3GPP TSG-RAN WG2 #119-bis-e R2-22xxxxx

Electronic meeting, 10th – 19th October 2022

Agenda Item: x.x.x

Source: Ericsson

Title: [Post119-e][048][feMob] Candidate target configurations for L1/L2 mobility

Document for: Discussion, Decision

# 1 Introduction

This paper addresses the following email discussion:

* [Post119-e][048][feMob] Candidate target configurations for L1/L2 mobility (Ericsson)

Scope: Explore/Identify the pros/cons of options on the table in the support of the different target scenarios, supporting with high performance cell changes without reconfiguration. Can identify specific aspects of the configurations, that are potentially necessary.

Intended outcome: Report, with proposals to be addressed at next meeting.

Deadline: long (to next meeting)

According to the chair instruction, the outcome of this email discussion is for the next RAN2 meeting in October. Because of this, the rapporteur would like to set the following deadlines:

A first round with Deadline on September 23th 10:00 UTC to provide comments an input.

A final round with Final Deadline on September 26th 12:00 UTC to check the report and the proposals.

# 2 Contact information

|  |  |  |
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# 3 Discussion

## 3.1 Aspects to be considered when modelling a candidate target configuration for L1/L2 inter-cell mobility

Before going deep into the possible RRC models for configure a L1/L2 inter-cell mobility candidate target cell, it would be good to set what aspects one should keep in mind when analysing the pros and cons of a certain model. This is because how to configure a L1/L2 inter-cell mobility candidate target cell may have an impact on the latency (of course) but also on the configuration and execution parts of the overall L1/L2 inter-cell mobility procedure.

According to this, in addition to the latency caused by a certain model (that seems quite a straightforward aspect), one should also at least consider how the model is scalable when considering the scenarios that needs to be addressed in the WID, but also how complex is a certain model. Further, also the degree of configuration flexibility in relation to the signalling overhead required should also be kept in mind when analysing the different RRC models.

**Question 1**: Do companies agree that the following aspects should be kept in mind when considering a certain RRC model for modelling a candidate target configuration for L1/L2 inter-cell mobility?

* Impact on latency
* Support of the scenarios mentioned in the WID (i.e., non-CA, CA, NR-DC, inter-DU, intra-DU, inter-frequency, intra-frequency)
* Complexity
* Degree of configuration flexibility versus signalling overhead.

*Please provide in the “Detailed comments” column if there is some other aspect that you think should be considered.*

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| --- | --- | --- |
| Company | Yes/No | Detailed comments |
| MediaTek | Yes | The abovementioned aspects are important. Regarding configuration flexibility, we think it should consider not only the flexibility of candidate configurations, but also the flexibility or configuration complexity for UE to switch between candidates (e.g., UE switching back-and-forth between two nearby cells)  Moreover, we’d like to point out that only one solution should be selected from the three for candidate configuration in L1/L2-based inter-cell mobility. |
| InterDigital | Yes |  |
| Huawei, HiSilicon | Yes for scenarios;  "Complexity" is vague;  Not sure about latency and signalling overhead | 2nd bullet can be “Support of the scenarios mentioned in the WID (i.e., non-CA, CA, NR-DC, inter-DU, intra-DU, inter-frequency, intra-frequency, especially the highlighted agreed ones.)  3rd bullet should be: “Complexity (UE complexity and spec changing complexity)”  4th bullet: Signalling overhead in pre-configuration is not a huge concern because it can be transmitted when radio conditions are good (not when handover is needed). We should consider the overhead in both pre-configuration and HO command.  We are not sure the model can really impact the latency. |
| Nokia, Nokia Shanghai Bell | Depends: Maybe yes, maybe not | These are all important but are not the only aspects, and especially the latter two are subjective. So it would be better to explain what exactly this question means? These are all normal design goals but are not that useful in email discussion question. Of course we do agree that complexity (in terms of implementation and standardization) is anyway something that we always need to be mindful of so we can complete the WI as planned.  So the first two should be the focus on design: **Solutions should at least indicate the expected latency impact and supported scenarios.** |
| Ericsson | Yes |  |
| Intel | Yes | In addition, we think that the impact to inter-node (CU-DU) signalling should be minimized. |
| Spreadtrum | Yes | We think the abovementioned aspects are the basic principle of the configuration for L1/L2-based inter-cell mobility. |
| Xiaomi | Yes |  |
| OPPO | Yes |  |
| CATT | Yes | In general we agree with the aspects listed by rapporteur, we’d like to add some more details on some aspects,   1. On Impact on latency, the aspects to reduce latency includes a)reduce latency by avoiding L2 reconfiguration for some cases, b).store the candidate cell configuration for subsequent cell changes between candidate cells. 2. on Complexity, it also includes  * reuse the legacy signalling structure/procedure as much as possible * consider the configuration complexity for the case that intra-DU and inter-DU are configured at the same RRC message   to also consider the case that switching the role of a cell between spCell and scell |
| Vodafone | Yes in general | With regards to 2nd bullet on scenarios, our understanding is that not all the scenarios listed in WID have been agreed yet.  Complexity should address UE complexity as well as specification complexity.  Not quite sure what it meant by “Degree of configuration flexibility versus signalling overhead” and its implication of the performance. The configuration could be done in advance hence flexibility or signalling overhead may not be an issue. |
| NEC | Yes | We think these are important aspects in general, while there could be a trade-off between the bullets, e.g. the first (latency) and the fourth (flexibility) and that should be also considered. |
| ZTE | Yes |  |
| Samsung | Yes | We also agree the abovementioned aspects are important for RRC modelling but those are not perfect for the decision because some aspects are conflict for making the model e.g. flexibility and signalling overhead.  Anyhow RAN2 needs to determine how RRC model would be based on above aspects. |
| Sharp | Yes |  |

## 3.2 RRC models for a candidate target configuration for L1/L2 inter-cell mobility

The first aspect to be clarified is what is meant with a L1/L2 inter-cell mobility candidate target configuration. Regarding this, one interpretation is that, in L1/L2 inter-cell mobility, a candidate target configuration is an RRC configuration used by the UE to operate in a candidate (target) cell and that is received and stored by the UE during preparation (e.g., in an *RRCReconfiguration* message) before the network sends the lower layer switching command for L1/L2 inter-cell mobility execution. Therefore, the following question is asked:

**Question 2**: Do companies agree that a L1/L2 inter-cell mobility candidate target configuration is a configuration for L1/L2 inter-cell mobility received in an RRC message (e.g., *RRCReconfiguration* message) and that is used to operate in a L1/L2 inter-cell mobility candidate target cell upon later reception of a lower layer switching command from the network?

