**3GPP TSG-RAN WG2 Meeting #121 R2-23xx**

**Electronic, 27 February – 3 March, 2023**

**Agenda item: 8.17.2**

**Source: Qualcomm Incorporated**

**Title: [Post119bis-e][212][MUSIM] Rel-18 MUSIM solutions (Qualcomm/vivo)**

**Document for: Discussion and decision**

# Introduction

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

* [Post119bis-e][212][MUSIM] Rel-18 MUSIM solutions (Qualcomm/vivo)

Scope: Discuss MUSIM solutions for Rel-18 (QC), including RAN3/RAN4 impact analysis (vivo). Should try to understand the pros and cons, can consider Stage-2 details.

Intended outcome: Report

Deadline: Long (starts only after RAN2#120)

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# Discussion

## Solutions for UE capability update

In RAN2#119bis-e, several options for the signaling of temporary UE capability changes (restrictions and their removal) were discussed. Even though there was no decision for a single solution, the following was agreed:

* RAN2 aims to prioritize only few solutions and avoid multiple solutions for the same problem (FFS pending on solution details).

Most of the contributions in RAN2#119bis-e either proposed UAI or were fine with this option as the signaling solution. Therefore, this can be a baseline to build upon. Note that this does not exclude introducing other signaling (e.g. MAC CE) in addition to UAI.

**Question A1: As a working assumption, can we consider UAI as a baseline option for the signaling of temporary UE capability changes for dual-active MUSIM?**

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

**Proposal:**

For the legacy UAI procedures, the UE is configured for a particular reporting type (e.g. overheating, power savings). Then, the UE sends the report when the conditions are satisfied (e.g. UE experiences overheating). The triggering of the report for dual-active MUSIM was also discussed in RAN2#119bis-e and the following was agreed:

* A7: The UE can initiate signaling for UE capability restrictions on NW A if NW A allows it. The specification will not capture NW B events which can cause such need.

One difference between legacy UAI and dual-active MUSIM is that the conditions for the signaling are also affected by the activity on the other USIM (NW B). Per the agreement above, NW B events will not be captured in the specifications. In addition, as in Rel-17, there will not be any coordination between NW A and NW B (this is practically not possible in deployments, at least between different operators). Then, the only source of “coordination” would be via the UE.

In Rel-17 MUSIM, it was agreed that it is up to the UE implementation which NW to select for signaling of paging collision avoidance and the following was captured in 38.300:

NOTE: It is left to UE implementation as to how it selects one of the two RATs/networks for paging collision avoidance.

The same principle can also apply to dual-active MUSIM. In fact, the UE may have to signal the changes to both networks as needed for optimal performance. In some cases, it may be sufficient to signal to only one NW (if the other NW is E-UTRAN, this will be the only option). In either case, the necessary information will only be known by the UE.

**Question A2: Similar to Rel-17 MUSIM outcome, can we agree that it is up to the UE implementation which network(s) to select for the signaling of UE capability changes for dual-active MUSIM?**

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

**Proposal:**

RAN2 has agreed that the UE can initiate the signaling if “NW A allows it”. In legacy UAI, the UE can send the report if it is configured as such via RRC. This can be fine in situations where the other NW B activity (e.g. moving to Connected mode) happens before this configuration. However, it is also possible that NW B activity can happen earlier and thus reporting and waiting for re-configuration may cause unexpected behavior on NW A.

As a first step, we can establish that “NW allows it” will be done via RRC signaling. Whether only dedicated signaling (as in legacy UAI) is sufficient or not can be discussed later.

**Question A3: Can we confirm that the UE will be informed via RRC signaling whether the “NW allows” the reporting of UE capability change for dual-active MUSIM ?**

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**Summary:**

**Proposal:**

In legacy UAI, there is a prohibit timer which controls how often the UE can send the UAI report. For Rel-17 MUSIM gaps, it was debated whether this would also be applicable to MUSIM. The argument against the timer was that the conditions for the gaps may change quickly on the other NW and thus the UE should not be forced to wait for a timer. As a compromise, the timer was kept but a value of “0ms” was added to the configuration. The same argument also applies to dual-active MUSIM. In fact, waiting can be even worse since the UE is already in Connected mode on the other NW. In MUSIM gaps, a delay for the report and subsequent configuration would only mean that the UE may miss a first page or incur latency in Idle mode measurements. Given the slower time-scale of Idle mode procedures, this may not be not very costly. However, a delay in simultaneous connections can cause lost packets and RRM procedures (e.g. handovers). Therefore, the argument for no prohibit timer is stronger for dual-active MUSIM.

