3GPP TSG RAN WG2 Meeting #127 R2-2406476

Maastricht, The Netherlands, 19-23 August 2024

**Agenda item:** 7.4.2

**Source:** Intel Corporation (Rapporteur)

**Title:** Report of [Post126][514][R18MobE] UE capabilities Open Issues (Intel)

**Document for:** Report

# 1 Introduction

This email discussion is to try to reach conclusion on the remaining UE capabilities for Mobility enhancements.

* [Post126][514][R18MobE] UE capabilities Open Issues (intel)

Scope: progress open issues

Intended outcome: Report, TP/draftCRs if applicable

Deadline: Long

The meeting minutes provides more details of this email discussion:

* Long email discussion on the FFS and possibly other points (can take into account late LSes from other groups).

RAN2 had sent an LS R2-2400385 [1] to RAN1 and RAN4 asking the following questions:

**Question 1 :** Are the above intra-frequency and inter-frequency L1 measurement and reporting features (45-1 and 45-1a) prerequisites to support intra-frequency and inter-frequency LTM, respectively?

**Question 2:** The above features, 45-1 and 45-1a, from RAN1 and related RAN4 features (39-1, 39-2, 39-3-1, 39-3-2, 39-3-3, 39-3-4, 39-3-5, 39-3-6) are defined per BC for both intra-frequency and inter-frequency measurements. RAN2 would like check with RAN1/4 for which BC (e.g. BC of current serving cells, BC including current serving cells and cell to be measured or something else) these capabilities are to be considered for L1 intra-frequency and inter-frequency LTM measurements?

While RAN2 was waiting for the LS response, RAN2 made the following agreements in R2-126:

* The LTM L1 measurement capability and LTM capabilities are decoupled
* As the LTM L1 measurement capability and LTM capabilities are decoupled:

1. A UE which reports LTM capability without 45-1 may not perform L1 measurement reporting, and it is up to network implementation how to trigger the LTM execution.

2. The granularity is FFS, e.g. whether LTM capability is divided into two separate capabilities for inter-frequency and intra-frequency.

RAN1 did not send an LS response but made some conclusions from the discussions. RAN4 sent RAN2 an LS response in R4-2410303 [2] (not yet handled by RAN2). As RAN1 and RAN4 were only able to reach partial agreement on the questions in the LS, this email discussion is to get company views in RAN2 and attempt to see if agreements can be made on these. Sections 2.1 and 2.2 cover these LTM L1 questions in the LS.

The granularity for RAN2 LTM capabilities that were dependent on L1 measurement capabilities were removed from the specs last meeting and needs to be re-discussed based on the new understanding of the LTM L1 measurements questions above. This is discussed in section 2.3.

# 2 Discussion

## 2.1 Dependency of LTM cell switch on LTM L1 measurements

The first question to RAN1/4 was:

**Question 1 :** Are the above intra-frequency and inter-frequency L1 measurement and reporting features (45-1 and 45-1a) prerequisites to support intra-frequency and inter-frequency LTM, respectively?

RAN1’s conclusion was:

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| **Conclusion:** There is no consensus in RAN1 in regards to Question 1. At this point, RAN1 will not revisit question 1 and leaves final determination to other RAN WGs. |

RAN4’s response was:

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| **Reply to the Question 1:**  For whether intra-frequency and inter-frequency L1 measurements and reporting are prerequisites to support intra-frequency and inter-frequency LTM, RAN4 analysed RAN4 requirements and achieved following agreements   * For FR1, RAN4 Rel-18 related LTM requirements are applicable to the case without L1 measurement and reporting of LTM candidate cells. * For FR2, RAN4 Rel-18 related LTM requirements are not applicable if L1 measurements for LTM candidate cells are not supported by the UE, or not configured by the network. |

RAN1 was not able to reach an agreement and has left it to other groups and RAN4 has a response that LTM measurements are a prerequisite for FR2 but not for FR1.

