**3GPP TSG-RAN WG2 Meeting #112-e R2-200xxx**

Online, 2-13 November 2020

Agenda Item: 8.1.2.2

Source: CMCC

Title: Summary of email discussion [Post111-e][905][MBS] Connected Mode Mobility with Service Continuity

Document for: Discussion and Decision

# 1 Introduction

This document is for the following offline discussion, particularly for topics in 8.1.2.2:

**[Post111-e][905][MBS] Connected Mode Mobility with Service Continuity (CMCC)**

Scope: Aim to understand what proposals are on the table, what can potentially be reused from existing mobility functions, and identify potential consequences / characteristics of options.

Intended outcome: Report

Deadline: Long

The final deadline of this email discussion is Wednesday, 2020-10-15, 23:59 Pacific Time. Earlier inputs are appreciated so that the rapporteur can have time to prepare the summary.

The Connected Mode Mobility with Service Continuity related aspects were discussed in many company contributions submitted to RAN2#111-e meeting [1]-[16]. Based on the discussions during the meeting, RAN2 made the following agreements with respect to connected mode mobility with service continuity:

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| * Focus on MBS-MBS scenario initially (i.e. shared delivery), including both PTM and PTP (if applicable). Other scenarios later, TBD. * Requirements for lossless mobility are TBD. Assume for now that R2 will anyway discuss service continuity functionality for low or no data loss. * R2 assumes that for Rel-17 NR multicast Mobility in Connected mode, handover (including variants) is the baseline, TBD exactly which variants. |

Meanwhile, RAN3#109-e had an email discussion regarding the topic of connected mode mobility with service continuity, and RAN3 made the following conclusions:

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| * We Define MBS session resource in analogy with PDU session resource, e.g. including radio part, CP part, NG-UP part, MBS context in RAN * MBS session resource establishment is requested by 5GC (similarly to the PDU session establishment for unicast) * RAN may request MBS session resource UP establishment, e.g. in handover (FFS). The signalling procedure (e.g. nested in handover signalling or new procedure, whether a single procedure is used or not, … ) is FFS. * Prioritize work on support of mobility scenarios of UEs moving from a cell with established MBS session resource to another cell with established or to be established MBS session resource. * For the prioritized scenario, intra-CU mobility and Xn/NG based inter-gNB mobility will be considered. * WA: the UE Context to be transferred to the target gNB contains information about the MBS Session(s) the UE joined. Details are FFS. * Next meeting: start with message flows and start deriving protocol functions on all impacted interfaces. * To be continued... |

To progress the topic of connected mode mobility with service continuity, this email discussion will cover the following scope:

* **Progress TBD related to requirements for lossless mobility under the MBS-MBS scenario;**
* **Progress the down-selection of approaches for Minimization of data loss**
* **Progress the handover procedure enhancement for Mobility with service continuity**

# 2 Discussion

As descripted in [1]-[16], the scenarios are identified for MBS mobility are as follows:

1. **MBS to Unicast Handover.**
2. **Unicast to MBS Handover.**
3. **MBS to MBS handover.**

And in RAN2#111-e, the following text is agreed:

1. **Focus on MBS-MBS scenario initially (i.e. shared delivery), including both PTM and PTP (if applicable). Other scenarios later, TBD.**

Hence, this email discussion will use this agreement as the basis, which means RAN2 will start with the basic mobility scenario, i.e. a UE moving from a cell where an MBS Session is ongoing to another cell which is able to support that MBS Session. And other left scenarios will be discussed later and FFS. If 5GC delivers the MBS traffic in the shared delivery manner, either PTM or PTP transmission for the UEs can be selected over air interface. Therefore, there are the following possible cases during MBS to MBS handover, as figure 1 [6]:

* **Scenario 1: PTP->PTP;**
* **Scenario 2.1: PTP->PTM with PTP;**
* **Scenario 2.2: PTP->PTM;**
* **Scenario 3.1: PTM with PTP->PTP;**
* **Scenario 3.2: PTM ->PTP;**
* **Scenario 4.1: PTM with PTP->PTM with PTP;**
* **Scenario 4.2: PTM ->PTM;**
* **Scenario 4.3: PTM ->PTM with PTP;**



**Scenario 4.3**

**Figure 1 Scenarios to support service continuity during handover** [6]

## Minimization of data loss

### Scenarios Supporting Handover Lossless

As mentioned above, in RAN2#111-e, the following text is agreed:

* Requirements for lossless mobility are TBD. Assume for now that R2 will anyway discuss service continuity functionality for low or no data loss.
* R2 assumes that for Rel-17 NR multicast Mobility in Connected mode, handover (including variants) is the baseline, TBD exactly which variants.

And in RAN3#109-e, the following text is agreed:

* Working Assumption: NG-RAN protocols shall support minimization of data loss. Discussion on using or adapting existing protocol functions for support of lossless mobility is deprioritized due to expected issues with scalability.

Several papers have proposed that RAN2 should strive to minimize data loss in the MBS-to-MBS Handover scenario. For example, in [1], [3], [5], [7], [16], [15], it mentioned that in the WID, an important objective for NR MBS is the service continuity during mobility, i.e. the MBS service is still available after mobility. And use cases of NR MBS mainly consist of public safety and mission critical, V2X applications, transparent IPv4/IPv6 multicast delivery, IPTV, software delivery over wireless, group communications and IoT applications. Most of these use cases involve MBS service reception during inter-node mobility, e.g. public safety, V2X applications and so on. Obviously, the above use cases require high reliability, for example, according to 5GAA, V2X applications require up to 99.9999% reliability. Regarding public safety, the MCPTT service also requires up to 99.9999% reliability.

On the other hand, some companies have different understanding:

* For example, as expressed in [9], they concerns that the cost of optimization to achieve lossless in some case is very high, e.g. Handover in PTM to PTM manner.
* Meanwhile, as mentioned in [8] , refer to [16], there was already an evaluation and discussion on the possible packet loss due to the unsynchronized SC-PTM scheduling between two adjacent cells during the standardization of SC-PTM solution. The conclusion is that the possible data loss due to the unsynchronized SC-PTM scheduling over the radio link between two adjacent cells is not a serious problem to address. The potential packet loss could be avoided/minimized by network implementation.

