ-ACK is available for unicast transmission with A/N as HARQ-ACK feedback depending on the HARQ-ACK indicator in 2nd SCI.
		- As CWS adjustment method for PSSCH(s) with one or more groupcast transmission with NACK only feedback
			* If no NACK feedbacks are received from the other SL UEs, CWS should be reset for the next PSSCH transmission,
			* Elseif, all NACK feedbacks are received from the other group of SL UEs, CWS should be increased to the higher allowed CWS value,
			* Else, one or more NACK feedbacks except all NACK feedbacks are received, CWS should be reset for the next PSSCH transmission since it can be considered that at least one of groups of SL UEs successfully received PSSCH with groupcast transmission.
* **CAPC**
	+ NR-U CAPC table for DL is used for SL-U: [3/FW] (initiator), [4/Nokia, NSB], [6/HW, HiSi] (during IUC), [19/Transsion], [28/QC], [35/E///]
		- Applications with anchor-node UE to consistently share longer duration COTs.
		- Acting as a supervising role in Mode 2 IUC
	+ NR-U CAPC table for UL is used for SL-U: [3/FW] (responder), [6/HW, HiSi] (baseline), [7/Spreadtrum], [8/vivo], [9/ZTE, SC], [16/NEC], [14/Fraunhofer], [15/Lenovo], [17/Intel], [18/xiaomi], [19/Transsion], [21/Samsung], [23/CMCC], [26/IDC], [29/Sharp], [31/Apple], [28/QC], [36/WILUS]
		- In ultra-dense networks, a wider range of CWs offers more chances to back off if collisions occur.
		- A larger CWmax allows more channel access opportunities if one fails.
		- Acting as a supervised role in Mode 1
		- Unified scheme to access the channel between UL and SL transmissions.
	+ [4/Nokia, NSB]: In case of simultaneous PSFCH transmissions mapped to the same PSFCH slot, if type 1 LBT is applied for transmitting PSFCH, the UEs should select the CAPC associated with the highest transmission priority among the monitored SCIs.
	+ [6/HW, HiSi]: Mapping between CAPC and sidelink PQI should be discussed in RAN2.
	+ [15/Lenovo]: Mapping every two consecutive L1 priorities to one channel access priority class is feasible.
	+ [17/Intel]: RAN1 should discuss how to relate the ProSe Per Packet Priorities (PPPP) defined in SL and the Channel access priority classes (CAPC), since the latest must be supported for compliance to regulatory requirements. Furthermore, RAN1 should send an LS to RAN2 for the identified issue.
	+ [24/MediaTek]: The CAPC in SL-U can be mapped from PQI with the following two options:
		- Option 1: Indirectly mapped from PQI with 5QI as an intermediary.
		- Option 2: Directly mapped from PQI with a new defined mapping relation between CAPC and PQI.
	+ [28/QC]: Multiple mapping functions between either L1 priority of QoS flows and CAPC can be adopted in SL-U. Only one mapping function is configured for a UE at any given time. The mapping function between L1 priority and CAPC can be determined with one alternative between: a) on a UE profile, or b) can be configured by the gNB.
	+ [32/DCM]: If treated as supervising device, DL CAPC table in 37.213 is reused. If treated as supervised device, UL CAPC table in 37.213 is reused.
		- CAPC of TXs including SL data TX is adjusted based on SL HARQ feedback.
		- CAPC is determined such that subsequent TXs are included in the same COT.
* **Inter-UE / mutual blocking**
	+ [17/Intel]: RAN1 should discuss whether to support sub-channelization and in case should study mechanisms to mitigate mutual blocking across frequency multiplexed transmissions. RAN1 should investigate mechanisms to mitigate interference across UEs transmitting in a TDM’ed manner, since different UEs could have overlapping pool of resources and can potentially start transmission at the same time. RAN1 should investigate the impact of the ON/OFF and OFF/ON transient period to the LBT procedure performed by a UE when transmission of a PFSCH may require LBT and a SL slot may contain a PSFCH transmission.
		- a UE may incur into SL synchronization errors (e.g., GNSS sync error or gNB synchronization error), which may be in the order of up to 3 us.
		- a gNB SL synchronization includes propagation delays that for macro cell deployments can be in the order of several us (e.g., 2 us or 4 us for gNB-UE distance of 600 m and 1200 m respectively).
		- a UE typically has an ON/OFF and OFF/ON transient period in the order of 10 us, but these transient periods may vary based on UE’s capability.
		- UEs’ transmissions are subject to different propagation delays.
	+ [32/DCM]: In SL-U, for two non-contiguous TXs of a single UE, there is a case where LBT duration for 2nd TX is overlapped with the 1st TX. Study the following potential solutions.
		- Option 1: LBT back-off count is pending during the 1st TX and restarted after that
		- Option 2: LBT back-off count is maintained without LBT sensing duration the 1st TX
		- Option 3: the UE assumes the LBT for the 2nd TX is failed
		- Option 4: resource allocation is performed such that the situation does not occur
	+ [32/DCM]: In SL-U, for two non-contiguous TXs of different UEs, there is a case where LBT duration for UE-B’s TX is overlapped with UE-A’s TX. Study the following potential solutions.
		- Option 1: When UE-B detects a busy LBT-sensing slot, UE-B continues LBT until completion timing of SL-TX decoding from the busy LBT-sensing slot.
			* If UE-A’s SL TX is detected, UE follows behaviour for two non-contiguous TXs of a single UEs; otherwise, UE-B assumes the LBT is failed
		- Option 2: UE-B assumes the LBT is failed
		- Option 3: resource allocation is performed such that the situation does not occur
	+ [35/E///]: Timing offsets are used for preventing inter-UE blocking of high-priority transmissions and transmissions on reserved resources.
* **Mode 1 operation**
	+ [3/FW]:
		- Cell wide configuration for shared spectrum SL-U operation is provided by gNB in dedicated SIB12-U, which is based on SIB12 design. SIB12-U may contain shared spectrum specific channel access configurations, for instance those required by the spectrum regulations. Mode 1 SL-U initiation procedures are based on Mode 1 NR-U initiation procedures.
		- SL-U UE supports UL reports, on Uu link, of channel occupancy and channel busy ratio for dedicated resource pools in shared spectrum that exclude other RAT persistent interference/transmissions.
		- Define or extend a DCI format 3\_x that supports SL-U Mode 1 of operation in shared spectrum. The new DCI includes, in addition to SL resources, specific configurations for SL-U shared spectrum operation such as channel access type, CP extension, etc.
	+ [19/Transsion]: L3 RSSI measurement and channel occupancy reporting from sidelink UE should be supported in sidelink unlicensed access system.
	+ [24/MediaTek]: The uncertainty of LBT operation may introduce additional time consumption for legacy Mode 1 resource allocation procedure and thus may invalidate the allocated resources. Study the impact on the timeline for Mode 1 resource allocation procedure due to the additional time for LBT operation.
	+ [17/Intel]: While a gNB may be able to send a scheduling DCI on the licensed carrier, it cannot either perform sensing or transmit on the SL unlicensed carrier(s).
	+ [28/QC]: Introduce an LBT failure report from mode 1 UE to the gNB so that the gNB can provide LBT-aware resource allocation for the mode 1 UE in the form of grants over DCI 3\_0. The LBT failure report can be sent to the gNB via: a) MAC-CE over PUSCH or b) PUCCH.
* **Mode 2 operation**
	+ [8/vivo]: SL UE deems channel busy only if the UE detects transmission other than SL occupying the channel (e.g., exceeding the energy detection threshold) during the LBT duration, i.e., the energy detection in LBT procedure does not take into account the SL transmissions.
	+ [24/MediaTek]:
		- The uncertainty of LBT operation may introduce additional time consumption for legacy Mode 2 resource allocation and thus may invalidate the selected resources and degrade the UPT performance of the system. Study the impact on the timeline for Mode 2 resource allocation procedure due to the additional time for LBT operation.
		- Occupying the channel at the end of the LBT procedure can improve the channel access efficiency and reduce collision ratio. The enhancements (e.g., partial slot transmission of PSSCH) should be considered between the end of LBT procedure and the start of SL transmission to retain the channel.
* **Others**
	+ [8/vivo]: UE implementation decides the start time of the LBT procedure and UE holds on the LBT procedure when detecting a busy channel.
	+ [9/ZTE, SC]
		- A UE cannot initiate a COT by using type 2B/2C.
		- From the perspective of the system, the gap between any two SL occasions can be (pre-)configured less than a symbol, e.g., as 16us or 25us.
		- In SL-U, it is not supported that only a part of the symbols in a slot is configured as sidelink symbols, i.e., 14 symbols in a slot as the default.
	+ [24/MediaTek]:
		- It is slim chance for FDM operation within 20MHz for out-of-COT operation considering the nature of 20MHz LBT sensing unit, and uncertainty length of LBT and potential CPE operation.
		- The operation of FDM within 20MHz for out-of-COT may significantly complicate the UE implementation and power consumption for the increased number of blind decoding for PSCCH in frequency domain.
		- The FDM operation within 20MHz for in-COT operation under the scheduling of the COT initiator can be more efficient compared to the SCI sensing based FDM.
		- Study whether/how to support FDM transmissions for in-COT operation considering the spec impact, UE complexity and performance.
	+ [19/Transsion]: Channel bandwidth for sidelink unlicensed access system can be {10, 20, 30, 40, 60, 80} MHz.

