

3GPP TSG RAN Rel-19 workshop  
Taipei, June 15 – 16, 2023

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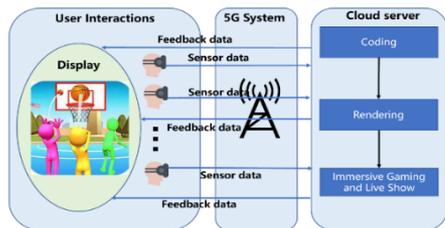
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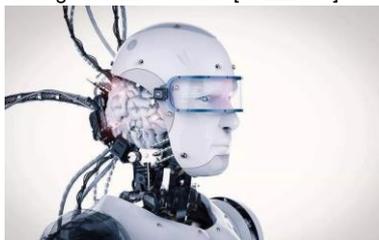
# Views on metaverse and multi-modality in Rel-19



# Metaverse and Multi-modality service



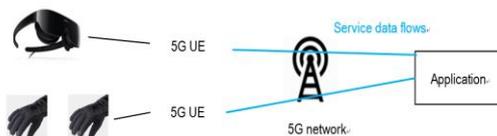
Use case 1: Mobile Metaverse for Immersive Gaming and Live Shows [TR22.856]



Use case 3: Remote control robot [TR22.847]



Use case 2: XR enabled collaborative and concurrent engineering in product design [TR22.856]



Use case 4: Immersive multi-modal VR application with multiple 5G UEs directly connected [TR22.847]

Use Case	Data rate	Reliability	E2E Latency
1. Mobile Metaverse for Immersive Gaming and Live Shows	1~1000 Mbps	99.99%	5~20 ms
2. XR enabled collaborative and concurrent engineering in product design	<b>Video/Audio:</b> 1~100 Mbps <b>Haptic:</b> 0.016~2Mbps	Audio/video: 99.9% Haptic: <b>99.999%</b>	Video/Audio: 10 ms Haptic: <b>5 ms</b>
3. Remote control robot	<b>Video/Audio/Sensor:</b> 1~100 Mbps <b>Haptic:</b> 0.016~2 Mbps	Video/Haptic/Sensor: 99.999% Audio: 99.9%	Haptic: 1~100 ms Video/Audio/Sensor: <b>5 ms</b>
4. Immersive multi-modal VR application with multiple 5G UEs directly connected	<b>Video/Audio:</b> 1~100 Mbps <b>Haptic:</b> 0.016~2 Mbps	Video/Audio: 99.9% Haptic: <b>99.999%</b>	Video/Audio: 10 ms Haptic: <b>5 ms</b>

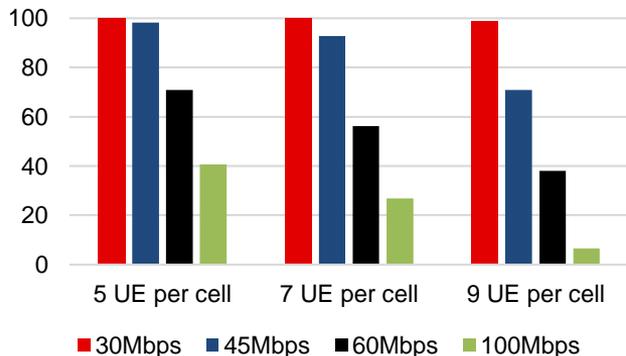
**Observation 1: Synchronization and coordination of multi-flow services for single/multiple UEs can be considered.**

**Observation 2: Higher performance requirements of higher data rate, higher reliability, lower latency for Metaverse/ Multi-modality service are identified compared with Rel-17/18 XR.**

# Metaverse and Multi-modality service

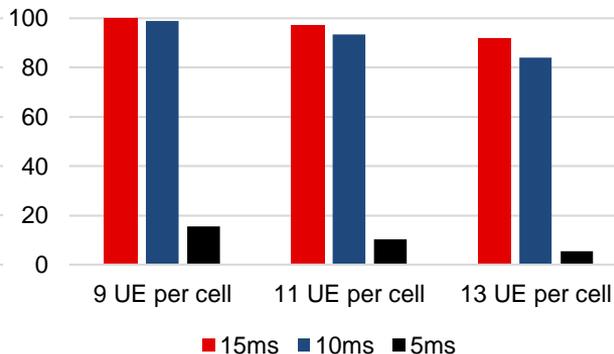
## Impact on different data rates

UE satisfactory percentage (%), different DR  
99% FSR & 10ms PDB, Indoor HotSpot



