

## RAN-R18-WS-crossFunc-Overall - Version 0.0.1

### RAN

3GPP TSG RAN Rel-18 workshop

RWS-210656

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.3

Source: RAN Vice-Chair (CMCC)

Title: Email discussion summary for [RAN-R18-WS-crossFunc-Overall]

Document for: Information

This NWM thread is not meant to handle Questions/Comments/Answers already handled in the related NWM threads before the RAN Rel-18 Workshop.

**Per the RAN Rel-18 Workshop Management document in RWS-210002, the NWM thread is NOT intended to debate the list of topics!** It is meant to focus on Q&A to address comments/questions common to multiple contributions and interactions among different topics.

The participants shall avoid asking questions/giving comments of supportive/unsupportive nature in order to influence any prioritization/promotion of the topic, as in this phase there is no prioritization discussion.

Time line:

Questions/comments: June 28 08:00 UTC – June 30 8:00 UTC

Answers/comments: June 30 08:00 UTC – July 1<sup>st</sup> 12:00 UTC

**Each company is expected to provide up to one input covering the set of topics of interest in each of the above two windows.**

An email discussion summary is to be uploaded right after July 1st 12:00 UTC.

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## 1 Evolution of duplex operation

This section is targeted at identifying commonalities and interactions for Evolution of duplex operation.

### Feedback Form 1: Questions/Comments

#### 1 – Nokia Corporation

Enabling flexible UL/DL resource allocation on TDD bands according to UL/DL traffic seem one common theme in many contributions and especially need for improvements to addresses practical deployments needs due to interference issues. Need for better support of flexible UL/DL allocations and UL heavy traffic is also mentioned in other contributions like RWS-210277, RWS-210362, RWS-210304, RWS-210034 and RWS-210459, which are listed under other topics like IIoT/URLLC, Security Enhancements, Network

## Slicing Enhancements and Uplink Enhancements.

For enabling enhancements for practical deployments in the near future we think that it would be good to progress step by step by first addressing simpler solutions and deployment scenarios like gNB-to-gNB interference mitigation solutions for enabling flexible UL/DL allocations in short term and later followed by more challenging deployments and solutions flexible and full duplexing solutions both for gNB and UE, which require more studies and impact analyses for equipment not supporting such solutions.

### **2 – ZTE Corporation**

For duplex operation, we agree with other companies that

- (1) we can start with sub-band full duplex in Rel-18 with reasonable workload.
- (2) we should avoid the duplication of the study in the previous items, such as Rel-16 CLI and TDD co-existence.
- (3) the objectives relevant to RAN4 should also be identified as early as possible.

Regarding the potential scope, we think some enhancements, such as more inter-gNB exchange information for CLI mitigation should be considered. The details can be found in our Tdoc RWS-210487. And the gNB-gNB interference (especially considering the misalignment of symbol boundary in different cells) should also be addressed.

### **3 – VODAFONE Group Plc**

It will be important to study the full system benefits of new duplex operation modes compared to other techniques for uplink improvements (e.g. averaging of UE uplink over greater than a few frames).

### **4 – Deutsche Telekom AG**

We support the development of a mode flexible duplex operation. This is relevant for TDD to allow PRACTICAL usage of dynamic UL/DL allocation (which is today fixed per country, or even wider) and also for FDD where it shall be possible to flexibly pair UL of a lower band with DL on a mid or higher band on a per UE basis (depending on the needs), without defining new bands for these new pairs of spectrum. Our contribution RWS-210032 illustrates this in the annex A.

### **5 – Futurewei Technologies**

We think the motivation for duplexity extension should be on UL data rate/coverage/latency improvement as well as possibly IAB operation. The feasibility study and merit (versus cost) evaluation should be done first in RAN4 and RAN1 before moving on to normative work. The study also needs to focus on, for example, subband full duplex at the gNB only.

### **6 – LG Electronics France**

We also think that duplexing enhancement is an important area which should be introduced in Rel-18.

Especially as proposed in RWS-210242 co-sourced by multiple companies, and also discussed/proposed in other papers such as RWS-210488, RWS-210353, RWS-210326, RWS-210397, RWS-210026, RWS-210054, RWS-210175, RWS-210145, RWS-210363, etc., we suggest studying full duplex operation including both SB-FD (sub-band division full duplex) and SS-FD (spectrum-shared full duplex). While SS-FD may provide potential gain in spectrum utilization, SB-FD may provide potential merits providing more UL time slots with relatively simpler interference handling. The suitable scenarios for SB-FD and SS-FD may be different. Therefore, we suggest studying scenarios and gains of different full duplex operation options in Rel-18, which may result in recommendations on the possible normative works in the next phase.

## **7 – Motorola Mobility UK Ltd.**

Many companies including Lenovo/Motorola Mobility think that full duplex (FD) operation at least by gNB has potential benefit for latency reduction, UL coverage/capacity enhancement, and throughput increase, and suggest studying interference issues such as self-interference at FD gNB, cross-link interference (intra/inter-operator interference), and coexistence with legacy (e.g. interference to legacy UL).

In our view, further RAN discussion points are:

- o deployment scenarios (e.g. urban macro vs indoor, indoor vs indoor, FR1 vs FR2, subband full duplex vs single frequency full duplex)
- o whether to study potential new UE behaviors and UE RF requirements to support FD gNB
- o whether to include FD IAB enhancement in the FD study

## **8 – AT&T**

Especially for intra-DU flexible duplex operation, beam management features (e.g. multi-panel enhancements) and the existing CLI framework can be leveraged/taken as a starting point for practical and feasible operating scenarios

## **9 – Spark NZ Ltd**

In a band where multiple operators exist, all must follow the same flexible duplex arrangement otherwise there is potential for very significant inter operator interference- this is a bit like un synchronised TDD .

Pure full duplex where DL/UL share the same band and time slots is signal processing intensive at the BS ( due to SIC receivers) and may also pose challenges at the UE. However there may be other options where sub bands are divided to support DL or UL but then in that case the design of duplex filters is challenging. we need to agree on a scenario that is practical and should be validated via simulations.

## **10 – Apple Hungary Kft.**

It seems to us majority of proponents are considering full-duplex operation as follows (although detailed proposals are observed as well, but this seems common to majority of proponents)

- 1- in a TDD band
- 2- half-duplex UE and full-duplex gNB
- 3- sub-band full-duplex (UL& DL are non-overlapped in frequency)

For the basic scenario as mentioned above, the achievable gain under the areas claimed by the proponents (like system capacity, UL latency reduction, etc needs further justification. For example, for a half-duplex UE, it anyway needs to apply TA after Rx to Tx switching time and of course physical UL transmission cannot overlap with DL reception. Such a delay anyway contributes to UL latency regardless of regular TDD operation or gNB at full duplex. As a result, the gain from UL latency if any, depends on TDD configuration. Given that other flavors, like FD UE, or single-frequency FD at gNB, needs further RAN4/RAN1 specification effort than the basic scenario, and starting the basic scenario without clear justification is not preferred, we propose to study sub-band full-duplex only as part of eIAB in R18, which will be a smooth continuation from R17 duplexing enhancement. If/once the feasibility is well-studied for full-duplex operation in eIAB, we may consider in the next stage full-duplex for gNB serving half-duplex UEs as well.

## **11 – vivo Communication Technology**

1. It seems most companies share the views of studying full-duplex only at the gNB side for Rel-18, at the UE side, still half-duplex is used. We suggest to make it clear .

2. About the full duplex mode at the gNB side e.g. sub-band full duplex (e.g. XDD) and frequency fully overlapped full duplex, we think it would be good to focus the sub-band full duplex as the first step.
3. It would be also important to avoid UE hardware change (i.e. RF) in Rel-18 work, we suggest to make it clear.

## **12 – CATT**

Duplexing enhancement could potentially benefit system in terms of spectrum efficiency, latency, and uplink coverage etc. On the other hand, suppression/management of self-interference and inter-cell interference would be very challenging and is a prerequisite to reap those potential gains. In order to avoid too broad objectives and reduce working load, Rel-18 could first focus on isolated scenarios (at least for frequency overlapping full duplex ) with less impact from inter-cell cross link interference.

## **13 – China Mobile Com. Corporation**

Regarding the evolution of duplex operation, generally, we think we should focus on TDD bands, and assume UE does not support simultaneous transmission and reception. Both sub-band wise full duplex and spectrum sharing full duplex could be considered, and for spectrum sharing full duplex we can focus on isolated scenario which is possible for some indoor scenarios and factory scenarios. In addition, the UE hardware impact should be minimized (e.g., more stringent RF requirements).

Firstly, we need to identify the scenarios for different variants of full duplex operation in TDD bands, including the deployment scenarios (e.g., Isolated, Indoor, Urban, Rural), frequency range and regulation (e.g., FR1, FR2), duplex mode at gNB (e.g., Sub-band wise FD, Spectrum sharing FD), antenna configuration (e.g., Single-/multi-panel, Co-located/distributed antennas, antenna scale).

Secondly, we need study the feasibility of interference cancellation to enable full duplex, including studying the techniques of self-interference/cross-link interference cancellation and corresponding capabilities, studying the requirement of self-interference cancellation capabilities for different deployment scenarios. Coexistence among different operators in adjacent channels and coexistence with legacy UE should also be studied.

Thirdly, we need to evaluate the performance of full duplex. The evaluation methodology and performance metrics (e.g., spectrum efficiency, user perceived throughput, latency, etc.) should also be studied.

Lastly, we need to identify the potential standardization impact to support full duplex operation.

## **14 – Guangdong OPPO Mobile Telecom.**

We are open to discuss full duplex in TDD band. Between sub-band full duplex (SBFD) and spectrum-sharing full duplex (SSFD), we prefer to start with SBFD in the condition that only legacy half duplex is assumed for UE. RAN4's involvement from beginning is truly necessary to guarantee no additional RF/Demo requirement is required for UE. In addition RAN4 can also help to identify the requirement on guard band and model intra-cell and inter-cell interference. Exemplary TDD band should be identified as first step. The potential enhancement area could be self-interference mitigation, cross-link interference management (including inter-cell, intra-operator, inter-operator), beam coordination, MIMO enhancement (e.g., CSI measurement/reporting, m-TRP), duplex adaptation, BWP/sub-band specific DL/UL configuration etc.

## **15 – China Telecommunications**

Many aspects of the enhancements were proposed by companies for the evolution of duplex operation, including: 1) dynamic FDD without simultaneous UL and DL at the same time on a carrier, 2) further enhancements on handling of CLI for dynamic TDD, 3) full duplex at gNB side with simultaneous UL and DL targeting unpaired spectrum, paired spectrum, frequency overlapped UL DL, frequency non-overlapped

UL DL. From our view, we'd like to have a comprehensive study of the enhancement techniques in Rel-18 to determine the feasibility and priority in different scenarios.

#### **16 – Samsung R&D Institute UK**

From the many tdocs submitted on TDD duplexing enhancements by the listed companies, we observe a clearly expressed need for TDD improvements. The 3 main categories of desired TDD improvements by operators and vendors are coverage (compared to FDD), capacity (UL), and latency (compared to FDD). The possibility to avoid regulator-imposed UL-DL slot structures with fixed DL/UL traffic ratios for EU operators should also be mentioned.

The proposed TDD duplexing enhancements can be broadly divided into 2 approaches. First, sub-band methods such as XDD where DL and UL resources on a time-domain resource are in FDM and cannot overlap. Second, full duplex of DL and UL with either partially or fully overlapping frequency-domain resource assignments on a given time-domain resource. Furthermore, need for TDD duplexing enhancements has been expressed both for FR1 and FR2. UEs supporting TDD duplexing enhancements can still operate using half-duplex like existing TDD, while it is possible to also consider full-duplex UE implementations. A single-carrier solution for TDD duplexing enhancements is needed for deployment flexibility, and a CA/DC based mode should not be precluded.

We see a R18 SI as a first step towards bringing new duplexing flexibility to 5G. A step-by-step approach is necessary. It is important that R18 evaluation options in the SI properly account for device complexity. A natural first step is to keep the TDD (single-carrier) UE half-duplex as before. Support for limited advanced duplex operation on the Uu is provided by the gNB. This half-duplex UE & enhanced duplex gNB design assumption is mentioned by many contributions (026, 042, 054, 136, 286, 175, 197, 199, 219, 295, 326, 352, 353, 397, 416, 422 and many more).

Duplexing enhancements for mid-band TDD (FR1) may be more important in the immediate future than FR2, but both are needed near-term. FR1 may be more challenging due to antenna spacing and wavelength than FR2 with 2 or more panels.

Gains and feasibility of FR1 mid-band XDD should certainly be evaluated for small and micro cells, e.g., local area and medium range base station classes. Their comparatively smaller Tx power, typical below-rooftop deployments, reduced interference levels and short-term burst traffic scheduling allow for dynamic TDD operation. However, evaluating and if feasible supporting TDD duplexing enhancements suitable for wide area base stations should have the highest priority. For many operators, duplexing enhancements for macro cells the TDD mid bands are key to improve network performance compared to initial NR deployments.

#### **17 – CEWiT**

Based on the contributions focused on duplexing enhancements, we feel that most of the companies are interested in sub-band full duplex and full duplex at gNB as the initial duplexing enhancement study. This can potentially increase spectral efficiency and provide latency enhancement. It is also important to study the effects of the different interferences (eg., self interference, CLI) that need to be managed since the performance of the system is highly dependent on them. gNB-gNB CLI need be focused on as well. Further, various potential scenarios need to be analysed w.r.t. requirements and benefits of the duplexing enhancements. This also includes IAB scenarios where the enhancements wrt full duplexing have not been completely looked into in previous release. We also believe that involvement of RAN 4 in early stage is important to define clear scope of study.

#### **18 – Beijing Xiaomi Mobile Software**

From our point of view there should be no tightening RF requirements for UE in order to support flexible/full duplex SID in Rel-18.

## **19 – Huawei Tech.(UK) Co.. Ltd**

The list of Tdocs provided for this topic by the RAN chair are: RWS-210026, 0032, 0036, 0042, 0054, 0081, 0122, 0175, 0180, 0197, 0199, 0212, 0219, 0241/0242, 0274, 0275, 0286, 0295, 0326, 0353, 0363, 0388, 0397, 0416, 0488.

Huawei's documents 0436 and 0442 are relevant to this topic and should also be discussed under "evolution of duplexing operation".

On this topic, several Tdocs already provided a clear classification of the potential scenarios assuming full duplex operation at gNB and/or UE, and whether DL and UL are fully overlapped from the full duplex node point-of-view, or separated in frequency domain but in the same OFDM symbol. While these considerations are focused on intra-cell interference, it should not be overlooked that inter-cell interference will also be affected and that the types of challenges are the same as in unsynchronized TDD operation or when neighbor cells use different DL/UL configuration. Such inter-cell interference with different DL/UL configurations needs to be part of the study. In addition, our view is that full duplex operation at the gNB in the case of a small cell should be the first target.

## **20 – Spreadtrum Communications**

We are open to study the evolution of duplex operation in Rel-18. We think it should be assumed that UEs do not support full duplex and no more stringent RF requirements are expected for UE.

## **21 – Ericsson France S.A.S**

Full duplex operation affects many parts of the system with potential gains being highly dependent on many factors including strategies for antenna isolation with different beam directions and real world impacts, performance of digital IC (for both full band and sub-band, where the IC is on PA non-linearity products), deployment scenarios, adjacent channel (including inter-operator) and in-channel CLI, impact of CLI avoidance by the scheduler on achievable gains (in particular for latency), reduced DL array gain if the array is split, RX selectivity requirement for the case of sub-band full duplex, any impacts of reduced reciprocity due to splitting the array and/or time/frequency differences between DL and UL.

The above are well known major issues that will need significant study. Besides these, a couple more questions about CLI:

Q1: CLI mitigation is a challenging problem that has been studied before where issues such as timing misalignment can increase the complexity of implementing IC. Practical challenges can potentially limit gains significantly in the real world. For example, traffic can be quite bursty in many scenarios which makes estimating the characteristics of the interfering signals difficult. Has anything changed on the issue of CLI mitigation, especially on such fundamentally difficult issues, that makes CLI mitigation more feasible in practice now compared to the last time this was studied?

Q2: The impact to legacy UEs that will not have any CLI mitigation has been discussed. Another question is whether all new UEs will implement CLI mitigation methods. If some UEs don't, full duplex can potentially have severely negative impacts on their performance. In this sense, full duplex methods that cause CLI are operationally non-backward compatible even if they are not functionally non-backward compatible. Will it therefore be necessary to separate UEs capable of CLI mitigation techniques to be assigned separate time and frequency resources from UEs that are not? Alternately, should CLI mitigation be mandatory for all new UEs? An aspect that should be included in a potential study on full duplex is the evaluation of gains when only a fraction of UEs implement CLI mitigation schemes.

Q3: Given the challenges with CLI mitigation, considering a limited number of scenarios where CLI can be significantly reduced or avoided, such as sub-band full duplex where all cells have the same DL and UL allocations in time and frequency, and full duplex in an isolated cell, have been discussed. However, for the

former scenario, when transitioning from a half duplex deployment to a sub-band full duplex deployment, all cells must be simultaneously upgraded. How feasible is this in practice? Would the transition of any network to a sub-band full duplex network need the same kind of measures as transitioning to a non-backward compatible system such as a next generation system, i.e., completely separated resources in frequency and time for full duplex and non-full duplex operation?

Apart from co-channel CLI, we also need to bear in mind that adjacent channel CLI is also a major issue. Potentially sub-band Full Duplex may enable some mitigation of adjacent channel CLI, but adjacent channel should be studied and solved in addition.

Considering the need to study aspects such as antenna isolation and performance, filtering and interference rejection and adjacent channel interferences there is clearly a need for both RAN1 and RAN4 to be involved from the start.

## **22 – KDDI Corporation**

Many companies proposed that duplex operation should be studied in Rel-18, and most company think that enhanced duplex operation for gNB side only. We believe that duplex operation enhancements on unpaired spectrum can achieve UL relevant enhancement especially reduction of UL latency thanks to flexile UL resource in each slot. As several companies pointed out, system level benefit should be evaluated at first.

For duplex operation option for gNB side, from operator perspective, considering interference to adjacent channel in real/practical deployment and intra-operator interference handling, spectrum sharing full duplex is more challenging than sub-band full duplex. Therefore, we should start with sub-band full duplex in Rel-18 considering workload on study.

## **23 – China Unicom**

The gNB cross-link interference scenario is really critical for commercial deployment. But this issue is related with network deployment, while the Cross-link interference cancellation of full duplex is mainly focusing on intra-gNB scenario, it is also important to focus on the solutions related with deployment scenario. If inter-gNBs cross link interference is included in full duplex, this topic has potential impacts on RAN3 and RAN1(if identified).

### **Feedback Form 2: Answers/Comments**

#### **1 – LG Electronics France**

##### **Comments to #1, #2, #23**

We also think that solutions for gNB to gNB interference should be studied for flexible UL/DL operation. This may be valid even for the study of sub-band or shared spectrum full duplex operation.

##### **Comments to #2, #5, #9, #10, #11, #14, #16, #22**

We also think SB-FD (sub-band full duplex) operation is an important option to be studied to balance the time domain opportunity between DL and UL. On the other hand, SS-FD (spectrum-shared full duplex) is another important option to allow better spectral efficiency and more dynamics in DL/UL resource allocation. In our initial analysis, gain in UL coverage by SB-FD is restrictive for the case of small packet delivery since it should intercept part of DL spectrum (with additional guard band). SS-FD can be considered as a technology to explode both DL/UL spectrum utilization with more flexibility.

Regarding study scope, the following points should be stressed:

- Spectrum sharing between DL and UL may not necessarily over a whole carrier but DL/UL sharing within a sub-band is also possible to mitigate inter-operator/adjacent-carrier CLI

- Component technologies to be studied for self-interference handling between SB-FD and SS-FD is similar, such as, spatial domain separation, digital/analog cancellation.

- CLI between neighbor cells can be handled relatively easily in some scenarios, e.g., isolated/micro-cell deployments

Therefore, we think it is reasonable to do a comprehensive study over flexible/full duplex operation including both SB-FD and SS-FD to find out suitable scenarios/gains/solutions in Rel-18 timeline rather than considering a single option in the study.

**Comments to Q1 in #21:**

We agree CLI is an important issue and essentially included in the gain analysis of full duplex operation. In our view, solutions for CLI mitigation should be a part of the study scope. However, part of CLI problem may be handled by proper scheduling of, for example, beam allocation, power control, etc., depending on the deployment scenarios.

**Comments to Q2 in #21**

We agree backward compatibility should be considered in any functional improvements. Especially regarding CLI at UE side, simple approach is to avoid severe UE to UE interference by scheduling by, for example, avoiding DL-UL simultaneous scheduling between adjacent UEs. Also, avoiding UL scheduling for cell boundary UEs in a potential DL scheduling time/frequency resources can mitigate UE to UE interference. These approaches may not involve any backward compatibility issues. However, it is something to be considered further if special implementation for CLI handling at UE side, which we believe should not affect the performance of the legacy UEs either.

