**3GPP TSG RAN WG1 Meeting #111 R1-22xxxxx**

**Toulouse, France, November 14th – 18th, 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

This contribution is a Feature Lead (FL) summary for A.I. 9.12.1: L1 enhancements for inter-cell beam management.

# Plan for discussion

Detailed plan will be provided by the rapporteur.





The important topics in this meeting are listed below:

* Proposal 1-2: L1 Inter-frequency measurement (Introduction of L1 inter-frequency measurement)
* Proposal 3-1-1: Beam indication mechanism (TCI framework)
* Proposal 1-4: Measurement RS (CSI-RS)
* Proposal 5: Preparation for handover before reception of cell switch command (DL sync)

Other topics are treated depending on the situation during the meeting.

# Contact Person

Please input the contact information for each company below:

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| --- | --- | --- |
| Company | Name  | Email  |
| Qualcomm | Yan | yanzhou@qti.qualcomm.com |
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# List of Contributions

|  |  |  |
| --- | --- | --- |
| R1-2210897 | L1 enhancements for inter-cell beam management | Huawei, HiSilicon |
| R1-2210942 | L1 enhancements for inter-cell beam management | ZTE |
| R1-2211028 | Disccussion on L1 enhancements for L1/L2 mobility | vivo |
| R1-2211053 | L1 enhancements to inter-cell beam management | Ericsson |
| R1-2211083 | Views on L1 enhancements for inter-cell beam management | Fujitsu |
| R1-2211130 | On Intercell beam management enhancement for NR mobility enhancement | Google |
| R1-2211180 | Discussion on L1 enhancements for inter-cell beam management | CATT |
| R1-2211250 | Discussion on L1 enhancements for inter-cell beam management | Spreadtrum Communications |
| R1-2211297 | L1 enhancements for inter-cell beam management | Lenovo |
| R1-2211306 | Discussion on L1 enhancements for L1/L2-triggered mobility | Nokia, Nokia Shanghai Bell |
| R1-2211322 | L1 enhancements for inter-cell beam management | InterDigital, Inc. |
| R1-2211346 | Discussion on L1 enhancements for inter-cell beam management | xiaomi |
| R1-2211418 | L1 Enhancements for Inter-cell Beam Management | Intel Corporation |
| R1-2211440 | Discussions on Inter-cell beam management enhancement | OPPO |
| R1-2211702 | Discussion on L1 enhancements for inter-cell beam management | CMCC |
| R1-2211753 | Discussion on L1 enhancements for inter-cell beam management | NEC |
| R1-2211832 | L1 enhancements to inter-cell beam management | Apple |
| R1-2211873 | Enhancements on inter-cell beam management for mobility | LG Electronics |
| R1-2212004 | Discussion on L1 enhancements for inter-cell mobility | NTT DOCOMO, INC. |
| R1-2212068 | On L1 enhancements for inter-cell beam management | Samsung |
| [**R1-2212140**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_111/Docs/R1-2212140.zip) | L1 Enhancements for Inter-Cell Beam Management | Qualcomm Incorporated |
| R1-2212235 | L1 enhancements for inter-cell beam management | MediaTek Inc. |

# Discussion

## L1 measurement

### [Closed] L1 Intra-frequency measurement

##### [Conclusion at RAN1#110b-e]

Agreement

* For Rel-18 L1/L2 mobility, L1 intra-frequency measurement for candidate cell is supported
	+ At least the following aspects are for RAN1 further study:
		- RAN1 assumes Rel-17 ICBM CSI measurement as starting point.
		- Whether and how to apply relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement defined in 9.13.2 of TS38.133, where RAN4 impact is foreseen, e.g.
			* SFN offset alignment 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 intra-frequency L3 measurement
		- Commonality with L1 inter-frequency measurement for measurement configuration
* Send an LS to RAN4 (CC RAN2)
	+ RAN1 to ask RAN4 if the restriction on e.g., SFN offset alignment, BWP setting and Rx timing difference, etc, described in 9.13.2 of TS38.133 for intra-frequency L1 non-serving measurement can be relaxed or not.
	+ RAN1 assumes Rel-17 ICBM CSI measurement as starting point.

##### [Summary of contributions]

* Qualcomm: In R18 L1/L2 mobility with potential Rx timing difference > CP, similar scheduling restriction rule as for L3 intra-frequency measurement on TDD band can be reused
	+ If candidate cell for SSB measurement has DL Tx timing aligned with current serving cell
	+ No Rx/Tx also on X symbols before and after measured SSBs with X depending on BWP SCS
	+ Otherwise, no Rx/Tx on all symbols within SMTC
* Qualcomm: To reduce L1 measurement/report latency, UE capability can be introduced to measure overlapped SSBs in time
	+ In R17 inter-cell BM/mTRP, for FR2, UE is not expected to perform L1 measurement on overlapped SSBs with different PCIs. In addition, for FR2, UE is not expected to perform L1 measurement on non-serving cell SSBs overlapped with SMTC for L3 measurement.

##### [FL observation]

The follow-up proposals from RAN1#110b-e were made by one company. However, from FL point of view, the proposals shouldn’t be discussed without the reply from RAN4. Otherwise, the

Therefore, No FL proposal is made in this meeting, i.e. the discussion in RAN1 will be commenced after receiving RAN4 reply LS.

##### [Comments if any]

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| Company | Comment | Response from FL |
| QC | We are fine to discuss after RAN4 LS response |  |
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### [High1] L1 Inter-frequency measurement

##### [Conclusion at RAN1#110b-e]

Agreement

* For Rel-18 L1/L2 mobility, further study the potential RAN1 spec impact of L1 inter-frequency measurement
	+ The definition and scenarios of L1 inter-frequency measurement is determined by RAN4, and RAN1 assumes at least the following until receiving their confirmation
		- The scenarios not included in intra-frequency are regarded as inter-frequency, which includes at least the following scenarios:
			* The frequency of the measured RS not covered by any of the active BWPs of SpCell and Scells configured for a UE, but covered by some of the configured BWPs of SpCell and Scells configured for a UE.
			* The frequency of the measured RS not covered by any of the configured BWPs of SpCell and Scells configured for a UE
	+ At least the following aspect is studied:
		- Commonality with L1 intra-frequency measurement for measurement configuration
* Send an LS to RAN4 (CC RAN2)
	+ RAN1 would like to confirm our understanding that the supported scenarios not included in intra-frequency are regarded as inter-frequency, which includes at least the following scenarios:
		- The frequency of the measured RS not covered by any of the active BWPs of SpCell and Scells configured for a UE, but covered by some of the configured BWPs of SpCell and Scells configured for a UE.
		- The frequency of the measured RS not covered by any of the configured BWPs of SpCell and Scells configured for a UE
	+ It is RAN1 understanding that the introduction of measurement gap and SMTC for L1 inter-frequency measurement, if any, is expected to be a RAN4 issue
	+ Note: this content is included in the LS agreed for intra-frequency L1 measurement

##### [Summary of contributions]

While RAN2 agreed to support inter-frequency scenario for LTM, RAN1 has not agreed to introduce L1 inter-frequency measurement. In this meeting, there are a lot of proposals related to this aspect

* **Support L1 inter-frequency measurement (4)**
	+ Huawei, Fujitsu, CATT, DOCOMO
* **Deprioritize the discussion (1)**
	+ vivo: For L1 measurement and report, initially focus on intra-frequency scenarios (until the reply LS from RAN4 is received)
* **Up to RAN4 (1)**
	+ MediaTek: it’s up to RAN4 decision on the support of L1 inter-frequency measurement and the necessary information for L1 inter-frequency measurement, if supported.

While RAN1 has send an LS to RAN4 describing that measurement gap and SMTC is a RAN4 issue, there are a lot of proposals related to measurement gap and SMTC in RAN1#111

* Spreadtrum: SMTC and Measurement gap for L1 mobility need to be studied for inter-frequency L1 measurement.
* Google: Support to introduce symbol-level L1 measurement gap for SSB/CSI-RS from the neighbor cells configured for L1-RSRP/L1-SINR report or CBD.
* Lenovo: Support measurement gap for L1 beam measurement for inter-frequency L1/L2 mobility.
* Nokia: Any changes to Rel-17 based L1 CSI configuration framework, e.g., measurement gap configuration, to facilitate any relaxation to intra-frequency measurements can be discussed after RAN4 confirmation on intra-frequency measurements.
* Xiaomi: L1 measurement gap/window needs to be introduced to support inter-frequency beam measurement.
* OPPO: Support SMTC and measurement gap for L1-RSRP measurement for L1/L2 mobility.
	+ Support L1/L2-based measurement gap activation for L1 measurement for mobility.
* Qualcomm Introduce measurement gap for L1 measurement of non-serving SSB on different frequency
	+ Configured measurement gap can be linked to L1 measurement/report config
	+ L1/L2 signalling activates/triggers SP/AP L1 measurement together with measurement gap
	+ Frequency tuning period may be reserved after/before the start/end of measurement gap
* Apple: Support configuring and triggering aperiodic CSI reports associated with CSI resource sets on a non-active DL BWP of the candidate cells.

##### [FL observation]

One of the most important decisions in RAN#111 is the introduction of L1 inter-frequency measurement. This is because it has a non-marginal spec impact in RAN1 as well as RAN2/RAN4. In addition, RAN2 has already agreed to support inter-frequency scenarios for LTM. While the final decision should be made by RAN4 considering their spec impact and feasibility etc., RAN1 should decide the design principle how to support the L1 inter-frequency measurement because the allocated TUs are quite limited.

As indicated in the LS to RAN4 that has already sent after RAN1#110b-e, RAN1 has no immediate action on the measurement gap and SMTC. The discussion can be commenced after received RAN4 reply LS.

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

* For Rel-18 LTM, L1 inter-frequency measurement is supported from RAN1 point of view.
	+ Final confirmation shall be performed by RAN4.

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

Please provide your comments on the FL proposal above, if any.

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| Company | Comment to proposal 1-1-v1 | Response from FL |
| QC | Fine for FL’s proposal 1-2-v1. Btw, the table title should be updated? To our knowledge, RAN4 may revert the RAN1 definition of both L1 intra and inter-frequency measurements. So better to wait for RAN4 LS response |  |
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### [Closed] Support of L3 measurement

##### [Conclusion at RAN1#110b-e]

The following offline consensus was reached during the email discussion.

* 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.*

##### [Summary of contributions]

Huawei made the following proposal, which means (if FL understands correctly) that an LS to RAN3 is send to confirm their understanding

* Confirm the RAN3 understanding that L3 measurement is used by gNB-CU in the preparation phase to determine the L1/L2 mobility configuration, including the L1 measurement and report configuration.

##### [FL observation]

As discussed and concluded at RAN1#110b-e, FL doesn’t see strong need to trigger the discussion on LS. FL believes that this is the role of leading WG (i.e. RAN2), and hence there is no FL proposal under this section.

##### [Comments if any]

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| Company | Comment to proposal 1-3-v1 | Response from FL |
| QC | Fine for FL’s above observation. Btw, the table title “Proposal 1-3-v1” may need to be updated |  |
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### [High3] Measurement RS

##### [Conclusion at RAN1#110b-e]

The following agreement was made in GTW on Oct 12. With this, the email discussion of this section is closed.

Agreement

* For Rel-18 L1/L2 mobility,
	+ SSB is supported for L1 intra-frequency measurement
	+ SSB is supported for L1 inter-frequency measurement if inter-frequency L1 measurements are supported
* Further study the following L1 measurement RS for candidate cell
	+ CSI-RS for tracking, beam management, CSI and mobility, CSI-IM, which is for L1 intra-frequency and L1 inter-frequency (if supported)

##### [Summary of contributions]

There were a lot of discussion on the support of CSI-RS type for L1 measurement.

