3GPP TSG RAN Meeting #102
Edinburgh, Scotland, December 11-15, 2023

RP-233497

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Document for: Discussion

On RAN4 led RRM and Demod Enhancement in Rel-19

Rel-19 RRM Enhancement

Rel-19 RRM enh-4 | NR RRM enhancement WI for R19

- Rel-19 RRM enhancement for NR and MR-DC is an umbrella WI for RRM enhancement, aiming to include:
  - All newly identified RRM enhancement during Rel-18
    - FR2 Multi-Rx RRM Continuation **(High Priority)**
      - Enhancement for UE operating in multi-Rx simultaneous reception mode
    - RRM measurement delay reduction for both FR1 and FR2 **(High Priority)**
    - A-TRS based RRM enhancements **(High Priority)**
    - Dynamic RTD/TTD status update **(High Priority)**
    - Other miscellaneous RRM features that are not in any other dedicated Rel-19 WI
  - Leftover RRM related topics/issues from Rel-18 and earlier release:
    - Further SCell activation and PSCell addition/change/activation enhancement based on R18 enhancement solutions **(High Priority)**
    - Requirement for SRS antenna port switching with full-slot SRS (Medium Priority)
    - HO with PSCell for new scenarios (Medium Priority)
    - Parallel measurement with NCSG

Rel-19 RRM enh-4 | FR2 Multi-Rx Continuation

- **Enhancement for UE operating in multi-Rx simultaneous reception mode**
  - L3 measurement enhancements: intra/inter-freq. Measurement delay, scheduling restriction, support of simultaneous L1 and L3 measurements, and simultaneous L3 measurement and data/control
  - Dual TCI state switching based on R17/18 unified TCI framework
  - RRM requirement for the case of RTD > CP case

Rel-19 RRM enh-4 | RRM Measurement delay reduction

- Background:
  - With larger number of serving CCs in FR2, it would result into FR1 with huge long measurement/detection delay to degrade mobility performance based on CSSF factor without MG.

Table 9.2.5.2-1: Measurement period for intra-frequency measurements without gaps(FR1)

DRX cycle	$T_{SSB_measurement_period_intra}$
No DRX	max(200ms, ceil(5 x K_p) x SMTC period)[Note 1] x $CSSF_{intra}$
DRX cycle≤ 320ms	max(200ms, ceil(1.5x 5 x K_p) x max(SMTC period,DRX cycle)) x $CSSF_{intra}$
DRX cycle>320ms	ceil(5 x K_p) x DRX cycle x $CSSF_{intra}$
NOTE 1: If different SMTC periodicities are configured for different cells, the SMTC period in the requirement is the one used by the cell being identified	

2.1 Number of serving carriers for SA

irements for standalone NR with NR PCell are applicable for the UE configured with the following number of ng NR CCs:

up to 16 NR DL CCs in total, with 1 UL (or 2 UL if SUL is configured) in PCell and up to 8 UL (or 9 UL if SUL is configured) in total for SCells.

SUL may be configured together with one of the UL

For instance,

CSSF = 15 if 16 CCs are configured as CA (15 SCC share one searcher), and Scell measurement delay: 15*5=75 SMTC period (Kp=1 for simplicity)