**Question 1: Companies are requested to express their view whether RAN2 should support handover lossless in the MBS-to-MBS Handover scenario and justify shortly the choice. Or, which of the above scenarios should support the handover lossless (scenario 1- scenario 4)?**

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| **Company** | **Support or not/ Alternatively, which of the above cases should support the handover lossless?** | **Comment / alternative proposal** |
| CMCC | Yes |  |
| Mediatek |  | Lossless is more of a QoS requirement. For certain services, lossless HO should be supported, while for other services, lossless HO is not required. For the services having tight reliability requirement, PTM with unicast channel or PTP transmission with RLC AM mode would be configured for the corresponding MRB. While for the services having loose reliability requirement, PTM or PTP transmission with RLC UM mode can be configured. Therefore, the same reliability requirement should be maintained for the MRB during mobility. Based on this logic, if the MBS services doesn’t have high reliability requirement and are delivered in PTM transmission without unicast channel, lossless handover doesn’t need to be supported.  Therefore, lossless handover doesn’t need to be supported for the following scenarios:   * Scenario 2.2: PTP->PTM without unicast; * Scenario 3.2: PTM without unicast->PTP; * Scenario 4.2: PTM without unicast->PTM without unicast.   Lossless handover can be supported for the following scenarios:   * Scenario 1: PTP->PTP; * Scenario 2.1: PTP->PTM with unicast; * Scenario 3.1: PTM with unicast->PTP; * Scenario 4.1: PTM with unicast->PTM with unicast.   But from specification point of view, we should have a unified procedure with flexible configurations to support those scenarios. |
| Huawei, HiSilicon | Yes, prioritize Scenario 4.1, and 4.3 can be supported without additional efforts | First, lossless requirement is important for the use case like V2X, as well as some essential services for public safety.  We should not still assume that NR broadcast/multicast can only support services which don’t have strong reliability requirements like in LTE solutions. As agreed by RAN1, In physical layer, HARQ will be supported for NR MBS, which means that NR MBS is possible to achieve similar reliability performance like NR unicast.  Secondly, regarding the scenarios to be supported for lossless handover, according to the RAN2 agreement, “**Focus on MBS-MBS scenario initially (i.e. shared delivery), including both PTM and PTP (if applicable). Other scenarios later, TBD**” , we should focus on MBS bearers which are associated with MBS sessions for support of lossless handover. In this sense, we don’t see the need to support the case of PTP only (which is basically Unicast DRB in Uu).  At the same time, in order to support lossless handover, it seems essential to have a PTP leg (in addition to PTM) at the target to deliver the missing packets dedicatedly to the UE.  Therefore, we think Scenario 4.1 should be the baseline scenario, in which PTP/PTM switch is possible in both source and target, and lossless handover can be achieved by using the PTP leg at the target to deliver the missing packets.  Lossless handover in Scenario 4.3 can also be achieved with the same solutions for Scenario 4.1. |
| CATT | FFS | Certainly we should try to minimize the data loss, but to avoid over design; we should make it clear that whether there is clear requirement for lossless delivery.  In NR unicast, lossless is only supported for RLC AM.  Therefore we can wait for conclusion on RLC AM for MRB, which is covered by email discussion “[Post111-e][904][MBS] L2 Architecture (Huawei)” |
| Kyocera | Yes | RAN2 already agreed that “*Assume for now that R2 will anyway discuss service continuity functionality for low or no data loss.*” |
| OPPO | Yes, prioritize 1, 2.1, 3.1/3/2, 4.1/4.3 | Lossless is Qos requirement of service during HO. If the service has the lossless requirement, then the PTP or PTP+PTM should be used in the target. Otherwise, the lossless cannot be guaranteed.  On the other hand, the packet duplication during HO should also be considered when we consider lossless HO.  If lossless can not be guaranteed, the low loss can also be considered during HO in other scenarios. |
| Lenovo, Motorola Mobility | Yes | The reliability requirement of V2X and MCPTT is very strict and it is a kind of QoS requirement. Lossless during mobility is important to satisfy the QoS requirement. |
| QC | Yes (i.e loss-less HO and service continuity to be supported for NR Multicast) for all cases. | Loss-less HO is mainly intended for NR Multicast mode. Multicast main goal is to provide high reliability data delivery to a group of UEs and improve radio efficiency by using common radio resources for group of UEs. Many applications like V2X, MCPTT, Public safety etc have high reliability requirements and loss-less HO is essential to meet those high reliability requirements (i.e PTM reliability requirements are same as PTP). RLC AM support PTM is one key requirement to support loss-less HO.  **NR Multicast services requiring high reliability QoS shall support both loss-less HO and service continuity.**  In LTE SC-PTM, only broadcast is supported and broadcast services have different reliability requirements than that of high reliability multicast. Comparing LTE Broadcast with NR Multicast is not correct.  **NR Broadcast need not to support loss-less HO and is similar to LTE Broadcast and but service continuity shall be supported.** |
| Ericsson |  | We are not sure "lossless handover" is strictly defined. Similarly to Mediatek we think different services may have different requirements and thus various forms of data delivery and corresponding handovers would be possible, probably for some of the QoS requirements user data cannot be provided using 5MBS. All means for minimization of data loss at UE mobility specified for handover will not suit all services and vice versa.  For now, the WA from RAN3 seems to be adoptable by RAN2 as well. This topic is overlapping with RAN3, which needs mutual involvement.  RAN2 could start addressing scenario 4.2, and later address 4.1 and 4.3 once it is established what this PTM+PTP configuration corresponds to. |
| Samsung | No  Only PTP 🡨🡪 PTP | In MBS, the main issue of service continuity should be to minimize interruption time. Assuming RLC UM for PTM reception, lossless handover is not possible, as lossless is only possible for RLC AM.  Services requiring high reliability should be configured with RLC AM unicast bearer, irrespective of cast type of CN. Multicasting is not appropriate. |
| Sharp |  | Regardless of the above scenarios, it should be up to a service whether lossless handover needs to be supported as in legacy handover (e.g. if the service is real-time communication such as MCPTT, realtimeness is more important than lossless.).  If the service requires lossless, and if PTP is used for guaranteeing lossless as explained in [6], we agree to MTK’s observation. |
| LG | No | Several architectural options are being proposed and discussed to enhance reliability of MBS transmission without mobility. We think that it may be too early to discuss lossless MBS-to-MBS handover. In addition, it is fine to discuss how to support low loss and enhanced reliability. However, we have some doubt on achieving lossless handover in MBS scenario. |
| Sony | Yes but | We also agree with the Mediatek observation that not all services require lossless HO. We also share the view that RLC-AM is less likely to be supported for PTM so effectively, PTP-PTP HO may be lossless. |
| BT |  | First, it will be required to define “lossless”.  Based on the service, lossless is required or not. Therefore, if any of the above scenarios may support services required in an emergency with first responders, lossless is required.  We consider the following scenarios valid for an emergency:   * Scenario 1: PTP->PTP; * Scenario 2.1: PTP->PTM with PTP; * Scenario 2.2: PTP->PTM; * Scenario 3.1: PTM with PTP->PTP; * Scenario 3.2: PTM ->PTP; * Scenario 4.1: PTM with PTP->PTM with PTP; * Scenario 4.2: PTM ->PTM; * Scenario 4.3: PTM ->PTM with PTP;   As not all services require lossless handovers, RAN2 should define a mechanisms that based on the service, handover lossless mechanism applies or not. |
| Futurewei | Yes, for certain MBS applications | We also agree on that for certain MBS applications with very high reliability requirement, lossless mobility should be supported.  When such an MBS application is to be delivered, the network and the associated UEs should be configured such that the lossless mobility is supported for this MBS application. In order to achieve lossless HO, basically at least PTP should be configured for activation at the target to unicast deliver the possible short of PDU delivery at the source during the HO from the source to the target. Typical configurations to allow lossless are scenarios 4.1, 4.3. Other scenarios with MBS PTP configured at the target should also be able to achieve lossless if it is one of the factors considered by the network for mobility configuration. |
| NEC | Not all | We think lossless handover is a requirement for some of the services depending on the QoS. And it is quite obvious that the following scenarios can support lossless handover without any enhancement:   * Scenario 2.2: PTP->PTM without unicast; * Scenario 1: PTP->PTP; * Scenario 4.1: PTM with unicast->PTM with unicast.   Therefore, for the other cases, we firstly should discuss whether it is necessary to support the lossless handover. |
| vivo | Yes with comments | We think lossless handover should be supported under a proper cost.  Regarding the following 2 scenarios:   * **Scenario 1: PTP->PTP;** * **Scenario 3.2: PTM ->PTP;**   since the target transmission mode is PTP, status report & retransmission can be relatively easy to be achieved. Thus, we think the lossless handover should be guaranteed in **Scenario 1** and **Scenario 3.2** as the baseline.  Further, if there is a PTP associated with the target PTM (e.g. common PDCP and split PTM/PTP legs), status report & retransmission can be achieved via the PTP leg. Hence we can further consider lossless handover for the following scenarios:   * **Scenario 2.1: PTP->PTM with PTP;** * **Scenario 4.3: PTM ->PTM with PTP;** * **Scenario 4.1: PTM with PTP->PTM with PTP;**   For the last two scenarios:   * **Scenario 2.2: PTP->PTM;** * **Scenario 4.2: PTM ->PTM;**   given that status report & retransmission can be hardly supported via the target PTM mode, we think lossless handover for these two scenarios is difficult and not necessary.  Last but not least, we think that L2 SN alignment for an MBS bearer between neighbor cells, e.g. PDCP SN, may be a basic requirement to support lossless handover. |