* **Support CSI-RS for beam management (9):** ZTE, vivo, Nokia (as a starting point), Intel, CMCC (for intra-frequency), Apple, DOCOMO, (Samsung – for study), Qualcomm
	+ to enable more accurate L1 measurement for candidate cell and improve demodulation performance
	+ CSI-RS based BM provides more flexibility in terms of narrower beamwidth, time-domain location (e.g., aperiodic transmission) and frequency allocation (e.g., larger number of RBs), which can be tailored for a specific UE to fine tune and refine its beam during LTM procedure.
		- this transparent approach for non-serving cell CSI-RS based measurement is operated with certain restrictions at the non-serving cell, which include an aligned Point A configuration, a same SCS, an aligned center frequency and SFN offset with the serving cell
* **Support CSI-RS for tracking(5)**: ZTE, vivo, DOCOMO, (Samsung – for study), Qualcomm
	+ to enable more accurate L1 measurement for candidate cell and improve demodulation performance
* **Support CSI-RS for** **Mobility(3)**: ZTE, OPPO, Samsung
* **Support CSI-RS for CSI(2)**: vivo, DOCOMO
* **Support CSI-RS for** **CSI-IM(2)**: CMCC, DOCOMO
	+ for interference measurement for intra-frequency (up to RAN4 for inter-frequency)

Another discussion is if CSI-RS can be supported for L1 inter-frequency measurement.

* Apple: Support CSI-RS for beam management for L1 intra-frequency and inter-frequency measurement.
* Nokia: For the inter-frequency measurements of candidate cell(s), depending on the RAN1 agreements on L1-RSRP or/and L1-SINR using SSBs or/and CSI-RSs, RAN4 would need to define inter-frequency measurements requirements for each of the supported RAN1 scenario (e.g., L1-RSRP using SSB, L1-RSRP using CSI-RS, L1-SINR using SSB, L1-SINR using CSI-RS)
* Qualcomm: Support TCI state configuration per CSI-RS resource at least for L1 inter-frequency measurement

##### [FL observation]

Regarding the support of CSI-RS for L1 measurement, the number of companies’ input was not sufficient to decide the majority for some types, unfortunately. If CSI-RS is supported for L1 measurement, CSI-RS for beam management can be supported considering the interest from companies (and also technically reasonable). On the other hand, the necessity to support other types is not clear at this moment.

On the other hand, support of L1 inter-frequency measurement requires RAN4 assessments. Therefore, even though its support can be agreed in RAN1 from RAN1 perspective, final decision cannot be made without RAN4 guidance.

Given the analysis above, the following FL proposal can be made.

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

* For Rel-18 LTM,
	+ CSI-RS for beam management is supported for L1 intra-frequency measurement.
		- Applicability to L1-RSRP and/or L1-SINR is separately discussed.
		- FFS for the support of other CSI-RS types (i.e. tracking, CSI, mobility and CSI-IM).
	+ CSI-RS for beam management is supported for L1 inter-frequency measurement
		- Applicability to L1-RSRP and/or L1-SINR is separately discussed.
		- Final decision will be made after RAN4’s confirmation.
		- FFS for the support of other CSI-RS types (i.e. tracking, CSI, mobility and CSI-IM).

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

Please provide your comments on the FL proposal above, if any.

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| Company | Comment to proposal 1-4-v1 | Response from FL |
| QC | Fine for FL’s proposal 1-4-v1 as starting point |  |
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### [Mid] Measurement quantity

##### [Conclusion at RAN1#110b-e]

Agreement

* For candidate cell measurement for Rel-18 L1/L2 mobility,
	+ L1-RSRP is supported for intra-frequency candidate cell measurement.
	+ Further study the following measurement quantities for candidate cell measurement
		- L1-RSRP for inter-frequency (if supported)
		- L1-SINR for intra-frequency and inter-frequency (if supported)
* FFS: to assess the use case and the benefit of UL measurement instead of/in addition to DL L1 measurement, which includes:
	+ How the UL measurement result is used, e.g. handover decision
	+ Signals/channels used for UL measurement, e.g. SRS
	+ Spec impact including other WGs, e.g. definition of gNB measurement, interface to transfer RS configuration or measurement results
	+ Note: The next discussion will take place based on companies’ contribution in future meeting.

##### [Summary of contributions]

* **Whether to support L1-RSRP for inter frequency**
	+ Support (8): Ericsson, Google, Spreadtrum, Nokia, CMCC, DOCOMO, Samsung, Qualcomm
	+ Not support (0)
* **Whether to Support L1-SINR, especially beneficial for inter-frequency**
	+ Support SSB-based L1-SINR (1): Huawei
	+ Support CSI-RS based(3): vivo (CSI-IM based, synchronous scenario), CMCC (for intra-frequency), DCM, (intra- and inter-frequency)
	+ Support L1-SINR but RS is not clearly indicated (3); Google, Nokia (as CU can make appropriate CMR and IMR configuration using serving and all the selected candidate cells’ RS configuration information), vivo (As for reporting metrics, besides L1-RSRP already supported in Rel-17, we think the interference caused by neighbor cells also needs to be considered.)
	+ For further study (1): Samsung(reliability and latency of L1-SINR measurement metric for L1/L2 mobility.)
	+ Not support (2): Intel (L1-RSRP may be sufficient to facilitate inter-cell beam management for L1/L2 based mobility), Qualcomm (L1-SINR may not be suitable for short-term beam/cell selection if the interference is unpredictable, e.g. due to bursty traffic of neighbour cell/UE.)
* **Support of UL measurement**
	+ Support (1)
		- vivo: DL measurement causes a large delay and requires a high computing capability at the UE, especially when the number of candidate cells for L1 measurement is large, and support UL measurement to reduce measurement delay and UE computation complexity for L1/L2 mobility
	+ Concern/low priority(5)
		- Huawei: deprioritize – resource coordination and network synchronization issue
		- Ericsson: Concern, RS transmission overhead, implementation based solution can work
		- Nokia: UL measurement based LTM may be studied later.
		- Intel: DL may be sufficient to facilitate inter-cell beam management for L1/L2 based mobility
		- Samsung: Uplink measurements for L1/L2 mobility are performed by gNB and hence be left for network implementation.

##### [FL observation]

There is clear majority on the support of L1-RSRP for L1 inter-frequency measurement, which looks agreeable in RAN1#111.

Meanwhile, the companies’ position on the L1-SINR is not converged, especially the following points:

* Benefit
	+ Clear for inter-frequency, but not sure for intra-frequency (L1-RSRP is sufficient?)
* Reliability of SINR measurement result
	+ L1 measurement is an instantaneous value while interference situation varies in time.
* Complexity/Impact to RAN4
	+ RAN4 needs to work depending on the scenarios (e.g., L1-RSRP using SSB, L1-RSRP using CSI-RS, L1-SINR using SSB, L1-SINR using CSI-RS)

Given this situation, FL recommends further discussion on the necessity/feasibility of L1-SINR for both intra- and inter-frequency scenarios.

As for UL measurements, the situation is clear that majority’s view is not to spend RAN1 time on this issue. We can put this issue on hold and commence the discussion based on the companies’ contribution.

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

NOTE: This proposal has a dependency on FL proposal 1-4

* For candidate cell measurement for Rel-18 LTM,
	+ For intra-frequency L1-RSRP,
		- SSB-based measurement is supported
		- CSI-RS-based measurement is supported, where CSI-RS type is beam management
			* FFS for other CSI-RS type
	+ L1-RSRP is supported for inter-frequency candidate cell measurement.
		- SSB-based measurement is supported
		- CSI-RS-based measurement is supported, where CSI-RS type is beam management
			* FFS for other CSI-RS type
	+ FFS for the support of L1-SINR, and the following aspects are considered:
		- Support of intra- and inter-frequency
		- Measurement RS, SSB and/or CSI-RS (and its type)
		- The accuracy of interference measurement
		- Complexity and feasibility from RAN4 perspective

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

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| Company | Comment to proposal 1-5-v1 | Response from FL |
| QC | Fine for FL’s proposal 1-5-v1 as starting point |  |
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### [Low] Filtering for L1 measurement results

##### [Conclusion at RAN1#110b-e]

FL proposal below was not agreed and postponed to the further RAN1 meeting.

* For Rel-18 L1/L2 mobility, [study the importance of mitigating the ping-pong issue for L1/L2 mobility, which is expected to align with RAN2. If important ~~yes~~,] further study at least the following mitigation aspects: FL: A concern was raised if RAN1 can perform a proper study on ping-pong issue, CATT, Samsung, LG wants to keep it. FL thinks we can keep it as long as companies say they can perform their analysis,
	+ UE-based filtering to the L1 measurement results, where the definition of filtering includes:
		- Time domain filtering: e.g. exact definition of time domain filtering, and/or
		- Cell-level (spatial domain) filtering: e.g. how many beams are averaged, and/or how the beams are chosen.
	+ Applicability to L1-RSRP and L1-SINR (if supported)
	+ Applicability to intra-frequency and inter-frequency (if supported)
	+ Necessity to be specified in standard considering the presence of alternative implementation-based solutions, e.g. gNB-based filtering and/or L3 measurement (when involved)

##### [Summary of contributions]

**L1 filtering is necessary (5)**

* CATT: L1 cell-level measurement result, i.e. spatial filtered L1-RSRP, should be supported in addition to the beam-level L1-RSRP.
* Lenovo: Proposal 4 Study to introduce filtered L1-RSRP and cell-level measurement results in L1 beam reporting for L1/L2 mobility triggering
* OPPO: The L1-RSRP measurement for L1/L2 inter-cell mobility shall be filtered.
* Intel: see their observation below: on ping-pong issue
* Nokia: see their observation below: on ping-pong issue

**L1 filtering is not necessary (4)**

* Huawei: just introduce delay, robustness is achieved by L3 measurement in preparation phase
* vivo: Support gNB-based filtering to mitigate the ping-pong effect.
* Spreadtrum: Time domain filtering to L1-RSRP can be implemented by gNB.
	+ Cell-level filtering to L1-RSRP can be further studied.
	+ Xiaomi: There is no need to further apply filtering to L1 measurement results.
* MediaTek: UE-based filtering to L1 measurement results is not supported.
	+ the ping-pong effect seems to be a minor issue from Rel-18 mobility enhancement point of view and further optimization on the L1 measurement filtering might hinder the dynamic cell switching procedure.
	+ network can apply further L1 measurement filtering before sending the cell switching command to address the ping-pong effect.

**Analysis on ping-pong issue**

* ZTE: It is recommended that RAN1 send an LS to RAN2 to confirm and clarify the importance of ping-pong issue and impact on Rel-18 L1/L2 triggered mobility.
* vivo: For inter-DU cases, frequent cell switches may lead to lower efficiency.
* CATT: Ping-pong effect needs to be solved to avoid frequent cell switch.
* Nokia: Evaluation results are shown and the following observations and proposal is made:
	+ Filtering the L1 beam measurements can decrease the number of ping-pongs substantially for LTM.
	+ The cost of ping-pong is higher for inter-DU than intra-DU case in terms of signalling overhead and latency in re-transmitting the pending packets.

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| (a) | (b) | (c) |

* + Figure 1 Performance evaluation of L1 LTM and L1-F LTM with respect to (a) Ping pongs, (b) RLFs, and (c) RLPs (R1-2211306)
	+ Different L1 filtering configurations are supported for different groups of cells, where one group can contain the candidate cells belong to serving DU and another group can contain the candidate cells belong to different DU than the serving DU.
* Intel
	+ L1 based handover modelling suffers from ping-pong effect especially when impairments such as UE rotation is considered. To this end, time and spatial domain filtering for L1-RSRP reporting and UE triggered serving cell change event might need to be considered. Additionally, it should be clarified how L1/L2 based handover co-exists with current L3 handover framework?
* CMCC
	+ we propose do defer the issue of filtering until more details of candidate cell detection and handover latency reduction have been determined.

##### [FL observation]

The companies view on the necessity of filtering (for both time domain and cell level) at UE side for L1 measurement results.

* Companies’ view on the necessity of the filtering for L1 measurement results is equally split.
* Other solution is available (e.g. filtering by gNB, use of L3 measurement for preparation)
* An evaluation results showed that the number of ping-pong can be reduced by the filtering.
* The negative impact caused by frequent ping-pong needs more discussion because RAN1 is currently not sure the consequence.
	+ No problem for intra-DU case
	+ How about inter-DU case?
* RAN2 should perform the evaluation. However, RAN2 LS mentioned that *“RAN2 assumes that RAN1 will drive discussions on L1 measurement enhancements, if any. If RAN1 identifies the need for e.g. event reporting, filtering etc, RAN2 can then be involved if needed.”*, and hence FL thinks RAN1 needs to a common understanding on the necessity. Otherwise, our request will just drain RAN2’s precious time.
* The decision should be deferred until the other aspects are clarified (candidate cell detection, handover latency reduction techniques etc.)