## UE-to-UE COT sharing

* **Applicable channels / operation / receiver / cast types**
	+ [3/FW], [23/CMCC]: In a SL-U COT sharing, the responder UEs that shares that COT may transmit unicast PSSCH only to the SL UE that initiated that COT.
	+ [4/Nokia, NSB], [6/HW, HiSi], [8/vivo], [9/ZTE, SC], [25/JHU]: Applies to all UEs within proximity of the COT sharing UE that received the COT.
		- For a SL-U device to take the role of responding device, then at least one of the required conditions is for the device being able to decode the COT sharing information.
		- Whether there are additional conditions for taking the role of responding device, such as: i) the message from the responding device during the COT should be fully addressed to COT initiator device, or, ii) it is sufficient that only part of the message during the COT is addressed to COT initiator device.
		- UE-UE COT sharing is not subject to CAPC or destination ID.
	+ [6/HW, HiSi]: A COT sharing indication is transmitted by the COT initiating UE to share the COT, and only the UE(s) granted by the COT sharing indication could use the shared COT. In SL-U, a COT can be shared to any SL channels/signals. COT indication includes the following contents as follows.
		- COT length: to indicate the length of initiated COT owned by the initiating UE;
		- COT structure information: to indicate specific time-frequency resources;
		- UE ID related information: for associated UE(s) to transmit within the shared COT.
	+ [7/Spreadtrum]: A minimum time gap between COT sharing indication and transmission of shared UE should be introduced.
	+ [11/Fujitsu] Proposal 2 For COT sharing, when UE-A has received a COT indicator from UE-B, the follows should be considered to determine whether UE-A can share the indicated COT.
		- The RSRP or distance between UE-A and UE-B.
		- The TX-RX relationship between UE-A and UE-B.
		- The cast type of UE-A and the cast type of UE-B.
	+ [12/OPPO]: When a RX UE is a target receiver (determined by the destination ID), then it is allowed to utilize a shared COT
	+ [12/OPPO], [18/Xiaomi], [26/IDC]: A RX/responding UE utilizes a shared COT for a transmission when the COT initiator UE is one of the target receivers of the transmission.
		- In unicast, a RX UE can use a shared COT from a TX UE only if the RX UE is performing a unicast transmission back to the TX UE (based on source ID).
		- In groupcast/broadcast, a RX UE can use a shared COT from a TX UE only if the RX UE is performing a transmission with the same groupcast/broadcast destination ID.
	+ [13/CATT, SC] The cast type should be considered for COT sharing operation:
		- For unicast, the COT sharing duration between the unicast pair can be determined as that in NR-U.
		- For groupcast or broadcast, the COT sharing ending time for all the COT sharing UEs is an absolute time, i.e., determined by the absolute duration from the starting occasion of COT sharing.
	+ [14/Fraunhofer]
		- TX UEs can initiate COT sharing with an RX UE when performing at least unicast transmissions.
		- UEs should maintain minimum time gap between transmissions to ensure COT continuity.
	+ [15/Lenovo]
		- A COT initiator should have the flexibility to transmit COT sharing indicator to a one-one or one to many UEs/destinations.
		- A COT recipient should have the flexibility to use the shared COT to transmit unicast, groupcast, broadcast data.
		- COT recipient could use the shared COT to make PSSCH, PSFCH transmissions to any UEs or destination ids with a restriction that at least one transmission is to be made to the UE or source-destination id that provided the COT sharing indicator.
		- RAN1 needs to study mechanism for COT recipient to select one COT sharing indicator/COT donor.
	+ [18/Xiaomi]:
		- From complexity point of view, it is simplest that Tx resource in the COT is allocated by initiated COT UE in the unicast scenario.
		- At least one of the following options can be supported to determine the initiated COT UE:
			* A mode2 UE which performs type1 LBT and accesses the channel successfully can be initiated COT UE
			* The initiated COT UE is determined by (pre)configuration
		- If the Tx resource of UE is allocated by initiated COT UE, there is no need to perform resource selection for UE.
	+ [23/CMCC]: Distance based COT sharing mechanism can be considered in SL-U.
		- If the distance between a pair of UEs is less than or equal to the threshold, COT sharing can be performed between them;
		- Otherwise, SL transmission can only be performed after successfully initializing a new COT.
	+ [24/MediaTek]: For COT sharing, it may be more efficient to utilize the shared COT in the style of scheduling (e.g., multiple UEs can be scheduled by the COT initiator to use a shared COT in the way of FDM).
	+ [26/IDC]:
		- Option 1 is the COT initiator UE to indicate which LBT type the Rx UE can use. This is used if the COT initiating UE is planning to use the COT in a later occasion.
		- Option 2 is the UE initiating a COT will stop transmitting and Rx UE decides which LBT type to use depending on the gap between the two transmissions. This can be used if the COT initiating UE has finished its all of its transmissions within the COT.
	+ [28/QC]: A responding UE can use COT sharing to perform transmissions where the initiating UE is one of the recipients, which includes:
		- a) The transmission is unicast data back to initiating UE,
		- b) The transmission is connection based groupcast that includes the initiating node in the group,
