**3GPP TSG-RAN** **WG2 Meeting #113bis-e R2-210xxxx**

**Electronic, April 12 – 20, 2021**

**Source: Samsung**

**Title: Summary of email discussion [AT113bis-e][035][feMIMO] L1L2 Centric Mobility (Samsung)**

**Document for: Discussion and Decision**

**Agenda Item: 8.17**

# Introduction

This document summarizes the following email discussion.

* [AT113bis-e][035][feMIMO] (Samsung)
* Scope: Progress R2 discussion on the relevant questions in the LS (on a high level). Conclude on whether serving cell change is part of this scope or not (if possible). Identify major discussion points for R2. Determine questions that should be asked to R1, if any.
* Intended outcome: Report, TBD LS out (questions to R1, no reply)
* Deadline: In time for CB Tuesday April 20.

During the online session, RAN2 shotly discussed the L1/L2 centric mobility based on RAN1 LSes [1][2] and RAN2 tried to share the understanding on this issue, but it is unclear what is the RAN1 intention and goal for this issues e.g. whether serving cell change during L1/L2 centric mobility is intended or not.

[R2-2102627](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2102627.zip) 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

DISCUSSION

- Samsung think the main difference between companies’ views is whether this is HO-style mobility or not.

- Intel think we can have offline, and not clear whether serving cell change is needed or not. Intel wonder what is R1 assumption on serving cell change. Samsung think serving cell change is not the intention of the eMIMO WI. Think this might need to be clarified.

- vivo agrees serving cell change need to be clear. Think multi-TRP and BFR are additional topics for R2 in this WI. Think we need to consider TU allocation and scope.

- MTK would prefer to not change serving cell.

- Huawei think that we should start with a simple scenario. Think we shold focus on the first 4 questions.

[R2-2103330](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2103330.zip) Considerations on L1/L2 centric inter-cell mobility Samsung discussion Rel-17 TEI17

DISCUSSION

- MTK think the observations are reasonable

- Nokia is wondering whether Multi-TRP paradigm is used or not. Nokia wonder if this is mobility or not.

- QC agrees we shall clarify whether this is multi-TRP. Isn’t it easier to configure these as serving cells.

- Huawei think serving non-serving cell shall be preconfigured. Wonder how data transmission can be done on a non-serving cell. Think we can start on Pcell change. Can focus on intra-DU case.

- vivo thikn that indeed this can be preconfigured. Thikn this is for both multi-TRP and mobility cases.

- Ericsson think R1 may not be clear what serving/non-serving cell is from R2 perspective. Would be good to provide definitions to RAN1.

- Intel think it is unclear from WID whether this is multi-TRP or mobility. The WID seesm to address two cases. Think that as long as the UE is in serving cell coverage multi-TRP can be used, but if serving cell coverage is lost, serving cell change is needed.

- Nokia think we need to determine what is feasible.

In this offline discussion, RAN2 focus on summarizing the RAN2 impact to support L1/L2 centric inter-cell mobility based on what RAN1 agreed.

# Contact Points

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

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| --- | --- | --- |
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# Discussion:

In R2-21026625 (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

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| * [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
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## Serving cell change during L1/L2-centric inter-cell mobility

The grey area is the need of serving cell change during L1/L2-centric inter-cell mobility as RAN1 also indicated in cyan highlight below. One company contribution [5] explain the possible scenario which can be expected from the RAN1 agreements.



* Scenario 1: TCI state can be updated from TCI 1 associated with serving cell and TCI 2 associated with the non-serving cell. The UE is still in the coverage of serving cell.
* Scenario 2: TCI state is switched from TCI 1 associated with serving cell and TCI 3 associated to non-serving cell. Different from Scenario 1, the UE is not in the coverage of serving cell.

Meanwhile, some other companies think this serving cell change is not the mandated operation i.e. only if serving cell change is required to support above functionalities it can be introduced. Some companies also indicated that RAN2 TUs for feMIMO are not enough to introduce the complicated procedure and RAN2 should minimize the impact on this issue.