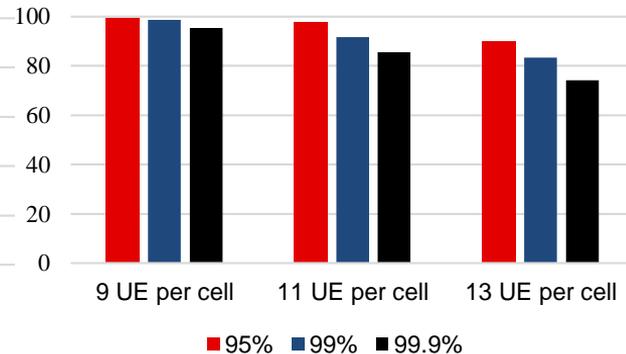
## Impact on different latencies

UE satisfactory percentage (%), different PDB,  
30Mbps, 99% FSR, Indoor HotSpot



## Impact on different reliabilities

UE satisfactory percentage (%), different FSR  
30Mbps, 10ms PDB, Indoor HotSpot

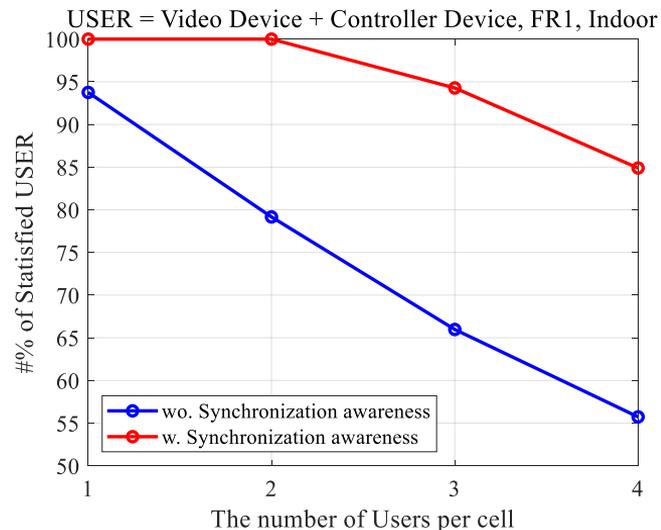


**Observation 3: Capacity performance loss occurs when higher performance requirements including, e.g., data rate, latency and reliability are needed.**

# Enhancement for multi-flow synchronization

## XR-awareness information about synchronization for gNB

- **Motivation:** Multiple flows or devices exist in Metaverse/Multi-modal use case, and synchronization of multi-flow or multi-device should be considered for UE experience enhancement. 5G RAN with better awareness of the synchronization request can adaptively and swiftly process the data with synchronization requirement
- **Solution:** Notify synchronization-awareness information from CN to gNB.



- **wo. Synchronization awareness:** 5G RAN cannot be aware of synchronization request and schedule data based on the QoS.
- **w. Synchronization awareness:** 5G RAN can be aware of synchronization and schedule data based on QoS as well as synchronization requirement
- Haptic flow modelling is in Appendix A1
- Simulation assumptions are listed in Appendix B1

# Enhancement for multi-flow synchronization-Cont

## Scheduler optimization based on XR-awareness information about synchronization

- **Motivation:** The scheduling mechanism, session and mobility management mainly focus on service delivery and control for a single UE. In Rel-19, it is necessary to discuss how to leverage the synchronization relationship of PDU SET in multiple flows of a single UE and of multiple UEs.
  - For example, based on the synchronization information, the scheduler in Rel-19 can enable group based RRM UEs and enable group based mobility.
  - In addition, more features including DRX configuration, paging could also be improved considering the requirements for a group of UEs which require synchronization/coordination. SA2 is foreseen to be involved in this study.
- **Proposal:** RAN enhancement mechanism on synchronization and coordination for multi-flow of single UE or multiple UEs needs to be studied in Rel-19 for Metaverse/Multi-modal service.

# Services performance monitoring mechanism

## Study multi-modality/metaverse communication services performance monitoring mechanism

- **Motivation:**
  - Tactile and multi-modal communication services enable multi-modal interactions. Compared to services in previous releases, the multi-modal communication services require timely and synchronized delivery of data with further requirements for high data rate/low latency. With more and more multi-modal communication services introduced in 3GPP (e.g., XR, AR, Metaverse), it is possible to further enhance these aspects in Rel-19. Such enhancements require monitoring the system performance, to ensure synchronization and coordination for multi-flow of single UE and among multiple UEs.
  - New metrics such as 'motion-to-photon' latency relate to XR/Metaverse/Multi-modality need to be studied in Rel-19. Consumer virtual reality (VR) systems are increasingly being deployed. The 'motion-to-photon' latency (the lag between a user making a movement and the movement being displayed within the display) is a particularly important metric as temporal delays can degrade sensorimotor performance. The metric is very different from current performance metrics such as packet delay or packet loss. In Rel-19, the new metric should be investigated with coordination with SA4. It also needs to study which entity monitors these metrics. (e.g. by Network or by UE or both).
- **Proposal:**
  - Possible new metrics (e.g., jitters, motion to sound/photon latency) need to be studied in Rel-19 for Metaverse/Multi-modal services.

