**3GPP 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

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| --- | --- | --- |
| **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 | One alternative way would be to discuss both issue A and issue B in one shot: L2 based reliability improvement. The reason is 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 the following options are on the table:  **C1:** **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).  Within C1, it is expected to support PDCP anchored PTM/PTP switch.  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.  **C2: RLC based reliability improvement (RLC AM for PTM is not supported).**  In addition to L1 based reliability improvement, RLC packets can be retransmitted via PTP leg, based on RLC status report (reuse current RLC SR trigger). There are independent RLC entities established for PTM leg and PTP leg and they may run in different mode. There is a common RLC SN allocation for all RLC packets of MRB (PTM and PTP). UE combines the received packets at RLC layer based on the unified SN allocation between PTM and PTP leg (where reordering and duplicate handling are supported).  Within C2, it is expected to support RLC anchored PTM/PTP switch.  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.  **C3: 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  Within C3, it is expected to support RLC anchored PTM/PTP switch.  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 C1/C2/C3:**  C1 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.  C2 may be challenging. As there may be difficult for UE to receive both RLC PTM UM leg and RLC PTP AM leg since RLC UM and RLC AM use different Rx window management (one is Pull based, another one is Push based). Then C2 requires the UE to adopt a unified Rx window (UM based or AM based) for RLC packet reception.  C3 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 each alternative before the decision. |
| 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). |
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