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Detailed comments |
| MediaTek | Yes |  |
| InterDigital | Yes | We assume the UE will receive multiple candidate configurations, and L1/2 signalling is used to trigger the reconfiguration to one (or potentially more, in case of SpCell + SCell changes and depending on model) of those |
| Huawei, HiSilicon | Yes |  |
| Nokia, Nokia Shanghai Bell | - | The question seems to ask the following: **Do you agree that RRC configures lower layer mobility configuration before UE is triggered to apply it according to a lower layer message (i.e. similar as the BWP configuration and switching in Rel-15)?**  Broadly speaking, we agree this is the primary mechanism but it hides quite many things, for example:   1. What exactly is configured by RRC (i.e. what are the aspects that are pre-configured)? 2. Does the UE validate the configuration upon reception of the RRC message (note that this was also discussed for CHO in Rel-16)? 3. What exactly does the lower layer message trigger as UE actions? 4. How many candidate target cell configurations can be provided?   So considering potential agreements coming from this question, we can agree that **RRC can configure the L1/L2 mobility configuration before the L1/L2 mobility is triggered**. |
| Ericsson | Yes | We think that Nokia has raised fair points that need to be clarified during the work we will do on this work item. However, even if we think that such questions are something to keep in mind, probably those are details that we cannot clarify in this email discussion. |
| Intel | Yes | We assume the pre-configured target cells information are sent to the UE via RRC message. UE may decode the configuration but activate only when L1/L2 mobility command is received. |
| Spreadtrum | Yes |  |
| Xiaomi | Yes |  |
| OPPO | Yes |  |
| CATT | Yes with comments | Generally agree with the rapporteur’s description, perhaps we can clarify that whether the part of configuration that UE applies before the cell switch command (e.g.L1 measurement of candidate cells, etc.) is considered as part of “the candidate target configuration”. In our understanding, those should not be part of the candidate target configuration, which can be discussed further. |
| Vodafone | Yes in general | We understand the description for L1/L2 based mobility provided is two-step procedure, where RRC configuration is provided in advance and the execution of the mobility is triggered by a lower layer command. The point highlighted by Nokia should certainly be discussed during the work. In addition, our understanding is that there can be more than one candidate cell configuration provided to the UE for L1/L2 based mobility. |
| NEC | Yes | We agree with this from high level perspective. Also, we agree with the points from Nokia, which should be considered further. |
| ZTE | Yes |  |
| Samsung | Yes |  |
| Sharp | Yes |  |

To model a L1/L2 inter-cell mobility candidate target configuration, different RRC models can be considered. Hereafter we are going to analyse pros and cons of the main three RRC models that has been decided in the last RAN2 meeting to be considered in this email discussion.

### 3.2.1 Model 1: one *RRCReconfiguration* message for each candidate target configuration

This is the solution that provides the full flexibility in the modelling of a L1/L2 inter-cell mobility candidate target configuration (similar to a L3 handover). In this case the UE receives one *RRCReconfiguration* message for each L1/L2 inter-cell mobility candidate target cell. Each *RRCReconfiguration* message containing the configuration of a L1/L2 inter-cell mobility candidate target SpCell and SCell(s) needs to be stored by the UE upon reception and applied/used/activated when receiving the lower layer signaling for L1/L2 inter-cell mobility serving cell change by the network.

To address CA, each *RRCReconfiguration* has a *CellGroupConfig* IE, with an SpCell configuration and the configuration of one or more SCell(s). In inter-DU, a target candidate DU (which may be the same as the Serving DU) generates the *CellGroupConfig* IE for the target candidate and provides to the CU, which generates the *RRCReconfiguration* per target candidate cell to be included in the L1/L2 inter-cell mobility configuration. In such a model, upon L1/L2 inter-cell mobility execution (reception of the lower layer signaling) the UE changes its SpCell and the set of SCells for the MCG (or SCG).

RRCReconfiguration-IEs ::= SEQUENCE {

radioBearerConfig RadioBearerConfig OPTIONAL, -- Need M

masterCellGroup OCTET STRING (CONTAINING CellGroupConfig) OPTIONAL, -- Cond SCG

measConfig MeasConfig OPTIONAL, -- Need M

lateNonCriticalExtension OCTET STRING OPTIONAL,

nonCriticalExtension RRCReconfiguration-v1530-Ies OPTIONAL

}

RRCReconfiguration-vXXXX-Ies ::= SEQUENCE {

candidates-L1L2-Config-r18 Candidates-L1L2-Config OPTIONAL,

lateNonCriticalExtension OCTET STRING OPTIONAL,

nonCriticalExtension RRCReconfiguration-v1530-Ies OPTIONAL

}

Candidates-L1L2-Config-r18 ::= SEQUENCE {

candidates-L1L2-ToRemoveList-r16 Candidates-L1L2-ToRemoveList-r18 OPTIONAL, -- Need N

candidates-L1L2-ToAddModList-r16 Candidates-L1L2-ToAddModList-r18 OPTIONAL, -- Need N

…

}

Candidates-L1L2-ToAddModList-r18 ::= SEQUENCE (SIZE (1.. maxNrofL1L2Candidates-r18)) OF Candidates-L1L2-ToAddMod-r18

candidates-L1L2-ToAddMod-r18 ::= SEQUENCE {

candidates-L1L2-Id-r18 Candidates-L1L2Id-r18,

candidates-L1L2-CellsConfig-r18 OCTET STRING (CONTAINING RRCReconfiguration) OPTIONAL,

}

**Figure 1. Example of configuring a L1/L2 inter-cell mobility candidate target configuration with an RRCReconfiguration message (*Note that this ASN.1 implementation is just an example, and the final implementation of this model may look different*).**

Even if this solution allows for full flexibility, one may question whether this full flexibility is needed as only few configurations and/or parameter (e.g., as generated by a target candidate DU) may change when performing the execution of L1/L2 inter-cell mobility serving cell change. Further, the fact that the UE needs to process and store multiple *RRCReconfiguration* messages may result in long latency unless restrictions on what can be reconfigured and stricter latency requirements in the RRC processing of the message(s) are applied.