**Q1: What is the companies understanding on the required scope of the L1/L2-centric inter-cell mobility based on the RAN1 agreements and WID?**

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| **Company name** | **Scenario 1/ Scenario 2/ Both** | **Comments** |
| Nokia, Nokia Shanghai Bell | Both, but... | The scenarios listed above are not all scenarios: They completely ignore the dynamic of the case. We had some basic consideration for the procedures needed for the case in [8] (R2-2103639), which also relate to the scenario discussion - see the excerpted figure below.We would also note that scenario 1 can be just seen simply as the multi-TRP case discussed by RAN1 for Rel-16 already: UE is configured with additional CORESET pool or TCI state, it's just that in Rel-17 that can also come from different serving cell. Regardless, we think focus should be on the scenario 1 from above, but then what happens when UE moves from scenario 1 to Scenario 2 is all under RAN2 umbrella and needs discussion. That also ties into the question of how L3 mobility and the new L1/2 operation are used together. We think "serving cell change" is ambiguous in the RAN1 questions: Does it mean that L3 mobility is used (i.e. legacy case)? If it does, how does that work with the "non-serving cell addition/modification/change/release" when L1/2 mobility is used (i.e. Rel-17 scenarios)? This was also how we understood the RAN1 question: They are asking RAN2 to take a stance on how the two operations can be used together, but it's not so simple to answer that question without going into details.  |
| Samsung | Both, but should focus on Scenario 1 | From our understanding, “serving cell change” is not the main objective based on what RAN1 agreed above. The key factor RAN1 tried to introduce is:* DL RX from and UL TX to non-serving cell(s) along with TCI state update (beam indication)
* Beam measurement/reporting for non-serving cell(s) for that purpose

I agree that it could be the extension of Rel-16 multi-TRP operation but one difference is that the configuration of “non-serving cell(s), i.e. some TRP(s) is configured in non-serving cell(s)”. We have also curious about the motivation why RAN1 tried to support multi-TRP operation for non-serving cells, we assume that they want to enhance mTRP operation for the different PCI which were not supported in Rel-16.In short, we believe this issue would be more like inter-PCI TRP switch where the new beam happens to be on the non-serving cell rather than L3 HO. This is well and good for dedicated channels. For common channels, we think the story is a bit different, the UE continues to receive the common channels of the serving cell. The common channels of the serving cell are sent using the beams of the serving cell. The beams of serving cell have lower quality (this is why the UE switched to a beam of a non-serving cell for the dedicated channels). If the UE is moving away from the serving cell, after a while the quality of the link to the serving cell degrades to the point that it can no longer receive the common channels of the serving cell. After the L1-L2 centric handover, L3 HO (whatever we have, legacy HO, CHO, or DAPS HO) will be required to able to receive and transmit common channels on the non-serving cell. The L3 HO doesn’t need to occur simultaneously with the L1-L2 centric handover, but may happen “soon” after it. |
| OPPO | Scenario1 | There are some difference between serving cell and non-serving cell in terms of:NAS layer: the GCI is different. TA could be also different. It is not clear about PLMNAS CP: content and procedure related to common channel, namely BCCH, PCCH and RACH; RLM/RLF; RRM measurement and relevant mobility proceduresAS UP: RLC/MAC layer could be not co-located hence their configuration could be different. PHY layer configuration as well as beam management are separated. It is assumed at least SDAP and PDCP can be shared between serving cell and non-serving cellIn scenario 1, dedicated data channel and control channel could be taken as extra radio resource, hence only physical layer is impacted. So serving cell should not be changed at all. If cell A and cell B is not in same DU, then in AS UP layer, it worth discussing how to model it. If cell A and cell B belongs to different frequency, then it looks more like split bearer of NR-DC architecture. Otherwise it looks like something between NR-DC and CA but for same frequency.In scenario2, if the change is based on handover, then there is no extra issue since cell B is changed to be serving cell and UE and network is aligned in all above mentioned protocol layers. But if the change is done not via sort of L1/L2 centric mobility solution without handover then it results in misalignment between network and UE w.r.t. to above mentioned NAS layer, AS CP layer aspects. For AS UP layer aspects, for intra-DU scenario it is feasible to switch the role for cell A and cell B from L2/L3 point of view. But it doesn’t work for the case that cell A and cell B is not co-located.Overall, we think serving cell should not be changed unless it is done via normal handover procedure. |