**Question A4: Should there be a prohibit timer for the signaling of UE capability changes? If there is, should the value “0” be allowed?**

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**Summary:**

**Proposal:**

In RAN2#119bis-e, what can be reported in the UE capability change was discussed. However, there was no agreement on the actual parameters but only the following:

* RAN2 needs to discuss which UE capabilities can be impacted by sharing of resources between the MUSIM links.
* A4: RAN2 to discuss whether the following UE capabilities (not a complete list) are impacted for dual-active MUSIM: MIMO layers, BC capabilities, Measurement capabilities, Bandwidth, *srs-TxSwitch,* UL tx power, Power Class.

Before discussing invidiual parameters, a baseline can be established on the nature of the parameters. Since the expected response to the UE capability update is RRC re-configuration or L1/L2 signaling, it is natural that the UE should only send changes or requests which can be configured by the gNB. In other words, a change in UE capability due to MUSIM operation should only incur a new configuration at the UE.

**Question A5: Can we agree that the UE reporting should only include capabilities or parameters which can be controlled by L1/L2 or RRC signaling?**

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**Summary:**

**Proposal:**

The WID already points out to some examples for the UE capability change as “e.g. release of cells, (de)activation of configured resources”.

In RAN2#119bis-e, there was wide support to include release and/or de-activiation of SCells as well as SCG This seems quite basic and we can make another attempt to agree.

**Question A6: Do you agree that the UE signaling should support request for release (and reversal) of SCells and SCG?**

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**Summary:**

**Proposal:**

**Question A7: Do you agree that the UE signaling should support request for de-activation (and reversal) of SCells and SCG?**

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**Summary:**

**Proposal:**

Agreeing on a comprehensive list of UE capabilities may not be easy at this stage. In an attempt to make some progress, we can discuss what type of UE capabilities can be impacted during dual-active MUSIM operation. Since the UE will be sharing RF and baseband resources between the two links, the following type of UE capabilities (not a comprehensive list) can be expected to be impacted:

* Transmission and reception capabilties (e.g. MIMO layers)
* Measurement capabilities (e.g. gaps)
* Supported bandwidth
* Supported band-combinations

We note that some upper layer capabilities may also be impacted. Since this was not discussed in previous meetings, it was not listed here.

**Question A8: Do you agree that the UE capabilities in the above categories can be impacted by dual-active MUSIM operation? Individual parameters for each category can be discussed later.**

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**Summary:**

**Proposal:**

## B – RAN3 impact

In RAN2#119bis meeting, the below agreements were made:

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| * The Core Network is not aware of the temporary restrictions of the UE capability; * CX: RAN2 to continue evaluation of any Xn-AP, F1-AP or RAN4 impact due to dual-active MUSIM operation. |

Therefore, there is no NG-AP impact, and RAN2 can continue studying the potential Xn-AP, F1-AP and RAN4 impact for Rel-18 dual-active MUSIM operation.

**Question B1: Do you agree that there is no NG-AP impact due to changes in UE capability for dual-active MUSIM operation?**

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

**Proposal:**

In RAN2#119bis agreements, the solutions **B1-B3, B5** were listed. So, the potential RAN3 impact of these solution can be discussed first.