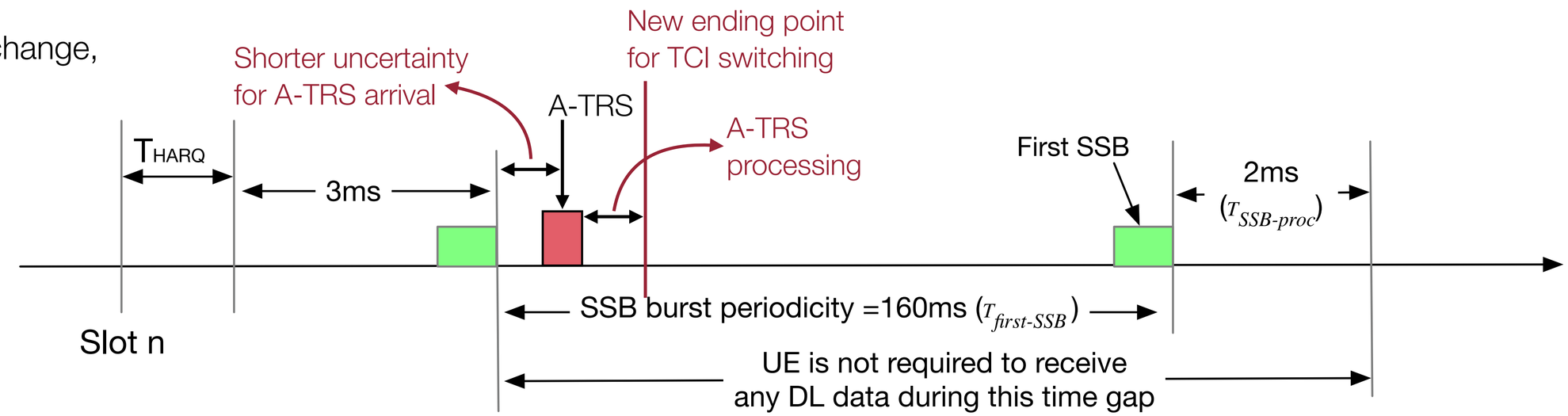
- SMTC periodicity = 160ms, the total measurement delay can be up to 12000ms

  - For FR2, the measurement delay is defined as max(600ms, ceil($M_{pss/sss_sync_w/o_gaps}$ x K_{FR} x K_p x $K_{layer1_measurement}$) x SMTC $_{period}$)x $CSSF_{intra}$, without DRX. In the field, such delay can be easily exceeding 1000ms.

- R19 enhancement:
  - Cell identification and measurement delay reduction in both FR1 and FR2

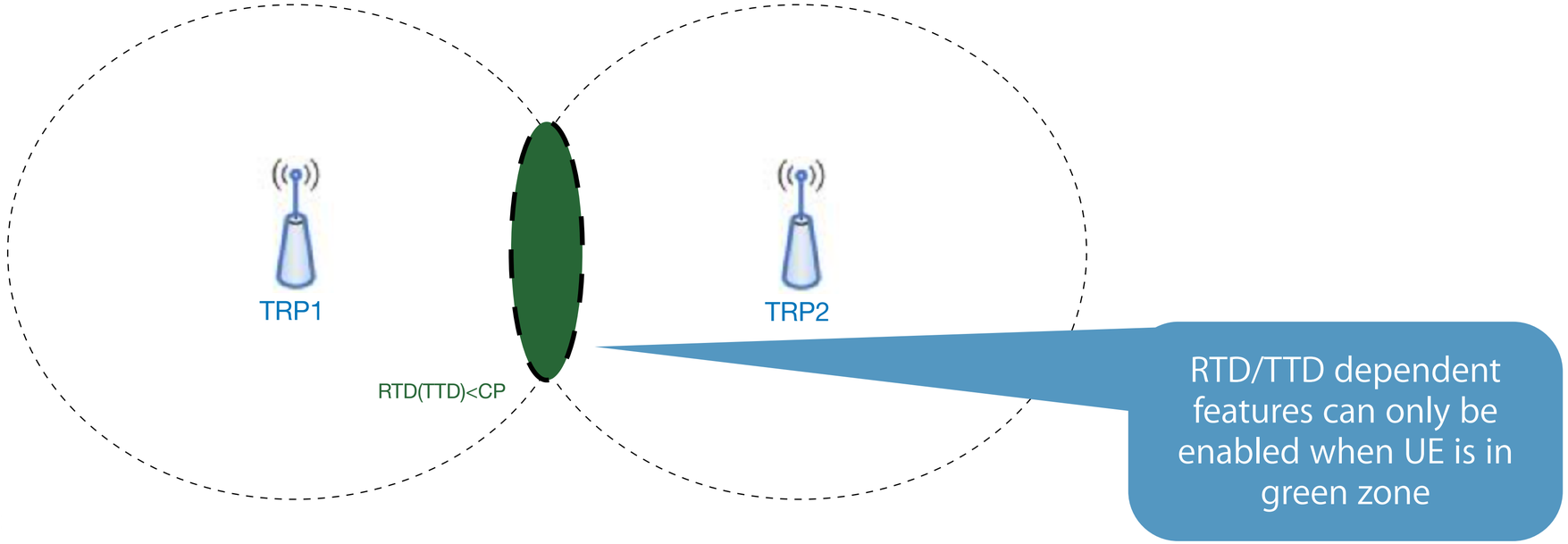
Rel-19 RRM enh-4 | A-TRS based RRM enhancement