| Ericsson | Scenario 2 is most relevant | The question clearly states that it is about L1/L2 centric inter-cell **mobility**. Scenario-2 is the most relevant scenario from the mobility point of view. Scenario-1 is more of inter-cell multi-TRP related scenario wherein the serving cell is kep constant but the UE can received/transmit data from/to a non-serving cell as we well. This is an expansion of the multi-TRP work done in Rel-16. But it is important to note that there is no ‘mobility’ here as the serving PCI is always the same.We believe the scenario-2 is about the mobility and RAN2 should consider this scenario as the baseline scenario for L1/L2-centric inter-cell mobility. |
| Huawei, HiSilicon | Both, but | That the key question here is not whether the UE is in the coverage of serving cell or not, we understand the question is when the UE moves between Cell A and Cell B, whether the serving cell should be changed. In our view, serving cell has clear definition in RAN2 spec and only serving cell can transmit/receive data, and this concept should not be changed. Note that the terminology of “non-serving cell” is widely used in this LS and RAN1 agreements which is somehow misled, so we should not mess up “serving cell” and “non-serving cell” and the definition of “serving cell” should be consistent across WGs. More specifically, in scenario 1, the serving cell (cell A) configures the UE to use TCI2 to receive data from non-serving cell (cell B) even though the UE is still camped on cell A (e.g. receiving SI) and only knows of cell A as the “serving cell”. Otherwise, it should fall into the scope CA/DC, not inter-cell MTRP. While in scenario 2, the UE is now in Point B and left the coverage of cell A, the serving cell (cell A) configures the UE to use TCI3, now cell B becomes the “serving cell” and cell A becomes the “non-serving cell”, so there is still only one serving cell. From RAN2 perspective, both scenarios have some commonalities in terms of inter-cell beam management and relevant configurations. If both scenarios are included in the scope of Rel-17, we should strike to align the procedures as much as possible. |
| Intel | Both with comments | RAN1 is looking at both scenarios because from dedicated channels in multi-TRP operation point of view, Scenario 1 and scenario 2 should be the same in the sense that TRP switching can be done with L1/L2 signaling in TCI state update framework. For scenario 2, the clear thing is that the serving cell should be changed. Otherwise, there is RLF as the UE is out of coverage in serving cell according to the current RLM/RLF operation. As Nokia raised a question, for scenario 2, basically, L3 handover can be still applied. However, we see some benefit to consider L1/L2 centric serving cell in multiple TRP operation in order to reduce interruption during serving cell change. As long as this is applied to intra-DU scenario, the benefit would surpass the complexity/required work in REl-17. In our understanding, main difference between L3 handover and L1/L2 centric serving cell change is that there is no change/re-establishment in MAC/RLC. Only change is PHY layer and RRC (RLM, RRM, etc.) for L1/L2 centric cell change. |
| Apple | Both, but  | We share Huawei’s view on the “serving cell” conept. It is clearly defined at least in RAN2 spec and UE should always perform the UE dedicated data transmission or reception on the serving cell. Following the current model, UE is not allowed to perform UE dedicated data transmission/reception on non-serving cell. According to the two scenarios, we agree with Ericsson that for the L1/L2 centric inter-cell mobility the scenario 2 is more relevant, since scenario 2 is especially related to the PCell change. For scenario 1, it’s more like the CA/DC architecture, e.g. UE’s PCell is not change but the SCell is changed more frequent via L1/L2 signaling.  |
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It is also true that RAN2 can first study all aspects to make answers on the questions from RAN1 LS in [2], otherwise RAN2 ask RAN1 to confirm what is the scope of the L1/L2-centric inter-cell mobility in terms of serving cell change.