# Services performance monitoring mechanism-Cont

## Study multi-modality/metaverse communication services performance monitoring mechanism

- **Motivation:**

- New measurements for evaluating metaverse/multi-modal service need to be investigated. For example, how to evaluate the synchronization performance of QoS flows need to be studied. During Rel-18 XR WID, the concept of PDU SET has been introduced. It should be noted the synchronization of PDU SET among QoS flows belong to one UE or multiple UE is key for better experience of XR/metaverse/multi-modal service.
- In addition, RAN node may need new UE assistant information as input for performance evaluation. For example, the configuration of Prioritized Bit Rate (PBR) and Bucket Size Duration (BSD) are key parameters for the uplink traffic shaping and rate limiting for XR/metaverse/multi-modal service. UE assistance information may need to dynamically configure and reconfigure these key parameters during the multi-modality/metaverse related sessions.

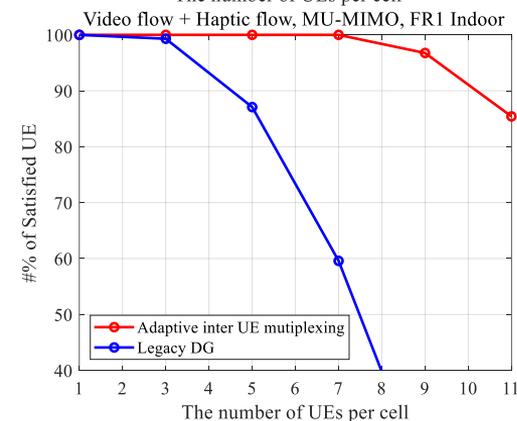
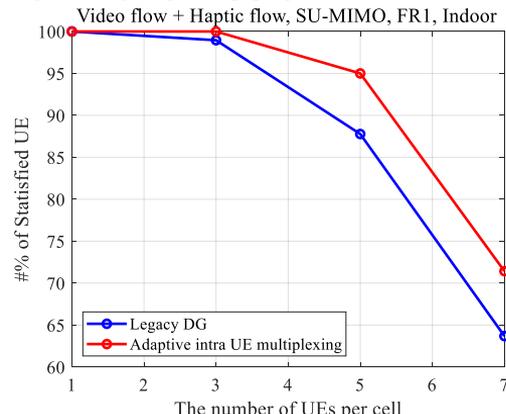
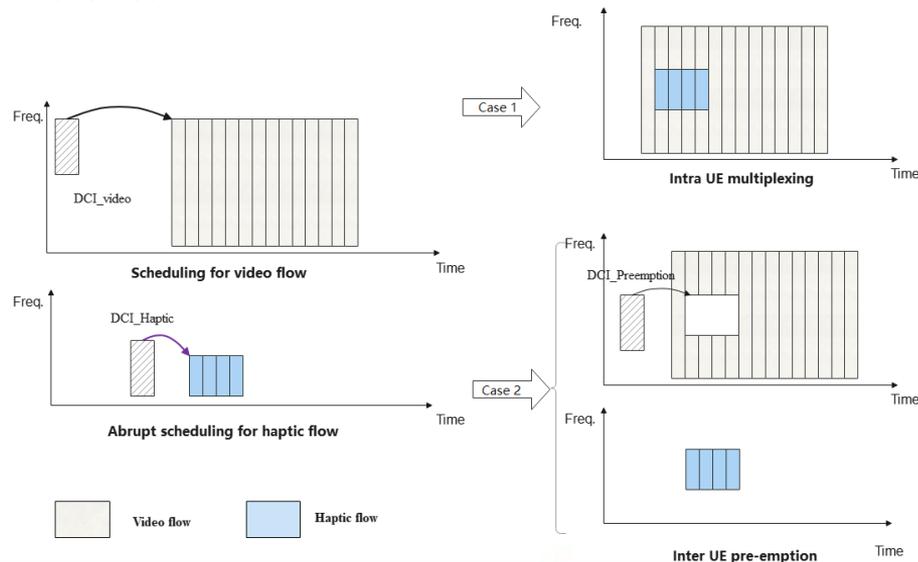
- **Proposal:**

- New measurements for multi-modality/metaverse communication services need to be studied in Rel-19 for metaverse/multi-modal service.

# Enhancement for multi-flow transmission

## Adaptive intra/inter UE multiplexing/pre-emption for multi-flow transmission

- **Motivation:** Latency sensitive traffic (e.g., haptic flow) may arrive after the resource has been allocated to other flow. Postponing the latency sensitive traffic would cause performance loss. As a result, ensuring the transmission of latency sensitive traffic without sacrificing the performance of other flow transmission can be considered.
- **Solution:** Adaptive intra/inter UE multiplexing/pre-emption for multi-flow transmission

