**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

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|  |  |
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# 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)

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 |  |

**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?**

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| --- | --- | --- |
| **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 |  |

**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*?**

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| --- | --- | --- |
| **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. |

**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. |

**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?**

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| --- | --- | --- |
| **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. |

**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.**

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| --- | --- | --- |
| **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. |

**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. |

**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