**Q2: Do you think RAN2 needs to ask RAN1 on the scope of the L1/L2-centric inter-cell mobility in terms of serving cell change?**

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| **Company name** | **Yes/No** | **Comments**  |
| Nokia, Nokia Shanghai Bell | Yes but... | We should definitely ask as the LS was unclear in this (likely because RAN1 hadn't really thought it through yet), but RAN2 should point out that this depends heavily on whether the multi-TRP model is used: For example, without multi-TRP "serving cell change" likely means L3 mobility, but with multi-TRP, serving cell could perhaps remain. Hence, to make this clearer RAN2 could ask whether the L1/2 mobility is supposed to work 1) together with L3 mobility OR 2) separately from L3 mobility and whether this implies something for the multi-TRP operation? In our view we should separate the procedures for L1/2 and L3 mobility since the legacy L3 mobility has to be possible still (as it is the legacy procedure). We also think it would be useful to at least consider whether we can reuse the Rel-16 multi-TRP model as that could reduce RAN2 efforts.So how to ask the question and what information to give to RAN1 is crucial here - it's very clear there are a lot of details to handle even with the very basic operation, so indicating that to RAN1 is important to avoid having overly ambitious scenarios. |
| Samsung | No | We think RAN2 first focus on how to reply the RAN1 LS, they already provide many questions with agreements. This kind of asking for clarification e.g. needs of serving cell change, should be internally done to reduce the redundant time loss. |
| OPPO | No | we think RAN2 should digest the questions from RAN1 first and give RAN2’s preference. After that we can discuss whether any questions to RAN1 is necessary. |
| Ericsson | No (avoid back and forth LSs with questions) | Sending back and forth LSs on questions is not beneficial. From RAN2, we can provide our views on the scenarios and the way certain configurations are handled. RAN1 can get back to us if they are not happy with our answers.Mobility involves changing of the serving cell as per RAN2’s understanding. We can mention in our reply LS that the UE needs to have the PDCCH, PDSCH, PUCCH and PUSCH configurations of a cell in order to receive/transmit data from/to that cell. The RAN2 signaling enables the UE to be configured with these configurations via serving cell configuration and therefore, in RAN2’s understanding, there is a serving cell change during L1/L2-centric inter-cell mobility. |
| Huawei, HiSilicon | Yes (this is RAN1-led objective in WID) | We understand we should first inform RAN1 of the definition of “serving cell” already existing in RAN2 spec and the meaning of it. Many of the questions in the LS from RAN1 stem from the possible impacts to higher layers from L1/L2-mobility, but RAN1 mixed up inter-cell M-TRP and L1/L2-mobility together which makes the LS pretty hard to read. So it is reasonable to confirm with RAN1 so that RAN1 could further describe the scenarios they want to solve for a clarity, but the detailed solution and terminology used should be discussed jointly with RAN2, RAN4 etc. Otherwise, we have concerns on the understanding gaps when going further for procedure design.  |
| Intel | No but.. | RAN1 is looking at both scenarios but they are still under discussion waiting for RAN2 feedback on whether both scenarios are feasible to support. Therefore, it is not so useful to ask RAN1 on the scope because it will be endless ping-pong between RAN1 and RAN2. However, RAN2 could ask some questions to progress. From our perspective, one of basic questions is if serving cell will change back and forth frequently in scenario 2. If it is not so frequent, we could consider to reuse existing handover framework. If it is frequent, we would need a new serving cell change mechanism.  |
| Apple | No | RAN2 should focus on how to answer the RAN1 questions based on current RAN2 model, and clarify that current RAN2 model is that UE dedicated transmission is only allowed to be performed on serving cell.  |
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## RAN2 impacts on L1/L2-centric inter-cell mobility

In this sub-clause, we want to treat the RAN2 impact to support L1/L2-centric inter-cell mobility in order to make answers for the questions from RAN1 LS [2].

UE measures reference signals corresponding to beams for non-serving cells, if the signal quality of that RS (beam) of the non-serving cell is better than those of the serving cell, the network can indicate to the UE to start using the beam corresponding to the non-serving cell. Here, this L1/L2 signaling could be either beam switching and HO command based on the scenarios.

For Scenario 1, this is just a beam switch, where the new beam happens to be on the non-serving cell but UE has to support DL reception/UL transmission from the serving cell as well as non-serving cell while connected to the serving cell.

For Scenario 2, UE should change the dedicated channels from the source cell to non-serving cell when UE receives L1/L2 centric mobility signalling.

Below questions are related to the serving cell issues and those can be further investigated to make answers. How to handle UE-dedicated configuration and common configuration (i.e. RACH, SIB/MIB, etc) would be considered.

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| **Question 1**: In regard of serving cell, 1. Is there a need for a UE 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?
2. If so, how can the addition, release or change of a non-serving cell for DL reception and/or UL transmission be done? For example, would any of such actions require L3 handover and/or selection/activation among pre-configured candidate cells from RAN2 perspective?
3. If so, how can the TCI states associated with the previous serving cell be handled?
4. If so, what is the impact on the system information reception by the UE?
5. If so, what is the impact on the RACH and PUCCH-related procedures and configurations?
6. If not, what is the impact on the applicable use cases? That is, in what scenarios can the UE be configured for DL reception from or UL transmission to another (non-serving) cell, at least on UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH, if the serving cell does not change?
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**Q3: Do companies have any further comments on “Question 1” including discussion points?**

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| Nokia, Nokia Shanghai Bell | We would like to make several points about these aspects:* **DL Resource usage** between "serving cell" and "non-serving cell" still requires that UE can receive both (more or less) simultaneously, but there are some obvious challenges in that. Hence, RAN2 should ask what are the real uses cases RAN1 would like to enable for the L1/L2 mobility.
* **UL resource usage** (especially in intra-frequency cases) can be tricky as was seen e.g. during DAPS work in Rel-16. Hence, RAN2 could request RAN1 to clarify how UL is expected to work for L1/L2 mobility.
* **RRC configuration** for the "non-serving cell" would still require the same information as serving cell requires for the corresponding PxxCH to be used. Hence, it's quite likely that the configuration size will be large for most typical cases.
* **TCI state handling** is done via MAC, so the reply could state that to have efficient TCI state handling, a single MAC entity is needed.
* **System information** reception should not be required from non-serving cell (similarly as in CA/DC) and dedicated signalling can be used to provide the necessary information to UE.

