**3GPP TSG-RAN** **WG2 Meeting #114 electronic R2-210xxxx**

**Online, 19 – 27 May, 2021**

**Source: Samsung**

**Title: Summary of email discussion [Post113bis-e][061][feMIMO] InterCell mTRP and L1L2 mobility (Samsung)**

**Document for: Discussion and Decision**

**Agenda Item: x.xx**

# Introduction

This document summarizes the following email discussion.

* [Post113bis-e][061][feMIMO] InterCell mTRP and L1L2 mobility (Samsung)

 Scope: Based on R1 LS and discussion at R2 113bis-e, achieve better understanding of impact in R2, pave the way for potential high level decisions, pave the way for decisions needed to reply to R1 LS, identify questions that R2 shold ask R1, if any (can e.g. apply P3 from R2-2104632). Intention to provide a reply to R1 from next meeting.

 Intended outcome: Report

 Deadline: Long

In RAN2#113bis-e meeting, RAN2 intensively discussed the L1/L2 centric mobility based on RAN1 LSes [1][2] and RAN2 tried to share the understanding on this issue. As results of the offline discussion [3], RAN2 progress some aspects to support L1/L2 centric inter-cell mobility but the main use cases what RAN1 intended are stil unclear i.e. companies have different understanding the scope of this issue.

[R2-2104632](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2104632.zip) Summary of email discussion [AT113bis-e][035][feMIMO] L1L2 Centric Mobility Samsung

DISCUSSION

P1

- Nokia think the intent is that we indicate something to R1, extra-cell?

- ZTE think indeed the term is strange.

- Chair wonder what is the L1 difference of non-serving cell? SS and ZTE think the only difference is PCI otherwise nothing?

P2

- Chair think it would be good to understand the m-TRP model in order to understand to what extent HO model is needed and how it can work.

- replying to Q from Intel. Samsung think RAN2 can provide understanding for both cases.

- Ericsson think the LS is about two separate questions, mTRP and HO and both are supported from R1 perspective, both Scenario 1` and 2 are applicable and included.

- vivo has similar understanding as Ericsson, need to assume both. Not sure there is enough Tus in R2, can discuss more on common parts between these cases.

- Oppo think mTRP is scenario 1 and HO is scenario 2. Confusion seems to apply for scenario 2. RAN1 hasn’t finished their job so we can focus on Secnario 1 and possibly HO for scenario 2.

- MTK think the scenarios are different and think that in scenario 2 Pcell is changed, can ficus on scenario 1.

- Xiaomi think we should first focus on scenario 1. For Scenario 2 we’d anyway need to send an LS.

- Huawei think the key difference between 1 and 2 is if the serving cell shall be changed. Think we can just agree P2. Also see some commonality between the scenarios.

- Apple think we should cover scenario 1 and 2, not sure what is the new issue of scenario 1.

- QC think the two WI objectives are separate in R1 and this LS is ony about L1 L2 mobility and changing the cell.

- FW also think the amin difference between scenarios is wheher we need to change the Pcell, need to start with Scenario 1 to see impact of L2 procedures for mobility etc.

- LG think it is easy to support mTRP objective but not the mobility objective and think due to TU we should focus on the first.

- Nokia think we can ask R1 about the intentions.

- Samsung think that scenario 1 and 2 are different and 2 brings much more R2 impact, we can focus on scenario 1 now.

P4

- Nokia think the plural of candidate cell(s) should be removed.

- intel wonder whether this proposal is intended to address both HO and mTRP. SS think this is only for mTRP. ZTE think that if this is just for mTRP then this is invisible to the UE. ZTE think this applies to HO

- Chair: it seems this is widely supported but unclear what problem is addressed.

P6

- Huawei wonder how different C-RNTI will work, it may impact ID handling for the RACH procedure.

* The term “non-serving cell(s)” seems to cause confusion, and should be changed (to be consistent with the current RAN2 definitions).
* RAN2 further study the impact on L1/L2 centric mobility for inter-cell multi-TRP-like model and inter-cell HO-like model.
* Chair: while unclear, there seems to be support for: RRC provides the pre-configured configuration of “the candidate cell for L1/L2 centric mobility” (FFS if > 1), and L1/L2 signaling can be used/feasible for the dynamic switching of the pre-configured value.

Chairman: For now, Work on both mTRP and Mobility scenarios.

* Continue by long email discussion, to better understand impact in R2, pave the way for potential high level decisions, and get replies and Q to R1 LS

In this offline discussion, RAN2 tried to get better understanding of the RAN2 impact on both inter-cell multi-TRP-like model and inter-cell HO-like model as chariman suggested. Based on the RAN2 impact on both scenario, RAN2 will be able to provide the reply LS with the answers for the questions in RAN1 LS [2].

# Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Samsung | Seungri Jin | seungri.jin@samsung.com |
| Nokia | Tero Henttonen | tero.henttonen@nokia.com |
| OPPO | Zhongda Du | duzhongda@oppo.com |
| Ericsson | Pradeepa Ramachandra | pradeepa.ramachandra@ericsson.com |
| Apple | Fangli XU | fangli\_xu@apple.com |
| Intel | Youn Heo | Youn.hyoung.heo@intel.com |
| Xiaomi | Yumin Wu | wuyumin@xiaomi.com |
| ASUSTeK | Xinra Kung | Xinra\_Kung@asus.com |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Discussion:

## RAN2 impacts on L1/L2-centric inter-cell mobility

In R2-2102625 (LS on Agreements Pertaining to L1/L2-Centric Inter-Cell Mobility)[1], all agreements on L1/L2 centric inter-cell mobility issue are included. First, it is very important RAN2 know what is the scope of this WI especially for support L1/L2 Centric Inter-Cell Mobility. One hint based on the RAN1 agreements in [1] is that RAN1 initially assumed that this feature potentially can extend the Rel-16 mobility mechanism but the main outcome seems to be dynamic TCI state update using the TCI framework for inter-cell case (i.e. to extend Rel-15/16 mTRP operation for intra-cell to inter-cell), see below yellow highlight.

