**3GPP TSG-RAN WG2 Meeting #121bis-e R2-23xx**

**Electronic, 17 – 25 March, 2023**

**Agenda item: 7.4.2.2**

**Source: Qualcomm Incorporated**

**Title: [AT121bis-e][019][eMob] L1 Measurements (Qualcomm)**

**Document for: Discussion and decision**

# Introduction

This document will report the outcome of the following offline discussion:

* [[AT121bis-e][019][eMob] L1 Measurements (Qualcomm)

Scope: Based on measurements input to current meeting, identify agreements (easy / tentative) and open issues (to be addressed at next meeting),

Intended outcome: Report

Deadline: CB W2 Wednesday

Please provide your contact information in the table below.

|  |  |
| --- | --- |
| **Company** | **Contact Name, Email** |
| Qualcomm | Ozcan Ozturk, oozturk@qti.qualcomm.com |
| MediaTek | Li-Chuan Tseng, li-chuan.tseng@mediatek.com |
| ZTE | Mengjie Zhang, zhang.mengjie@zte.com.cn |
| Panasonic | Quan Kuang, quan.kuang@eu.panasonic.com |
| Apple | Naveen Palle naveen.palle at apple |
| CATT | Bufang Zhang, zhangbufang@catt.cn |
| Futturewei | Jialin Zou, [jialinzou88@yahoo.com](mailto:jialinzou88@yahoo.com) |
| Lenovo | pmallick@lenovo.com |
| OPPO | Xin You, youxin@oppo.com |
| Xiaomi | xiongyi3@xiaomi.com |
| Vivo | Chenli, Chenli5g@vivo.com |
| Intel | Candy Yiu, candy.yiu@intel.com |
| Transsion Holdings | Junwei Huang, junwei.huang@transsion.com |
| CMCC | Xiaoxuan Tang, tangxiaoxuan@chinamobile.com |
| Samsung | Seungri Jin, seungri.jin@samsung.com |
| Huawei, HiSilicon | David Lecompte, david.lecompte@huawei.com |
| NTT DOCOMO | Souki Watanabe, souki.watanabe.gf@nttdocomo.com |
| Ericsson | Antonino Orsino, antonino.orsino@ericsson.com |
| InterDigital | Brian Martin (brian.martin@interdigital.com) |
| Nokia | Endrit Dosti (endrit.dosti@nokia.com) |
| Sharp | Kyosuke Inoue, [kyosuke\_inoue@sharp.co.jp](mailto:kyosuke_inoue@sharp.co.jp) |
| LGE | Siyoung Choi, see0.choi@lge.com |

# Discussion

## Location of measurement config

We can divide the measurement configuration into three parts, similar to L3 measurements:

* 1. What to measure (measurement object in L3)
  2. How to measure (quantity configuration in L3)
  3. When to report (report configuration in L3)

In L3 measurements, all of these are part of *MeasConfig* which is an IE in *RRCReconfiguration* independent from cell group configuration.

RAN1 has discussed how to configure L1 measurements for LTM and made several agreements. RAN1#111 agreed that SSB-based L1 measurements of intra/inter-frequency LTM cells is supported.

We can start with “measurement object” alike. RAN1#112 has agreed that the SSB based L1-RSRP measurement RS configuration includes:

* PCI or logical ID for both intra- and inter- frequency
* SMTC or periodicity and SSB position in burst for both intra- and inter- frequency
* Frequency location + SCS info for inter-frequency

RAN1#112 has also discussed three configuration options for the SSB-based L1 measurement RS configurations:

* + **Option 1**: as part of the ServingCellConfig(s) of the serving cell(s).
  + **Option 2**: external to the ServingCellConfig(s) of the serving cell(s) and external to the configuration of the candidate cells
  + **Option 3**: as part of the configuration of the candidate cell(s)
  + Option 4: as part of the reference configuration (e.g. in SpCellConfig, but exact location TBD).

In Option 1, the RS configuration for the target candidate cells will be provided in the serving cell configuration (as part of the container *CellGroupConfig*). Option 2 is similar to the legacy RRM configuration as mentioned above where a separate list/IE is configured independently from the configuration of serving cells*.* In Option 3, the target candidate cell will provide the RS configuration. Note that the definition of Option 3 from RAN1 as above may not be clear but their intention with this option was that the RS configuration will be placed in the target cell *RRCReconfiguration* container.

We can assume that the “L1 measurement object” includes the above list from RAN1 for now, i.e. PCI or logical ID, SMTC configuration, frequency location etc.. Other elements can be added if/when RAN1 makes further agreements. Note that the term “L1 measurement object” is not meant literally here and how it is implemented in ASN.1 can be discussed later.

