**3GPP TSG-RAN WG4 Meeting #106 R4-2303175**

**Athens, Greece, 27 February –03 March, 2023**

**Title:** WF on L1/L2 based inter-cell mobility

**Agenda Item:** 9.23.7

**Source:** MediaTek Inc.

**Document for:** Approval

# 0 Notes:

In this document,

* < **Agreement** > represents the decisions made by in this meeting
* < **Wayforward** > represents the next step in later meetings

# 1 Topic #1: General and work plan

**Issue 1-1: Work plan proposals**

***Placeholder***

**< Agreement/** **Wayforward >**:

Approve work plan in R4-2300926 ??

# 2 Topic #2: LTM - General aspects and scenarios

## 2.1 Sub-topic 2-1 Simultaneous data Rx/Tx in source cell and target cell?

**Issue 2-1-1: Simultaneous data Rx/Tx in source cell and target cell?**

**< Agreement>:**

* + Discuss what interruption requirements, scheduling restriction and measurement restriction to define instead of discussing whether simultaneous Rx/Tx in source cell and target cell is allowed.

## 2.2 Sub-topic 2-2 Definition of inter-frequency cell switch

**Issue 2-2-1:** **Definition of inter-frequency cell switch**

**< Wayforward >**: FFS the following options

* + Option 1 (Apple, CTC, CATT, MTK, DOCOMO, OPPO, vivo, Huawei, Nokia, Ericsson): Inter-frequency cell switch is defined where the SSB of Pcell and/or PScell and the candidate target cell are on different frequency layers.
	+ Option 2 (CATT, DOCOMO, CMCC, vivo): Inter-frequency cell switch is defined where the SSBs of active serving cell(s) and the corresponding candidate target cell(s) are on different frequency layers
	+ Option 3 (CMCC): no need to have the definition of inter-frequency cell switch if cell switch delay requirements are agnostic for intra-frequency and inter-frequency, same as existing HO delay requirements.

## 2.3 Sub-topic 2-3 Definition of synchronous and non-synchronous

**Issue 2-3-1: Definition of synchronous and non-synchronous**

*Ad hoc agreement*

**<Agreement>:**

* + It is unnecessary to define sync and async scenarios for LTM requirements.

## 2.4 Sub-topic 2-4 Requirements for DL/UL synchronization before cell switch command

**Issue 2-4-1: Whether to specific requirements for downlink/uplink synchronisation before cell switch**

**< Wayforward >**: FFS the following options

* + Option 1 (Apple): No need to define specific requirements for downlink synchronisation before cell switch since it has already been covered by existing L3 measurement requirements.
	+ Option 2 (Intel): If TCI state switch command can be sent before cell switch, depending on progress of RAN1, RAN4 may need to further discuss how to update current requirement for TCI activation, e.g. timing offset, active BWP.
	+ Option 3 (QC): RAN4 to discuss whether and how to define delay and interruption requirements for PDCCH ordered PRACH transmission to LTM cell for which UE needs additional processing to build and load RF scripts. It is also up to decisions from other working groups.
	+ Option 4 (Ericsson):
		- RAN4 to study interruption requirements due to PRACH transmission
		- RAN4 to discuss the DL synchronization requirements and the number of cells for which DL pre-synchronization can be maintained at the UE.
		- RAN4 to discuss downlink synchronisation requirements for UE before receiving cell switch command.

### 2.5 Sub-topic 2-5 Whether to consider FR2-2

**Issue 2-5-1: Whether to consider FR2-2**

**< Agreement>:**

* + Not consider FR2-2 in R18 LTM.

### 2.6 Sub-topic 2-6 others

**Issue 2-6-3: Others**

**< Wayforward >**: FFS the following option

* + Option 1 (QC): LTM requirements are applicable only when a QCL source reference signal of “PDCCH ordered PRACH to an LTM candidate cell before LTM handover” or “an active TCI state to be used immediately after LTM handover” is the same or one of the reference signals configured and used for LTM L1-RSRP measurements from the cell.