Given the analysis above, FL thinks no progress or only a small step on this topic is expected in RAN1#111. Thus, FL would like to ask interested companies to provide their preference on the approach below.

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

Companies are encouraged to show their preference from the following approach. If majority of the companies support approach 2 or 3, FL will promote it to the FL proposal. Note that this topic has lower priority given the interest level.

* + Approach 1:
		- Do nothing at RAN1#111 (No conclusion, No agreement)
		- Continue discussion based on the contributions at RAN1#112
		- Companies are encouraged to update their contributions based on the FL observation above.
	+ Approach 2:
		- Send an LS to RAN2 to ask for their analysis on ping-pong issue, and RAN1 discussion will be performed based on their reply.
	+ Approach 3:
		- Try the same FL proposal made at RAN1#110b-e (i.e. FL proposal 1-6-v5 in RAN1#110b-e below) with necessary modification (i.e. yellow shadow part)
* For Rel-18 L1/L2 mobility, study the importance of mitigating the ping-pong issue for L1/L2 mobility, which is expected to align with RAN2. If important, further study at least the following mitigation aspects:
	+ UE-based filtering to the L1 measurement results, where the definition of filtering includes:
		- Time domain filtering: e.g. exact definition of time domain filtering, and/or
		- Cell-level (spatial domain) filtering: e.g. how many beams are averaged, and/or how the beams are chosen.
	+ Applicability to L1-RSRP and L1-SINR (if supported)
	+ Applicability to intra-frequency and inter-frequency (if supported)
	+ Necessity to be specified in standard considering the presence of alternative implementation-based solutions, e.g. gNB-based filtering and/or L3 measurement (when involved)

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

Please provide your comments on the FL proposal above, if any.

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| --- | --- | --- |
| Company | Comment to proposal 1-6-v1 | Response from FL |
| QC | We are fine for either Approach 2 or 3. Ping-pong effect should be controlled, since the cell switch latency can be much longer than R17 beam switch latency, e.g. X ms vs a few slots. In addition, using filtering at gNB may not be efficient in the context of event-triggered report, where UE only reports when filtered metric across threshold to save unnecessary report. Finally, spatial filtering is not only for Ping-pong but also useful for UE to rank the cells and report up to X best cells to save reporting overhead. So we suggest to have a separate proposal to discuss whether cell level L1 metric based on spatial filtering across multiple beams per cell are needed in the context of reporting overhead reduction  |  |
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### [Mid] Configurations for L1 measurement

##### [Conclusion]

FL proposal 1-7-v5 was discussed in the GTW on Oct-19 and following proposal was agreed.

Agreement

* Send an LS to RAN2/RAN3 asking the clarification on intra-/inter-DU scenario:
	+ RAN1 has started the discussion on the configuration for L1 measurement and TCI states for candidate cells. Regarding the following RAN2 agreements captured in RAN2 LS (R1-2208331/R2-2209257), it is not clear for RAN1 which kind of information/configuration for candidate cell(s) are available at a serving cell for inter-DU case for Rel-18 L1/L2 mobility. Thus, companies have different understanding on the implication of the sentence “as much commonality as reasonable” in the LS.
		- *The design for intra-DU and inter-DU L1/L2-based mobility should share as much commonality as reasonable. FFS which aspects need to be different.*
	+ RAN1 respectfully asks RAN2 and RAN3 if the serving DU knows the measurement RS configuration and TCI state configuration of cells served by another DU

For other part (below), RAN1 was not able to reach the consensus, so the remaining proposal is postponed to the future RAN1 meeting.

* 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., candidate cells), which is 7 for Rel-17 ICBM
		- ~~[~~Note: this includes the concept not to indicate any PCIs for L1 measurement~~]~~ FL: Let’s keep this bullet as there is a clear request from a company, but several companies want to delete it
	+ Whether to change the maximum number of RSs associated with each candidate cell that can be configured for L1 measurement, which is 64 for Rel-17 ICBM
		- ~~[~~Note: this includes the concept not to indicate any RSs for L1 measurement~~]~~ FL: Let’s keep this bullet as there is a clear request from a company, but several companies want to delete it
	+ Whether the RSs for the measurement per candidate cell is configured under the corresponding candidate cell, or under the serving cell configuring the L1 measurement/report FL:QC proposal (including sub-bullet). Apple thinks RAN1 can study first
	+ Whether to introduce enhancements for L1 measurement to avoid a large amount of active measurement configurations or frequent reconfiguration, e.g.
		- MAC CE to activate/deactivate beam(s)/cell(s) for L1 measurement
		- ~~[Reuse the existing mechanism, e.g. L3 measurement and report (if involved), which has no RAN1 spec impact]~~ FL: Now Huawei is OK to delete it if it is the common understanding that no enh is an option
	+ How to accommodate L1 inter-frequency measurement (if agreed)
	+ FFS until LS reply from RAN2 and 3 is received: Whether and how to ensure the commonality of the configuration between intra- and inter-DU case.
	+ Information required for configuring the measurement RS

##### [Summary of contributions]

**Structure for L1 measurement configurations**

* Classification of the configuration structure (proposed by ZTE and Option-4 is added by FL) – Key aspect is how to support L1 inter-frequency measurement
	+ Option-1: Follow CSI measurement configuration specified in Rel-17 ICBM
		- CSI-MeasConfig for serving cell and non-serving cell, which requires inter-DU coordination
		- For inter-frequency, introduce the frequency information, SMTC or measurement gap (MG) with candidate cell
	+ Option-2: Introduce an independent measurement configuration for all candidate cells, which is decoupled with serving cell configuration.
		- L1 measurement resource set can be configured outside ServingCellConfig or CellGroupConfig
		- The benefit to do this is to build a lighter and more flexible RRC configuration structure to avoid duplicate configuration of L1 measurement resource for candidate cells in subsequent cell switch scenario.
	+ Option-3: Measurement configuration for each candidate cell
		- L1 measurement resource set can be configured inside ServingCellConfig or CellGroupConfig
		- This approach can avoid to introduce new signaling to let serving DU know the measurement configuration of candidate cell served by candidate DU
	+ Option-4: Do not include RS information in measurement configuration for candidate cells
		- For intra-frequency, neither SSB indices nor PCI is configured.
		- For inter-frequency, neither SSB indices nor PCI is configured, but frequency information is configured
* Preference by each company
	+ Option-1(6)
		- ZTE: Rel-17 ICBM measurement framework can be considered as good starting point for measurement configuration of Rel-18 L1/L2 triggered mobility.
		- Fujitsu: L1 measurement configuration is independent of candidate configuration.
			* For L1 measurement configuration, at least PCI and/or RS-ID for candidate cells should be indicated to a UE.
		- Nokia: Rel-17 based L1 CSI configuration framework can be reused for Rel-18 LTM L1-RSRP intra-frequency measurements on SSB(s) of candidate cell(s) if there is no change in the RAN4 requirements for L1-RSRP intra-frequency measurements using SSB(s) for a non-serving cell.
		- Apple: Support to add the ARFCN value, SCS and measurement gap information into the Rel-17 CSI measurement configuration for inter-frequency L1 measurement.
		- DOCOMO: Rel-17 ICBM CSI configuration framework is starting point for L1 intra-frequency and inter-frequency measurement configuration.
			* Support to explicitly configure cell index for SSB/CSI-RS in CSI configuration signaling.
		- MediaTek: For Rel-18 L1/L2 mobility, reuse Rel-17 ICBM CSI measurement framework for L1 intra-frequency measurement.
	+ Option-2(1)
		- Huawei: Support to explicitly configure the measurement resources for neighbor cell independently from serving cell’s resources for L1/L2 mobility.
			* Rel-17 ICBM flamework does not work for inter-frequency
			* The configuration method for CSI-RS in Rel-17 ICBM is even more challenging to support L1 inter frequency and asynchronous deployment, if supported.
	+ Option-3(1)
		- xiaomi: It is better to configure the measurement RSs of each candidate cell under the corresponding candidate cell configuration.
	+ Option-4(1)
		- Ericsson: The LTM intra-cell measurements on SSB do not require explicit configuration of PCIs, or SSB indices.The LTM inter-cell measurements on SSB only require the configuration of a target frequency.

**Number of measurement PCIs**

* DOCOMO: For the maximum number of candidate cells for L1 measurement/reporting,
	+ Support 7 (same as Rel-17 ICBM) for intra-frequency measurement
	+ Support to study larger value than 7 for inter-frequency measurement

**Number of measurement RSs**

* No input from companies

**RRC Configuration + activation to limit the number of measurements**

* ZTE: From UE energy consumption point of view, support selection of candidate cells from pre-configured candidate cell pool by RRC.
	+ Optionally, TCI state(s) associated with the selected candidate cell can be determined simultaneously.
* vivo: Support dynamic indication of the set of candidate cells or RSs for L1 measurement by MAC CE to achieve an efficient L1 measurement for L1/L2 cell switch.
* CATT: MAC-CE would activate/deactivate the measurement of reference signals (e.g. SSB, CSI-RS for mobility, CSI-RS for beam management) of certain candidate cells.
* Nokia: Consider mechanisms to activate subset of configured set of reference signals/reporting configurations to be active for L1 reporting of LTM candidate cells.
* DCM: Support to study MAC CE based activation/deactivation of candidate beams/cells for L1 measurement.
* Qualcomm: Support MAC-CE activation of L1 report for a set of PCIs
	+ Related measurement/reporting config may also be updated by the MAC-CE

**Support of inter-frequency (also discussed in the configuration structure discussions)**

* Nokia: Interaction with RAN4 reply LS
	+ Any changes to Rel-17 based L1 CSI configuration framework to support inter-frequency measurements can be discussed after RAN4 confirmation on intra-frequency measurements.

**Other aspects**

* Nokia: Configuration for CSI-RS for L1 measurement (FL note: can be discussed after the introduction of CSI-RS for L1 measurement is agree)
	+ To configure the NZP-CSI-RS measurements from candidate cell, reuse the Rel-17 principle of QCL chain for associating NZP-CSI-RSs with specific PCI.
	+ If CSI-RS measurements with a candidate cell are supported, RAN1 to study mechanism(s) to configure or/and measure CSI-RSs of candidate cell relevant to the measuring UE.
		- Without any additional information of the UE (e.g., location), after receiving the request from the serving cell (via CU), candidate cell’s CSI-RS configuration may not contain CSI-RSs relevant for the measuring UE.

##### [FL observation]

Even though we couldn’t reach the consensus in RAN1#110b-e, more detailed proposals are shown up in this meeting, which means that the same proposal in the last meeting needs not to be challenged and we can go one step farther.

* More detailed structure for measurement configurations
	+ How to support inter-frequency is considered there.
	+ Note that the RAN1 can discuss the overall direction, but the final decision shall be made by RAN2.
* MAC CE activation for L1 measurement configurations
	+ 6 companies showed their interest on its introduction
* Number of configured PCIs and RSs for L1 measurement
	+ It has a dependency on the structure for measurement configurations
* Configuration for CSI-RS
	+ This issue can be discussed after the introduction of CSI-RS for L1 measurement is agreed

Given the companies’ input, the FL proposal from RAN1#110b-e can be updated.