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| * For B1-B3, B5, the solution details need more discussion. May prioritize B1, B2 and B5. FFS on signalling details. Other solutions are not precluded (requires company input with details) and none of B1-B5 are agreed as solutions for this WI. * Do not consider solution B4 in Rel-18 (since it may have CN impacts which are precluded in this WI)   B1: For UAI based solution, the following steps can be used as a baseline:  The UE is in Connected Mode on NW A .  The UE is configured for UE capability update via UAI.  The UE intends to start or stop connection with NW B or is already in Connected mode in NW B.  The UE requests a change (restriction or removal of restriction) of the UE capabilities at NW A via UAI.  NW A reconfigures the UE, if needed, according to its new capabilities (FFS if NW response is mandatory)  The UE operates in NW A with the updated configuration.  B2: For delta-signaling of UE capability, the following steps can be used as a baseline:  The UE is in Connected Mode in NW A.  The UE is configured for UE capability update.  The UE starts or stops connection with NW B or is already in Connected mode in NW B.  The UE signals the changed UE capabilities to NW A via delta-signaling.  NW A reconfigures, if needed, the UE according to its new capabilities (FFS if NW response is mandatory).  The UE operates in NW A with the updated configuration.  B3: The solution for the repetition of UE capability enquiry, the following steps can be used as a baseline:  The UE is in Connected Mode in NW A.  The UE is configured for UE capability update.  The UE starts or stops connection with NW B or is already in Connected mode in NW B.  The UE requests a UE capabilty update request.  NW A sends *UECapabilityEnquiry* to the UE  UE sends *UECapabilityInformation* to the NW A gNB.  NW A reconfigures, if needed, the UE according to its new capabilities (FFS if NW response is mandatory.  The UE operates in NW A with the updated configuration.  B4: The solution based on using UE-profiles for capability restriction, the following steps can be used as a baseline:  The UE signals different temporary UE capability sets during registration (FFS if these profiles can be updated later)  The UE is in Connected Mode in NW A .  The UE starts or stops connection with NW B or is already in Connected mode in NW B.  The UE requests to switch to a different UE capability profile, e.g. by signaling an index of the profile.  NW A reconfigures the UE according to its new capabilities.  The UE operates in NW A with the updated configuration.  B5 (11/15): A baseline procedure for MAC-CE based SCell (de)-activation can be considered as follows:  The UE is in Connected Mode in NW A .  The UE is configured for MAC-CE based SCell (de)-activation operation.  The UE starts or stops connection with NW B or is already in Connected mode in NW B.  The UE sends a request to deactivate SCells via MAC-CE.  NW A deactivates, if needed, the requested SCells (FFS if NW response is mandatory).  The UE operates in NW A with the updated configuration. |

Solutions B1, B2, B3

For B1~B3, the UE can indicate its capability restriction information to the NW A via UE capability signalling (e.g., solution B3), or UAI (e.g., solution B1) or a new UL RRC message (e.g., solution B2).

**Handover/RRC Resume/RRC Re-establishment:**

Currently, HandoverPreparationInformation inter-node message supports transferring UE capability information (via ue-CapabilityRAT-List) and the last UAI reported by the UE (via ueAssistanceInformation) from source gNB to target gNB during HO, resume or re-establishment, and also from CU to DU. And if a new UL RRC message is introduced for delta UE capability reporting, this can be also included in HandoverPreparationInformation message. **So, there is no XnAP and F1AP impact for transferring temporary capability restriction information during handover, RRC resume, and RRC re-establishment.**

**Question B2: Do you agree that there is no Xn-AP and F1-AP impact for the above B1, B2, B3 options?**

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

**Proposal:**

**MN-SN coordination:**

For NR-DC, RAN2 has made the below agreements：

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| * 1: RAN2 can discuss NW A MN-SN coordination of Rel-18 MUSIM temporary capability restrictions due to UE being configured with NR-DC in NW A. |

And the below options were discussed in RAN2#119bis AT meeting email discussion for DC capability restriction:

* **Option 1:** The UE indicates DC is not supported temporarily via UAI or UE capability signalling.
* **Option 2:** The UE requests SCG release for MUSIM purpose.
* **Option 3:** The UE requests SCG deactivation for MUSIM purpose.

**Option 1**

For option 1, when receiving the DC capability restriction information from the UE, the MN can notify it to the SN via the ue-CapabilityInfo field in CG-ConfigInfo inter-node message. Then the SN can decide to deactivate or release the SCG based on its local strategy. And the SN, if supports CU-DU split, the CG-ConfigInfo including the DC capability restriction information can be further transferred from the CU to the DU. **So, there is no XnAP and F1AP impact for transferring DC capability restriction information neither between MN and SN nor CU and DU.**

**Question B3: Do you agree that there is no Xn-AP and F1-AP impact if DC operation is disabled via UE capability update?**

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**Summary:**

**Proposal:**

**Option 2**

For option 2, currently, the UE can request SCG release to the SN for power saving purpose. And the UE’s SCG release request is transparent to the MN.

