**3GPP TSG RAN WG1 #109-e R1-220xxxx**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.10.2

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary#4 of discussion on multi-carrier UL Tx switching scheme

**Document for:** Discussion and Decision

# Introduction

This contribution is the intermediate summary of following email discussion on multi-carrier UL Tx switching schemes for GTW session on 20th May.

//This one is to use NWM – please use RAN1-109-e-NWM-R18-MC\_Enh-02 as the document name

[109-e-R18-MC\_Enh-02] Email discussion on multi-cell UL Tx switching by May 20 – Hiroki (DOCOMO)

* Check points: May 12, May 18, May 20

# Summary of proposals

## 3.1. (Closed) Whether to specify UL Tx switching schemes across up to 3 or 4 bands in Rel-18

(Already closed with following observation and agreement)

**RAN1 Observation**

Four contributions ([R1-2203136](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2203136.zip), [R1-2204724](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2204724.zip), [R1-2204909](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2204909.zip), [R1-2205131](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2205131.zip)) from three companies show their evaluation results on UL Tx switching across 3 or 4 bands at RAN1#109-e meeting.

* All evaluation results show the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 2 bands, assuming TDD bands with different TDD UL/DL configurations are included in 4 bands.
	+ Evaluation results in [R1-2203136](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2203136.zip) show the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 3 bands.
	+ Evaluation results in [R1-2204724](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_109-e%5CDocs%5CR1-2204724.zip) show that the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 2 bands depends on achievable switching period, and the longer switching period for UL Tx switching across 4 bands compared with UL Tx switching across 2 bands leads to reduction of the performance gain. Other evaluation results did not consider the impact of longer switching period for UL Tx switching across 4 bands compared with UL Tx switching across 2 bands.
	+ Evaluation results in 5131 observe that the gain highly depends on the scheduling mechanism.
	+ The range of performance gains shown in four contributions varies depending on the simulation assumptions.

**Agreement**

Send LS to RAN4 to ask their feedback on the potential increase of switching period and complexity in the case of UL Tx switching across 3 or 4 bands

* In the LS, observations based on the evaluation results and alternative switching mechanisms discussed in RAN1 are captured for the information to RAN4
* In the LS, RAN1 also asks RAN4 feedback on whether following assumption can be considered as baseline UE assumption/behavior even in case of the UL Tx switching across 3 or 4 bands
	+ When one of the two Tx chains is triggered to switch from one band to another band, another Tx chain which is in any of bands is also not expected to be used for transmission during the switching period

LS is endorsed in R1-220XXXX.

## 3.2. (Closed) Whether to support inter-band UL CA Option 1 and Option 2 in Rel-18

(Proposal in this section was merged to the proposal in section 3.3)

## 3.3. Whether to support inter-band UL CA + SUL scenario(s) in Rel-18

After the 5th-round email discussion, companies’ feedbacks can be summarized as below.

* Fine with the proposed working assumption
	+ CATT, Xiaomi
* Suggest modifying the first note to “Note: it does not imply SUL is precluded”
	+ LG
	+ Suggest removing the first note
		- ZTE
* Suggest not bundling the supporting “CA Opt 1 and 2 without SUL” with discussion on CA with SUL
	+ QCM, ZTE
* Suggest moving “defining necessary mechanisms to support inter-band UL CA without SUL is prioritized” to the main bullet for CA without SUL
	+ QCM
	+ Suggest adding “UL Tx switching across 3 and 4 different bands” in main bullet
		- ZTE
* Suggest removing the last note
	+ ZTE
* Suggest adding “FFS: whether intra-band contiguous carriers are supported”

Based on the feedbacks, the proposed working assumption is updated as below. First, the moderator would like to continue suggesting this formulation of working assumption i.e., including both CA without SUL and CA with SUL as target scenarios to be considered for defining necessary mechanisms to avoid unnecessary discussion such as scenario priority between with SUL and without SUL. In this formulation, the note “SUL is not precluded” is unnecessary. Companies can agree that both scenarios are to be supported as WA if Rel-18 UL Tx switching is supported. Second, whether to remove the note regarding “CA option 2 + SUL”, even if the part is removed, we don’t say it is precluded in this WA. As there are multiple companies who prefer to support CA Opt.2 + SUL, current description of the note seems reasonable since it says “it can be discussed if extra necessary mechanisms specific to the scenario are identified and time allows”. Regarding the last note, based on the discussion so far, it seems different from the previous note for CA option 2 + SUL. Although the note says “if time allows, this does not preclude ~”, there are quite strong concerns from multiple companies. Hence, the moderator suggests removing the note from this proposed WA, while we don’t exclude it at this moment as we are saying “at least consider” in main bullet.