As mentioned above, in RAN2 conclusion, assumption for now is that R2 will anyway discuss service continuity functionality for low or no data loss. Based on this, preferred approaches need to be down-selected among the possible solutions. For example in [1], [3], [4], [12], there are some solutions to minimize the data gap related to the unsynchronized MBS data transmission between source cell and target cell. In summary, there could be some possible solutions to address the related issue, e.g., as described in [3], [7], [9], [6] and [8], [14].

### Issue 1# How to synchronize the MBS data transmission between source cell and target cell

In summary, the potential approaches related to this issue are as follows:

**Option 1:** Synchronized delivery over the radio between cells could be provided with employing SFN operation at NG-RAN side:

**1-1:** The SFN operation could be implemented at network side without standardization;

**1-2:** Introduction of SYNC which is to support SN synchronization among the RAN nodes which perform PTM transmission for the same 5G MBS service by enabling gNBs to identify the timing for radio frame transmission and detect packet loss. Based on this, gNB can buffer MBMS packet and wait for the transmission timing indicated in the SYNC protocol.

**Option 2:** DL PDCP SN synchronization and continuity between the source cell and the target cell should be guaranteed by the network side to realize the lossless handover for 5G MBS services, e.g. common PDCP or one PDCP in charge of PDCP SN assignment for both source cell and target cell.

Option 3: No PDCP SN synchronization.

