**3GPP TSG RAN WG1 Meeting #110bis-e R1-22xxxxx**

**e-Meeting, October 10th – 19th, 2022**

**Source: Moderator (Fujitsu)**

**Title: FL summary 1 on L1 enhancements for inter-cell beam management**

**Agenda Item: 9.12.1**

**Document for: Information**

# Introduction

In this contribution, we share our view on the work area of L1 enhancements for inter-cell beam management, which includes L1 measurement and reporting, beam indication, and dynamic switch mechanism among candidate serving cells (including SpCell and SCell) [1].

# Plan for discussion

[110bis-e-R18-Mobility-01] Email discussion on L1 enhancements for inter-cell beam management by October 19 – TBD (TBD)

* To be kicked off after first GTW session
* Check points: October 14, October 19



1st deadline: October 11, 23:59am UTC 🡪 Updated FL proposals will be provided

Intermediate deadline: October 12, 10:59am UTC 🡪 Selected proposals will be discussed in the Wed GTW session

* GTW topic will be chosen from section 5.1.X and 5.2.X considering the maturity of the discussion
  + High priority for proposals 1-1, 1-4, 1-5, 2-1
  + Other proposal will be treated on a best effort basis.

2nd deadline: October 13, 23:59am UTC 🡪 Updated FL proposal will be provided for the 1st checkpoint (October 14th)

FFS after the 1st checkpoint

# Contact Person

Please input the contact information for each company below:

|  |  |  |
| --- | --- | --- |
| Company | Name | Email |
| Google | Yushu Zhang | yushuzhang@google.com |
| Qualcomm | Yan Zhou | yanzhou@qti.qualcomm.com |
| Apple | Hong He | hhe5@apple.com |
| NTT DOCOMO | Jing Wang | wangj@docomolabs-beijing.com.cn |
| Lenovo | Bingchao Liu | liubc2@lenovo |
| NEC | Zhen He | he\_zhen@nec.cn |
| ZTE | Ling Yang | yang.ling17@zte.com.cn |
| Huawei, HiSilicon | Jiayin Zhang | zhangjiayin@huawei.com |
| CMCC | Jun Zuo | zuojun@chinamobile.com |
| CATT | Da Wang | wangda@catt.cn |

# List of Contributions

|  |  |  |
| --- | --- | --- |
| [**R1-2208406**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208406.zip) | L1 enhancements for inter-cell beam management | Huawei, HiSilicon |
| [**R1-2208500**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208500.zip) | Discussion on L1 enhancements for L1/L2-based inter-cell mobility | Nokia, Nokia Shanghai Bell |
| [**R1-2208509**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208509.zip) | L1 enhancements for inter-cell beam management | ZTE |
| [**R1-2208570**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208570.zip) | Discussion on L1 enhancements for inter-cell beam management | Spreadtrum Communications |
| [**R1-2208664**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208664.zip) | Discussion on L1 enhancements for L1/L2 mobility | vivo |
| [**R1-2208679**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208679.zip) | L1 enhancements to inter-cell beam management | Ericsson |
| [**R1-2208747**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208747.zip) | L1 enhancements for inter-cell beam management | Lenovo |
| [**R1-2208805**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208805.zip) | Discussions on Inter-cell beam management enhancement | OPPO |
| [**R1-2208884**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208884.zip) | On Intercell beam management enhancement for NR mobility enhancement | Google |
| [**R1-2208905**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208905.zip) | Enhancements on inter-cell beam management for mobility | LG Electronics |
| [**R1-2208958**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208958.zip) | On L1 enhancements for inter-cell beam management | CATT |
| [**R1-2209024**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209024.zip) | Views on L1 enhancements for inter-cell beam management | Fujitsu |
| [**R1-2209073**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209073.zip) | L1 Enhancements for Inter-cell Beam Management | Intel Corporation |
| [**R1-2209203**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209203.zip) | L1 enhancements for inter-cell beam management | InterDigital, Inc. |
| [**R1-2209268**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209268.zip) | Discussion on L1 enhancements and Dynamic switch mechanism | xiaomi |
| [**R1-2209359**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209359.zip) | Discussion on L1 enhancements for inter-cell beam management | CMCC |
| [**R1-2209428**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209428.zip) | Discussion on L1 enhancements for inter-cell beam management | NEC |
| [**R1-2209498**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209498.zip) | L1 enhancements for inter-cell beam management | MediaTek Inc. |
| [**R1-2209603**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209603.zip) | On L1 enhancements for inter-cell mobility | Apple |
| [**R1-2209754**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209754.zip) | On L1 enhancements for inter-cell beam management | Samsung |
| [**R1-2209923**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209923.zip) | Discussion on L1 enhancements for inter-cell mobility | NTT DOCOMO, INC. |
| [**R1-2210008**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210008.zip) | L1 Enhancements for Inter-Cell Beam Management | Qualcomm Incorporated |

# Discussion

## L1 measurement

### Intra-frequency L1 measurement

##### [Summary of contributions]

* Even though it is not always explicitly proposed by companies to support intra-frequency L1 measurement, it is deemed that many companies assumed that intra-frequency L1 measurement is supported for Rel-18 L1/L2 mobility.
  + Some companies clearly mentioned that Rel-17 L1 measurement (i.e. *CSI-SSB-ResourceSet*) is a starting point, which includes intra-frequency L1 measurement.
* Meanwhile, it is also mentioned that the mechanism of intra-frequency measurement is not necessarily follow Rel-17 ICBM mechanism because RAN2 has agreed that Rel-17 ICBM is not a prerequisite feature for L1/L2 mobility, i.e. commonality with inter-frequency measurement is important.
* Furthermore, potential issues below are raised to support Rel-18 L/L2 mobility scenarios, which require more discussion in RAN1. It is noted that this requires additional RAN4 work.
  + Restriction on Rel-17 L1 intra-frequency measurement is still valid or not, e.g.
    - The same SCS and *sfn-SSB-Offset* as the serving cell
    - The same center frequency as the SSB of the serving cell
    - Rx time difference, i.e. SSB from non-serving cell should be received within the CP of that for serving cell
      * This may require symbol level L1 measurement gap or SMTC for asynchronous cells
    - Measurement for overlapping SSBs

##### [FL observation]

Given the majority view, FL thinks that intra-frequency non-serving cell L1 measurement should be supported for Rel-18 L1/L2 mobility, and this can be agreed in this meeting. Meanwhile, further discussion is needed whether Rel-17 mechanism for ICBM can be reused, modification is necessary or new mechanism is more suitable to support Rel-18 scenarios. FL proposal would like to request interested companies to further study what is the best design for intra-frequency L1 measurement until the next RAN1 meeting taking into account the proposals from companies:

##### [FL proposal 1-1-v1]

* For Rel-18 L1/L2 mobility, intra-frequency non-serving cell L1 measurement is supported
  + At least the following aspects are for RAN1 further study:
    - Possibility to reuse of Rel-17 ICBM CSI measurement framework
    - Relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement, where RAN4 impact is foreseen, i.e.
      * SCS alignment with serving cell
      * Center frequency alignment and/or SFN offset compared with serving cell
      * BWP setting, i.e. non-serving cell SSB should be covered by serving cell active BWP
      * Introduction of symbol level gap or SMTC for larger Rx timing difference (i.e. larger than CP length)
    - Commonality with inter-frequency L1 measurement (if supported)
* *FL note: this issue is a high priority issue from FL point of view*

