**3GPP TSG-RAN WG2 Meeting #119bis-e R2-220**

**Electronic, 10 – 19 October 2022**

**Agenda item: 8.17.2.2**

**Source: Qualcomm Incorporated**

**Title: [AT119bis-e][211][MUSIM] MUSIM solutions for Rel-18 (QC)**

**Document for: Discussion and decision**

# Introduction

This document will report the outcome of the following offline discussion:

* [AT119bis-e][211][MUSIM] MUSIM solutions for Rel-18 (QC)

      Scope: Discuss the technical details of solutions on the table for Rel-18 MUSIM and whether they may have RAN3/4 impacts. Can consider all documents from this meeting.

 Intended outcome: Report in in [R2-2210823](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210823.zip).

 Deadline: Deadline 2.5 (report)

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|  |  |
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# Discussion

## Baseline

The starting point for the solutions will be the following two contributions discussed online:

[R2-2209575](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209575.zip) UE Capability Update for Dual-Active MUSIM Qualcomm Incorporated

[R2-2210514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210514.zip) Discussion on R18 MUSIM Solutions MediaTek Inc.

In [R2-2209575](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209575.zip), it is proposed that a solution for UE capability restriction “*should be flexible enough to signal changes to all UE capabilities which can be impacted by sharing of resources between the MUSIM links”*

In addition, the following four solution directions are listed in Proposal 4:

* *Option 1: Delta signaling of UE capability*
* *Option 2: Repeated UE capability procedure*
* *Option 3: Extension of UAI procedure with new parameters*
* *Option 4: Pre-configuring multiple capabilities or profiles*

In [R2-2210514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210514.zip), it is proposed that :

*Proposal 1: RAN2 assumes that the temporary UE capability restriction (for MUSIM) is mainly focus on the number of supported CC in a network*

The Chair also captured the following agreement:

* RAN2 needs to discuss which UE capabilities can be impacted by sharing of resources between the MUSIM links.

As a first step, it would be good to establish a basic understanding related to the agreement for the affected UE capabilities. The WID includes the statement that the signaling will support “(e.g. capability update, release of cells, (de)activation of configured resources) with NW A”. We can also note that NW A could be configured with CA or DC per WID.

In the sequel, we will refer to the UE request to update the UE capability (restriction or removal) simply as “UE signaling” for brevity and use the term “Dual-Active” to refer to simultaneous Connected mode on both MUSIM links.

We can also assume that only the gNB will be aware of the capability restriction and the restrictions will not override the initial full UE capablity, based on the RAN2#119bis-e agreement:

* The Core Network is not aware of the temporary restrictions of the UE capability;

Per WID, the release of SCells (and SCG) is expected to be part of the UE capability restrictions. In [R2-2210514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210514.zip), it is suggested that release of SCells should be the main focus. As a first step, we can confirm that this will be part of the UE signaling.

**Question A1: Can we confirm that the UE signaling will at least support the release (and removal of release) request of SCells and SCG on NW A?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes |  |
| MediaTek | Acceptable | In our view, deactivation of SCell is enough to allow UE entering CONNECTED mode in another SIM. Release of SCell could work but seems require more effort to bring the SCell back while restriction is removed. Release of SCG has even more signaling overheat (including inter-node) compared to SCell Release. However, as the WID also mention this possibility, we would be fine to allow this option. |
| Intel | See comments | Our understanding is that the UE signalling may result in the gNB releasing the SCell and the SCG. What is in the UE signalling should be further discussed – it may not be to directly request the release of specific existing SCells/SCG but an indication of restriction on certain bands which could then result in gNB releasing SCell/SCG. |

**Summary:**

**Proposal:**

**Question A2: Should UE signaling support request for (de)-activation of SCells and SCG on NW A?**

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| **Company** | **Response** | **Comments** |
| Xiaomi | Yes, but | We think that for SCell, we should select one solution between SCell release and SCell deactivation. Both SCell release and SCell deactivation seem resolving the same issue. |
| MediaTek | Yes (Proponet) | This is most easiest way to do temporary capability limitation. |
| Intel | See comments | Same as our previous comments. Our understanding is that the UE signalling may result in the gNB (de)-activation of the SCell and the SCG. What is in the UE signalling should be further discussed – it may not be to directly request the (de)activating of specific existing SCells/SCG but an indication of restriction on certain bands which could then result in gNB releasing SCell/SCG.  |