The detail functionalities to support the TCI state update (beam indication) for DL reception from and UL transmission to non-serving cell(s) – at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH are also listed as green highlight below. According to this required functionalities,

1. UE receives from serving cell, configuration of SSBs/CSI-RSs of non serving cell for beam measurement.
2. UE performs beam measurement for non-serving cell and report it to serving cell.
3. Based on the above reports, TCI state of non-serving cell is activated from the serving cell (by L1/L2 signaling).
4. Prior to and upon activation of TCI state of non-serving cell, actions performed by UE are unclear and needs discussion.
	* UE starts receiving UE-dedicated PDSCH, PDCCH from non serving cell
	* UE starts transmitting UE-dedicated PUSCH, and PUCCH to non serving cell

|  |
| --- |
| * [Issue 2] For Rel.17 NR FeMIMO, on L1/L2-centric inter-cell mobility:
	1. In RAN1#103-e, finalize scope and use cases for L1/L2-centric inter-cell mobility, including:
		+ Applicability in various non-CA and CA setups such as intra-band and inter-band CA
		+ Use cases in comparison to Rel.15 L3-based handover (HO) taking into account potential extension of DAPS-based Rel.16 mobility enhancement to FR2-FR2 HO
		+ The extent of RAN2 impact (MAC CE, RRC, user plane protocols)
		+ Network architecture, e.g. NSA vs. SA, inter-RAT scenarios
	2. In RAN1#103-e, depending on the outcome of 2a), further identify additional components –along with the associated alternatives –required for supporting inter-cell mobility based on the same unified TCI framework as that for intra-cell mobility (including dynamic TCI state update signaling), including
		+ Method(s) for incorporating non-serving cell information associated with TCI
		+ Method(s) for DL measurements and UE reporting (e.g. L1-RSRP) associated with non-serving cell(s)
		+ UE behavior for reception of signals and non-UE-specific control and data channels associated with non-serving cell(s)
		+ UL-related enhancements, e.g. related to RA procedure including TA
		+ Beam-level event-driven mechanism for L1/L2-centric inter-cell mobility
* FFS: The following enhancement scope is assumed by RAN1:
	1. Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated
		+ A non-serving cell RS is an RS that is or has an SSB of a non-serving cell as direct or indirect QCL source
		+ This implies no C-RNTI update when UE receives DL channel RS associated to non-serving cell RS as QCL source.
		+ FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels.
	2. Whether some RRC parameters need to be updated without additional RRC signaling, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source
	3. Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility.
	4. The above assumption to be verified by RAN2
 |

However, RAN1 also indicated whether the serving cell change could be possible in cyan highlight above, it seems RAN1 tried to introduce the inter-cell mobility by L1 signaling e.g. L1 triggered L3 HO.

Since RAN1 asked if UE need to change a serving cell for DL reception from or UL transmission to another (non-serving) cell, at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH. If the answer is yes, RAN2 needs to provides more information as requested by RAN1 e.g. how the configuration is provided, how TCI states associated, system information impact, RACH and PUCCH-related impact, etc.

In below questions, it is requested to gather the expected RAN2 impact on each scenarios to pave the way for potential high level decisions.

* Scenario 1: Inter-cell multi-TRP-like model (i.e. without serving cell change)
* Scenario 2: Inter-cell HO-like model (i.e. with serving cell change)

**Q1: What is the expected RAN2 impact for inter-cell multi-TRP-like model (i.e. Scenario 1)?**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Nokia, Nokia Shanghai Bell | The basic requirement is to allow linking a TCI state or CORESET pool to utilize SSB that uses different PCI than the serving cell PCI. Then the exact changes depend on how RAN1 decides this is done, but require at least the following:* Addition/release/modification of inter-cell multi-TRP (i.e. PxxCH configuration with different TCI states linked to a different PCI than serving cell PCI)
* Measurements and procedures to use the inter-cell multi-TRP (e.g. activation/deactivation via MAC CE, measurement reporting configuration)
* TCI state linkage for inter-cell multi-TRP (e.g. does the current TCI state definition require modifications)
* Inter-cell multi-TRP interaction with (L3) handovers and RRM measurements
 |
| OPPO | We think the title of the issue itself is bit misleading because both issues are not necessary “inter-cell” issues i.e. cell A and cell B in figure below could be same cell but with different TRP.In this way only beam management constrained within same PCI is extended to two PCIs. To us this is mainly RAN1 issue and transparent to L2/L3 i.e. no RAN2 impact apart from potential update of the beam management relevant configuration which is business as usual for RAN2.But if cell A and cell B are different cell,RAN2 first need discuss how to model it in user plane. Whether it could be taken as carrier aggregation between intra-frequency carriers or what else? In control plane it is also not clear what is the relationship between cell switch between cell A/cell B and cell role change. And RAN2 need discuss what is potential procedure to change cell role e.g. whether it is legacy HO procedure or it could be MAC layer procedure or even physical layer procedure etc.In Rel17 there are 8 MIMO agenda items and L1/L2 mobility is one of the 6 sub-topics of one MIMO agenda items. For RAN1 if cell A and cell B could be completely different cell, then the workload for RAN1 is also very big.Overall we think cell A and cell B should be taken as same cell to avoid potential RAN2 impact and high RAN1 workload in Rel17. |
| Ericsson | Firstly, we would like to highlight that inter-cell multi-TRP like model concerns the following objective of the WID (RP-193133).1. Enhancement on the support for multi-TRP deployment, targeting both FR1 and FR2:
	1. Identify and specify features to improve reliability and robustness for channels other than PDSCH (that is, PDCCH, PUSCH, and PUCCH) using multi-TRP and/or multi-panel, with Rel.16 reliability features as the baseline