##### [Discussion on proposal 1-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-1-v1 | Response from FL |
| MediaTek | We support the direction of the proposal. However, we might need to first clarify the definition of “intra-frequency”. Whether we can reuse Rel-17 ICBM intra-frequency L1 measurement restriction or having some modification on top of it might need RAN2/RAN4 inputs to ensure that RAN1 discussion scenario is aligned with other working groups. Also, whether to have similar time domain restriction as specified for Rel-17 ICBM should also be discussed together with the proposal. Therefore, we suggest following update on the first sub-bullet  Possibility to reuse of Rel-17 ICBM CSI measurement framework and restriction  As for the second sub-bullet, it’s our understanding that the discussion should focus on how to relax Rel-17 ICBM restriction if reusing the same restriction and framework is not feasible. Therefore, we suggest the following update on the second sub-bullet   * + - Whether and how to apply ~~Rr~~elaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement, where RAN4 impact is foreseen, i.e.   We also would like to add a bullet about sending LS to RAN2/4 on intra-frequency requirement/restriction clarification.   * + Send LS to RAN2/4 regarding intra-frequency restriction |  |
| Google | Support in principle |  |
| OPPO | The revision suggested by MediaTek is good to us. It really need to first discuss whether relation is needed or possible. |  |
| QC | We have the following comments: 1) Good to change “non-serving cell” to “candidate cell”, since serving cell as candidate cell is under RAN2 discussion as in the RAN2 LS; 2) Add “for measurement configuration” to be consistent with the next proposal to be more specific.   * For Rel-18 L1/L2 mobility, intra-frequency ~~non-serving~~ candidate cell L1 measurement is supported   + At least the following aspects are for RAN1 further study:     - Possibility to reuse of Rel-17 ICBM CSI measurement framework     - Relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement, where RAN4 impact is foreseen, i.e.       * SCS alignment with serving cell       * Center frequency alignment and/or SFN offset compared with serving cell       * BWP setting, i.e. non-serving cell SSB should be covered by serving cell active BWP       * Introduction of symbol level gap or SMTC for larger Rx timing difference (i.e. larger than CP length)   Commonality with inter-frequency L1 measurement for measurement configuration (if supported) |  |
| Fujitsu | Support. From our understanding, the definition of intra-frequency will be addressed by the “relaxation” sub-sub-bullet. E.g., if relaxation for the restrictions on Rel-17 intra-frequency measurement is agreed, the definition of intra-frequency will be different from that of Rel-17 ICBM. Agree QC’s suggestion to add “for measurement configuration”. |  |
| Apple | Support.  Fine with Qualcomm modification to align the terms used in RAN2 LS. |  |
| DOCOMO | We support the revisions proposed by MTK and QC. |  |
| Lenovo | Fine with QC’s version |  |
| New H3C | Fine with QC’s modification |  |
| ZTE | We are generally fine with QC’s modification, but to further improve readability and align with other proposals’ wording, we have made the following minor updates:   * For Rel-18 L1/L2 mobility, L1 intra-frequency measurement for ~~non-serving~~ candidate cell ~~L1 measurement~~ is supported   + At least the following aspects are for RAN1 further study:     - Possibility to reuse of Rel-17 ICBM CSI measurement framework     - Relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement, where RAN4 impact is foreseen, i.e.       * SCS alignment with serving cell       * Center frequency alignment and/or SFN offset compared with serving cell       * BWP setting, i.e. non-serving cell SSB should be covered by serving cell active BWP       * Introduction of symbol level gap or SMTC for larger Rx timing difference (i.e. larger than CP length)     - Commonality with L1 inter-frequency ~~L1~~ measurement for measurement configuration (if supported) |  |
| Huawei, HiSilicon | We need to figure out the clear definition of “intra frequency” for L1 measurement. Theoretically, there is no definition in RAN4 spec on intra/inter frequency for L1 measurement. If compared with the definition of intra frequency in L3 measurement, the requirement for ICBM is a subset of intra frequency in L3.  We think at least the requirement for Rel-17 ICBM should be one of valid scenario for L1/L2 mobility as intra frequency. Thus, we suggest to add a note under main bullet as following:  Note: At least the requirements defined in 9.13.2 in TS38.133 for Rel-17 ICBM can be regarded as intra frequency for L1 measurement.  As for the bullet of “Possibility to reuse of Rel-17 ICBM CSI measurement framework”, does it imply that it might be a new CSI measurement framework for L1/2 mobility even for a UE support ICBM capability in the ICBM scenario?  We are open to further relax the applicable requirement in ICBM for L1 intra frequency measurement. However, some candidate looks like inter frequency as compared with L3 measurement, such as SCS, center frequency.  The last bullet is not quite clear to us. We expect there is no overlapped scenario between inter and intra. Why there is commonality? |  |
| LG | Fine with MediaTek’s version |  |
| CMCC | ZTE’s update is fine to us. We also agree to send LS to RAN2/4 regarding intra-frequency restriction. |  |
| CATT | Support. Fine with Qualcomm modification. |  |
| vivo | Fine with revisions proposed by MTK and QC. |  |

### Inter-frequency L1 measurement

##### [Summary of contributions]

* Although the discussion on inter-frequency measurement is ongoing in RAN2, many companies showed their interest on the support of inter-frequency L1 measurement, which is required for inter-cell mobility scenario captured in the WID.
* It is also pointed out by many companies that the introduction of SMTC and measurement gap would be needed to perform inter-frequency L1 measurement.
* The definition of inter-frequency scenario is however not clear, and hence the clear distinction of intra-frequency and inter-frequency is needed, which may require RAN4’s help.
  + For example, even when the frequency of non-serving cell SSB is the same as serving cell SSB, it might be categorized as inter-frequency if the SCS not identical.
* It is proposed to use CSI-RS based measurement and reporting for inter-frequency (and this will be discussed in section 5.1.4)

##### [FL observation]

FL thinks that the scenario discussions should be done in RAN2 although spec impact should be analysed in RAN1 and RAN4. Given the situation that RAN2 discussion on inter-frequency mobility is still ongoing, RAN1 should wait for their input to avoid the duplicated discussion. Therefore, FL would propose to focus only on the potential RAN1 spec impact at this moment, and the detailed discussion can be started after receiving RAN2 LS.

##### [FL proposal 1-2-v1]

* For Rel-18 L1/L2 mobility, further study the potential RAN1 spec impact of inter-frequency L1 measurement
  + At least the following aspects are considered:
    - Introduction of measurement gap and SMTC for L1 inter-frequency measurement
    - Commonality with L1 intra-frequency measurement for measurement configuration
  + The definition of inter-frequency includes at least:
    - the frequency of the measured RS is not covered by any of the active BWPs of SpCell and Scells configured for a UE.
  + The decision on the introduction of inter-frequency L1 measurement is up to RAN2
* *FL note: this issue is a high priority issue from FL point of view, but RAN1 should wait for the decision by RAN2*

##### [Discussion on proposal 1-2-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-2-v1 | Response from FL |
| MediaTek | We agree that inter-frequency is an essential discussion aspect in Rel-18 mobility enhancement. However, as mentioned in FL note, we also prefer to wait for RAN2 discussion outcome on the inter-frequency scenario/definition. Then whether and how to introduce measurement gap can be RAN4 discussion. Note that we only have limited TU shared with 9.12.2 and overlapped discussion topics with RAN2 is not desirable. Therefore, we suggest to postpone the discussion of this proposal in this meeting and wait for RAN2 decision. |  |
| Google | Support in principle |  |
| OPPO | We prefer to wait for the RAN2 discussion on inter-frequency scenario. The proposal has a bullet of “definition of ..”, which seems also need to wait for RAN2 discussion too. |  |
| QC | Suggest to split the inter-frequency definition into two cases, which may have different treatment, e.g. whether measurement gap is needed. Also, prefer to carry on the high-level discuss without waiting for RAN2 LS, since inter-frequency is already supported in WID, and RAN1 has already waited for 2 meetings   * For Rel-18 L1/L2 mobility, further study the potential RAN1 spec impact of inter-frequency L1 measurement   + At least the following aspects are considered:     - Introduction of measurement gap and SMTC for L1 inter-frequency measurement     - Commonality with L1 intra-frequency measurement for measurement configuration   + The definition of inter-frequency includes at least:     - the frequency of the measured RS is not covered by any of the active BWPs of SpCell and Scells configured for a UE, but is covered by some of the configured BWPs of SpCell and Scells configured for a UE.     - the frequency of the measured RS is not covered by any of the configured BWPs of SpCell and Scells configured for a UE   + The decision on the introduction of inter-frequency L1 measurement is up to RAN2   *FL note: this issue is a high priority issue from FL point of view, ~~but RAN1 should wait for the decision by RAN2~~ and RAN1 should update the decision based on further RAN2 input* |  |
| Fujitsu | Support |  |
| Apple | Measurement gap and SMTC-setting are topics handled by RAN4. Also, the inter-frequency vs. intra-frequency definition were introduced by RAN4. Not sure RAN1 needs to handle them.  In our view, RAN1 needs to first discuss and identify any related RAN1 work for inter-frequency mobility, except the RAN4-centric topics listed above. |  |
| DOCOMO | We also prefer to have some discussion on this issue without waiting for RAN2 LS.  And we think that the cases not covered by ‘relaxation of the restrictions for intra-frequency’ (i.e., the outcome of FL proposal 1-1) can be also discussed as cases for inter-frequency. |  |
| Lenovo | WID has noted that both inter-frequency and intra-frequency are supported for L1/L2 mobility, so we prefer to study the related issues without RAN2 LS.  And we agree with Apple that measurement gap and SMTC should be handled by RAN4, no need to discuss in RAN1. |  |
| New H3C | Fine with this proposal in principal. |  |
| ZTE, Sanechips | Although the related issues are being discussed in other working groups, but in order to avoid duplicated discussion and waiting time for other WGs LS, we think that RAN1 can discuss inter-freq related issues with other WGs, such as RAN2/4 in parallel. Besides, RAN1 can send an LS to other WGs to sync or inform RAN1’s progress. |  |
| Huawei, HiSilicon | To our understanding, both inter frequency and intra frequency scenario are supported according to WID. We could start to work on RAN1 specific issue without waiting for RAN2.  Similar as our comment in 5.1.1, we are not quite sure the meaning of sentence “Commonality with L1 intra-frequency measurement for measurement configuration”  As for the definition of inter frequency, maybe we do not need to list here. Actually, it is up to RAN4. And usually, the supported scenario not included in intra frequency will be regarded as inter frequency. |  |
| LG | Fine in principle. But on the definition/scenario of inter-frequency, it would be better to wait the result of RAN2 discussion. Also, we have a similar view with Apple for measurement gap and SMTC setting. |  |
| CMCC | Support the proposal. According to the WID, both inter-frequency and intra-frequency are supported for L1/L2 mobility. |  |
| CATT | Since WID already includes both inter frequency and intra frequency scenario, we prefer to parallel discuss this issue with other WGs and sync with each other.  The definition of inter-frequency is RAN4 scope. We don’t need to discuss it currently. |  |
| vivo | Similar with intra-frequency, we think the potential RAN1 spec impact of inter-frequency L1 measurement should not be discussed until the definition of inter-frequency is determined by RAN4. Otherwise, potential spec impact cannot be analysed clearly. Therefore, we also prefer to wait for RAN4 discussion outcome on the inter-frequency definition. |  |

