[RAN94e-R18Prep-24] UE Aggregation - Version 0.0.5
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-24] UE aggregation

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 SID or WID. Can verify level of controversy per subarea/objectives. If needed for an objective, can determine alternative objectives with less controversy.

1.2 Starting Status

The Starting status of the discussion on UE aggregation is captured in RP-211666 as follows:

UE aggregation (SI). This whole proposed SI is contentious. The support is significant and includes some major operators.

UE aggregation (SI) Areas / Scope:

- *Determine the level of coordination between the UEs and the assumptions for the interconnect link (e.g. non-specified high performance link). Determine if / to what extent the multiplicity of UEs is handled by / is visible to the Core Network / higher layers. (RAN2)*
- *UP operation and architecture, e.g. PDCP aggregation. (RAN2)*
- *CP AS coordination and handling for the multiple connections (e.g. Setup/Modification/Release procedures for the UE aggregation and mobility in coordination manner), (RAN2)*

Note

- *Justification (main): To support Applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are usually not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive. Additionally it is argued by some companies that lower layer aggregation in general will always be more efficient than higher layer aggregation. It is further noted that aggregation will also benefit DL performance.*
- *Contentious Points (Observation): A number of companies think MP-TCP can perform similar aggregation (without impact). Some company assumes that SL relay may be used for the desired aggregation. Target scenario and motivation (what to achieve) and detailed reasons why are not clear. The impact may be unreasonably high in Rel-18.*

1.3 Input tdocs

RP-211992 Discussion on UE Aggregation CMCC

RP-212083 Views on UE aggregation for Rel-18 Qualcomm Incorporated

RP-212399 Discussion on UE aggregation ZTE, Sanechips

RP-212282 Updated views on Rel-18 UE aggregation Huawei, HiSilicon

The input papers will not be explicitly treated here, but are mentioned for reference.

2 Initial Round

2.1 General

Current assumption that this would be a Study Item led by RAN2. Not discussed whether it would or could be followed by a WI in the same release.

Q: Comment on the above.

Feedback Form 1: General

1 – Ericsson LM Too early to decide.
2 – China Unicom From operator perspective, the commercial interest is the most important factor to be considered at this stage. It is important to see if the feature itself is helpful for improving the service availability and providing a good service quality, and if it will bring some opportunities to extend to some new market. Due to the restriction/limitation on UL transmission power of UE, the cell-edge area is always the bottleneck for UL

performance. Even though there are some approaches based on application layer, the drawbacks of the application layer solution are obvious, and it has been proved such kind of application layer solutions cannot be widely commercial deployed in the existing wireless network.

3 – Nokia Corporation

Indeed there are significant RAN2 impacts for eventual work in this area. However, there is also a need for significant involvement from RAN1 and RAN4 in an early stage in any case. This arises, e.g. from the need for clarification of regulatory framework in case co-located UEs are transmitting at the same time, especially as in case of UE aggregation such simultaneous transmission could happen rather often by design. Moreover, there would be a need to understand implications of physical layer coordination of transmissions to physical layer procedures, in particular in case strict coordination would be needed.

In addition, RAN1 and RAN4 would need to be involved in evaluation of potential gain mechanisms from UE aggregation schemes, which in turn would depend to a large extent on the assumptions on the link between the aggregated UEs. Such aspects would need to be clarified before considering a potential SID, such that we are able to assess the scope of the work and potential gain mechanisms.

Having said all that, it is clear that this is a large exercise with unclear direction and regulatory foundation, and hence we **do not support** a study item on this topic in Rel-18.

4 – LG Electronics Inc.

It is early to decide. We see no urgency to have a SI for UE Aggregation.

5 – vivo Mobile Communication Co.

With regards to whether SL relay may be used for the desired aggregation, we think that For UE aggregation, a standalone Study Item led by RAN2 is needed. Since there are some aspects not related to SL relay that should be studied. Such as different levels for coordination, several assumptions for the interconnect link between two UEs, e.g. non-specified high-performance link, wireless non-ideal link and so on, CN impacts, e.g. separate PDU sessions, common PDU session for two UEs, PDCP anchor UP architecture and other potential UP architecture, CP procedure and impact to two UEs. To allow a widespread deployment of UE aggregation, the solution should be decoupled with specific interconnection link such as PC5. The solution should be flexible to be used with different kind of interconnection link, such as WIFI, wireline and PC5.

6 – China Mobile Com. Corporation

The justification of the study on UE aggregation is summarized by moderator Johan during the email discussion in RAN#93 (RP-211666) as below:

To support applications requiring high UL bitrates on 5G terminals, normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are usually not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive.

Furthermore **as John noted in this section that support is significant and includes some major operators.** CMCC understands and shares other major operators' concern, that is to say, the commercial interests and bottleneck eliminating identified in our real network should be regarded as key factors during

the feature evaluation. The restriction on UL transmission power, especially in cell edge area is always the bottleneck for UL performance. Even there are some approaches had been mentioned during previous email discussion, the limitation of them, as summarized in RP-211666, is obvious and the approaches failed to be taken into application widely, which does not go far to solve our present problem. In this sense, we kindly request companies to take seriously considering this feature.

On the other hand, we have different understanding from NOKIA, the proposed possible approaches, except for UE aggregation in physical layer, bring minor impact on RAN1 and RAN4. And current the scope is not restricted to only study physical layer-based approach, hence, it is indefensible to deny the whole feature just relying on one possible solution. Honestly, the promising approach proposed in the feedback from majority is L2 approaches, e.g. DAPS-like or DC-like solutions. And we prefer to limit the current scope just in layer2.

Besides, some companies assume that multi-path in SL relay may be used for the desired aggregation. However, it is not clear whether the approaches to be specified in SL relay can fulfil the scenario and requirement of the UE aggregation. Consequently, we think an explicit study scope for generic UE aggregation is needed in Rel-18.

7 – Samsung R&D Institute UK

It is too early to make any assumption or decision.

8 – Lenovo Mobile Com. Technology

We think to create a study item is reasonable consider this the first time to study UE aggregation in 3GPP.

Since many issues in this stage is not clear enough e.g. the level of aggregation, interface between UEs, whether to support mobility etc., we think followed by a WI in the same release has potential risk.

9 – Rakuten Mobile

We would like to keep it open for now.

10 – TCL Communication Ltd.

The restriction of UL transmission of UE is anyway the limitation especially for the application requiring high UL bitrates. Generally it is beneficial to start the related study from SI.

11 – Spreadtrum Communications

We think a study item on this topic in Rel-18 is needed.

There are many things need to be discussed. The scope can be narrow down through the discussions in SI.

The Uu transmission coordination between related UEs can be handled by gNB, the impacts to RAN1 and RAN4 may be small.

12 – China Telecommunications

In general SL relay based multi-path connection and UE aggregation are seen useful for different scenarios, e.g., UE aggregation is more useful for some specific aggregation scenarios like video monitoring. We think it is helpful to identify what are the common and specific parts for SL relay based multi-path connection and UE aggregation.

13 – Guangdong OPPO Mobile Telecom.

Given the commonality between this topic and SL Relay (as commented by many companies), if this work is deemed value and to be done in R18, it would be beneficial (from work load perspective) to aim at most common / unified design as studied/specified for L2 U2N Relay, i.e., end-to-end PDCP + hop-by-hop RLC with the assistance of adaptation layer in-between. Based on this assumption, in case the work is deemed necessary/motivated by other companies, we see possibility to merge this work into SL relay for unified design/scheme. In that case, the work can be reflected as a study phase in SL Relay WI, potentially focusing on the delta part, i.e., non-3GPP interface for inter-UE connection.

Otherwise, if the target architecture is different, e.g., the integration happens at L1 (PHY layer) or L3 (above RAN), the commonality with SL relay is less, and separate item is more reasonable (in case the work is sufficiently justified).

14 – ZTE Corporation

In our view, UE aggregation can improve the UE capability in terms of transmission power, RF chains,

processing capability, bandwidth, etc, to support higher data rate/reliability. For example, a virtual user formed by the aggregated devices has a higher capability, in terms of number of RF chains, supported bandwidth, transmission power and processing capability etc. This high capability device may forward the data for another low capability device such that the overall capability of latter UE is improved or the coverage is extended in case the latter UE is out of the coverage. In addition, it can improve the robustness because the transmission can still continue even if the Uu link of the latter UE is broken. Compared with the application level solution, we think RAN-level solution is more efficient and should be considered. To achieve this, the coordination should be carefully studied by taking into account the performance, flexibility and the spec impact. As for the detailed objectives, we suggest the following as a starting point.

•Study the use cases and performance evaluation of UE aggregation [RAN1,RAN2].

•Study coordination level/layer at RAN level [RAN2, RAN1].

•Study potential protocol stacks enhancements to support UE aggregation [RAN2].

15 – ZTE Corporation

Please ignore the previous answer of ZTE and refer to this answer for this Question.

We think it is beneficial to have a SI for the UE aggregation in Rel-18. UE aggregation can improve UL capacity, coverage and reliability, especially for the devices with limited bandwidth and power. For example, a device can forward portion of the UL data for another device belonging to the same user to effectively boost up the antenna/power capabilities i.e. more RF chains can be utilized in a user. The scenario and the benefit are recognized by the UE vendors and network vendors in the previous discussion. Therefore, we support the study of UE aggregation in Rel-18.

16 – CATT

We think a SI is useful to better understand the impact to the protocol stack and procedures. We tend to this this is mainly R2/3 but not much to do with physical layer enhancements.

17 – HuaWei Technologies Co.

We think the requirement of UE aggregation is helpful to improve UL performance. To move forward, we suggest the potential middle ground can be that SL relay WI considers support of UE aggregation requirement.

18 – Philips International B.V.

We support this SI/WI and agree with the statements made by China Unicom, Vivo, TCL and Spreadtrum

19 – Apple AB

If this feature is agreed for Release 18 under RAN2 leadership, then the focus should be on protocol layer enhancements. We believe it should be possible to come up with a UE aggregation solution which does not require significant involvement from other groups like RAN1 and RAN4, much like in the initial days of dual connectivity. We expect some impact on system architecture so will need to liaise as needed with SA/CT groups. Our preference is to start with a study item with the objective of reusing as much of existing technology (DC, DAPs, LWA, LWIP) as possible.

20 – Qualcomm CDMA Technologies

We were supportive of a general SI during the September email discussion and still believe in the benefits of UE aggregation. However, there is strong concern from many companies on the scope and RAN impact. Therefore, UE aggregation as part of SL Relay Enhancements, so-called multi-path, seems to be the only viable option at this point. That one will be based on PDCP aggregation, as being discussed in the email discussion for that project, and further scope and details can be finalized in that discussion.

21 – Intel Corporation (UK) Ltd

If SI is agreed, whether to have WI depends on conclusion from SI. Our expectation is that there might be substantial work for the SI and WI, therefore it might be challenging to fit both SI and WI into Rel-18. Hence a full release SI (if agreed) might be needed.

22 – Futurewei Technologies

Given companies' concerns on potential workload and uncertainty of its use, leveraging enhancement of multi-path SL relay in sidelink relay WI may be a more pragmatic approach.

23 – China Mobile Com. Corporation

Additional comment for this bullet, we would like to clarify that in most cases, the UE wherein is non hand-held UE, e.g. equipped in the assembling line of factory , or UAV for live video or 3D map transmission. In addition to improve UL bitrates on 5G terminals, as we mentioned before in this section, it can also improve the reliability and reduce delay of uplink services, that is, if the channel condition of a terminal is deteriorating, another terminal can be used to make up for the traffic performance unsteadiness caused by channel condition variation.

2.2 Justification and high level objective

Justification (main): To support Applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are usually not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive. Additionally it is argued by some companies that lower layer aggregation in general will always be more efficient than higher layer aggregation. It is further noted that aggregation will also benefit DL performance.

Moderator: For a SI, the justification, the high level objectives - what we really want to achieve, and the scenarios to address should be very important.

Q: Please comment in order to reach consensus on what should be the high level objective (what benefits to achieve) and its justification. Can also provide and discuss explicit example scenarios. As this may still be contentious, opponents are asked to provide, in addition to opposing comments, also information on what high level objective could be acceptable, which limitations could make this work acceptable (if any).

Feedback Form 2: Justification and high level objective

1 – Ericsson LM

We dont see any formulation of objectives which would make this work acceptable. This will have huge complexity which would easily, by far, be the biggest item in Rel-18. And as already identified, techniques exist already today which could be used to address the suggested use cases, e.g. MP-TPC. That MP-TCP has not been deployed today is not an argument for deploying a competing solution (which does not have higher chances of being adopted). Adding more solutions for the same problem is not the way to go.

2 – Nokia Corporation

The proposed justification is very broad, and it does not provide a clear guidance on what would be the focus of the work. For example, it mainly discusses uplink aspects, but in the end mention potential DL benefits. Are we supposed to consider both UL and DL in the study? One main issue with the justification is that it does not properly define UE aggregation, and hence it is very difficult to dispute the claims or assess the gain vs pain tradeoffs. It should define more clearly also the targets, for example higher data rates, higher coverage, and/or diversity.

Another issue is that nothing is mentioned about the challenges of UE aggregation regarding the most critical aspect, i.e. how to share the data between UEs in a timely manner. System aspects related to such sharing of data within RAN need to be addressed too, as there is no clear reference in SA to provide a basis for this work.

3 – LG Electronics Inc.

Whole picture of the UE aggregation is not clear yet. The UE aggregation is basically based on the tight coordination between the UEs. Although it assumes some interconnect link, which is non-specified high performance link, it is not presented what it is and what could be assumed in performance perspective. Without having a clear concept of UE aggregation, it is difficult to understand what can be achieved and/or whether it is justified.

4 – vivo Mobile Communication Co.

