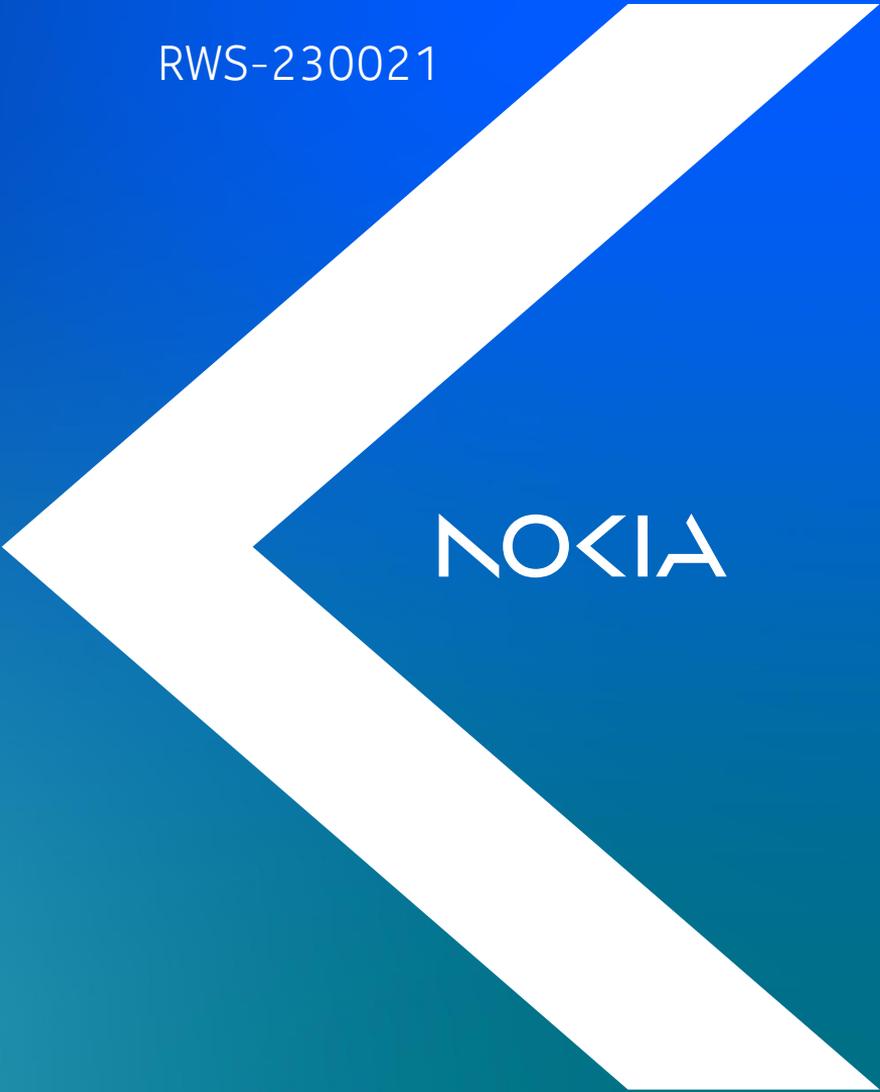


# XR Enhancements

The Nokia logo is positioned on the right side of the slide, centered vertically. It consists of the word "NOKIA" in a white, sans-serif font, set against a large, stylized white arrow graphic that points to the left. The arrow is composed of two thick, parallel lines that converge to a point on the left side of the slide.

