3GPP TSG-RAN WG4 Meeting #112 R4-2414026

Maastricht, Netherlands, 19th – 23rd August, 2024

**Agenda item:** 8.15.4

**Source:** Apple

**Title:** WF for NR\_RRM\_Ph5\_Part1

**Document for:** Approval

# Topic #1: FR2-1 L3 measurement delay by optimizing Rx beam sweeping factor (8.15.2.1)

**Applicability requirement:**

Updated Agreement in online session:

Baseline: L3 delay enhancements in Rel-19 by optimizing Rx BSF for UE supporting multi-rx simultaneous reception are applicable provided that:

* the target carrier(s) to be measured: only one carrier in the single FR2-1 band is configured for L3 SSB measurement and
* UE serving carrier(s): UE is configured with single carrier on FR2-1 band, i.e. FR2-1 PCell without CA/DC.

Note: Target and serving carrier frequency can be the same or different.

Note: The ‘other UE CA/DC modes (e.g., 1 or 2 FR2-1 bands CA, or FR1+FR2 CA/DC, or EN-DC)’ and/or the ‘other number of target to-be-measured carrier(s) on FR2-1 band’ can be FFS after concluding the baseline above. These extra FFS parts will NOT delay the WI completion.

**UE Power class:**

Agreement in online session:

Baseline: RAN4 to consider UE supporting FR2-1 power class 3 as first priority.

Note: whether other power classes could apply the outcome of the WI discussion can be FFS after concluding on PC3. These extra FFS parts will NOT delay the WI completion.

**Other clarification on WID:**

Agreement in online session:

Remove {FFS: “For UE supporting multiple-Rx simultaneous reception for L3 delay enhancement” means UE supporting “simultaneous reception of multiple SSBs from different directions of the same target frequency layer inside a SMTC window. But it does not mean “UE can process multiple SSBs from different directions of the target frequency in parallel.”}.

**Issue 1-2-1: FFS: multi-Rx simultaneous reception of UE is in active mode, which is expected to follow the one specified in Rel-18 for multi-Rx simultaneous reception feature**

Agreement in online session:

* + - The conditions for UE to apply L3 measurement delay reduction by optimizing Rx BSF is that multi-Rx simultaneous reception of UE is in active mode. And it does not assume that the condition of in active mode is same as that for Rel-18 multi-Rx simultaneous reception.

**Issue 1-2-2: FFS: UE’s mobility status, e.g., whether HST is precluded or not**

Agreement in online session:

* + - * RAN4 to consider UE in non-HST case as first priority.
			* Note: whether or how HST case could use the outcome of the WI discussion can be FFS after concluding on non-HST case. These extra FFS parts will NOT delay the WI completion.

**Issue 1-2-3: FFS: RRM measurement with two panels activated, two searchers are occupied by this single carrier**

[Way forward]:

FFS:

* + - Option A/1a: Two searchers are occupied by this single carrier to the requirements of enhanced BSF for single carrier. Discuss CA case later. (HW, CATT, Apple, OPPO, LGE, Xiaomi)
		- Option B: Consider one searcher for single carrier. (MTK, ZTE, OPPO, QC, Nokia, Intel, vivo, Ericsson, Apple, Xiaomi, CATT)

**Issue 1-2-4: FFS: SSB processing delay/time for processing multiple beams received in a SMTC**

[Way forward]:

FFS:

* + - Option 1 (CATT, vivo): No need to add additional processing time due to multiple SSBs within one SMTC.
		- Option 2 (Apple): allow additional processing time for UE supporting multiple-Rx simultaneous reception for L3 delay enhancement if there is only one searcher available for the processing
		- Option 3 (Ericsson): Extra SSB post-processing time in several ms, as side effect of BSF enhancement, may be acceptable, but it depends on how much we can gain with BSF enhancement
		- Option 4 (Intel):
* Consider UE baseband processing capabilities when specifying the L3 delay reduction for simultaneous receptions on multiple FR2 SSB-s.
* Different (or whether or not) delay reduction applies when the ratio of number of SSB within a burst and time duration of the measurement periodicity varies.
	+ - Option 5 (Nokia):
* If additional time for SSB processing is needed when UE is measuring multiple beams in one SMTC, RAN4 to consider measurement delay with SSB processing as
	+ a. Tidentify\_intra\_without\_index = (TPSS/SSS\_sync\_intra + T SSB\_measurement\_period\_intra+TSSB\_processing) ms
	+ b. Tidentify\_inter\_without\_index = (TPSS/SSS\_sync\_inter + T SSB\_measurement\_period\_inter+TSSB\_processing) ms
	+ c. where TSSB\_processing = 2 ms

