3GPP TSG RAN Meeting #101

Bangalore, India, September 11-15, 2023

RP-232441

Views on Rel-19 RAN4-led topics

Agenda Item: 8A.3

Source: Intel Corporation

Document for: Discussion & Decision

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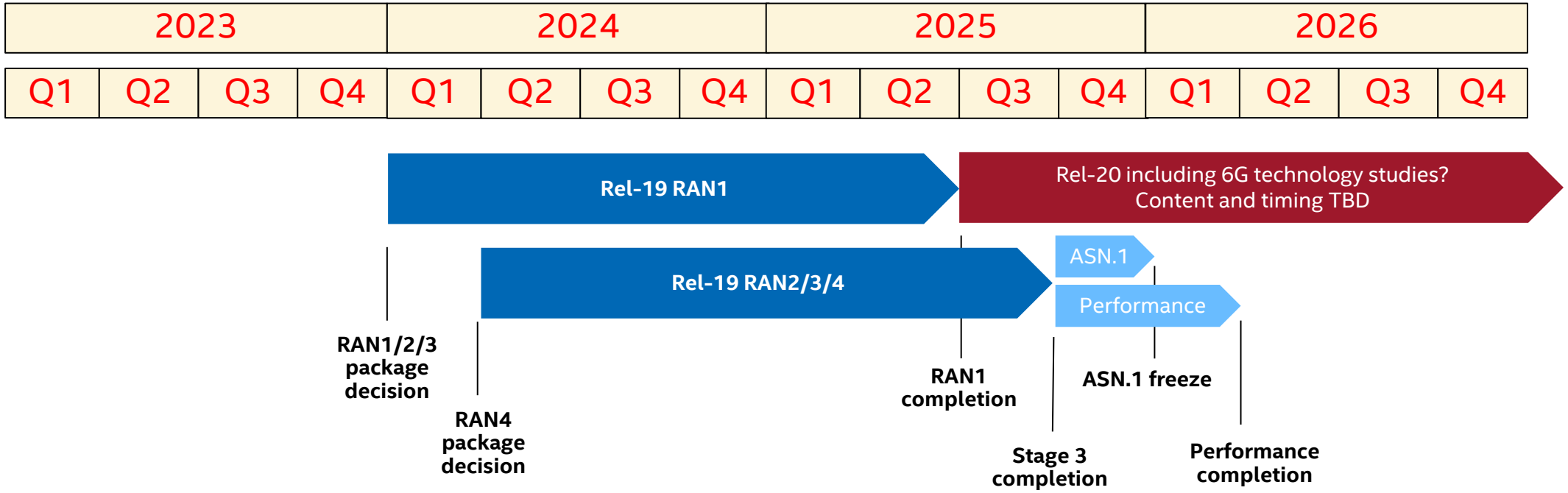
Rel-19 Timeline

- Rel-19 duration and timeline agreed at TSG#99
- Rel-19 package scope needs to be properly dimensioned to fit the timeline



General Principles

Multiple RAN4-led proposals were submitted for Rel-19 Workshop covering a wide set of topic areas.

Similar to Rel-18 an extensive prioritization of proposals is required to fit the constrained RAN4 capacity.

Key principles for RAN4 WI package contents

- Balance the needs of the industry and RAN4 workload constraints
- Balance the work among in-field issues, leftover issues from early release(s), and new enhancements
- Balance between short terms commercial demands for practical deployment and forward-looking opportunities for further network evolution
- Lay a foundation for baseline device and network design concepts before the start of 6G work

RAN4 Rel-19 Workload and TU budget

Observation on Rel-18 RAN4 workload

- RAN4 Rel-18 planning was better than Rel-17, but RAN4 workload in Rel-18 was still very high
- A substantial workload comes just from the number of parallel WIs with > 35 ongoing non-spectrum items
- RAN4 impacts were not well-planned for some RAN1/2-led WIs (e.g., TU request for some WIs was below the required time, while some TU requests were higher than the actual required time)
- Multiple new non-spectrum WIs were approved during Rel-18 timeframe further increasing RAN4 workload after the initial package was approved

Proposals

- Reserve dedicated RAN4 TUs for RAN4-led WI/SI and WI/SI led by other WGs.
- Clearly identify RAN4-related objectives as well as required TUs for Rel-19 WI/SI led other WGs in December 2023
- Reserve sufficient TUs for RAN1/2/3-led items and consider 1.0-1.5 TUs per RAN4 session for items with big RAN4 scope and 0.5 – 1.0 TUs for items with medium scope. 0.25 TUs shall be used on rare occasions for items with minimum scope
- Number of Rel-19 RAN4-led and RAN1/2/3-led SI/WIs with RAN4 impact needs to be reduced comparing to Rel-18
- Minimize approval of new RAN4 items/topics after the package is finalized.

RAN4 Rel-18 package overview

- **Device evolution**
  - FR2 multi-Rx chain UE
- **RF evolution**
  - FR1 UE RF evolution
  - FR2 UE RF evolution
  - *mmWave multi-band BS SI*
  - *Spectrum-specific (700/800/900 MHz BCs, sub-1GHz)*
  - *Irregular CBW SI*
- **RRM evolution**
  - RRM enhancements
  - MG enhancements
  - BWP without restriction
- **Performance evolution**
  - Demodulation enhancements
- **Deployments & Use Cases evolution**
  - FR2 HST enhancements
  - Air-to-Ground
  - Intra-band non-collocated CA/DC
  - NR < 5MHz CBW
- **OTA**
  - FR1 MIMO OTA
  - FR1 TRP/TRS
  - *FR2 OTA test methods SI*
- **Other**
  - Channel raster enhancements
  - IOT NTN requirements
  - BS/UE EMC enhancements
- **Spectrum**
  - Bands, BW, CA/DC, HPUE, ...