**Summary:**

**Proposal:**

Even though a comprehensive list of UE capabilities is beyond the scope of this email discussion and should be completed during stage-3 phase, it may be possible to agree on using the existing capability restrictions in the current specification used for other purposes. Namely, for power savings and overheating, the UE can indicate its preference via UAI using the following IEs (similar IEs were introduced in other releases for other purposes and bands):

OverheatingAssistance ::= SEQUENCE {

 reducedMaxCCs ReducedMaxCCs-r16 OPTIONAL,

 reducedMaxBW-FR1 ReducedMaxBW-FRx-r16 OPTIONAL,

 reducedMaxBW-FR2 ReducedMaxBW-FRx-r16 OPTIONAL,

 reducedMaxMIMO-LayersFR1 SEQUENCE {

 reducedMIMO-LayersFR1-DL MIMO-LayersDL,

 reducedMIMO-LayersFR1-UL MIMO-LayersUL

 } OPTIONAL,

 reducedMaxMIMO-LayersFR2 SEQUENCE {

 reducedMIMO-LayersFR2-DL MIMO-LayersDL,

 reducedMIMO-LayersFR2-UL MIMO-LayersUL

 } OPTIONAL

}

**Question A3: As a baseline, can the UE request restriction (or removal of restriction) of maximum BW and MIMO layers as in Rel-15/16/17 but for MUSIM purposes?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes, but | If we are going to introduce the UE assistance information on the release/deactivation of SCell/SCG, “reducedMaxCCs” which is applicable for the same use case seems not needed |
| MediaTek | Acceptable | We agree BW and MIMO layer could also be sharing resource. We however think dynamic changing of BW / MIMO layer is more difficult than changing number of CC. That’s why we suggest number of CC first. But we are also fine with this.BTW, in our understanding, only reduced CC is supported by network for overheating.  |
| Intel | See comments | Further study is needed to show how reducing the BW and MIMO layers will help for MUSIM purpose. In our view, band conflict between NW A and B should also be one of the candidate for UE request restriction (or removal of restriction)  |

**Summary:**

**Proposal:**

It would also be useful to collect initial opinion on what other capabilities can be signaled by the UE signaling. For example, “maximum power” is suggested in [R2-2209423](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209423.zip) (Oppo).

**Question A4: Please list other UE capabilities that can be impacted due to resource sharing between two active MUSIM links and which can be requested for restriction via UE signaling?**

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| **Company** | **Response** | **Comments** |
| Xiaomi | *srs-TxSwitch* | The SRS switching capability can be impacted by two active MUSIM links due to the occupation of the antenna in another network-B. According to our logged field data, due to the wrong channel estimation for srs-TxSwitch capability, the DL throughput could be reduced by 24.5% in some cases. This means that if the UE can correctly report its SRS switching capability to network-A when its antenna is shared by another active MUSIM link of network-B, the UE throughput can be improvided a lot in network-A. |
| MediaTek | Same as the capabilities in Overheating | We prefer not to go beyond the parameters presenting in Overheating IE. There are already number of CC, BW, and MIMO layer and in our view those are enough.For maximum UL power, it can be resolved by implementation. We think there will be no issue if the UE reduce its Tx Power for short period of time. It is not clear to us what NW should do while receiving this UL TX power limitation for MUSIM purpose. |
| Intel | Band conflict between NW A and B | As mentioned in our previous response. Two options are possible here on how to signal the capability restriction – (i) the actual capability restrictions in network A or (ii) the capability in use in network B. These are discussed below.(i) For signalling the capability restriction in network A, UE request for temporary UE capability restriction on the bands and/or CCs within a band can be provided explicitly for example like the following:1) For CC in NW A that has not been configured as a serving cell yet (e.g. SCell):• The FrequencyInfoDL (SCS-SpecificCarrier, absoluteFrequencyPointA, FreqBandIndicatorNRs) for DL CC(s)/Band which is no longer possible • The FrequencyInfoUL (SCS-SpecificCarrier, absoluteFrequencyPointA, FreqBandIndicatorNRs) for DL CC(s)/Band which is no longer possible 2) For CC in NW A that has already been configured as a serving cell, the UE can provide the SCellIndex instead of indicating the frequency info of the DL/UL CC.(ii) Alternatively, the UE can provide the bands or CCs within a band that are currently used by NW B to NW A and NW A can infer the band/CC/band combination restrictions based on the existing band combinations for CA and DC in the UE capability. |

**Summary:**

**Proposal:**

In [R2-2210514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210514.zip), it is proposed to use MAC CE signaling for the release of SCells. A similar proposal was included in [R2-2210018](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210018.zip) (HW). Several other contributions also considered MAC based signaling for UE capability restriction in general or a combination of RRC and MAC.