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| TS 37.340:  SCG specific UE assistance information for power saving is directly transmitted to the SN via SRB3, if SRB3 is configured, otherwise UE transmits SCG specific UE assistance information for power saving in a transparent container to the MN. UE can implicitly indicate a preference for NR SCG release by indicating zero number of carriers and zero aggregated maximum bandwidth in both FR1 and FR2. |

And in TS 38.423, a cause value ‘UE power saving’ was introduced in R3-204731, see below:

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| **Reason for change:** | UE may release the SN for power saving in dual connection. RAN 2 has a conclusion that UE transmits SCG specific UE assistance information (UAI) in a transparent container to the MN and the MN then forwards the received container to the SN. For this case, the current release not includes UAI in RRC container. It would cause UAI cannot be sent from MN to SN by RRC transfer.  Since the power saving prodedure is triggered by UE, introducing UAI to RRC container as UE report IE achieving SN release procedure would be much reasonable. Furthermore, reusing the existing IE would have little impact on specifications.  In addition, it is better to introduce “UE power saving” as a new cause value for SN initiated SN release procedure. Base on the conclusion in the last meeting for power saving procedure, it was agreed to introduce a new cause value. |

And if we agree that the UE can request SCG release to the SN for MUSIM purpose, similarly to the UE power saving case, **it is better to introduce a new cause value for SN initiated SN release procedure**, to notify to the MN the exact reason of SCG release is for MUSIM purpose. With this cause, the MN can know what the proper action is, for example, whether to find another SN or do nothing.

**Question B4: Do you agree that a new cause value on Xn-AP is useful when SN initiated SN release procedure is used upon UE sending SCG release request to the SN?**

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

**Proposal:**

**Option 3**

For option 3, in Rel-17 SCG deactivation feature, the UE can request SCG deactivation by sending UAI to MN and then MN can request the SN to deactivate the SCG. And there are some RAN3 work for this feature. Specifically, a *SCG Activation Request* IE was introduced in S-NODE ADDITION REQUEST / S-NODE MODIFICATION REQUEST / S-NODE MODIFICATION REQUIRED message.And *a SCG Activation Status* IE in the S-NODE ADDITION REQUEST ACKNOWLEDGE / S-NODE MODIFICATION REQUEST ACKNOWLEDGE message in XnAP. Similar IE was also introduced in F1AP specification.

**9.2.3.154 SCG Activation Request**

This IE indicates whether the SCG resources are required to be activated or deactivated.

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| IE/Group Name | Presence | Range | IE type and reference | Semantics description |
| SCG Activation Request | M |  | ENUMERATED (Activate SCG, Deactivate SCG, …) |  |

**9.2.3.155 SCG Activation Status**

This IE indicates the status of the SCG resources.

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| IE/Group Name | Presence | Range | IE Type and Reference | Semantics Description |
| SCG Activation Status | M |  | ENUMERATED (SCG  activated, SCG deactivated, …) |  |

And there are two cause value were introduced in RAN3.

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| SCG activation deactivation failure | The action failed due to rejection of the SCG activation deactivation request. |
| SCG deactivation failure due to data transmission | The SCG deactivation failure due to ongoing or arriving data transmission. |

And if we agree that the UE can request SCG release to the SN for MUSIM purpose, there are two reasons to **introduce a new cause value in RAN3 (XnAP and F1AP):**

* if the MN knows the SCG deactivation request is requested by the UE for MUSIM purpose, it can indicate to the SN in order to let the SN to configure AS configuration properly. OR
* During SCG deactivation, if the SN requests the MN to activate the SCG due to the DL data arrival at the SN. The MN may reject the SCG activation request with a cause related to MUSIM purpose.

