**3GPP TSG RAN WG2 Meeting #121b-e R2-230xxxx
E-Conference, 17th – 26th April 2023**

**Agenda item: 7.15.6**

**Source: Apple**

**Title: Summary report of [AT121bis-e][507] Applicability of carrier mapping from V2X layer to UC (Apple)**

**WID/SID: NR\_SL\_enh2 – Release 18**

**Document for: Discussion and Decision**

# 1 Introduction

This is discussion document for below offline discussion:

* [AT121bis-e][507][V2X/SL] Applicability of carrier mapping from V2X layer to UC (Apple)

**Scope:** Identify WF for whether carrier mapping provided by V2X layer is applicable to UC transmission (P1, 3379), will not touch upon backwards compatibility issue, and no discussion on PC5-RRC content design.

 **Intended outcome:** Discussion summary in R2-2304232.

**Deadline:** Comeback at 4/25 CB session

Because Rapporteur need time to prepare summary proposal, please provide your input by 4/24 14:00 UTC.

# 2 Discussion

In LTE SL, only broadcast and groupcast are supported. To support LTE SL CA, the UE is configured by V2X layer with the carrier(s) which are allowed for a specific service based on the L2 destination ID (i.e. service to frequency mapping), as highlighted in below copy of CT1 spec TS 23.386 [1] and TS 36.300 [2].

**From section 6.1.2.1 of TS 23.386 [1]:**

Upon a request from upper layers to send a V2X message of a V2X service identified by a V2X service identifier using V2X communication over PC5, if the UE is configured with V2X service identifier to V2X frequency mapping rules for V2X communication over PC5 as specified in subclause 5.2.4 and there is one or more V2X frequencies associated with the V2X service identifier of the V2X service for the V2X message in the current the geographical area, pass the one or more V2X frequencies associated with the V2X service identifier of the V2X service for the V2X message to the lower layers. Then, the UE shall proceed as follows:

**From section 23.14.1.1 of TS 36.300:**

If the UE supports multiple transmission chains, it may simultaneously transmit on multiple carriers via PC5. For the case where multiple frequencies for V2X are supported, a mapping between V2X service types and V2X frequencies is configured by upper layers. The UE should ensure a V2X service to be transmitted on the corresponding frequency. For scheduled resource allocation, the eNB can schedule a V2X transmission on a frequency based on the Sidelink BSR, as specified in TS 36.321 [13], in which the UE includes the Destination Index uniquely associated with a frequency reported by the UE to the eNB in Sidelink UE Information message as specified in TS 36.331 [16].

Observation 1: In LTE SL CA, a mapping between V2X service identifier and V2X frequencies is configured by upper layers. The UE should ensure the V2X service to be transmitted only on the corresponding frequencies.

For NR SL unicast transmission, Rapporteur observed that latest CT1 spec TS 24.587 [3] has captured the same mapping as LTE SL CA:

**From section 6.1.2.12 of TS 24.587 V18.0.0 (2022-12):**

**6.1.2** **Unicast mode communication over NR based PC5**

**6.1.2.12 PC5 QoS flow establishment over PC5 unicast link**

The UE shall also pass the one or more V2X frequencies associated with the V2X service identifier and the communication mode which is set to unicast mode for the V2X service identifier to the lower layers, if:

a) the UE is configured with V2X service identifier to V2X frequency mapping rules for V2X communication over PC5 as specified in clause 5.2.3; and

b) there is one or more V2X frequencies associated with the V2X service identifier in the current geographical area.

However, Rapporteur identified two issues:

***# Issue 1: Unclear mapping between L2 ID of unicast link and frequencies***

And as specified in Figure 5.3.1.31 of TS 24.588 [4] , (which is based on SA2 TS 23.287 [6] clause 5.1.2. For clarity, we just cite Stage-3 specification here):

* The highlighted part shows that V2X layer is provisioned with a mapping of service identifier and frequencies.
* The highlighted part shows that V2X layer is provisioned with a mapping of service identifier and L2 address used for broadcast and groupcast.
* The highlighted part shows that V2X layer is provisioned with a mapping of service identifier and L2 address used for unicast initial signaling.