		- c) The transmission is connectionless groupcast that includes the initiating node as the receiver node,
		- d) The transmission is broadcast.
	+ [28/QC]: The eligible UE(s) for COT sharing can be determined based on either
		- a) being a destination of the COT initiator over the current COT
		- b) being a destination of the COT initiator of the transmission containing a COT sharing indication
	+ [30/Panasonic]
		- For both sidelink resource allocation Mode 1 and Mode2, SCI indicates possible remaining COT duration in each slot. When UE detects the SCI in N-1 slot and remaining COT duration >1, Type 2 channel access and CP extension are used for slot N within the COT for a COT sharing.
		- In sidelink resource allocation Mode 1, gNB indicates Type1 or Type 2 channel access, priority class(p) and remaining COT duration. When UE doesn’t detect SCI on slot N-1, even if UE indicated Type 2 channel access from gNB, UE use Type 1 channel access to initiate COT in slot N.
		- In sidelink resource allocation Mode 2, UE can reserve the resources with current resource allocation by SCI. When UE selects slot N for PSCCH/PSSCH transmission, UE prepares sensing for Type 1 channel access of slot N and decides the COT duration based on priority class(p). When UE detect a SCI on slot N-1 and remaining COT duration >1, UE use shared COT with Type 2 channel access. Otherwise, UE initiate a COT with Type 1 channel access.
	+ [31/Apple]
		- For unicast COT sharing, the SL-U COT can be shared with the unicast devices associated with the initiating device for PSSCH, PSCCH and PSFCH. User plane data with higher or equal CAPC can be transmitted within shared COT.
		- For groupcast COT sharing, the COT can be shared for PSFCH transmission with ACK/NACK or NACK only transmission.
		- For broadcast COT, no COT sharing is allowed.
	+ [36/WILUS] At least for the unicast/groupcast SL transmission with HARQ-ACK enabled, UE-to-UE COT sharing should be supported in Rel-18 to guarantee PSFCH transmission opportunity to a receiver UE.
		- The UE-to-UE COT sharing may be desirable to be applied from PSCCH/PSSCH transmission to the nearest PSFCH transmission after channel access with a minimum period for UE-to-UE COT sharing.
	+ COT sharing for PSFCH and S-SSB
		- [23/CMCC]: For PSFCH transmission, FFS whether a COT sharing target UE can only perform the transmission to the COT initiator UE in a COT.
		- [28/QC]: A UE can send PSFCH or S-SSB with COT sharing in a configured opportunity based on one of the following alternatives:
			* a) the UE is a destination of the initiator over the COT duration (needs to receive COT-SI), or
			* b) the UE is indicated sharing for the specific transmission opportunity via SCI or,
			* c) the opportunity falls within an ongoing COT (needs to receive COT-SI).
* **Non-applicable operations**
	+ COT forwarding/relaying: [5/LGE], [12/OPPO], [28/QC]
		- Only the COT initiator UE (after a successful Type 1 LBT) explicitly signals/shares the COT information to others. That is, a UE that receives a COT and performs a Type 2 LBT does not signals/shares COT information during transmission(s).
* **COT sharing information contents for dynamic channel access (LBE)**
	+ COT length (remaining): [6/HW, HiSi], [9/ZTE, SC], [13/CATT, SC], [14/Fraunhofer], [15/Lenovo], [30/Panasonic], [31/Apple]
	+ COT structure information (time and frequency resources): [6/HW, HiSi], [28/QC]
	+ UE ID: [6/HW, HiSi], [12/OPPO, 13/CATT, GH, 15/Lenovo] (source/destination ID/range of COT recipient/Zone ID)
	+ CAPC (priority): [13/CATT, GH], [17/Intel], [12/OPPO], [29/Sharp], [31/Apple]
	+ Sensed LBT sub-bands / RB sets: [13/CATT, GH], [12/OPPO]
	+ Initial Tx within the COT: [32/DCM]
	+ LBT type to be used: [14/Fraunhofer], [29/Sharp], [31/Apple]
	+ CP extension: [29/Sharp], [31/Apple] (CPE index)
	+ EDT: [31/Apple]
* **COT sharing information contents for semi-static channel access (FBE)**
	+ Fixed frame period (FFP): [17/Intel]
	+ Offset information: [17/Intel]
* **Container**
	+ SCI (1st or 2nd stage): [5/LGE] (2nd), [9/ZTE, SC], [12/OPPO] (2nd), [17/Intel], [18/Xiaomi], [28/QC], [31/Apple]
	+ MAC CE: [12/OPPO], [18/Xiaomi]
* **Semi-static COT sharing (in FBE)**
	+ [5/LGE]:
		- The absence of any other technology sharing the channel can be guaranteed on a long-term basis
		- The absence of certain link(s) sharing the channel can be guaranteed on a long-term basis
		- The absence of UE with SL Mode 2 resource (re)selection procedure sharing the channel can be guaranteed on a long-term basis
		- FFS how to set FFP (fixed frame period) and what is the granularity of configuration for FFP
* **Others**
	+ [8/vivo]: When a UE is intended to transmit S-SSB, it can directly transmit S-SSBs on subsequent SSB candidates after detecting a S-SSB from another UE with the same synchronization reference.
	+ [9/ZTE, SC]: A COT can be shared with all SL signals/channels including PSCCH/PSSCH, PSFCH, and S-SSB.
	+ [13/CATT, GH] The following conditions should be introduced under which UE can perform COT sharing:
		- UE has data to transmit.
		- The remaining COT is larger than a (pre-)configured threshold or the channel access priority value is larger than a (pre-)configured value.
* **Topics for further study**
	+ [28/QC]: Whether and how to resume transmissions on the COT initiator’s side over a COT that has been shared to another UE, subject to regulations.
	+ [34/BOSCH]: FFS possible switching gap durations between transmitting UEs sharing the initiated COT. And whether/how to support multiple switching times.

