3GPP TSG RAN WG1 #114 **R1-2306405**
Toulouse, France, August 21st – 25th, 2023

FL plan on L1 enhancements for LTM at RAN1#114

Document For: **Information**
Agenda item **9.10.1**
Source: **Moderator (Fujitsu, MediaTek)**

Discussion plan

Summary of Q2 2023(April and May meeting)

- **RAN1#112bis (April)**
  - Online time was consumed for the important & controversial issues, e.g. DL synchronization. As a result, the overall progress of this WI was **NOT** so good.
  - A lot of agreements on small issue were made.

- **RAN1#113 (May)**
  - Thanks to the active offline discussions, very good progress were achieved in this meeting. And the key issues are almost concluded.
  - Initial version of CRs were prepared by the spec editors.
  - Running CR in RAN2 have captured the RAN1 agreements.

- RAN#100 (June)
  - It was agreed to focus on SSB-based L1-measurement in Rel-18, which means that CSI-RS based L1-measurement is out-of-scope in Rel-18
  - It was also agreed to prioritize MCG for Rel-18 LTM

Goal of RAN1#114(August)

- **RAN1#114 (August)**
  - This is the final meeting for RAN1 in Rel-18
    - The issues with RRC impact will be discussed with highest priority
    - Other issues will be treated with best-effort basis
  - RAN1 RRC parameters needs to be finalized
  - Editors will prepare next version of the specs

Running CRs

- RAN1
  - 38.211: No CR
  - 38.212: R1-2306316(Summary), R1-2306317(CR)
  - 38.213: R1-2306293(Summary), R1-2306294(CR)
  - 38.214: R1-2306333(Summary), R1-2306334(CR)

- RAN2
  - 38.331: moderator proposal in R2-2306015

Detailed plan for each meeting

Meeting No	Key issues	
RAN1#114 (August)	**Essential issues (Essential and potential RRC impact)** • Details of RS configuration in TCI state configurations for candidate cells • Determination of unified TCI state type (joint and/or pair of DL/UL) (and the necessity of unifiedTCI-StateType configuration for candidate cells) • Details of BeamAppTime for LTM (though, exact value cannot be defined without reply LS from RAN2/4) • This includes clarification of the difference of BeamAppTime between the following cases • TCI state activation is performed together with TCI state indication • TCI state activation is performed prior to TCI state indication • Final details of the bit fields of cell switch command from RAN1 perspective • Beam indication for multiple cells (i.e. CA case), if CA scenario is supported by RAN2	**Mid priority issues (Essential but no RRC impact)** • Completion of L1-RSRP measurement reporting • (WA) Number of cells and beams • Indices of cells/beams for each L1 measurement result • Introduction of zero padding, if necessary • Quantization of L1 meas. results • UE behaviour where Rel-17 unifiled TCI framework cannot apply (i.e. alt 1 vs alt 4) • Whether/How the QCL reference information of TCI states of the candidate cell should be mapped to the source SSB **Low priority issues (Optimization)** • Introduction of MAC CE to update the subset of L1 measurement RSs • Scenario 1 and 3 for beam indication timing • Simultaneous operation of ICBM and LTM (see the reason in page 25)
RAN#101 (Sept)	Approval of RAN1 completion	

red part: handled by Fujitsu
blue part: handled by MediaTek

RAN1 agreements and FL plans for RAN1#114

L1 measurement: L1 Intra-freq 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.

[Conclusion at RAN1#111, #112, #112bis, #113]

No discussion, wait for RAN4 LS

No RAN1 issue is foreseen

L1 measurement: L1 Inter-freq 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

[Conclusion at RAN1#111]

Agreement

- For Rel-18 LTM, L1 inter-frequency measurement is supported from RAN1 point of view.

[Conclusion at RAN1#112, #112bis, #113]

No discussion, wait for RAN4 LS

No RAN1 issue at RAN1#114 is foreseen

L1 measurement: L1 intra- and inter-freq measurement

Definition of L1 measurement based on the RAN4 LSs:

- SSB-based Intra-frequency L1 measurement:
  - Center frequency and SCS of the SSB of the candidate cell are the same as those for serving cells, which is indicated in ServingCellConfigCommon
  - For the time offset,
    - The SFN offset alignment can be relaxed if UE performs L3 measurement before L1 measurement *(FL note: it is not clear if this has any RAN1 spec impact – and maybe none)*
    - The scenario that RTD between the SSBs of serving cell and candidate cell on the same carrier is larger than CP length of the corresponding SCS is supported with additional UE capability.
      - The UE capability is discussed and defined in RAN4
  - For the BWP setting,
    - The SSB for intra-frequency L1 measurement may not be covered by serving cell active BWP at least in some scenario.
      - The definition of the scenario is determined by RAN4
- SSB-based Inter-frequency L1 measurement:
  - The supported scenarios not included in intra-frequency L1 measurement are regarded as inter-frequency L1 measurement.