# 3 Topic #3: LTM - L1-RSRP measurement requirements

### 3.1 Sub-topic 3-1 General principles

**Issue 3-1-1: Basic assumption for L1 measurement on neighbour cell**

**< Wayforward >**: FFS the following proposal

* + Proposal 1 (QC): L1-RSRP measurement for LTM should not require a separate FFT engine or cell search.

**Issue 3-1-2: DL/UL synchronization assumption for L1 measurements**

**< Wayforward >**: FFS the following proposals

* + Proposal 1 (QC): RAN4 to discuss whether and how to address a potential issue where the total number of active TCI states from a serving cell plus the total number of SSBs to perform intra-frequency L1-RSRP measurements from LTM cells exceed the UE capability on the number of total active TCI states, e.g. requirement applicability rule in terms of latency requirements, etc.
	+ Proposal 2 (vivo): RAN4 to clarify DL/UL synchronization assumption for L1 measurements performed on target cell, especially if L1 measurement is performed before cell switch, but DL/UL synchronization is done after cell switch.

**Issue 3-1-3: Whether to** **use** **intermediate L3 measurement results in L1 measurement reporting**

*Ad hoc agreement*

**<Agreement>:**

* + In FR2:
		- Fine beam can be assumed for L1 measurement on intra-frequency neighbor cell. FFS on inter-frequency neighbor cell.
		- FFS whether to consider rough beam for L1 measurement on neighbor cell (including intra and inter-frequency).

**Issue 3-1-4: Whether L1 measurement configured after receiving L3 measurement report on that cell**

*As the agreed LTM framework in R2-2213332 and the agreed procedure in R3-226050, L3 measurement results need to be reported before L1 measurement is configured. Moderator suggests following RAN2 and RAN3 running CR and the majority view in RAN4.*

**< Agreement>:**

* + Network shall configure L1 measurement on a neighbour cell after receiving L3 measurement report on that cell.

**Issue 3-1-5:** **Whether to define L1-RSRP measurement delay requirement for unknown cell?**

**< Wayforward >**: FFS the following Options

* + Option 1 (QC, Apple, Intel, Xiaomi): RAN4 to define L1 measurement requirements for known cell case only.
	+ Option 2 (Nokia): RAN4 waits for RAN2 agreements on LTM timer before defining L1-RSRP measurement delay requirement for unknown cells.
	+ Option 3 (Ericsson): RAN4 to define L1 measurement requirements for both known and unknown cells.

**Issue 3-1-6:** **known cell condition for L1-RSRP measurement**

**< Agreement>:**

* + In L1-RSRP measurement for neighbour cell, target cell is considered as known if the following conditions are met in this requirement:
		- The UE has sent a valid L3 measurement report during the last [5] seconds, and
		- The SSB from the target cell remains detectable according to the cell identification requirements specified in clause 9.2 and 9.3.
	+ Otherwise, it is unknown

**Issue 3-1-7: Whether candidate cell L1-RSRP measurements can be measured within SMTC?**

*There are three folds to allow L1-RSRP measurements within SMTC:*

* *Use R15/R16/R17 L1-RSRP measurement framework*
	+ *Intra-frequency L1-RSRP measurement, L1-RSRP can be measured within SMTC if SSB occasions are fully overlapped with SMTC in FR2*
	+ *Inter-frequency L1-RSRP measurement (if supported): UE may have to perform L1 measurement within SMTC overlapped with gap*
* *If using L3 measurement framework (using L3 intermediate results for L1 report), L1-RSRP measurement would be measured within SMTC*

*Option 1 is reasonable independent of other issues. Moderator recommends agree on Option 1.*

**< Agreement>:**

* + Candidate cell L1-RSRP measurements are allowed to be measured within SMTC.

### 3.2 Sub-topic 3-2 Intra-frequency L1-RSRP measurement delay requirement

**Issue 3-2-1: Intra-frequency L1-RSRP measurement requirements**

**< Agreement>:**

* + For intra-frequency L1-RSRP measurement on neighbor cell, use the requirements for L1 measurement on NSC in R17 as a baseline:
		- FFS: whether to consider multiple neighbor cells in a frequency layer,
		- FFS how to define requirements when RTD between neighbor cell and serving cell larger than a CP.