For NR SL GC/BC, similar to LTE V2X , both the service identifier to frequencies mapping and service identifier to L2 address mapping are available at UE’s V2X layer, so we can confidently conclude that the SL frequencies associated with a certain GC/BC L2 destination address can be safely provided by V2X layer to the AS layer even without exposing the V2X service identifier(s) to the lower layers.

However, for Sidelink unicast, the L2 address used for unicast initial signaling is only used in DCR and will be replaced by a self-chosen Layer 2 Src ID in PC5-S link establishment procedure. Then the mapping with L2 address used for unicast initial signaling is only helpful for determining the frequencies used to send the initial PC5-S signaling (i.e., DCR). So, the V2X UE will end up with no clear mapping of a Layer 2 unicast address associated with a PC5 Link and the corresponding frequencies.

Issue 1: According to TS 24.588, V2X layer is only provisioned with a mapping between service identifier and initial L2 address used for unicast. But the initial L2 ID will only used in DCR and be replaced by a self-chosen Layer 2 ID in PC5-S link establishment procedure. So, the V2X UE will end up with no clear mapping of L2 unicast destination address and frequencies.

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| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |  |
| Length of V2X communication over PC5 in NR-PC5 contents | octet o5+1octet o5+2 |
| DDL2IBI | VSINFMRI | PDBGI | 0Spare | 0Spare | 0Spare | 0Spare | 0Spare | octet o5+3 |
| V2X service identifier to V2X NR frequency mapping rules | octet (o5+4)\*octet o45\* |
| V2X service identifier to destination layer-2 ID for broadcast mapping rules | octet o108(see NOTE)octet o46 |
| V2X service identifier to destination layer-2 ID for groupcast mapping rules | octet o46+1octet o47 |
| V2X service identifier to destination layer-2 ID for unicast initial signalling mapping rules | octet o47+1octet o48 |
| V2X service identifier to PC5 QoS parameters mapping rules | octet o48+1octet o49 |
| AS configuration | octet o49+1octet o50 |
| Default destination layer-2 ID for broadcast | octet (o50+1)\*octet (o50+3)\*  |
| NR-PC5 unicast security policies | octet o93 (see NOTE)octet o84 |
| V2X service identifier to default mode of communication mapping rules | octet (o84+1)octet o85 |
| PC5 DRX configuration for broadcast, groupcast and unicast initial signalling | octet (o85+1)\*octet o123\* = octet l |

Figure 5.3.1.31: V2X communication over PC5 in NR-PC5

(from TS 24.588 [4])

***# Issue 2: How to handle that case that V2X services/PC5 QoS flows of the PC5 unicast link is modified***

In Clause 6.1.2.3 of TS 24.587 [3], it is specified that PC5 unicast allows UEs to add/modify/remove V2X services/PC5 QoS flows to the same L2 ID pair without any limitation. So, it seems no way to restrict the destination-to-carrier restriction or LCH-to-carrier restriction. Correspondingly, if the same principle of LTE SL CA is reused, it is not clear how the UE can ensure the V2X service to be transmitted only on the corresponding frequency when V2X services/PC5 QoS flows of the PC5 unicast are modified.

#### 6.1.2.3 PC5 unicast link modification procedure

##### 6.1.2.3.1 General

The purpose of the PC5 unicast link modification procedure is to modify the existing PC5 unicast link to:

a) add new PC5 QoS flow(s) to the existing PC5 unicast link;

b) modify existing PC5 QoS flow(s) for updating PC5 QoS parameters of the existing PC5 QoS flow(s);

c) modify existing PC5 QoS flow(s) for associating new V2X service(s) with the existing PC5 QoS flow(s);

d) modify existing PC5 QoS flow(s) for removing the associated V2X service(s) from the existing PC5 QoS flow(s); or

e) remove existing PC5 QoS flow(s) from the existing PC5 unicast link.

In this procedure, the UE sending the DIRECT LINK MODIFICATION REQUEST message is called the "initiating UE" and the other UE is called the "target UE".

Issue 2: According to TS 24.587, PC5 unicast allows UEs to add/modify/remove V2X services/PC5 QoS flows to the same L2 ID pair without any limitation. It is not clear how the UE can ensure the modified V2X services to be transmitted only on the corresponding frequency.