**Question 3**: Companies are invited to provide pros and cons of this solution and whether or not they see it feasible to be used as RRC model for a L1/L2 inter-cell mobility candidate target cell.

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| --- | --- | --- |
| Company | Pros | Cons |
| MediaTek | Such ‘CHO-like’ method may be straightforward as it allows us to ‘reuse’ the CHO works. | This method may not be a good choice for L1/L2 mobility. The reasons are two-fold: First, modelling candidates using *RRCReconfiguration* container provided best configuration flexibility (everything can be reconfigured), but since the scenario is limited to intra-CU, layers above RLC should not be reconfigured (e.g., *RadioBearerConfig* should be the same) upon cell switch. If we adopt this method, we may need to clarify in the spec which part should not change. Second, unlike CHO where other candidates are released upon HO/CHO execution, in L1/L2-mobility we expect that UE switches between 2 or 3 nearby cells. This is not possible if the candidates are modelled as *RRCReconfiguration* unless every *RRCReconfiguration* is a full config. Signalling optimization is possible, but then we cannot reuse CHO designs. |
| InterDigital | This could allow the same framework to be used for both CHO and L1/2 cell change. With correct design of “delta” configuration the overhead may not be significantly worse than any other option. It would also be more future proof in case e.g. inter-CU is supported in the future. | It can work but in most cases only cell switch is needed, and inter-CU is not needed for L1/2 mobility in R18 so this degree of flexibility may be overkill. |
| Huawei, HiSilicon | 1) Supporting full flexibility and scenarios:  - can change L3 measurement configuration to better match with new UE location. This is needed at least/very likely to update the MO or the MO associated with trigger event of measurement config upon inter-frequency/inter-DU mobility, since the frequency of MO is likely to change after switching DU.  - can delivery dedicatedSIB1-Delivery of the target cell, if NW wants to save the latency for UE acquisition SIB1.  2) Less impact to the RRC procedure:  - This allows reusing the Rel-15 reconfiguration procedure, upon applying the HO command (not CHO procedure):  - can signal combination of SpCell and SCells, and of both MCG and SCG;  - can use RRC complete message to inform the CU upon HO successful completion.  3) Easy to support the L2 reset indication:  - can reuse *reestablishRLC* and *recoverPDCP* at inter-DU mobility case (from RadioBearerConfig). Otherwise, it requires adding new indications in L1/L2 HO command/pre-configuration.  4) It can achieve same signalling overhead as other model, if NW wants:  - can omit the Need M fields that don't change.  5) Future extension:  In future release, we may support inter-CU scenario. This model is more compatible/easy to extend for future inter-CU scenario. | (Note on MediaTek's comment: it would be a field separate from conditionalReconfiguration that is used for CHO, so it does not need to have autonomous UE actions for release.  In general, we prefer to avoid autonomous UE release actions, it is makes specification more complex and difficult to maintain/extend).  (Note on rapporteur’s comment on “fact that the UE needs to process and store multiple RRCReconfiguration messages may result in long latency”: it cause no extra delay and storage, when IEs in RRCReconfiguration other than CellGroupConfig as absent.  At UE side, there is no difference on decoding/storing multiple RRCReconfiguraiton messages and multiple IEs, if the IEs other than CellGroupConfig as absent in RRCReconfiguraiton, or if we have the same restriction on what we can udapte.)  (Note that this does not have to a message container. It can be a IE of “RRCReconfiguration-IEs”)  **It becomes same as model 2**, if NW implementation sets the IEs other than CellGroupConfig as absent, since there are Need M/Need N. It means that model 1 allowed NW implementation to choose between flexibility to change more parameters and less signalling overhead.  Possible drawbacks:  - if RAN2 decides many changes to existing procedures (e.g., no RRC complete message), it may affect existing reconfiguration procedures a little bit. |
| Nokia, Nokia Shanghai Bell | - Allows most flexibility with target cell configuration  - Works in all scenarios (i.e. intra-DU and inter-DU)  - Similar to CHO model (i.e. most aspects are already known and latency would follow CHO) | - signalling size may be larger than with other options  - Higher interruption time due to the time spent in L1/2, radio bearers and security reconfiguration during cell change, unless restrictions are imposed on what it can be reconfigured by the target node.  - recursive RRC messages may cause issues if not handled carefully  - delta signalling needs to be discussed |
| Ericsson | - This is the model that enables full flexibility as the network can basically change any parameter or configuration at the UE (this includes also providing a new measurement configuration on the UE to be used after performing the switching).  - The configuration of CA and DC (or both at the same time) may be simpler as most of the legacy procedures and ASN.1 structures can be reused. | - Providing multiple *RRCReconfiguration* message, one for each candidate target configuration, may pose a big burden on the UE in terms of processing delay.  It is true that the network may, by implementation, reduce the number of IEs included in each RRCReconfiguration message but the UE needs anyway to do a validity check for each RRCReconfiguration message separately.  Further, in case the network decides to exploit the full flexibility that this option allow, we think that issues with the message size may have an impact on the UE. Already for the RRC segmentation feature we had to increase the processing delay requirement for the UE because RAN2 consensus was that this had an impact of the time necessary for the UE to execute the ASN.1 decoding and validity check.  - In Rel-18 only intra-CU is supported and some configuration that are “outside” of the CellGroupConfig may not need to be changes (e.g., like the RadioBearerConfig and MeasConfig) it should be an overkill to provide a full configuration at the UE. Also, to reply to Huawei’s comment on the MeasConfig (in the pros column), even if the network decides to change this configuration at the UE, it can always do it once that the switch from the UE is completed.  - If RRC procedures are impacted by L1/L2 mobility, RAN2 may spend very long time to adjust of change existing RRC reconfiguration procedures and configurations. |
| Intel | Possibility to re-use CHO framework.  With RRCReconfiguration, all mobility framework can be reused with full flexibility of configuration including RRM configuration. This option is also future proof and extend to other scenarios.  We haven’t discussed in detail on the potentially need for explicit indication for PDCP recovery . If it is required to be signalled, then RRCReconfiguration has to be used. | Agree it is more signaling overhead but this should be minimal if the fields that are not relevant are not populated.  Some clarification on what fields can be present may need to be captured. |
| Spreadtrum | It is a CHO-like framework, which allows to reuse the configuration framework as that for CHO. | Though it is flexible to change many more parameters, a heavy signalling overhead might be caused due to a large message size. |
| Xiaomi | This model can support all scenarios including intra-DU and inter-DU. | A candidate configuration can only be either MCG or SCG. If a candidate configuration of a cell wants to be changed to PCell and/or SpCell, or If a candidate configuration of a cell group wants to be changed to MCG and/or SCG, the network needs to send two candidate configurations. This causes unnecessary signalling overheads.  Some extra signalling overheads are required for switching off some optional fields which are not needed for the candidate configuration. For example, *RadioBearerConfig* incuding securityConfig and pdcp-Config should be the same for each candidate configuration, given that we only support intra-CU case. |
| OPPO | * CHO-like way can be reused. * Model 1 works for all scenarios. | Configuring a L1/L2 inter-cell mobility candidate configuration with an RRCReconfiguration message may bring extra signalling overhead since the configurations of CU may also be indicated. But for L1/L2 mobility, CU-related configurations such as radioBearerConfig, masterKeyUpdate are not needed.  And even similar signalling overhead as option 2 and 3 can be achieved by delta configuration, i.e., not including the IEs that can be maintained, there may be additional complexity on studying which configuration in RRCReconfiguration message is allowed or restricted for L1/L2 mobility.  The RRC processing delay may be long due to multiple RRC reconfigurations for multiple candidate cells. |
| CATT | 1. Clearer signalling structure.   * 2.Easy to extend to support more scenarios in the future | 1. More spec effort to specify the procedure and to handle the optional IEs.  2. The mechanism to generate the message is more complex(e.g. the configuration is on DU level only ,but CU always needs to be involved to composite the message unnecessarily)  3. UE needs to send RRCReconfigurationComplete message for confirmation, which is not needed for model 2 and model 3. RRC signalling may cause more latency than L1/L2 signalling |
| Vodafone | -This model provides the flexibility with target cell configuration and applicable scenarios.  - most of the legacy procedures can be reused | - signalling size may be large compared to other solutions, possible optimisation with delta configuration should be investigated.  - as only intra-CU is supported in Rel-18, some parameters related to radio bearer configuration, measurement configuration do not change due to L1/L2 mobility thus these signalling could be optimised. |
| NEC | This has more flexibility in target cell configuration and all the listed scenarios can be supported.  The CHO mechanism can be reused a lot with a difference in triggering the mobility. | Some more latency is caused in UE processing compared to other models.  Considering the intention to introduce L1/L2 inter-cell mobility, the full flexibility may not be necessary, e.g. no security key update to avoid L2 reset.  - if some restrictions are set (e.g. no security update), the latency drawback can be avoided. But this is a bit odd..  More signalling overhead (although we do not think overhead is the critical factor to select a model). |
| ZTE | - This model provides full flexibility for all parameters reconfiguration;  - Applicable to all supported scenarios. | - Signalling size may be larger compared to other models;  - Considering that only intra-CU case is supported in Rel-18, radio bearer reconfiguration and security key refresh is not required. So some extra spec impact may be needed to specify which parameter reconfiguration is allowed or restricted for L1/L2 mobility. |
| Samsung | - This model gives full flexibility of inter-cell mobility.  - The CHO mechanism can be referred to design the RRC model of L1/L2 mobility. | This RRC modelling is not aligned with the concept of L1/L2 inter-cell mobility  - Do not see the benefit to reduce the overall latency because of signalling overhead and processing time.  - Do not need to cover all deployment scenarios using L1/L2 mobility, we assume this feature is only used for limited scenarios.  - RRC message size will be huge because of a number of candidate RRC configurations (e.g. CA, DC, TCI states, etc.) |
| Sharp | * full flexibility * support all scenarios * less spec impact to RRC spec due to performing like CHO procedure | * long latency * large signalling overhead * Need to discuss delta configuration due to the agreement below:  **RAN2 to consider preparation of target cell configurations capable of dynamic switching without need for full configuration.** |