There are two issues which need to be addressed:

1. Whether to use only RRC signaling for UE capability restriction
2. Whether to have a common or separate signaling between SCell/SCG release and other possible UE capability changes.

These question are naturally linked to the actual solutions to be developed. Even though it may be early to agree on these, it can help to see where the majority of companies stand.

**Question A5 : Should a common signaling framework (e.g. UAI based) be considered for release of SCells/SCG and restriction of other UE capabilities?**

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| **Company** | **Response** | **Comments** |
| Xiaomi | Yes | A common signalling framework based on UAI can save our standard efforts. |
| MediaTek | See Comment | We think there could be two main solutions in this Objective1. MAC CE based UE-triggered SCell Activation/Deactivation
2. UAI based temporary capability restriction

For SCell/SCG release and other capability restriction that requests RRC Reconfiguration, we can use single RRC message (UAI) for this. However, for SCell activation/deactivation, MAC CE is much simpler and straightforward.  |
| Intel | Yes | Our preference is to reuse the UAI framework also for temporary UE capability restriction  |

**Summary:**

**Proposal:**

**Question A6: Which signaling options can be considered for UE signaling of capablity restrictions?**

* **Option 1: RRC signaling only**
* **Option 2: A combination of RRC and MAC signaling**
* **Option 3: MAC signaling only**

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| **Company** | **Response** | **Comments** |
| Xiaomi | Option 1 | We are open for the UL MAC CE discussion. However it would be better to confirm that RRC signalling is the baseline.  |
| MediaTek | See Comment | See our comment in previous question (A5). We can have two method and it is not necessary to *combine* them. |
| Intel | Option 1 | Reuse of UAI framework. But we are also open to Option 2 if there is justification for using MAC. |

**Summary:**

**Proposal:**

Another issue is whether the UE can initiate UE capability restriction only when its configuration changes on NW A or also at other times. These were described in [R2-2209638](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209638.zip) (Intel) where the latter option was called “proactive”. The Rapporteur assumes that the UE signaling will be triggered when there are changes on NW B which will not be captured in the specification and thus the UE does not necessarily trigger the signaling in response to NW A configuration changes.

**Question A7: Can the UE initiate signaling for capability restrictions when there are no configuration changes on NW A?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi |  | We are open to discuss all use cases for capability restriction. We would assume that the baseline is that the UE initiates signaling for capability restrictions when configuration changes on NW A are required. |
| MediaTek | Yes | We think both “proactive” and “reactive” behavior should be allowed.The UE trigger this capability due to the activities from other SIM. The indicator to NW-A will be somehow like “reactive” if NW-A already configured/activated the resource this and it will be “proactive” if NW has not configured/activated the resource.  |
| Intel | Yes, this should be discussed further and RAN2 should also discuss reactive cases as well | For proactive indication, the UE indicates restrictions to NW A whenever the configuration in NW B imposes any restriction on the UE capability, irrespective of whether it will be configured or likely to be configured by NW A. One main issue is that it may result in unnecessary signalling overhead to NW A, particularly if this capability restrictions indicated by UE are not going to be configured (now or in the future) by NW A.On the other hand, when capability restriction is reactive, the restriction is only signalled when the NW A tries to configure or has configured something that is not possible due to a configuration in NW B. One issue here is that it can introduce additional delay if the configuration is not acceptable to the UE due to MUSIM. And it goes against one of the fundamental principles of RRC for a long time – network only provides a configuration that is compliant to the UE capability.These pros and cons should be discussed further. |

**Summary:**

**Proposal:**

## B - Possible Solutions

As the next step, we can attempt to identify the possible solutions for the UE signaling. We can make some simplifying assumptions here, even though these can be discussed later.

* NW A does not reject the UE request for capability restriction; the actual decision on this and the complications can be dealt later
* What UE does on NW B will not be specified and NW A will not be aware of this.

In several contributions, UAI was proposed as the signaling option. Even though UAI is well known and has been used for many features, it would be useful to establish a common understanding for MUSIM Dual-Active scenario.