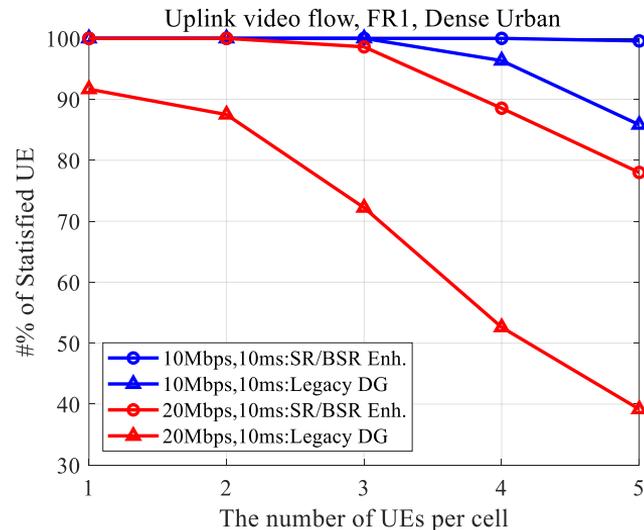
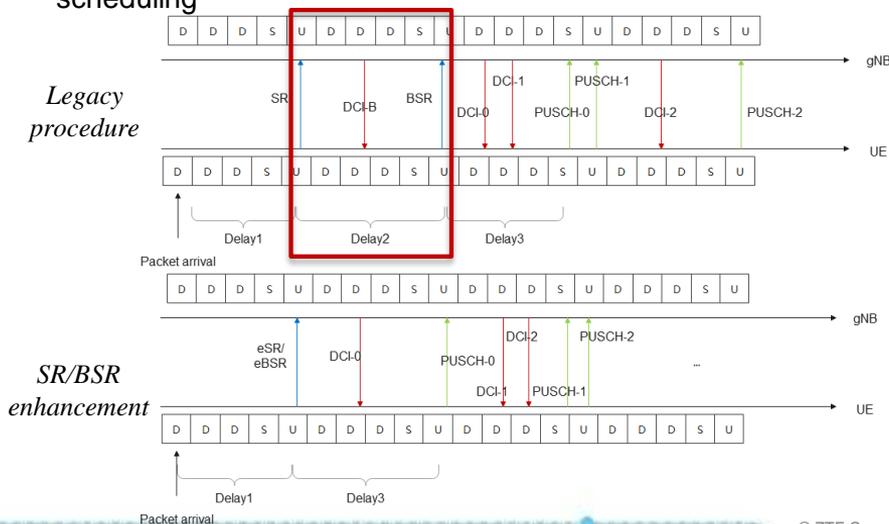


- Multi-flow modelling is in Appendix A2
- Simulation assumptions are listed in Appendix B1

# Capacity enhancement

## SR enhancement for stringent latency uplink transmission

- Motivation:** Dynamic grant for uplink transmission would undergo the procedure of SR and BSR, which causes large scheduling delay. For the uplink traffic, including e.g., haptic, data and video, with stringent latency requirement, enhanced procedure of SR and BSR should be considered to avoid large scheduling delay and capacity performance loss.
- Solution:** SR/BSR enhancement to enhance the procedure of scheduling

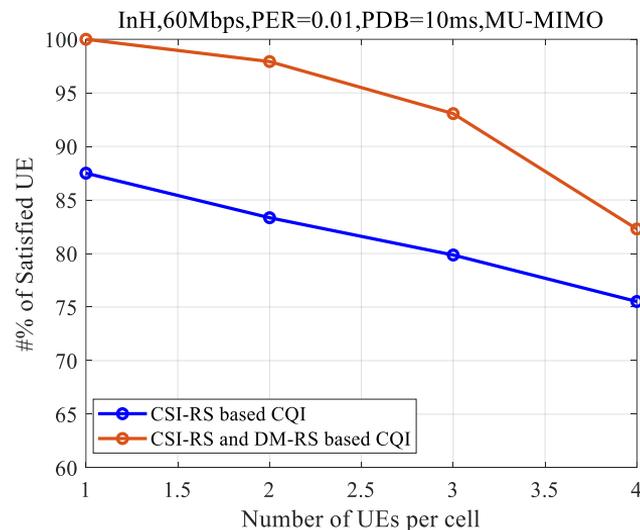


- Simulation assumptions are listed in Appendix B2

# Capacity enhancement

## DM-RS based CSI enhancement

- **Motivation:** High resource occupation and limited re-transmission times occurs for metaverse and multi-modality transmission. If aggressive MCS level is considered in a poor channel condition, packets call for frequent re-transmissions and are prone to be dropped (e.g. if the PDB exceeds). Therefore, obtaining the suitable MCS level according to precise CSI feedback can be considered to avoid frequent re-transmissions.
- **Solution:**
  - Feedback of delta MCS information.
  - Delta MCS information based scheduling MCS.