There are clear trends of increasing wearable devices per User and trends of increasing IoT devices in home environment, in small offices and factories. In order to address the issue of the shortage of UL UE transmission power in 5G, e.g., in coverage limitation case, a user equipped with more than one UEs can use those UEs to aggregated UL transmission to boost UL throughput improvement with separated UL transmission from those different UEs.

Usually, to abide by SAR requirement, a wearable may not transmit at its maximum transmission power. In such case a user may couple a smart watch and smart phone in an aggregation way to to boost UL transmission to satisfy user UL throughput requirement.

In some other cases, in order to address the issue of failing to meet the high reliability communication, improved reliability and robustness for URLLC scenario, e.g. an industrial machine/Robot equipped with two/multiple UEs working in a factory, are urgently needed.

Some companies think MP-TCP can perform similar aggregation, but with MP-TCP the high layer cannot be aware of the condition of air interface and can neither appropriately allocate the radio resources according to the radio link condition, nor achieve the gain from the link adaptive. And also, it requires that both UE and server to support this solution. But, currently not all server support this solution. Please note that usually the server is not located in operator network so it may not be easy for operator to make the necessary upgrade to support MP-TCP.

5 – China Mobile Com. Corporation

Justification (main):

To support Applications requiring high UL bitrates on 5G terminals, in cases normal UEs are too limited by UL UE transmission power to achieve required bitrate via supporting wider UL transmission bandwidths, especially at the edge of a cell. This feature is to support UE aggregation whereby multiple UEs are configured to enable data or service split with in-sequence data delivery among aggregated UE anchored in L2 UP layer. This means a given user's service (s) can be simultaneously transmit on one or multiple UEs depending on its capabilities. And the determination of the strategy of data or service split is by RAN, and anchor layer is located in L2 UP layer. And the interface between the aggregated UEs is open.

Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are usually not available as they need to be available both in server and device, which does not go far to solve our present problem in deployed network. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive.

6 – Lenovo Mobile Com. Technology

We think UE aggregation can bring high UL data rate especially for cell edge UE with power limitation. Such kind of capability improvement is very useful for industry application e.g. 4k/8k live video.

On the other hand, we think the scenario need further clarification. Firstly, whether more than two UE aggregation is needed, which is important to determine which architecture is used for UE aggregation. Secondly, whether high mobility needs consideration, which impact the scope of the study. Thirdly, whether there needs wireless interface between UEs.

7 – Samsung R&D Institute UK

We are not in favor of defining the justification of AS level aggregation without specific usage scenarios, E2E evaluation/analysis including comparison with higher layer aggregation solutions. As the applicability and availability of higher layer aggregation is up to device vendor, the limitation of higher layer aggregation solutions in Justification (main) as above should not be a reason to justify AS level aggregation solutions.

8 – Spreadtrum Communications

We are ok with the justification from moderator.

As discussed before, the main motivation to resolve the restriction/limitation on UL transmission power of UE to improve the throughput, we think the justification is persuasive considering the market requirement.

9 – ZTE Corporation

In our view, UE aggregation can improve the UE capability in terms of transmission power, RF chains, processing capability, bandwidth, etc, to support higher data rate/reliability. For example, a virtual user formed by the aggregated devices has a higher capability, in terms of number of RF chains, supported bandwidth, transmission power and processing capability etc. This high capability device may forward the data for another low capability device such that the overall capability of latter UE is improved or the coverage is extended in case the latter UE is out of the coverage. In addition, it can improve the robustness because the transmission can still continue even if the Uu link of the latter UE is broken. Compared with the application level solution, we think RAN-level solution is more efficient and should be considered. To achieve this, the coordination should be carefully studied by taking into account the performance, flexibility and the spec impact. As for the detailed objectives, we suggest the following as a starting point.

•Study the use cases and performance evaluation of UE aggregation [RAN1,RAN2].

•Study coordination level/layer at RAN level [RAN2, RAN1].

•Study potential protocol stacks enhancements to support UE aggregation [RAN2].

10 – CATT

We think there are benefits to achieve higher UL data rate, as the TX power and processing capability are aggregated compared with a single UE. The new framework has better flexibility and applicability compared with existing solutions.

11 – Philips International B.V.

We very much agree with the statements made by Vivo, China Mobile, ZTE and CATT.

12 – Qualcomm CDMA Technologies

UE aggregation has the potential to improve UE and system performance by increasing the UE throughput for both DL and UL, lowering per-bit energy, and thus increasing total system capacity.

13 – Intel Corporation (UK) Ltd

In general, our expectation is that required standardization efforts for UE aggregation is substantial, as it will span several RAN/SA WGs, as well as control and user plane areas. Therefore before initiating related work in RAN WGs, we prefer that proponents to show performance evaluation results demonstrating the benefits over the other potential Rel-18 enhancement like sidelink relay as well as state-of-the-art technologies like high layer aggregation (e.g. MP-TCP), high power UE etc, and provide sufficiently detailed evaluation / simulation assumptions for the aggregation scenario(s).

14 – Futurewei Technologies

It needs an end-to-end system level study involving at least SA2/SA3, and RAN1/2/4.

15 – China Mobile Com. Corporation

Additional comment for this bullet, we would like to clarify that in most cases, the UE wherein is non hand-held UE, e.g. equipped in the assembling line of factory , or UAV for live video or 3D map transmission. In addition to improve UL bitrates on 5G terminals, as we mentioned before in this section, it can also improve the reliability and reduce delay of uplink services, that is, if the channel condition of a terminal is deteriorating, another terminal can be used to make up for the traffic performance unsteadiness caused by channel condition variation.

2.3 UE coordination General

Determine the level of coordination between the UEs and the assumptions for the interconnect link (e.g. non-specified high performance link). Determine if / to what extent the multiplicity of UEs is handled by / is visible to the Core Network / higher layers. (RAN2)

Q: Feedback on this potential SI objective! Also, Should there be further limitations or other changes to focus the work?

Feedback Form 3: UE coordination General

1 – Nokia Corporation

Performance studies can be performed based on different assumptions for the interconnect link, which can point out the conditions under which UE aggregation can provide gains. Even if RAN would focus only in the case of non-specified high performance link, it is important to characterize under which conditions such link can be assumed to be available, as that would define other limitations on target scenarios, e.g. with impacts on possible levels of coordination. It is not clear which scenarios could be contemplated with such high-performance link, and hence it is not possible to determine if the SID would be addressing a niche use case or something with broader commercial application.

At this stage we should not limit the role of Core Network / higher layers regarding the multiplicity of UEs, given the level of uncertainty on the topic.

2 – vivo Mobile Communication Co.

With regard to coordination level at least the points should be considered:

- For different level of coordination between UEs, RAN based coordination solutions and CN based coordination solutions can be considered and analyzed. RAN2 can focus on RAN based solution.
- For RAN based coordination solution, impacts on CN as little as possible should be considered to reduce inter-group interaction.
- For the interconnect link between UEs, non-specified high-performance link will simplify the whole design and solution.

To avoid some additional work for inter-UE discovery, the SI may consider aggregation of UEs belonging to the same user.

3 – China Mobile Com. Corporation

From our perspective, the UE coordination mechanism is similar as DAPS or DC, just the original protocol stack and procedure is for coordination between two network nodes, the coordination herein is between more than one UEs. Hence, our preferred scope is:

² Determine the AS high level of coordination between the UEs and the assumptions for the interconnect link (e.g. non-specified high performance link).

n Determine if / to what extent the multiplicity of UEs is handled by / is visible to the Core Network / higher layers. (RAN2)

4 – Lenovo Mobile Com. Technology

Generally we are fine for this objective, we think firstly SI needs to determine whether the coordination between UEs and interface between UEs needs to be defined in 3GPP. For example, if two UEs are actually two modules in one device, then the coordination maybe depending on device implementation. This highly relates to the scenario, as we stated in last comments.

5 – Rakuten Mobile

We agree with Vivo.

”For different level of coordination between UEs, RAN based coordination solutions and CN based coordination solutions can be considered and analyzed. RAN2 can focus on RAN based solution.”

6 – Spreadtrum Communications

We are fine with this objective. We think the SA2 will be involved, e.g. for the selection of coordination UEs.

7 – Guangdong OPPO Mobile Telecom.

For the interconnect link, since logically the target link type (non-specified link) includes both 3GPP (PC5) and non-3GPP link types, it would be preferred to aim at a unified design, i.e., similar to the work done in R15 FeD2D and R17 SL Relay, to aim at a unified design of end-to-end PDCP on hop-by-hop RLC, with the assistance of adaptation layer at UE-to-UE interface and Uu interface. With the clarification/confirm on architecture from the beginning, there seems less need to further study the architecture, given the study work done in R17 SL Relay as captured in TR 38.836 / TR 23.752 for L2 U2N Relay. I.e., the study effort should be more on the specific solution based on the solid/concrete architecture assumption.

Furthermore, for the “*multiplicity of UE*”, we understand the start point of the scenario should be one UE act as the PDCP anchor point and another UE act as the assistant, and both connect to the same gNB. Which is helpful to simplify the problem and can be later (if needed) to be extended to other scenario with more assistant-UEs.

So we propose to change the objective here as a NOTE, to clarify that the architecture assumption is to reuse the one for L2 U2N design in R17.

Otherwise, only if in the architecture is different, e.g., the integration happens at L1 (PHY layer) or L3 (above RAN), we tend to agree with the necessity for study on architecture.

8 – ZTE Corporation

Different levels of coordination were mentioned in previous email discussion. It is fair to clarify the details of different level of coordinations. The benefits and limiations of different coordination levels can be studied and evaluated in SI. In our view, RAN-level based on PDCP layer is preferred due to its efficiency compared to CT level. The studied solution should be general enough that can be applied to all kinds of interconnect links. Moreover, if TU budget is the concern of this SI, we can consider to prioritize the case that aggregated UEs come from the same UE vendor to reduce spec impact.

9 – CATT

We think the current objective is generally fine. Our understanding is that the framework is general so that it does not pose much limitation/restriction to the type of inter-UE link.

10 – HuaWei Technologies Co.

We also think to study RAN-level solution, we can focus on PDCP layer aggregation. In addition, we think the scenarios can be started with the case that aggregated UEs from the same user for simplicity.

11 – Philips International B.V.

In general we agree with the objective, but probably some form of discovery and connection setup between UEs needs to be considered, so that may need to be mentioned as well.

12 – Apple AB

We think the feature should be agnostic to the interconnect link. It can be assumed to be a high-speed link e.g., wired, WiFi, HT BT, or Sidelink. We do not think it is necessary for RAN2 to assume any specific characteristics of this link. The UEs and the network should have some idea of the performance of this link in terms of throughput and delay. It is then up to them to deploy UE aggregation if it is deemed useful.

Re visibility to the core network, we think this aspect should be studied further. It is possible to conceive of a purely RAN level solution which is transparent to the core network. On the other hand, core network involvement may be useful to address subscription and charging matters.

13 – Qualcomm CDMA Technologies

If PC5 is used between the UEs, the UE coordination can be done by using Rel-17 SL discovery. If the link is a non-3GPP RAT or unspecified, the UE coordination should be left to UE implementation.

14 – Intel Corporation (UK) Ltd

It seems that proponents have quite diverse views about the scenarios of aggregated UEs. Some assume that the UEs are physically collocated, while others assume that UEs are physically separated.

- For the physically co-located UEs, clarification is needed on regulation compliance (e.g. SAR).
- For the physically separately UEs, since aggregation is performed in lower layer, our understanding is that the interconnect link between aggregated UEs should also operate in a rather low level. Clarification is needed on the assumptions on the interconnect link, e.g. whether the interconnect link supports multi-vendor operation.

15 – Futurewei Technologies

If the coordination is not intended to be done at AS layers, or interconnect link is out of RAN charter, the study should be initiated and led by SA2.

2.4 User Plane Principles

UP operation and architecture, e.g. PDCP aggregation. (RAN2)

Q: Feedback on this potential SI objective. Also, Should there be further limitations or other changes to focus the work?

Feedback Form 4: User Plane Principles

1 – Nokia Corporation

As mentioned above, more clear definition of UE aggregation itself is needed to better characterize if lower layer aggregation needs to be considered as well. Without such assessment it is very difficult to properly estimate the effort required for such SID.

2 – LG Electronics Inc.

The performance of this interconnect link may impact to whole performance of UE aggregation but It is unclear what can be assumed to the interconnect link now, hence difficult to decide the level of coordination/multiplicity.

3 – vivo Mobile Communication Co.

PDCP anchor based UP protocol is a typical coordination architecture and is successfully used in Dual Connectivity, IAB and L2 Relay. Its advantage is that PDCP anchor based solution is compatible with all types of backhaul link.

However, other UP architecture, such as MAC anchor based, should also be an alternative. MAC anchor based UP architecture, which is used successfully in CA, can provide better transmission performance especially in the case of high-performance interconnect link.

4 – China Mobile Com. Corporation

In this phase, from our perspective, we should focus on approaches based on L2 UP layer in RAN. We prefer to exclude the physical layer-based approach. Hence, our preferred scope is:

[2] UP operation and architecture, i.e. DAPS-like or DC-like solution (RAN2)

5 – China Mobile Com. Corporation

[2] Study the functions on how to support multiple UEs to be configured to enable UL data or DRB split among aggregated UE anchored in L2 UP layer, including:

- the Setup/Modification/Release procedures of the Radio Bearer for UE UL data or DRB split of aggregated UEs ;and
- Mobility in coordination manner (RAN2)

6 – Lenovo Mobile Com. Technology

We agree to take PDCP aggregation as a starting point for the study. PDCP aggregation is a mature tool and has been discussed and utilized widely in e.g. CA/DC, sidelink, IIoT etc. We see this tool can also be used to UE aggregation, maybe with some enhancement.

7 – Rakuten Mobile

We agree with Nokia here.. More more clear definition of UE aggregation is needed before we decide on aggregation protocol.

8 – Spreadtrum Communications

We prefer to apply the UE aggregation based on L2 UP layer. And the DC-like architecture can be as baseline to reduce the workload.

