[RAN94e-R18Prep-25] High Speed Packetization - Version 0.0.4
RAN

3GPP TSG RAN#94e RP-21xxxx

Electronic Meeting, December 6 - 17, 2021

Agenda Item:

Source: RAN2 chair (MediaTek)

Title: Moderator's summary for discussion [RAN94e-R18Prep-25] High Speed Packetization

Document for: Discussion

1 Introduction

1.1 General

General Scope, Instructions, Deadline, Organization can be found in RP-212657, RP-212608.

The goal of the email discussion is to focus on potential scope/areas for each potential WI or SI. Aim to identify whether a topic should be a SI, or WI (including possibly a study phase for some scope(s)). Aim to identify the leading WG (including if any change compared with those in RP-212608) and the secondary WG(s). Aim to identify on the potential interaction with SA/CT. Critical to keep all items under rigorous check; important to avoid "number counting" driven discussion, but focus on tangible commercial interests.

Moderator: The discussion should establish objectives text and justifications text for input into a tentative WID. Can verify level of controversy per subarea/objectives.

1.2 Starting Status

The Starting status of the discussion on High Speed Packetization is captured in RP-211666:

High-speed Packetization (SI). This whole proposed SI is contentious. There is significant support but also blocking opposition.

High-speed Packetization (SI) Areas / Scope:

- *To avoid throughput degradation at high data rates*
    - *To study concatenation in PDCP layer to reduce the number of L2 headers (i.e. MAC, RLC, and PDCP), and to simplify the processing for UPIP. (RAN2)*

Note: Justification seems clear and there is support, but there are also Contentious comments of blocking nature that this kind of change is too fundamental to be introduced now for NR (moderators interpretation of comment: Implementations may take long time to take this into account).

1.3 Input tdocs

RP-211801 High-Speed Packetization for Rel-18 Samsung

RP-211802 New WID proposal: High-Speed Packetization Samsung

The input papers will not be explicitly treated here, but are mentioned for reference. The moderator observes that there are also other papers on user plane aspects, which can potentially be input under other below.

2 Initial Round

2.1 General

It is assumed that this can be a Study Item, led by RAN2. Not discussed yet, whether the SI can be followed by a WI in the same release.

Q: feedback on the above

Feedback Form 1: General

1 – Ericsson LM Too early to decide this.
2 – Samsung Electronics Co. We believe RAN2 can start a SI first, which can be followed by a WI in the same release. Since the scope is very clear from the discussion during workshop and additional emails, it would not take too much time to complete the SI in Rel-18.
3 – HuaWei Technologies Co. We also think this can be started as a short study item to figure out the feasible solutions.
4 – LG Electronics Inc. It can be discussed after the exact scope is decided.
5 – Guangdong OPPO Mobile Telecom. It's too early to decide whether it's SI or WI
6 – Nokia Corporation If this happens, it should be a RAN2-led SI. Of course overly large scope needs to be avoided, and we should aim to not re-open old discussions from Rel-15 design phase. The study could focus could on issues already noted with existing implementations to better understand those. As data rates keep increasing, it's likely that we will start to see more practical issues related to those so studying them now can help keep NR functioning well. Where there are real issues with high data rates

currently, we should be pragmatic in trying to resolve them and **we have seen some issues with throughput degradation with high data rates in the field already.**

7 – LG Uplus

We think this can be started with SI first.

8 – Motorola Mobility España SA

We are fine to start a short SI following a WI. While, whether to start a WI in the same release can be decided later according to the progress of SI.

9 – ZTE Corporation

It is too early to decide this

10 – Futurewei Technologies

It can start as an SI.

11 – MediaTek Inc.

If this topic is pursued, it should be as an SI.

12 – Philips International B.V.

Requires some study to determine and evaluate possible alternative solutions

13 – Apple GmbH

We are fine to start with a SI. Whether the SI can be followed by a WI can be decided based on the outcome of the study. This item should be led by RAN2.

14 – Qualcomm CDMA Technologies

Too early to discuss.

15 – Intel Corporation (UK) Ltd

We agree that this work can be a short SI followed by a WI in the same release, if SI concludes to proceed with WI.

2.2 PDCP Concatenation

To avoid throughput degradation at high data rates:

- *To study concatenation in PDCP layer to reduce the number of L2 headers (i.e. MAC, RLC, and PDCP), and to simplify the processing for UPIP. (RAN2)*

Q: Feedback on the above SI objective. As this was controversial, opponents please in addition to opposition comments and reasons for them, indicate also whether any aspect could be acceptable.

Feedback Form 2: PDCP Concatenation

1 – Ericsson LM

It changes core UP-stack functionality. RAN2 intentionally (after long discussions turning every stone) came to the conclusion to not have concatention. It is too late to change this.

We can revisit this topic in 6G.

No aspect is acceptable.

2 – Samsung Electronics Co.

In the early stage of NR, RAN2 discussed whether to have concatenation as a ”mandatory” feature as in LTE, but now, the main point is to specify PDCP concatenation as an ”add-on” feature, which can be configured to a particular service for better efficiency and higher data rates with no impact to the other service. Moreover, ”Full-rate UPIP” was not considered/expected for protocol stacks during the Rel-15 discussion, which currently results in low UPIP efficiency and causes performance degradation. It should also be noted that it does not deviate from the legacy data structure either.

3 – HuaWei Technologies Co.

We agree to the objective proposed by the moderator. As we already stated several times, to mandate full-rate UPIP was not expected in Rel-15 and now it becomes the agreement, and thus any solution which can improve the processing efficiency of UPIP is seen useful. If the feasible solution can be further studied, the target can also include compatibility with existing L2 structure, we don’t see it is a blocking issue to have a SI phase first as the motivation has been acknowledged in previous email discussions.

4 – LG Electronics Inc.

If full rate UPIP is the major concern, we can think about various solutions than PDCP concatenation, e.g. applying security to part of PDCP SDUs. The PDCP concatenation is one specific solution, and we oppose to list only PDCP concatenation in the objectives. Moreover, we oppose to ”concatenation **in** PDCP layer”, because we think ”concatenation **above** PDCP layer” is much simple without affecting existing specification.