### 3.2.2 Model 2: one CellGroupConfig IE for each candidate target configuration

In this model the UE receives within an *RRCReconfiguration* message a list of *CellGroupConfig* IEs and each one of them associated to a configuration of a L1/L2 inter-cell mobility candidate target cell. In this case, each *CellGroupConfig* IE is stored at the UE upon reception, during preparation. The configuration may be applied/used/activated when receiving the lower layer signaling for L1/L2 inter-cell mobility serving cell change by the network.

RRCReconfiguration-Ies ::= SEQUENCE {

radioBearerConfig RadioBearerConfig OPTIONAL, -- Need M

masterCellGroup OCTET STRING (CONTAINING CellGroupConfig) OPTIONAL, -- Cond SCG

measConfig MeasConfig OPTIONAL, -- Need M

lateNonCriticalExtension OCTET STRING OPTIONAL,

nonCriticalExtension RRCReconfiguration-v1530-Ies OPTIONAL

}

RRCReconfiguration-vXXXX-Ies ::= SEQUENCE {

candidates-L1L2-Config-r18 Candidates-L1L2-Config OPTIONAL,

lateNonCriticalExtension OCTET STRING OPTIONAL,

nonCriticalExtension RRCReconfiguration-v1530-Ies OPTIONAL

}

Candidates-L1L2-Config-r18 ::= SEQUENCE {

candidates-L1L2-ToRemoveList-r16 Candidates-L1L2-ToRemoveList-r16 OPTIONAL, -- Need N

candidates-L1L2-ToAddModList-r16 Candidates-L1L2-ToAddModList-r16 OPTIONAL, -- Need N

…

}

Candidates-L1L2-ToAddModList-r18 ::= SEQUENCE (SIZE (1.. maxNrofL1L2Candidates-r18)) OF Candidates-L1L2-ToAddMod-r18

candidates-L1L2-ToAddMod-r18 ::= SEQUENCE {

candidates-L1L2-Id-r18 Candidates-L1L2Id-r18,

candidates-L1L2-CellsConfig-r18 OCTET STRING (CONTAINING CellGroupConfig) OPTIONAL,

}

**Figure 2. Example of configuring a L1/L2 inter-cell mobility candidate target configuration with a list of CellGroupConfig IEs (*Note that this ASN.1 implementation is just an example, and the final implementation of this model may look different*).**

This model allows the target node to modify/release/keep any parameter/field that is part of a *CellGroupConfig* IE while the rest of the *RRCReconfiguration* message (that is where the *CellGroupConfig* IE is received by the UE) remain unchanged. This means that some higher layer configurations e.g., bearers, and security are not changed when performing the switch from a L1/L2 inter-cell mobility serving cell to a target cell, which makes sense as the UE is in the same CU.