**Comments to Q3 in #21:**

Desirably, it may be good all the network components can be upgraded at the same time to get the benefits of full duplex. However, in case of gradual immigration, we think it is still possible to have some buffer by using those resources for full duplex scheduling only for the UEs with less impact to the neighbor cells. In this case, spectrum-shared full duplex operation at gNB side may be beneficial since the resources with limited UL scheduling can be also used as DL scheduling simultaneously.

**2 – LG Uplus**

In commercialization viewpoint, we think XDD should be prioritized and specified in Rel-18 timeline. UL throughput and coverage enhancement is most prioritized issue met by 5G-Advance area. Definitely, further study is required but we think XDD would not severely push complex device implementation and we believe current Rel-15 and Rel-16 device could also get the benefit by software upgrade since XDD is transparent to device.

In long-term point of view, we see the benefit on study for various full duplex scheme after Rel-19.

**3 – Samsung R&D Institute UK**

**Comment to #14:**

The key purpose of having a guard-band is not to receive UL signal without any DL interference. The key purpose of the guardband should be to maintain the DL interference to a level that can be handled by digital SIC. As long as DL interference can be handled by digital SIC, reducing the size of guardband or even without guardband is always possible.

**Comment to #11 and #20:**

We also share same view about not to increase UE's side complexity.

**Answer to #21:**

Regarding CLI, we can have study whether such UE can be problem and impact on the performance together with how to enhance. Anyway our design goal is of course full backwards-compatibility. For network update, one of implementation is temporary to block DL transmission for overlapped UL subband of the neighboring new XDD site.

**4 – China Mobile Com. Corporation****Answer to #21:**

Regarding Q1, for sub-band wise full duplex, at least for the case that the same time-frequency pattern is used for different cells, the intra-operator CLI is from adjacent sub-bands, which will be much weaker than that in dynamic TDD. For inter-operator CLI, we think it can be managed based on frequency separation with DL sub-band as the guard band and careful antenna/spatial isolation even if they are co-site deployed. In China, similar case exists in the commercial network deployment that a TDD band of operator A and an UL FDD band of Operator B are adjacent with only 5MHz guard band between them, which means it is possible that 5MHz guard band can provide a good separation for DL of operator A and UL of operator B.

Regarding Q2, in our view, it is not mandatory that all new UEs have CLI mitigation capabilities. For legacy UEs with R16 CLI capabilities, based on UE's measurements and reports, gNB can also perform proper scheduling to reduce the CLI at UE side by avoid scheduling two UEs close to each other at the same time. For legacy UEs without any CLI capabilities, we think gNB can also perform proper scheduling based on UE's beam/CSI reporting. There may be some level of performance degradation for the legacy UEs and new UEs without CLI mitigation capabilities, the concrete performance degradation can be further evaluated during the study.

Regarding Q3, in our view, the most probable bands that full duplex is used are the mid-bands (e.g., 4.9GHz) or FR2 bands, whose coverages are usually not seamless, it is relatively easy to upgrade all the cells in an area. Even for a wide area coverage with many cells, we think it may not be necessary to upgrade all the cells simultaneously to support full duplex. The non-FD neighboring cells of a FD cell can reduce the transmission power or do not transmit anything in the corresponding sub-band in which UL is applied in the FD cell to reduce CLI interference.

In addition, we agree that adjacent channel CLI should be studied and solved, and RAN4 should be involved from the start.

**5 – Fraunhofer HHI**

We consider Subband-FD (SB-FD) as an important initial step to be studied and standardized within the scope of release 18 in particular to allow exploitation of flexible TDD configurations for low latency applications.

Furthermore, SB-FD is considered by many companies as an enabler for a more flexible usage of TDD and FDD band combinations for various use cases.

Scope wise we agree to study:

- Self interference mitigation schemes for Subband and band sharing schemes
- gNB-2-gNB CLI framework and mitigation techniques
- Spectrum sharing studies in SB-FD include adjacent band CLI for intra- and inter-operator scenarios.

A comprehensive study of use cases, scenarios, link and system gains and solution components is advised for the start of Rel.18 followed by WI in a later stage and WI continuation in Rel.19

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## 2 AI/ML

This section is targeted at identifying commonalities and interactions for AI/ML.

### Feedback Form 3: Questions/Comments

#### 1 – ZTE Corporation

##### AI on air interface:

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Generally we see convergence on identified use cases for evaluation and study in Rel-18. CSI feedback, beam/mobility management, RS overhead reduction and positioning attract the interest from the majority of companies in 3GPP. Hence we suggest to select these 4 areas for further discussion of study scope. We would like to check whether this is acceptable for the group.

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For companies having interest in RAN-level study at the beginning of Rel-18: We would like to seek clarification on how this RAN-level study can help, as whether AI/ML is beneficial for different use cases requires very technical evaluation and debate. Further, as we mentioned in the comment above, there is already majority support on a small set of use cases based on companies' views expressed so far. Do you think this RAN-level study is still needed if only these four use cases are selected for Rel-18?

##### AI on network:

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We see convergence on focus on the normative work of prioritized use cases first in Rel-18 WI. Other user cases including new or on-going discussion in Rel-17 need also taken into account. The AI-based use case could be RAN slicing, QoE optimization.

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With normative work on user cases in Rel-18, to define management procedures in NGAP/XnAP/F1AP to enable AI/ML function start/stop, AI/ML measurement request/report, AI/ML model distributing/update is also part of Rel-18 WID.

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In addition, configuration commands of the AI/ML model and data including measurements and training data need to be transferred via security connection. If the AI Entity be provided by the third party, how to provide secure connection between AI Entity and RAN need to be part of Rel-18 WID.

#### 2 – Nokia

**AI/ML for NG-RAN:** There seems to be consensus to focus Rel-18 normative work on an AI/ML functional framework for NG-RAN and on the prioritized use cases, while continuing to study other potential use cases separately.

**AI/ML for Air Interface:** AI/ML proposals for air interface area are rather diverse. In any case, most proposals do indicate that fundamental studies are needed first. In our view, for a successful introduction of AI/ML in NR, these fundamental studies should include aspects like:

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evaluation methodology,

-  
definition of applicable AI/ML framework,

-  
comparability of results, and

-  
how to ensure and verify through test cases predictable UE behavior with AI/ML and that the UE meet all the existing UE minimum requirements while also obtaining performance and minimum requirements improvements with AI/ML.

### **3 – Futurewei Technologies**

We support to have an SI on AI/ML for NR air interface in R18 focusing on: 1) Use cases (CSI, channel estimation, beam prediction as high priority, can accept one as a ‘test case’ if needed); 2) Evaluation methodology (including datasets, performance metrics); 3) Protocol framework on related signaling and procedure.

### **4 – T-Mobile USA Inc.**

R18 needs to start out with SI on AI/ML looking at use cases, required interfaces, evaluation methodology, and protocol framework. 3GPP needs to determine if AI/ML will be treated like RF schedulers or if 3GPP will specify the algorithms and training data.

### **5 – Apple Hungary Kft.**

Questions and comments on the “ML-based network optimizations” sub-topic:

Some papers (e.g. RWS-210253) suggest to study and specify distributed and federated learning schemes. While we acknowledge that those can be beneficial, it is not clear how such schemes can be specified without specifying (at least to some extent) AI/ML models (which may be hard). Hence the question is - are we going to study AI/ML models and if not, how can we study/specify distributed and/or federated (between network nodes and between network nodes and UE) learning schemes without specifying the models?

Additionally, some companies (e.g. RWS-210104) propose very specific AI/ML related optimizations (e.g. AI traffic compression, e.g. AI model encoding, sparsification and quantization) which raises a similar question - how such schemes can be studied and specified without discussing the specifics of AI/ML models?

### **6 – vivo Communication Technology**

1. Study of AI/ML over air interface is serving the long term needs. The study should build the baseline for evolution for next few releases. We should adopt a step by step approach rather than be in hurry to force down-selection of use cases without clear understanding on the use case itself.

2. The whole procedure of applying AI/ML (including data collection, training to communication between multi-parties) over air interface should be clearly discussed before we specify the corresponding

aspects. There would be two parallel AI/ML items in RAN in Rel-18, i.e. air-interface AI/ML (RAN1 led) and network side AI/ML (RAN3 led). The framework defined in RAN3 can be used as the baseline for the discussion of working procedure of applying AI/ML over air interface.

3. Evaluation methodology should also be carefully studied to serve long term needs in next few releases. Model alignment between companies might be necessary to facilitate a fair comparison between different companies. For evaluation purpose, the way of aligning different companies model and extent of alignment deserve detailed discussion in the study.

## **7 – CATT**

In our view, the greatest challenges of applying AI/ML to physical layer are:

- AI/ML algorithm suitable for physical layer is still under study in academia. Most classical AI/ML algorithms are designed for pattern recognition, image processing, natural language processing, etc. 3GPP needs more understanding and insight on the AI/ML algorithm instead of simply trying an AI/ML algorithm for a particular use case, and then another.

- There is no well recognized dataset for training and testing, like ImageNet for image processing. AI/ML algorithm is data-driven which is very different from those model-driven algorithms we used in the past. We need to align channel model and other evaluation parameters to give fair comparison between model-driven algorithms. Similarly we need to align dataset for data-driven algorithms.

- Real-time training is a challenging task for network and UE. If the training of the AI model is split between network and UE, then network and UE need to synchronize the parameters/intermediate results of AI model leading to complex signaling exchange between network and UE. It would be very challenge to finish this kind of study in Rel-18.

The study on AI/ML to physical layer could first address above challenges: gaining better understanding and insight on AI/ML algorithm in 3GPP; establishing evaluation methodology for fair comparison between different AI/ML algorithm including construction of dataset; identifying use cases that does not require online training split between network and UE.

As to AI/ML on higher layer, our view is that we could have a Rel-18 WI to specify the use cases which have conclusion in Rel-17 SI. For the use cases which is low prioritized in Rel-17 due to the limited time, it could be further studied in Rel-18.

Question: Considering that the amount of data for AI model is big, do you think that further improvement on transmission efficiency for AI model is needed, e.g. compression of data for AI model?

## **8 – Guangdong OPPO Mobile Telecom.**

The study of AI/ML should cover both aspects i.e. AI/ML solution to improve NR RAN performance and NR RAN solution to improve AI/ML traffic performance. In general it is encouraging that AI/ML is the hottest topic in the cross area. Nevertheless potential challenge should be also taken into account. For example iterative online training seems necessary to deal with variant channel in PHY layer but link level issues also demand real time reaction i.e. the time for training and inference is short which demand high overhead in terms of communication, computing power and large storage. So in general we need figure out a tradeoff point to leverage the benefit of AI/ML. The study should focus on following issues:

- 1, To identify most interested use cases which have standard impact. From the submitted contributions we observed that the potential use cases could be CSI feedback including CSI compression, beam management, RS reduction/channel estimation, positioning (UE based),link adaption and mobility enhancement.

- 2, To identify evaluation methodology. The benchmark supposes to be existing scheme. The performance metrics could be not difficult but how to quantize the AI/ML itself is not easy job considering we will take this as black box in general. Another challenge is how to manage data set to enable meaningful comparison among companies

3, To identify standard impact. Apart from potential new signal/measurement/relevant procedure to enable AI/ML algorithm, it is also important to manage AI/ML model e.g. how to configure/identify DNN between UE and gNB. The definition of UE capability will be significant different from legacy UE capability also

## 9 – Samsung R&D Institute UK

For physical layer, AI might be suitable to solve issues for which conventional solutions have either model deficit or algorithm deficit. Based on the contributions and discussions in the workshop, CSI processing, beam management, non-linearity handling as well as position are potential topics for AI for PHY:

**CSI processing:** The characteristics of CSI data allow ML algorithm help UE and network feedback/compress/estimate CSI, achieving higher demod performance, where preliminary results had been showed by several companies.

**Beam management:** From our preliminary result, ML based beam management algorithm could largely save the beam measurement occasions and shorten the time consuming for beam sweeping especially for UEs with more beams in the future.

**Non-linearity handling:** AI is efficient to deal with non-linear distortion caused by high PAPR, which can improve link performance and increase energy efficiency. Such property means better support for high data rate such as 256QAM.

Some further discussions on the evaluation methodology including whether/how to collect data-sources for training might be needed in RAN or WG.

For high layer, we support to prioritize SI agreed use cases in R18 WI to study related spec impact. And it is better to have a separate SI (either extending current SI or set up a new one) to study other potential use cases such as AI for URLLC, slicing etc.

## 10 – NEC Corporation

Based on the analysis of papers related to RAN AI/ML submitted to this 3GPP RAN Rel-18 WS, we believe that the following 5 directions could be considered in Rel-18:

1. AI/ML for NR physical layer
2. Enhanced data collection
3. Enhanced NG-RAN support of AI/ML
4. AI/ML related traffic over 5G-Advanced
5. UE-based or RAN-UE distributed AI/ML.

Directions 4 and 5 could be studied separately or integrated into 1 or 3.

### 1. AI/ML for NR physical layer

Potential topics to study:

-

Identify and prioritize use cases

-

*Benefits and difficulties of introducing each use case*

-  
Analyze potential solutions

-  
Analyze standardization impacts

-  
*Uu interface*

-  
*RAN interfaces*

-  
Agree on the evaluation methodology

-  
*Test datasets for evaluation*

-  
*Evaluation metrics*

-  
*Performance requirements.*

A lot of different use cases have been proposed by different companies, for example, CSI compression, beam management, link prediction and adaptation, etc.

## **2. Enhanced data collection**

Potential topics for normative work:

-  
Focus on the current NG-RAN architecture and interfaces

-  
Use cases prioritized in Rel-17 RAN3 Study on enhancement for data collection for NR and ENDC

-  
*Energy Saving*

-  
*Load Balancing*

-  
*Traffic Steering/Mobility enhancements*

-  
Architecture/deployment options for the selected use cases

-  
Procedures for data collection for model training and inference

- Procedures for output provisioning to actors.

### **3. Enhanced NG-RAN support of AI/ML**

Potential topics to study:

- Non-prioritized use cases from the Rel-17 RAN3 Study on enhancement for data collection for NR and ENDC

- Integration and collaboration of 5GC AI/ML, OAM AI/ML, and RAN AI/ML

- Potentially, new interfaces and/or functional entities may be considered

- Multi-vendor interoperability between different ML model parts (data preparation, model training, model inference)

- Secure storage of collected data

- Possibility to pre-select and pre-train some ML models for given tasks

- Study distributed/federated AI/ML within NG-RAN.

Different use cases have been proposed by different companies, for example, UE mobility prediction, traffic prediction, access management, network slicing, RAN QoE optimization, IAB network, etc.

### **4. AI/ML related traffic over 5G-Advanced**

Potential topics to study:

- Identify potential AI/ML use cases

- AI/ML traffic pattern of identified use case and their performance requirement

- Mechanism, e.g. encoding, to optimize AI/ML model transfer overhead

-  
AI/ML model transfer and distribution.

## 5. UE-based or RAN/UE distributed AI/ML

Potential topics to study:

-  
Mobility enhancement by UE based AI/ML

-  
AI/ML integration in both network and device

-  
Approaches where AI/ML operation is in UE/NW only, and where AI/ML is distributed across UE and NW

-  
Signaling and measurement procedures

-  
Procedures for device AI/ML.

## 11 – Beijing Xiaomi Mobile Software

Besides the physical layer procedure, many companies proposed to utilize AI in higher layer procedure, e.g. mobility management. Especially in FR2, legacy mobility management may result in suboptimal throughput and large signaling overhead due to the rapidly changing radio channel condition. AI inference result based mobility management could provide better performance from throughput and signaling overhead perspective.

Also, due to privacy requirement, UE information, e.g. UE location, may not be available at gNB, which is very beneficial to improve mobility performance in FR2.

UE centric AI inference could utilize these UE information without privacy issue. **We recommend to investigate the AI utilization in both PHY and Higher layer.**

One question RAN need to clarify is whether AI model should be specified in 3GPP or up to UE/NW implementation?

## 12 – Ericsson LM

On the structure of this topic, we would like to ask for some clarification: What are the expected outcomes and purpose of each category? For example, higher-layer and physical layer standardization issues might depend on the particular use case and both are considered together in this section.

Ericsson supports an AI on PHY study item that covers KPIs, evaluation methodologies, and standardization issues (higher- and physical layer) for selected use cases. More specifically, we proposed in RWS-210383 and RWS-210382 that the study item considers the following:

· The SI forms an initial common understanding on how can we approach AI/ML on PHY in 3GPP (e.g., discuss and list options on how we can study model training, validation, provisioning, and evaluations).

- The SI completes detailed studies on selected use cases (we recommended to study a single use case, AI/ML-enhanced CSI reporting).
- The SI documents general learnings from the high-level discussions and detailed studies to create a template for future AI on PHY use cases in 3GPP.

On Higher-layer AI/ML: The assumption is that the current architecture and interfaces are reused. We expect that a functional framework identifying the main functions supporting AI in a 3GPP RAN are identified, as well as identification of standardization impacts on a use case by use case basis, where the prioritized use cases are Load Balancing, Traffic Steering and Energy Efficiency. We assume that the study will provide mechanisms for an inference and training function to be able to subscribe to the inputs required to run the inference and training processes. We assume that the study will provide means for external nodes to subscribe to the reception of model inference outputs, where such outputs will be specified in 3GPP.

### 13 – CAICT

AI/ML for air interface should be studied in R18. AI/ML for air interface is an important part for the integration of 5G and AI. As for the study area, at least use cases, applicable AI/ML framework, evaluation methodology (dataset construction, AI model, performance matrix, etc.) and detail evaluation should be included.

In general, it is the first time that AI/ML for air interface is discussed in RAN. Before the detail study of evaluation methodology, some consensuses on use cases selection, dataset construction, AI models, computation resources distribution and specification frameworks are beneficial not only for the study and specification works in RAN but also for the industry to understand the process of wireless and AI integration in 5G evolution.

### 14 – Spreadtrum Communications

We are interested in AI enabled RAN/PHY in R18. Given that 5G for AI and AI for 5G have been commercial success nowadays, we believe it is the right time to start the study at the intrinsic AI in 5G, to empower better 5G Advanced.

We think it is fine that firstly start a RAN level study to form some consensus, e.g., professional information of AI field, dataset construction, use cases, simulation methodology; then transfer to WG level study to carry out detailed evaluation and research.

Regarding the dataset, we notice that some contributions (RWS-210357, RWS-210413, RWS-210235, RWS-210063, RWS-210260, RWS-210430, RWS-210038, RWS-210128, RWS-210170, RWS-210185) proposed different views on how to construct dataset used for training and inference. We have one question for clarification:

-  
For evaluate and verify the potential use cases, would it be considered to provide a common dataset or only define the method to generate dataset?

### 15 – Lenovo (Beijing) Ltd

We have following comments on the two AI/ML topics in Rel.18:

#### AI/ML for PHY enhancement

From the contributions and two-round Q&A, we see that many companies show interests to have a SI on AI/ML for physical layer enhancement. The proposals mainly focus on the time plan in different RAN groups, use-cases selection and evaluation methodology. We have the following comments:

-  
*Use case selection:* CSI compression and feedback (vs. Type II), beam management (vs. SSB/CSI-RS-based), positioning (vs. NLOS) and channel estimation (vs. LMMSE) from high to low priority.

-  
*Evaluation methodology:* we need to define and limit the study scope of AI/ML relevant issues, such as input/output, model type and structure (e.g., CNN/DNN/RNN), operations (e.g., training/validation), dataset construction (e.g., simulation/field test). Thus, to avoid discussing the AI/ML model construction and optimization in details, it is better to introduce a **separate function** to cover such concerns. In this way, we can separately evaluate the potential gains and overhead from AI/ML to obtain the quantizable results for comparison.

In summary, we support to have such SI with the above proposals.

### **AI/ML on network evolution**

We think there is also a potential study on the network evolution for distributed intelligence, including the following studies:

-  
Study RAN architecture evolution to support *RAN enabled AI service*;

-  
Study potential enhancements on *RAN interfaces* between RAN nodes or between RAN node and UE to support distributed intelligence, which may include intelligent task segmentation, data sharing, computing offloading and learning model sharing among devices and RAN nodes for a certain AI task;

-  
Study potential enhancements on *air interface* to address the QoS related requirements regarding data sharing, computing offloading and learning model sharing between UE and RAN node.

We are wondering the continuation of R17 SI can cover the case.

### **16 – MediaTek Inc.**

Two main points as below:

AI/ML integration, the study needs to include:

- evaluation on the benefits of AI/ML integration of *selective* RAN/AS function
- clearly identified (with evaluation/analysis) use cases with AI/ML integration: For example, CSI-RS reduction, mobility prediction, and positioning enhancements, etc.
- how AI/ML integration in both network and device sides

AI/ML traffic, the study needs to include:

- study the traffic pattern and QoS requirements of AI/ML traffic generated from the OTT applications
- evaluation on whether there are any gaps in the system to support such traffic and if so, develop related solutions.