In summary, before providing final answers, RAN2 should indicate to RAN1 that the exact scenarios where this operation is aimed will impact these answers: If all possible cases are to be supported, it is likely that the workload will make this part of the work impossible to be completed within the allotted TUs for this WI in Rel-17. |
| Samsung | We think releavant configurations for non-serving cell(s) can be provided by RRC pre-configuration:1. For PUCCH/PUSCH/PDCCH/PDSCH on non-serving cell, UE needs to know the corresponding configuration (BWP, physical channel configuration, CG configurations, TCI states, etc.).
2. Common configuration (e.g. RACH configuration, C-RNTI) included in SIB/MIB value change upon inter PCI/TRP change is required to start transmitting RACH based on that configuration.
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| OPPO | As we answer to Q1, we think normal handover procedure is sufficient. Then for point 6, in Rel17 only intra-DU scenario is preferred. In this case SDAP/PDCP/RLC/MAC protpocol layers are shared between serving cell and non-serving cell. |
| Ericsson | **PxxCh configraution related:**The UE needs to have PDSCH, PDCCH, PUSCH and PUCCH configurations associated to a cell from/to which it receives/sends data. All these configurations are part of the servigng cell configuration.So, from RAN2 we could clarify that the L1/L2 centric inter-cell mobility will result in serving cell change from RAN2 point of view i.e., the UE treats the target PCI of the L1/L2 centric inter-cell mobility as the serving cell after such a mobility procedure and the previous serving cell is no more a serving cell. The UE receives multiple serving cell related configurations (on the same frequency) of which only one of them is applicable to the UE at any given point in time. To enable the L1/L2 centric inter-cell mobility, the UE needs to be configured with the servingCellconfigCommon related parameters associated to all the PCIs amongst which the L1/L2 centric mobility can be enabled. The dedicated servingCellConfig parameters could be the same across all these PCIs or they could be different. So, it is not straightforward to say how much larger would be the new RRC message delivering all the required multiple PCI related PxxCH configurations to the UE. It is definitely larger than the legacy message but how large depends on how much thes PxxCH configurations are different amongst these PCIs.**TCI state handling related:**The association between TCI states and the non-serving cell needs to be provided to the UE beforehand. There would be a list of TCI states, some associated to the original PCI and some to the non-serving cell PCI. With this, L2 signaling can change the TCI state between original serving cell SSB and added SSB that has different PCI than the original SSB.**System Info related:**There are different ways to enable system information acquisition upon performing the L1/L2 based switching from the current serving cell to the non-serving cell.1. Preconfiguring the UE with the relevant system information associated to the non-serving cell.

This method is similar to providing the servingCellConfigCommon for the SCells in the existing dedicated message or providing the servingCellConfigCommon for the SpCell in the reconfiguration with sync message.1. Requiring the UE to acquire the system information upon L1/L2 switching.

This method is similar to performing reconfiguration with sync procedure in the existing methods wherein the UE is expected acquire the system information at the completion of this procedure as not all the system information might be delivered in the reconfiguration with sync message. It should be possible to enable the same procedure as used in the reconfiguration with sync procedure wherein part of the system info could be delivered via dedicated message and the rest needs to be acquired by the UE after completing the reconfiguration with sync procedure as they are not essential for accessing the target cell.  |
| Huawei, HiSilicon | We think we probably need to first address question 1.1 (i.e. Q1 above) here, question 1.2-1.6 are dependent on the answer of Q1. We would like to indicate some concerns on some specific issues that needs to be confirmed by RAN1.- **TCI state handling**, our understanding is that TCI state maintenance is not in the RAN2 scope, we are not sure what is the expected RAN2 answer and the intention by asking. From RAN2 point, we only take care of corresponding configuration and relevant signalling design. - **RACH,** we understand TA has to be maintained when serving cell is changed. For L1/L2 mobility, we are not sure whether it has enough time in Rel-17 to discuss all these issues, and also if RACH has to be performed, the L1/L2 mobility still has the interruption similar to L3 mobility. What is the point and benefit of having RACH? |
| Intel | It seems RAN2 start to discuss what is the L1/L2 centric serving cell change and how it looks like for the scenario 2. From our understanding, switching of dedicated channels would be the same as scenario 1 i.e. beam switching to change DL/UL TCI state. The different aspect would be that serving cell should be switched from cell A to cell B upon beam switching. Given that there is no re-establishment in MAC/RLC/PDCP, the serving cell change would be performed in RRC related configurations.   |
| Apple | We have the same understanding as HW that we should first focus on Q1.1. We should clarify that according to the current model the non serving cell has to be changed to serving cell for the UE dedicated data transmission. In addition we would like to clarify the following points in the responses:1. **About “non-serving cell” configuration:** NW provides the candidate cell’s configuration in advance via the RRC signaling, and the candidate cell can be switched into serving cell when the data transmission is performed on it.
2. **About the TCI state and cell association:** The association between TCI state and each serving cell/candidate cell are explicitly configured by NW.
3. **About the impact on RACH:** If RACH is kept during the cell change procedure as legacy handover, there is no impact on RACH and PUCCH configuration and transmission after cell change. Otherwise (if RACH is skipped), RAN2 needs to discuss how to support it, and RAN1 is requested to provide more information.
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RAN2 impact especially for configuration aspect to support L1/L2 centric mobility should be considered, in general RAN2 use 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.