NOKIA

Taipei, June 15-16, 2023

Agenda Item: 5

Source: Nokia, Nokia Shanghai Bell

# Motivation

**XR devices and traffic are expected to be increased heavily by 2030 (e.g., more than 300 million devices as per ABI Research report)**

## **Release 18 forms baseline for XR enhancements**

- Foreseen practical use cases are still expected to need improvements for capacity and UE power consumption, also studying mixed traffic scenarios is beneficial
- Follow-up from Release 18 development on traffic awareness

## **XR Release 19 enhancement areas**

- Follow-up on Rel18 capacity, power saving, and traffic awareness
- Higher layer enhancements
- Address new traffic scenarios (e.g., mixed traffic scenario)



# RRM enhancements - Relax scheduling restrictions

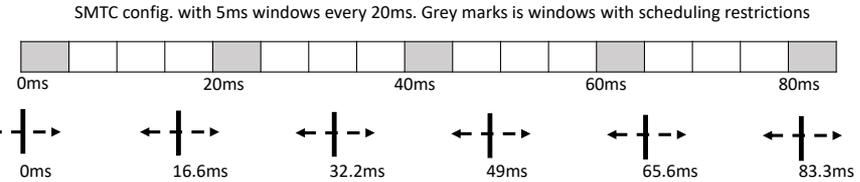
## RAN1/2/4 led objectives

### Problem:

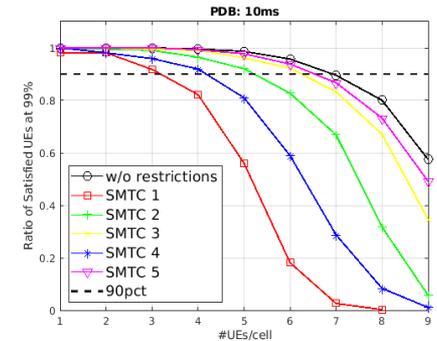
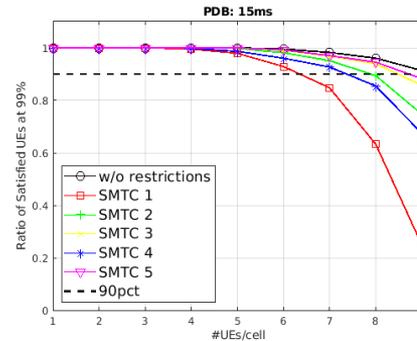
- Scheduling XR users according to agreed QoS constraints in 3GPP TR 38.838 is seriously challenged for FR2 if subject to scheduling restrictions with SSB based measurement timing configuration (SMTC) windows of e.g., 5-3 ms every e.g., 20-40 ms time-period
- Similar problem is observed for gap assisted inter-frequency RRM measurements as defined in 3GPP TS 38.133

### Objective:

- NW-centric and/or UE-centric solutions allowing UE to prioritize PDCCH/PDSCH decoding and/or PUSCH transmissions within SMTC window or measurement gap (MG) (RAN1/2)
- Impacts on RAN4 RRM requirements



Vertical bars indicate arrive arrival times of XR frames. Dashed arrows indicate jitter per frame.



	CG (PDB: 15ms)	AR/VR (PDB: 10ms)	Capacity loss w.r.t. no scheduling restrictions	
	CG (PDB: 15ms)	AR/VR (PDB: 10ms)		
W/O scheduling restrictions	9 UEs	7 UEs	-	-
SMTC 1 (20ms, 5ms)	6.2 UEs	3.1 UEs	31% ↓	56% ↓
SMTC 2 (20ms, 3ms)	8 UEs	5.1 UEs	11% ↓	27% ↓
SMTC 3 (20ms, 2ms)	8.5 UEs	6.5 UEs	6% ↓	7% ↓
SMTC 4 (40ms, 5ms)	7.3 UEs	4.1 UEs	19% ↓	41% ↓
SMTC 5 (40ms, 2ms)	8.6 UEs	6.6 UEs	4% ↓	6% ↓