**Question A1: For the location of the “L1 measurement object” for SSB-based measurements of candidate cells, which of the above Options 1,2,3 do you support? If another option, please explain.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | Option 2 | The L1 measurment RS configuration of candidate cell(s) is not a part of serving cell, and this it should not be in serving cell configuration (Option 1). Moreover, it is used by UE before cell switch. If included in candidate cell configuration (Option 3), it means that UE needs to access candidate configuration when it is still served by current serving cell. While this is technical feasible, it may not be a good practice. Therefore, we prefer Option 2. |
| NEC | Option-2 |  |
| ZTE | Option 2 | Option 1 may need to configure repeated L1 measurement RS configuration of candidate cells in serving cell and each candidate cell, to support subsequent LTM. So it shall cause the heavy signaling structure and considerable signaling overhead.  Option 3 requires the UE to decode and apply the candidate cell configuration for L1 measurement before executing LTM cell switch, which introduces new UE behaviour and increases the UE complexity to parse all information of corresponding cell.  So we prefer option 2. |
| Panasonic | Option 2 | Option 1 makes the size of ServingCellConfig unnecessarily large and increases the signalling overhead, because RS configurations of candidate cells need to be duplicated in every candidate cell configuration.  Option 3 is also not preferred, because it brings computational complexity in UE side to process all candidate cell configurations in order to obtain full picture of RS configurations. |
| CATT | Option 2 | For option 3, UE is not allwed to apply the candidate cell configuration before access to the cell. So obviously option 3 should be precluded.  For option 1, it cannot work for subsequent LTM case, since according to legacy procedure, if the L1 measurement RS configuration is configured only in the serving cell configuration, then the L1 measurement RS configuration will be released by UE. |
| Futurewei | Option 2 |  |
| Lenovo | Option 2 |  |
| OPPO | Option 2 | Option 2 does not have redundancy L1 measurement RS configuration for each candidate as for Option 1. And early decoding of all the candidate cell configurations can be avoided by providing the measurement RS configuration outside of LTM candidate cell configuraiotn. |
| Xiaomi | Option 2 |  |
| vivo | Option 2 or 3 | Option 1 should be excluded because it will bring significant configuration redundancy for subsequent LTM. With this option, the ServingCellConfig of one candidate cell(e.g. cell A) needs to include the L1 measurement configuraiton of other candidate cell(s)(e.g. cell B) to allow subsequent LTM form cell A to cell B.  Currently, the ServingCellConfig(s) of one serving cell includes its own L1 measurement configuraiton, i.e. csi-MeasConfig. We wonder whether option2 means the legacy csi-MeasConfig configuration of serving cell needs to be included in the configuraiton external to the configuration of both serving and candidate cells?  If yes, we prefer option3, which keeps the legacy design, i.e. the L1 measurement configuraiton of each cell is incuded in the ServingCellConfig of the cell. Otherwise, option 2 is also acceptable.  Some companies raise the concern that UE needs to decode the candidate cell configuration for L1 measurement before executing LTM cell switch, but we think early decode is anyway needed to shorten the LTM handover duration. |
| Apple | Option 2, but | Op1 and Op3 are a bit similar, they associate with each serving cell, and op2 does not – this is also a bit like current meas config per CG.  But, we should also acknowledge that some meas objs might not be useful for UE to measure in certain LTM cells, and this signalling is not possible with op2, unless additional per-cell delata is possible. |
| Intel | Option 2 | We think that L1 meausrement object configuration should be similar to L3 MO configuration. Serving cell will provide such configuration to the UE for all candidate cells.  As for option 3, if target cells have to prepare the each measurement object configuration, there may be too many inter-node messages just to coordinate measurement. The potenetial issue will be to support subsequent LTM without RRC reconfiguration, whether the current L1 meausrmeent RS configuration should be maintained after each LTM cell switch. Furthermore, UE may not decode the LTM candidate configuration right away when received it. Therefore, it is better to use option 2. |
| Transsion | Option 1 & 2 | For Option 1, the current R17 ICMB measurement configuration *csi-MeasConfig* was contain in *ServingCellConfig*, which contains both L1 measurement resources and repoort resources. The legacy R17 ICBM measurement for neighbor serving cell was using *servingAdditionalPCIList-r17* to represent. In R18, it can be as a start point.  For Option 2, it is useful to avoid the duplicated configurations for measurement configurations. In addition, regarding PCI or logical ID included in measurement configuration, we prefer logical ID from the perspective of signaling overhead.  For Option 3, additional UE complexity is required before LTM cell switch. |
| CMCC | Option 1/2 | For option 3, UE needs to decoding and applies the measurement part in advance with unnecessary UE processing since not all the RRC reconfiguration will be applied. Thus, Option 3 is less preferred.  Option 1/2 are both feasible for the configuration of “L1 measurement object” and can be used for subsequent LTM with the assumption that the UE stores the related L1 measurement configuration upon reception. Option 1 has less spec impact. Option 2 has less RRC signalling overhead. But the association between report configuration (assumed in Servingcellconfig) and RS configuration should be further clarified. |
| Samsung | Option 1/2 | We initially prefer option 1 because the configurations of LTM could be similar for Rel-17 ICBM. From our understanding, UE should measure L1 measruement for ICBM and LTM if both are configured. In that sense, if the deployment of LTM candidate cells are selected from the ICBM candidate cells the signalling overhead could be minimized. However, we share the view that in general option 1 requires many singalinng overhead to support subsequent LTM (note: ICBM do not support subsequent ICBM operation). |