- **Background:**
  - In current spec, periodical RS (e.g., SSB) is mainly used for AGC and T/F tracking during RRM procedures, e.g., HO, TCI switching, SCell activation, and PSCell addition/change.
- **R19 enhancement:**
  - RAN4 can explore a general solution of utilizing A-TRS for the enhancement to the corresponding UE activities:
    - HO (incl. LTM),
    - TCI switching,
      - Example: In legacy TCI switching requirement, there was a time gap from “slot n+ THARQ +(3 ms) / NR slot length” to “slot n+ THARQ +(3 ms +TOk*(Tfirst-SSB + TSSB-proc)) / NR slot length”. Since UE is not required to receive DL data during this time gap, it will probably impact the throughput performance in case the first SSB arrives 160ms later (analyzed in R4-2006616).
      - R19 enhancement: enhancement to use A-TRS for TCI T/F tracking to shorten the total switching delay.
    - SCell activation,
    - PSCell addition/change,
    - Others



Rel-19 RRM enh-4 | Dynamic RTD/TTD status update

- **Dynamic RTD/TTD status update**
  - More and more RAN4 requirements are RTD/TTD dependent. Specifically, in R17/R18 design, RAN4 requirements are not applicable in the following work item when RTD>CP:
    - multi-Rx
    - multi-TRPs in MIMO (for UE incapable of RTD>CP)
    - Intra-band non-collocated CA (for type 3a/3b UE)
    - LTM (L1 measurement on neighbor cell, for UE incapable of RTD>CP)
  - However, actual RTD at UE side it unknown to network. Network doesn't know whether RTD at UE side is less than CP or not.



- Example solution for multi-TRP with 2TAs:
  - Step 1: UE indicates its category to NW after access NW (baseline UE or advanced UE).
  - Step 2: Network configures UE to monitor RTD between the two TRPs.
  - Step 3: UE monitors the RTD consistently, and report to network when status changes (into or out of green zone)
  - Step 4: Upon receiving RTD status change from UE, network can update configuration accordingly (e.g. fallback to single TAG or enable 2 TAs).

Rel-19 RRM enh-4 | Further SCell activation and PSCell addition/change/activation enhancement

- **Further SCell activation and PSCell addition/change/activation enhancement based on R18 enhancement solutions**
  - Background: in R18, the unknown SCell activation enhancements only focus on limited scenarios, but the similar solution can actually apply for other scenarios
  - The new scenarios for enhancement as illustrated below,

R18 enhancement for FR2 unknown SCell activation, including:
- Enh 1: Report of L3 measurement during activation,
- Enh 2: Beam sweeping factor reduction;
- Enh 3: Activation delay reduction by using SSB periodicity.