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| **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?
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**Q4: Do companies agree that RRC configuration would be required to configure the required non-serving cell configurations (e.g. UE-dedicated PDSCH, PDCCH, PUSCH, and PUCCH, common configurations, etc) by pre-configuration?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes but... | We are not sure what "preconfiguration" means here: Is this now implicitly accepting all the complexity that comes up with having to handle multiple non-serving cells? We have seen all of this before and it's sensible to limit to the essentials in the first release. Otherwise there's a risk that what is specified in Rel-17 is both incomplete and needlessly complicated, making it difficult to implement and/or deploy the feature. Hence, it would be far simpler from RAN2 perspective if we only limit to a single non-serving cell in Rel-17 and do not specify "dynamic switching" between multiple those. Anyway a single "non-serving cell" would still contain multiple TCI resources, so the need to have multiple of those seems rather unnecessary. But all this relates to which use cases are being considered in RAN1 and the scope of what is possible to do.Finally, it is of course "feasible" to have dynamic switching in the long run, but ensuring that the baseline operation works in Rel-17 is important: Once a stable baseline is established, further functionality can be built on top of that in later releases. We really should learn from the past and first create a simple baseline (with few capabilities) before heavy optimizations: Otherwise we risk having a large set of very fragmented capabilities that are difficult to implement, test and deploy, which is why we think the Rel-17 scope should be made clear. |
| Samsung | Yes | Agree with Nokia that dynamic switching of pre-configured value by L1/L2 is feasible but it requires many burden to RRC configuration. This could be just the extension of the main function so we first focus on the simple design in Rel-17. |
| OPPO | Yes | By allowing RRC configuration for dedicated data/control channel of non-serving cell, it allows network to configure different parameters for those channels and keep the flexibility for future extension/enhancement. Otherwise it means the configuration should be the same compared to serving cell by default. But it at least doesn’t work for configuration of RS configuration for beam management e.g. TCI state/SRS etc. which is the essential part of this scheme. MAC or DCI signalling can help to start or stop data transmission to / reception from non-serving cell but not dynamic switch in Rel-17 frame i.e. serving cell should be always retained. |
| Ericsson | Yes but.. | We agree in general that the UE needs to be aware of the PxxCH configurations to be used in each of the PCI within which L1/L2-centric mobility can be enabled but it is too early to say that all these configurations have to be different. There could be parts/all that can be reused across multiple PCIs. Therefore we can discuss further as to what extent the UE-dedicated conffigurations need to change at L1-L2 centric inter-cell mobility. |
| Huawei, HiSilicon | Yes, but | This is somewhat dependent on what is called serving cell. So we prefer to avoid using “non-serving cell” term here. This also applies to the subsequent questions.Regardless of scenarios, one of the key points is measurement on beams of concerned cells, we think the **inter-cell beam management parameters** associated with concerned cells need be pre-configured by RRC, and for other RRC parameters, and whether they should be common among cells can be discussed later. Basically, as for the **control/data channel**, we think the relevant RRC parameters associated with concerned cells need to be pre-configured to the UE, and NW uses dynamic signalling (e.g. TCI associated with a PCI) to indicate the corresponding RRC configurations to apply. And we understand that is the key principle for L1/L2-centric mobility and also in line with the WID objective as follows. iii. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)In addition, to reduce the RRC signalling burden from multiple cells, we think most RRC parameter values can be reused across cells by default for intra-DU case, and this should be the baseline for the signalling design in RAN2. |
| Intel | Yes  | We agree with Nokia that we should target 1 non-serving cell in Rel-17. Just to clarify, dynamic switching (beam switching) between serving cell and non-serving cell is already assumed in Scenario 1. For scenario 2, it can be FFS whether serving cell would change back-and-forth frequently or change one-time (similar to HO).  |
| Apple | Yes, but | We agree with other companies that the feasible way is for RRC to provide the pre-configured configuration of “candidate transmission cells”, and L1/L2 siganling is used for the dynamic switching of the pre-configured value. To minimize the RRC signaling overload for the pre-configuration part, NW can configure the common part amongst all the cells or only configure the the minimum configuration for UE to access and perform transmission in the candidate cells via RRC signaling.  |
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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.