| Huawei, HiSilicon | Option 4 | Example:  Cell 1 configures CSI resources for cells 2, 3, 4, 5, 6, 7 and 8 Cell 2 configures CSI resources for cell 1, 3, 4, 5, 6, 7 and 8 etc.  Reference configuration is copied from cell 1 configuration.  If CSI-ResourceConfig is used for neighbour cell RS measurements, when the UE moves to cell 2-8, at least the CSI-ResourceConfig for 6 our of 7 neighbour cells is already in the reference configuration, so signalling is already pretty optimized. It could even be 7 out of 7 if the CSI-ResourceConfig for inter-cell measurement of cell 1 is included in the reference configuration.  So, with option 4, the "reference configuration" can give the same benefits like option 2, without the need to create a new IE. |
| NTT DOCOMO | Option2 | Option 1 would set a duplicate L1 measurement object configuration in the serving cell config of each candidate cell config, which would increase the size of the configuration.  Option 3 requires the UE to decode the candidate configuration before applying it, increasing unnecessary processing.  Option 2 is relatively preferable in light of the above, but its impact on subsequent LTM requires further discussion. |
| Ericsson | Option 3, option 2, but exclude option 1 | In our view, RAN2 agreements point in a direction in which LTM measurements are configured as in CSI legacy measurements, to some extent. In legacy CSI measurements, what RAN1 calls “RS configuration” refers to the resource configuration, which is included in each cell configuration e.g. resource of cell A is included in the cell A configuration. Thus, it would not make sense to ad resources of a cell A within another cell configuration. For that reason, Option 1 should be excluded.  About options 2 and/or 3, if we follow the closest solution to the legacy CSI reporting framework, resources of an LTM candidate cell should be configured in the LTM candidate configuration itself (a natural place could be the CSI-ResourceConfig). However, RAN1 has agreed on configurations present in the ServingCellConfigCommon of the SpCell of each LTM candidate configuration (denoted by rapporteur as target cell RRCReconfiguration container), which the UE could easily decode (as it does for CHO, to figure out the applicable cell). In that solution, each C-DU is not required to generate additional and repeated configuration. For that reason, until RAN1 proposes further configuration, that could be considered as baseline. Therefore we think that first option should be:  Preferred is Option 3: ServingCellConfigCommon of each LTM candidate configuration  Another alternative relies on the fact that most of the RS configuration info is present in the MeascObjectNR the UE is configured with in the current serving cell e.g. SSB frequencies, time domain properties, etc. For each frequency having LTM candidates there should anyways be a MeasObjectNR, as the candidates are typically chosen base on L3 measurement reports, so the UE is already configured with the MeasObjectNR(s) associated to the frequency of the LTM candidates. This would be something like Option 3.  Can accept Option 2: MeasObjectNR in the UE is configured with frequencies associated to LTM candidates |
| InterDigital | Option 2 |  |
| Nokia, Nokia Shanghai Bell | Option 2 | It does not matter much where the measurement RS configurations are placed, but whether it is part of the candidate cell. In our view it shouldbe outside of the configuration of the candidate cell to ensure that the UE will not need to decode it for all target cells to perform mobility among the prepared cells and also that the L1 measurement object will not change as the UE moves among the cells. This ensured with option 2. |
| Fujitsu | Option 1 or Option 2 | Option 3 is not preferred considering that it requires a UE to decode the candiate cell configuration before cell switch command. Further down-selection can be performed between Option 1 and Option 2 by considering the support of subsequence LTM. |
| Sharp | Option 3 | For Option 1, serving cell configuration and associated RS configuration for the target candidate cells are changed upon LTM execution and if the same L1 measurement RS configuration is used for both serving cell and candidate cell, this option causes additional signalling overhead for subsequent LTM.  For Option 2, we have the same concern as vivo. If the same L1 measurement RS configuration is used for both serving cell and candidate cell, the RS configuration within the candidate cell configuration and the RS configuration external to both the ServingCellConfig and the candidate cell configuration might be duplicated. |
| LGE | Prefer Option 2 as a part of reference.  Exclude Option 1. | For Option 1, each servingCellConfig of every candidate cell should include the RS information for measuring other candidate cells, which may result in large and duplicated signalling. So Option 1 needs to be excluded.  Prefer Option 2, and this can be provided as a part of reference. We have sympathy with Huawei’s observation given above. Option 2 does not present duplicated L1 measurement RS configuration for each candidate cell unlike Option 1. If L1 measurement RS configurations are not provided in candidate cell configuration (e.g., delta or reference), UE needs to receive L1 measurement RS configurations after every LTM cell switch. This imples that LTM cell switch between LTM candidate cells requires RRC reconfiguration in between (i.e. subsequent LTM is not supported). Therefore, it is desirable to provide L1 measurement RS configurations as part of reference configuration to support subsequent LTM.  Option 3 is questionable since UE is required to decode and construct the candidate cell configuration for every canddiates. RAN2 agreed that UE “may” do that but UE cannot be mandated to do so. Furthermore, UE operates in accordance with active configuration provided by the serving cell but the candidate cell confiruation is not active but only a preconfiguration that becomes active only upon LTM to the candidate cell. |