### Support of L3 measurement

##### [Summary of contributions]

* It is proposed by one company to reuse L3 measurement mechanism for neighbour cell detection in L1/L2 based mobility.

##### [FL observation]

This issue has been discussed in RAN2 and captured as FFS in their minute. Duplicated discussion among WGs should be avoided.

##### [FL proposal 1-3-v1]

* RAN1 will not discuss the necessity of L3 measurement for L1/L2 mobility unless explicit request from RAN2 is received.
* *FL note: It is not intended that this proposal is captured in Chair’s note.*
* *FL note: this issue is a low priority issue from FL point of view.*

##### [Discussion on proposal 1-3-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-3-v1 | Response from FL |
| MediaTek | We agree with FL’s assessment that the debating between L3 and L1 measurement for Rel-18 cell switching mechanism has been discussed in RAN2 and we should wait for RAN2’s discussion outcome and postpone the discussion in this meeting. |  |
| Google | Support |  |
| OPPO | This can be a conclusion. |  |
| QC | Agree with FL. RAN2 LS already indicated that L1/L2 mobility is triggered by L1 measurement. Also, this agenda only handles L1 enhancement |  |
| Fujitsu | Support |  |
| Apple | Agree with FL assessment. |  |
| DOCOMO | Agree with FL. |  |
| Lenovo | Agree with FL. |  |
| New H3C | Agree with FL proposal |  |
| ZTE | Agree with FL’s proposal, but I would like to confirm whether we can further discuss or clarify the relationship between L1 measurement and L3 measurement to align understanding each other. |  |
| Huawei, HiSilicon | In response to QC, L3 measurement is used to have a rough selection of candidate cell on which L1 measurement is going to perform, considering the reporting overhead and resource for measurement. The cell switching is still be on L1 signalling. Whether this rough selection based on L3 measurement will impact L1 design, such as maximum number of candidate cell for L1 measurement.  As mentioned by FL, we can wait for RAN2 decision if there is ongoing discussion there. |  |
| LG | Agree with FL’s assessment |  |
| CMCC | Support the proposal. |  |
| CATT | Agree with FL’s assessment |  |
| vivo | Agree with FL. |  |

### Measurement RS

##### [Summary of contributions]

* It seems that most of the companies (all the companies?) think SSB should be used for L1 measurement for Rel-18 L1/L2 mobility.
* In addition, many companies have a view that CSI-RS based non-serving cell L1 measurement should be supported to enables larger bandwidth with short period, or to obtaining new refined beams for latency reduction.
  + This is to introduce explicit configuration for neighbour cell measurement, i.e. proponent companies do not want to mimic as if non-serving cell RS comes from the serving cell.
  + Also, it is also proposed to use CSI-RS for tracking, CSI-RS for beam management QCLed with SSB associated with non-serving cell for non-serving cell L1 measurement.

##### [FL observation]

While SSB can be a baseline for non-serving cell L1 measurement, use of CSI-RS for non-serving cell L1 measurement can be further discussed in RAN1 given the companies’ interest and potential benefits. The potential discussion includes the necessity itself, and how the configuration is performed. It is noted that the introduction of CSI-RS L1 measurement requires RAN4 to specify it’s requirements.

##### [FL proposal 1-4-v1]

* For Rel-18 L1/L2 mobility, SSB is supported for intra-frequency L1 measurement
* Further study the following for non-serving cell L1 measurement RS
  + SSB for inter-frequency (if supported)
  + CSI-RS associated with non-serving cell PCI, i.e. *additionalPCI*, for intra-frequency and inter-frequency (if supported)
* *FL note: this issue is a high priority issue (at least for SSB) from FL point of view. On the other hand, the use of CSI-RS looks an optional feature and an optimization, and FL doesn’t recommend spending much time.*

##### [Discussion on proposal 1-4-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-4-v1 | Response from FL |
| MediaTek | We support the proposal in general. However, as mentioned in our comment in Proposal 1-1, the definition of intra-frequency should be clarified first. We also see the benefit of measuring CSI-RS associated with non-serving, e.g., flexibility of configuration, early beam refinement possibility, and it should be further studied as stated in the proposal. |  |
| Google | We suggest clarifying the type of CSI-RS, is it CSI-RS for BM? |  |
| OPPO | Ok in principle |  |
| QC | Suggest to replace “non-serving cell” with “candidate cell”, since serving cell as candidate cell is still under RAN2 discussion as in the LS. Also, suggest to remove “additionalPCI”, which is the configuration name in R17 and may not be reused in R18   * For Rel-18 L1/L2 mobility, SSB is supported for intra-frequency L1 measurement * Further study the following for ~~non-serving~~ candidate cell L1 measurement RS   + SSB for inter-frequency (if supported)   CSI-RS associated with ~~non-serving~~ candidate cell PCI, ~~i.e.~~ *~~additionalPCI~~*~~,~~ for intra-frequency and inter-frequency (if supported) |  |
| Fujitsu | Support |  |
| Apple | Support. Fine with modification from QCM. |  |
| DOCOMO | Support in principle.  We also prefer to clarify the possible type of CSI-RS in last bullet. |  |
| Lenovo | Fine with QC’s version. |  |
| New H3C | Support |  |
| NEC | Support |  |
| ZTE | We have similar view with other companies and support QC’s modification with minor update, as follows:   * For Rel-18 L1/L2 mobility, SSB is supported for L1 intra-frequency ~~L1~~ measurement * Further study the following L1 measurement RS for ~~non-serving~~ candidate cell ~~L1 measurement RS~~   + SSB for inter-frequency (if supported)   + CSI-RS for tracking   + CSI-RS for beam management     - CSI-RS associated with ~~non-serving~~ candidate cell PCI, ~~i.e.~~ *~~additionalPCI~~*~~,~~ for intra-frequency and inter-frequency (if supported) |  |
| Huawei, HiSilicon | Support the proposal and fine with QC’s revision |  |
| LG | Fine with the Qualcomm’s modification. |  |
| CMCC | Support the proposal. |  |
| CATT | Support the proposal with ZTE’s update. |  |
| vivo | Support. |  |

### Measurement quantity

##### [Summary of contributions]

* It seems that most of the companies (all the companies?) think L1-RSRP should be used for Rel-18 L1/L2 mobility.
* L1-SINR is also proposed to measure interference situation and more flexible target cell selection.
* Furthermore, use of UL measurement is proposed to avoid delay and computation complexity at a UE.

##### [FL observation]

Along with the majority companies view, L1-RSRP should be used for L1 measurement for Rel-18 L1/L2 mobility. In addition, introduction of L1-SINR for non-serving cell measurement need further discussion because only a limited number of companies mentioned about the necessity in their contribuions. In addition, UL measurement may be useful for Rel-18 L1/L2 mobility, even though the details are not clear at this moment. Companies are encouraged to further study the benefit, drawback and RAN1 spec impact.