5 – Guangdong OPPO Mobile Telecom.

We’re also hesitating to be supportive of this fundamental change proposal, as we all know in the beginning R15, it’s a long and hot discussion on removing concatenation from RLC, and then finally we agreed no concatenation in RLC. Now, it comes to the proposal that concatenation is needed in PDCP. It would be good to understand how often and how serious the issue is before going to a detailed solution. Besides, by introducing concatenation in PDCP, it may cause security concerns because multiple concatenated PDCP SDUs are expected to share the same MAC-I, it would be good to confirm with SA3.

6 – Nokia Corporation

We are fine to consider this as one aspect to study: Are there problems in the field currently with high data rates? However, we also share the concerns from Ericsson that fundamental changes to L2 design need to be avoided and we really shouldn’t re-open old discussions from Rel-15.

But we need to be pragmatic and understand if there are problems in the field currently with high data rate UEs - for example, UPIP increases the processing load, so it is a practical issue to consider, so one aspect could be to study how to mitigate increased processing load due to UPIP.

7 – LG Uplus

As many companies indicated, full rate UPIP was not mandatory in Rel-15, so now the situation is changed and identifying the corresponding solution is reasonable.

8 – Motorola Mobility España SA

In addition to the listed SI objective, we prefer to consider PDCP concatenation harmonizing with other features. Also, the compatibility with the existing L2 structure can be studied.

9 – ZTE Corporation

We share the views that we should be careful about making such big changes to the protocol at this stage.

10 – Futurewei Technologies

There were long and tense discussions in Rel-14 about the need of concatenation when NR UP protocol was studied. Though it is gratifying to see more companies come to recognize the performance issue without concatenation, it is also true that this can only be an optional enhancement in future releases, and UPIP is already mandatory for all data rate since Rel-16. Hence, it may be more beneficial, at this stage of NR development, to have a study on potential enhancement for high data rate transmission, without limiting the scope only to PDCP concatenation.

11 – Philips International B.V.

Instead of looking at PDCP concatenation only, we should also consider other solutions that can improve the throughput whilst still offering integrity protection at high data rates, such as integrity protection on the link layer as described in solution #4 in TR 33.853 (I.e. the SA3 study on user plane integrity protection).

12 – MediaTek Inc.

We are not in favour of introducing PDCP concatenation, as it is quite a significant change to the UP stack at this late stage of NR.

13 – Apple GmbH

PDCP (or SDU) concatentation should not lead to major design changes that are generally applicable to NR. Rather, we aim to identify means to incorporate new solutions as an optional component that can extend upon the existing L2 architecture.

We further think that the study scope is a bit restrictive by focusing on a specific solution and excluding concatenation in layers above PDCP. RAN2 should first evaluate the different design choices and identify all possible solutions. Thus we would like to propose following extension of the SI objective.

To avoid throughput degradation at high data rates

- *To study SDU concatenation in higher layers to reduce the number of L2 headers (i.e. MAC, RLC, and PDCP), and to simplify the processing for UPIP. (RAN2)*

14 – Qualcomm CDMA Technologies

We also think this is a major change to the L2 UP protocol stack and can't be pursued at this late stage. As commented before, all Rel-16 UEs have to support full rate UPIP with the current UP stack; therefore, UE implementation challenges are not reasonable justifications. There could be many theoretical ideas to improve L2 UP performance on paper and some of these were discussed during NR Study Item phase. We should investigate the performance of 5G networks and bring the lessons learned to the 6G design.

15 – Intel Corporation (UK) Ltd

We are fine with the objective in general. It might be better to clarify what needs to be studied, e.g. "required protocol enhancements to support concatenation in PDCP layer". Since "*to reduce the number of L2 headers (i.e. MAC, RLC, and PDCP), and to simplify the processing for UPIP*" are mainly the benefits of PDCP concatenation, maybe it can be removed to simplify the objective, or the scope can be restructured (to group the benefits together) below:

- To avoid throughput degradation at high data rates, to reduce the number of L2 headers (i.e. MAC, RLC, and PDCP), and to simplify the processing for UPIP.
  - To study required protocol enhancements to support concatenation in PDCP layer.

2.3 Other

Other objectives, other aspects.

Moderator: If you whish to discuss other objectives please add your discussion points below asap, to allow other companies to comment in the initial round.

Feedback Form 3: Other

1 – Futurewei Technologies

The following may also be considered for enhancement of high throughput transmission:

1) Prioritize transmission of selective TCP ACKs on UL to maximize DL TCP throughput and reduce UL traffic load;

2) 1:M flexible and dynamic mapping from QoS flow to DRBs to maximize throughput;

3) Active queue management of DRBs during QoS flow to DRB mapping to reduce latency.

More details of these enhancements can be found in RWS-210040.

2 – Philips International B.V.

As mentioned in comments 2.1 and 2.2, also other solutions, such as document in solution #4 of TR 33.853 should be considered.

3 – Apple GmbH

We think that Rel-18 should evaluate whether any L2 optimizations are required for the 5G user plane. With 5G NR entering the next phase of technology evolution, 3GPP should evaluate what user plane enhancements are necessary to support the evolved set of services envisioned for 5G-Advanced. Therefore, we would like to include the following item.

1) Sub-DRB differentiation for enhanced performance and special packet prioritization (RP-212357)

- Note: This can serve as an alternative to PDCP concatenation. In addition, the treatment of large quantities of TCP ACKs can be optimized.

Please find further details on the respective objectives in RP-212358. The scope of these items would mainly fall under RAN2. We are open as to whether it could be considered a separate item or included as an objective to 'high-speed packetization' here, both options are fine to us.

We would further like to point out that SDU concatenation does not come for free since it entails latency, so any new design should be sensitive to that aspect.