FL sees no strong necessity to update the RAN1 agreements at RAN1#114.

L1 measurement: Measurement RS

[Conclusion at RAN1#110b-e]

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)

[Conclusion at RAN1#111]

The FL proposal 1-4-v3 was not due to the lack of time during RAN1#111. Companies are encouraged to perform their analysis based on the latest proposal below:

- For Rel-18 LTM,
  - L1 measurement based on CSI-RS for beam management for candidate cells is supported for L1 intra-frequency measurement and L1 inter-frequency measurement if supported in RAN4
    - The definition of intra- and inter- frequency for CSI-RS is defined in RAN4
    - The CSI-RS is explicitly linked to a candidate cell
  - 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).

[Conclusion at RAN1#112]

No consensus on the following proposal (No time to come back), postpone to the next meeting.

- [Working assumption: CSI-RS is introduced for L1-RSRP measurement from RAN1 point of view
  - Intra- and inter- frequency is supported
  - At least CSI-RS for BM [mobility] is supported
  - Send an LS to RAN4 to explicitly ask their feasibility to finalize their work in Rel-18]

[Conclusion at RAN1#113]

- No agreement

[Conclusion at RAN#100]

- Revise Objective#1 to state that for LTM L1 measurements, only SSB measurement is supported in Rel-18.

With the conclusion at RAN#100, there is no open issue related to measurement RS

L1 measurement: 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.

[Conclusion at RAN1#111]

- Agreement

- For candidate cell measurement for Rel-18 LTM,
  - SSB based L1-RSRP is supported for intra-frequency measurement
  - SSB based L1-RSRP is supported for inter-frequency measurement from RAN1 point of view
  - FFS: L1-SINR, CSI-RS based L1-RSRP

[Conclusion at RAN1#112]

No consensus on the following proposal

- [CSI-RS based L1-SINR (with channel measurement and interference measurement using CSI-RS) is introduced from RAN1 point of view
  - ➢ If supported, both intra- and inter-frequency L1-SINR is supported
  - ➢ Send an LS to RAN4 to explicitly ask their availability in Rel-18]

[Conclusion at RAN1#112bis, #113]

No discussion on the introduction of L1-SINR

Companies view is that the benefit of L1-SINR cannot be seen without CSI-RS.
Thus, no discussion on L1-SINR is expected in RAN1#114.

L1 measurement: Filtering for L1 measurement results

[Conclusion at RAN1#110b-e]

Postponed (FL proposal 1-6)

- 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:
  - 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)

[Conclusion at RAN1#111]

Given the comments from companies, FL believes no positive result can be obtained on this topic even when we discuss the discussion in this meeting. Therefore, FL would like to take approach 1 this meeting and to encourages to have offline discussions for the next meeting.

With this analysis, the discussion on this section is closed. If companies have any comments, the following table can be used or further input.

[Conclusion at RAN1#111, 112, 112bis, 113]

No discussion

FL plan no discussion in RAN1#114.

L1 measurement: Configurations for L1 measurement - 1

[Conclusion at RAN1#112]