**Issue 3-2-2:** **Whether to consider RTD of serving cell and neighbour cell larger than one CP for intra-frequency L1-RSRP measurement**

*Online agreement*

**<Agreement>:**

* + For SSB based intra-frequency L1 measurement, support the scenario that RTD between the SSBs of serving cell and neighbour is larger than CP length of the corresponding SCS with additional UE capability.
		- Note: the need for UE capability can be further discussed subject to the outcome of the discussion on measurement framework

**Issue 3-2-3: Whether sfn-SSB-Offset alignment can be relaxed?**

*Revised based on online tentative agreement*

**< Agreement>:**

* + The restriction of sfn-SSB-Offset can be removed if UE performs L3 measurement before L1 measurement. UE should have obtained SSB index information of intra-frequency neighbour cell through L3 measurement and/or network configuration.

**Issue 3-2-4: Whether SSB for intra-frequency L1 measurement should be covered by serving cell active BWP**

*Revised based on online tentative agreement*

**< Agreement>:**

* + If introduce a new UE capability or reuse bwp-WithoutRestriction, it is possible that the SSB for L1-RSRP measurement of non-serving cell is not in the active BWP if serving cell’s SSB is not in the active BWP.
	+ If the intra-frequency cell is neighbour cell of de-activated Cell, the SSB for L1-RSRP measurement of non-serving cell is not in the active BWP.

**Issue 3-2-5: Whether to specify requirements for SSB for intra-frequency L1 measurement not covered by serving cell active BWP**

**< Agreement>:**

* + The requirements for the case that target SSB is not within active BWP can be hold on after the conclusion of BWP operation without restriction
	+ FFS discuss whether to define intra-frequency L1-RSRP measurement requirements if the cell to measure is neighbor cell of deactivated Cell after checking with RAN1/2 whether L1-RSRP measurement is supported on deactivated SCell or PSCell.

### 3.3 Sub-topic 3-3 inter-frequency L1-RSRP measurement requirements

**Issue 3-3-1: Whether to cover inter-frequency L1-RSRP measurement**

*Online agreement*

**<Agreement>:**

* + Introduce inter-frequency L1-RSRP measurement requirements in Rel-18 LTM
		- Option 1: Inter-frequency L1-RSRP measurements without gap
		- Option 2: Inter-frequency L1-RSRP measurements with gap
		- Option 3: Inter-frequency L1-RSRP measurements with gap and without gap

**Issue 3-3-2: inter-frequency L1-RSRP measurement with MG**

**< Wayforward >**: FFS the following proposals

* + Proposal 1 (xiaomi):
		- RAN4 to consider whether to use the gap shared with L3 measurement or to configure a dedicated gap for L1-RSRP measurement.
		- RAN4 to define the requirement for inter-frequency L1-RSRP measurement with type 1 MG in first phase.
		- RAN4 to consider to define the requirement for inter-frequency L1-RSRP measurement with NCSG or ‘needforgap’ or type2 MG in late phase/release.
	+ Proposal 2 (Huawei): For SSB based L1-RSRP inter-frequency measurement with legacy gap:
		- In FR1, SSB based L1-RSRP can be performed simultaneously with L3-RSRP measurement;
		- In FR2, either L1 measurement sharing with L3 gap, or a dedicated measurement gap for L1-RSRP can be considered.

**Issue 3-3-3: inter-frequency L1-RSRP measurement with NCSG**

**< Wayforward >**: FFS the following proposals

* + Proposal 1 (Huawei): For SSB based L1-RSRP inter-frequency measurement with NCSG:
		- In FR1, SSB based L1-RSRP measurement can be performed simultaneously with L3-RSRP measurement;
		- In FR2, SSB based L1-RSRP measurement is to be shared with L3 measurement with NCSG. The measurement delay with NCSG is the same as that with shared legacy gap.