**Question 2: Companies are requested to indicate their preferred approach, or provide new approaches.**

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| **Company** | **Preferred Option** | **Comment / alternative proposal** |
| CMCC | Option 2;  Option 1-1 ? | In our understanding, usage of DL PDCP SN synchronization and continuity is more compatible to the existing protocol design during handover and possible protocol split way for dynamic switch between PTM and PTP. |
| Mediatek | Option 2? | In order to support lossless HO, DL PDCP SN synchronization and continuity should be guaranteed by the network. This is a requirement instead of solution. How to realize PDCP SN synchronization and continuity should be discussed by RAN3. Maybe a sync protocol needs to be introduced for SN synchronization, or it can be left to network implementation. |
| Huawei, HiSilicon | Option-2 | In this release, SFN can only be achieved in a single gNB-DU by implementation, so option-1 is not a reliable solution.  Option-2 can be supported to avoid or minimize the packet loss by reusing existing PDCP mechanisms. |
| CATT | Option 1  Option 2  Option 3 | Option 1 is pure network implementation as no standardized support specifically for SFN according to RAN WI.  Option 2 should be discussed by RAN3 firstly.  Besides, No PDCP SN synchronization could also be possible so we add Option 3 in the description above. |
| Kyocera | Option 2 | For Option 1-1, we don’t think it can ensure lossless delivery, considering different scheduling in different cells.  For Option 1-2, RAN3 already agreed that “*No SYNC protocol for this release.*” So, we think it’s no longer visible.  For Option 2, in general we think the DL PDCP SN synchronization among cells is a possible candidate since it allows the retransmission in the target cell if the UE failed to receive some DL MBS packets. |
| OPPO | Option 2 | For option 1-1, it can be considered, but it is deprioritized.  For option 1-2, No SYNC is agreed by RAN3.  For option 2, common SN can improve the low loss requirement and duplication detection requirement. |
| Lenovo, Motorola Mobility | Option 2 | SFN operation across gNBs needs some necessary standardization and is out of scope of R17 WI. The main purpose of SYNC protocol is for SFN operation. If SFN operation across gNBs is not supported, the SNYC protocol is not needed.  As the legacy behavior of lossless handover for unicast, we prefer to have DL PDCP SN synchronization and continuity between the source cell and the target cell for 5G MBS. |
| QC | Option 2 | Like Huawei mentioned, SFN support is limited to Intra DU case and Option 1 is not suitable. Note that RAN3 already agreed that there is no support for SYNC protocol and no MCE functionality specified.  In order to support loss-less HO, PDCP SN synchronization has to be supported. It is possible to synchronize multiple gNBs PDCP SN synchronization by using GTP tunnel SN (between UPF and Multiple gNBs PDCP SNs) and this can be further discussed by RAN2 based on RAN3 discussion. |
| Ericsson | Option 2 | Option 1 (SFN and SYNC) is off the table for Rel-17.  Option 2: a common point of PDCP SN allocation might be one mean to enable some level of synchronization and to enable minimization of data loss, but is not sufficient.  This topic is in RAN3 realm, but we regard the outlined and potential other solutions being implementation options. |
| Samsung | Option 1-1 | We think SN synchronized mechanism is too much burden to NW side. Since HO-based dedicated reconfiguration can support short interruption, such a small data gap may not be a problem. |
| Sharp | Option 2 | DL PDCP SN synchronization and continuity seems reasonable. |
| LG | Option 2 | We think that Option 2 is helpful to reduce packet loss and service interruption during/after MBS-to-MBS handover. With DL PDCP SN synchronization, a copy of each IP multicast packet is encapsulated into a PDCP PDU with the same SN at each gNB. This will make it possible to perform reordering, status reporting and retransmission, if possible, at the target cell by using PDCP SN. But, it’s not sure that option 2 guarantee lossless handover. |
| Sony | Option 2 | Option 1-1 is not in the scope and option 1-2 is for RAN3 to discuss/revisit. |
| BT | Option 2 but | Option 1 is not an option in Rel-17  Option 2 should be discussed in RAN3.  Option 3 is not clear to us. |
| Futurewei | Option 2 | DL PDCP SN synchronization can be achieved among the gNBs by network. It is relatively simple. We may need to get input from SA3. |
| NEC | Option 2 | If the PDCP SN is aligned among gNBs, then the lossless handover can be guaranteed. |
| vivo | Option 2 | We think that DL PDCP SN synchronization is a basic requirement to support lossless handover between cells no matter whether PTM or PTP is ongoing.  For Option 1, considering that SFN-related standardization work is out of the scope and RAN3 had agreed that no SYNC protocol needs to be supported in NR MBS in the previous meeting, we think it is not a potential solution. |

### Issue 2# How to guarantee the minimize data loss during handover

In summary, the potential approaches related to this issue are as follows:

**Option 1**: the UE will receive the multicast MBS of source and target multicast MBS simultaneously until the UE receive the all the data in the data gap.

**Option 2:** the source gNB will forward the data to the target gNB and the target gNB will deliver the forwarding data via unicast. After that, the UE will receive the MBS in the target cell via multicast. Meanwhile, the SN STATUS TRANSFER should be extended to cover the PDCP SN for MBS data.

**Option 3:** MBS can be configured as AM bearer, then lossless packet delivery based on PDCP status report and PDCP re-establishment/recovery can be supported as well.