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

* For Rel-18 LTM, further study the following structure for L1 measurement configurations.
	+ Option-1: Follow CSI measurement configuration specified in Rel-17 ICBM
		- CSI-MeasConfig for serving cell and non-serving cell, which requires inter-DU coordination
		- For inter-frequency, at least the frequency information, SMTC or measurement gap (MG) with candidate cell are additionally introduced
	+ Option-2: Introduce an independent measurement configuration for all candidate cells, which is decoupled with serving cell configuration.
		- L1 measurement resource set can be configured outside candidate cell configurations (i.e. ServingCellConfig or CellGroupConfig)
	+ Option-3: Reuse measurement configuration for each candidate cell
		- L1 measurement resource set can be configured inside candidate cell configurations (i.e. ServingCellConfig or CellGroupConfig)
	+ Option-4: Do not include neither RS information nor cell information in measurement configurations
		- For intra-frequency, neither SSB/RS indices nor PCI is configured.
		- For inter-frequency, neither SSB/RS indices nor PCI is configured, but frequency information is configured
* Depending on the decision on structure for L1 measurement configurations, the following aspects are further discussed
	+ The maximum number of additional cells (i.e., candidate cells), which is 7 for Rel-17 ICBM
	+ The maximum number of RSs associated with each candidate cell that can be configured for L1 measurement, which is 64 for Rel-17 ICBM
	+ Introduction of MAC CE to activate/deactivate beam(s)/cell(s) to perform L1 measurement
	+ Information required for configuring the measurement RS

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

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| Company | Comment to proposal 2-1-v1 | Response from FL |
| QC | Fine for FL’s proposal 1-7-v1 as starting point. Btw, the table title “2-1-v1” may need to be updated |  |
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### [Paused] LS to RAN2,3 and 4

##### [FL observation]

TBD

##### [FL proposal 1-8-v1]

TBD

##### [Discussion on proposal 1-8-v1]

Please input your view in the table below:

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| Company | Comment to proposal 1-8-v1 | Response from FL |
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##  L1 measurement reporting

### [Mid] Container/format of L1 measurement reporting

#####  [Conclusion at RAN1#110b-e]

Agreement

* For L1 measurement report for Rel-18 L1/L2 mobility, further study the following mechanisms:
	+ Report as UCI on PUCCH or PUSCH
		- Periodic report on PUCCH, semi-persistent report on PUCCH/PUSCH, and aperiodic report on PUSCH
		- Potential enhancements to Rel-17 ICBM report format to accommodate Rel-18 scenarios, e.g.
			* Inter-frequency measurement, if supported
			* Increasing the maximum number of reported beams, which is 4 for Rel-17 ICBM
			* Flexible size beam report, e.g., two-part UCI (e.g., the 1st part contains the best beam/cell and the number (e.g., N) of reported beams/cells, the 2nd part contains the rest (N-1) beams/cells
			* Reducing the reporting overhead by e.g. choosing beams/cells per frequency or across frequencies to report (FFS how)
	+ Report on MAC CE
		- Both gNB scheduled and/or UE initiated (if supported) report are studied

##### [Summary of contributions]

**L1 measurement reporting on PUCCH/PUSCH (9)**

* Huawei: Periodic report on PUCCH, semi-persistent report on PUCCH/PUSCH, and aperiodic report on PUSCH for L1 measurement for L1/L2 mobility should be supported.
* Fujitsu: For L1 measurement report, at least report as UCI on PUCCH or PUSCH is supported.
	+ Periodic report, semi-persistent report and aperiodic report are supported.
* Google: Support beam report as UCI on PUCCH/PUSCH for NW-triggered beam report.
* Spreadtrum: For L1 measurement report of L1/L2 mobility on PUCCH or PUSCH, periodic report on PUCCH, semi-persistent report on PUCCH/PUSCH, and aperiodic report on PUSCH can be supported.
* Nokia: Support all the CSI reporting time types for Rel-18 LTM: aperiodic, semi-persistent, periodic
* Apple: Support periodic, semi-persistent and aperiodic L1 measurement reporting for candidate cells as UCI on PUCCH and PUSCH.
* Samsung: For L1 measurement report for Rel-18 L1/L2 mobility, the container for the beam measurement report is UCI on PUCCH or PUSCH. The beam measurement report can include K groups of SSBRI (or CRI)/L1 metric/Capability Index, using a format similar to that of Rel-17 inter-cell measurement report.
	+ The size of report can be up to: (6 (field for SSBRI or CRI) + 7 (field for first L1-metric)+2(Capability Index)) + (4(value of K) – 1) \* (6 (field for SSBRI or CRI) + 4 (field for remaining L1-metric) +2(Capability Index)) = 51 bits. If the size of the report were to increase for L1/L2 mobility for example having K=6 and 7 bits for the SSBRI/CRI field, the size of the report would be less than 100 bits
* Qualcomm: Support gNB scheduled L1 report on UCI, which can be carried in PUCCH/PUSCH
	+ for gNB scheduled report, the advantage seems unclear for gNB scheduled L2 report on MAC-CE, compared with gNB scheduled L1 report on UCI
* CATT: For NW initiated L1 measurement report, MAC-CE based report is **not** needed.
	+ PUCCH and PUSCH based report is enough in our point of view

**L1 measurement reporting on MAC CE(2)**

* Ericsson: The beam reporting for LTM is performed over MAC.
	+ the size of the report could then easily be 200 bits, if e.g. inter-frequency measurement is included. additional reliability from the retransmissions
* OPPO: Support to report L1 measurement for L1/L2 mobility through MAC CE.
	+ using UCI mechanism to report mobility measurement would cause large waste the uplink PUCCH resource
	+ The reporting payload of measurement of L1/L2 mobility could be general large. Reporting in UCI could cause reliability issue.

**How to support L1 inter-frequency measurement report**

* Nokia: To support inter-frequency measurements, a frequency identifier is needed either in the CSI report config or in the L1 reporting.
* Samsung: Study the following alternatives for the L1 measurement report taking into account the timing of respective measurements:
	+ Alternative 1: A common measurement report for L1 intra-frequency measurement and L1 inter-frequency measurement.
	+ Alternative 2: Separate measurement reports for L1 intra-frequency measurement and L1 inter-frequency measurement.
* Qualcomm: For L1 inter-frequency measurement, support UE to report X best candidate cells across all measured frequencies with Y best beams per reported candidate cell in the same report
	+ X and Y can be configured subject to corresponding UE capabilities
* Ericsson: The beam measurement reports to assist LTM include measurement information on serving and target cells.
* xiaomi: The L1 measurement results of serving cell and candidate cells can be reported together or separately based on Network configuration

**Number of reporting beams**

* ZTE: In a single reporting instance, the maximum number of reported beam can be 4 for Rel-18 L1/L2 triggered mobility, which is same with Rel-17 ICBM.
* vivo: Support a number of the reported beams larger than 4 for L1 report and the exact value is FFS.
* CATT: The maximum value of K, i.e. the number of beams associated at least with candidate cell(s) reported in a single CSI reporting instance, could be larger than 4.
* Nokia: As a starting point, the maximum number of reported RS in a single reporting instance is 4.

**Reporting format**

* ZTE: The format of beam based measurement reporting specified in Rel-17 ICBM can be reused for Rel-18 L1/L2 triggered mobility
* Ericsson: entry in the measurement report would need at least 23 bits.
	+ 16bits to identify measurement target, 7bits for RSRP quantization
* xiaomi: How to distinguish the measurement results of each cell should be specified if L1 measurement results of serving cell and candidate cells are reported together.

**Support of flexible-size report**

* vivo: Support flexible-size beam report to accommodate the larger number of beam reports.
* Samsung: Support reporting a variable number of SSBRI (or CRI)/RSRP/Capability index groups, wherein a UE reports in a single reporting instance a two-part beam report using the two-part UCI structure.
	+ Part 1 includes the beam measurement(s) for the serving cell and indicates the size of part 2
	+ Part 2 includes the remaining beam measurement(s)

**Selection of the L1 measurement results**

* Qualcomm:
	+ For L1 intra-frequency measurement, support UE to report X best candidate cells with Y best beams per reported candidate cell in the same report
		- X and Y can be configured subject to corresponding UE capabilities
	+ To reduce L1 report overhead, L1 cell-level metric can be introduced to rank and select X best measured candidate cells for reporting
		- L1 cell-level metric can be linear average of Y>1 best beams per cell, e.g. Y=2 or 3
* Huawei: Support the beam group based reporting, i.e. grouping resources by cell and UE need to report best N beams for each group in a single reporting instance.

##### [FL observation]

**Container (UCI on PUSCH/PUCCH or on MAC CE)**

Majority of companies (9) support UCI on PUSCH/PUCCH based approach along with the Rel-17 ICBM mechanism. Meanwhile, 2 companies proposed to support MAC CE based approach because of the capacity and reliability reason. FL understands that the container discussion may have a dependency on the structure discussion for L1 measurement configuration. From FL point of view, there is no strong reason to support two different containers for NW initiated report.

**How to support L1 inter-frequency measurement report**

The first step discussion would be whether or not a common measurement report is used for L1 inter-frequency and intra-frequency measurement report (this includes the possibility of network configurability). Given the contributions in this meeting, majority companies think a common measurement report can be used. Further optimization e.g. how to choose the L1 measurement result among the candidate cells, can be discussed as the next step.

**Number of reporting beams**

As for the number of reporting beams, 2 companies proposed to extend the number from 4, which is supported for Rel-17 ICBM. But it is not clear at this moment if there is a strong need for other value. FL’s proposal is to support at least 4 and additional value can be discussed later.

**Reporting format**

The common understanding is that the same format as Rel-17 ICBM can be reused, which means RS identifier, 7 bit L1-RSRP(L1-SINR) value should be included. The bit size for identifier needs more discussion because the necessity of frequency information, PCI and SSB/RS identifier depends on other discussions.

**Support of flexible-size report**

Currently only 2 companies showed their interest on flexible-size report. This topic can be discussed after other aspects above is concluded

**Selection of the L1 measurement results**

Currently only 2 companies showed their interest on Selection of the L1 measurement results. This topic can be discussed after other aspects above is concluded

FL would like to suggest having a progress on Container (UCI on PUSCH/PUCCH or on MAC CE) and the following proposal is made:

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

* For L1 measurement report for Rel-18 LTM, report as UCI on PUCCH or PUSCH is supported
	+ Support periodic report on PUCCH, semi-persistent report on PUCCH/PUSCH, and aperiodic report on PUSCH
	+ In a single report instance, report for serving cell and candidate cell(s) for intra-frequency and/or inter-frequency can be included.
* FFS for report on MAC CE for gNB scheduled report

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

Please provide your comments on the FL proposal above, if any.

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| Company | Comment to proposal 2-1-v1 | Response from FL |
| QC | Fine for the proposal. But suggest to add the following FFS items. For gNB scheduled MAC-CE, we don’t see any benefit compared with gNB scheduled UCI. But we can live with it as FFS- In a single report instance, report for serving cell and candidate cell(s) for intra-frequency and/or inter-frequency can be included.* FFS: Whether/how to select reported cell(s)/beam(s) among all measured cell(s)/beam(s) for this report

- FFS for report on MAC CE for gNB scheduled and/or UE initiated report |  |
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### [High5] UE/event triggered report for L1 measurement results

##### [Conclusion at RAN1#110b-e]

The following proposal was made just before the checkpoint of Oct 19. However, this proposal was not agreed due to the lack of review time (less than 20~24hours). Interested companies are asked to take this proposal into consideration for RAN1#111. With this, the discussion of this section is closed.

* For L1 measurement report for Rel-18 L1/L2 mobility, interested companies are encouraged to further study whether UE/event triggered report for L1 measurement results is supported, and the detailed design if supported
	+ At least the following aspects may be considered in the companies’ proposal
		- Exact definition of events, e.g. events defined for L3 event triggered report as a starting point, or new event(s)
		- Report container i.e. UCI transmitted on PUCCH or PUSCH and/or MAC CE etc.
		- Resource allocation/assignment for UE/event triggered report e.g. resource is allocated in advance, requested when the condition is met, and/or activated when the condition is met, resource acquired through random access 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, time to trigger, the number of times the condition is met, and/or threshold to judge whether to start/stop reporting
		- Contents of the report/reporting format, PCI, RS ID, measurement result etc.
		- The interaction with filtered L1 measurement results (if supported) , e.g., whether the UE/event triggered report is configured for filtered L1 measurement, or legacy L1 measurement without filtering.
		- Support of simultaneous configuration of both UE/event triggered and any of periodic/semi-persistence/aperiodic reporting, and solutions when both of them are configured.
		- Report destination, whether the report is sent to serving cell only or can be sent to a candidate cell.
		- FFS: Benefit when L3 measurement is involved

##### [Summary of contributions]

**Necessity and analysis of UE/event UE triggered report (Concern from one company)**

* Huawei
	+ Not necessary. L1 event is mostly triggered if L3 measurement is used for preparation, i.e. condition is mostly met
* Ericsson
	+ The latency of event-driven reporting is typically larger than the latency of NW-initiated reporting.
	+ Provided that the event is properly designed, the reporting overhead of event-driven reporting can be lower than NW-initiated reporting.
* Google
	+ Support to extend the BFR framework with new event definition for event-triggered beam report. BFR is transmitted by MAC CE, where only new beam index is reported
* Xiaomi
	+ Support event triggered beam measurement reporting mechanism.
		- In order to reduce the overhead, event triggered reporting mechanism, in which only these measurement results of the candidate cell that meet a certain condition need to be reported, can be supported in L1 measurement
* OPPO
	+ Support UE-initiated reporting of L1 measurement for L1/L2 mobility.
* Samsung
	+ For L1 measurement report for Rel-18 L1/L2 mobility, support UE/event triggered report for L1 measurement results.
		- Event triggered reporting is beneficial to reduce overhead associated beam reporting, the report is only sent when an event is triggered at the UE.