**Issue 3-3-4: Inter-frequency L1-RSRP measurement requirements**

**< Agreement >**:

* + Requirements for inter-frequency can be discussed after RAN4 concludes other related issues, such as which type of inter-frequency to define requirements for and so on.

### 3.4 Sub-topic 3-4 L1-RSRP measurement accuracy

**Issue 3-4-1: side condition of intra-frequency L1-RSRP measurement accuracy requirements**

**< Wayforward >**: FFS the following Options

* + Option 1 (Apple, MTK, OPPO, Huawei): Reuse legacy value SNR= -3dB
	+ Option 2 (ZTE, Ericsson): SNR =-6dB (same as L3 measurement)

# Topic #4: LTM - L1/L2 inter-cell mobility delay requirements

### 4.1 Sub-topic 4-1 General and Principles

**Issue 4-1-1: Whether define cell switch delay requirements for the case “PCell change with PSCell change”**

*Ad hoc agreement*

**< Agreement >**:

* + Only define requirements for serving cell change within one CG, e.g., not define cell switch delay requirements for the case “PCell change with PSCell change”.

**Issue 4-1-2:** **Define cell switch delay requirements for SpCell change without SCell change**

**< Agreement >**:

* + Define cell switch delay requirements for:
		- PCell change without SCell change
		- PSCell change without SCell change

**Issue 4-1-3: Whether to define cell switch delay requirements for SpCell change with SCell change**

**< Wayforward >**: FFS the following Options

* + Option 1 (CATT, MTK): The requirements of SpCell change without SCell change are applicable to PCell/PSCell for SpCell change with SCell change. FFS: define delay requirements for SCell change at PCell/PSCell change.
		- MTK: If time permits, define cell switch delay requirements for SCell change at PCell change and focus on single non-PUCCH SCell.
	+ Option 2 (Apple, Intel): FFS whether to define cell switch delay requirements for the following scenarios:
		- PCell change with SCell change
		- Role change between PCell and SCell in the same CG.
	+ Option 3 (Huawei, CMCC, vivo, Ericsson): Specify cell switch requirements for the following scenarios:
		- Target Pcell/SCell is not current SCell/PCell, and
		- Target Pcell/SCell is current SCell/PCell.

**Issue 4-1-4: Principles to follow and factors to consider when specify cell switch delay requirements**

**< Agreement >**:

* + RAN4 works for a general form of cell switch delay requirements and leave the value of some delay components as scenario-dependent, e.g.
		- FR1 to FR1, FR1 to FR2, FR2 to FR1, FR2 to FR2
		- With pre-sync and without pre-sync cases
		- When one of SCells is promoted to PCell, whether the SCell is for DL-only or both DL/UL
		- intra- and inter-frequency cell switch
		- FFS
	+ Companies are encouraged to analyse the impact on the components of cell switch delay of each factor.

**Issue 4-1-5: LTM delay requirements**

**< Agreement >**:

* + Not define the LTM delay requirement which starts from UE receives RRC configuration on candidate cell(s).

### 4.2 Sub-topic 4-2 Timeline of cell swith delay for Pcell/PSCell

**Issue 4-2-1: Starting** **point of cell switch delay for PCell/PSCell**

**< Agreement >**:

* + Cell switch delay for PCell/PSCell starts at UE receives cell switch command.

**Issue 4-2-2: Ending point of RACH-based cell switch delay for PCell/PSCell**

**< Agreement >**:

* + For RACH-based cell switch, cell switch delay for PCell/PSCell ends at UE transmitting PRACH to the target cell.

**Issue 4-2-3: Ending point of RACH-less cell switch delay for PCell/PSCell**

**< Wayforward >**: FFS the following Options

* + Option 1 (Apple, MTK, xiaomi): UE performs the first UL transmission on the indicated beam of the target cell.
	+ Option 2 (CTC, CMCC, ZTE, OPPO, Huawei): UE performs the first DL/UL reception/transmission on the indicated beam of the target cell.