9 – Guangdong OPPO Mobile Telecom.

As replied to 2.3, besides PDCP aggregation, we should aim at most common/unified design by taking advantage of adaptation layer at UE-to-UE interface and Uu interface, based on the work in SL Relay.

Based on the architecture assumption above, our understanding is the only left issue for UP (given the work on L2 U2N Relay in R17 SL Relay) is the operation for non-3GPP inter-UE connection, i.e., seems less need to further study for PC5 based inter-connection.

10 – ZTE Corporation

We think PDCP layer aggregation should be considered. It is more efficient and flexible than application level coordination. To be specific, the data split in MR-DC and the PDCP duplication in NR can be used as baseline to support the multi-path transmission between UE and gNB via different aggregation UEs. Suppose the PDCP layer is ended between UE and gNB, no matter how many aggregation UEs are involved, the in order delivery can be ensured with improved data rate and reliability.

11 – CATT

We think the aggregation is at the PDCP layer. But it seems useful to detail a bit the bullet to better understand the study scope. The CMCC wording seems a good starting point for further fine tuning.

12 – HuaWei Technologies Co.

We also think PDCP layer aggregation is sufficient. This also provides chances to have common design on UE aggregation and multi-path relay.

13 – Philips International B.V.

We support the formulation of China Mobile.

14 – Apple AB

We need to first figure out the granularity at which aggregation is being performed e.g., DRB or QoS flow level. Indeed one of the objectives of the study could be to select the granularity at which aggregation is performed. The details of L2 design can be worked out when the actual work starts.

15 – Qualcomm CDMA Technologies

Agree that the aggregation should be done at L2 layer. PDCP is a natural choice and one RAN2 is very familiar with since it has been used for DC, including between different RATs (LTE and NR, LTE and WLAN).

16 – Intel Corporation (UK) Ltd

Our preference is that if Rel-18 SI is agreed for UE aggregation, the focus is to identify the usage scenarios, evaluate the performance gains over existing solutions, and analyze the system impact. UP operation and architecture can be part of the performance evaluation and system impact analysis.

17 – Futurewei Technologies

Aggregation at PDCP layer has been applied in DC and LTE/WiFi integration. It can be taken as baseline.

2.5 Control Plane AS coordination

CP AS coordination and handling for the multiple connections (e.g. Setup/Modification/Release procedures for the UE aggregation and mobility in coordination manner), (RAN2)

Q: Feedback on this potential SI objective. Also, Should there be further limitations or other changes to focus the work?

Feedback Form 5: Control Plane AS Coordination

1 – Nokia Corporation

The potential scope is still too uncertain to evaluate these aspects.

2 – LG Electronics Inc.

PDCP aggregation has not yet been clearly defined while it seems to be the main protocol enhancement to realize UE aggregation. At this moment, it is not understood well the detailed scope/issue of PDCP aggregation, so it is difficult to say that PDCP aggregation is necessary or not, the impact is big or not.

3 – vivo Mobile Communication Co.

In first stage of CP aspect, common RRC connection and multiple RRC connections (e.g., each UE has its own RRC or a single common RRC is used for all UEs) should be firstly analyzed and compared. Furthermore, detailed CP procedure should be studied for necessary procedures. Besides for setup/Modification/Release procedures for the UE aggregation and mobility in coordination manner, we think link failure detection and recovery should also be considered.

4 – China Mobile Com. Corporation

[2] Study the functions on how to support multiple UEs to be configured to enable UL data or DRB split among aggregated UE anchored in L2 UP layer, including:

- the Setup/Modification/Release procedures of the Radio Bearer for UE UL data or DRB split of aggregated UEs ;and
- Mobility in coordination manner (RAN2)

5 – Lenovo Mobile Com. Technology

This somehow relates to section 2.3 and our understanding this objective assumes section 2.3 determines UE coordination is in AS layer. If so, such objective is anyway to be studied for each UE aggregation architecture.

6 – Guangdong OPPO Mobile Telecom.

As replied in 2.3 and 2.4, if the scenario is limited to the architecture adopted for L2 U2N Relay in R17, our understanding of the gap that requires study work for CP is the operation for non-3GPP inter-UE connection. Otherwise, there seems less need to further study for PC5 based inter-connection.

7 – ZTE Corporation

For the RAN level aggregation, we think it is important to consider this control plane objective. The gNB should be able to get the capability restrictions of different UEs and then select the candidate UEs to form a virtual group to meet the throughput and QoS requirement of specific UE. The corresponding RLC channel/bearer need to be configured for these candidate aggregation UEs. The mobility of these aggregation UE should be considered to avoid service interruption or degradation.

8 – CATT

We think it important to include the CP aspects in the study. Essentially we think all is under network control, based on the service requirement, network resource, as well as UE capabilities. So the objective is generally fine with us, but it is also related to some previous aspects such as the interaction with SA may also have impact in CP work. Then regarding mobility related aspects, it can be considered further.

9 – HuaWei Technologies Co.

we understand the major CP impacts are on the data bearer configuration, e.g. how to configure the split data bearers, which needs to taken these aggregated UEs into account. However the identification of which UEs are aggregated for the same user, seems to be more appropriate to be led by CN as this may be relevant to the user's privacy.

10 – Philips International B.V.

We agree with CATT

11 – Apple AB

UE aggregation involves coupling of the UEs that are involved. Some notion of identity (either at the CN or RRC level) needs to be designed. The formation of UE aggregation groups can also be facilitated by the CN. There is also a need to identify the primary UE and secondary UEs. Maybe a reasonable limitation is to assume that all the UEs in an aggregation group are connected to the same cell.

12 – Intel Corporation (UK) Ltd

Our preference is that if Rel-18 SI is agreed for UE aggregation, the focus is to identify the usage scenarios, evaluate the performance gains over existing solutions, and analyze the system impact. CP coordination can be part of the system impact analysis.

13 – Qualcomm CDMA Technologies

We assume that the gNB will be aware of the UE aggregation (so it won't be transparent to RAN). gNB will also know the identities of the UEs being involved and have context for each. CP signaling for the the control of aggregation, at least turning on and off the aggregation mode, is necessary.

14 – Futurewei Technologies

Study can first focus on UP architecture, evaluating performance in targeted use cases. CP issues can be identified and studied along the course for feasibility and standards impact. In the mean time, security and user privacy aspects should be addressed by SA2/SA3.

2.6 Other

Any other potential objectives, other aspects?

Feedback Form 6: Other

1 – Intel Corporation (UK) Ltd

We suggest adding one general objective if Rel-18 SI is agreed for UE aggregation.

- Identify the usage scenarios, and evaluate the performance gains over existing solutions.

3 Intermediate Round

3.1 Report of the Previous Round

Opposition / Support

Moderator Report and Suggestion: There are still a couple of opposing companies. This is noted, and it is suggested to anyway continue the scope discussions, and also the opposing companies are encouraged to participate constructively (will not be counted as support).

Organization of the work

Moderator report: Two alternatives are being proposed, Alt 1 and Alt 2:

1. Part of SL Relay WI Multipath objective, potentially with study phase.
2. Independent SI on UE aggregation.

Moderator Suggestion: Due to the opposition situation and the concerns expressed on high impact, the moderator considers that Alt 1. UE aggregation Part of SL Relay WI Multipath objective is an important way forward. Still Alt 2 Independent SI is still kept open for now.

Leading and Impacted Groups

Moderator Report:

- There seems to be consensus that leading group is RAN2.
- RAN4/RAN1 impacts for regulatory aspects for co-located UEs simultaneous transmission is TBD. Comment: One company suggested this open issue, and a couple of companies expressed that they didn't believe this is an issue.
- RAN1 impact for performance evaluation e.g. comparing with other solutions is TBD. Comment: A couple of companies indicated that there may be such impact. Moderator wonder if the need for evaluation would be present also for Org Alt 1.

- SA groups impacts is indicated by several companies. Comment: Moderator believes that in Org Alt 1, SA and CT groups impact will anyway need to be handled in the current objective for multipath SL relay, and in Org Alt 2 already in previous discussion it was mentioned that if needed, UE aggregation could be made transparent to NAS and Core network and was proposed to be studied.

Moderator Suggestion: Discuss the above one more iteration.

Justification High Level Objective

Moderator Report: Not much progress on the justification. An interesting question was raised whether the justification (and possibly the scope) should only be about UL.

Moderator Suggestion: Propose to keep the high level justification text from previous discussion, except the last line about DL. It can be discussed in the next round whether the justification (and possibly the scope) should only be about UL or whether DL enhancement need to be mentioned at all.

To support Applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are usually not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive. Additionally it is argued by some companies that lower layer aggregation in general will always be more efficient than higher layer aggregation.

TBD if it is required / expected / wanted that aggregation shall also benefit DL performance.

Scope

Moderator Report: There seems now to be convergence on many parts where there was divergence in the previous discussion, e.g. on PDCP level aggregation, that unspecified high performance UE-UE interconnect link is the way to support co-located UEs. There seems furthermore to be somewhat less support for non-co-located UEs, so the moderator assumes that support for PC5 for non-co-located UEs would only be present if Alt1 is chosen. All of this allows to make objectives more specific.

Moderator Suggestion:

Alt1: Part of SL Relay Multipath Objective:

- *Support of Unspecified high performance UE-UE interconnect link (non PC5) for Aggregation of Co-located UEs (RAN2)*

Alt2: Independent SI on UE aggregation:

- *Study the impacts to support RAN controlled PDCP aggregation using multiple co-located aggregated UEs communicating with one gNB, where PDCP is operating in one of the UEs (and the gNB), and the UEs are interconnected by an unspecified high performance UE-UE link. (RAN2)*
    - *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).*

- *Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).*

– *Study if / to what extent / the multiple aggregated UEs are visible at NAS layer and Core network. (RAN2, [SA2]).*

TBD if applicable (to Alt 1 and/or Alt 2 and/or both or neither):

– *Identify the usage scenarios, and evaluate the performance gains over existing solutions [RAN2, RAN1]*

– *Study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

3.2 Scope - Alt 1

Alt1: Part of SL Relay Multipath Objective:

– *Support of Unspecified high performance UE-UE interconnect link (non PC5) for Aggregation of Co-located UEs (RAN2)*

TBD if applicable (to Alt 1 and/or Alt 2 and/or both or neither):

– *Identify the usage scenarios, and evaluate the performance gains over existing solutions [RAN2, RAN1]*

– *Study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

Feedback Form 7: Objectives - Alt 1

1 – MediaTek Inc.

Moderator: After checking the current modelling it seems clear that the ”(non PC5)” in the text above need to be removed, in order to make possible the high degree of reuse.

2 – China Mobile Com. Corporation

We strongly support Alt 2, an independent SID for the study of the UE aggregation. This will benefit all have a clear understanding of what is really needed for UE aggregation and what functions we should specify for UE aggregation. From our perspective, the current proposed scope of side link is huge, which includes UE-to-UE relay and Service continuity enhancements, besides Relay Multipath. Moreover, the sidelink related projects are obviously over-emphasized, as there are a lot of sidelike related projects in current Rel-18 package. Moreover, if we go to Alt 1, part of SL Relay Multipath objective, how to make UE aggregation workable is not considered at all, which may have a risk that sidelink relay is defined but UE aggregation cannot be enabled, which will be challenging to guarantee the integration of the feature study. As we highlighted in initial round, this feature owns the commercial interests and bottleneck eliminating identified in our real network. Therefore, Alt 2 is more appropriate to handle the study of this feature which will be more executable and easy to have a distinct study scope.

Regarding issue related to the impact on RAN1/RAN4, if the scope is restricted to L2 UP anchor as moderator proposed, in our understanding, this is not an issue, as majorities’ view.

In addition to improve UL bitrates on 5G terminals in the summarized justification, it can also improve the

stability and reduce delay of uplink services, that is, if the channel condition of a terminal is deteriorating, another terminal can be used to make up for the traffic performance unsteadiness caused by channel condition variation. Besides, we would like to clarify that in most cases, the UE wherein is non handheld UE, e.g. equipped in the assembling line of factory or UAV for live video or 3D map transmission.

3 – vivo Mobile Communication Co.

General comment to Alt 1 and Alt2, if the UE aggregation is done at PDCP layer, from our understanding work on Alt1 and Alt2 does not require any work from RAN1 and/or RAN4 WGs. RAN2 can study the case and gain by ourselves during our study phase.

Based on Moderator's last comment to remove "non-PC5", the objective would become **"Support of unspecified high performance UE-UE interconnect link for Aggregation of Co-located UEs (RAN2)". From our understanding, the objective covers both PC5 based aggregation solution and non-PC5 link aggregation solution.**

In case of unspecified link based solution, both UE are connected to gNB and it does not matter which UE is relay UE or Remote UE. The gNB can configure the UEs for aggregation based on some simple CN indication.

We think the main point is to make the scope clear enough.

We wonder whether current PC5 can be reuse without significant work. From our analysis, the workload with Alt1 and Alt2 are quite the same.

For example, if we re-use current PC5 for UE-UE inter-connect link for UE aggregation, first of all both UE should support relay basic procedures. That mean one UE (P-UE) should first connect to relay (the secondary UE S-UE) as in normal Relay UE and remote, then addition Control plane procedure should be triggered by P-UE for UE aggregation request configuration. But, the criteria for Relay UE and remote PC5 connection should be re-investigated.

For UE aggregation with PC5, how the P-UE is connected to gNB may also require some significant study, e.g., does P-UE first connect to direct link first, then establish PC5+Uu link on the indirect path or P-UE first connect to indirect link first, then establish Uu link connection on the direct path.

From our understanding, the scope of Alt1 should be further clarified to get a clear assessment of this work.