# CQI enhancements for CBG-based transmissions

## RAN1 led objective

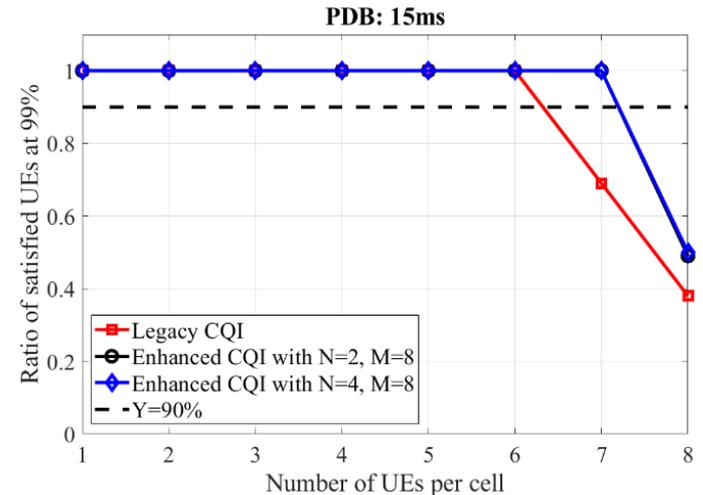
### Problem:

- Given large payloads for XR cases, Code block group (CBG)-based transmissions are attractive as a mean to have resource efficient transmissions to improve capacity
- However, in order to fully gain from CBG-based transmissions, we need to have efficient link adaptation tailored for the CBG-based transmissions through enhanced CQI (eCQI)
- The results in TR 38.835 confirm benefits of eCQI for XR

### Objectives:

- Enhance CQI report that ensures that only a certain maximum subset of CBGs will need retransmission with a controllable probability
- Other enhancements to CQI to accommodate CBG-based transmission are not excluded

With enhanced CQI working with a fixed CBG error probability to have at most  $N=2-4$  out of  $M=8$  failed CBGs, the number of satisfied XR users increases as compared to legacy CQI.



# UL specific UE power saving and capacity enhancements

## RAN1/2/4 led objectives

### **Avoid unnecessary UL transmissions to reduce UE power consumption (RAN1/RAN2)**

- **Problem:** Even when PDCCH monitoring skipping and/or Search Space Set Group (SSSG) switching is used, UE power saving gains may be compromised if the UE is configured with periodic UL transmissions during active time such as PUCCH for reporting CSI and/or SRS
- **Objective:** Enhancements enabling UE to drop unnecessary uplink transmissions based on inactivity detection in DL direction

### **Reduce SCell activation delay in case SCell activation is triggered by uplink traffic (RAN2/RAN4/RAN1)**

- **Problem:** Carrier aggregation (CA) with optimized SCell activation/deactivation based on instantaneous channel and traffic conditions can provide good trade-off between high data rate and low UE power consumption requirements of XR applications. In case CA is triggered by uplink traffic, SCell activation delay exists as UE first needs to indicate data arrival to gNB, and secondly receive an activation command from gNB, before it can initiate activation of the corresponding SCell
- **Objective:** Enhancements to decrease SCell activation delay when triggered by UL traffic

# Processing scalability to very high data rates

## RAN2 led objective

### Problem, processing pain points:

- Current NR stack requires IP-packet-specific:
  - headers at each of PDCP, RLC, and MAC (since concatenation only at MAC);
  - security-algorithm invocations at PDCP
- Integrity protection of every IP packet can be required from PDCP

### Objectives:

- Concatenation at PDCP
  - RLC/MAC headers and security processing per PDCP PDU, not SDU
  - E.g., within PDU Sets now defined in XR
- Partial integrity protection
  - Apply IP to only a subset of IP packets
  - Verification failure applied to whole MAC PDU

### Gain analysis on PDCP concatenation\*

<u>Overhead per PDCP SDU..</u>	<u>..by current standard:</u>	<u>..by concatenating N SDUs:</u>
<b>PDCP/RLC/MAC headers</b>	~11 octets	~17/N + 2 octets
<b>Security-algorithm invocations</b>	1	1/N

- For typical XR traffic, N could be dozens. The above shows reduction already by concatenating N=2 PDCP SDUs!
- \* Assumptions:
  - RLC UM; no segmentation in “by current standard”, segmentation into 2 in “by concatenating N SDUs”.