As in the previous case, CA is easily addressed as each *CellGroupConfig* IE has an SpCell configuration and the configuration of one or more SCell(s). In inter-DU, a target candidate DU (which may be the same as the Serving DU) generates the CellGroupConfig for the target candidate and provides to the CU, which includes it in the L1/L2 inter-cell mobility configuration (easier for CU compared to previous case). In such a model, as in the previous one, upon L1/L2 inter-cell mobility execution (reception of the lower layer signaling) the UE changes its SpCell and the set of SCells for the MCG (or SCG) by changing the CellGroupConfig configuration.

Further, among the benefits that this model brings, the configuration received by the UE works both in case of DC and CA and can be equally used in case of intra-DU and inter-DU scenarios. Most importantly, the configuration received by the UE is quite lean and thus its processing and application should be faster than in case of receiving the whole *RRCReconfiguration* message.

**Question 4**: Companies are invited to provide pros and cons of this solution and whether or not they see it feasible to be used as RRC model for a L1/L2 inter-cell mobility candidate target cell.

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| --- | --- | --- |
| Company | Pros | Cons |
| MediaTek | This method supports all scenarios (CA/non-CA, NR-DC, intra/inter-DU, intra-/inter-frequency), with reasonable signalling overhead. It also allows UE to switch back-and-forth between two candidate CGs, by e.g., keep two MCG configurations and applying the one for selected CG. Note that the cellGropuConfig needs not to be “full config”, signalling optimization is possible (e.g., keep some “reference cellGroupConfig” and model candidates as delta config) | No (This is our preference) |
| InterDigital | In case of inter-DU it is likely that cell group reconfiguration is needed. | For intra-DU where only the SpCell and/or SCell config changes this option could result in too much configuration overhead. Configuring one CellGroupConfig for each and every candidate cell is not necessary. Configuring one CellGroupConfig for multiple candidate cells seems more intuitive (this could also be supported using correct delta signalling design, there is not much difference) |
| Huawei, HiSilicon | (We assume that this is a list of pre-configurations which are a whole CG configuration, either for the MCG or for the SCG)  This allows to:  - signal combination of SpCell and SCells, for MCG of for SCG  - signal RLC/MAC parameters per target configuration  - omit the Need M fields that don't change | Using only cell group configuration procedure does not allow to:  - signal PDCP recovery flag (needed in inter-DU case): unclear how to do  - trigger RACH for mobility, as the RACH is in the procedure for reception of RRCReconfiguration, unclear how to do  - change L3 measConfig  - correlate MCG and SCG configuration  - send an RRCReconfigurationComplete message  So there may be the need for a new procedure. Of course, new procedure is not necessarily bad but that would somehow duplicate existing functions.  And it does not have the other pros of model 1. |
| Nokia, Nokia Shanghai Bell | - Allows DU-level flexibility for target cell configuration  - Works in both intra-DU and inter-DU scenarios  - Signalling size may be smaller than with *RRCReconfiguration*-option  - Non-recursive *RRCReconfiguration*  - Reduced interruption time compared to Model 1 as the UE needs to spend less time on reconfiguration during cell change (radio bearer, measurement configuration and security are not reconfigured). | - May always need signal the entire CellGroupConfig for each cell – delta signalling needs to be discussed  - Requires signalling all cells in the CG configuration even if only one cell would be changed |
| Ericsson | - This model allows configuration of DC and CA while keeping the size of the message provided to the UE quite lean.  It works also for the case of intra-DU and inter-DU and for intra- and inter-frequency.  - Since most likely the CellGroupConfig IE (or just part of it) is the only part of the ASN.1 structure that will be impacted during the switch of the UE to a new candidate cell, it should be in theory simple to set a reference configuration at the UE in order to allow delta signaling between configurations. This could speed up even more the processing delay at the UE and it should also allow the UE to be switched back of forth from one candidate target cell configuration to another (meaning that the candidate target cell and serving cell configuration are never deleted at the UE, unless indicated by the network). | - The procedural text for the reception of the CellGroupConfig that configures L1/L2 mobility candidate target cell need to be re-designed with respect to the existing procedure. However, we do not see this as a big issue as we may need to modify/enhance the RRC procedures anyway for this WI. Probably having a dedicated L1/L2 inter-cell mobility procedure is more a pros than a cons.  - Handling of the L2 reset need a separate handling (RLC/PDCP reestablishment, MAC reset, performing RACH).  - In case of DC, we may need a mapping to clarify which CellGroupConfig belongs to which cell group. |
| Intel | With cellGroupConfig, both intra-DU and inter-DU can be supported.  This is more light weight. | Cannot benefit from re-using CHO framework.  Less flexibility – if it later turns out that some fields outside of the cellGroupConfig needs to be included by the CU (either in this release or later release), it will be difficult to change at that time.  PDCP data recovery indication “recoverPDCP” is in the radioBearConfig and it may be needed for inter-DU cell change mobility. If so, this option cannot handle it. |
| Spreadtrum | Works in CA and DC, intra-DU and inter-DU with reasonable signalling overhead. | In the case, when some parameters for one cell needs to be change, an entire CG configuration is unavoidable, which is not expected. |
| Xiaomi | This model can support all scenarios including intra-DU and inter-DU. | For the intra-DU case, we may need extra signalling overheads, as the RLC-BearerConfig should be the same for many candidate configurations if the gNB only wants to change the cell-specific configuration.  Extra signalling (e.g. via RRC or L1/L2 switching command) is needed for PDCP recovery. |
| OPPO | * Applicable for all scenarios specified in WID. * Less RRC signalling processing time compared to model1 | Signalling overhead may be relatively larger compared to model3, especially for case that only SpCell change is needed. |
| CATT | * Agree with the rapporteur on the pros of model 2 | For intra-DU case, more spec effort is needed to specify the procedure and to handle the optional IEs |
| Vodafone | * Signalling overhead is smaller than RRCReconfiguration based option (eg. Radio bearer, measurement and security configuration are not reconfigured). | * Handling of L2 reset may need further discussion (eg. PDCP reestablishment, PDCP recovery, radio bearer configuration in case of inter-DU change) |
| NEC | Intra-DU scenario can be supported. Inter-DU scenario can be also supported with some limitation.  Less processing latency. Considering the intention to introduce L1/L2 inter-cell mobility, this seems more suitable from good trade-off between latency and flexibility.   * Less signalling overhead. | Less flexibility, e.g. no bearer change, security update.  In inter-DU scenario, PDCP data recovery may not work.   * Need to introduce a new procedure, where the UE applies the CellGroupConfig for a target upon L1/L2 mobility triggering. However, this is always the case when new function is introduced. |
| ZTE | - Applicable to all supported scenarios.  - Less signalling overhead than model 1. | For intra-DU case, more signalling overhead are required then model 3, especially in case of only SpCell change or SCell change. |
| Samsung | - This model could cover all candidate scenario for this WI i.e. intra/inter-DU and intra/inter-frequency.  - Less signalling overhead compared with Model 1 and it seems enough to cover required feature for L1/L2 mobility. | - Forward compatible issue for further scenario (e.g. inter-CU) but it would not be the scope of L1/L2 mobility.  - Further signalling support of L2 reset.  - Coordination of measurement configurations by NW to cover all candidate target cells.  - Require all CG-level configuration even one target cell configuration is needed. |
| Sharp | * All agreed scenarios (intra-DU/inter-DU, non-CA/CA) are supported | * In CA scenario, a lot of configurations of potential cell groups/combinations will be needed |