While RAN2 had a tentative agreement while waiting for the RAN1/4 response that L1 measurements are not a prerequisite for LTM cell switch, rapporteur believes that RAN4 response will overrule that.

**Question 1: Do companies agree to go with the RAN4 response that LTM L1 measurements are a prerequisite for FR2 but not for FR1.**

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| --- | --- | --- |
| Company | Yes/No | Justification if “no” |
| MediaTek | No | There is no need to revert the last meeting agreement:   * The LTM L1 measurement capability and LTM capabilities are decoupled   Decoupling FR1 while keeping FR2 coupled complicates LTM UE capabilities design to differ inter/intra frequency LTM in FR1/FR2, as well as other R1/R4 capabilities.  On the other hand, there is no RAN4 requirement on decoupling L1 measurements and LTM on FR2. Therefore, keep it decoupled in signalling in FR2 will not conflict with RAN4 LS and will make it more concise. |
| ZTE | No | We also prefer to stick to RAN2’s agreement.  After checking, we understand the concern (from company who supports coupling) is that, without L1-RSRP measurement, the LTM switching delay in FR2 will be slightly larger, so the benefit of LTM will not be significant. In the latest RAN4 spec, for TCI state activation requirement for LTM candidate cells, only “known TCI state” case is supported in FR2, while the determination of “known TCI state” is associated with L1-RSRP measurements.  However, we also notice that many companies in RAN4 see the need/feasibility to not mandate L1-RSRP for FR2 LTM.  From network perspective, we think the network should be allowed to trigger FR2 LTM based on L3 measurements, even if the LTM switching delay might be slightly larger than L1-RSRP based case, the support of subsequent LTM is still promising compared with legacy L3 HO. |
| Huawei, HiSilicon | Yes | However, the signalling for FR2 can be exactly the same like the signalling for FR1. It should only be captured that:  - in 38.306: the UE that indicates supports for LTM for some FR2 BC/source/target band (granularity to be defined) shall indicate support for some L1 neighbour cell intra- or inter-frequency measurements applicable for some or all (choice to be made) target cells of that FR2 BC/source/target band  - in 38.331, the network does not configure FR2 target cells without L1 measurements of them |
| Samsung | Yes | If we recall how RAN2 conclusion was made, it would be based on the comment that decoupling was concluded in RAN4. Therefore, it would be natural to follow RAN4 agreement. |
| Nokia | Yes | Similar view as Samsung and Huawei |
| Apple | Yes | In that we should capture in RAN2 spec that “in 38.331, the network does not configure FR2 target cells without L1 measurements of them” |
| Ericsson | No | Agree with MediaTek and ZTE. We see no point in having something different for FR1 and FR2. Better to have a uniform design. |

Summary:

Company views are equally split between RAN2 decision to keep LTM independent of L1 measurements for both FR-1 and FR2 and RAN4 decision to make it dependent for FR2. Based on the comments provided, rapporteur suggests the following compromise:

Proposal #1: No dependency between LTM and L1 measurements is captured in RAN2 specs (306, 331, 300). Any such dependency can be based on RAN4 defined performance requirements. Inform RAN1/4 of RAN2 decisions.

## 2.2 Granularity of the L1 measurement capability

On granularity of the L1 measurement capability, the question from RAN2 to RAN1/4 in [1] was:

**Question 2:** The above features, 45-1 and 45-1a, from RAN1 and related RAN4 features (39-1, 39-2, 39-3-1, 39-3-2, 39-3-3, 39-3-4, 39-3-5, 39-3-6) are defined per BC for both intra-frequency and inter-frequency measurements. RAN2 would like check with RAN1/4 for which BC (e.g. BC of current serving cells, BC including current serving cells and cell to be measured or something else) these capabilities are to be considered for L1 intra-frequency and inter-frequency LTM measurements?