# Rate control for Delay-critical GBR in UL

## RAN2 led objective

### Problem:

- In case of delay-critical GBR (DC-GBR) LCHs, current Logical Channel Prioritization (LCP) procedure at UE's MAC (based on PBR and BSD configuration) allows fulfilling either GFBR or MDBV (over PDB) rate requirement, but not both
- If LCH is served resources based on its average rate (i.e.,  $PBR=GFBR$ ), there are no guarantees that up to MDBV can be sent within PDB
- If LCH is served resources based on its burst peak rate (i.e.,  $PBR = MDBV/PDB > GFBR$ ), larger and/or more frequent UL grants need to be provided to UE to satisfy remaining LCHs (reduces cell capacity)
- If no larger or more frequent UL grants are provided to UE, there is risk of starvation for LCHs with lower priority

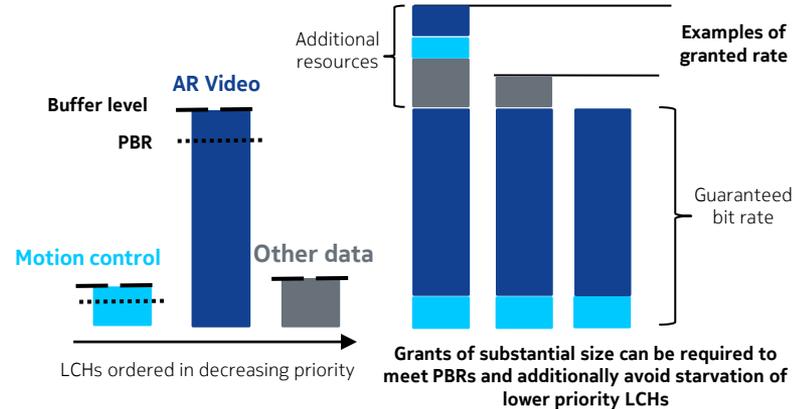
### Limitation based on current standard

- Configure LCH restrictions, e.g., configured grants, cells, numerology, etc., to isolate resource grant usage by DC-GBR LCHs → limited and with scalability issues in case of multiple delay-critical GBR LCHs per UE

### Objective:

- Enhancements to the current LCP to allow serving DC-GBR LCHs according to their QoS requirements. Efficient and separate enforcement of MDBV/PDB and GFBR in UL

Example UE configuration	Default data	Video for AR cloud rendering	Motion tracking data
LCH/DRB 5QI	9 (non-GBR)	90 (DC-GBR)	88 (DC-GBR)
LCH priority	15	6	5
PrioritisedBitRate (PBR)	infinity	$PBR=MDBV/PDB=63K B/20ms \approx 25Mbps$	$PBR=MDBV/PDB=1125B/10ms \approx 1Mbps$



# RLC re-transmission enhancements

## RAN2 led objective

**Problem:** RLC Acknowledged mode (AM) cannot operate with small packet delay budget (PDB) needed for services like XR:

- Retransmissions are triggered in transmitter by status reports received from receiver, and this may not be fast enough
- RLC never gives up on retransmitting a packet and if a packet reaches the maximum number of retransmissions, it notifies upper layers, which eventually triggers radio link failure (RLF)
- Use of RLC AM will be useful for cases for e.g., first Tx Link Adaptation MCS selection is far off, such that HARQ cannot recover

### Objective:

- Enhancements to enable use of RLC AM for XR use cases with PDB's of 10-20ms without falsely triggering RLF, etc.

#### TS 38.322

[...]

- if `RETX_COUNT = maxRetxThreshold`:

- indicate to upper layers that max retransmission has been reached.

[...]

#### TS 38.331

[...]

1> upon indication from MCG RLC that the maximum number of retransmissions has been reached:

2> if the indication is from MCG RLC and CA duplication is configured and activated, and for the corresponding logical channel *allowedServingCells* only includes SCell(s):

3> initiate the failure information procedure as specified in 5.7.5 to report RLC failure.

2> else:

3> consider radio link failure to be detected for the MCG, i.e. MCG RLF:

[...]