Agreement

- For L1-RSRP measurement RS configuration
  - For SSB based L1-RSRP measurement:
    - As a starting point, at least the following information needs to be provided to a UE, e.g.
      - For intra- and inter- frequency: PCI or logical ID (e.g., as being defined in R17 ICBM), time domain (e.g. SMTC or periodicity and SSB position in burst)
      - For inter-frequency: frequency domain location (e.g. center frequency), SCS
      - FFS: transmission power (for pathloss calculation)
    - Note: other parameters included in the configuration can be further discussed
    - Including above agreement into the LS
  - The detailed design of RRC structure is up to RAN2, and send an LS to RAN2 to request to work on the RRC structure design on the measurement configuration.
    - Following RAN1 understanding will be provided in the LS
      - RAN1 has discussed the following configuration options for L1 measurement configurations for SSB till RAN1#112:
        - Option 1) Configurations for L1 measurement RS is provided under ServingCellConfig for the serving cells
          - is useful to reuses the mechanism for Rel-17 ICBM and necessary information to support inter-frequency measurement will be added there.
        - Option 2) Configurations for L1 measurement RS is provided separately from ServingCellConfig for the serving cells and CellGroupConfig for the candidate cells
          - is useful to avoid the duplicated configurations for L1 measurement RSs, [and avoid UE to process configurations ~~for L1 measurement RS~~ provided under CellGroupConfig for the candidate cells]
        - Option 3) Configurations for L1 measurement RS is provided under CellGroupConfig for the candidate cells
          - can achieve the similar benefit as Option 2) by directly referring to the candidate cell configurations.
      - Note RAN2 has a full flexibility to design the whole RRC structure design.
      - RAN1 believes this is RAN2 expert region, and respectfully asks RAN2 to finalize the RRC structure design after RAN1 finalizes the discussion on RRC parameters.
      - It is noted that RAN1 foresees the necessity of similar discussions on TCI state pool for candidate cells and L1 measurement report configurations.

[Agreement at RAN1#112bis]

- RRC parameter ss-PBCH-BlockPower for candidate cells is included in the LTM configuration.
  - UE needs the parameter to (at least) perform RACH towards candidate cells
  - Note: how to capture this parameter and RRC structure are up to RAN2

[Agreement at RAN1#113]

- For the configuration of SSB based L1-RSRP measurement,
  - periodicity of SSB, SSB position in burst are provided as time domain information for intra- and inter- frequency

FL sees no open issues.
Details can be discussed under RRC parameter session.

L1 measurement: Configurations for L1 measurement - 2

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

- Reply from RAN2 (R2-2212988) available
  - *RAN2 assumes that LTM (intra DU and inter DU) is network-controlled mobility where the control is from the source, i.e., measurements (L1 measurements) are configured in the UE from the source Cell, and the decision to switch cell is by the source cell, and enhancements considered for LTM before cell switch, e.g. pre-synchronization, TA handling, target beam management (to the extent it is supported) may be made by the source cell. RAN2 understands that this may require cooperation among source DU, CU, target DU, and/or OAM. RAN2 don’t see any blocking issue to share information between DUs but the support of this is in RAN3 domain. RAN2 see no necessity for a direct inter-DU-interface to support this.*
- Reply from RAN3 (R3-226829) available
  - *Regarding Q3 about L1 measurement and TCI state configurations in the LS, RAN3 agreed that based on the current specification, the serving DU cannot know the measurement RS configuration and TCI state configuration of cells served by another DU.*
  - *Any possible consideration for Rel-18 on the coordination over F1 among serving DU, target DU, and CU would need clearly identified requirements from other groups.*

No specific action is planned before RAN1#114

L1 measurement reporting – Contents of gNB scheduled L1 measurement reporting

High Priority

[Conclusion at RAN1#110b-e]

Agreement (FL proposal 2-1-1)

- 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
    - Further study 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

[Conclusion at RAN1#112bis]

Agreement

For the beam selection for SSB based L1-RSRP measurement report,

- Beam selection is performed across the L cells from configured (or activated, if introduced) cells, i.e. M beams for each of the L cells
  - FFS: How to select the L cells and M beams per cells is up to UE
- M x L beams are reported in a single report instance
  - Max values of M and L are based on UE capability, and at least M x L=4 is supported as a UE capability, other UE capabilities are FFS
    - FFS if UE is allowed to report less than M x L beams
  - The values of M and L are configured to the UE in the reporting configuration
- FFS: The following configurability is introduced in the report configuration
  - 1) Whether serving cell is always selected in the L cell selection performed by the UE, and applicable when a UE is configured with L>=2
  - 2) at least one of the inter-frequency cells is always selected in the L cell selection performed by the UE, and applicable when a UE is configured with L>=2 and at least one cell in inter-frequency

[Conclusion at RAN1#113]

Working Assumption

- For the beam selection for SSB based L1-RSRP measurement report,
  - For the value of M, L
    - the RRC configured candidate values are:
      - M = 1, 2, 3, 4
      - L = [1], 2, 3, 4
    - Note: the maximum value of M*L and combination of M and L is up to UE capability

Agreement

- For the beam selection for SSB based L1-RSRP measurement report,
  - The inclusion of current SpCell in the L1 measurement report is configurable.
    - new UE capability(ies) are introduced and details can be discussed in UE feature

Conclusion

- For the beam selection for SSB based L1-RSRP measurement report, except SpCell is configured to be included,
  - the selection of cells for the L1 measurement report is up to UE implementation.
  - the selection of beams per cell for the L1 measurement report is the same as legacy behaviour.