As part of the multi-TRP enhancements, RAN1 has discussed the possibility of extending the multi-TRP enhancements of Rel-16 to also include TRPs transmitting different PCI in the SSBs. Associated to this, we forsee the following impacts in RAN2.1. Serving cell definition in RAN2 pertains a single PCI. There can be atmost one serving cell for a UE on a given frequency. A UE can transmit/receive data to/from only its configured serving cell. If one has to enable the transmission/reception of data to/from more than one PCI, then the following serving cell definition related discussion needs to take place in RAN2.
	1. Do we need to redefine the ‘serving cell’ definition in RAN2 as this feature supports the data transmission/reception from/to more than one cell on the same frequency?
	2. How does the ‘non-serving cell’ related PxxCH configuration configured to the UE? Does the serving cell configuration consist of more than one PCI related PxxCH configurations? Or do we provision the ‘non-serving cell’ related PxxCH configuration outside the serving cell configuration.
2. MAC CE associated if new MAC CEs are introduced that indicates the UE that it should start/stop receiving data from/to a cell with different PCI.
3. Impact on the RRM measurements related to the serving cell. As the inter-cell mTRP enhancements possibly include the PDCCH reception from more than one PCI, in principle we believe this could also affect the layer-3 RRM measurements associated to serving cell. Performing the layer-3 serving cell meausrements using the existing method might create a discrepancy between RLM and RRM measurements.
 |
| Apple | In scenario 1 (i.e. Inter-cell multi-TRP-like model), RAN2 impact may include the following aspects:1. **UE dedicated data transmission/reception model**

In legacy, UE is only allowed to perform data transmission and reception in serving cell. In scenario 1, UE is required to transmit data on the non-serving cell, which is contradict with legacy mode. In addition, in legacy it is only allowed to monitor the the data scheduling via one PCI in one frequency, but in this scenario UE is required to monitor scheduling with mulitple PCIs on one frequency.1. **TRP set/TCI state set management**

The signaling and procedure for the management of the TRP/TCI state set for data transmission, including the signaling design of the addition/modification/release, and the UE measurement report to help NW perform the set management.1. **DL Timing, UL TA, power control maintenance, BFD/BFR mechanism for the transmission on the non-serving cell.**

It’s unclear whether the non-serving cell for data transmission and reception will have the same as the serving cell, or whether UE should maintain each TRP/TCI state specific DL timing, UL TA or power control maintenance. If RACH is required for the non-serving cell’s transmission, it’s new concerpt to support the the RACH on the non-serving cell. 1. **RRM Measurement on the non-serving cell**

If the non-serving cell is within the PCell coverage, there may have no RRM measurement and mobility performance issue. Otherwise, i.e. non-serving cell is out of the PCell coverage, if no RRM/RLM measurement on the non-serving cell, UE may perform RLF when performing the data transmission on the non-serving cell. To support the scenario#1 with current RAN2 model, we may model the different TCI states/TRPs as the different BWPs. With this model, we can simply use the BWP switching to achieve the TRP change purpose.  |
| Intel | We think what the email rapporteur summarized is a reasonable starting point for Scenario 1. RRC provides the pre-configured configuration of “the candidate cell for L1/L2 centric mobility” (FFS if > 1), and L1/L2 signaling can be used/feasible for the dynamic switching of the pre-configured value.Nokia summarized well on the main points. We provide some additional thoughts below. * Configuration of TRP with different PCI: at least, the dedicated channels that are supported by TRP with different PCI (PDSCH, PDCCH, PUSCH and PUCCH) should be configured. In addition, cell specific parameters might be needed e.g. PRACH. SIB, paging, etc. Depending on how much cell specific parameters are required, RAN2 can consider how signaling structure is designed e.g. CA-like model or BWP like model.
* Dynamic switching (TCI state update): If RAN1 introduce an unified TCI frame work for inter-cell multiple TRPs, TCI update via MAC CE signaling and/or DCI based TCI switching would be used to switch between TCI1 and TCI2. We can wait until RAN1 progress it. In addition, it is not clear whether both DL and UL TCI state update can happen or can be independent. However, from RAN2 pov, it would be simpler to assume DL and UL TCI state update/switching should be done at the same time.
* Measurement to use the inter-cell multi-TRP: if RAN1 use an unified TCI framework for multi-TRPs, there would be no big impact to RAN2 as the current TCI framework can be simply extended.
* Inter-cell multi-TRP interaction with (L3) handovers and RRM measurements: we have not identified any impact to RRC (including HO and RRM) in Scenario1.
 |
| Xiaomi | We consider that RAN2 should firstly achieve the common understanding for both scenario 1 and scenario 2 of the L1/L2-centric inter-cell mobility at least on the following two points:Common understanding 1: When the L1/L2 signaling indicates the TCI state change, the UE changes its serving cell configuration to another candidate configuration (i.e. the preconfigured non-serving cell configuration) at least for PDSCH, PDCCH, PUSCH, and PUCCH.Common understanding 2: The TRP (or TCI state) change does not result in L2 reset (i.e. MAC/RLC/PDCP reset).RAN2 impacts for both Scenario 1 and Scenario 2 includes:1) Addition/release/modification of the non-serving cell associated to a serving cell2) MAC CEs for the L2-centric inter-cell mobility (needs to wait for more inputs from RAN1)3) TA maintenance (needs to wait for more inputs from RAN1)4) System information reception/configuration5) RRM measurement of the serving cell6) RLM of the PCellP.S. RAN2 should also firstly focus on the PCell configuration change via the L1/L2-based inter-cell mobility. |
| ASUSTeK | In addition to the impacts pointed out by companies above, * Beam management regarding multi-TRP. As TRP-specific BFR is agreed based on RAN1 discussion, current beam failure recovery procedure should be enhanced to adapt non-serving cell beam failure recovery including beam failure indication calculation based on TRPs, recovery procedures when beam failure occurs on non-serving cell TRPs, SR resource configuration/triggering for TRP specific BFR, and BFR MAC CE content design.
* TCI state configuration enhancement regarding mapping TCI states to “non-serving cells”.
* How the UE obtains TA to perform communication with the non-serving cell. Whether it’s obtained via RACH or a via message(s) provided by the NW should be discussed.
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