## 17 – HUAWEI TECHNOLOGIES Co. Ltd.

There are wide interest on AI/ML. The docs discussing AI/ML for physical layer and/or higher layer include RWS- 210024, 0032, 0038, 0051/0052, 0063, 0083, 0103/0104, 0122, 0128/0129, 0160, 0170/0177, 0185, 0198, 0214, 0225, 0233/0243, 0235/0236, 0253/0260, 0265, 0273, 0282, 0291, 0296, 0357/0359, 0363, 0373, 0383/0510, 0412/0413, 0430, 0448, 0478/0483, 0505. Based on the contributions and email discussions, some of the main areas proposed or discussed for further discussion are summarized as below:

- High-level principles of Rel-18 study on AI/ML for PHY (RWS-210038, 0051, 0128, 0260, 0273, 0291, 0383, 0448, 0505)

- o Rel-18 study of AI/ML for PHY should follow the principles that agreed for Rel-17 RAN3 SI ‘FSNRENDCollect’, i.e. reuse the existing NR network architecture and interface as implicitly/explicitly expressed in some contributions (RWS-210038, 0051, 0291, 0448), and detailed AI models and algorithms are left for implementation (RWS-210051, 0128, 0260, 0273, 0383, 0448, 0505).

- Evaluation methodology of AI/ML for PHY, including KPIs, inputs/outputs of model training and model inference, etc. (RWS-210024, 0038, 0063, 0103, 0170, 0185, 0198, 0225, 0235, 0243, 0260, 0273, 0357, 0383, 0413, 0430, 0448, 0478, 0505).

- Potential use cases of AI/ML for PHY.

- o Candidate use cases for further study, including CSI feedback/compression, RS design and channel estimation, beam management, positioning, link prediction, etc. (RWS-210024, 0038, 0051, 0063, 0170, 0185, 0198, 0225, 0235, 0243, 0260, 0273, 0291, 0357, 0373, 0383, 0413, 0430, 0478, 0505)

- o Performance evaluations to justify the potential beneficial use case(s) (RWS-210038, 0051, 0063, 0128, 0170, 0235, 0243, 0260, 0273, 0291, 0383, 0413, 0430, 0448).

In addition, with regards to the RAN3 AI/ML work and architecture, it should be understood by all proponents that the RAN3 WI will focus only on output of the on-going SI, nothing else for the normative part in REI-18.

## 18 – China Mobile International Ltd

For AI enabled NG-RAN□

A Rel-18 WI following on the Rel-17 SI should be carried out. It could take AI framework and recommended use cases in the Rel-17 TR to normative work, e.g.,

- AI/ML for energy saving.
- AI/ML for traffic steering
- AI/ML for load balancing

....

For AI enabled air interface:

Based on companies’ contributions, we think the evaluation methodology is the most important issue for SI on AI/ML. The SI should focus on study of evaluation methodology based on one or two of the identified use cases. Regarding the data set, we should study how to provide the common training data and test data for all companies. Regarding the AI model, typical model for each use case should be studied, at least for calibration. If the model offloading from gNB to UE is necessary, the typical AI model may need be specified.

How to organize the Rel-18 study on AI enabled NG-RAN and air interface should be further discussed.

## Feedback Form 4: Answers/Comments

### 1 – NTT DOCOMO INC.

**Answer to #1 ZTE’s question “Do you think this RAN-level study is still needed if only these four use cases are selected for Rel-18?”**

We are also supportive of confining a reasonable number of use cases for AI/ML study in physical layers before discussing evaluation methodology to reduce the burden for evaluation methodology discussion and evaluation campaign. If four use cases ZTE mentioned are selected for Rel-18, we think RAN-level study is not necessary. However, since some companies have an interest of different use cases, RAN-level study may be needed to decide which use cases we go for in Rel-18 based on expected gain and specification effort.

**Comment to #10 NEC’s comment “AI/ML for NR physical layer. Potential topics to study ..., CSI compression, beam management, link prediction and adaptation, etc.”**

We also think that Rel-18 AI/ML PHY potential topics listed in your comment need to be studied. As you pointed out, a lot of different use cases have been proposed. If we discuss evaluation methodology and performance evaluation for all proposed use cases, it could be too long period study. For this reason, we prefer prioritizing some use cases for AI-PHY as a first step of the study on AI-PHY, considering whether a new feature could be compatible with 5G NR and how much specification effort would be necessary. Other use cases can be studied in next step as AI-PHY would have great potential.

**Answer to #11 Xiaomi’s question “One question RAN need to clarify is whether AI model should be specified in 3GPP or up to UE/NW implementation?”**

We believe that AI model should be up to UE/NW implementation as much as possible, although this question depends on use cases for AI/ML study in Rel-18. In our view, even if there are some performance differences among companies due to details on AI/ML algorithm, 3GPP can derive general observations on the feasibility and gain of the proposed mechanism having certain specification impacts such as new parameter, configuration and/or reporting.

### 2 – LG Uplus

We prioritize SON as the first step of AI/ML application. ML/AI application distribution architecture would be another step.

In long-term study, RAN ML/AI application is interesting. However, we should carefully study ML/AI distribution interface via Uu and consider the risk of asynchronous ML inferencing between device and network due to volatile ML parameter changing.

### 3 – CATT

Answer to question from ZTE #1:

The listed use cases are quite different in terms of AI/ML algorithms and procedures. A RAN level study item would be helpful in understanding the commonality and differences, and selecting a limited set of use cases that could be handled in WG study.

Comment to Vivo #6:

We don't think including all use cases in a single study is helpful. The proposed use cases are quite different and require expertise of different domain. The study could start form a limited set of use cases and after the evaluation methodology and framework are built, more use cases can be considered.

Answer to question from Spreadtrum #14:

We think a common data set would be helpful in evaluating performance of different AI/ML algorithms. Even using a same method, the generated data set could be diverging in many aspects. In this case, a procedure to validate the data set is needed to ensure that the evaluation results are comparable.

#### 4 – CAICT

**Answer to #1 ZTE's question: "How this RAN-level study can help, as whether AI/ML is beneficial for different use cases requires very technical evaluation and debate."**

Due to the limitation of TU, limited use cases should be selected for further evaluation in RAN1. We think a study phase to capture potential use cases and initial analysis on potential specification works and deployment scenarios is important for further use case prioritizing and evaluation works. Even some use cases will not be evaluated in R18, the study phase for use cases identification is still benefit for the whole AI based physical layer enhancements works.

#### 5 – ZTE Corporation

Based on our review of 24 companies' contributions submitted to this RWS, the numbers of companies having interest on studying CSI feedback, RS overhead, beam management and positioning are 17, 16, 19 and 12, respectively. Interest level for the other use cases is relatively low ( $\leq 5$ ). Hence we think 3GPP already has convergence on these four use cases. The views are not divergent as we have already identified a small set of use cases. Further, we agree we should have a careful study on things like evaluation methodology, performance, complexity, feasibility and spec impact in WGs. These aspects on top of the four use cases with majority support should be the key points for the next stage of discussion and for Rel-18 study. We can discuss things like whether or not to have down-selection or prioritization within the four use cases and the basic principle for studying evaluation methodology, performance, complexity, feasibility and spec impact in the next stage of Rel-18 scope discussion.

#### 6 – China Mobile International Ltd

To all, based on the several round discussions before and during the workshop, there is convergence to have AI/ML as one of the Rel-18 topic, the potential aspects to be discussed for the next stage could be:

-

AI/ML for physical layer, including evaluation methodology and identified use cases, etc

-

AI/ML for high layer (NG-RAN), including a WI following Rel-17 SI on data collection and further study on other use cases

## 7 – Beijing Xiaomi Mobile Software

Response to ZTE about use cases:

Companies interested in many aspects, so we suggest RAN to first study the intended/useful use cases for AI utilization. Even if only these four use cases are selected, study item is needed to identify the framework and methodology. But we are open to whether it's RAN level or working group level.

Response to Nokia, OPPO about performance requirement on AI:

We agree there should be requirement on the AI inference performance to ensure trustable inference result, especially in UE based AI. 3GPP shall define corresponding requirement and means to test.

Response to Futurewei, NEC about scope:

We believe not only physical procedure, higher layer procedure could also benefit from AI utilization, for example mobility management. We support UE based AI to improve mobility performance.

Response to Apple, CATT, Ericsson, CMCC, about AI model specification:

We understand the AI/ML models would not be specified by 3GPP. UE may use different AI/ML models based on capability or use cases. However, requirement on the AI performance to ensure trustable inference result, especially in UE based AI. 3GPP shall define corresponding requirement and means to test. We understand in the first release, the solution should be agnostic to AI/ML model. Only the essential parts should be specified, e.g. inference result definition for higher layer AI solution. So AI model specific solution may be purchased in later releases.

Response to Vivo about AI model calibration:

We recommend a specific AI model could be used to evaluate the performance of solutions. However, the AI model should not be specified in the specification.

Response to CATT, OPPO, Spreadtrum, CMCC about Dataset:

Data set is one key component for AI research. So, in the study of AI in RAN, how to construct the data set for evaluation should also be discussed in the evaluation methodology. The dataset could be derived from a calibrated simulation platform, if practical dataset is not available.

Response to CATT about AI model training:

Regarding model training, we agree it's challenging to achieve real-time training. Therefore, we recommend training should be done by upper layer, which could be done by UE or network and doesn't require real-time training.

Response to CATT, HW about relation with R17 RAN3 SI:

We believe more use cases than R17 SI should be considered in higher layer. R17 considers NW centric AI solution. However, in higher layer, UE centric AI solution shall also be considered, which was not included in R17 SI.

Response to OPPO, Lenovo about AI model transmission:

We understand the AI model should be invisible to RAN. The potential AI model transmission should be carried in user plane. If there is no new QoS requirement for AI model transmission, there seems to be no AS impact about AI model transmission.

Response to Samsung, Ericsson about relation between physical layer and higher layer AI:

If AI model acts as black box and only inference result is specified, we understand the frame work and solution seems to be very different for physical and higher layer. Therefore, separate SIs for physical and higher layer may be more efficient.

### 3 Network energy savings

This section is targeted at identifying commonalities and interactions for Network energy savings.

#### Feedback Form 5: Questions/Comments

##### 1 – ZTE Corporation

According to two rounds of email discussion, the following solutions to network energy efficiency are convergent among companies,

- (1) more dynamic gNB on-off operation should be considered, such as supporting dynamic adaptation of Tx/Rx antenna and beam.
- (2) Network coordination for network energy efficiency.
- (3) UE assistance information for gNB on-off operation.

In addition, extending the transmission interval/periodicity of “always-on” channel/signal is also beneficial to network power saving. We also agree that the impact on at least legacy UE should be minimized.

##### 2 – Nokia Corporation

In general we see common interest among companies to ensure network energy efficiency can be further improved, and is not degraded by features introduced in Rel-18, be they for improving UE energy efficiency or other enhancements. The key element is to see how to ensure each activity takes the impact of network energy efficiency into account. The approach mentioned by many companies (including some GTW presentations) would be to have network energy efficiency as part of each WI/SI item to identify if there is impact to network energy efficiency from the solutions being considered. Thus there would be no need for a separate WI for this, but network energy efficiency related considerations should be included more widely.

##### 3 – BBC

We note that a number of contributions have identified network energy savings as a potential feature in Release 18 and the BBC supports measures to improve the sustainability of the 5G RAN.

In particular we’re keen to see a realistic and standardised methodology for the measurement and modelling of power consumption in networks to help operators to reduce their impact. In addition, as a content provider, the BBC would like the ability to better understand the impact of our content being consumed over these networks to also drive down our impact.

#### **4 – VODAFONE Group Plc**

In addition to the preceding comments, we believe that it is important that 'energy saving' work takes the likely need for the long term support of LTE (alongside NR) on low frequency bands into account.

#### **5 – Deutsche Telekom AG**

Besides what has been said above the definition of standardised measurements, measurement reporting and the delivery of data needs a framework to be defined in 3GPP. This should also be extended to the usage with an ML/AI framework to enable ML/AI based minimisation of energy consumption. We see it of utmost importance that 3GPP works on such solutions as part of 5G-Advanced as other fora do already and the development of 3GPP technologies shall support meeting the UN Sustainable Development Goals 2030 (SDG2030).

#### **6 – Ericsson LM**

In our motivation slides RWS-210310, as well as the proposed SID RWS-210311, we have provided the motivation for having a dedicated a SI related to NW energy efficiency in Rel 18.

In summary, while NR has been designed to be lean in terms of transmission, it has also introduced additional elements which can raise the energy consumption at the NW side, e.g., an NR base station may be designed with up to 64 TX/RX ports with their underlying digital RF chains as well as beamforming and L1/L2 processing. The impact of the new functionality in NR on NW energy consumption can be significant. For example, in a 64 TX/RX base station, digital front-end together with beamforming consumes more than 50% of the energy. A large percentage of this additional energy consumption is indeed not due to the transmission, rather related to operations which the NW has to perform even when it does not transmit anything (when NW is idle). Therefore, NR NW energy consumption should be a focus of Rel-18, where an evaluation methodology is developed with the goal to determine focus areas and potential solutions.

#### **7 – Motorola Mobility UK Ltd.**

Many companies including Lenovo/Motorola Mobility proposed studying dynamic network configuration (e.g. gNB/TRP/beam dormancy, adaptation of periodic/broadcast signal/channel) to improve network energy efficiency and pointed out that balancing energy efficiency between network sides and UE sides is important.

In our view, further RAN discussion points are:

- o How to determine initiation of network configuration change (e.g. based on network implementation (e.g. AI/ML), UE assistance information, and/or gNB wake-up mechanism)
- o How much power saving can be achieved by TTI-level network on/off?
- o What CSI measurement enhancements are needed for network energy saving?

#### **8 – Apple Hungary Kft.**

We are open to consider the study of network energy saving. Some companies are proposing that the network energy saving should be considered under each individual WI. It is unclear to us how this would work. Does it mean that for each feature we need to analyze the impact on network power consumption?

#### **9 – CATT**

We are very supportive of systematic network energy saving schemes with semi-static and dynamic indication to the UE. We would also like to have the general requirement of minimum impact to the UE service when the network energy saving schemes is enabled.

## 10 – vivo Communication Technology

1. The backward compatibility to legacy UEs shall be maintained for any NW energy saving features considered in Rel-18. The UE performance (including but not limited to power, service latency, etc) should be carefully evaluated, a joint design across NW and UE is preferred.
2. As one potential joint design, the UL signal transmitted by the UE (e.g. in IDLE/INACTIVE mode) can be used to “wake-up” gNB, as well as used by gNB to reduce the Paging message transmission area, for NW energy saving and overhead reduction purposes. From this perspective, there is some commonality with the UL based mobility enhancement as proposed in the mobility email thread.

## 11 – Guangdong OPPO Mobile Telecom.

First of all, we acknowledge that this is important issue to be addressed in field. The solution frequently mentioned by companies is assistant information from UE to network, namely traffic prediction. However it is not very clear how frequent does UE report and what kind of information can be helpful

## 12 – China Telecommunications

Generally, we think some network energy saving scenarios, possible enhancements and the need of studying network energy consumption evaluation method are identified and clarified by some companies according to the contributions and the two rounds of pre-R18 workshop email discussion. These are not in the scope of current R17 work items/study items. And it’s hard to have a comprehensive study of network energy saving without a dedicated item.

On the other hand, we would like to point out that some mechanisms of network energy saving which may have impact on UE experience/network performance can also be considered. From operator’s perspective, it is very important to find a good balance of network energy consumption and UE experience/network performance.

## 13 – MediaTek Inc.

For network power savings, we would like to suggest the following:

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It should **cover all network components, including gNB and UEs.**

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**Quantitative evaluation methodology should be developed** to investigate the gap between academic expectation (NR is lean carriers and less power consuming than LTE) and operator observation (NR exhibits 3x power consumption w.r.t. LTE). Extension from the methodology in TR 38.840 can be the starting point.

-

**Joint gNB and UE power saving adaptation design** should be the focus of this work area. gNB-only power saving can rely on network implementation and likely to keep UE monitoring disabled resources and reduce UE power saving. On the other hand, joint gNB and UE power saving adaptation will bring **win-win** for overall system energy efficiency. Wide UE support is also key to successful gNB power savings.

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**Integrating WUR for joint gNB and UE power saving is suggested.** In WIFI, WUR can be applied to UEs and base-stations, and NR WUR design, if targeted, should not be worse than WIFI design.

#### **14 – Spreadtrum Communications**

In our view, the tradeoff between UE power saving and network power saving should be considered. In other words, the evaluation methodology for network power saving should include the consideration of UE power consumption as well. For RWS-210025, we share the similar view that we should consider “improving end to end power efficiency at both network nodes and UE sides”. For RWS-210106, we share the similar view that UE power saving can be also considered together with network power saving in the scope of “system energy enhancements”.

#### **15 – Beijing Xiaomi Mobile Software**

1. Both idle mode and connected mode should be considered
2. When considering network power saving, UE access delay should be avoid as much as possible and any UE power increase should be avoid.
3. Network power consumption modeling should be studied first and it should balance with the data rate, energy per bit may be a comparison basis.

We wonder whether any prioritisation for frequency range should be considered e.g. FR2 only or should both be considered equally and also whether UE power saving beyond R17 should be included with this item?

#### **16 – HUAWEI TECHNOLOGIES Co. Ltd.**

There are wide interest to support network energy saving. The tdocs discussing network energy saving include RWS-210025, 0032, 0033, 0106, 0118, 0122, 0153, 0160, 0281, 0310, 0358, 0363, 0398, 0415, 0438, 0447, 0462, 0486. Based on the email discussion, some other companies seem to support this direction also though they don't have corresponding papers.

Based on the contributions and email discussions, the areas proposed or discussed for network energy saving can be summarized as below, based on which we can further identify a set of focused areas for further study:

1. KPIs and evaluation methodology, including deployment scenario, KPIs, energy consumption model, etc.

-

Source: RWS-210025, 0033, 0106, 0153, 0310, 0398, 0447, 0462. More companies would support this area based on the email discussions though they don't have specific discussion in their paper. For the study of network energy saving, this area is necessary.

2. Potential enhancements for network energy saving considering balance between network energy saving and user experience/spectral efficiency.

- o Network energy saving techniques in spatial domain, including efficient dynamic gNB/TRP/antenna/TRX/panel/beam on-off, node dormancy, etc.

-

Source: RWS-210025, 0310, 0106, 0153, 0122, 0358, 0398, 0415, 0447, 0486. In general companies support this direction though detailed proposals may be different.

- o Network energy saving techniques in time domain, e.g. efficient configuration of periodic/broadcast signals, new design of initial access procedure for FR2, etc.

-  
Source: RWS-210025, 0106, 0118, 0310, 0358, 0447, 0486, 0398.

- o Network energy saving techniques in frequency domain, e.g. efficient multi-carrier adaptation using additional information/signaling from UE, adjustment of TX/RX bandwidth, etc.

-  
Source: RWS-210310, 0358, 0415, 0447. Note that multi-carrier adaptation here can include CA and DC scenario.

- o Network energy saving techniques in power domain, e.g. dynamic adjustment of transmit power level.

-  
Source: RWS-210447.

- o UE assistance information and/or intra network assistance information helping network energy saving.

-  
Source: RWS-210310, 0153, 0486, 0447.

- o L1 processing for improving PA power efficiency.

-  
Source: RWS-210025

### 17 – China Mobile International Ltd

For network energy saving, a general requirement in our view is solutions for network energy saving should allow early implementation, i.e., not largely rely on terminal assistance.

The potential objectives could include:

- Evaluation methodology of power saving mode and transition time, etc
- Definition of different energy saving modes and network signalling support to enable energy saving.
- Multi-RAT/Multi-carrier synergy energy saving mechanisms
- Traffic/UE behavior/user experience aware energy saving mechanisms

### Feedback Form 6: Answers/Comments

#### 1 – Nokia Corporation

We would like to answer the question from Apple on "Some companies are proposing that the network energy saving should be considered under each individual WI. It is unclear to us how this would work. Does it mean that for each feature we need to analyze the impact on network power consumption?" ANSWER: "Yes, this would mean that for each new feature one would need to discuss if there is expected to be impact on network energy consumption. Our concern is that currently one considers only other aspects like capacity impact, latency impact or UE power saving, but NOT impact to network energy efficiency. A dedicated SI/WI can't discuss all features on the table in Release 18. This is not in conflict of having ALSO an a WI item to address some network specific solutions on network energy saving if those can be identified.

## 2 – ZTE Corporation

Comments to #2:

-

We think it is unrealistic to put a note in each SI/WI to emphasize that network energy efficiency should be considered and evaluated. So we prefer to have a dedicated SI/WI for network power saving.

Answer to # 11:

-

Thanks for the questions with regard to UE assistance information. We think the detailed UE assistance information can be discussed in the later phase. And the reported frequency can be controlled by a timer, as other legacy UE assistance information.

Answer to # 15:

-

Thanks for the questions. We think both FR1 and FR2 should be considered.