Conclusion: From our understanding, the workload for Alt1 and Alt2 are almost the same. So, their corresponding objectives should reflect this similarity. **We also strongly support Alt 2. Merge SL relay with UE aggregation will not reduce the workload and a clear scenario and case will give fast understanding about the gain and solution of what is really needed for UE aggregation considering SI is needed for UE aggregation.**

4 – MediaTek Inc.

At least Alt.1 could be addressed, with the proposed correction in this case that PC5 (and **only PC5**) is covered (where the underlying transport may be sidelink or otherwise). Synergies with the ongoing work planning for SL Relay (multipath incl. one direct path and one indirect path to the same cell/gNB) can and should be exploited which would natively allow some form of traffic aggregation/splitting at the Remote UE. We see this as a natural evolution step that could deliver some of the intended goals of UE aggregation with reasonable effort across RAN/SA/CT groups. This part of the work would in practice be best addressed in SL Relay work.

5 – Qualcomm CDMA Technologies

The main issue is not whether we have a separate SI or not but what kind of UE aggregation should be considered. In that regard, it is not clear if Alt-1 stated above has anything in common with SL Relay enhancements. Our understanding of using SL relay work for UE aggregation was that this will be based on L2-relay architecture. It is fine not to specify the inter-UE link, which can be PC5 or another RAT. But if we don't specify this link, there is also no reason to have the "collocated" condition as, in this case, collocated or not will have no impact on the specifications and is also not testable. So we can modify Alt-1 as: S*upport of Aggregation of UEs based on unspecified high performance UE-UE link and Rel-17 L2-relay Uu link.*

6 – Apple AB

We do not support studying UE aggregation as part of SL Relay Multipath WI.

In our view, the link between the UEs could be Sidelink or any other technology. We think the solution developed for UE aggregation should be agnostic to the technology used for the direct link between the aggregated UEs.

7 – Guangdong OPPO Mobile Telecom.

For the main bullet, "*Support of Unspecified high performance UE-UE interconnect link (non PC5) for Aggregation of Co-located UEs (RAN2)*". We are fine to remove non-PC5 to avoid misunderstanding the final solution is limited to non-PC5, surely the PC5-based work in SL relay can be used to enable UE-aggregation, and we do not have a strong view on whether non-PC5 should be adopted for Alt-1 (our understanding was just that (if adopted) is not something covered by SL Relay, so worth study first).

Assuming unspecified link may include PC5 and non-PC5, the latter case (non-PC5), if adopted finally (we do not have strong view here), worth some check on whether / how it works without any specification at all, or it finally also requires some work to adapt with the non-PC5 lower layer.

For the TBD part, we share the view with moderator that the first bullet on performance evaluation seems not needed for alt-1 since the architecture assumption behind alternative-1 should be clear enough, i.e., same as the one adopted for L2 U2N Relay.

8 – HuaWei Technologies Co.

We think both Alt 1 and Alt 2 are possible, this is not the key issue and we should first define the main objectives to achieve here. One thing for clarification is the term "unspecified high performance UE-UE interconnect link", we understand if go for Alt1, both PC5 and non PC5 can be considered aiming at a common solution design, and non PC5 link itself does not require any 3GPP work.

9 – ZTE Corporation

As we mentioned before, we prefer to have a separate SI for the UE aggregation in Rel-18 since it can improve UL capacity, coverage and reliability, especially for the devices with limited bandwidth and power. However, it is also fine for us to merge the UE aggregation study into sidelink relay with explicit objective, such as UE aggregation through multi-path sidelink relay. Both ways can eventually support the UE aggregation feature for UE.

On the other hand, we have similar view with QC that it is not necessary to confine the Alt-1 with co-located UE if sidelink is to be considered. So it is suggested to change it into "*Support of Unspecified high performance UE-UE interconnect link for Aggregation of UEs (RAN2)* ".

10 – Futurewei Technologies

SL relay multipath solution, where data aggregation is done between L2 UE-to-network relay and direct Uu connection, looks very much as a ready solution in the first TBD objective. Hence, Alt 1 afford us to only study incremental requirements for UE aggregation through non-PC5 connection.

11 – Lenovo Mobile Com. Technology

Firstly we think if go multi-path SL relay way, the scope needs to be discussed together with SL relay topic, since there also has scope discussion for multipath relay.

We agree to add the objective for supporting unspecified UE-UE interconnect link though, as the additional objective compared with SL relay multi-path objectives. And we understand it is not only non PC5 interface, but also non 3GPP interface. We prefer to clearly indicate it in the scope.

Support of Unspecified high performance UE-UE interconnect link (non ~~PC5~~ 3GPP interface) for Aggregation of Co-located UEs (RAN2)

Further, we think support two UEs is the first step of UE aggregation, which also aligns with SL relay multi-path discussion

12 – Nokia Corporation

Our understanding is that if this is considered under the scope of SL relay, then there is no such thing as an unspecified higher performance UE-UE interconnect link anymore. The interconnect link in this case is the PC5 interface itself. If this is not the case, then more clarification is needed on the intentions here. Anyway, it is a contradiction in terms to add an objective to specify support for an unspecified interface.

The identification of usage scenarios and performance evaluations need to be done in any case, i.e. for both Alt1 and Alt2, or any other conceivable alternative that may arise during the discussion. We maintain our view that it is important to clarify the regulatory aspects and potential constraints for simultaneous transmission for co-located UEs. One needs to take into account these are not randomly placed UEs with independent traffic, but UEs that are supposed to have coordinated traffic and being co-located by deployment.

13 – TCL Communication Ltd.

We support Alt 2. The link between UEs are not necessarily restricted to SL at this stage.

14 – LG Electronics Inc.

If UE aggregation is to be progressed as a part of SL multi-path, the detailed objectives needs to be discussed and decided together with SL relay because it would have impact on other objectives under discussion.

15 – Spreadtrum Communications

We support the ALT2.

We think we should design a unified architecture for the different types of the link between the UEs.

If we merge this study into SL relay, it will not reduce the workload because a new architecture also is needed for the non-PC5 case. Besides, there are already too many objectives considered in the SL Relay item.

16 – Ericsson LM

While both Alt 1 and Alt 2 is likely going to have huge overall impact (on both RAN and core), Alt 1 seem at least to have less impact than Alt 2 since Alt1 is (or is it?) relying on something which is in the spec today, namely Sidelink.

Alt 2 is too open to even understand what is on the table. Certainly, different proponents may have a clear view what, in their mind, should be done, but collectively we dont see a clear direction for this topic (i.e. hence this will likely be a very big item, likely the biggest in the whole release).

17 – CATT

We tend to think for both alt. 1 and alt. 2 the goal should be to fulfill the real requirement from the market/operators. Then with alt. 1 one might assume the work load is less but that is unclear to us based on the discussions so far.

18 – ROBERT BOSCH GmbH

Alt 1 is simpler that Alt 2; however, it should not overload Relay discussion in SL Relay enhancements. However, we support a SI for ALT2 to understand the underlying architecture.

19 – Samsung R&D Institute UK

It is understood that SL relay multi-path is considered as one potential objective for UE aggregation. But we wonder whether the justification and scenarios of SL relay multi-path are aligned with what this UE aggregation is to support and we think that this should be clarified if Alt1 is considered. Regarding for both Alt1 and Alt2, we think that the specific target usage scenarios including the support of co-located UEs or non-co-located UEs, any regulatory impacts due to simultaneous transmission for co-located UEs should be studied and evaluated. We also think that this UE aggregation needs not only RAN2 or RAN level study but the E2E framework should also be evaluated including CN impacts for practicality of this UE aggregation.

20 – Intel Corporation (UK) Ltd

We have slight preference for Alt 1 (with the correction that PC5 is used as interconnect link) as it can support the motivations of UE aggregation using existing relay framework, and Alt 1 can also work in multi-vendor scenario.

21 – Fujitsu Limited

We tend to support Alt2 since the UE aggregation should be common function regardless whether it is deployed only on SL or not. Perhaps, it looks good to setup a new SI (Alt2) and RAN2 can discuss detailed usage cases and technical details/feasibility including whether UE aggregation would be applied to SL or not, how large the specification impact is, and so on. Depending on the outcome of the new SI, RAN can decide to setup a new WI whether UE aggregation is only on SL or not, what is the scope/objective to work out is, and so on.

3.3 Scope - Alt 2

Alt2: Independent SI on UE aggregation:

- *Study the impacts to support RAN controlled PDCP aggregation using multiple co-located aggregated UEs communicating with one gNB, where PDCP is operating in one of the UEs (and the gNB), and the*

UEs are interconnected by an unspecified high performance UE-UE link. (RAN2)

- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).*
- *Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).*

– *Study if / to what extent / the multiple aggregated UEs are visible at NAS layer and Core network. (RAN2, [SA2]).*

TBD if applicable (to Alt 1 and/or Alt 2 and/or both or neither):

– *Identify the usage scenarios, and evaluate the performance gains over existing solutions [RAN2, RAN1]*

– *Study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

Feedback Form 8: Objectives - Alt 2

1 – China Mobile Com. Corporation

As we expressed in section 3.2, we strongly support Alt2, an independent SID for the study of the UE aggregation. And we are fine with the scope restricted to AS high layers.

2 – vivo Mobile Communication Co.

See General comments on Objective Alt1.

We agree to moderator wording of this Alt2.

But if TU is limited, some compromise may be considered, such as UE aggregation transparent to Core network, reusing NAS procedure as much as possible, enhanced RRC procedure with necessary aggregation related fields, using PDCP anchor based UP architecture like DC without any new adaptation layer and so on.

3 – MediaTek Inc.

We think **Alt.2** should be clarified esp. wrt **architecture** - if the scope is restricted to AS layers, it means essentially that this is transparent to the CN, i.e. it implies a ***single* logical UE** registered to the network (even if there may be a multiplicity of colocated physical devices (using e.g. rSAP?)) i.e. NAS is not affected at all. In addition, and in line with the Alt2 proposal above, it also implies NG-RAN sees a single UE (single RRC connection, single UE context), not a multiplicity of UEs. Under this assumption, this could be considerably simplified. **Please confirm whether this is a correct understanding.**

4 – Apple AB

We think the current set of objectives is mostly OK but would prefer the following changes.

1. We think it is a bit too early to anchor aggregation at the PDCP layer though the PDCP layer may turn out to be the most suitable option. But at this point we would prefer to replace ‘PDCP” with “user plane” to allow exploration of other options (e.g., SDAP layer or a new layer).

2. We do not think it is super useful to study performance gains over existing solutions. RAN based UE aggregation is quite likely to do at least as well as MP-TCP (if not much better), and has the advantage of not being tied to a specific transport layer protocol.

5 – HuaWei Technologies Co.

In general the objectives should be the same in our view irrespective whether it is an indivual SI or under SL relay WI. We are fine either way and if the majority prefers Alt2, we are fine to go with it.

So for the detailed objectives: 1) we are not sure why this requires RAN1 and RAN4 involvement, as in our understanding this is purely a higher layer study and if gains need to be evaluated, it seems sufficient to study it in RAN2; 2) it is also unclear why it must be co-located aggregated UEs, we understand the solution is the same even if the aggregated UEs are not co-located. As long as these UEs connecting to the same gNB, there should be no difference. Thus we suggest to remove this co-located restriction; 3) we think SA2 coordination should be kept, as the identifiction of these associated UEs need support from the CN, RAN cannot do such work on its own as this may be relevant to the subscrption information etc.

6 – ZTE Corporation

We are basically fine with this Alt1. For the PDCP layer aggregation, it is suggested to focus on AS layer solution. To save cross-group interaction time, it is suggested to minimize the potential impact to NAS or CN.

7 – Qualcomm CDMA Technologies

Agree with MTK that we should have clarity on the architectural assumptions. If the aggregation is not transparent to CN (e.g. common PDU sessions between the UEs), then the work will need to involve SA and CT, possibly in a separate companion Study Item there. Since this will complicate things both technically and procedurally, it may be simpler to start in Rel-18 with solutions limited to AS only. PDCP-layer is an easy choice for UP aggregation since it has been used for DC and inter-RAT (LWA); but we can also leave the choice open at this stage and just put ”L2 layer aggregation” if people would like to explore other ideas.

8 – Futurewei Technologies

The study scope of Alt. 2, outlined by moderator, looks reasonable. And it shows that extra study areas (e.g., adaptation layer, CP procedures, and NAS aspects) would be needed in a separate SI (if SL relay models are not reused).

If it is also to study aggregation anchor above PDCP layer, as suggested by some company, security and privacy protection of UE data needs also be looked into.

9 – China Telecomunication Corp.

We slightly prefer to have a seperate SI on UE aggregation, i.e., Alt.2.

Since there is no consensus for different level of coordination between UEs, it maybe better to fully consider and analyze coordination solutions with different level, e.g. RAN/CN/higher layer based coordination, in a seperate SI.

10 – Nokia Corporation

Similar objectives should apply to Alt1 as well, as it refers to the aggregation operation itself, only the link would be different, as noted in our previous comment to Alt1. However, we strongly disagree with earlier statements that overall objectives of the study should be the same, regardless of Alt1 or Alt2. In Alt1 **we are only considering the common aspects**, not the whole possible spectrum of UE aggregation functionalities. In Alt2 we would consider more general scenarios, including the architectural aspects raised by Mediatek above.

As mentioned above, performance evaluation is critical in any alternative, as we need to understand the potential benefits of different approaches. Hence, even if unspecified, the link between UEs needs to be well characterized, otherwise the performance trade-offs cannot be defined properly. Same statement for regulatory aspects applies here as in Alt.1, this is something that needs to be well understood from the beginning.

11 – China Mobile Com. Corporation

Reply to Mediatek's view: We assume for the UE aggregation, the current framework of PDU session setup can be reused, that is, establishment of two separate PDU session for two individual UEs; Then for the service in aggregation, only PDU session of the service is established for one UE, e.g. anchor UE, and RAN determine the data split among multiple UEs and establish split radio bear over multiple UEs, which all owns separate RRC connection as legacy UEs.

