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:**

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| --- | --- | --- |
| **#** | **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, IDC, Spreadtrum, google, Lenovo, OPPO, LG, CMCC, Fraunhofer, Nokia, MTK
* **Not support**:

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

FDM-A scheme:* **Support**: ZTE, Qualcomm, vivo, MTK, CATT, Intel, Xiaomi, Samsung (high priority), IDC, Lenovo, Fraunhofer, Nokia
* **Not support**: Ericsson, Google

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

SDM repetition scheme:* **Support**: ZTE, Intel, Xiaomi, IDC, Fraunhofer
* **Not support**: MTK, Ericsson, Qualcomm, Lenovo
 |
| 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
 |
| 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, IDC, Fujitsu, google, OPPO, Qualcomm, Sharp
* **Alt-B**: ZTE, Intel, Xiaomi, CMCC (only if 2 CW is supported),Spreadtrum, Lenovo
 |
| 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, Intel, Xiaomi, Spreadtrum, OPPO, Fujitsu, Intel, LG, Google, Lenovo, Fraunhofer
* **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, Samsung, Spreadtrum, google, Fujitsu, OPPO, LG, Apple, Fraunhofer**Option 1-2:** Samsung, Nokia, Lenovo**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**Option 2-2:** Samsung, Nokia, Lenovo**Q3: SRI/TPMI indication for SFN scheme:****Option 3-1:** OPPO,Spreadtrum, Fraunhofer**Option 3-2:** MTK, Nokia**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
* **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
* **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**1.8 Q2:** **Option 2-1:** **Option 2-2:** ZTE, Qualcomm, vivo, MTK, Intel, Xiaomi, Samsung, IDC, Fujitsu, Huawei/HiSilicon, OPPO, Google, DOCOMO, Lenovo, Fraunhofer**1.8 Q3:****Option 3-1:** ZTE, OPPO, Google (CG-PUSCH)**Option 3-2:** vivo, MTK, Fujitsu, Intel, Google (DG-PUSCH)**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 |

## 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, IDC, google, Lenovo, OPPO, LG, Fraunhofer, Spreadtrum
* **Not support**:
 |
| 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

**2.2 Q2:** Overlapping in frequency domain* **Alt 2A:** Samsung (high priority)
* **Alt 2B:** ZTE
* **Alt 2C:** Qualcomm, vivo, DOCOMO, MTK, CATT, Xiaomi, Samsung (low priority), IDC, google, Lenovo, OPPO, LG, Fraunhofer, Apple (deprioritizing partial overlapping), Nokia,Spreadtrum
 |
| 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:**
 |
| 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
* **Not support:**
 |
| 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
* **Not support:** LG, Spreadtrum, Fraunhofer
 |
| 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
* **not support:**
 |
| 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:**
 |

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. |

## 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.
 | **Please input your views on those schemes:****PUCCH FDM-A:*** **Support**: ZTE, CATT, Intel (for PUCCH format 2 only), Samsung, Lenovo, Xiaomi, Apple, Nokia
* **Not support**: Google, MTK

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

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

**Option 4:*** **Support**: Google
* **Not support**:
 |
| 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
* **Not support:**
 |
| 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
* **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. |
|  |  |
|  |  |

## 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, Intel, Apple4.1.2 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 |

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 1: 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 2: 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
 |
| 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

|  |  |  |  |
| --- | --- | --- | --- |
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| 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 |
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| 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 |
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