R19 SCell Activation enhancement, including:
- FR2-2 SCell activation enhancement using enh 1/2/3

R19 PSCell addition/change enhancement, including:
- FR1 PSCell addition/change enhancement using enh 1/3；
- FR2-1 and FR2-2 PSCell addition/change enhancement using enh 1/2/3；

R19 SCG activation enhancement, including:
- FR1 SCG activation enhancement using enh 1/3；
- FR2-1 and FR2-2 SCG activation enhancement using enh 1/2/3；

Rel-19 RRM enh-4 | SRS antenna port switching with full-slot SRS

- **SRS antenna port switching with full-slot SRS**
  - Background
    - In Rel-17 FeRRM WI RRM requirements for SRS antenna port switching were introduced for SRS in last 6 symbols of slot
    - In Rel-16 RAN1 introduced feature start symbol for SRS transmission in any symbol

srs-StartAnyOFDM-Symbol-r16 Indicates whether the UE supports transmitting SRS starting in all symbols (0 to 13) of a slot. This capability is also applicable to a frequency band that does not require shared spectrum access.	Band	No	N/A	N/A

    - RRM requirements for full slot SRS transmission are not defined
  - Rel-19 Enhancement
    - Evaluate the scope of requirements for full slot SRS transmission
    - Define RRM requirements to support full slot SRS transmission

Rel-19 RRM enh-4 | HO with PSCell for new scenarios

- **HO with PSCell for new scenarios**
  - Requirement design for scenarios not covered in R17 RRM enhancement
    - from NR SA to NE-DC
    - from NR SA to NR-DC
    - from LTE SA to EN-DC

Supported in R17 FeRRM WI

Scenarios for new requirements

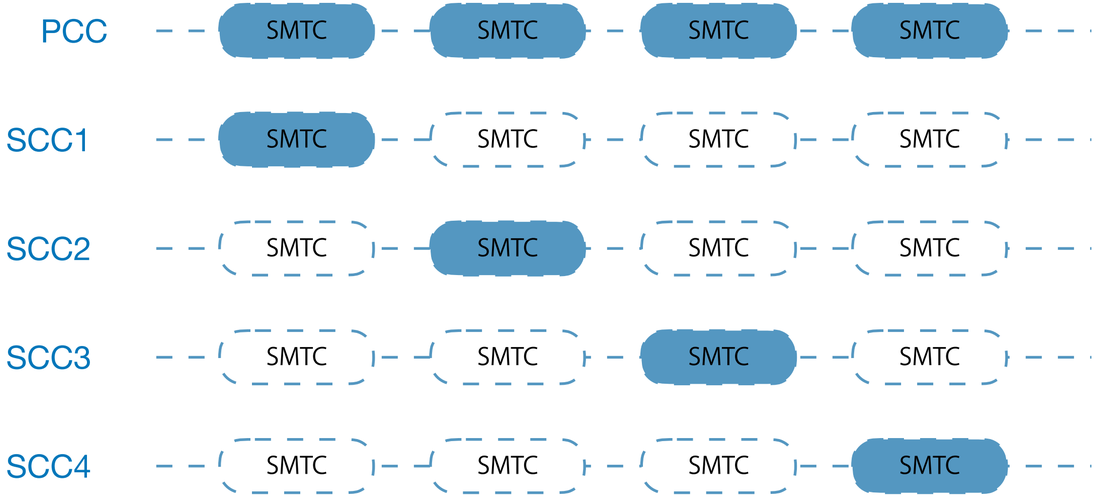
Table B-1: Supported MR-DC handover scenarios.