**Question 3: Companies are requested to indicate their preferred approach, or provide new approaches.**

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| **Company** | **Preferred Option** | **Comment / alternative proposal** |
| CMCC | Option 1-3 | The three options are different but complementary. |
| Mediatek |  | First of all, I have one question for clarification: do the above options assume that PDCP SN is synchronized between the source cell and the target cell?  In my understanding, the above options make sense only we assumes that the PDCP SN is synchronized between the source and the target. Otherwise, the there is no SN reference for SN status transfer in option 2 or PDCP status report in option 3.  If I understand correctly, option2+option 3 is the legacy procedure to realize lossless HO for the DRB with RLC AM mode. So option 2 or option 3 alone can’t minimize the data loss during HO.  For PTP transmission during HO, the legacy mechanism i.e. option2 (at the network side)+option3 (at the UE side) can be used to guarantee lossless HO.  For PTM transmission during HO, the MBS services may being broadcast at the target cell during HO. For the basic HO procedure, UE will miss the packets which are being transmitted at the target side when UE perform HO procedure. One solution is that the network always cache some amount of DL packets for MBS services in case some UEs performs HO from other cells.  Option 4: Option 2+option 3+ network caching |
| Huawei, HiSilicon | Option 2, Option 3 partly (AM only for PTP leg) | Option-1 itself is not a reliable solution, which may very much depend on the UE capability, and sometimes, it cannot be guaranteed that the UE can still receive the MBS packets from the source successfully during the handover.  Like legacy unicast, data forwarding from the source to the target can make sure the target gNB can fill in the packet gaps which the UE missed due to the interruption during handover and delivery misalignment.  For option-3, it is possible to configure PTP with RLC AM mode, and the target gNB can deliver the missing packets via PTP to guarantee the reliability. |
| CATT | Option 2 | Option 1 have high requirement on UE capability, no all UE could receive MBS from source cell and target cell simultaneously  For RLC AM mentioned in option 3, it is covered by email discussion “[Post111-e][904][MBS] L2 Architecture (Huawei)”,we can wait conclusion from it. |
| Kyocera | Option 2 & 3 | For Option 1, we’re wondering how long time it needs before the data gap can be filled, considering both the source cell and the target cell continue DL MBS transmissions over their PTM legs.  For Option 2, we think it works since the usage of PTP leg can fill the data gap.  For Option 3, we think it’s reasonable to reuse the existing functions. |
| OPPO | Option 1 and 2 | For option 1, if the UE capability allows, it can reduce the data loss and it is supported in LTE MBMS.  For option 2, it is typical solution to reduce the data loss during HO.  For option 3, it may work, but it is too complex and increase the delay for MBS service. |
| Lenovo, Motorola Mobility | Option 2 and Option 3 | Option 1 needs additional UE capability such as DAPS. We are not sure that all 5G MBS UEs have such kind of capability. Solutions for UEs without DAPS capability are also required. Option 1 also needs PDCP synchronization between source and target.  Option 2 and option 3 are complementary as in the legacy unicast handover. In option 3, the MBS bearer is not necessary to be configured as AM. We agree to have option 2 and option 3 in principle, but the details need more discussion. |
| QC | Option 2 and Option 3 (both PTP and PTM can be configured with RLC AM mode) | Option 1 means UE should be capable of dual Rx and DAPS support. But this option still needs data forwarding support as well. Baseline should be R15 loss-less HO.  Like MediaTek commented, Option 2 is at NW side and Option 3 is from UE side. In order to support loss-less HO, both are needed. Based on NW implementation target gNB may be serving Multicast PDCP SN either ahead or delayed w.r.t source gNB multicast delivery and based on target gNB request source gNB should be able to forward multicast data to target gNB. As gNB implementation, it can store successfully delivered multicast PDCP SNs to facilitate re-transmission for handover UEs.  Our understanding is multiple gNBs PDCP SNs need to be synchronized, which we commented for Q2 response. |
| Ericsson | Option 2 | The baseline for 5MBS⇔5MBS multicast mobility should be “no data forwarding”, assuming that the 5MBS bearer is already established in the target when the UE commanded to the target. This was discussed in RAN3 and should ensure minimum interruption.  Then we think option 2 (i.e. reusing legacy data forwarding) could be added for services where the QoS requirements are high. So further discussion and study in RAN2 and RAN3 would be needed. |
| Samsung |  | We think for RLC UM data, lossless is not necessary.  We also think lossless can be achieved by legacy SN status transfer and data forwarding of unicast delivery. No enhancement is necessary. |
| Sharp |  | This should be discussed after the architecture is concluded. |
| LG | Option 2 & 3 | But, it can be discussed when proper PDCP SN handling is supported (e.g. DL PDCP SN synchronization). |
| Sony | Option 2 and 3 |  |
| BT |  | Option 1 is not acceptable as it completely depends on UE capabilities like DAPS.  For Option 2, we should first agree in point 2.1.2.  Option 3, do we expect services that requires lossless handover to be configured with RLC UM? |
| Futurewei | Option 2 | Option 2 is a generic method which can work to minimize the data loss in all different scenarios.  Option 3 is not a generic loss less method. It works but only for the MBS applications which require/allow the AM MBS bearer.  Option 1 is not a guaranteed loss less method. There is chance the leg with the source is dropped due to mobility before the data gap is filled in case the target data delivery is much advanced than the source. |
| NEC |  | I think firstly we should clarify RLC UM and AM. Secondly, we should discuss the scenarios one by one. We can’t gave the conclusion simply by giving the preference of these three options. |
| vivo | Option 2 and Option 3 with comments | As mentioned by the other companies, Option 1 might be not applicable for the low-end MBS UE.  In our understanding, for MBS services with UM characteristics, PDCP SN synchronization between neighbor cells is enough.  For MBS services with AM characteristics, it is a feasible way that UE reports PDCP status report and receives retransmitted packets via target PTP leg to achieve lossless handover.  Furthermore, with the assumption of PDCP SN synchronization and source/target cells in a common CN multicast group, data forwarding is needed only for the case where the UE joins into a new CN multicast group at the target cell. |

## Procedure of MBS to MBS handover

As mentioned above, RAN2 made the following agreement with respect to connected mode mobility with service continuity:

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| * R2 assumes that for Rel-17 NR multicast Mobility in Connected mode, handover (including variants) is the baseline, TBD exactly which variants. |

Meanwhile, RAN3#109-e had an email discussion regarding the topic of connected mode mobility with service continuity, and RAN3 made the following conclusions:

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| * RAN may request MBS session resource UP establishment, e.g. in handover (FFS). The signalling procedure (e.g. nested in handover signalling or new procedure, whether a single procedure is used or not, … ) is FFS. * WA: the UE Context to be transferred to the target gNB contains information about the MBS Session(s) the UE joined. Details are FFS. |

According to RAN2 conclusion, the existing mobility functions defined in Rel-16 handover can be reused as baseline, and this subsection is to progress the handover procedure enhancement for Mobility with service continuity, for example in [2], [7],[8], [9], [11], [13], [14],. For UEs in RRC\_CONNCETED receiving (a) Multicast session, the high level mobility procedure can be as shown in Figure2, during the mobility of the UE moving from the source gNB to the target gNB, which are both support MBS:



**Figure 2: High level procedure of inter-gNB handover for NR MBS**

### Issue 3#: Necessity of reporting interested MBS services by UE in RRC\_CONNECTED state

As in illustrated in [2] [8], in LTE SC-PTM and eMBMS, in order to support service continuity during handover, when UE is interested to receive or receiving broadcast service(s) it sends RRC MBMS interest indication message to eNB indicating broadcast service(s) UE is interested to receive, service area Information, frequencies supporting the services as assistance information for eNB to handover the UE to the correct neighbouring cell(s) supporting the MBMS services if possible. However, in case of Rel-17 NR Multicast service, UE is expected to join multicast session by using either NAS session management based mechanism or IGMP user plane based method, which requires UE to establish RRC Connection. Both 5GC and NR RAN knows which multicast services the UE is interested in. This means to support NR multicast service continuity during handover, there is no need for multicast UE to send LTE-like MBMS interest indication to gNB, which indicates MBS service(s) UE is interested to receive.

On the other hand, other companies, e.g., as mentioned in [9], they think that it will bring benefit to allow the UE to report and update its interested or receiving MBS service(s) to its Pcell/Spcell upon change of interest/session/permission. Furthermore, priority information between MBS service(s) and unicast service(s) can also be reported by UE for the case where MBS service and unicast service cannot be supported simultaneously.