The high-level steps for the UAI option can be listed as follows:

1. The UE is in Connected Mode or moves to Connected Mode in NW A .
2. The UE is configured for UE capability update via UAI.
3. The UE starts or stops connection with NW B.
4. The UE requests a change (restriction or removal of restriction) of the UE capabilities at NW A via UAI.
5. NW A reconfigures the UE according to its new capabilities.
6. The UE operates in NW A with the updated configuration.

Here, moving to Connected mode can be due to RRC Setup, Resume, or Re-establishment. Other details pertinent to UAI procedure (prohibit timers etc.) can be discussed later.

**Question B1: Do you agree with the basic steps above for UAI based signaling for Dual-Active MUSIM operation?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes |  |
| MeidaTek | Yes |  |
| Intel | Yes with comments | Maybe Step 5 here should be ‘NW A reconfigures the UE according to the change in its UE capabilities’.RAN2 should also need to handle the case where UE is already connected to NW B when Step 1 occurs. |

**Summary:**

**Proposal:**

Another option mentioned in [R2-2209575](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209575.zip) (QC) is using “delta-signaling” of the UE capability. A baseline procedure can be envisioned as follows:

1. The UE is in Connected Mode or moves to Connected Mode in NW A .
2. The UE is configured for UE capability update.
3. The UE starts or stops connection with NW B.
4. The UE signals the changed UE capabilities to NW A.
5. NW A reconfigures the UE according to its new capabilities.
6. The UE operates in NW A with the updated configuration.

The critical part of this solution is Step 4. Here, the message used for this purpose could be an extended version of *UECapabilityInformation* or a new messsage or even UAI. If UAI is used, the main difference compared to the pure UAI solution above would be how the IEs are structured. Currently UAI has its own IEs. If UAI is used for delta-signaling of UE capabilities, the IEs from *UE-NR-Capability* can be referred. Another option could be where the temporary capability restriction is signaled by feature set list/Band combination in UAI. This option was called “Direction 2” or “MN-SN coordination alike scheme” in [R2-2209392](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209392.zip) (ZTE) and was proposed as the recommended option.

**Question B2: Do you agree with the basic steps for delta signaling of UE capabilities for Dual-Active MUSIM operation?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes |  |
| MediaTek | See comments | UL Delta aspect could be complicate. It is not clear to us whether the baseline capability is the one signaling in UE Capability Information or the one in UE Capability Information + previous UAI message.Our preference it just provide some simple limitation on few capability parameters as in overheating procedure. |
| Intel | Yes |  |

**Summary:**

**Proposal:**

A simple method for UE signaling could be the repetition of the UE capability procedure. This was one of the options considered during Rel-14 NR Study Item. A baseline procedure can be envisioned as follows:

|  |  |
| --- | --- |
| 1. The UE is in Connected Mode or moves to Connected Mode in NW A .
2. The UE is configured for UE capability update.
3. The UE starts or stops connection with NW B.
4. The UE requests a UE capabilty update request.
5. NW A sends *UECapabilityEnquiry* to the UE
6. UE sends *UECapabilityInformation* to the NW A gNB.
7. NW A reconfigures the UE according to its new capabilities.
8. The UE operates in NW A with the updated configuration.
 | A screenshot of a computer  Description automatically generated with medium confidence |

In step 4, a new message or UAI can be used. At a minimum, the UE can send a “flag” requesting the update of the UE capability.

**Question B3: Do you agree with the basic steps for repetition of UE capabilities for Dual-Active MUSIM operation?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes, but | It seems also possible for the UE to report its full capability directly to the gNB without using Step 4 and Step 5. |
| MediaTek | Yes, but | The solution is feasible but seems request quite a lot signaling. Actually, this flow could be used if we find some use case to change UE capability permanently. For MUSIM, it seems too heavy procedure. |
| Intel | Yes |  |

**Summary:**

**Proposal:**

Another option mentioned in [R2-2209575](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209575.zip) (QC) and [R2-2209392](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2209392.zip) (ZTE) is to signal the capability restriction as a different UE capability profile. A baseline procedure can be considered as follows:

1. The UE signals different temporary UE capability sets during registration (FFS if these profiles can be updated later)
2. The UE is in Connected Mode or moves to Connected Mode in NW A .
3. The UE starts or stops connection with NW B.
4. The UE requests to switch to a different UE capabilty profile, e.g. by signaling an index of the profile.
5. NW A reconfigures the UE according to its new capabilities.
6. The UE operates in NW A with the updated configuration.