**Detailed design of UE/event UE triggered report**

* ZTE: It can be considered as a supplementary method for CSI reporting since it is beneficial to reduce signaling overhead and UE energy consumption and reporting latency.
	+ MAC CE (e.g., similar BFR MAC CE) can be used carrying measurement report to avoid waste of resources.
* vivo: Support event-triggered L2 reporting to save resources and UE power consumption.
	+ Event(s) is defined based on L1 measurement results without filtering.
	+ The condition to start the reporting is needed to define, e.g., L1 measurement results are consistently greater than a certain threshold over a period of time.
	+ Reported L1 measurement results of beam level are carried in MAC CE signaling.
* Ericsson
	+ Study simplified event-driven reporting to assist LTM over MAC: The framework for event-driven reporting over L3 is very complex and should not be copied if RAN1 decides to introduce event-driven beam reporting.
* CATT: Event-trggered reporting should be supported in Rel-18 inter-cell mobility. The following details could be considerred:
	+ Reuse events defined for L3 event triggered report for Rel-18 LTM.
	+ Support MAC CE based event-driven beam reporting for Rel-18 LTM. And UE could send SR to request for available resources for PUSCH transmission when condition is met.
	+ Time to trigger is necessary for the robustness.
	+ The report quantities include at least the measurement results (e.g. SSBRI, L1-RSRP, spatial filterred L1-RSRP if supported) and cell index of the selected candidate cell.
	+ Support of simultaneous configuration of both event triggered and any of periodic/semi-persistent/aperiodic reporting.
* Spreadtrum
	+ Report on MAC-CE is proper for UE initiated report.
* Lenovo
	+ Support event-based beam report for L1/L2 mobility
* Nokia
	+ UE is not required to perform L1 measurements on candidate cell(s) if the serving cell quality is above a threshold value. FFS same or separate threshold as for the L3 measurements.
	+ In event-based reporting, UE provides an indication to network on which reporting configurations should be activated.
	+ Consider a reporting format/rule where serving cell and at least one candidate cell beams are reported in specific limits in the report.
	+ For carrying payload for event-based report, MAC CE is used.
	+ L1 measurement reports for Rel-18 LTM are sent to the serving cell unless the UE is in Rel-17 ICBM operation where UE-dedicated signals/channels are transmitted/received via a non-serving cell.
		- the serving cell makes cell the decision of cell switch
		- Reporting to a LTM candidate cell when it is not an ICBM non-serving cell would require inter-cell/DU coordination to make the measurement results available at the serving cell and also reservation of UL resources at the candidate cell for the reports to be sent by the UE.
	+ RAN1 to update the priority rules for CSI reports for Rel-18 LTM event triggered reporting if supported.
* IDC: RRC provisioning of L1 measurement resources is not scalable to LTM area spanning large number of cells.
	+ Support reporting of strongest detected SSB resources in MAC CE.
	+ Support association of SSB resource to a CSI SSB resource set by MAC CE.
	+ Support association of SSB resource to a TCI state by MAC CE.
	+ Support triggering of MAC CE measurement report when there is a change in the set of strongest detected SSB resources.
* Xiaomi: We support to introduce new event, denoted as L1 event to distinguish it from L3 event, for event triggered beam measurement reporting.
	+ For example, the average value of L1 measurement results of a candidate cell > the average value of L1 measurement results of serving cell + Offset.
* Intel:
	+ UE event driven L1/L2 centric mobility triggering should be considered
		- Dedicated PUCCH resource can be configured where UE transmits an SR when L1-RSRP of at least one of the non-serving cell beams exceeds that of the serving cell beam(s) by a threshold
		- On reception of PUCCH SR for mobility, gNB can trigger an aperiodic L1-RSRP report where the UE reports the RS index and the corresponding L1-RSRP for up to K non-serving cell beams
* CMCC
	+ For L1/L2 mobility, event-based beam reporting can be considered. Event A3 can be considered as the starting point for defining the event.
* NEC
	+ Specify a default or configurable time duration for active L1 measurements of candidate cells for inter-cell mobility monitoring.
	+ Specify measurement threshold for deactivating L1 measurements for inter-cell mobility
* Apple
	+ Consider reusing the existing event A5 event (i.e., SpCell becomes worse than threshold1 and neighbour becomes better than threshold2) to support event-triggered L1 reporting for LTM procedure
	+ The threshold values are controlled by network as part of event-based measurement configuration.
	+ The event-triggered CSI report can be carried by a MAC-CE over PUSCH.
	+ If event-trigger measurement reporting is supported, study the need of configurable time-to-trigger (TTT) mechanism to mitigate the higher Ping-pong effect caused by L1-based measurement reporting.
* LGE
	+ Consider event-driven L1-based beam reporting for non-serving cells and study how to extend conventional L3 criteria for triggering of an NR measurement reporting event for L1-based beam reporting.
		- Event-based reporting analogous to L3 measurement and reporting procedure would be efficient
		- When the event is occurred, serving cell beam report could be replaced by non-serving cell beam report or non-serving cell beam report can be added into the serving cell report
	+ Consider filtering L1 measurement results to mitigate ‘ping-pong’ issue by taking into account the followings.
		- Add or modify event triggering condition in ReportConfigNR with L1-based threshold/offset
		- Check event triggering condition in terms of beam quality based on ‘time to trigger’ operation
* DCM: Support UE/event triggered L1 report. Support to further study following two methods for UE/event triggered L1 report.
	+ Opt1: UE/event triggered report for legacy non-filtered L1 results, with the new event(s) considering time domain and/or spatial domain variations, e.g., a report is triggered when certain measurement threshold condition is met for a time duration or multiple beams.
	+ Opt2: UE/event triggered report for filtered L1 results, with the new event(s) mainly considering one-shot comparison, e.g., a report is triggered when certain measurement threshold condition is met for the filtered L1 results, while the filtered L1 results consider time domain and/or spatial domain filtering.
* Qualcomm: Support UE initiated L2 report on MAC-CE, similar to existing event triggered L2 report
	+ Support event triggered L1 report for candidate cells for L1/L2 based mobility
		- The report can be carried in MAC-CE or UCI
	+ For event triggered L1 report, at least a triggering condition similar to Event A3 for L3 report can be considered as starting point, e.g. candidate cell becomes amount of offset better than SpCell
	+ For event triggered L1 report, L1 cell-level metric can be used to quantify the quality per cell considered in the triggering condition
		- L1 cell-level metric can be linear average of Y>1 best beams per cell, e.g. Y=2 or 3
* MediaTek: On Rel-18 L1 enhancement for inter-cell beam management, support event-driven beam reporting and the following can be starting points for discussion
	+ L1-RSRP report is triggered when the defined event(s) occurs
		- At least the following event can be defined
			* The L1-RSRP from one SSB within list of SSBs with PCIs different from serving cell is larger than a pre-defined value which is configured by RRC
			* The list of SSBs with PCIs different from serving cell are configured by RRC
	+ The L1-RSRP report is transmitted by MAC-CE, which include
		- SSBRI from the list of SSBs with PCI different from serving cell
		- L1-RSRP for the corresponding SSB
		- Serving cell ID

##### [FL observation]

Besides the concern by single company, UE/event triggered report for L1 measurement results are proposed by many companies, which is very good. On the other hand, it is unfortunate that the proposals by companies are still high level, and nobody provided a complete design of UE/event triggered report.

One potential consensus is to use MAC CE for a report container. In addition, No companies showed the detailed design for report destination while a concern was raised by one company.

Given the analysis above, FL proposal is to try the FL proposal in RAN1#110b-e again, and include the concrete proposal for the report container.

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

* For L1 measurement report for Rel-18 L1/L2 mobility, interested companies are encouraged to further study whether UE/event triggered report for L1 measurement results is supported, and the detailed design if supported
	+ At least the following aspects may be considered in the companies’ proposal
		- Exact definition of events, e.g. events defined for L3 event triggered report as a starting point, or new event(s)
		- Report container ~~i.e. UCI transmitted on PUCCH or PUSCH and/or~~ is MAC CE ~~etc.~~
		- Resource allocation/assignment for UE/event triggered report e.g. resource is allocated in advance, requested when the condition is met, and/or activated when the condition is met, resource acquired through random access 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, time to trigger, the number of times the condition is met, and/or threshold to judge whether to start/stop reporting
		- Contents of the report/reporting format, PCI, RS ID, measurement result etc.
		- The interaction with filtered L1 measurement results (if supported) , e.g., whether the UE/event triggered report is configured for filtered L1 measurement, or legacy L1 measurement without filtering.
		- Support of simultaneous configuration of both UE/event triggered and any of periodic/semi-persistence/aperiodic reporting, and solutions when both of them are configured.
		- ~~Report destination, whether the report is sent to serving cell only or can be sent to a candidate cell.~~
		- FFS: Benefit when L3 measurement is involved

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

Please provide your comments on the FL proposal above, if any.

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 2-3-v1 | Response from FL |
| QC | Fine for FL’s proposal 2-2-v1 as starting point. |  |
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## Beam indication

### [High2] Beam indication mechanism:

##### [Conclusion at RAN1#110b-e]

Agreement

* RAN1 to further study if the beam indication of candidate cell(s) L1/L2 mobility should be designed for a specific TCI framework below, and their potential RAN1 spec impact.
	+ **Option A:**  Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-17 TCI framework mechanism
	+ **Option B:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-15 TCI framework mechanism
	+ **Option C:** Beam indication for Rel-18 L1/L2 mobility is designed based on both Rel-15 and Rel-17 TCI framework mechanisms

##### [Summary of contributions]

**Design of beam indication for Rel-18 LTM**

* **Option A (Rel-17 only): (15)**
	+ **The standardization efforts can be minimized, one TCI state contains the QCL information, and the UL properties**
	+ Huawei, ZTE, vivo, Fujitsu, Google, CATT, Spreadtrum, Xiaomi, Intel, OPPO, CMCC, Apple, Qualcomm, MediaTek, DOCOMO
* **Option B (Rel-15 only): (3)**
	+ **Accelerate the market introduction, easy deployment and implementation. The concept is to use a common TCI/QCL mechanism for the TCI framework in each release**
	+ MediaTek
	+ Ericsson? (The beam indication contains an explicit identifier of a reference signal, which is used to aid DL reception and UL transmission)
	+ Nokia (Different cells may be configured with different TCI frameworks (Rel-15 or Rel-17), e.g., the serving cell and a candidate cell may use a different TCI state framework.)
		- In Rel-18 LTM, at least a TCI state or a QCL source RS associated with the target cell can be provided as a beam indication before the cell switch.
		- UE can determine a DL RS via the provided TCI state or the QCL source RS for monitoring at least one DL channel and/or transmission of at least one UL channel of the target cell after the cell switch until it receives a new activation/beam indication from the new target cell.
		- The UE can be configured to consider that once it has completed the RRC reconfiguration (i.e. the handover is complete), it has not been provided with an indication of a TCI state or has not received activation for any TCI state in relation to the target cell.
* **Option C (Rel-15 and 17): (1)**
	+ **The concept is to introduce two different mechanism, i.e. Option A and B.**
	+ CMCC
		- we can discuss whether the beam indication mechanism can be extended to Rel-15 TCI framework if the workload is acceptable.