**Q2: What is the expected RAN2 impact for inter-cell HO-like model (i.e. Scenario 2)?**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Nokia, Nokia Shanghai Bell | The basic requirement for the inter-cell HO-like model is to allow network to use L1/L2-signalling to trigger serving cell change. We will call this as **L1 mobility** from now on. This further requires at least the following:* Addition/modification/release of L1 mobility configurations (including the content of what can and needs to be pre-configured)
* How to ensure L1 mobility reliability and prevent configuration mismatches (e.g. how to ensure the signalling triggering L1 mobility is secure and robust enough, and what happens on failure)
* Analysis of security of L1 mobility (i.e. to avoid attacks causing unnecessary cell changes, which may require SA3 consultation)
* L1 mobility interaction with other features (e.g. HO, CHO, DAPS, multi-TRP, CA, DC, etc.)
* User plane impacts (e.g. how does MAC/RLC/PDCP/SDAP work during L1 mobility)
* Dynamic switching between stored L1 mobility configurations (if more than one configuration is supported)
* Measurement reporting for L1 mobility (e.g. how do RRM/RLM measurements work with L1 mobility, is additional event-triggered reporting needed, etc.)
 |
| OPPO | Following our answer to Q1, if we take cell A and cell B as one cell, then no serving cell change is needed at all also in scenario2. The main difference compared to scenario 1 is that TRP must be changed which could be taken as normal beam management procedure. |
| Ericsson | Firstly, we would like to highlight that the inter-cell HO-like model concerns the following objective of the WID (RP-193133).1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:
	1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility and/or a larger number of configured TCI states:
		1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA
		2. Unified TCI framework for DL and UL beam indication
		3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)

As part of the L1/L2 centric inter-cell mobility, RAN1 has discussed the possibility of switching the PxxCH reception/transmission from one PCI to the other PCI using the lower layer procedures (TCI state update). Associated to this, we forsee the following impacts in RAN2.1. How does the ‘non-serving cell’ related PxxCH configuration configured to the UE? Does the serving cell configuration consist of more than one PCI related PxxCH configurations? Or do we provision the ‘non-serving cell’ related PxxCH configuration outside the serving cell configuration. Further the servingCellConfigCommon associated to the ‘non-serving cell’ should also be delivered to the UE.
2. MAC CE associated if new MAC CEs are introduced that indicates the UE the need to switch the serving PCI from one PCI to the other.
3. RAN2 needs to look into the impact of serving PCI change from the lower layers on the layer-3 based RRM measurements framework. Upon switching the serving cell from one PCI to the other using L1/L2 signaling, the serving cell measurements as per layer-3 evaluations need to be updated and any ongoing event evaluation needs to be handled.
 |
| Apple | In scenario 2 (i.e. inter-cell HO-like model), RAN2 impact may include the following aspects:1. **The candidate cell (non serving cell) set configuration and maintenance**

NW can preconfigure the non serving cell as the candidate cells by RRC signaling, and switch the candidate cell to the serving cell when perform the UE dedicated data transmission. 1. **Candidate cell and serving cell switching**

The candidate cell shall be switched into the serving cell for the UE dedicated data transmission. The cell type role switching should be performed by L1/L2 signaling or when the condition is fulfilled.1. **User plane impact**

For intra-DU case, since NW anchor for L2 handling is not changed, so the SDAP/PDCP/RLC/MAC layer has no change during the cell change procedure, and UE just uses the target cell’s PHY configuration to perform the UL/DL data transmission  |
| Intel | * Although RAN1 is looking for the possible enhancement that serving cell change is initiated upon TCI state update or upon any other L1/L2 indication, it is not clear how serving cell switching upon L1/L2 indication looks. For example, if it is one-directional switch from serving to non-serving cell, we could consider this switching based on existing L3 handover procedure e.g. handover triggered by L1/L2 indication. On the other hand, if bi-directional and frequent switch among serving cell and TRP(s) is required, serving cell change would be different from existing handover procedure and be more like activation/deactivation among pre-configured candidate cells.
* One-directional HO: in Rel-16, CHO is introduced, in which multiple candidate cells are configured and handover is executed when the execution condition is met. With CHO framework, RAN2 impact is not so big but we should evaluate whether L1 measurement is stable enough to execute handover and how much gain is expected with L1/L2 indication based CHO.
* Bi-directional HO: cell switching between serving cell and TRP with different PCI. In this approach, both serving cell and TRP with different PCI could be configured as serving cells similar to CA. With L1/L2 indication, one cell can be activated similar to Scenario A. It might be feasible for SCells. However, given that PCell cannot be deactivated, further change would be needed for PCell.
 |
| Xiaomi | RAN2 impacts for both Scenario 1 and Scenario 2 includes:1) Addition/release/modification of the non-serving cell associated to a serving cell2) MAC CEs for the L2-centric inter-cell mobility (needs to wait for more inputs from RAN1)3) TA maintenance (needs to wait for more inputs from RAN1)4) System information reception/configuration5) RRM measurement of the serving cell6) RLM of the PCellWe think that although the RAN2 impacts for both Scenario 1 and 2 are expected to be quite the same. The solutions for modifying the corresponding functions for Scenrio 1 and 2 could be different. |
| ASUSTeK | * Inter-cell handover procedure design using L1/L2 signaling. Based on common support in the last meeting, configured values for candidcate cell can be provided in advance via RRC message, and a L1/L2 signaling can be used to trigger the UE to switch SpCell to the configured cell. The exact content for the RRC message and L1/L2 signaling needs to be discussed.
* How the UE obtains TA to perform handover to the target non-serving cell. The UE can perform a random access procedure to otain TA from the target cell, or the TA value can be indicated by src cell’s RRC message (via RRC message or via L1/L2 signaling).
* L2 signaling (e.g. MAC CE) design for inter-cell HO if L2 signaling is used to trigger inter-cell HO.
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

