**RAN-R18-WS-eMBB-Samsung - Version 0.0.6**
**RAN**

**3GPP TSG RAN Rel-18 workshop** **RWS-210541**

**Electronic Meeting, June 28 - July 2, 2021**

**Agenda Item: 4.1**

**Source: Samsung**

**Title: Email discussion summary for [RAN-R18-WS-eMBB-Samsung]**

# 1 Introduction

This NWM document is intended to capture the comments and questions from interested companies on the proposals from Samsung for eMBB in 5G-Advanced. According to the guideline from the RAN chair, the following timeline is to be followed.

Round 1 Q&A: Questions: June 14 08:00 UTC – June 17 8:00 UTC; Answers: June 17 8:00 UTC – June 18 23:59 UTC

Round 2 Q&A: Questions: June 21 08:00 UTC – June 23 8:00 UTC; Answers: June 23 8:00 UTC – June 24 18:00 UTC

Before June 25 18:00 UTC, email discussion summary is to be uploaded

## 1.1 Related documents

This email discussion summary covers the following documents:

- RWS-210180 XDD (cross-division duplex) for enhanced duplexing operation in 5G Advanced

- RWS-210181 On Rel-18 NR MIMO enhancements for 5G Advanced

- RWS-210182 High-speed Packetization for 5G Advanced

- RWS-210183 Multi-RAT Multi-connectivity (MR-MC) for 5G Advanced

# 2 Technical items to be discussed

## 2.1 XDD (Cross-Division Duplex) in RWS-210180

XDD is an advanced duplexing scheme that enables simultaneous downlink and uplink operation within a TDD carrier (FR1) or among adjacent carriers (FR2).

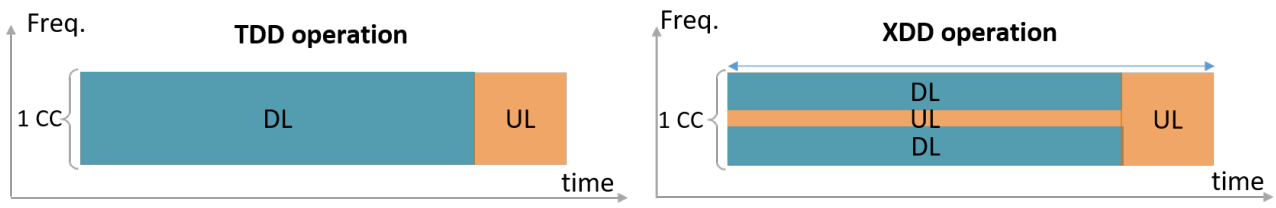


**Figure 1: XDD operation in FR1 (compared to TDD)**

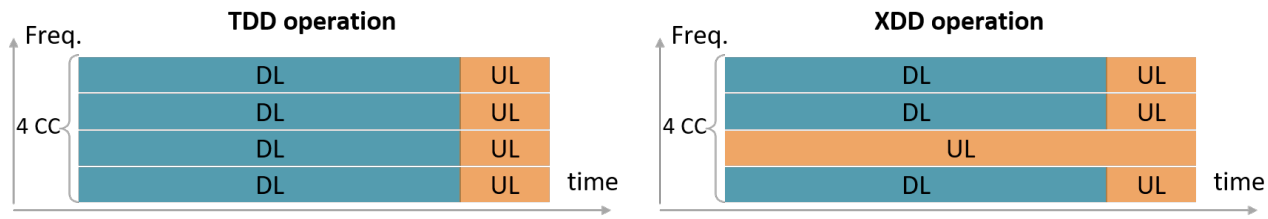


**Figure 2: XDD operation in FR2**

Key benefits of XDD are:

- Coverage extension

- Uplink capacity enhancement

- Latency reduction

## 2.2 NR-MIMO enhancement in RWS-210181

NR-MIMO enhancement for Rel-18 focuses on expanding multi-antenna benefits to the lower FR1 spectrum (such as 700 MHz) with distributed MIMO (D-MIMO), continuing the multi-beam/multi-TRP operation and CSI enhancement.

Enabling new use cases and deployment scenarios

- FR1: high throughput for sub-1GHz regime

- FR2: 60GHz regime, high-speed, asymmetric DL-UL (e.g. UL dense deployment)

Extending features introduced in Rel-16/17

- Unified TCI framework: better support for multi-TRP and MP-UE

- Inter-cell beam management to facilitate L1/L2-centric inter-cell mobility: including higher-layer RAN2/3 enhancements

- FeType-II codebook with Doppler-domain (DD) compression in addition to SD+FD

## 2.3 HSP (High Speed Packetization) in RWS-210182

Although the NR data structure was designed to support fast data processing, several aspects need to be further considered:

- The L2 headers are added to each PDCP SDU, which incurs a tremendous number of L2 headers to be processed at a high data rate, e.g. 1.6 million of L2 headers at 20Gbps.

- The User Plane Integrity Protection (UPIP) adopted from Rel 16 onward would result in significant performance degradation on data processing.

- The data processing capacity of HWA is not fully utilized, i.e. to process only 1500 byte with the capacity of 9000 byte.

## 2.4 MR-MC (Multi-RAT Multi-Connectivity) in RWS-210183

NR supports Dual-Connectivity (DC) and Carrier Aggregation (CA), however, DC supports only two independent scheduling entities connected with the non-ideal interface. In addition, within a single scheduling entity (i.e. Carrier Aggregation), all the cells are connected with the ideal interface.

Multi-RAT Multi-Connectivity (MR-MC) aims to break the limitation of co-located deployment of scheduling entity and using an ideal interface for peak throughput, and further reduce interruption. We proposed to support triple connectivity with at most two active uplink cells and SN mobility enhancements.

# 3 General comments (if any)

Please use section 3 to provide any general comments on the proposals from Samsung on eMBB evolution for 5G-Advanced (XDD, NR-MIMO, high-speed packetization, and Multi-RAT Multi-Connectivity).

**Feedback Form 1: General comments (if any)**

**1 – Sony Corporation**

NR-MIMO:

Regarding the features introduced in Rel.17 but not fully complete due to limited TU, we feel the same way to extend those (i.e. unified TCI state to multi-TRP and scenario 2 defined by RAN2 for L1/L2 inter-cell mobility) into Rel.18.

**Feedback Form 2: Reply for general comment**

# 4 Q&A on XDD (RWS-210180)

## 4.1 Round 1 Question

**Feedback Form 3: QA on XDD (RWS-210180)**

**1 – CATT**

Thanks for the contribution and we have following questions for clarification:

Q1: On page 5, simultaneous Tx and Rx can be performed within a TDD carrier for FR1, but for FR2, it is in adjacent carriers? Why would FR1 and FR2 behave differently?

Q2: NR has already supported cross-link interference measurement such as CLI-RSSI since Rel-16. What additional specification support is needed to enable XDD?

**2 – vivo Communication Technology**

Thanks for the nice proposal. We generally agree with Samsung that sub-band Full duplex at gNB side (i.e. XDD) is beneficial and more importantly, more practical for Rel-18 to consider, especially considering the cross-link interference in adjacent channel. And we have folloiwng questions for clarification:

1. We wonder what is Samsung's view on the UE impact due to XDD, does it require potential more stringent UE RF requirement to handle the intra-cell UE-to-UE interference? From our perspective, it would be very important to avoid UE hardware change for the full duplex in Rel-18.

2. For the frequency domain partition of DL and UL in XDD, do you think semi-static partition is sufficient, or do we need dynamic partition?

3. In P5, for FR2, why inter-carrier XDD is considered, instead of intra-carrier XDD as in FR1?

**3 – Lenovo (Beijing) Ltd**

Thanks Samsung for the nice contribution for FD.

It seems that the proposal is to have XDD being supported in gNB side only, instead of supported in both gNB and UE side? Maybe good to clarify a bit.

FR1 and FR2 have different behavior as in page 5, what is the motivation here?

Besides XDD, whether FD (maybe in gNB only) can be supported in Rel.18 depends very much on RAN4 evaluations. Will you be open to let RAN4 to study the feasibility of FD in Rel.18?

**4 – China Telecommunications**

Thank you for the proposal. We also have interests in duplex enhancement aspects. We have the following questions for clarification:

1) NR already supports flexible symbols in which the transmission direction can be determined by dynamic scheduling. Can it be implemented by gNB scheduling simultaneous non-overlapping UL DL in a carrier for different UEs or some specification change is necessary from the UL DL configuration perspective?

2) Does it require some guard PRBs between the simultaneous UL and DL in a carrier?

3) In page 6, CLI handling is feasible for XDD since UL and DL can use non-overlapping frequency resources. Does it mean the UL DL resource pattern should be the same for different cells?

We think flexible duplex is also necessary for FDD spectrum to adapt the traffic with asymmetric DL UL, how do you think about FDD spectrum?

**5 – Guangdong OPPO Mobile Telecom.**

Thanks for the contribution. Here are some comments for our side.

1. The scope and precedure seems reasonable, e.g., prioritizing XDD over the full duplex. Additionally, we would like to emphaize the following two aspects

a: No impact on UE RF and demodulation requirement is assumed in this study

b: No new XDD mode from UE point of view shall be assumed

2. the target frequency bands should also be included

3. Impact of XDD on legacy UE should also be studied

**6 – MediaTek Inc.**

Q1: Can you confirm that XDD does not imply simultaneous Tx/Rx capability for UEs?

Q2: What is the impact of XDD onto NR legacy terminals from R15/16/17 due to UE-UE CLI? How can these terminals be protected from UE-UE CLI? Legacy UEs cannot implement any CLI mitigation techniques or CLI-related measurements.

Q3: What is the impact on legacy gNB because of gNB-gNB CLI?

Q4: Is there any expected RF specification tightening for future R18 Half Duplex UEs (ACLR, ACS, in-band blocking, etc) to operate in a XDD-capable gNB?

Q5: Is there a significant power consumption impact onto XDD-capable gNBs?

Q6: Is there any significant difference between FR1 and FR2 to minimise UE-UE CLI and gNB-gNB CLI.

Q7: A huge amount of effort will be needed in RAN4, which is already overloaded. Should the RAN4 effort be prioritised on FR2 over FR1?

Q8: Compared to Rel-16 CLI, what's the additional enhancement needed for inter-UE CLI mitigation?

**7 – Spreadtrum Communications**

Thank Samsung for this quality contribution. We are open to discuss XDD in Rel-18. Below please find two initial questions for clarification (and maybe more questions later.):
Q1: To reduce inter-operator adjacent carrier interference, it is proposed to place UL subband in middle of BW for FR1 and DL subband can act as a guardband. From our understanding, the SI may study how much guardband is needed between DL subbands and UL subband. Whether this work should be done per XDD band in RAN4? And how much RAN4 workload do you estimate for this SI?
Q2: For FR1 and FR2, different XDD schemes are proposed, i.e. intra-carrier XDD for FR1 and inter-carrier XDD for FR2. What is the difference of the two schemes from the implementation perspective for both gNB and UE?

**8 – LG Uplus**

We have the same view and intention. In appropriate time manner, we think it should be prioritized and standardized within Rel-18. Could you share the standardization plan?

**9 – China Unicom**

Thanks for this contribution on XDD. We are also interested in XDD as well as full duplex(FD). There are some difference btw XDD and FD and some common issues need to be solved during the study in R18.

Q1: What is the requirements for new UE if support XDD? How to accommodate the legacy UE in the same band if spectrum is sharing for XDD UE and legacy UE?

Q2: What is the potential impacts on gNB and network deployment to support flexible configurations for XDD pattern or FD?

**10 – Futurewei Technologies**

FUTUREWEI considers full duplex is an interesting topic that deserves RAN1 attention and a very careful study and agrees with you that is more challenging than XDD. We would like to know if Samsung has any preliminary result or estimation regarding the performance gain with respect to state of art and /or performance loss of XDD with respect of full duplex. Please take a look at our contribution RWS-210036 (https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_AHs/2021_06_RAN_Rel18_WS/Docs/RWS-210036.zip) and feel free to comment at: https://nwm-trial.etsi.org/#/documents/4580

**11 – InterDigital Communications**

Thanks for the proposals on XDD. We are also supportive that the XDD is included in Rel-18 as a study item and it would be a good starting point to assume that gNB only has full-duplex capability so that the self-interference handling leaves up to gNB implementation.

Q1: regarding interference handling enhancement in the last slide as Rel-18 scope, what enhancement schemes you have in mind? Also, what type of interference is most problematic from your perspective among the self interference, cross link interference, and cross-operator interference?

Q2: in the given scenario (i.e., UE has half duplex as before), what standards impact is expected from UE behavior perspective? For example, even if the legacy UE could be supported in a network performing XDD operation?

**12 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Given that basic feasibility of FD at gNB needs to be determined by RAN4 as a first step, what is your view on managing the studies across RAN1 and RAN4? Specifically, under what assumptions should RAN1 proceed with for their study w/o information on isolation and self-, adjacent channel interference effects that would need RAN4 expertise?

Q2. How does the proposal to limit XDD to adjacent carriers for FR2 align with the idea of placing UL in the middle of a DL carrier for addressing inter-operator/vendor interference?

Q3. What is your view on applicability to bands @ lower frequencies vs. higher frequencies (if relying on spatial separation based isolation)?

Q4. With panel-separation/partition, this could impact both DL and UL link performance due to partitioning of antenna panels/elements. Has this been considered in the evaluations for UL as well?

Q5. For XDD, given that this is not exactly same as pure ”FDM” and would require proper filtering, what is your view on need for guard bands between DL and UL within a CC?

Q6. For slide 6 claiming feasibility from perspective of CLI handling for XDD, does this hold for inter-cell considerations, i.e., without network coordination? And if coordination is assumed, is there a fundamental difference in this regard compared to dynamic TDD?

**13 – Verizon UK Ltd**

Thanks for the proposal. We have been searching for ways to further (potentially significantly) improve capacity and this seems to be a very promising direction. Like many other companies mentioned already, we are interested in more details and especially how it interacts with other NW functionalities, like RIM, CLI etc. We are looking forward some great findings.

**14 – Nokia Corporation**

What kind of performance impacts especially in DL performance do you foresee if UEs do not support XDD? How about handling and DL performance of legacy UEs?

We share your view that for XDD studies It is important to have RAN4 included from the start of such studies.

In our view this type of SI should also include fundamental BS-2-BS CLI for traditional TDD cases to enable better support for UL heavy configurations.

**15 – KT Corp.**

Uplink coverage enhancement is the most urgent feature needs some improvement in commercial 5G network. This seems to be very good approach of overcoming UL/DL coverage different issue. KT strongly support this item to be included in Rel-18 package.

**16 – KDDI Corporation**

Thank you for the good contribution. We are almost the same understandings on the motivation and the duplex operation scenario especially about FR1. In addition to this, we have the similar view about schedule to standardize XDD (SI and WI) in Rel-18.

**17 – Xiaomi Communications**

Thanks for this contribution on XDD. We are also interested in XDD. There are some difference between XDD and FD and some common issues need to be solved during the study in R18.

## 4.2 Round 1 Answer

**Feedback Form 4: Reply for round 1 Question**

**1 – Samsung Electronics Co.**

**1 – CATT**

Thanks for the contribution and we have following questions for clarification:

Q1: On page 5, simultaneous Tx and Rx can be performed within a TDD carrier for FR1, but for FR2, it is in adjacent carriers? Why would FR1 and FR2 behave differently?

Thanks CATT for your questions.

**A1: scenarios shown in slide 5 is our thinking about promising scenarios for FR1 and FR2. XDD itself can be applied inter and intra-carrier. However, since operators typically have multiple adjacent carriers in FR2, we think inter-carrier operation for XDD is more reasonable. So, XDD can behave same regardless of FR.**

**2 – Samsung Electronics Co.**

Reply to CATT #2

Q2: NR has already supported cross-link interference measurement such as CLI-RSSI since Rel-16. What additional specification support is needed to enable XDD?

**A2: Rel-16 CLI support L3 based measurement with periodic resource. This might be enhanced L1/L2 based with aperiodic resources for enhancement, if needed.**

**3 – Samsung Electronics Co.**

**2 – vivo Communication Technology**

Thanks for the nice proposal. We generally agree with Samsung that sub-band Full duplex at gNB side (i.e. XDD) is beneficial and more importantly, more practical for Rel-18 to consider, especially considering the cross-link interference in adjacent channel. And we have following questions for clarification:

1. We wonder what is Samsung's view on the UE impact due to XDD, does it require potential more stringent UE RF requirement to handle the intra-cell UE-to-UE interference? From our perspective, it would be very important to avoid UE hardware change for the full duplex in Rel-18.