3 Intermediate Round

3.1 Outcomes of the Previous Round

SI or WI

Moderator Report: Most companies think that this work, if agreed, would need to start as a SI. A couple of companies think it would be reasonable to assume a following WI in the same release. A couple of companies point out that whether there will is a WI is depending on the outcome of the SI. A couple of companies think it is too early to say. It is observed that a number of companies would like to not start with a strict solution restriction.

Moderator Suggestion: For the purpose of continued discussion in this R18 Preparation Discussion we assume this is an SI, and for now we dont make any assumptions on the continuation.

Leading Group

Moderator Report: Leading group is RAN2 (no further discussion needed)

Scope

Moderator Report:

- There is opposition to do PDCP concatenation.
  - Ericsson, Qualcomm, MediaTek all express negative views and don't support any work on this. Ericsson and Qualcomm think this could be re-evaluated for 6G. ZTE also prefers caution.
- There is some support to study issues.
  - Nokia and Oppo think the initial focus should be to identify problems in more detail, and can accept some continued solution work if problems can be confirmed. Nokia has observed bitrate degradation in field at high bitrate.
  - LG, Apple, Futurewei think that the study shall not be restricted to only concatenation in PDCP layer. LG will not accept a SI restricted to only concatenation in PDCP.
  - A number of companies express support to address how to alleviate the increased processing by Full Rate UPIP: Samsung, Huawei, Nokia (some support?), LG Uplus, Apple, Intel. Futurewei and Qualcomm comments that Full Rate UPIP is mandatory in R16 and this new L2 feature will need to be optional and think implementations need to handle this anyway.
  - L2 compatibility, harmonization, was proposed to be addressed, byHuawei and Motorola Mobility. *Comment: Moderator finds this rather vague and assumes that such aspects can always be take into account, and only need to be emphasized if there is a particular concern / issue.*
- There is some support to study PDCP concatenation.

- Samsung, Intel, Motorola Mob, Huawei, Intel express support for the proposed scope of PDCP concatenation.

- Other solutions (mentioned or proposed)
  - Applying security to PDCP SDUs, and Concatenation above PDCP as possible solutions (LGE)
  - Solution #4 of TR 33.853 (Philips)

- Additional Proposed Objectives / Solutions
  - Sub-DRB differentiation for enhanced performance and special packet prioritization. In addition, the treatment of large quantities of TCP ACKs can be optimized. (Apple RP-212357). *Comment: Apple has commented that this can be an alternative to PDCP concatenation, moderator is not sure.*
  - Prioritize transmission of selective TCP ACKs on UL to maximize DL TCP throughput and reduce UL traffic load (FW RWS-21004)
  - 1:M flexible and dynamic mapping from QoS flow to DRBs to maximize throughput; (FW RWS-21004)
  - Active queue management of DRBs during QoS flow to DRB mapping to reduce latency (FW RWS-21004)

Moderator suggestion: It is proposed to continue the discussion to arrive at most agreeable scope. Propose that opponents opposing comments are noted and will be part of the result of this discussion. In continuation, Opponents can make constructive comments on the scope without this being interpreted as support.

3.2 General

Moderator Suggestion: For the purpose of continued discussion in this R18 Preparation Discussion we assume this is an SI, and for now we dont make any assumptions on the continuation.

Moderator Report: Leading group is RAN2 (no further discussion needed)

Moderator suggestion: It is proposed to continue the discussion to arrive at most agreeable scope. Propose that opponents opposing comments are noted and will be part of the result of this discussion. In continuation, Opponents can make constructive comments on the scope without this being interpreted as support.

Feedback Form 4: General

1 – Samsung Electronics Co.

First of all, many thanks to the moderator for handling all these, and we agree the moderator suggestion and report.

Regarding agreeable scope, we would like to stress that the endorsed RP-212608 from last RAN meeting indicates that "*Additional email threads (one for each topic) is to be used to discuss the following potential RAN2/3-led topics (based on [1], [15] and [17])*", and [17] (i.e. RP-211666) containing HSP issue does not discuss any additional scope proposals listed in the subclause 3.4 below. We should refrain from putting all the miscellaneous UP enhancements (for other problems) to this agenda, but should focus on the concatenation "in/above" PDCP layer for the main problems (i.e. to reduce the number of L2 headers and to alleviate the processing burden for full rate UPIP), as discussed and summarized in RP-211666. We understand that the additional scope proposals do not address both the main problems above.

2 – HuaWei Technologies Co.

We agree that this could be a RAN2-led study item first. In addition we also have similar views as Samsung to focus on PDCP layer enhancements.

3 – Apple GmbH

We are fine with the suggestion to start with a SI led by RAN2.

4 – Futurewei Technologies

We agree that works on UP enhancement, if agreed, should start with SI.

As asked by several companies and clarified multiple times by RAN chair during online discussions, proposals in submissions to Rel-18 workshop and RAN#93e are in the scope of this round of email discussion.

5 – Qualcomm CDMA Technologies

We don't support this in any form. If it does get approved, it should be Study Item limited to RAN2.

6 – Nokia Germany

We support a study item focused on alleviating processing burden.

7 – LG Electronics Inc.

We think SI is not needed. But, if it is approved, the SI should include various kinds of solutions for alleviating full rate UPIP processing burden, not limited to PDCP concatenation.

In any case, we oppose to "concatenation **in** PDCP". If concatenation is used, it should be "**above** PDCP". Otherwise, whole PDCP procedures will be affected.

8 – Motorola Mobility España SA

Lenovo, Motorola Mobility

we are fine to start the related study.

9 – Intel Corporation (UK) Ltd

We are OK to start a RAN2-led SI first, and also agree with Samsung to focus on concatenation in/above PDCP layer.

10 – MediaTek Inc.

If this does go ahead, it should be as a RAN2-led study item

11 – Philips International B.V.

An SI led by RAN2 could be a good starting point to address the issue of alleviating the full rate UPIP processing burden. The SI should be open to various solutions and their evaluations (e.g. an analysis of the performance benefits per solution), not limited to PDCP concatenation.