**Question B4: Do you agree with the basic steps for profile-based method for tempoary UE capability restriction for Dual-Active MUSIM operation?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes, but | We are just wondering whether the solution is feasible from SA2’s perspective, since the temporary UE capability set for MUSIM would rely on the rather dynamic RRC configuration from network-B. This is different from the legacy procedure of UE capability set. |
| MediaTek | Yes, but | Profile-based could work. The flow is also feasible. But we prefer not impact NAS. |
| Intel | Yes, but | However, we think the issue of overhead here is due to the large number of profiles needed for all the possible configurations that may happen in NW B (e.g. for different bands that may be configured by NW B belonging to different PLMNs). |

**Summary:**

**Proposal:**

The solution described in [R2-2210514](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210514.zip) (MTK) for release of Scells has the following call flow where MAC CE is used in Steps 4 and 7.



**Question B5: Can the above call flow be used as a baseline for MAC CE based SCell (de)-activation for Dual-Active MUSIM?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes |  |
| MediaTek | Yes (Proponent) |  |
| Intel | Yes, but | Won’t there be network confirmation after Step 4 to allow the UE to deactivate the SCell? |

**Summary:**

**Proposal:**

We can also collect feedback on any other solution options.

**Question B6: Please describe any other option for tempoary UE capability restriction for Dual-Active MUSIM operation?**

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| **Company** | **Response** | **Comments** |
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**Summary:**

**Proposal:**

## C – RAN3/RAN4 impact

One outcome expected from this discussion is to evaluate whether the solutions “may have RAN3/4 impacts.”. For the above solutions as well as added other options, we can collect feedback.

It is rapporteur’s understanding that, irrespective of the Uu signaling options above, coordination between MN and SN will be needed for NW A when DC is used.

**Question C1: Do you agree that there will likely be Xn-AP impact due to MN-SN coordination when the UE has DC with NW A?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Yes |  |
| MediaTek | Yes | If SCG Release is agreed for MUSIM purpose, it could be potential RAN3 impact. |
| Intel | We think this is likely but it is too early to decide | We think that further detail study on the solution is needed before any conclusion can be made there is Xn-AP impact. |

**Summary:**

**Proposal:**

In addition, changes to the physical layer and MAC parameters will likely result in F1-AP signaling impact. The latter can particularly occur when MAC CE signaling is employed in the signaling for capability restrictions

**Question C2: Do you agree that there will likely be F1-AP impact due to PHY/MAC changes and MAC CE signaling caused by capability restriction?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | Depends on the content of the MAC CE  | If RAN2 agreed to use MAC CE signaling for capability restrictions, and depends on which capability restrictions (e.g. SCG deactivation) is applied via MAC CE, RAN2 solution may cause some impact in F1-AP. |
| MediaTek | possibly | It is unclear to us which part need to be changed but ok to discuss. |
| Intel | We think this is likely but it is too early to decide | We think that further detail study on the solution is needed before any conclusion can be made there is F1-AP impact. |

**Summary:**

**Proposal:**

The restrictions to UE capabilities will result in changes to the performance requirements. Therefore, it can be expected that there will be RAN4 work.

**Question C3: Do you agree that temporary UE capability restrictions impacts performance requirements and thus necessiates RAN4 work?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| Xiaomi | No | Since no new RRC configuration (e.g. gap) for radio resource control is expected from the network, we do not see any extra impact in RAN4.  |
| MediaTek | Not really | We assume that the “restrict version” of capability is also an valid UE capability in 3GPP SPEC and RAN4 should already define the requiremet for that (if different requirement is needed).For example, while 4 CC UE changing its capability to 3 CC UE, it just follow same requirement as defined for 3CC UE (if there is difference). |
| Intel | Too early to decide | We think that further detail study on the what capabilities are needed for MUSIM purpose before any conclusion can be made there is RAN4 impact. |

**Summary:**

**Proposal:**

**Question C4: What are the other possible RAN3 and RAN4 impacts due to Dual-Active MUSIM feature?**

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| **Company** | **Response** | **Comments** |
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**Summary:**

**Proposal:**

# Conclusion

Based on the discussion and the feedback from companies above, the following are proposed :