To (column) / HO from (row)	E-UTRA with EPC	E-UTRA with 5GC	NR	GERAN or UTRAN	EN-DC	NGEN-DC	NE-DC	NR-DC
E-UTRA with EPC	YES	YES	YES	YES	YES	NO	NO	NO
E-UTRA with 5GC	YES	YES	YES	NO	NO	YES	NO	NO
NR	YES	YES	YES	NOTE 1	YES	NO	YES	YES
GERAN or UTRAN	YES	NO	NO	YES	NO	NO	NO	NO
EN-DC	YES	YES	YES	YES	YES	NO	NO	NO
NGEN-DC	YES	YES	YES	NO	NO	YES	NO	NO
NE-DC	YES	YES	YES	NOTE 1	NO	NO	YES	NO
NR-DC	YES	YES	YES	NOTE 1	NO	NO	NO	YES

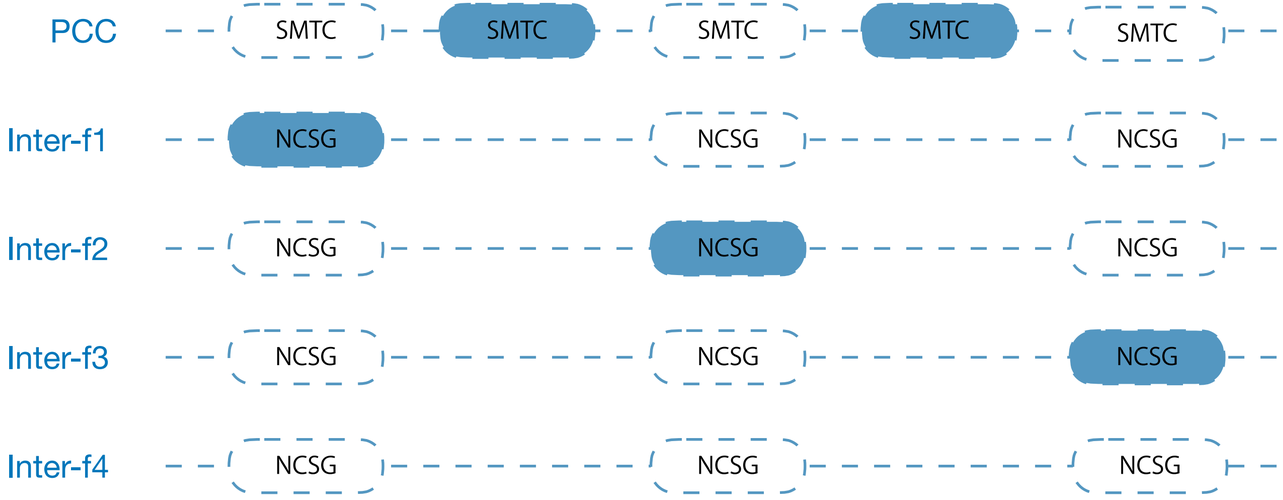
Note: Scenarios in above table are specified in TS37.340 Annex B

Rel-19 RRM enh-4 | Parallel measurement with NCSG

- **Parallel measurement with NCSG**
  - Background: existing RRM requirement is only for UE to measure one carrier within each NCSG occasion
  - R19 Enhancement:
    - RRM requirement for NCSG capable UE to support parallel measurement on at least two carriers simultaneously
    - RRM requirement for UE to support parallel measurement within legacy MG on at least two carriers simultaneously
      - Including UE which are not capable of NCSG or NFG.



In CA, UE is required to measure 2 CC in each occasion



In NCSG, UE is required to measure only one CC in NCSG

Rel-19 Demod Evolution

Rel-19 Demod Evolution | Candidate Topics

- **Apple's interest**
  - CRI reporting requirements for NR in R19
    - In Rel-15 CQI, PMI, RI reporting requirements were introduced for CSI reporting for NR
      - All requirements are with 1 NZP CSI-RS resource configured
      - No requirements for CRI reporting
- **Other candidate proposals**
  - Advanced receiver for BS - MMSE-IRC
  - Enhancements to Application Layer TP requirements
  - Advanced receiver for UE - Soft-IC for SU-MIMO
  - MIMO channel model enhancements
  - CRS-IM with 1RX
  - Demodulation requirements for MU-MIMO with Rel-18 DMRS
  - Demodulation requirements for PDSCH FDM'd with PDCCH
  - CQI report for R-ML SU-MIMO receiver