3.3 Scope - Throughput Degradation

Moderator Proposal:

1. *Study the issue of throughput degradation at high data rates.*
2. *To avoid throughput degradation at high data rates, Study enhancements to*
   - *Simplify the processing for UPIP*
   - *Reduce the number of L2 headers (e.g. MAC, RLC, PDCP)*

undefined *Solution(s) of Data Unit Concatenation, e.g. at PDCP layer, shall be considered, other variants are not precluded.*

Feedback Form 5: Throughput degradation at high data rates - Objective(s)

1 – Samsung Electronics Co.

We support the proposal from the moderator. From the discussion in RP-211666, we believe that all the companies discussed concatenation of PDCP SDU (i.e. not PDCP PDU), but details on how to concatenate PDCP SDU can be discussed in the study item phase. For instance, some companies have concern on where to concatenate the PDCP SDU (e.g. above the PDCP or in the PDCP) but all those aspects can be investigated in the study item phase by inspecting the actual specification and implementation impacts.

2 – Ericsson LM

If this is a study, we do not think we should restrict the solutions already now. One restriction added already now is that it is explicitly stated that concatenation in the PDCP layer is considered (even though only as ”e.g.”). If this is going to be a study, we should not do such limitations. In LTE we have concatenation in RLC and that should not be excluded before the study has even started. So, a small comment is that we think we should remove this wording, even if there is ”e.g.” and even if there is ”other variants are not precluded”:

Solution(s) of Data Unit Concatenation, e.g. at PDCP layer, shall be considered, other variants are not precluded.

For the record: We don’t see the need for this study item.

3 – HuaWei Technologies Co.

We are fine with the moderator’s proposal.

4 – Apple GmbH

Many thanks to the moderator for refining the SI scope. The refined scope could serve as a base set of topics, but we have a few extra comments on top.

a) “*Simplify the processing for UPIP*” might allow the interpretation that RAN is planning changes to the security algorithms and procedures around, which may not be the intention. We would prefer spelling out performance related aspects such as “*Simplify the L2 processing to reduce CPU intense tasks during, e.g., UPIP, processing high amount of small packets, RQI, etc.*”

b) Our understanding of concatenation in/above PDCP is that the method can be applied, for example, to concatenation of SDAP SDUs in SDAP or concatenation of PDCP SDUs in PDCP.

c) In addition, we would like to broaden the scope by including other items related to L2 optimizations such as the ones listed in our reply under section 3.4.

5 – ZTE Corporation

Similar have similar view as Ericsson.

In general, we need to understand if there is really an issue that needs to be solved. It should also be kept in mind that there are some higher layer features (above the 3GPP protocol stack – e.g. the jumbo frames) which can provide means to have single large payload packet. So, we need to see if the enhancements are necessary considering all such existing means to solve these issues.

6 – Futurewei Technologies

As UPIP is already mandatory since Rel-16 for full data rate, and Rel-15 made the conscious tweak to allow security operation to be done separately from L2 PDU generation (TS 38.323 - ”The data unit that is ciphered is the MAC-I (see clause 6.3.4) and the data part of the PDCP Data PDU (see clause 6.3.3) except the SDAP header and the SDAP Control PDU if included in the PDCP SDU.”), it is not clear why simplifying UPIP processing would have much impact on throughput.

And we agree with Ericsson’s comment on PDCP concatenation.

7 – Qualcomm CDMA Technologies

Agree with Ericsson and ZTE that, if this SI happens, no solutions should be mentioned in the Objectives. This should be a very targeted SI. The scope of the problems should be existing major issues/inefficiencies observed in actual NR deployments, especially for high data rates, and the goal should be to solve/improve such cases. We shouldn’t do theoretical analysis and/or simulations of different L2 UP architecture as such broad scope is more suited towards 6G. We also should not be targeting limitations of specific UE implementations (e.g. simplify UPIP for some UEs). So, the scope could be ”Study improvements to NR L2 User Plane for high-data rates, considering the inefficiencies observed in deployments” and have a Note that ” The study will not consider UE implementation specific limitations”.

8 – Nokia Germany

We share the concerns of Ericsson, Qualcomm and ZTE on the scope: possible solutions should not be mentioned already. And we also support Qualcomm’s wording ”*Study improvements to NR L2 User Plane for high-data rates, considering the inefficiencies observed in deployments*” but without the note.

9 – Guangdong OPPO Mobile Telecom.

We share the view of ZTE, it would be good to firslty understand the issue.

10 – LG Electronics Inc.

We think the SI is not needed, but if approved, we are ok to study the issue of throughput degradation at high data rates, but it should not be limited to PDCP concatenation. Actually, we are wondering how much the PDCP concatenation can improve the throughput. If the SI is approved, we propose to remove the last sentence.

~~*Solution(s) of Data Unit Concatenation, e.g. at PDCP layer, shall be considered, other variants are not precluded.*~~

11 – Motorola Mobility España SA Lenovo, Motorola Mobility we are fine with the objective proposed by the moderator.
12 – Intel Corporation (UK) Ltd We agree with moderator's proposal.
13 – MediaTek Inc. If this study goes ahead, it should not be limited to a specific solution. Rather it should focus on issues with NR to deal with high throughput scenarios. The wording from Qualcomm seems suitable in this respect.
14 – Philips International B.V. If this study goes ahead, it should not be limited to a specific solution. So propose to make clear that these are just examples.

3.4 Additional scope

Moderator Proposal: Discuss one more round to determine whether convergence on any of the additional scope proposals seems possible. Please don't hesitate to discuss justifications, motivations etc.

I.e. the following four proposals:

1. Sub-DRB differentiation for enhanced performance and special packet prioritization. In addition, the treatment of large quantities of TCP ACKs can be optimized. (Apple RP-212357). Comment: Apple has commented that this can be an alternative to PDCP concatenation, moderator is not sure.
2. Prioritize transmission of selective TCP ACKs on UL to maximize DL TCP throughput and reduce UL traffic load (FW RWS-21004)
3. 1:M flexible and dynamic mapping from QoS flow to DRBs to maximize throughput; (FW RWS-21004)
4. Active queue management of DRBs during QoS flow to DRB mapping to reduce latency (FW RWS-21004)

Feedback Form 6: Additional scope

1 – Samsung Electronics Co. As indicated our opinion in subclause 3.2 above, we should refrain from putting all the miscellaneous UP enhancements (for other problems) to this agenda, but should focus on the concatenation in/above PDCP layer for the main problems (i.e. to reduce the number of L2 headers and alleviate the processing burden for full rate UPIP), as discussed and summarized in RP-211666.
2 – HuaWei Technologies Co. We also felt it is a bit unclear on the target to have these additional bullets, we understand what is acknowledged is mainly for the UPIP processing and L2 headers reduction. These proposals seem not relevant on

the major requirements acknowledged.