**Issue 1-2-5: FFS: Power consumption issue (including conditions to trigger UE using FBS for L3 measurement)**

* + - Option 1 (Apple, LGE): For power saving purpose, there is a need to have a mechanism to activate/de-activate L3 fast beam sweeping. The R18 mechanism (i.e., multi-RX operation definition and UAI indication of preference) can be considered as a baseline, while other conditions are not precluded.
		- Option 2 (HW):
* RAN4 shall firstly identify the promising scenario(s) for L3 measurement delay reduction enabled by multi-Rx with clear/significant benefits, which could help to converge the discussion.
* One possible scenario to be considered is when there is strong demand of mobility performance (e.g. UE at cell edge or the link is about to break).
* It shall not be assumed that UE supporting this feature shall activate multiple panels all the time for all L3 measurement. RAN4 shall discuss the entering and/or exiting conditions for enhanced L3 measurement enabled by multi-Rx taking the targeting scenario into account.
	+ - Option 3 (Ericsson/Nokia): NW indicates UE enabling/disabling FBS through L3 or lower layers signaling.
		- Option 4 (vivo): Power consumption issue is important and BSF reduction of L3 measurement will not trigger UE to activate multi-Rx
		- Option 5 (Intel): Power consumption is not an issue in the scope since the total power consumption for a handover stays roughly the same even delay is reduced. Whether UE has prior knowledge or cell centre/edge conditions do not affect reduction in BSF but they are addressed in legacy side conditions.
* Option 6a (Nokia): Mobility Event triggering BSF reduction
* Option 6b (Nokia): FBS is triggered by conditional Handover configuration
* Option 6c (Nokia): BSF reduction is always enabled, but used for reduced measurement delay in cell edge and used for reduced scheduling restrictions in cell center (e.g. by extending T\_SMTC).
	+ - Option 7 (QC):

|  |
| --- |
| RAN4 to adopt the following framework for the fast UE Rx beam sweeping based L3 measurement and mobility requirements:* NW provides the following criteria for fast beam sweeping application, and the signaling details are FFS
	+ Cell edge condition: Threshold value of absolute L3 SSB-RSRP of SpCell
	+ High speed condition: Threshold value of L3 SSB-RSRP variation on SpCell over a time period T
	+ When the condition of not cell-edge (and not high-speed, if configured) is met, the UE is allowed to fallback Rx beam sweeping factor to the existing N value
	+ Note: the existing criteria defined for the relaxed idle/inactive mode measurement and/or RLM/BFD evaluation can be reused or served as a baseline
* Report configuration for the status of fast beam sweeping factor application, and the signaling details are FFS
	+ A TTT-like time window or N310-like timer, which starts running or counting upon the first satisfaction of the condition “not cell-edge (and not high-speed)” is observed by the UE, can be configured to avoid frequent status transitions and reports
	+ Note: the existing report defined for RLM/BFD relaxation status can be reused or served as a baseline
* Besides, other explicit signaling (e.g. FR2 CHO, FR HO, GBBR, etc.) may disallow the fallback of UE Rx beam sweeping factor to the existing N value until the signaled configuration is no longer in effect or the relevant task has been completed.
* FFS on the application delay of UE Rx beam sweeping factor switch
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* + - Option 8 (MTK): Activating multi-Rx for L3 measurements (intra/inter-frequency) may or may not be always necessary, depending on UE current conditions:
			* UE location (cell centre or cell edge)
			* UE mobility (stationary or moving)
			* Both above
			* Option 8a (MTK):
	+ On UE mobility status, RAN4 should consider low/medium speed mobility of the UEs as one of the conditions to activate multi-Rx for L3 measurement delay reduction.
	+ RAN4 to discuss UE indication capability to the NW whenever UE requires to deactivate multi-Rx for FR2-1 SSB based L3 measurement delay reduction (e.g., indication due to overheating resulting from activating multiple panels for long time).
		- Option 9 (ZTE): Due to L3 measurement is long-term operation, power consumption issue could be considered, which may lead to some interaction signalling. But which would not be the applicability condition of applying fast beam sweeping.