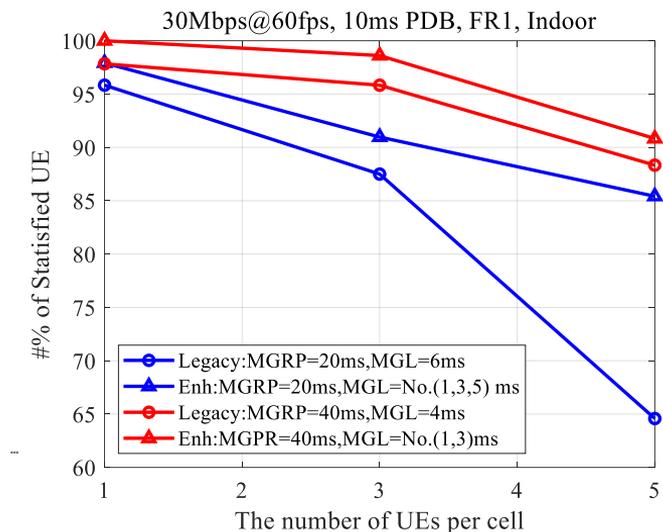


- *Simulation assumptions are listed in Appendix B1*

# Capacity enhancement

## Measurement gap enhancement

- **Motivation:** Network is not able to schedule UEs to transmit/re-transmit/receive data in measurement gap for inter-frequency neighbour cell measurement and the corresponding RF tuning for RRM proposes, which causes capacity performance loss. As a result, avoiding the scheduling restriction in the measurement gap can be considered in order to increase capacity performance.
- **Solution:** Enable data scheduling during measurement gap, e.g., adaptive measurement gap pattern for XR traffic.

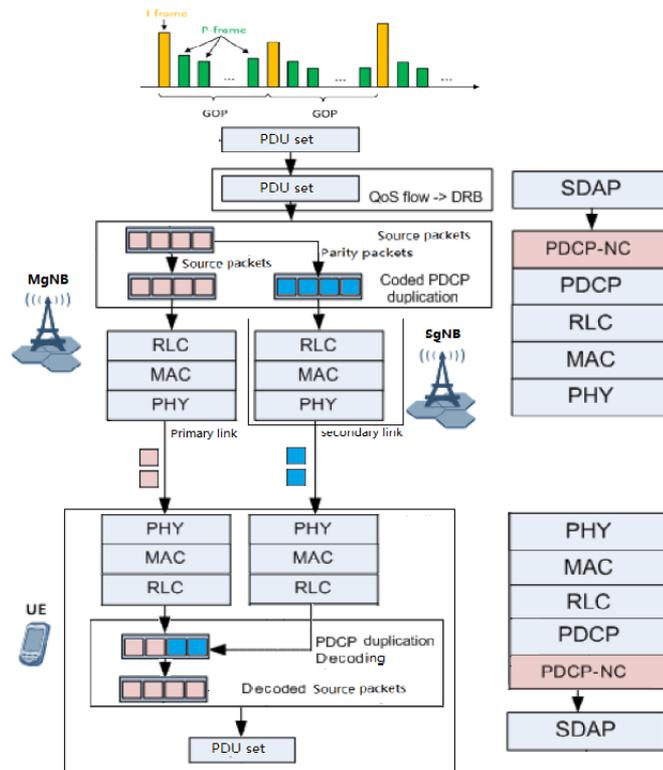


- *Simulation assumptions are listed in Appendix B1*

# Capacity enhancement

## Network coding coded PDCP duplication

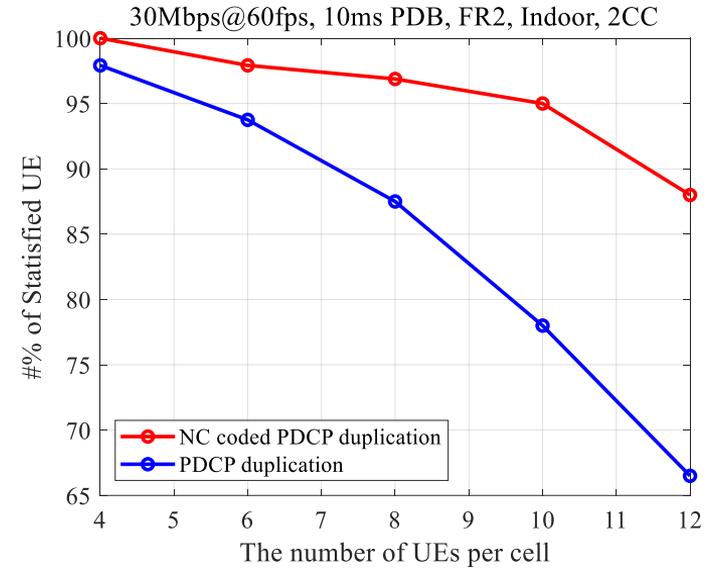
- **Motivation:** PDCP duplication is capable of fulfilling latency and reliability requirements for XR transmission without having to resort to HARQ/RLC retransmission but at cost of constant redundancy, resulting in excessive system load, unexpected congestion and capacity loss. As a result, fulfilling latency and reliability requirements for XR/Metaverse/Multi-modal transmission with adaptive redundancy and efficient operation by adapting to the current traffic can be considered.
- **Solution:** Network coding coded PDCP duplication
  - At transmitter side, the source block is processed by NC sublayer to produce  $N=K+M$  coded packets encapsulated into a sequence of coded PDCP PDUs.
  - At receiver side, the  $K$  coded packets are extracted from PDCP PDU until the content of the source block is reconstructed.