**Summary:**.

**Proposal.**

From RAN1 LS:

*It is noted that RAN2 has a full flexibility to design the whole RRC structure design, and RAN1 foresees the necessity of similar discussions on TCI state pool for candidate cells and L1 measurement report configurations*

Since RS and TCI configurations are inherently linked, it is reasonable that they are placed in the same location. RAN2 can make a decision as RAN1 will likely ask this question per their LS as quoted above.

**Question A2: Should the location of “TCI state pools” for the candidate cells be same as the location of “L1 measurement object”, i.e. the same Option 1/2/3 is used for both of them?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | Yes | Candidate information needed before cell switch, including but not limited to L1 measurement RS, TCI states, and CFRA configuration, should be configured following the same principle. |
| NEC | Yes |  |
| ZTE | Yes |  |
| Panasonic | Yes |  |
| CATT | Yes |  |
| Futurewei | Yes |  |
| Lenovo | Yes |  |
| OPPO | Yes |  |
| Xiaomi | Yes |  |
| vivo | Yes, but | From RAN2 view, it is clearer and more straightforwared to place TCI and RS configurations in the same location, and same RRC structure should be used for TCI and RS configurations.  However, joint TCI state pool or independent TCI state pool configured for candidate cells is still under discussion in RAN1, and may have impacts for RAN2 on the design of RRC structure for TCI state. Therefore, we think the RRC structure design for TCI state can be decided after RAN1 has more progree on the TCI state related issues. |
| Apple | Yes |  |
| Intel | yes | Agree with rapp that it is reasonable to place them in the same location. |
| Transsion | Yes |  |
| CMCC | Yes |  |
| Samsung | Yes |  |
| Huawei, HiSilicon | Maybe no in option 2. No question in option 4. | In our understanding, the TCI state of the target cell is only used at execution. It is no use if the UE does not move to the corresponding target cell. In option 2, it could be put together but there is no benefit to do so.  However, in option 4, this question does not exist because anything from CellGroupConfig can be included in the reference configuration that can be used by every candidate target configuration. |
| NTT DOCOMO | Yes |  |
| Ericsson | Wait for RAN1 | The TCI configuration is only needed when the UE receives the LTM cell switch command. Also, that is configured per active BWP i.e. it is not simple to give the TCI list only.  RAN2 has not agreed that the UE requires the TCI state pool of LTM candidate(s) before receiving the LTM cell switch MAC CE, so is not clear for us for what do we need the TCI pool beforehand. |
| InterDigital | Yes |  |
| Nokia, Nokia Shanghai Bell | Agree | We agree to that **the location of “TCI state pools” for the candidate cells be same as the location of “L1 measurement object”**. For each of the L1 measurement beams a TCI state can be added. |
| Fujitsu | Yes |  |
| Sharp | Yes |  |
| LGE | Yes |  |

**Summary:**.

**Proposal.**

A similar discussion may be needed for CSI-RS measurements. Since RAN1 has not made any agreements on this yet, it will skipped here. However, it is quite likely that our decision for SSB above will also be applicable to CSI-RS.