##### [FL proposal 1-5-v1]

* For non-serving cell measurement for Rel-18 L1/L2 mobility,
  + L1-RSRP is supported for intra-frequency non-serving cell measurement.
  + Further study the following measurement quantities for non-serving cell measurement
    - L1-RSRP for inter-frequency (if supported)
    - L1-SINR for intra-frequency and inter-frequency (if supported)
    - UL measurement for intra-frequency (and inter-frequency, feasibility should be further assessed)
* *FL note: this issue is a high priority issue (at least for RSRP) from FL point of view. Not sure of other quantity, thus companies’ input is appreciated.*

##### [Discussion on proposal 1-5-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-5-v1 | Response from FL |
| MediaTek | We are generally fine with the proposal based on the assumption that we should first clarify the definition of intra-frequency. On the other hand, the design of UL measurement is not clear in the proposal and we are not sure it is desirable to include this bullet in the proposal. Therefore, we suggest proponent can elaborate the details a little more and have a separate discussion on UL measurement. |  |
| Google | Support |  |
| OPPO |  |  |
| QC | Name change as previous comments. Fine to study all options at this stage   * For ~~non-serving~~ candidate cell measurement for Rel-18 L1/L2 mobility,   + L1-RSRP is supported for intra-frequency ~~non-serving~~ candidate cell measurement.   + Further study the following measurement quantities for ~~non-serving~~ candidate cell measurement     - L1-RSRP for inter-frequency (if supported)     - L1-SINR for intra-frequency and inter-frequency (if supported)   UL measurement for intra-frequency (and inter-frequency, feasibility should be further assessed) |  |
| Fujitsu | Support |  |
| Apple | Support. |  |
| DOCOMO | Generally okay.  But we also think the UL measurement part is unclear. |  |
| Lenovo | Fine with QC’s version.  UL measurement is not clear to us. |  |
| New H3C | Support |  |
| ZTE | We are okay with QC’s modification and have the same issue raised by DOCOMO and Lenovo. |  |
| Huawei, HiSilicon | Fine with the proposal except for the UL measurement part, which need to further clarify in detail. |  |
| LG | Support |  |
| CMCC | The motivation of UL measurement is not clear to us. |  |
| CATT | Fine with QC’s update, except for UL measurement part. We also think it is unclear. |  |
| vivo | The motivation of UL measurement is to reduce measurement delay and UE computation complexity. Compared to measurement on SSBs from multiple candidate cells, UE only needs to transmit UL signals, e.g., SRS, and candidate cells monitor the UL signals according to the configuration of UL signals forwarded from the serving cell. Based on measurement value from different candidate cells, and the source cell could make the handover decision. In a nutshell, UL measurement achieve the same functionality as the DL measurement, and it just reverses the roles of the gNB and the UE.  We are fine to discuss UL measurement in this issue. But if some companies think it is not suitable, we suggest to discussing in issue 1-4. |  |

### Filtering for L1 measurement results

##### [Summary of contributions]

* Many companies see the necessity of filtering for mobility robustness, i.e. avoiding ping-pong, avoiding large amount of measurement results for gNB, or relaxing the negative impact by UE rotation.
* Two types of filtering are proposed at this meeting:
  + L3 filtering (in time domain):
  + cell-level filtering (in spatial domain), which includes the averaging of best X beams in a cell

##### [FL observation]

While the interest by many companies on filtering, the importance of “ping-pong avoidance” has not been confirmed in RAN2. Hence, the decision on ping-pong should be concluded in RAN2 first, and then RAN1 can decide which way to go. FL recommendation is to wait for RAN2 LS and then to make RAN1 decision whether or not filtering is applied to L1 measurement results. Until then, RAN1 can discuss the potential definition of filtering and applicability of L1 measurement quantities.

##### [FL proposal 1-6-v1]

* For Rel-18 L1/L2 mobility, further study the necessity of filtering to L1 measurement results considering at least the following aspects:
  + Exact definition of filtering
    - L3 filtering (in time domain): e.g. exact definition of time domain filtering
    - Cell-level measurement (in spatial domain): e.g. how many beams are averaged, and/or how the beams are chosen.
  + Importance to avoid ping-pong handover for L1/L2 mobility
    - Alignment with RAN2 is expected
  + Impact of UE rotation
  + Applicability to L1-RSRP and L1-SINR (if supported)
  + Applicability to intra-frequency and inter-frequency (if supported)
* *FL note: this issue is a medium priority issue, the system will work without this functionality even though it is not optimum. Thus FL recommends not to spending much time on this issue and make our decision at an early stage of Rel-18.*

##### [Discussion on proposal 1-6-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-6-v1 | Response from FL |
| MediaTek | We agree with FL’s assessment that RAN1 should have an aligned view with RAN2 on the ping-pong issue before we discuss the solution to address the issue. Also, whether and how to apply filtering should be discussed after proposal 1-4 and 1-5. Therefore, we suggest to deprioritize the discussion in this meeting. |  |
| Google | We do not think filtering related needs to be studied. L1-RSRP measurement behaviour should be the same as legacy. |  |
| OPPO | Support in principle. The measurement results without filtering could cause ping-pong issue likely due to the variation in measurement results. However, a well balance between the reliability and latency shall be considered. |  |
| QC | Support proposal 1-6-v1. This issue is important. Because the cell switch cannot be as fast as intra-cell beam switch to our understanding, e.g. UE loading the new cell configuration may take a few ms. So it is critical to minimize the frequent HO. LS can be sent to RAN4/2 on the cell switch latency number. |  |
| Fujitsu | Support. The necessity of filtering should be studied. |  |
| Apple | Support.  RAN1 can study and justify the need while waiting for RAN2 further inputs on this. |  |
| DOCOMO | Support in principle. |  |
| Lenovo | Support in principle. |  |
| New H3C | Support in principle |  |
| ZTE | We understand that we can study the necessity of filtering to measurement result, but from our point of view, we don’t see a strong need to introduce filtering operation since the main motivation of Rel-18 L1/L2 mobility is to reduce latency, so ping-ping is not a big deal in case of low latency. |  |
| Huawei, HiSilicon | This issue also relates to whether L3 measurement are involved. For example, if L3 can be used to roughly select the candidate cell, the cell level measurement in L1 seems not necessary. As for the time domain filter, it may reduce the responsiveness of L1/L2 mobility which is the major benefit. Moreover, the filtering can be implemented at network side without spec impact.  We share similar view as MTK, it should be deprioritized in this meeting and require more input from RAN2. |  |
| LG | Agree with FL’s assessment |  |
| CMCC | OK to defer the discussion and wait for RAN2 to confirm whether “ping-pong avoidance” should be introduced. |  |
| CATT | Agree with FL’s assessment. To avoid the ping-pong issue, filtering for L1 measurement is needed and can be further studied. |  |
| vivo | We share similar view with MediaTek. |  |

### Configurations for L1 measurement

##### [Summary of contributions]

* Due to the support of multi-beam/multi-frequency/multi-cell measurements under Rel-18 L1/L2 mobility scenarios, it is required for gNB and UE to handle large amount of measurement (and configuration) in order to find the best beam/cell for mobility. Thus, it is questioned that the number of cells/RSs need to be extended from Rel-17 ICBM.
  + Change the maximum number of additional cells (i.e. non-serving cells)
  + Change the maximum number of RSs associated with each cell that can be configured for L1 measurement
  + Note that if nothing is changed, gNB may be required to perform RRC reconfiguration
* On the other hand, companies also see the necessity to enhance the configuration on L1 measurement to avoid the complication at a gNB, and memory requirement for a UE, e.g.
  + The beam measurements for L1/L2 mobility should require only a minimum of configuration, i.e.
    - Similar approach as L3 measurement: the L3 measurements only require a target frequency, and intra-frequency L3 measurements do not require any configuration at all. In particular, the UE does not need to be informed which PCIs it should measure: the UE finds the SSBs of any relevant PCI without explicit configuration
  + Use MAC CE to activate/deactivate the measurement of reference signals for a cell or the measurement PCIs, and reporting set may also be updated due to this activation.
  + Possibility to reuse pre-configuration for target cell(s), which may include RRC parameters for measurement RS and TCI states
* Furthermore, it is pointed out that the commonality between intra-DU and inter-DU case, where obtaining full RRC configuration for the target cells is not undesirable.

##### [FL observation]

It would be straightfoward to consider to the extention of configured nubmer of PCIs and RSs becuase a UE is required to measure more number of beams for non-serving cells in order to find the best beam/cell for handover. However, there is a trade-off relationship between performance and complexity. Therefore, it is resonable for RAN1 to closely look at this issue, and FL would propose RAN1 to further study this issue, and to find a well-balanced system design on this matter.