# Capacity enhancement

## Evaluation of NC coded PDCP duplication

- **Simulation scenario:** FR2, Indoor HotSpot
- **Key simulation assumptions:**
  - Mean frame size: 62500 Byte
  - Range of frame size: 31250~93750 Byte
  - Range for K: 21~63, IP packet MTU = 1500 Byte.
  - At transmitter side, K packets are segmented and transmitted per carrier, implying that 2K packets are transmitted in total at two carriers.
  - At receiver side, K packets are received and the frame can be reconstructed and received successfully.

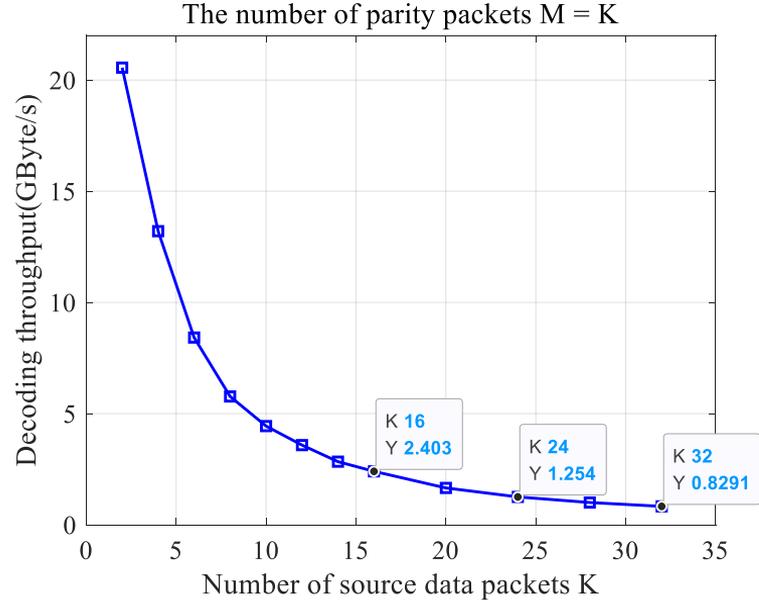


- *More detailed simulation assumptions are listed in Appendix B2*

# Capacity enhancement

## Evaluation of Network coding

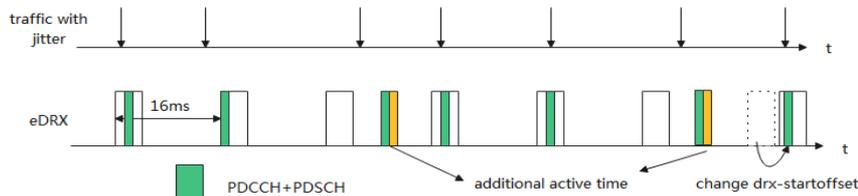
- **Simulation environment:** CPU 2 \* Intel(R) Xeon(R) Gold 6248R CPU @ 3.00GHz .
- **Simulation assumption for decoding throughput:**
  - The transmitter sends  $N = 2K$  encoded data packets, including  $K$  source data packets and  $K$  parity data packets, where the size of the packet is set to 4KB.
  - At receiver side, the source blocks are assumed to be successfully recovered if  $K$  parity data packets are received.
  - The instruction acceleration technology in ISA-L (Intelligent Storage Acceleration Library) is used.
- It can be observed that the decoding throughput decreases as  $K$  increases.
- **Observation 4:** When  $K$  is a small value(e.g., ranging from 2 to 32), a high decoding throughput can be reached.



# Power saving enhancement

## Additional active time for C-DRX

- Motivation:** The arrival time of XR packets with jitter makes the packet arrival fluctuating around periodic benchmarks. The mismatch between XR traffic and DRX cycle would restrict the XR traffic scheduling and cause capacity loss. As a result, some enhancements to avoid the mismatch should be considered.
- Solution:** Dynamically adjust the C-DRX ON duration and PDCCH monitoring occasion based on the traffic pattern (e.g. the jitter of burst arrive time)



FR1 power consumption results in Indoor scenario (45Mbps, fps=60, jitter=[-8,8]ms)

Power saving scheme	CDRX cycle (ms)	ODT (ms)	IAT (ms)	#UE /cell	floor (Capacity)	Percentage of satisfied UE	Mean PSG of all Ues (%)
Aligned CDRX with XR traffic	Aligned every 50ms	14	5	7	7	88.10%	4.60%
Aligned CDRX with XR traffic	Aligned every 50ms	12	5	7	7	80%	9.46%
Flexible additional active time + aligned CDRX	Aligned every 50ms	2	4	7	7	89.48%	19%