List of open issues (UE capability discussion is excluded)

- Confirmation of working assumption: also consider the number of candidate cells
- How/whether to include the cell/beam indices to which L1-RSRP measurement results correspond - (No RRC impact)
- Zero padding to ensure payload size greater than 12bits, if this case happens (No RRC impact)

L1 measurement reporting – Quantization of L1 measurement result

Mid Priority

[Conclusion at RAN1#113]

Final form of FL proposal

- For the report of SSB based L1-RSRP,
  - L1-RSRP is quantized to a 7-bit value in the range [-140, -44] dBm with 1dB step size, and the remaining RSRP values are indicated with a differential L1-RSRP quantized to a 4-bit value where the differential L1-RSRP value is computed with 2 dB step size with a reference to the largest measured L1-RSRP value
  - The following option is down-selected in RAN1#114
    - Option A: Differential encoding is performed per cell, i.e. for each cell, a beam to apply absolute L1-RSRP is chosen among M beams and the differential L1-RSRP is applied to M-1 beams
    - Option B: a beam to apply absolute L1-RSRP is chosen among M *L beams and the differential L1-RSRP is applied to M*L-1 beams
    - Option C: Take the following 2-step approach
      - Step one: Differential encoding is performed per cell, i.e. for each cell, a beam to apply absolute L1-RSRP is chosen among M beams and the differential L1-RSRP is applied to M-1 beams.
      - Step two: a beam to apply absolute L1-RSRP is chosen among L beams applying absolute L1-RSRP in step one and the differential L1-RSRP is applied to L-1 beams.

Quantization of L1 measurement result is an essential issue, and the FL proposal above needs to be discussed in RAN1#114.
- However, no RRC impact is foreseen at this moment
Companies' views on the choice of Option A-C is greatly appreciated (other options are not precluded)

L1 measurement reporting - Container of gNB scheduled L1 measurement reporting

[Conclusion at RAN1#110b-e]

Agreement (FL proposal 2-1-1)

- 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
    - Further study 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

[Conclusion at RAN1#111]

Agreement

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

[Conclusion at RAN1#112bis]

Agreement

- Periodic and semi-persistent report on PUCCH are also supported for gNB scheduled L1-measurement reporting

There might a proposal to introduce MAC CE as an additional container, but FL thinks it is not essential.
FL sees no open issues at RAN1#114

L1 measurement reporting - Configuration for gNB scheduled L1 measurement report

[Conclusion at RAN1#110b-e]

Agreement related to an LS to RAN2

- The detailed design of RRC structure is up to RAN2, and send an LS to RAN2 to request to work on the RRC structure design on the measurement configuration.
  - Following RAN1 understanding will be provided in the LS
    - RAN1 has discussed the following configuration options for L1 measurement configurations for SSB till RAN1#112:
      - Option 1) Configurations for L1 measurement RS is provided under ServingCellConfig for the serving cells
        - is useful to reuses the mechanism for Rel-17 ICBM and necessary information to support inter-frequency measurement will be added there.
      - Option 2) Configurations for L1 measurement RS is provided separately from ServingCellConfig for the serving cells and CellGroupConfig for the candidate cells
        - is useful to avoid the duplicated configurations for L1 measurement RSs, [and avoid UE to process configurations ~~for L1 measurement RS~~ provided under CellGroupConfig for the candidate cells]
      - Option 3) Configurations for L1 measurement RS is provided under CellGroupConfig for the candidate cells
        - can achieve the similar benefit as Option 2) by directly referring to the candidate cell configurations.
    - Note RAN2 has a full flexibility to design the whole RRC structure design.
    - RAN1 believes this is RAN2 expert region, and respectfully asks RAN2 to finalize the RRC structure design after RAN1 finalizes the discussion on RRC parameters.
    - It is noted that RAN1 foresees the necessity of similar discussions on TCI state pool for candidate cells and L1 measurement report configurations.

Assuming that the legacy IE for CSI reporting can be reused for LTM, FL thinks we can directly go to RRC parameter discussion without additional agreement

- Potential discussion: Introduction of MAC CE (or other means) to update the subset of L1 measurement RSs to be reported (but this might be an optimization … need more discussion at RAN1#114)

L1 measurement reporting - UE/event triggered report for L1 measurement results

[Conclusion at RAN1#113]
No consensus to introduce UE/event triggered report for L1 measurement results for LTM in Rel-18

No discussion in RAN1#114.