## Measurement triggering and reporting

In L3 measurements, the reporting configuration is generated by the source gNB. We need to decide if the similar conclusion is applicable to L1 measurements. The other alternative is for the candidate cells to generate this and provide to the UE via the source cell. The first option seems more natural given that the UE will report the results to the source cell which should have the control of when/how reporting happens.

**Question B1: For L1 measurements of LTM candidate cells, do you agree that the reporting configuration is not included in the target cell *RRCReconfiguration*?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | Agree |  |
| NEC | Yes | This may be the natural way for the handling |
| ZTE | Yes |  |
| Panasonic | Not sure about the question | Since UE reports measurement results to the serving cell, the reporting configuration should be applied to the serving cell (e.g. the PUSCH/PUCCH resources in the serving cell). However, we think the reporting configuration can be prepared by the candidate cell beforehand and included in the candidate cell configuration such that once the candiate cell becomes a new serving cell, the reporting configuration can be immediately applied.  If the above question is asking whether the new serving cell needs to generate the reporting configuration by RRC after cell switch, we think this would cause delay and therefore not favorable. |
| CATT | It depends | For the case of one-shot LTM, I agree there is no need to include the reporting configuration in the target cell RRCReconfiguration. Since after the LTM cell switch is triggerd, the LTM procedure is ended and UE release all the LTM candidates.  But for the subsequent LTM, I think the reporting configuration for LTM also need to be configured within the candidate cell configuration. Otherwise, NW has to reconfiguration after each cell switch. That’s because, the L1 measurement reporting is different like L3 measurement reporting, where the the reporting resources are configured via RRC and it is not dynamical changed. How can UE to report the L1 measurement to the new serving cell but still using the last serving cell’s resources?  CSI-ReportConfig ::=                SEQUENCE {      reportConfigId                          CSI-ReportConfigId,      carrier                                 ServCellIndex                   OPTIONAL,   -- Need S      resourcesForChannelMeasurement          CSI-ResourceConfigId,      csi-IM-ResourcesForInterference         CSI-ResourceConfigId            OPTIONAL,   -- Need R      nzp-CSI-RS-ResourcesForInterference     CSI-ResourceConfigId            OPTIONAL,   -- Need R      reportConfigType                        CHOICE {          periodic                                SEQUENCE {              reportSlotConfig                        CSI-ReportPeriodicityAndOffset,              pucch-CSI-ResourceList                  SEQUENCE (SIZE (1..maxNrofBWPs)) OF PUCCH-CSI-Resource          },          semiPersistentOnPUCCH                   SEQUENCE {              reportSlotConfig                        CSI-ReportPeriodicityAndOffset,              pucch-CSI-ResourceList                  SEQUENCE (SIZE (1..maxNrofBWPs)) OF PUCCH-CSI-Resource          },          semiPersistentOnPUSCH                   SEQUENCE {              reportSlotConfig                        ENUMERATED {sl5, sl10, sl20, sl40, sl80, sl160, sl320},              reportSlotOffsetList                SEQUENCE (SIZE (1.. maxNrofUL-Allocations)) OF INTEGER(0..32),              p0alpha                                 P0-PUSCH-AlphaSetId          },          aperiodic                               SEQUENCE {              reportSlotOffsetList                SEQUENCE (SIZE (1..maxNrofUL-Allocations)) OF INTEGER(0..32)          }      }, |
| Futurewei | Not really | We have similar view as CATT. L1 measurement configuration should be used by the UE in current serving cell. Therefore, it should be configured for current serving cell and each candidate cell. The configuration for a candidate cell will be used by the UE when the candidate cell become the serving cell after the cell switch. The the UE in the new serving cell, the L1 measurement should be on its own candidate cells which can include previous serving cell. Therefore, the L1 measurement should be configured at per current serving cell and future serving cell (current candidate cell) basis. Therefore, it would be convenient to include the candidate cell L1 measurement configuration in RRC configuration of each candidate cell, and the measurement configuration separately for current serving cell. If we want to have the L1 measurement configuration totally separate, then we will need to clearly specify the per candidate cell and L1 measurement association. |
| ^Lenovo | No | CATT and Futurewei have a point that the reporting configuration needs to be understandable by the “current” serving cell which keeps changing due to *subsequent* handovers. |
| OPPO | See comments | Agree with CATT and Futurewei. Report config should be provided per serving(candidate) cell, as the UL resources is configured per serving cell, i.e. under the CSI report config within serving cell config for each candidate cell. UE perform L1 measurement reporting based on report config of current serving cell. |
| Xiaomi | Not really | Share the same view with CATT. For subsequent LTM, the L1 measurement reporting configuration can be included in the LTM candidate configuration, which can be used for L1 measurement reporting when the candidate cell becomes the serving cell. |
| vivo | Yes | It depends on the measurement reporting discussion in RAN4/RAN1(?).  As far as I known, it was agreed that the corresponding measurement would not be reported in L1 report in RAN4 discussion. Besides, it is also preferred not to include the reporting configuration in the target cell RRCRconfiguration in RAN4. But we could wait for more progress in RAN4.  In case it was agreed the measurement results will be reported via L1, the corresponding configuration could be configured in serving cell configuration. Otherwise, i.e. via L2 reporting, the reporting configuration could be independent with the serving cell configuration, which could be a separate configuration, similar as Option 2 in Question A1. |
| Apple | No (pls see comments) | We prefer this to be part of candidate cell, as we commented to earlier question, the configuration should have some per-cell configurability option.. and this is possible with per-candidate cell confg. |
| Intel | Yes | The report configure should also be generated and controlled by source. |
| Transsion | No | The current both L3 and L1 measurement configurations , i.e. *MeasConfig* and *CSI-MeasConfig*, are inculding in *RRCReconfiguration*, it should be used as a baseline. |
| CMCC | See comments | Reportconfig is provided by the serving cell (previous candidiate cell) since it is related to the UL resource allocation. Before the switch, the reporting configuration is within the ServingCellConfig of the serving cell (as question B2). But this not precludes involving reporting configuration in the RRCReconfiguration of candidate cell, i.e., this report configuration of the target cell could be used after the switch. |
| Samsung | See comments | Agree with CATT and Futurewei. |
| Huawei, HiSilicon | Yes | We understand that the question is whether the configuration to report L1 measurements for neighbour cells when in cell X should be included in cell X configuration or could be in the candidate configuration for the neighbour cell.  The concern from CATT seems not about this, they seem to understand the question differently. |
| NTT DOCOMO | FFS | Further discussion is needed on whether the reporting configuration can be used repeatedly after LTM execution and whether it needs to be updated to be used. |
| Ericsson | Yes but | The report needs to be interpreted by the S-DU. Therefore, using S-DU resources assigned accordingly e.g. periodic, semi-persistent, aperiodic. Thus, the only solution which makes sense based on RAN1 agreements is that the S-DU generates its own CSI-ReportConfig. Thus, we agree that the reporting configuration is not included in the target cell RRCReconfiguration.  We also agree with CATT’s point: each candidate cell configuration, assuming that it becomes a serving cell to which the UE report other LTM candidates, needs to have their own CSI-ReportConfig for LTM, without the need to an RRCReconfiguration after every LTM cell switch.  So a better formulation could be to say that CSI-REportconfig for LTM is included in a serving cell configuration in which the UE needs to report LTM related measurements. |
| InterDigital | Yes | Should the question/proposal rather be where the configuration is, rather than where it is not? i.e. Agree with Ericsson 3rd point. |
| Nokia, Nokia Shanghai Bell |  | Reporting configuration should belong to current serving cell. The L1-measurement-config and TCI state-config is maintained at UE as common (or reference configuration) outside the serving cell configuration. Because after cell-switch, the reporting-config should be of new cell. |
| Fujitsu | Comments | The question may not be clear. Considering the support for subsequent LTM, the reporting configuration can be provided on a per cell basis, i.e., per serving cell and per candidate cell. To support this, the reporting configuration can be also included in candidate cell configuration and provided per candidate cell. |
| Sharp | Yes | If the report configuration is configured under ServingCellConfig, new measurement configuration can be applied by the delta configuration of ServingCellConfig without any change of the candidate cell configuration upon LTM cell switch, so we agree that the reporting configuration is not included in the candidate configuration. Also, some companies prefer this approach according to the ongoing RAN1 discussion. Besides, we agree with CATT’s concern and this can be solved by Ericsson’s formulation. |
| LGE | Yes | Since UE should report L1 measurements of candidate cells to the current serving cell, it does not make any sense that L1 report configuration is included in candidate cell configuration. Furthermore, UE cannot be mandated to do early candidate cell construction for every candidates. |