**Next-step issues:**

* Whether Rel-18 unified TCI can be considered (ZTE)
* Whether Rel-16 TCI framework can be considered (DOCOMO)
* Details of TCI state pool (vivo)
	+ Both mixed TCI state pool, i.e., Rel-17 ICBM TCI framework, and independent TCI state pool should be considered.
		- Mixed TCI state pool: some TCI states in the TCI state pool are associated with candidate cell(s)
		- Independent TCI state pool: all of the TCI states in the TCI state pool are only associated with the cell where the TCI state pool is configured.
* Beam application time (vivo, Fujitsu, Google, DCM)
	+ When beam indication is received before the cell switch command or together with the cell switch command, the application time of the indicated TCI state needs to be enhanced to support different application scenarios, such as in inter-DU and inter-frequency.
	+ It should be further studied how to define the beam application time by taking both cell switch and beam switch into account.
	+ Support to introduce a second beam application delay for unified TCI indication with serving cell change.
	+ Support to study cell application timing for the cell switch command.
	+ Application time should be specified for the SpCell/CG update command
		- Application time can be different for previously activated and deactivated new SpCell/CG
* Acknowledgement to beam indication (note: RAN2 is discussing the necessity of handover completion indication from UE to gNB. The difference needs to be clarified)
	+ Google: Study fallback operation with regard to incorrect detection of ACK/NACK for unified TCI indication that requires serving cell change.
	+ DCM: Support to study the acknowledgement of the cell switch command.
	+ QC: To ensure reliability, SpCell/CG update based on L1/L2 signalling should be acknowledged
* Coexistence with Rel-17 ICBM (OPPO)
* TCI state configuration and activation (Apple)
	+ Support the TCI states of a candidate cell is pre-configured under each candidate cell during the pre-configuration phase.
	+ Support the TCI states of a candidate cell is pre-configured under each candidate cell during the pre-configuration phase.
* Linkage between TCI state indication and cell switch (Samsung)
	+ For beam indication for L1/L2 mobility, the TCI state can be associated with a cell (target serving cell) having a PCI different from the PCI of the serving cell.
* Follow-up procedure after TCI state indication (Samsung, Qualcomm)
	+ For beam indication for L1/L2 mobility, an indicated TCI state on the target serving cell can trigger
		- AP CSI-RS resource on the target serving cell followed by a AP CSI measurement report.
		- AP-SRS resource to the target serving cell.
	+ To reduce TRS tracking and beam refinement latency after SpCell update, SpCell update command can also trigger TRS or beam refinement
* DL/UL TCI indication (Samsung)
	+ Non-serving cell TCI indication should include joint TCI or both of separated DL/UL TCI states except for DC scenario.
* beam indication for cells/CG (Qualcomm)
	+ Support SpCell/CG update command to carry beam indication for joint cell/CG & beam switch
		- The CG update command can carry beam indication(s) for multiple target cells
		- Beam indication can include both activated and indicated TCI state(s)
	+ Existing cell/beam activation/indication signalling can be extended for the SpCell/CG update
		- E.g. SCell or unified TCI state activation MAC-CE, unified TCI state indication DCI
* Support of UE triggered LTM
	+ This is proposed by a couple of companies, but FL has no plan to treat this proposal without explicit request from RAN2.

##### [FL observation]

**Design of beam indication for Rel-18 LTM**

Even though clear majority companies support Option A (Rel-17 TCI framework only), 3 companies support Option B (Rel-15 TCI framework only) while 1 company support Option C if time allows. According to the contributions in this meeting, the supporting companies of Option A claims that the total design of Option A would be much simpler, and the spec impact is also rather small. On the other hand, the proponents of Option B suggest using beam indication containing an explicit identifier of a reference signal, which looks simple as well at least from gNB perspective. However, this mechanism may require different handling of QCL from UE perspective during LTM process. From FL point of view, going with majority view (without conflict) is easy to achieve the consensus. However, considering the huge impacts to other parts of LTM, RAN1 should spend more time on this matter to achieve a good system design. Note that these options should be exclusive and only one option should be chosen. Also, it is preferred to perform the down selection in this meeting considering the

**Next-step issues**

There are a lot of next step issues after deciding the beam indication for Rel-18 LTM. It is noted that most of the issues listed above are the single company proposal. Given this situation, FL thinks it is not good idea to have an official discussion in RAN1#111. Companies are encouraged to think about these issues more and come back in RAN1#112 based on the companies’ contributions.

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

* The beam indication of candidate cell(s) for Rel-18 LTM should be designed based on the following option (down-selection is expected in RAN1#111)
	+ **Option A:**  Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-17 TCI framework mechanism
		- Supported by: Huawei, ZTE, vivo, Fujitsu, Google, CATT, Spreadtrum, Xiaomi, Intel, OPPO, CMCC, Apple, Qualcomm, MediaTek, DOCOMO
	+ **Option B:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-15 TCI framework mechanism, i.e. explicit identifier of a reference signal of QCL source is included in beam indication
		- Supported by Ericsson, Nokia, MediaTek
* *FL Note: We need to consider the discussion status in RAN2 and RAN3 on the reply LS*

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

Please provide your comments on the FL proposal above, if any.

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 3-1-v1 | Response from FL |
| QC | Support Option A. First, R18 MIMO features are only based on unified TCI, e.g. STxMP, PDSCH-CJT. Second, legacy TCI is inefficient in terms of beam indication, e.g. different channel/RS has its own mechanism. This also complicates the design unnecessarily. Third, R17 ICBM only considers unified TCI. We prefer to keep same spirit for R18 mobility. |  |
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### [Mid] Timing of beam indication:

##### [Conclusion at RAN1#110b-e]

Agreement

* 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 further RAN1 assessment and RAN2 decision on the time chart
	+ Scenario 1: Beam indication before cell switch command
	+ Scenario 2: Beam indication together with cell switch command
	+ Scenario 3: Beam indication after cell switch command
* Interested companies are encouraged to further study the validity of the scenarios and the potential spec impact.

##### [Summary of contributions]

* **Scenario 1 (before): (7)**
	+ **latency reduction, similar procedure as Rel-17 ICBM (except inter-frequency scenario), intra-DU case, target cell must support the configuration of the source cell)**
	+ vivo, Fujitsu (what is the condition to apply early beam indication, e.g. inter-frequency case), CATT, Nokia (Rel-17 ICBM is operated before cell switch command), Apple, DOCOMO, Samsung
* **Scenario 2 (together): (2)**
	+ **latency reduction, signaling overhead reduction, support of inter-DU**
	+ ZTE, vivo, Ericsson, Fujitsu, CATT, Spreadtrum, Nokia(The UE can be indicated whether there a TCI state or a DL RS is present or not in the cell switch command.), Xiaomi, NEC, Apple, DOCOMO, Samsung
* **Scenario 3 (after): (0)**
	+ **useful for beam refinement after receiving cell swich, less benefit in terms of latency reduction, more like legacy procedure**

##### [FL observation]

The majority supports scenario 2 while scenario 1 is also supported by many companies. There were not technical concerns on scenario 3 because this is a legacy scenario, it is also pointed out that the handover latency cannot be reduced by scenario.

Given this situation, RAN1 can focus on scenario 2 and 3 for RAN1’s future study.

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

* From RAN1 perspective, the following scenarios are supported for beam indication timing for Rel-18 LTM, and interested companies are encouraged to perform their analysis on the necessary procedure and spec impacts
	+ Scenario 1: Beam indication before cell switch command
		- Difference from the Rel-17 ICBM should be clarified, e.g. support of inter-frequency, activation/selection of TCI states for deactivated cell(s), TA for candidate cell, synchronization between serving cell and candidate cell, support of inter-DU scenario etc.
	+ Scenario 2: Beam indication together with cell switch command

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

Please provide your comments on the FL proposal above, if any.

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 3-2-v1 | Response from FL |
| QC | Fine with FL’s proposal 3-2-v1 as starting point |  |
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## [Mid] Cell switch command

##### [Conclusion at RAN1#110b-e]

Agreement

* Interested companies are encouraged to perform technical analysis of the cell switch command from a 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

##### [Summary of contributions]

**Potential information included in the cell switch command from RAN1 perspective**

* Huawei
	+ Most of configuration for target cell is not necessary in cell switch command.
	+ At least cell identity and TCI state for the target cell should be indicated in cell switch command.
* ZTE
	+ Cell identification
	+ Beam indication
	+ RACH-less Flag
	+ DL sync flag
* vivo
	+ the TA for the target cell
	+ information related to trigger TRS tracking and CSI acquisition
* Ericsson
	+ Cell switch command (10 bits?)
	+ The beam indication contains an explicit identifier of a reference signal, which is used to aid DL reception and UL transmission (RS identifier(s): 6 bits per serving cells)
	+ The beam indication contains a TA value for the target cell (12bits)
	+ The beam indication contains ID of the active DL and UL BWPs for the target cells (2+2(per serving cells?)
* CATT
	+ cell index of the target cell
	+ TCI state(s) of the subsequent transmission
	+ correponding TA value
* Nokia
	+ The UE can be indicated whether there a TCI state or a DL RS is present or not in the cell switch command.
* IDC
	+ indication of active TCI state in target cell.
	+ an uplink resource of target cell for the confirmation of execution of the cell switch.
* Xiaomi
	+ target cell(s) indicator(s)
* Apple
	+ TCI state ID (7bits)
	+ TA value
* DOCOMO
	+ Target cell/cell group ID (with or without BWP ID)
	+ TCI state of target cell/cell group
	+ A flag to indicate cell switch or beam switching in R17 ICBM (explicitly/implicitly)
* Qualcomm
	+ DL/UL BWPs to be used for the new cell can be indicated in cell update command
* CATT
	+ The multiple candidate cell index can be configured for each CSI-RS resource setting and CSI reporting, and activated one based on handover signalling

**Container to carry cell switch command. Note that FL has no intention to discuss this issue in RAN1#111**

* MAC CE
	+ Huawei, vivo(together with cell switch command), Ericsson (the same MAC CE is used for the actual triggering.), Xiaomi, Intel
* DCI
	+ ZTE, vivo(for beam indication before cell switch command), Google (the indicated unified TCI applied associated with a neighbor cell SSB to dedicated signals can also be applicable to non-UE dedicated signals.), Lenovo, DOCOMO

##### [FL observation]

The companies’ proposals on the necessary information included in the cell swich command are summarized as follows. Nevertheless, FL is not sure if some of them are really L1 centric information, which requires more clarification during RAN1#111.

* + Cell identity / Cell group identity
	+ TCI state ID/Beam indication
	+ DL/UL BWP indication
	+ Differentiation between Rel-17 ICBM and Rel-18 LTM (if DCI is used for cell switch command)
	+ TA value
	+ [UL resource indication for sending acknowledgement of LTM: FL note: FL believes RAN2 will define the necessary information for cell/cell group identification. It should be clarified if]

For the container to carry cell switch command, it is noted that FL has no intention to discuss this issue in RAN1#111

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

* The following contents are further studied for the contents included in the cell switch command from layer 1 perspective. The bit number required for the contents needs further discussion.
	+ Cell identity / Cell group identity – (ID or index?, what is the necessity from physical layer POV)
	+ TCI state ID/Beam indication
	+ DL/UL BWP indication
	+ Differentiation between Rel-17 ICBM and Rel-18 LTM (if the DCI for Rel-17 ICBM is reused for cell switch command)
	+ TA value
	+ [UL resource indication for sending acknowledgement of LTM : if RAN1 identify the necessity from L1 point of view]

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

Please provide your comments on the FL proposal above, if any.

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 4-1-v1 | Response from FL |
| QC | We prefer to add the triggered AP CSI-RS resource set ID and AP SRS resource set ID in the FFS list. The 1st one is for the cell switch command to trigger beam refinement, TRS, or CSI. The 2nd one is for cell switch command to refine the UL TA based on triggered SRS, which is transmitted by the initiated TA indicated in the cell switch command* The following contents are further studied for the contents included in the cell switch command from layer 1 perspective. The bit number required for the contents needs further discussion.
	+ Cell identity / Cell group identity – (ID or index?, what is the necessity from physical layer POV)
	+ TCI state ID/Beam indication
	+ DL/UL BWP indication
	+ Differentiation between Rel-17 ICBM and Rel-18 LTM (if the DCI for Rel-17 ICBM is reused for cell switch command)
	+ TA value
	+ [UL resource indication for sending acknowledgement of LTM : if RAN1 identify the necessity from L1 point of view]
	+ Triggered aperiodic CSI-RS resource set ID
	+ Triggered aperiodic SRS resource set ID
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## [High4] Preparation for handover before reception of cell switch command

##### [Conclusion at RAN1#110b-e]

Agreement

* RAN1 to further study the potential RAN1 enhancements and spec impact to perform at least the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay / interruption
	+ DL synchronization for candidate cell(s)
	+ TRS tracking for candidate cell(s)
	+ CSI acquisition for candidate cell(s)
	+ Activation/Selection of TCI states for candidate cell(s), if feasible
	+ Note: Uplink synchronization aspect will not be discussed under this A.I.
	+ FFS: Whether the above procedures prior to the reception of L1/L2 cell switch command can be performed on candidate cell when it is deactivated SCell (if defined in RAN2)
* Detailed discussion will be commenced after receiving RAN2 LS.