**Proposed working assumption**

* **If Rel-18 UL Tx switching is supported, both inter-band UL CA Option 1 (i.e., switched UL) and Option 2 (i.e., dual UL) are considered to define necessary mechanisms for UL Tx switching across 3 and 4 different bands**
	+ **Note: defining necessary mechanisms to support inter-band UL CA Option 1 and 2 without SUL is prioritized**
	+ **~~Note: SUL is not precluded~~**
* **If Rel-18 UL Tx switching is supported, at least following inter-band UL CA + SUL scenarios are considered to define necessary mechanisms for UL Tx switching across 3 and 4 different bands in addition to inter-band UL CA without SUL scenarios in Rel-18**
	+ **{SUL band + corresponding NUL band} + other NUL band (if UL Tx switching across 3 different bands is supported)**
	+ **{SUL band + corresponding NUL band} + other NUL band + other NUL band (if UL Tx switching across 4 different bands is supported)**
	+ **Note: defining necessary mechanisms to support inter-band UL CA Option 1 + SUL is prioritized, and if extra necessary mechanisms specific to inter-band UL CA Option 2 + SUL are identified, they can be discussed if time allows**
	+ **~~Note: if time allows, this does not preclude discussing other scenarios of inter-band UL CA + SUL in Rel-18 as long as no specific handling is necessary for the scenarios~~**

## 3.4. (Closed) Whether to support inter-band UL CA + EN-DC scenario(s) in Rel-18

(Already closed with following conclusion)

**Conclusion**

* **EN-DC cases are out of scope for Rel-18 UL Tx switching**

## 3.5. (Closed) Whether to support “UL transmission on a carrier without corresponding DL carrier” in Rel-18

(Already closed with following conclusion)

**Conclusion**

* **UL only cell cases are out of scope for Rel-18 UL Tx switching**

## 3.6. Whether to support inter-band UL CA with intra-band contiguous carriers within band(s) in Rel-18

After the 5th-round email discussion, companies’ feedbacks can be summarized as below.

* Fine with the FL proposal
	+ CATT, Xiaomi, LG
* Suggest adding “A single RF chain would cover both carriers in one band and UE jointly checks the configuration of the two carriers and use the maximum ports number among the scheduling for the two carriers on the band to decide whether to switch or not” to the first note
	+ QCM
* Suggest removing the last note or putting FFS on the last note
	+ QCM
* Suggest clarifying that intra-band contiguous carriers can be in non-SUL band
	+ QCM, ZTE

Based on the feedbacks, the proposed working assumption is updated as below. Regarding “non-SUL” part, it is true that in Rel-17 only non-SUL band can have two contiguous carriers as cribbedbed in the Rel-17 WID (“*Specify UE requirements to enable Tx switching between cases, where 1 carrier on band A and 2 contiguous aggregated carriers on band B, and band A is for SUL or non-SUL and band B is a non-SUL band*”). Regarding the first note, it is the moderator’s understanding that this note is to clarify the meaning/consequence of the sentence in main bullet “the same state of Tx chain is applied to the intra-band contiguous carriers within the band” and hence detailed explanation is helpful. Regarding the last note, although it was a note with “may not”, we can put FFS at this moment considering the feedback of potential concern.

**Proposed working assumption**

* **If Rel-18 UL Tx switching is supported, for Rel-18 UL Tx switching across up to 3 or 4 bands, there can be up to two contiguous carriers within a non-SUL band, and the same state of Tx chain is applied to the intra-band contiguous carriers within the band**
	+ **Note: A single RF chain would cover both carriers in one band and UE jointly checks the configuration of the two carriers and use the maximum ports number among the scheduling for the two carriers on the band to decide whether to switch or not (i.e., the Rel-17 mechanism on whether/when a UL Tx switching occurs or not is reused)**
	+ **One band can have up to two contiguous carriers within a band among 3 or 4 bands**
		- **Companies are encouraged to investigate whether there is any issue/impact if there are more than one band with contiguous carriers**
		- **FFS: whether the spec may not restrict which band can have up to two contiguous carriers within the band**

## 3.7. (Closed) Whether to support UL Tx switching with multiple TAGs in Rel-18 and how to proceed the discussion between RAN1 and RAN4

(Already closed with following conclusion)

