**3GPP TSG RAN WG1 #109-e R1-2205471**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.10.2

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

**Title:** Summary#3 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 19th 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

RAN1 chair declared that following observation will be captured in the chair note and following agreement was made.

**RAN1 observation**

* **Four contributions (3136, 4724, 4909, 5131) 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 3136 show the performance gain of UL Tx switching across 4 bands compared with UL Tx switching across 3 bands.**
		- **Evaluation results in 4724 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.**

**Proposed agreement (from section 3.1)**

* **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**

## 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

Based on the discussion so far, it seems companies would have different understanding on “SUL configurability in existing CA framework” while it seems to be agreeable to support at least some scenarios of inter-band CA + SUL (such as scenarios with only one SUL) if Rel-18 UL Tx switching is supported. In that sense, the moderator suggested changing the main bullet from “~ scenarios are supported” to “~ scenarios are considered to define necessary mechanisms” so that companies can discuss necessary mechanisms for some different scenarios where some differences on the mechanism may exist, while other scenarios are not precluded as long as no specific handling is necessary for the scenarios.

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

* Suggest removing 1st note to have no priority between CA Opt.1+SUL and CA Opt.2+SUL
	+ OPPO, Xiaomi, ZTE
	+ Should keep 1st note, or preclude CA Opt.2+SUL
		- QCM, Intel, IDC
	+ Modify the 1st note “if extra necessary mechanisms specific to CA Opt.2+SUL are identified, they can be discussed if time allows”
		- HW
* Suggest modifying 2nd note to change “support” to “discussion”
	+ Apple, vivo, LG, E///
	+ Should be removed
		- QCM, ZTE, IDC
	+ Should keep 2nd note
		- HW
* Suggest adding a note “intra-band SUL/SUL and intra-band SUL/NUL are not supported”
	+ ZTE
* Suggest not bundling CA without SUL and CA+SUL
	+ ZTE
* Suggest modifying the 2nd main bullet “define necessary mechanisms in addition to CA without SUL in Rel-18 which has no RAN1 optimization specific to the inter-band UL-CA+SUL scenarios other than the following scenarios”
	+ HW

Based on the above situation, companies still have concerns/different views on following points even though the moderator’s proposal already considered a compromise for these points.

* Whether CA Opt.2 + SUL should be supported or precluded (whether it requires extra effort/spec impact)
* Whether scenarios with more than one SUL should be supported or precluded (whether current CA framework allows such configuration)

As there are several suggestions for modifications, we can further discuss on them to find a possible compromised point companies can accept for progress.

**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**
	+ **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 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 bands is supported)**
	+ **{SUL band + corresponding NUL band} + other NUL band + other NUL band (if UL Tx switching across 4 bands is supported)**
	+ **Note: defining necessary mechanisms to support inter-band UL CA without SUL and inter-band UL CA Option 1 + SUL (which can reuse mechanisms for inter-band UL CA Option 1 without SUL) are 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

Based on the discussion so far, the moderator suggested some modifications according to the feedbacks so far. In addition, considering that there are several companies prefer to not restrict the number of bands with contiguous carriers to only one, the moderator suggested making a working assumption and companies can be encouraged to investigate whether there is any issue/impact if there are more than one band with contiguous carriers.

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

* Fine with the FL proposal
	+ Apple, vivo, CT, LG, Xiaomi, IDC, HW
* Suggest removing 2nd note
	+ QCM, Intel
* Suggest removing 3rd note
	+ QCM, Intel
	+ Suggest revising “may be” to “is”
* Suggest modifying 2nd sub-bullet “one or more band”
	+ ZTE
* Suggest adding a note “intra-band SUL/SUL and intra-band SUL/NUL are not supported”
	+ ZTE
	+ Suggest focusing on L1/L2/L3 functionality rather than RAN4 requirements
		- HW

Based on the above situation, although there are still concerns on the notes, the moderator thinks current proposal would be only possible compromised way forward at this moment given different views among companies, such as only one band with two carriers vs more than one band with two carriers. As the proposal is working assumption and the notes are described with “may/may not”, the moderator would like to ask companies again to consider proposed working assumption for making progress.