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| **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)?
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**Q5: Do companies agree that C-RNTI for non-serving cell may be different to serving cell, but it can be assigned the same value by implementation (e.g. intra-DU case)?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Each serving cell configures its own resources and this should be retained. If we were to require same C-RNTI in both cells, that will make the feature less usable: Requiring network to tightly coordinate the resources just makes the feature less likely to be usable. Thus, UE would have one C-RNTI for serving cell and another one for the "non-serving cell". |
| Samsung | Yes | In general, C-RNTI would be different between serving cells to identify each cell but it can be assigned the same value by implementation for some cases e.g. if the CU is same for the serving and non-serving cell(s). then CU can assign same value. |
| OPPO | Yes | If we limit the C-RNTI of non-serving cell to the usage of data transmission to /reception from non-serving cell only i.e. C-RNTI of serving cell will be the only input for the L2/L3 relevant procedure e.g. MAC-I calculation, then it doesn’t matter whether C-RNTI of non-serving cell is the same or not. And different C-RNTI could help to differentiate between serving cell and non-serving cell in L2/L3 protocol specification, if any. |
| Ericsson | Yes | This is upto the implementation. This is already the case in the RRC based reconfiguration with sync procedure and we can keep the same principles for L1/L2-centric inter-cell mobility procedure. |
| Huawei, HiSilicon | Same C-RNTI should be baseline | As we mentioned above, RAN2 should strike for a common procedure to cover both scenarios as much as possible. For inter-cell M-TRP case, we do see the necessity of tight coordination between TRPs. With the spirit of reusing RRC parameters across cells, we tend to think that C-RNTI can be assigned to the same values among associated cells. Note that the principle could be also applied for other RRC configured RNTI values. In general we do not think this is the most critical thing to discuss right now, this can be left to a later phase discussion. |
| Intel | Yes | If C-RNTI provided by the serving cell is reserved in the non-serving cell for this UE, the same C-RNTI value can be assigned.  |
| Apple | Yes | NW should be able to allocate the separate C-RNTI for the serving cell and each candidate transmission cell. It’s up to NW implementation.  |
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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.

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

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | We think the entire "non-serving cell" configuration can be provided via RRC and that would also include the C-RNTI. |
| Samsung | Yes | Agree with Nokia. |
| OPPO | Yes | RRC procedure is sufficient. |
| Ericcson | 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 in each PCI associated to 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. |
| Huawei, HiSilicon | Yes | Again we do not think this is the most critical thing to discuss right now, this can be left to a later phase discussion.Anyway we think we should stick to the same principle of legacy L3-based handover that the target C-RNTI is configured by RRC. This also applies to all other parameters configured via RRC, which has been integrity protected and ciphered. |
| Intel | Yes | Agree with Nokia. |
| Apple | Yes | C-RNTI allocation could be follow the legacy HO principle, i.e. via RRC signaling.  |
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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.

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| **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)
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**Q7: Do companies agree that restriction of deployment scenario only for intra-DU is needed? What RAN2 specification impact would be concerned?**