Rapporteur think both of those two issues related to service-to-frequencies mapping were never encountered during the Rel-15 LTE SL CA discussion in RAN2. They are definitely worth some discussion on whether/how those two issues will impact the NR SL CA design. So, we would like to first confirm whether company agree with issue 1 and issue 2.

**Q1: do you agree the below two issues on mapping between V2X identifier and frequencies for unicast?**

* Issue 1: According to TS 24.588, V2X layer is only provisioned with a mapping between service identifier and initial L2 address used for unicast. But the initial L2 ID will only be used in DCR and be replaced by a self-chosen Layer 2 ID in PC5-S link establishment procedure. So, the V2X UE will end up with no clear mapping of L2 unicast destination address and frequencies.
* Issue 2: According to TS 24.587, PC5 unicast allows UEs to add/modify/remove V2X services/PC5 QoS flows to the same L2 ID pair without any limitation. It is not clear how the UE can ensure the modified V2X services to be transmitted only on the corresponding frequencies.

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| **Company** | **Yes / No**  | **Detailed Comments if any** |
| OPPO | See comment | We tend to agree with the observation of the two issues. Yet the premise of the issues is we will apply the carrier mapping from V2X layer to unicast as well, for that, we are not quite sure yet, and maybe R2 can try to generate a view on that firstly.  |
| Ericsson | Yes | The rapporteur raised two issues are relevant. |
| NEC | See comment | For issue 1, the thing is the initial service to frequency mapping is indeed exist, in the following the UE just change the L2 ID (without service modification) so actually the service to frequency mapping is still applicable for the updated L2 IDTherefore, we should be focused on issue 2. |
| Xiaomi | Yes | Agree with the issues raised by rapporteur. Regarding comments from NEC, we think if the L2 ID is changed compared with initiating signaling, the associated service is changed since different L2 ID may be associated with different service, so even the service to frequency mapping can be reused, there seems no mapping of the service and the updated L2 ID? So the UE is still not able to derive the mapping of the unicast L2 ID and frequency? |
| ZTE | Disagree for first issue.Yes for second issue. | For the first issue, we think AS layer can associate the frequency to changed/self-assigned L2 ID. As shown in following, except the L2 ID, V2X layer will also self assign a link ID which will not change, and also pass the link ID to AS layer:

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| After receiving the DIRECT LINK ESTABLISHMENT ACCEPT message, the initiating UE shall provide the following information along with the layer-2 IDs to the lower layer, which enables the lower layer to handle the coming PC5 signalling or traffic data:a) the PC5 link identifier self-assigned for this PC5 unicast link;b) PQFI(s) and its corresponding PC5 QoS parameters; andc) an indication of activation of the PC5 unicast user plane security protection for the PC5 unicast link, if applicable. |

And after L2 ID updating, the new L2 ID will also be informed to AS layer along with link ID

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| Upon sending the DIRECT LINK IDENTIFIER UPDATE ACK message, the initiating UE shall update the associated PC5 unicast link context with the new identifiers and pass the new layer-2 IDs (i.e. initiating UE's new layer-2 ID for unicast communication and target UE's new layer-2 ID for unicast communication if changed) along with the PC5 link identifier down to the lower layer.  |

Therefore, the association between new L2 ID and old L2 ID is knows by AS layer by identifying the same link ID, then AS layer can identify the corresponding frequencies for old L2 ID and new L2 ID. |
| Intel | See comment | For the first issue, we think the comments from ZTE are valid in that even if the L2 ID is changed afterwards, the AS layer can still keep track of the initial L2 ID and the mapped frequencies for a given unicast link (i.e. by use of the link identifier).We agree that the second issue may be valid  |
| vivo | See comment | For Issue #1: The only ambiguity part is that whether the above information are available for unicast initial singnalling, which is used for PC5 unicast link establishment procedure. Our observations are as follows:As cited from section 6.1.2.12 of TS 24.587 above, it’s specified that when performing PC5 QoS flow establishment over PC5 unicast link ( which means the PC5 unicast link establishment procedure is completed), the following information is available within the V2X layer:1. V2X Service identifier (e.g. PSID or ITS-AID);
2. the source layer-2 ID and the destination layer-2 ID; and
3. one or more V2X frequencies associated with the V2X service identifier