##### [FL proposal 1-7-v1]

* For Rel-18 L1/L2 mobility, further study at least the following aspects for the configuration of L1 measurement:
  + Whether to change the maximum number of additional cells (i.e., non-serving cells), which is 7 for Rel-17 ICBM
    - this includes the concept not to indicate any PCIs for L1 measurement
  + Whether to change the maximum number of RSs associated with each cell that can be configured for L1 measurement, which is 64 for Rel-17 ICBM
    - this includes the concept not to indicate any RSs for L1 measurement
  + Whether to introduce enhancements for L1 measurement to avoid a large amount of active measurement configurations or frequent reconfiguration.
  + Whether and how to communize the configuration for intra- and inter-DU case.
* *FL note: this issue is a medium priority issue; the system may work without this functionality even though it is not optimum. It would be good for RAN1 to better understand the problem first.*

##### [Discussion on proposal 1-7-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 1-7-v1 | Response from FL |
| Google | So far we have not seen a necessity for these study points. |  |
| QC | Suggest to add a new issue below, which we think is important.  Whether the measurement RS for a candidate cell is configured under active serving cell or candidate cell |  |
| Fujitsu | Support in general. Suggest to add an additional FFS aspect as below. It is generally mentioning to study the detailed contents of the measurement configuration  Information required for configuring the measurement RS |  |
| Apple | Support in general. Also suggest to add the bullet proposed by QC. |  |
| DOCOMO | Support in principle. |  |
| Lenovo | Support in principle |  |
| New H3C | Support |  |
| NEC | Support the configuration of a subset of candidate cells to be measured simultaneously. |  |
| ZTE | We propose to first evaluate the necessity of these aspects listed above and then discuss detailed enhancements. |  |
| Huawei, HiSilicon | Support in princple |  |
| CMCC | Support |  |
| CATT | Support in princple |  |
| vivo | Support in principle. |  |

## L1 measurement reporting

##### [Summary of contributions]

* According to the submitted contributions that many companies have an understanding that the gNB triggered/configured reporting, which is supported for Rel-17 ICBM, can be reused for Rel-18 L1/L2 mobility
  + Periodic, semi-persistent and aperiodic L1 measurement reporting using reference signals associated with non-serving cell PCI
  + Reuse the reporting format for Rel-17 ICBM, i.e. 4 beams can be reported in a report instance, including serving cell and non-serving cell, where absolute 7-bit RSRP and remaining 4-bit differential RSRP value relative to the absolute value
  + Also, there are discussions about the reporting format to support Rel-18 scenarios
    - Frequency indicator if inter-frequency L1 measurement is supported.
    - Support of more than 4 beams in a report instance.
    - Support of reporting a variable number of SSBRI/RSRP pairs, wherein a UE reports in a single reporting instance a two-part beam report using the Rel-15 two-part UCI. The 1st part has fixed payload size while the 2nd part is used to report the remaining information.
    - Support reporting for top N candidate cells with cell-level filtered measurement results.
* On the other hand, L1 measurement report using MAC CE is also proposed to enable large size of reports, and to achieve more reliability.
* In addition, many companies propose to introduce UE /event triggered report (which was discussed in Rel-17 ICBM but not agreed) to reduce reporting overhead and UE power consumption while it is claimed that the motivation of event triggered L1 reporting is not clear.
  + Nevertheless, companies have quite different understanding on the detailed design: i.e. triggering event (reuse of L3 event, or new event, etc.), resources allocation/request used for reporting, indication to gNB if the condition is met (using SR or MAC CE), how to start or stop the report (timer base), how the target RS and PCI is configured, necessity of TTT (Time To Trigger) and/or contents of the beam report etc.

##### [FL observation]

There are small number of proposals on L1 measurement report in this meeting. Some companies propose to reuse the mechanism for Rel-17 ICBM (i.e. reporting format). On top of that, some also see the necessity to enhance it to support Rel-18 scenarios (such as inter-frequency handover which may result in large number of measurement and report). Another idea to cope with Rel-18 scenario is to use MAC CE to enable large amount of L1 measurement report with higher reliability.

Event/UE triggered report was proposed by many companies, similarly to Rel-17. While this technique is well-known in RAN1 for a long time, it seems companies still have quite different views on the details design of UE /event triggered report (despite the simple name, unfortunately). This situation prevents FL from coming up with concrete options for UE /event triggered report (i.e. option 1, option 2 ~~) for down selection because tons of combinations can be considered. Therefore, FL would like to propose two phase approach, i.e. (1) summarize and agree the discussion points at this meeting, and (2) discuss and decide if event/UE triggered report is supported or not, and agree the limited number of options for further discussion at RAN1#111. Spending much time on this issue is not recommended.

##### [FL proposal 2-1-v1]

* For L1 measurement report for Rel-18 L1/L2 mobility, further study the following mechanisms:
  + Report as UCI on PUCCH or PUSCH
    - Periodic report on PUCCH, semi-persistent report on PUSCH and aperiodic report on PUSCH
    - Reuse the report format defined for Rel-17 ICBM, and further study the enhancements to accommodate Rel-18 scenarios, e.g.
      * Inter-frequency measurement, if supported
      * Increasing the maximum number of reporting beams, which is 4 for Rel-17 ICBM
      * Reducing the reporting overhead by e.g. choosing N-best beams/cells
  + Report on MAC CE
* For L1 measurement report for Rel-18 L1/L2 mobility, interested companies are encouraged to further study the necessity of UE/event triggered report for L1 measurement results and the detailed design until RAN1#111
  + At least the following aspects should be considered in the companies’ proposal
    - Exact definition of events, i.e. events defined for L3 measurement report, or something new
    - Report container i.e. UCI transmitted on PUCCH or PUSCH and/or MAC CE etc.
    - Resource allocation/assignment for UE/event triggered report i.e. resource is allocated in advance, requested when the event is met, and/or activated when the condition is met etc.
    - Necessity of indication to gNB when the condition is met, and how
    - Necessity to define the condition to start/stop the reporting, e.g. timer
    - Necessity of time to trigger
    - Contents of the report/reporting format, PCI, RS ID, measurement result etc.
* *FL note: this issue is a high priority issue; at least one container shall be defined. On the other hand, UE event triggered report look like an optimization. Thus FL doesn’t recommend spending much time on this issue.*

##### [Discussion on proposal 2-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal2-1-v1 | Response from FL |
| Google | We think the following bullet should be removed:   * + - * Reducing the reporting overhead by e.g. choosing N-best beams/cells   For event-based report, since this is L1 measurement report, we think the definition of event should be based on L1 measurement report instead of L3 measurement report. |  |
| QC | Suggest a few changes as below. R17 report format may not be reused for inter-frequency, which may report top X best beams/cells per frequency for multiple frequencies in the same report   * + - Reuse the report format defined for Rel-17 ICBM at least for intra-frequency measurement, and further study the enhancements to accommodate Rel-18 scenarios, e.g.       * Inter-frequency measurement, if supported       * Increasing the maximum number of reporting beams, which is 4 for Rel-17 ICBM   Reducing the reporting overhead by e.g. choosing N-best beams/cells per frequency or across frequencies |  |
| Fujitsu | Support |  |
| Apple | Support in general.  This provides a simply list for the potential study areas and whether adopt or not is a sperate discussion. |  |
| DOCOMO | Suggest adding a following bullet in the end, as we need to decide whether such event is for legacy L1 measurement/reporting or filtered L1 measurement/reporting.   * + - The interaction with filtered L1 measurement results (if supported) |  |
| Lenovo | Support in principle |  |
| New H3C | Support |  |
| NEC | Support that a timer is started for the candidate cell SSB measurements upon receipt of the L1/L2 mobility configuration. The timer expires when no handover is triggered.  Support that L1 measurement results are filtered for measurement reporting, e.g. averaged after removing the highest/lowest X percentile measurement values |  |
| ZTE | Regarding report format, we suggest that report format for Rel-17 ICBM can be used as starting point, since Rel-17 ICBM just support non-group based report method, not support group-based report method. So at this stage, we think these two report method should be considered. |  |
| Huawei, HiSilicon | We support the first part of proposal.  As for the event triggered report, we agreed width moderator’s assessment. It is an optimization and the benefit are quite related to the amount of report, such as number of candidate cells and whether L3 measurement can be used in advanced. |  |
| LG | Fine with the proposal |  |
| CMCC | In our view, report as UCI and report on MAC-CE are two options. Is the intention to do down-selectin between the two options? |  |
| CATT | General fine with the proposal.  Just for clarification for the 2nd part, why do we need to add RAN1#111 for the event triggered report? Does that mean we need to final decide whether to support event triggered report and decide all following sub-bullets in the next meeting? |  |
| vivo | In general, P/SP/AP L1 measurement report is carried by PUCCH/PUSCH. We don’t understand the motivation of reporting on MAC CE. Therefore, we suggest to removing the wording “ Report on MAC CE” in the first bullet. |  |