We think it would be better RAN2 provides the preference on the scope of L1/L2 centric mobility based on RAN2 impact

**Q3: Which Scenario could be the scope of the L1/L2 centric mobility in Rel-17?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Scenario** | **Comments** |
| Nokia, Nokia Shanghai Bell | Scenario 1 but... | We think scenario 1 is simpler but it would be preferable to consider what is the intent of the WI: It seems to us that scenario 1 is the pre-requisite to scenario 2 (as UE needs to be configured with the inter-cell resources before it can switch between them), but if the scenario 2 allows for faster mobility performance (compared to L3 mobility), that may be beneficial. Ultimately this is RANP decision and RAN2 should just consider what is possible within Rel-17 as **even** scenario 1 likely requires considerable amount of work from RAN12345. |
| OPPO | Both with comments | If cell A and cell B are taken as same cell, there is no essential difference from RAN2 point of view. But if cell A and cell B are taken as different cell, then we prefer to prioritize scenario 1 in Rel17. |
| Ericsson | Both | The WID covers both scenarios and therefore both scenarios should be supported. Reducing the scope of the WID is not in the realm of RAN2. |
| Apple | Both | The WI includes both scenarios. As RAN1 request, RAN2 should provide the RAN2 impact for both scenarios, and should not perform down selection.  |
| Intel | Both Scenarios | Scenario 1 would be simpler from specification work point of view but it is worthwhile to study the feasibility of L1/L2 triggerd mobility to utilize multi-TRP operation for mobilty enhancement.  |
| Xiaomi | Both | We think both scenario can be included. Prioritizing scenario 1 could be considered given the limited TU in the Rel-17 FeMIMO. RAN2 can also ask RAN1 to clarify which scenario should be prioritized, as the solutions for the two scenarios are quited different.  |
| ASUSTeK | Scenario 2 | The WID covers both scenarios but “L1/L2 centric mobility” should be focusing on Scenario 2. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

|  |
| --- |
| **Question 2**: In regard of RRC configuration, RAN1 is discussing whether to allow a UE to be configured for DL reception from or UL transmission to a non-serving cell on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH. From RAN2 perspective1. Depending on the answer to question 1-1, what would be the impact of allowing the UE to transmit and/or receive on some or all of those channels and which RRC parameter(s) would need to be reconfigured for the UE?
2. Is it feasible to update some of the above RRC parameter(s) via dynamic signaling (e.g. MAC CE and/or DCI, potentially selecting pre-configured values) without any additional RRC reconfiguration signaling?
 |

For above questions, RAN2 impact especially for configuration aspect to support L1/L2 centric mobility was discussed during the RAN2#113bis-e meeing, in general RAN2 uses RRC configuration to configure UE-dedicated configuration and it is clear that new RRC configuration for non-serving cell is required. In addition, dynamic signaling (MAC CE and/or DCI, potentially selecting pre-configured values) could be possible so it can be introduced if needed.

Following proposal was made in RAN2#113bis-e meeing:

**Proposal A: RRC provides the pre-configured configuration of “the cells for L1/L2 centric mobility”, and L1/L2 signaling can be used/feasible for the dynamic switching of the pre-configured value.**

**Q4: Do companies agree the above proposal (i.e. Proposal A), if yes, which scenario this proposal could be applied?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Depends on interpretation | It's impossible to answer this before the details are understood: We don't even know what the "L1/L2-centric mobility" means yet (see scenario discussion above). It's certainly feasible to allow L1/L2 signalling to impact used UE configuration (that's how BWP switching works), but whether such switching provides any performance gain requires further studies. Hence, the "feasibility" should also consider the gains achievable from the feature and the impacts to RAN WG workload. |
| OPPO | No | We think cell A and cell B should be same cell. In order to enable beam management via reference signal associated to up to two PCIs, network can configure additional configuration e.g. reference signal,TCI state etc relevant to another PCI but not another cell. |
| Ericsson | Yes | This proposal is clearly about ‘mobility’ as stated in the proposal itself. Therefore, in our understanding this refers only to scenario-2. |
| Apple | Yes | The proposal could be applicable for both scenarios. For scenario#1, if different TRPs are modelled as the different BWP, then we can use the BWP switching model to achieve it. For scenario#2, L2/L1 signaling based cell change indication could be used to trigger the cell change.  |
| Intel | Probably yes | From RAN2 pov, we don’t see any critical issue to enable dynamic switching by keeping the pre-configured configuration when it is deactivated. Probably, it is more dependent on RAN1 design how all deactivated TRPs can be maintained.  |
| Xiaomi | Yes | We think this high level understanding is aligned with the RAN1 discussion. The detailed configurations can be up to RAN1 to decide. |
| ASUSTeK | Yes | Since the proposal states it’s for mobility, it’s made for inter-cell HO-like model (Scenario 2). Similar mechanism may be applied to mTRP procedure as well, but needs further discussion. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

For the number of cells for L1/L2 centric mobility to be configured by RRC, companies had different understanding so below propsoal was made.