[Way forward]:

discussion can be mainly focus on 3 directions: (1)“additional triggering for this R19 L3 measurement with FBS” (use option 8 for discussion) or (2)“L3 measurement with FBS can be activated/deactivation following on R18 mechanism” (use option 1 for discussion) or (3)“up to network indication” (use option 3 for discussion).

Discuss option 1/3/8 together, and then add details from other options if needed.

**Issue 1-2-6: FFS: UE has prior knowledge on the cell to be measured**

Agreement:

On top of the UE capability of supporting Multi-Rx, no additional conditions of prior knowledge for target cell is needed

**Issue 1-2-7: FFS: Rel-19 L3 measurement with multi-Rx DL reception is irrelevant to multi-TRP operation deployment**

Agreement:

Rel-19 L3 measurement with multi-Rx DL reception is irrelevant to multi-TRP operation deployment

**Issue 1-2-8: FFS: cell-centre UE or cell-edge UE**

[Way forward]:

this issue can be discussed in issue 1-2-5. No more duplicated discussion in issue 1-2-8.

**Issue 1-2-9: FFS: DRX is configured or not**

[Way forward]:

FFS:

* + - Option 1 (Xiaomi): SSB based L3 measurement delay reduction with DRX shall be deprioritized
		- Option 2 (Ericsson): FBS may cover DRX cases, no need to deprioritize DRX case.

**Issue 1-2-10: FFS: Simultaneous operation between L3 and L1 measurements**

Agreement:

* Do not consider simultaneous Multi-Rx operation for both L1 and L3 measurement on the same symbols in this WI.

**Issue 1-3: Scenarios to use L3 measurement delay reduction by optimizing Rx BSF**

**Which scenarios are considered to use L3 measurement delay reduction by optimizing Rx BSF:**

* + Scenario 1: SSB based Intra-frequency measurement without MG, including TPSS/SSS\_sync\_intra and TSSB\_measurement\_period\_intra
	+ Scenario 2: SSB based Intra-frequency measurement with MG, including TPSS/SSS\_sync\_intra and TSSB\_measurement\_period\_intra
	+ Scenario 3: SSB based Inter-frequency measurement without MG, including TPSS/SSS\_sync\_inter, TSSB\_time\_index\_inter and TSSB\_measurement\_period\_inter
	+ Scenario 4: SSB based Inter-frequency measurement with MG, including TPSS/SSS\_sync\_inter, TSSB\_time\_index\_inter and TSSB\_measurement\_period\_inter
	+ Scenario 5: Handover
	+ Scenario 6: PSCell addition
	+ Scenario 7: RRC Re-establishment/RRC Connection Release with Redirection
	+ Scenario 8: SCell activation
	+ Scenario 9: SCG activation
	+ Scenario 10: CGI identification
	+ Scenario 11: CSI-RS based intra-/inter-frequency measurements, the CSI-RS is configured *associatedSSB*. The discussion on CSI-RS configured with associatedSSB could be revisited if SSB based L3 measurement delay reduction is concluded.

Agreement:

* + Scenario 1/2/3/4/5/7 can be considered as first priority. After RAN4 has conclusion(s) on the solution(s) of L3 measurement delay reduction for the baseline scenarios 1/2/3/4/5/7, RAN4 can discuss whether and how the solutions(s) can be extended to the other scenarios. The discussion on other scenarios will NOT delay the WI completion.

**Issue 1-4: Solutions to apply/specify L3 measurement delay reduction by optimizing Rx BSF**

[Way forward]:

FFS:

* Proposal 1 (CATT):
	+ For UE supporting Multi-Rx operation for L3 measurement, the Rx BSF can be reduced to 2, 4 or 6 according to the UE capability.
* Proposal 2 (Apple, CTC):
	+ For UE supporting multiple-Rx simultaneous reception, it is proposed to reduce L3 measurement delay by reducing Rx BSF, and Rel-18 Rx BSF reduction in L1 measurement can be used as baseline.
* Proposal 3 (Xiaomi):
	+ In order to shorten the overall L3 measurements delay, the smaller RX beam sweeping factor for SSB index acquiring and SSB measurement can be used in comparison with that for PSS/SSS detection.
* Proposal 4 (LGE):
	+ If UE supports multi-Rx reception simultaneously for L3 measurement and signal quality for serving cell is low, L3 measurement delay reduction by optimizing Rx BSF could be applied to scenario 1 to 4.
		- RAN4 to discuss how to reduce M values for SSB based intra- / inter-frequency measurements for UE supporting multi-Rx simultaneous reception
* Proposal 5 (Ericsson):
	+ As a result of FBS, RX beam sweep factor can be defined as [4].
* Proposal 6 (Ericsson):
	+ RAN4 to study the requirements relevant to switching between different operations, including:
		- Transition time period when enabling and disabling FBS in Rel-19.
		- Transition time period when switching between FBS in Rel-19 and multi-Rx in Rel-18.
* Proposal 7 (Samsung):
	+ To define the delay requirements for intra-frequency and inter-frequency measurement w/o MG for L3 multi-Rx measurement, suggest to take N=4, M=20 as the baseline
		- Whether to/How to define the other values can be based on SLS results (if necessary)