## Beam indication

### Beam indication mechanism:

##### [Summary of contributions]

* Many companies think the beam indication at target cell(s) (this includes SpCell and SCell(s) as agreed in RAN2) is performed based on Rel-17 TCI framework (Option. A below). Meanwhile, it is also pointed out that Rel-15 TCI framework (Option. B below) needs to be considered if Rel-17 TCI framework cannot be a prerequisite for Rel-18 L1/L2 mobility.
  + **Option A:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-17 TCI framework mechanism
    - RRC configurations of DL/UL/joint TCI states for potential target cell(s) are activated by MAC CE, and indicated by DCI
    - Potential issues pointed out by companies
      * Coexistence with Rel-17 inter-cell beam mTRP
      * Support of CA, i.e. how to perform beam indication for multiple cells
      * Handling of common-PDCCH (which cannot be switched to non-serving cell in Rel-17)
      * How and whether the list of TCI states associated with target cell(s) is/can be configured, including whether the TCI states for target cell(s) are availble or not
      * Application time for new beam activation need to be updated compared with Rel-17 ICBM.
  + **Option B:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-15 TCI framework mechanism
    - TCI indication is valid only for a certain channel, and update by RRC reconfiguration is required to update QCL/Tx spatial filter/pathloss reference.
    - Detailed mechanism and potential issues need further discussion (i.e. the details are not discussed by the contributions submitted to this meeting)
* Alt.1 and Alt.2 may or may not be exclusive to each other. Choosing Option A only (i.e. Rel-17 TCI framework as baseline) will make the specification simpler, but Choosing Option A+B will make the deployment and implementation (at least for network side) easier resulting in earlier market introduction.
* There is a proposal that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

While many companies assume Rel-17 TCI framework can be the baseline for Rel-18 L1/L2 mobility, it should be firstly decided if Rel-18 L1/L2 mobility should assume a specific TCI framework, i.e. whether Rel-15 TCI framework need to be considered. FL thinks the decision on this matter is very important for this WI because it has a big impact for the whole design of Rel-18 L1/L2 mobility. As already indicated by RAN2 LS, prerequisite discussion has already happened in RAN2 and the same situation is expected for TCI framework assumption. In this sense, FL believes the RAN1 discussion should be hold a bit until RAN2 concludes their discussion. Note that FL confirmed that a RAN2 contribution bringing up this issue is submitted to RAN2#119b-e, and hence no LS from RAN1 would be necessary.

##### [FL proposal 3-1-v1]

* RAN1 to further study if the beam indication of target cell(s) L1/L2 mobility should be designed for a specific TCI framework, e.g. Rel-17 unified TCI, and their potential spec impact. RAN1 discussion will be commenced after receiving RAN2 LS.
* Interested companies are encouraged to work with their RAN2 colleagues to accelerate the discussion.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue.*

##### [Discussion on proposal 3-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 3-1-v1 | Response from FL |
| MediaTek | Agree with FL’s assessment that the discussion should wait for RAN2 LS. The discussion of TCI framework has essential impact on the design of dynamic cell switching discussion in RAN2 and we prefer to wait for RAN2’s input. |  |
| Google | We think “e.g.” should be replaced by “i.e.” since the enhancement is based on ICBM according to WID, where ICBM is based on unified TCI. In addition, what is the RAN2 LS mentioned in this proposal? |  |
| OPPO | How to indicate beam indication for L1/L2 mobility target cell critically depends on the L1/L2 mobility handover procedure and handover command design. We are not sure if the Rel-17 Unified TCI can be used here.  Furthermore, inter-cell BM is supported in Rel-17 Unified TCI, how to coordinate between the inter-cell BM and beam indication for L1/L2 mobility shall be carefully considered. |  |
| QC | Fine for the proposal. However, to our understanding, this should be best decided in RAN1 |  |
| Fujitsu | Support |  |
| Apple | Our view is that unified TCI framework is an optional feature and should not be a pre-requisite for L1/L2-based handover feature. Therefore, the design should support both legacy TCI framework and Rel-17 unified TCI.  We also share QC’s view that this should be decided in RAN1. |  |
| DOCOMO | We tend to agree with QC that the TCI framework should be discussed in RAN1. |  |
| Lenovo | We agree with QC and DOCOMO that the TCI framework should be decided by RAN1.  The WID says to specify “L1 enhancements for inter-cell beam management” which is based on Rel-17 unified TCI framework; therefore, we think L1/L2 mobility should be specified based on unified TCI framework. |  |
| New H3C | The TCI framework should be discussed in RAN1. |  |
| ZTE | We tend to discuss this issue in RAN1, not after receiving RAN2 LS. |  |
| Huawei, HiSilicon | The TCI frame can be decided by RAN1. To our understanding, unified TCI framework in Rel-17 is more efficient to indicate beam for multiple channels/signals in multiple cells from the perspective of signalling overhead. Considering the difference between unified TCI framework and R15 TCI framework, developing L1/L2 measurement for both may result large work load considering limited TU. We support to design based on R17 unified TCI frame work with high priority. |  |
| LG | We have a similar view with QC’s comment |  |
| CMCC | We agree with other companies that the TCI framework should be decided by RAN1. |  |
| CATT | We think the TCI framework should be decided in RAN1 and we prefer to design based on Rel-17 unified TCI. |  |
| vivo | We prefer L1/L2 mobility based on unified TCI framework as starting point. |  |

### Timing of beam indication:

##### [Summary of contributions]

* Many companies assume that the beam indication for the target cell(s) comes together with L1/L2 cell switch command. Meanwhile, it is also proposed that the beam indication can be performed before the command is received. These mechanisms are useful to reduce the handover latency due to the beam search procedure.
* Also, the necessity of beam indication after L1/L2 mobility command is also discussed in the case where L1 measurement results for target cells are not available when the command is sent. For example, support of cell level L1 measurement and the use of L3 measurement are also proposed and if so, it is not clear if the gNB has a sufficient information which beam is the best for a UE. In this case, the beam indication at the target cell(s) may be performed after the handover command is sent out (i.e. target cell is determined but exact beam is not determined). However, it is not clear at this moment if this is a valid scenario.

##### [FL observation]

RAN2 is now discussing the time chart after enhancement, and timing of beam indication is an open issue. Hence, RAN2 view is important to make the final decision at RAN1 on the timing of beam indication. Given this situation, RAN1 should not have any specific assumption on the timing of beam indication at this moment, and the detailed discussion can be started after receiving RAN2 LS. RAN1 can keep the following 3 scenarios below for now, and FL would encourage interested companies to further study the validity of the scenarios and potential RAN1 spec impacts until then.

* Scenario 1: Beam indication before command
* Scenario 2: Beam indication together with command
* Scenario 3: Beam indication after command

##### [FL proposal 3-2-v1]

* From RAN1 perspective, the following scenarios can be considered for Rel-18 L1/L2 mobility for beam indication timing. This will be updated depending on RAN2 decision on the time chart
  + Scenario 1: Beam indication before command
    - This scenario happens when, e.g. Rel-17 ICBM is enabled before receiving handover command.
  + Scenario 2: Beam indication together with command
    - This scenario happens when, e.g. the best/appropriate beam for a UE is known to the source cell when the commend is sent to the UE.
  + Scenario 3: Beam indication after command
    - This scenario happens when, e.g. the best/appropriate beam for a UE is not known to the source cell when the L1/L2 mobility command is sent to the UE
* Interested companies are encouraged to further study the validity of the scenarios and the potential spec impact.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue*

##### [Discussion on proposal 3-2-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 3-2-v1 | Response from FL |
| MediaTek | Agree with FL’s assessment that the discussion should depend on RAN2 decision on the time chart decision for dynamic cell switching design. It’s not desirable to have overlapped discussion topics with RAN2. |  |
| Google | Not sure whether a command in addition to beam indication signalling is needed or not. Maybe we can wait to see more details on the command. |  |
| OPPO | How to indicate beam indication for L1/L2 mobility target cell critically depends on the L1/L2 mobility handover procedure and handover command design. We shall wait for RAN2 discussion result. |  |
| QC | For scenario 1, suggest to add one more example, which does not assume ICBM is enabled, e.g. a good beam for a promising candidate cell can be activated before gNB decides to select this candidate cell   Scenario 1: Beam indication before command   This scenario happens when, e.g. Rel-17 ICBM is enabled, or the best/appropriate beam for a candidate cell is known before receiving handover command |  |
| Fujitsu | Support |  |
| Apple | Support in general.  On the other hand, not sure RAN2 will discuss this issue i.e., when L1 HO CMD is transmitted. LS maybe needed to trigger RAN2 discussions by listing these three scenarios to seek for guideline. |  |
| DOCOMO | Support in principle. And QC’s revision looks good. |  |
| Lenovo | Fine with QC’s version. |  |
| New H3C | Support |  |
| NEC | Support |  |
| ZTE | Agree with QC’s version. |  |
| Huawei, HiSilicon | We think the addition by QC is necessary to differentiate the scenario L1/2 mobility from ICBM in R17. For the option 3, what is the difference from existing HO mechanism? |  |
| LG | QC’s revision seems reasonable. |  |
| CMCC | Support |  |
| CATT | Fine with FL’s assessment and agree with QC’s update. We also think for down-selection we need to wait RAN2 LS. |  |
| vivo | We agree to wait for RAN2 discussion result. For the QC’s revision, we think that “the best/appropriate beam for a candidate cell is known” needs further clarification. |  |