**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 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**
		- **Note: the spec may not restrict which band can have up to two contiguous carriers within the band**
	+ **Note: RAN1 spec may be described agnostic to number of carriers within a band**

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

Based on the discussion so far, it seems RAN1 would not be ready to say "there is no RAN1 specification impact" even for 2 bands with 2 TAGs case, while other parts of the proposed conclusion seems agreeable. Therefore, the moderator suggested to make a conclusion.

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

* Fine with the proposed conclusion
	+ Apple, vivo, CT, QCM, Xiaomi, ZTE, Intel, IDC
* Suggest removing “whether to support” from the main bullet as in previous version (it’s moderator’s mistake)
	+ HW
* Suggest clarifying the meaning of the last sub-bullet
	+ LG

Based on the above situation, the moderator thinks the proposed conclusion is agreeable. The comment from Huawei is reflected as it was just moderator’s mistake. Regarding LG’s comment, the moderator’s understanding is that there are multiple companies who prefer to have this limitation if UL Tx switching with multiple TAGs is supported. On the other hand, RAN4 would also discuss how many TAGs can be allowed if UL Tx switching with multiple TAGs is supported. Therefore, it is captured as “RAN1’s working assumption” so that if RAN4 identifies more than 2 TAGs can be allowed, RAN1 can discuss it again and can share RAN1’s view with RAN4 if necessary.

**Proposed conclusion**

* **It is RAN1’s understanding that RAN4 should lead the discussion on ~~whether to support~~ 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. Clarifications on some general assumptions for Rel-18 UL Tx switching

As agreed in the section 3.1, RAN1 will ask RAN4’s 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

So, in this section, the moderator suggested making agreement on the straightforward assumption on 2-ports UL transmission in Rel-18.

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

* Fine with the FL proposal
	+ Apple, vivo, CT, LG, Xiaomi, ZTE, Intel, IDC

Based on the above situation, the following FL proposal is agreeable.

**Proposed agreement**

* **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. Potential mechanisms for dynamic Tx carrier switching across the configured bands

RAN1 chair declared that following agreement was made.

**Proposed agreement (from section 4.1)**

* **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**

Based on the discussion so far, the moderator also suggested capturing 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 as observation in chair note.

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

* Fine with the proposed conclusion
	+ Apple, CT, LG, QCM, Xiaomi, ZTE, Intel, IDC

Based on the above situation, the following FL proposal to be captured in chair note is agreeable.

**Proposed 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. Potential switching configuration(s) to be supported for Rel-18 UL Tx switching

Based on the discussion so far, the moderator suggested capturing all possible switching configurations as observation in chair note.

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

* Fine with the proposed observation
	+ LG, Xiaomi, IDC
	+ Suggest modifying “the down-selection” to “if any of the following switching configurations need to be supported” in main bullet
		- Apple, CT
	+ Suggest modifying “RAN1 will discuss” to “RAN1 may discuss”
		- ZTE
	+ Suggest modifying “down-selection” to “switching configuration” in 1st note
		- CT
		- Suggest removing 1st note (same as agreement in section 4.1)
			* QCM, ZTE
	+ Suggest removing “for down-selection” from 2nd note
		- CT
		- Suggest removing 2nd note (same as agreement in section 4.1)
			* QCM, ZTE
	+ Suggest removing 3rd note
		- Intel (too early to discuss restriction in the spec)
		- Clarified that RAN1 should avoid restricting the Tx chain mapped to certain band(s) as this should be left to UE implementation (UE can report e.g., supporting 2Tx on band A/B and 1Tx on band C, and the UE can select the Tx chain for switching by implementation without violating the Tx number restriction on one band)
			* CT, QCM

Based on the above situation, the moderator suggests discussing following updated observation.

**Proposed 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. It is up to UE implementation.**