Rel-19 Demod Evolution | CSI Reporting Requirements Enhancement

- **Background**
  - Multiple NZP CSI resources are configured in deployments
    - No requirements to verify CRI reporting from UE in NR
    - CRI reporting was introdced in LTE for FD-MIMO
  - Different configurations are possible with multiple NZP CSI-RS with large antenna arrays
  - In Rel-15 CQI, PMI, RI reporting requirements were introduced for CSI reporting for NR
    - All requirements are with 1 NZP CSI-RS resource configured
    - No requirements for CRI reporting
- **Motivation**
  - Defining CRI reporting requirements in RAN4 will promote adoption of same test methodology for CRI reporting verification
  - Defining requirements in RAN4 will reduce carrier specific tests
- **Objectives**
    - Study the framework and methodology for CRI reporting requirements
      - Re-use the LTE CRI reporting framework as a starting point
    - Define CRI reporting requirements
- **Proposal**
  - Introduce CQI reporting requirements with the above objectives

Rel-19 Demod Evolution | Views on other candidate topics

- **Advanced receiver for BS - MMSE-IRC**
  - UL performance and coverage enhancement has been investigated mostly at UE side including HPUE, increasing number of Tx, etc.
  - Advanced receiver for mitigating interference is beneficial for UL performance enhancement
  - Introduce requirements with advanced receiver for BS
- **Enhancements to Application Layer TP requirements**
  - *Requirements with OLLA*
    - It is not clear how OLLA impacts UE processing - only changes the MCS used to schedule PDSCH
    - Tests with different MCS is already part of several FRC test cases
    - OLLA model to be used in RAN4 will need further discussion to accommodate different infra-vendor implementation
  - *Max rank 4 requirements*
    - Motivation is not clear to extend requirements for up to rank 4, since no request from RAN5
  - Do not introduce APT requirements with OLLA or up to Rank 4
- **Advanced receiver for UE - Soft-IC for SU-MIMO**
  - In NR baseline receiver is MMSE-IRC and advanced receiver is R-ML
  - Motivation for another advanced receiver soft-IC is not clear
  - Do not introduce requirements with soft-IC for SU-MIMO
- **MIMO channel model enhancements - CDL channel model**
  - Need to confirm feasibility to implement CDL from TE vendor
  - Diverse performance and calibration issue have been there unresolved for a long while. No clear solution has been identified.
  - RAN4 needs to spend significant time to calibrate the channel model
  - Do not study CDL channel model in RAN4 in R19

Rel-19 Demod Evolution | Views on other candidate topics

- **CRS-IM with 1RX**
  - CRS-IM introduced in Rel-17 was for specific co-existence scenarios
  - UE complexity to support CRS-IM is not trivial
  - Not practical for reduced capability device to support advanced receiver processing for CRS-IM
  - Do not introduce requirements with RedCap UE for CRS-IM
- **Demodulation requirements for MU-MIMO with Rel-18 DMRS**
  - UE processing with R18 DMRS is already verified in R18 with SU-MIMO requirements
  - No performance benefit is expected with eDMRS for MU-MIMO with the same antenna config used in R17/R18 for MU-MIMO
  - Do not introduce requirements for MU-MIMO with eDMRS
- **Demodulation requirements for PDSCH FDM'd with PDCCH**
  - Need to understand the motivation for this
  - Don't expect to see PDSCH performance impact with PDSCH FDM'd with PDCCH
  - Further discussion and clarification is needed for requirements for PDSCH FDM'd with PDCCH
- **CQI report for R-ML SU-MIMO receiver**
  - It would be useful to introduce CQI reporting requirement with R-ML for completeness
  - Need to further evaluate how to distinguish requirement/ performance for CQI reporting with R-ML compared to baseline receiver
  - Further discussion and clarification is needed for CQI reporting requirements with R-ML

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