### 3.2.3 Model 3: one SpCellConfig IE (and eventually SCellConfig IE) for each candidate target configuration

With this model, the UE receives a list of *SpCellConfig* IEs (and eventually a list of *SCellConfig* IEs) one for each L1/L2 inter-cell mobility candidate cell. In this case, each *SpCellConfig* IE (and *SCellConfig* IE) is stored at the UE in the moment is received and is applied/used/activated when receiving the lower layer signaling for L1/L2 inter-cell mobility serving cell change by the network.

CellGroupConfig ::= SEQUENCE {

cellGroupId CellGroupId,

rlc-BearerToAddModList SEQUENCE (SIZE(1..maxLC-ID)) OF RLC-BearerConfig OPTIONAL, -- Need N

rlc-BearerToReleaseList SEQUENCE (SIZE(1..maxLC-ID)) OF LogicalChannelIdentity OPTIONAL, -- Need N

mac-CellGroupConfig MAC-CellGroupConfig OPTIONAL, -- Need M

physicalCellGroupConfig PhysicalCellGroupConfig OPTIONAL, -- Need M

spCellConfig SpCellConfig OPTIONAL, -- Need M

sCellToAddModList SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellConfig OPTIONAL, -- Need N

sCellToReleaseList SEQUENCE (SIZE (1..maxNrofSCells)) OF SCellIndex OPTIONAL, -- Need N

...,

[[

candidate-L1L2-Config Candidates-L1L2-Config OPTIONAL,

}

Candidates-L1L2-Config-r18 ::= SEQUENCE {

sCell-L1L2-ToRemoveList-r18 Candidates-L1L2-ToRemoveList-r18 OPTIONAL, -- Need N

sCell-L1L2-ToAddModList-r18 SEQUENCE (SIZE (1..maxNrof-L1L2-Cells)) OF SCellConfig OPTIONAL, -- Need N

spCell-L1L2-ToRemoveList-r18 Candidates-L1L2-ToRemoveList-r18 OPTIONAL, -- Need N

spCell-L1L2-ToAddModList-r18 SEQUENCE (SIZE (1..maxNrof-L1L2-Cells)) OF SpCellConfig OPTIONAL, -- Need N

}

**Figure 3. Example of configuring a L1/L2 inter-cell mobility candidate target configuration with a list of SpCellConfig IEs (*Note that this ASN.1 implementation is just an example, and the final implementation of this model may look different*).**

This model allows for less flexibility compared to the models based on the *RRCReconfiguration* message and the *CellGroupConfig* IEs in terms of what may be modified during L1/L2 inter-cell mobility execution, but the configuration received by the UE to be applied/ switched to is even more lean, which speeds up the processing during L1/L2 inter-cell mobility execution. Nevertheless, while this model works fine for configuring the P(S)Cell, the UE also needs a list of *SCellConfig* IEs to support CA. Here the tricky part is that one *SpCellConfig* may be associated with one or multiple *SCellConfig* IEs and thus also a mapping between candidate P(S)Cell and SCell(s) needs to be provided, either during preparation and/or execution. One advantage of this model is that it enables the possibility to have L1/L2 inter-cell mobility execution per serving cell (e.g., SCell(s)), not for the whole cell group.

**Question 5**: Companies are invited to provide pros and cons of this solution and whether or not they see it feasible to be used as RRC model for a L1/L2 inter-cell mobility candidate target cell.