Beam indication - Beam indication mechanism based on Rel-17 unified TCI framework

Mid Priority

[Conclusion at RAN1#110b-e]

Agreement(FL proposal 3-1)

- 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

[Conclusion at RAN1#111]

Agreement

- The beam indication of candidate cell(s) for Rel-18 LTM should be designed based on the following:
  - Beam indication for Rel-18 LTM is designed based on Rel-17 unified TCI framework, if both serving cell and candidate cell support Rel-17 unified TCI framework
  - FFS: whether/how to design mechanism for Beam indication for Rel-18 LTM when at-least one from serving cell and candidate cell supports only Rel-15 TCI framework.
  - Note: How and whether to indicate the new serving cell(s) and timing for beam indication are separately discussed

[Conclusion at RAN1#112]

Agreement

- At least for Rel-17 unified TCI framework based beam indication included in cell switch command (i.e. scenario 2), beam indication applies to signals/channels that follow or are configured to follow Rel-17 unified TCI at the target cell(s)
- FFS: beam indication for mTRP case

The following proposals are postponed

- The existing mechanism, i.e. simultaneousTCI-UpdateList1 and simultaneousTCI-UpdateList2, is reused to indicate TCI states for multiple target cells
- Beam application time may be different from that for Rel-17 ICBM, FFS the exact value(s)

[Conclusion at RAN1#112bis]

Agreement

- Adopt Alt.2 for beam indication of target cell(s) and TCI state activation for candidate cell(s) (if supported) ,
  - Alt. 1: By indicating RS identifier, i.e. mapping between RS identifier and Rel-17 unified TCI state is done by a UE
  - Alt. 2: By indicating Rel-17 TCI state index

[Conclusion at RAN1#113]

companies are encouraged to continue their assessment on the following proposal

For beam indication of target cell based on Rel-17 unified TCI framework applied to CORESET#0 and CORESETs (other than CORESET#0) associated with Type 0A/1/2-PDCCH CSS sets where no TCI state activation is provided, followUnifiedTCI-state is not enabled or not provided

- Alt.1: Follow the indicated TCI state until a new TCI state is configured or activated by the target cell
- Alt.4: No new behaviour is introduced on top of Rel-17 unified TCI

RAN1 needs to chose Alt.1 or Alt.4 (other alternatives are not precluded) to conclude Rel-17 unified TCI framework-based Beam indication

However, no impact on RRC is foreseen

Beam indication - Configuration for TCI states based on Rel-17 unified TCI framework

[Conclusion at RAN1#113]

Agreement

- Each TCI state included up to 2 qcl-types and each qcl-type source RS in a QCL-Info of the TCI state is provided at least based on the RS configuration for LTM
  - FFS: other RS index outside measurement RS configuration for LTM
  - FFS: Additional contents of TCI states for LTM

Agreement

- For TCI state activation for candidate cell(s) before the cell switch command,
  - MAC CE is used and the details of MAC-CE for TCI state activation for LTM is up to RAN2
  - Further study if PDCCH order for candidate cell(s) can be used

- Open issues
  - Essential: Details of RS configuration (highlighted with yellow maker above)
    - This has a dependency on the FFS in slide #30, which will be discussed first at RAN1#114
  - Necessity of unifiedTCI-StateType for candidate cell(s)
    - This has a dependency on the discussion of "pair of DL/UL TCI state is allowed or not"

```
TCI-State ::=                        SEQUENCE {
    tci-StateId                          TCI-StateId
    qcl-Type1                            QCL-Info
    qcl-Type2                            QCL-Info
    ...,
    [[
    additionalPCI-r17                      AdditionalPCIIndex-r17
    pathlossReferenceRS-Id-r17              PathlossReferenceRS-Id-r17
    ul-powerControl-r17                    Uplink-powerControlId-r17
    ]]
}

QCL-Info::=                        SEQUENCE {
    cell                                ServCellIndex
    bwp-Id                              BWP-Id
    referenceSignal                       CHOICE {
        csi-rs                                NZP-CSI-RS-ResourceId
        ssb                                   SSB-Index
    },
    qcl-Type                            ENUMERATED {typeA, typeB, typeC, typeD},
    ...
}
```