**Summary:**.

**Proposal.**

In L3 measurements, the triggers for the report are configured in *“ReportConfigNR”.* The reporting configuration can be linked to one or more measurement object where each linkage is assigned a measurement ID.

The legacy L1 measurements for a serving cell is configured in the serving cell configuration.

For L1 measurements of LTM candidate cells, assuming the response to Question B1 is “Yes”, the choice will be to put this inside or outside serving cell configuration.

**Question B2: Should “L1 reporting configuration” for SSB-based measurements of candidate cells be included in inside or outside source serving cell configuration? If another option, please explain.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | Inside | L1 measurment report is sent to serving cell, and thus it should be in serving cell configuration. |
| NEC | Outside | Maybe it is good to align with the LTM MO configuration, i.e outside source serving cell configuration |
| ZTE | Outside | Agree with NEC.  Besides, if the report configuration is included in the serving cell configuration (i.e. under ServingCellConfig), in order to support subsequent LTM, the report configuration is also required to be included in each candidate cell configuration (i.e. used when the candidate cell becomes the current serving cell). So each DU needs to know the L1 measurement RS configuration from other DUs, to generate the right report configuration under the candidate cell configuration, which may require complicated inter-DU coordination among serving and candidate DUs. |
| Panasonic | Inside | The reporting configuration, e.g. UL resources, is applicable to the serving cell only. It makes sense to be inside the serving cell configuration. The reporting configuration can point to a set of RS configurations that are outside every candidate cell configuration and managed separately. Therefore, the issue mentioned by ZTE seems not existing. |
| CATT | At least inside serving cell configuration, But, | To associate the measurement RS and the corresponding report configuration, I think at least inside the source serving cell configuration by referring to the L1 measurement RS configurations configured using above option 2. And as we comment in Question B1, for subsequent LTM, the L1 reporting configuration also need to be included within the candidate cell configuration by referring to the L1 measurement RS configurations configured using above option 2. The following is an example how this works. |
| Futurewei | It is depends | It should be in current serving cell configuration for UE reporting to the current serving cell. For other candidate cells, the L1 measurement reporting should be configured for them and will be used by the UE when the candidate cell becomes the new serving cell and the UE reports to the new serving cell. |
| Lenovo | Inside | Inside is preferable but I think both can be made to work since we are talking about “standardized” solution as part of stage-3 work and both transmitter as well as receiver would know. |
| OPPO | Inside source serving cell configuration | The L1 measurement report configuration needs to be included in current serving cell configuration. |
| Xiaomi | Inside | As in legacy, the L1 reporting configuration can be included in inside source serving cell configuration for the candidate cell and the L1 reporting configuration will be used when the candidate cell becomes the serving cell. |
| vivo | Inside | See our answer for Question B1. |
| Apple | It should be per candidate LTM cell, inside or outside, but prefer inside. |  |
| Intel | Outside serving cell configuration | Similar to MO configuration, it should be outside of serving cell configuration to handle the inter-DU case. |
| Transsion | Inside | As replied to Question A1, the current R17 ICMB measurement configuration *csi-MeasConfig* was contain in *ServingCellConfig*, which contains both L1 measurement resources and repoort resources. |
| CMCC | Inside source serving cell configuration |  |
| Samsung | Inside |  |
| Huawei, HiSilicon | Inside probably | The reporting configuration includes the resources for reporting. If candidate cell 1 and candidate cell 2 both ask the UE to report L1 measurements of cell 3, candidate cell 1 and candidate cell 2 will use different resources for the reporting, so the resources for reporting are obvious inside each candidate configuration.  With respect to what to measure exactly, e.g. quantity, it is possible that candidate cell 1 and candidate cell 2 want to measure the same quantity but perhaps they will decide otherwise, then it will be different. |
| Ericsson | Inside with comment | The CSI-MeasConfig is currently generated by the DU. And, as measurements needs to be processed there, the DU will also determine these. Thus, we see no reason to modify that.  We agree with the issue raised by ZTE concerning sub-sequent LTM; and it would be nice to avoid. However, moving ReportConfig outside the ServingCellConfig (as in L3 measconfig) may not be possible in the light of the current RAN1 agreements in which reports are like in CSI reports (periodic, aperiodic, semi-persistent), and not event triggered and/or depending on Scheduling Requests on normal PUSCH resources.  However, we are also open for discussing solutions for outside, depending on what is required in CSI-ReportConfig for LTM. |
| InterDigital | Outside | Agree with others that we should align with MO case. |
| Nokia, Nokia Shanghai Bell | No | The CSI-Report-config which maps to PUCCH and PUSCH resources should belong to the current serving-cell. So it should be within cell-specific configuration. |
| Fujitsu | Inside with comments | As replied for question B1, the reporting configuration for a source cell is included inside source cell serving cell configuration, and the reporting configuration for a candidate cell is included inside candidate cell serving cell configuration. |
| Sharp | Inside | L1 measurement report can be sent on serving cell. Please see our comments on Question B1. Besides, we agree with ZTE’s issue for subsequent LTM and how to avoid this issue can be discussed in RAN3. |
| LGE | Need more investivation | For legacy CSI measurements, UE performs CSI measurements on reference signal provided by a serving cell (or RS associated with the serving cell in case of mTRP), and CSI reporting is transmitted to the serving cell. Therefore, it is quite natural that reporting configuration is configured as part of serving cell configuration. If we attempt to reuse existing IEs related to CSI measurement reporting, we need to start with “inside” option.  For LTM, however, UE is required to perform CSI measurements that are provided by non-serving cell, and CSI reporting is transmitted to the serving cell. This is similar to L3 RRM measurement reporting, where L3 RRM measurement is configured as part of cell group configuration, outside serving cell configuration. If we follow L3 RRM approach, “outside” approach is more suitable.  For now it is not clear what are required functionalities for CSI measurement reporting for LTM and where to best place the CSI measurement and reporting configuration. RAN2 should have thorough discussion on this based on contribution at next meeting. |