- Simulation assumptions are listed in Appendix B1 and Appendix C

# Objectives of Rel-19 Metaverse and Multi-modality

Study on enhancement of supporting multi-modality/metaverse communication services (RAN3,RAN2)

- Study new measurements (NG-RAN and UE), define new evaluation mechanisms for synchronization of media and the performance of multi-modality/metaverse communication services, including:
  - Study multi-modality/metaverse communication services **performance monitoring** mechanism:
    - Possible **new metrics** (e.g., jitter, motion to sound/photon latency). Configure threshold(s) and/or condition(s) for triggering reports.
    - **New measurements** for multi-modality/metaverse communication services: To evaluate the UE experience quality for multi-modality/metaverse communication service in a cell, the RAN may need to obtain UE assistance information for evaluation (e.g. UE-level or 5QI-level PSDB/PSER data, PSDB satisfaction rate).
- Study RAN enhancement mechanism on **synchronization and coordination for multi-flow of single UE** (e.g., haptic, voice, video)
  - Multi-flow awareness for multi-modality/metaverse communication service.
  - Scheduling enhancement on synchronization and coordination for multi-flow of single UE.
  - Coordinated discarding of PDU sets across multiple-flows of single UE
- Study RAN enhancement mechanism on **synchronization and coordination for multi-flow among multiple UEs**:
  - UE grouping based on RAN awareness for synchronization and coordination of multi-flows among multiple UEs (e.g. , for DRX configuration, paging, mobility enhancements ).
  - Scheduling enhancement on synchronization and coordination for multi-flow among multiple UEs.
  - Coordinate discarding of PDU sets for multi-flow/multi-modality applications across multiple UEs.

# Objectives of Rel-19 Metaverse and Multi-modality

Study and specify potential capacity enhancement for ultra large data rate, high reliability and low latency traffic transmission based on metaverse/ multi-modality traffic characteristics (RAN1, RAN2, RAN4)

- Multi-modal traffic handling enhancement, e.g., enhanced intra/inter UE multiplexing/pre-emption PDSCH reception.
- Dynamic grant enhancement for multi-UE, multi-modal services, e.g., SR/BSR enhancement for improving the procedure of scheduling, and multicast of multi-UE/ multi-modal services.
- Measurement gap enhancement, e.g. adaptive measurement gap pattern for XR traffic.
- Network coding (NC) coded PDCP duplication.
- Link adaptation enhancement, e.g., DM-RS based CSI enhancement

Study and specify potential power enhancement for ultra large data rate, high reliability and low latency traffic transmission based on metaverse/ multi-modality traffic characteristics (RAN1, RAN2)

- Dynamically adjust the C-DRX ON duration and PDCCH monitoring occasion based on the traffic pattern (e.g. the jitter of burst arrive time)

# Thanks



Tomorrow never waits



# Reference

- [1] TR22.856, V1.0.0, “Feasibility Study on Localized Mobile Metaverse Services”. (Release 19)
- [2] TR22.847, V18.2.0, “Study on supporting tactile and multi-modality communication services”; Stage 1 (Release 18)
- [3] TR38.838, V17.0.0, “Study on XR (Extended Reality) Evaluations for NR”. (Release 17)

# Appendix A1

## Haptic flow modeling

- **Inter-arrival time of two Haptic packets following the distribution below:**

$$f_x^{arrival} = \frac{\alpha_1 k_1^{\alpha_1}}{x^{\alpha_1}}, \quad k_1 \leq x < m_1$$

$$f_x^{arrival} = \left( \frac{k_1}{m_1} \right)^{\alpha_1}, \quad x = m_1$$

where  $\alpha_1$  is a shape parameter,  $k_1$  is the minimum inter-arrival time of two Haptic packets, while  $m_1$  is the maximum inter-arrival time of two Haptic packets

- **Packet size of the Haptic packets following the distribution below:**

$$f_x^{size} = \frac{\alpha_2 k_2^{\alpha_2}}{x^{\alpha_2}}, \quad k_2 \leq x < m_2$$

$$f_x^{size} = \left( \frac{k_2}{m_2} \right)^{\alpha_2}, \quad x = m_2$$

where  $\alpha_2$  is a shape parameter,  $k_2$  is the minimum inter-arrival time of two Haptic packets, while  $m_2$  is the maximum inter-arrival time of two Haptic packets.