RAN1 had the following conclusion:

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| **Conclusion:** There is no consensus in RAN1 in regards to Question 2 at this point. It is RAN1’s understanding that RAN2 can implement this FG as is, and RAN1 will continue discussion at RAN1 #118. |

RAN4 provided the following response:

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| **Reply to the Question 2:**  RAN4 discussed the following options. Option 1 is supported by majority companies in RAN4, but RAN4 cannot reach consensus on option 1. Meanwhile, RAN4 discussed the compromised option in Option 3, and the feasibility and details are up to RAN2.   * Option 1: The BC granularity is BC of serving cells. * Option 2: The BC granularity is BC including serving cells and candidate cells to be measured. * Option 3: The UE capability is based on option 1 and introduce additional UE capability to accommodate option 2.   From RAN4 perspective, the UE capabilities can be implemented into the specification based on RAN2 conclusion. |

On this, neither RAN1 nor RAN4 was able to reach an agreement. RAN4 provided 3 options and seems to have left it to RAN2. RAN1 may discuss it further.

As the majority in RAN4 preferred option 1 (The BC granularity is BC of serving cells), we can try to see that would be acceptable for companies in RAN2. Option 3 is not clear to the rapporteur.

**Q2: For L1 measurements, would it be acceptable for companies to go with RAN4 “Option 1: The BC granularity is BC of serving cells”?**

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| --- | --- | --- |
| Company | Yes/No | If “No”, please indicate which option would be acceptable to you and the justification. If option 3, please also provide details of option 3. |
| MediaTek | Yes | It is not clear how to design option 3. It may decrease the readability of this feature due to the distinct meanings of option1 and 2. |
| ZTE | Yes | For Option2/3, our concern is that the UE will report many “BC” that not applicable for CA/DC and further increasing the signalling overhead. |
| Huawei, HiSilicon | No | Such design would imply that the UE that indicates support of L1 inter-frequency measurements, while having serving cells in a BC, can do L1 inter-frequency measurements of cells in any band.  This means that there is no way to leverage UE CA capabilities for L1 inter-frequency measurements e.g., if the UE supports BC1 = (band X, band Y, band Z), when the UE has serving cells only in band X and band Y, the UE can efficiently measure cells in band Y, but with this signalling, the UE cannot signal that it can only do L1 inter-frequency measurements in bands X, Y and Z but not in other supported bands.  We prefer option 2, but as a compromise, the UE that indicates support for L1 inter-frequency measurements (RAN1 45-1a) in a 4  If the UE says "in any supported band," this is like option 1. If the UE says "only in bands of that BC", the network can only configure L1 measurements for candidate cell in a band of that BC, and the network can check the UE capability for L1 inter-frequency measurement in all BCs that are a superset of the serving BC.  So this leaves the flexibility to the UE to select option 1 or option 2 and let the network know. |
| Samsung | Yes for intra, FFS for inter | At least for intra-frequency, option 1 seems sufficient given that a similar UE capability for Inter-BM (unifiedJointTCI-mTRP-InterCell-BM-r17) is per band (even more coarse granularity).  For inter-frequency case, further information might be needed but without further information from RAN1/RAN4, it would be difficult to come up with additional signalling in RAN2 We prefer to wait for RAN1 input. |
| Nokia | See comments | Our understanding of the RAN4 discussion is that the main problem some companies have is whether the “per BC of the serving cell” means that the inter-frequency L1 measurements with gap can be configured and/or performed on any of the supported BC (option 2), or whether the BC needs to be in the same band combination of the serving cell (option 1). The option 1 means that the UE cannot perform inter-frequency measurements with gap if the BC is not part of the serving cell band combination.  We don’t see a reason to limit the network configuration in inter-frequency with gap scenario, hence the UE should be able to measure the inter-frequency carrier regardless of the BC of the serving cell.  As we already have existing definition of inter-frequency measurement, and option 1 would add additional limitations to it, we think that option 2 is the one to support. |
| Apple | Yes | Op1 is the simplest and safest for us, while Op2/3 brings more questions and more signaling overhead. |
| Ericsson | Yes |  |