## Multi-channel access

* **NR-U DL Type A and Type B multi-channel access (independent Type 1 or 2 LBT in each channel)**
	+ Support: [6/HW, HiSi], [8/vivo], [9/ZTE, SC], [12/OPPO], [17/Intel], [29/Sharp] (mode 2), [21/Samsung], [25/JHU], [28/QC], [32/DCM], [35/E///]
* **NR-U channel access procedures for UL multi-channel transmission(s) (all-or-nothing access)**
	+ Support: [23/CMCC], [28/QC], [32/DCM], [29/Sharp] (mode 1), [30/Panasonic], [31/Apple]
* **NR-U semi-static based channel access procedures for transmission(s) on multiple channels**
	+ Support: [6/HW, HiSi], [17/Intel], [21/Samsung], [25/JHU]
* **Others**
	+ [9/ZTE, SC]: Multi-channel access mechanism is not support for PSFCH/S-SSB transmissions, i.e., independent channel access procedure is performed on each channel for multi-channel PSFCH/S-SSB transmissions.
* **Topics for further study**
	+ [4/Nokia, NSB]: RAN 1 to postpone selection on whether the downlink, uplink and/or semi-static multiple channel access procedure are supported until discussion on the definition of Resource Pool, sub-channel, interlace and their relation to RB sets have been concluded.
	+ [13/CATT, GH]: For multiple channel access procedure,
		- How to identify initial contention window counter Ninit
		- How to perform COT sharing
		- The impact of half duplex
	+ [28/QC]: Study simultaneous UL and SL transmissions over the unlicensed carrier, and multi-channel access mechanisms for simultaneous UL and SL transmissions.
	+ [34/BOSCH] For SL-U wideband operation, study at least the following details
		- The different LBT operation of the multiple channel access and its impact on/from sensing
		- SL-BWP/resource pool adaptation for expandable transmission based on multiple channel access
		- Whether SL-U multiple channel access is considered for semi-static operation and slot-aggregation specifically

## Short Control Signalling transmission (SCSt)

* **According to European regulation (ETSI EN 301 893), following limitations apply**
	+ within an observation period of 50ms, the number of Short Control Signalling Transmissions by the equipment shall be equal to or less than 50; and
	+ the total duration of the equipment's Short Control Signalling Transmissions shall be less than 2 500 µs within said observation period.
* **Support in principle:** [4/Nokia, NSB] (with/without Type 2A)
	+ PSFCH: [12/OPPO], [13/CATT, SC], [15/Lenovo], [28/QC] (within limitations of SCSt)
	+ S-SSB: [5/LGE], [12/OPPO], [15/Lenovo], [21/Samsung], [28/QC] (FFS), [17/Intel]
	+ For use cases / deployment where the presence of other technologies is not expected. E.g., when FBE channel access is used.
	+ Possible SL channel / signal to be considered: PSFCH, S-SSB, SL configured grants
* **Further study on whether to support SCSt for PSFCH and/or S-SSB:** [6/HW, HiSi], [9/ZTE, SC], [17/Intel]
* **Topics for further study**
	+ Channel access procedure for SCSt
		- Option 1: As long as these signals meet the minimum requirements to qualify as a short control signalling, they can be transmitted without LBT (following ETSI BRAN)
		- Option 2: As long as these signals meet the minimum requirements to qualify as a short control signalling, they can be transmitted using Type 2A LBT (following NR-U)

## CP extension (CPE)

* **Timing location of CPE is transmitted**
	+ CPE is transmitted in the GP/last symbol of a SL slot (before the AGC symbol of the next SL slot):
		- [25/Johns Hopkin U], [32/DCM]
	+ CPE is transmitted in the symbol before the AGC symbol for PSFCH:
		- [25/Johns Hopkin U],
* **Length of a CPE**
	+ [6/HW, HiSi]: To avoid inter-UE blocking of high priority transmission or facilitate FDM Tx:
		- When UE is transmitting using the whole RB set, the 7 access points (reused from NR-U) can be associated with priority, and the index of access point can be indicated by priority.
		- When a mode 1 UE is transmitting using a partial RB set, a configured CPE length is used (same as NR-U).
		- When a mode 2 UE is transmitting using a partial RB set, FFS.
		- For a shared COT, the CPE length is indicated in the COT sharing information in SCI.
	+ [7/Spreadtrum]: CPE index for PSFCH should be (pre)-configured per resource pool to support FDM transmissions of multiple PSFCHs.
	+ [18/Xiaomi]: FFS whether the length of CP extension can be greater than a symbol duration.
	+ [26/IDC]: At least re-use CPE to retain the channel for duration less than one symbol.
	+ [32/DCM]
		- Option 1: CPE duration is (pre-)configured per resource pool
		- Option 2: UE performs CPE to apply Type 2X LBT defined or (pre-)configured per resource pool
		- Option 3: UE performs CPE to apply Type 2X LBT indicated in some previous TX
* **Applicable scenarios**
	+ [4/Nokia, NSB]: CP extension is supported at least for PSFCH. Other SL-U channels and signals are FFS.
	+ [18/Xiaomi]:
		- CPE is used in the guard symbol between PSCCH/PSSCH and PSFCH from different UE in a COT duration.
		- CPE is used in the guard symbol at the end of the slot in a COT duration
		- CPE is used in the guard symbol between PSCCH/PSSCH and PSFCH in a slot if a UE transmits both
		- CPE is used in the guard symbol at the end of the slot if a UE transmit its in multi continuous slot
	+ [19/Transsion]:
		- CP extension should be applied at least before the first symbol of PSFCH transmission within a COT.
		- CP extension should be applied before the first symbol of a transmission to guarantee continuous transmission.
	+ [30/Panasonic]:
		- For sidelink resource allocation Mode 1 configured grant, NR-U behaviour of CP extension is baseline.
		- For sidelink resource allocation Mode 1 dynamic grant, gNB indicates Type of channel access (Type 1, Type 2A, Type 2B, Type 2C) and CP length for Type 2 is indicated. For Type 1 channel access, CP extension is not necessary.
		- For sidelink resource allocation Mode 2, for a resource pool, one of Type 2A, 2B or 2C is (pre-)configured and CP length is (pre-)configured.