**Thanks vivo for supporting XDD proposal.**

**A1: We also think UE hardware change should be avoided if XDD is specified in Rel-18. At this moment, we do not have clear motivation for RAN4 impact but can be studied in Rel-18.**

2. For the frequency domain partition of DL and UL in XDD, do you think semi-static partition is sufficient, or do we need dynamic partition?

**A2: Both approach is possible directions for XDD operation. Envision to the enhancement of duplex scheme, we can firstly focus on semi-static and move forward to dynamic.**

3. In P5, for FR2, why inter-carrier XDD is considered, instead of intra-carrier XDD as in FR1?

**A3: scenarios shown in slide 5 is our thinking about promising scenarios for FR1 and FR2. XDD itself can be applied inter and intra-carrier. However, since operators typically have multiple adjacent carriers in FR2, we think inter-carrier operation for XDD is more reasonable.**

**4 – Samsung Electronics Co.**

**3 – Lenovo (Beijing) Ltd**

Thanks Samsung for the nice contribution for FD.

It seems that the proposal is to have XDD being supported in gNB side only, instead of supported in both gNB and UE side? Maybe good to clarify a bit.

FR1 and FR2 have different behavior as in page 5, what is the motivation here?

Besides XDD, whether FD (maybe in gNB only) can be supported in Rel.18 depends very much on RAN4 evaluations. Will you be open to let RAN4 to study the feasibility of FD in Rel.18?

**Thanks Lenovo for your questions: yes we think no FD is considered for UE side. In addition, scenarios shown in slide 5 is our thinking about promising scenarios for FR1 and FR2. XDD itself can be applied inter and intra-carrier. However, since operators typically have multiple adjacent carriers in FR2, we think inter-carrier operation for XDD is more reasonable. So, XDD can behave same regardless of FR.**

**Regarding FD, we also see some benefit in specific scenarios but not for typical access link, if RAN4 TU allows, study FD might be good for preparing the next step of XDD for future release.**

**5 – Samsung Electronics Co.**

**4 – China Telecommunications**

Thank you for the proposal. We also have interests in duplex enhancement aspects. We have the following questions for clarification:

1) NR already supports flexible symbols in which the transmission direction can be determined by dynamic scheduling. Can it be implemented by gNB scheduling simultaneous non-overlapping UL DL in a carrier for different UEs or some specification change is necessary from the UL DL configuration perspective?

**Thanks China telecom for your questions:**

**A1: Yes, we are agree that UE-specific dynamic TDD is allowed in NR. However, there is some limitation for using XDD without spec support. For example, pure DL and pure UL resources limits the benefits of XDD in terms of coverage/capacity/latency.**

2) Does it require some guard PRBs between the simultaneous UL and DL in a carrier?

**A2: It depends on implementation of SIC at the gNB. However, we think there is implementation options without using guard-band and we think the benefit of XDD will increase more with such implementation.**

3) In page 6, CLI handling is feasible for XDD since UL and DL can use non-overlapping frequency resources.

Does it mean the UL DL resource pattern should be the same for different cells?

We think flexible duplex is also necessary for FDD spectrum to adapt the traffic with asymmetric DL UL, how do you think about FDD spectrum?

**A3: Regarding UL/DL resource pattern, in practical deployment, it is not easy to have different pattern between cells. Also, flexible duplex in FDD, this will be DL transmission in UL band of FDD spectrum. We think this approach can help DL performance but there are some difficulties for this approach: e.g., regulation not allow DL TX in UL band, inter-operator cross-link interference is more severe in FDD spectrum.**

**6 – Samsung Electronics Co.**

**5 – Guangdong OPPO Mobile Telecom.**

Thanks for the contribution. Here are some comments for our side.

1. The scope and procedure seems reasonable, e.g., prioritizing XDD over the full duplex. Additionally, we would like to emphasize the following two aspects

a: No impact on UE RF and demodulation requirement is assumed in this study

b: No new XDD mode from UE point of view shall be assumed

2. the target frequency bands should also be included

3. Impact of XDD on legacy UE should also be studied

**Thanks OPPO for your comments on XDD: We also think we should support legacy UE even XDD gNB is deployed and should minimize UE impact in Rel.18.**

**RAN4 shall further evaluate the UE RF requirements by leveraging the co-existence study for CLI in Rel-16 in which UE ACLR/ACS is concluded to be unchanged. Also, the other requirements like in-band emission can be also evaluated by certainly deployment scenario (as in slide 5) shall be considered to minimize or avoid the impact to UE hardware changes.**

**Regarding new XDD mode, we are clear about what aspect are you assumed. If you clarify more, this can be replied in the 2nd round.**

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**7 – Samsung Electronics Co.**

**6 – MediaTek Inc.**

Q1: Can you confirm that XDD does not imply simultaneous Tx/Rx capability for UEs?

**Thanks MedioTek for your questions**

**A1: Yes, we confirm that no TX/RX capability in UE.**

Q2: What is the impact of XDD onto NR legacy terminals from R15/16/17 due to UE-UE CLI? How can these terminals be protected from UE-UE CLI? Legacy UEs cannot implement any CLI mitigation techniques or CLI-related measurements.

**A2: If UE does not support CLI measurement, the one of possible options for support XDD with legacy UEs is to rely on implementation based: e.g., RSRP based inter/outer UE grouping.**

Q3: What is the impact on legacy gNB because of gNB-gNB CLI?

**A3: For legacy gNB, it does not change gNB-gNB interference when XDD support same DL ratio between legacy gNB.**

Q4: Is there any expected RF specification tightening for future R18 Half Duplex UEs (ACLR, ACS, in-band blocking, etc) to operate in a XDD-capable gNB?

**A4: Even though we did not expect RF spec tightening, RF impact shall be evaluated in RAN4. Rel-16 co-existence study for CLI can be leveraged in RAN4 evaluation on ACLR and ACS. At least narrow-band blocking and in-band emission are not of immediate concern for XDD due to deployment considerations**

Q5: Is there a significant power consumption impact onto XDD-capable gNBs?

**A5: No, we think that XDD does not require additional power consumption at least for RF part and might increase baseband part for digital cancellation, but not significant.**

Q6: Is there any significant difference between FR1 and FR2 to minimise UE-UE CLI and gNB-gNB CLI.

**A6: We believe there will be no significant difference.**

Q7: A huge amount of effort will be needed in RAN4, which is already overloaded. Should the RAN4 effort be prioritised on FR2 over FR1?

**A7: We also agree that FR1 is our highest priority. Also, for RAN4 workload in Rel-18, we think the overloaded situation shall be improved comparing with Rel-17. We are open to deprioritize FR2 in RAN4 study if workload is concern.**

Q8: Compared to Rel-16 CLI, what's the additional enhancement needed for inter-UE CLI mitigation?

**A8: Rel-16 CLI support L3 based measurement with periodic resource. This might be enhanced L1/L2 based with aperiodic resources for enhancement, if needed.**

**8 – Samsung Electronics Co.**

**7 – Spreadtrum Communications**

Thank Samsung for this quality contribution. We are open to discuss XDD in Rel-18. Below please find two initial questions for clarification (and maybe more questions later.):

Q1: To reduce inter-operator adjacent carrier interference, it is proposed to place UL subband in middle of BW for FR1 and DL subband can act as a guardband. From our understanding, the SI may study how much guardband is needed between DL subbands and UL subband. Whether this work should be done per XDD band in RAN4? And how much RAN4 workload do you estimate for this SI? Thanks for your questions, see our response.

**A1: Yes, XDD work will be done for both RAN1 and RAN4 and such RAN4 input will be needed for XDD study.**

Q2: For FR1 and FR2, different XDD schemes are proposed, i.e. intra-carrier XDD for FR1 and intercarrier XDD for FR2. What is the difference of the two schemes from the implementation perspective for both gNB and UE?

**A2: Scenarios shown in slide 5 is our thinking about promising scenarios for FR1 and FR2. XDD itself can be applied inter and intra-carrier. However, since operators typically have multiple adjacent carriers in FR2, we think inter-carrier operation for XDD is more reasonable. So, XDD can behave same regardless of FR.**

**9 – Samsung Electronics Co.**

**8 – LG Uplus**

We have the same view and intention. In appropriate time manner, we think it should be prioritized and standardized within Rel-18. Could you share the standardization plan?

**Thanks LG Uplus for sharing view and support.**

**As we mentioned in out Tdoc, our priority is to use XDD at gNB only and do not consider UE side full duplex operation. In Rel-18, we propose to start SI and follow-up WI. Also, we can enhance more advanced features e.g., FD in future release.**

**10 – Samsung Electronics Co.**

**9 – China Unicom**

Thanks for this contribution on XDD. We are also interested in XDD as well as full duplex(FD). There are some difference btw XDD and FD and some common issues need to be solved during the study in R18.

Q1: What is the requirements for new UE if support XDD? How to accommodate the legacy UE in the same band if spectrum is sharing for XDD UE and legacy UE?

Thanks China Uniform for your interest for XDD.

**A1: The main difference will be whether UE knows subband DL/UL resource configuration or not. XDD UE will know this information but legacy will not. For handling legacy UE with XDD gNB, the one of possible options to rely on implementation based: e.g., RSRP based inter/outer UE grouping.**

Q2: What is the potential impacts on gNB and network deployment to support flexible configurations for XDD pattern or FD?

**A2: Due to cross-link interference between operators and other, it is not easy to have FD configuration in the access link, however, since XDD can place UL subband in the middle, such limitation is not needed but might align UL subband to avoid such interference.**

**11 – Samsung Electronics Co.**

**10 – Futurewei Technologies**

FUTUREWEI considers full duplex is an interesting topic that deserves RAN1 attention and a very careful study and agrees with you that is more challenging than XDD. We would like to know if Samsung has any preliminary result or estimation regarding the performance gain with respect to state of art and /or performance loss of XDD with respect of full duplex. Please take a look at our contribution RWS-210036 and feel free to comment on NWM.

**Thanks Futurewei for your comment. In our internal study, there will be no clear solution to handle cross-link interference (inter-gNB, and inter-operator) for FD. We will look at your contribution and will give feedback in the next round.**

**12 – Samsung Electronics Co.**

**11 – InterDigital Communications**

Thanks for the proposals on XDD. We are also supportive that the XDD is included in Rel-18 as a study item and it would be a good starting point to assume that gNB only has full-duplex capability so that the self-interference handling leaves up to gNB implementation.

Q1: regarding interference handling enhancement in the last slide as Rel-18 scope, what enhancement schemes you have in mind? Also, what type of interference is most problematic from your perspective among the self interference, cross link interference, and cross-operator interference?

**Thanks IDC for support XDD study.**

**A1: Among various interference, self-interference can be handled by implantation and cross-operator interference can be handled by placing UL subband in the middle. However, for cross-link interference, we can use CLI measurement but since Rel-16 CLI support L3 based measurement with periodic resource. This might be enhanced L1/L2 based with aperiodic resources for enhancement, if needed.**

Q2: in the given scenario (i.e., UE has half duplex as before), what standards impact is expected from UE behavior perspective? For example, even if the legacy UE could be supported in a network performing XDD operation?

**A2: The main difference will be whether UE knows subband DL/UL resource configuration or not. XDD UE will know this information but legacy will not. For handling legacy UE with XDD gNB, the one of possible options to rely on implementation based e.g., RSRP based inter/outer UE grouping but will have limitation for benefit of XDD due to fixed DL and UL resources.**

**13 – Samsung Electronics Co.**

**12 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Given that basic feasibility of FD at gNB needs to be determined by RAN4 as a first step, what is your view on managing the studies across RAN1 and RAN4? Specifically, under what assumptions should

RAN1 proceed with for their study w/o information on isolation and self-, adjacent channel interference effects that would need RAN4 expertise?

**Thanks Intel for your questions**

**A1: We agree that there should be both RAN1 and RAN4 study for XDD. We expect some parallel and tight work is needed between RAN1 and 4 sharing views on self-interference and other aspect.**

Q2. How does the proposal to limit XDD to adjacent carriers for FR2 align with the idea of placing UL in the middle of a DL carrier for addressing inter-operator/vendor interference?

**A2: For FR2, there will be multiple carriers per operator and if we place UL heavy carrier in the middle, other DL carriers act guard-band between UL carrier in one operator and DL carries in the other operator.**

Q3. What is your view on applicability to bands @ lower frequencies vs. higher frequencies (if relying on spatial separation based isolation)?

**A3: We think that both FR1 and FR2 can enjoy benefit of XDD. In FR2, we can rely on better spatial-domain isolation than FR1 but has drawback due to high ACLR than FR1.**

Q4. With panel-separation/partition, this could impact both DL and UL link performance due to partitioning of antenna panels/elements. Has this been considered in the evaluations for UL as well?

**A4: Consider 4:1 TDD configuration, UL transmission can be 5 times more with XDD, if we divide panel for support DL and UL simultaneously, RX antenna gain will have 3dB reduction but still enjoy UL resource for latency improvement.**

Q5. For XDD, given that this is not exactly same as pure ”FDM” and would require proper filtering, what is your view on need for guard bands between DL and UL within a CC?

**A5: It depends on implementation of SIC at the gNB. However, we think there is implementation options without using guard-band and we think the benefit of XDD will increase more with such implementation.**

Q6. For slide 6 claiming feasibility from perspective of CLI handling for XDD, does this hold for inter-cell considerations, i.e., without network coordination? And if coordination is assumed, is there a fundamental difference in this regard compared to dynamic TDD?

**A6: What we mentioned in slide 6 is the possibility to use Rel-16 CLI as intra-CLI measurement. Between XDD and dynamic TDD, the difference would be CLI of adjacent subband in XDD (same subband for dynamic TDD). For inter-cell case, XDD can be applied having same UL subband between cells.**

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**14 – Samsung Electronics Co.**

**13 – Verizon UK Ltd**

Thanks for the proposal. We have been searching for ways to further (potentially significantly) improve capacity and this seems to be a very promising direction. Like many other companies mentioned already, we are interested in more details and especially how it interacts with other NW functionalities, like RIM, CLI etc. We are looking forward some great findings.

**Thanks Verizon for your interest on XDD. We think that XDD can enjoy both coverage and capacity (throughout with latency reduction) depending of deployment requirements and scenarios. In addition, we also think there might be some enhancement is needed for RIM and/or CLI for better inference measurement in the future. However, we are trying to have XDD as minimum changes as possible.**

**15 – Samsung Electronics Co.**

**14 – Nokia Corporation**

What kind of performance impacts especially in DL performance do you foresee if UEs do not support XDD? How about handling and DL performance of legacy UEs?

We share your view that for XDD studies It is important to have RAN4 included from the start of such studies.

In our view this type of SI should also include fundamental BS-2-BS CLI for traditional TDD cases to enable better support for UL heavy configurations.

**Thanks Nokia for your questions**

**For legacy UE, DL performance can be maintained depending on implementation of XDD gNB. For example, scheduler can TDMed legacy UE and XDD UE so that the legacy UE will have same performance as before. If XDD gNB can support simultaneous TX and RX by separating panels (ports) in same slot, antenna gain will reduce in those slot.**

**We agree that there should be both RAN1 and RAN4 study for XDD. We expect some parallel and tight work is needed between RAN1 and 4 sharing views on self-interference and other aspect.**

**For gNB-to-gNB CLI, we think that by aligning UL subband between gNB, the problem will not be different from the conventional TDD.**

**16 – Samsung Electronics Co.**

**15 – KT Corp.**

Uplink coverage enhancement is the most urgent feature needs some improvement in commercial 5G network. This seems to be very good approach of overcoming UL/DL coverage different issue. KT strongly support this item to be included in Rel-18 package.

**Thanks KT for your interest about XDD and your strong support.**

**17 – Samsung Electronics Co.**

**16- KDDI Corporation**

Thank you for the good contribution. We are almost the same understandings on the motivation and the duplex operation scenario especially about FR1. In addition to this, we have the similar view about schedule to standardize XDD (SI and WI) in Rel-18.

**Thanks KDDI for sharing your view on XDD and support.**

**18 – Samsung Electronics Co.**

**17 - Xiaomi Communications**

Thanks for this contribution on XDD. We are also interested in XDD. There are some difference between XDD and FD and some common issues need to be solved during the study in R18.