Intel views on possible RAN4 Rel-19 package

- **Device evolution**
  - FR2 multi-panel UE evolution
- **RF evolution**
  - UE FR1 & FR2 RF evolution
  - BS RF (mmWave MB BS)
  - Irregular CBW
- **RRM evolution**
  - Measurement Gaps evolution
  - RRM evolution
- **Deployments & Use Cases evolution**
  - mTRP operation with RTD > CP
  - Intra-band Non-contiguous CA/DC
  - ATG enhancements
  - FR2 HST enhancements
- **Performance evolution**
  - Demodulation requirement enhancements
- **OTA**
  - FR1 OTA
  - FR2 OTA
- **Spectrum**
  - Bands, BW, CA/DC, HPUE, ...

Intel proposals on RAN4 Rel-19 Topics

- Requirements to enable mTRP operation with RTD > CP
  - Extended set of UE RRM/Demod requirements for mTRP deployments operation with RTD > CP
- Evolved FR2 multi-panel UE
  - Multi-Rx: CA support; improved RF/RRM/Demod requirements; FR2-2
  - Multi-Tx: Baseline RF/RRM requirements
- Measurement Gaps evolution
  - Pre-configured NCSG
  - Enhanced collision handling for concurrent MGs
- RRM requirements evolution
  - Enhanced TCI state switch requirements
  - URLLC-enabling requirements
  - Improved Beam switching requirements
- Demodulation Evolution
  - BS MMSE-IRC receivers for inter-cell interference
  - UE Soft IC receivers
  - Application layer throughput with OLLA
- Irregular Channel Bandwidth
- FR1 RF Evolution
  - FR1 6Rx
  - HPUEs evolution
- mmWave multi-band BS
- FR2 HST enhancements
- ATG enhancements
- Intra-band non-collated CA/EN-DC enhancements

See next slides for detailed views on potential scope for different areas

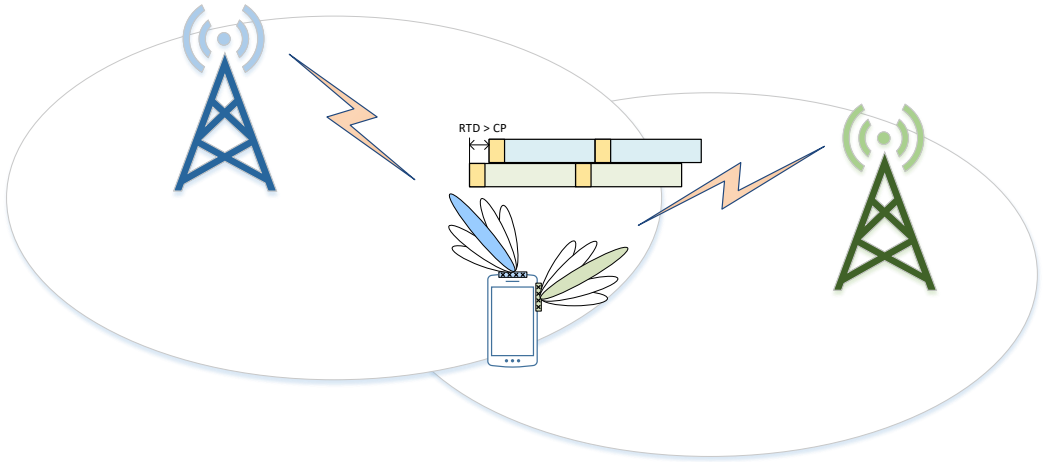
RAN4 Rel-19 Topics

Requirements to enable mTRP operation with RTD > CP

Requirements to enable mTRP operation with RTD > CP

Background

- In practical deployments it is challenging to guarantee that timing offsets between signals from different TRPs are within a CP, especially for FR2 operation with a high SCS, which limits the efficiency of mTRP operation
- Many existing baseline RRM/Demod requirements for mTRP scenarios are defined under an assumption that timing offsets between signals are less than CP



- Support of RTD > CP is being discussed under several Rel-18 work items, but a relatively limited support is expected to be introduced
  - **Rel-18 NR MIMO:** New UE capabilities are defined by RAN1 to enable Rx timing difference between the two DL reference timings > CP. A very limited set of RAN4 requirements is being introduced (MRTD/MTTD).
  - **Rel-18 NR FR2 HST:** RTD > CP is supported FR2 UE PC6. RRM requirements are limited to MRTD. Demod requirements are FFS.
  - **Rel-18 NR FR2 Multi-Rx Chain:** RTD > CP scenario is de-prioritized.
  - **Rel-18 NR MobEnh:** RTD > CP support depends on UE capability. Separate RRM requirements are discussed corresponding to different UE capabilities.