|  |  |  |
| --- | --- | --- |
| Company | Pros | Cons |
| MediaTek | Signalling overhead may be low | This method may not support inter-DU scenario, where RLC/MAC configurations are needed |
| InterDigital | Suitable for most cases of cell change (SpCell and/or SCell). | We don’t really agree with the rapporteur’s suggestion that one SpCellConfig needs to be associated with one or more SCellConfig, a more intuitive approach would be to have a list of multiple candidate cells, each having an SpCellConfig and an SCellConfig (i.e. the candidate cell can be configured as either a SpCell or an SCell).  Cell group reconfiguration, however, needs to be supported for inter-DU, this may require a different ASN.1 structure, although this isn’t a significant drawback. Each candidate cell can be linked with a CellGroupConfig, it’s not complicated. |
| Huawei, HiSilicon | (We assume that, with this method, the L1/L2 HO command would indicate the target PCell and the target SCells)  Possibly smaller RRC signalling for more allowed combinations of SpCell/SCell. | For inter-DU scenario, RLC configuration needs to be changed, which is not allowed by this model.  Many physical/MAC parameters are also outside ServingCellConfig, which is not able to be updated (e.g. mac-CellGroupConfig, physicalCellGroupConfig). This can be a critical issue for inter-DU case.  Larger size of L1/L2 HO command to indicate multiple target cells.  New procedures required in MAC and in RRC for reconfiguration of serving cells.  Does not allow to:  - signal PDCP recovery / RLC re-establishment: unclear how to do  - change L3 measConfig  - correlate MCG and SCG configuration  - send an RRCReconfigurationComplete message |
| Nokia, Nokia Shanghai Bell | - Signalling only includes the changed cell configuration | - Mapping between SpCells and SCells is tricky  - Applicability to inter-DU case is unclear (since CellGroupConfig is generated by the DU and the per-cell config is within that) and may cause additional steps to be useful  - PDCP/RLC/MAC/PHY configurations are outside the target cell config, but may have linkages to the changed serving cell (at least for SpCell cases)  - delta signalling needs to be discussed  - Restrictive in terms of RLC/MAC/PHY reconfigurations that is allowed in inter-DU scenarios. |
| Ericsson | - This is the option the require the less signaling for configuring SpCell and SCell(s). | - For the cases in which is assumed that a reconfiguration with sync in not needs when performing the switch, the handling of the ServingCellCommon needs a special handling for the SpCell (while for the SCell(s) there should be no issues).  - This model implies that RLC and MAC configuration are never changed but this may not be true for the inter-DU case.  - In case of CA, we may need to map each permutation of one SpCellConfig with multiple SCellConfig and this it may be complicated to achieve, unless some restrictions are not set. Similar it may happen also in case DC is configured.  - Handling of the L2 reset need a separate handling (RLC/PDCP reestablishment, MAC reset, performing RACH). |
| Intel | Suitable for intra-DU PCell change only case with the least overhead. | PDCP data recovery, RLC and MAC configurations are not supported. In particular,for inter-DU mobility, the explicit indications for PDCP recovery and RLC re-establishment need to be sent and this can only be provided in radioBearerConfig and RLC-BearerConfig in CellGroupConfig’  Least flexible for any additional configurations.  Doesn’t support common design for intra-DU and inter-DU as this an only support intra-DU. |
| Spreadtrum | Low signalling overhead. | The case of inter-DU cannot be supported by this model due to that RLC-configuration cannot be updated. |
| Xiaomi | Low signalling overheads for supporting cell-level configuration switching. | It is difficult to support the inter-DU case, as the cell-level configuration does not include RLC configuration for different DUs. |
| OPPO | Less signalling overhead. | This model may not be applicable for the scenario of cell group switching, especially for inter-DU case where cell group change is required. |
| CATT | Less signalling overhead in some cases. | For inter-DU case, configuration of RLC/MAC maybe needed, it is impossible with the legacy signalling structure of “SpCellConfig” |
| Vodafone | Low signalling overhead | * Applicability scenario is restrictive * Unclear on how to handle PDCP recovery in inter-DU scenarios. * Handling of the L2 reset needs further discussion * Doesn’t support for unified solution for inter-DU and intra-DU scenarios |
| NEC | Less latency and overhead. | Only intra-DU case can be supported with limitation (i.e. even no MAC/RLC reconfigurations).   * Inter-DU case can/may not be supported. |
| ZTE | - Low signalling overhead;  - Allow more flexible cell combination of SpCell and SCell with less signalling overhead. | It may be not applicable to inter-DU case considering that CellGroupConfig is generated and transferred by each candidate DU to the CU in the current CU/DU coordination procedure, i.e. not per-cell level configuration. |
| Samsung | - Less latency and overhead  - Quite align the intra-DU model and some additional configuration on top of ICBM is possible. | - Tricky handling of L2 reset and cell indication to support inter-DU case and CA.  - It may require some restriction in terms of configurations. |
| Sharp | * latency and signalling overhead may be low | * less flexibility for RLC/MAC/PHY reconfigurations * supporting inter-DU scenario may be difficult |

## 3.3 Final remarks and additional aspects

According to the inputs provided in section 3.2, the final aspect is which RRC model is the preferred one to be used for modelling a L1/L2 inter-cell candidate target configuration. In doing this, please keep in mind that during the last RAN2#119-e meeting the following agreement was made:

* The design for intra-DU and inter-DU L1/L2-based mobility should share as much commonality as reasonable. FFS which aspects need to be different.

**Question 6**: Which RRC model do companies believe that is the most appropriate for modelling a L1/L2 inter-cell mobility candidate target configuration?