3 – Apple GmbH

As for the additional scope proposals in this section, proposal 1) may be considered an alternative or add-on to SDU concatenation in the sense that it can enhance performance, for example, of small data packets and TCP ACKs. Moreover, the solution allows to reduce unimportant packets, limit head of line blocking, and prioritize other control data (such as RTCP). If PDCP concatenation is applied, assuming it is configured for a DRB, the UE may not be able to switch between concatenated and non-concatenated modes very quickly. This means a DRB configured with concatenation incurs additional delay as multiple SDUs need to be collected to fit into one 9K PDCP PDU. Proposal 1 relies on a LIFO queuing mechanism at RLC through which the most recent packet can be sent. Similarly, important packets can be separated out within a DRB and sent through a higher priority RLC entity. Even in cases where the throughput is not very high, reduction of the impact of the TCP ACK handling in 3GPP can lead to increased efficiency in air-interface resources leading to overall improved system performance from the gNB's perspective.

On proposals 3 and 4, we are not convinced the specific set of enhancements will be efficient enough, however, there are a number of enhancements possible and we are open to consider SDAP as an area for optimizations. If any of these solutions result into bigger changes we prefer addressing them in Rel-18 as one compound item, looking at SDAP holistically together with other user plane optimizations. Thus, we are open to add one item for "SDAP enhancements" to the study. Other areas to include are listed in our paper RP-212354, specifically reliability related aspects and enhancements to optimize the processing of RQI for reflective QoS, and the support of handover.

4 – Futurewei Technologies

At this stage of NR deployment - UPIP is already mandated for all data rates, and UE hardware are already dimensioned for high data rate transmission, if there are to be works for UP enhancement, it'd be better to focus on general UP efficiency, than limited to PDCP concatenation.

On proposal 1, we'd like to note that deviation from the principle that "At **Access Stratum** level, the data radio bearer (DRB) defines the packet treatment on the radio interface (Uu). A DRB serves packets with the same packet forwarding treatment." (TS 38.300) could cause significant impact on UP operation. Differentiated packet handling of a QoS flow should not be done below SDAP layer, after QoS flow to DRB mapping.

5 – Qualcomm CDMA Technologies

Similar to the previous comment, we don't need to capture any solutions at this point. These can be discussed during the actual Study Item.

6 – Apple GmbH

In response to Futurewei, we would like to clarify that the solution may as well encompass a new type of RLC bearer to carry data of similar importance. The mapping of data into this bearer can still be controlled on higher layers, by UE implementation, or through other means. In other words, unlike a typical FIFO with priority queues a RLC bearer may use a LIFO queue with discard of least recently arrived packets (i.e., latest packets enqueued on this bearer are dequeued first). The network configures the bearer at the RAN layer using standard RRC mechanisms. Then we can still have a separate treatment of this logical channel on MAC level, same as today.

(Of course other options are possible too and this could be investigated if deemed necessary, however, that may not be the main focus here.) We do not agree with the premise that packets belonging to the same

DRB cannot be treated differently at lower layers. Any solution developed as part of this study will have impact on the user plane architecture.

7 – Nokia Germany

In our opinion, these miscellaneous enhancements should be handled as TEI. The scope of the study item should be limited to alleviating processing burdens.

8 – LG Electronics Inc.

If the SI is approved, various solutions can be studied including all the solutions above. However, they don't need to be captured in the objectives.

9 – Motorola Mobility España SA

Lenovo, Motorola Mobility

we are open to Proposal 4. For Proposal 1, Proposal 2 and Proposal 3, we think the complexity is relatively high and there could be larger spec impact.

10 – Intel Corporation (UK) Ltd

We agree with Samsung to focus on concatenation in/above PDCP layer.

11 – MediaTek Inc.

Agree with Nokia that the scope of this SI should be to alleviate processing burden. If these solutions help do so (unclear from the explanations provided), that should be further explained during the study. For now, such solutions should not be part of the objectives.

4 Final Round

4.1 Outcome of the previous Round

General

Moderator Report: There were no objections to assuming this to be a RAN2 led SI

Scope - Throughput degradation

Moderator Background: In comparison with original proposal the following changes had been made for the intermediate Rnd:

- A point to study the issues (the problems) was added.
- The solution objective was loosened to avoid the wording *in PDCP* and to allow also other solution variants.

Moderator Report:

- Some detailed opinions were made, e.g. that it should be clarified that this SI would target alleviating processing burden. Some companies thought the issues shall be studied first (no parallellism?).
- The proponents of this work accepted the moderators proposal to slightly enlarge the scope.
- The companies expressing blocking opposition had the unified view that if the study shall be done there shall be no restrictions to the solution scope.
- The companies proposing additional scope (see below) also preferred either no scope restrictions, or rewriting the objectives to also leave room for the additional scope.

Moderator Analysis:

- The proponents of this work intended a limited quite specific change to lower the L2 processing burden. A main part of the justification to do this is the requirement of UPIP.
- Three of the companies expressing blocking opposition expresses that such L2 change is too architectural from implementation point of view to be supported for NR, next opportunity is for 6G.
- The blocking opponents proposal to have a general objective e.g. to ”Study improvements to NR L2 User Plane for high-data rates, considering the inefficiencies observed in deployments” is significantly different from the original proposal and
    - It is not clear whether a study with such objective would have support (at all)
    - If the outcome of such SI would recommend e.g. to introduce PDU concatenation as a solution, could that then be accepted for NR, e.g. in the next release? or is the study result doomed to only be applicable for a later generation?