Combine the above information, we think the mapping of the destination layer-2 ID and frequencies is determined at least for an established PC5 unicast link. As to the unicast initial singnalling transmission, the above bullet 2) can be addressed by the highlighted V2X service identifier to destination layer-2 ID for unicast initial signalling mapping rules, but for the above bullet 1) and 3) , there could be different ways to determine the frequencies by upper layers, for example:* Option 1: NO V2X service identifier to V2X NR frequency mapping rules for unicast initial signalling
* Option 2: introduce V2X service identifier to V2X NR frequency mapping rules that are dedicated for unicast initial signalling
* Option 3: rely on the unicast services that are to be established by the PC5 unicast link establishment procedure, combining with the existing V2X service identifier to V2X NR frequency mapping rules

However, We think it’s up to SA2 to make the final decision. So a LS to SA2 is preferred.For Issue #2:We don’t see any problem as described in above Issue #2. According to current TS 24.587, the V2X layer would always provide the up-to-date information to AS layer, e.g, when the destination L2-ID needs to be changed, the PC5 unicast link identifier update procedure is executed to make aligned understanding between TX and RX UEs, see clause 6.1.2.5 of TS 24.587. We assume similar mechanism can be reused when the the mapping of the destination layer-2 ID and frequencies needs to be changed. |
| Sharp | Yes | Agree with the two issues raised by rapp. |
| Qualcomm | Comment | Issue 1: yes, there is no direct mapping between the established unicast L2 destination ID (picked by the UE) and the carrier(s), but both UEs know the mapping for the service (e.g., initial DCR) and the UEs can keep using the mapped carrier(s). Otherwise Rel 16 & Rel 17 unicast would not work.Issue 2: for an established unicast, the L2 destination ID has no association with a service type, therefore changing the L2 destination ID doesn’t mean changing the service. The service stays the same (based on the initial DRC) and so do the carrier(s).The question here is really: if we allow UEs to select carrier(s) during the PC5 establishment procedure. In our view, UEs should be allowed to do so, e.g., based on UE’s capability, as long as the carriers are allowed for such service. |

Then, for issue 1, Rapporteur has no idea how RAN2 can resolve it without SA2 involvement. So, company is invited to show their opinions on how to resolve it.

Q2: For issue 1, do you think RAN2 can resolve it without SA2 involvement? If yes, please provide your solution

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| **Company** | **Yes / No**  | **Please provide your solution if you think RAN2 can resolve it without SA2 involvement** |
| OPPO | See comment | As replied to Q1, maybe firstly we can check whether the carrier mapping is applicable to unicast. |
| Ericsson | Yes and No | The carriers mapping rules (same as GC and/or BC) provided by upper layers (i.e., V2X layer) can give a set of carriers (e.g., set 1 of the carriers) to let a UE to further select carriers for a unicast link. The UE may conduct further selection of carriers for unicast (i.e., to determine set 2 of carriers) among the set of carriers (i.e., set 1 of carriers) based some unicast specific criteria. SA2 needs to be contacted to introduce changes for supporting carrier mapping (e.g., service to carrier mapping for DRBs) also for unicast. |
| NEC | Yes | As mentioned in Q1, UE just updated its L2 ID yet the service to frequency mapping is still exist, therefore, UE can still use that service to frequency mapping provision. |
| Xiaomi | No | We think SA2 needs to be involved if carrier mapping needs to be supported for unicast and the detailed mapping between services to frequency for unicast should be determined by SA2.  |
| ZTE | See comment | See comments in Q1. |
| Intel | See comment | As commented in the pervious question, we think we can use the link identifier to resolve this aspect. If needed, we can inform SA2 and check their view if they have some concern. |
| vivo | No | We assume this is within the remit of SA2. |
| Sharp | No | We think SA2 need to be involved for issue 1. |
| Qualcomm | No/Yes | NO: The mapping is there as least for initial DCR. We believe this mapping is also used after the PC5 connection establishment. Otherwise, Rel 16 and Rel 17 unicast cannot work without a known carrier, at least for OOC case. As long as UE selects the carriers allowed by a service in a region, it should be OK. YES: But it doesn’t hurt to double check with SA2. |