|  |  |  |
| --- | --- | --- |
| Company | Model (1/2/3) | Detailed comments |
| MediaTek | Model 2 |  |
| InterDigital | Model 2/3 | A hybrid approach could also be considered. It’s not necessary to provide a cell group configuration for every possible cell change (e.g. intra-DU) when the ServingCellConfig would suffice. On the other hand, there are some cases (at least inter-DU) which require cell group reconfiguration. We could consider multiple cell group configurations (e.g. 1 per DU), each having multiple candidate cell (SpCell and SCell) configurations, rather than having a cell group configuration for every single possible cell change. While this would need more of an ASN.1 structure re-design, it isn’t particularly complicated e.g. we just need to associate a list of candidate cell configs with each CellGroupConfig (e.g. SpCell + SCell config for each candidate cell associated with the cell group) and provides a reasonable trade-off between overhead and flexibility.  As long as the L1/2 signalling can uniquely identify the candidate cell configuration, and we consider how to do the delta signalling in a good way, then actually any of the 3 models can work and they are not that different – it’s not completely clear at this stage which one would be best because we have not agreed the overall procedure.  Perhaps we should look more at the stage 2 details before agreeing the ASN.1 signalling structure. |
| Huawei, HiSilicon | Model 1 is preferred.  Model 2 is FFS.  Model 3 does not address sufficient scenario. | RAN2 should first discuss and agree the functions / flexibility.  For "model 1", we can apply the existing reconfiguration procedure as it is, like is done for CHO/CPC, but for "model 2" and "model 3", there is no procedure so we are not sure how it exactly works.  Therefore, we would like RRC TPs with procedures to judge model 2/3, or we need to postpone this decision.  Model 3 can be dropped, which does not cover the agreed inter-DU scenario.  Note that we are fine to add some restriction on the parameter to be updated to model 1, if that’s the concern from others. |
| Nokia, Nokia Shanghai Bell | Prefer model 1  Model 2 may be acceptable, but needs more detailed assessment | Model 1 is known, but model 2 may also work and could be discussed more carefully.  Model 3 just doesn’t work well with inter-DU scenarios: It would require using transparent containers that are sent as follows: target DU  CU  source DU  source CU  UE (via source DU), whereas both models 1&2 require only target DU  target CU  UE (i.e. two F1AP messages less and less source DU processing). |
| Ericsson | Model 2 (as working assumption) | We believe that model 2 may be a good compromise to model a L1/L2 inter-cell candidate target cell configuration but at the same time we also understand the concerns from other companies that, until a TP on how a model it looks like in the ASN.1, is difficult to express a clear and definitive preference.  However, since progresses need to be made and is quite important to assume at least an RRC model for the work we have to do in the next months, our proposal would be to set Model 2 as a working assumption and the final decision to be made once that we progress more on the ASN.1. |
| Intel | Model 1/2 | The selection of which model depends on what functions are needed for the L1/L2 mobility with serving cell change. With the support of inter-DU mobility, it will require the RadioBearerConfig in RRCReconfiguration to explicitly indicate the PDCP recovery. And RAN2 has not yet discussed whether RRM configuration will need to change for L1/L2 mobility which will require measConfig in RRCReconfiguration. A decision needs to make on each of this aspect before a model can be selected” |
| Spreatrum | Model 2 | Considering factors about signalling overhead, flexibility and feasibility, mode 2 can be considered as a compromise method. |
| Xiaomi | Model 2 | We think that the extra signalling overheads for model 1 could be very large, if a cell group configuration can be either MCG or SCG, or if a cell configuration can be either PCell or PSCell. In these cases, the network has to provide several independent RRCReconfiguration configurations for the same cell group, when this cell group can be switched between MCG and SCG. |
| OPPO | Model 2/1 | Both Model 1 and 2 works, while considering we are discussing the RRC model for intra-CU L1/L2 mobility, model 2 seems more appropriate. |
| CATT | Combination of Model 2 and model 3 | A Choice signalling structure of model 2 and model 3 can be used. which one to use depends on scenarios (intra-DU, or inter-DU).Then UE can perform different procedure according to different model, and there is no redundant signalling. |
| Vodafone | Model 1  Model 2 – but require more details/ analysis | Model 1 is known and also provide future proofness if more deployment scenarios to be considered.  Model 2 should be investigated carefully with support of inter-DU and intra-DU cases with possibility to have a unified solution. Also, performance of model 2 should be evaluated compared to model 1 to see the potential/additional benefits of Model 2. |
| NEC | Model 1 or 2 | At this moment, it is sure that the model 1 can work for all the listed scenarios. To reduce some latency concern or avoid a possibility of non-essential flexibility, we may consider a restriction, where necessary. The model 1 is our preference.  The model 2 seems also work well in intra-DU scenario and inter-DU scenario with some limitation. Before selecting this as the way to go, further detail discussions are required but we are fine to have such discussions. |
| ZTE | Combination of Model 2 and model 3 | Model 2 can be used for inter-DU scenario and model 3 can be considered for intra-DU scenario, to achieve a good compromise between the signalling overhead and configuration flexibility. |
| Samsung | Model 2/3 | We think most important factor to decide the RRC modelling is the use case of L1/L2 inter-cell mobility even it should be generally supported for all deployment scenario.  As the main purpose of this WI is to reduce the overall cell change time (e.g. latency and interruption time) so Model 3 would be first considered. This is also quite aligned with the extension of ICBM what feMIMO achieved. From our understanding this L1/L2 mobility is started from MIMO works.  However, we share the view Model 3 requires many specification work to support inter-DU case. So, we may consider Model 2 could be the starting point but some modification (Model 3 like) could be achieved i.e. hybrid approach. |
| Sharp | Model 2 | By considering to reduce signalling overhead for RRC configurations which may impact on HO interruption time, RAN2 should down-select between Model 2 and Model 3. It may be difficult for Model 3 to support inter-DU scenario, so we prefer Model 2. |

Finally, companies are invited to provide additional inputs on aspects that should be considered in the email discussion and that have not been included so far.

**Question 7**: Companies are invited to point out additional aspects that should be addressed in this email discussion and that not included so far.

|  |  |
| --- | --- |
| Company | Detailed comments |
| Huawei, HiSilicon | It is unclear how model 2 and model 3 procedures would be.  However, it may be premature anyway if RAN2 wants to go with model 2/3. |
| Nokia, Nokia Shanghai Bell | **The terminology** of “L1/L2 inter-cell mobility” is extremely cumbersome to use and is partly misleading: For one thing, we don’t even know what are the L1 and L2 parts and the split between them.  Hence, we would propose to use something simpler for the mechanism. **Our proposal is to use “lower layer mobility” or “LLM” for short when we talk about the “L1/L2 inter-cell mobility”**. That would make both writing and speaking about the mechanisms faster. |
| Ericsson | Our understanding is that Model 1 may not be as close as normal HO or CHO as it seems. Some of the legacy procedures cannot be reused anyway and new procedures need to be specified for L1/L2 inter-cell mobility. Therefore, we are not sure what impact will have this on the existing RRC procedures and on the restrictions that may need to be formulated.  Regardless on the model we chose to adopt, we believe that having a separate and independent procedure for L1/L2 inter-cell mobility would bring more pros than cons. Will make the understand of the overall procedure much easier and we would also avoid adding text in the already complex RRC procedural text (e.g., section 5.3.5.3 of TS 38.331) that we currently have. |
| Xiaomi | We should also discuss whether to allow cell type change (e.g. PCell or SCell) for a cell configuration or cell group type (e.g. MCG or SCG) change for a cell group configuration via the L1/L2 mobility. |

# 5 Conclusion

Based on the discussion in the previous sections we propose the following:

[Proposal 1 To be updated.](#_Toc509923397)