**Issue 1-5: feature capability of L3 measurement delay reduction by optimizing Rx BSF**

[Way forward]:

FFS:

* Option 1(Apple, vivo, Nokia, Samsung):
	+ RAN4 to introduce a new individual optional capability for L3 BSF reduction due to multi-Rx operation in R19.
	+ Option 1a(Apple): The detailed definition can be postponed to the end of the core part discussion.
* Option 2(Eircsson):
	+ To support FBS, RAN4 to check if those capabilities for multi-Rx in Rel-18, e.g., faster RX beam sweeping, enhanced scheduling and measurement restrictions and multi-Rx preference indication, can be used directly. If the NW indicates FBS and multi-RX in Rel-18 is not enabled parallelly, we can observe the possibility of reusing at least part of such capabilities.

**Issue 1-6: scheduling/measurement restriction relaxation**

Agreement:

* RAN4 to not consider simultaneous operation between L3 measurement and data reception on the same OFDM symbols.

**Issue 1-7: whether and/or which previous release feature shall also be considered in “ FR2-1 L3 measurement delay by optimizing Rx beam sweeping factor”**

[Way forward]:

FFS:

* Option 1 (LGE):
	+ RAN4 not to consider SSB based L3 measurement delay enhancement with other features and previous release features.
* Option 2 (Ericsson):
	+ Regarding FBS, only Rel-18 multi-Rx scenario should be assumed, and we should not assume that the UE is also supporting other features. But it is noted that it doesn’t mean L1 measurement enhancement by multi-Rx in Rel-18 is mandatory for FBS.

# Topic #2: FR2-1 L3 measurement delay by optimizing CSSF outside gap in CA/DC (8.15.2.2)

### Issue 2-1: Clarification on the bullets in WID for this CSSF optimization

[Way forward]:

FFS:

* + Option a (ZTE, CMCC, Intel, CATT, MTK):
		- Rel-19 CSSF optimization applies for the both cases: (1)UE is not capable of Rel-18 multi-Rx simultaneous reception, (2)UE is capable of Rel-18 multi-Rx simultaneous reception but not work in multiple-Rx reception mode currently.
		- Note: if option a is agreeable, then work on wording polishing based on option 1a/1b.
	+ Option b (HW, MTK, Samsung, E///):
		- Rel-19 CSSF optimization applies for case that UE is not capable of Rel-18 multi-Rx simultaneous reception.
	+ Option c (Apple, Nokia, QC):
		- Rel-19 CSSF optimization applies for CA/DC scenarios with at least two FR2 serving cells, independently of the UE support of multi-Rx capabilities.
	+ Option d (newly added):
		- Same Rel-19 CSSF optimization applies for the both cases: (1) UE is not capable of Rel-18 and Rel-19 multi-Rx simultaneous reception, (2) UE is capable of Rel-18 or Rel-19 multi-Rx simultaneous reception but not work in multiple-Rx reception mode currently.

### Issue 2-2: UE measurement procedure to use L3 measurement delay reduction by optimizing CSSF

Agreement in online session:

* + The following aspects in CA/DC to use L3 measurement delay reduction by optimizing CSSF shall be discussed, and further prioritization among the 3 aspects can be discussed in future meeting:
		- Aspect 1: SSB based Intra-frequency measurement without MG, including:
			* TPSS/SSS\_sync\_intra and TSSB\_measurement\_period\_intra
			* CSSFintra for intra-frequency measurement without gap which is defined since Rel-15
		- Aspect 2: SSB based Inter-frequency measurement without MG, including:
			* TPSS/SSS\_sync\_inter, TSSB\_time\_index\_inter and TSSB\_measurement\_period\_inter
			* CSSFinter for inter-frequency measurement without gap.
		- Aspect 3: Inter-RAT SSB measurement without MG, including:
			* CSSFinterRAT for inter-RAT measurement without gap if the UE indicates ‘nogap-noncsg’ via NeedForGapNCSG-InfoEUTRA for the inter-RAT measurement.
		- MG related features to be considered in aspect 1/2/3 including:
			* R16 Inter-frequency measurement without gap where SSB is completely contained in active BWP
			* R17 NCSG measurement with ‘nogap-noncsg’
			* R18 NeedForGaps measurement with ‘no-gap-no-interruption’ or with “no-gap-with-interruption”