##### [Summary of contributions]

****

* **DL synchronization before cell switch command**
	+ ZTE: On Rel-18 L1/L2 triggered mobility, in order to reduce interruption latency, DL synchronization can be done before cell switch command.
		- Through pre-searching target cell, the target cell is a known cell, e.g., Tsearch = 0;
		- Through reusing procedure specified in fast SCell activation (e.g., SSB can be replaced with AP-TRS for time and frequency tracking), time for fine tracking and acquiring full timing information can be saved, e.g., TΔ =0.
	+ vivo: Support performing downlink synchronization before the reception of the cell switch command.
	+ Ericsson: The UE can be configured to store the QCL properties of a subset of the RSs it has reported for a limited period
		- In legacy, the UE discards the synchronization information it used to perform a measurement once the measurement has been performed.
		- If the UE would store the QCL properties of the RSs on which it has performed beam management measurements, the activation delay could be avoided. It would be sufficient if the UE stored the QCL properties for a small number of RSs for a limited period.
	+ Fujitsu: At least DL synchronization before receiving cell switch command should be supported.
	+ Nokia: UE can be configured to store the DL timing information acquired via L1 measurements performed for a candidate cell.
	+ IDC: Support DL synchronization to candidate cell(s) before reception of cell switch command.
		- Support DL synchronization before reception of cell switch for both intra-frequency and inter-frequency candidate cell(s).
	+ Intel: From RAN1 perspective, RAN2’s assumption of DL synchronization to candidate/target cell before cell switch command for the case of an already active serving cell should be feasible and RAN1 can further discuss how this may be performed.
	+ CMCC: it is feasible to get DL ssynchronization for candidate cell(s) before the reception of L1/L2 cell switch command.
	+ DOCOMO: procedures prior to the reception of L1/L2 cell switch command can be performed on candidate cell when it is deactivated SCell
	+ Qualcomm: Support NW to indicate candidate cell(s) for UE to maintain corresponding DL Rx timing(s)
		- Maximum number of candidate cell(s) to maintain the DL Rx timing can be up to UE capability
* **UL synchronization before cell switch command (not the scope of this AI)**
	+ ZTE: On Rel-18 L1/L2 triggered mobility, in order to reduce interruption latency, the following method can be considered:
		- Method-1: UL synchronization (e.g., PDCCH-order based PRACH) can be done before cell switch command;
		- Method-2: RACH-less, e.g, TA is 0 if target cell is small cell, or the target cell belongs to the same TAG of serving cell
		- Note that the usage of the above two methods depends on gNB configuration.
* **TRS tracking for candidate cell(s) before cell switch command**
	+ ZTE
		- improvement of demod performance compared with SSB
		- AP-TRS can be considered for latency reduction
	+ vivo: QCL-type A source reference signal for PDCCH/PDSCH can only be TRS. Therefore, TRS tracking for candidate cell(s) must be performed before the cell switch command
		- Support TRS tracking and CSI acquisition for candidate cell(s) to be performed before cell switch command, when beam indication is received before the cell switch command.
	+ Ericsson: UE is capable of demodulating PDCCH and PDSCH also without assistance from a TRS. the performance benefits of TRS are not huge
	+ CATT: TRS and CSI-RS for CSI of the candidate cell(s) could be pre-configured, and UE could perform TRS tracking and CSI-RS measurement before handover.
	+ Nokia: Support early TRS tracking and CSI acquisition of candidate cell(s). For the early TRS and CSI acquisition, RAN1 to study mechanism(s) to configure or/and measure TRSs or/and CSI-RS for CSI of candidate cell in the relevant directions of the UE.
	+ IDC: Support TRS tracking and CSI acquisition at least for intra-frequency candidate cell(s) before reception of cell switch command.
		- It may not be feasible if the candidate cells are on a frequency for which the UE requires measurement gaps
	+ CMCC: For inter-frequency scenario, measurement gap may be needed for TRS tracking and CSI acquisition.
	+ NEC: Consider how to obtain the QCL-TypeA RS applied for the target cell based on the TCI state indicated by the source cell.
	+ Qualcomm: Support NW to provide activated TCI state(s)/beam(s) for candidate cell before the cell switch command
		- The TRS tracking for candidate cell is achieved via activating the corresponding TCI state
	+ MediaTek
		- Send LS to RAN2 regarding whether candidate cell TRS processing should be considered to achieve DL synchronization with candidate cells before cell switching command.
			* whether such benefits are essential to Rel-18 mobility enhancement should be confirmed by RAN2
* **CSI acquisition for candidate cells before cell switch command**
	+ ZTE: urgency of introducing CSI-RS for beam refinement?, This should be included in the measurement latency (i.e. Tmeas)
	+ vivo: Support TRS tracking and CSI acquisition for candidate cell(s) to be performed before cell switch command, when beam indication is received before the cell switch command.
	+ Ericsson: RSRP report of the candidate can be used for initial choice of MCS. If the UE can provide additional information, e.g., on the interference situation, before the cell-switch performance can be improved
	+ CATT: TRS and CSI-RS for CSI of the candidate cell(s) could be pre-configured, and UE could perform TRS tracking and CSI-RS measurement before handover.
	+ Nokia: Support early TRS tracking and CSI acquisition of candidate cell(s). For the early TRS and CSI acquisition, RAN1 to study mechanism(s) to configure or/and measure TRSs or/and CSI-RS for CSI of candidate cell in the relevant directions of the UE.
	+ IDC: Support TRS tracking and CSI acquisition at least for intra-frequency candidate cell(s) before reception of cell switch command.
		- It may not be feasible if the candidate cells are on a frequency for which the UE requires measurement gaps
	+ CMCC: it may need to define the CSI processing criteria and priority rules for CSI reports of candidate cell(s). Moreover, for inter-frequency scenario, measurement gap may be needed for TRS tracking and CSI acquisition.
	+ DCM: procedures prior to the reception of L1/L2 cell switch command can be performed on candidate cell when it is deactivated SCell
* **Activation/selection of TCI states before cell switch command**
	+ Ericsson: the beam indication provides information corresponding to the TCI states. This implies that the NW has already selected a suitable TCI state. In our understanding, there is no specification impact of this
	+ CMCC: it is supported in Rel-17 ICBM
	+ NEC: Support the source cell to indicate a TCI state applied for the target cell.
	+ DCM: procedures prior to the reception of L1/L2 cell switch command can be performed on candidate cell when it is deactivated SCell
	+ Qualcomm: Support NW to provide activated TCI state(s)/beam(s) for candidate cell before the cell switch command
		- This should be applicable if the candidate cell is deactivated SCell, which currently does not allow TCI state activation prior to SCell activation
			* The application of indicated TCI state(s)/beam(s) typically has low latency, e.g. a few slots, and can be performed in parallel with other preparations after the cell switch command is received

##### [FL observation]

**DL synchronization before cell switch command**

All the companies (10) gave positive feedback on the support of DL synchronization before cell switch command. The common understanding is that the UE can store the DL timing information that can be obtained during the measurement. The remaining issue is the maximum number of candidate cell(s) to maintain the DL timing information, which is up to UE capability, and its configuration.

**TRS tracking for candidate cell(s) before cell switch command**

Most of the companies are positive to support TRS tracking for candidate cell(s) before cell switch command to give a QCL-typeA information to a UE for demodulation performance improvement. Meanwhile one company pointed out that the system will work without TRS tracking and the performance gain is not huge. Also, it is questioned that TRS tracking is essential for this work item (LS to RAN2 can be sent). Another issue is whether TRS tracking is possible for inter-frequency scenario because gap is required for that case.

In summary, the support of TRS tracking for candidate cell(s) before cell switch command needs more discussion in RAN1.

**CSI acquisition for candidate cells before cell switch command**

All the companies (8) gave positive feedback on the support of CSI acquisition for candidate cells before cell switch command to enable appropriate MCS choice at the first DL transmission at the new serving cell. On the other hand, some technical issues were identified, e.g. CSI processing criteria, priority rules for CSI reports of candidate cell(s), and the necessity of gap for inter-frequency scenario.

**Activation/selection of TCI states before cell switch command**

After seeing the comments from companies, FL thinks that what we want to discuss here is the same as the discussion under section 5.3.2, i.e. Scenario 1: Beam indication before cell switch command. If companies have common understanding, it would be appreciated if the discussion can be continued under the section.

Given the analysis above, FL proposal is made as follows:

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

* Regarding the potential RAN1 enhancements to reduce the handover delay / interruption for Rel-18 LTM,
	+ Support DL synchronization before cell switch command
		- Further study the necessary mechanism, e.g. signaling and UE capability
	+ Study further the support of TRS tracking for candidate cell(s) before cell switch command from the following aspects:
		- Performance gain of DL reception over no TRS case
		- Support of inter-frequency scenario and the spec impact
		- Essentiality for LTM to reduce the handover delay / interruption
	+ Study further the support of CSI acquisition for candidate cells before cell switch command from the following aspects
		- Performance gain of DL reception over gNB based MCS estimation without CSI feedback
		- CSI processing criteria
		- CSI feedback mechanism and priority rule
		- Support of inter-frequency scenario and the spec impact
		- Essentiality for LTM to reduce the handover delay / interruption
	+ Note: RAN2 LS will be sent after the analysis above has completed.

FL note: proposal on activation/selection of TCI states before cell switch command is considered in FL proposal 3-2

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

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 5-1-v1 | Response from FL |
| QC | Fine for FL’s proposal 5-1-v1 |  |
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## Other topics

### [Closed] BFR for Rel-18 L1/L2 mobility

##### [Offline consensus at RAN1#110b-e]

* 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*

##### [Summary of contributions]

* Google: 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
* IDC: Support beam failure recovery on resources of non-serving cell.

##### [FL observation]

The situation is completely same as the previous meeting. Thus, FL plan is not to treat these proposals in this meeting. We can comeback if time allows and many companies see the necessity.

##### [Comments if any]

Please input your view in the table below:

|  |  |  |
| --- | --- | --- |
| Company | Comment to proposal 6-1-v1 | Response from FL |
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### void

### void

# 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



# Agreements at RAN1#110b-e

Agreement

* For Rel-18 L1/L2 mobility, L1 intra-frequency measurement for candidate cell is supported
	+ At least the following aspects are for RAN1 further study:
		- RAN1 assumes Rel-17 ICBM CSI measurement as starting point.
		- Whether and how to apply relaxation for the restrictions imposed on the Rel-17 intra-frequency L1 non-serving cell measurement defined in 9.13.2 of TS38.133, where RAN4 impact is foreseen, e.g.
			* SFN offset alignment 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 intra-frequency L3 measurement
		- Commonality with L1 inter-frequency measurement for measurement configuration
* Send an LS to RAN4 (CC RAN2)
	+ RAN1 to ask RAN4 if the restriction on e.g., SFN offset alignment, BWP setting and Rx timing difference, etc, described in 9.13.2 of TS38.133 for intra-frequency L1 non-serving measurement can be relaxed or not.
	+ RAN1 assumes Rel-17 ICBM CSI measurement as starting point.