**Question 4: Companies are requested to express your position on the necessity of reporting interested MBS services by UE in RRC\_CONNECTED state to NG-RAN.**

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| --- | --- | --- |
| **Company** | **YES/NO** | **Comment / alternative proposal** |
| CMCC | No | In case of Rel-17 NR MBS service, UE is expected to join multicast session by using either NAS session management based mechanism or IGMP user plane based method which requires UE to enter into RRC Connection firstly. Both 5GC and NR RAN are aware of which multicast services the UE is interested in. |
| Mediatek | No | UE doesn’t need to report interested MBS services for service continuity during HO. |
| Huawei, HiSilicon | No for Multicast, Yes for Broadcast | If the gNB knows which MBS services the UE is receiving, the gNB can select a dedicated UE configuration which, according to UE capability, allows reception of PTM bearers.  Otherwise, PTM bearers may be transmitted in frequency locations that the UE cannot receive due to reception of other frequency locations for PTP bearers for non-MBS services.  For multicast, we agree with CMCC that the gNB can be aware of the information about the MBS services of interest from the CN. For broadcast, the CN does not know in which MBS services the UE is interested in. In LTE MBMS/SC-PTM, according to assumptions on UE capabilities, reporting LTE frequency of MBMS services of interest was considered sufficient, although it was realised later that in some cases UE capabilities could actually be exceeded.  For NR, to avoid any issue, we suggest that the UE reports MBS services of interest. |
| CATT | Yes | Reporting UE interest is needed at least for some use cases, for example, for broadcast services, join procedure is not needed, CN and RAN is not aware of UE interest. For UE which is receiving broadcast services in connected mode, it should report interest to NG-RAN. then NG-RAN can prioritize to handover UE to cell supporting the ongoing MBS services . |
| Kyocera | Yes | In the last RAN plenary, it was decided to keep the broadcast services in Rel-17 NR MBS as in RP-202086, which is aligned with SA plenary’s conclusion as in SP-200884. In addition, we also think the dynamic reporting of UE’s interests is beneficial as mentioned in [9]. So, we still think MII is useful at least for these purposes. |
| OPPO | No for Multicast, Yes for Broadcast | For multicast, the UE context will include the MBS service and the UE context will be forwarded to the target.  For broadcast, it is necessary as LTE did. |
| Lenovo, Motorola Mobility | No | The NG-RAN nodes have already known the information from core network e.g. during MBS Join or MBS Session Management procedures.  The end-to end procedure for broadcast is FFS. |
| QC | No for Multicast  Yes for Broadcast | For multicast, agree with CMCC view and there is no need for UE to report MBS Interest Indication.  For Broadcast, similar to LTE SC-PTM broadcast service, UE need to report MBMS Interest Indication for service continuity. |
| Ericsson | No | As explained by others, there is no need for the UE to send any indications, at least not for multicast services.  On broadcast services, we think RAN2 could wait for SA2 to progress more. For example, if the UE would only signal interest indication for broadcast services, then there needs to be a distinction between these two "service types" known to the UE. Does this imply that multicast/broadcast is a characteristic of the service and not the distribution method in RAN? We think this framework has not been developed by SA2 yet, and hence RAN2 should postpone that discussion and let SA2 conclude.  Note, that RAN3 already agreed to not include any “counting” procedures on their interfaces. |
| Samsung | Yes | We think interest indication seems beneficial. It would not just reflect whether UE joined the service but also assist network in case UE capabilities restrict simultaneous reception of MBS (PTM) and unicast. I.e. so network can set a configuration that ensures UE can receive the service(s) it prioritises most. |
| Sharp | Yes | AS other companies say, interest indication will be necessary at least for broadcast services. |
| LG | Yes | For broadcast reception, UE is not expected to have a NAS procedure to join the session, so UE still needs to report the MBS interest indication to network for service continuity in RRC\_CONNECTED. |
| Sony | No for multicast and Yes for Broadcast | Agree with others regarding the need of MII for broadcast services |
| Futurewei | No for multicast and Yes for Broadcast in initial cell | Agree with HW and QC’s point. It appears even for broadcast, only to the cell which the UE initial accesses, reporting interest is needed. Later on, as long as a new serving cell is connected by handover, the UE’s MBS interest should be known from the UE context. For the lossless HO the only thing the UE needed is the bearer information of this MBS service at the target. The UE context serves as information request should be delivered to the target by HO request from the source cell. |
| NEC | Yes | RAN should be aware of the UE interests. |
| vivo | Yes | In the previous RAN plenary, RAN replied an LS to SA2 to confirm that broadcast is also supported in R17 MBS. Based on that, we think MBS services interesting report is needed due to the following reasons:  1. For broadcast, there is no joining procedure, UE should report its newest MBS services interesting information to its serving cell;  2. Priority information between MBS service(s) and unicast service(s) and capability information of multi-receiving can also be reported by UE for the case where MBS service and unicast service cannot be supported simultaneously;  3. Since SA2 is also in the SI stage, many solutions are on the table. The join procedure is not sure to always guarantee gNB to acquire UE’s newest interesting information, e.g. initially joining and/or reporting with any interest change.  Therefore, we suggest that the UE reports MBS interested information. |

### Issue 4#: Necessity of forward the information of supported MBS/ongoing MBS/interested MBS service information of UE to the target by Source

In LTE MBMS, for handover preparation, the source eNB forwards the MBMS interest of the UE, if available, to the target eNB, while in NR, based on the SA2 discussion, the source gNB may know the multicast service information, which is received by UE in RRC-CONNECTED state. With this information, it could be helpful for the target node to perform access control or decide the transmission mode. Therefore, in NR MBS handover, it’s better for the source node to transfer on-going or interested MBS service information to target node, if possible. Of course, RAN3 should be involved together with RAN2 to develop a unified solution addressing the mobility issue for the connected mode UE.