# Appendix A2

## Multi-flow modeling

- Inter-arrival time

<i>Haptic: Pareto distribution for arrival interval</i>	
<b>Parameter</b>	<b>Value</b>
Alpha	1.2
Minimum arrival interval	1 (ms)
<i>Video: Periodic arrival</i>	
Frame per second	60FPS

- Packet size and QoS

<i>Pareto distribution for Haptic packet size</i>	
<b>Parameter</b>	<b>Value</b>
Alpha	1.2
Minimum packet size	62.5 Byte
Maximum packet size	750 Byte
Packet Delay budget	5 ms
Packet Error Rate	1e-3
Target BLER	0.001

<i>Truncated Gaussian distribution for video packet size</i>	
<b>Parameter</b>	<b>Value</b>
Minimum packet size	31250 Byte
Mean packet size	62500 Byte
Maximum packet size	93750 Byte
Packet Delay budget	10 ms
Packet Error Rate	1e-2
Target BLER	0.01

# Appendix B1

## Simulation assumptions for downlink FR1

Parameter	Value	
Scenario	Indoor Hotspot 12 nodes in 50m x 120m	Dense Urban hexagonal layout with 7, 3 Sectors
Inter-BS distance	20m	200m
Carrier frequency	4 GHz	
Simulation bandwidth	100 MHz	
Subcarrier spacing	30 KHz	
TDD pattern	DDDSU (10D:2G:2U)	
BS antenna configuration	32 Tx antenna ports, and $(dH, dV) = (0.5\lambda, 0.5\lambda)$ 32 Tx: (M, N, P, Mg, Ng; Mp, Np) = (4, 4, 2, 1, 1; 4, 4) The antenna tilt is 90 degrees	64 Tx antenna ports, and $(dH, dV) = (0.5\lambda, 0.5\lambda)$ ; 64TX:(M, N, P, Mg, Ng; Mp, Np) = (8,8, 2, 1, 1; 4, 8); The antenna tilt is 12 degrees.
UE antenna configuration	4 Rx antenna ports, and Panel model 1: $dH = 0.5\lambda$ 4 Rx: (M, N, P, Mg, Ng; Mp, Np)	
Scheduling algorithm	SU-MIMO+PF / MU-MIMO+PF	
BS height	3 m	25m
UE height	1.5 m	Outdoor UEs: 1.5 m Indoor UTs: $3(nfl - 1) + 1.5$ ;
Antenna element gain	5dBi for BS and 0 dBi for UE	8dBi for BS and 0 dBi for UE
Receiver Noise Figure	5dB for BS and 9 dB for UE	
HARQ/Repetition	HARQ retransmission	

# Appendix B2

## Simulation assumptions for uplink FR1

Parameter	Value
Scenario	Dense Urban
Inter-BS distance	200m
Carrier frequency	4GHz
Simulation bandwidth	100 MHz
Subcarrier spacing	30 KHz
TDD pattern	DDDSU (10D:2G:2U)
BS antenna configuration	For 64R: (8,8, 2, 1, 1; 4, 8) (dH,dV) = (0.5λ, 0.5λ); Down-tilt 12 degrees
UE antenna configuration	For 2T: (1,1,2,1,1;1,1) (dH, dV)=( 0.5, N/A)λ
Scheduling algorithm	SU-MIMO+PF
Power control	P0 = -80 dBm, alpha = 0.8
Receiver Noise Figure	5dB for BS and 9dB for UE
HARQ/Repetition	HARQ retransmission

# Appendix B3

## Simulation assumptions for FR2

Parameter	Value
Scenario	Indoor Hotspot 12 nodes in 50m x 120m
Inter-BS distance	20m
Carrier frequency	30 GHz & 39 GHz
Simulation bandwidth	100 MHz per CA
Subcarrier spacing	120 KHz
TDD pattern	DDDSU (10D:2G:2U)
BS antenna configuration	2Tx antenna ports, and $(dH, dV) = (0.5\lambda, 0.5\lambda)$ $(M, N, P, Mg, Ng; Mp, Np) = (16, 8, 2, 1, 1; 1, 1)$ ; The antenna tilt is 0 degrees
UE antenna configuration	4Rx antennas per panel, and Panel model 1: $dH = 0.5\lambda$ $(M, N, P, Mg, Ng; Mp, Np) = (2, 4, 2, 1, 2; 1, 2)$ ;
Scheduling algorithm	SU-MIMO+PF
BS height	3 m
UE height	1.5 m
Antenna element gain	8dBi for BS and 5 dBi for UE
Receiver Noise Figure	7 dB for BS and 13dB for UE
HARQ/Repetition	HARQ retransmission

# Appendix C

## Power model

<i>Power model for DL</i>	
<b>Power state</b>	<b>Relative Power(1 slot)</b>
PDCCH-only	100
PDCCH+PDSCH	300
Micro sleep	45
Light sleep	20
Deep sleep	1

<i>Power model for UL</i>			
<b>Power state</b>	<b>Relative Power(1 slot)</b>		
	0dBm	23dBm	Other Tx power
UL long PUCCH or long PUSCH	250	700	Obtained by step function
PDCCH + PUSCH	Sum(PDCCH-only, PUSCH)		
PDCCH+PDSCH+PUSCH	Sum(PDCCH+PDSCH, PUSCH)		

Note: The power of “PDCCH+PDSCH+PUSCH” slot, “PDSCH+PUSCH” slot and “PDCCH+PUSCH” slot is the sum of corresponding DL power consumption and PUSCH power consumption. For example, the power value of “PDCCH+PUSCH” is equal to the sum of power of “PDCCH-only” and power of “PUSCH”.