For example, it is possible the different or same packets of a given DRB corresponding to one service split in the UE1 and UE2. In order to guarantee service quality and in-sequence delivery during the scheduling or transmission, there will be a common logical layer in AS L2 layer to guarantee the service quality and continuity in gNB and UE side as DC-like or SDAP-like.

12 – LG Electronics Inc.

If we have a separate item for inter-UE aggregation, it would be good to limit the study/work to AS-only solution for now. In the meanwhile, the overall performance of inter-UE aggregation would depend on the performance of interconnect link but it is still unclear what we can assume for this link. Thus, we have a concern on starting the discussion of inter-UE aggregation without well clarifying/defining overall architecture including the interconnect link.

13 – Spreadtrum Communications

We support the ALT2. A separate SI for the UE aggregation in Rel-18 is needed.

We agree with Huawei's comments.

14 – China Unicom

We support Alt2, it's needed to have a separate SID for UE aggregation in R18. And regarding the scope, we agree to focus on study AS high layers.

15 – CATT

We tend to think alt. 2 is better. Our reasoning are mainly

1. If unspecified high performance UE-UE interconnect link should be considered, it seems better to use a new SI instead of merging it with sidelink relay, of which itself is already a large WI with multiple scenairos/objectives.

2. Even if PC5 is used as the UE-UE interconnect link, the detailed mechanisms suitable for sidelink relay may not always be suitable for UE aggregation. E.g., the rule for selecting the coordination UE, the coordination UE authorization and etc. So far we do not know for sure how much difference is there in the protocal stack or procedure, but with a seperate SI it seems more efficient to plan the studies.

16 – ROBERT BOSCH GmbH

Alt 2 seems to be huge with significant impact on specs. We recommend to limit it to AS layers only.

We propose to limit Alt 2 to co-located UEs where we may have the chance to study different aggregation levels, i.e., whether we aggregate individual UEs or some layers only.

17 – Samsung R&D Institute UK

As commented for Alt1, the specific target usage scenarios including the support of co-located UEs or non-co-located UEs, any regulatory impacts due to simultaneous transmission for co-located UEs should be studied and evaluated from E2E perspective including CN/RAN impacts for the practicality of UE aggregation.

18 – Rakuten Mobile

We agree with Samsung, There are many open issues such as usecase definitions, Regulatory/Spectrum that needs to be resolved before we jump to the aggregation layer discussion.

19 – Fujitsu Limited

We tend to support Alt2 since the UE aggregation should be common function regardless whether it is deployed only on SL or not. Perhaps, it looks good to setup a new SI (Alt2) and RAN2 can discuss detailed usage cases and technical details/feasibility including whether UE aggregation would be applied to SL or not, how large the specification impact is, and so on. Depending on the outcome of the new SI, RAN can decide to setup a new WI whether UE aggregation is only on SL or not, what is the scope/objective to work out is, and so on.

3.4 Objectives - other

other comments on the objectives.

Feedback Form 9: Objectives Other

3.5 General

Organization of the work

Moderator report: Two alternatives are being proposed, Alt 1 and Alt 2:

1. Part of SL Relay WI Multipath objective, potentially with study phase.
2. Independent SI on UE aggregation.

Moderator Suggestion: Due to the opposition situation and the concerns expressed on high impact, the moderator considers that Alt 1. UE aggregation Part of SL Relay WI Multipath objective is an important way forward. Still Alt 2 Independent SI is still kept open for now.

Leading and Impacted Groups

Moderator Report:

- There seems to be consensus that leading group is RAN2.
- *RAN1 and RAN4 potential impacts in the scope discussion.*
- SA groups impacts is indicated by several companies. Comment: Moderator believes that in Org Alt 1, SA and CT groups impact will anyway need to be handled in the current objective for multipath SL relay, and in Org Alt 2 already in previous discussion it was mentioned that if needed, UE aggregation could be made transparent to NAS and Core network and was proposed to be studied.

Moderator Suggestion: Discuss the above one more iteration

Feedback Form 10: General

1 – China Mobile Com. Corporation

As we expressed in section 3.2, we strongly support Alt 2, an independent SID for the study of the UE aggregation. This will benefit all have a clear understanding of what is really needed for UE aggregation and what functions we should specify for UE aggregation.

Regarding issue related to the impact on RAN1/RAN4, if the scope is restricted to L2 UP anchor as moderator proposed, in our understanding, this is not an issue, as majorities' view.

2 – vivo Mobile Communication Co.

We think this is a new requirement and totally different from SL relay. A separate SI is preferable. if the UE aggregation is done at PDCP layer, from our understanding work on Alt1 and Alt2 does not require any work from RAN1 and/or RAN4 WGs. Some SA relate Works can be LS driven or SI in SA2.

3 – MediaTek Inc.

We see Alt1 is feasible in Rel-18 (as part of SL Relay mPath work). Alt2: please see the comment above whether it can be restricted to a single logical UE (NAS, AS) which would considerably simplify the scenarios and work at hand.

4 – Qualcomm CDMA Technologies

Alt-1, assuming our clarification above, is acceptable. We have sympathy for a general Aggregation study but due to the extent of the scope and concerns from other companies, it doesn't seem that we will be able to converge on that for Rel-18.

5 – Apple AB

If the UE aggregation feature is agreed, we think an independent SI led by RAN2 along the lines of Alt.2 would be most suitable. We expect some interaction with SA groups but that would be business as usual.

6 – Guangdong OPPO Mobile Telecom.

We tend to share the view by others that Alt-1 is the more feasible way-out compared to Alt-2.

For alt-1, we tend to agree that RAN2 as primary and RAN1/4 as secondary group, and SA/CT impact can be handled in the current objective for multipath SL Relay.

7 – HuaWei Technologies Co.

As long as the main objectives are clear enough, it does not make much difference between Alt1 and Alt2. We have preference to go with Alt2 considering this could be a more cleaner approach as several companies already expressed. We also agree with the moderator that SA/CT impact needs to be considered.

8 – ZTE Corporation

A separate SI for the UE aggregation in Rel-18 is prefered. However, we can also accept the merge of UE aggregation with sidelink relay multi-path support since they are quite similar in nature. Both ways can eventually support the UE aggregation feature. With regard to the RAN1/4 impact, we see little impact based on the current Alt1 and Alt2 proposal.

9 – Futurewei Technologies

The trade-off of Alt 1 and Alt 2 seems to be:

- Alt 1 reuses SL models of adaptation layer, aggregation anchor, NAS operation, and CP procedures, and only needs to work on incremental requirements for UE aggregation (mostly for non-PC5 connection);
- Alt 2 can potentially have more comprehensive study, and allows more freedom in exploring different models of adaptation layer, aggregation anchor, NAS operation, CP procedures, without being limited to SL framework.

  Though we have sympathy for a more systematic study like Alt 2, we appreciate the concerns that it may have too big a scope for Rel-18 and the benefit is not clear over a readily available solution based on SL relay multipath approach.

10 – Lenovo Mobile Com. Technology

Alt 1 seems reasonable since the current protocol stack of sidelink relay can be reused for UL aggregation. In addition, for the case with non-3GPP between UE-UE, the related discussion also happened in SI FeD2D topic, which are captured in TR36746.

For Alt1, the work and scope discussion is better to combined with SL relay since there also has multipath SL relay discussion. Then it equally to add one additional motivation and objective on top of what SL relay has been discussed. And the whole work load should be justified in SL relay.

11 – Nokia Corporation

We do not support Alt2 as it leads to much larger objective and broader system impact. While we do not see a strong need for Alt1 either, in our view the best way forward in this discussion is to consider the **aspects of UE aggregation that are common to multipath SL relay**, and address those in the corresponding SI/WI. This does not mean that the multipath SL relay objective itself should be enlarged to consider all potential aspects of UE aggregation though.

12 – Spreadtrum Communications

We prefer to have a separate SI for the UE aggregation in R18.

We agree that SA groups may be involved.

13 – Ericsson LM Agree with Nokia in that Alt 2 seem to broad. It is difficult to foresee what may fall out of an SI that would be framed as Alt 2.
14 – Intel Corporation (UK) Ltd We agree with the moderator that Alt 1 can be a way forward to fulfill the motivation of UE aggregation with reasonable workload in Rel-18.

3.6 Justification

Further discussion on justification detailed wording postponed to final round.

Question for discussion: TBD if it is required / expected / wanted that aggregation shall also benefit DL performance

Note that moderator has assumed that this would impact mainly the justification, and the moderator view is that if this is a not a requirement it should be left out, but can maybe anyway be supported in a WI if cheap.

Feedback Form 11: DL?

1 – vivo Mobile Communication Co. UL limitation is the starting point of UE aggregation. However, UE aggregation architecture can also provide benefits in DL, such as DL throughput increasing, concurrent reliability enhancement and latency reduction.
2 – Deutsche Telekom AG We doubt the need for the entire work on UE aggregation in Rel-18. But if this work should be progressed it should be a simple solution (but we can not see how this can be realised) focussing only on the UL.
3 – Qualcomm CDMA Technologies Aggregation can improve data rates QoS, system performance, and battery consumption. Both DL and UL can benefit from aggregation. If we go with Alt-1, both DL or UL will be supported inherently.
4 – Apple AB Our view is that the primary justification is for UL. Having said that, UE aggregation permits a natural diversity gain in allowing the network to choose between different paths, so we are also OK to include DL enhancements (with lower priority).
5 – HuaWei Technologies Co. We think the UE aggregation may benefit DL performance but the key point is for the UL performance improvement. We agree with the moderator that we don't need to address DL at this stage and can focus on UL.

6 – ZTE Corporation We think UL is more important than DL for UE aggregation. We may start from the UL and then DL if time allows.
7 – Futurewei Technologies As possible aggregation layer is PDCP and above, it may be more complicated to exclude DL in the design of aggregation framework. And we agree with other companies that UE aggregation can benefit DL as well.
8 – Lenovo Mobile Com. Technology We do not see clearly benefit for SL throughput.
9 – Nokia Corporation DL should not be considered further, as the justification is even less clear in that case, and it is hard to see anything in this scope that could be considered “cheap” in a potential WI.
10 – Spreadtrum Communications DL will benefit from UE aggregation also. We can start with UL.
11 – Ericsson LM It seems that different proponents of this topic had different use cases in mind (Is it throughput increase? Coverage improvement? Reliability?). This is worrying in our mind. However, at least we though that all proponents were having UL in mind.
12 – Intel Corporation (UK) Ltd It is preferred to focus on UL performance improvements in SI, if an SI is agreed.
13 – Fujitsu Limited We think that UL would be the fist priority to improve UL throughput and so on.

4 Final Round

4.1 Report of the previous Round

General

Moderator Report

The following comments (collected from multiple places in the document, not just general) regarding Alt 1 and Alt 2 reflect the status at this particular instance in time. They are just noted for memory.

- Alt1 upsides: A Number of Companies think Alt 1 have less impact, consume less time. In fact it seems like the Multipath objective for SL relay without modification implements PDCP split bearer distributed

over 2 UEs with a Sidelink as UE-UE interconnect link (almost UE aggregation) so the main adaptation would be to allow to replace Physical Side link with an unspecified link, FFS other smaller changes. It seems like this alternative can now be acceptable also to the opponents.

- Alt 1 downsides: The main issue with Alt 1 is that the main proponents are convinced that Alt 1 will not result in the useful functionality that is wanted. Also, doubts are expressed whether there is any time consumption gain, e.g. it may need to be discussed how to handle the functions that are needed for Sidelink but not for UE aggregation (when not using the physical sidelink) and in general Sidelink modifications bring change in multiple working groups. Also organization wise the SL items in R18 seems already very large and additional scope may not receive the attention needed for useful results.
- Alt 2 upsides: Supporters think It is possible to make a reasonably focused work without any NAS or CN impact, keeping the multi-UE multi-bearer handling in AS and RAN. In principle can also build on earlier split bearer and multi-link solutions such as DC. Proponents think the size of this item is not the blocking issue, and the support of > 2 UEs is good.
- Alt 2 downsides: A couple of Companies think Alt 2 is too large, the scope is too wide, and it has been commented that the scope is not clear. These companies has stated that Alt 2 seems not acceptable. These companies have not only referred to work and size but also pointed to other alternative solutions such as MPTCP.

Moderator Conclusion: Alt 1 can be accepted by Opponents but not the main Proponents. Alt 2 cannot be accepted by Opponents but by proponents. THUS, No conclusion - for now need to keep both alternatives on the table.

Justification

Moderator Report: It seems the main justification for UE aggregation is not related to DL.

Moderator Suggestion: Remove DL from justifications text, but don't introduce any particular restrictions in the objectives (Comment: a UE anyway normally need its DL to function normally).

Scope - Alt 1

Moderator Report:

- There were a number of comments on PC5, most of them confusing. The reason why the previous wording wasn't good is that simply it should be part of the study to determine to what extent PC5 modelling can be reused. If we want to reuse most of control by NAS we may need to keep this model. PC5 is a reference point.
- vivo point out that using L2 side-link relay would come with many things that are not needed for UE aggregation and we would need to look at how to use this in the context of UE aggregation where both relay and sidelink are not Really used. Moderator think it is a reasonable point that we would evaluate the reasonable level of reuse.
- Co-located wording can be removed.
- As the objectives for Alt 2 now has been expanded for clarity I also made an effort to expand the potential objectives for Alt 1.