For issue 2. Rapporteur think there are basically two solutions:

* Solution 1: V2X layer dynamically provide an updated mapping between modified V2X service(s) and frequencies upon modification of V2X services/PC5 QoS flows of the unicast link
	+ Rapporteur think whether it is feasible needs SA2 confirmation.
* Solution 2: AS layer tracks V2X service(s) change, and can configure to use different frequencies from V2X layer (e.g. a subset of the frequencies configured by V2X layer) to match the modified V2X service(s)
	+ Note that solution 2 needs spec change on PC5-RRC to allow TX UE to configure frequencies to be used for the unicast transmission.
	+ Rapporteur is not sure whether SA2 allows it because it seems to imply that the UE's AS layer can ignore the service to frequency mapping provided by V2X layer.

Company is invited to share their view.

Q3: For issue 2, do you think how the UE can ensure the modified V2X services to be transmitted only on the corresponding frequencies?

* **Solution 1: V2X layer dynamically provide an updated mapping between modified V2X service(s) and frequencies upon modification of V2X services/PC5 QoS flows of the unicast link**
* **Solution 2: AS layer tracks V2X service(s) change, and can configure to use different frequencies from V2X layer (e.g. a subset of the frequencies configured by V2X layer) to match the modified V2X service(s)**
* **Solution 3: The initial provision of service to frequency mapping can still be used after UE’s add/remove/modify PC5 QoS flow/services (need to consult with SA2)**
* **Others (please provide solution)**

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| **Company** | **Preferred solution**  | **Detailed Comments if any** |
| OPPO | See comment | As replied to Q1, maybe firstly we can check whether the carrier mapping is applicable to unicast. |
| Ericsson | Solution 2 similar/like | We prefer a solution that AS layer can determine carriers without bothering upper layer too much.  |
| NEC | Solution 3 | For solution 1, it is totally SA2 scope of discussion, where it is quite strange that RAN2 to provide an SA2 solution and ask them to adoptFor solution 2, we still prefer an unified solution that the service to frequency mapping configuration for GC/BC/UC arre all coming from V2X layerThereforee, we provide solution 3 and hope to check it with SA2 first. |
| Xiaomi | See comments | We think it seems too early to discuss about the solutions for issue 2. At least if carrier mapping is supported for unicast, we need to inform SA2 of RAN2’s understanding on this issue and ask SA2 to provide the solutions. At least from our point of view, RAN2 cannot agree with either solution 1 or solution 2, both of them should be discussed/confirmed by SA2.  |
| ZTE | See comments | Agree with Xiaomi, we should check the SA2’s preference. For solution-2, we think it is inefficient and unpractical. For example,how does AS layer track the service removal? Does V2X layer pass the indication of removing service to AS layer? The service tracking(modify/add/remove) is done in V2X layer, we do not see the benefit to duplicate the work in AS layer. |
| Intel | See comment | We think this issue has significant SA2 dependence, specifically solution 1. We share Xiaomi’s view that we can inform them of RAN2’s understanding of this issue and ask if they have solutions in mind |
| vivo | Solution 1 | We are fine to confirm the understanding with SA2 by Solution 1. And solution 2 is not needed. But what is important in AS is whether the applicable carrier frequency(ies) are indicated per L2 ID by the upper layers — This is what RAN2 finally aims to get an answer for from SA2/CT1.  |
| Sharp | See comment | It is too early to discuss the solution for issue 2. We share the view with Xiaomi that SA2 needs to be involved. |
| Qualcomm | Comment | Too early to conclude a solution before all companies converge their views on the Issue 1 and Issue 2. |

Q4: Besides the 2 issues in Q2/3, do you see other issue / ambiguity to apply service to frequency mapping to unicast?