Requirements to enable mTRP operation with RTD > CP

Motivation

- A systematic and generic approach is desirable to introduce the support of mTRP operation with time offsets larger than CP including RRM and Demodulation requirements to facilitate feature adoption for different device types
- At least the following RAN4 requirements are defined under an assumption of RTD < CP and limit mTRP operation
  - RRM
    - Inter-cell beam management
    - TCI state activation
    - LTM – L2 triggered mobility
    - CSI-RS based L3 measurements (intra-frequency)
  - Demodulation
    - Simultaneous demodulation of mTRP DL signals

Candidate objectives/scope

- Study and introduce UE requirements to enable mTRP operation with RTD > CP incl. DL/UL operation
- FR1 & FR2 scenarios
- Handheld, CPE/FWA and HST devices
- Consider both single carrier and CA scenarios
- UEs with and without simultaneous data reception capabilities
- RRM requirements to enable RTD > CP
- UE demodulation requirements to enable RTD > CP

RAN4 Rel-19 Topics

Evolved FR2 UE Simultaneous Multi-Panel Operation

Evolved FR2 UE Simultaneous Multi-Panel Operation

Simultaneous Multi-panel RX

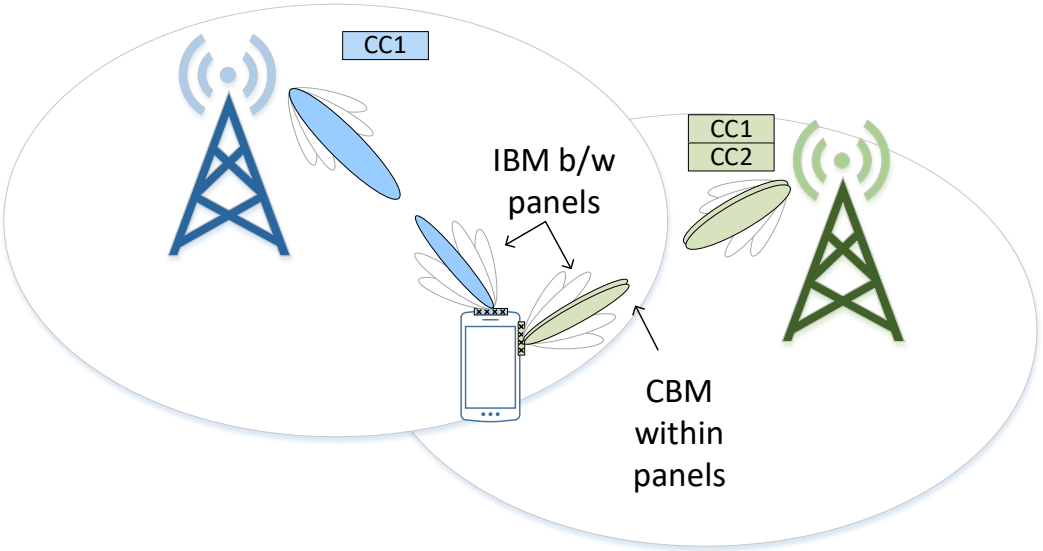
Motivation

- Support of FR2 simultaneous multi-Rx chain requirements is being introduced in Rel-18 NR_FR2_multiRX_DL WI. The Rel-18 requirements are limited to a single carrier scenario, and multiple potential enhancements were de-prioritized.
- Further evolution of Multi-Rx operation requirements is required to extract full benefits of advanced UE implementations

Candidate objectives/scope

- **DL CA multi-panel simultaneous RX**: Focus on intra-band CA and common beam management (CBM) within each panel. Introduce corresponding RF/RRM/Demod requirements and test methods.
- **Enhanced RRM requirements**: Rel-18 leftovers incl. L3 enhancements, inter-cell mTRP TCI state switch and beam management.
- **Enhanced demodulation requirements**: Joint processing of simultaneous mTRP signals.
- **Extension to FR2-2** (incl. RF/RRM/Demod requirements).
- **Extension to additional FR2 power classes** beyond PC3 including FWA/CPE devices.

Multi-RX CA operation framework



Evolved FR2 UE Simultaneous Multi-Panel Operation

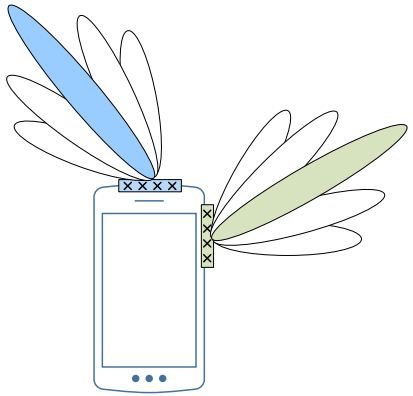
Simultaneous Multi-panel TX

Motivation

- Simultaneous FR2 multi-panel transmission (STxMP) feature can improve FR2 UL performance including data rate and connection robustness
- Support of STxMP is introduced in Rel-18 FeMIMO WI. However, it is expected that a limited set of RAN4 requirements is planned to be introduced in Rel-18 (Pcmax).
- Rel-18 scope does not include RF and FR2 Test Methods for STxMP. Extensive RAN4 studies work are needed to introduce the baseline requirements.

Candidate objectives/scope

- Focus on leftovers from Rel-18 work
- UE requirements to support single carrier STxMP operation including at least RF and RRM requirements.
- Limit to 2 Tx panels case, handheld and FWA/CPE UEs and single carrier STxMP operation.
- **SRS multi-panel simultaneous Tx**
- **RF requirements:** At least consider EIRP and new requirement concept based on spherical coverage
- **RRM requirements:** UL TCI state switch requirements, UL beam management procedures (e.g., beam selection)
- **OTA test methods** to enable STxMP testing



RAN4 Rel-19 Topics

Measurement Gaps Evolution

Measurement Gaps Evolution

Overview of R19 workshop proposals

NCSG enhancements

- Pre-configured NCSG
- Parallel measurements upon NCSG collisions
- L1 inter-frequency measurements in NCSG
- NCSG enhancements for deactivated SCell

Others

- Per CC gaps
- Gap overhead enhancements
- Independent gap configuration for DC
- Calculation of Kp enhancements
- L1 inter-frequency measurements by NeedForGap UE

Intel proposals

Down-selection of proposals taking into consideration commercial needs and deployment plans is required