**Issue 4-2-4: Procedure of cell switch**

**< Wayforward >**: FFS the following Option

* + Option 1 (MTK): Further discuss whether UE can perform T/F fine tracking (TΔ) if needed at first and then L1/L2/L3 processing (Tprocessing,2) to reduce the interruption time during cell switch.

### 4.3 Sub-topic 4-3 Detail of cell swith delay requirements for Pcell/PSCell

**Issue 4-3-1: RACH-based Cell switch delay for Pcell/PSCell**

**< Agreement >**:

* + The baseline of RACH-based cell switch delay is

Tdelay = Tcmd + Tprocessing + Tsearch + T∆ + Tmargin + TIU, where TIU is the uncertainty in acquiring the first available PRACH occasion in the new cell.

* + - FFS: the exact value of each component. Some components can be 0 in certain cases, if agreed.
		- FFS: add other component(s).

**Issue 4-3-2: RACH-less Cell switch delay for Pcell/PSCell**

**< Agreement >**:

* + The baseline of RACH-less cell switch delay is

Tdelay = Tcmd + Tprocessing + Tsearch + T∆ + Tmargin + TIU, where TIU is the uncertainty in acquiring the first available PRACH occasion in the new cell.

* + - FFS: the ending point
		- FFS: the exact value of each component. Some components can be 0 in certain cases, if agreed.
		- FFS: add other component(s).

**Issue 4-3-3: Processing time: Tprocessing**

**< Wayforward >**: FFS the following Options

* + Option 1 (CTC, Huawei, CMCC, ZTE, Nokia): The time for UE processing could be reduced if some procedures have been done before UE receive the cell switch command or for some scenarios.
		- Option 1a (CMCC): Tprocessing = 0 for the case that DL synchronization for candidate cell(s) is performed before cell switch command
		- Option 1b (ZTE): For intra-DU scenario, UE processing time could be reduced.
		- Option 1c (Nokia): LTM is very different from legacy L3 HO. MAC / RLC reset, BB retuning and RF retuning scenarios for LTM are captured in TLTM-processing instead of Tprocessing2. TLTM-processing is 0ms depending in some conditions (no extra processing needed).
	+ Option 2 (Apple): Reuse execution time defined in CHO as the processing time in LTM cell switch delay requirements.
	+ Option 3 (QC): RAN4 to not assume UE can always finish a processing of RRC configurations for LTM cells before LTM handover command reception, e.g. the processing and loading the configuration before the LTM handover command reception can be limited to measurement related configurations of the LTM cells. And RAN4 to not assume the processing and loading the measurement configuration of the LTM cell before LTM handover command reception means the entire downlink configuration of the LTM target cell is processed and loaded.
	+ Option 4 (MTK):
		- To avoid defining too much Tprocessing,2 values for different scenarios, suggest focusing only on the typical scenarios and classifying the scenarios into limited groups.
		- Categorize all the scenarios into at most four groups depending on if L2/L3 reconfiguration or L1 reconfiguration is needed:

|  |  |  |  |
| --- | --- | --- | --- |
|  | L2/L3 reconfiguration | L1 reconfiguration | Typical scenario |
| Group#1 | Y | Y | * intra-DU or Inter-DU, intra-frequency or inter-frequency cell switch with L1 and L2/L3 reconfiguration
 |
| Group#2 | N | Y | * intra-DU or Inter-DU, intra-frequency or inter-frequency cell switch without L2/L3 reconfiguration but with L1 reconfiguration:
	+ including switch to active SCell without L2/L3 reconfiguration
 |
| Group#3 | N | N | * intra-frequency cell switch without L1/L2/L3 reconfiguration, maybe intra-DU or inter-DU
 |
| Group#4 | Y | N | * intra-frequency cell switch with L2/L3 reconfiguration, maybe intra-DU or inter-DU
 |

* + - Tprocessing,2=20ms for intra-FR cell switch and Tprocessing,2=40ms for inter-FR cell switch when software processing for L2/L3 reconfiguration and L1 reconfiguration is needed. FFS: the value for other groups.