## Resource allocation enhancements (mode 1 and mode 2) in SL-U

* **Common aspects / enhancements**
	+ [8/vivo]: The AGC overhead and PSCCH decoding complexity would increase, when introducing multiple starting symbols in a slot or mini-slot based transmission for SL transmission. SL transmission starting from an earlier starting symbol of a given slot would block the SL transmission starting from a later starting symbol in the same slot.
	+ [9/ZTE, SC]: It is suggested that more resources can be selected/allocated for a TB in SL-U and the same resources can be selected/allocated for multiple different UEs. (FFS: How to resolve the transmission conflict from different UEs on the same resource)
	+ [23/CMCC]: There is no need to do enhancement between the end of the LBT procedure and the start of the SL transmission to retain channel access.
	+ [24/MediaTek]: Study solutions (e.g., overbooking mechanism, protection margin for LBT) to combat the potential LBT failure in both Mode 1 and Mode 2 resource allocation.
	+ [29/Sharp]: Enhance the sensing and selection procedure for Mode 2 RA to support COT(s) as granularity in the time domain for SL-U.
	+ [31/Apple]
		- Type 1 channel access procedure can start any time after traffic arrival at the buffer. If type-1 CCA success before selected resource, the UE can freeze the counter and perform type-2 LBT right before selected resource for transmission.
		- Use the last 25us of the gap symbol in slot structure for type-2 CCA.
* **Multi-consecutive slots / Back-to-back / Burst transmission**
	+ Support (for same TB or different TBs): [3/FW], [7/Spreadtrum], [9/ZTE, SC], [13/CATT, GH], [8/vivo], [15/Lenovo], [16/NEC], [5/LGE], [18/Xiaomi], [20/China Telecom], [21/Samsung], [23/CMCC], [28/QC], [29/Sharp] (more than 3 slots), [33/ASUSTeK] (mode 1, 3 slots), [34/BOSCH], [35/E///]
		- COT retaining to avoid long gap (at slot level) between SL transmissions
		- Improve channel access efficiency by reducing number of channel accesses for transmitting a TB or multiple TBs
		- Enhancements to resource reservation to enable the overbooking of multiple consecutive slots
	+ Not support: [32/DCM]
	+ [3/FW]: eliminate the guard symbol between the slots by repeating the last symbol, since no channel sensing is necessary between the consecutive slots provided that the transmissions belong to the same COT.
	+ [5/LGE]: UE performs transmission(s) after a gap not greater than 16us within a SL transmission burst without sensing the corresponding channel(s) for availability.
		- CP extension or rate-matching can be used to ensure the time gap requirement between transmissions in a SL transmission burst.
		- Transmissions from a UE separated by a gap of more than 16μs are considered as separate SL transmission bursts.
	+ [9/ZTE, SC]:
		- In the frequency domain, multiple selected resources are in the same channel(s).
		- In order to avoid the interruption due to PSFCH symbols, it is suggested that occupying signals may be transmitted on a PSFCH occasion within the continuous sidelink slots.
	+ [15/Lenovo]: Multiple PSSCHs scheduled by a single SCI is supported for sidelink transmissions in FR1 unlicensed spectrum.
	+ [28/QC]:
		- Within the COT transmission, use CP extension (CPE) of the AGC symbol to fill into the gap symbol of the previous slot so that the one symbol transmission gap in between the slots becomes narrower.
		- In addition to CPE method, study how to rate match PSSCH into the gap symbol or/and AGC symbol.
		- For the gap before PSFCH, use CP extension to maintain the right length gap to match the channel access type or keep the COT.
		- The COT-initiating transmitter is allowed to send or trigger its receiver to send PSFCH-like padding signals on its own PSFCH resource at unused PSFCH symbols to hold the COT if it is neither expecting to receive A/N’s nor transmitting A/N’s.
	+ Issues that should be further studied:
		- FFS: Whether the destination of transmissions within a SL transmission burst can be different or not.
		- FFS: Whether TBs of transmissions within a SL transmission burst can be different or not.
		- FFS: Whether CAPC values of transmissions within a SL transmission burst can be different or not.
* **Mode 1 RA**
	+ Indication of LBT failure to gNB
		- Reporting HARQ-NACK: [5/LGE], [12/OPPO] (when SL-HARQ enabled), [28/QC] (additional bit in PUCCH for LBT failure)
		- Other means: [5/LGE], [12/OPPO] (when SL-HARQ disabled), [28/QC]
	+ [6/HW, HiSi]: For mode 1, a COT initiating UE can share a COT to other UEs according to DG/CG by gNB with procedures as follows
		- All UEs should report UE ID related information to gNB.
		- SL DG/CG resources and the UE ID related information needs be indicated by gNB.
		- COT sharing indication including UE ID related information should be indicated by the initiating UE to share the COT.
	+ [8/vivo]: For mode-1 UE,
		- it should be clarified if LBT type as well as the priority class is decided by gNB or up to UE implementation.
		- gNB schedules a set of resource to a group of UE, where the UE in the group can perform LBT for the scheduled resources and possibly COT sharing between UEs.
		- reporting of LBT result for the scheduled grant is supported.
	+ [14/Fraunhofer]: In Mode 1, the gNB can provide resource grants to the UE after checking for the resource availability by using reports by other Mode 1 UEs indicating the resource usage, or by performing some basic energy measurements.
	+ [16/NEC]
		- No assistant information related to the scheduling in the unlicensed spectrum needs to be exchanged between UE and gNB.
		- In the case that both licensed and unlicensed spectrum resources are configured for sidelink mode 1, it needs to be considered how to identify DCI for sidelink scheduling in the licensed spectrum or the unlicensed spectrum.
	+ [23/CMCC]: For mode 1, enhancements on both DG and CG can be considered to allocate consecutive time domain resources, the design of DCI format 0\_1 and CG configuration in NR-U can be a reference.
	+ [26/IDC]:
		- Support configuring Mode 1 UE with time window and set of frequency resources to initiate a COT in SL-U to reduce the impact of LBT failure.
		- Study reporting of the channel access outcome to the gNB in mode 1 SL U.
	+ [32/DCM]:
		- gNB does not configure/indicate LBT type and CAPC for SL TXs
		- UE detects information relevant to UE-to-UE COT sharing; i.e., UE performs sensing/RX even within SL DRX inactive time
		- UE reports NACK when, due to LBT failure, the UE does not transmit a PSSCH in any of the resources provided by DG or, for a CG, in any of the resources provided in a single period and for which the UE is provided a PUCCH resource to report HARQ-ACK
	+ Topics for further study
		- [28/QC]: Study how to report LBT failure for multi-consecutive slots Tx in mode 1
* **Mode 2 RA**
	+ [3/FW]: Define mechanisms to mitigate the impact of other RAT transmissions in resource pool selection, and IUC procedures.
	+ [4/Nokia, NSB]: RAN1 should investigate the interaction of channel access procedure with resource allocation mode 1 and 2 in order to avoid resource allocation which may cause LBT failures, e.g.:
		1. before a reserved resource in case the transmitting symbols of candidate resource overlap with LBT of the reserved resource;
		2. after a reserved resource in case the transmitting symbols of the reserved resource overlap with LBT of candidate resource.
	+ [5/LGE] (start Type 1 LBT and trigger resource selection at the same time after TB arrival):
		- UE knows the CAPC or the necessity of channel access after the UE triggers SL resource (re)selection procedure. And the UE attempts to access the channel according to Type 1 SL channel access procedure after the resource (re)selection procedure is triggered at the UE side.
		- Considering that the channel sensing duration can be larger than *Tproc,1*, if the first available time location of SL resource is close to the start of the resource selection window, the UE may not have enough time to complete the Type 1 LBT. In this case, down-select one or more of the followings:
			* Option 1: Drop the SL transmission and attempt to access the channel for the next transmission on the reserved resources.
			* Option 2: Reselect the resources for the SL transmission
			* Option 3: First available time location of SL resource is determined to ensure the channel sensing duration
		- In case of SL HARQ reporting is enabled, UE selects retransmission resources so that the time gap between any two resources covers channel sensing duration.
		- Once UE detects reserved resources of another UE and determines to exclude these resources from the candidate resource set, the UE also needs to exclude the channel sensing interval for the reserved resources to avoid inter-UE blocking.
		- When UE performs SL resource (re)selection, if there is COT duration available for the UE, the UE should first select resources inside the COT duration as much as possible. If the COT is not available for the UE to transmit SL, the UE should select resource outside the COT to avoid Type 1 LBT failure.
		- For the case when a resource pool consists of more than one RB sets,
			* for a given number of sub-channels, smaller number of RB set(s) are prioritized for PSSCH transmission resources.
			* before selecting transmission resources, UE first selects RB set(s) for PSSCH transmission.
	+ [6/HW, HiSi]:
		- Timing of performing LBT and resource selection, as well as timing relationship between them is up to UE implementation with the following restrictions:
			* Selected resources can only be used if LBT is successful
			* Resources reselection is required if LBT fails
		- For mode 2, sensing-based resource selection should take into account whether selected resources will block channel access of other UEs for PSSCH transmission with higher priority.
		- For Mode 2 sensing and resource exclusion procedure within a COT initiated by a UE,
			* The UE can use candidate resources reserved by other UE of which transmission priority is lower than that of its own transmission.
			* The UE cannot use the candidate resources reserved by other UE of which transmission priority is higher than that of its own transmission.
		- For mode 2, sensing-based resource selection should consider whether selected resources will be blocked by Type 1 channel access for its PSSCH transmission.
		- Within a COT, consecutive slots should be selected by an initiating UE and shared UEs if any.
	+ [8/vivo]:
		- Mode 2 resource selection should be enhanced to guarantee sufficient LBT duration before the SL transmission resource(s).
		- Transmission resource should be selected as early as possible to approach the end of the LBT procedure.
	+ [13/CATT, GH] UE should perform resource selection procedure to determine the corresponding PSCCH/PSSCH transmission resources and then perform LBT procedure, the reasons are provided as following:
		- Firstly, LBT should be carried out at identified resource(s). Otherwise, UE need to perform LBT for all LBT sub-bands, which will cause higher workload for channel access operation especially when multiple LBT sub-bands are configured, such as 100MHz bandwidth.
		- Secondly, the sensing processing time (Tproc,0) and Tx processing time (Tproc,1) should also be considered. If UE starts to perform resource selection after the successful LBT procedure, then perform resource selection, due to the duration of sensing and Tx processing time, other RAT can access and occupy the channel during the duration. The previous LBT success will be useless.
	+ [13/CATT, GH] (enhancement)
		- Considering that the unavailable resources caused by Type 1 channel access and *additional selected candidate resources* which are not really used will not indicated in SCI, so it will not affect the sensing and resource exclusion operations for other UEs.
		- The received COT can be used to identify resource selection window or be treated as the restrictions for resource selection. UE will choose resources within the received remaining COT so that this UE only need to perform Type 2 channel access. [11/Fujitsu]
	+ [14/ Fraunhofer]: UEs can select more resources for redundancy in the case of LBT failures.
	+ [16/NEC] Considering the potential improvement of mode 2 procedure to make it more appropriate for SL-U, the following factors may be considered:
		- uncertainty of the reserved resources indicated in SCI of UEs;
		- RSRP threshold used in excluding resources;
		- COT information;
	+ [21/Samsung]:
		- Support resource allocation based on performing channel access procedure first, and then determining actual transmission resources by performing mode-2 resource determination procedure.
		- To compensate throughput and latency performance degradation in the existing resource allocation mechanism due to frequent LBT failure,
			* One solution is multiple transmission occasions for a given (re-)transmission. UE could try to pass LBT procedure in each occasion, and after LBT procedure passed, the remaining occasions can be released or used for next (re-)transmission. Correspondingly, UE needs to determine multiple resources during sensing and selection procedure. Drawback is the overbooking issue.
			* Another solution is a new trigger of LBT failure for legacy resource allocation procedure.
			* One more solution for UEs with multiple SL transmissions using different HARQ process or HARQ disabled, is to select consecutive TX resources during resource selection procedure. UE can send signals on the guard and/or AGC symbols to eliminate transmission gap and maintain channel contiguously being occupied (see accompany contribution [3] for details), then LBT procedure only happens at the beginning of first transmission.
	+ [23/CMCC]:
		- For contiguous RB-based transmissions, mode 2 resource exclusion procedure should be enhanced with the consideration of multiple channel access and intra-cell guard band.
		- For interlace RB-based transmissions, RAN1 should further discuss the variable resource granularity issue for mode 2.
		- RAN1 should further study whether unified/separate resource selection mechanism should be deployed for in-COT and out-of-COT case.
			* Option 1: In-COT and out-of-COT case use a unified resource selection mechanism, such as the legacy mode 2 resource selection procedure defined in Rel-16;