Summary:

Most companies were OK with option 1, BC granularity is per BC of the serving cells. However, a couple of companies raised concerns that this option does not allow UE to implement inter frequency L1 measurement only in bands of that BC. One company suggested to wait for further RAN1 input. Given the significant majority support for option 1, rapporteur proposes:

Proposal #2: BC of the Intra and Inter-frequency measurements is “Option 1: The BC granularity is BC of serving cells”.

As concerns were raised with this option, rapporteur also proposes:

Proposal #3: Discuss whether to introduce another capability bit which indicates that UE supports inter-frequency L1 measurements only in bands of that BC.

## 2.3 Granularity of RAN2 LTM capability

At least for FR1, there is no dependency on L1 measurements according to RAN4 and hence RAN2 need to decide on the granularity of the RAN2 LTM MCG/SCG capabilities. Some possible options are listed below.

Option 1) split LTM capabilities (for MCG and SCG) into per UE intra and inter-frequency capabilities each as suggested in [3]

Option 2) Define LTM capabilities (for MCG and SCG) per band and UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands, all TDD-FR2-1 bands and all TDD-FR2-2 bands (as done for many other HO capabilities)

Option 3) Define LTM capabilities (for MCG and SCG) per serving cell BC.

Option 4) Option 2 or 3 plus option 1 (e.g., have an additional intra and inter-frequency capability bit that will be applicable intra-FR1, FR2 etc. )

Option 5) Option 2 plus additional per UE capabilities to indicate the support of inter-freq, FDD-TDD, FR1-FR2 scenarios.

**Q3: Please provide your preference for LTM capabilities (for MCG and SCG) – which of the above options or any other new option.**

|  |  |  |
| --- | --- | --- |
| Company | Option # or new option | Comments/justification |
| MediaTek | Option2+4 | The current per FR capabilities are implemented per band, so legacy design (option2) can be reused. Meanwhile, the inter/intra-frequency support can be implemented by one additional bit to indicate the support of inter-frequency LTM. |
| ZTE | Option 5 | We have added Option 5).  Option 2) is the basis, but purely Option 2 capability value only indicate the support of intra-freq LTM.  For inter-freq, we can introduce below additional per UE capabilities:   * *ltmInterF*: If reported, the UE supports inter-freq LTM on the bands where the UE indicates the support of Option 2 capability.   If we want to further differentiate FDD-TDD, FR1-FR2 cases, can further introduce below per UE capabilities:   * *ltmFDD-TDD* * *ltmFR1-FR2*   If *ltmFDD-TDD*, *ltmFR1-FR2* are introduced, then *ltmInterF* only indicates the support of inter-freq LTM on the bands of the same xDD/FRx. |
| Huawei | Option 3+4 | As L1 inter-frequency measurement of candidates is per BC, it seems clearer to have the capabilities per BC as well (option 3). |
| Samsung | Option 2 + 4 | It seems reasonable. |
| Nokia | Option 2 + 4 | Similar view as MTK. We also think that the legacy design can be re-used, while having an additional bit to indicate the support for inter-frequency LTM. |
| Apple | Op2 + 4 seems resonable |  |
| Ericsson | Option 2 + 4 |  |

Summary:

Majority of the companies support a combination of option 2 and 4. One company preferred option 3+4 and another company proposed option 5. Given the majority, rapporteur proposes:

Proposal #4: Chose option 2+4 for LTM MCG and SCG capabilities. That is, define capabilities per band consistent across all TDD-FR1 bands, all TDD-FR2-1 bands and all TDD-FR2-2 bands. And introduce another capability bit (per UE) to indicate inter-frequency LTM (UE indicating this capability shall also support intra-freq, (MCG or SCG) LTM i.e, the default indicated by the per band bits).

