**Sony3GPP TSG-RAN WG2 Meeting #113-eR2-21xxxxx**

**Online, 25th Jan – 5th Feb 2021**

**Agenda item: 8.1.1**

**Source: Chairman (Mediatek Inc)**

**Title: [Offline-038][MBS] UP Architecture Desicions**

**Document for: Discussion**

# 1 Introduction

This is to report the result of the following email discussion.

* [AT113-e][038][MBS] UP architecture decisions (Chairman)

Scope: Gather comments to facilitate a CB to address two decisions: A) on L2 ARQ for PTM, B) for PTM PTP switch, which layer to be the anchor.

Intended outcome: Report with collection of comments

Deadline: Friday Jan 29 1200 UTC

The Discussion scope is to gather comments to facilitate a online CB discussion to address two decisions: A) on L2 ARQ for PTM, B) for PTM PTP switch, which layer to be the anchor.

Companies are strongly encouraged to voice their opinions here.

# 2 Contact Information

To make it easier to find the correct contact delegate in each company for potential follow-up questions, the rapporteur encourages the delegates who provide input to provide their contact information in this table:

|  |  |
| --- | --- |
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# 3 Discussion

## 3.1 Need for UP decisions

Chairman’s View:

First, pointing out the obvious: The MBS Work Item is large, there is a lot of functionality that need to be supported in RAN2, it impacts many specifications, has impact in all other group with need for work coordination. Both User Plane and Mobility is impacted which both are among the most difficult to progress topics in RAN2. Behind each alternative, also behind the seemingly “simple” alternatives, there is a lot of detailed issues that requires significant work and significant lead times to converge on.

The non-decided architecture blocks the possibility to progress many parts. Architecture = which functionality exists and where is it located (which protocol layer, which peer entity).

The current decision status is that there was a working assumption established last meeting that PTM will not support RLC-AM, and no further decision has been taken since to either overturn or confirm this. For the anchoring of PTP PTM switch there is no present decision.

It is important that RAN2 consolidates MBS user plane architectural decisions soon.

## 3.2 UP decisions

**The main two points that seems to need resolution/consolidation are the following**

*A. L2 ARQ for PTM for normal data transfer*

*B. Which layer anchors the PTM PTP switch, i.e. at PTM PTP switch which layer remains the same, (and might be responsible for service continuity).*

Both point A and B are included here because several companies indicate that they are inter-dependent,

**For A. there seems to be the following options on the table:**

A1. No L2 ARQ for PTM

A2. L2 ARQ by PDCP for PTM

A3. L2 ARQ by RLC-AM for PTM

**For B. There seems to be the following options on the table:**

B1. PDCP anchored PTM/PTP switch

B2. RLC anchored PTM/PTP Switch

Different combinations of Ax/Bx seems to be technically possible, but they seems to come with different complexity, different level of reuse and different characteristics.

## 3.3 This email discussion

The purpose of this discussion is to have opportunity to put on the table opinions and arguments of all interested companies with less time consumption.

As this is a controversial topic it seems there will not be sufficient on-line time to allow everyone to voice their opinions on-line on all these aspects. It is encouraged that companies voice their main opinions / suggestions and supporting arguments relating to the options and combination of A and B.

Similar to online debate It is furthermore encouraged that companies respond to other companies’ comments (not endlessly but maybe one round). Comments are numbered to facilitate this.