Agreement

* For Rel-18 L1/L2 mobility,
	+ SSB is supported for L1 intra-frequency measurement
	+ SSB is supported for L1 inter-frequency measurement if inter-frequency L1 measurements are supported
* Further study the following L1 measurement RS for candidate cell
	+ CSI-RS for tracking, beam management, CSI and mobility, CSI-IM, which is for L1 intra-frequency and L1 inter-frequency (if supported)

Agreement

* For candidate cell measurement for Rel-18 L1/L2 mobility,
	+ L1-RSRP is supported for intra-frequency candidate cell measurement.
	+ Further study the following measurement quantities for candidate cell measurement
		- L1-RSRP for inter-frequency (if supported)
		- L1-SINR for intra-frequency and inter-frequency (if supported)
* FFS: to assess the use case and the benefit of UL measurement instead of/in addition to DL L1 measurement, which includes:
	+ How the UL measurement result is used, e.g. handover decision
	+ Signals/channels used for UL measurement, e.g. SRS
	+ Spec impact including other WGs, e.g. definition of gNB measurement, interface to transfer RS configuration or measurement results
	+ Note: The next discussion will take place based on companies’ contribution in future meeting.

Agreement

* For Rel-18 L1/L2 mobility, further study the potential RAN1 spec impact of L1 inter-frequency measurement
	+ The definition and scenarios of L1 inter-frequency measurement is determined by RAN4, and RAN1 assumes at least the following until receiving their confirmation
		- The scenarios not included in intra-frequency are regarded as inter-frequency, which includes at least the following scenarios:
			* The frequency of the measured RS not covered by any of the active BWPs of SpCell and Scells configured for a UE, but covered by some of the configured BWPs of SpCell and Scells configured for a UE.
			* The frequency of the measured RS not covered by any of the configured BWPs of SpCell and Scells configured for a UE
	+ At least the following aspect is studied:
		- Commonality with L1 intra-frequency measurement for measurement configuration
* Send an LS to RAN4 (CC RAN2)
	+ RAN1 would like to confirm our understanding that the supported scenarios not included in intra-frequency are regarded as inter-frequency, which includes at least the following scenarios:
		- The frequency of the measured RS not covered by any of the active BWPs of SpCell and Scells configured for a UE, but covered by some of the configured BWPs of SpCell and Scells configured for a UE.
		- The frequency of the measured RS not covered by any of the configured BWPs of SpCell and Scells configured for a UE
	+ It is RAN1 understanding that the introduction of measurement gap and SMTC for L1 inter-frequency measurement, if any, is expected to be a RAN4 issue
	+ Note: this content is included in the LS agreed for intra-frequency L1 measurement

Agreement

* 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 PUCCH/PUSCH, and aperiodic report on PUSCH
		- Potential enhancements to Rel-17 ICBM report format to accommodate Rel-18 scenarios, e.g.
			* Inter-frequency measurement, if supported
			* Increasing the maximum number of reported beams, which is 4 for Rel-17 ICBM
			* Flexible size beam report, e.g., two-part UCI (e.g., the 1st part contains the best beam/cell and the number (e.g., N) of reported beams/cells, the 2nd part contains the rest (N-1) beams/cells
			* Reducing the reporting overhead by e.g. choosing beams/cells per frequency or across frequencies to report (FFS how)
	+ Report on MAC CE
		- Both gNB scheduled and/or UE initiated (if supported) report are studied

Agreement

* RAN1 to further study if the beam indication of candidate cell(s) L1/L2 mobility should be designed for a specific TCI framework below, and their potential RAN1 spec impact.
	+ **Option A:**  Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-17 TCI framework mechanism
	+ **Option B:** Beam indication for Rel-18 L1/L2 mobility is designed based on Rel-15 TCI framework mechanism
	+ **Option C:** Beam indication for Rel-18 L1/L2 mobility is designed based on both Rel-15 and Rel-17 TCI framework mechanisms

Agreement

-  Send an LS to RAN2/RAN3 asking the clarification on intra-/inter-DU scenario:

-      RAN1 has started the discussion on the configuration for L1 measurement and TCI states for candidate cells. Regarding the following RAN2 agreements captured in RAN2 LS (R1-2208331/R2-2209257), it is not clear for RAN1 which kind of information/configuration for candidate cell(s) are available at a serving cell for inter-DU case for Rel-18 L1/L2 mobility. Thus, companies have different understanding on the implication of the sentence “as much commonality as reasonable” in the LS.

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

-  RAN1 respectfully asks RAN2 and RAN3 if the serving DU knows the measurement RS configuration and TCI state configuration of cells served by another DU

Agreement

* Send an LS to RAN2, 3 and 4 to inform them of the agreements under A.I 9.12.1 and A.I. 9.12.2
* If the LS related proposal under A.I 9.12.1 and 9.12.2 are agreed, the contents are also included.

Agreement

* RAN1 to further study the potential RAN1 enhancements and spec impact to perform at least the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay / interruption
	+ DL synchronization for candidate cell(s)
	+ TRS tracking for candidate cell(s)
	+ CSI acquisition for candidate cell(s)
	+ Activation/Selection of TCI states for candidate cell(s), if feasible
	+ Note: Uplink synchronization aspect will not be discussed under this A.I.
	+ FFS: Whether the above procedures prior to the reception of L1/L2 cell switch command can be performed on candidate cell when it is deactivated SCell (if defined in RAN2)
* Detailed discussion will be commenced after receiving RAN2 LS.

Agreement

* 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 further RAN1 assessment and RAN2 decision on the time chart
	+ Scenario 1: Beam indication before cell switch command
	+ Scenario 2: Beam indication together with cell switch command
	+ Scenario 3: Beam indication after cell switch command
* Interested companies are encouraged to further study the validity of the scenarios and the potential spec impact.

Agreement

* Interested companies are encouraged to perform technical analysis of the cell switch command from a 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

**Agreement**

Support TA acquisition of candidate cell(s) before cell switch command is received in L1/L2 based mobility.

* FFS: whether this can be applied to candidate cell when it is deactivated SCell (if defined in RAN2)

**Agreement**

On mechanism to acquire TA of the candidate cells, the following solutions can be further studied:

•         RACH-based solutions

e.g., PDCCH ordered RACH, UE-triggered RACH, higher layer triggered RACH from NW other than L3 HO cmd

•         RACH-less solutions

e.g., SRS based TA acquisition, Rx timing difference based, RACH-less mechanism as in LTE, UE based TA measurement (including UE based TA measurement with one TAC from serving cell)

Agreement

For TA acquisition of a candidate cell before cell switch command is received, study at least the following alternatives of associating TA/TAG to candidate cell:

* Alt1: Associate TA/TAG and candidate cell implicitly, e.g.,
* the association between TA/TAG and TCI states can be configured
* Alt2: Associate TA/TAG and candidate cell explicitly, e.g.,
* the association is provided as a part of candidate cell(s) configuration
* the association between TA/TAG and SSB(s)/TRS(s) is provided as a part of candidate cell(s) configuration

# Agreements at RAN2#119b-e(R2-2211061)

Terminology

* RAN2 to use “LTM” as term for the L1/L2-triggered mobility.
* Use the term “cell switch” for the procedure of triggering change of cells via the LTM feature
* Use the term “Subsequent” LTM for the case when cell switch between L1/L2 mobility candidates is done without RRC reconfiguration in between.

Target performance enhancements

* No security update support in Rel-18 with L1/L2 based mobility.
* FFS whether ASN.1 decoding and validity/compliance check of candidate cell configuration are performed upon reception of the candidate cells configuration. FFS if this need to be specified.
* For UE processing, the following (not exhaustive) is assumed to be performed after receiving the cell switch command:

MAC/RLC reset (when configured)

RF retuning (e.g. needed for inter-frequency), baseband retuning

* R2 assumes that the following items may be discussed by RAN1 and RAN4 (and may be scenario specific):

- Whether to perform DL synchronization to candidate/target cell before receiving the cell switch command. R2 assumes this is feasible at least for the case that the target cell is already an active serving cell.

- Whether to support of performing TRS tracking and CSI measurement of candidate/target cell before/by cell switch command

* L1L2 based mobility supports the following CA scenarios:

PCell change without SCell change

PCell change with SCell change

* Support NR-DC scenario in L1L2 based mobility, at least for the PSCell change without MN involvement case, i.e. intra-SN.

L1 measurements and beam indication

* RAN2 assumes that RAN1 will drive discussions on L1 measurement enhancements, if any. If RAN1 identifies the need for e.g. event reporting, filtering etc, RAN2 can then be involved if needed.
* Inter-freq L1L2 mobility: R2 Confirms that For L1L2 mobility inter-freq scenarios in general should be supported (including mobility to inter-frequency cell that is not a current serving cell), including the support of inter-frequency L1 measurements, if feasible by R4 and R1.
* RAN2 assumes that whether to use the unified TCI framework as the baseline for beam indication for L1L2 mobility is up to RAN1 (RAN2 observes that L1/L2 mobility need to support inter-freq cases).

RRC

* A L1/L2 inter-cell mobility candidate (target) configuration is received within an RRC message before the L1/L2 dynamic switch is triggered.
* For L1L2 mobility, Target Pcell/SCell can be current SCell/PCell, i.e., current SCell/PCell can be configured as candidates.
* RAN2 assumes that sequential L1L2 cell change between Candidates without RRC reconfiguration can be supported.

Dynamic cell switching

* RAN2 assumes L1/2 mobility trigger information is conveyed in a MAC CE, FFS if the MAC CE or a DCI is used for the actual triggering.
* RAN2 assumes the MAC CE for L1/2 mobility trigger contains at least a candidate configuration index.
* FFS if it should be possible to perform SCell activation/deactivation (amongst SCells associated with the candidate configuration) simultaneously with L1 L2 mobility trigger MAC CE (if so, FFS how this is determined).
* RAN2 assumes that both RACH-based (CFRA, CBRA) and RACH-less procedures for L1 L2 mobility switch may be supported. RACH-less if the UE doesn’t need to acquire TA during the cell switch. RAN2 understands that the feasibility of RACH-less may depend on RAN1, and expect that RAN1 is working on this.
* RAN2 assumes RACH resource for CFRA for L1 L2 dynamic switch may be provided in RRC configuration (or potentially by MAC CE FFS).
* FFS if the MAC CE can indicate TCI state(s) (or other beam info) to activate for the target Cell(s), dep on RAN1 progress.
* R2 assumes that at L1L2 cell switch: Whether the UE performs partial or full MAC reset (FFS what partial reset is, e.g. to avoid data loss), re-establish RLC, perform data recovery with PDCP is explicitly controlled by the network. R2 assumes that this can be configured by RRC. FFS if MAC CE indication(s) is/are needed.

# Agreements at RAN2#119-e (R1-2208331/ R2-2209257)

* Assumption: HO interruption time for L1/L2-based inter-cell mobility is the time from UE receives the cell switch command to UE performs the first DL/UL reception/transmission on the indicated beam of the target cell. FFS if TRS tracking after HO and CSI RS measurement should also be included, i.e. the time to use a high-performance beam (can be clarified further).
* Assumption: To reduce HO interruption time, investigate e.g. solutions to reduce the time for UE reconfiguration (already in the WID), downlink and uplink synchronization after handover decision (other parts of dynamic switch not precluded).
* Confirm to Support L1/L2-based inter-cell mobility for inter-DU scenario (as well as intra-DU scenarios).
* The design for intra-DU and inter-DU L1/L2-based mobility should share as much commonality as reasonable. FFS which aspects need to be different.
* R2 assumes that L2 is continued whenever possible (e.g. intra-DU), without Reset, with the target to avoid data loss, and the additional delay of data recovery.
* ICBM is one scenario considered for L1L2 mobility, but is not the only one, and is not a prerequisite for using L1L2 mobility.
* RAN2 to consider preparation of target cell configurations capable of dynamic switching without need for full configuration.
* Measurement delay can/may be considered in this work
* Assume that we rely on L1 measurements to trigger L1L2 mobility (still measurement for preparation could be L3, FFS)
* R2 will initially focus on PCell mobility.
* R2 assumption: Rel-18 L1/L2 mobility includes both non-CA (PCell only) and CA scenarios (PCell and SCell). This includes the following cases

a) the target PCell/target SCell(s) is not a current serving cell (CA 🡪 CA scenario with PCell change)

b) FFS the target PCell is a current SCell

c) FFS the target SCell is the current PCell.

* DC scenarios are FFS (e.g. PSCell mobility may be a low hanging fruit FFS).
* Current options on the table: to configure a L1/L2 inter-cell mobility candidate cell:

a. One RRCReconfiguration message for candidate target cell

b. One CellGroupConfig IE for each candidate target cell

c. One SpCellConfig IE for each candidate target cell

* Will send an LS to RAN1 and RAN3 on the progress of this meeting.