## 3 – MediaTek Inc.

Thanks for the good discussion. From companies' valuable inputs, we would like to provide the following additional comments:

-

There are 9 out of 17 companies indicating the importance of UE consideration in the previous feedback form. One practical way forward to reflect the strong demand is to explicitly target joint gNB and UE power saving designs that will enhance UE power saving benefit instead of reducing it.

-

The initial categorization for potential enhancements in comment #16 is very informative. For spatial-domain power saving adaptation, there is limited investigation in R16 and R17 UE power saving items. Enhancements toward this direction also implies opportunities of joint gNB and UE power saving enhancements. Regarding time and frequency domain power saving adaptations, there are quite a few UE power saving designs which can be leveraged and extended to accommodate gNB power savings. Such enhancements can also benefit from wide UE support by virtue of reused UE behaviors.

-

Specifying network power saving state is one practical direction to move forward. One example is SCell dormancy where dormancy state has clear specification to allow effective UE (as well as SCell) power saving. Extending such power saving state for more network node types (e.g., PCell and TRP) can be targeted for Rel-18 network power savings.

#### **4 – BBC**

Further to our previous comment, we feel that any methodology developed to assess and compare the benefits of different power-saving techniques could serve as a useful tool for 3GPP going forward. For example, the methodology could be used to take account of energy performance when deciding between two techniques with similar technical performance.

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## **4 Inter-gNB coordination**

This section is targeted at identifying commonalities and interactions for Inter-gNB coordination.

### **Feedback Form 7: Questions/Comments**

#### **1 – KDDI Corporation**

Let me provide the comments from KDDI below.

##### **1. Related contributions**

We think the following contributions should be discussed under this section

- RWS-210327 Motivation of Study on Inter-gNB Coordination NTT DOCOMO
- RWS-210140 Considerations on inter-gNB coordination for NR KDDI Corporation
- RWS-210022 On RAN slicing enhancements for Rel-18 QUALCOMM
- RWS-210084 Resiliency for disaggregated gNB architecture in Rel-18 Nokia

##### **2. Use cases**

We think that we should identify the possible use cases which require the inter-gNB coordination. We can list the following as a base line for this discussion. We also believe that we should identify the requirements, what should be supported first.

Use case 1. Inter-DU coordination

Use case 1-1. Carrier Aggregation without uu interface change

Use case 1-2. Triple connectivity with uu interface change

Use case 1-3. Multi TRP

Use case 2. Multiple CUs

Use case 2-1. Resiliency of gNB-CUs

Use case 2-2. Slice dedicated gNB-CU

Use case 2-3. Load balancing of gNB-CUs

##### **3. Possible approach for Use case1**

Based on the QA round [RWS-210626 RAN-R18-WS-crossFunc-KDDI], we feel that we may want to discuss on the following aspects to progress the discussion.

3. High level architecture assumption to identify possible changes on NG and Xn interface (i.e. Whether gNB-CUs are separate multiple logical gNBs or supposed to be single gNB, Whether assume a hierarchy structure) (Ericsson)

4. High level design of the coordination for CA, i.e. what is done in primary DU and what is done in secondary DU, scheduler aspects, U-plane handling mechanism in DUs (Intel, CATT)

#### **4. Possible approach for use case2**

Based on the QA round [RWS-210590 RAN-R18-WS-non-eMBB-Qualcomm], we felt that one possible approach to develop a solution for use case2 is to reuse the current RAN3 mechanism for RAN sharing as a baseline. With this approach, we may want to identify the gap from the current specification and try to make RAN3 impacts more clear. But if there are other more suitable approaches, we are also fine with those approaches.

## **2 – ZTE Corporation**

-

For the inter-gNB/DU multi-TRP operation, it seems similar as CoMP (Coordinated Multi-Point operation) in LTE. In LTE, two SIs have been made in RAN1 for the CoMP with ideal backhaul and Non-ideal backhaul to understand the use case and scenarios, study the potential solutions, evaluate the performance gain and identify the potential impact on RAN1/RAN2/RAN3 (i.e. Study on Coordinated Multi-Point operation for LTE (RP-101425) and Study on Coordinated Multi-Point (CoMP) operation for LTE with Non-Ideal Backhaul(RP-130847)). For the inter-gNB/DU multi-TRP operation in NR, we prefer to follow the same approach as LTE CoMP to study (in a RAN1-led SI or a study phase with RAN1 involved) and identify the required information to be exchanged among gNBs firstly.

-

For the inter-gNB/DU coordination, we prefer to re-open the discussion for function split between CU and DU to enable a more efficient framework for inter-gNB/DU coordination. For example, in order to support inter-gNB/DU carrier aggregation, whether to move part of RLC function from DU to CU to enable a more efficient RLC re-transmission can be further studied.

## **3 – Ericsson LM**

Related to the proposal of introducing “inter DU interfaces”:

- o Networks where the transport does not allow for round trip delays in the order of few ms will not be able to take advantage of the solution.
- o If we introduce it, we end up have master/slave gNB-DU. It is not in line with 3GPP architecture where RAN nodes are peers
- o Scheduling and RRM are implementation dependent. This should not be changed.

The proposal makes big changes on the interface which requires lots of effort but the benefit is not proved. Furthermore, current F1 is specified assuming no inter-DU interface (basic building block of NG-RAN since Rel-15). This sort of functionality would require a comprehensive revisiting of NG-RAN architecture.

Related to the proposals on “Enhancement for resiliency of gNB-CU”:

o implies a major change in NG-RAN architecture as it changes the cardinality of the split RAN and it breaks the definition of “one gNB contains only one gNB-CU” and “one gNB-DU is connected to only one gNB-CU”.

Further the fall back connection of a DU to a different CU is already allowed today.

#### **4 – Nokia**

The 3 sub-topics have very little in common, other than they all impact the NG-RAN architecture/interfaces. Also, for inter-node multi-carrier operation and inter-node TRP operation, there appears to be consensus that RAN1/RAN2 study is first needed to evaluate e.g. benefits, backhaul requirements, UE impacts, etc.

Therefore, it may make sense to restructure the discussion, e.g. move any further discussion of inter-node multi-carrier operation to “CA/DC enhancements”, and inter-node TRP operation to “Evolution for DL MIMO”. Then, enhancement for resiliency of gNB-CU could have its own dedicated discussion, for which we note that RWS-210084 is closely related.

#### **5 – DOCOMO Communications Lab.**

Our current thinking of how to proceed multi-carrier and multi-TRP work is:

1. identify information exchanged between nodes
2. identify timing constraints based on above
3. evaluate interface/architecture options that fulfills the requirements above

In [RAN-R18-WS-crossFunc-NTT\_DOCOMO], several companies were wondering about Uu impact, which leads to interactions between this topic and DC/CA. Our preference at this stage is to have no impact on Uu i.e. make the feature transparent to (R15) UEs. However, in step 3 above, if it is concluded that tight coordination between nodes is infeasible, then we are open to discuss Uu enhancements. Our contribution in RWS-210327 is more about requirement rather than specific techniques to help such discussion.

As we see some commonality in terms of architecture between resiliency of gNB-CU and service-specific gNB-CU (RWS-210022), we are open to discuss them in this topic if service-specific CU requires inter-gNB/DU coordination. Though our reading of [RAN-R18-WS-non-eMBB-Qualcomm] is that proponent is looking to leave it to a single vendor’s private implementation, inter-vendor operation would also be beneficial in terms of slicing, like in DECOR examples.

#### **6 – CATT**

During the first round of discussion based on contribution in RWS-210327 and RWS-210140, we observed that there are still some technical concerns/questions on whether/how to realize inter-gNB CA/multiple-TRP, e.g. the requirement on the latency of backhaul, the information which should be coordinated between two neighbor nodes, the impact to user plane handling, etc. Although the final specification impact maybe mainly in RAN3 scope, it seems most of the questions could only be answered by RAN1/RAN2. We propose to study and evaluate the overall requirement/impact in RAN1 and RAN2 first, then RAN3 could further discuss based on the conclusions.

As to gNB-CU resiliency, we think we could further discuss the use cases/scenarios together with other proposals e.g. slicing in CU in the next round of discussion.

#### **7 – vivo Communication Technology**

1. For the purpose of standardized solutions for previously stated challenges of CA and DC, e.g. inter-gNB/gNB-DU carrier aggregation, is a standardized inter-DU interface should be considered?
2. What may be UE impact to inter-gNB/gNB-DU carrier aggregation, if any?

3. Would the SI proposal have RAN2 impact?

**8 – Guangdong OPPO Mobile Telecom.**

We understand the main motivation is to enable inter-DU or inter-CU carrier aggregation to improve uplink coverage. To make thing simpler ideal backhaul should be assumed. In addition to keep backward compatibility, it is desirable not to change any Uu features so that legacy UE can be configured with such new carrier aggregation

**9 – Samsung R&D Institute UK**

After some observation in this workshop, we have similar view as Nokia. Three items in this topic has different features, so each item needs to be separately discussed. And for inter-gNB CA/mTRP operation, RAN1 and RAN2 should be involved and they have similarities with other topics listed in this workshop. So, we also think the inter-gNB CA is moved to “CA/DC enhancements” and inter-gNB mTRP to “Evolution for DL MIMO”. Moreover, we feel that before specification, and the benefit of both inter-gNB CA and inter-gNB mTRP should be justified first considering the impact to the gNB architecture. For the resiliency of gNB-CU, it could be discussed together with other multi-CU related item (e.g., slicing-specific CU), and this cannot be considered as the feature of inter-gNB coordination.

**10 – Huawei Tech.(UK) Co.. Ltd**

We would like to discuss some aspects which are not possible to solve at WG level, and would probably bias the conclusion of such study. Please note also we focus below on gNB-CA but the reasoning and argument are same for the resilience CU problem.

1) Could you clarified the expected cost benefit of the feature development and deployment of gNB-CA considering that there will be more cost from network side due to extensive CP exchange between the node compare to MR-DC. This traffic could not be charge to customer as CP-traffic “is for free” for the end user. This will also increase the energy consumption of the Network... MR-DC will indeed have more constraints on the UE, but this is more a cost for the end user

2) Then they are two basics principle of the standard that we should avoid the feature duplication and allow product differentiation between vendors. For both the gNB-CA and the resilience, it was clarified during the Q&A that the gNB-CA is more flexible but MR-DC responds to same requirements. Same for CU resilience, today the RAN3 specification does not precludes the pooling and redundancy in term of CU. Does the study is going for duplication of existing solutions? Then by forcing tight coordination, between vendors for gNB-CA and resilience mechanism are not removing product differentiation?

**Feedback Form 8: Answers/Comments**

**1 – Qualcomm Incorporated**

**To KDDI’s comment related to RAN sharing based approach, addressed to Qualcomm:**

**[Question]** Based on the QA round [RWS-210590 RAN-R18-WS-non-eMBB-Qualcomm], we fell that one possible approach to develop a solution for use case2 is to reuse the current RAN3 mechanism for RAN sharing as a baseline. With this approach, we may want to identify the gap from the current specification and try to make RAN3 impacts more clear. But if there are other more suitable approaches, we are also fine with those approaches.

**[Answer]** Yes, RAN sharing approach could be used as baseline and reference. We are open to study other solutions. In current RAN sharing, CU is PLMN specific. We would like to extend it to slice specific. So, the CU selection/reselection procedure needs to be enhanced. This may also impact the procedure at access, handover and change of active PDU sessions. SIB is provided by CU. In slice specific CU, the SIB

control may need to be enhanced too.

**To DOCOMO's comment on inter-vendor operation in terms of slicing, addressed to Qualcomm:**

**[Question]** As we see some commonality in terms of architecture between resiliency of gNB-CU and service-specific gNB-CU (RWS-210022), we are open to discuss them in this topic if service-specific CU requires inter-gNB/DU coordination. Though our reading of [RAN-R18-WS-non-eMBB-Qualcomm] is that proponent is looking to leave it to a single vendor's private implementation, inter-vendor operation would also be beneficial in terms of slicing, like in DECOR examples.

**[Answer]** We agree some inter-CU coordination is needed, same as current RAN sharing (PLMN specific CUs sharing one DU). In RAN sharing, this coordination is up to implementation. We are open to discuss whether the coordination should be standardized.

**2 – DOCOMO Communications Lab.**

Thanks everyone for your valuable comments. Our impression is that some comments might be unrelated to the agenda/guidance (i.e. not related to commonality/interaction), but here we also try to address those out-of-topic comments where possible.

**Answer to #1 (KDDI)**

[Topics to discuss for inter-gNB/DU multi-carrier/TRP] The topics mentioned (architecture assumption and coordination design) should indeed be discussed in our view. We would like to continue discussion on how to organize this work.

[Slicing/load balancing] We are happy to discuss such topic in the next round of discussion.

**Answer to #2 (ZTE)**

[Starting WG] Since this work requires architectural consideration, our current preference is to start this work in RAN3 as in NR fronthaul work (RAN3 firstly studies the processing chain and required info etc. along with architecture, and LSeS was exchanged with RAN1/2). Anyway we're open to continue discussion, as this NWM is supposed to discuss commonality/interaction between proposals.

[Functional split] We're very happy to discuss specific realization in the study phase. But if we focus on functional split between DUs (say, master and secondary DU) then we might not need to re-open the functional split discussion between CU and DU?

**Answer to #3 (Ericsson)**

I just wonder what aspect of your comment helps to identify commonality/interaction, but thanks anyway for your discussion.

[Applicability to non-ideal backhaul / benefits] As for multi-carrier operation, we also think we should focus on (near-)ideal backhaul. This somewhat limits deployment flexibility, i.e. coordinating nodes are limited to not-too-distant buildings, but even with that much more flexible deployment than today can be unlocked and we could aim to make the feature transparent to UE. As for multi-TRP and resiliency, we do not expect ideal backhaul limitation. Thus we, along with other operators, expect substantial benefit from this feature.

[Master/secondary DU] We also think some architectural enhancements would be needed. We're happy to discuss how to enhance the architecture or the existing interface while minimizing practical (not conceptual) drawback in the study.

[Scheduling and RRM / Product Differentiation] We think we know where you're coming from about product differentiation. Though we aim to specify a common interface, it might be beneficial to support vendor-specific extension mechanism as in existing interfaces.

[Resiliency] We should indeed find a good balance between improved resiliency and impact to specifications/architecture in the study. We think we must admit option 3 (hot failover) might be a stretch. As

pointed out connection to multiple CUs are already allowed in some cases (implementation-specific fall-back, RAN sharing), so why don't we seek for standardized solution.

**Answer to #4 (Nokia)**

As we pointed out in the question phase, for all the topics we should firstly identify the information to be exchanged, and then identify timing requirements, and discuss interface/architecture enhancements. Therefore our view is that this work should not be split.

As for starting WG, please see answer to #2.

**Answer to #6 (CATT)**

As for starting WG, please see answer to #2. As for the CU slicing, please see answer to #1.

**Answer to #7 (vivo)**

[1. inter-DU interface] Our current thinking is that inter-DU interface should be considered at least for inter-gNB/DU multi-carrier operation.

[2. UE impact] Our preference at this stage is to have no impact on Uu, i.e., make the feature transparent to (R15) UEs. However, in the study phase, if it is concluded that tight coordination between nodes is infeasible, then we are open to discuss Uu enhancements.

[3. RAN2 impact] In addition to what is stated above, we assume coordination with RAN2 and RAN1 would be needed in terms of information to be exchanged etc.

**Answer to #8 (OPPO)**

Our motivation is deployment flexibility as compared to single-node CA, or UL coverage and more UE support as compared to today's DC.

Yes we aim for legacy UE support. As for backhaul latency, please see our answer to #3.

**Answer to #9 (Samsung)**

Please see our answers to #3 for applicable area/benefits, #4 on proposal splitting, and #1 for slice-specific CU.

**Answer to #10 (Huawei)**

I just wonder what aspect of your comment helps to identify commonality/interaction, but thanks anyway for your discussion.

1) If DC is used, then we have to deploy more sites to compensate for the coverage, and more baseband units to enable CA for UEs not supporting DC, etc. We are also not sure whether the amount of additional C-Plane traffic compares to that of U-Plane.

2) Our motivation of the multi-carrier proposal is deployment flexibility as compared to single-node CA, or UL coverage and more UE support as compared to today's DC. In this sense current DC is not enough to operators. As for resiliency, please note that standardized solution is needed for operators, and we also think this would be a good opportunity to have even better resiliency through community discussion. As for product differentiation, please see our answer to #3.

Thanks again.

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## 5 Misc. RAN1/2/3 improvements: set 3

### 5.1 Network coding

This section is targeted at identifying commonalities and interactions for Network coding.

## Feedback Form 9: Questions/Comments

### 1 – ZTE Corporation

For network coding, we think we need to identify the potential applicable scenarios, where one of the promising applications is network coding based PDCP duplication according the first two rounds of email discussion. Furthermore, the impact of introducing network coding on architecture and protocol should be studied. To exploit the benefits of increased reliability and reduced throughput, a proper network coding scheme should be also studied.

### 2 – Deutsche Telekom AG

We agree with ZTE that we should define suitable use cases for which Network Coding provides benefits in terms of reliability. Only if clear benefits for widely accepted use cases are identified, Network Coding should be progressed in 3GPP (not just of the sake of adding it to the technology) development.

### 3 – Motorola Mobility UK Ltd.

[Lenovo, Motorola Mobility]:

Network coding has the potential for improved efficiency and reliability, however, we should first identify suitable use cases and applications of the technology. In evaluating the merits of network coding over existing techniques (e.g., packet duplication), we need to take in to account realistic performance including additional complexity and latency introduced, analysis of the which layer network coding is performed, and the number of packet segments that are feasible to meet the packet delay bound.

### 4 – Apple Hungary Kft.

What kind of coding schemes is ZTE envisioning as part of the network codes? In general, is there an estimate on the savings from the different proponents in terms of replacing retransmissions/duplication at PDCP layer with network coding in terms of memory and CPU impact on the UEs ? Also what is the view on trying this scheme out in isolated network only scenarios such as IAB before involving the UE?

### 5 – vivo Communication Technology

On network coding support we think some clarification may be useful as follows:

1. Is network coding performed at RLC or PDCP layer?
2. What is the maximum size of K for better network performance compared to current Tx without coding?
3. Is there any relation between the coding size K and the coding header overhead?

### 6 – Guangdong OPPO Mobile Telecom.

We are interested in network coding in general which could be useful for features such as URLLC, XR etc. and solution to extend network topologies such as IAB, SL relay, smart repeat etc. So maybe a general study is better i.e. not to scatter among difference features. Not all classical network coding algorithms in academic paper could fit 5G NR system, so the first job is to identify typical algorithm(s) to be evaluated. As for the protocol stack, we think PDCP could be right place. The comparison between network coding and current PDCP duplication as well as other features to improve reliability introduced in e.g. URLLC is necessary

**7 – Ericsson LM**

It seems one major use case is to replace/enhance PDCP duplication with some form of packet coding on the same layer. We think the current PDCP duplication balances improved reliability with low latency as only one of the duplicates need to be correctly received. The packet coding will inevitably increase latency. There could also be a need for flow control – with multiple paths with encoded packets, slower path(s) may get piled up with packets, e.g., when UE manages to decode using packets through another path.

**8 – Nokia Corporation**

We also agree with comments from DT that we should have widely accepted use case for network coding before progressing with the detailed investigations in 3GPP

**Feedback Form 10: Answers/Comments**

**1 – ZTE Corporation**

Answer to #4:

-

Response 1: We think LDGM (low density generator matrix codes) and RS should be studied firstly. And we are also open to other schemes. The final scheme should be decided by a trade-off between the complexity and the performance.

-

Response 2: The estimation is not provided. As to the concerns about the additional complexity, we think there are many ways to address it according to the previous email and GTW discussions.

o

The NW code/decoding at higher layer is operated in finite/binary field. Hence, at least the decoding complexity is much lower than the channel code decoding.

o

Proper setting of the number of segments. The encoding/decoding complexity is determined by the number of segments. A proper setting of the number of segments can achieve a trade-off between performance and complexity.

o

Reduce the complexity of the encoding operation by, for example, using a LUT, or a proper design of generator polynomial or matrix.

o

Reduce the complexity of the decoding operation by a proper design of generator polynomial or matrix. For example, considering to use iterative elimination, instead of traditional Gaussian elimination for decoding in the design of coding scheme.

-

Response 3: We are open to consider the scenario that introduces NW coding in IAB without impact on UE. It should also be noted that NC can bring benefit not only to base station but also to UEs, thus it is better that the introduction of NC is limited to IAB scenarios in the early stage. As to the concerns about the additional complexity, please see the response 2.

Answer to # 5:

-

Response 1: There are three options which include PDCP layer, RLC layer, or a new sub-layer between RLC and PDCP suggested by some other companies. It is preferred that the down-selection can be performed after carefully comparison in the SI stage if the SI is permitted.

-

Response 2: According to our simulation results, a larger K brings about larger coding gain, but also higher decoding complexity. Hence, we need to choose a proper K value to achieve a trade-off between performance and complexity.

-

Response 3: Yes, the coding header overhead would increase with a larger coding size K.