# 4 Discussion

**For A. there seems to be the following options on the table:**

A1. No L2 ARQ for PTM

A2. L2 ARQ by PDCP for PTM

A3. L2 ARQ by RLC-AM for PTM

**For B. There seems to be the following options on the table:**

B1. PDCP anchored PTM/PTP switch

B2. RLC anchored PTM/PTP Switch

|  |  |  |
| --- | --- | --- |
| **N** | **COMPANY** | **COMMENT** |
| 1 | Chairman | **My high level understanding of the proposals:**  **A1:** No L2 ARQ for PTM, UNDERSTANDING: For normal data transfer, reliability is handled by L1, HARQ, and switching from PTM to PTP if the link gets bad and vice versa. PTP could be configured different to PTM, e.g. with RLC-AM.  **A2:** L2 ARQ by PDCP for PTM, UNDERSTANDING: In addition to A1, there is possibility to have PDCP retransmission of SDUs across PTP at lost data, which could be triggered by a PDCP status report (other trigger FFS).  **A3**: L2 ARQ by RLC-AM for PTM, UNDERSTANDING: RLC-AM is adapted such that dedicated protocol control and dedicated retransmissions uses the PTP leg. RLC-AM segments are retransmitted at lost data (as normal). It is assumed possible to keep current protocol including also e.g. Poll/Ack Nack supervision and retriggering mechanisms. Further It is proposed that both PTP and PTM is one single RLC-AM protocol instance (same SN, buffer status etc) and this would bring benefits at PTP PTM switching. However, this doesn’t seem to be a core part, so for a good discussion this point could be considered FFS. A1 or A2 could be supported in addition to A3 in order to support RLC-UM.  **B1**: PDCP anchored PTM/PTP switch, UNDERSTANDING: Similar as Mobility, PDCP SN is the basis for service continuity. Receiver packet handling is anyway in PDCP, reordering duplicate handling, triggering of status report (FFS new triggers). When lost data at switch need to be recovered, transmitter can perform retransmissions of SDUs on PTP.  B1 Can work with all of the alternatives of A1 A2 A3 and requires no particular interdependency from the lower protocols (e.g. RLC AM for PTP and RLC-UM for PTM would be ok).  **B2:** RLC anchored PTM/PTP Switch, UNDERSTANDING: RLC anchored PTP PTM switch is intended for the case that both PTP and PTM is one single RLC-AM protocol instance where data lost at the switch is retransmitted as RLC-AM segments by the same protocol mechanisms as during normal data transfer.  For RLC-UM cases, B2 would not be used, in particular if RLC-AM/PTP and RLC-UM/PTM shall be supported (my understanding). |
| 2 | LG | **Summary of LG’s view**:   * A1: strong support * A2: support * A3: not support * B1: strong support * B2: not support   **A1**: We have same understanding with Chairman. Switching from PTM to PTP should be considered for high reliability because A2 and A3 cannot be as reliable as PTP because PTM should consider Ack/Nack feedbacks from multiple UEs. Either the rx and tx windows would be stuck for the worst case UE, or some of UE would suffer packet losses.  **A2**: We have same understanding with Chairman. We can re-use the MRB structure for dynamic PTM/PTP switch where there is a common PDCP and two legs for PTM and PTP. PDCP already essential functionality for retransmission and status report, and the PTP leg can provide PTM with uplink path for UL feedback and additional downlink path for retransmission. We can mainly focus on enhancement of status report triggers. We think, the main benefit of reliability enhancement of PTM is that UEs can be kept more to be served by PTM and this would increase resource efficiency.  **A3**: Although A3 could be considered for enhancing reliability of PTM, we don’t see reasons for adopting A3 rather than A2. We can enhance reliability of PTM by A2. The required functionalities for retransmission and uplink feedback are same for A2 and A3 at high level description. We think that the enhanced reliability levels which can be achieved are expected to be similar considering that PTM should consider multiple UE’s behaviours as mentioned in A1. However, A3 would require new changes which are related to essential RLC function, for example, rx/tx window management, and induce more complexity. We prefer A2 to A3 for enhancing reliability of PTM.  **B1**: We shares Chairman’s understanding. We support B1 (PDCP anchored PTM/PTP switch). We also considered that it is well-aligned with mobility procedure and it can work with A1 A2 A3 as mentioned by Chairman.  **B2**: Basically, states of the RLC entity would be different for PTM and PTP because the state for PTP is specific to the UE and the state of PTM is common for UEs of the group. Moreover, RLC mode can be different between PTM and PTP. So, we believe that PTM/PTP switching may requires full change of RLC state of the RLC entity. We think this kind of change is not desirable for an anchor entity. |
| 3 | Huawei, HiSilicon | First, many thanks to Chair to lead this offline. From rapporteur’s point of view, we really need to conclude the user plane architecture as soon as possible, as many discussions would be stuck if the architecture is not clear in both RAN2 and RAN3.  We share the same understanding with Chair on overall picture of issues and solutions on the table for the architecture discussion. Our view is summarized as below:   * A1: acceptable in Rel-17 * A2: acceptable (a simple solution only in Rel-17) * A3: not support * B1: support * B2: strong concern (not working technically for RLC UM)   **A1**: most of MBS services are video/audio, which mostly use UDP/IP and doesn’t require very high reliability (e.g. lossless). In LTE, these services are supported by eMBMS with RLC UM only without L1 feedback and retransmission. In NR, it has already been agreed that L1 HARQ would be supported for MBS, which is a significant feature to improve the reliability and efficiency for MBS delivery. Therefore, we think it should be acceptable at least for the first release of NR MBS without L2 ARQ.  **A2**: in case people have strong view to support very high reliabilities (lossless) in this release, we can accept a simple PDCP based solution. A benefit of PDCP based solution would be that retransmissions can be delivered on PTP leg, which can improve the transmission reliability.  **A3**: implementation of A3 could be simple from the UE side, but it will introduce significant complexity to the network side, as the RLC entity(ies) at the gNB need to take care of RLC contexts of multiple UEs. The transmission window management at the gNB would be extremely complicated and not possible to be specified. Someone may argue that this can be done up to gNB implementation and doesn’t need standardization, but we still need to assume what kind of gNB implementation could be when discussing if there is any problem, which would be time consuming if there is no common understanding on a gNB implementation.  **B1**: PDCP based split is already a symbol of NR, and a lot of features are now based on this architecture, e.g. duplication, CU-DU and etc, which would make the support PTP/PTM switch easier and require much less specification efforts.  **B2**: The biggest problem in option B2 is the support of RLC UM, which is most practical configuration for MBS as mentioned above. A difference in NR compared to LTE was that for RLC UM only the segmented RLC SDUs are associated RLC SNs (as in NR the re-ordering function has been moved up to PDCP). For RLC AM, each RLC SDU is associated with a SN.  The problem for RLC UM now is that if we support PTP/PTM dynamic switch, PTP scheduling should be adapted to radio links of different UEs, and the scheduled grants would be different for UEs, and for sure will be different from the PTM scheduling. As the consequence the RLC SN allocation would become different if some UEs are scheduled based on PTP and some others are based on PTM, which will make PTM UM+PTP UM not working as SNs are not aligned.  The problem has been illustrated in the following figure of our contribution R2-2101012.  cid:image001.png@01D6F412.F7C83490  Note that it is unacceptable to apply different user plane architectures for UM and AM, e.g. B1 used for UM and B2 used for AM, at least from rapporteur’s point of view, given the heavy work load of this WI already. |
| 4 | MediaTek | For L1 based reliability improvement (**A1**), we think it would be anyway needed and it is being discussed at RAN1 regardless of our discussion from High layer perspective to improve reliablity. We also think that A1 can be coupled with **B1, B2** or both of them.  For L2 based reliability improvement, we think that, PDCP based architecture may be in a better position to support PDCP anchored PTM/PTP Switch and this applies to RLC based architecture as well. Then one alternative way would be to discuss both issue A and issue B considering their combinations for L2 based reliability improvement. Then we would mainly consider the following combinations:  **A2+B1:** **PDCP based reliability improvement (split RB alike UP arch).** In addition to L1 based reliability improvement, PDCP packets can be retransmitted via PTP leg, based on PDCP status report (exact trigger is FFS). There are independent RLC entities established for PTM leg and PTP leg and they run in different mode. There is a common PDCP SN allocation for all PDCP packets of MRB (PTM and PTP). UE combines the received packets at PDCP layer based on the unified SN allocation between PTM and PTP leg (where reordering and duplicate handling are supported).  In case of dynamic switch between PTM and PTP, consistent PDCP SN is automatically supported. PDCP layer data retransmission may be supported during dynamic switch.  **A3+B2: RLC based reliability improvement (RLC AM for PTM is supported).**  In addition to L1 based reliability improvement, RLC packets can be retransmitted via PTM leg (running in RLC AM mode), based on RLC status report from multiple receiving UEs. There is only a single RLC entity for MRB, which runs in AM mode. Mechanisms needs to be defined for the transmitter to handle RLC Tx window movement based on feedback from multiple receivers RLC status reports. Mechanisms needs to be defined in order to avoid the RLC entity being stalled when lack of the feedback from one or a few UEs. UE receiver keeps the similar behaviour as unicast since there is no packet combination between PTM and PTP  In case of dynamic switch between PTM and PTP, consistent RLC SN is automatically supported. RLC layer data retransmission may be supported during dynamic switch. UE needs to combines the received packets from PTM and PTP during dynamic switch.  **Our comments on A2+B1/A3+B2:**  **A2+B1** is feasible but the PDCP SR based PDCP data retransmission basically requires the PDCP RX window movement follows the same principle as RLC ARQ window. In Addition, the triggers for PDCP SR needs to be defined and dynamic control of PDCP SR is expected comparing to legacy RRC controlled PDCP SR.  **A3+B2** is feasible but there is a need to specify new behaviour for the transmitter (at Base Station) to manage the RLC window management to avoid the Tx window stalling (However this aspect may be network implementation). Meanwhile, it seems UE side reception largely follows legacy operation.  In general, it would be helpful to understand the specs impact for the combinations before the decision. At least, the specs impact comparison between A2+B1 and A3+B2 should be clarified as below:  **Required specs impact for A2+B1**   * Enable the PDCP SR based PDCP retransmission via PTP from Tx/gNB side,which requires the PTP specific buffer for PDCP packets (maybe gNB implemention) * New triggers for PDCP status report (e.g. when t-reordering timer expires) at the UE side * Update of PDCP Rx window lower edge maintenance to wait for retransmitted PDCP packets at the UE side in order to take both original received packets and retransmitted packets into accounts( to be captured in section 5.2.2.2 of TS38.323) * Establishment of the uplink feedback channel (assuming at PDCP PTP leg) * Implicit or explicit dynamic switch signaling   **Required spec impact for A3+B2**   * Enable multiple-UE-RLC-SR based RLC retransmission via PTM and Tx window management at Tx/gNB side, which requires to avoid the Tx window stalling (maybe gNB implemention) * There is a constraint to enable PTM-PTP switch (only AM-AM can be supported) * FFS if there is any RLC impact for UE from Rx perspective * Establishment of the uplink feedback channel(assuming at RLC PTP leg) * Implicit or explicit dynamic switch signaling   **Our oberservation:** A3+B2 has the less UE impact; A2+B1 has less network impact.  **Our position:**  **(1) A1 should be supported, regardless of its coupling with B1 and/or B2**  **(2) B1 should be supported for mobility as agreed**  **(3) For L2 reliablilty improvement, we support both combinations below with A2+B1 as our priority:**   * **A2+B1 (priority)** * **A3+B2** |