## Cell switch command

##### [Summary of contributions]

* A number of companies proposed the signaling details on cell switch command, and DCI and MAC CE are proposed to carry L1/L2 cell switch command. It is pointed out that RAN1 spec impact is clearly foreseen if DCI is chosen as cell switching command.
* The proponents of DCI think the design would be an extension of Rel-17 unified TCI (activated by MAC CE plus indicated by DCI), and at least the following aspects need to be considered to fit L1/L2 mobility:
  + Incorrect detection of command, then acknowledgement is necessary. FL notes that RAN2 is more appropriate place to discuss if the intention is handover complete message,
  + Configuration and activation of the TCI states for non-serving cells
  + Update of TCI state (QCL RSs) after cell switch
* Meanwhile, there are multiple companies who is supportive for MAC CE due to the following reasons:
  + Better flexibility to extend the capacity to carry more necessary information.
  + It is still challenging to carry at least the identity of target cell and TCI state to be applied in target cell by re-purposing fields in current DCI format.
* When making the decision on the mechanism, it is proposed to consider the following aspects/scenarios, i.e. the design of L1/L2 cell switch command should be common (as much as possible) irrespective of the scenarios below:
  + Support of inter-/intra-DU, inter/intra-frequency scenario
  + Whether the command will trigger DL sync, UL sync and/or beam indication at a target cell as well as cell switch
* Additionally, UE autonomous triggering of cell switch (a.k.a. UE-initiated dynamic cell switch) is also proposed by some companies, which has not been discussed in RAN2 yet. The mechanism is e.g.
  + The UE can indicate a handover request in its measurement report. The cell-switch can be triggered once the measurement report is received by the network.
* Some companies have performed their analyses on the necessary information included in L1/L2 cell switch command. The following is the summary of the information proposed by companies:
  + cell/cell group ID for target cell/cell group
  + SSB Index
  + TCI state for the target cell
  + pointer to a target configuration
  + QCL source (or QCL source switching) for DL reception
  + TA value for the target cell.
  + BWP ID for DL and UL for target cells
  + Activation information of CSI-RS resource setting and CSI reporting
  + Random Access Preamble Index, PRACH Mask Index
  + Handover flag (to differentiate Rel-17 inter-cell mTRP and Rel-18 L1/L2 mobility)
  + Triggering of DL/UL synchronization
* It is noted that one company proposes to that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

Even though some RAN1 spec impact is foreseen (especially when DCI is selected), FL thinks that this is a RAN2 driven issue and duplicated discussion in RAN1 should be avoided. Thus, FL proposal is to hold the discussion in RAN1 until we receive a RAN2 LS to request RAN1 work. What RAN1 should/can do for now is to perform a technical analysis on the pros/cons for DCI/MAC CE based activation from RAN1 perspective, and to list the necessary information included in the command from RAN1 perspective, which would be useful for RAN2 decision.

Regarding the contents of handover command, it looks that the contents proposed in this meeting are fundamental information of “mobility”, which should be handled by RAN2. FL recommendation is to firstly list the “RAN1 relevant” information, and then to send it to RAN2 as necessary. Then RAN2 will make the decision on the container of L1/L2 cell switch command. If their decision is to use DCI, then RAN1 will start our work on the exact design of the DCI.

##### [FL proposal 4-1-v1]

* From RAN1 point of view, both DCI and MAC CE based L1/L2 cell switch command can be considered, and it is expected that RAN2 will make the final decision on which one to employ.
  + Interested companies are encouraged to perform technical analysis from RAN1 point of view, e.g.
    - Necessary information included in the command, which is relevant for RAN1 discussion
    - Necessary number of bits for the information
    - L1 impact or concern to use DCI or MAC CE for L1/L2 cell switch command
  + An LS can be sent to RAN2, as necessary
* The discussion on UE-initiated dynamic cell switch will be held in RAN2 first. RAN1 discussion can be started after receiving explicit indication from RAN2.
* *FL Note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue, but should be led by RAN2*

##### [Discussion on proposal 4-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 4-1-v1 | Response from FL |
| MediaTek | Agree with FL’s assessment that RAN2 should make the decision on either of both DCI and MAC CE should be used for cell switching command. Also, UE- initiate dynamic cell switching feature design should be RAN2 discussion. Therefore, we suggest to postpone the discussion of the proposal in this meeting. |  |
| Google | Not sure whether a command in addition to beam indication signalling is needed or not. Maybe we can wait to see more details on the command. |  |
| OPPO | Cell switch command (or handover command) shall be part of RAN2 discussion. |  |
| QC | Prefer DCI as cell switching command, which should be faster than 3ms MAC-CE command application time |  |
| Fujitsu | Support |  |
| Apple | Support FL proposal in general.  On the other hand, L1/L2 triggering CMD can be studied in RAN1 as well focusing on RAN1 perspective to provide suggestion/recommendation to RAN2. |  |
| DOCOMO | We suggest discussing this issue in RAN1 as well. The analysis and comparison of DCI and MAC CE based cell switch command is important. |  |
| Lenovo | We think the L1/L2 cell switch command should also be discussed in RAN1 and prefer DCI based design at least for the scenario that the best beam for target cell is know for source cell then the cell switch command can be send along with beam indication. |  |
| NEC | Support DCI based design where beam ID may be sent along with target cell indication. |  |
| ZTE | We understand that which signal will be used to carry cell switch command can be decided in RAN1 or at least need to RAN1 involvement. |  |
| Huawei, HiSilicon | the content of cell switching command should be determined before the container. |  |
| CMCC | We think using DCI or MAC CE for L1/L2 cell switch command can be discussed in RAN1. But the necessary information in the command should be first discussed. |  |
| CATT | Agree with FL’s assessment that RAN2 should make the final decision on either of DCI and MAC CE. RAN1 can first discuss the content of cell switching command from RAN1’s point of view. |  |
| vivo | We think the L1/L2 cell switch command should also be discussed in RAN1. But before the discussion, the scenarios of L1/L2 Mobility should be determined by RAN2. Since for different scenarios, the information included in the cell switch command is different. Therefore, we suggest to postpone this discussion until the scenarios is determined completely. |  |

## Preparation for handover before reception of cell switch command

##### [Summary of contributions]

* Based on the discussion on time chart in RAN2, companies have proposed their own view which part of UE procedures, i.e. DL Synchronization, UL synchronization and TRS tracking and CSI acquisition, can be performed before cell switch command.
  + For DL synchronization
    - the UE should acquire the DL synchronization before processing the handover command, which can be achieved by storing QCL properties (when measurement is performed) for RSs for a certain period.
    - TCI states for target cell can be activated before the command
  + For UL synchronization
    - Should be discussed in another AI, 9.12.2
  + For TRS tracking and CSI acquisition
    - TRS tracking (obtaining QCL-TypeA RS) and CSI measurement for potential target cell(s) should be performed before handover, or can be triggered by cell switch command.
    - If so, RAN1 needs to discuss how to configure the necessary parameters for the target cells and how to active it.
* There is a proposal that discussion on potential L1 signaling design and enhancements on L1 measurement/reporting related to dynamic serving cell switch should be deprioritized till further RAN2 inputs are provided.

##### [FL observation]

Despite of the companies’ proposals in this meeting, FL thinks the proposals from the companies are based on the “ongoing RAN2 discussion”, and RAN2 has not concluded yet which procedure should/can be done before the command. While RAN1 spec impact is foreseen, RAN1 should wait for the formal input from RAN2 regarding their final decision on what is the expected time chart achieved by Rel-18 L1/L2 mobility.