Moderator suggestion: In the final round, elaborate both alternatives

1. Draft a SID around the objective as proposed for the intermediate round, do wording polishing. Despite opposition, the Moderator think this may still be the most agreeable way forward.
2. Elaborate and collect more comments around the possibility to have a wider L2 efficiency study, e.g. to ”Study improvements to NR L2 User Plane for high-data rates, considering the inefficiencies observed in deployments”.

Additional scope

Moderator Report: There was no support expressed for the additional scope except proponents. There were comments that this scope doesn’t fit with the above.

Moderator suggestion:

1. We make the assumption that the additional scope indeed is disjoint from the above L2 efficiency / throughput degradation / PDU concatenation scope.
2. With the assumption above, we continue to collect comments on the additional scope in the final round, to guide proponents and to help understand whether there is any support to work on any of these additional scope aspects in Rel-18 (we don’t discuss which WI would be targeted).

4.2 SID - Throughput Degradation

Moderator suggestion: 1. Draft a SID around the objective as proposed for the intermediate round, do wording polishing. Despite opposition, the Moderator think this may still be the most agreeable way forward.

Major comments are provided here, and smaller rewording comments can preferably be provided as MS word bubble comments in the Draft SID document in the draft folders.

4.2.1 Justification

Moderator: The below is a slight modification of the proposal in RP-211802. Note that according to instructions, the proposed justification is considered preliminary.

Proposal:

The NR data structure adopted from Release 15 onwards causes high number of L2 headers at high data rates, which leads to high complexity of data processing because the number of L2 headers is directly related to the number of RLC and PDCP Sequence Numbers (SN) giving high complexity of window management as well as header parsing. Moreover, support of User Plane Integrity Protection (UPIP) at any data rate became a mandatory feature to support secure communication in the late stage of Release 16 of NR, which incur performance degradation due to higher data processing.

In order to alleviate these difficulties and better support high data rate, user plane protocol enhancement should be considered, e.g. PDU concatenation.

Feedback Form 7: SID Justification

1 – Nokia Germany We do not think we need to go into such details. What is now described as as a list of drawbacks is highly dependent on implementations. It is important to remember that the L2 radio protocols of NR were designed to push RT operations down the stack, to maximise offline processing and allow parallelism. A generic statement about helping UEs to meet the constraints of a combination of very high bit rate and UPIP should be enough. This would allow us to also study issues resulting from design choices (e.g. number of parallel streams).
2 – HuaWei Technologies Co. We are fine with the moderator's justification, it seems clearly reflecting the background.
3 – Apple GmbH We are OK with the justification at this stage.
4 – Futurewei Technologies Complexity and processing load are not the same thing - it was argued in NR study that the current L2 UP PDU structure can reduce UE implementation complexity (e.g., the mitigation of stringent timeline management in generating PDU at the reception UL grant), at the expense of extra header load. And it is not clear that PDU concatenation can help UPIP processing efficiency, given that

- UPIP is already mandated for all data rates;
- Conscious tweak was made to the UP structure for security operation to be done on individual (instead of batch) PDUs.

  It is suggested to simplify the justification as " The NR data structure adopted from Release 15 onwards causes high number of L2 headers at high data rates~~, which leads to high complexity of data processing~~ because the number of L2 headers is directly related to the number of RLC and PDCP PDUs ~~Sequence Numbers (SN) giving high complexity of window management as well as header parsing. Moreover, support of User Plane Integrity Protection (UPIP) at any data rate became a mandatory feature to support secure communication in the late stage of Release 16 of NR, which incur performance degradation due to higher data processing.~~ In order to ~~alleviate these difficulties and~~ better support high data rate, user plane protocol enhancement should be considered, e.g. PDU concatenation."

5 – Qualcomm CDMA Technologies

Agree with Nokia and HW data the above justification is too detailed and point at certain solutions. A generic statement is sufficient: "Based on the issues observed in the field, current NR L2 UP may benefit from optimizations for operation at very high data rates "

6 – LG Electronics Inc.

The PDU concatenation is a specific solution, and it should not be addressed. Thus, we propose to remove "e.g. PDU concatenation".

7 – Samsung Electronics Co.

We are fine with the proposed justification. We believe that, as indicated by RAN2 chair to RAN reflector early October, the objective and the scope should not be vague and broad merely to make everyone happy. This would simply result in too many options in the WG-level discussion, which make difficult to proceed, as observed in the past. Since this thread is to address the problems identified from the previous email discussion, the proposal from the moderator is reasonable to us.

8 – Motorola Mobility España SA

Lenovo, Motorola Mobility

We are fine with the justification proposed by the moderator.

9 – Philips International B.V.

We are fine with the proposed justification

10 – ZTE Corporation

We agree that the justification should not have any specific implementation constraints.

11 – Intel Corporation (UK) Ltd

We agree with the justification from the moderator.

4.2.2 Objective

Proposal:

- *Study the issue of throughput degradation at high data rates.*
- *To avoid throughput degradation at high data rates, Study enhancements to*
  - *Simplify the L2 processing for UPIP*
  - *Reduce the number of L2 headers (e.g. MAC, RLC, PDCP).*
  - *Solution(s) of Data Unit Concatenation, e.g. at PDCP layer, shall be considered, other variants are not precluded.*

Feedback Form 8: SID Objective

1 – Nokia Germany

As commented earlier, we believe a SID should not list solutions but the areas to study. We believe this proposal is perhaps too restrictive.

2 – HuaWei Technologies Co.

We think the scope looks good, it already provides sufficient room for companies to study different solutions. We are fine with this one.

3 – Apple GmbH

The proposal looks acceptable although we prefer to expand the first sub-bullet beyond UPIP only.

4 – Ericsson LM

First bullet about ”Throughput degradation at high data rates”

Some UE vendors have indicated ”throughput degradation at high data rates” to be an issue.

But some other UE vendors indicated that the issue is not about throughput at high data rates but about many small packets which the UE may need to perform some processing for. Many small packets is different from ”high data rates”.