**Issue 4-3-4: T/F fine tracking: TΔ and Tmargin**

**< Wayforward >**: FFS the following Options

* + Option 1 (Apple, MTK, Xiaomi): The baseline is: TΔ=1 Tfirst-RS, Tmargin = 2ms
		- FFS: whether TΔ and Tmargin can be 0 under certain conditions.
	+ Option 2 (CMCC, Huawei): TΔ = 0 for the case that DL synchronization for candidate cell(s) is performed before cell switch command

**Issue 4-3-5: Cell search for RACH-based cell switch: Tsearch**

**< Agreement >**:

* + For RACH-based cell switch, Tsearch equals to 0 when target cell is known or target cell is current active Scell
		- FFS: whether to define requirements for unknown cell.

**Issue 4-3-6: Cell search for RACH-less cell switch: Tsearch**

**< Agreement >**:

* + For RACH-less cell switch, Tsearch equals to 0 when target cell is known or target cell is current active Scell.

**Issue 4-3-7:** **TCI state switching time**

**< Wayforward >**: FFS the following Options

* + Option 1 (Intel, MTK, OPPO): no need to add TCI state switching time in cell switch delay.
	+ Option 2 (ZTE, Xiaomi): FFS to add TCI state switching time in cell switch delay.

**Issue4-3-8: Whether to define PCell/PSCell switch delay requirements for unknown TCI state case**

**< Agreement >**:

* + Only define cell switch requirement for known TCI state case in LTM.

**Issue 4-3-9:** **Execution time**

**< Wayforward >**:

* + Option1 (CATT, MTK): wait for RAN2 progress.

**Issue 4-3-10: PL-RS measurement**

**< Wayforward >**: FFS the following Option

* + Option 1 (Intel): If UL TCI state switch is included in cell switch command, possible extra delay is expected due to non-maintained PL-RS. Further discuss whether to consider non maintained PL-RS case.

**Issue 4-3-11: Tinterruption**

**< Wayforward >**: FFS the following proposals

* + Proposal 1 (Apple, CTC, CMCC, OPPO): The components of L1/L2 cell switch interruption Tinterruption are the components of L1/L2 inter-cell mobility delay except Tcmd
	+ Proposal 2 (Nokia): LTM cell switch interruption time should be minimized, and upper limit should be agreed not to exceed the existing L3 HO interruption time. The target should be to be as close to a beam switch delay as possible.
	+ Proposal 3 (Huawei): There is almost no interruption during cell switch procedure when target Pcell/SCell is current SCell/PCell.

### 4.4 Sub-topic 4-4 Known conditions

**Issue 4-4-1: known cell conditions**

**< Agreement >**:

* + Use the following known cell condition as a baseline:
		- The target cell is known if it has been meeting the following conditions:
			* During the last 5 seconds before the reception of the cell switch command:
			* the UE has sent a valid L1 or [L3] measurement report for the target cell and
			* One of the SSBs measured from the NR target cell being configured remains detectable according to the cell identification conditions specified in clause 9.3,
			* One of the SSBs measured from the target cell also remains detectable during the cell switch delay according to the cell identification conditions specified in clause 9.3.
		- otherwise it is unknown.

**Issue 4-4-2: known TCI state conditions**

**< Agreement >**:

* + Use the following known TCI state condition as a baseline:
		- The TCI state is known if the following conditions are met:
			* During the period from the last transmission of the RS resource used for the L1-RSRP measurement reporting for the target TCI state to the completion of cell switch, where the RS resource for L1-RSRP measurement is the RS in target TCI state or QCLed to the target TCI state
				+ Cell switch command is received within 1280 ms upon the last transmission of the RS resource for beam reporting or measurement
				+ The UE has sent at least 1 L1-RSRP report for the target TCI state before the cell switch command
				+ The TCI state remains detectable during the cell switching period
				+ The SSB associated with the TCI state remain detectable during the cell witching period

SNR of the TCI state ≥ -3dB

* + Otherwise, the TCI state is unknown.