**Summary:**.

**Proposal.**

In L3 measurements, the configuration is always done by RRC and can only be disabled by RRC signaling. There were several papers which proposed to use L1/L2 signaling to “control” L1 measurement configuration, e.g. (de)-activation of a configuration. One motivation for this could be for the source to dynamically activate L1 meaurements for only certain candidate cells in order to prevent excessive measurement and reporting.

We can first check if there is any interest in using L1/L2 signaling for this purpose and can then decide later on what parts of the configuration can be changed. It is also possible that this decision is made by RAN1.

**Question B3: Do you support using L1/L2 signaling to control or change L1 measurement/reporting configuration? If yes, should this be left to RAN1 to decide?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | No | We understand that UE may not be able to perform L1 measurements for many candidate cells due to e.g., hardware limitation. However, it would be simpler to limit the number of candidates, e.g., only two or three nearby cells. Candidates can be added or removed based on L3 measurments. |
| NEC | See comments | From RAN2 perspective, RRC control is preferable, while if RAN1 see enough motivation, they can bring it up. We are fine to leave it to RAN1 |
| ZTE | Yes | We support using L1/L2 signalling (e.g. MAC CE) to dynamically activate/select a subset of candidate cells or beams to be measured/reported, to prevent excessive and unnecessary measurement and reporting, e.g. for subsequent LTM.  If there are most RAN2 companies interested in this, perhaps RAN2 can confirm the feasibility and benefit. But the final decision can be left to RAN1. |
| Panasonic | Yes | One motivation to introduce activation/deactivation of candidate cells comes from the limitation on the number of beams that UE is able to simultaneously measure. Although such capability discussion has not started yet for Rel-18 UE supporting LTM, we can obtain some insights from the existing Rel-15/16/17 UE beam measurement capability.  For Rel-15/16, beam management can only be done within serving cells. The basic UE is mandatorily required to be able to measure 8 number of SSB/CSI-RS (one-port) per slot across all serving cells in total. (see 38.306 for the parameter *maxNumberSSB-CSI-RS-ResourceOneTx,* andalsoNR UE FG 2-24). Advanced UE can report other values such as 16,32,64. (see NR UE FG 2-24). On the other hand, inter-cell beam management (ICBM) has been introduced in Rel-17. For Rel-17 UE supporting ICBM (optional feature by itself), the maximum number of SSB resources configured to measure L1-RSRP within a slot with PCI(s) same as or different from serving cell PCI across all CC can be {1,2,4,8}. (see NR UE FG 23-1-2).  For Rel-18 UE supporting LTM, capability of Rel-17 ICBM can be a starting point. It can be debated whether the minimum requirement is 1 SSB measurement per slot for both serving cell and candidate cell, or 1 SSB for serving cell and 1 for candidate cell (i.e. minimum is 2). Some companies have been proposing that the L1 measurement report for LTM always includes one measurement from serving cell. If this is the case, minimum 2 (or larger) SSB measurement per slot needs to be supported. Higher capability can be further discussed, but it is not expected a dramatic increase in the capability for Rel-18 UE supporting LTM from the UE complexity and power consumption point of view. Note that measurement can be dominant part of the power consumption when longer DRX periodicity is configured.  Regarding the number of configured LTM candidate cells by RRC, it is reasonable to have more than one to avoid frequent RRC reconfiguration. If the number of candidate cells is 4, or 8, it seems already reasonable to introduce activation/deactivation of candidate cell to reduce the UE burden, seeing the UE capability of ICBM.  For the signaling aspect, MAC CE is preferred because of shorter latency than RRC and being less costly than DCI. |
| CATT | Yes | Performing measurement on all pre-configured candidate cells even it is far away from the UE, is not necessary and will lead to high complexity of UE. And although one may agure that the number of the candidate cell may be quite limited, e.g., 2 or 3, but since SSB is periodic, for aperidic reporting, some kinds of UE may always measure these signals to prepare the report quantities before being triggerred.  So we think there is clear benefit, e.g., power saving, UE requirement, to support such dynamic controlled measurement. |
| Futurewei | No | So far we don’t see the need to involve L1/L2 signaling to change measurement configuration. RRC delta configuration should be good enough to serve the purpose for configuration changes. Unless there is really delay sensitive need to involve L1/L2 signaling. Then it should be decided by RAN1. |
| Lenovo | No | Configuration is RRC domain and should remain so. |
| OPPO | No | It is RAN1 scope to determine whether to introduce such meachanism for optmization.  Considering we will limit the number of candidate cells for LTM as in R16 CHO, the measurement overhead can be reduced by avoiding configure too many candidate cells. |
| Xiaomi | No | The RRC Configuration is enough for the control of L1 measurement configuration. |
| vivo | Yes | Using L1/L2 signaling to dynamically activate/deactivate the L1 measurement/reporting configuration provided by RRC is more flexible and faster than using RRC reconfiguration. Anyway, this can be left to RAN1 to decide since RAN1 is also discussing this issue. |
| Apple | Yes | As a means for the UE to be “configured” with meas that is relevant to where the UE is located. |
| Intel |  | If the configuration is in RRC, the modification should also be in RRC. |
| Transsion | Yes | According to RAN1#110b-e agreements, RAN1 tooks using MAC CE report L1 mereaurements into consideration. At the same time, the current R17 measurement report can report only 4 RSRP results uging delta values, in R18 mesusmre report may need to contain more information than R17 which cannot be carried using L1-RSRP report, RAN2 can introduce MAC CE for L1 measurement report. Respectively, RAN2 can introduce MAC CE to implement L1 measreuemt controls simultaneously.  **RAN1#110b-e**  Agreement   * For L1 measurement report for Rel-18 L1/L2 mobility, further study the following mechanisms:   + Report as UCI on PUCCH or PUSCH     - ...   + Report on MAC CE     - Both gNB scheduled and/or UE initiated (if supported) report are studied |
| CMCC | No | L1 measurement/reporting configuration is provided in RRC. For the activation part, RAN1 could trigger the discussion if they find it is needed. |
| Samsung | No | The RRC Configuration is enough for the control of L1 measurement configuration. If RAN1 agreed to introduce this we can re discuss how to support it. |
| Huawei, HiSilicon | Can reuse semi-persistent reporting mechanism | Mechanisms already exist to start/stop reporting, we can reuse them |
| NTT DOCOMO |  | I think there are certainly advantages to a mechanism to dynamically change the measurement target, as ZTE and CATT have mentioned. We can discuss such a solution, but we may need to convey to RAN1 the motivation for such a discussion. |
| Ericsson | Maybe | We are open to discuss that possibility, especially if that enables a better scheme for sub-sequent LTM. It may be easier for the UE to get a simple RRC configuration for LTM measConfig once, and, receive MAC CE(s) to activae/ deactivate measurements as the UE moves across cells in sub-sequent LTM.  However, we would not accept any agreement on that at the moment. It is really premature. We should simply keep that in mind as a possibility to resolve the issues related to the sub-sequent LTM raised above. |
| InterDigital | Yes | Limiting the number of configured candidates and relying on L3 may not be sufficient. |
| Nokia, Nokia Shanghai Bell | Yes to the first  No to the second | Serving DU should be able to activate/deactivate a reporting configuration to give more flexibility in the reporting. We think that this is fully in the scope of RAN2. |
| Fujitsu | Yes | Relatively dynamic control of the L1 measurement is preferred. |
| Sharp | Yes | This approach can be flexible and the decision can be made by RAN1. |
| LGE | No | At this moment, we think RRC signaling is sufficient for control or change L1 measurement/reporting configuration. |

**Summary:**.

**Proposal.**

## Other

In [9], it is proposed that filtering, Hysteresis and time-to-trigger are configured for L1 measurements. This is similar to what is configured by legacy *QuantityConfig* which controls L3 filtering but where the L1 filtering is left to the UE implementation. RAN2/RAN1 need to make a decision whether to introduce new L1 filtering or keep it as in legacy.