A wording which probably captures the essence of what we are trying here is: ”Study potential issues with processing in the L2 UP stack”

”processing for UP IP”

Some UE vendors said that UP IP is an issue. Some others said it was not an issue. So clearly there are different UE implementations that performs differently well. So it may just be an issue with certain implementations, rather than with the standard. If it is not a problem with the standard, then to change the standard is of course not the way to go.

This SID proposal suggests studying potential issues in the standard. Perhaps UP IP is one issue, perhaps not (UE vendors do not agree among themselves). It is pre-mature to conclude that UP IP should be the target of this study.

”Reduce the number of L2 headers”

We are not sure yet (before the study) that the actual **number** of headers is a problem. It may very well be **placement** of header-information which is problematic (interspersed in-between the data vs. collection

of header info in the beginning of the PDU). Placement of header information was one aspect that RAN2 discussed a lot during Rel-15 times and is very important when it comes to how fast processing can be.

So, the bullet about reducing the number of L2 headers jumps to conclusions about the result of the study about the issues. We should remove this bullet to not limit the solution space before the issues are identified.

Last bullet in the Objectives:

Again, we cannot limit the solution-space before the issues have been identified. And as said, UE vendors do not agree on the issues with the standard or whether concatenation is the way to go. We should remove that last bullet.

-.-.-.

10 – Ericsson LM

And also for the record: we also do not support this Study Item. But the comments above was given with the assumption that something should be done.

11 – MediaTek Inc.

Moderator (and R2 chair): User plane solution discussions are always difficult and controversial in R2, especially addressing a problem as general as optimizing the UE processing. Stating that discussions shall be based on observations is also difficult as vendors usually are not very willing to reveal details about their implementation bottlenecks, and test observations would anyway need to be followed by a cause analysis. IMHO the reasonable and practical methods to make WG discussions more focused is to restrict which solutions to look for (e.g. concatenation), or describe the issue in a way that can be practically used in WG, e.g. reducing the number of L2 headers and/or focusing on UPIP processing. SO, IMHO the proponents approach is a reasonable one in this perspective. It seems that the final discussion didn't really change anything.

12 – Philips International B.V.

We are fine with the moderator's proposal.

13 – ZTE Corporation

We also think that we should not list any specific solutions. We first need to identify problematic scenarios assuming no implementation specific constraints and taking into account features that are available above the 3GPP protocol stack (e.g. jumbo frames).

14 – Intel Corporation (UK) Ltd

We agree with the objectives from the moderator.

15 – MediaTek Inc.

To clarify, we do not support this study item.

Having said that, the first draft objective on UPIP simplification is not needed. It has been used as a justification for the need for L2 processing overhead reduction, while not suggesting that UPIP itself needs simplification. The remaining objectives result in a clear RAN2 scope for this study.

4.3 Alternative Wider L2 Efficiency SI

Moderator suggestion: Elaborate and collect more comments around the possibility to have a wider L2 efficiency study, e.g. to "Study improvements to NR L2 User Plane for high-data rates, considering the inefficiencies observed in deployments", as there were a number of supporting comments in this direction.

First determine whether there are any possibility at all for such alternative, e.g. address the following:

- It is not clear whether a study with such objective would have support (at all).
- If the outcome of such SI would recommend e.g. to introduce PDU concatenation as a solution, could that then be accepted for NR, e.g. in the next release? or is the study result anyway doomed to only be applicable for a later generation?

Feedback Form 9: Alt Wider L2 Efficiency SI

1 – Nokia Germany

In our opinion, the wording Qualcomm had suggested does not necessarily mean a much wider scope since it suggests to focus on high data rate supports and issues observed in deployments.

2 – HuaWei Technologies Co.

We understand even go for a study, this does not mean no specific directions and we start from scratch. If the scope is such broad, the target is not clear anymore and would be difficult to identify useful solutions. Thus we do NOT support this alternative.

3 – Apple GmbH

We are open to a wider L2 efficiency study if the intention is to truly evaluate a range of solutions including the additional topics in section 4.4. However, the study direction is not very clear. In particular, the wording "considering the inefficiencies observed in deployments" can make it hard to meet the goal of a forward-looking study, as it typically takes several years until relevant features are seen in the field. Moreover, a study of "improvements to NR L2 User Plane for high-data rates" is not so much different from a study of "the issue of throughput degradation at high data rates", what could be emphasized more is "efficiency" or "complexity reduction".

Following completion of the study it is conceivable to us to introduce SDU concatenation as an option in the next release, we are aiming for a good solution that is not done in vain.

4 – Futurewei Technologies

We are fine with "Study improvements to NR L2 User Plane for high-data rates", and share similar concern of Apple on the "considering the inefficiencies observed in deployments". We note that we usually don't have this kind of statement in SI/WI to allow continuous standards evolvement in anticipation of industry needs.

5 – Qualcomm CDMA Technologies

We can paraphrase "inefficiencies observed" if that is the concern, e.g. call it "Study optimizations to NR L2 User Plane for high-data rates to improve performance of NR deployments". The gist of this is that we shouldn't look at theoretical or academic problems and focus on things which can really be implementable.

6 – LG Electronics Inc.

If this item is to be approved, we think the scope should be open for wide area.

7 – Samsung Electronics Co.

As we expressed our concern in subclause 4.2.1 above, 3GPP should avoid having such vague and broad objective in general. We understand that, from the title of the thread, this thread is to address the problems identified from the previous discussion, and should not be used to study the "general" enhancements/improvements for other purposes.

8 – Motorola Mobility España SA Lenovo, Motorola Mobility we have the concern on the ambiguity or overlap between the SID objective and the alternative wider L2 efficiency SI. We prefer to focus on the study of the proposed objective.
9 – MediaTek Inc. **Moderator:** The support to have a wider L2 efficiency SI is clearly less than than the support of the original proposal to have a more focused study, and it is not clear whether the results of such study could be reflected in changes to 5G NR.
10 – Philips International B.V. We are open to having a broader study.
11 – ZTE Corporation At the moment, we are not convinced about the urgency of this study. But if really there is a majority view to have the study item agreed, then we should keep it simple and target identifying some real problematic scenarios before we can develop solutions.
12 – Intel Corporation (UK) Ltd

4.4 Additional scope

We make the assumption that the additional scope indeed is **disjoint** from the above L2 efficiency / throughput degradation / PDU concatenation scope (**different SI/WI**).