### Issue 2-3: Applicability requirement of L3 measurement delay reduction by optimizing CSSF

Agreement:

* + - RAN4 to consider following CA/DC mode for L3 measurement delay reduction by optimizing CSSFoutside\_gap,i
		- Final applicability of the solutions can be FFS
			* EN-DC
				+ EN-DC with FR2 only intra band CA
				+ EN-DC with FR2 only inter band CA
				+ EN-DC with FR1 +FR2 CA (FR1 PSCell)
				+ EN-DC with FR1 +FR2 CA (FR2 PSCell)
			* NE-DC
				+ NE-DC with FR2 only intra band CA
				+ NE-DC with FR2 only inter band CA
				+ NE-DC with FR1 +FR2 CA (FR1 PCell)
			* SA
				+ FR1+FR2 CA (FR1 PCell)
				+ FR1+FR2 CA (FR2 PCell)
				+ FR2 only intra-band CA
				+ FR2 only inter-band CA
			* NR-DC
				+ FR1 + FR2 NR-DC (FR1 PCell and FR2 PScell)

### Issue 2-4: Searcher assumption to apply L3 measurement delay reduction by optimizing CSSF

[Way forward]:

FFS:

* Option 1 (CATT): Not to preclude the solutions based on 3 searchers assumption in current stage.
	+ Option 1a (CMCC, HW): it is proposed to consider both the CSSF optimization based on 2 searchers and the CSSF optimization based on 3 searchers.
	+ Option 1b (QC): RAN4 to consider introducing a new UE optional capability regarding the number of cell search/L3-measurement engines for CSSF enhancement, with the details to be finalized (FFS).
* Option 2 (Apple, CTC, Nokia, Ericsson): RAN4 only consider the enhancement based on 2 searchers, i.e., same as previous release, for L3 measurement delay reduction by optimizing CSSF.
	+ Option 2a (Apple): If companies cannot achieve consensus, RAN4 work can start with the baseline assumption in WID, i.e., 2 searchers.
	+ Option 2b (Nokia) RAN4 to confirm if one of the searchers is assumed for PCC/PSCC measurement and the other is assumed for the measurements on all SCCs.

### Issue 2-5: Solutions to apply/specify L3 measurement delay reduction by optimizing CSSF outside gap in CA/DC

[Way forward]:

FFS:

* Option 1 (Apple, CTC. Ericsson, Intel, Samsung, ZTE): UE only needs to measure one serving CC per band if multiple serving CCs are in the same band
* Option 2 (CATT, Apple, CTC, ZTE): UE can change the searcher occupancy ratio of PCC or PSCC measurement to speed up SCC measurement for some conditions
* Option 4 (CATT, HW):
	+ For UE supporting per FR gap, when all MOs are to be measured outside gap, the searcher used for within gap can be leveraged for outside gap. CSSFoutsidegap can be optimized, as these MOs can share totally three searchers. (HW, CATT)
	+ We are open to further discuss the applicable condition of the three searcher solution and whether a new capability is needed. (HW)

### Issue 2-6: feature capability of L3 measurement delay reduction by optimizing CSSF

[Way forward]:

FFS:

* Option 1 (Apple, Nokia): RAN4 to introduce a new individual capability for CSSF reduction in R19.
	+ Option 1a(Nokia):The reduced CSSF shall be applied to the UE supporting the capability and starting from R19
* Option 2 (CATT, Apple): delay the capability discussion to the end of the core part.

### Issue 2-7: Other WID scope discussion

[Way forward]:

FFS:

* Proposal 1(CMCC, CTC): after FR2-1 L3 measurement delay reduction by optimizing CSSF is concluded, the technical solutions can be extended to FR1 if applicable.

### Issue 2-8: whether and/or which previous release feature shall also be considered in “ FR2-1 L3 measurement delay by optimizing CSSF outside gap in CA/DC”

[Way forward]: Discuss this issue together with issue 2-2