## 2 – Intel Technology India Pvt Ltd

### Response to ZTE, Deutsche Telekom, Nokia

Our proposal for Rel-18 study on linear packet coding (RWS-210368) is well aligned with ZTE's proposal, and from Intel's perspective, we share the same view with ZTE on the scope of study.

And we believe that the benefits of packet coding (summarized in our slide 4) are clear for widely accepted use cases, as it has potentials to be applied to any scenario that Rel-16 packet duplication is applicable, as well as to any multi-route multi-connectivity scenario such as IAB.

### Response to Lenovo, Motorola Mobility, Vivo, OPPO

We believe our paper RWS-210368 provides a thorough analysis in terms of protocol and overhead aspects, complexity, all the way up to simulations with realistic configurations in comparing packet coding to Rel-16 packet duplication. The benefits we can achieve by packet coding are summarized in our slide 4.

We also believe PDCP is the right place to apply packet coding, but there can be other placement considerations, which is up for study.

The optimal value of k for the best performance of packet coding depends on various factors, such as type of coding used, # of coded segments (i.e. n), # of paths and independent erasures that coded segments can go through, original packet size, etc. But in general, fixing k/n (code rate) and increasing k and n would improve the reliability performance as long as the generated coded segments go through independent erasures. The amount of overhead depends on the amount of header bytes needed for each coded segment, original packet size, and value of k, which is also analyzed in our slide 5.

But we believe that even with very small values of k (with less complexity and overhead), packet coding has potential to bring huge performance gain, as shown in simulation results in our slides 11, 12, and 13.

### Response to Ericsson

Though it is true that Rel-16 packet duplication requires only one PDCP duplicate to be correctly received, any other duplicate correctly received if any is simply discarded wasting radio resources. And it is also true that our packet coding proposal requires multiple coded segments to restore the original packet, but as described in our paper RWS-210368 slide 10, an original packet is first chopped into  $k$  input segments and then encoded into  $n$  coded segments. Even with a simple setting of  $(k, n) = (2, 4)$ , if we use a linear block code that satisfies MDS (maximum distance separable) property, the receiver only needs any 2 out of  $n = 4$  coded segments to restore the original packet. The amount of bits transmitted over the radio required to restore the original packet is equivalent to one duplicate of Rel-16 packet duplication. Total amounts of bits transmitted over the radio for  $(k, n) = (2, 4)$  are equivalent to sending 2 duplicates in Rel-16 packet duplication. As a result, by applying coding per packet basis, there is no loss in terms of radio resource efficiency that may lead to latency increase. Of course, there is some overhead chipping in, but as analyzed in our slide 5, overhead is less than 1% when we use  $k = 2$  for 1500 bytes regular IP packet, which is very small compared to the reliability gain we get that can be converted to overall system throughput increase.

In fact, packet coding can be chosen to save resources compared to Rel-16 packet duplication while still delivering better reliability than Rel-16 packet duplication, e.g. by choosing  $(k, n) = (2, 3)$ . Even with this setting, we have proven that reliability gain can be significant (see our slide 11).

The impact on latency is actually from the additional computation coming from encoding and decoding operations that perform a series of additions or multiplications over finite field. But as analyzed in our slide 6, we can circumvent high cost direct computation and minimize latency impact by table look-up which stored all the addition or multiplication results between finite field symbols. Moreover, applying coding “per packet basis” enables flexible coding decision – applying coding or not can be decided per packet basis and thus it can be chosen not to apply coding for some packets if processing delay becomes a concern for latency.

Moreover, it is true that coded segments may get piled up over slower paths, but one advantage of packet coding is that, with respect to decoding, we can make no dependency between any coded segment transmitted over the radio. As explained above, if we use a code satisfying MDS property, e.g.  $(k, n) = (2, 4)$ , then the receiver only needs any 2 out of  $n = 4$  coded segments to restore the original packet. This allows us to efficiently use route diversity by adaptively choosing how many coded segments to transmit over each route based on its available capacity changing over time. Using packet coding indeed enables us an elegant flow control by properly reacting to different link situations adaptively and avoiding packets piled up over slower paths.

This is in contrast to Rel-16 packet duplication, for which a PDCP PDU duplicated and transmitted over multiple routes are treated independently to restore the PDCP PDU. Each PDCP PDU may be split and transmitted due to RLC segmentation over each route, but those segments have dependency – i.e. different segments transmitted over different routes cannot be combined to restore the PDCP PDU. As a result, if latency becomes an issue, there is no other way but to stop sending duplicates over slower paths, which would drastically reduce reliability and diversity and may delay subsequent packets.

## 5.2 MUSIM

This section is targeted at identifying commonalities and interactions for MUSIM.

## Feedback Form 11: Questions/Comments

### 1 – ZTE Corporation

We think more study is required to understand the target scenario and potential impact on specs. From our perspective, the reduction of number of CCs, BW and MIMO layers seems not sufficient, the NW need to know the exactly band/band combination/feature set combination supported for each USIM whenever such capability is changed. Otherwise the NW may handover the UE to a band which can not be supported due to the change of capability. The measurement capability should be taken into account as well.

### 2 – Ericsson LM

We think that the Rel-17 Multi-SIM work item provides a good solution to address the main issues for multi-SIM UEs. It would of course be possible to add further optimizations, e.g. like it is proposed to optimize for cases when a multi-SIM UE is connected to two networks. However, we understand that it is possible to use the features specified in the Rel-17 work item to address scenarios where a dual-TX UE connects to two networks. For example, the UE would be able to adjust its UE capabilities to not run in to a situation where the UE has overpromised on its capabilities.

### 3 – Apple Hungary Kft.

We are positive on the proposals (in RWS-210176) of signaling overhead reduction and paging monitoring optimization since they can further reduce UE power and simplify the MULTI-SIM UE's operation. And we are open for the discussion on the dual Rx/dual Tx UEs.

### 4 – Lenovo (Beijing) Ltd

We are fine to enhance the case of the same operator scenario and Dual-Tx/Dual-Rx MUSIM devices. But we have the Rel-17 solution to address the switching issues in the case of single TX, which can be applied for the case that the different SIMs belong to the different/same operators. Therefore, we need to identify whether we can reuse the solution supported by Rel-17. At least, Dual-Tx/Dual-Rx MUSIM device belonging to the same operator can be further optimized.

### 5 – China Telecommunications

For capabilities coordination and SCG/Scell release/deactivation for Multi-SIM purpose□ We think it is important to figure out what are impacted during the Tx/ Rx chains switching, therefore we can see in which direction to go for the solution.

For optimization for intra-PLMN scenario□ we think further discussion on following aspect are needed□

-Whether any security issue needs to be solved? There seems no consensus during previous discussion.

-What kinds of optimization should be considered? Idle mode or connected mode? Whether this optimization also applies to Dual Tx/ Dual Rx UE type.

### 6 – Guangdong OPPO Mobile Telecom.

In general we would like to understand what the benefit to further enhance MUSIM is. There is no paging collision issue for UEs with dual RX/TX which can already support parallel session in different cell. The temporary change of RF capability due to cell switch is more or less reflected in CSI report which is both feasible in LTE and NR system. The intra-PLMN coordination can be also done in application layer so that no AS impact is necessary

### 7 – HuaWei Technologies Co.

There seems some support on MUSIM enhancements and we are interested on UE capability coordination for dual Tx/Rx mode, and among which there is good support on UE capability coordination for dual Tx/Rx UEs (0004, 0127, 0176, 0208 and 0299). It may need further clarification how fast it is required for the network to react on UE capability coordination, and what is the expected network behavior, e.g. release/deactivate SCG/SCell, reduce MIMO capabilities in one network?

Other proposals are diverging and we are wondering whether implementation or reusing Rel-17 features can already be sufficient?

### 8 – Beijing Xiaomi Mobile Software

We think that the capability sharing issue/solution for MUSIM overlaps with the capability sharing issue/solution for the IDC discussion. We should consider some harmonized solution for both MUSIM and IDC (eMBB enhancement), so as to avoid some duplicated standard work and avoid the collision between different functions.

### 9 – Spreadtrum Communications

For RWS-210004 from Qualcomm:

1. Could you provide more details/clarifications on Primary/secondary DSDA links, for example, how to determine the primary link, or how to apply the configuration from primary link to secondary link?
2. For intra-PLMN, how to understand “getting paging for both USIMS on one link”, only monitor the PO of one SIM?

For RWS-210176 from vivo:

1. Just for clarification, for “ unified/common mobility management”, and “paging UEs in one device within the same PO”, this require the two SIMs belonging to the same RAT of the same operator, right?

For RWS-210208 from Charter:

For scheduling gaps issue, this can be resolved by network implementation, right?

## Feedback Form 12: Answers/Comments

### 1 – Qualcomm Incorporated

**To Spreadtrum’s questions addressed to Qualcomm:**

**[Question 1]** Could you provide more details/clarifications on Primary/secondary DSDA links, for example, how to determine the primary link, or how to apply the configuration from primary link to secondary link?

**[Answer 1]** The choice of the primary link can be up to the UE or decided by the gNB upon UE request. The main goal of the primary/secondary separation is not to repeat the configuration of common parts shared by the two USIMs. For example, if both PHY and MAC are shared by the two USIMs, it is sufficient to send the RRC configuration of PHY and MAC only on one link, which would be considered the “primary”.

**[Question 2]** For intra-PLMN, how to understand “getting paging for both USIMS on one link”, only monitor the PO of one SIM?

**[Answer 2]** Yes, it is monitoring the PO of one USIM. Since the NW is aware of two USIMs at the same UE, it is sufficient to monitor only one PO which would be used to transmit paging from either USIM.

## **2 – HuaWei Technologies Co.**

### **Regarding ZTE's comment:**

On specific band combination and featureset combination, we do not understand why this is a problem. The UE would anyway report supported BCs and featureset combinations, even if it is in multi-SIM case, the network should have no chance to handover UE to the non-supported BCs.

## **3 – ROBERT BOSCH GmbH**

One final comment from our side: MUSIM with dual SIM (or more) active at the same time is very important for automotive use cases. One example, if a SIM is used for one service (e.g., infotainment) and the other SIM is used for V2X communication (including functional safety communication). Same PLMN is a valid and justifiable option. We understand that network acknowledgement of this feature to avoid interruptions and/or unwanted prioritization is very useful.

## **4 – Sony Europe B.V.**

We think that further studies should involve SA2 when it comes to e.g. capability co-ordination, for the different cases of single Tx/Rx and dual-Tx/Rx, and for the cases of same and different operator, in order to handle potential capability conflicts, from an overall system perspective.

## **5 – vivo Communication Technology**

### **Answer to #1 (ZTE):**

We agree that the band combination/feature set combination supported for each USIM should be reported to the network. We are open for the discussion on this issue.

### **Answer to #2 (Ericsson):**

Does it mean a MUSIM device always reserve some capability for MUSIM B even MUSIM B is in idle? In our understanding, it will lead to impact on MUSIM A's performance, since the MUSIM A is never allowed to use the total capability of the device. We prefer to avoid the such strong limitation.

### **Answer to #3 (Apple):**

We also have interest in signaling overhead reduction and paging monitoring optimization further reduce the power consumption.

### **Answer to #4 (Lenovo):**

We agree with the general principle that the existing solution should be reused if possible. In our understanding, capabilities coordination between two RRC\_Connected UEs in a MUSIM device has not been considered in Rel-17 for Dual-Tx/Dual-Rx devices. Some solutions for this scenario may be needed.

### **Answer to #5 (China Telecom):**

Regarding the security issues, we are open but think it should be studied by SA3.

Regarding the optimization for intra-PLMN scenario, both idle (e.g. optimization for paging monitoring) and connected (e.g. signaling overhead reduction) mode can be considered. The optimization can benefit Dual Tx/ Dual Rx UE by reducing power consumption and signaling overhead.

### **Answer to #6 (OPPO):**

The potential benefit includes avoid the NW schedules UE exceeds capability via capabilities coordination, reducing power consumption and signaling overhead.

### **Answer to #7 (Huawei):**

In our understanding, to react on UE capability coordination request, one network may release/deactivate SCG/SCell, reduce MIMO capabilities to enable the UE to communicate with another network. The details can be studied in Rel-18.

**Answer to #8 (Xiaomi):**

We think that IDC and MUSIM are different issues. For capability change, we think hardware sharing between NR and WIFI may happen in some cases. In our understanding, some issues, e.g. MIMO capability reduction, are MUSIM specific issues.

**Answer to #9 (Spreadtrum):**

Yes, we target the scenario where the two SIMs are belonging to the same RAT. And we assume in most cases, the two SIMs are served by the same cell.

### 5.3 UE aggregation

This section is targeted at identifying commonalities and interactions for UE aggregation.

#### Feedback Form 13: Questions/Comments

##### 1 – ZTE Corporation

From scenario/use case perspective, we see the following commonalities among the proponents based on the first two rounds of email discussion. We'd like to confirm whether our understanding is correct or not.

-

It's more urgent to focus on UL, i.e., aggregated UL transmission from multiple UEs.

-

There are no limitations on how the aggregated UEs are connected.

As for the how to perform the split/aggregation, e.g., RAN level or core network level, we are in general open at this stage.

##### 2 – VODAFONE Group Plc

We see UL aggregation as the important aspect of UE aggregation. For other than simple scenarios (e.g. 2 UEs wired to one machine) there are numerous system level aspects (including charging, LI and inter-UE-link-security) that would need to be considered.

##### 3 – Deutsche Telekom AG

This proposal requires more end-2-end thinking from a system perspective. We propose interested companies bring this topic also to the SA Rel-18 WS in Sept., e2e topics we have in mind are around privacy, security, identity, charging etc.

Depending on the use case and environment this concept might become complex (rather simple in industry/Campus environment, challenging in public eMBB)

##### 4 – Apple Hungary Kft.

There are different levels of UE aggregation. Some aggregation mechanisms can achieve the same purpose but transparent in 3GPP, e.g. Application layer's aggregation. If the aggregation is considered in RAN/CN level, extra UE complexity will be introduced, e.g. UE coordination, UE association, and the data splitting

amongst multiple UEs. And several questions need to be clarified or to be resolved, e.g. whether all associated UEs can work well individually (registration, TAU, separate NAS/RRC connection), which assumption is for the data transmission between the two associated UEs. Therefore, It is unclear to us the benefit of the UE aggregation in RAN/CN level.

#### **5 – CATT**

In general, we are interested in this topic. The use case and requirement were already discussed and confirmed in SA1. The UE aggregation can improve the throughput and reliability, especially for the uplink case. However, since it is a completely new topic, we prefer to have a study item first to do further study and evaluate the potential impact to the specification.

#### **6 – vivo Communication Technology**

We also mention UE aggregation in our paper RWS-210172. We think that service switching for consumer and industry (as being discussed in agenda item "7.5 Other IoT Enhancements" in non-eMBB thread) and aggregation between UEs can be considered together in the next step of discussion because both belong to collaborative UE and have same CP and UP architecture in RAN, if gNB is as the anchor.

#### **7 – Guangdong OPPO Mobile Telecom.**

We understand the main intention of UE aggregation is improve uplink capability in terms of transmission power and antenna ports. The first issue is group management which supposes to happen in NAS layer. As for the solution to communication among UEs in the group, we think PC5 interface is a good choice. Then the key issue is to identify the anchor protocol stack just like we did it before for dual connectivity. In initial stage we propose only study up to two devices to evaluate the performance gain which is also realistic case e.g. one smart phone and another digital device belonging to same person

#### **8 – HuaWei Technologies Co.**

We understand there is good support on the motivation to consider UE aggregation (0451, 0436, 0199, 0355, 0479, 0056 and 0192). The solution proposed by companies are mainly SL relay multi-path aggregation and UE aggregation without specifying UE-UE non-3GPP interface, and quite a few companies proposed to have L2 aggregation (0355, 0451, 0436, 0192), which seems have commonalities on what to be considered mainly, including enabling aggregation, L2 signaling and data transmission handling and service continuity mainly focusing on the UL.

There is also some discussion relevant to capability coordination (0479, 0056), we are not sure whether this is directly related to aggregation itself, or it is more relevant to capability coordination discussed in MUSIM? It is also a bit unclear whether this also touches L1 and RF capabilities for the UEs?

#### **9 – Samsung R&D Institute UK**

Question on user virtualization/UE virtual cluster in RWS-210479/RWS-210199, we need some clarification how user virtualization provides UL enhancement and wonder whether the proponent proposes to specify user virtualization mechanism in RAN.

Comment on UE aggregation: the UE aggregation looks interesting but to get the expected gain, not only focus on L2 mechanisms and procedures we need more investigation and analysis throughout overall system architecture.

### **10 – China Mobile Com. Corporation**

From CMCC perspective, we see the following commonalities among the listed contribution in the table of the email discussion:

- The motivation of this topic is to support the applications with wide UL bandwidth on 5G terminals and investigate how to address the issue of the shortage of UL UE transmission power in 5G via UE aggregation( in some contributions, usage of the term “ collaboration”) mechanism;
- The basic Procedures for UE aggregation, i.e., Setup/Modification/Release procedures for the UE aggregation, the identify of aggregated UEs from RAN side;
- L2 architecture, functionalities and interfaces to allow aggregated UEs to receive control signalling/-data in coordination mode, e.g. without data disorder or data duplication during the data splitting between the aggregated UEs;
- Mobility of aggregated UEs with Service continuity.

### **11 – Beijing Xiaomi Mobile Software**

we are interested in the terminals coordination for these cases.

From the companies docs, we cannot see what is the proposed interface between the 2 UEs. We would like to understand whether companies consider specifying the interface between the 2 UEs using PC5 or not to specify it and leave it to implementations?

### **12 – Spreadtrum Communications**

We are interested in this topic. The UE aggregation can improve the UL throughput and reliability to meet the market requirement. We are open to all the possible frameworks in this stage. We think the security issue and complexity of UEs also need to be considered.

### **13 – Ericsson LM**

Two scenarios are presented. In one scenario the setup is quite static in a factory environment and the proposal is to coordinate to boost power using two UEs which are more or less connected to each other or at least controlled together. If this power boost is from 23 to 26 dBm we wonder if it is not possible to have a single UE with a higher power class instead. The other scenario is more mobile and argues for using sidelink to transfer the data from one UE to the other before transmitting it to the network. This means that we combine sidelink relaying where the remote UE also transmits the data to the network simultaneously as the relay UE. We think the gains over using sidelink relaying alone have not been shown.

### **14 – Nokia Corporation**

We agree with DT that overall system aspects of UE aggregation need to be considered before considering specific work in radio WGs.

## **Feedback Form 14: Answers/Comments**

### **1 – Samsung R&D Institute UK**

#### **Comment to #3 (Deutsche Telekom):**

We agree with DT’s proposal that the proponents bring the UE aggregation to SA to evaluate expected E2E issues.

**Comment to #4 (Apple):**

We share the view of Apple that benefit of RAN/CN level aggregation is not clear comparing with application level aggregation. Evaluation and comparison of these candidate aggregation types should be preceded.

**2 – HuaWei Technologies Co.****Comment to ZTE:**

we also think UL should have the priority.

**Comment to Ericsson:**

The UE that supports 26 dBm transmit power would double the transmit power of 23 dBm UE and it is difficult to mandate UEs to support so, which would also add complexity and cost. To use UEs with 23dBm can easily be done for such enhancements. In addition, the UE aggregation not only bring transmit power gain but also other enhanced performance. That is especially beneficial under the circumstances that additional UE capability is not introduced or forming UEs with lower capability to an aggregated UE with enhanced capability. For multi-path relay, as both remote UE and relay UE would transmit the data from remote UE to the network, improved throughput and reliability would be achieved. If the gains are seen for aggregation in general, this applies to SL relay as well and there is no such limitation that SL relay can only be considered in more mobile case.

**3 – ZTE Corporation**

## Comment to #4 Apple

-

First of all, we think it is clear that the aggregated transmissions from multiple UEs could boost the overall UL power, and also make the aggregated UEs enjoy higher MIMO and carrier processing capability. All of these benefits could improve UL performance. As for the questions, our view is that the associated UEs could be aggregated to one virtual UE or can be worked independently, and the network can switch (e.g., semi-statically or dynamically) between the two modes. For instance, if split/aggregation is at PDCP, these UEs could be scheduled independently or some L1 scheduling enhancements could be considered depending on whether network can identify the grouping of the UEs at L1 layer. Anyway, we think the details could be further studied.

## Answer to #8 HuaWei

-

Our intention is to allow aggregated transmissions from multiple UEs to improve UL performance. Depending on use cases/detailed design, it may also involve L1 work. For instance, if the multiple UEs are connected by wire, these UEs could be regarded as one super virtual UE and jointly scheduled at L1 layer. In some scenarios, if split/aggregation is at PDCP, these UEs could be scheduled independently (i.e., no L1 involvement) or some L1 scheduling enhancements could be considered depending on whether network can identify the grouping of the UEs at L1 layer. Our understanding about the scenario of MUSIM is for one UE across multiple networks, which is different from the scenario here.