With the assumption above, continue to collect comments on the additional scope in the final round, to guide proponents and to help understand whether there is any support to work on any of these additional scope aspects in Rel-18 (we don't discuss here which WI would be targeted)

1. Sub-DRB differentiation for enhanced performance and special packet prioritization. In addition, the treatment of large quantities of TCP ACKs can be optimized. (Apple RP-212357).
2. Prioritize transmission of selective TCP ACKs on UL to maximize DL TCP throughput and reduce UL traffic load (FW RWS-21004)
3. 1:M flexible and dynamic mapping from QoS flow to DRBs to maximize throughput; (FW RWS-21004)
4. Active queue management of DRBs during QoS flow to DRB mapping to reduce latency (FW RWS-21004)

If you choose to not comment, but have commented in earlier phase, it is assumed that your earlier comment applies.

Feedback Form 10: Additional Scope - Cont Collection of Comments

1 – Nokia Germany

We would like to express some concerns on still collecting individual proposals at this stage. They do not seem related to processing constraints and seem well suited as separate inputs for TEI18 later on.

2 – HuaWei Technologies Co.

We have similar view as Nokia.

3 – Apple GmbH

Our papers in RP-212358 and RP-212354 include an initial set of justifications and objectives. If RAN chooses to go into this direction we can further adjust the contents, it can serve as a starting point.

4 – Futurewei Technologies

We don't agree with the assumption that these proposals are disjoint from the L2 efficiency enhancement scope. The design/enhancement of L2 UP stack should not consider only one specific aspect, as it impacts handling of all traffic. And given the significance of change to L2 UP stack, enhancement to L2 UP is better not to be discussed as TEI. We'd be surprised if PDCP concatenation and these proposals would be treated differently in terms of project management - one can be considered as SI and the others have to be considered as TEI.

5 – Qualcomm CDMA Technologies

These are very specific solutions. Some can be done as UE implementation (e.g. #2). But we are open to discussing them as TEI-17 or 18.

6 – LG Electronics Inc.

We don't understand why the PDU concatenation is in the scope and other are out of the scope. They are all potential solutions, and could be considered in this SI.

However, they don't need to be listed in the SI objectives.

7 – Samsung Electronics Co.

We share the view with Nokia and Huawei: they are not relevant to the main issue for this topic (i.e. to relieve the processing burden), and can be discussed separately e.g. as a TEI.

8 – MediaTek Inc.

Moderator: Well we can only conclude that in the context of this preparation discussion there was no significant support expressed for any of these proposals. There were also some comments that they don't match the scope of the discussion of "High-Speed Packetization".

9 – ZTE Corporation

Same view as Nokia and Qualcomm that we should not expand the scope beyond identification of problematic scenarios. Solutions are not yet necessary to be discussed in our view.

10 – Intel Corporation (UK) Ltd

We share Nokia's view, there is no need to expand the scope.

5 Report and Conclusions

Moderator Report:

- SI led by RAN2 seems agreeable.
- There are objections: A couple of companies stated that they could not accept this proposal because: a) the impact is too architectural for NR implementations (can be considered for 6G). b) if a study shall be done it shall be more wide, not restrict to a certain solution (noted that this was expressed also by companies having opinion above.
- Scope modification: To modify this Item to be more agreeable to the objecting companies, a objective including an activity to study the issues was added, and flexibility was introduced to allow other solution variants in addition to the proposed PDCP concatenation.
    - This updated slightly wider SID variant was accepted by proponents but not the opponents.
- A more substantial change: It was discussed whether there was any real interest to have a Wider L2 performance study to look at L2 processing load in general.
    - It is concluded that such proposal has less support than the original scope.
- Thus, the associated SID with its contents as below seems to be the best supported one, but there is still not consensus.

SID Justification

The NR data structure adopted from Release 15 onwards causes high number of L2 headers at high data rates, which leads to high complexity of data processing because the number of L2 headers is directly related to the number of RLC and PDCP Sequence Numbers (SN) giving high complexity of window management as well as header parsing. Moreover, support of User Plane Integrity Protection (UPIP) at any data rate became a mandatory feature to support secure communication in the late stage of Release 16 of NR, which incur performance degradation due to higher data processing.

In order to alleviate these difficulties and better support high data rate, user plane protocol enhancement should be considered, e.g. PDU concatenation

SID Objectives

Study the issue of throughput degradation at high data rates.

To avoid throughput degradation at high data rates, Study enhancements to

- Simplify the L2 processing for UPIP

- Reduce the number of L2 headers (e.g. MAC, RLC, PDCP).
- Solution(s) of Data Unit Concatenation, e.g. at PDCP layer, shall be considered, other variants are not precluded.

Additional Scope

In this discussion of High Speed Packetization also the following scope was added as suggested by proponents in the beginning of discussion.

- Sub-DRB differentiation for enhanced performance and special packet prioritization. In addition, the treatment of large quantities of TCP ACKs can be optimized. (Apple RP-212357).
- Prioritize transmission of selective TCP ACKs on UL to maximize DL TCP throughput and reduce UL traffic load (FW RWS-21004)
- 1:M flexible and dynamic mapping from QoS flow to DRBs to maximize throughput; (FW RWS-21004)
- Active queue management of DRBs during QoS flow to DRB mapping to reduce latency (FW RWS-21004)

There were comments that this additional scope is disjoint from the original proposal. The moderator anyway allowed to collect comments for this, regardless assumptions whether to add in the same WI/SI or have it in a separate WI/SI

- No significant support from this discussion: Except proponents there was no support expressed, and/but there was also not much discussion, on problems, use case, benefits etc.