Moderator Suggestion:

Alt1.1: Part of SL Relay Multipath (updated short version, for comparison)

- *Support of Unspecified high performance UE-UE interconnect link (non PC5) for Aggregation of UEs (RAN2)*
- *TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

Alt1.2: Part of SL Relay Multipath (expanded version, suggested)

- *Study the impacts to support UE aggregation working according to the following assumptions:*
  - *Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of TWO bearers, where One bearer may be served by a non-anchor aggregation UE. The aggregated bearers terminate at a single gNB that houses the peer PDCP instance. [assume most/all of this is done anyway for SL L2 relay multipath]*
  - *The aggregation is controlled by RAN/AS and Core Network/NAS by applying a direct Uu link + a SL L2 UE-Network Relay link between gNB and UE, and the non-anchor aggregation UE is the relaying UE [assume this is done anyway for SL L2 relay multipath]*
- *Study how to support that instead of physical sidelink, an Unspecified high performance UE-UE interconnect link is used for Aggregation. Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2, [SA2])*
- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2) [assume that most of this is done anyway for SL L2 relay multipath]*
- *TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

Scope - Alt 2

Moderator Report:

- It seems agreeable now to assume to avoid or minimize the impact to NAS and Core Network.
- There were many questions on the architecture and what is really the proposal. I have included CMCCs explanation for how to avoid NAS CN impact, which I think seems correct. I further expanded the assumptions text into several bullets for better understanding.
- A couple of companies are concerned by the large expected work. Moderator: Maybe it could be considered to introduce some more statements on what not to do, e.g. Not consider any cross-UE optimization below PDCP, e.g. Emphasize to Really leave the unspecified UE-UE link unspecified (can possibly pass an unstructured lower layer address for a inter UE link if helpful).
- Some companies makes reference to dual connectivity etc, which may indeed be a baseline, but it is not clear exactly to what extent it can be reused. Note that for Dual connectivity the layers below PDCP are indeed independent.
- There is not much support and a couple of objections to do a performance comparison study, so this part is removed.

- There is also not much support to look at regulatory issues etc, but also somewhat less objection, companies seem not certain so it is kept as TBD.
- Now again there are some companies that want to explore aggregation in other layers than PDCP. As there are concerns on the size of this work, and no clear motivation is given, the PDCP assumption is kept.

Moderator Suggestion:

Alt2: Independent SI on UE aggregation:

- *Study the impacts to support UE aggregation working according to the following assumptions:*
  - *Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of multiple bearers, where each bearer may be individually served by a aggregation UE respectively. All aggregated bearers terminate at a single gNB that houses the peer PDCP instance.*
  - *The aggregation UEs are interconnected by an unspecified high performance UE-UE link, which carries the data between the aggregation PDCP instance and lower layer for bearers served by non-anchor aggregation UEs.*
  - *The aggregation is controlled by RAN at Access Stratum.*
  - *The impact to NAS and Core Network shall be minimized.*
    - *E.g. The bearers for aggregation by non-anchor UEs shall not be visible to NAS or Core Network. Only the anchor UE that houses the aggregation PDCP instance is visible at NAS as terminating the PDU session of the Data Radio Bearer(s) which are aggregated.*
- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).*
- *Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).*
- *TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

  TBD?? Note: This SI should Not consider any cross-UE optimization below PDCP. This SI might use Dual Connectivity as baseline for some multilink aspects.

4.2 SI Justification

Proposal:

The intention with UE aggregation is to support Applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are often not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive.

Q1: Please comment.

Q2: Can there be a common justification that works for both Alt 1 and Alt 2?

Feedback Form 12: SID - Justification

1 – Nokia Corporation

Some comments to the justification text which are not editorial details in our view:

- This part is actually confusing for someone not following this discussion closely: ”*Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated.* ” The point is about how may UEs are using aggregation, but that a single UE could split its transmission through multiple paths.

- Also this one is not truly accurately reflecting the discussion: ”*Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive.”* –> it is not clear in the discussion of the potential content of a SID if this adaptation to radio conditions in different links is considered at all, in either alternative 1 or 2. If the link between the UEs is unspecified, there is nothing guaranteeing radio conditions are taken into account there, and is the original UE aware of the connection of the other UEs and gNB, and taking this information into account for the splitting of data? Nothing on the discussion so far seems to indicate that. We acknowledge it would be possible if there was a willingness to define such feedback control loops, but again this does not seem to be in scope of the discussion. Hence, we propose to remove this sentence.

In general it is not clear to us if we can truly reuse the same justification in both alternatives. Multi-path SL relay is discussing reliability in addition to increased throughput as motivations, while proponents of alt. 2 seem to be focused on throughput as the driving force for the study.

2 – Ericsson LM

Based on the discussion so far, we think this is not going in a direction which is addressing the concerns from the opponents. **But luckily**, we note that in the Rel-18 SL relaying item, there are proposals to have multi-path relaying, which should, in our mind, also allow for ”aggregation”. We think that UE relaying can even be a work item directly. But the direction of what is discussed here is for a study item.

The use cases attempted to be addressed by this ”UE aggregation”-item is therefore already covered.

3 – Futurewei Technologies

Not sure MPTCP is relevant here, as it can be done with a single UE, without involving multiple UEs.

4 – vivo Mobile Communication Co.

If we go with Alt1, some companies just want to consider PC5 only based solution. With regard to ONLY PC5 based UE aggregation solution (w/o support unspecified link UE-UE support) means this feature can only be used after operators deploy SL relay functionalities. Currently some operators clearly express that they do not yet have any plan to deploy SL relay.

On Alt2, the UE scenario can be well focus on **practical user scenario**, e.g., the user smart phone and smart watch/VR glasses, where the smart phone can used for aggregation of VR glasses data. **Or the scenario proposed by CMCC**. In such kind of scenario **study on procedures for discovery are not needed at all**, as these devices can be in advance correlated, e.g., correlated with **user subscription or user binding**. And using the inter-UEs link (that can be any kind of link) the UEs can connected to each other once ON (similar to smart phone connecting earphone with Bluetooth) or user triggered. In such case none of these two UEs need to support relay function.

5 – Qualcomm CDMA Technologies

As we commented earlier, the goal of aggregation is not just to improve uplink power and throughput. Just like in multi-path Relay option, reliability and downlink performance can be improved and these are as important as uplink. Agree with FW that multi-path TCP is not a relevant comparison here.

6 – Lenovo Mobile Com. Technology

We think justification is generally fine. In justification, most content are common to Alt 1 and Alt 2 except "*UE aggregation is more flexible in that a flexible number of UEs can be aggregated.", which is not so suitable for Alt 1 since SL relay limit to two UEs for aggregation i.e. remote UE and SL relay UE.*

7 – TCL Communication Ltd.

All other air solutions will be eliminated except for PC5 if we go for alt1. Alt 2 could be a better way to start the related study.

8 – LG Electronics Inc.

We are not comfortable with justifying the work on UE aggregation without telling what can be assumed to be done for the unspecified link. The only aspect defined for such interconnect link is that it is high performance link, which gives no clue on what we can define more for coordination or split transmission by using this link. As it seems to be one of most important factor impacting the gain/performance of UE aggregation, we are not sure whether leaving this interconnect link unspecified allows us to achieve high thoughput gain for power limited UEs although we somewhat have sympathy to better support of those UEs.

9 – HuaWei Technologies Co.

We are fine with the justification in general and this is independent with the selection between Atl1 and Atl2.

10 – ZTE Corporation

If the UE aggregation is to be merged with SL relay, it is suggested to also mention the motivation of high reliability in addition to high UL bit rate application support. In addition, it is suggested to mention the the support for both PC5 and non-PC5 link among aggregated UEs in justification part. Otherwise,people may tend to think that the UE aggregation objective in SL relay is restricted to PC5 link based aggregation.

11 – CATT

Generally fine with the justification.

12 – Samsung R&D Institute UK

First of all, thanks to the moderator for the great efforts, even if we do not support this Study Item in any form (alternatives). Since each company still has diverged view on the actual scope (e.g. PC5 vs. unspecified; non-collocated UEs vs. collocated UEs/transparent UE, etc.), the proposal from the moderator might be the most acceptable one for now.

13 – China Mobile Com. Corporation

In addition to the reply from my colleague marked CMDI's comment, we have some other comments as follows:

1: to the comment of removing the sentence that "Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive": Although the link between the UEs is unspecified, it cannot be a obstacle to guarantee radio conditions being taken into account there. It is feasible that the original UE can aware of the connection of the other UEs via information exchanged over unspecified interface in implementation or transferred the information via gNB, and then taking this information into account for the splitting of data.

2: to the comment that **the use cases attempted to be addressed by this "UE aggregation"-item is therefore already covered by multi-path relaying**, we think the adverse effect of original Alt1 summarized by moderator and explained by some companies during the discussion is very distinct as follows:

1) Using L2 side-link relay would come with many things that are not needed for UE aggregation, e.g. study on procedures for discovery are not needed at all, and we would need to look at how to use this in the context of UE aggregation where both relay and sidelink are not Really used.

2) On the other hand, the current proposed scope of side link is huge, if we go to the umbrella of SL, it will further burden the workload for SL relay topic.

4.3 Alt 1 Objectives

Moderator: As there is still high level of confusion in the discussion, it is proposed to use the more wordy expanded proposed objectives for now also for Alt1. It is easy to compress and remove redundant text later at RP 94e if needed.

It is possible to provide major comments here and detail wording polishing comments as MS Word bubble comments in the Draft SID in the Drafts folders

Objectives:

- *Study the impacts to support UE aggregation working according to the following assumptions:*
  - *Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of two bearers, where one bearer may be served by a non-anchor aggregation UE. The aggregated bearers terminate at a single gNB that houses the peer PDCP instance. [Editors note: assume most/all of this is done anyway for SL L2 relay multipath]*
  - *The aggregation is controlled by RAN/AS and Core Network/NAS by applying a direct Uu link + a SL L2 UE-Network Relay link between gNB and UE, and the non-anchor aggregation UE is the relaying UE [Editors note: Assume this is done anyway for SL L2 relay multipath]*
- *Study how to support that instead of physical sidelink, an Unspecified high performance UE-UE interconnect link is used for Aggregation. Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2, [SA2])*
- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2) [Editors note: assume that most of this is done anyway for SL L2 relay multipath]*
- *TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

Feedback Form 13: ALT1 objectives

1 – Nokia Corporation

It is disappointing that the moderator removed the considerations on performance evaluation. We have indicated this as absolutely necessary while other companies were mute about it or mentioned it wouldn't be "super useful". How that leads to the moderator's conclusion is puzzling to us. This is particularly critical in this discussion, as it is not obvious in which circumstances there is actual throughput gain or loss. A lot of it will depend on the link between the UEs and that between the UEs and gNB. It depends also on how the UE discovery would be done, is it considering the radio conditions of all UEs, random, "unspecified"...? These are important aspects that need to be considered before moving to any specification stage.

This objective is still very unclear to us: "*Study how to support that instead of physical sidelink, an Unspecified high performance UE-UE interconnect link is used for Aggregation. Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2, [SA2])* " –> What is the content of this study, given the link is unspecified? And why do need to consider such unspecified link when the MP SL relay study would give us a clear, specified, link already? Again, we should not only study "how" to do things, but also "why", and for this the performance evaluation part plays a critical role.

In any case, this Alt 1 seems to be the only promising direction, as there are clearly lots of commonalities with the MP SL relay objective, as nicely written down by the moderator above.

2 – MediaTek Inc.

Moderator: I have assumed that the main case for UE aggregation is as CMCC explained, to have the aggregation UEs mounted physically together, and use multiple radio connections and the multiplicity of the L1 UE capabilities for multiple UEs to overcome the performance limitations of a single UE, in particular the UL limitations.

For this main UE aggregation case, sidelink functions like UE discovery and selection is not dynamic and the complexity of the SL functions is actually not needed. Moreover, the physical sidelink itself is actually not used, but instead replaced by an non-specified high performance link, and a main study point it how to / to what extent to use the SL / PC5 system for the control of this. A possible reuse could be that the PDCP multilink behaviour for UE aggregation can maybe be reused also in configurations with the Real sidelink, to support bitrate enhancement in addition to other used cases which may be supported by the multipath objective like robustness ..

Moderator: There is very high confusion level in these discussions. It seems the proponents explanations and motivations has come out slightly differently in SA vs RAN discussions (but I have not followed discussions in SAx).

3 – Ericsson LM

The Rel-18 sidelink relaying item is already covering the use cases discussed for this feature. So it seems that we can close this discussion?

4 – Futurewei Technologies

It'd be worth capturing the clarification of the intended use case in the objective as pointed out by the moderator - the aggregation UEs are physically mounted together, with their identities known to each other, and there is no need of UE discovery and dynamic selection in 3GPP AS.

It'd be better to also clearly indicate if a 3GPP interface needs to be specified between these aggregation UEs. For example, how is a PDCP PDU identified to the corresponding PDCP entity from the unspecified inter-UE connection? and can a relay UE be involved in multiple inter-UE connections with different

UEs? in other words, how a PDCP PDU be identified for the target UE's corresponding PDCP entity? Is an adaptation layer needed or all these issues would be taken care by the unspecified inter-UE connection?

5 – CMDI

To Nokia's comments on the evaluation, in the MIMO discussion, almost all companies one UE with multiple Panel will benefit from Panel selection and simultaneous Panel transmission considering resilience and throughput, it is quite strange here Nokia suspect the aggregated UEs can not benefit from the multiple transmitters. In addition, on one side, Nokia comments this or that is not clear, then say it is not necessary to study since they suspect if it is super useful, if it require huge resource, on another side, Nokia just selectively skip the objectives which has made the study very focus and manageable. we would like to invite Nokia to have a look into the detailed scope and provide constructive comments. As to other parts, I believe Moderator has already provided a good summary and observation.

6 – Apple AB

We do not believe that Alt. 1 is the way to go . But we think the moderator has adequately captured the objectives, should Alt.1 be selected.

7 – vivo Mobile Communication Co.

If people agree to the work under multi-path relay with also non-PC5 solution support, we have to consider**: a) what is PC5 based solution procedure to support UE aggregation and b) what is the solution procedure when there is no PC5 unspecified link.**

For a) current SL discovery procedure would not be used for UE aggregation purpose because the basic discovery purposed are the same. So, the current discovery procedure should be enhanced, that require other WGs such as SA2. Or alternatively, if we remove the discovery procedure, we have deal with how to re design PC5 establishment with and without discovery procedure.