Beam indication - Beam indication mechanism applicable to gNBs not supporting Rel-17 TCI framework

[Conclusion at RAN1#110b-e]

Agreement(FL proposal 3-1)

- 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

[Conclusion at RAN1#111]

Agreement

- The beam indication of candidate cell(s) for Rel-18 LTM should be designed based on the following:
  - Beam indication for Rel-18 LTM is designed based on Rel-17 unified TCI framework, if both serving cell and candidate cell support Rel-17 unified TCI framework
  - FFS: whether/how to design mechanism for Beam indication for Rel-18 LTM when at least one from serving cell and candidate cell supports only Rel-15 TCI framework.
  - Note: How and whether to indicate the new serving cell(s) and timing for beam indication are separately discussed

[Conclusion at RAN1#112]

FL proposal

- Interested companies are encouraged to check the proposal on by proponent companies, and to input their contribution to the future meeting as necessity.

[Conclusion at RAN1#114]

No discussion

This topic will be handled on low priority basis for the timely completion of this WI

Beam indication: Timing of beam indication– scenario 2 except TCI state activation

[Conclusion at RAN1#110b-e]

Agreement(FL proposal 3-2)

- 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.

[Conclusion at RAN1#111]

Agreement

- For beam indication timing for Rel-18 LTM,
  - Support Scenario 2: Beam indication together with cell switch command,
    - For Rel-17 unified TCI framework,
      - Beam indication indicates TCI state for each target serving cell
  - FFS: Scenario 1: Beam indication before cell switch command
  - FFS: Scenario 3: Beam indication after cell switch command
- FFS: Activation of TCI state(s) of target serving and/or candidate cell(s).

[Conclusion at RAN1#112]

Agreement

- RAN1 shares the same understanding as RAN2 on agreement:
  - The LTM mobility trigger information is conveyed in a MAC CE
- The same MAC CE is used for the LTM triggering.

Agreement

- The agreement on scenario 2 (Beam indication together with cell switch command) at RAN1#111 is further clarified as the following:
  - Beam indication for the target cell(s) is conveyed in the MAC CE used for LTM triggering for scenario 2

[Conclusion at RAN1#113]

- No discussion, (No proposal was made)

There is no open issue on this matter

Beam indication: Timing of beam indication – scenario 1 and/or 3

[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.

[Conclusion at RAN1#111]

Agreement

- For beam indication timing for Rel-18 LTM,
  - Support Scenario 2: Beam indication together with cell switch command,
    - For Rel-17 unified TCI framework,
      - Beam indication indicates TCI state for each target serving cell
  - FFS: Scenario 1: Beam indication before cell switch command
  - FFS: Scenario 3: Beam indication after cell switch command
- FFS: Activation of TCI state(s) of target serving and/or candidate cell(s).

[Conclusion at RAN1#112bis-e]

The following FL proposal was postponed

Companies are encouraged to further study the spec impact when Rel-17 ICBM and Rel-18 LTM can be operated simultaneously, e.g.

- *TCI state pool for Rel-18 LTM can include or have any dependency of TCI states for Rel-17 ICBM operation*
- *UE capability*

There was no common understanding on the necessity of scenario 3, as a fall-back operation.

[Conclusion at RAN1#113]

Action to the next meeting:

- Check the spec impact of simultaneous operation of Rel-17 ICBM and Rel-18 LTM
- Discuss scenario 1 and 3 after scenario 2 can be finalized
  - Benefit and spec impact by introducing scenario 1 (except simultaneous operation of ICBM and LTM)
  - Necessity of fallback operation i.e. scenario 3, and its benefit.

Open issues

- Simultaneous operation of Rel-17 ICBM and Rel-18 LTM
  - This would be possible if the following conditions (any other?)
    - TCI state lists for Rel-17 ICBM and Rel-18 LTM are separately defined
    - Activated TCI states for Rel-17 ICBM and Rel-18 LTM are separately managed by a UE
    - (Note; however, beam indication may not be exclusive)
  - Then, all the issues can be handled under UE capability session
- Scenario 1 and 3 (including the necessity of fallback operation) will be handled on low-priority basis

Beam application time

[Conclusion at RAN1#112]

The following FL proposal was made, but not discussed due to the lack of time

- Beam application time may be different from that for Rel-17 ICBM, FFS the exact value(s)

[Conclusion at RAN1#112bis-e]

Agreement

- Companies are encouraged to study the beam application time for Rel-18 LTM, which may be different from that without serving cell change
  - Definition of the beam application time
  - The exact value(s), condition and UE capability
  - Consider the interaction with the application of the candidate RRC configuration.