# 3 Any other comments/new capabilities

**Q4: Please use the table below to provide any other comments not covered by the above questions related to L1 measurements or associated RAN2 capabilities. E.g., any new split for other capabilities/new capabilities etc.**

|  |  |
| --- | --- |
| Company | Comments/justification |
| MediaTek | If LTM capabilities has intra/inter differentiation (i.e., Option4 in Q3), RAN2 may need to further discuss if related early DL and UL R1 capabilities need to be updated with intra/inter diff. E.g., 45-3a/4a, 45-5/5a/6.  If LTM capability does not support inter-frequency, it should be meaningless to support inter-f capabilities in DL/UL sync stage. RAN2 can confirm this with RAN1. |
| Huawei, HiSilicon | We are ok to ask RAN1 about the need to differentiate inter/intra for 45-3a/4a, 45-5/5a/6.  We are not sure about the meaning of "If LTM capability does not support inter-frequency, it should be meaningless to support inter-f capabilities in DL/UL sync stage." |
| Samsung | We tend to agree with MediaTek’s comment. It is good to clarify with RAN1.  In addition, it would be good to clarify pre-requisite relationship.  According to the original description on ltm-MCG-r18, ltm-BeamIndicationJointTCI-r18 (45-3) and ltm-BeamIndicationSeparateTCI-r18 (45-4).  For example, if we have per band ltm-MCG-r18 but indicate consistently for all FDD-FR1 bands, does it mean that UE supports 45-3 and 45-4 for all FDD-FR1 bands or could we still assume that final capability is based on the support of ltm-MCG-r18 and the support of 45-3/4 for each band? |
| Nokia | Agree with the comment by MTK. In addition to that, we think it would be beneficial to clarify how the UE-based TA capabilities would be split between MCG and SCG. |
| Ericsson | Agree with the first part of MTK comment. |

Summary:

Some companies suggested further clarifications from RAN1 on whether RAN1 capabilities 45-3a/4a, 45-5/5a/6 can also be different intra and inter-frequency. Some companies also suggested to get further clarifications on other issues from RAN1.

Proposal #5: Send LS to RAN1 to get clarification on whether RAN1 capabilities 45-3a/4a, 45-5/5a/6 can also be different intra and inter-frequency.

Proposal #6: Discuss if there is support to request clarifications from RAN1 on the other issues raised.

# 4 Summary and proposals

Based on the company comments, rapporteur suggests the following proposals:

Proposal #1: No dependency between LTM and L1 measurements is captured in RAN2 specs (306, 331, 300). Any such dependency can be based on RAN4 defined performance requirements. Inform RAN1/4 of RAN2 decisions.

Proposal #2: BC of the Intra and Inter-frequency measurements is “Option 1: The BC granularity is BC of serving cells”.

Proposal #3: Discuss whether to introduce another capability bit which indicates that UE supports inter-frequency L1 measurements only in bands of that BC.

Proposal #4: Chose option 2+4 for LTM MCG and SCG capabilities. That is, define capabilities per band consistent across all TDD-FR1 bands, all TDD-FR2-1 bands and all TDD-FR2-2 bands. And introduce another capability bit (per UE) to indicate inter-frequency LTM (UE indicating this capability shall also support intra-freq, (MCG or SCG) LTM i.e, the default indicated by the per band bits).

Proposal #5: Send LS to RAN1 to get clarification on whether RAN1 capabilities 45-3a/4a, 45-5/5a/6 can also be different intra and inter-frequency.

Proposal #6: Discuss if there is support to request clarifications from RAN1 on the other issues raised.

# 5 References

[1] R2-2400385 LS on LTM L1 intra and inter-frequency measurements

[2] R4-2410303 Reply LS on LTM L1 intra and inter-frequency measurements

[3] R2-2404299 LTM UE capabilities *MediaTek inc.*