##### [FL proposal 5-1-v1]

* RAN1 to further study the potential RAN1 enhancements and spec impact to perform the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay / interruption
  + DL synchronization for potential target cell(s)
  + TRS tracking for potential target cell(s)
  + CSI acquisition for potential target cell(s)
  + Note: Uplink synchronization aspect will not be discussed under this A.I.
* Detailed discussion will be commenced after receiving RAN2 LS.
* *FL note: FL doesn’t see a strong necessity to make any agreement/conclusion for this proposal at this meeting while some email discussion is expected in this meeting. The result of the email discussion will be used as a reference for RAN1#111.*
* *FL note: this issue is a high priority issue*

##### [Discussion on proposal 5-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 5-1-v1 | Response from FL |
| MediaTek | Agree with FL’s assessment that which procedure should be considered before cell switch command should be determined in RAN2. Therefore, we also prefer to wait for RAN2 decision on this topic and deprioritize the discussion in this meeting. |  |
| Google | These look to be implementation related aspects. |  |
| QC | Suggest to discuss for activated and deactivated potential target cell(s) separately. For example, all those can be performed today if potential target cell is activated Scell. Otherwise, at least CSI report for deactivated cell is not allowed now.  RAN1 to further study the potential RAN1 enhancements and spec impact to perform the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay / interruption, for activated and deactivated potential target cell(s), respectively |  |
| Fujitsu | Support |  |
| Apple | Support |  |
| DOCOMO | Suggest adding following bullet for further study.   * + Activation of TCI states for potential target cell(s) |  |
| Lenovo | Support. |  |
| New H3C | Support |  |
| NEC | Support |  |
| ZTE | Share the same view with DOCOMO, we also need to further consider activation of TCI states for candidate cell and/or activation of candidate cells. |  |
| Huawei, HiSilicon | support |  |
| CMCC | Support. We also agree to study activation of TCI states for target cells. |  |
| CATT | Support and also fine with DOCOMO’s suggestion. |  |
| ZTE | Share the same view with DOCOMO, we also need to further consider activation of TCI states for candidate cell and/or activation of candidate cells. |  |

## Other topics

### BFR for Rel-18 L1/L2 mobility

##### [Summary of contributions]

* Two companies propose enhancements for BFR in conjunction with Rel-18 L1/L2 mobility, which is to choose non-serving cell as beam failure recovery.
  + Support the UE updates the beam for channels including both dedicated and non-dedicated channels based on the newly reported beam requiring serving cell change after 28+X symbols after the UE receives the BFR response
    - X is the delay for serving cell change
  + Support beam failure recovery on resources of non-serving cell.

##### [FL observation]

BFR is not clearly described in the WID, and this enhancement is proposed by two companies in this meeting. Thus, FL would encourage proponents and interested companies to have further assessments until RAN#111, and come back based on companies’ contribution, if necessary, even though WID revision may be required for RAN1 work.

##### [FL proposal 6-1-v1]

* Companies are encouraged to further study the necessity of BFR enhancements in conjunction with Rel-18 L1/L2 mobility. The discussion can be held in the future RAN1 meetings based on companies’ contribution.
* *FL note: this issue is a low priority issue at least in this meeting*

##### [Discussion on proposal 6-1-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 6-1-v1 | Response from FL |
| Google | BFR is an important aspect for beam management, which is also part of ICBM. We failed to see any reason to preclude it. |  |
| QC | Fine to discuss BFR later |  |
| Fujitsu | Agree to discuss it later |  |
| Apple | Fine to progress first on main component of this WI to enable L1/L2-based inter-cell mobility and then discuss the potential BFR for target cell. |  |
| DOCOMO | Lower priority than other issues. |  |
| Lenovo | Agree with FL assessment. |  |
| New H3C | Support |  |
| ZTE | Agree on low priority for this issue. |  |
| LG | Agree with FL’s assessment |  |
| CATT | Agree with FL’s assessment |  |
| vivo | We share similar view with DOCOMO. |  |

### Interaction between inter-cell mTRP and L1/L2 mobility

##### [Summary of contributions]

One company points out the interaction between Rel-17 ICBM and Rel-18 L1/L2 handover, and the potential scenarios are shown in their contribution (see section 2.4 of R1-2208500). More concretely, Rel-17 ICBM can be operated before L1/L2 mobility, and inter-cell mTRP can also be activated right after the mobility. R1-2208500 proposes to clarify the possible scenario(s).

##### [FL observation]

Even though the proponent company propose to study the scenario in R1-2208500 first, FL wonders if the scenarios listed in this contribution is the major use cases to be addressed in this WI (in other word, this discussion is essential to realize Rel-18 L1/L2 mobility). Interested companies are encouraged to review section 2.4 of R1-2208500, and input their contributions in the next meetings, as necessary.

##### [FL proposal 6-2-v1]

* Interested companies to review section 2.4 of R1-2208500 and bring a contribution in the future RAN1 meetings.
* *FL note: this issue is a low priority issue at least in this meeting*

##### [Discussion on proposal 6-2-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 6-2-v1 | Response from FL |
| QC | Does this mean RAN1 will decide and send LS to RAN2 on the decision? If so, better clarify in the proposal, e.g. LS will be sent to RAN2 with RAN1 decision |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### Measurement requirements

##### [Summary of contributions]

An issue is raised by R1-2208679 regarding the measurement requirement, which mentions that the overall process can be accelerated by applying the same requirements for intra-frequency and inter-frequency measurement:

* The intra-frequency measurements used for L1/L2 mobility have the same requirements as the intra-frequency measurements
* The inter-frequency measurements used for L1/L2 mobility have the same requirements as the inter-frequency measurements.

Otherwise, the measurements could not be performed at the same time. Then, it is proposed to send an LS to RAN4 describing the accuracy requirements for the measurements used for L1/L2 mobility.

##### [FL observation]

Given the fact that inter-frequency mobility scenario has not been agreed in RAN2, it would be premature to discuss this issue. In addition, it is not clear why this discussion is triggered in RAN1. RAN2 (as a leading WG) or RAN4 should discuss this issue directly to avoid the overhead.

##### [FL proposal 6-3-v1]

* Interested companies are encouraged to bring intra-frequency and inter-frequency measurement requirement issue to RAN2 and/or RAN4.
* *FL note: this is a low priority issue at least for RAN1 from FL perspective.*

##### [Discussion on proposal 6-3-v1]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 6-3-v1 | Response from FL |
| QC | Fine for leave to RAN2/4. Some issues can be triggered by RAN1 via LS, e.g. scheduling restriction/rate matching related issues |  |
| Apple | These should be handled by RAN4 and RAN2 unless these would result in different designs in RAN1. |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Annex

# WID in RP-222332

The detailed objective of this work item is captured below:

1. To specify mechanism and procedures of L1/L2 based inter-cell mobility for mobility latency reduction:

* Configuration and maintenance for multiple candidate cells to allow fast application of configurations for candidate cells [RAN2, RAN3]
* Dynamic switch mechanism among candidate serving cells (including SpCell and SCell) for the potential applicable scenarios based on L1/L2 signalling [RAN2, RAN1]
* L1 enhancements for inter-cell beam management, including L1 measurement and reporting, and beam indication [RAN1, RAN2]
  + *Note 1: Early RAN2 involvement is necessary, including the possibility of further clarifying the interaction between this bullet with the previous bullet*
* Timing Advance management [RAN1, RAN2]
* CU-DU interface signaling to support L1/L2 mobility, if needed [RAN3]

*Note 2: FR2 specific enhancements are not precluded, if any.*

*Note 3: The procedure of L1/L2 based inter-cell mobility are applicable to the following scenarios:*

* + - *Standalone, CA and NR-DC case with serving cell change within one CG*
    - *Intra-DU case and intra-CU inter-DU case (applicable for Standalone and CA: no new RAN interfaces are expected)*
    - *Both intra-frequency and inter-frequency*
    - *Both FR1 and FR2*
    - *Source and target cells may be synchronized or non-synchronized*

1. To specify mechanism and procedures of NR-DC with selective activation of the cell groups (at least for SCG) via L3 enhancements:

* To allow subsequent cell group change after changing CG without reconfiguration and re-initiation of CPC/CPA [RAN2, RAN3, RAN4]

*Note 4: A harmonized* RRC modelling approach for objectives 1 and 2 could be considered to minimize the workload in RAN2.

1. To specify data forwarding optimizations for CHO including target MCG and target SCG in NR-DC [RAN3].
2. To specify CHO including target MCG and candidate SCGs for CPC/CPA in NR-DC [RAN3, RAN2]

* CHO including target MCG and target SCG is used as the baseline

1. To specify RRM core requirements for the following, as necessary [RAN4]:

* L1/L2-based inter-cell mobility
* Enhanced CHO configurations addressed by this WI

1. To specify RF requirements to cover inter-frequency L1/L2-based mobility, as necessary [RAN4].
2. To study the following, with completion targeted by RAN#98 meeting [RAN4]:

* The impact of FR2 RRM mobility measurement acquisition and reporting on FR2 SCell/SCG setup/resume delay for a UE connecting from idle/inactive mode.
* The level of feasible improvement in FR2 SCell/SCG setup delay from defining new UE measurement procedures and RRM core requirements, and whether additional information from the network would help the UE to perform those measurements effectively. The following sequence of events should be assumed.
  + - The UE initiates and performs improved measurements when it requests RRC connection setup/resume.
    - After acquiring those improved measurements, the UE subsequently reports those measurements to the network to support SCell/SCG setup.

# TU allocation