[Conclusion at RAN1#113]

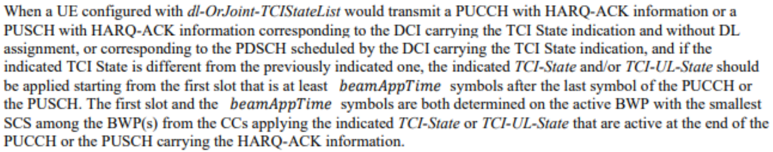
Agreement

- For the beam application time for Rel-18 LTM,
  - Beam application time is supported, and starts after the last symbol of the PUCCH or PUSCH carrying the HARQ-ACK for the PDSCH which carries MAC-CE containing cell switch command with the beam indication for the target cell(s)
    - FFS: reference SCS, i.e. serving cell and/or target cell
  - At least the following components are further studied to define the beam application time
    - Whether TCI state activation is received before/together with cell switch command
    - Legacy values 3*N^subframe_slot* and BeamAppTime-r17
    - RF retuning time when inter-frequency switch is performed, which is up to RAN4
    - Whether the target cell is one of the current serving cells
- Cell switching time, which is defined by RAN2 and RAN4, may or may not include the potential components of beam application time above.
- Send an LS to RAN2 and RAN4 to ask their feedback

Details of BeamAppTime for LTM needs to be defined

- Specific value(s) in 38.331 → Reply LS from RAN2/4 is needed, and this can be discussed under UE capability session
- Reference SCS
- Behavior when beams of multiple target cells are simultaneously indicated

38.214 5.1.5



When a UE configured with *dl-OrJoint-TCIStateList* would transmit a PUCCH with HARQ-ACK information or a PUSCH with HARQ-ACK information corresponding to the DCI carrying the TCI State indication and without DL assignment, or corresponding to the PDSCH scheduled by the DCI carrying the TCI State indication, and if the indicated TCI State is different from the previously indicated one, the indicated *TCI-State* and/or *TCI-UL-State* should be applied starting from the first slot that is at least *beamAppTime* symbols after the last symbol of the PUCCH or the PUSCH. The first slot and the *beamAppTime* symbols are both determined on the active BWP with the smallest SCS among the BWP(s) from the CCs applying the indicated *TCI-State* or *TCI-UL-State* that are active at the end of the PUCCH or the PUSCH carrying the HARQ-ACK information.

Beam indication for mTRP

[Conclusion at RAN1#112]

Agreement

- At least for Rel-17 unified TCI framework based beam indication included in cell switch command (i.e. scenario 2), beam indication applies to signals/channels that follow or are configured to follow Rel-17 unified TCI at the target cell(s)
- FFS: beam indication for mTRP case

This topic will be handled on low priority basis

Cell switch command

High Priority

[Conclusion at RAN1#110b-e]

Agreement(FL proposal 4-1)

- 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

[Conclusion at RAN1#112bis-e]

Agreement

- From RAN1 point of view, at least the following information can be included in the cell switch command, which is conveyed by MAC CE
  - Information to identify the target cell(s)
    - The details including bit number are designed by RAN2
  - TA related information (details up to the discussion in A.I. 9.10.2)
  - 1 joint or 1 pair of UL and DL unified TCI State index for the target Cell
    - Note: discussion on target SpCell is not precluded
  - Active DL and UL BWPs for the target cell
  - FFS: Triggering of aperiodic TRS transmitted from the target cell
  - FFS: Triggering the CSI acquisition of the target cell and reporting to the target cell
  - FFS: Triggering of aperiodic SRS transmission to the target cell
  - FFS: C-RNTI
- FFS: the presence of each field (i.e. always present or configurable)

Working Assumption

On the presence of beam indication within cell switch command, at least for scenario 2, following is supported:

- A field to indicate 1 joint or 1 pair of UL and DL unified TCI State index for the target cell field is always present in the cell switch command.

- Note: If scenarios 1 and 3 are agreed to be supported in R18 LTM other solutions may be considered.