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| **Company name** | **Yes/No** | **Comments** |
| Nokia, Nokia Shanghai Bell | Yes | Since the MAC configuration is contained within on DU, doing inter-DU would require different approach for the RRC configuration itself. Supporting inter-DU might also imply different CU-UP, which would complicate CU handling. And even if we restrict to only one CU-UP and CU-CP, that would both require extra inter-node signalling but also significant changes in RAN2 configuration, so it would be simpler to limit to intra-DU cases. |
| Samsung | No | It is too early to determine the restricions on deployment scenarios before RAN2 start to study details. We tend to agree supporting inter-DU (for both same CU or different CU) requires additional inter-node signalling but we already have structure to sharing the configuration between nodes. RAN2 should target to support this functionality for general deployment scenario if possible, complexity should not be the reason to determine the applicable deployment scenario. |
| OPPO | Yes | If serving cell and non-serving cell are not in same DU, it basically means only SDAP and PDCP are shared for same DRB and RLC/MAC layer protocols need be split. when link between UE and non-serving cell is added or released it means concerned LCHs will be also added or released. This results in buffer flush of RLC , MAC layer and PDCP recovery. In addition it is also possible that non-serving cell belongs to another TA group, then it also means RACH procedure will be triggered every time. In short the procotol stacks will looks like NR-DC which can’t serve the L1/L2 centric mobility scheme well since it supposes to be softer than carrier aggregation. |
| 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.  |
| Huawei, HiSilicon | Yes | We prefer to limit to intra-DU case in Rel-17 considering the tight timeline. We are fine to consider other cases in future releases.  |
| 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.  |
| Apple |  | We have no strong view. But from UP interruption reduction perspective, intra-DU scenario can avoid L2 reset.  |
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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.

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| **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.
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**Q8: What do you think about supporting intra- and inter- frequency issues?**

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| **Company name** | **Intra-freq/ Inter-freq/ Up to RAN4** | **Comments** |
| Nokia, Nokia Shanghai Bell | At least Intra-freq but Up to RAN4 | This depends heavily on the envisioned use case: Since the work is done under "fast beam management", it seems targeted towards intra-frequency. Similarly, since it's even called "L1/L2-centric inter-cell **mobility**", this implies it would be working with similar cases as mobility, for which intra-frequency is the most useful case. So this question also ties to the question on expected use cases and scenarios - RAN1 should provide more information on those, and RAN4 should evaluate what is possible based on those. |
| Samsung | At least Intra-freq but Up to RAN4 | Agree with Nokia. Signalling support would be possible from the RAN2 perspective but the actual functionality may be determined by RAN1/RAN4 from our understading. |
| OPPO | Intra-freq | We think in Rel-17 intra-freq case is enough |
| Ericsson | Intra-freq in Rel-17 | Inter-freq mobility requires the UE to be pre-configured with measurement gaps to allow for the inter-frequency measurements. This is possible for layer-3 based mobility but L1/L2 measurements are always intra-frequency. We prefer to keep the same principles in rel-17 and one can expand to include L1/L2-centric inter-frequency inter-cell mobility in future releases. |
| Huawei, HiSilicon | Intra-freq | This mainly relies on RAN4 decision and better to leave to RAN4. From RAN2 perspective, we are fine to prioritize intra-frequency case in Rel-17. |
| Intel | Up to RAN4 | From RAN point of view, there is not much difference between intra- and inter-frequency. However, since CA can be supported in inter-frequency case, it is not clear what is benefit of supporting multi-TRP operation considering the complexity.  |
| Apple | Up to RAN4 | The support of intra-frequency and inter-frequency scenario may have the different impact on the RRM measurement on the neighbor cells, i.e. the need of the measurement gap. But it should be discussed in RAN4.  |
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**Q9: Do companies have any further issues to be discussed here?**

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| **Company name** | **Comments** |
| Nokia, Nokia Shanghai Bell | So far it seems the terminology for this feature is rather confusing so RAN2 could be proactive and define the terminology for this topic, including the used acronym (e.g. "Seamless beam switch (SBS)", "Lower Layer Mobility (LLM)" or something similar). This could help also RAN1 and RAN2 tends to anyway view the overall functionality more so is in better position to consider such aspects.  |
| Huawei, HiSilicon | The terminology of this feature is not the key factor, but the “non-serving cell” causes the confusion to RAN2. So we think the most crucial issue is to tell RAN1 of RAN2 understandings and definitions of “serving cell”. Thinking of another fancy terminology doesn't work to remove the confusion. |
| Intel | We are supportive to have a clear terminology especially for scenario 2. But, during Rel-15 NR discussion, we categorized beam switching as L1 mobiltiy. In addition, we can say scenario 1 as beam switching, which is the same as beam switching in MIMO framework. Therefore, the suggested Lower Layer Mobility would be confusing to know which mechanism is referred. In case of scenario 2, we will need the change of serving cell from RRC pov rather than limiting to lower layer mobiltiy. Our preference would be L1/L2 based serving cell switch for scenario 2 where serving cell change is required but no L2 reset is required.  |
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# Conclusion

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