3GPP TSG RAN WG1 #110 R1-220xxxx

Toulouse, France, August 22nd – 26th, 2022

Source: Moderator (OPPO)

Title: Summary on Rel-18 STxMP

Agenda Item: 9.1.4.1

Document for: Discussion and Decision

# Introduction

The Rel-18 WID for MIMO Evolution for Downlink and Uplink includes the following objectives:

1. Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, focusing on FR2 and multi-TRP, assuming up to 2 TRPs and up to 2 panels, targeting CPE/FWA/vehicle/industrial devices (if applicable)
	* UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
		+ The total number of layers is up to four across all panels and total number of codewords is up to two across all panels, considering single DCI and multi-DCI based multi-TRP operation.

This document summarizes the company proposals of AI 9.1.4.1 and further updates/views:

1. Summary of companies’ views

## single-DCI based STxMP PUSCH

**Tabel 1-A: summary of issues on S-DCI based STxMP PUSCH:**

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1.1 | **[109e]Agreement**For STxMP PUSCH in single-DCI based mTRP system, study and evaluate the following schemes for PUSCH:* SDM scheme: different layers/DMRS ports of one PUSCH are separately precoded and transmitted from different UE panels simultaneously.
	+ Study and evaluate whether to support 2 CWs in SDM manner and transmitted from two different panel simultaneously.
* FDM-B scheme: two PUSCH transmission occasions with same/different RV of the same TB are transmitted from different UE panels on non-overlapped frequency domain resources and the same time domain resources.
* FDM-A scheme: different parts of the frequency domain resource of one PUSCH transmission occasion are transmitted from different UE panels.
* SFN-based transmission scheme: all of the same layers/DMRS ports of one PUSCH are transmitted from two different UE panels simultaneously.
* SDM repetition scheme: two PUSCH transmission occasions with different RV of the same TB are transmitted from two different UE panels simultaneously.

Note: Companies are encouraged to evaluate the different schemes for possible down-selection in RAN1#110.Note: other schemes are not precluded | **Which one(s) of those schemes do you support to specify in rel-18?**SDM scheme:* **Support**: ZTE, Qualcomm, vivo, DOCOMO, CATT, Intel, Xiaomi, (Samsung (low priority)(if justified)), IDC, Spreadtrum, google, Lenovo, OPPO, LG, CMCC, Fraunhofer, Nokia, MTK, NEC
* **Not support**: Huawei, HiSilicon

FDM-B scheme:* **Support**: ZTE, Qualcomm, vivo, DOCOMO, MTK, CATT, Intel, Xiaomi, (Samsung (if justified)), IDC, Lenovo, OPPO, CMCC, Fraunhofer, Nokia, NEC
* **Not support**: Ericsson, Huawei, HiSilicon

FDM-A scheme:* **Support**: ZTE, Qualcomm, vivo, MTK, CATT, Intel, Xiaomi, (Samsung (if justified)), IDC, Lenovo, Fraunhofer,
* **Not support**: Ericsson, Google, Huawei, HiSilicon

SFN-based transmission scheme:* **Support**: ZTE, vivo, Qualcomm (lower priority), MTK, CATT, Intel, Xiaomi, (Samsung (low priority)(if justified)), IDC, Huawei/HiSilicon (high priority), Spreadtrum, OPPO, LG, Fraunhofer, Nokia, Lenovo
* **Not support**: Ericsson, Huawei, HiSilicon

SDM repetition scheme:* **Support**: ZTE, Intel, Xiaomi, IDC, Fraunhofer, NEC
* **Not support**: MTK, Ericsson, Qualcomm, Lenovo, Huawei, HiSilicon
 |
| 1.2 | **[109e]Agreement**For STxMP PUSCH in single-DCI based mTRP system, study and evaluate the following schemes for PUSCH:* SDM scheme: different layers/DMRS ports of one PUSCH are separately precoded and transmitted from different UE panels simultaneously.
	+ Study and evaluate whether to support 2 CWs in SDM manner and transmitted from two different panel simultaneously.

…**Q: Whether to support 2CW in SDM scheme?*** Alt A: support 2 CW in SDM scheme
* Alt B: not support 2 CW in SDM scheme, i.e., only 1 CW in SDM scheme
 | **Which one of these two Alt do you support on 2 CW in SDM?*** **Alt A:** ZTE, DOCOMO, CATT, Xiaomi, IDC, CMCC, Lenovo
* **Alt B:** Qualcomm, vivo, MTK, Intel, Ericsson, Nokia,Spreadtrum, Google, Fraunhofer, LG, Samsung
 |
| 1.3 | [109e] **Agreement**Study the layer combinations of {1+1, 1+2, 2+1, 2+2} for the SDM scheme (if supported) of single-DCI based STxMP PUSCH,* This is for 1 CW at least.
* The layer combination for the SDM scheme can be further studied for 2 CW if 2 CW in SDM scheme is supported.
* FFS: study the layer combinations of {1+3, 3+1} under the above conditions.
* Companies are encouraged to provide SLS/LLS for their proposed layer combinations for the SDM scheme of single-DCI based STxMP PUSCH.

The following two options for layer combination for SDM scheme are provided in tdocs:* Option 1: 1+1, 1+2, 2+1, 2+2,
* Option 2: 1+1, 1+1, 2+1, 2+2, 1+3, 3+1.

FL Note: Looks like layer combination 1+1, 1+2, 2+1 and 2+2 are common understanding in tdocs and the issue here is whether 1+3 and 3+1 are supported additionally.**Proposal 1.C** For STxMP PUSCH SDM scheme, support the layer combinations of {1+1, 1+2, 2+1 and 2+2}. Regarding the 1+3 and 3+1, there are two Alternatives:* Alt-A: not support 1+3 and 3+1
* Alt-B: support 1+3 and 3+1.
 | **Proposal 1.C:*** **Alt-A**: MTK, Fujitsu, google, OPPO, Qualcomm, Sharp, Nokia
* **Alt-B**: ZTE, Intel, Xiaomi, CMCC (only if 2 CW is supported),Spreadtrum, Lenovo, IDC, LG
 |
| 1.4 | [109e] **Agreement**Study if any enhancement is needed on DMRS port indication for the SDM scheme (if supported) of single-DCI based STxMP PUSCH * FFS how to map DMRS ports to two joint/UL TCI states/CWs/panels/TRPs/SRS resource sets/PUSCH layers for codebook-based and non-codebook based PUSCH respectively.

**On enhancement on port indication to support layer combination in SDM scheme of STxMP PUSCH transmission,** **we have the following 3 options for port indication enhancement**:* **Option 1**: reuse the current DCI field “Antenna ports” to indicate two different CDM groups for PUSCH transmission associated with the 1st SRS resource set and the 2nd SRS resource set. The sum of ranks of two panels is used to determine the DMRS port indication table. Add new entry (0,2,3) in port table for rank combination 1+2.
* **Option2**: DMRS ports of two panels can be in same or different CDM group. Rank combination indicated to the UE is used to partition the ports to two panels, for example as a new column in DMRS port indication table.
* **Option 3**: introduce a second “Antenna ports” field to indicate the ports for PUSCH associated with the 2nd SRS resource set.
 | **Port indication enhancement:*** **Option 1:** vivo, DOCOMO, MTK, Xiaomi(lower priority), Spreadtrum, OPPO, Fujitsu, Google, Lenovo, Fraunhofer, Nokia
* **Option 2:** Xiaomi
* **Option 3:** OPPO
 |
| 1.5 | [109e] **Agreement**Study the enhancement of SRS resource set configuration and SRI/TPMI indication for single-DCI based STxMP PUSCH scheme:* The configuration of two SRS resource sets, SRS resource set indicator field, two SRI fields and two TPMI fields of Rel-17 mTRP PUSCH TDM repetition is the starting point.
* FFS: The configuration of one SRS resource set, one or two SRI fields and one or two TPMI fields
* Note: This proposal does not mean that any possible SRI/TPMI enhancement on STxMP would be precluded. In RAN1#110, companies can suggest the detail SRI/TPMI enhancement with reasonable analysis and evaluation result.

**Q1: The following options for SRI/TPMI indication for SDM scheme were provided in tdocs**:* Option 1-1: Configure two SRS resource sets for PUSCH. reuse the two SRIs field, two TMPI field in current DCI to indicate SRS resources and precoding/rank for PUSCH from two panels. For CB PUSCH, each TMPI field separately indicates precoding and number of layers for each panel. For nonCB PUSCH, each SRI field separately indicates the SRS resources and number of layers for each panel.
* Option 1-2: configure one SRS resource set. one SRI is used to indicate a pair of SRS resources. One TPMI indicates a precoding matrix across all SRS ports associated with indicated SRS resources or two TPMIs associated with each indicated SRS resource are indicated.
* Option 1-3: Configure two SRS resource sets for PUSCH. reuse the two SRIs field, two TMPI field in DCI to indicate SRS resources and TPMI for PUSCH from two panels. For CB PUSCH, each TMPI field separately indicates only the precoding for each panel. For nonCB PUSCH, each SRI field separately indicates only the SRS resources for each panel. The number of layer per panel is indicated by the “antenna ports” field described in issue#1.4 Option.2.

**Q2: The following option for SRI/TPMI indication for FDM-A/B scheme were provided in tdocs**:* Option 2-1: Reuse the rel17 two SRI fields, two TPMI field signaling method for FDM-A/B scheme. Same number of layers is applied to both PUSCH repetitions in FDM-B scheme.
* Option 2-2: Configure one SRS resource set, one SRI indicating a pair of SRS resources, one TPMI indicating a precoding matrix across all SRS ports associated with indicated SRS resources or two TPMIs associated with each indicated SRS resource

**Q3: The following options for SRI/TPMI indication for SFN scheme is provided in tdocs:*** Option 3-1: Reuse the rel-17 signaling method: two SRS resource sets are configured, two SRI and two TPMI fields in DCI are reused/indicated for two panels.
* Option 3-2: configuration of one SRS resource set, on SRI field and one TPMI field in DCI
* Option 3-3: Two SRI fields and one TPMI are indicated
 | **Q1: SRI/TPMI indication for SDM scheme****Option 1-1:** ZTE, vivo, Qualcomm, DOCOMO, MTK, CATT, Xiaomi(lower priority), Samsung, Spreadtrum, google, Fujitsu, OPPO, LG, Apple, Fraunhofer, IDC, NEC, Nokia**Option 1-2:** Samsung, Nokia, Lenovo, LG, NEC**Option 1-3: Xiaomi****Q2: SRI/TPMI indication for FDM-A/B scheme:****Option 2-1:** ZTE, Qualcomm, DOCOMO, MTK, Fujitsu, google, OPPO, Lenovo, Fraunhofer, IDC, Samsung, Nokia, CATT**Option 2-2:** Samsung, Nokia, Lenovo**Q3: SRI/TPMI indication for SFN scheme:****Option 3-1:** OPPO,Spreadtrum, Fraunhofer, LG, Nokia, CATT**Option 3-2:** MTK, Nokia, LG**Option 3-3:** Fujitsu |
| 1.6 | The issue of frequency resource partition for FDM-A/B scheme were discussed in tdocs and the following two options were presented in tdocs:* **Option 1**: PRB-based partition for both Allocation Type 0 and Allocation Type1. For example, first ⌈n\_PRB/2⌉ PRBs are assigned to PUSCH associated with 1st SRS resource set and the remaining PRBs are assigned to PUSCH associated with 2nd SRS resource set.
* **Option 2**: use RBG-based partition for Allocation Type 0 (for example, partition into even RBGs and odd RBG, for example, partition into the first half of RBGs and second half of RBGs) and use PRB-based partition for Allocation Type 1.
 | **On the frequency domain resource partition for FDM A/B scheme, which option do you support?*** **Option 1:** DOCOMO, Qualcomm. Lenovo, OPPO, Apple, Nokia,Xiaomi
* **Option 2:** MTK, Lenovo, OPPO
 |
| 1.7 | The issue of enhancement PTRS for STxMP PUSCH SDM scheme is discussed in tdocs and following proposal is proposed**Proposal 1.G**: Support 2 PTRS ports in SDM scheme of STxMP PUSCH and Enhance the PTRS-DMRS association to associate each PTRS port with one DMRS port associated with each SRS resource set, * For example, 1st bit in PTRS-DMRS association indicates the DMRS port associated PTRS port 0 and 2nd bit in PTRS-DMRS association indicates the DMRS port associated with PTRS port 1.
 | **Proposal 1.G:*** **Support:** Qualcomm, vivo, Intel, Lenovo, Google, DOCOMO, MTK, NEC, Nokia
* **Not support:**
 |
| 1.8 | The issues of switching/configuring STxMP schemes:**1.8 Q1: How to switch/configure between STxMP schemes**:* Option 1-1: semi-statically configured in RRC
* Option 1-2: dynamic switch/indication through DCI

**1.8 Q2: How to switch between STxMP and single-panel transmission**:* Option 2-1: semi-statically configured in RRC
* Option 2-2: support dynamic switch in DCI and use the SRS resource set indicator in DCI to indicate single-panel transmission or STxMP transmission.

**1.8 Q3: How to switch between STxMP scheme and Rel-17 TDM-based repetition schemes**:* Option 3-1: semi-statically configured in RRC
* Option 3-2: dynamic switch through DCI, e.g., based on the indicated repetition number.
* Option 3-3: Support to configure STxMP scheme and Rel-17 TDM-based repetition scheme on the same PUSCH simultaneously
 | **1.8 Q1:****Option 1-1:** ZTE, vivo, Spreadtrum, OPPO, Fraunhofer, Lenovo**Option 1-2:** MTK, Xiaomi, LG, NEC, Nokia**1.8 Q2:** **Option 2-1:** **Option 2-2:** ZTE, Qualcomm, vivo, MTK, Xiaomi, Samsung, IDC, Fujitsu, Huawei/HiSilicon, OPPO, Google, DOCOMO, Lenovo, Fraunhofer, LG, NEC**,Nokia****1.8 Q3:****Option 3-1:** ZTE, OPPO, Google (CG-PUSCH)**Option 3-2:** vivo, MTK, Fujitsu, Google (DG-PUSCH), NEC, Samsung (based on indicated TCI states), Nokia**Option 3-3:** LG |

Observations….

Draft proposals….

Table 1B: additional inputs: the issue of single-DCI based STxMP PUSCH

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check and input/update your views in Table 1A.**
2. **Share additional inputs/Alts here, if needed**
3. **Draft proposals/updates will be provided in next version later based on the collected views.**
 |
| Xiaomi | Thanks FL for the efforts. It seems one of our proposals is missing here for #1.5, and an option is added as below.**Q1: The following options for SRI/TPMI indication for SDM scheme were provided in tdocs**:* Option 1-1: Configure two SRS resource sets for PUSCH. reuse the two SRIs field, two TMPI field in current DCI to indicate SRS resources and precoding/rank for PUSCH from two panels. For CB PUSCH, each TMPI field separately indicates precoding and number of layers for each panel. For nonCB PUSCH, each SRI field separately indicates the SRS resources and number of layers for each panel.
* Option 1-2: configure one SRS resource set. one SRI is used to indicate a pair of SRS resources. One TPMI indicates a precoding matrix across all SRS ports associated with indicated SRS resources or two TPMIs associated with each indicated SRS resource are indicated.
* Option 1-3: Configure two SRS resource sets for PUSCH. reuse the two SRIs field, two TMPI field in DCI to indicate SRS resources and TPMI for PUSCH from two panels. For CB PUSCH, each TMPI field separately indicates only the precoding for each panel. For nonCB PUSCH, each SRI field separately indicates only the SRS resources for each panel. The number of layer per panel is indicated by the “antenna ports” field described in issue#1.4 Option.2.
 |
| Google | Our views are provided |
| NTT DOCOMO | For Issue1.8, we think it can be discussed after the scheme of STxMP is decided. And if multiple schemes are supported, for Q1/Q3, different option may be considered for switching between different schemes. For example, in M-TRP PDSCH, FDM-A and FDM-B can be switched by RRC, SDM and other schemes can be dynamically switched by CDM group, TDM and other schemes can be switched by repetition number. Thus, in our view, after it is decided which one or multiple STxMP schemes are supported, whether the switching between each two schemes is semi-static or dynamic can be further discussed.  |
| QC | 1.4: We support Option 1 with the following modification:* **Option 1A**: reuse the current DCI field “Antenna ports” to indicate DMRS ports associated with both panels. The sum of ranks (r1+r2) of two panels is used to determine the DMRS port indication table, and the r1/r2 DMRS ports are mapped to first/second panels.

We do not see the need to add a new DMRS port entry, or the need for restriction that two CDM groups should be used. This is UL, and, both scheduling and channel estimation is performed by the network. Hence, it is up to the network whether DMRS ports are in different CDM groups or not.1.5, Q3: For SFN, there could be other alternatives. If SRS itself is also SFN, then SFN PUSCH can be Rel-15-based (transparent). In this case, the enhancement would be applicable to SRS transmission itself.1.6: Can companies clarify how Option 2 can work for UL? RBs (per panel) need to be continuous. Also, we do not support option 1, but we think for RA Type 1, using similar mechanism as intra-slot frequency hopping makes more sense as it ensures that the two sets of RBs have always the same size. RA Type 0 and RA Type 2 can be discussed with lower priority as the main RA Type for UL is Type 1.1.8: Q1 and Q3: We support RRC; For Q2: We support dynamic, but the following 2 cases needs to be considered as we described in our contribution, which impacts the details of SRI/TPMI indication* Case 1: Maximum number of PUSCH layers associated with one SRS resource set is the same irrespective of whether the PUSCH is associated with one SRS resource set (sTRP) or two SRS resource sets (STxMP).
	+ Example: With up to 1+1 layers for STxMP, sTRP with up to 1 layer can be scheduled.
* Case 2: Maximum number of PUSCH layers associated with one SRS resource set depends on whether the PUSCH is associated with one SRS resource set (sTRP) or two SRS resource sets (STxMP).
	+ Example: With up to 1+1 layers for STxMP, sTRP with up to 2 layers can be scheduled.
 |
| Lenovo  | We suggest that issue 1.8 should be discussed when all the supported STxMP schemes are agreed. In this early stage, it’s hard to decide which signal should be used for the switching among different schemes. |
| MediaTek | Issue 1.4: We think that applying the mapping between CDM groups and SRS resource sets for SDM scheme has less spec effort and less indication overhead, which has been already used in Rel-16. For QC’s proposal, port to layer mapping should be one-to-one, and that is feasible for non-codebook-based UL but not for codebook-based UL (port to layer mapping can be many-to-1).Issue 1.5: Agreed with QC. Option 3-2 supported by us has the same concept to achieve SFN-based SRS transmission, and SFN-based PUSCH will be transparent (one SRI and one TPMI is needed). Issue 1.6: We think RBG-based partition can be used for Allocation Type 0 as well as Type 1. Based on current UL resource allocation rule, when *resourceAllocationType1GranularityDCI-0-2* is configured and the PUSCH is scheduled by DCI format 0\_2, the frequency-domain resource allocation is RBG-based. Hence, we suggest modifying option 2 as follows:**Option 2**: use RBG-based partition for Allocation Type 0 and Type 1 if *resourceAllocationType1GranularityDCI-0-2* is configured and the PUSCH is scheduled by DCI 0\_2(for example, partition into even RBGs and odd RBG, for example, partition into the first half of RBGs and second half of RBGs) and use PRB-based partition for Allocation Type 1.In addition, could QC elaborate more about why allocated RBs should be continuous? |
| Fraunhofer IIS/HHI | Updated our views in the table |
| InterDigital | Our inputs are added in the table. |
| Intel | For issue 1.4, we think the number of CDM group for different STxMP PUSCH schemes can be decided first, and then the design of DMRS port indication could be discussed in detail.For issue 1.8, we share similar view with DCM and Lenovo that the dynamic switching can be discussed after the transmission schemes are determined.  |
| LG | * Issue 1.1

Considering that the objective of this AI is to enhance UL throughput and reliability, at least two schemes need to be supported.* Issue 1.4

We support Option 1A suggested by QC.* Issue 1.5

Q1: Regarding Option 1-1, if we “reuse the two SRIs field, two TMPI field in current DCI”, we cannot indicate different RI for each panel because the field size of 2nd SRI/TPMI in current DCI is reduced assuming the same rank as 1st SRI/TPMI. Maybe it can be simply resolved with revised wording “use the two SRIs field, two TMPI field in DCI”. Also, in order to save DCI overhead we also support Option 1-2.Q3: We support Option 3-1 for SFN STxMP and Option 3-2 for coherent SFN STxMP.* Issue 1.7

It depends on whether 1+3, 3+1 layer combination is supported.* Issue 1.8

Q1: Support Option 1-2 for dynamic switching between eMBB STxMP and URLLC STxMP. In Rel-16, MTRP PDSCH schemes, i.e., between eMBB scheme and URLLC scheme, can be dynamically switched based on # of CDM groups or # of repetition. Q3: Option 3-3 can be discussed separately. Q3 is about how to switch but Option 3-3 is about whether to support simultaneous configuration for STxMP and TDM repetition so they are different issue. Regarding switching, we support Option 3-2. |
| NEC | Our inputs are provided in the table. |
| Samsung | **STx2P schemes**First, we are open for listed schemes. However, justification of each scheme should be preceded. In our current evaluation with LLS, we could not see the huge benefit. After justifying the benefit of STx2P schemes and usage cases, we can support some of schemes. **Switching between STx2P PUSCH and Rel-17 TDM PUSCH**If STx2P PUSCH is supported after checking benefit, we think Option 3-2 can be available. One possible way to support this switching is to check whether two indicated TCI states are for STx2P or not. According to group based beam reporting, certain TCI state pairs can be used for STx2P (e.g. beam pair in the same group) or other TCI state pairs are only used for TDM based repetition. Each TCI state codepoint can indicate different pair and depending on indicated TCI state pair, switching between STx2P PUSCH and TDMed PUSCH repetition can be supported. |
| NTT DOCOMO2 | (More input is added here)For issue 1.1, we support SDM scheme and FDM-B which are beneficial for throughput and reliability, respectively. For issue 1.2, we support 2CW which is beneficial when different MCS is needed for two panels/TRPsFor issue 1.4, we support option1. Considering there may be multiple options for the mapping between DMRS ports and panels, one possible way is that we can first decide that the current DCI field “Antenna ports” is reused and the sum of ranks of two panels is used to determine the DMRS port indication table, and to further study the mapping between DMRS ports and panels.For issue 1.6, we support option1. We would like to understand the benefit of option2. In our understanding, even if the frequency domain allocation is RBG based, option1 is applicable. And compared to PRB based resource partition, RBG based resource partition for two panels may lead to larger difference between the size of two sets of RBs. |
| Nokia/NSB | Our views are added. Issue 1.1: Related to question on specification in Rel-18, we support SDM, FDM-B and SFN schemes. Regarding to FDM-A, it requires further analysis on its feasibility both in terms of performance and network complexity. Issue 1.2: In addition to Alt B and we are fine to study further Alt A,Issue 1.3: Support Alt-AIssue 1.4: Support Option 1Issue 1.5: OkIssue 1.6: Support Option 1Issue 1.7: Support Proposal 1.GIssue 1.8. Support Options 1-2, 2-2 and 3-2  |
| CATT | For issue 1.4, we prefer to use one “Antenna ports” field to indicate DMRS ports for the two panels. We are fine to discuss whether forcing DMRS ports of two panels in different CDM groups or allowing DMRS ports of two panels in the same or different CDM groups. For option 1, discussion on whether adding new entry (0,2,3) in port table for rank combination 1+2 is needed since TRI is indicated by “precoding information and number of layers” field(s), the entry for 2+1 may also be used for combination 1+2. For option 2, adding rank combination indicated to the UE is not needed since rank combination of the two panels can be indicated by “precoding information and number of layers” field(s).For issue 1.5, we propose a unified SRI/TPMI indication method for SDM/FDM/SFN schemes to facilitate flexible switching between these schemes. In the unified indication framework,* Configure two SRS resource sets for PUSCH. Reuse the two SRI~~s~~ fields, two TMPI fields in current DCI to indicate SRS resources and precoding/rank for PUSCH from two panels. For CB PUSCH, each TMPI field separately indicates precoding and number of layers for each panel/layer group/transmission occasion. For nonCB PUSCH, each SRI field separately indicates the SRS resources and number of layers for each panel/layer group/transmission occasion.
 |
| Xiaomi | For issue#1.1, we think SFN scheme needs to be justified, but can be introduced together with the support of STxMP for PUCCH. FDM-B and SDM can be prioritized, and SDM repetition and FDM-A can be considered to support for more flexibility.For issue#1.4, agree with QC that to restrain the DMRS ports of different panels from allocating within different CDM group(s) for S-DCI case is not needed, and more discussion is needed. Option 1A and Option.2 are both schemes according to this principle. To my understanding, the difference is that for Option 1A the rank combination for SDM can be got from the SRI/TPMI fields’ indication of both TRIs,i.e.,r1/r2, and for Option 2 the rank combination can be indicated by reusing extra reserved codepoints in Antenna ports field. Only rank 3 is needed for the extension without any extra overhead, and rank 4 is needed if the support of {1+3, 3+1} is agreed.With the derived rank combination, r1 and r2 are not needed to be indicated by the two SRI/TPMI fields, so option.3 is a natural choice for SDM case for issue1.5 Q1. Similar design is the second SRI/TPMI which only indicated SRI/TPMI without indicating TRI for TOs related to the second TRP considering of the DCI overhead reduction of 1-2bits. So with Option 2, at least 2 bits could be saved. Also whether different codebook configuration per panel can be separately configured or not is related to all the designs in our view, which means the SRI/TPMI mapping table can be different per panel.For Issue 1.8, it would be good to have the transmission schemes agreed first. From our point of view, we think dynamic switching can benefit both the UE and the NW which can achieve a similar level of support as Rel-16 DL MTRP.  |
| Huawei, HiSilicon | **1.1:** Regarding s-DCI based STxMP schemes in 1.1, we think that, following the WID, “UL precoding indication for PUSCH” and “UL beam indication for PUCCH/PUSCH” for such schemes may be specified only if a considerable performance gain is verified by SLS/LLS in comparison with the baseline TxSP. To our understanding, among the 25 companies that submitted their t-docs to this AI, only 8 companies provided any LLS/SLS results to compare the performance of a STxMP scheme and the baseline:* + For SDM STxMP, 7 companies provided SLS results
		- 6 companies (ZTE, OPPO, MTK, Ericsson, QC, DCM) showed some performance gain for low (20-30 %) traffic load
		- No company showed a performance gain for higher traffic loads,
		- 3 companies (Ericsson, MTK, HW) showed performance loss for higher traffic (eg >= 30%).
	+ For SFN STxMP, 1 company (LGE) provided SLS results and showed performance gain
	+ For SFN STxMP, 2 companies (DCM, HW) provided LLS results and showed performance loss compared to the baseline.
	+ For FDM STxMP, 3 companies (ZTE, HW, DCM) provided LLS results and no company observed a performance gain compared to the baseline.

For SDM repetition STxMP, 1 company (ZTE) provided LLS results with a similar performance to the baseline In our view, from above results, we can draw following conclusions: 1. Only a limited number of companies (less than 30%) provided any SLS/LLS results to evaluate any STxMP scheme.
2. Except SDM STxMP, the SLS/LLS study of other schemes (SDM repetition, SFN, FDM) is very limited. The limited submitted performance results for these schemes generally show that these schemes don’t have a performance gain compared to the baseline.
3. Based on the inputs to this meeting, SDM STxMP shows performance gain in low traffic (less than 30%) and performance loss in a higher traffic. However, in our view, the amount of performance gain in lower traffic depends on the underlying assumptions:
	1. Maximum UE Tx Power assumption: whether Option 1 (per UE) or Option 2 (Per panel) power assumption is used. While both are agreed to be studied, only one may be an acceptable choice for RAN4.
	2. The used scheme for the baseline: eg, Single panel, multi-panel with a panel selection, multi-panel with TDM repetition.
	3. Dynamic switching between STxMP and baseline: Whether or not the dynamic switching between STxMP and single-panel transmission is possible.

Our view is that, at this point, the evaluation results submitted by companies do not warrant supporting any of the listed s-DCI based STxMP schemes in RAN1 109-e and further studies should be carried out. Further, to facilitate a more accurate comparison between STxMP performance and the baseline, we suggest to discuss the following two issues in RAN1 110-e:1. To agree on a default Baseline scheme. This could be a choice between one of the Option 1 or Option 2 of the “Baseline Scheme” in RAN1 109-e.
2. To discuss whether or not Dynamic switching between STxMP and baseline could be assumed in practice and used for the evaluation purposes.

Since we don’t think that the evaluation results justify supporting any of the listed s-DCI based schemes in 1.1, we are not supportive of the proposals in 1.2 to 1.8 that specify details of these schemes. However, we have the following suggestions for further studies: **Relevant to 1.3 and 1.8:****Proposal:** As a part of SDM based STxMP study, layer combination 0+x, x+0 should also be considered to support dynamic switching between single-panel and multi-panel transmission.**Relevant to 1.5:**For SDM-based STxMP, the number of required bits for TPMI/SRI indication can be doubled which may have an impact on the PDCCH coverage. Consequently, DCI payload reduction solutions for TPMI indication in STxMP should be considered. In Rel-17, TDM-based PUSCH repetition is supported, and up to two SRS resource sets and SRI/TPMI fields can be configured to UE for codebook or non-codebook based PUSCH transmission. The TPMI indication payload is reduced by considering the restriction that the number of layers transmitted to two TRPs is always the same, thus only a subset of TPMIs can be indicated for the second TRP once the rank is determined. A similar design can be reused in Rel-18 in some STxMP transmission modes such as SFN or SDM repetition. **Proposal:** TPMI indication overhead for various STxMP transmission modes should be examined as a part of STxMP study. A similar design in Rel-17 PUSCH repetition may considered as a starting point.**Other aspects:**To enhance the UL coverage, NR supports single carrier based UL transmission for both PUSCH and PUCCH. As a part of STxMP study in Rel-18, transform precoding should also be considered for different UL channels.**Proposal:** transform precoding enabled UL transmission should also be considered as a part of STxMP study.  |

## Multi-DCI based STxMP PUSCH

**Table 2A: summary of Issues of multi-DCI based STxMP PUSCH**

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | [109e] **Agreement**For multi-DCI based STxMP PUSCH+PUSCH transmission, study and evaluate the following aspects:* Two PUSCHs are associated with different TRPs and transmitted from different UE panels. The total number of layers of these two PUSCHs is up to 4.
* Study STxMP of PUSCH+PUSCH transmission where it is some combination of DG-PUSCH, CG-PUSCH and msg3/msgA PUSCH.
* The overlapping type(s) of fully/partially in time domain and fully/partially/non-overlapping in frequency domain are to be studied and justified for PUSCH+PUSCH.

Note: The above study shall take into account the UE implementation and RF considerations.Note: Study the conditions required for STxMP PUSCH+PUSCH.Note: Other aspects are not precluded.**Proposal 2.A** Support STxMP PUSCH+PUSCH transmission in multi-DCI based system in rel-18. Two PUSCHs associated with different TRPs are transmitted from different UE panels. The total number of layers of these two overlapping PUSCHs is up to 4 | **Proposal 2.A:** * **Support**: ZTE, Qualcomm, MTK, DOCOMO, CATT, Intel, Xiaomi, (Samsung (if justified)), IDC, google, Lenovo, OPPO, LG, Fraunhofer, Spreadtrum, NEC, Nokia
* **Not support**: Huawei, HiSilicon
 |
| 2.2 | [109e] **Agreement**For multi-DCI based STxMP PUSCH+PUSCH transmission, study and evaluate the following aspects:* Two PUSCHs are associated with different TRPs and transmitted from different UE panels. The total number of layers of these two PUSCHs is up to 4.
* Study STxMP of PUSCH+PUSCH transmission where it is some combination of DG-PUSCH, CG-PUSCH and msg3/msgA PUSCH.
* The overlapping type(s) of fully/partially in time domain and fully/partially/non-overlapping in frequency domain are to be studied and justified for PUSCH+PUSCH.

Note: The above study shall take into account the UE implementation and RF considerations.Note: Study the conditions required for STxMP PUSCH+PUSCH.Note: Other aspects are not precluded.**What type(s) of overlapping can be supported for STxMP PUSCH+PUSCH transmission:****2.2 Q1**: what type of overlapping in time domain shall be supported:* Alt 1A: fully overlapping
* Alt 1B: both partially and fully overlapping

**2.2 Q2**: what type of overlapping in frequency domain shall be supported:* Alt 2A: only non-overlapping
* Alt 2B: only fully overlapping
* Alt 2C: partially/fully/non-overlapping
 | **2.2 Q1:** Overlapping in time domain* **Alt 1A:** ZTE, LG
* **Alt 1B:** Qualcomm, vivo, DOCOMO, MTK, CATT, Xiaomi, Samsung, IDC, google, Lenovo, OPPO, Fraunhofer, Nokia,Spreadtrum, NEC

**2.2 Q2:** Overlapping in frequency domain* **Alt 2A:** Samsung (high priority if justified)
* **Alt 2B:** ZTE
* **Alt 2C:** Qualcomm, vivo, DOCOMO, MTK, CATT, Xiaomi, Samsung (low priority if justified), IDC, google, Lenovo, OPPO, LG, Fraunhofer, Apple (deprioritizing partial overlapping), Nokia,Spreadtrum, NEC
 |
| 2.3 | [109e] **Agreement**For multi-DCI based STxMP PUSCH+PUSCH transmission, study and evaluate the following aspects:* Two PUSCHs are associated with different TRPs and transmitted from different UE panels. The total number of layers of these two PUSCHs is up to 4.
* Study STxMP of PUSCH+PUSCH transmission where it is some combination of DG-PUSCH, CG-PUSCH and msg3/msgA PUSCH.
* The overlapping type(s) of fully/partially in time domain and fully/partially/non-overlapping in frequency domain are to be studied and justified for PUSCH+PUSCH.

Note: The above study shall take into account the UE implementation and RF considerations.Note: Study the conditions required for STxMP PUSCH+PUSCH.Note: Other aspects are not precluded.**FL Note: it looks like no company propose to include msg3/MsgA PUSCH in STxMP PUSCH+PUSCH in tdoc. Thus, the following proposal is made:****Proposal 2.C**: In multi-DCI based STxMP PUSCH+PUSCH transmission, support the combination of DG-PUSCH+DG-PUSCH, DG-PUSCH+CG-PUSCH and CG-PUSCH+CG-PUSCH | **Proposal 2.C:*** **Support:** Qualcomm, vivo, MTK, CATT, Intel, Xiaomi, OPPO, Ericsson, Nokia, Spreadtrum, DOCOMO
* **Not support:** Huawei, HiSilicon
 |
| 2.4 | [109e] **Agreement**For multi-DCI based STxMP PUSCH+PUSCH transmission, study and evaluate the following aspects:* Two PUSCHs are associated with different TRPs and transmitted from different UE panels. The total number of layers of these two PUSCHs is up to 4.
* Study STxMP of PUSCH+PUSCH transmission where it is some combination of DG-PUSCH, CG-PUSCH and msg3/msgA PUSCH.
* The overlapping type(s) of fully/partially in time domain and fully/partially/non-overlapping in frequency domain are to be studied and justified for PUSCH+PUSCH.

Note: The above study shall take into account the UE implementation and RF considerations.Note: Study the conditions required for STxMP PUSCH+PUSCH.Note: Other aspects are not precluded.Companies proposed various condition for STxMP PUSCH+PUSCH in M-DCI system:**Proposal 2.D**: Study the conditions needed for STxMP PUSCH+PUSCH in M-DCI based mTRPsystem, including but not limited:* Whether to configure same DMRS configurations: e.g, same type, same number of DMRS,
* Whether need No DMRS and data collision
* Whether DMRS ports of different PUSCH must belong to different CDM groups
* Whether to limit One TCI state per CDM group
* Whether should the overlapping PUSCHs have same or different priority levels.
* In same active BWP and with same SCS
 | **Proposal 2.D*** **Support:** vivo, CATT, Xiaomi, Lenovo, Support, DOCOMO, Fraunhofer, NEC, Huawei, HiSilicon
* **Not support: Nokia**
 |
| 2.5 | Whether to support multi-DCI STxMP PUSCH+PUSCH repetition scheme:Example of PUSCH+PUSCH repetition scheme**Proposal 2.E** Support multi-DCI STxMP PUSCH+PUSCH repetition scheme | **Proposal 2.E:*** **Support:** ZTE, Google, Nokia
* **Not support:** LG, Spreadtrum, Fraunhofer, Huawei, HiSilicon
 |
| 2.6 | The issue of SRS resource set configuration, SRI/TPMI indication for STxMP PUSCH+PUSCH transmission in multi-DCI based system were discussed in tdocs. The proposals were summarized as follows:**Proposal 2.F** For STxMP PUSCH+PUSCH in multi-DCI based mTRP system, configure two SRS resource sets for PUSCH transmission and each set is associated with one TRP.* The indicated SRI/TPMI fields in DCI correspond to the SRS resource set associated with the TRP where the DCI is received from.
* FFS how to associate with TRP, e.g., through CORESETPoolIndex, UE capability set index, indicated joint or UL TCI state.
 | **Proposal 2.F*** **support:** Qualcomm, vivo, CATT, google, OPPO, MTK, Spreadtrum, DOCOMO, Lenovo, LG, NEC, Nokia
* **not support:** Huawei, HiSilicon
 |
| 2.7 | Company proposes to support a dynamic switch between single panel transmission and STxMP transmission for PUSCHs in M-DCI based system.**Proposal 2.G** Support dynamic switch between single panel transmission and STxMP PUSCH+PUSCH transmission in multi-DCI based mTRP system | **Proposal 2.G*** **Support:** vivo, Google
* **Not support: Nokia,** Huawei, HISilicon
 |

Observations….

Draft proposals….

Table 2B: additional inputs: the issue of multi-DCI based STxMP PUSCH

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check and input/update your views in Table 2A.**
2. **Share additional inputs/Alts here, if needed**
3. **Draft proposals/updates will be provided in next version later based on the collected views.**
 |
| Google | For proposal 2.C, we suggest clarification for the “combination”. In our understanding, the PUSCHs in a combination are transmitted from different panels. But the condition “In multi-DCI based…” seems to suggest the DG-PUSCH should be scheduled by multiple DCIs. We suggest the following revisions.**Proposal 2.C**: ~~In multi-DCI based~~ For STxMP PUSCH+PUSCH transmission, support the combination of DG-PUSCH+DG-PUSCH, DG-PUSCH+CG-PUSCH and CG-PUSCH+CG-PUSCH * The PUSCHs in a combination are transmitted from different panels
 |
| QC | 2.4: We do not see the need for these. Regarding “same BWP / SCS”, it is obvious as we already have multi-DCI PUSCH (TDM) in Rel-16. Regarding DMRS alignment / CDM groups, it is up to gNB scheduling. Unlike DL, the entity who schedules (gNB) is the same as the entity who receives and does the channel estimation. Hence, it is up to gNB whether different CDM groups should be used or not.2.5: Do not support.2.6: FFS is not needed. No reason to change the current spec wrt how TRP is defined with multi-DCI based mTRP.2.7: The meaning of dynamic switching in the context of multi-DCI is not clear. |
| Lenovo  | We are confused on Proposal 2.G. In multi-DCI mTRP system with STxMP, different TRP independently schedule PUSCH transmission, only one PUSCH or two overlapped PUSCHs may be scheduled by different TRPs. So dynamic switching between single panel and multi-panel shall be straightforwardly supported in mDCI mTRP system. |
| Mediatek | On Proposal 2.A, we prefer the following update:**Proposal 2.A** Support STxMP PUSCH+PUSCH transmission in multi-DCI based system in rel-18 if two PUSCHs are associated with different TRPs * The total number of layers of these two overlapping PUSCHs is up to 4
* FFS: How to associate each PUSCH with a TRP

On Proposal 2.C, we prefer to further clarify that DG-PUSCH means the PUSCH scheduled by DCI, i.e., not including PUSCH scheduled by RAR.* Note: DG-PUSCH means PUSCH scheduled by DCI

On Proposal 2.G, we don’t see why this needs an agreement. If NW can individually schedule two PUSCHs w/ or w/o overlapping in time domain, and UE may use one panel or two panel to perform corresponding transmission. Dynamic switch between single panel transmission and STxMP is already supported naturally by scheduling. |
| InterDigital | Our inputs are added in the table. |
| Intel | Proposal 2.G is not clear to us. We think dynamic switching is supported by mDCI scheduling mechanism.  |
| LG | * Issue 2.6

Regarding FFS on Proposal 2.F, CORESETpoolindex is sufficient for DG PUSCH. For CG PUSCH, we may need further discussion on how to use CORESETpoolindex.* Issue 2.7

Intention is not clear. In M-DCI case, each TRP schedule PUSCH independently so that PUSCHs for two TRP can be overlapped or non-overlapped in time opportunistically. In that sense, dynamic switching is possible. |
| NEC | Our inputs are provided in the table. |
| Samsung | When we consider the progress, it seems better to verify and discuss sDCI based STx2P schemes first. Based on the results of sDCI based schemes (considering overlapping cases), mDCI based schemes can be specified. |
| NTT DOCOMO | For 2.6 (2.F), share similar view with QC. It is straightforward to reuse CORESETPoolIndex for M-DCI M-TRP.For 2.7 (2.G), share similar view with Intel/LG. Since each TRP schedules its PUSCH independently, dynamic switching is supported naturally. |
| Nokia/NSB | Issue 2.1: Support proposal 2.AIssue 2.2: OkIssue 2.3: OkIssue 2.4: In general, proposal 2.D remains unclear and need further clarifications. It worth noting that different may have different capabilities in terms of UL TX antenna ports. Issue 2.5: Proposal 2.E could be depriorized.Issue 2.6: Support 2.FIssue 2.7: This proposal is not needed (each TRP is assumed to schedule single UE panel). |
| CATT | For issue 2.4, the following condition can be added to Proposal 2.D:* Whether to limit the number of layers scheduled by each TRP/DCI

For issue 2.6, the wording of Proposal 2.F can be adjusted slightly to not preclude the association between SRS resource set and panel:**Proposal 2.F** For STxMP PUSCH+PUSCH in multi-DCI based mTRP system, configure two SRS resource sets for PUSCH transmission and each set is associated with one TRP/panel.* The indicated SRI/TPMI fields in DCI correspond to the SRS resource set associated with the TRP where the DCI is received from.
* FFS how to associate with TRP, e.g., through CORESETPoolIndex, UE capability set index, indicated joint or UL TCI state.
 |
| Xiaomi | Support in general. |
| Huawei, HiSilicon | **2.1:** Similar to our view about the s-DCI based schemes, we think that, following the WID, “UL precoding indication for PUSCH” and “UL beam indication for PUCCH/PUSCH” for m-DCI based STxMP may be specified only if a considerable performance gain is verified by SLS/LLS in comparison with the baseline TxSP. To our understanding, there is no simulation results for m-DCI based STxMP among the submissions to this meeting and, therefore, we are not ready to agree specifying m-DCI based STxMP. **2.3**We are supportive of further studying CG-PUSCH/DG-PUSCH combinations using SLS/LLS evaluations. In parallel, companies could further study TCI state application and the transmission occasion dropping rules for CG-PUSCH+ CG-PUSCH. Also, when two UL TCI states are indicated, mechanisms to enable/disable STxMP for a CG-PUSCH should be considered as a part of STxMP study. |

## STxMP PUCCH

**Table 3A: summary of Issues of STxMP PUCCH**

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | For the STxMP PUCCH transmission in S-DCI based mTRP system, the following schemes were proposed in Tdocs:* Option 1 PUCCH FDM-A scheme: different parts of frequency domain resource of one PUCCH are transmitted from different UE panels.
* Option 2: PUCCH FDM-B scheme: two PUCCH transmission occasion are transmitted from different UE panels on non-overlapping frequency resource and same time-domain resource.
* Option 3: PUCCH SFN scheme: same PUCCH is transmitted from two different UE panels simultaneously.
* Option 4: one UCI is transmitted in two PUCCH resources.
* Option 5: PUCCH CDM scheme (PFs 0/1/4): one UCI is transmitted from two panels, using the same frequency and time domain resource but orthogonal cyclic shifts/OCCs.
 | **Please input your views on those schemes:****PUCCH FDM-A:*** **Support**: ZTE, CATT, Intel (for PUCCH format 2 only), Lenovo, Xiaomi, Apple, Nokia
* **Not support**: Google, MTK, Huawei, HiSilicon

**PUCCH FDM-B:*** **Support**: ZTE, CATT, Intel, Lenovo, Xiaomi, Apple, Nokia
* **Not support**: Google, MTK, Huawei, HiSilicon

**PUCCH SFN:*** **Support**: ZTE, vivo, DOCOMO, CATT, Intel, Lenovo, Xiaomi, Apple, Nokia
* **Not support**: Google, LG, Huawei, HiSilicon

**Option 4:*** **Support**: Google
* **Not support**: Huawei, HiSilicon

**Option 5 (PUCCH CDM):*** **Support**: Intel
 |
| 3.2 | For STxMP PUCCH in multi-DCI based mTRP system, companies proposed to support PUCCH+PUCCH STxMP. Two PUCCHs are transmitted from different panels and to different TRP and they can be fully/partially/non-overlapping in time domain **Proposal 3.B**: Support STxMP PUCCH+PUCCH in multi-DCI based mTRP system. Two PUCCHs transmitted from different panels and to different TRP can be fully/partially overlapping in time domain and fully/partially/non-overlapping in frequency domain. | **Proposal 3.B:*** **Support:** ZTE, Qualcomm, vivo (frequency non-overlapping), DOCOMO, MTK, CATT, Nokia, Spreadtrum, Google, Lenovo, NEC
* **Not support:** Huawei, HiSilicon
 |
| 3.3 | Companies proposed to investigate the UCI multiplexing/dropping rule for multi-DCI based STxMP PUCCH+PUCCH transmission. **Proposal 3.C**: Study the UCI dropping/multiplexing mechanism enhancement for the case that PUSCH/PUCCH of different TRPs overlap in time domain:* FFS TRP-specific UCI multiplexing mechanism

  | **Proposal 3.C:*** **Support:** ZTE, Spreadtrum, vivo, Lenovo, Intel, MTK, Qualcomm, Apple, DOCOMO, Google, Nokia,CATT, Huawei, HiSilicon
* **Not Support:**
 |

Observations….

Draft proposals….

Table 3B: additional inputs: the issue of STxMP PUCCH

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check and input/update your views in Table 3A.**
2. **Share additional inputs/Alts here, if needed**
3. **Draft proposals will be provided in next version later based on the collected views.**
 |
| Spreadtrum | For issue 3.1, in current specification, there are five PUCCH formats where some PUCCH formats, e.g., format 0, is with one PRB. We are not clear about how to realize FDM transmission for such formats. |
| Google | For issue 3.1, in our view, option 4 is the most flexible compared to other options, which is similar to mTRP PDCCH. |
| Intel | We think PUCCH CDM scheme can also be supported, added as option-5. By using the same frequency-time resource but different cyclic shifts/OCCs for the two panels, this scheme can achieve more diversity than single-panel transmission and it is less complicated than FDM-A/B schemes. |
| LG | * Issue 3.3

Is proposal 3.C about M-DCI? If yes, motivation is not clear to us. Why dropping/multiplexing is needed between two PUCCHs for different TRPs? Since UE is capable of STxMP, UE can transmit the two PUCCH at the same time without dropping or multiplexing.  |
| NEC | Our inputs are provided in the table. |
| Samsung | We are open to support PUCCH STx2P after verifying STx2P schemes. If we can see the benefit with STx2P first, we can extend the schemes to support STx2P PUCCH. |
| NTT DOCOMO | For 3.1, we support option3 (SFN) which has less spec. impact. |
| Nokia/NSB | Issue 3.1: In addition to FDM-A and SFN, we support also FDM-B. Issue 3.2: OkIssue 3.3: Support Proposal 3.c |
| CATT | For S-DCI based STxMP PUCCH transmission (issue 3.1), we propose to clarify the number of PUCCH resources for each transmission scheme. Considering that there is no big difference between single PUCCH resource and multiple PUCCH resources from functionality point of view, and single PUCCH resource scheme needs less standardization work, single PUCCH resource is preferred.For issue 3.3, our view is added in the table. |
| Huawei, HiSilicon | **3.1:**The need for STxMP PUCCH should be verified using evaluation before deciding whether or not to support it. LLS maybe performed for PUCCH+PUCCH to compare its reliability in comparison with legacy PUCCH (both sTRP based PUCCH transmission and mTRP based PUCCH repetition). If necessary, EVM assumptions relevant to STxMP PUCCH may be developed.**3.3:** In general, open to study this issue. PUCCH + PUCCH and PUSCH+PUSCH case can only be considered as PUCCH + PUSCH is out of scope. For Rel-18, PUCCH does not multiplex with PUSCH. Companies may agree either the PUCCH is dropped or UE is not expected to be scheduled with PUCCH and PUSCH on the same time resources.  |
| QC | Given the discussions in the previous meeting on STxMP PUCCH, an unofficial offline meeting was organized. A few interested companies discussed the issue, and the following was captured as meeting notes to move forward:* **Studying STxMP PUCCH and decision on whether to support or not is to take place in 9.1.4.1.**
* **It is ok to list [minimal number of] schemes for STxMP PUCCH for the purpose of study / evaluation.**
	+ **Huawei / Ericsson: It can be listed as part of EVM (SLS/LLS) if needed.**
	+ **Ericsson: Should avoid long list of schemes. Preferably one scheme can be mentioned (one for single-DCI and one for multi-DCI?)**
	+ **Other participating companies: Ok to follow the same approach as PUSCH (list all candidate schemes for study based on companies’ proposals)**

Given this outcome, I would like to suggest the following proposal, which is a compromise considering all the views and the meeting notes above:**Proposal: Study and evaluate STxMP PUCCH based on the following:*** **For single-DCI based STxMP PUCCH transmissions, FDM or SFN schemes can be considered.**
* **For multi-DCI based STxMP PUCCH transmissions, transmitting two PUCCH resources to different TRPs with different UE panels that are fully or partially overlapping in time domain can be considered.**
* **Note: Companies can reuse the EVM assumptions of Rel-18 STxMP as agreed in RAN1#109-e (other than the parameters that are specific to PUSCH ) as well as Rel-17 EVM for PUCCH as agreed in RAN1#102-e (PUCCH format, # of RBs/symbols, UCI payload, and Frequency hopping as shown below).**
	+ **Baseline scheme can be Rel-15 PUCCH or Rel-17 mTRP PUCCH repetition.**

|  |  |
| --- | --- |
| Parameters | Potential values |
| Baseline scheme | Rel-15 PUCCH or Rel-17 mTRP PUCCH repetition |
| PUCCH format | Format 1 and 3.Other PUCCH Formats can be optionally considered. |
| # of RBs/symbols | PUCCH Format 1: 4 symbols, 1 RBPUCCH Format 3: 4 and 8 symbols, 1 RBOther combinations are not precluded. |
| UCI payload | 2 bits for PUCCH Format 1 (and Format 0, if considered). Companies to report assumptions on other PUCCH Formats |
| Frequency hopping | Reported by companies |

 |

## Other Issues

**Table 4A: Summary of other issues**

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4.1 | Issues related with Power control and PHR for STxMP transmission:* 4.1.1: Enhance PHR procedure for STxMP: e.g, For single-DCI based STxMP, support joint PHR triggering and reporting. For multi-DCI based STxMP, support both joint and separate PHR triggering and reporting, e.g., panel-specific PHR
* 4.1.2: Introduce panel-specific power limit, panel-specific power control
* 4.1.3: support power splitting equally or with a variable fraction for multi-panel transmission
* 4.1.4: power control enhancement is needed when the total power of two overlapping PUSCH/PUCCH exceed the maximal power
 | 4.1.1: Qualcomm, vivo, Apple, Nokia4.1.2 vivo, MTK4.1.3: Intel4.1.4: Spreadtrum |
| 4.2 | TCI state/Beam indication:* 4.2.1: TCI states indication designed for single-DCI based mTRP is applicable for STxMP, and they are applied for two SRS resource sets respectively. TCI states corresponds to each panel
* 4.2.2: CORESETPoolIndex is used to associate the indicated TCI state and scheduled channels
* 4.2.3: In STxMP, 1st and 2nd TCI state correspond to the 1st and 2nd panel respectively. 1st TCI state is associated with the first CDM group in SDM scheme.
 | 4.2.1: vivo, Intel4.2.2: vivo4.2.3: Intel  |
| 4.3 | UE capability reporting:* 4.3.1 Study UE capability reporting method for supporting STxMP, including consideration that can easily extend to > 2 panels
* 4.3.2: the information of beam correspondence per panel.
* 4.3.3: The information of receive-only panel
 | 4.3.1: Sony, NEC, CMCC, Nokia4.3.2: Sony4.3.3: Sony |

Please input your views on those issues:

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V00 | Please check and update your views in Table 4A and share more here inputs if needed. |
| Google | We think issue 4.1 can be discussed after decision of mTRP PUSCH scheme. Issue 4.2 should be discussed in 9.1.1? Issue 4.3 can be discussed later. |
| NTT DOCOMO | In our understanding, power control and beam indication may be discussed in 9.1.1.1. |
| QC | 4.1.3/4: Not support. The power is not shared across panels (transmitting different beams).Other issues listed are either not high priority now, or will be discussed in 9.1.1.1. |
| Lenovo | According to the Chair arrangement, all the three issues should be discussed in AI 9.1.1.1(eUTCI)  |
| Mediatek | For Issue 4.1, we think power-related issue (e.g., power splitting scheme, PHR) should be discussed after deciding which per-UE and per-panel power limitation is supported. And Issue 4.2 and Issue 4.3 should be discussed in 9.1.1.1 |
| Intel | In current specification, the PHR triggering conditions do not distinguish different TRPs. Thus, for issue 4.1.1, the difference between joint PHR triggering and separate PHR triggering needs some clarification. |
| LG | In our understanding, power control and beam indication may be discussed in 9.1.1.1. |
| Samsung | We can share the same view with LG. |
| Nokia/NSB | Capability reporting enhancement is needed to enable STxMP in Rel-18. Therefore, we support 4.3.1. |
| CATT | In our understanding, power control, PHR and TCI/beam indication may be discussed in 9.1.1.1. |
|  | **4.1 and 4.3:** 4.1 and 4.3 can be delayed and can be further studied if STxMP is supported**4.2**: Ok to study in 9.1.1.1. **Other issues:**To enhance the UL coverage, NR supports single carrier based UL transmission for both PUSCH and PUCCH. As a part of STxMP study in Rel-18, transform precoding should also be considered for different UL channels.**Proposal:** transform precoding enabled UL transmission should also be considered as a part of STxMP study.  |

1. Summary of results/observations from SLS/LLS

**Table 5A: summary of SLS/LLS on SDM scheme**

|  |  |  |
| --- | --- | --- |
| **Company** | **Metric** | **Key observation** |
| ZTE | SLS, 5%,50%, 95%-ile UE throughput25% RU40%RUOption 1 Maximum UE Tx Power | * Observation 2: Compared with single panel based transmission with panel selection, both 1 CW and 2 CWs based SDM scheme for STxMP PUSCH transmission in MTRP operation could obtain considerable throughput improvement.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **RU** | **Transmission scheme** | **Mean UE** | **5%-ile UE** | **50%-ile UE** | **95%-ile UE** |
| ~25% | Single panel transmission with panel selection | 357.32 | 117.78 | 390.50 | 524.57 |
| 1 CW for SDM scheme | 386.678.2% (+) | 107.34-8.9% (-) | 386.01-1.1% (-) | 769.6546.7% (+) |
| 2 CWs for SDM scheme | 412.4214.4% (+) | 118.630.7% (+) | 409.414.8% (+) | 790.2050.6% (+) |
|  |
| ~40% | Single panel transmission with panel selection | 269.57 | 60.35 | 238.97 | 524.57 |
| 1 CW for SDM scheme | 284.115.4% (+) | 59.72-1.0% (-) | 243.171.8% (+) | 578.5910.3% (+) |
| 2 CWs for SDM scheme | 303.7612.7% (+) | 69.4815.1% (+) | 265.4511.1% (+) | 627.3919.6% (+) |

 |
| Huawei/HiSilicon | SLS: throughput, Full bufferMaximum UE Tx power option 1 | * Observation 1: Based on our LLS and SLS performance comparisons between STxMP and the baseline TxSP schemes, specifying STxMP is not well-justified.

Table 1: SLS result comparison between STxMP and TxSP

|  |  |
| --- | --- |
| Scheme | Throughput  |
| TxSP | 112.20Mbps (100%) |
| STxMP | 89.65 Mbps(79.9%) |

 |
| OPPO | SLS: throughputRU 20%Maximum UE Tx Power option 1Maximum UE Tx power option 2 | * Observation 2: Compared with panel selection operation, single DCI based multi-panel PUSCH transmission via SDM scheme can obtain considerable throughput improvement.
* Observation 3: For both Maximum UE Tx Power option 1 and option 2, single DCI based multi-panel PUSCH transmission via SDM scheme is considerable for average throughput improvement.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RU | Transmission scheme | Mean | 5% | 50% | 95% |
| 20% | Panel selection | 357.076 | 226.520 | 331.152 | 592.305 |
| 20% | SDM scheme(Power limitation per panel) | 438.678(+22.7%) | 219.311(-3.1%) | 398.381(+20.2%) | 802.959(+35.5%) |

 |
| MTK | SLS: ThroughputFTP mode 1: low loading and high loadingPer-UE power limitPer-panel power limit | * Observation 1: For S-DCI based PUSCH STxMP, supporting two CWs in SDM scheme provides marginal improvement on throughput performance, comparing to supporting one CW in SDM scheme
* Observation 2: For S-DCI based PUSCH STxMP, SDM scheme is more feasible in low traffic loading scenario due to more interference caused by multi-panel transmissions from other UEs

 |
| Ericsson | SLS: ThroughputBoth UE Tx power option 1 and Option 2Non-full buffer | * STxMP only provides gains at low load. When the RU exceeds 30%, panel selection is better.
* Legacy UEs will suffer from the increased resource consumption of the STxMP UEs.
* If the total UE Tx power is not increased, STxMP is always inferior to panel selection.

|  |  |  |  |
| --- | --- | --- | --- |
|  | 20% RU  | 30% RU  | 40% RU  |
| Total TRP | 23dBm | 26dBm | 23dBm | 26dBm | 23dBm | 26dBm |
| Mean | 16% | 18% | 7% | 5% | -8% | -6% |
| Cell-edge | -11% | -14% | -24% | -25% | -59% | -58% |
| 50% | 2% | 3% | -12% | -11% | -23% | -23% |
| 95% | 62% | 64% | 54% | 57% | 47% | 51% |

Table 2: The gain of STxMP at different load levels for InH.

|  |  |  |  |
| --- | --- | --- | --- |
|  | 20% RU  | 30% RU  | 40% RU  |
| Total TRP | 23dBm | 26dBm | 23dBm | 26dBm | 23dBm | 26dBm |
| Mean | -10% | 5% | -30% | -11% | -47% | -27% |
| Cell-edge | -20% | 19% | -38% | -19% | -55% | -41% |
| 50% | -18% | -2% | -39% | -15% | -58% | -37% |
| 95% | 7% | 10% | 11% | 7% | -22% | 0% |

Table 3: The gain of STxMP at different load levels for DU. |
| Qualcomm | SLS: ThroughputBoth Tx power assumption 1 and 2 | * Observation 1: For indoor hotspot, STxMP can provide ~40% gain in mean UPT, ~80% gain in 90%ile UPT, and ~18-25% gain in tail UPT depending on Tx assumption 1 or Tx assumption 2 compared to sTRP with panel selection.

Figure 1: Indoor Hotspot system-level simulation results for Tx power assumption 1 and 2.* Observation 2: For dense urban, STxMP can provide ~15% gain in mean UPT, ~30% gain in 90%ile UPT, and ~0% gain in tail UPT compared to sTRP with panel selection with Tx assumption 1; STxMP can provide ~27% gain in mean UPT, ~30% gain in 90%ile UPT, and ~30% gain in tail UPT compared to sTRP with panel selection with Tx assumption 2.

Figure 2: Dense urban system-level simulation results for Tx power assumption 1 and 2. |
| DOCOMO | SLS: ThroughputTx power limitation Option 2 | * For STxMP PUSCH in S-DCI M-TRP, SDM scheme with two CWs transmitted in a PUSCH achieves obvious performance gain of throughput compared to single panel Tx.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RU | (Mbps)　 | Single panel Tx | SDM with 2CWs | Gain of SDM with 2CWs |
| 20% | Avg. UPT | 256.54 | 273.90 | 6.77% |
| 5% UPT | 85.09 | 102.61 | 20.59% |
| 50% | Avg. UPT | 203.37 | 217.48 | 6.94% |
| 5% UPT | 50.23 | 57.07 | 13.62% |

 |

**Table 5B: summary of SLS/LLS on FDM scheme**

|  |  |  |
| --- | --- | --- |
| **Company** | **Metric** | **Key observation** |
| ZTE | LLS: BLER | * Observation 1: Compared with Rel-17 TDM based MTRP PUSCH repetition, both SDM and FDM schemes based STxMP PUSCH repetition in MTRP operation perform almost the same BLER performance.

 |
| Huawei/HiSilicon | LLS: BLER | (a): MCS = 2 (b): MCS = 5 |
| Samsung | LLS: BLER | * Observation 1: Considering same amount of resource allocation and same transmission power for all schemes, the performances of FDM schemes for STx2P are similar to Rel-17 based schemes (mTRP PUSCH repetition, panel selection).

 |
| DOCOMO | LLS: BLER | * For STxMP PUSCH in S-DCI M-TRP, FDM-B scheme achieves almost the same BLER performance as Rel-17 M-TRP TDM repetition, while SFN/SDM repetition scheme has worse BLER performance that Rel-17 M-TRP TDM repetition and FDM-B scheme.

 |

**Table 5C: summary of SLS/LLS on SFN scheme**

|  |  |  |
| --- | --- | --- |
| **Company** | **Metric** | **Key observation** |
| Huawei/HiSilicon | LLS: BLER | (a): MCS = 2 (b): MCS = 5  |
| LG | SLS: Distribution of RSRP difference, Throughput | * Observation 4: RSRP difference between the strongest and the second strongest UE panels are less than 5dB in urban macro and 9dB in indoor hotspot scenarios, respectively, for half of UEs

Figure 2. Average/edge UPT gain for RU=30%Figure 3. Average/edge UPT gain for RU=60%**Observation 5: In SLS evaluation, significant cell edge throughput gain (120% for RU=30%, 72% for RU=60%) of 2-panel SFN STxMP over the best 1-panel selection based UL transmission (as baseline) is observed for 3 panel UE.** |
| DOCOMO | LLS: BLER | * For STxMP PUSCH in S-DCI M-TRP, FDM-B scheme achieves almost the same BLER performance as Rel-17 M-TRP TDM repetition, while SFN/SDM repetition scheme has worse BLER performance that Rel-17 M-TRP TDM repetition and FDM-B scheme.
 |

1. Reference

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | [R1-2205821](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205821.zip) | Discussion on Uplink Multi-panel Transmission | InterDigital, Inc. |
| 2 | [R1-2205884](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205884.zip) | Discussion on UL precoding indication for multi-panel transmission | Huawei, HiSilicon |
| 3 | [R1-2205923](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205923.zip) | Enhancements on UL precoding indication for multi-panel transmission | ZTE |
| 4 | [R1-2205986](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205986.zip) | Discussion on UL precoding indication for multi-panel transmission | Spreadtrum Communications |
| 5 | [R1-2206029](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206029.zip) | Discussion on UL precoding indication for multi-panel transmission | vivo |
| 6 | [R1-2206111](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206111.zip) | Considerations on UL for multi-panel transmission | Sony |
| 7 | [R1-2206162](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206162.zip) | Discussion on UL precoding indication for multi-panel transmission | Fujitsu |
| 8 | [R1-2206192](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206192.zip) | On Simultaneous Multi-Panel Transmission | Google |
| 9 | [R1-2206214](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206214.zip) | UL precoding indication for multi-panel transmission | Lenovo |
| 10 | [R1-2206268](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206268.zip) | Transmission scheme and UL precoding indicaton for multi-panel transmission | OPPO |
| 11 | [R1-2206380](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206380.zip) | Discussion on UL precoding indication for multi-panel transmission | CATT |
| 12 | [R1-2206465](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206465.zip) | Discussion on UL precoding indication for multi-panel transmission | NEC |
| 13 | [R1-2206575](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206575.zip) | UL precoding indication for multi-panel transmission (STxMP) | Intel Corporation |
| 14 | [R1-2206625](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206625.zip) | Enhancements on multi-panel uplink transmission | Xiaomi |
| 15 | [R1-2206817](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206817.zip) | Views on UL precoding indication for STxMP | Samsung |
| 16 | [R1-2206871](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206871.zip) | UL precoding indication for multi-panel transmission | LG Electronics |
| 17 | [R1-2206899](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206899.zip) | Discussion on UL precoding indication for multi-panel transmission | CMCC |
| 18 | [R1-2206997](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206997.zip) | Simultaneous transmission across multiple UE panels | MediaTek Inc. |
| 19 | [R1-2207112](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207112.zip) | UL precoding indication for multi-panel transmission | Ericsson |
| 20 | [R1-2207145](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207145.zip) | On UL precoding indication for simultaneous multi-panel transmission | Fraunhofer IIS, Fraunhofer HHI |
| 21 | [R1-2207220](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207220.zip) | Simultaneous multi-panel transmission | Qualcomm Incorporated |
| 22 | [R1-2207325](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207325.zip) | Views on UL precoding indication for multi-panel simultaneous PUSCH transmissions | Apple |
| 23 | [R1-2207398](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207398.zip) | Discussion on multi-panel transmission | NTT DOCOMO, INC. |
| 24 | [R1-2207455](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207455.zip) | Views on UL multi-panel transmission | Sharp |
| 25 | [R1-2207549](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207549.zip) | Precoder Indication for Multi-Panel UL Transmission | Nokia, Nokia Shanghai Bell |