[Outcome of RAN1-113]

Through the discussion in RAN1#113, it is confirmed that whether C-RNTI needs to be included within the MAC-CE containing cell switch command will be left to RAN2 decision. Also, it will be left to RAN2 decision whether the following fields are always present or not in the cell switch command:

- Active DL and UL BWPs for the target cell
- TA related information

Open issues:

- Confirm the working assumption a RAN1#112bis-e
  - **A field to indicate 1 joint or 1 pair of UL and DL unified TCI State index for the target cell field is always present in the cell switch command**
- Presence of the TCI state indication filed:
  - The design varies depending on the number of activated TCI states by a single TCI state activation MAC CE
  - The simplest solution would be: a field to indicate 1 joint or 1 pair of UL and DL unified TCI State index for the target cell field is always present in the cell switch command irrespective of the timing of TCI state activation - (this issue has RAN2 impact)
- Whether/how to perform the beam indication for multiple cells (i.e. CA case) - (this issue has RRC impact)
  - Note: Support of CA scenario is up to RAN2, and FL assumes this is the case unless explicit message is received from RAN2.

Preparation for LTM: Details on DL synchronization to candidate cell(s)

High Priority

[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.

[Conclusion at RAN1#111]

Agreement

- Regarding the potential RAN1 enhancements to reduce the handover delay / interruption for Rel-18 LTM
  - Support at least DL synchronization for candidate cell(s) based on at least SSB before cell switch command
    - Further study the necessary mechanism, e.g. signaling and UE capability

[Conclusion at RAN1#112bis-e]

Agreement

For the Rel-17 unified TCI based beam indication in Rel-18 LTM, at least Alt 1 is supported:

- **Alt 1:** TCI state activation of a candidate cell is received before the reception of beam indication of the candidate cell,
- **Alt 2:** TCI state activation of a candidate cell is received together with the reception of beam indication of the candidate cell
  - FFS: signalling details for TCI state indication, if both activation and indication are done in the same MAC CE message carrying switch command
- **Alt 3:** Alt 1 and/or Alt 2 can be supported based on the UE capability

FFS: signalling details for TCI state activation

FFS: For Alt 1, whether/how TCI state activation for candidate cell(s) is allowed

Note: If scenarios 1 and 3 are to be supported other beam indication/TCI activation timing relationships are not precluded.

[Conclusion at RAN1-113]

The following were agreed during RAN1-113.

Conclusion

For R18 LTM, in order to activate multiple joint TCI state or/and pair of (DL/UL) TCI states for candidate cell case, do not support TCI state activation together with beam indication of the candidate cell in the same MAC-CE message.

- **FFS:** UE assumption on the active TCI states other than the indicated TCI state after the reception of the cell switch command.

Agreement

A UE can be indicated and activated a single joint TCI state or a pair of UL/DL TCI state in the cell switch command.

Open issues

- **Further details of TCI state activation**
  - **Clarification of the difference of UE bahavior (e.g. beam application time, definition of beam indication field in cell switch command MAC CE etc.) between the following cases:**
    - **TCI state activation is performed together with TCI state indication**
    - **TCI state activation is performed prior to TCI state indication**
  - **Number of activated TCI states, and the number of cells correspond to the activated TCI states when TCI state activation is performed prior to beam indication**
    - **This can be left to UE capability discussion**

Preparation for LTM: TRS tracking and CSI acquisition

[Conclusion at RAN1#110b-e]

Agreement(FL proposal 5-1)

- 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)

[Conclusion at RAN1#111]

Agreement

- Regarding the potential RAN1 enhancements to reduce the handover delay / interruption for Rel-18 LTM
  - Support at least DL synchronization for candidate cell(s) based on at least SSB before cell switch command
    - Further study the necessary mechanism, e.g. signaling and UE capability

[Conclusion at RAN1#113]

Conclusion

There is no consensus to support the following procedures prior to the reception of L1/L2 cell switch command aiming at the reduction of handover delay/interruption in Rel-18 LTM

- CSI acquisition for candidate before reception of cell switch command

Note: At least for the candidate cells which are current serving cells, the CSI acquisition prior to cell switch command will be supported

There is no consensus to introduce additional mechanism to support the following procedures prior to and joint with the reception of L1/L2 cell switch command aiming at the reduction of handover delay/interruption in Rel-18 LTM

- TRS tracking for candidate cells

FFS: Whether/How the QCL reference information of TCI states of the candidate cell should be mapped to the source SSB

Note: At least for the candidate cells which are current serving cells, TRS tracking prior to cell switch command is supported

Open issue: Resolution of FFS

- **Whether/How the QCL reference information of TCI states of the candidate cell should be mapped to the source SSB**
  - **(please also refer to the related issue in slide #22)**

Thank you