## Answer to #9 Samsung

-  
First of all, it's our view that user virtualization is a similar concept of UE aggregation. If aggregated transmissions from multiple UEs is allowed, it could improve UL performance from aspects 1) higher UL transmission power, 2) higher UL MIMO capabilities by sharing all the Tx among UEs 3) higher processing capabilities by sharing all the processing modems among UEs.

-  
Yes, mechanisms needs to be specified in RAN.

Comment to #13 Ericsson

-  
We agree that there are different scenarios. Overall, we think the specification impacts and performance gain for different scenarios could be studied and evaluated with a SI first.

#### **4 – China Mobile Com. Corporation**

##### **Answer to #3 DT:**

Firstly, regarding the UE aggregation, the most impact is on RAN side, e.g., the identify the associated UE can be implemented in RAN side, transparent to CN, moreover, we think the charging, security are common issues combined with many of topics, e.g., sidelink UE, Relay UE, which are studied in RAN and SA in parallel. Hence, we don't think we need wait for SA2's study result and wait for SA2 to analyze and notify us what impact on RAN.

##### **Answer to #11 Xiaomi:**

Regarding the selected communication technology applied to the interface between the two devices, we are open on this, which can be cable/3GPP Uu/3GPP sidelink/WiFi/BlueTooth. Hence, if the interface is cable, WiFi or BlueTooth, the interface design can be left to implementation. If the interface is Uu/sidelink, the interface design should be specified.

#### **5 – vivo Communication Technology**

##### **Answer to #3(DT), #4(Apple),#14(Nokia):**

We agree that some issues should be discussed in SA2. However RAN can also study it based on RAN requirement, i.e., coverage enhancement, data throughput enhancement, service interruption requirement.

##### **Answer to #13(Ericsson),**

We think that we can not require all UEs to implement 26dBm and even if implemented, UE cannot always transmit as 26dBm due to SAR limitations. And for some XR devices (e.g. glasses), it may not be able to transmit at 26dBm. And sperate UE will also give flexibility about split transmission based different channel condition.

### **5.4 Security enhancement**

This section is targeted at identifying commonalities and interactions for Security enhancement.

## Feedback Form 15: Questions/Comments

### 1 – ZTE Corporation

We support the security enhancements against False Base Stations (FBS), based on the solution identified by SA3. For the other aspect, we think it should be discussed in SA3 first, and RAN can follow the requirements from SA3 if any conclusion can be made in SA3.

### 2 – VODAFONE Group Plc

We support that RAN should allocate some TU for "False Base Station" solutions that SA3 specify.

### 3 – Deutsche Telekom AG

Depending on the outcome of the SA3 Rel-17 work, RAN might enhance the security framework as part of its Rel-18.

We think that security, trustworthiness and privacy enhancements play a significantly important role, so that they should be considered with the appropriate TU allocation in Rel-18. More fundamental changes might not be easily possible due to the legacy constraints or the risk of down-grade attacks in practical scenarios.

### 4 – Lenovo Mobile Com. Technology

*We propose a Rel-18 study item focusing security enhancements to address the increased threat being reported by various studies e.g. from GSMA. RAN2 may anyway need to invest time if SA3 decides to make changes as part of their current work/ study and in the absence of required TUs, the RAN2 R18 efforts can't be channelized efficiently. Having said that we do not see protected System information as part of the study or any R18 solution. The following objectives can be included in a R18 study:*

-

*Countering a fake base station by designing means to protect so far unprotected L3, L2 and L1 signaling, and*

-

*Studying if some very low latency application will fail to perform full integrity protection and providing a suitable solution if the need be.*

### 5 – Apple Hungary Kft.

We are positive on the RAN security enhancement. But it should be clarified first that it is associated to the SA3 false base station SI.

For the lower layer AS information protection mentioned in 0184 and 0379 (for example MAC CEs in L2), we are supportive too, but the related protection mechanisms should be initiated in SA3 TR33.809.

For 0362, Page 5 on security enhancements, it was mentioned developing blockchain and Quantum Key Distribution in 3GPP system, but the specific use case is not clear. Would KT clarify which use case can those technology be applied?

For 0379 on security of virtualization of BS, page 3 proposes to build a trust relationship between UE and network even for L2/L1 signalling. Wouldn't this be addressed by the vitalization technology instead of 3GPP protocol design?

#### **6 – vivo Communication Technology**

The objectives currently listed in 0184 does not mention IAB, does the SI proposal in 0184 include IAB ? If yes, does the SI objective BAP control PDU? Or which element of IAB is considered?

#### **7 – Guangdong OPPO Mobile Telecom.**

Security of L1/L2 message could be an issue to be discussed in e.g. L1/L2 centric mobility topic which supposes to happen in Rel18. Then based on the discussion in that topic RAN2 can have better understanding what could be potential security issue after checking with SA3. At this stage we don't think it is necessary to check all L1/L2 message in general

#### **8 – HuaWei Technologies Co.**

There are a few companies proposed security enhancements but the exact proposals are diverging or at quite high level, including enhancements from L1 to L3. We are wondering whether this should first be discussed and analyzed in SA3 to undertand better what are the most risky problems, as the relevant study is still ongoing in SA3.

Note that for lower layer security especially for L2, GSMA has already sent an LS (R2-2104705 User location identification from Carrier Aggregation secondary cell activation messages) to 3GPP before, RAN2 and SA3 have already discussed this aspect, the LS in S3-212305 to GSMA already indicated that the risks are quite low, and no action is needed for the time being. We are wondering whether there is sufficient motivation to start this work in RAN right now with considerable impact on fundamental air interface design, backward compatility and potential performance degradation.

#### **9 – Samsung R&D Institute UK**

We definitely support the work for the AS security enhancements for Rel-18, and see several supports from the Q&A discussion before as well, but at the same time, this work seems to require clear input from SA3, which would be available only after SA3 concludes which issue(s) have to be addressed for the work. Since SA3 is still discussing the scope of False Base Station WI for both Rel-17 and Rel-18, and they are also considering other enhancements which may impact to RAN specifications (e.g. security enhancements for CU-CP and CU-UP split, etc.), RAN needs to wait their progress in practice, but at the same time, RAN should get prepared for the required TUs for the possible work in the RAN side, considering the potential impact to RAN specifications.

#### **10 – Beijing Xiaomi Mobile Software**

Comment 1: We think the security enhancement is important in Rel-18. However the RAN scope may have some dependences on the final security solutions selected by SA3. The detailed RAN work can be decided later after SA3 made the final decisions on the Rel-18 work.

Comment 2: Regardless of which issue/solution is selected, we consider that the solutions should be applicable for both Uu interface and the PC5 interface, so as to enhance the car communication security which is critical for car vendors.

#### **11 – Spreadtrum Communications**

1. We support to continue the false gNB related study since it has not been fully addressed in R17. And the PWS over NPN related security issues may be added according to the SA3 output in R17.

2. Could KT further clarify what impacts Blockchain and Quantum Key Distribution technology have to 5G? We are interested in this topic and would like to support studying them in R18 if necessary.
3. Could Xiaomi clarify that since the full-rate UPIP has supported in R16 then what R18 UPIP needs to further study?

#### **12 – Ericsson LM**

The appropriate group for studying and assessing security is SA3. If SA3 sees need for RAN work we expect RAN/relevant RAN groups will be informed and can take it from there.

We believe it would be prudent, however, to not overcommit Rel-18 content, so that RAN has capacity to address aspects originating from other groups in Rel-18 time frame.

#### **13 – Philips International B.V.**

If the RAN groups do not want to start their own work item for this important work related to fake-base stations, and wait for SA3, then it has to be made sure that sufficient TUs remain unallocated to be able to do the respective work during release 18.

### **Feedback Form 16: Answers/Comments**

#### **1 – Samsung R&D Institute UK**

Answer to #6 (vivo):

Even though our 0184 does not mention IAB explicitly, we believe that the solution for protecting L2 control message, if introduced, would be applicable to all the L2 control message, including BAP control PDU.

#### **2 – Sony Europe B.V.**

Answer to Apple:

We think virtualisation and sharing of gNB resources will bring a new challenge from security point of view and virtualisation technology may be able to help the protection of data transfer between nodes. However, our main concern is that if UE can trust the DU at the same level as the CU and if the interface between the UE and the DU needs protection. its effectively the same issue as fake BS.

### **5.5 SON/MDT**

This section is targeted at identifying commonalities and interactions for SON/MDT.

### **Feedback Form 17: Questions/Comments**

#### **1 – ZTE Corporation**

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We understand that SON/MDT is more meaningful to the information collection and optimization of the functions used on a large scale, for example, mobility enhancement in the Rel-10. SON/MDT in the Rel-18 can continue its evolution, but we should be cautious about selecting the new functions introduced by Rel-16 and Rel-17. We see some convergence on SON/MDT of MBS, NTN, Rel-17 left-over issues (e.g. RACH Report trigger from DU to CU).

-  
While for IAB, our view is some SON related enhancement is necessary in R18, but we prefer discussing it in IAB WI. We mainly focus on the mobile IAB scenario (deployed on the vehicle). In this scenario we need SON enhancement so that the mobile IAB node can update and maintain NCRT in a timely manner when moving. For example, during the moving process, the mobile IAB can only be switched to a specific IAB donor. When the vehicle arrives at the station, the updated NCR needs to be obtained in a timely manner to support the UE switch between IAB node and macro node.

## 2 – Huawei Tech.(UK) Co.. Ltd

The SON/MDT proposal until rel-17 focusing on feeling the gap to LTE and enforcing the “classical” network management, the emails discussion and definition of September WID should give a better opportunity to the definition of SON for verticals; e.g. V2X, IIoT, XR etc ....

## 3 – Deutsche Telekom AG

We also see the need to extend the SON/MDT work and the framework to be defined as part of RAN Data Analytics also important for upcoming vertical needs. This is on the one side configuration for vertical specifica, and on the other hand measurement and data collection to monitor and prove SLAs for example. With the work on RAN Data Collection RAN3 layed a foundation for an improved Data Analytics Model which shall be aligned with SA2/SA5 and built the basis for a foundation of a framework applicable to ML and AI. In our contribution RWS-210032 we propose to study and identify the possibilites for base such a framework on Service Based Architecture (“SBA”) principles, which are already used in 5GC to enable a soft migration into a fully cloudified environment for the entire Data Analytics and ML/AI.

## 4 – Ericsson LM

It is fine to work on the SON/MDT topics that have been identified/analyzed early ( if not finished in Rel 17) in Rel 18.

But, SON/MDT enhancement for “MBS, IAB, V2X and NTN” should be analyzed in the dedicated WI. We need to clarify the needs and the use cases first.

## 5 – Lenovo Information Technology

For Rel-18 SON/MDT enhancements, we think the following high level aspects should be considered:

-  
MRO enhancements for CPAC

-  
Successful PSCell Change Reporting

-  
MRO for fast MCG recovery (if it will not be supported in Rel-17)

-  
MRO for Inter-RAT HO from NR to E-UTRA for voice fallback

-  
MDT enhancements for NR MBS in idle/inactive

-  
SON enhancements for IAB Topology and Routing Optimization

-  
SON enhancement for NR V2X, e.g. resource allocation optimization for mode 2.

-  
SON enhancement for NTN mobility

We are open to consider other cases such as SON for NPN and SON for slicing.

#### **6 – CATT**

In general, we think SON/MDT should be continued in Rel-18 with more features considered. During the discussion in the previous two weeks, we observed that there is no question on NPN, MBS and MR-DC enhancement cases. Based on that, we think at least the above 3 use cases should be included. As to other features/use cases, e.g. IAB, NTN, v2x, we could further discuss in the latter half of this year and then make conclusion on whether these aspects should be within the scope of Rel-18 SON/MDT WI or not.

#### **7 – vivo Communication Technology**

On QoE enhancement (0237) it just mentioned for RRCIDLE, *does the support for QoE enhancement include support of QoE measurement in RRCINACTIVE?*

*What is the main service type considered for support of QoE measurement in RRCIDLE? And eventually for RRCINACTIVE?*

#### **8 – Guangdong OPPO Mobile Telecom.**

In general we support further SON/MDT work in Rel18 on newly introduced R17 features with clear scope and objectives

#### **9 – Samsung R&D Institute UK**

For R18 SON/MDT, R17 leftovers should be prioritized. The second priority may be the optimization of R16/17 features that operators have any implementation plan. Thus, we wonder what the R16/17 features that operators have currently focused on are.

On the other hand, the optimizations have to be introduced while minimizing both specification impact and UE burden, e.g. the existing mechanisms/RRC message should be reused as much as possible.

#### **10 – China Mobile International Ltd**

We think further enhancement of SON/MDT in Rel-18 is necessary. The potential objectives in our view could include Rel-17 leftovers, optimization of some Rel-16 features which was discussed during WI drafting phase but not included eventually due to TU constraints, e.g., NPN, IAB, and as well as the optimization of Rel-17 new features, e.g., MR-DC (CPAC), NTN, MBS.

Regarding how to organize future work, we suggest the email discussion after the workshop if any, could focus on discussion of the new objectives; the leftover issues could be handled in the later stage.

## Feedback Form 18: Answers/Comments

### 1 – LG Uplus

We think MDT/ANR is essential as the first step of AI/ML application. Hence, we think that some features of MDT/ANR should be mandatory. We did not want to deprioritize them for commercialization any more. Further, we think more flexible measurement configuration for per-beam data collection is desired (RWS-210275).

### 2 – LG Uplus

We think MDT/ANR is essential for AI/ML SON. We think some features of MDT/ANR by device should be mandatory, when we do not want to sustain from delay of AI/ML data collection by device any more. Further, more flexible measurement configuration per beam is desired in order to help smart beam management (RWS-210275).

### 3 – ZTE Corporation

Comment to #3 Deutsche Telecom, regarding service based architecture (SBA).

-  
We see some impact when introducing SBA based services in RAN. In current specification, functions of SON/MDT are embedded in RAN node. If functions can be run as service (e.g. MRO, MLB, CCO), the interactive between service and data (e.g. SON data collection) and instructions for RAN node parameter optimization between service node and RAN node should be standardized.

### 4 – China Mobile International Ltd

Comment to #1 ZTE,

We think SON for IAB can also be discussed in the SON/MDT WI if use cases are clear, similar as other feature optimization enabled by SON. Regarding SON for mobile IAB, we are not sure whether we can discuss it in Rel-18 since mobile IAB has not been supported in Rel-17

Comment to #3 DT,

We acknowledge the direction of aligning framework for data collection and AI with SA2/SA5, but it seems SON/MDT WI is not the right place to handle this. We have tried in the data collection enhancement SI, but the current agreed principle is still to reuse the current architecture and interfaces.

Comments to #4 Ericsson,

It is sensible that SON for other use cases are considered in SON/MDT WI, since normally discussion on SON/MDT involves different camps and expertise, but we also agree we need to first understand the use cases first, this can be done in the next stage.

## 5.6 Others

This section is targeted at identifying commonalities and interactions for other topics submitted to cross functionality which are not categorized in any topic above.

## Feedback Form 19: Questions/Comments

### 1 – Futurewei Technologies

SDAP (Service Data Adaptation Protocol) was introduced and specified in R15 to provide 5G RAN with QoS control capability through QoS flow to DRB mapping configured by RRC signaling. In R16 and R17, SA has been introducing more flow based QoS measurement and enforcement, such as MDBV, survival time, Slice-MRB, etc., to meet increasing need of latency critical application data burst. RAN2 has been looking for solutions to support those new QoS metrics in RAN. It is proposed in RWS-210040 to enhance SDAP in R18 with flow-based latency and data rate awareness to achieve bounded latency with high capacity.

### 2 – vivo Communication Technology

The lower UE power class as proposed in RWS-210135 and 0171 seems to be more applicable to redcap devices, suggest to move these papers in Redcap evolution email thread and consider them together with other redcap proposals

### 3 – HuaWei Technologies Co.

regarding 0452, in previous 3GPP discussion we sometimes face the situation that compatibility issue results in impact on a considerable number of UEs. This proposal is to allow UEs having initial access problem to use a new mechanism for recovery, e.g. to always have a chance to setup the connection with the network and get recovery information by network assistance. We think this proposal can be further discussed and welcome more technical views.

### 4 – EURECOM

Concerning RWS-210506 "Visible Light Communication for 5G", we intend to create awareness that this technology exists and integrates well into 5G. It can provide a complementary high-throughput 5G technology to mmWave in environments where RF operation is undesired or must be kept to a minimum, e.g. airplanes, hospitals, certain kinds of factories.

## Feedback Form 20: Answers/Comments

## 6 Potential RAN4 improvements

This section is targeted at identifying commonalities and interactions for Potential RAN4 improvements.

### 6.1 Spectrum related topics

This section is targeted at identifying commonalities and interactions for spectrum related topics.

## Feedback Form 21: Questions/Comments

### 1 – ZTE Corporation

We are open to discuss with operators request on spectrum related WIDs/SIDs, since spectrum related items are different from non-spectrum related items, it's better to be treated in different way and clear deadline

for the request of spectrum related items in Rel-18 should be set to leave enough time for RAN4 to do the study.

## **2 – Ericsson France S.A.S**

RWS-210375 (Intel): P5/6: Spectrum WIs into 2 groups: non-basket and basket WIs: non-basket WI should be approved whenever needed; but basket WIs should be approved in March 2022 when R17 basket WIs will be done.

## **3 – Apple Hungary Kft.**

Regarding future spectrum flexibility in RWS-210032, we think this is an interesting idea. To some extent, this seems to be the extension of SUL and variable duplex operation work in RAN4. Besides the normal work of specifying band pairs/new bands with associated requirements being examined, we also need to understand what “dynamically configurable pairs” implies from both network and UE’s standpoint. In our understanding, it at least should include the following work: RAN1 (scheduling, CSI feedback, etc.), RAN2 (signaling support of dynamic configuration), and RAN4 (bands/band pairs definition, switching time, interruption time, etc.). Also, the following issues are to be further clarified.

## **4 – CATT**

Agree with Ericsson comments that spectrum should be categorized into spectrum basket WI and non-basket spectrum WI and the timeline could be different.

## **5 – China Telecommunications**

To address operators’ needs in a timely way, it is not necessary to limit the approval of spectrum items to the certain meetings or time period. In general, for spectrum items, we can just follow the existing way in Rel-17.

Concerning the spectrum basket WIs, it can be further split into two sub-groups if needed: 1) continuation of Rel-17 basket WIs, 2) new basket WIs that cannot be foreseen at the beginning of Rel-17. For the sub-group 1), they can be approved at March 2022. For sub-group 2), they can be treated in the same way as spectrum non-basket WIs.

## **6 – Guangdong OPPO Mobile Telecom.**

First of all we wonder whether there is no regulation issue changing from fixed duplex to dynamically configurable pairs. Usually any change of spectrum utilization is not trivial since it might have regulation impact. Now the FDD and TDD are well defined in 3GPP and being used for many years in or out of 3GPP. The regulation impact is one of the major issue that need to be carefully investigated, and another issue is the impact to RAN4 requirements like the Tx impacts to Rx, cross band impacts and also the impacts to UE implementations. Without knowing these background better, introducing new spectrum utilization might be risky

## **7 – Beijing Xiaomi Mobile Software**

For RWS-210033 we wonder whether the intention is to classify the UE by OTA value for the same power class or for power class agnostic? As is well known, OTA requirement cannot be easily defined and it is band specific, Is the threshold for classification also band specific?

Regarding RWS-210419 the BS EMC test simplification has been fully discussed during the Rel-17 WID discussion and an umbrella EMC WID for RAN4 covering both UE and BS aspects has been proposed

with quite stable objectives. We think to accomplish the BS and UE EMC enhancement in Rel-18 is quite feasible and helpful to the industry.

As presented in RWS-210075 we have concerns on proposal 1 and 2 regarding the approval of non-spectrum work items and the proposed delay to approval. In our view those topics which have already been discussed in R17 shall be high priority Rel-18 RAN4 tasks, as the scope is clear and stable and the reason they didn't get on board in R17 was just because of RAN4 TU limitation in R17.

Regarding RWS-210393 we prefer to have a feasibility study first in order to get a clear picture on what is the main factor /assumption to make better MSD.

## **8 – Huawei Technologies France**

For spectrum related topics, there are inputs from companies RWS-210455, RWS-210279, RWS-210423, RWS-210249 and RWS-210276. And in our view the discussion under this section should focus on potential RAN4-led work. Some works discussed here seems related to other WG work and should be discussed together with other related contributions like 0032 which seem related to flexible spectrum integration.

The following topics are proposed:

- Enhancement for 700+800+900 band combination (RWS-210455). We see big interests from companies and the work should not focus on a certain feature like CA. The discussion in Rel-17 could be used but we see some difference from Rel-17 where the CPE with larger form factor would be considered.
- Simplification of band combinations (RWS-210455)
- New NTN bands (RWS-210423)
- Addition of power class in 39GHz (RWS-210249)
- Inter-band UL/DL CA for FR2 (RWS-210249, RWS-210276). We see common interest from operators on the inter-band CA for both FR1 and FR2.
- Intra-band NC NR-DC for n77 (RWS-210276)

It seems meaningless to split it into basket and non-basket. All the topics which need discussion is non-basket. For basket, we do not need spend too much effort in this following email discussions.