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| **Company** | **Detailed Comments if any** |
| OPPO | As replied to Q1, maybe firstly we can check whether the carrier mapping is applicable to unicast. |
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In R2-2303379 [5], another alternative is proposed that RAN2 only focus on broadcast/groupcast SL CA in Rel-18. The reasons provided by [4] are:

* RAN2 may not have sufficient time to thoroughly study NR SL unicast CA.
	+ Only 4 TU left in RAN2 (1TU for RAN2#122/123/123b/124).
	+ RAN2 may need some input from RAN1, but it is not clear when RAN1 can start SL CA.
	+ If RAN2 send LS to SA2 on questions related to applicability of carrier mapping of unicast, RAN2 schedule of SL CA study will be tough.
* Given limited remaining TU in Rel-18, it is expected that same design of LTE SL CA will be largely reused. It may put artificial restrictions on NR SL unicast CA, and Rel-19 may have to design backward combability solutions.

Rapporteur would like to collect company view.

**Q5: What is your view on RAN2 work in Rel-18 SL unicast CA**:

* **Alt-1: RAN2 only study broadcast/groupcast SL CA in Rel-18.**
* **Alt-2: RAN2 try to resolve the issues in Q2/3 for NR SL CA unicast without SA2 involvement.**
* **Alt-3: RAN2 first study broadcast/groupcast SL CA, meanwhile send LS to SA2 for their input on issues of Q2/3.**

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| **Company** | **Alt-1/Alt-2/Alt-3**  | **Detailed Comments if any** |
| OPPO | See comment | The current WID did not exclude unicast yet, so maybe leave the WI scoping discussion to plenary, yet focus more on the technical solution in WG level? So Alt1 is not perferred.Our view for the carrier mapping issue here is: there is no need to apply the carrier-mapping (by V2X layer) to unicast (we can send R2 assumption to S2 for awareness). And there seems No need to suspend all unicast related work for this issue, so neither Alt2 nor Alt3, but something in the middle. |
| Ericsson | comment | We somewhat prefer Alt-2, but SA2 needs to be contacted at least to introduce the same carrier mapping rules for unicast as for GC and BC, among the set of carriers, UE can further select carriers for unicast link.It is not preferred for us to exclude unicast in R18, we can aim for a simple design framework for unicast. |
| NEC | Comment | The discussion of WID scope should be in plenary meeting rather than this offline discussion. |
| Xiaomi | Alt-3 | For alt-1, we agree with OPPO this is within the scope of RAN. For alt-2, as we replied on previous questions, we don’t think RAN2 can solve this alone without any involvement of SA2. So we think we can focus on groupcast/broadcast in RAN2 and send LS to SA2 to ask for some input on unicast.  |
| ZTE | Alt-3 | For alt-1, share same view with OPPO.For alt-2, see comments in Q3 and share same view with Xiaomi. |
| Intel | See comment | We also share view with OPPO that excluding unicast is more like scope discussion and should be in the plenary. From RAN2 perspective, both Alt-2 and Alt-3 are feasible |
| vivo | Alt-3 | We suggest to send LS to SA2 for unicast case in this meeting, the LS scope can be based on the outcome of Issue#1 and Issue #2. |
| Sharp | Alt-3 | We don’t think unicast should be excluded in Rel-18 and we also confirm there are specific issues for unicast case which should be consulted with SA2. So Alt-3 is ok for us. |
| Qualcomm | None | Eliminating unicast is not indicated in current WID and could be discussed at RAN meeting in June.Maybe we can discuss Alt 2 or Alt 3 at RAN2 meeting in May after companies converging their views on the issues discussed previously. |

# 3 Conclusion

TBD based on company input.

# 4 References

[1] TS 24.386-v17.2.0, User Equipment (UE) to V2X control function, protocol aspects, 2023-3.

[2] TS 36.300-v17.1.0, Overall description; Stage 2, 2022-6.

[3] TS 24.587-v18.0.0, Vehicle-to-Everything (V2X) services in 5G System (5GS), 2022-12.

[4] TS 24.588-v17.2.0, Vehicle-to-Everything (V2X) services in 5G System (5GS) User Equipment (UE) policies, 2022-12.

[5] R2-2303379 Initial discussion on Sidelink CA, Apple.

[6] TS 23.287