**Thanks Xiaomi for sharing your view on XDD and FD. We think that FD have more challenges for handling various interferences than XDD.**

## 4.3 Round 2 Question

**Feedback Form 5:**

**1 – vivo Communication Technology**

Thanks for the reply. Regarding UE RF impact, we would rather prefer to make it clear that in Rel-18 XDD we do not consider more stringent UE RF requirement, we could rely on gNB scheduler to handle the intra-cell UE-to-UE interference.

**2 – Xiaomi Communications**

We have similar view as vivo's, tighter UE RF requirement should be avoided in R18 XDD.

**3 – Charter Communications**

Thanks for the contribution. Is the XDD format intended to be applied to all control/RS/data transmissions, or only to data channels?

**4 – VODAFONE Group Plc**

Thank you for the contribution, we are interested in techniques that can overall increase the uplink capacity and coverage.

Regarding the deployment, what would the impacts be in terms of gNB and UE implementation? What are the impacts on the legacy duplexing schemes, meaning interference between a XDD cell and FDD/TDD cell?

**5 – Guangdong OPPO Mobile Telecom.**

Thanks for your reply. One more question: For "Explicit feedback" of eigenvectors (non-ULA array geometry), what is the application scenarios in mind?

**6 – Verizon UK Ltd**

Thanks for the proposal. We think that this is one of the major remaining areas to explore to improve 5G capacity universally. There are many questions need to be answered but this is an important first step in the path towards full Tx/Rx duplex. At this point, like many other companies, we are most curious about the UE/gNB impact, especially HW/RF impact if any. Is this a tradeoff of performance vs. (intelligence) complexity or vs. more stringent HW/RF requirement.

**7 – China Unicom**

In your response, "XDD can place UL subband in the middle" does this mean when using XDD, adjacent gNB should only apply XDD in the middle subband and the other part of band should use the same frame structure?

**8 – LG Electronics Inc.**

Thanks for good discussion and good suggestion. We also have interest in full duplex operation. We are thinking that full duplex operation for unpaired spectrum can provide benefits such as latency reduction and system resource utilization improvement as explained in the paper. In addition, when full duplex is applied, we may expect further uplink coverage enhancement due to more occasion for UL.

Q1) In Rel-17, specification work for coverage enhancement is ongoing. Do you think what is different point/work scope between coverage enhancement in Rel-17 and coverage enhancement by full duplex.

We have three more questions.
Q2) Regarding the feasibility of full duplex operation, do you have an idea to determine whether full duplex operation is feasible or not.

Q3) If XDD is introduced, we may expect band emission is reduced. For more reduction, subband-filter can be adopted. Do you consider to adopt subband-filter for operating XDD?

Q4) For XDD, do you consider static frequency resource partitioning or dynamic partitioning? And, do you expect how many resource blocks are required as guard frequency between frequency resources for DL and UL?

## 4.4 Round 2 Answer

**Feedback Form 6:**

**1 – Samsung Electronics Co.**

**vivo Communication Technology**

# 1

Thanks for the reply. Regarding UE RF impact, we would rather prefer to make it clear that in Rel-18 XDD we do not consider more stringent UE RF requirement, we could rely on gNB scheduler to handle the intra-cell UE-to-UE interference.

A: We agree vivo's view. Our intention is to use reuse the legacy UE and what we want to say is that such study might be needed in RAN4.

**2 – Samsung Electronics Co.**

**Xiaomi Communications**

# 2

We have similar view as vivo's, tighter UE RF requirement should be avoided in R18 XDD.

A: We agree your Xiaomi's view. Our intention is to use reuse the legacy UE and what we want to say is that such study might be needed in RAN4.

**3 – Samsung Electronics Co.**

**Charter Communications, Inc**

# 3

Thanks for the contribution. Is the XDD format intended to be applied to all control/RS/data transmissions, or only to data channels?

A: Yes, all signal/channels can be used in XDD operation.

**4 – Samsung Electronics Co.**

**VODAFONE Group Plc**

# 4

Thank you for the contribution, we are interested in techniques that can overall increase the uplink capacity and coverage.

Regarding the deployment, what would the impacts be in terms of gNB and UE implementation? What are the impacts on the legacy duplexing schemes, meaning interference between a XDD cell and FDD/TDD cell?

A: Thanks Vodofone for your interest, we believe that gNB should implement SIC capability but should be support the conventional UE operating half duplex. For interference handling, it's similar as TDD, XDD format should be aligned with neighboring cells if closed enough.

**5 – Samsung Electronics Co.**

**Guangdong OPPO Mobile Telecom.**

# 5

Thanks for your reply. One more question: For "Explicit feedback" of eigenvectors (non-ULA array geometry), what is the application scenarios in mind?

A: We think this question should be moved to MIMO.

**6 – Samsung Electronics Co.**

**Verizon UK Ltd**

# 6

Thanks for the proposal. We think that this is one of the major remaining areas to explore to improve 5G capacity universally. There are many questions need to be answered but this is an important first step in the path towards full Tx/Rx duplex. At this point, like many other companies, we are most curious about the UE/gNB impact, especially HW/RF impact if any. Is this a tradeoff of performance vs. (intelligence) complexity or vs. more stringent HW/RF requirement.

A: There should be RAN4 study about HW/RF impact for gNB and UE. From our point of view, while these questions should be evaluated as part of the RAN4 RF & coexistence study for XDD, we think it is very desirable that ACLR and ACS for R18 HD-UEs remain the same as R15. Regarding trade-off, it will depend on implementation but give requirement, performance should be guarantee with reasonable complexity.

**7 – Samsung Electronics Co.**

**China Unicom**

# 7

In your response, “XDD can place UL subband in the middle” does this mean when using XDD, adjacent gNB should only apply XDD in the middle subband and the other part of band should use the same frame structure?

A: Aligned UL subband can be useful for handling inter-gNB cross-link interference between cells.

**8 – Samsung Electronics Co.**

**LG Electronics Inc.**

# 8

Thanks for good discussion and good suggestion. We also have interest in full duplex operation. We are thinking that full duplex operation for unpaired spectrum can provide benefits such as latency reduction and system resource utilization improvement as explained in the paper. In addition, when full duplex is applied, we may expect further uplink coverage enhancement due to more occasion for UL.

Q1) In Rel-17, specification work for coverage enhancement is ongoing. Do you think what is different point/work scope between coverage enhancement in Rel-17 and coverage enhancement by full duplex.

A1) We think XDD is more focus on how to operate and the legacy coverage enhancement scheme can be used when UL subband is prepared.

We have three more questions.
Q2) Regarding the feasibility of full duplex operation, do you have an idea to determine whether full duplex operation is feasible or not.

Q2) Together with RAN4 study, RAN1 can evaluate as we have done in other items.

Q3) If XDD is introduced, we may expect band emission is reduced. For more reduction, subband-filter can be adopted. Do you consider to adopt subband-filter for operating XDD?

A3) Subband filter is not of option for implementation to avoid ADC saturation for RX path, we think there are other options without filter.

Q4) For XDD, do you consider static frequency resource partitioning or dynamic partitioning? And, do you expect how many resource blocks are required as guard frequency between frequency resources for DL and UL?

A4) As we mentioned in Q3, subband is not always used and both static and dynamic partitioning are possible options as we designed dynamic TDD in NR.

# 5 Q&A on NR-MIMO (RWS-210181)

## 5.1 Round 1 Question

**Feedback Form 7: QA on NR-MIMO (RWS-210181)**

**1 – LG Electronics Inc.**

For DL, distributed MIMO seems same as coherent joint mTRP transmission. Is this correct understanding? Could you clarify UL enhancements considered for distributed MIMO?

**2 – Apple Computer Trading Co. Ltd**

We have one question on one use case for FR2 about asymmetric DL-UL. Does it mean UE may use different DL/UL beams to communicate with network, e.g. UE may communicate with different TRPs in DL and UL?

In addition, we see another possible use case is high density of UEs. There would be more and more UEs in the network. But currently MIMO operation is like a UE-dedicated mode, where each UE can measure and report its CSI/beam indenpendantly. With high density of UEs, some group UEs based MIMO operation can be worse for a consideration with regard to overhead reduction and UE power saving.

**3 – Beijing Xiaomi Mobile Software**

- Q1: The study on distributed MIMO deployments with multiple RRH or Active Antenna modules needs more discussion. We are not clear about the scenario. Here what is the difference of multi-TRP and Multi-RRHs? Is the difference that Multi-TRP are co-located, while Multi-RRH are non co-located with ideal backhaul? And we are wondering how to realize modified eType-II with FD across RRHs. In my understanding, frequency domain resource can be reused among Multi-RRHs and there are different spatial parameters among Multi-RRHs.

- Q2: For asymmetric DL-UL, Could you please provide more information? We are wondering what is the difference between separate DL/UL TCI in Rel-17 and this enhancement?

- Q3: For 'FR2: Extend coverage-improving features developed in Rel-16 with Rel-17 unified TCI', does it mean the PDCCH/PUCCH repetition with unified TCI?

- Q4: For 'Facilitate multi-panel reception at the UE (especially FR2)', we want to clarify that what is the special issue compared to Rel-16/17?

**4 – ZTE Corporation**

Thanks so much for sharing this contribution. Please find our following comment(s) for clarification.

- On P2, is there any specific thought on PC aspects for UL TCI?
- On P3 and P4, distributed MIMO:

- Q1: Can the Rel-15/16/17 MTRP be used to solve the implementation need for the proposed distributed MIMO system? For example, for the codebook enhancement, isn't Rel-17 MTRP CSI or Rel-15 multi-panel codebook a good solution to address this?

- Q2: How many RRHs do you expect to cooperate for the proposed distributed MIMO transmission? A few (e.g., 2 or 4), or a large number (e.g., >20)?

- Q3: What is the major target scenario? Indoor or outdoor? SU-MIMO or MU-MIMO? Are there more than 12 users to be scheduled by all the RRHs? All RRHs serves all users or different RRH set serves different users?

- Q4: If the main target transmission scheme is coherent JT, typically it is hard to solve hardware misalignment issues for implementing coherent JT. How do you think about this?

- Q5: What's the typical distance between two RRHs in your mind? Is there ideal backhaul between CPU and RRH?

- On P6, in general, we prefer to handle Scenario-1 only by Rel-17, and then the Scenario-2 is led by RAN2 for Rel-18, e.g., as in mobility SID/WID. Regarding potential new L1/L2-triggered inter-cell mobility (HO), does it mean that CHO is introduced into L1-level. Any clarification is highly appreciated.
- On P8: We are not clear now about the justification on compressing CSI in time domain. The following are two questions from our side.

- Q1: Are there any initial evaluation results to justify the benefit of compressing high-resolution CSI in time domain? Is the channel sufficiently stable/correlated to be compressed in a large granularity of time?

- Q2: Further, the main benefit of high-resolution CSI is for MU scheduling. Is MU scheduling typical for high-speed UEs?

**5 – vivo Communication Technology**

1) On distributed MIMO, it is proposed new (interference) measurement for enabling dynamic RRH selection. Does it mean DPS type of operation is assumed?

2) On evaluation

CB1:eType-II per RRH, is it coherent JT scenario?

CB2: Modified eType-II (SD per RRH, FD across RRHs), how FD across RRHs is computed?

3) On inter-cell mobility, what is difference/benefit of inter DU compared to DAPS/CHO/MRDC?

**6 – NTT DOCOMO INC.**

Thank you very much for sharing the contribution. Please find some questions:

Q1) Asymmetric DL-UL (e.g. UL dense deployment):

We think possible enhancements are UL TPC, TA, UL beam management, etc. What enhancement do you have in mind?

Q2) DL distributed MIMO deployments:

We assume the proposal is coherent joint transmission (i.e. one MIMO layer is transmitted from multiples points). Do you mean "dynamic RRH selection" is that gNB can dynamically indicate the combination of RRHs (e.g. sometimes one MIMO layer is transmitted from RRH#1 and RRH#2, and on next time, one MIMO layer is transmitted from RRH#2 and RRH#3)?

Q3) Evaluation assumption:

On simulation result (p.4), MU-MIMO and Type II CSI are assumed. We assume this enhancement is beneficial even for SU-MIMO. Do you have any reason to consider MU-MIMO and Type II CSI? (i.e. Is this just an example, or do you intend MU-MIMO would be the main target on this scenario?)

**7 – Guangdong OPPO Mobile Telecom.**

Thanks for the contribution. Some questions from our side

**Q1:** Is there any model in mind for non-ideal factors on the backhal of the distributed MIMO?

**Q2:** The scope seems too large. Is there any preference on priority of issues?

**Q3:** For 5-d, does it mean that UE needs to transmit on one panel and Rx on another panel?

**8 – Beijing Lenovo Software Ltd.**

Q1: Extending features introduced in Rel-17

Do you want to re-design the mTRP operation specified in Rel-16/17 based on the R el-17 unified TCI framework? For example, multi-TRP PDCCH/PDSCH/PUSCH/PUCCH repetition by using unfied TCI framework and the related BFR procedure?

Q2: Distributed MIMO

1) Does more than one RRH can be selected in dynamic RRC selection mode? For example, dynamic RRH-pair selection by the UE for mTRP DL transmission.

2) Do you want to support simultaneous multi-panel UL transmission targetting multiple TRPs?

Q3: TRP/panel specific DL UL (TDD) configuration

Does it means that support full duplex operation in UE side?

**9 – Sony Corporation**

For distributed MIMO at lower FR1 spectrum, can we understand that multi-RRH represents multi-TRP? And does the extension of multi-TRP imply introducing more than 2 TRPs (RRHs), e.g. 4 or 8 TRPs in Rel.18? Due to nature of distributed RRHs, should UE be able to assume multiple QCL assumption/TCI states at FR1?

**10 – NEC Corporation**

We have a few questions on distributed MIMO.

a) What is the connection between enhancements on distributed MIMO and on Multi-TRP/panel? Should MTRP be a special case of distributed MIMO? And is it the intention that the enhancement will be based on Rel-17 MTRP framework?

b) Is this objective restricted for < 1GHz? Or it can be general for FR1?

c) On page 3, it is a bit confusing why there is coverage limitation for sub 1 GHz, is this compared to the coverage of e.g. C-band?

**11 – Fraunhofer IIS**

Thanks for your contribution. We have few questions with respect to your proposals.

Distributed MIMO:

Q1: What is the typical deployment scenario, distribution of RRHs and spacing between RRHs?

Q2: Is coherent joint transmission considered here? If yes, what are the requirements on synchronization between the RRHs?

Q3: Can the R15 type-I multi-panel CB be used in this deployment? If yes, how does your proposed codebook compares to the R15 type-I multi-panel CB in terms of performance and feedback overhead?

CSI codebook:

Doppler-domain compression:

We have a similar view with same motivation on Doppler-domain compression and support this proposal.

Explicit feedback:

Q4: Non-ULA array geometries is mentioned in the slides. What kind of array geometries do you have in mind? What are the deployment scenarios for non-ULA array geometries?

**12 – Motorola Mobility Germany GmbH**

[Lenovo, Motorola Mobility]: Questions on Advanced Beam-Management

- In slide 5, do you envision that only a group leader performs all beam measurements/reporting for scenario where multiple UEs have similar path/movement? We somewhat have similar thinking that independent CSI measurements and reporting for beam management is not efficient, especially for scenarios where the multiple UEs follow similar path. UE grouping for sharing beam measurements/reporting will be quite beneficial for overhead reduction, lower latency and power saving. We have also discussed this in our contribution RWS-210396.
- Do you consider predicting/indicating beams for future N time instances/slots in the middle figure that you have shown in slide 5?

**13 – Intel Corporation (UK) Ltd**

<Intel>

Q1. How the issue of non-ideal frequency synchronization between TRPs can be addressed by mTRP codebook design?

Q2. What is importance of enhancing MIMO <1GHz considering limited spectrum available at such frequency bands on overall limited impact in the final throughput

**14 – MediaTek Inc.**

C1. For enhanced separate DL/UL TCI, we see enhanced beam measurement/reporting for UL Tx beam may be also needed for the use cases identified in the slides.

C2. We also see ”group-based” beam update can be also considered to support more efficient L1/L2 mobility for some important use cases, e.g., HST.

Q1. For distributed MIMO, some elaboration is required for CB1 and CB2 as the descriptions are a bit vague. For example, for CB1, how does eType II applies to each RRH specifically?