Measurement Gaps Evolution

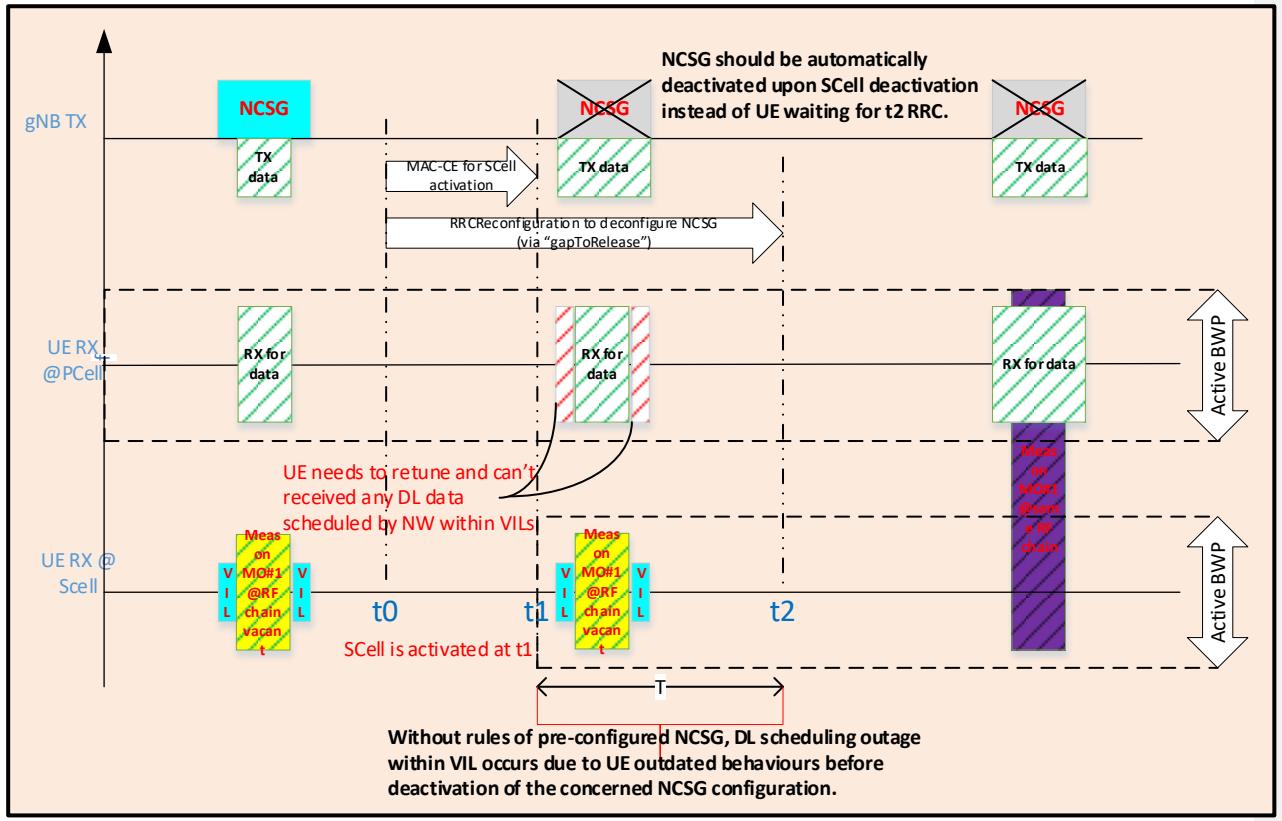
Pre-configured NCSG

Motivation

- The combination of pre-configured MG and NCSG features was de-prioritized in Rel-18 timeframe.
- Under CA operations, UE measures on SCell-s either within NCSG or outside of gap depending on SCell activation status (assuming SCell SSBs are within UE's active BWP). Problems are observed in the below cases without pre-configured NCSG:
  - Case 1: During SCell activation, DL scheduling could be lost due to RRC processing for releasing the associated NCSG.
  - Case 2: During SCell deactivation, UE does not perform measurements on the SSBs on the deactivated SCell until that the UE completes RRC processing for the new NCSG or MG. The measurement latency will be largely extended due to UE RRC processing time.

Candidate objectives/scope:

- Pre-configured NCSG
  - Mechanism to configure the pre-configured NCSG
  - Activation/deactivation procedure
  - UE capability



Preconfigured NCSG de-activation

Measurement Gaps Evolution

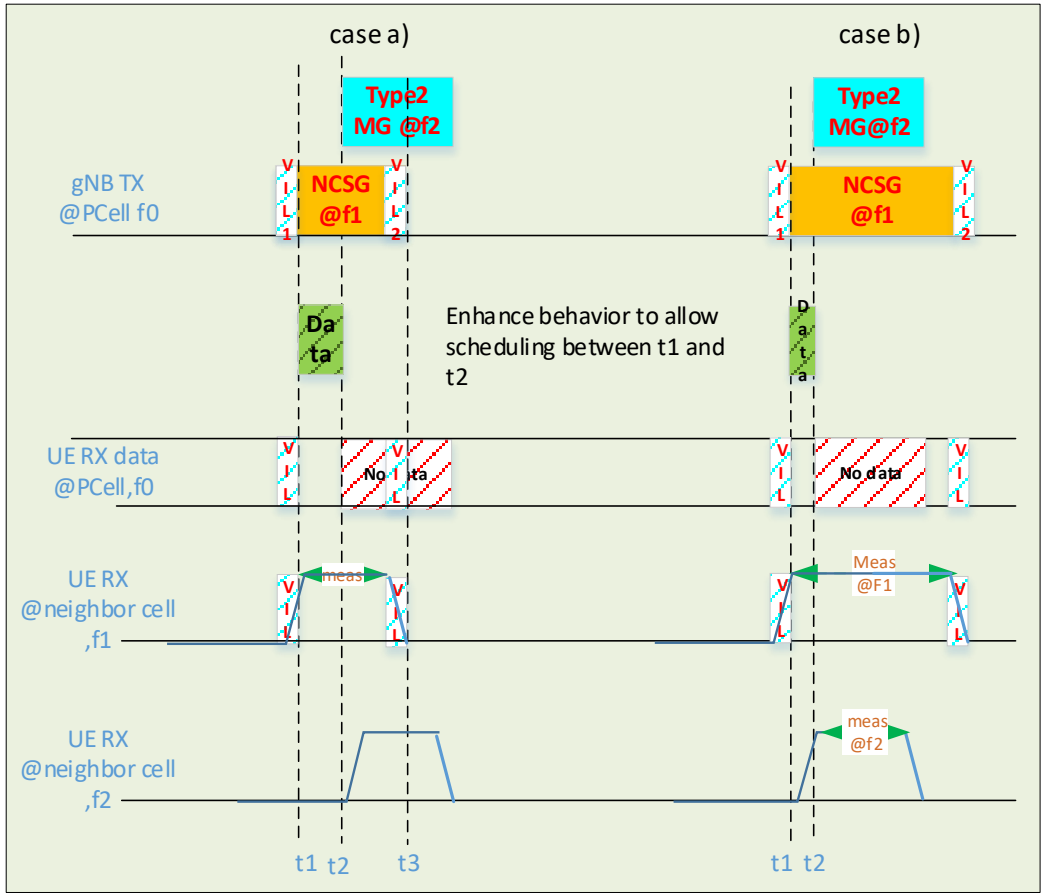
Enhanced collision handling for concurrent MGs

Motivation

- Based on current design for concurrent MGs with NCSG, UE needs to drop one of the gap instances when they are collided for intra-band measurements or inter-band measurements (e.g., both (f0+f1) and (f1+f2) band combinations).
- UEs with vacant RF chain(s) can utilize them for parallel measurements for the multiple gaps no matter they are collided or not. The enhanced dropping rule can be beneficial to increase overall both UE and NW efficiency.

Candidate objectives/scope:

- Enhanced UE behavior upon gap collisions
  - Optimized dropping rules when NCSGs are within concurrent MGs



NCSG collision handling

RAN4 Rel-19 Topics

RRM Evolution

RRM Evolution

Overview of R19 workshop proposals

Measurement reporting enhancements

FR2 delay reduction
- CSSF without MG enhancements
- RLM and BFD reduction
- General L3 delay reduction

Further enhanced EMR
- Selection of a reduced set of carriers
- Improved reporting during connected mode

CSI-RS enhancements
- CMTC
- Collisions between L3 and L1
- Inter-cell L1 measurements based on CSI-RS

Mobility and procedure enhancements

- Enhanced TCI state switch
- URLLC enabling requirements
- Improved UE Rx beam switching
- Further SCell activation enhancements based on R18 solutions
- Unified TCI extension to multi-TRP
- BWP switching enhancements
- Dynamic RTD/TTD update
- HO interruption reduction

Missing requirements

- SRS antenna port switching during whole slot
- HO with PSCell enhancements
- Missing requirements for RedCap UE
- NR RACH-less HO requirements
- Second RLM BLER pair requirements
- BFD reconfiguration requirements

Others

Relaxed RRM requirements and UE power saving
- To apply RedCap requirements to non-RedCap UE
- 1Rx NTN UE requirements
- eDRX requirements
- Relaxed RLM/BFD requirements

AI/ML based Rx beam sweeping
- Reduced delay requirements
- RSRP map, deep learning and image super-resolution

Intel proposals

Down-selection of proposals taking into consideration commercial needs and deployment plans is required

RRM Evolution

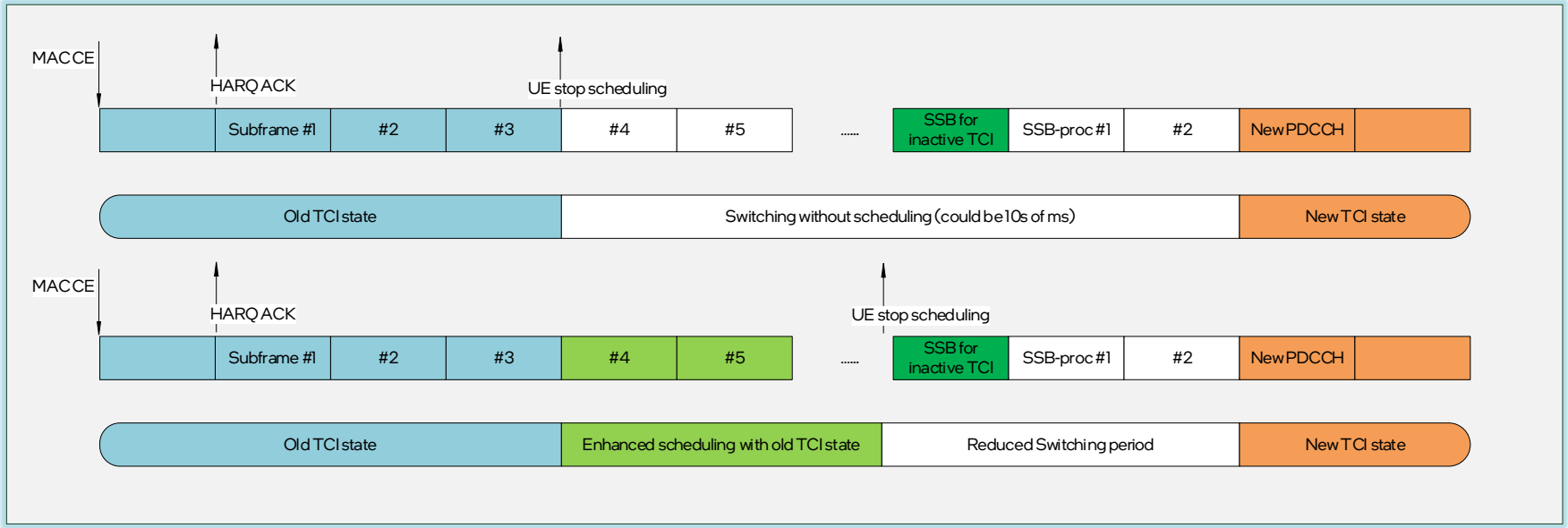
Enhanced TCI state switch requirements

Background

- In TCI state switching requirements, there is a time gap where UE is not required to receive or transmit data.
- The gap has an impact on the throughput performance in case the first SSB arrives relatively late for DL TCI state switching and in case the first PL-RS arrives late for UL TCI state switching.
- UE behavior can be enhanced to receive and transmit data during the time gap of Tfirst-SSB for DL TCI state switching or during the Tfirst_target-PL-RS.

Candidate objectives

- Enhancements to maintain the UE reception and transmission during the period (or part of period) of DL, UL and joint DL/UL active TCI state switching



Current MAC CE based TCI state switch timeline

Enhanced MAC CE based TCI state switch timeline

Example of MAC-CE based downlink TCI state switch

RRM Evolution
URLLC-enabling requirements

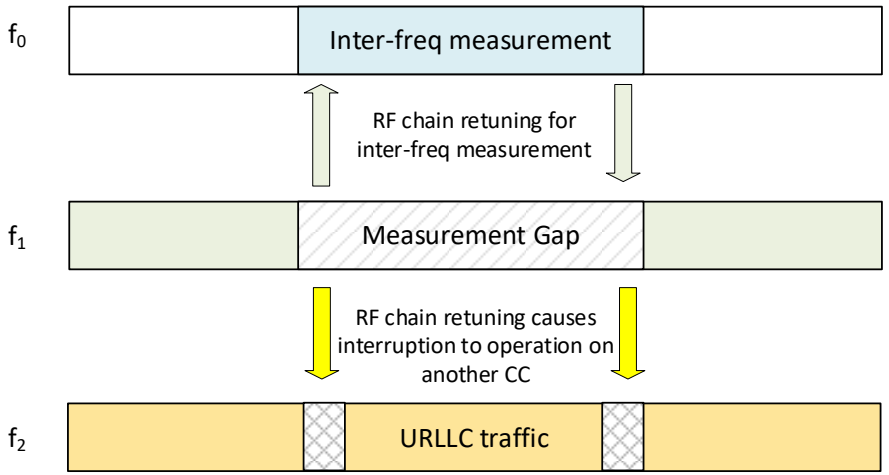
Background

- URLLC is one of key applications for 5G/5G-A.
- From RRM requirements perspective URLLC data is no different to eMBB in terms of allowed disruptions in data, which is not well fulfilling URLLC service requirements regarding mission criticality. RRM procedures such as measurements, interruptions due to RF retuning, SCell activation, etc. may affect URLLC traffic.
- Further enhancements to RRM requirements and UE capabilities can be considered to minimize disruptions on URLLC traffic.

Candidate objectives

- Study and specify enhancements for protection of carriers with URLLC traffic from RRM-related disruptions
  - Identify the cases, where disruptions on carriers with URLLC traffic may occur
  - Enhancement to reduce the allowed interruption length on carriers with URLLC traffic
  - Mechanisms for interruption protection on carriers with URLLC traffic
  - Additional UE capabilities for interruption free RF chains dedicated for carriers with URLLC traffic

Note: The same set of enhancements can be applied to other time-sensitive or reliability-sensitive types of services incl. XR. The work can be a part of RRM or MG evolution.



Interruption impact on carriers with URLLC traffic

RRM Evolution

Improved UE Rx Beam switching requirements

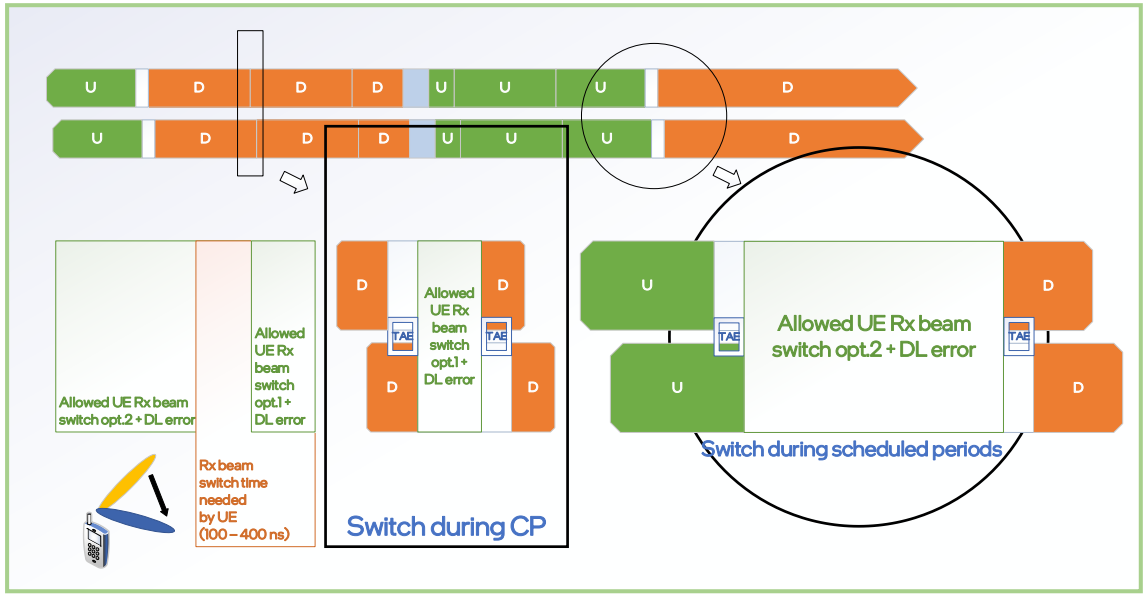
Background

- In FR2, there are cases where the CP length cannot accommodate the switching time of UE Rx beam switching properly, therefore causing interruptions on scheduling every time the UE switches its Rx beam.
- Performance degradation is expected on the serving cell for both single carrier and CA scenarios with CBM.
- Dedicated scheduled time periods or guard periods between UL and DL symbols for beam switching can be used to avoid performance loss.

Candidate objectives

- Enhancement to schedule time periods for FR2 UE Rx beam switching

SCS	CP length	TAE for Contiguous CA	DL timing error
120kHz	580ns	130ns	~33ns
480kHz	146ns	32.5ns	~8ns
960kHz	73ns	32.5ns	~4ns
Note: UE Rx beam switching time ranges from 100 to 400 ns.			



Comparison between switching during CP and during scheduled periods

RAN4 Rel-19 Topics

RF-centric topics

Irregular Channel Bandwidth

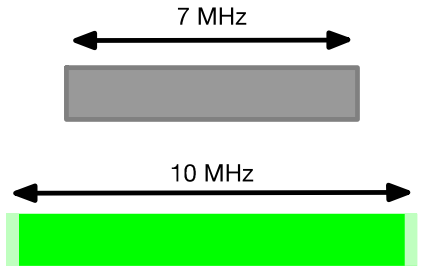
Motivation

- Increase spectrum utilization by allowing operators to flexibly use available spectrum blocks of any RB granularity instead of only traditional BW sizes at multiples of 5MHz.
- Several solutions were identified in the Rel-18 NR Irregular CBW SI (TR 38.844), but no follow up WI was approved.

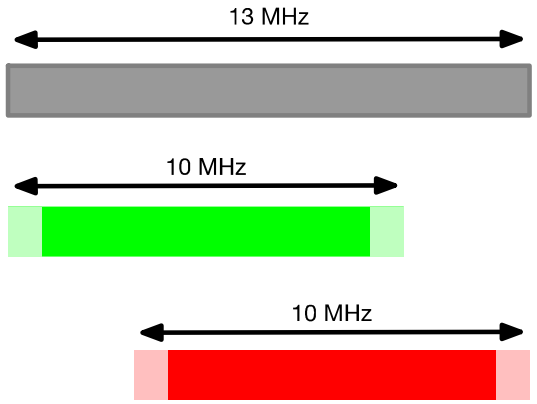
Candidate objectives

- Introduce specification support for the following irregular CBW methods
  - Larger Channel BW than licensed BW
  - Overlapping UE CBW from Network Perspective
- Address potential issues with initial access for irregular channel BW less that 10MHz

TR 38.844: Larger channel bandwidth (example for 7MHz)



TR 38.844: Overlapping carriers (example for 13MHz)



RF Evolution

FR1 UE RF evolution

- FR1 UEs with 6RX antennas
  - Support of operation with up to 8RX antennas for CPE/FWA type of devices was introduced in Rel-18, while smartphone type of devices are equipped with up to 4RX.
  - Further enhancement of the number of RX antennas at the UE side for NR can be considered to meet the market requests.
  - To allow more flexibility for UE implementations **support of 6RX** shall be considered **for different form factors** including smartphone and CPE/FWA type of devices.
- FR1 HPUE evolution
  - Multiple proposals submitted for R19 workshop on extending the HPUE for CA and other scenarios.
  - The Rel-18 HPUE framework is very diverse and handled across multiple different Wis.
  - A **single umbrella item** (FR1 RF WI) is recommended **for all HPUE topics** to efficiently control the work scope and benefit from joint approach for handling adjacent technical problems.
  - The current framework for HPUE CA specification may be challenging to be extended in future. Further work on defining a **general framework for HPUE with CA** (as in RWS-230225) can be beneficial to build the path towards the next generation.

BS RF evolution

- mmWave multi-band BS
  - Rel-18 SI concluded on feasibility of multi-band mmWave BS implementations and a follow up Rel-19 WI is required to make the specification changes.

RAN4 Rel-19 Topics

Demodulation Evolution

BS Demodulation

MMSE-IRC for inter-cell interference

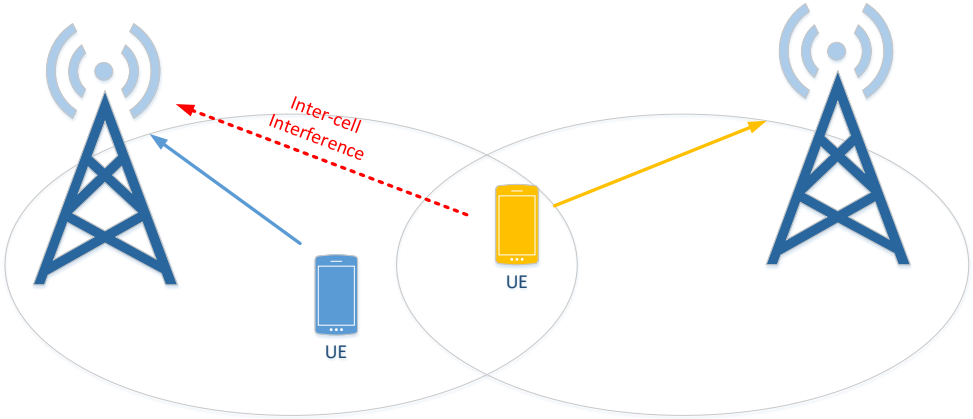
Motivation

- Existing BS requirements are defined for noise limited conditions and do not allow verification of BS interference rejection capabilities under practical conditions.
- Interference-limited conditions are quite typical for 5G deployments and support of MMSE-IRC processing is important to guarantee good performance in the field (see typical LTE profiles on the right).

Candidate objectives

- Study NR UL inter-cell interference profiles
- Define **BS MMSE-IRC demodulation requirements** for inter-cell interference scenarios for SU-MIMO cases

UL inter-cell interference



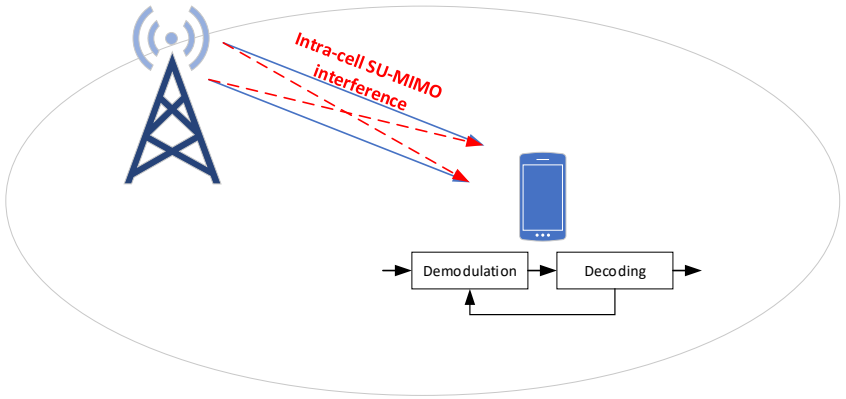
Typical UL DIP/INR values
for 85% DIP CDF based on TR 36.884

	HomoNet		HetNet	
	DIP	INR	DIP	INR
Interf UE1	-1.11	7.29	-0.43	12.38
Interf UE2	-10.91	-2.51	-13.78	-0.97

UE Demodulation

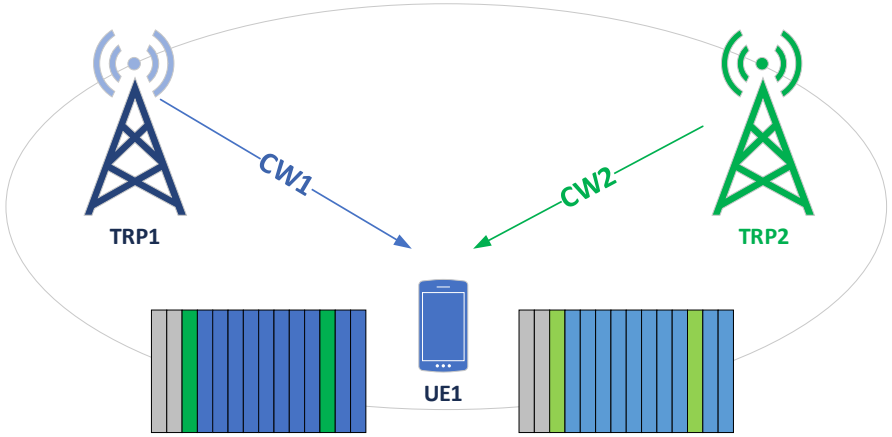
Soft IC receivers for DL SU-MIMO and multi-TRP

- Motivation: DL SU-MIMO requirements are defined for MMSE-IRC and R-ML receivers. Rel-16 eMIMO requirements for multi-DCI multi TRP scenario are defined for scenarios with non-overlapping PDSCH allocation and MMSE-IRC receiver. Soft IC receivers can be used to improve PDSCH performance for both scenarios.
- Candidate objectives: Study performance benefits and specify UE requirements for **Soft IC receiver for DL SU-MIMO and for multi-DCI multi TRP scenarios**



Application layer throughput requirements with OLLA

- Motivation: Misalignment of UE CSI feedback algorithms with network-controlled OLLA algorithms may potentially cause reduced performance in the field.
- Candidate objectives: Study and introduce **ATP requirements with OLLA** to ensure robust performance under realistic field conditions



RAN4 Rel-19 Topics

Other areas

Other Areas

The work on selected Rel-18 areas and use cases is recommended to continue to introduce a more complete set of functionality, but a relatively small work scope and load is anticipated

➢FR2 HST enhancements

- Support of multi-RX operation for PC6 in CA scenarios

➢ATG enhancements

- Support of CA scenarios
- RRM leftovers and improvements (e.g., Location based CHO)

➢Intra-band non-collated CA/EN-DC enhancements

- Support for scenarios deprioritized in Rel-18 ("*Support non-co-located scenarios for both FR1 inter-band EN-DC with overlapping and FR1 intra-band NR-CA, except for 2-layer case already specified in Rel-16, 17 and 18*")

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