But, with Alt2 we just consider what is the solution procedure regardless of the link between the 2 UEs, i.e., just b) above. From this point we may argue that the workload of Alt1 may be very significant. Consequently, the **TU requirement for SL relay WI would be much more BIGGER** than actually considered. Please note that some companies have already complained that SL is taking too much TUs.

Additionally, if enough TU is not allocated to SL relay WI and the work of UE aggregation s done under Multi-path SL relay with Alt1, we may end up with ONLY a PC5 based solution that would not be useful. Or in the worst case, companies which are not in favor of UE aggregation would try to down-prioritize this objective during SL relay discussion.

8 – Guangdong OPPO Mobile Telecom.

Just to focus on the formulation of the objective bullets:

By reading the explaination in sub-bullets of objective-1, seems this bullet is for sidelink case (while the 2nd bullet is for non-sidelink case?)? In fact, we are still thinking that with SL as the inter-UE connection, the current scope of multi-path SL relay is sufficient to support UE aggregation, i.e., the main delta part that requiring work is for non-SL part (if it is needed to be done). But surely confirming the assumption is helpful for a clearer scope. And by reading objective-3, we wonder what is the delta part of this bullet compared to the two objectives (1 and 2) above? For now, seems it is OK to remove this bullet (if our understanding is correct, i.e., objective-1 is for SL case, and objective-2 is for the delta part due to non-SL case)?

9 – Qualcomm CDMA Technologies

We assume Alt-1 will be done as part of SL Relay WI and the objectives here can proceed to specification phase directly, at least for the PC5 link between the UEs since multi-path SL relay is well understood. The rest of the description is mostly fine. A few comments:

- We can remove the part ”by a UE PDCP instance that splits/merges data of two bearers, where one bearer may be served by a non-anchor aggregation UE.” There is always only one DRB for PDCP aggregation.
- The CN does not need to be involved for either PC5 or unspecified link so we can simply say ”*The aggregation is controlled by RAN/AS”*
- Not sure why we emphasize ”high-performance link”, if unspecified. Is something as good as PC5 ”high performance”? Seems unnecessary.

10 – Lenovo Mobile Com. Technology

We are fine for the wording of the objectives, but thinks anyway this needs to be discussed in SL relay if go this way. We agree with opponents of Alt 1 that this will further burden the workload for SL relay topic consider the scope is already large.

11 – Nokia Corporation

Reply to CMCC on Nokia comments above: the key difference between the UE with multiple panels and the aggregated UEs is the assumption of the link between the UEs. In case of multi-panel UEs the panels are clearly inside the same physical UE with ideal interface between them and baseband, and the maximum output power is clear. The UE aggregation adds an unclear link between them, with undisclosed performance. This is where we see a need for performance evaluation and clarity on that interface. The most constructive way forwards we can see is to either follow the non-ideal link within the SL objective, or follow the moderator’s direction of narrowing down the scope here to the case of ”ideal” link between the aggregated UEs, with pre-knowledge on IDs etc. That would be a better baseline for discussion.

12 – LG Electronics Inc.

It is confusing from the comments that the UEs are mounted physically together. We have assumed that they are physically apart so that the connection via physical link is a baseline assumption, which is PC5 in Alt1 while unspecified one in Alt2. The assumption of the scenario, whether it is physically one UE or not, has certainly different impact on the level of discussion and work to be done.

We don’t think the Alt1 is to define another unspeficied link and relevant protocol by reflecting the PC5 but it is to assume using PC5 link between the UEs. Therefore, ’Study how to support that instead of physical sidelink, an Unspecified high performance UE-UE interconnect link is used for Aggregation. Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2, [SA2])’ is unlcear to us. if it is to define another unspecified link, it cannot be covered by R18 SL relay.

13 – HuaWei Technologies Co.

For Alt 1, we understand only the below objective is needed as other aspects have been covered by L2 multi-path SL relay. We are still confused what “*Unspecified high performance*” is, we suggest to remove “high performance”. We also do not understand what need and can be studied under RAN1/RAN4 on this regulatory aspects, we do not support expanding this study to other WGs without clear target, and suggest to remove this bullet.

Study how to support that instead of physical sidelink, an Unspecified ***~~high performance~~*** *UE-UE interconnect link is used for Aggregation. Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2, [SA2])*

~~TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]~~

14 – ZTE Corporation

For Alt1 which aims to merge the UE aggregation with SL relay, it seems that current objectives plan to have SI objective for SL relay. However, multi-path under SL relay umbrella is now discussing whether it should be a WI objective. It is suggested to consider the gap between them.

For the detailed objectives, we think not only data split but also data duplication may be considered for multi-path relay. So it is suggested to change the objective to mention both data split and data duplication operation of multi-path Radio Bearer.

15 – CATT

We don't see this shall impact R1 or R4. In our view this is a higher layer foucsed topic.

For alt. 1 in general, we tend to agree some companies' comment that the use cases are not tightly linked to PC5, so then the two step work as outlined above (i.e., first to SL and then look at other cases) might not be the best efficient way. What's more we have the concern that this actually impacts the sl relay WID which is already large.

16 – Samsung R&D Institute UK

Again, we do not support this item, but if we have to choose between the two, then Alt1 is "relatively" preferred approach than Alt2. We think that Alt2 leaves too many things to implementation, which seems undesirable to us.

Regarding Alt1 objectives, we are not clear about the 2nd objective "support unspecified higher performance UE-UE interconnect link". The link should be PC5 in multi-path relay, so the objective on unspecified UE-UE link does not have to be included.

17 – Intel Corporation (UK) Ltd

We have slight preference for Alt 1. Our understanding of discussion in "[RAN94e-R18Prep-12] Sidelink relay enhancements" is that there is wide support for multi-path sidelink relay. Given that Alt 1 and multi-path sidelink relay are targeted for same use cases, consolidation of the two email discussions is needed.

18 – China Unicom

We support Alt1. I agree with the moderator and he has already provided a good summary and observation.

19 – MediaTek Inc.

Moderator Observation: It seems that in this discussion some companies prefers an alternative even less than ALT1, i.e. to just go with Multipath UEtoNetwork L2 SL relay with no change, (meaning that also co-located UEs physically mounted together would communicate by physical radio sidelink). I assume this is already in the current SL relay discussions, so maybe we should refer to this as ALT0.

20 – MediaTek Inc.

Moderator: There were a number of questions, and The reason for indicating that the unspecified UE-UE link is *high performance* is to indicate that it has sufficiently high performance so the performance aspect doesn't need to be taken into account in the standards work - maybe the word *ideal* is more frequently used. Companies that question this wording, would you like to take the performance of this link into account? and if yes? how?

21 – China Unicom

I have to clarify therr is typo for our first feedback. We support Alt.2, a seperate SI for UE aggregation is our preference. Thanks for the good summary and observation.

4.4 Alt 2 Objectives

Moderator: As there is still high level of confusion in the discussion, it is proposed to use the more wordy expanded proposed objectives for now also for Alt2. It is easy to compress and remove redundant text later at RP 94e if needed.

It is possible to provide major comments here and detail wording polishing comments as MS Word bubble comments in the Draft SID in the Drafts folders

Objectives:

- *Study the impacts to support UE aggregation working according to the following assumptions:*
  - *Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of multiple bearers, where each bearer may be individually served by a aggregation UE respectively. All aggregated bearers terminate at a single gNB that houses the peer PDCP instance.*
  - *The aggregation UEs are interconnected by an unspecified high performance UE-UE link, which carries the data between the aggregation PDCP instance in the anchor UE and lower layer for bearers served by non-anchor aggregation UEs.*
  - *The aggregation is controlled by RAN at Access Stratum.*
  - *The impact to NAS and Core Network shall be minimized.*
    - *E.g. The bearers for aggregation by non-anchor UEs shall not be visible to NAS or Core Network. Only the anchor UE that houses the aggregation PDCP instance is visible at NAS as terminating the PDU session of the Data Radio Bearer(s) which are aggregated.*
- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).*
- *Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).*
- *TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*

TBD?? Note: This SI should Not consider any cross-UE optimizations below PDCP. This SI might use Dual Connectivity as baseline for some multilink aspects.

Feedback Form 14: ALT2 Objectives

1 – MediaTek Inc.

Moderator: This Feedback form was missing by accident at first. I added it now. I also copy pasted the attached comment by Nokia Corporation from below, which I find relevant.

Nokia Corporation:

Here me must reiterate that it is disappointing that the moderator removed the considerations on performance evaluation, this is a critical aspect to understand *if* there is any throughput gain in the end, and under which conditions. This is what will then guide any possible specification work, as we would know which elements must be present to ensure there are gains and that the feature would be deployed eventually. Moreover we can't see how to achieve the conclusion that performance evaluations can be ignored based on the earlier replies.

The scope proposed here is quite large, and we don't see it fitting to foreseen Rel-18 plans. Some of this uncertainty is because of the unspecified link, which brings many possible combinations to be addressed, depending on how such link would be modelled. Assuming the work on MP SL relay would proceed in Rel-18, this study would need to consider the common aspects with that work and other possible modelling of the unspecified interface into account, and possibly other mechanisms for aggregation itself.

On the objectives, it is missing the study on procedures for discovery of the potential aggregated UEs and selection of suitable UEs. Even if selection is left for UE implementation, there is a need to consider which information is shared between the UEs to allow this selection. There is also a need to consider how this information is kept up to date, as radio conditions may vary in different ways for the UEs involved in aggregation. Mobility assumptions need to be described too, as otherwise we need to consider also scenarios where some of the UEs are entering/moving away from aggregation area.

Overall we do not see this Alternative 2 as viable, and we strongly prefer further considerations to be based on Alt1 only.

2 – MediaTek Inc.

Moderator Comment to Nokias comments:

On the scope of the impact study:

On the mobility parts. I guess that regardless if the aggregation UEs are mounted physically fixed together, each radio layer may have different coverage situations and be served by different DUs / Network Antennas, so I don't see how to avoid that aggregation links are dropped / added dynamically - I assume this is one case to indeed consider. The goal for mobility would be to keep the connections between UEs and one and the same gNB CU, but as this is anyway controlled by gNB I'd expect that R2 as always leaves mobility steering optimizations in connected for gNB implementation.

On the discovery and selection of UEs, as the interconnect link is to be unspecified, I had assumed that any dynamic options are out of the question, leaving only hardcoded options which indeed need to be looked at but should be not complex, but indeed some of this may need to be clarified so companies can have an aligned view.

On common aspects with SL Relay multipath, I'd guess that the User Plane PDCP behavior could be similar, possibly including some RRC part if PDCP behaviors need to be triggered by RRC (e.g. at link add drop). Do you see other commonalities? The CP assumptions seem quite different between Alt 1 and Alt 2.

3 – Ericsson LM

The Rel-18 sidelink relaying item is already covering the use cases discussed for this feature. So it seems that we can close this discussion?

4 – Futurewei Technologies

Similar comments to Alt 1 objectives.

In addition, is it the intention that PC5 is excluded from consideration for UE aggregation? Or does the second sub-bullet of the first bullet indicate that the design needs to work no matter whether the underlying connection is sidelink or other non-3GPP RAT?

5 – CMDI

when we are talking about the relationship between the ”UE aggregation” and ”Multi-Path”, we need to have explicit objective to define what is needed to enable ”UE aggregation” rather than think ”UE aggregation” is just a subset of ”Multi-path”, i.e., “Multi-path” will by default enable ”UE aggregation”. in this sense, we need to study first of what should be considered for “UE aggregation”.

6 – Apple AB

We are mostly fine with the proposal by the moderator.

But we want to reiterate that we should not make this PDCP based for now and leave other possible user plane options for the study.

We agree that impact on NAS and core network should be minimized. But it seems too early to agree to the text in the sub-bullet (after e.g.). And if it anyways an example, strictly speaking, it need not be part of the objective. At the very least is should be included as a NOTE, if at all.

7 – vivo Mobile Communication Co.

From our understanding the scoping of **Alt2 is straightforward after second discussion**:

· UE aggregation will be at the PDCP layer

· The UEs will be served by a single gNB (e.g., for the case smart phone and smart watch for same user)

· The gNB will control the UE aggregation (e.g. Setup/Modification/Release)

· UE aggregation will be transparent to CN and NAS.

· The inter-UE link is unspecified.

· The UEs could be collocated or non-collocated (no need for discovery procedure as explained in the justification part)

As shown in the justification part, the scenario can be more practical and simpler. The architecture is also simple as it can mimic current DC architecture, for example in case of smart phone and VR, the PDCP can be anchored VR and gNB, both VR and smart phone connected to gNB, VR end-to-end radio bearer can be one to one mapped on to smart phone Uu RLC channel through the link between VR and smart phone. No need for any adaptation header and bearer aggregation.

8 – Qualcomm CDMA Technologies

The description can benefit from some simplifications. A few comments in that direction:

- It is not clear what ”*by a UE PDCP instance that splits/merges data of multiple bearers, where each bearer may be individually served by a aggregation UE respectively.* ” means. As in Alt-1, there is only DRB for PDCP aggregation. Since Alt-2 will be a separate SI, we can also keep the scope more general and consider ”below PDCP” options as Apple has commented. So the first bullet can be ”*Aggregation is performed at L2 (PDCP or lower) layer”*

- As in Alt-1 comment, we can remove the phrase ”high performance” as it can’t be quantified or can cause only confusion. E.g. is PC5 or BT high performance link? Also, we don’t need to specify how the ”unspecified link” operates. Therefore, we suggest to simplify this objective to ”*The aggregated UEs are interconnected by an unspecified UE-to-UE link”*
- Since we are not just considering the relay architecture here, we don’t need to use the terms ”anchor” and ”non-anchor” . We can simply say ”Aggregation will not be visible to CN at User Plane”.
- Not clear what the intention with the TBD on ”*...Not consider any cross-UE optimizations below PDCP...”* so suggest to remove.