## **Feedback Form 22: Answers/Comments**

### **1 – Samsung R&D Institute UK**

#### **Comments to #1, #2 and #4:**

We share same understanding as other companies, spectrum related topics can be further categorized as basket WIs, and non-basket spectrum WIs.

In previous Releases, RAN4 use package TU assignment to cover basket and spectrum respectively i.e. 4TUs for basket WIs, 2TUs for spectrum WIs.

With increased request on band combinations, new spectrum and new channel bandwidths; there is a risk that the workload become un-controllable. Some new measures need to be considered for management, e.g., increasing reserved TUs for spectrum related topics

A clear guidance should be given to classify the proposals belongs to spectrum topics or non- spectrum topic.

### **2 – Intel Corporation (UK) Ltd**

#### **To Ericsson, CATT, Huawei, China Telecom on spectrum WI approval process**

Question/Comment #1 (Ericsson): RWS-210375 (Intel): P5/6: Spectrum WIs into 2 groups: non-basket

and basket WIs: non-basket WI should be approved whenever needed; but basket WIs should be approved in March 2022 when R17 basket WIs will be done

Question/Comment #3 (CATT): Agree with Ericsson comments that spectrum should be categorized into spectrum basket WI and non-basket spectrum WI and the timeline could be different.

Question/Comment #5 (China Telecom): Concerning the spectrum basket WIs, it can be further split into two sub-groups if needed: 1) continuation of Rel-17 basket WIs, 2) new basket WIs that cannot be foreseen at the beginning of Rel-17. For the sub-group 1), they can be approved at March 2022. For sub-group 2), they can be treated in the same way as spectrum non-basket WIs.

Question/Comment #8 (Huawei): It seems meaningless to split it into basket and non-basket. All the topics which need discussion is non-basket. For basket, we do not need spend too much effort in this following email discussions

Answer: Thank you for the comments. Our original idea was that new basket WIs can be approved in Dec 2021. Meantime, RAN4 can continue work to finalize the contents of Rel-17 basket WIs in Q1'2022. Further extension of the contents of basket WIs can take place in March 2022 following the regular procedure. The proposal to further split basket and non-basket WIs is also good and we agree that timelines can be different.

#### **To Xiaomi on non-spectrum WI timelines**

Question/Comment #7: As presented in RWS-210075 we have concerns on proposal 1 and 2 regarding the approval of non-spectrum work items and the proposed delay to approval. In our view those topics which have already been discussed in R17 shall be high priority Rel-18 RAN4 tasks, as the scope is clear and stable and the reason they didn't get on board in R17 was just because of RAN4 TU limitation in R17.

Answer: Thank you for the comment. We think that all R18 proposals should be treated on a fair basis and clear prioritization among all proposals should be done. Early approval of selected proposals would have negative impact from this perspective.

#### **To China Telecom on spectrum WI approval process**

Question/Comment #5: To address operators' needs in a timely way, it is not necessary to limit the approval of spectrum items to the certain meetings or time period. In general, for spectrum items, we can just follow the existing way in Rel-17.

Answer: Thank you for the comment. Existing Rel-17 approach results in approval of numerous new WIs in each meeting and further scope adjustments in the next meetings. Same time, we fully acknowledge that some requests can be urgent and need to be addressed in a timely manner. So, further discussion on how to improve the process is encouraged.

### **3 – Huawei Technologies France**

For spectrum:

[Huawei]: We agree with China Telecom comments that there is no need to limit the approval of spectrum items to a certain meetings or time period.

Regarding Rel-18 continuation basket work items, we think we do not need to discuss them in the following-up email discussion. We only focus on the new items in the email discussion. Rel-18 continuation basket work items could be discussed and endorsed in RAN4 and then go to RAN plenary.

Regarding comments on dynamically configurable pairs, the work should be led by other WG. But we agree that dynamic pairing should follow the regulation.

Regarding improving MSD, we should wait for the outcome of Rel-17 discussion.

## 6.2 RF related topics

This section is targeted at identifying commonalities and interactions for RF related topics.

### Feedback Form 23: Questions/Comments

#### 1 – ZTE Corporation

We are also open to further discuss BS and UE RF enhancement if it's approved to be beneficial to the system performance, however some items are still under discussion in Rel-17 e.g. MSD improvement for band combination, 700+800+900MHz CA, maybe we could postpone the discussion until we have clear conclusion in Rel-17.

#### 2 – Ericsson France S.A.S

There are some potential RF improvements that can improve Rel-17 performance and (depending on other workload) may be handled with a reasonable effort, such as A-MPR and MSD improvement/signaling, relevant simultaneous TX/RX cases, SCell dropping (if not solved in Rel-17), improved beam correspondence requirements (in particular for PRACH), TX switching for non-co-located scenarios and general improvements to power and power dynamics accuracy. We think that a candidate list of small improvements that are incremental and achievable should be made and then prioritized for RF improvements.

Some comments on specific contributions:

(RWS-210032: DT)-> BS EMC measure: Mechanism used for EMC measurements for massive MIMO should be based on existing implementation in the BS without requiring new test mode specific for EMC testing.

(RWS-210340: CMCC)-> Regarding further BS class home eNB; it should be clarified if this is only RAN4 (CSG etc.). The local area class does not prevent low power implementations (since the TX power is a maximum limit, not a target) and we have not yet seen which other RF requirements need consideration, but welcome clarification. Also, deployment scenarios should be clarified.

(RWS-210033: TI): P2) TDD format: BS requirements are applicable for all formats. UE requirements are defined for specific formats. If needed some UE requirements can be defined for an additional format. P3) Inter-operator RRM: Async TDD operation very much depends on agreements between operators e.g. guard band. It could be rather challenging to converge on one or few solutions and a means of prioritization. Inter-operator signaling for RRM etc., is up to now outside 3GPP scope; it may be converge to a solution. P4) How should conformance testing be performed for existing devices ? Also, even if there is a solution in 3GPP then it is a question how to demonstrate regulatory compliance. P6) EMF: this is a very important issue, but it is currently handled in regulatory for a and not in the scope of 3GPP. There may be a risk of duplicating efforts and ultimately it is the regulatory requirements that must be complied to.

(RWS-210456: HW)->MB-MSR. Feasibility of wide RF components covering multiple bands need some study as it would result in very large RFBW (several GHz). It would be relevant to consider a SI first with in-depth investigation of feasibility and implementation aspects. Also, it would be interesting to get further operator feedback on the urgency. .

RWS-210029 (QC): There is a very clear need to improve UE testing and testability and we welcome proposals for this. Without proper testing then more advanced requirements and features are undermined, so we think that time should be set aside for this aim. Of course, there is a need to prioritize the RF TUs with other topics and focus the scope.

RWS-210249 (LG): Simultaneous Rx/Tx for intra-band NC: we wonder if simultaneous Rx/Tx is feasible in the same TDD band?

RWS-210393 (Nokia): We agree that A-MPR optimization and MSD improvement should be prioritization in Rel-18. MSD reduction is important area but we do not see benefit of signaling.

RWS-210455 (HW): 1) 4Tx UL MIMO requirements: need further discussion if 4Tx UL MIMO provides significant gain compared to 2Tx UL MIMO 2) Simultaneous RX/TX on 700+800+900MHz bands. Requirements cannot be specified without the feature is defined in RAN1.

### **3 – Apple Hungary Kft.**

Regarding UE RF performance indicator in RWS-210033, it is subject to further clarification how this can be achieved as usually RAN4 only defines one set of minimal requirements. While supporting the development of OTA minimum requirements, we also realized that defining one set of requirements for UE TRP/TRS has proven to be difficult based on the LTE experience (the LTE UE TRP/TRS WI had to be stopped). It may be much harder to define a scale of performance requirements. Also, it is worth discussing how this would help network deployment if some underperforming UEs are allowed, e.g. how will a potential UE RF performance indicator be calibrated against network performance parameters, such as inter-site distance, actual BS output power, overall cell load, and propagation conditions?

Regarding FR2 multi-beam simultaneous reception (RWS-210375) and 4-Layer DL in FR2 (RWS-210029), both proposals require UE activation of two panels for reception on a single carrier. Study is needed to understand the performance gain and the related form factor/power limitations. In addition, it should be clarified the performance gain can be quantified.

Regarding simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band in RWS-210249, we think it would not be feasible as there is no intra-band filtering to provide isolation between Tx and Rx. The Rx desensitization is expected to be rather substantial.

Regarding FR2 UL 256QAM in RWS-210455: it was extensively discussed in R15 and RAN4 decided not to specify requirements because of UE implementation challenges and lack of real system gain. It would be good to study those aspects first.

### **4 – CATT**

We agree that some aspects or items may need to be addressed in Rel-18. But would like to discuss the whole package later since now it is still a very early stage for RAN4 proposals and more proposals might come in later meetings.

### **5 – China Telecommunications**

For MSD improvement (RWS-210393, Nokia), we share the same view with ZTE that it depends on the Rel-17 progress, and we can focus on Rel-17 discussion for now.

For 700+800+900MHz CA (RWS-210455, Huawei), we have requested BC CA\_n5A-n8A-n28A with 3DL and 2UL bands in Rel-17. It is desirable to further look at these BCs and better utilize the spectrum in these rare and valuable bands in Rel-18. We are also ok to discuss the details later based on the Rel-17 outcome.

### **6 – Guangdong OPPO Mobile Telecom.**

For UE performance discrimination. This has been raised in recent RAN4 meetings because certain companies are not satisfied with defined requirements and would like to define another set of requirements for the “optimized” UEs. However, this is not typical RAN4 work area where the minimum requirements were always the focus. If define another “good requirements” RAN4 specification impacts and market divergence need to be carefully considered. And this might lead to more and more different requirements and capabilities in RAN4.

As for high capability UE, these UEs are advanced in theory but probably user experience could be not good in reality. Considering the larger power consumption and large number of antennas to be supported and very limited applicable scenario, although Rel-18 UE will roll out few years later, it is expected these very high capability will not be widely supported by commercial UEs.

#### **7 – LG Electronics Deutschland**

We think topics on RF enhancement that are under discussion in Rel-17 can be discussed after the finalization of related Rel-17 discussion. The scope of Rel-18 enhancement for RF in FR1/FR2 should be ones that are not in the current scope of discussion in Rel-17. We expect more proposals in the coming RAN and we are open to discuss further based on the more inputs from other companies.

1. Comment on RWS-210393 (Nokia):

We think it is necessary to wait for the decision on Rel-17 MSD Capability signaling discussion.

For the A-MPR improvement, RAN4 needs further discussion on the scope and way how to improve the detailed A-MPR along with simulation assumptions.

2. Comment on RWS-210455 (Huawei)

In Rel-17, the target device is FWA for the LB-LB-LB combinations. We need further discussion on the feasibility of applying the same RF architecture (3 antennas) to the smart phone type UE in Rel-18.

#### **8 – China Mobile Com. Corporation**

General comments:

For the Rel-17 improvement topics, we propose to discuss later depending on the Rel-17 completion, e.g. FR1/FR2 RF enhancements. For the new topics, we propose to discuss and approve in Dec. 2021 together with other RAN1/2/3 WIs.

@RWS-210249 LGE, one comment on the simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band, we would like to understand better what is the motivation or use case to use different TDD configurations in the same band? Thank you.

#### **9 – Beijing Xiaomi Mobile Software**

(resubmitted from section above)

For RWS-210033 we wonder whether the intention is to classify the UE by OTA value for the same power class or for power class agnostic? As is well known, OTA requirement cannot be easily defined and it is band specific, Is the threshold for classification also band specific?

Regarding RWS-210419 the BS EMC test simplification has been fully discussed during the Rel-17 WID discussion and an umbrella EMC WID for RAN4 covering both UE and BS aspects has been proposed with quite stable objectives. We think to accomplish the BS and UE EMC enhancement in Rel-18 is quite feasible and helpful to the industry.

As presented in RWS-210075 we have concerns on proposal 1 and 2 regarding the approval of non-spectrum work items and the proposed delay to approval. In our view those topics which have already been discussed in R17 shall be high priority Rel-18 RAN4 tasks, as the scope is clear and stable and the reason they didn't get on board in R17 was just because of RAN4 TU limitation in R17.

Regarding RWS-210393 we prefer to have a feasibility study first in order to get a clear picture on what is the main factor /assumption to make better MSD.

## 10 – Huawei Technologies France

For non-spectrum related topics, there are inputs from some companies at RWS-210455, RWS-210249, RWS-210212, RWS-210135, RWS-210393, RWS-210276, RWS-210029, RWS-210456, RWS-210340/1, RWS-210033, RWS-210032 and RWS-210419/20. There are some proposals as below:

### UE:

- HPUE

We are supportive to have further enhancement for HPUE. As HPUE related to lots of WIs in Rel-16 and Rel-17, the objectives in Rel-18 can be further discussed.

- 4Tx

We are supportive to have study for 4 Tx, which would be helpful to enhance the performance. Considering the form factor issue, 4Tx can be considered for CPE.

- Simultaneous Rx/Tx for intra-band NC CA/DC

Similar view as some other companies, the feasibility should be considered firstly for the scenario.

- A-MPR optimization
- MSD optimization

Generally we are supportive to have some MSD improvement, but as we commented in round 2, there are some issues need to be figured out firstly. E.g. How to utilize the MSD UE capability if only a small portion of UE have optimized MSD? How to handle a band combination with different MSD sources, e.g. IMD, harmonic, harmonic mixing, cross band isolation, etc. How to handle MSD for specific frequency configuration not covered in the specification?

- lower power class

This is also related to discussion in other WG topics. The discussion in other WGs should be considered together.

- OTA testing/TRS&TRP

Generally we are supportive to have further study of OTA test. The scope should be further discussed.

### BS:

- mmWave multi-band BS

We see there are some FR2 inter-band combinations proposed already. Similar to low frequency bands, wide band implementation could be a trend for deployment perspective.

- NR home BS

In general we are supportive to have study of the new BS class, but would like to know better of the potential deployment scenario.

- BS OTA testing

### EMC, EMF:

In general we are supportive to investigate possible EMC testing simplifications. Motivation for the BS EMC testing simplification has been discussed already in the past, with the focus on the MSR BS testing of the EMC requirements. As this topic currently aims Rel-18, it is proposed widen the scope of the Study phase and to look for possible simplifications also looking at the SRAT BS, possibly considering RAT-agnostic framework (FFS).

Content of this WI has been already discussed in the past. As now it aims for Rel-18, it is proposed to set more ambitious goal to have more fundamental simplification of the EMC part of the RAN4 work.

On top of the proposed content, it is proposed to define two umbrella EMC specifications (replacing the legacy specs):

- Single UE EMC spec for all RATs,
- Single BS/repeater/IAB spec for all RATs, including SRAT and MSR testing.

The above is motivated by the fact that:

- all EMC core requirements are referred from external EMC specifications (IEC, CISPR).
- Significant parts of the EMC specifications are basically copy-paste from legacy EMC specs,
- Testability aspects reuse RF agreements on test signals and test models.

The above is expected to significantly reduce the EMC workload in RAN4 in future.

## Feedback Form 24: Answers/Comments

### 1 – Qualcomm Incorporated

#### To Ericsson's comment on FR2 UE testing and testability, addressed to Qualcomm:

[Answer] Thank you for the question/comment.

We agree that this study will require some time but we believe that this should be prioritized because there is a clear need for it, as you also point out. We are open to start with a relatively simple setup like UE rotation (e.g. UE is rotated in the chamber during the test) and then proceed with more complicated testing such as the "travel model".

#### To Apple's comment on 4L in FR2:

[Answer] Thank you for the question comment.

As 4L in FR2 and multi panel operation is already defined in other working groups, the performance benefits should be clear so we do not see the need to do another study. The performance gain should be straightforward, 4L vs 2L should bring a very clear gain that is directly measurement in a performance test.

### 2 – Beijing Xiaomi Mobile Software

To Huawei's comment on EMC:

[Answer] Thank you for the comment and supportive view for EMC enhancement.

As mentioned in our previous comment, the EMC enhancement WID for both UE and BS has been fully discussed during Rel-17 WID discussion with quite stable objectives and many supporting companies. To avoid making more confusions we might prefer keep the current WID objectives while further enhancement can be proposed after Rel-18. For the umbrella specification, we see the EU regulation is doing so. However, for maintenance perspective, we don't see the benefit by using a large spec covering all the RATs/Releases/equipment types.

### 3 – Intel Corporation (UK) Ltd

#### To Apple on FR2 multi-beam reception

Question/Comment #3 (Apple): Regarding FR2 multi-beam simultaneous reception (RWS-210375) and 4-Layer DL in FR2 (RWS-210029), both proposals require UE activation of two panels for reception on a single carrier. Study is needed to understand the performance gain and the related form factor/power limitations. In addition, it should be clarified the performance gain can be quantified.

Answer: Thank you for the comment. Support of multi-beam simultaneous reception was enabled from RAN1 specification perspective in Rel-16 to further improve FR2 performance (peak rates as well as robustness). The performance gains will be observed in dense deployments and we do not see the need to repeat the work done on other WGs in terms of studies. So, we agree with Qualcomm comment above. In addition, improved RRM performance is obviously achievable. Finally, the respective enhancements may be applicable to selected devices, since this is already an optional feature.

### 4 – Huawei Technologies France

#### 1 – Answers to Ericsson:

Thank you for your comments.

RWS-210455 UE RF: For simultaneous Rx/Tx on 700+800+900, we would like to focus on RF requirements and architecture part based on the existing features like CA/DC first and then extend it to other possible features. Could you elaborate more which feature should be specified first in RAN1 in your mind.

RWS-210456 FR2 MB-BS: It would be challenging for FR2 BS to support multi bands, especially for the RF components and antenna design. Agree that more study is needed from implementation perspective. We see there are some FR2 inter-band combinations proposed already. Also similar to low frequency bands, wide band implementation could be beneficial for staged deployment scenario.

## **2 – Answers to Apple on RWS-210455 UE RF:**

Thank you for your comments.

There will be some limitation on the condition for the use case. But we see the importance to boost uplink capacity. UL 256QAM would be more efficient and feasible way than other techniques. We are open to further study.

## **3 - Answers to China Telecom and LG Electronics on RWS-210455 UE RF:**

Thank you for your comments.

In our view, in Rel-17 the discussion may focus on the device with larger form factor. We need consider smart phone. More discussions on the feasibility and UE architecture are needed. But we can take Rel-17 input into account.

## **5 – LG Electronics Deutschland**

### **Answers to Ericsson(#2), Apple(#3), CMCC(#5) and Huawei(#10)**

**Answer to #2)** RAN4 did not discuss the feasibility on the intra-band non-contiguous CA/DC scenarios with simultaneous Rx/Tx. So, we think feasibility study is needed including the required frequency gap for the simultaneous Tx/Rx operation in intra-band non-contiguous CA/DC scenarios (e.g. n79).

**Answer to #3)** We think that RAN4 needs to study how much frequency gap is required to guarantee the acceptable interference level from transmitter to receiver when considering simultaneous Tx/Rx operation.

**Answer to #5)** The motivation is that in Rel-17 sidelink enh., there is a on-going discussion on intra-band simultaneous Rx/Tx operation, i.e. V2X con-current operation (NR Uu + NR PC5 operation) in n79. This motivated us to expand Rel-17 simultaneous Rx/Tx in Uu+PC5 scope to simultaneous Rx/Tx in Uu+Uu configuration in Rel-18.

**Answer to #10)** We are open to discuss on the feasibility study for the simultaneous Rx/Tx operation in intra-band non-contiguous CA/DC.

## **6 – Ericsson LM**

### **Comments on EMC work (RWS-210419):**

We have same view as Xiaomi that EMC WID (covering both UE and BS aspects) has been quite stable objectives. The approval is already deferred to R18. So we support to approve the WID in R18 without any further updates/additions. We also need to be mindful of RAN4 workload in R18. The current WID scope is reasonable and manageable in R18 while considering other RF areas.

We do understand Huawei concern on having multiple specs for EMC (BS, IAB, repeater..) but having significant overlap. However, creating new common umbrella BS/UE EMC specifications to replace existing BS/UE EMC specs, will divert focus of this WI and increase work load. This is also primarily administrative rather technical work. We therefore do not want to do such activity under this WI. We are open for discussion for some consolidation within NR for BS EMC specs in future but after this WI is closed in R18.

## **7 – ZTE Corporation**

Comment to #10 Huawei:

-

In regard to have the umbrella spec for BS regardless of RAT, we fully disagree with that proposal since we already have a couples of EMC spec defined for the specific RAT in past, like NR BS, IAB, repeater. All these network nodes are in different form of RF architecture and different RF requirements been defined. For EMC part, these kind of difference had also been taken into account. To have umbrella spec to cover all RATs, like NR, IAB, repeater, it is redundant and just to waste the valuable and limited RAN4 TU. Instead, to have separate EMC spec for each RAT, this is easier to the industry to have better picture how EMC requirement are defined for each RAT and this could also avoid the unstable EMC spec structure and extremely lengthy EMC spec at the end.