**Proposal B: RAN2 prefer minimizing the RRC signaling overload for the pre-configuration part in Rel-17.**

* **FFS: the number of candidate cells for L1/L2 centric mobility, contents of common configurations**

It seems too early to decide the detail configuration but if companies reached the common view on this aspect it would be better to determine how many configurations configured by RRC.

**Q5: What would be the preferred number of pre-configuration part for cells for L1/L2 centric mobility in Rel-17?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Answer** | **Comments** |
| Nokia, Nokia Shanghai Bell | 1 (see answer) | One seems like the minimum number to start with to minimize complexity and thus, required time. Then later releases can consider optimizations. |
| OPPO |  | We think beam management configuration relevant to additional one PCI is sufficient in Rel17 |
| Ericsson | Atleast 8 (as supported for CHO) | Some companies expressed concerns over the overhead associated to multiple intra-frequency cells related configurations via the RRC. We would like to highlight that this is already the case for conditional handover wherein it is possible to send the conditional handover configurations of up to 8 neighbour cells. Therefore, we believe atleast 8 cells related serving cell configuration should be supported.As part of the serving cell configuration for the scenario-1, we believe providing only servingCellConfig associated to upto 8 intra-frequency cells should suffice. We would further like to highlight that this does not mean that the UE could transmit/receive to/from all these 8 cells simultaneously. RAN1 has already agreed as part of inter-cell multi-TRP work that the UE can receive atmost from two PCIs (one belonging to the ‘original’ serving cell and the other being one of these 8 cells).As part of the serving cell configuration for the scenario-2, we believe providing both servingCellConfig and servingCellConfigCommon associated to upto 8 intra-frequency cells is required. Again, this is already the case in CHO. So, we are not proposing to increase the size of the message compared to an existing RRC message. |
| Apple | 8 | The pre-configured candidate cell concept is similar as the CHO. So from signalling overhead perspective, 8 candidate cells should be acceptable.  |
| Intel | 1 | Limiting to 1 should be practical in Rel-17.  |
| Xiaomi | Wait until the ASN.1 signaling structure is provided. | No strong preference. We think the maximum number of preconfigured non-serving cells can be discussed later after we see the full picture of the ASN.1 design. |
| ASUSTeK | 8 | We can follow the configuration similar to CHO.  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

For C-RNTI handling, it's also not at all clear what is the motivation of taking away the per-cell C-RNTI assignment: C-RNTI is just the identifier used to address UE via PDCCH. In addition, it is also clear that each cell can have a C-RNTI i.e. C-RNTI for non-serving cell may be different to serving cell, but it can be assigned the same value by implementation.

|  |
| --- |
| **Question 3**: In regard of C-RNTI:1. Is there a need to assign a UE a separate C-RNTI for DL reception from and UL transmission to a non-serving cell, or can the same C-RNTI from the serving cell be reused, at least for transmission and reception on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH?
2. In restricting the use of the same C-RNTI for serving and non-serving cells, what would be the impact in applicable use cases and/or required specification support, if any?
3. If separate C-RNTIs are considered necessary in some cases, for serving and non-serving cells, how would this be configured for UE, i.e. is RRC reconfiguration signaling or some other (dynamic) signaling needed for configuring the separate C-RNTI(s)?
 |

As results of the offline discussion, below proposal was made but some companies have concerns on the meaning of below text i.e. some companies think C-RNTI between serving cell and non-serving cell should be aligned by NW implementation to support L1/L2 centric mobility.

**Proposal C: RAN2 confirms that each cell may use different C-RNTIs: Same C-RNTI is allowed but network shall not be required to use the same C-RNTI in different cells.**

**Q5: Do companies agree the above proposal (i.e. Proposal C)?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Since each cell assigns its own configuration, the basic assumption should be separate C-RNTIs unless there is a reason this doesn't work. |
| OPPO | No | We think cell A and cell B should be same cell, hence there is no C-RNTI issue at all i.e. there is only one C-RNTI. |
| Ericsson | Yes | Usage of different C-RNTIs in different cells in the typical implementation but nothing precludes the network from reusing the same. For scenario-1, we believe there are advantages of reusing the same C-RNTI from the UE perspective as the UE needs to receive/transmit data from/to two TRPs belonging to different PCIs. In such a case, it is easier if the same C-RNTI is used.For scenario-2, we do not see any strong reason to reuse the same C-RNTI amongst different cells as the UE is transmitting/receiving data to/from only one of these cells at any given point in time and the corresponding cell would be the serving cell from the UE perspective. The RRC should be used to configure the UE with multiple C-RNTI values as RRC message is encrypted and integrity protected.  |
| Apple | Yes | Currently the C-RNTI is allocated per cell and by NW implementation. The same requirement should be kept.  |
| Intel | Yes  |  |
| Xiaomi | No | We need to firstly analyse the RAN2 specification impacts of using different C-RNTIs. As mentioned by many other companies, using different C-RNTIs (e.g. for Scenario 1) may impact the C-RNTI MAC CE in the RACH msg3. It seems that it is not a big deal to use a single C-RNTI in the intra-DU scenario. Given that CA also uses one C-RNTI, we should focus on the legacy MAC design that C-RNTI is unique per MAC. |
| ASUSTeK | Yes | For inter-cell HO, different C-RNTIs are normally allocated for a UE among different cells. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