| 5 | Ericsson | A1: Strong support  A2: Support  A3: Strongly not supporting  B1: Support  B2: Not support  More information can be found in our contribution R2-2101172.  **A1:** It can be assumed that support for PTM using RLC AM would entail numerous RLC status reports from multiple UEs for which a gNB would need to maintain its RLC SN transmit window operation. Ideally, RLC retransmissions would follow for each unsuccessfully transmitted RLC PDU if to fulfil the reliability. These retransmissions should anyway end up on a PTP as performance (e.g. spectral efficiency) would otherwise suffer.  If one assumes that the most common reason for lost packets are due to radio conditions specific and limited to a few particular UEs when receiving the PTM beam scheduled by G-RNTI, one can assume that a switch to a UE specific PTP beam using C-RNTI would be beneficial. Doing so, retransmitted packets are only needed for those UEs. I.e. re-transmission can be sent through unicast (PTP) RLC AM leg only. Ideally, this leads to maintained spectrum efficiency for the MBS service while increasing the reliability.  **A2:** PDCP functionality such as PDCP status reporting can be used to increase reliability. By receiving PDCP status PDU(s) from UEs, the gNB transmitting PDCP entity can detect when one or several PDCP PDUs is missing at the receiver side and initiate a retransmission of those. Currently, this mechanism is limited to HO and would need to be extended if to be used for MRBs.  If the MRB configuration for UEs combines the PTM RLC UM bearer with a PTP RLC AM bearer, it seems reasonable to equivale dynamic switches from PTM to PTP with bearer type change etc., in current functionality. As a result, it may be useful for the gNB to be able to retransmit PDCP PDU(s) after a PTM to PTP switch, where RLC AM can then be used for the PTP RLC AM bearer. By this sufficient reliability for the Multicast service can be met and the use of PDCP ARQ is made redundant for this use case. However, the need for PDCP ARQ is still there when performing handovers, like in legacy unicast. We think is it straight forward to support PDCP ARQ for the legacy use cases also for MRBs.  For dynamic switch, i.e. when a multicast service is transmitted to the UE using a unicast PTP stream with RLC AM, then there may be benefit in retransmitting PDCP PDUs already sent through PTM. This depends on what premises the switch decision is based upon, and if triggered before the detection of loss of data (e.g. HARQ failure).  **A3:** As mentioned, it can be assumed that support for PTM using RLC AM would entail numerous RLC status reports from multiple UEs for which a gNB would need to maintain its RLC SN transmit window operation. Ideally, RLC retransmissions would follow for each unsuccessfully transmitted RLC PDU if to fulfil the reliability.  Related to A2, we think that in case of packet losses on PTM despite of HARQ, PDCP status reports can provide the gNB with sufficient information to be able to retransmit a PDCP PDU as part of the PTM to PTP switch, after where RLC AM can be used for the PTP RLC bearer.  **B1:** A PDCP anchored switch fits well with the split-bearer design and is also already supported for mobility. This will alleviate RAN2 of extra design work.  **B2:** We want the RLC mode to be different in the two legs (PTP and PTM). We don’t understand how to achieve this with an RLC anchored design with reasonable complexity. |
| 6 | Futurewei | **A1:** With the same considerations to have two types of DRB (RLC-AM bearer and RLC-UM bearer), there should be two types of MRB, with and without L2 retransmission. If a bearer type with L2 retransmission is configured for MRB, then retransmission should be performed when transmission failure of PDCP/RLC PDU is detected.  A clarification question on **Chairman’s comment** – “switching from PTM to PTP if the link gets bad and vice versa. PTP could be configured different to PTM, e.g. with RLC-AM” – “switching from PTM to PTP” refers to dynamic switch from PTM leg to PTP leg of a (split bearer like) MRB, right? If PTP is a separate DRB, it is about bearer type change and should be done through RRC reconfiguration. But if UE is already configured with PTM leg, and actively monitoring and receiving data from PTM leg, it would - more often than not - receive transmissions over PTM, wouldn’t it be beneficial to take advantage of those transmissions? After all, the benefit of L2 retransmission – compared to PDCP duplication or blind bundling/repetition - comes from the opportunistic success of the initial transmission.  Hence, if a MRB is of the type requiring L2 retransmission, it doesn’t seem sensible to assume that no transmission over PTM can be received by a UE, or L2 retransmission can’t be done for those transmissions of PDCP/RLC PDU over PTM leg.  **A2:** As analysed in R2-2100354, significant specification change would be needed to PDCP operation for PDCP status report triggering and management of receiving window. These changes basically replicate RLC functionalities at PDCP sublayer, with inferior performance due to additional delay over front-haul between DU and CU and always retransmitting the whole PDCP PDU (vs. only the lost segment in RLC). Furthermore, a new type of PDCP (MRB PDCP) also makes bearer type configuration and mobility complicated –   * An MRB of MRB PDCP+PTM UM+PTP AM means there’d be two loops of L2 retransmission at RLC sublayer and PDCP sublayer, and it is no clear how timers and state variables at PDCP and RLC sublayers can be configured and managed to avoid the intertwining of PDCP retransmission and RLC retransmission – (n+1)th retransmission of a PDCP PDU starts when RLC still performs retransmission on the n-th transmission of a PDCP PDU. * An MRB of MRB PDCP+PTM UM+PTP UM means there’d be two types of PTP operation for reliable transmission – MRB PDCP+RLC UM vs. (normal) PDCP+RLC AM. * An MRB of MRB PDCP (either with PTP AM or PTP UM) means the progress on mobility from RAN2#112e needs to be revisited, as RLC-AM bearer was assumed “at least PTP-PTP”, whose protocol structure is (normal) PDCP+RLC AM.   **A3:** when an MRB requiring L2 retransmission is configured, retransmission can be done over PTP leg for a transmission previously done over PTM leg at RLC sublayer. PTM differs from PTP mainly at transmitter side in terms of scheduling (transmission timing and resource). There shouldn’t be significant difference in L2 operation at UE side, as reception operation doesn’t depend on if and how other UE receives the same packet. In fact, it helps keep specs impact minimal if it is transparent to RLC/PDCP entity whether a packet is received through G-RNTI or C-RNT, as long as a common SN is used. Unlike RLC AM in DRB, RLC transmitter is always at network for MRB. Hence there’d be no extra specs works for transmitter of MRB RLC AM entity. There is additional requirement on network implementation for PTM scheduling, which stems from the fact that one transmission needs to target at multiple UEs. The functional requirement doesn’t change if it is implemented at RLC or PDCP sublayer. That is, if retransmission is done at PDCP layer, then PDCP sublayer also needs to define a transmission window, and to move the transmission window based on the status report of all UE receiving from PTM. As scheduling is at DU (where MAC and RLC sublayers reside), handling transmission window at PDCP sublayer, which reside at CU, further incur front haul delay between CU and DU in transmission window and scheduling operation.  Comparing A2 and A3 in terms of specs impact (and UE implementation), system performance, and network implementation, there doesn’t seem to be any benefit of performing L2 retransmission at PDCP sublalyer, i.e., A2 is inferior to A3.  **B1:** PDCP anchor for PDCP PDU transmission - no **re**transmission based on PDCP status report, duplication or blind retransmission is at network discretion - which is consistent with DC and CA operation.  **B2:** RLC anchor for RLC PDU retransmission based on RLC status report, if L2 retransmission is configured, which is consistent with RLC-AM bearer. At UE side, single RLC AM receiving entity is configured for both PTM and PTP legs. At network side, separate RLC entities for PTM and PTP, as PTM and PTP transmissions may require different segmentation (e.g., common beam vs. dedicated beam).  B1 if L2 retransmission is not required, and B1+B2 if L2 retransmission is required, which is the same as DC. The fact that PTM RLC entity and PTP RLC entity are collocated at a DU in MBS enables dynamic switch between PTM/PTP RLC entities at network and single receiving RLC entity at UE to simplify UE implementation. |
| 7 | Qualcomm | * A1: not to support (not reliable) * A2: not to support (more complexity than others) * A3 strong support for PTM reliability. * B1: support for certain use cases like loss-less mobility, switching between multicast and unicast bearer in loss-less manner * B2: strong support, as baseline to support A3.   A3. L2 ARQ by RLC-AM for PTM: We strongly support this solution. This solution means, at PTM RLC level gNB can perform RLC Re-transmissions based on UE(s) RLC feedback. RLC Re-Transmissions can be either to specific UE or to a group of multicast UEs.  Refer to multi company contribution R2-2100319.  **Benefits:**   1. Leverage existing unicast RLC AM functionality as much as possible (ex: window management, status reports etc.). 2. Provide high reliability for PTM link 3. At PTM RLC level, Original RLC Tx can be multicast and re-transmission can be either multicast or unicast depending on number of UEs reporting NACKs. 4. Higher radio efficiency due to Multicast Re-Tx possible. 5. It is not always necessary to have 2 RLC entities to support L2 Re-Tx, which is more efficient for UEs L2 buffer requirements, lower processing requirement etc. 6. Less spec complexity when compared to Solution A2 (PDCP based). 7. Less overhead compared to A1 and A2 solutions. 8. RLC segmentation benefits are available and scheduler has more flexibility than A1, A2 PDCP Re-transmissions. 9. Common PDCP can still be used for switching between PTM RLC leg and PTP RLC leg, with no PDCP spec impact. 10. PTM RLC AM fits into both B1 and B2 options. PTM RLC can be configured in either AM or UM. During loss-less HO, using common PDCP associated with Multicast and Unicast RLC entities, gNB can easily switch from Multicast to unicast bearer easily.   **Issues/change needed:**   1. gNB PTM RLC AM window movement has to take RLC feedback from multiple UEs into account. Similar mechanism needed for PDCP based solution A1/A2 as well. In fact even for PTM HARQ support, L1 has to take multiple UEs’ HARQ feedback into account and decide whether to perform HARQ Re-Tx using G-RNTI or C-RNTI. If L1 can do this, there is no reason for not being able to do in L2 RLC ARQ Re-Transmission. 2. To prevent stalling of gNB RLC Tx window, based on gNB implementation taking into account max. number of RLC PDU Re-transmission, gNB has to move its Tx window. UEs which are moving out of multicast beam coverage or in worst coverage can potentially cause this RLC Tx window stall due to repeated requests. gNB can switch to unicast RLC bearer for these identified problematic UE(s) and use PTP RLC bearer for all subsequent initial and re-transmissions (i.e. using common PDCP with 2 RLC legs, each RLC leg can be activated/deactivated based on need). This prevents UEs experiencing poor radio channel quality of multicast beam from stalling gNB Tx window movement. 