**Question 5: Do you agree that the source gNB is allowed to forward the information of supported MBS/ongoing MBS/interested MBS service information to the target gNB?**

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| --- | --- | --- |
| **Company** | **YES/NO** | **Comment / alternative proposal** |
| CMCC | Yes | Carry the on-going or interested MBS service information during the handover request message could help the target node perform access control odecide the transmission mode. And RAN3 had achieved the working assumption that the UE Context to be transferred to the target gNB contains information about the MBS Session(s) the UE joined. |
| Mediatek | Yes | In order to support the service continuity, the source node needs to transfer the information related to the interested MBS service to the target node in HQ request, and then the target node responds HO request ACK carrying the configuration for the MBS service, which is delivered to UE through HO command. |
| Huawei, HiSilicon | Yes | RAN3 has agreed that *“- Xn Handover Request and the NG Handover Request message should contain MBS context information for the UE”*. |
| CATT | Yes | Agree with Huawei, RAN3 already concluded it. |
| Kyocera | Yes | RAN3 agreed that “*WA: the UE Context to be transferred to the target gNB contains information about the MBS Session(s) the UE joined.*” We assume the *UE Context* would include the MBS sessions of UE’s interest etc., specifically MII as same with LTE eMBMS. |
| OPPO | Yes | It aligns with RAN3 agreements. |
| Lenovo, Motorola Mobility | Yes | Follow RAN3’s agreements in RAN3#109e:   * Xn Handover Request and the NG Handover Request message should contain MBS context information for the UE * The MBS configuration decided at target gNB is sent to the UE via the source gNB (details e.g. RRC container etc. pending RAN2 progress) |
| QC | Yes | Agree with CMCC, Huawei, MediaTek |
| Ericsson | Yes | It should be part of the UE context and the topic is within RAN3 realm, which agreed that “Xn Handover Request and NG Handover Request message should contain MBS context information of the UE.” |
| Samsung | Yes |  |
| Sharp | Yes | We are fine to align with RAN3 agreement. |
| LG | Yes | The information about the interested MBS service should be delivered to target gNB, as in LTE. |
| Sony | Yes | We are fine to align with RAN3 agreement |
| BT | Yes | RAN2 should align with RAN3 agreement |
| Futurewei | Yes |  |
| NEC | Yes |  |
| vivo | Yes | Forwarding MBS interested information to the target is useful for admission control/decision and the MBS configuration quick acquisition from the target. |

### Issue 5#: Necessity of delivery the MBS bearer configuration of the target cell to UE via source cell during handover

In SC-PTM, there were discussions that SC-PTM control info of the target cell could be provided to the UE by handover command to minimize the service interruption time. For MBS in NR, we should reconsider whether to deliver the MBS bearer configuration to the UE by RRC signaling due to the new requirement and new architecture.

**Question 6: Do you agree that the MBS bearer configuration of the target cell can be delivered by source cell to UE in RRC Reconfiguration message?**

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| --- | --- | --- |
| **Company** | **YES/NO** | **Comment / alternative proposal** |
| CMCC | Yes | This enhancement allows the UE to be able to continue receiving ongoing MBS service(s) in a new cell/gNB, without the phase of acquisition of the MBS configuration upon accessing the new cell/gNB, which can effectively reduce the interruption time. |
| Mediatek | Yes | In order to support service continuity during HO, the MBS bearer configuration of the target cell should be delivered to the UE through HO command. |
| Huawei, HiSilicon | Yes | RAN3 has agreed “*- The MBS configuration decided at target gNB is sent to the UE via the source gNB (details e.g. RRC container etc. pending RAN2 progress)*.”  The RRC signaling can be delivered in the exactly the same way as for the handover, i.e. it would be part of RRCReconfiguration. |
| CATT | Yes | Agree with Huawei, RAN3 already concluded it. |
| Kyocera | Yes | We think this is the basis of service continuity in Connected mode mobility, and RAN3 already agreed that “*The MBS configuration decided at target gNB is sent to the UE via the source gNB (details e.g. RRC container etc. pending RAN2 progress)*”. Otherwise, the UE needs to be reconfigured with MBS bearers in the target cell after handover completion, which causes service interruption. |
| OPPO | Yes | It aligns with RAN3. |
| Lenovo, Motorola Mobility | Yes | Follow RAN3’s agreements in RAN3#109e:   * Xn Handover Request and the NG Handover Request message should contain MBS context information for the UE * The MBS configuration decided at target gNB is sent to the UE via the source gNB (details e.g. RRC container etc. pending RAN2 progress)   The MBS context information should include the RRC MBS bearer configuration. |
| QC | Yes | Agree with Huawei and MediaTek |
| Ericsson | Yes | This seems most aligned to RAN3’s view. |
| Samsung | Yes | To minimize interruption time, RRC Reconfiguration needs to include target cell’s MBS bearer configuration. |
| Sharp | Yes | We are fine to align with RAN3 agreement. |
| LG | Yes | The MRB configuration of the target cell should be included in the handover command, like DRB configuration. |
| Sony | Yes |  |
| BT | Yes | RAN2 should align with RAN3 agreement |
| Futurewei | Yes |  |
| NEC | Yes |  |
| vivo | Yes | Similarly to the legacy handover procedure, unicast configuration and SIB information of the target can be carried in the handover command signaling. |

### Issue 6#: MBS capable NG-RAN node can request the establishment of the N3 multicast tunnel

If there’s no MBS session in the target node, when and which entity trigger the MBS session establishment should be taken into consideration. For example, RAN triggers the MBS session establishment. The target node could trigger the procedure after it receives the handover request with the service information that UE is receiving or interested in as soon as possible, while the other way is the core network entities, such as UPF or SMF triggers the procedure. Compared the two kinds of method, RAN triggering approach has the advantage that the MBS session may early be prepared for UE, which may help to improve the robustness of handover and avoid extra handover delay due to MBS session establishment. Meanwhile, as discussed in [8], MBS capable NG-RAN node can request the establishment of the N3 multicast tunnel according to the solutions agreed in SA2 SI for MBS. If MBS session could be established on demand in NG-RAN, NG-RAN/5GC can request N3 multicast tunnel establishment or MBS session resource setup towards the target RAN, thereby enabling multicast transport. With this mechanism, RAN3 impact such as impact to NG, Xn interface could be expected. Though we may also need to investigate the potential impact to RAN2.

**Question 7: Companies are requested to indicate your view on whether MBS capable NG-RAN node can request the establishment of the N3 multicast tunnel and if required, corresponding potential** **RAN2 impact on mobility with service continuity based on the assumption that N3 multicast tunnel could be established on demand in MBS capable target cell.**

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| **Company** | **YES/NO** | **Comment / alternative proposal** |
| CMCC | Yes | Target node triggering approach may help to improve the robustness of handover and avoid extra handover delay due to MBS session establishment. |
| Huawei, HiSilicon | Up to RAN3 | We suggest to discuss this issue in RAN3, given that there has been a discussion there, and they already made some agreement as below:  *- MBS session resource establishment is requested by 5GC (similarly to the PDU session establishment for unicast).*  *- RAN may request MBS session resource UP establishment, e.g. in handover (FFS). The signaling procedure (e.g. nested in handover signaling or new procedure, whether a single procedure is used or not) is FFS.* |
| CATT | Yes | NG-RAN node triggering the establishment of the N3 multicast tunnel on demand will provide a dynamic coverage for service such as group call.  And RAN3 has some agreement on it, as mentioned by Huawei. |
| Kyocera |  | We tend to agree with the target node triggering approach, but think it’s related to RAN3 agreement that “*RAN may request MBS session resource UP establishment, e.g. in handover (FFS).*” So, we think RAN2 should wait for RAN3’s further progress. |
| OPPO | Yes | But it is RAN3 scope. |
| Lenovo, Motorola Mobility | Yes | Follow RAN3’s working assumption:  WA: In RRC\_CONNECTED state, the MBS multicast tree is updated between the gNB and the MB-UPF at least for the first UE joining an MBS multicast session at a gNB. Similarly, the MBS multicast tree is updated between the target gNB and the MB-UPF at least for the first UE requesting an MBS multicast session and accepted into the target gNB. |
| QC | Yes | We think gNB capable of Multicast service should be able to request N3 tunnel setup during HO preparation phase if target gNB does not have established shared MBS session. As Huawei mentioned, this is under discussion by RAN3 as well. |
| Ericsson | Up to RAN3 | This topic is in RAN3’s responsibility. |
| Samsung | Yes | Agree with CMCC |
| Sharp |  | It is up to RAN3 |
| LG |  | It is entirely RAN3 scope. |
| Sony | Upto RAN3 |  |
| BT | Up to RAN3 | This is not RAN2 discussion |
| Futurewei |  | It is beneficial in certain mobility scenarios. It should be determined by RAN3. |
| NEC | Up to RAN3 |  |
| vivo |  | We think this is a RAN3 issue. |

### Issue 7#: Necessity of measurement and reporting enhancement for MBS

As mentioned in [7], existing measurement and reporting framework can be fully reused. It means that additional enhancement is not necessary.

On the other hand, as mentioned in [2], for single cell broadcast/multicast, existing measurement for unicast can be used. For MRB carried over small area SFN with a given DU, the unicast measurement does not reflect the SFN signal quality. For this case, MBS specific measurement may need to be specified and it is up to RAN1 to decide how small area SFN is to be supported as network implementation choice. The MRB configuration has to be exchanged between gNBs using non-UE specific signalling for Gnb to accurately configure MBS measurement for UE. The information is also used for target cell/Gnb selection by source for handover.

**Question 8: Do you agree to enhance the measurement configuration or/and reporting mechanism for MBS, e.g. SFN based measurement configuration and reporting?**

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| --- | --- | --- |
| **Company** | **YES/NO** | **Comment / alternative proposal** |
| CMCC | No | But, it may depend on how to support small area SFN with a given DU discussed in RAN1/RAN3. |
| Mediatek | No |  |
| Huawei, HiSilicon |  | So far we have not seen a need to enhance the measurement configuration for SFN.  SFN in this release is done within a Gnb-DU by implementation. Even if a specific DL control signal such as CSI-RS is need for SFN transmission, this can be done by the Gnb implementation to configure a specific measurement object by using the existing signaling.  Anyway, if there is any impact to specifications, this should be first discussed by RAN1. |
| CATT | No | We do not need to discuss solutions related to SFN. Because it is clearly stated in WI that no standardized support specifically for SFN. |
| Kyocera | No | We would prefer to stick with the WID that states “*No standardized support specifically for SFN, is provided in this WI. Any SFN operation is transparent to the UE, and any related synchronization is left to network implementation.*” |
| OPPO | No | Agree with Kyocera, follow WID statement. |
| Lenovo, Motorola Mobility | No | Referring to WID, any SFN operation is transparent to the UE. So, the current RRC measurement principle to measure and report cells on different frequencies looks enough. |
| QC | Yes based on further RAN1 discussion about SFN. | RAN2 can wait to discuss about need for measurement enhancements based on RAN1 discussion progress for SFN. For now, this can be FFS in RAN2. |
| Ericsson | Wait for RAN1 | RAN1 are discussing small-area SFN and RAN2 should wait for their analysis to conclude. |
| Samsung | No | For MBS service, cell-level measurement can be reused to determine cast type, i.e., PTM, PTP, and handover. From RAN2 perspective, no enhancement is needed. |
| Sharp | No |  |
| LG | No |  |
| Sony | No |  |
| BT |  | To be discussed in RAN1 |
| Futurewei | No | In general, the mobility measurement should meet the need of normal unicast services. Maybe it is sub-optimum for MBS PTM, but MBS may still need unicast assistance such as unicast signaling. So from RAN2 perspective, we don’t see it worth the effort to have MBS specific measurement for mobility. |
| NEC | No |  |
| vivo |  | In our understanding, any standardized work for SFN (e.g. SFN based measurement) is not needed according to the newest WID. For the measurement and reporting enhancement without SFN involved, RAN2 should wait for further RAN1 progress. |

### Other issues and/or enhancements need to be considered

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| **Company** | **Issues/Motivations** | **Corresponding Enhancements** |
| QC | RAN2 need to discuss about applicability of R16 CHO, DAPS HO for Multicast loss-less HO. |  |
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# **3 Conclusion**

TBD

# 4 References

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6. R2-2006827 Scenarios and Requirements for Mobility with Service Continuity MediaTek Inc. discussion
7. R2-2008061 MBS Mobility for Connected Mode UEs Samsung discussion Rel-17 NR\_MBS-Core
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12. R2-2007467 PDCP Count Value Alignment to support of Loss-less handover for 5G MBS Lenovo, Motorola Mobility discussion Rel-17
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14. R2-2007628 Mobility for NR MBS Ericsson discussion Rel-17 NR\_MBS-Core
15. R2-2007991 MBS service continuity LG Electronics Inc. discussion

# **6 Proposals in summary contribution**