**Conclusion**

* **It is RAN1’s understanding that RAN4 should lead the discussion on UL Tx switching with multiple TAGs for both 2 bands case and more than 2 bands case**
	+ **For further discussion in RAN1 with regards to UL Tx switching with multiple TAGs, it will be discussed only if triggered by RAN4**
	+ **If it is decided to support UL Tx switching with multiple TAGs, it is RAN1's working assumption that the number of TAGs should be limited to up to 2**

## 3.8. (Closed) Clarifications on some general assumptions for Rel-18 UL Tx switching

(Already closed with following conclusion)

**Conclusion**

* **If Rel-18 UL Tx switching is supported, following assumption is applied for Rel-18 UL Tx switching across up to 3 or 4 bands**
	+ **Only when the two Tx chains are linked to one NR band, the 2-ports UL transmission on the NR band is possible**

## 4.1. (Closed) Potential mechanisms for dynamic Tx carrier switching across the configured bands

(Already closed with following agreement and observation)

**Agreement**

Companies are encouraged to investigate pros and cons of following possible mechanisms for dynamic Tx carrier switching across the configured bands, and RAN1 strives for the down-selection at RAN1#110

* Alt.1: Dynamic Tx carrier switching can be across all the supported switching cases by the UE and based on the UL scheduling, i.e., via UL grant and/or RRC configuration for UL transmission
* Alt.2: NW indicates 2 bands out of the configured bands (3 or 4 bands) via DCI or MAC-CE, and dynamic Tx carrier switching between indicated bands is same as Rel-17
* Alt.3: One anchor band is selected among configured bands (3 or 4 bands), and dynamic Tx carrier switching can be performed only from the anchor band to a non-anchor band and from a non-anchor band to the anchor band
* Note: Other mechanisms are not precluded

**RAN1 Observation**

* **Following proposals to address the concern on UE/gNB complexity increase or scheduling restriction due to UL Tx switching across larger number of bands compared with Rel-16/17 are identified in contributions submitted at RAN1#109-e, and companies are encouraged to investigate pros and cons of the proposals so that one or some of them may be down-selected after the down-selection of the mechanism for dynamic Tx carrier switching across the configured bands**
	+ **UE can report the supports of only some of concurrent UL cases (combinations of 2 bands for concurrent UL transmissions)**
	+ **Switching across 0/1/2 ports is supported only for 2 configured bands out of 3 or 4 configured bands and other bands support switching across 0/1 port only**
	+ **Only switching across 0/1 port is supported across all configured bands when 3 or 4 bands are configured**
	+ **Prioritization rules between uplink carriers are specified**
	+ **No restriction on the UEs choice of MIMO capability on any of the bands/CCs involved in the UL Tx switching band combination is introduced**
	+ **After one RF state switch, the next RF state switch must occur after 14 symbols or later (FFS: which SCS is assumed for the symbol duration)**
	+ **Note: Other solutions are not precluded**
	+ **Note: each proposal assumes certain mechanism for dynamic Tx carrier switching across the configured bands, and hence some or all of the proposals may not be necessary depending on the down selection of the mechanism for dynamic Tx carrier switching across the configured bands**

## 4.2. (Closed) Potential switching configuration(s) to be supported for Rel-18 UL Tx switching

(Already closed with following observation)

**RAN1 Observation**

* **Following possible switching configurations can be considered, and RAN1 may discuss if any of the following switching configurations need to be supported after making some progress on the discussion on the switching mechanism**
	+ **For 3 bands case**
		- **Switching configuration.3-1: all the 3 bands support up to 2Tx**
		- **Switching configuration.3-2: only 1 band out of 3 bands support up to 2Tx**
		- **Switching configuration.3-3: only 2 bands out of 3 bands support up to 2Tx**
	+ **For 4 bands case**
		- **Switching configuration.4-1: all the 4 bands support up to 2Tx**
		- **Switching configuration.4-2: only 1 band out of 4 bands support up to 2Tx**
		- **Switching configuration.4-3: only 2 bands out of 4 bands support up to 2Tx**
		- **Switching configuration.4-4: only 3 bands out of 4 bands support up to 2Tx**
	+ **~~Note: separate switching configuration for switched UL and dual UL is not precluded~~**
	+ **~~Note: In addition to the UE/gNB complexity reduction, performance reduction caused by any scheduling restriction can also be taken into account~~**
	+ **Note: The Spec should not restrict which Tx chain is fixed or switched across certain bands.**