3. Optionally UEs’ RLC Rx window movement has to move based on network RLC Tx window status. This can be avoided as much as possible if gNB can switch poor channel condition UEs to unicast radio bearer (i.e. unicast PTP RLC associated with common PDCP entity).   Note that even in case of unicast DRB, if a RLC PDU from gNB RLC transmitter (i.e. for DL case) is re-transmitted for a max number of re-transmissions based on NACK\_SN reported by RLC STATUS PDU, then it is up to gNB implementation to handle this scenario (ex: gNB may re-configure radio bearer or release etc.). This challenge is not unique to PTM RLC AM.  All L2 re-transmissions will have additional latency and is applicable for all A1, A2, A3 solutions and even for Unicast DRB as well but A3 provides much needed robust QoS reliability.  **A1. No L2 ARQ for PTM:** We do not support this solution due to lack of reliability. Based on our understanding, PDCP performs re-transmissions by switching from PTM RLC to PTP RLC leg and PDCP uses PTM leg HARQ feedback to make PDCP level re-tx via PTP RLC leg.  Issues:   1. There is limited PTM leg reliability and is limited to PTM HARQ reliability (HARQ reliability ~2\*10^-4). 2. PDCP level re-tx (by switching from PTM RLC to PTP RLC leg) is based on PTM leg HARQ feedback from UE (i.e gNB is using cross layer interaction between HARQ and PDCP switch decision). But HARQ provides limited reliability upto 2\*10^-4 and QOS level reliability requirement is upto 10^-6 and use of HARQ feedback for L2 PDCP Re-Tx decision is not reliable (HARQ reliability ~2\*10^-4, detailed calculations are shown in response of Q5 in the Email discussion report for [Post112-e][071][MBS] UP Performance (see R2-2100322) and can not meet high reliability requirement of 10^-6) and if common PUCCH resources are used for group NACK mechanism, it is not even possible for gNB to detect which UEs are reporting NACKs. Any such switching decisions are not reliable and therefore impacts multicast service reliability. 3. Every PDCP L2 Re-Tx by switching to PTP RLC leg means all the multicast packet errors due to HARQ BLER will result in PTP RLC switching, which is not efficient due to above reliability gap between HARQ and QoS reliability. This results in increased/frequent PTP RLC switching traffic, as L2 packet errors are unavoidable on PTM leg and does not take advantage of radio efficient PTM based retransmissions. 4. Upon PDCP T\_reordering expiry, UE moves the left edge of the Rx window and delivers the PDUs to upper layers. This means, any PDCP PDU retransmissions recovered through PTP leg will be discarded due to out-of-window condition and causes loss of data. 5. UE is always configured with 2 RLC legs, which requires higher L2 buffer requirements and high processing requirements. 6. In unicast DRB, L2 RLC re-transmissions are used based on L2 RLC feedback due to robustness of L2 feedback than L1 level HARQ feedback. PTM/PTP switching based on L1 feedback is not robust mechanism and which impacts QoS reliability.   gNB PDCP Tx side has to still maintain PDCP SNs in its buffer until it successfully delivers to all multicast UEs, this is true even for A2 and for A3 (PTM RLC). This is not any additional benefit for A1.  **Benefit:** less spec work but at the expense of loss of PTM reliability and MRB reliability, Multicast radio efficiency for L2 Re-transmissions etc.  PTM to PTP RLC bearer switching (assuming common PDCP anchor) is useful for cases like certain UEs are moving out of multicast beam coverage, those UEs can be served by using UE specific radio bearer (i.e. PTP leg) mapped to unicast beam. All L1 HARQ and L2 (Re)-transmissions will use PTP leg.  A2. L2 ARQ by PDCP for PTM: We do not support this solution due to increased complexity compared to other solutions. Based on our understanding, this option means DL PDCP based PTM/PTP RLC switching is used to perform PDCP Re-Tx using PTP RLC leg and new PDCP status reporting triggers to be used to make PDCP level re-tx via PTP RLC leg.  **Issues:** Issue 1,3,4,5 mentioned above for A1 are also applicable for solution A2. Below are additional challenges/impacts.   * **Issue 1:** PDCP Rx window moves when *t\_reordering* timer expires and delivers PDCP packets to upper layers. In order to have PDCP based feedback to inform missing packets, we need to introduce new PDCP Status Reports and additional new triggers based on polling, timer expiry, number of missing PDU etc. we need to introduce new timer similar to t\_reassembly timer to trigger new status reports. Potential need of new PDCP status reports similar to RLC AM Status Report. * **Issue 2:** Current PDCP Rx window movement need to be modified similar to RLC AM window movement, otherwise any DL PDCP PDU Re-Tx will fall outside of PDCP Rx window and UE will simply discard them. This is same as duplicating RLC AM functionality into PDCP layer and adds unwanted PDCP complexity and no additional benefits compared to PTM RLC AM solution. * **Issue 3:** From gNB Tx side, PDCP still has to take multiple UEs PDCP feedback into account and make decision to re-transmit via PTP RLC leg and PDCP Tx window has to keep PDUs in its buffer until receiving ACK from multiple UEs. This effort is same at gNB whether we use PTM RLC AM or PDCP based solution. It is matter of, which layer implements. * **Issue 4:** Using PDCP based Re-Tx using PTP RLC leg, even if multiple UEs are requesting Re-Tx for same PDCP SN, it cannot perform Multicast Re-Tx to UEs (which is radio inefficient). * **Issue 5:** Using PDCP based solution, it cannot take advantage of RLC segmentation. i.e. every PDCP re-transmission has to be full PDCP PDU Re-transmission (RLC segmentation/Re-segmentation benefit is lost), which is not radio efficient. * **Issue 6:** If we introduce AM type function in PDCP, to synchronize UE Rx window with gNB PDCP Tx window, we still need to introduce mechanism about to convey PDCP Tx window movement to UEs (of course this is needed even for A3 based PTM RLC as well)   **Benefit:** No changes to RLC spec.  All these PDCP changes adds more complexity in PDCP as they are mostly duplication of RLC AM function in PDCP layer. In our view, this does not provide additional benefit compared to solution A3 (PTM RLC AM enhancement).  By taking multicast PTM performance, spec changes, efficiency into consideration, **we prefer solution A3 for PTM reliability.**  **B2. RLC anchored PTM/PTP Switch**: This is needed to support solution A3 to achieve high reliability for PTM and to meet high reliability QoS requirements. This option gives flexibility to perform PTM RLC Re-Tx to specific UE (using C-RNTI) or to multiple UEs (using G-RNTI). If gNB decides to re-transmit RLC PDUs to all multicast UEs, it is possible to use a bit in PDCCH to indicate L2 Re-Tx or using associated another G-RNTI (so that some UEs, not expecting any RLC Re-Tx can avoid processing).  **B1. PDCP anchored PTM/PTP switch**: This need to be supported for certain cases. PDCP based PTM to PTP switching is more useful to switch Multicast data transmission to unicast mode for UE(s) which have completely moved out of Multicast beam coverage and these UEs can be better served by unicast DRB associated with unicast beams and for other cases like loss-less HO requiring fallback to unicast radio bearer. But this shall not be baseline to provide L2 reliability like solution A1/A2 discussed above.  **We support B2 as primary method for PTM reliability and B1 for additional use cases.** |
| 8 | Kyocera | **A1**: We assume L2 reliability is ensured by PTP-leg after PTM🡪PTP switching, in case the PTP/PTM split bearer is configured and the PTP-leg is configured with RLC AM. The packet loss at PTM-leg and during PTM🡪PTP switching may not be recovered. The spectral efficiency is same with the legacy unicast bearer.  **A2**: We assume L2 reliability is ensured by PDCP SDU retransmission triggered by PDCP status report. It may need some ARQ-like function in PDCP, e.g., by a new trigger of PDCP status report. The spectrum efficiency is better than A1, if the PDCP SDU retransmission is done over PTM-leg; otherwise, it’s almost same with the legacy unicast bearer.  **A3**: We assume L2 reliability is ensured by the existing RLC ARQ, whereby the RLC feedback is sent over PTP-leg. The spectrum efficiency is better than A2 due to segmentation if the RLC segment retransmission is done over PTM-leg; otherwise, it’s same with legacy unicast bearer.  **B1**: We assume it’s almost same with the existing split bearer for DC. As similar to A1, it may need to consider the packet loss during PTM🡪PTP, e.g., by a new triggering condition for PDCP status report.  **B2**: We assume RLC entity is associated with PTP LCH and PTM LCH. The packet loss during PTM🡪PTP is recovered by the existing RLC ARQ.  We assume any combinations of Ax and Bx can work together, while it could be considered as good matching between A2 and B1, and between A3 and B2.  We assume RLC UM does not need high reliability in general. So, for UM type of services, we’re wondering if it really needs L2 retransmission or PTP-leg assistance (i.e., with “split bearer”). In this case, there is no significant problem if the service is just provided over PTM with RLC UM or PTP with RLC UM, i.e., relying on HARQ retransmission, without L2 retransmission and without dynamic switching.  In light of the observations above, we support A3 + B2 in terms of spectral efficiency, considering specification impacts and reliability. |
| 9 | Xiaomi | **Summary of our preference:**  A1: Acceptable  A2: Preferred  A3: Not support  B1: Preferred  B2: Not support  **Our understandings of the proposals:**  **A1:** No L2 ARQ for PTM, UNDERSTANDING: RAN2 had a long time discussion that the HARQ cannot ensure very high reliability of the transmission, and then decided to have the RLC ARQ and the PDCP duplication. I guess that in order to make the MBS more commercially successful, many operators want to make the PTM more reliable so that the PTM can carry more traffic types (not just TV as UTRAN or E-URAN). We also understand that if the PTM link gets bad, the anchor point of the gNB can switch the transmission to the PTP leg to ensure more reliable transmission. However when the transmitter is aware that the PTM link gets bad (e.g. via CSI/RSRQ/HARQ-ACK), the receiver could have already missed some packets in RLC/PDCP. Then the L2 retransmission would be needed for the normal data transmission.  **A2:** L2 ARQ by PDCP for PTM, UNDERSTANDING: The PDCP status report is via the PTP leg. The retransmission leg (e.g. via either PTP or PTM) can be left to the gNB implementation. The PDCP retransmission based on PDCP status report during the handover has already been agreed. Then the only extra standard effort would be to define new trigger conditions for the PDCP status report for the normal data transmission. For the example the PDCP status report can be triggered based on the expiry of the t-reordering or the polling from the gNB (as the LTE LWA). If we use the PDCP polling from the gNB, the PDCP polling would be much simpler than the RLC polling, as the trigger of the gNB polling transmission for the DL data is up to the gNB implementation. Other benefits are: 1) A2 seems supporting the DAPS handover (i.e. “0”ms interruption) by default. 2) A2 supports the DL PDCP duplication by default, which can provide even more reliable transmission. 3) A2 supports the lossless handover from PTP (not supporting PTM) to PTM and from PTM to PTP (not supporting PTM) when both the source link and the target link are kept during the handover.  **A3**: L2 ARQ by RLC-AM for PTM, UNDERSTANDING: A3 has the lack of supporting mobility which is a big drawback. If the PDCP retransmission via A2 is anyway needed for the handover This architecture seems redundant. RAN2 would require more standard efforts to support the RLC-AM PTM. Extra standard efforts would be: 1) two DL logical channel IDs (i.e. one for PTP and one for PTM) and one UL logical channel (i.e. for the RLC Control PDU) associated with a single RLC AM entity, which impacts RRC/RLC/MAC. 2) In order to avoid the loss of out-of-window RLC PDU, we needs to consider a solution to force the moving of the RLC receiving window, which would also cause packet loss for some UEs. Given that the RLC receiving window is push-window which can only move forward when the RLC submits RLC SDUs to the upper layer. If we do not force the moving of the RLC push-window, the UEs of bad link would slow down transmission bit rate of the PTM.  **B1**: PDCP anchored PTM/PTP switch, UNDERSTANDING: Same comments as for A2. B1 reuses the split bearer design, which cause less impact on the RRC signalling configuration and the L2 architecture.  **B2:** RLC anchored PTM/PTP Switch, UNDERSTANDING: Same comments as for B3. We understand that the RLC switch could have some benefit for the CU-DC split architecture, as the DU (which is the RLC anchor) can determine the PTP/PTM switching without the CU-DU transmission delay. However we would expect that the PTP/PTM switching would not be too frequent, as the gNB needs to count the radio conditions of multiple UEs for the PTM. |
| 10 | Lenovo, Motorola Mobility | A1: Support  A2: Not support  A3: Not support  B1: Support  B2: Not support  **The need of RLC AM for PTM:**  First of all, we agree some MBS service could require high reliability low latency, but we don’t believe MBS QoS requirement is comparable to URLLC. It is also common understanding that RAN can transmit MBS packets using either PTP or PTM leg, and PTP leg is not much different than unicast and can be configured with RLC AM. With existence of PTP leg and smart NW implementation, we believe QoS requirement of a MBS service can be fulfilled without introducing RLC AM for PTM.  Besides, we don’t want to say it’s impossible to have RLC AM for PTM, but quite some specification effort is needed to resolve e.g. RLC TX/RX window shifting, RLC status report transmission etc.  Considering 1. MBS QoS requirement can be met without RLC AM for PTM 2. Heavy specification effort is required to design RLC AM for PTM properly, we don’t think RLC AM for PTM is needed.  **PDCP anchored PTM/PTP switch:**  First of all, PDCP anchored design has been used in the legacy e.g. for duplication, from specification point of view we can reuse the legacy design as much as possible. Besides, if we assume PTM leg only supports RLC UM and PTP leg supports RLC UM and AM, it also seems a cleaner design to let PTP and PTM have their own RLC entity and anchor at PDCP.  **PDCP based retransmission via PTM:**  If PDCP anchored PTM/PTP switch is agreed, it seems straight forward to reduce the packet loss during the switch using PDCP based retransmission at least via PTP leg. For example, when a UE switches from PTP to PTM or switch from PTM to PTP, NW can retransmit missing PDCP SDUs based on PDCP status report via PTP leg.  On the other hand, we are not sure if PDCP based retransmission at PTM leg is really helpful during PTP-PTM switch. For example, assuming a UE switches from PTP to PTM and few PDCP packets are missing, if NW retransmits the missing PDCP packets via PTM, other UEs will also receive them which does seem reasonable.  Other than PTP-PTM switch scenario, we don’t think PTM PDCP retransmission on regular basis (i.e. similar as RLC AM) is necessary for the same reason that PTM RLC AM is not needed.  Based on above, we don’t think PDCP retransmission via PTM is really needed. |
| 11 | CATT | **CATT’s view:**   * A1: Baseline, should be supported * A2: Enhancement, may be supported * A3: Enhancement, should not be supported * B1: should be supported * B2: should not be supported   First of all, we’d like to clarify that our general view is that A1 is the baseline, both A2 and A3 are just enhancement.  We understand the general principle is:   * For baseline which is essential, it should be supported. * For enhancement which is not essential, the tradeoff between complexity and benefit should always be considered.   Our understanding to each solutions are below,  **A1:** **A1 is the baseline as it includes the basic functions, which is sufficient to meet reliability requirement of MBS.**  A1 include the basic functions (e.g. L1 HARQ, dynamic PTM/PTP switch, RLC AM on PTP, etc) which have already been agreed by RAN 1 and RAN2. More than that, with these functions, the QoS requirement for MBS services could be met completely. By the way, It is worth to point out again the QoS requirement for MBS services is not necessarily to be always fulfilled by PTM mode in any scenarios.  **Summary: A1 can be baseline as it can meet the reliability requirement of MBS.**  **A2: A2 is an enhancement to improve reliability of PTM, which can be implemented in a simple way**.  We agree with chairman’s understanding on A2.  There are three options to perform PDCP ARQ for PTM. The complexities of options are quite different.  A2: the PDCP status report of PTM is transmitted on UL path associated to PTP leg and the retransmission also performed on DL path associated to PTP leg.  By simply add new trigger for PDCP status report, and then reuse the existing mechanism in PDCP, reliability could be improved. So A2 is simple and effective. It is worth to mention that lossless is not aim to be achieved by A2.  A2.1: the PDCP status report of PTM is transmitted on UL path associated to PTM leg and the retransmission also performed on DL path associated to PTM leg.  A2.1 may have similar complexity (e.g. Tx window management) as A3.  A2.2: replicate all the RLC ARQ functionalities(e.g. Poll/t\_reassembly timer,etc) to PDCP sublayer  A2.2 is trying to achieve lossless by PDCP ARQ.  We observed that Some companies think A2 need similar Tx window management as A3 or need to replicate RLC functionalities (e.g. poll/ t\_reassembly timer, etc) to PDCP. It seems they are talking A2.1 or A2.2. It should be a misunderstanding to A2. Mechanism in A2.1 and A2.2 is never mentioned by chairman.  **Summary: A2 can be implemented in a simple way, so as an enhancement, whether to support it can be open for now.**  **A3**: **A3 is an enhancement to improve reliability of PTM but the complexity is unacceptable and unavoidable**.  We agree that A3 has the following complexities, which has been mentioned by companies above.   * Complexity on Tx window management based on feedback from multiple UEs. * Complexity on efficient retransmissions based on feedback from multiple UEs. * Complexity on Synchronization between UE and gNB on the RLC window.   It is worth to point out that the complexities above seems unavoidable.  **Summary: A3 is complex and the complexity is unavoidable. So it should not be supported as it is just an enhancement.**  **B1**: we agree that PDCP anchored PTM/PTP switch can avoid extra design by reusing the legacy PDCP based split-bearer architecture, as already mentioned by companies above**.**  **B2:** we agree that anchored PTM/PTP Switch has the following drawback as mentioned by companies above,   * Without supporting RLC AM for PTM, RLC anchored PTM/PTP switch is not feasible. As for RLC UM, the SN is not always there and it is hard to align the RLC SN between PTM and PTP.   It will mandate PTM and PTP to use the same RLC mode. Such restriction is not what we expect as PTM and PTP is supposed to support separate RLC mode. |
| 12 | Spreadtrum | **Our views:**   * A1: strong support * A2: not support * A3: not support * B1: strong support * B2: not support   A1: The high reliability can be accomplished by PTP which has RLC AM. The gNB can also configure the PTM, PTP or PTM and PTM simultaneous transmission mode for UE according to the different QoS requirements and radio conditons.  A2: The Retransmission in PDCP via PTM will have the same questions introduced in RLC AM for PTM in A3. For the retransmission in PDCP only performed in PTP which has the RLC AM leg, we think this can be discussed in the service continuity of dynamic PTP and PTM switching issue.  A3: This solution is too complex and has some drawbacks as discussed above.  B1: B1 can reuse the split bearer design as possible, and then some features can be applied easily, e.g. PDCP duplication. It can also facilitate the support of dynamic switch between PTM and PTP.  B2: we do not support the RLCＡM for PTM in A3, then for the RLC UM PTM and RLC AM PTP case, the RLC anchored PTM/PTP Switch will have many problems, such as the lack of SN of RLC UM PDU. |
| 13 | Nokia | **Observation 1**: when both a UM leg and an AM leg are active at the same time (either B1 or B2), the challenge lies in 1) informing the TX anchor point of missing PDUs from the UM leg to retransmit them on the AM leg; and 2) if duplication occurs, informing the TX anchor point of successfully received PDUs on the UM leg to cancel possible retransmissions on the AM leg.  **Observation 2**: if truly lossless delivery to all UEs without potential stall of TX window at the anchor is needed (B1/B2), then PTP only with RLC AM should be used for all UEs.  **Observation 3**: COUNT synchronisation is required in all scenarios to ensure service continuity.  **A1**: PTM cannot guarantee lossless since errors on PTM leg (RLC UM) are not reported to the transmitter. PDCP behaviour needs to be redefined if PDCP has two RLC legs with different RLC mode. Lossless delivery can be guaranteed by using PTP only with RLC AM. In light of some of the comments above, our understanding is that this option does not preclude a handover-type of procedure to PTP and relying on existing status reports to minimise losses when switching.  **A2**: Specification of new trigger(s) of PDCP status report needed, similar TX window handling as for RLC AM needs to be specified for PDCP and bad UEs may stall the TX window. If the TX window is advanced before receiving ACK from all UEs, then this scheme does not guarantee lossless delivery to all UEs.  **A3**: In order to avoid stalling of RLC AM TX window due to bad UEs, advance of TX window has been proposed. If the TX window is advanced before receiving RLC ACK from all UEs, then this scheme does not guarantee lossless delivery to all UEs.  **B1**: PDCP behaviour needs to be redefined if PDCP has two RLC legs with different RLC mode.  **B2**: disagree that this would result into a single RLC-AM instance on the network side due to different segmentation on individual PTP legs.  In our understanding, the possible combinations are:  **A1+B1**: simplest approach, very limited changes to PDCP, no changes to RLC. PTM cannot be truly lossless. Handover type of operation between PTM (RLC UM) and PTP (RLC AM).  **A2+B1**: moving RLC-AM type of window to PDCP, duplicating functions and increasing complexity. PTM cannot always be truly lossless.  **A3+B2**: complex modifications to RLC and possible increased overhead. PTM cannot always be truly lossless.  **A3+B1**: not sure this actually excludes B2 within (for the RLC ARQ to work). |
| 13 | Intel | **Summary of Intel’s view:**  - A1: Support this for delivery mode 2, as well as for services with low latency requirement for delivery mode 1.  - A2: No support.  - A3: Support for services with requirements of high reliability and moderate latency in delivery mode 1.  - B1: Support in case of mobility.  - B2: Support for PTM/PTP switching  We have analyzed L2 ARQ aspects in contribution R2-2101049 and UP architecture in R2-2101051.  **A1:** Since delivery mode 2 can be received by RRC\_IDLE/INACTIVE UEs, it is natural that L2 ARQ is not supported. For delivery mode 1, whether to enable L2 ARQ depends on service QoS requirements. For example, for services with low latency requirements, it is expected that RLC UM is used, and L2 ARQ is not applicable.  **A2:** We don’t think it is necessary to introduce PDCP based retransmissions. To support PDCP based retransmission for PTM, similar mechanisms as RLC status report needs to be introduced. This requires standardization efforts. In addition, PDCP based retransmissions have similar gNB complexity as RLC AM for PTM (option A3), since gNB also needs to track the received status of each PDCP SDU based on aggregated PDCP status report, and decides whether to perform PDCP retransmission. Option A3 is more resource-efficient compared with Option A2 since only RLC segments not correctly received need to be retransmitted in Option A3.  **A3:** We'd like to emphasize that from air interface perspective, the main benefit of using MBS is the radio efficiency. With that in mind, for service with high reliability and moderate latency, we think RLC AM for PTM is a good way to achieve radio efficiency and high reliability simultaneously. If we always use PTP for such services, we lose the benefits of using MBS. In addition, purely relying on switching from PTM to PTP might not support services with high reliability well since there is potential physical layer error (NACK to ACK), which cannot be know by gNB if L2 feedback is not provided from UE to gNB. For complexity, we think unicast RLC AM can be mostly reused, with gNB implementation taking care of the aggregated status report.  **B1:** We think PDCP based anchoring is anyway needed in mobility, as already agreed in last meeting. Note that in our view, PDCP based anchoring can be implemented either with two RLC entities, or with a single RLC entity, as discussed in Option B2 below.  **B2:** Our main motivation to propose B2 is to have single RLC entity to minimize complexity of L2 architecture as well as UE complexity and cost. With single RLC entity, of course RLC mode for PTP and PTM should be the same, as Chairman pointed out. We doubt the necessity of configuring different RLC modes for the same MRB. RLC mode is chosen based on QoS requirements. For the same MRB/service, it is questionable why different RLC modes should be supported. Currently in NR packet duplication, for a bearer associated with multiple RLC entities, “All RLC entities have the same RLC mode” as from TS 38.300 clause 16.1.3.  Regarding Huawei’s comment on RLC UM, our understanding is that gNB implementation can maintain a consistent RLC SN allocation for RLC SDU segments (e.g. state variable TX\_Next is maintained per MRB, instead of PTM and PTP leg(s) separately) to avoid wrong reassembly. |
| 14 | Sony | A1: Support  A2: Either A2 or A3 should be supported  A3: Either A2 or A3 should be supported  B1: Support as baseline  B2: discussed if time permits  A1: We believe A1 is sufficient for some use cases but not for all use cases. Either A2 or A3 is required in addition, for multicast or delivery mode 1 and even for PTM. A1 is sufficient from RAN2 point of view for delivery mode 2.  A2/A3: We have no strong preference. But acknowledge that RLC-AM for PTM might be complex for the network. At the same time, PDCP Status report enhanced for LTE-LWA could be the baseline.  B1: We think PDCP anchored PTP-PTM switch should be the baseline  B2: RLC based can be studied further if time permits. |
| 15 | FirstNet | A1: Not support  A2: Not support  A3: Strong support  B1: Support (for mobility)  B2: Strong support for MBS  A1-We think at PDCP level, switching from PTM to PTP leg, based on HARQ feedback received from the PTM leg, is not reliable.  If every PDCP retransmission is going to use PTP leg that will significantly reduce the radio efficiency defeating the purpose multicast for efficient use of spectrum.  A2-The only difference from A1 is that PDCP feedback introduction that requires RLC-AM type of functionality in PDCP. We prefer to keep the AM functionality in RLC layer instead of duplicating it in PDCP.  A3- This option, requires an enhancement to existing RLC-AM functionality while providing higher reliability with L2 retransmission on top of L1 HARQ. From the network point of view, this option provides higher reliability while retaining efficient use of valuable spectrum.  B1: Appears to support mobility services  B2- This option appears to maintain one RLC entity that supports both multicast and unicast. |
| 16 | Convida | * A1: not support * A2: support (preferred) * A3: support * B1: support * B2: not support   A1: If the A1 option is just L1 HARQ, then this is not suitable for high reliability MBS services. The QoS requirements for MBS sessions are expected to be similar to those of PDU sessions. For the latter case (PDU sessions), RAN2 has already decided that L1 HARQ alone, is not enough to meet stringent reliability requirements.  If the A1 option includes dynamic switching from PTM to PTP, our concern is that it is still unclear if this will be supported by (or enabled for) all UEs. Furthermore, although dynamic switching may address the reliability requirement, one can argue that to enable this, a form of L2 ARQ is needed to at least inform the gNB of the missing PDUs so that these can be transmitted.  As a result, our view is that a L2 ARQ mechanism is needed for high reliability MBS services.  A2: A form of this is already supported for lossless handover. The question is whether this should be implemented during normal data transmission as well, which would require new functionality to implement the procedure. In our view, we do not see the necessity to limit the retransmission to a PTP leg. Depending on the number of UEs requiring retransmissions, the channel conditions to these UEs, and the capability of these UEs, the retransmission could be over a PTM leg.  A3: The advantages are expected to be similar to A2, but with additional functionality in the RLC layer to handle the multiple RLC status reports from multiple UEs and deal with the potential window issues.  B1: This is aligned with the split-bearer architecture and already well understood based on its use for DC and duplication  B2: We agree with the arguments by some companies that there are some benefits over option B1. However, option B2 is well understood, and may be needed regardless to support mobility. |
| 17 | OPPO | * A1: not support * A2: support (A2 or A3, no strong view) * A3: support (A2 or A3, no strong view) * B1: strong support * B2: not support   In NR, only AM mode RLC will indicate PDCP about the successful delivery of the RLC SDU. So only for AM RLC, the PDCP will know the PDCP PDU of successful delivery or not. For UM RLC, the PDCP does not know it. For PTM transmission, the gNB RLC does not know if the data is received successfully or not due to no RLC feedback.  In the case that the PTP and PTM shared one common PDCP, if the PTP RLC is configured as RLC AM, the PTP RLC only can ensure the data reliability when the gNB switches PTM to PTP. During PTM transmission, the reliability cannot be guaranteed due to the dynamic PTP and PTM switching in gNB. Some person may think network should ensure there is no dynamic switching between PTM and PTM for the UE if PTP is configured with AM RLC. However, the common PDCP will maintain all the UE’s PDCP PDU delivery status. It is too complex for the PDCP.  **🡺A1 cannot ensure lossless requirement if dynamic switching between PTM and PTP is supported even if PTP is configured with RLC AM.**  For A2, it is complex for the RLC in gNB side, because the RLC will receive multiple UE’s RLC feedback to maintain the RLC transmission window. However, PTM can be used for the MBS service with data lossless requirement.  For A3, it is complex for the PDCP in gNB side, because the PDCP will receive multiple UE’s PDCP feedback to maintain the PDCP transmission window. And it is also complex for the PDCP in UE side, because UE will support PDCP feedback. However, PTM can be used for the MBS service with data lossless requirement.  **🡺The complexity is similar for A2 and A3.**  For B1 and B2, we have no strong view. however, we think we should also consider common MAC architecture if RAN1 confirm PTP is used for retransmission for PTM. |
| 18 | Samsung | A1. Support  A2. Support only for mobility  A3. Strongly not support  B1. Acceptable/Support  B2. Not support  **A1 vs A3:** PTP-AM is not necessary due to the following reasons:  - L1 HARQ can support sufficiently high reliability by robust MCS and retransmissions.  - Bundling can increase reliability dramatically without HARQ feedback error.  - If NW thinks L2 ARQ is needed, PTP RLC can be used. There is no critical reason why RLC AM is needed for PTM RLC.  -NW can performs duplicate transmission via both PTP RLC and PTM RLC.  - Even without PTP RLC, gNB can transmit duplicate packets for PTM RLC for additional reliability without feedback.  - RLC AM for PTM is totally new. Considering the scope of this WI, it would be better not to repeat the discussion.  **A2:** In unicast, PDCP retransmission is supported only for mobility cases and AM bearer. Our preference is to align multicast with unicast as much as possible.  - If PTP-AM is supported, then L2 ARQ in PTP leg will work. Then, PDCP retransmission will be redundant.  - Assuming PTM-UM, there is no need to support retransmission for UM bearer. In other words, PDCP retransmission for UM bearer is not necessary.  **B1 vs B2:** PDCP switching is much simpler than RLC switching.  - Assuming PTM-UM, RLC switching will not work or need huge modification of UM PDU format. In RLC UM, only segmented PDU has its SN. If we allow the switching and retransmission, PTM shall support either AM or new mode. Otherwise, UM split-like bearer is almost useless. |
| 19 | Sharp | A1: Support  A2: Support  A3: Not support  B1: Support  B2: Not support  **Reason:**  **A1:** This is necessary especially for real-time services.  **A2:** This needs to be supported for data loss sensitive service. We assume (and prefer) that only RLC UM is supported for PTM and PDCP is anchor for PTM/PTP (i.e., B1). In order to achieve loss less, PDCP status report based re-transmission by PTP would be simple approach. We also think PDCP status report based re-transmission by PTP should be supported even if RLC UM is configured for PTP.  **A3:** A3 would work only with B2. However we prefer to support B1 only in Rel-17, because:  - If we consider Rel-17 timeline, we should select either B1 or B2.  - As A1 is mandatory to be supported, we have to select at least RLC UM for PTM which is only supported by B1.  - We think the architecture that RLC UM for PTM and RLC AM for PTP is really a resource efficient way for the scenario that most of the UEs are in good radio condition, in which feedback and retransmission can be performed on RLC AM for PTP only for those UEs in bad radio condition.  **B1, B2:** The reason is mentioned in A3 |
| 20 | APT | In general, we share the same understanding with Chair on each identified proposal. Please find APT’s view below.  APT’s view:   * A1: strong support * A2: support * A3: not support * B1: strong support * B2: not support   We strongly support having no L2 ARQ for PTM (A1). The reason of having A1 is because most MBS services do not require very high reliability. Moreover, RAN1 has already started discussing about L1 feedback and retransmission mechanisms for MBS services. In this sense, for most MBS services, the reliability requirement could have been satisfied with L1 feedback and retransmission mechanisms. For example, if the data transmitted on the PTM leg is not received by a UE, the UE could receive L1 retransmission on the PTP leg after leg switching.  For certain MBS services that would require exceptionally high reliability (if identified), A2 could be adopted. With A2, the UE could send a PDCP status report when certain conditions are met in order to provide the network information related to the missing PDCP PDUs. The missing PDCP PDU could then be retransmitted, by the network, after receiving the PDCP status report. Our understanding is that L2 ARQ by PDCP for PTM can work along with the L1 feedback and retransmission mechanism to further improve the reliability.  The reason to not support A3 is due to the complexity introduced at the gNB side, e.g., the transmission window operation.  Regarding the architecture for PTP/PTM switch, we would like to support PDCP anchored PTP PTM switch (B1). The reason is that some existing mechanisms have already been introduced based on this architecture, e.g., split bearer for DC, PDCP duplication, etc. Hence, the specification impact of B1 would be much less than B2. |
| 20 | ZTE | We appreciate Chair's efforts and insights on the status quo. Our preference is as below (note: no solution is wrong, but all is about choices with compromises):  // for L2 ARQ  A1: Support  A2: FFS  A3: NOT Support  // for mode switch  B1: Support  B2: NOT support  Please note that when we are talking about both standardizing solutions and network implementations, we can never neglect the complexity in the standardized solution & implementation (and resulted in possible delay in the scheduling of the work item), although most of the time the intentions are good.  # Complexity for solution A3:  - management to the movement of RLC Tx Window, i.e., the state variable needs to be updated according to the RLC status report.  - management to the movement of RLC Rx Window which needs to be synced under the control of gNB.  - gNB needs to receive numerous RLC status report from all UEs, especially in the cases of UE receiving in the PTM manner, which is usually a compromised way (less sufficient channel adaptation compared to PTP).  - dynamic group management for the PTM transmission in AM mode (i.e., network has to determine who is in which PTM transmission group or sub-group, and who will get his PTP reception). Assume one PTM group will be maintained by network to achieve an optimized balance between efficiency and reliability, UEs who is lagging behind or gets stalled on the reception windows will be kicked out of the group ideally. Although one won't expect this happen frequently considering the anticipated signaling overhead, but this could be the case in real implementation. The signaling overhead and group management delay will erase part of the gain we can get from PTM transmission in AM.  - standardization efforts (e.g., one RLC entity has to be associated to two logical channels; - introduce mechanisms about to convey RLC Tx window movement to UEs, impacting UP protocol and the UE behavior, etc.. which all can be easily realized by existing standard)  Of course we admit that there will be gain that can be obtained from some kind of "smart implementation", however the efforts needed to achieve this will be challenging, especially from vendors' perspective.  # Reason not to have B2 as the mode switch solution:  - B2 asks for the same segmentation from the same RLC entity for all the PTM or PTP delivery in the same cell or same DU, which is going to be a huge impact to the existing scheduling mechanism for network. In conventional scheduling, the segmentation is based on per UE channel status, but now it has to be based on all the per UE which is in PTP & per group which is for all UEs in the PTM group. This simply is not scalable in real network implementation and thus not acceptable. A more scalable solution shall allow independent scheduling/RLC segmentation for distinctively different channel condition of the UEs or UE groups.  - For UEs interested with the same MBS session in one gNB but served by different gNB-DU hence different RLC instances, the user plane architecture falls back to PDCP as the anchor layer.  Meanwhile, B1 (PDCP as the anchor layer) as many companies suggested, it just fits into current NR L2 architecture, and has been proved working well in mobility, DC, CU/DU split cases to support packet data handling including SN continuity, re-ordering, duplication discarding, and lossless feature. We see no reason not to adopt B1 as the solution, i.e., PDCP as the anchor layer in PTM/PTP switch to benefit from the above existing specification efforts/features. |
| 21 | Fujitsu | A1: Support  A2: Not support  A3: Not support  B1: Support  B2: Not support  **A1**: The high reliable service should be served by PTP.  **A2:**  PDCP protocol has been developed for PTP communications. There could be some protocol implications to be checked e.g. PDCP status reporting, exact timing of missing data retransmissions.  **A3**: RLC protocol has been developed for PTP communications. If it is applied to PTM transmission, there are many protocol implications to be checked e.g. RLC status reporting, failure handling, windowing, parameter configurations.  **B1**: PDCP anchored is straightforward since it has been already feasible according to DC split bearer.  **B2**: This seems to require RLC mode switch (AM <=> UM). Then there seems to be many implications to be considered in case of switching e.g. RLC status report handling, ARQ handling, windowing, parameter configurations/update. |
| 22 | BT | * A1: Acceptable in Rel-17 * A2: not support * A3: support * B1: support * B2: support with A3   **A1.** With this solution, reliability provided by RLC AM is only supported with PTP and switching between PTM and PTP is limited for RLC UM. Therefore, fully reliability is limited to PTP. This can compromise the spectrum efficiency of RLC AM services for UEs that are in similar radio conditions.  **A2.** PDCP supporting L2 reliability implies that RLC AM functionalities are moved to PDCP. Problems highlighted above for A3 solution will be replicated here, i.e. rx and tx window management for PTM UEs.  **A3.** This solution ensures reliable communications at L2. New mechanisms are required in the gNB, e.g. to maintain the rx and tx windows, to ensure switching between PTP/PTM and others raised by network vendors.  **B1.** Required for mobility as pointed above by several companies  **B2.** Required to ensure L2 reliability in MBS using PTP/PTM. We share chairman views, this is required in combination with A3. |
| 23 | vivo | Our preference is given as follows,  **A1: Support**  **A2: Support**  **A3: Not support**  **B1: Support**  **B2: Not support**  **Our understandings of the proposals:**  **A1:** For MBS service with high-reliability requirements, PTP is supposed to be configured for a specific UE (i.e. reliability can be guaranteed by L1/L2 feedback and re-transmission), which is similar to the legacy unicast DRB. For normal data transfer, there is no need to introduce extra enhancement to support L2 ARQ for PTM.  **A2:** During PTP/PTM switching, some packets in the air may not be received successfully by UE. PDCP re-transmission based on PDCP status report is an efficient method to realize lossless switching. As RAN2 has agreed that PDCP re-transmission based PDCP status report is supported for handover case, it is not difficult to extend it to PTP/PTM switching case. From our understanding, the main enhancement is that new trigger for PDCP status report should be introduced. Considering that the PDCP status report for DAPS handover with UM Mode has been supported, for PTP/PTM switching case RAN2 can take specification work in mobility WI as reference. Anyway, we think the specification effort is limited.  **A3**: Firstly, to support RLC AM for PTM, a new split architecture with common RLC entity needs to be introduced. Secondly, for RLC AM of PTM, gNB should configure dedicated UL RLC channel associated to the DL PTM RLC channel for each UE and has to gather all RLC feedbacks from all UEs in the group to support lossless transmission for RLC AM. Consequently, we need to research how to maintain the related RLC variables and guarantee consecutive SNs and how to handle the status report from group of UEs. Compared with the huge specification impacts, the benefit brought by introducing RLC-AM for PTM is not much attractive.  **B1**: In-order delivery/duplicate handling/retransmission is performed in PDCP layer. Thus, PDCP is the best choice to be the anchor to realize service continuity during handover and lossless PTP/PTM switching. Moreover, PDCP anchored PTP/PTM switch reuses the architecture of the split bearer and is easy to realize dynamical switching, which has less spec impacts.  **B2:** Firstly, our understanding is that RLC anchored PTP PTM switching means that the corresponding MRB has common PDCP and RLC layer. In legacy mechanism, RLC layer performs segmentation to adapt different radio link quality. For RLC anchored PTP PTM switching, the advantage of RLC segmentation seems to go away as the common RLC layer should transit the same RLC segmentation to all the UEs in the group via PTM. To a certain extent, RLC anchored PTP/PTM violates the design principle of NR protocol stack and function split, which is not preferred. |
| 24 | CMCC | A1. Support as baseline  A2. Support as optimization (or depends on the WID progress)  A3. Not support in Rel-17  B1. Support  B2. Not support in Rel-17  For A1:  In NR, to support service with high reliability requirement, such as public safety and mission critical, V2X applications, RAN1 has agreed that for RRC\_CONNECTED UEs, HARQ-ACK feedback is supported for multicast and at least support slot-level repetition is supported for group-common PDSCH. Although as specified in TS 38.104 clause 11.3.2.3.1.2, NACK to ACK probability is around 0.1%, which means the HARQ reliability is up to 99.9%, switching from PTM to PTP should be considered for the guarantee of high reliability.  For A2:  Several companies argued that PDCP based re-transmission requires RLC AM kind of functionality at PDCP and adds additional overhead as well. However, current PDCP retransmission has already been supported during Handover, **just with the extension of application scenario**, where the data transmission between PTM and PTP. Although R2-2100354 aims to justify that the PDCP retransmission suffers performance degradation by providing the history discussion on the PDCP retransmission in split bearer like architecture, we also **noted that PDCP retransmission had been accepted in the LTE LWA scenario, and there is no much enhancement description in the specification.** This means PDCP retransmission in LTE LWA like architecture for PTP/PTM dynamic switch is feasible from technical point of view. Anyway, this is regarded as optimization, whether to specify the item depends on our WID progress.  A3: as we commented on line, we think there are **too many ambiguity points for this item:**  • How to realize the RLX Tx window management based on feedback from multiple UEs  • What is the criteria to determine whether to retransmissions based on feedback from multiple UEs, and the objects of the retransmission  • How to realize the UE L2 feedback, by another PTP leg under the RLC, or the tunnel due to the dual link of RLC AM, or PTP leg under the PDCP (2 loop?)  • And this RLC AM will go the way of RLC as anchor of PTP and PTM dynamic switching, which exits obvious problematic points, e.g. **the RLC split architecture cannot generate different RLC PDUs according to different radio condition of PTP and PTM**, which will result in performance degradation due to the transmission size tailored by the poorer radio link.  B1, B2 see answer in A3. |
| 25 | AT&T | A1: Not support  A2: Not support  A3: Support  B1: Support (for mobility)  B2: Support for MBS |
| 26 | TD Tech, Chengdu TD Tech | Our opinions are listed below.  For question A:  A1. No L2 ARQ for PTM: support  A2. L2 ARQ by PDCP for PTM: support  A3. L2 ARQ by RLC-AM for PTM: Not support  For question B:  B1. PDCP anchored PTM/PTP switch: support  B2. RLC anchored PTM/PTP Switch: Not support |
| 27 | UIC | The focus of this elaboration is on determining the options from the user's point of view.  For rail safety related data exchange requires always high reliability under train speed conditions 0-500km/h.  This means that extremely robust data transmission must always be made available for this speed range mentioned. Based on the expertise, error correction procedures on higher layers cause additional delays, which ultimately lead to the loss of the connection and thus cause delays. Approaches that enable quick and individual error correction are to be preferred.  The area of application of multicast in the rail environment is complex. In the following there are constellations that can be differentiated on the basis of the speed profile:  -High speed only (tracks);  -Static to medium speed (station and shunting yards);  -Mixed high-speed operation as through traffic affected by train stations/shunting yards. Due to different speed profiles different radio link reliabilities are present in certain areas.  Hence, the answers to the proposed options are the following:  A1: will cause non-reliability issues – no support;  A2: will cover some reliability issues but increases complexity; doubts about individual transmission error correction. – no support;  A3: is assumed to be the most reliable - strongly supported;  In the context of the proposed anchoring option toggling between unicast and multicast is that option B2 is the preferred one which goes hand in hand with A3. B1 will be the one for the different mobility scenarios in the rail context. |

**Opinions Summary:**

Participated: **27**

Support A1: **21** Prefer only A1/No L2 ARQ: **12**

Support A2 or A3: **21** Prefer A2 or A3: **12**

Support A1 vs not **21 – 6**

Support A2 vs not **15 – 11**

Support A3 vs not **12 – 15**

Support B1 vs not **24 – 3**

Support B2 vs not **10 – 17**

**Observations A1 A2 A3**

- L2 ARQ for PTM cannot guarantee lossless delivery (any PTM mechanism would have trouble adapting to the worst radio UEs without dropping data if the worst UEs cannot keep up and stretches the TX window to its limit).   
[It seems that everyone agrees to this, but the proposed mechanisms may have different performance]

- PTM – PTP switching is needed regardless whether L2 ARQ is supported  
[It seems that everyone agrees to this, but in the different mechanisms it is expected that higher or lower number of UEs would be served by PTP / PTM at any moment in time]

**Need for L2 ARQ**

- Reliability will not be sufficient without L2 ARQ. Requirement is 10^-6 and HARQ control channel limits HARQ reliability to 2\*10^-4 (Src: Qualcomm, all A2 supporters).

- Efficiency will be better with PTM L2 ARQ as more UEs can receive PTM rather then switch to PTP (Src: Qualcomm, all A2 supporters).

- Reliability of PTM with HARQ will be better than LTE SC-PTM, is sufficient for most applications, and it is unreasonable to require more. The most stringent applications can use PTP (Src: Most of the prefer-only-A1-companies). Data loss depend on radio conditions, HARQ should work well in good radio, can switch UEs in bad radio conditions to PTP (Eri). With URLLC the NR requirement is 10^-6 (Huawei).

[Chair Comment: Browsing TS23.501, It seems that voice and video (also mission critical) follows legacy requirements 10^-2 and 10^-3, and there is requirement for MCPTT CP of 10^-6 assume this is Unicast, however there is a requirement for 5QI 70, mission critical data with reliability requirement 10^-6, PDB 200ms. Assume this requirement to be applicable to “cell edge”].

**Ambition level L2 reliability in PTM (high to low)**

- **A3:** **RLC AM** supports retransmission of segments whereas PDCP retransmits SDUs, so RLC AM would typically be more efficient (Src: QC, all A2 supporters).

- **A2: PDCP ARQ** for normal PTM transmissions. It seems that the proponents are not considering to reflect the whole RLC-AM functionality, but instead go for a simpler function, and keep similarity with current PDCP buffering / retransmissions (a number of A2 supporters)

- **A1: PDCP recovery at PTP-PTM-switch.** Would support switching PTP-PTM. Exact trigger FFS but It has been mentioned that there could be a configuration that switching to PTP is triggered any time PTM packet loss is detected, and the lost packet is retransmitted by PTP. PTP-PTM switch without any data recovery, used for RLC-UM + RLC-UM cases

**Complexity**

- There are divergent views on complexity. Both camps state their solution is the simplest.

**A3: RLC-AM ARQ** – proponents point to very limited impact as the retransmission triggering etc can be re-used as is. However a number of companies are afraid there is a lot of standardization complexity as RLC-AM was designed for PTP.

**A2: PDCP ARQ** – proponents ack that there is impact in how to trigger retransmission. Most propose a new status report trigger. Several proponents point to PDCP as the layer already handling split bearer, DC, mobility etc with similar functionality. Opponents indicate that window handling need to be updated etc.

**A1: PDCP protect PTP-PTM-switch** – proposal that this would work similar to other procedures that PDCP protect currently, trigger may be specified. Was also stated that Transmission overlap without a status report could reduce probability of data loss.

**Observations B1 B2**

**B2** seems like a less liked proposal. One argument is that it doesn’t support RLC-UM due to sequence numbers not being sent with unsegmented packets in NR (e.g. Huawei). Another argument is that a joint RLC for PTP and PTM might not be good as the PTP RLC-AM should support to be scheduled differently than PTM (e.g. different TB size) (e.g. ZTE CMCC). Several companies (e.g. Eri Sharp) has requested that the configuration of PTM RLC-UM + PTP RLC-AM, which cannot easily be supported by B2.

**B1** is supported by many, arguments being e.g. that it could support both RLC UM and RLC AM, functionality already in PDCP can be reused also for PTP PTM switch.

**Observation General**

Most of the companies focusing on A1 (and to some extent the A2’s) motivate that simplicity is needed, e.g. ZTE Samsung think we will have difficulty handling the scope of L2 ARQ for PTM in the current WI.

Chair: TU is an issue. Preferably if doing L2 ARQ should add 25-50% more time (dep on impact).

**PROPOSALS:**

It has already been agreed that RLC UM shall be supported both for PTM and PTP, and it seems like services like conversational voice and conversational video shall be supported, so the following is proposed:

**Proposal 1: A1+B1, No L2 ARQ with PDCP anchored PTM – PTP switching shall be supported, at least for the case that both PTM and PTP are RLC-UM.**

**Proposal 2: Discuss whether to support any of:   
- A1+B1 for PTM RLC-UM + PTP RLC-AM, possibly with some kind of data recovery in the switching procedure.**

**- A2+B1 for PTM RLC-UM + PTP RLC-AM**

**- A3+B2(+B1) For PTM RLC-AM + PTP RLC-AM**