**Question B5: Do you agree that there may be Xn-AP or F1-AP impact if the UE sends SCG release request to MN?**

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

**Proposal:**

**Solutions B5**

For this solution, gNB-CU is responsible to configure whether MAC CE based SCell de-activation request is allowed. And the potential F1AP impact could be, before or after configuring the function to the UE, gNB-CU may have some coordination with the gNB-DU to support this function, for example, a request or notification.

**Question B6: Do you agree that CU-DU coordination may be needed for MAC-CE based SCell (de)-activation request for MUSIM?**

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

**Proposal:**

## C – RAN4 impact

For capability restriction case, the following agreements were made:

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| * A4: RAN2 to discuss whether the following UE capabilities (not a complete list) are impacted for dual-active MUSIM: MIMO layers, BC capabilities, Measurement capabilities, Bandwidth, *srs-TxSwitch,* UL tx power, Power Class. |

Since the temporary restricted capabilities is only a subset of UE capabilities and there is no new RRC configuration, so there is no RAN4 impact on this. However, the reconfiguration in network A, due to MUSM capability change, there will be interruption like CA Scell deactivation and release. It is not clear if there are additional RAN4 impact. Do we need to send a LS to RAN4 to confirm?

**Question C1: Do you think the UE capability change due to MUSIM can impact interruption time like the interruption time due to CA SCell deactivation and release? If so, should RAN2 send an LS to RAN4 to confirm?**

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**Summary:**

**Proposal:**

There is one contribution submitted in RAN4 ([R4-2212343](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104-e/Docs/R4-2212343.zip)) which mentioned the below power back-off issues cause by MUSIM operation.

* *Total Tx power.* A UE design has a limit on the total maximum Tx power that the device can output. Irrespective of the actual device power class, e.g. +23dBm or +26dBm, there can be a situation when a UE ends up to the cell edge as perceived by both networks, where a UE has registered with two SIM cards. In this case every network may instruct the UE to operate at its maximum Tx power, but a UE will not be able to do that because the Tx power will have to be shared between two UL transmissions. In fact, it is enough to be on the cell edge of just one network, which most likely will be instructing a UE to use the maximum UL power. However, from an individual network perspective a UE will be applying power back-off that goes beyond the limits of what existing A-MPR margins allow.

- *Inter-modulation*. Another potential reason for the extra power back-off is the intermodulation issues between two UL transmissions. RAN WG4 framework already accounts for the inter-modulation issues in certain UL CA configurations and allows the UE to apply extra power back-off in addition to the A-MPR margin. However, in the MUSIM case one network is not aware of the second network or even the second UL transmission. Thus, from an individual network perspective a UE will be applying power back-off, which is larger than what the existing specifications allow for the single UL case.

To our understanding if RAN2 does not introduce UE power class/UL Tx power as impacted UE capabilities, a pragmatic way is to use P-MPR solution to handle this issue since it was used to account for the total transmission per UE perspective. The power back off could happen even the NW A and NW B does not have any coordination. Regarding the inter-modulation due to two UL transmission, RAN4 has already accounts for the inter-modulation issues back to Rel-10 CA era and MPR was defined to deal with this issue. However, for the MUSIM operation, the two UL transmission maybe any two bands or more from different operator (or any two bands or more from the same operator) hence method used before to handle the inter-modulation cannot work in practice since it is impossible to define MRP for all combination of two bands (or more) from any two operators. For this issue our currently understanding is up to UE implementation since dual SIM card UE do exist a long time.

**Question C2: Do you agree that handling of uplink tx power can be left to the UE implementation for dual-active MUSIM and thus will not require RAN4 work?**

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**Summary:**

**Proposal:**

**For the below scenario and agreement, the RAN4 impact is not foreseen during the offline or leave it as UE implementation.**

* 1: RAN2 can consider such Band conflict scenarios for MUSIM in CONNECTED to arrive at a graceful specification-based solution intended to mitigate such conflicts.

**Question C3: Do you agree that there should not be any RAN4 impact for the band-conflict scenario discussed in RAN2#119bis-e per contribution** [**R2-2210485**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119bis-e/Docs/R2-2210485.zip)**?**

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**Summary:**

**Proposal:**

# Conclusion

Based on the discussion and the feedback from companies above, the following are proposed for dual-active MUSIM operation: