

Discussion on Rel-19 XR enhancements



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Ericsson

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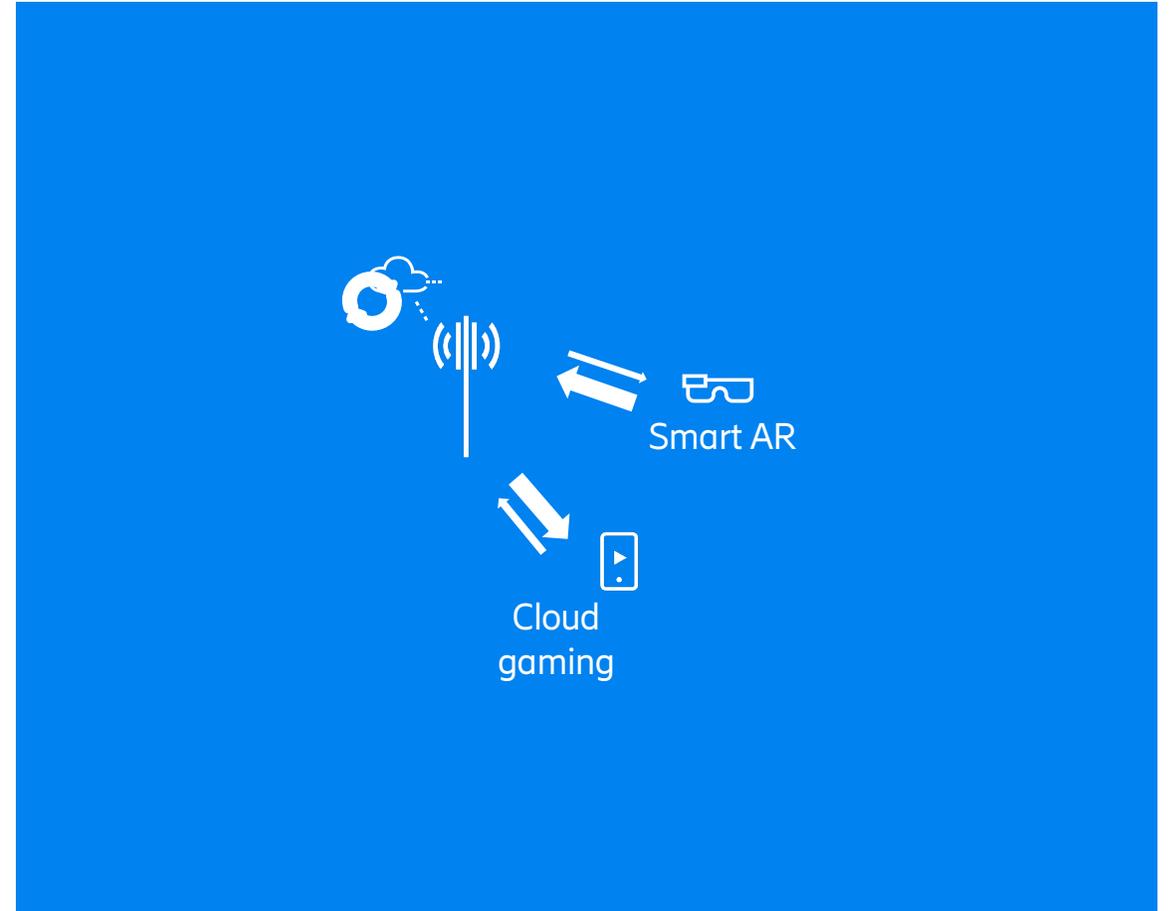


Rel-19 XR in RAN



Justification

- Rel-17 XR SI evaluated XR performance and identified bottlenecks
- Rel-18 XR SI/WI has been focusing on finding solutions in RAN to enhance XR capacity and power saving when assistance information about application is provided
- Rel-19 XR should aim to further improve primarily the area of capacity, but also UE power saving and XR awareness



Multi-modality



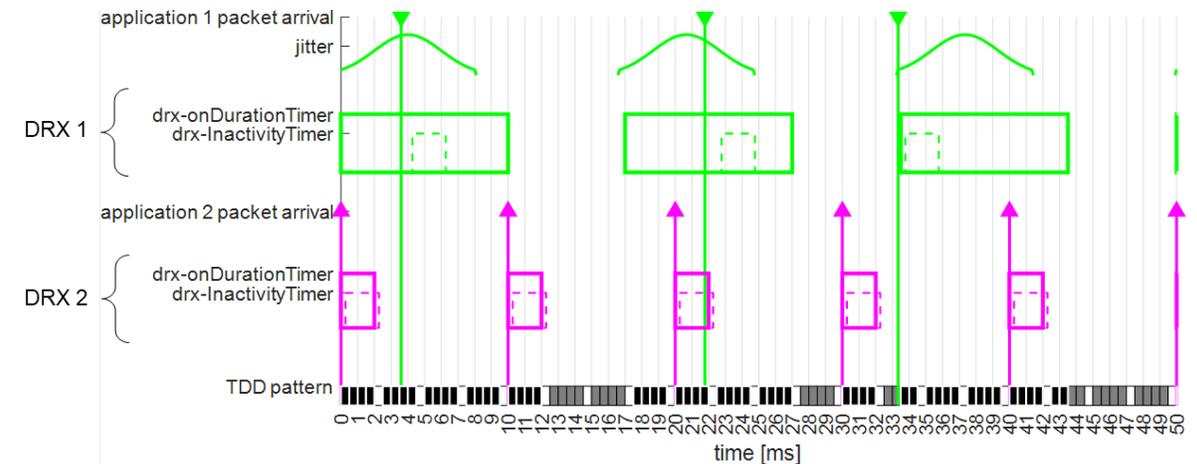
- Despite significant support from companies for multi-modality aspects, especially coordination/synchronization of different QoS flows, it is not clear what the problems are with multi-modality handling in RAN. Furthermore, SA2 has already studied multi-modality and has not concluded on any impact on RAN, regarding coordination/synchronization of different QoS flows. For reference see Rel-18 (Key Issue #1 and #2 in [TR 23.700-60](#)) and Rel-19 SID ([SP-231198](#)).
- Neither capacity nor power saving gains were shown for coordination/synchronization of different QoS flows in RAN.
- If something is to be studied in RAN Rel-19, first study what is missing from existing QoS handling in RAN and align with SA2/SA4.
- The scope of the study shall be narrowed down to a simple case, e.g., only intra-UE QoS flow handling. Solutions are to be specified only if sufficient capacity and/or power saving gains can be shown.

Proposal: Study and, *if sufficient capacity and/or power saving gains are shown*, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (intra-UE) (with coordination with SA2/SA4), and other aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact) [RAN2].

Multi-modality: Multiple active DRX configurations



- Multiple active DRX configurations was discussed in RAN #101 in the multi-modality context [[RP-232619](#)]
- If multiple interleaved periodic XR flows exist, it is difficult to minimize delay & also save UE power in the irregular sleeping gaps, with only one DRX configuration
- Solution: Multiple active DRX configurations (for the same serving cell/carrier of a UE) provide up to 13.6% power saving gain (and 88.4% satisfied UEs) [3GPP TR 38.835 Annex B.2.8, R2-2212886]
- Note that this enhancement does not require synchronization/coordination across QoS flows. Individual per-QoS flow characteristics are sufficient.

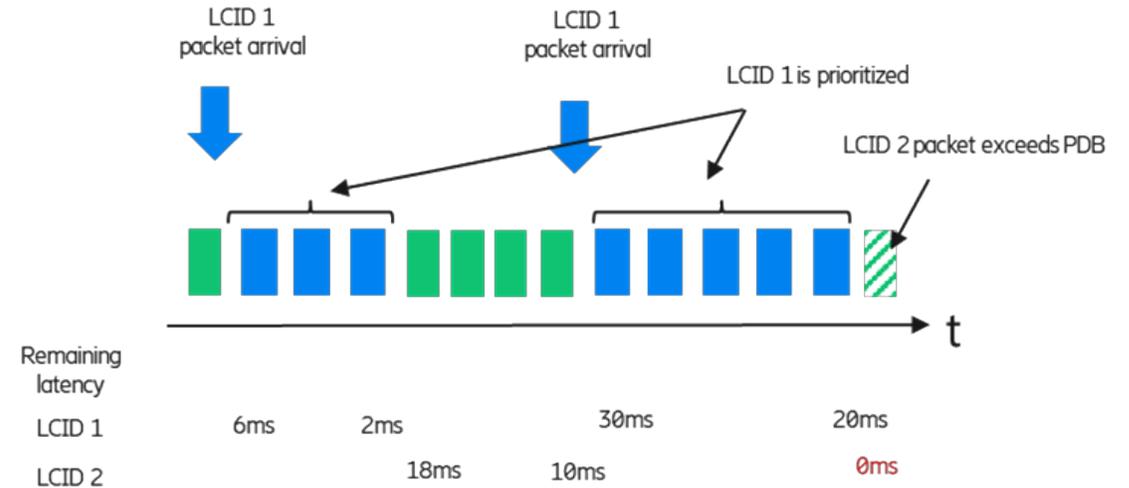


Proposal: Specify multiple simultaneous DRX configurations to optimize power saving of UEs with multi-flow XR services [RAN2].

UL delay-aware scheduling



- Context
 - Multiple flows within the same UE (XR and others)
 - Rel-18 will introduce signaling of remaining delay, e.g., DSR
 - The DSR can enable gNB to understand which logical channel data requires immediate transmission before its PDB expires
- Motivation
 - Existing logical channel prioritization (LCP) is based on fixed priority levels & bucket size for each LCID → restriction to prioritize urgent packets if they belong to the lower priority logical channel
- **Solution:** Enhanced UL delay-aware scheduling with dynamic LCP
 - The gNB can decide logical channel reprioritization based on DSR, and indicate the prioritization status in uplink dynamic grant
 - The same uplink dynamic grant can be utilized to simultaneously schedule resources and the dynamic LCP of data on the scheduled resources



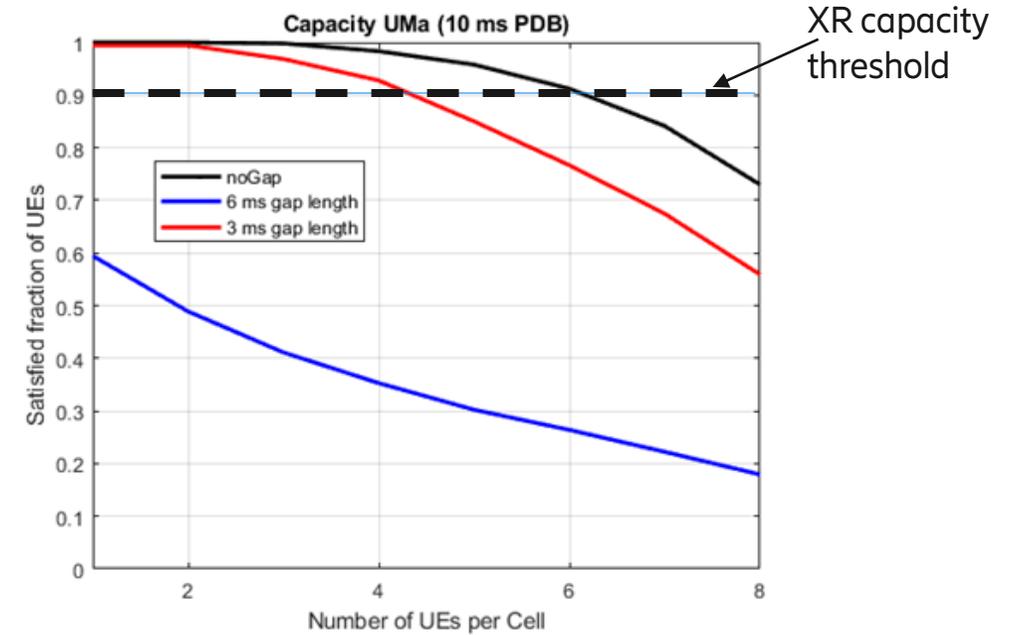
E.g. for two LCIDs: During a short period of time (shorter than RRC reconfiguration time), if some packets in LCID 2 (lower priority) become more urgent than packets in LCID 1 (higher priority), i.e. their remaining delay becomes shorter, the UE should reprioritize LCID 2 over LCID 1.

Proposal: Support enhanced UL delay-aware scheduling with dynamic logical channel prioritization [RAN1, RAN2].

Measurement gaps



- Measurement gaps (MGs) are periodic gaps in TX/RX that need to be configured in some cells, primarily for inter-frequency handover measurements, but may be needed also for intra-frequency measurements
- Large degradation of XR capacity in cells with MG
- **Solution:** gNB-controlled L1 signaling for dynamic utilization of MGs for XR mobility
 - Both dynamic triggering and dynamic cancellation of MGs can be considered



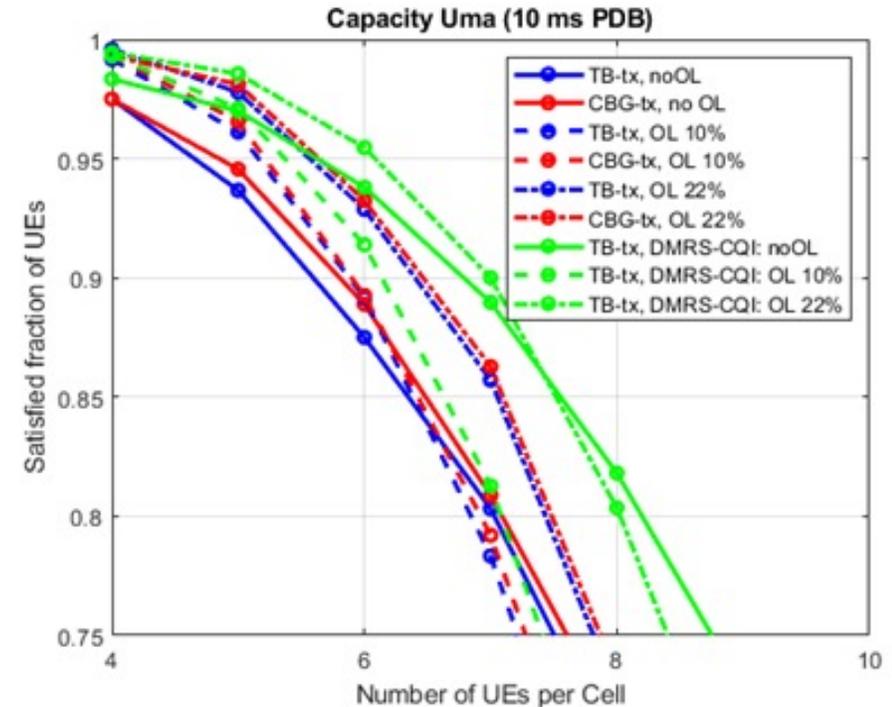
Fraction of satisfied XR users (60 frames/sec) with or without measurement gap configured and activated. For 'noGap', no user has measurement gap, while for '3 ms gap length' and '6 ms gap length' all users have measurement gaps configured and activated with 3 ms or 6 ms gap length and 80 ms gap repetition period.

Proposal: Specify gNB-controlled L1 signaling for dynamic utilization of measurement gaps for XR mobility [RAN1, RAN2, RAN4].

PDSCH reception based CQI



- CSI reports are inaccurate
 - Resource for measurement is separate from resource for PDSCH transmission
- Solution: Introduce PDSCH reception based CQI report
 - Motivation for XR: XR continuously generates PDSCH transmission, which can be used to improve CSI accuracy
- Benefits:
 - Improved link adaption for re-transmissions -> XR capacity improvement (right figure, 'green' compared to 'blue')
 - Improved link adaptation for next initial transmission
 - Faster outer-loop link adaption convergence



Reference: R1- 2208401

Proposal: Specify CQI reporting with HARQ-ACK timing based on actual received PDSCH quality (e.g., PDSCH DMRS or PDSCH decoding based CQI) [RAN1, RAN2].

Remaining topics from Rel-18: CG enhancements



- UTO-UCI enhancements
 - To a large extent Rel-18 UTO-UCI reporting is left to UE implementation without clear and testable UE behavior.
 - We believe UTO-UCI has the potential to be beneficial for both gNB and UE, but we also strongly believe that this is conditioned that UE behavior is clear and testable.
 - We support a) or a)+b), but not b) alone:
 - (a) *Specify clear and testable UE behaviour for the determination of the content of UTO-UCI [RAN2]*
 - (b) *Including extension of UTO-UCI indication across multiple CG configuration of the same UE [RAN2, RAN1]*
- Non-integer periodicities for CG [RAN2]
 - Context: Many XR arrival rates (FPS) have non-integer periodicities
 - Problem: The CG periodicities currently defined are only restricted to integer periodicities
 - XR traffic cannot be mapped exactly to existing CG occasions
 - Due to this limitation, the delay from offsets between XR arrivals and CG occasions may accumulate over time and render some occasions useless or wasted
 - The problem becomes excessive, if the bands are TDD based, resulting in fewer uplink resources
 - Solution: Specify non-integer CG periodicities to cater XR traffic
 - Rules can be defined to map CG occasions based on non-integer periodicity to physical uplink resources

Proposal: For UTO-UCI, support multiple CG configurations [RAN1, RAN2] provided clear and testable UE behavior is specified [RAN2].

Proposal: Specify non-integer CG periodicities [RAN2].

Remaining topics from Rel-18: DSR enhancements



- DSR enhancements
 - Rel-18 introduced delay reporting (DSR) but with the limitation of a single value per LCG
 - The consequences of this is that inferior information will be provided to the RAN scheduler
 - Example: **PDU Set 2** triggers a DSR when **PDU Set 1** still has bits remaining in the buffer → The delay value reported in the DSR will be the remaining time for **PDU Set 1** but the size reported will be the sum of **PDU Set 1 + PDU Set 2**
 - Solution: Enhance DSR to support multiple value reporting
 - This will solve so there is no ambiguity in the delay value reporting
 - Can be done by simply adding more rows to DSR or multiple reporting/trigger thresholds
 - This is also a potential enhancement to support multiplexing of multiple flows, e.g. multi-modality

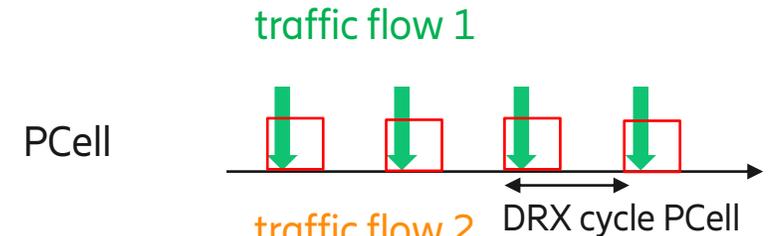
Proposal: Enhance DSR to support multiple value reporting [RAN2].

UE power saving: DRX enhancement for CA

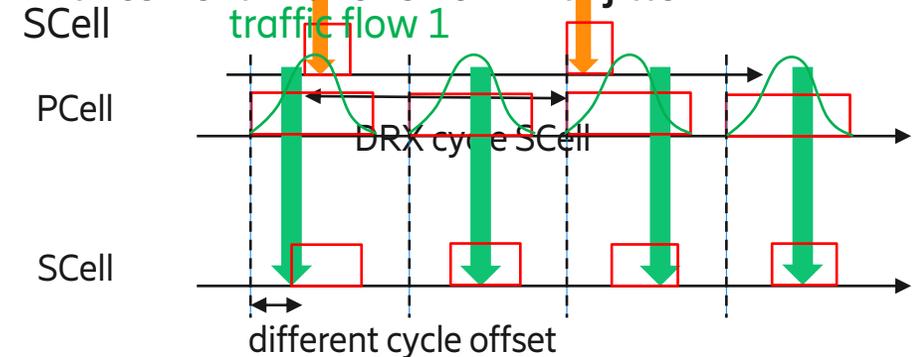


- A secondary DRX group can be configured for a UE and some serving cells can be associated to it. However, only the onDuration and InactivityTimer can take different values for the first and secondary DRX groups.
- For CA, different traffic patterns could occur on different carriers, e.g., different XR flows could be mapped to different carriers.
- Also, for a single DL video flow with jitter that is sent on two carriers, starting on-duration at the beginning of the jitter range for both carriers may waste power.
- Solution: Independent DRX configurations per carrier

Enhancement with two flows



Enhancement with one flow with jitter



Proposal: Specify more flexible configuration for the secondary DRX group in CA [RAN2].

Enhancements for XR (RAN2-led): Summary



- Multi-modality flows
 - Study and, if capacity and/or power saving gains are shown, specify aspects related to multi-modality(intra-UE)/multi-QoS flow (intra-UE) (with coordination with SA2/SA4), and other aspects requiring coordination w/ SA initiated work as necessary (e.g., SA2/SA4 task list which may potential have RAN impact) [RAN2].
 - (Power saving:) Specify multiple simultaneous DRX configurations to optimize power saving of UEs with multi-flow XR services [RAN2].
- Support enhanced UL delay-aware scheduling with dynamic logical channel prioritization [RAN1, RAN2].
- Specify gNB-controlled L1 signaling for dynamic utilization of measurement gaps for XR mobility [RAN1, RAN2, RAN4].
- Specify CQI reporting with HARQ-ACK timing based on actual received PDSCH quality (e.g., PDSCH DMRS or PDSCH decoding based CQI) [RAN1, RAN2].
- For UTO-UCI, support multiple CG configurations [RAN1, RAN2] provided clear and testable UE behavior is specified [RAN2].
- Specify non-integer CG periodicities [RAN2].
- Enhance DSR to support multiple value reporting [RAN2].
- Power saving objectives
 - Specify more flexible configuration for the secondary DRX group in CA [RAN2].



Appendix: Simulation assumptions



- Simulation assumptions for PDSCH reception based CQI and measurement gap simulation results are according to the table on the right side.
- For simulations with measurement gaps enabled, the measurement gaps are only used for SSB measurements and are configured to be aligned with SSB locations where the SSBs are transmitted. The SSBs have a 20 ms periodicity.
- To avoid all UEs to have measurement gaps at the same time, the UEs are randomly assigned to one of four measurement gap groups, where group $i=0, 1, 2, 3$ has measurement gaps with a starting time T_i in ms:

$$T_i \pmod{80} = i20$$

Parameter	Deployment scenarios		
	Dense Urban / Urban Macro (38.913 w/ following parameters)		
Layout	9 cells with wraparound ISD: 500m (Urban Macro)		
Channel model	UMa (38.901)		
UE Distribution	80% indoor, 20% outdoor		
Carrier frequency	4 GHz		
Subcarrier spacing	30 kHz		
BS height	25m		
UE height	For Dense urban and Urban Macro, the UE height for indoor UEs is updated as following based on Table 6-1 in TR 38.873.		
	UE height (h_{UT}) in meters	general equation for UE height	$h_{UT}=3(n_u - 1) + 1.5$
		n_u for outdoor UEs	1
	n_u for indoor UEs	$n_u \sim \text{uniform}(1, N_u)$ where $N_u \sim \text{uniform}(4, 8)$	
BS noise figure	5 dB		
UE noise figure	9 dB		
BS receiver	MMSE-IRC		
UE receiver	MMSE-IRC		
Channel estimation	Realistic		
UE speed	3 km/h		
MCS	Up to 256QAM		
BS Antenna Pattern	3-sector antenna radiation pattern, 8 dBi		
BS Antenna Configuration	64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,2,1,1;4,8) (dH, dV) = (0.5λ, 0.5λ)		
UE Antenna Pattern	Omni-directional, 0 dBi		
UE Antenna Configuration	2T/4R, (M, N, P, Mg, Ng; Mp, Np) = (1,2,2,1,1;1,2), (dH, dV) = (0.5, N/A)λ		
Down Tilt	12 degrees		
BS Transmt Power	44 dBm per 20 MHz Note: For system BW larger than above, Tx power scales up accordingly.		
UE max tx power	23dBm		
System Bandwidth	100 MHz		
TDD Configuration	DDDSU		
Scheduler	Delay scheduler (Measurement GAP), PF scheduler (PDSCH reception based CQI)		
PHY processing delay	UE processing Capability #1 DL NACK to retransmission delay 1.5ms		
DMRS overhead	1 DMRS symbol per PDSCH/PUSCH		
Power control parameter	alpha: 0.8		
CSI reporting	periodic 2.5 ms, Rank restriction: ≤ 2		
Transmission scheme	Reciprocity-based precoding		