### 6.3 RRM related topic

This section is targeted at identifying commonalities and interactions for RRM enhancement.

#### Feedback Form 25: Questions/Comments

##### 1 – SoftBank Corp.

In RAN#92e, it was decided that so many RRM items cannot not be supported in Rel-17 due to the RAN4 workload issue.

- Objective #1: RRM requirements for FR1+FR1 NR-DC
- Objective #2: RRM requirements for UE capability ‘NeedForGap’
- Objective #3: Enhanced indication of UE per-FR gap capabilities
- Objective #4: Support of non-co-located deployment for FR1 intra-band NR-CA/EN-DC
- Objective #5: HO with PSCell requirements for additional scenarios
- Objective #6: CMTTC for CSI-RS L3 measurement
- Objective #7: TCI switching enhancement
- Objective #8: Collision between SSB/CSI-RS based L1 and CSI-RS L3
- Objective #9: CGI reading requirement for NR-U cell

We would clarify if this kind of spill over can be automatically included in the next step discussion even though they are not explicitly mentioned by the companies’ contributions.

##### 2 – ZTE Corporation

We are also open to further discuss potential RRM items. In addition, we have lots of Rel-17 leftover items for RRM enhancement which are also important for both operators and vendors, therefore we would like to treat them in fair manner with new items proposed in Rel-18 since this is difficult to judge which one is more important than others.

##### 3 – Ericsson France S.A.S

RWS-210375 (Intel): We expect very large number of proposed RRM objectives. There were 9 objectives at RAN#92e. Given RAN4 work load the objectives which have high commercial demand should be considered. While proposed objectives are good candidates for R18, but in our view needforgap and FR1-FR2 NR DC have higher commercial need.

RWS-210249 (LG): RX beams between different MOs: we wonder if there is any benefit of such requirements.

RWS-210457 (HW): we agree that proposed objectives are good candidates for R18. At the end objectives which have high commercial demand or which can bring significant improvement to current deployment should be considered.

#### **4 – Ericsson France S.A.S**

There are a large scope of proposals for UE receiver algorithms (different interference mitigation algorithms, different types of signal, aligned or not aligned interference between cells etc.). The work is simulation heavy and time consuming, so there is a need for focused objectives. The scope of advanced receivers needs to be balanced in terms of workload with other proposals such as 8RX, higher order modulations etc. In general, achievable and targeted receiver improvements may bring more general benefits that demod requirements that relate to specific scenarios (e.g. very high modulation orders).

Some comments to specific contributions:

(RWS-210163; Vivo)-> IRC enhancement: It is premature to do IRC enhancement to address potential issues related to proposed Rel-18 features. In existing inference scenarios, the IRC performance without new signaling/assistance information is adequate. signaling/assistance information seems not likely to give any significant gain compared to existing IRC performance.

RWS-210375 (Intel): 1) UE adv receivers: any new requirements should avoid assistance information. Any discussion on assistance information if needed must include RAN1. 2) BS Rx enhancement: It can be left for BS implementation to save RAN4 resources and give more implementation freedom.

RWS-210458 (HW): UE adv receivers. It is preferable to consider the scenarios here, which do not require assistance information. Due to work load only one or few necessary scenarios providing significant gain should be considered. It is questionable if inter-cell SSB/CSI-RS interference mitigation will provide any significant improvement since these signals are infrequently sent e.g. once ever 20-40 ms.

RWS-210029 (QC): 4 layer FR2 might be useful, but a problem is that currently it is not testable.

#### **5 – Apple Hungary Kft.**

We think many RRM related scopes should be revisited after RAN4 concludes the requirements in R17, e.g. measurement delay reduction, FR2 DAPS, etc. On top of that, there are many left-over issues identified in R16 and more are expected out of R17. They should be considered and decided together subject to TU limitation.

#### **6 – CATT**

We agree that some aspects or items may need to be addressed in Rel-18. But would like to discuss the whole package later since now it is still a very early stage for RAN4 proposals and more proposals might come in later meetings.

#### **7 – vivo Communication Technology**

Receiver performance enhancement as discussed in RWS-210163 could be part of RAN1 work scope, separate item or part of MIMO.

**Answer to Ericsson:** we are not proposing for assistance information to facilitate receiver performance enhancement. Could you please clarify how various types of inferences are taken into account in IRC receiver, e.g. in sub-slot based scheduling, inter-cell interference and potentially gNB-gNB interference in the case non-aligned TDD frame structure? From UE receiver perspective, Rnn estimation on data is too complex. Our proposal is to introduce simple solution such as null REs to facilitate Rnn estimation at receiver, of course potential gain and overhead should be considered.

## **8 – China Telecommunications**

Perhaps we can consider the proposals discussed in RAN #92e and new proposals together, by taking into account the Rel-17 progress at a later stage. In our understanding, no matter one topic is a “old” or “new” topic, it belongs to the “old” area of RRM J, and not sure if this is the common understanding to all companies. In this sense, we agree with the proposal 1 in Intel paper (RWS-210375) to move RAN4 package approval of non-spectrum work items to March 2022.

## **9 – Guangdong OPPO Mobile Telecom.**

Rel-18 probably still cannot include all the items that proposed in this meeting and also in the following meetings considering the scope of Rel-17. Identify the real urgent demands is important and this actually doesn't automatically mean the Rel-17 left over items is of high priority than the new items proposed specifically for Rel-18

## **10 – LG Electronics Deutschland**

We expect more proposals related to Rel-18 RAN4 package are to be submitted after this WS. For the efficient discussion on the package, we think it is better to categorize two or three topics for RRM and prioritize some objectives in each topic.

## **11 – China Mobile Com. Corporation**

There are some Rel-16 RRM leftover topics (even Rel-15 RRM topics) that cannot be specified in Rel-17, e.g. NR-DC, measurement without gap, etc. These topics can be treated in the 1st phase (e.g. Dec. 2021). At the same time, there may also be some Rel-17 leftover issues depending on Rel-17 completion, these items can be treated in the 2nd phase (e.g. Mar. 2022 or later). Another option is to treat all the RRM enhancement topics equally in the 2nd phase.

## **12 – Huawei Technologies France**

For RRM related topics, there are inputs from companies RWS-210493, RWS-210457, RWS-210249 and RWS-210375. There are proposals as below:

- RWS-210493(Mobility and High Frequency Range Enhancement). In current specification, it is allowed to configure the same resource set for RLM and BFD/CBD. It is up to network configuration.
- RWS-210249 (Enhancement for device requirement). We understand that Rx beamforming is up to UE implementation. Based on RAN1 agreement, the selection of Rx beam set to perform measurement on carrier is left to the UE implementation with the limitation that the same Rx beam set is used to measure the same carrier, so the benefit of the requirements needs further evaluation.

Regarding the objectives which were not approved in R17, we suggest to re-visit these leftovers and re-discuss the importance after R17 WIs are stable, and then take the new items proposed in this workshop and the important leftovers to be considered together and decide the priorities.

## **Feedback Form 26: Answers/Comments**

### **1 – Qualcomm Incorporated**

#### **To Ericsson's question on 4L in FR2, addressed to Qualcomm:**

**[Answer]** Thank you for the comment. We are aware that 4L in FR2 is not testable with any available 3GPP test setup, this is why we have been proposing already in Rel-17 to study this aspect. A new study to introduce such a test setup will be needed in Rel-18 as an extension of Rel-17 feMIMO, which defined multi panel operation. The test setup should be very similar for the case with/without simultaneous transmission

from two panels(test setup is like the same, the number of active antennas on the TE side will be different).

## 2 – vivo Communication Technology

**Answer to #4 (Ericsson) about IRC receiver:** we are not proposing for assistance information to facilitate receiver performance enhancement. Could you please clarify how various types of inferences are taken into account in IRC receiver, e.g. in sub-slot based scheduling, inter-cell interference and potentially gNB-gNB interference in the case non-aligned TDD frame structure? From UE receiver perspective, Rnn estimation on data is too complex. Our proposal is to introduce simple solution such as null REs to facilitate Rnn estimation at receiver, of course potential gain and overhead should be considered.

## 3 – Huawei Technologies France

### To Ericsson's comments on RWS-210458(HW): UE adv receivers

[Answer] Thank you for the comments. Regarding scenarios, we agree that we should focus on the scenarios where there is significant gain. Regarding assistant signaling, we think it is necessary, otherwise UE complexity would be unacceptable and it is very difficult for UE to support the corresponding scenarios. But we can minimize the overhead of signaling. Regarding inter-cell SSB/CSI-RS interference mitigation, whether there is improvement may depend on the scenario. For example, in some scenario where TRS collides in adjacent cells, the TRS-IM would bring the significant gain.

## 4 – LG Electronics Deutschland

### Answers to Ericsson(#3) and Huawei(#12)

**Answer to #3 :** For different Rx beam sets, there can be benefit on mobility management if some behavior related to the beam sets becomes clearer from both network and UE perspectives.

**Answer to #12 :** As answered in pre-2nd round, different sets of RX beams can be used for different measurement objects. Inter-frequency measurement can be one example. We think it is necessary to study and specify the related behavior for network and UE considering all possible cases.

## 6.4 Demodulation

This section is targeted at identifying commonalities and interactions for Demodulation related topics.

### Feedback Form 27: Questions/Comments

## 1 – ZTE Corporation

We are also interested in advanced IRC receiver for both UE and BS sides to further improve the system performance.

## 2 – Ericsson France S.A.S

Ericsson comments: There are a large scope of proposals for UE receiver algorithms (different interference mitigation algorithms, different types of signal, aligned or not aligned interference between cells etc.). The work is simulation heavy and time consuming, so there is a need for focused objectives. The scope of advanced receivers needs to be balanced in terms of workload with other proposals such as 8RX, higher order modulations etc. In general, achievable and targeted receiver improvements may bring more general benefits that demod requirements that relate to specific scenarios (e.g. very high modulation orders).

Some comments to specific contributions:

(RWS-210163; Vivo)-> IRC enhancement: It is premature to do IRC enhancement to address potential

issues related to proposed Rel-18 features. In existing inference scenarios, the IRC performance without new signaling/assistance information is adequate. signaling/assistance information seems not likely to give any significant gain compared to existing IRC performance.

RWS-210375 (Intel): 1) UE adv receivers: any new requirements should avoid assistance information. Any discussion on assistance information if needed must include RAN1. 2) BS Rx enhancement: It can be left for BS implementation to save RAN4 resources and give more implementation freedom.

RWS-210458 (HW): UE adv receivers. It is preferable to consider the scenarios here, which do not require assistance information. Due to work load only one or few necessary scenarios providing significant gain should be considered. It is questionable if inter-cell SSB/CSI-RS interference mitigation will provide any significant improvement since these signals are infrequently sent e.g. once ever 20-40 ms.

RWS-210029 (QC): 4 layer FR2 might be useful, but a problem is that currently it is not testable.

### **3 – Apple Hungary Kft.**

Time selective interference rejection/mitigation would be very relevant and useful in NR. But without adequate network assistance it would have significant power and complexity impact on the UE. On other advanced receivers for inter cell or inter-user interference mitigation, our view is that they can be considered for further study with some network assistance assumed.

### **4 – CATT**

We agree that some aspects or items may need to be addressed in Rel-18. But would like to discuss the whole package later since now it is still a very early stage for RAN4 proposals and more proposals might come in later meetings.

### **5 – China Telecommunications**

In general, we believe the receiver evolution is an essential direction for Rel-18. By looking at the proposals shown in this workshop, different aspects for the further enhancement are considered, including the scenario (inter-cell, intra-user, inter-stream), receiver type (IRC data based, E-IRC, SL-IC, R-ML, Soft-IC), number of Rx antennas (8 for FR1, 4 for FR2), target/interference channel (PDSCH, CSI-RS/TRS, SSB, PUSCH). We agree that prioritization is needed, and the priority should be given to the receivers that are applicable to more common scenarios, with obvious gain and is doable for more UEs.

Some specific comments:

For 4 layer FR2, we share similar view with E/// that, currently the main issue is that it is not testable. When it becomes testable, the corresponding receiver requirements will be defined.

For network assistance information for advanced receiver, for RAN4-led items, at least semi-static RRC signaling cannot be precluded.

### **6 – China Mobile Com. Corporation**

Since the Rel-17 performance part will be frozen in Sep. 2022, it is too early to discuss the demodulation improvements at this early stage, especially for the pure demod topics, e.g. advanced receivers.

### **7 – Huawei Technologies France**

For demodulation, companies provide inputs in RWS-210499, RWS-210458, RWS-210163, RWS-210461, RWS-210375 and RWS-210122. We summarized the inputs into a number of categories:

- UE advanced receiver (RWS-210122)
- MU-MIMO scenario (RWS-210499, RWS-210458, RWS-210461, RWS-210375)
- MMSE-IRC under uneven interference (RWS-210458, RWS-210163, RWS-210461, RWS-210375)

- Soft-IC (RWS-210458)
- inter-cell RS-IM (RWS-210458)
- BS advanced receiver (RWS-210375, RWS-210122)
- IRC for inter-cell interference

We see the common interest on MU-MIMO scenario, IRC for uneven scenario. And maybe we could focus on UE advanced receiver in Rel-18.

## Feedback Form 28: Answers/Comments

### 1 – vivo Communication Technology

**Answer to #2 (Ericsson) about IRC receiver:** we are not proposing for assistance information to facilitate receiver performance enhancement. Could you please clarify how various types of inferences are taken into account in IRC receiver, e.g. in sub-slot based scheduling, inter-cell interference and potentially gNB-gNB interference in the case non-aligned TDD frame structure? From UE receiver perspective, Rnn estimation on data is too complex. Our proposal is to introduce simple solution such as null REs to facilitate Rnn estimation at receiver, of course potential gain and overhead should be considered.

### 2 – Intel Corporation (UK) Ltd

#### To Ericsson on UE advanced receivers

Question/Comment: UE adv receivers: any new requirements should avoid assistance information. Any discussion on assistance information if needed must include RAN1.

Answer: We agree that it can be preferable to minimize the amount of assistance information. Meantime, further studies are required to identify if meaningful improvements can be achieved in case additional network assistance is provided. For MU-MIMO receivers with modulation assistance RAN1 involvement may be required.

#### To Ericsson and China Telecom on 4 layer FR2

Question/Comment (Ericsson): 4 layer FR2 might be useful, but a problem is that currently it is not testable.

Answer: We think that RAN4 should spend efforts to enable testing of 4 layer FR2 and it can be the scope of Rel-18 discussion. The work on the definition of requirements can be done in parallel with the work on test methods.

Question/Comment (China Telecom): For 4 layer FR2, we share similar view with E/// that, currently the main issue is that it is not testable. When it becomes testable, the corresponding receiver requirements will be defined.

Answer: We think that RAN4 should spend efforts to enable testing of 4 layer FR2 and it can be the scope of Rel-18 discussion. The work on the definition of requirements can be done in parallel with the work on test methods.

#### To CMCC on Rel-18 Demod scope

Question/Comment: Since the Rel-17 performance part will be frozen in Sep. 2022, it is too early to discuss the demodulation improvements at this early stage, especially for the pure demod topics, e.g. advanced receivers.

Answer: The work on Rel-18 for RAN4-led items will start in Q2'2022. So, the scope of demodulation enhancements should be discussed jointly with other topics.

## 6.5 Cross topics

This section is targeted at identifying commonalities and interactions for Cross RF, RRM and/or demodulation

topics.

## Feedback Form 29: Questions/Comments

### 1 – SoftBank Corp.

Our contribution RWS-210276 is not listed in the Chair’s initial list of related contributions, but we have a RAN4 proposal to support non-colocated scenario for intra-band non-contiguous CA/DC using band 41 and n77/n78 with type 2 UE, which may have impact on RRM, DEMOD and potentially RF. Actually this was also proposed in Rel-17, so more details can be found in RP-211299. It would be appreciated if this proposal is also taken into consideration.

### 2 – ZTE Corporation

For NR based ATG, since this has been extensively discussed in Rel-17 and received lots of support from both operators, legacy vendors and also aircraft vendors, therefore we propose to complete the work in Rel-18 time frame.

### 3 – Ericsson France S.A.S

There is a very large amount of proposed work, which is in addition to the substantial impacts to RAN4 from other RAN1/2 lead work items (for example, Full Duplex and flexible spectrum will need significant RAN4 input). As ever it is important to manage workload and also to keep good focus on a manageable amount of items. Some proposals are different to the current scope in RAN4, and in our view, we should take care to establish 5G-Advanced in this release and keep to proposals that are within the existing scope of RAN4. Regarding specific contributions:

RWS-210375 (Intel): P1: It is good idea to consider approval of all non-spectrum WIs together e.g. in March 2022 as the workload on RAN4 from the overall work package will be better understood.

RWS-210337 (CMCC)/RWS-210477 (ZTE) We note that ATG has been discussed for some time, is stable and is motivated by a need. It should be further discussed whether, if the Intel proposal is approved it should be treated in March 2022 or earlier since it is mature and part of NTN.

### 4 – Apple Hungary Kft.

We are OK with Intel’s proposal to approve RAN4 package in March 2020 considering the definition of “new” and “old” items is not clear. It is not suggested to spend too much to discuss the definition of “new” and “old” itself.

RAN4 TU should be reasonably reserved for RAN4-led WI/SI in Dec plenary by R17 TU status as the reference.

### 5 – China Telecommunications

For ATG (RWS-210337 CMCC, RWS-210477 ZTE), we also agree the scope is stable.

### 6 – China Mobile Com. Corporation

We propose to discuss and approve RAN4 topics in Dec. 2021 together with RAN1/2/3 WIs. The motivation to discuss together with RAN1/2/3 is that we should avoid that RAN4 TUs are always be fully occupied by other WG WIs. RAN4 topics are commercial driven and more related to deployment. For the Rel-17 improvement topics, since they depend on the completion of Rel-17, it is difficult to start the discussion in Dec. 2021. But for new topics, we support to approve RAN4 topics in Dec. 2021 together with RAN1/2/3 WI.

## 7 – Huawei Technologies France

For cross topics, there are inputs from some companies at RWS-210337/8, RWS-210362, RWS-210477, RWS-210455, RWS-210029, RWS-210029, RWS-210461, RWS-210375, RWS-210276. There are some proposals for ATG, 8Rx for FR1, FR2 UL 256QAM, FR2 4-layer DL.

Since 8Rx is already supported for LTE, we think that this feature should be supported for NR at least for FWA UE.

For FR2 UL 256QAM, in our view, it is a viable solution to further enhance UL performance for FR2.

For FR2 4-layer DL, as it could be related to multi-panel implementation and MIMO enhancement discussion in other WGs, we'd like to have further discussion for the proposal.

## Feedback Form 30: Answers/Comments

### 1 – LG Uplus

Like Softbank said, the non-colocated scenario for intra-band non-contiguous CA/DC using frequency around 3.5GHz is related with RF, RRM and Demod together and very important to related operators. We think this becomes more important to other region as additional spectrum auction will be held adjacent existing 5G spectrum for operators. We fully agree to have this in Rel-18 while we tried to have it in Rel-17 until the last minutes in RAN #92.

### 2 – Samsung R&D Institute UK

#### Comments to #3, #4 and #6:

For Rel-18 RAN4 package approval timeline, we support proposal 1 from RWS-210375 (Intel). RAN4 Rel-17 completion date has one quarter shift compared to other WGs i.e. March 2022 for core part and performance part as September 2022. Given this, we can only start RAN4 Rel-18 WIs earliest from Q2 2022 except some urgency spectrum related WIs.

It's unclear what is "new" and what is "old". Most of proposals have been discussed/proposed in the past either in WG level or in RAN plenary level, and some of them were decided to be precluded in Rel-17 timeframe due to limited TU capability in RAN4. Also some Rel-17 "left-over"/"continued" topics are expected to be proposed from on-going Rel-17 WIs i.e. RRM enhancement, performance enhancement and FR2 HST WIs. The scope of these proposals are largely depends on the progress in Rel-17.

We proposed to have below timeline for RAN4 package approval:

- 1) Some urgent spectrum WIs can be approved in Dec 2021;
- 2) All others should be approved in March 2022 as a whole package considering the overall RAN4 work-load and TU capacity.
- 3) In August Rel-18 Email discussion phase, we should focus on RAN4 TU budget assessment.

Regarding RAN4 Rel-18 TU assessment, some observations with experience from previous releases are provided:

- 1) The work for most of other WG led WIs pending on the progress on other WGs, RAN4 only can trigger efficient discussion after the specified feature is stable enough.
- 2) Heavy work load for both RAN4 leading and other WG leading WIs in the last two quarters of the release

We proposed:

- 1) Stagger the TU assignment for RAN4 led and other WGs' led proposals in different stage of the release i.e.
  - a) Early stage (first 2 quarter): focused on Legacy release maintenance and RAN4 lead proposals with the target of completing RAN4 led WIs 2 quarter before the completion of release. Incoming LS from other WG for other WG led proposals can be handled as usual.
  - b) Later stage (last 2 quarter): focused on other WGs led proposals.