			* Option 2: Separate mechanism should be designed for in-COT case, e.g., a COT initiator UE can allocate the resources in the remaining slots of a COT to the COT sharing target UE.
	+ [25/JHU]: Support enhancing sidelink mode 2 resource selection procedure to account for LBT blocks. Study supporting the following in the enhanced version
		- Resources that are already reserved during and after LBT blocks
		- Starting UE transmissions after an LBT block
		- Sensing and selection window sizes
		- New TB arrivals during LBT blocks
		- Absence of sidelink reservations in some time slots
	+ [26/IDC]:
		- UE excludes time window(s) corresponding to COT(s) initiated by other SL UEs.
		- Study reservation of a periodic time window for periodic type of traffic in SL unlicensed spectrum.
	+ [28/QC]:
		- Enhancements to TDM operation
			* A UE can select and reserve a set of subchannels for a duration of N2 slots in time where N2>N1 with N1 being the number of TBs to be transmitted.
			* Alternative to the random selection of resources within the selection window, a UE can select a set of resources based on implementation.
			* Introduce UEs starting transmissions in one of a set of contention slots with granularity 9μs around the slot (or mini-slot if supported) boundary. The UE can start transmission with CPE, if the contention slot is located before the boundary, or with AGC symbol puncturing, if the contention slot is located after the boundary.
			* Introduce the additional dimension of contention slot in resource selection and reservation. The contention slot can be selected according to one of the following policies: a) at random, b) L1 priority, c) CAPC, d) according to the transmitted channel/signal, d) a combinations of the aforementioned options.
			* Soft exclusion:
				+ Introduce the “soft exclusion” step in resource selection, with associated report from the PHY to the MAC containing the set of excluded resources alongside a supporting information for each exclusion. The excluded resources can still be selected in MAC.
				+ Candidates for the supporting information related to the observed reservations are: a) L1 priority, b) CAPC, c) contention slot index of the reservation that triggered the soft exclusion.
				+ Introduce a modified resource selection and reservation step, where the MAC can use the soft-exclusion report to still select and reserve any of the candidate resources, with the constraint that excluded resources can be selected only with a later contention slot.
			* Resource pre-emption
				+ Introduce contention slot selection adjustment (select a later contention slot) in last-minute evaluation to respect the late-coming reservation for the same TX starting point, in case it has higher-priority, and still potentially transmit if the transmission associated with the reservation is not performed.
				+ Introduce Triggering resource re-selection in the last minute evaluation step if a higher-priority reservation is detected with TX start time within a within a pre-emption window of size T from the target TX start point the own transmission.
				+ Introduce an exclusion region in the resource selection step so that a UE1’s MAC can exclude slots from selection before the active higher-priority reservation with overlapping LBT BW.
				+ Introduce UE1 stopping transmissions T slots before the transmission time and for the whole transmission time indicated in a higher priority-reservation sent from UE2.
				+ Introduce UE1 indicating COT sharing to UE2, based on UE2 being a destination in UE1’s COT, and a transmission time indicated by a reservation from UE2. UE2 can determine if the channel access with COT sharing can be used, based on UE1 being the destination for UE2’s transmission.
				+ Introduce a destination indication in SCI-1 reservation to facilitate COT sharing towards the reserving UE.
		- Enhancements to FDM operation
			* Introduce a resource selection enhancement for which a UE1 can select the same slot and contention slot as a transmission starting point of an acquired reservation from another UE2. The exclusion rule for subchannels in the frequency domain will eliminate the candidate frequency resources that partially overlap with those from the reservation of UE2.
			* Introduce a SCI reservation enhanced signalling where UE1 can signal TDRA/FDRA for COT reservation, and LBT parameters including a) LBT start time, b) maximum LBT end time, c) backoff counter value, d) defer duration, in order to synchronize the channel access and transmission starting point and achieve FDM operation across UEs. A zone parameter can be considered to restrict the UEs that can attempt FDM with synchronized LBT.
	+ [31/Apple]:
		- Further discussion whether reservation signal can be sent independently for aperiodic traffic.
		- Other UE can continue perform CCA sensing on reserved resources.
	+ [32/DCM]:
		- Study the following options to avoid a case where LBT-sensing starting timing for a selected resource is earlier than the resource selection timing.
			* Option 1: LBT duration is determined firstly and then selection window is determined based on the LBT duration
			* Option 2: LBT duration is determined firstly and then resources corresponding to the LBT duration are excluded from *SA*
			* Option 3: resource is selected firstly and then LBT duration is determined based on timing of the selected resource
		- In resource selection from the identified resource set S\_A, resource(s) is preferentially selected such that the selected resource is contiguous with a resource already selected by the UE, if possible.
	+ [35/E///]: To comply with CCA regulations of unlicensed spectrum and be able to reuse most of mode-2 based resource allocation procedure for SL, we believe that LBT is to be seen as a procedure that is applied on top. For example, CCA/LBT is performed before a transmission on the resources selected based on mode-2 SL resource allocation. Enhancement in mode 2 can include:
		- SL-U Mode 2 supports opportunistic transmission (i.e., early transmission) based on LBT success.
			* Step 1: A UE performs sensing and resource selection based on the resource selection procedures specified in SL Rel-16 (or Rel-17), to select resources for an initial transmission and possibly for some retransmissions of a TB.
			* Step 2: The UE starts performing CCA/LBT as soon as the packet arrives at the buffer and in addition also selects the first available resource (from the set of available resources) when the channel is found to be available by LBT procedure. We call this as opportunistic transmission. In case the channel is not found to be available by LBT procedure before the initially selected resource, the UE waits to transmit on the initially selected resource.
		- To reduce the spread of different transmissions over time, we propose to adopt ‘frequency-first’ selection instead of random selection during resource selection procedure (step 1 above).
		- LBT failure before the selected resource triggers resource re-selection.
		- RAN1 specifies enhancements to resource selection for wideband mode such that the selected resources are confined within a single channel unless TB size demands otherwise.