**Question C1: Should a new configuration be introduced for filtering, hysteresis, and time-to-trigger for L1 measurements? If not, it is assumed that this will be left to the UE implementation as in legacy NR.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | No | This is a RAN1 topic, and our understanding is that RAN1 has de-prioritized this. |
| NEC | Yes | This can be handled by UE implementation. |
| ZTE | No | Agree with MediaTek. |
| CATT |  | I think the intention of the filtering, Hysteresis or time-to-trigger is to address the ping-pong related issue, since the L1 measurement is indeed not stable enough like L3 measurement. And I also agree this is indeed RAN1 related issue on how to enhance the L1 measurement. But as I know, the reason why RAN1 de-prioritized the discussion is that they are waiting for RAN2’s confirmation that the ping-pong issue is indeed need to be addressed, i.e., RAN1 think handover performance, i.e., ping-pong, are RAN2 apsect, they can begin the work until RAN2 confirm this is indeed a issue.  So, I am thinking how about RAN2 to discuss whether the ping-pong issue is valid for LTM, and then we can ask RAN1 to continue on the discussion? |
| Futurewei | No | Agree with MTK. We should leave it to RAN1. |
| Lenovo | Not until RAN1 says to do so |  |
| OPPO | Yes | We think introducing filtering, Hysteresis or time-to-trigger has benefits to improve robustness of L1 measurement results, which can avoid ping-pong issue for LTM.  And L1 measurement is RAN1 scope, we can leave it to RAN1 decision. |
| Xiaomi | No | Agree with MTK. |
| vivo | No | In our view, L1 filtering can be done in the network after receiving the L1 measurement results from UE. There is no need to introduce any new configuration for filtering, hysteresis, and time-to-trigger in the UE for L1 measurements. |
| Apple | Upto RAN1 |  |
| Intel |  | In general, L1 measurement is up to UE implementation or decide by RAN1. |
| Transsion | Yes | The introduction of filtering, Hysteresis or time-to-trigger is to address the ping-pong related issue.  Agree with CATT that RAN2 can first confirm the ping-pong issue is need to be addressed as the ping-pong are RAN2 aspect and maybe also give some suggestion for this issue. |
| CMCC | Up to RAN1 |  |
| Samsung | Upto RAN1 | We think introducing filtering is benefitial but it should be determined by RAN1. |
| Huawei, HiSilicon | No |  |
| NTT DOCOMO | Up to RAN1 |  |
| Ercisson | No |  |
| InterDigital | Up to RAN1 | L1 measurements are not in the scope of RAN2. |
| Nokia, Nokia Shanghai Bell | Yes (see comments) | As shown in our evaluations in [R2-2208212] introduction of L1 filtering can reduce the number of ping pongs without impacting negatively the LTM performance. Thus we think that some kind of filtering should be introduced in the L1 measurements. Introduction of hysteresis and TTT on the DU-side could also be beneficial but this should be FFS. RAN4 should be informed of the matter. |
| Fujitsu | No | Agree with MTK |
| Sharp | No | Agree with MTK. |
| LGE | Up to RAN1 | Agree with MTK. |

**Summary:**.

**Proposal.**

In [1], handling of deactivated SCells is discussed. In current NR, the UE performs measurements on deactivated SCells differently than activated SCells. However, if a deactivated SCell is an LTM candidate cell, it is expected that the UE should perform measurements to assess its potential as a mobility target, similar to other candidate cells. RAN2 should discuss which option should apply in this case.

**Question C2: If a deactivated SCell is an LTM candidate cell, should the UE perform L1 measurements like other LTM candidate cells?**

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| --- | --- | --- |
| **Company** | **Response** | **Comments** |
| MediaTek | Yes |  |
| NEC | No | We think LTM candidate cell should be a cell that the UE can access without any further activation signalling. If deactivated SCell can be candidate, it should be treated same as other candidate cells, which means it does not matter whether it is deactivated SCell or non serving cell |
| ZTE | See comments | If a deactivated SCell is taken as an LTM candidate cell, the NW should explicitly configure it as a candidate cell, including L1 measurement configuration. The UE just needs to perform L1 measurements on candidate cells, based on the NW configuration. |
| CATT |  | It depends on whether the deactivated SCell is configured as candidate (target) SPCell. For both activated SCell, or deactivated SCell, if it not configured as candidate (target) SPCell, there is no need to perform the L1 measurement in this Cell for cell switch descision. |
| Futurewei | Yes | L1 Measurement is still needed for triggering the activation. RACH is not needed but instead UE can transmit SRS directly to the target Scell. |
| Lenovo | No | Agree with NEC |
| OPPO | Yes |  |
| Xiaomi | See comments | If the deactivation SCell is configured as an LTM candidate cell, Network can configure the candidate cell in the LTM candidate configuration, UE should perform L1 measurements based on the LTM candidate configuration. If the deactivation SCell is not included in the LTM candidate configuration, UE should not perform L1 measurements for the Cell. |
| vivo | Yes | If a deactivated SCell is a candidate cell, it’s natural for the UE to perform L1 measurements like other LTM candidate cells. However, there is no active BWP for the deactivated SCell. RAN4 is still discussing this issue and we think RAN2 can further discuss this after RAN4 makes the corresponding decision. |
| Apple | Pls see comments | CA swap as LTM has many optimizations. Maybe we can discuss this after the basic framework is done. |
| Intel |  | Yes, unless network remove from measurement config. |
| Transsion | No |  |
| CMCC | Yes |  |
| Samsung | Yes |  |
| Huawei, HiSilicon | Question is unclear |  |
| Ericsson | Too early for this | We don’t even have the basic principles in place and we are already trying to optimizing procedures. We should discuss this once that the basis on this topic have been settled. |
| InterDigital | Yes? | If the UE has been configured to do so, then it should. |
| Nokia, Nokia Shanghai Bell | Yes (see comments) | A (deactivated) SCell can be an LTM candidate cell if configured. Thus, it should be treated the same as other LTM candidate cells regardless of whether it is a (deactivated) SCell. |
| Fujitsu | Yes |  |
| Sharp | Yes | If the deactivated SCell is an LTM candidate cell, UE should consider this SCell as neighbour cell, not serving cell. |
| LGE | Comments | Even if a serving SCell is set as a candidate cell, the LTM measurement configuration will not be different from other candidate cells (i.e., currently a non serving cell). That is, the UE may receive the separate L1 measurement configurations for a cell, where one is for being an LTM candidate cell and another is for being a serving cell. |

**Summary:**.

**Proposal.**

# Conclusion

Based on the discussion and the feedback from companies above, the following are proposed for L1 measurements for LTM:

# References

[1] R2-2302831 RRC Aspects of LTM Qualcomm Inc.

[2] R2-2304103 L1 measurements aspects for LTM Ericsson

[3] R2-2302552 Discussion on RRC aspects for LTM CATT

[4] R2-2302754 Considerations on L1 measurement configuration for LTM Panasonic discussion

[5] R2-2302484 L1 Measurement for Cell Switch NEC

[6] R2-2303533 Considerations on measurment related issues CMCC

[7] R2-2303534 [Draft] LS on measurement related issues for L1L2-based inter-cell mobility CMCC

[8] R2-2303710 LTM Measurement considerations Interdigital, Inc.

[9] R2-2303474 Discussion on measurement enhancement of L1L2 triggered mobility Transsion Holdings

[10] R2-2302053 LS on L1 measurement RS configuration and PDCCH ordered RACH for LTM