It also seems reasonable to assume that, just like currently, UE would obtain the non-serving cell C-RNTI via either 1) random access (i.e. similar to initial connection setup) or 2) RRC configuration (i.e. similar to handover). While the RRC configuration option would seem most suitable here, it's still not clear what would be required for UE to access the non-serving cell, so the first option might also be feasible if UE would have both UL and DL towards the non-serving cell. But using RRC configuration (from target cell) should be the baseline. Therefore below proposal was made in RAN2#113bis meeting.

**Proposal D: RRC configurations of non-serving cell, including C-RNTI, are configured by RRC.**

**Q6: Do companies agree that RRC configuration (from target cell) should be the baseline for configuring the C-RNTI for non-serving cell?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Since RRC configuration is anyway needed, C-RNTI should also be given via RRC.  |
| OPPO |  | If we take cell A and cell B as one cell, this is not a valid issue. |
| Ericsson | Yes | Any information that is related to a UE identity should not be made visible to an interceptor. RRC signaling is encrypted and integrity protected whereas MAC/PHY is not. Therefore, information like C-RNTI that can be used in the new serving cell after L1-L2 centric inter-cell mobility should be communicated via RRC. Having said that pre-configuring the C-RNTI to be used after the L1-L2 centric inter-cell mobility would result in inefficient allocation of C-RNTI as only one instance of such an allocation is used at any given point in time. Therefore, RAN2 can further work on enabling network flexibility in managing these C-RNTI configurations flexibly but without comprosminsing on the encrypted way of delivering C-RNTI to the UE. |
| Apple | Yes |  |
| Intel | Yes | We don’t see any issue to use RRC configuration.  |
| Xiaomi |  | If only one C-RNTI per MAC is used, there is no need to configure another C-RNTI. |
| ASUSTeK | Yes |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

For CU/DU split question, it is related to we restrict the L1/L2 centric mobility for some cases (e.g. intra-DU deployment). Some companies proposed to restrict this feature only for intra-DU case in order to reduce the complexity of the Rel-17 work. Meanwhile, other companies proposed to apply this feature for general deployment scenarios including inter-DU deployment because complexity is not the critical reason to object the general support of the feature.

|  |
| --- |
| **Question 4**: In regard of CU-DU split, from RAN2/3 perspective, is there any difference between supporting intra-DU only and supporting inter- in addition to intra-DU, in terms of the following? 1. The associated RAN2 specification impact,
2. Applicable use cases (e.g. deployment scenarios), and
3. Network inter-operability (e.g. across different gNB vendors)
 |

As results of the offline discussion in RAN2#113bis meeting, below proposal was made.

**Proposal E: RAN2 prefer to restrict the scope only for intra-DU case in Rel-17 .**

**Q7: Do companies agree that restriction of deployment scenario only for intra-DU is needed?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes but... | We expect RAN3 can give better answer to this but from RAN2 side, intra-DU is simpler than inter-DU.  |
| OPPO | Yes |  |
| Ericsson | Yes | To reduce the user plane impacts, we should avoid those deployments in which MAC/RLC resetting is involved. If the source and the target cell of the L1/L2-centric inter-cell mobility is in the same DU then MAC/RLC resetting is not required as the network MAC/RLC entity is still in the same gNB-DU.  |
| Apple | Yes |  |
| Intel | Yes | If DU is different, MAC/RLC cannot be shared. It should be re-established and HO like procedure is necessary to switch the serving cell. Furthermore, there is no standardized inter-DU interface. So, it is hard to support dynamic/fast coordination for multi-TRP operation.  |
| Xiaomi | Yes |  |
| ASUSTeK | Yes |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

According to the companies contributions, companies think the RAN2 impact on CA and RF impacts of L1/L2 mobility is quite limited i.e. only UE capability issues will be expected. RAN1 seem to support intra-frequency scenarios (i.e. serving and non-serving cells share the same SSB frequency) but inter-frequency cases (i.e. serving and non-serving cells have different SSB frequency) bring some more issues (e.g. measurement gaps, UE capabilities, etc). In addition, many companies provided the comments that the decision/answer to support intra- and inter- frequency is up to RAN4.

|  |
| --- |
| **Question 5**: In regard of CA issues, RAN1 is discussing whether the operation is supported only for intra-band CA scenario (i.e. UE is configured to operate with serving and non-serving cells that belong to the same frequency band) or for both intra-band CA and inter-band CA scenarios. Note that one common TCI state ID associated with a non-serving cell, if supported, may be optionally applied for CCs in a band.1. Are there specific RAN2/4 issues (including higher-layer impact) that need to be considered for deciding between the two alternatives?

**Question 6**: In regard of inter-frequency issues, from RAN2/4 perspective, what would be the higher-layer and RRM impact assuming inter-frequency scenarios as opposed to intra-frequency scenarios? For intra-frequency scenario, it is assumed that SSBs of non-serving cells have the same center frequency and SCS as the SSBs of the serving cell.* Note: RAN1 has agreed to support intra-frequency scenarios, whereas the support for inter-frequency scenarios is still for further study.
 |

As results of the offline discussion in RAN2#113bis meeting, below proposal was made.