## Others

* [3/FW]: Modify the definitions of CBR and CR metrics for SL unlicensed access by considering the transmissions from other RATs.
* [4/Nokia, NSB]: Study and specify changes to SL-U procedures to mitigate the impact of uncertainty due to LBT in accessing the channel considering at least HARQ, S-SS/PSBCH transmission, semi-persistent PSCCH/PSSCH, etc, if necessary.
* [13/CATT, GH]: Only HARQ ACK/NACK-based feedback can be supported, i.e., NACK-based feedback is not supported in SL-U.
* [15/Lenovo]
	+ RAN1 to study the benefit of introducing the one-shot HARQ feedback, non-numerical HARQ feedback timing indicator features for sidelink unlicensed operation
	+ RAN1 to study the benefit of delaying the generation and transmission of SL HARQ feedback using non-numerical HARQ feedback timing value for an unlicensed spectrum
	+ RAN1 could further study the PSFCH enhancement to mitigate problems arising due to delayed sidelink HARQ feedback reception for an unlicensed spectrum
* [17/Intel], [24/MediaTek]: Study support of very low power (VLP) operation for SL-U.
* [24/MediaTek] (VLP):
	+ LBT is necessary to stabilize system interference especially for non-coordinated SL-U deployment with higher max transmission power (18dBm, non-VLP).
	+ Compared with higher SL-U max transmission power (18dBm, non-VLP), the UPT of NR-U can be improved for the case with lower SL-U max transmission power (5dBm, VLP) in coexistence scenario.
	+ Compared to higher SL-U max transmission power (18dBm, non-VLP), the UPT performance of SL-U can be improved for the case of lower SL-U max transmission power (5dBm, VLP) together with no LBT operation in the coexistence scenario.
	+ Compared with SL-U with higher max transmission power (18dBm, non-VLP), the SL-U with lower max transmission power (5dBm, VLP) can better support XR traffic with an increased UE satisfaction rate and system capacity.
	+ Compared with SL-U with 1 SCI decoding number, 2 SCI decoding number can improve the UE satisfaction rate and system capacity especially for larger SL-U pair number.
* [35/E///]
	+ RAN1/RAN2 to study mechanisms to avoid frequent/incorrect RLF due to LBT failures
	+ Discussions on congestion control for SL operation in unlicensed spectrum are down-prioritized in Rel-18

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Appendix (outcomes of past meetings)

## RAN1#109-e (09 – 20 May 2022)

**Agreement**

Type 1 and Type 2 (2A/2B/2C) channel access procedures, transmission gap and LBT sensing idle time requirements specified in TS37.213 for NR-U are taken as baseline for NR sidelink operation in a shared channel.

* FFS conditions for the actual channel access type(s) used for each SL channel and signal transmitted, and based on COT sharing conditions (if supported)
* FFS whether UL CAPC or DL CAPC or both should be used as the baseline,
	+ FFS how the channel access priority classes apply to each SL channel and signal
	+ FFS sidelink priority levels (PQI or L1 priority), channel and signal mapping to the 4 channel access priority classes. The discussion may involve other WGs.

**Agreement**

* UE-to-UE COT sharing is supported in NR sidelink operation in a shared channel (SL-U).
	+ FFS applicable SL channels and signals (e.g., PSCCH/PSSCH, PSFCH, S-SSB) for shared COT access and any restrictions (e.g. whether the COT can be shared with a single UE or multiple UEs)
	+ FFS all other details in compliance with the regulatory requirements
* CP extension (CPE) is supported for NR sidelink operation in a shared channel.
	+ FFS all remaining details including applicable scenarios, usage, PHY structure, etc.

**Agreement**

Channel access procedures for transmission(s) on multiple channels are supported for NR sidelink operation as defined by TS37.213 for NR-U (wherever applicable)

* FFS whether the downlink, uplink and/or semi-static multiple channel access procedure(s) (if supported) from NR-U should be used as a baseline and whether/how they are applied in SL mode 1 and mode 2 operation

**Agreement**

* The existing sidelink mode 1 RA including dynamic grant, Type 1 and Type 2 configured grants are supported as a baseline for sidelink operation in a shared carrier, subject to applicable regional regulations. At least in dynamic channel access, SL UE performs Type 1 or one of the Type 2 LBTs before SLtransmission using the allocated resource(s), in compliance with transmission gap and LBT sensing idle time requirements specified in TS37.213.
	+ FFS whether/how mode 1 resource allocation ~~selection~~ procedure needs to be updated / enhanced due to shared spectrum channel access
* The existing sidelink mode 2 RA schemes are supported as a baseline for sidelink operation in a shared carrier, subject to applicable regional regulations. At least in dynamic channel access, SL UE performs Type 1 or one of the Type 2 LBTs before SL transmission using the selected and/or reserved resources, in compliance with transmission gap and LBT sensing idle time requirements specified in TS37.213.
	+ FFS whether/how mode 2 resource selection procedure needs to be updated / enhanced due to shared spectrum channel access
* FFS whether/how multi-consecutive slots transmission can be supported for NR sidelink operation in unlicensed spectrum, including the following aspects
	+ channel access, resource allocation and PHY channel design
* FFS whether/how enhancement is needed between the end of the LBT procedure and the start of the SL transmission to retain channel access
* RAN1 to strive for a common solution for channel access for Mode 1 and Mode 2