9 – Lenovo Mobile Com. Technology

We support to go Alt 2, if CN/NAS impact can be minimized. And we suggest UL UE aggregation could be set as first priority compared with DL UE aggregation. So in first objective “/merge” may be removed or place in other sentences.

Some modifications are suggested as following

*Study the **UP protocol and** operation of multilink split Radio Bearer for UE aggregation (RAN2).*

10 – LG Electronics Inc.

Different from Alt1, Alt2 requires more careful consideration on this unspecified link as it is a key to decide what kind of coordination/dynmicity we can assume for UE aggregation. Therefore, it seems essential to point out that we first start to discuss this interconnect link rather than simply leaving this as ”which carries the data between the aggregation PDCP instance in the anchor UE and lower layer for bearers served by non-anchor aggregation UEs”

It is also questionable what RAN can control without knowing this unspecified link. Do we assume the RAN control soly depends on anchor UE situation without considering the situation of this unspecified link or try to do something for this unspecified link, e.g., specifying the link?

Regarding ’coordinated mobility for the aggregated UEs’, depending on the assumption of UEs whether it is physically collocated or not, this ’coordinated mobility’ would have different aspect to be addressed. Therefore, it should be discussed what scenarios we are talking here, either physically collocated UE or aparted UE, or both, which we think is something that should be discussed/confirmed before starting any item, i.e., not during the item.

Overall, we think there are many aspects to be clarified/understood before starting this work via Alt2.

11 – China Telecomunication Corp.

We think UE aggregation is different from multi-path SL relay, it’s better to go for alt 2. The current scope description of alt 2 is clear for us. The word ’high performance’ seems not needed for the UE-UE link.

12 – Spreadtrum Communications

We prefer ALT2 as commented before.

We are fine with the objectives from moderator generally.

A few comments:

- We think there will be only one bearer as the previous discussion that the DC-like architecture can be used.
- For the coordinated mobility, RAN3 needs to be involved.

13 – HuaWei Technologies Co.

For Alt 2, as explained above, we are confused what "unspecified high performance" is. We suggest to remove it. Then we also think the aggregation is controlled by RAN is mainly for the user plane data transmission, how to identify UEs association would need help from the CN and thus we are fine to minimize CN impact, but it is difficult to be zero. In addition we are not convinced on the regulatory aspects and we suggest to remove this bullet.

Regarding the note, we understand the main impacts are for Uu interface and the link between the UEs is unspecified, and thus we don't think there is a need to have any cross-UE optimization at any layer. We are fine with the remaining part. Here below is our updates:

- *Study the impacts to support UE aggregation working according to the following assumptions:*

○ *Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of multiple bearers, where each bearer may be individually served by a aggregation UE respectively. All aggregated bearers terminate at a single gNB that houses the peer PDCP instance.*

○ *The aggregation UEs are interconnected by an unspecified* ~~***high performance***~~ *UE-UE link, which carries the data between the aggregation PDCP instance in the anchor UE and lower layer for bearers served by non-anchor aggregation UEs.*

○ *The aggregation* ***of user plane data transmission*** *is controlled by RAN at Access Stratum.*

○ *The impact to NAS and Core Network shall be* ***analyzed and*** *minimized.*

§ *E.g. The bearers for aggregation by non-anchor UEs shall not be visible to NAS or Core Network. Only the anchor UE that houses the aggregation PDCP instance is visible at NAS as terminating the PDU session of the Data Radio Bearer(s) which are aggregated.*

- *Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).*

- *Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).*

- ~~*TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs [RAN4, RAN1]*~~

TBD?? Note: This SI should Not consider any cross-UE optimizations ~~*below PDCP*~~*. This SI might use Dual Connectivity as baseline for some multilink aspects.*

With the above changes, We are fine to go Alt 2.

14 – ZTE Corporation

We are basically fine with alt 2.

15 – Samsung R&D Institute UK

No additional comments (see our responses above)

16 – CATT

Like for alt. 1 we do not see a need to imapct R1/4.

One way to totally aviod CN impact is to have sort of predefined association btw the aggregated UEs, in such a way that no standardization support is needed to identify their relationship.

We think alt. 2 is better in terms of work management. And, if the work load is the major concern here we could try to add some limitation on the ambition level, e.g., to clairfy that no impact is expected to certain protocol layers, etc..

17 – Intel Corporation (UK) Ltd

As commented before, we have slight preference for Alt 1.

For Alt 2, we still prefer that performance evaluation is one of the objectives.

18 – MediaTek Inc.

Avoiding/minimizing NAS impact is necessary to keep this as manageable as possible - essentially this implies traffic aggregation/split at the AS only. This can be done either through

- A. a single logical UE with necessary additional AS capabilities, RAN-coordinated, or
- B. different RAN-coordinated UEs that include one UP Anchor UE and a number of Helper UEs that can carry (DRB) packets on behalf of the Anchor UE. I.e. the PDU Session(s) of which traffic is split/aggregated is(are) homed in the Anchor UE. Helper UEs are normally registered without PDU Session establishment (as readily specified) - or if they have PDU Sessions established it is for their own traffic.

We understand Alt2 focuses on B - both A and B bear similarities in AS, though A would be fully transparent to CN/NAS.

B will require some (minimal) CN/NAS effort (e.g. mobility restrictions, registration incl. authorization, charging).

The aggregation/split takes place at the Anchor UE / NG-RAN peer PDCP entities.

Rather than saying that the inter-UE link is unspecified, it may be better to state it is ”out of scope”. We agree with earlier statements to also remove the ”high-performance” qualifier.

Mobility aspects should also be investigated, e.g. coordination of Anchor UE and Helper UEs mobility at RAN.

19 – China Unicom

We support Alt.2, a seperate SI for UE aggregation is our preference. Thanks for the good summary and observation.

4.5 Other

Other Comments

Feedback Form 15: Other Comments

1 – Nokia Corporation

Here me must reiterate that it is disappointing that the moderator removed the considerations on performance evaluation, this is a critical aspect to understand *if* there is any throughput gain in the end, and under which conditions. This is what will then guide any possible specification work, as we would know which elements must be present to ensure there are gains and that the feature would be deployed eventually. Moreover we can’t see how to achieve the conclusion that performance evaluations can be ignored based on the earlier replies.

The scope proposed here is quite large, and we don’t see it fitting to foreseen Rel-18 plans. Some of this uncertainty is because of the unspecified link, which brings many possible combinations to be addressed, depending on how such link would be modelled. Assuming the work on MP SL relay would proceed in

Rel-18, this study would need to consider the common aspects with that work and other possible modelling of the unspecified interface into account, and possibly other mechanisms for aggregation itself.

On the objectives, it is missing the study on procedures for discovery of the potential aggregated UEs and selection of suitable UEs. Even if selection is left for UE implementation, there is a need to consider which information is shared between the UEs to allow this selection. There is also a need to consider how this information is kept up to date, as radio conditions may vary in different ways for the UEs involved in aggregation. Mobility assumptions need to be described too, as otherwise we need to consider also scenarios where some of the UEs are entering/moving away from aggregation area.

Overall we do not see this Alternative 2 as viable, and we strongly prefer further considerations to be based on Alt1 only.

2 – Nokia Corporation

BTW, just realized this comment was sent to section 4.5, as there is no form for comments on section 4.4.

5 Report and Conclusions

Moderator Report:

First, the primary case of this discussion, e.g. as indicated by the primary proponent is the following:

1. Multiple aggregation UEs are mounted physically together, and
2. The aggregation UEs intercommunicate with a UE-UE non-specified link.

There was confusion regarding the assumed case, as it seems for SL L2 Relay discussion on the Multipath objective companies are also referring to *UE aggregation*, but for the case of Sidelink to Interconnect Two UEs and refers to use cases where aggregation UEs are not mounted together.

There was also comments and questions on the assumptions for the non-specified UE-UE link. In summary it is assumed to be high performance / ideal.

It was requested that there should be performance evaluation objectives. There were objections to this and limited support so it was not included in the end.

Two Alternatives: There were two direction alternatives identified

ALT1 - based on SL Relay multipath (it is assumed that this could be done together with the SL Relay Enhancements WI).

- The main impact to add support for the UE-UE non specified link (instead of SL).

ALT2 - A separate SI (not based on SL Relay, somewhat similar to DC).

- Study the impact to support only the case of UEs mounted together, interconnected by a non-specified link, using PDCP split bearer to load share over several bearers where each bearer is served by an

Aggregation UE respectively, and where the aggregation is not visible to NAS/Core Network, i.e. there is no separate PDU sessions for the additional aggregation bearers.

Support / Contention level

- ALT1 seems acceptable to most opponents, main argument that it can similar to SL Relay multipath. ALT1 is not acceptable to main proponents of UE aggregation, main arguments that it brings a lot of overhead that is not needed in the UE aggregation scenario (the SL and SL relay framework).
- ALT2 opposition is slightly less than when discussion started. There are still opposing companies arguing that nothing more than SL Relay multipath is needed, and expressing concern on the size of the work. ALT2 proponents think it provides a more adequate product, supporting multiple UEs and with relatively simple deployment.
- THUS, There is still high interest e.g. by some major operators, but full consensus seems to not have been achieved yet.

Justification Report of Discussion

- The justification is preliminary, and could be the same (or eventually: similar) between ALT1 and ALT2. For ALT1, if merged with SL relay WI, the justification may be merged with other justifications from that discussion, e.g. to support high reliability.
- The justification currently mentions the UE aggregation proposal in comparison also with proposed alternatives such as Higher UL power, MPTCP. There were comments that these parts may not be needed or fully applicable. The moderator think that the statements reduces the confused discussion and unless these are shown to be incorrect they should be kept until the discussion has converged and decisions has been taken.

ALT1 Objectives Discussion Report:

- Moderator Reflection: This whole discussion is cumbersome and VERY time consuming to conduct offline. In one phase companies complain ”I dont understand”, When explanatory text has been added in the next phase same companies complain ”this text is not needed, why is this text there”. Due to the nature of this discussion, moderator asks that word smithing (e.g. removal of redundant text making the objectives perfectly concise) should be done after convergence / decisions.
- The objective descriptions is somewhat reduced according to those comments that were not challenged in last round, e.g. indications of potential SA2 impact was removed. The editors notes has been somewhat expanded.
- For both alternatives the *high performance* has been removed and replaced with *Ideal* in brackets.
- The TBD objective of regulatory impact has been converted into an Editors note for both alternatives.

ALT2 Objectives Discussion Report:

- For both alternatives the *high performance* has been removed and replaced with *Ideal* in brackets.

- There was no support expressed for the question-marked note *Note: This SI should Not consider any cross-UE optimizations below PDCP. This SI might use Dual Connectivity as baseline for some multilink aspects.* so it is removed
- The Huawei comment that the aggregation is for *Data Radio Bearers* is significant in RAN2, as support for *Signalling Radio Bearers* bring some additional things. It is assumed this is agreeable as there were no other comments.
- There were comments to reduce the descriptive assumptions for this alternative as well. These comments has not been followed as for ALT2 there is no baseline architecture and they are helpful for understanding and giving focus.
- The TBD objective of regulatory impact has been converted into an Editors note for both alternatives.

Resulting WI/SI texts

Justification

Editors note: The justification is preliminary.

The intention with UE aggregation is to support Applications requiring high UL bitrates on 5G terminals, in cases when normal UEs are too limited by UL UE transmission power to achieve required bitrate, especially at the edge of a cell. Compared to just supporting higher power, UE aggregation is more flexible in that a flexible number of UEs can be aggregated. Higher layer solutions such as MPTCP are often not available as they need to be available both in server and device. Also a higher layer aggregation function will never be able to take radio conditions into account, be link adaptive.

ALT1 Objectives

- Support UE aggregation working according to the following assumptions:
    - Aggregation is performed at PDCP layer. [Editors note: This bullet is mostly for description, e.g. to compare with Alt 2, assume most/all of this is done anyway for SL L2 relay multipath, Possibly aggregation adds a somewhat different behavior compared to high reliability]
    - The aggregation is controlled by RAN/AS by using a direct Uu link + a SL L2 UE-Network Relay link between gNB and UE, and the non-anchor aggregation UE is the relaying UE [Editors note: This bullet is for description, e.g. to compare with Alt 2, Assume this is done anyway for SL L2 relay multipath]
- Support that instead of physical sidelink, a Unspecified physical UE-UE interconnect link is used for Aggregation (assumed Ideal). Assume to reuse PC5 or side-link modelling when possible/reasonable, e.g. from control plane perspective. (RAN2)

[Editors Note: It is TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs.]

ALT2 Objectives

- Study the impacts to support UE aggregation working according to the following assumptions:

- Data Radio Bearer Aggregation is performed at PDCP layer, by a UE PDCP instance that splits/merges data of multiple bearers, where each bearer may be individually served by a aggregation UE respectively. All aggregated bearers terminate at a single gNB that houses the peer PDCP instance.
- The aggregation UEs are interconnected by an unspecified UE-UE link (assumed Ideal), which carries the data between the aggregation PDCP instance in the anchor UE and lower layer for bearers served by non-anchor aggregation UEs.
- The aggregation is controlled by RAN at Access Stratum.
- The impact to NAS and Core Network shall be analyzed and minimized.
  - The bearers for aggregation by non-anchor UEs shall not be visible to NAS or Core Network. Only the anchor UE that houses the aggregation PDCP instance is visible at NAS as terminating the PDU session of the Data Radio Bearer(s) which are aggregated.

– Study the operation of multilink split Radio Bearer for UE aggregation (RAN2).

– Study the RRC procedures (e.g. Setup/Modification/Release) for control of the (multilink) Radio Bearer and Coordinated mobility for the aggregated UEs (RAN2).

[Editors Note: It is TBD whether it is needed to study impacts due to regulatory aspects at simultaneous transmission for co-located UEs.]