**Proposal F: RAN2 prioritize intra-frequency case in Rel-17, but RAN2 follows the RAN4 decision to support inter-frequency case.**

**Q8: Do companies agree the proposal above (i.e. Proposal F)?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Intra-frequency seems most relevant for both scenario 1 and 2, so it makes sense to focus on that if RAN4 confirms it makes sense and is feasible. |
| OPPO | Yes but | the deployment scenario of inter-frequency is not clear in both RAN1 and RAN2. Working groups should not start to discuss this until it is made clear by RAN1. So RAN2 should not rely on RAN4 to make decision. Instead RAN2 should ask clarification question to RAN1 in response LS. |
| Ericsson | Yes |  |
| Apple | Yes |  |
| Intel | Yes |  |
| Xiaomi | Yes |  |
| ASUSTeK | Yes |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

**Q9: Do companies have any further issues to be discussed here?**

|  |  |
| --- | --- |
| **Company name** | **Comments** |
| Nokia, Nokia Shanghai Bell | Once it's understood what L1/L2-centric mobility is, measurement reporting needs to be discussed as RRM measurements are currently only sent to CU (and DU need not even comprehend them). This may also open up some issues with security and consultation with SA3 may be needed. |
| OPPO | In general we realize L1/2 mobility between two cells are interesting but it obviously can’t fit in Rel17 in both RAN1 and RAN2.If we take cell A and cell B as two different serving cells and their role are also different (as hinted by term serving cell and non-serving cell) and one cell looks like “shadow” of another cell. The switch between one cell and its shadow cell can only be done via RRC signalling especially for PCell and PScell so far. To only relies on L1/L2 signaling invites more impact on control plan. In user plane, the impact mainly depends on how do we model these two cells in MAC layer. |
| Ericsson | ‘non-serving cell’ definition could be clarified for each scenario. This term has different meaning for the inter-cell mTRP scenario (the UE can transmit/receive data to/from this cell alongwith the serving cell) and for inter-cell mobility scenario (the UE switches to this cell and treats this as the new serving cell and the previous serving cell is no more a serving cell just like in L3 reconfiguration with sync procedures).  |
| Apple | 1> “non-serving cell” defination should be clarified, and we prefer to use other term in RAN2, e.g. candidate cells. 2> The DL timing acquisition, UL TA, RACH procedure in the candidate cell for data transmission should be further clarified in scenario#1. 3> It should be clarified that from user plane perspective there should be no impact in L2 , at least in DAP/PDCP/RLC. And for MAC, the impact is related to the PHY related procedure as clarified in the second points. 4> RRM measurement when UE performing data in the “candidate cell” should be clarified in scenario#1. |
| Intel | Regarding Nokia’s point, we think we need more discussion on whether L1 RSRP/RSRQ/SINR is enough for L1/L2 centric mobility or not. We understand RAN1 is currently discussing to use L1 RSRP/RSRQ/SINR. If it is agreed such, there is no much difference from the existing CSI reporting framework. But, it would be questionable whether it is stable or sufficient. If RRM measurement is eventually needed, further discussion might be needed as Nokia pointed out. Regarding “non-serving cell” term, our preference is TRP with different PCI for now. Eventually, we may need another “cell” name. But, it might be good to see how the actual operation would be modelled before deciding the name.  |
|  |  |
|  |  |
|  |  |

# Conclusion

**TBD**

# Reference

1. R2-2102625 LS on Agreements Pertaining to L1/L2-Centric Inter-Cell Mobility (R1-2102209; contact: Samsung) RAN1 LS in Rel-17 NR\_feMIMO-Core To:RAN2 Cc:RAN3, RAN4
2. R2-2102627 LS on TCI State Update for L1/L2-Centric Inter-Cell Mobility (R1-2102248; contact: Samsung) RAN1 LS in Rel-16 NR\_feMIMO-Core To:RAN2, RAN3, RAN4 Cc:RAN
3. R2-2104632 Summary of email discussion [AT113bis-e][035][feMIMO] L1L2 Centric Mobility Samsung DISCUSSION
4. R2-2103330 Considerations on L1/L2 centric inter-cell mobility Samsung discussion Rel-17 TEI17 DISCUSSION
5. R2-2102855 Discussion on L1 L2-Centric Inter-Cell Mobility vivo discussion Rel-17 NR\_feMIMO-Core
6. R2-2102870 Discussion on L1/L2-Centric Inter-Cell Mobility Intel Corporation discussion Rel-17 NR\_feMIMO-Core
7. R2-2103079 Discussion on L1/L2 Mobility Qualcomm Incorporated discussion
8. R2-2103260 RAN2 Impacts of L1L2-Centric Inter-Cell Mobility MediaTek Inc. discussion
9. R2-2103639 Discussion on RAN1 LS for L1/L2-Centric Inter-Cell Mobility Nokia, Nokia Shanghai Bell discussion Rel-17 NR\_feMIMO-Core
10. R2-2103823 On RAN1 LS (R2-21xxxxx) for L1/L2 centric inter-cell mobility Ericsson discussion
11. R2-2103866 L1/L2-centric inter-cell mobility Apple discussion Rel-17 NR\_feMIMO-Core
12. R2-2104116 RAN2 impact of L1/L2 centric mobility and inter-cell multi-TRP Huawei, HiSilicon discussion
13. R2-2103341 DRAFT LS Reply on TCI State Update for L1/L2-Centric Inter-Cell Mobility Samsung LS out Rel-17 TEI17 To:RAN1 Cc:RAN3, RAN4
14. R2-2103673 Draft Reply LS on TCI State Update for L1/L2-Centric Inter-Cell Mobility Nokia, Nokia Shanghai Bell LS out Rel-17 NR\_feMIMO-Core To:RAN1 Cc:RAN3, RAN4, RAN