Q2. What is the motivation of TRP/panel specific TDD configuration?

**15 – InterDigital Communications**

Thanks for the proposals. We are also supportive on MIMO enhancement in Rel-18 especially for the extension of unified TCI framework for M-TRP and MP-UE scenario. Few questions as following:

Q1. I see lots of new proposals as a scope in the slides. Do you have any priority order in the case we have a limited TU for MIMO WI in Rel-18?

Q2. for distributed MIMO, what is the assumption related to timing synchronization across distributed antenna/panels?

Q3. in the slide 7, TRP/panel-specific DL-UL configuration, inter-panel (self-) interference which is mainly from full duplex operation? If yes, is it for UE or gNB? What is standards impact you expect assuming that those cancellation could be part of UE/gNB implementation?

Q4. for the UL frequency selective precoding in slide 8, do you also expect UL codebook re-design/optimization or just simply reuse existing UL codebook?

**16 – Motorola Mobility UK Ltd.**

Thank you for the interesting contribution. My question is related to your proposal in the ***"Ultra HD CSI/codebook"*** section, which reads *"DL MIMO: Doppler-domain compression in addition to space- and frequency-domain (enhancement over Rel.16 eType-II)"*. Do you envision the Doppler-domain CSI compression enhancement as CSI measurement and reporting enhancements or only as a codebook enhancement?

**17 – Verizon UK Ltd**

Thanks for the excellent leadership in the area. Of distributed MIMO, one question we have is, does this allow us to adequately leverage our legacy systems in LTE with e.g., discrete 1/2/4 antennas, together with NR arrays of various forms? What level of synchronization is required? Can it seamlessly work together with the current NR MIMO?

**18 – Qualcomm communications-France**

Regarding "distributed MIMO deployments": Q1: What is the phase coherency assumption across different TRPs? Q2: For CB1 in the evaluations, is CJT assumed across TRPs? How the phase / precoding across the TRPs are determined? Q3: Regarding "UE-assisted calibration", can you elaborate a bit more? E.g. what type of calibration between TRPs is intended and UE's role for this purpose? Q4: Regarding "interference measurement to enable dynamic RRH selection", more clarifications would be helpful as to why existing CSI framework is not sufficient.

Q5: Regarding "multi-panel reception at UE", compared to Rel. 16 and 17 enhancements, which left-over aspect is in mind?

**19 – HuaWei Technologies Co.**

Thanks for the contribution, we have the following comments and questions:

1. On Page 3, for Distributed MIMO enhancement, is that only for 700M and RMa cases? The discussion is indeed similar as coherent joint transmission in M-TRP, which can be merged together.

2. On Page 4, in the evaluation, not sure why FD across RRHs can be work better than independent design as CB1, while the angle and delay information from different Panels/TRPs will be different?

3. On Page 8, what does ”Explicit feedback” means? Could you elaborate a little bit more?
4. On Page 5, what’s the meaning of ”Combination between DL mTRP and UL STxMP”?

**20 – AT&T**

Thanks for the contribution.

On goal 1.1: D-MIMO for sub 1GHz, can you comment more on the deployment scenarios you envision and the potential channel modeling needs? Can you also elaborate on the need and the procedure for UE-assisted calibration for the multi-RRH transmission? Will this be building on coherent JT mTRP?

**21 – Ericsson LM**

· We have a couple of clarification questions on slide 3 related to Distributed MIMO:

o Could you elaborate what is meant by UE-assisted calibration?

o What is the motivation for introducing ‘New (interference) measurement for enabling dynamic RRH selection’?

**22 – Nokia Corporation**

**Q1:** Have the gains of L1 mobility been verified, and how much gain does the L1 mobility bring over L3 mobility?

**Q2:** RRC is ciphered so L3 mobility is inherently secure, whereas GSMA has already warned about potential security problems with MAC CEs. How is the L1 mobility protected from malicious attacks to change the serving cell of many UEs?

**Q3:** Is it assumed there are no changes to RRM or L1 measurements due to L1 mobility (since none are mentioned)?

**Q4:** What kind of workload is envisioned for this work in Rel-18? And it is really true that there is no RAN4 impact (since this is not indicated)?

**Q5:** A plethora of MIMO features have been specified but never deployed in the past, due to e.g, complexity and power consumption. How can these proposed new MIMO features be made such that they can be more easily deployed (compared to what have already been defined but not deployed)?

**23 – China Unicom**

Thanks for the contribution, the following questions are listed for clarification:

Q1: What is the potential enhancement for FDD Massive MIMO?

Q2: For multi-TRP, considering the deployment scenario, how to support more than 2 TRPs for intra-cell and inter-cell scenarios in R18?

## 5.2 Round 1 Answer

**Feedback Form 8: Reply for round 1 Question**

**1 – Samsung Research America**

First, we would like to thank all the companies for their careful reviews and good questions. This process helps us to gauge interest and level of importance across companies on different topics.

**2 – Samsung Research America**

Response to LG

For DL, distributed MIMO seems same as coherent joint mTRP transmission. Is this correct understanding?

**Answer: While overlapping in some aspects, D-MIMO and mTRP are inherently different. On the DL side, D-MIMO is perhaps better implemented as a single TRP operation with antenna ports distributed across multiple locations. C-JT is possible but not necessary.**

Could you clarify UL enhancements considered for distributed MIMO?

**Answer: Since the cell size in low frequency band would be large, hence we can consider the corresponding required UL features as the UL enhancements, e.g., multiple TAs, power control including pathloss RS, etc. Also, if CSI enhancement for D-MIMO is considered, the corresponding enhanced CSI report can be also considered as an UL enhancement.**

**3 – Samsung Research America**

Response to Apple

We have one question on one use case for FR2 about asymmetric DL-UL. Does it mean UE may use different DL/UL beams to communicate with network, e.g. UE may communicate with different TRPs in DL and UL?

**Answer: Yes, UE may communicate with different TRPs in DL and UL, e.g. due to interference or power considerations.**

In addition, we see another possible use case is high density of UEs. There would be more and more UEs in the network. But currently MIMO operation is like a UE-dedicated mode, where each UE can measure and report its CSI/beam independently. With high density of UEs, some group UEs based MIMO operation can be worse for a consideration with regard to overhead reduction and UE power saving.

**Answer: This would be up to the network to decide. The network has the full picture about all UEs. But we tend to agree in such cases group-based measurement/reporting has some potential at least in terms of overhead reduction.**

**4 – Samsung Research America**

Response to Xiaomi

Q1: The study on distributed MIMO deployments with multiple RRH or Active Antenna modules needs more discussion. We are not clear about the scenario. Here what is the difference of multi-TRP and Multi-RRHs? Is the difference that Multi-TRP are co-located, while Multi-RRH are non co-located with ideal backhaul? And we are wondering how to realize modified eType-II with FD across RRHs. In my understanding, frequency domain resource can be reused among Multi-RRHs

and there are different spatial parameters among Multi-RRHs.

**Answer: please see our 1st response to LGE on D-MIMO vs mTRP discussion. In short, D-MIMO and mTRP are inherently different. The scenario is low frequency band wherein it is not possible to mount large number of antennae at one site due to large antenna form factor at these frequencies, hence, antennae need to be distributed at multiple sites (within a cell). And yes, ideal backhaul for D-MIMO may be reasonable since multiple RRHs can be connected to a common baseband processing unit. Re modified e-Type II, the W1 (SD basis) can be separate per RRH, and Wf can be obtained based on aggregated channel across RRHs (projected on respective W1).**

Q2: For asymmetric DL-UL, Could you please provide more information? We are wondering what is the difference between separate DL/UL TCI in Rel-17 and this enhancement?

**Answer: UE may communicate with different TRPs in DL and UL, e.g. due to interference or power considerations. This is one use case of separate DL/UL TCI.**

Q3: For 'FR2: Extend coverage-improving features developed in Rel-16 with Rel-17 unified TCI', does it mean the PDCCH/PUCCH repetition with unified TCI?

**Answer: Yes, one important use case of leveraging Rel. 17 unified TCI framework for Rel. 18 MTRP enhancements is the downlink/uplink control channel repetition for coverage improvement; we also see the need of PDSCH/PUSCH repetition with unified TCI framework. It is overall a natural extension.**

Q4: For 'Facilitate multi-panel reception at the UE (especially FR2)', we want to clarify that what is the special issue compared to Rel-16/17?

**Answer: We envision that there would be essential carry-over from Rel. 17 to facilitate multi-panel reception at the UE in Rel. 18 such as CMR/IMR configuration enhancements to facilitate channel/interference measurement/reporting and enhancements related to simultaneous reception of various RSs/channels.**

**5 – Samsung Research America**

Response to ZTE

Thanks so much for sharing this contribution. Please find our following comment(s) for clarification.

- On P2, is there any specific thought on PC aspects for UL TCI?

**Answer: In Rel-17 we have PC support for N=1 for the unified TCI framework. Rel-18 can include any leftovers, as well as support for N>1.**

- On P3 and P4, distributed MIMO:

Q1: Can the Rel-15/16/17 MTRP be used to solve the implementation need for the proposed distributed MIMO system? For example, for the codebook enhancement, isn't Rel-17 MTRP CSI or Rel-15 multi-panel codebook a good solution to address this?

**Answer: That mTRP schemes (so far geared toward NC-JT) and MP CB (designed for reasonably co-located panels with no-so-large inter-panel phase shift) can be readily used for D-MIMO is unclear. In addition, there is no high-resolution (Type-II) codebook for mTRP or MP yet.**

Q2: How many RRHs do you expect to cooperate for the proposed distributed MIMO transmission? A few (e.g., 2 or 4), or a large number (e.g., >20)?

**Answer: The number of RRHs depends on NW and cell size planning and antenna form factors. Perhaps, 4 or 8 are reasonable, and > 8 can also be studied.**

Q3: What is the major target scenario? Indoor or outdoor? SU-MIMO or MU-MIMO? Are there more than 12 users to be scheduled by all the RRHs? All RRHs serves all users or different RRH set serves different users?

**Answer: The main target scenario is outdoor and MU. The number of MU layers can be up to 12. And, all RRHs need not be used for MU scheduling.**

Q4: If the main target transmission scheme is coherent JT, typically it is hard to solve hardware misalignment issues for implementing coherent JT. How do you think about this?

**Answer: Please see 1st response to LG regarding C-JT vs D-MIMO. We don't see anything extra needed on "D-MIMO" if NC-JT is used. This assumes DL.**

Q5: What's the typical distance between two RRHs in your mind? Is there ideal backhaul between CPU and RRH?

**Answer: The inter-RRH distance can be discussed, and depends on cell size, can be in several 100s. Yes, ideal backhaul can be assumed.**

- On P6, in general, we prefer to handle Scenario-1 only by Rel-17, and then the Scenario-2 is led by RAN2 for Rel-18, e.g., as in mobility SID/WID. Regarding potential new L1/L2-triggered inter-cell mobility (HO), does it mean that CHO is introduced into L1-level. Any clarification is highly appreciated.

**Answer: We agree that scenario 1 is handled in Rel-17, as discussed in RAN#92-e. L1/L2-triggered inter-cell HO is scenario 2 or scenario 2-like, where beam management triggers a change in serving cell, this can be discussed in Rel-18.**

- On P8: We are not clear now about the justification on compressing CSI in time domain.

**Answer: since the CSI ages fast with UE mobility, the performance (e.g. MU throughout) will degrade very fast even at moderate UE speeds (e.g. 30 kmph). There are real world scenarios in which UEs move at high speeds (e.g. UEs insides a moving vehicle). In those scenarios, there is a clear need to enhance CSI reporting by considering the channel variations in time domain.**

The following are two questions from our side.

Q1: Are there any initial evaluation results to justify the benefit of compressing high-resolution CSI in time domain? Is the channel sufficiently stable/correlated to be compressed in a large granularity of time?

**Answer: there are results available from several companies from Rel. 16/17 WID discussions. Re the channel being correlation/stable, the answer is yes, i.e., the mobility profile of UE channel can be estimated and reported by the UE.**

-

Q2: Further, the main benefit of high-resolution CSI is for MU scheduling. Is MU scheduling typical for high-speed UEs?

**Answer: first, the benefits are not limited to MU, there are benefits for SU case also. Now, in high speed scenarios such as highway, train, bus, etc., there is likely to be MU scheduling gains. Even in scenarios in which we have a mix of slow and fast moving UEs, the NW can still perform MU scheduling, if the CSI report can take care of the channel variations due to UE speed. We believe this is worth investigating in Rel-18.**

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**6 – Samsung Research America**

Response to Vivo

1) On distributed MIMO, it is proposed new (interference) measurement for enabling dynamic RRH selection.

Does it mean DPS type of operation is assumed?

**Answer: Yes, if RRH selection is allowed, then interference measurement hypothesis will depend on whether an RRH is selected for transmission**

2) On evaluation

CB1:eType-II per RRH, is it coherent JT scenario?

CB2: Modified eType-II (SD per RRH, FD across RRHs), how FD across RRHs is computed?

**Answer: Yes, the scenario is C-JT-like for both CB1 and CB2. For CB2, the FD components are computed after aggregating W2 (=W1^H x channel) of all RRHs.**

3) On inter-cell mobility, what is difference/benefit of inter DU compared to DAPS/CHO/MRDC?

**Answer: L2/L1 Inter-cell mobility is based on beam management. This allows faster handover and more signaling lenient overhead especially on the UE side compared to other HO schemes.**

**7 – Samsung Research America**

Response to NTT Docomo

Thank you very much for sharing the contribution. Please find some questions:

Q1) Asymmetric DL-UL (e.g. UL dense deployment):

We think possible enhancements are UL TPC, TA, UL beam management, etc. What enhancement do you have in mind?

**Answer: UE may communicate with different TRPs in DL and UL, e.g. due to interference or power considerations. This includes UL PC, TA, separate TCI across cells. In addition, depending on the Rel-17 outcome of separate DL/UL TCI, there could be some enhancements needed to ensure UL dense deployment is fully accommodated. For example, if separate DL/UL TCI is not supported for inter-cell beam management in Rel-17 due to, e.g M/N issue, this needs to be addressed in Rel-18.**

Q2) DL distributed MIMO deployments:

We assume the proposal is coherent joint transmission (i.e. one MIMO layer is transmitted from multiples points). Do you mean "dynamic RRH selection" is that gNB can dynamically indicate the combination of RRHs (e.g. sometimes one MIMO layer is transmitted from RRH#1 and RRH#2, and on next time, one MIMO layer is transmitted from RRH#2 and RRH#3)?

**Answer: yes, for CB based scheme, coherent transmission is assumed. Re dynamic RRH selection, a subset of RRHs can be selected for CSI reporting and data transmission. But, it may or may not be fully dynamic.**

Q3) Evaluation assumption:

On simulation result (p.4), MU-MIMO and Type II CSI are assumed. We assume this enhancement is beneficial even for SU-MIMO. Do you have any reason to consider MU-MIMO and Type II CSI? (i.e. Is this just an example, or do you intend MU-MIMO would be the main target on this scenario?)

**Answer: Yes, the benefits can be even for Type-I and other scenarios including Type-II and SU-MIMO. The reason MU-MIMO is simulated is because MU-MIMO is starting to gain traction (although still limited) in actual deployments. Given the timeline for Rel-18 deployment (still a few years from now), assessing the gain for MU-MIMO seems fitting.**

**8 – Samsung Research America**

Response to OPPO

Thanks for the contribution. Some questions from our side

Q1**:** Is there any model in mind for non-ideal factors on the backhal of the distributed MIMO?

**Answer: no, we didn't consider non-ideal backhaul in simulation. Ideal backhaul is reasonable in our view. But, non-ideal backhaul can also be studied.**

Q2**:** The scope seems too large. Is there any preference on priority of issues?

**Answer: Since this is a starting point of Rel-18, we wrote all the proposals what we consider as important. We also agree that it may seem too large, so we can finalize an exact (smaller) scope for Rel-18 based on the further discussion.**

**Q3:** For 5-d, does it mean that UE needs to transmit on one panel and Rx on another panel?

**Answer: Yes, the UE shall be capable of transmitting on one panel and receiving on a different panel. Different panels are well separated/isolated to avoid severe cross-link interference. Enhancements on interference measurement may be needed (should at least be studied).**

**9 – Samsung Research America**

Response to Lenovo

Q1: Extending features introduced in Rel-17

Do you want to re-design the mTRP operation specified in Rel-16/17 based on the R el-17 unified TCI framework? For example, multi-TRP PDCCH/PDSCH/PUSCH/PUCCH repetition by using unfied TCI framework and the related BFR procedure?

**Answer: unified TCI framework brings efficiencies in terms of reduced overhead and lower beam switching latency. In Rel-17 the focus, so far, has been single TRP operation. In Rel-18, we want to extend the unified TCI framework to mTRP (N>1 and M>1) to bring these efficiencies to mTRP.**

Q2: Distributed MIMO

1) Does more than one RRH can be selected in dynamic RRC selection mode? For example, dynamic RRH-pair selection by the UE for mTRP DL transmission.

2) Do you want to support simultaneous multi-panel UL transmission targetting multiple TRPs?

**Answer: Dynamic RRH selection can be for both CSI reporting and DL transmission. How fast this selection will happen and who performs this selection can be discussed. Regarding 2), we also have similar view on simultaneous MP UL transmission toward mTRPs.**

Q3: TRP/panel specific DL UL (TDD) configuration

Does it means that support full duplex operation in UE side?

**Answer: For this enhancement, the UE shall be capable of transmitting on one panel and receiving on another panel. Different panels equipped at the UE are well separated/isolated to avoid severe cross-link interference. Enhancements on the interference measurement are needed.**

**10 – Samsung Research America**

Response to Sony

For distributed MIMO at lower FR1 spectrum, can we understand that multi-RRH represents multi-TRP?

**Answer: Please see our replies to LGE and Xiaomi, wherein we explained our view about the difference between D-MIMO and mTRP operations.**

And does the extension of multi-TRP imply introducing more than 2 TRPs (RRHs), e.g. 4 or 8 TRPs in Rel.18?

**Answer: Re #RRHs, we think it should certainly be more than 2, e.g. 4 or 8 or even higher value can be studied. The exact value depends on scenarios and cell sizes.**

Due to nature of distributed RRHs, should UE be able to assume multiple QCL assumption/TCI states at FR1?

**Answer: Yes, multiple QCL assumptions is possible.**

**11 – Samsung Research America**

Response to NEC

We have a few questions on distributed MIMO.

a) What is the connection between enhancements on distributed MIMO and on Multi-TRP/panel? Should MTRP be a special case of distributed MIMO? And is it the intention that the enhancement will be based on Rel-17 MTRP framework?

**Answer: Please see our replies to LGE and Xiaomi, wherein we explained our view about the difference between D-MIMO and mTRP operations. Some enhancements/solutions can be based on mTRP (e.g. for UL), but they should be limited. For example, for the coherent case, the enhancements can be needed in codebook and CSI reporting.**

b) Is this objective restricted for < 1GHz? Or it can be general for FR1?

**Answer: Below 1GHz is the target (or higher priority) scenario, but we can consider FR1 also.**

c) On page 3, it is a bit confusing why there is coverage limitation for sub 1 GHz, is this compared to the coverage of e.g. C-band?

**Answer: Since number of antennae is likely to be small (due to large antenna form factor), and cell sizes are likely to be large, the coverage can be problem (for centralized MIMO case)**

**12 – Samsung Research America**

Response to Fraunhofer IIS/HHI

Thanks for your contribution. We have few questions with respect to your proposals.

Distributed MIMO:

Q1: What is the typical deployment scenario, distribution of RRHs and spacing between RRHs?

**Answer: Scenarios with large cell size, e.g. rural, is one example. The RRH distributions/spacings are up to NW planning and cell sizes. Perhaps, several 100s of meters between RRHs is reasonable.**

Q2: Is coherent joint transmission considered here? If yes, what are the requirements on synchronization between the RRHs?

**Answer: Coherent-JT-like (SU-MIMO) scenario is considered in results assuming ideal backhaul. This is perhaps the most effective paradigm for DL.**

Q3: Can the R15 type-I multi-panel CB be used in this deployment? If yes, how does your proposed codebook compares to the R15 type-I multi-panel CB in terms of performance and feedback overhead?

**Answer: Type I MP CB (designed for reasonably co-located panels with no-so-large inter-panel phase shift) is not designed/optimized for D-MIMO. It can be baseline, but we need to enhance codebooks to achieve gains with D-MIMO. In particular, the Type II codebook can be enhanced.**

CSI codebook:

Doppler-domain compression:

We have a similar view with same motivation on Doppler-domain compression and support this proposal.

Explicit feedback:

Q4: Non-ULA array geometries is mentioned in the slides. What kind of array geometries do you have in mind? What are the deployment scenarios for non-ULA array geometries?

**Answer: if the antenna structure is not uniform and structured, then DFT based codebooks (e.g. Type II) can't be beneficial. In such unstructured antennae, explicit feedback is one of reporting high-res CSI.**

**13 – Samsung Research America**

Response to Motorola Mobility Germany

[Lenovo, Motorola Mobility]: Questions on Advanced Beam-Management

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In slide 5, do you envision that only a group leader performs all beam measurements/reporting for scenario where multiple UEs have similar path/movement? We somewhat have similar thinking that independent CSI measurements and reporting for beam management is not efficient, especially

**Answer: Yes, one scenario we considered is having a group leader UE to provide beam measurements. This reduces signaling overhead. It can also save power for the other UEs. The group leader can be a CPE.**

for scenarios where the multiple UEs follow similar path. UE grouping for sharing beam measurements/ reporting will be quite beneficial for overhead reduction, lower latency and power saving. We have also discussed this in our contribution RWS-210396.

**Answer: Thank you for the feedback. We in general agree.**

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Do you consider predicting/indicating beams for future N time instances/slots in the middle figure that you have shown in slide 5?

**Answer: Yes, when the UE follows a predictable path, future TCI states can be indicated, this saves signaling overhead and improves latency.**

**14 – Samsung Research America**

Response to Intel

Q1. How the issue of non-ideal frequency synchronization between TRPs can be addressed by mTRP codebook design?

**Answer: The CSI codebook can be used for both ideal and non-ideal cases. For non-ideal cases, gNB can use the CSI feedback and compensate (e.g. diversity scheme across RRHs) for the non-ideality.**

Q2. What is importance of enhancing MIMO <1GHz considering limited spectrum available at such frequency bands on overall limited impact in the final throughput

**Answer: Actually this is precisely the reason we need to enhance MIMO for sub-1GHz. With limited spectrum, the only viable way to improve spectral efficiency (not just coverage, but also average TP) is via spatial domain. As demonstrated, there can be large gains with D-MIMO at <1GHz band, and 10MHz BW (our simulation).**

**15 – Samsung Research America**

Response to MediaTek

C1. For enhanced separate DL/UL TCI, we see enhanced beam measurement/reporting for UL Tx beam may be also needed for the use cases identified in the slides.

C2. We also see ”group-based” beam update can be also considered to support more efficient L1/L2 mobility for some important use cases, e.g., HST.

**Answer: Thank you for sharing your feedback. This sounds reasonable.**

Q1. For distributed MIMO, some elaboration is required for CB1 and CB2 as the descriptions are a bit vague. For example, for CB1, how does eType II applies to each RRH specifically?

**Answer: CB1 has two components: per RRH (based on R16 TypeII) and inter-RRH (amp/phase). CB2 is based on R16 Type II, wherein W1 (SB basis) is obtained for each RRH, and one common Wf is obtained based on the aggregated channel across RRHs (projected on respective W1)**

Q2. What is the motivation of TRP/panel specific TDD configuration?

**Answer: The motivation/use case of TRP/panel specific TDD configuration is to enable fully dynamic DL and UL traffic adaptation by leveraging multi-panel UE with well separated/isolated panels (avoiding severe cross-link interference).**

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**16 – Samsung Research America**

Response to IDC

Thanks for the proposals. We are also supportive on MIMO enhancement in Rel-18 especially for the extension of unified TCI framework for M-TRP and MP-UE scenario. Few questions as following:

Q1. I see lots of new proposals as a scope in the slides. Do you have any priority order in the case we have a limited TU for MIMO WI in Rel-18?

**Answer: Since this is a starting point of Rel-18, we wrote all the proposals what we consider as important. We also agree that it may seem too large, so we can make an exact scope of Rel-18 based on the further discussion.**

Q2. for distributed MIMO, what is the assumption related to timing synchronization across distributed antenna/panels?

**Answer: in SLS results, we assume ideal backhaul.**

Q3. in the slide 7, TRP/panel-specific DL-UL configuration, inter-panel (self-) interference which is mainly from full duplex operation? If yes, is it for UE or gNB? What is standards impact you expect assuming that those cancellation could be part of UE/gNB implementation?

**Answer: Yes, for this enhancement, the UE shall be capable of transmitting on one panel and receiving on another panel. Different panels equipped at the UE are well separated/isolated to avoid severe cross-link interference. Enhancements on interference measurement and reporting are needed for the interference cancellation.**

Q4. for the UL frequency selective precoding in slide 8, do you also expect UL codebook re-design/optimization or just simply reuse existing UL codebook?

**Answer: We prefer to reuse DL Type I codebook for freq selective UL precoding**

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**17 – Samsung Research America**

Response to Motorola Mobility UK

Thank you for the interesting contribution. My question is related to your proposal in the ***“Ultra HD CSI/codebook”*** section, which reads *“DL MIMO: Doppler-domain compression in addition to space- and frequency-domain (enhancement over Rel.16 eType-II)”*. Do you envision the Doppler-domain CSI compression enhancement as CSI measurement and reporting enhancements or only as a codebook enhancement?

**Answer: We would like to investigate a new codebook, and related enhancements at least on CSI measurement part. Enhancements on CSI reporting if any will be small.**

**18 – Samsung Research America**

Response to Verizon

Thanks for the excellent leadership in the area. Of distributed MIMO, one question we have is, does this allow us to adequately leverage our legacy systems in LTE with e.g., discrete 1/2/4 antennas, together with NR arrays of various forms? What level of synchronization is required? Can it seamlessly work together with the current NR MIMO?

**Answer: Thank you for the kind words. At the first stage, antenna forms used in LTE deployment can be reused for NR D-MIMO having different number of antenna ports between site but can be integrated to more advanced antenna form in the future. The required level of NW (inter-RRH) synchronization can be studied together with D-MIMO scope, if needed.**

**19 – Samsung Research America**

Response to Qualcomm

Regarding "distributed MIMO deployments":

Q1: What is the phase coherency assumption across different TRPs?

**Answer: phase coherency (non-coherency) need to be compensated for depending on the transmission scheme. We assumed coherent case in simulation results.**

Q2: For CB1 in the evaluations, is CJT assumed across TRPs? How the phase / precoding across the TRPs are determined?

**Answer: Yes, amp/phase component is considered for each RRH (aided with CSI feedback).**

Q3: Regarding "UE-assisted calibration", can you elaborate a bit more?

E.g. what type of calibration between TRPs is intended and UE's role for this purpose?

**Answer: In order to help the phase/timing alignment between RRHs with geographically separated, UE can assist using e.g., feedback or UL transmission.**

Q4: Regarding "interference measurement to enable dynamic RRH selection", more clarifications would be helpful as to why existing CSI framework is not sufficient.

**Answer: if RRH selection is performed by UE, an RRH can be serving or interfering depending on selection hypothesis. The existing CSI framework may not support this.**

Q5: Regarding "multi-panel reception at UE", compared to Rel. 16 and 17 enhancements, which left-over aspect is in mind?

**Answer: We envision that there would be essential carry-over from Rel. 17 to facilitate multi-panel reception at the UE in Rel. 18 such as CMR/IMR configuration enhancements to facilitate channel/interference measurement/reporting and enhancements related to simultaneous reception of various RSs/channels.**

**20 – Samsung Research America**

Response to Huawei

Thanks for the contribution, we have the following comments and questions:

1. On Page 3, for Distributed MIMO enhancement, is that only for 700M and RMa cases? The discussion is indeed similar as coherent joint transmission in M-TRP, which can be merged together.

**Answer: no, 700MHz + RMa is just an example representing a moderate/large cell size and 700MHz a common sub-1GHz band.**

2. On Page 4, in the evaluation, not sure why FD across RRHs can be work better than independent design as CB1, while the angle and delay information from different Panels/TRPs will be different?

**Answer: joint FD compression across aggregated channels (of RRHs) can represent the ideal pre-coding more accurately**

3. On Page 8, what does ”Explicit feedback” means? Could you elaborate a little bit more?

**Answer: SVD type feedback is one example of explicit. In particular, channel can be quantized directly without the DFT basis. This is intended for high overhead regime where DFT basis saturates in performance.**

4. On Page 5, what’s the meaning of ”Combination between DL mTRP and UL STxMP”?

**Answer: In a mTRP deployment with a UE having more than one panel, there can be simultaneous UL transmissions to different TRPs from different panels.**

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**21 – Samsung Research America**

Response to AT&T

Thanks for the contribution.

On goal 1.1: D-MIMO for sub 1GHz, can you comment more on the deployment scenarios you envision and the potential channel modeling needs? Can you also elaborate on the need and the procedure for UE assisted calibration for the multi-RRH transmission? Will this be building on coherent JT mTRP?

**Answer:**

**Scenario: multiple RRHs (antenna units) connected to a baseband processing unit, RRH deployed within a large cell, each RRH includes small #antenna.**

**In order to help the phase/timing alignment between RRHs with geographically separated, UE can assist using e.g., feedback or UL transmission.**

**Channel model: can be based on 5GCM, RMa is an example.**

**For DL, the most effective paradigm is single TRP (“typical” MIMO) which has affinity with C-JT. For UL, m-TRP paradigm (not all TRPs receive the UL transmission) seems to be more fitting.**

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**22 – Samsung Research America**

Response to Ericsson

· We have a couple of clarification questions on slide 3 related to Distributed MIMO:

o Could you elaborate what is meant by UE-assisted calibration?

**Answer: In order to help the phase/timing alignment between RRHs with geographically separated, UE can assist using e.g., feedback or UL transmission.**

o What is the motivation for introducing ‘New (interference) measurement for enabling dynamic RRH selection’?

**Answer: if RRH selection is performed by UE, an RRH can be serving or interfering depending on selection hypothesis. The existing CSI framework may not support this.**

**23 – Samsung Research America**

Response to Nokia

Q1: Have the gains of L1 mobility been verified, and how much gain does the L1 mobility bring over L3 mobility?

**Answer: L3 suffers from longer interruption time and higher signaling overhead making it less efficient for high speed scenarios. Based on the Rel-17 simulation assumptions (R1-200715) in FR2 the distance a UE travels in a cell is less than 120 m, some cells can have a travel distance as low as a few tens of meters depending on the travel trajectory. For a UE traveling at 70 m/s (252 km/h) the UE spends less than 2 seconds in a cell. With a L3 handover the interruption time can be in the order of 100's of milli-seconds, this can lead to a significant loss of throughput and even dropped calls. Some estimates of L3 interruption time (R1-2006128) are in the order of seconds, making L3 handover unusable for these scenarios.**

Q2: RRC is ciphered so L3 mobility is inherently secure, whereas GSMA has already warned about potential security problems with MAC CEs. How is the L1 mobility protected from malicious attacks to change the serving cell of many Ues?

**Answer: On top of the beam management triggered serving cell change, RAN3 can implement the security procedures for HO. This allows for dedicated traffic to switch quickly to the new cell (short interruption time) based on inter-cell beam management, while the RAN3 security and other procedures are triggered for the serving cell change.**

Q3: Is it assumed there are no changes to RRM or L1 measurements due to L1 mobility (since none are mentioned)?

**Answer: Measurements for inter-cell beam management are part of Rel-17 WI. We expect that there will be no further changes in Rel-18.**

Q4: What kind of workload is envisioned for this work in Rel-18? And it is really true that there is no RAN4 impact (since this is not indicated)?

**Answer: If a new handover scheme is specified, there will be some RAN4 work related to RRM. Regarding workload in general, please see below.**

Q5: A plethora of MIMO features have been specified but never deployed in the past, due to e.g, complexity and power consumption. How can these proposed new MIMO features be made such that they can be more easily deployed (compared to what have already been defined but not deployed)?

**Answer: I believe this is a general question that should be asked for any MIMO feature. For this feature, the key would be modularity. While we describe the overall picture here, what can be done in Rel-18 is simply a subset given, e.g. TU allocation. If the feature is modular, a phased (multi-release) approach in specification can be used. Which also applies to deployment.**

**24 – Samsung Research America**

Response to China Unicom

Thanks for the contribution, the following questions are listed for clarification:

Q1: What is the potential enhancement for FDD Massive MIMO?

**Answer: As one of the potential enhancement for FDD massive MIMO, we consider D-MIMO in low frequency band in order to overcome a limited available BW in that band, since the capacity/coverage boosting can be achieved by enabling massive MIMO as distributed manner due to the large form factor. Another example can be supporting more than 32 ports.**

Q2: For multi-TRP, considering the deployment scenario, how to support more than 2 TRPs for intra-cell and inter-cell scenarios in R18?

**Answer: To support more than 2 TRPs for multi-TRP operation (intra-cell and inter-cell), enhancements related to TCI state indication, rate matching, non-serving cell information indication and beam measurement/reporting are needed. Dynamic TRP selection could be enabled as well with new (interference) measurement design.**

**25 – Beijing Xiaomi Mobile Software**

Thanks for your answers. Please see our further questions below:

Q1: As for "W1 per RRH", we agree it will be beneficial. While for "Wf can be obtained based on aggregated channel across RRHs", we want to clarify that what is the meaning of aggregated channel, does it mean FDM between RRHs or same frequency domain resource between RRHs? Do you mean that same Wf is sufficient?

Q2: As for the scope of Rel-18 MIMO, We think it is reasonable to include the 1st item (Multi-beam) and 2nd item (Multi-TRP) in the scope since it can be seen as further enhancement based on Rel-17. But for the 3rd (D-MIMO) and 4th item (Ultra HD Codebook/CSI), we think there will be much higher workload for each one. Do you have any priority? Or can we down select some issues in each item?

## 5.3 Round 2 Question

**Feedback Form 9:**

**1 – Beijing Xiaomi Mobile Software**

Thanks for your answers. Please see our further questions below:

Q1: As for "W1 per RRH", we agree it will be beneficial. While for "Wf can be obtained based on aggregated channel across RRHs", we want to clarify that what is the meaning of aggregated channel, does it mean FDM between RRHs or same frequency domain resource between RRHs? Do you mean that same Wf is sufficient?

Q2: We think it is reasonable to include the 1st item (Multi-beam) and 2nd item (Multi-TRP) in the scope since it can be seen as further enhancement based on Rel-17. But for the 3rd (D-MIMO) and 4th item (Ultra HD Codebook/CSI), we think there will be much higher workload for each one. Do you have any priority? Or can we down select some issues in each item?

**2 – vivo Communication Technology**

there are many proposals on MIMO enhancement in Rel-18 from companies. There are features never implemented in each release (this may be true for other WIs as well!), which ones do you think are urgent from real deployment perspective?

**3 – Spreadtrum Communications**

Thanks for the discussion. Regarding the CB for UL FS precoding, have you evaluated the gain of the proposed CB comparing with indicating multiple TPMIs, considering the tradeoff between performance

and signaling overhead? Due to the fact that the max # UL port is 4, we wonder whether there's clear benefit of the new UL CB.

**4 – Spreadtrum Communications**

Our comment is about your answer that 'We prefer to reuse DL Type I codebook for freq selective UL precoding'. Sorry for the potential confusion.

**5 – ZTE Corporation**

Thank you so much for your reply. Regarding L1/L2-centric mobility, we are open to further study Scenario #2 in Rel-18 considering that some enhancement for Scenario #1 will be well done in Rel-17. In general, we need to identify which aspects of Scenario #2 are relevant to PHY/RAN1 or RAN2, respectively. In our initial views, RAN1 may lead UE-initialized L1/L2 reporting/handover, and others, RRC-involved HO procedure, may be left to RAN2.

Then we have the further comments as follows:

- Regarding UL MIMO, our preference/discussion can be found in Page 7 8 of our companion contribution RWS-210479. Multiple codeword enhancement for UL (also for no more than 4 DL layer) should be considered, if >4 layers are introduced for UL. Some field tests to prove the necessity of introducing multiple codewords for UL can be found in our contribution R1-2104596 which was supported by many operators.

- Regarding P5 advance beam refinement/tracking, we also realize the benefits of DCI based beam indication that is enhanced by unified TCI framework. But, how to find/track Tx beam change based on normal DL beam measurement is much tough, and huge RS overhead is another issue. Some clarification is appreciated.

**6 – HuaWei Technologies Co.**

Q1: From your reply "single TRP operation with antenna ports distributed across multiple locations. C-JT is possible but not necessary", do you mean D-MIMO belongs to C-JT? TRP is transparent to specs, both C-JT and D-MIMO transmission are from different RRHs, which seems no difference.

Q2: Then, for possible enhancements for C-JT/D-MIMO, we share the similar view that codebook needs to enhanced for FDD, but for TDD part, do you have any consideration on the enhancements?

Q3: As mentioned that >32 ports is necessary for CSI reporting, whether means there are possible much more MU layers are possibly paired as well?

**7 – Qualcomm CDMA Technologies**

Regarding distributed MIMO deployments with CJT, we have the following follow-up questions:

Q1: Is the time alignment error (TAE) across TRPs envisioned to be the same as existing RAN4 requirements for MIMO (i.e., 65ns)? How this can be achieved?

Q2: Are you envisioning that the distributed TRPs share the same clock / PLL? If not, what are the phase drift requirements for CJT to work in practice?

Q3: For a given TRP, is phase continuity expected / required from one slot to another slot (more generally from the CSI report time to PDSCH scheduling time)? This is not required in existing NR deployments.

Q4: Given the questions above, and assuming some specification enhancement can alleviate the issues and make CJT across TRPs feasible, why would Rel. 18 should jump to CSI codebook enhancements? In other words, if CJT is proved to be feasible, isn't a first natural step to enable CJT in TDD through reciprocity-based beamforming (SRS-based, which has smaller overhead and less UE complexity) or do you think it can be done in a transparent manner?

**8 – vivo Communication Technology**

follow up on response to AT&T on channel model, the channel model is developed assuming single point transmission (antenna ports in one antenna panel are transmitted from one geographical location), with distributed MIMO if the antenna ports are spread on different locations, can current channel model be used without modification?

**9 – LG Electronics Inc.**

Thanks for the answer. As long as we understand, NR supports DPS operation based on CRI selection. If D-MIMO is intended for single TRP operation, could you explain further on why current CSI is insufficient?

**10 – Intel Corporation (UK) Ltd**

Thank you for the responses. We have an additional question below:

Q1. For distributed MIMO with coherent JT, we assume that SLNR-like precoder is used across RRHs in your evaluations. If that is the case, could you please clarify how power normalization has been performed in your evaluations to ensure that maximum RRH power won't exceed the maximum allowed value?

**11 – Verizon UK Ltd**

Thanks for the answers. MIMO is the fundamental radio link whose performance ties directly to NW KPI and it needs constant enhancement as long as NR evolves. This time, in addition, we are particularly interested in distributed MIMO. We need to make sure our legacy LTE systems can be used and we can enjoy at least a large part of the benefit with our current synchronization network. Thanks.

## 5.4 Round 2 Answer

**Feedback Form 10:**

**1 – Samsung Research America**

Thanks very much for your additional questions and comments. Please find our responses below.

**2 – Samsung Research America**

Response to Xiaomi

Thanks for your answers. Please see our further questions below:

Q1: As for "W1 per RRH", we agree it will be beneficial. While for "Wf can be obtained based on aggregated channel across RRHs", we want to clarify that what is the meaning of aggregated channel, does it mean FDM between RRHs or same frequency domain resource between RRHs? Do you mean that same Wf is sufficient?

**A1: For 2 RRHs, the aggregated channel is W11'xH1 stacked vertically with W12'xH2 in one matrix. W1i is the W1 for RRH i and Hi is the channel for RRH i. For the enhanced eType-II codebook (designed for D-MIMO), can be common (the same) across both RRHs.**

Q2: We think it is reasonable to include the 1st item (Multi-beam) and 2nd item (Multi-TRP) in the scope since it can be seen as further enhancement based on Rel-17. But for the 3rd (D-MIMO) and 4th item (Ultra HD Codebook/CSI), we think there will be much higher workload for each one. Do you have any priority? Or can we down select some issues in each item?

**A2: Based on the inputs from operators so far,**

- **Sub-1GHz enhancement is a high priority item (where D-MIMO fits in). But your point about scope is well-taken. Therefore, we don't expect everything needed on D-MIMO can be done in one release. For Rel-18, proper study on deployment scenarios is needed, followed by CSI enhancement for DL (at least for PDSCH, assuming sTRP) and calibration issues (if any). UL resembles mTRP and can be studied in future releases (e.g. Rel-19).**

- **Multi-beam (continuing on Rel-17 unified TCI) is also a high priority item to make sure it accommodates mTRP (e.g. M,N>1) and "UL dense NW", as well as "issue 6" in Rel-17**

**3 – Samsung Research America**

Response to vivo

there are many proposals on MIMO enhancement in Rel-18 from companies. There are features never implemented in each release (this may be true for other WIs as well!), which ones do you think are urgent from real deployment perspective?

**A: Thanks for stating the obvious!**

**A "proposal" is either to address an existing deployment issue or extend the existing deployment ("push the envelope"). From operator's perspective, the two are evidently important (sometimes almost equally). From our perspective (related to our proposals), see our response to Xiaomi on our initial priority – which will be refined based on further inputs from operators and other vendors.**

follow up on response to AT&T on channel model, the channel model is developed assuming single point transmission (antenna ports in one antenna panel are transmitted from one geographical location), with distributed MIMO if the antenna ports are spread on different locations, can current channel model be used without modification?

**A: One alternative is to re-use the current channel model for each RRH. This can be a good baseline. The need for another channel model or a modified version of the 5GCM channel for D-MIMO can be discussed or part of the work scope.**

**4 – Samsung Research America**

Response to Spreadtrum

Thanks for the discussion. Regarding the CB for UL FS precoding, have you evaluated the gain of the proposed CB comparing with indicating multiple TPMIs, considering the tradeoff between performance and signaling overhead? Due to the fact that the max # UL port is 4, we wonder whether there's clear benefit of the new UL CB.

Our comment is about your answer that 'We prefer to reuse DL Type I codebook for freq selective UL precoding'. Sorry for the potential confusion.

**A: Yes, simulation results can be found in R1-1713574**

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**5 – Samsung Research America**

Response to ZTE

Thank you so much for your reply. Regarding L1/L2-centric mobility, we are open to further study Scenario #2 in Rel-18 considering that some enhancement for Scenario #1 will be well done in Rel-17. In general, we need to identify which aspects of Scenario #2 are relevant to PHY/RAN1 or RAN2, respectively. In our initial views, RAN1 may lead UE-initialized L1/L2 reporting/handover, and others, RRC-involved HO procedure, may be left to RAN2.

**A: We agree.**

- **RAN1 centric: Beam measurement and reporting, as well as beam indication, should be largely common between scenario 1 and scenario 2. This is being worked on in Rel-17. Perhaps there are some optimizations that can be done in Rel-18.**
- **RAN2 centric: Other aspects of scenario 2 such as RRC and HO procedure. This is perhaps the major chunk of Rel-18 work pertaining to L1/L2-centric inter-cell mobility.**

Then we have the further comments as follows:

- Regarding UL MIMO, our preference/discussion can be found in Page 7 8 of our companion contribution RWS-210479. Multiple codeword enhancement for UL (also for no more than 4 DL layer) should be considered, if >4 layers are introduced for UL. Some field tests to prove the necessity of introducing multiple codewords for UL can be found in our contribution R1-2104596 which was supported by many operators.

**A: For >4 layers per UE (if introduced), we agree that 2 CWs can be supported. For <=4 layers per UE, we do not see the benefit for supporting 2 CWs.**

- Regarding P5 advance beam refinement/tracking, we also realize the benefits of DCI based beam indication that is enhanced by unified TCI framework. But, how to find/track Tx beam change based on normal DL beam measurement is much tough, and huge RS overhead is another issue. Some clarification is appreciated.

**A: When UEs are moving at a high speed, we agree that overhead due to measurement RS is high especially for latency beam management. To reduce overhead, there are several options we can investigate**

- **Combine beam indication and CSI trigger: latency and overhead are obviously reduced**
- **Group-based beam management: only one user measures and reports beams for a group of users.**
- **Predictive beam management and tie beam usage to UE position, this could also reduce beam measurement and reporting overhead.**

**6 – Samsung Research America**

Response to Huawei

Q1: From your reply "single TRP operation with antenna ports distributed across multiple locations. C-JT is possible but not necessary", do you mean D-MIMO belongs to C-JT? TRP is transparent to specs, both C-JT and D-MIMO transmission are from different RRHs, which seems no difference.

**A: In our view, D-MIMO comprises:**

- **DL: single TRP, traditional MIMO (SU and MU) – this shares some similarities with C-JT at least in terms of CSI and UE-dedicated reception**
- **UL: multi TRP**

**So "do you mean D-MIMO belongs to C-JT?" may be ill-posed J In fact, as you also said, RRHs will be transparent to the spec in C-JT. So C-JT can be perceived as a sTRP (traditional MIMO) scheme from spec perspective – just with a different antenna architecture.**

Q2: Then, for possible enhancements for C-JT/D-MIMO, we share the similar view that codebook needs to enhanced for FDD, but for TDD part, do you have any consideration on the enhancements?

**A: Regarding TDD, we can be open to enhancements, if needed. At this point, we are unsure whether we need any specific enhancements applicable to TDD only case given that sub-1GHz band is primarily FDD.**

Q3: As mentioned that >32 ports is necessary for CSI reporting, whether means there are possible much more MU layers are possibly paired as well?

**A: We are open to consider more MU layers for D-MIMO as well, if it is found beneficial.**

**7 – Samsung Research America**

Response to Qualcomm

Regarding distributed MIMO deployments with CJT, we have the following follow-up questions:

Q1: Is the time alignment error (TAE) across TRPs envisioned to be the same as existing RAN4 requirements for MIMO (i.e., 65ns)? How this can be achieved?

**A1: If needed, a new RAN4 requirements can be defined. We agree that the phase/timing difference between TRPs/RRHs is one issue to be investigated. One of the candidate solution is UE-assisted calibration which UE can estimate and report the phase/timing difference. Whether a dedicated UE report is needed or whether this can be incorporated in to CSI/codebook design (at least for UE-dedicated reception) can be studied.**

Q2: Are you envisioning that the distributed TRPs share the same clock / PLL? If not, what are the phase drift requirements for CJT to work in practice?

**A2: If RRHs are not in same location, sharing the same clock/PLL is perhaps infeasible. This and 1 belong to the calibration issue. Please see A1.**

Q3: For a given TRP, is phase continuity expected / required from one slot to another slot (more generally from the CSI report time to PDSCH scheduling time)? This is not required in existing NR deployments.

**A3: We do not think such requirement is needed for a given RRH.**

Q4: Given the questions above, and assuming some specification enhancement can alleviate the issues and make CJT across TRPs feasible, why would Rel. 18 should jump to CSI codebook enhancements? In other words, if CJT is proved to be feasible, isn't a first natural step to enable CJT in TDD through reciprocity-based beamforming (SRS-based, which has smaller overhead and less UE complexity) or do you think it can be done in a transparent manner?

**A4: In our view, FDD should have the same, if not more, priority as TDD for D-MIMO. For FDD, a new codebook would be needed to achieve potential performance gain of D-MIMO by enhancing the current Rel-15 multi-panel codebook since the codebook is designed for co-located panels with not so large inter-panel phase shift. Also, the R15 MP codebook is low-res (Type I). To achieve the maximum potential, a high-res (Type II) MP CB is needed.**

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**8 – Samsung Research America**

Response to LGE

Thanks for the answer. As long as we understand, NR supports DPS operation based on CRI selection. If D-MIMO is intended for single TRP operation, could you explain further on why current CSI is insufficient?

**A: I think you might have misunderstood our concept of D-MIMO. When we say it is sTRP, it doesn't mean RRH selection. For DL, a UE can receive DL transmission across M>1 RRHs where the M RRHs constitute a single "TRP" (hence a single antenna array). Also see our comment to Huawei.**

**Re codebook enhancements, the current Rel-15 multi-panel codebook, which is designed for reasonably co-located panels with not so large inter-panel phase shift, need to be enhanced for D-MIMO. For example, RRHs in D-MIMO can have different number of antennas and different distance gap among RRHs. Also, the R15 MP codebook is low-res (Type I). To achieve the maximum potential, a high-res (Type II) MP CB is needed.**

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**9 – Samsung Research America**

Response to Intel

Thank you for the responses. We have an additional question below:

Q1. For distributed MIMO with coherent JT, we assume that SLNR-like precoder is used across RRHs in your evaluations. If that is the case, could you please clarify how power normalization has been performed in your evaluations to ensure that maximum RRH power won't exceed the maximum allowed value?

**A: The Tx power is distributed across RRHs. For 2 RRHs, each RRH power is 3db less than the Tx power for the centralized MIMO case (single RRH).**

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**10 – Samsung Research America**

Response to Verizon

Thanks for the answers. MIMO is the fundamental radio link whose performance ties directly to NW KPI and it needs constant enhancement as long as NR evolves. This time, in addition, we are particularly interested in distributed MIMO. We need to make sure our legacy LTE systems can be used and we can enjoy at least a large part of the benefit with our current synchronization network. Thanks.

**A: Thanks for your supportive comment. We also consider that the target scenario is low frequency band, especially re-farming LTE FDD band.**

**11 – Samsung Research America**

Response to OPPO

Thanks for your reply. One more question: For "Explicit feedback" of eigenvectors (non-ULA array geometry), what is the application scenarios in mind?

**A: if the antenna structure is not uniform or is unstructured, then DFT based codebooks (e.g. Type II, designed with ULA in mind) do not match the structure of the antenna array. For such antenna configurations, explicit feedback can be more suited for reporting high-res CSI.**

**Also, the operation of interest is in high overhead regime, wherein DFT basis saturates in performance even for ULA-type arrays (due to its inherently limited spatial resolution). This has been demonstrated in early part of Rel-16 by several companies, especially by ZTE.**

# 6 Q&A on High-speed Packetization (RWS-210182)

## 6.1 Round 1 Question

**Feedback Form 11: QA on High-speed Packetization (RWS-210182)**

**1 – HuaWei Technologies Co.**

We have similar proposals with same motivation, and some questions for clarification: 1) What does "fixed L2 header" mean, only PDCP header or? 2. What is expected impact on RLC segmentation and do you see significant gains or essential need to have this enhancements? 3. CA/DC is independent of PDCP processing to generate a PDU, not clear what is impact in particular to CA/DC?

**2 – Ericsson LM**

The proposal seem to be to concatenate in PDCP, not RLC. For split bearers, how would it work to concatenate in PDCP for the SN-leg in DL? The MN does not know how many packets to concatenate?

**3 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Is "Enhance RLC segmentation" related to PDCP concatenation?

**4 – Qualcomm CDMA Technologies**

Could you please clarify what types of enhancements are considered for RLC segmentation (to reduce the overhead)?

**5 – Apple GmbH**

Could you please also elaborate on your views on how you see this feature working on noisy channels ? From what we understand it seems to be primarily applicable for peak throughput scenarios. But we do understand that it is CPU savings here primarily compared to header overhead.

## 6.2 Round 1 Answer

**Feedback Form 12: Reply for Round 1 Question**

**1 – Samsung Electronics Co.**

**1 – HuaWei Technologies Co.**

We have similar proposals with same motivation, and some questions for clarification: 1) What does ”fixed L2 header” mean, only PDCP header or? 2. What is expected impact on RLC segmentation and do you see significant gains or essential need to have this enhancements? 3. CA/DC is independent of PDCP processing to generate a PDU, not clear what is impact in particular to CA/DC?

**1) “fixed L2 header” means that the size of L2 headers (MAC/RLC/PDCP headers) are fixed, which are attached to user plane data. 2) RLC segmentation generates different size of RLC header due to SO field, which is not preferable for HWA. We think it would be good to have the fixed-sized RLC header regardless of segmentation, by enhancing the existing RLC segmentation method. 3) For now, we also think that PDCP processing including our proposal would be independent of CA/DC. However, further study may be needed, if any.**

**2 – Samsung Electronics Co.**

**2 – Ericsson LM**

The proposal seem to be to concatenate in PDCP, not RLC. For split bearers, how would it work to concatenate

in PDCP for the SN-leg in DL? The MN does not know how many packets to concatenate?

**We may need to discuss how many PDCP SDUs should be concatenated, e.g. static or dynamic manner. In our opinion, the MN can concatenate the buffered PDCP SDUs into pseudo SDUs in dynamic manner. The pseudo SDU including multiple PDCP SDUs by PDCP concatenation can be just considered as a large PDCP SDU. In this regard, we assume the behavior of split bearer would be the same as in legacy.**

**3 – Samsung Electronics Co.**

**3 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Is “Enhance RLC segmentation” related to PDCP concatenation?

**We assume they are separate ones but we cannot say they are independent since RLC segmentation may depend on the size of RLC SDU. Our intention is to enhance RLC segmentation in order to**

**make RLC header implementation-friendly because it would be preferable for HWA if the size of RLC header is fixed regardless of RLC segmentation.**

**4 – Samsung Electronics Co.**

**4 – Qualcomm CDMA Technologies**

Could you please clarify what types of enhancements are considered for RLC segmentation (to reduce the overhead)?

**For example, we think that 2byte SO field is redundant, which also makes the size of RLC header variable based on RLC segmentation. We can optimize the existing RLC segmentation method for RLC UM or AM.**

**5 – Samsung Electronics Co.**

**5- Apple GmbH**

Could you please also elaborate on your views on how you see this feature working on noisy channels ? From what we understand it seems to be primarily applicable for peak throughput scenarios. But we do understand that it is CPU savings here primarily compared to header overhead.

**Our proposal is to enhance L2 protocol, which seems not dependent on the channel characteristics as the actual size and MCS of TB would be determined by the scheduler in the network side. The main intention is to reduce the processing burden from UPIP as well as to reduce header overhead from L2 perspective.**

## 6.3 Round 2 Question

**Feedback Form 13:**

**1 – HuaWei Technologies Co.**

We think it is interesting to further consider RLC segmenetation optimization, but we understand this is independent with PDCP concatenation, do you have any priority for these aspects in Rel-18?

**2 – Verizon UK Ltd**

Maybe we should have asked this earlier: we are concerned about processing power driving towards peak data rate with high CA combinations. I wonder if you see any problem for e.g., device running over 10Gbps data on e.g., 1.4GHz combined total BW?

## 6.4 Round 2 Answer

**Feedback Form 14:**

**1 – Samsung Electronics Co.**

**HuaWei Technologies Co., Ltd**

# 1

We think it is interesting to further consider RLC segmenetation optimization, but we understand this is independent with PDCP concatenation, do you have any priority for these aspects in Rel-18?

[Samsung] We think PDCP concatenation should be prioritized to address our main concerns, e.g. performance degradation from UPIP and too many L2 headers to be processed.

**2 – Samsung Electronics Co.**

**Verizon UK Ltd**

# 2

Maybe we should have asked this earlier: we are concerned about processing power driving towards peak data rate with high CA combinations. I wonder if you see any problem for e.g., device running over 10Gbps data on e.g., 1.4GHz combined total BW?

[Samsung] For now, we would say that there would be significant performance degradation resulted from UPIP running high data rates. In this regard, we considered a way to improve the processing efficiency of device and ended up with our proposal, i.e. PDCP concatenation, which would be useful in your concerned scenarios as well.

# 7 Q&A on Multi-RAN Multi-Connectivity (RWS-210183)

## 7.1 Round 1 Question

**Feedback Form 15: QA on Multi-RAN Multi-Connectivity (RWS-210183)**

**1 – KDDI Corporation**

1. In P3, what is the use case of SN1-terminated SCG2 bearer?

2. In P4, is the uplink forwarding design aiming for only FDD, or both TDD & FDD? If taking into account of TDD, are you considering to enhance the current TDD config? we guess the uplink can be a bottle neck, since one uplink is shared by two downlink, which results in uplink resource shortage.

3. In P5, regarding Fast data forwarding, please add more explanation on how to realize it. Is it also useful for CA?

4. Regarding the serving SN/Pscell dynamically change that mentioned in P5, is it similar scenario as the Figure 3/Proposal 1 mentioned in RWS-210449?

5. Regarding inter-CU/Inter-DU coordination, is it similar as the one mentioned in RWS-210327?

**2 – LG Electronics Inc.**

Thank you for the proposals.

**Q**: Regarding active UL CG switching, it is understood to split UL period between CGs in advance due to UE power limitation. If so, do you consider such switching is required for all MR-MC UEs? or is as per UE capability or power class?

**3 – MediaTek Inc.**

Thanks for the quality contribution. The fundamental goal of the proposals looks to ensure data continuity when SCG blockage/failure. Toward this goal, **if SCG to MCG switching can be made sufficiently fast,**

**e.g., within 10 ms packet delay budget of CG/AR/VR services, existing DC framework of one MCG and one SCG can still be effective to ensure data continuity**. In this regard, we would like to first ask: **What is the fundamental goal for increasing SCG number and what is the critical gap existing DC mechanism cannot achieve?** We hope the answers to the above questions can help companies to identify the possible enhancement direction(s) with minimum impact to UEs and networks.

**4 – Beijing Xiaomi Mobile Software**

Thanks for the proposals.

Some questions:

1) Does the 2 SNs connected by ideal backhaul? since you have new bearer types introduced, e.g.,SN1-terminated SCG2 bearer

2) It seems for the uplink, UE's behavior is very complexed. UE need to select 1 SN for transmission. How UE selects the SN?

Since there are 3 legs for downlink and only 2 legs for uplink, does the PUCCH needs to forwarded from one node to another node? E.g., from MN to SN? What is the impact on none-ideal backhaul?

It seems there is huge sepc impact...

3) How to achieve dynamical SN change? Will some lay1 signaling introduced?

**5 – CATT**

We have one question for clarification:

here is the scope include that UE supporting more than 2 connections at the same time, as there might be concern on complexity vs gain....

**6 – HuaWei Technologies Co.**

Can you please clarify what is the difference on dynamic switch for UL cell group and SCG? We have similar consideration in RWS-210449, and we think this can be applied to wider sceanrios where we have multiple carriers deployment, which is not only for DC, what do you think?
Do you think the number of activated carriers/CGs has limitation?

**7 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Does multiple cell group (more than 2) require change on RAN4 basic assumption of UE implementation that number of RF chains does not exceed 2?

**8 – Nokia Corporation**

**Q1:** What is the main use case for the this: Intra-CU inter-DU, Intra-CU intra-DU or inter-CU?

**Q2:** What kind of DAPS is assumed for SN mobility, i.e. does UE retain connectivity to both source SCG and target SCG (i.e. triple connectivity)?

**Q3:** Can the UL be switched to a different cell group while DL stays the same, or does the entire cell group change simultaneously?

**Q4:** What are the RAN1 impacts of MR-MC if only two CGs are activate at the same time?

**Q5:** Is the proposal to have DU-DU interface standardized? If so, are other new interfaces needed?

**9 – Lenovo (Beijing) Ltd**

Thanks for your paper.

Q1: The maximum number of SCG is 2 in Rel-18?

Q2: Can you elaborate Serving SN/ Pscell can dynamically change among the pre-configured SNs/ Pscells? Is it CPC-like? UE triggers to change based on the condition configured by gNB.

Q3: What is fast data forwarding among serving nodes (e.g., user plane interface between gNB DUs)? Is new interface between DUs introduced for data forwarding?

**10 – Qualcomm CDMA Technologies**

For support of cross cell group feedback in the UL (Slide 4) is it required to introduce inter gNB-DU interfaces in the standards?

**11 – China Telecomunication Corp.**

[China Telecom] Thanks for the proposals. We have a few questions as below.

Q1: What is the use case or motivation of SN1-terminated SCG2 bearer in P3? Does the 2 SNs connected by ideal backhaul or non-ideal backhaul?

Q2: What are the use cases or scenarios of UL switching and UL forwarding in P4? For UL forwarding between SNs, whether new interface between DUs is needed?

## 7.2 Round 1 Answer

**Feedback Form 16: Reply for round 1 Question**

**1 – Samsung Electronics Co.**

**1 – KDDI Corporation**

1. In P3, what is the use case of SN1-terminated SCG2 bearer?

**Thank you for the questions.**

**1. It's for flexibility. If we have three nodes, there is no need to exclude such flexibility. A use case is, for instance, network slicing, i.e. different slices may use different termination nodes, e.g. SN1-terminated bearer for slice 1 and SN2-terminated bearer for slice 2. In this case, SN1-terminated bearer may use SCG2 resource.**

2. In P4, is the uplink forwarding design aiming for only FDD, or both TDD & FDD? If taking into account of TDD, are you considering to enhance the current TDD config? we guess the uplink can be a bottle neck, since one uplink is shared by two downlink, which results in uplink resource shortage.

**2. We understand the UL forwarding may be more beneficial for FDD. But, at this stage, we don't want to restrict this design to specific division duplex mode. In addition, the UL may be bottleneck for the UL switching as well as the UL forwarding since we just consider at most two ULs here. However, we think a consideration of at most two ULs is a practical assumption for now, which can avoid some issues such as uplink coverage loss due to power sharing and also UE complexity/burden.**

3. In P5, regarding Fast data forwarding, please add more explanation on how to realize it. Is it also useful

for CA?

**3. The fast data forwarding can be applied between two DUs during the SCG change. Specifically, if the UE is switched to DU2, the un-transmitted data packets buffered at DU1 can be directly forwarded to DU2 so that DU2 can continuously send packets to UE. This procedure can reduce the service interruption. For CA case, there is no data forwarding between gNB-DUs since all serving cells in CA belong to the same gNB-DU. If the intention of question "Is it also useful for CA" is related to inter-gNB CA, such fast data forwarding may be applicable.**

4. Regarding the serving SN/Pscell dynamically change that mentioned in P5, is it similar scenario as the Figure 3/Proposal 1 mentioned in RWS-210449?

**4. We think the scenario is similar to ours. However, P1 of RWS-210449 explicitly indicates that the UE capability is not increased. In our proposal, the restriction of 2 ULs is assumed for Rel-18, and we are open for further discussion on the assumption of UE capability at this stage. Also, we are considering one-step further to keep two ULs while three DLs at a given time.**

5. Regarding inter-CU/Inter-DU coordination, is it similar as the one mentioned in RWS-210327?

**5. The different from RWS-210327 is that we are focusing on extension of dual connectivity (DC) to multi connectivity (MC), while RWS-210327 proposed an extension of CA with inter-DU interface. Our main reason of MC is that MC (also DC) assumes "non-ideal" backhaul interface while CA may assume "ideal" backhaul interface. Also, we are thinking of less-tight inter-CU/DU coordination in MC to reduce the complexity compared to the inter-gNB/gNB-DU coordination in RWS-210327. We think our MR-MC has less restriction on NW deployment.**

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**2 – Samsung Electronics Co.**

**2 – LG Electronics Inc.**

Thank you for the proposals.

**Q**: Regarding active UL CG switching, it is understood to split UL period between CGs in advance due to UE power limitation. If so, do you consider such switching is required for all MR-MC UEs? or is as per UE capability or power class?

**Thank you for your question. We are thinking a consideration of at most two ULs is a practical assumption for now which can avoid some issues such as uplink coverage loss due to power sharing and also UE complexity/burden. At this stage, we understand that the UE capability may be different, even for UEs supporting MR-MC. Thus, for the applicable UEs, we are open for the further discussion.**

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**3 – Samsung Electronics Co.**

**3 – MediaTek Inc.**

Thanks for the quality contribution. The fundamental goal of the proposals looks to ensure data continuity when SCG blockage/failure. Toward this goal, **if SCG to MCG switching can be made sufficiently fast, e.g., within 10 ms packet delay budget of CG/AR/VR services, existing DC framework of one MCG and one SCG can still be effective to ensure data continuity**. In this regard, we would like to first ask: **What is the fundamental goal for increasing SCG number and what is the critical gap existing DC mechanism cannot achieve?** We hope the answers to the above questions can help companies to identify the possible enhancement direction(s) with minimum impact to UEs and networks.

**Thank you for your comments and questions.**

**The first fundamental goal is to increase the peak throughput by aggregation of all frequency bands which the operator has. Nowadays, we have multiple frequencies and multiple RATs (i.e. LTE & NR), due to the restrictions of different coverages, different locations of gNBs/DUs, and different network entities (e.g. One DU covers only one frequency range), it has been not easy to utilize those frequencies/RATs by the UE smoothly and efficiently so far. Our second fundamental goal is to reduce interruption of SCG change. For example, we can consider an LTE-NR aggregation where LTE is MCG and NR is SCG. Data of large data rate is served by NR SCG and LTE MCG delivers only some of important data. Then, if the channel status of SCG is fluctuated due to, e.g., UE mobility, the current DC scheme may result in service interruption due to the SCG change. Thus, we are aiming at minimizing such interruption.**

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**4 – Samsung Electronics Co.**

**4 – Beijing Xiaomi Mobile Software**

Thanks for the proposals.

Some questions:

1) Does the 2 SNs connected by ideal backhaul? since you have new bearer types introduced, e.g.,SN1-terminated SCG2 bearer

**Thank you for your questions.**

**1) No, we want not to have "ideal" interface. DC does not assume such ideal BH. Our intention was to extend DC to MC with keeping the assumption of "non-ideal backhaul." Even in non-ideal backhaul, such bearer type can be possible. We just mentioned this bearer type as an example of possible extension.**

2) It seems for the uplink, UE's behavior is very complexed. UE need to select 1 SN for transmission. How UE selects the SN?

Since there are 3 legs for downlink and only 2 legs for uplink, does the PUCCH needs to forwarded from one node to another node? E.g., from MN to SN? What is the impact on none-ideal backhaul?

It seems there is huge sepc impact...

**2) The SN for uplink transmission is configured to UE by the network. We are thinking UL forwarding may be considered in some scenario with ideal backhaul and may require direct inter-gNB-DU interface**

**In case of UL switching, we are thinking at least in terms of dynamic UL switching in UE side, it is not much different from the existing UL switching schemes such as UL/SUL switching and/or UL Tx switching. Also, deterministic switching by pre-configured pattern can be possible. We think detail can be discussed in WGs.**

3) How to achieve dynamical SN change? Will some lay1 signaling introduced?

**3) Dynamic SN change can be supported by L1/L2 signaling or RRC signaling. At this time, we prefer RRC signaling-based solution by considering the impact to RAN2 specifications, but we're open for this. In Rel-17, the SCG (de)activation is under design, which can be considered as one of solutions to realize the dynamic SN change.**

**5 – Samsung Electronics Co.**

**5 – CATT**

We have one question for clarification:

here is the scope include that UE supporting more than 2 connections at the same time, as there might be concern on complexity vs gain....

**Thank you for your valuable comment.**

**Yes, we understand the concern on complexity. However, we have been questioned that operators have multiple frequency ranges and multiple RAT (LTE & NR) but only 2 connections are currently possible. For instance, LTE+FR1+FR2 aggregation is not easily implemented. That was our initial motivation and we'd like to seek a feasible way to support this extension.**

**6 – Samsung Electronics Co.**

**6 – HuaWei Technologies Co.**

Thank you for your comments and nice contribution.

Q: Can you please clarify what is the difference on dynamic switch for UL cell group and SCG?

**A: Dynamic UL switching is that only uplink is switched to support triple connectivity, whereas in SCG switching, active SCG is switched from one to another, e.g. to support SN change.**

Q: We have similar consideration in RWS-210449, and we think this can be applied to wider scenarios where we have multiple carriers deployment, which is not only for DC, what do you think?

**A: The intention of considering triple connectivity is to balance the potential gain and the complexity (especially on UE complexity), and we assume that at most two active ULs can be used. So, if the wider scenarios, e.g., more than triple connectivity, are identified under the acceptable complexity, we are open for this discussion. On the other hand, RWS-210449 assumes that the UE capability is not increased. At this moment, we are open for this, i.e., either increasing or not increasing can be further discussed during the WI stage.**

Q: Do you think the number of activated carriers/CGs has limitation?

**A: It depends on UE capability. Currently UE can have only two ULs over two cell groups, respectively. We'd like to keep this restriction but achieve further throughput enhancement and reliable connection with three cell groups. However, if the more than triple connectivity can be realized by the acceptable complexity, we are open for this discussion.**

**7 – Samsung Electronics Co.**

**7 – Intel Corporation (UK) Ltd**

<Intel>

Q1. Does multiple cell group (more than 2) require change on RAN4 basic assumption of UE implementation

that number of RF chains does not exceed 2?

**Thank you for the question.**

**We think we do not need to change two uplink RFs.**

**8 – Samsung Electronics Co.**

**8 – Nokia Corporation**

**Q1:** What is the main use case for the this: Intra-CU inter-DU, Intra-CU intra-DU or inter-CU?

**Thank you for your questions.**

**1. The Intra-CU/Inter-DU and inter-CU/inter-DU operation are our main use cases. For throughput enhancement, different DUs with different frequencies can be aggregated. For mobility, SCG switching between different DUs will be useful.**

**Q2:** What kind of DAPS is assumed for SN mobility, i.e. does UE retain connectivity to both source SCG and target SCG (i.e. triple connectivity)?

**2. Yes, we propose triple connectivity. And some enhancements would be required to support DAPS-like SN change with two uplink RFs in UE.**

**Q3:** Can the UL be switched to a different cell group while DL stays the same, or does the entire cell group change simultaneously?

**3. UL switching is being considered in a perspective of UE transmission. We don't consider some change of the entire cell group for DL reception. It remains unchanged if there isn't additional RRC configuration to change/modify cell.**

**Q4:** What are the RAN1 impacts of MR-MC if only two CGs are activate at the same time?

**4. We are thinking the following RAN1 impacts:**

**- UL switching: UL switching mechanisms**

**- UL forwarding: feedback information multiplexing to transmit via two ULs.**

**Q5:** Is the proposal to have DU-DU interface standardized? If so, are other new interfaces needed?

**5. It depends on uplink scenario. For uplink switching, direct DU-DU interface would not be needed and the inter-DU coordination can be supported via the existing RAN3 interfaces. For uplink forwarding, direct DU-DU interface may be needed.**

**9 – Samsung Electronics Co.**

**9 – Lenovo (Beijing) Ltd**

Thanks for your paper.

Q1: The maximum number of SCG is 2 in Rel-18?

**Thank you for your valuable comments and questions.**

**1. Right. We think the maximum number of SCG is 2 in Rel-18. Moreover, we assume that the UE can have 2 active ULs at a time at most. However, if more than triple connectivity with 2 active ULs at most can be realized by the acceptable complexity, we are open for this discussion.**

Q2: Can you elaborate Serving SN/ Pscell can dynamically change among the pre-configured SNs/ Pscells?

Is it CPC-like? UE triggers to change based on the condition configured by gNB.

**2. Right. UE triggers to change serving SN/PSCell based on the condition configured by gNB, however the candidate SN configuration can be maintained even after serving SN is changed. And dynamic SN change can be supported by L1/L2 signaling or RRC signaling. At this time, we prefer RRC signaling-based solution by considering the impact to RAN2 specifications impact, but we're open for this.**

Q3: What is fast data forwarding among serving nodes (e.g., user plane interface between gNB DUs)? Is new interface between DUs introduced for data forwarding?

**3. The fast data forwarding can be applied between two DUs during the SCG change. Specifically, if the UE is switched to DU2, the un-transmitted data packets buffered at DU1 can be directly forwarded to DU2 so that DU2 can continuously send packets to UE. This procedure can reduce the service interruption. Since this data forwarding is referring to user plane, there may not need to define a new interface (e.g., define a new RAN3 specification) for the aspect of the fast data forwarding.**

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**10 – Samsung Electronics Co.**

**10 – Qualcomm CDMA Technologies**

For support of cross cell group feedback in the UL (Slide 4) is it required to introduce inter gNB-DU interfaces in the standards?

**Thank you for the question. Yes. For uplink forwarding, we think direct inter-gNB-DU interface may be needed. However, for uplink switching, direct inter-gNB-DU interface would not be needed and the inter-gNB-DU coordination can be supported via the existing RAN3 interfaces.**

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**11 – Samsung Electronics Co.**

**11- China Telecommunication Corp.**

[China Telecom] Thanks for the proposals. We have a few questions as below.

Q1: What is the use case or motivation of SN1-terminated SCG2 bearer in P3? Does the 2 SNs connected by ideal backhaul or non-ideal backhaul?

**Thank you for the questions.**

**1. It's for flexibility. If we have three nodes/CGs, there is no need to exclude such flexibility. A use case is for instance, network slicing, different slices may use different termination nodes, e.g. SN1-terminated bearer for slice 1 and SN2-terminated bearer for slice 2. In this case, SN1-terminated bearer may use SCG2 resource.**

**We think this bearer type is independent of ideal/non-ideal backhaul. Even in current MR-DC structure, SN-terminated MCG bearer and MN-terminated SCG bearer are possible, irrespective of ideal/non-ideal interface.**

Q2: What are the use cases or scenarios of UL switching and UL forwarding in P4? For UL forwarding between SNs, whether new interface between DUs is needed?

**2. - UL forwarding requires faster or almost ideal inter-DU interface. Thus, it's more appropriate for co-location of those DUs or ideal backhaul. We agree UL forwarding may require a new inter-DU interface.**

**- UL switching can be considered when the inter-DU interface is non-ideal or does not exist. The major target scenario is to support peak throughput by aggregation of all available frequency ranges.**

## 7.3 Round 2 Question

**Feedback Form 17:**

**1 – HuaWei Technologies Co.**

Thanks for your answer. We understand if it is only for UL switch as per your proposal, when we have triple connectivity, the UE supports 3 activatated DL CGs but only 2 UL CGs? And we then understand this principle of fast switch can also be applied to other multiple carriers cases, e.g. CA, SUL, do you agree?

**2 – China Telecomunication Corp.**

Thanks for your answer. Multi-connectivity and fast SCG activation/ deactivation are also our interests for Rel-18.

## 7.4 Round 2 Answer

**Feedback Form 18:**

**1 – Samsung Electronics Co.**

**HuaWei Technologies Co., Ltd**

# 1

Thanks for your answer. We understand if it is only for UL switch as per your proposal, when we have triple connectivity, the UE supports 3 activatated DL CGs but only 2 UL CGs? And we then understand this principle of fast switch can also be applied to other multiple carriers cases, e.g. CA, SUL, do you agree?

[Samsung] Thank you for your further questions and comments. Yes, for both UL switching and UL forwarding, we assumes UE supports three activated DL CGs and two activated UL CGs at a time.

We think the principle of fast switching can be applied to other cases of multiple carriers. However, CA/-SUL already assumes tight synchronization with ideal backhaul interface, so we think the UL switching may not be needed to support CA/SUL. Our main motivation of multi-connectivity is the aggregation of multiple nodes connected with non-ideal inter-node interface.

**2 – Samsung Electronics Co.**

**China Telecomunication Corp.**

# 2

Thanks for your answer. Multi-connectivity and fast SCG activation/ deactivation are also our interests for Rel-18.

[Samsung] Thank you for your interest and kind feedback.

# 8 Summary

We would like to thank all the companies for their careful reviews and good questions. This process helps us to gauge interest and level of importance across companies on different topics.

**- RWS-210180 XDD (cross-division duplex) for enhanced duplexing operation in 5G Advanced.**

17 companies participated in the 1st round discussion for XDD and 8 companies participated in the 2nd round discussion.

. 5 companies asked about XDD operations in FR1 and FR2, we replied that XDD can be operated for both intra and inter-CC with the same logic and also be used for both FRs depending on available bandwidth and CC segmentation.

-8 companies asked about the necessity of RF/HW requirements for gNB and/or UE, we replied that while these questions should be evaluated as part of the RAN4 RF & coexistence study for XDD, we think it is very desirable that ACLR and ACS for R18 half-duplex UEs remain the same as R15.

-7 companies asked about cross-link interference handling for XDD, we replied that CLI can be enhanced for L1/L2 based reporting and others if needed.

-4 companies asked about implementation and deployment complexity for XDD, we replied the possibility of complexity growth for handling self-interference cancellation at the gNB implementation and also needs of UL subband coordination between cells for cross-link interference handling.

-2 companies asked about the needs for using the guard-band between UL and DL subband, we replied that depending on implementation, the guard-band may not be necessary.

-2 companies asked about semi-static and dynamic XDD operation, we replied that both options are possible for XDD supports on top of Rel-17 NR supporting BWP and dynamic TDD.

We discussed various issues necessary from the viewpoint of RAN1 and RAN4, and most prefer to support without changing the UE size, and we have a consensus that duplex improvement is necessary to consider a realistically deployments.

From companies' interests on duplex enhancement, there is a clear interest/need and TSG-RAN needs to continue discussing the possible enhancement of duplex including at least target scenarios, interference handling, applicable spectrums, requirements, and more.

**- RWS-210181 On Rel-18 NR MIMO enhancements for 5G Advanced**

Four items are identified in RWS-210181:

-Multi-beam: Continuing/completing Rel-17 enhancements on unified TCI (e.g. extended support for mTRP beam indication and inter-cell beam management) and advanced beam refinement/tracking

-Distributed MIMO: CSI enhancement for DL, inter-RRH calibration

-Multi-TRP: Asynchronous cases, simultaneous RX/TX including across different channels

-High-resolution CSI: Doppler-domain compression, CSI for less structured antenna arrays

In round 1, 23 companies have participated with questions and/or comments. In round 2, 10 companies followed up with additional questions and/or comments. Per-item breakdown is as follows:

-Multi-beam: At least 11 companies have participated. In general, companies affirm the need for extending/completing the Rel-17 unified TCI and faster beam switching via reducing overhead/latency of beam measurement/reporting. Adding higher-layer support for L1/L2-centric inter-cell mobility is echoed by some companies while not supported by at least one company.

-Distributed MIMO: At least 19 companies have participated. Operators have voiced support on the need for enhancements for sub-1GHz bands using the distributed antenna architecture. Companies inquire on the presented results in RWS-210181 (slide 4) and other aspects of codebook design. Questions on inter-RRH synchronization requirements, backhaul assumptions, and inter-RRH calibration support were also asked. Finally, a few questions on the scope for D-MIMO in Rel-18 were asked.

-Multi-TRP: At least 8 companies have participated mostly inquiring on simultaneous TX/RX across multiple TRPs.

-High-resolution CSI: At least 6 companies have participated. The response to 'explicit' feedback is in general inquisitive or skeptical, while the response to Doppler-domain compression for Type-II CSI is mixed.

Based on the feedback from the participating companies:

-There is a clear interest/need for multi-beam enhancements, at least to extend/complete Rel-17 unified TCI (e.g. for mTRP beam indication) and specify features to facilitate faster beam switching with lower overhead/latency beam measurement/reporting. Such works can be perceived as carry-over from Rel-17 on multi-beam

-There is a clear interest for sub-1GHz band enhancements with distributed antenna architecture. The scope of this work in Rel-17 needs further discussion. Considering that this is a new item, assumptions on relevant deployment scenarios and use cases will need to take place.

**- RWS-210182 High-speed Packetization for 5G Advanced**

For PDCP concatenation, several companies asked its impact on legacy procedures, e.g. CA, DC, split bearer, and so on. Given that the pseudo SDU constructed by PDCP concatenation can be regarded as a large PDCP SDU in legacy, no critical impacts is foreseen. Regarding RLC segmentation, it was further clarified that RLC segmentation can be optimized to have fixed-sized RLC header regardless of segmentation, e.g. by removing SO field. Considering the benefit between them, it would be good to prioritize PDCP concatenation, if needed.

**- RWS-210183 Multi-RAT Multi-connectivity (MR-MC) for 5G Advanced**

11 companies participated in the 1st round discussion and 2 companies participated in the 2nd round discussion. We have been asked various questions including:

-5 companies asked about our target scenario and use case, and we replied that we are mainly considering multiple cell groups (multiple DUs) where those corresponding nodes are connected via "non-ideal backhaul", and UE's uplink cell group or DL&UL CG is dynamically switched.

- 4 companies asked about the necessity of a standardized inter-DU interface. We replied the inter-DU interface is required for uplink forwarding whereas it's not required for uplink switching.

- 3 companies asked the number of active (uplink) cell groups and UE capability. We replied we assume not to change the current limitation of two uplink cell groups but we are open to further discuss the capability issue in WI phase.

- 2 companies asked how dynamic (uplink) CG switching is achieved. We replied RRC signaling-based switching is preferred by considering the impact on RAN2 specifications, but we are open to other solutions for now.

We received no serious concern on our proposals. The scope in detail and standardization impact can be further discussed based on the understanding from this discussion.