Current standards extracts with problem highlights

# Study XR+eMBB mixed traffic scenarios

## RAN1 led objective

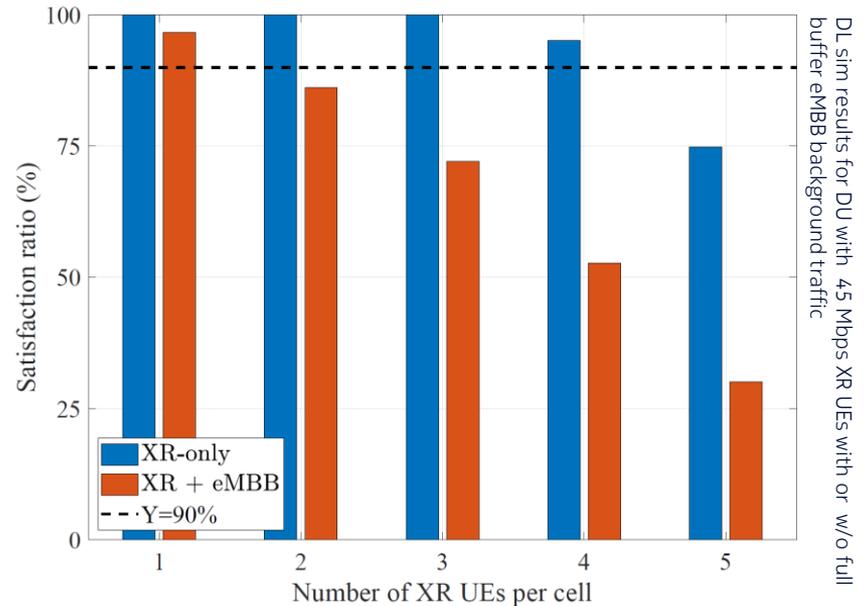
**Problem:** Rel-17 and Rel-18 XR SI's focused on cases with XR traffic only under fractional conditions

- Such scenarios typically result in high SINR conditions for users
- Scenarios with XR traffic only are not reflecting reality, where we will continue to have also e.g., eMBB traffic in addition to XR

### Objective:

- Agree on well-defined system-level simulation scenario with mixture of eMBB and XR traffic
- Rely on defined Rel-17 XR simulation scenarios, and add a case with eMBB traffic in addition to XR
- Focus on inter-UE cases, where some UEs are XR and others are eMBB
- Potential interference avoidance enhancements for cases with mixed XR and eMBB traffic to enhance capacity

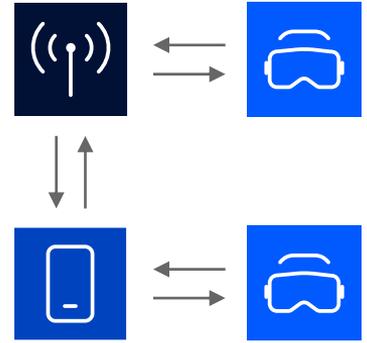
The XR capacity and the benefits of XR enhancements depends heavily on whether there is eMBB traffic present or not.



# Summary of proposed XR enhancements for Release 19

## Potential enhancements

- Follow-up on Rel18 capacity, power saving, and traffic awareness:
  - RRM enhancements to reduce/relax scheduling restrictions for FR1 and FR2 inter-frequency RRM measurements and FR2 intra-frequency RRM without measurement gap
  - CQI enhancements for CBG-based transmissions
  - UL specific UE power saving and capacity enhancements, e.g., adapting/omitting unnecessary UL transmissions to preserve UE power, Uplink transmission initiated SCell activation
  - XR application awareness in UL depending on SA2 outcome
- Higher layer enhancements:
  - Enhancements to alleviate support for very high data rates (PDCP concatenation, etc.)
  - Rate control for Delay-critical GBR in UL
  - RLC re-transmission enhancements allowing operation of RLC Acknowledged Mode (AM) with small packet delay budget
- Mixed traffic scenario of XR and eMBB



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