Qualcomm

November 8, 2022

Enabling the metaverse with 5G

Qualcomm Technologies, Inc.

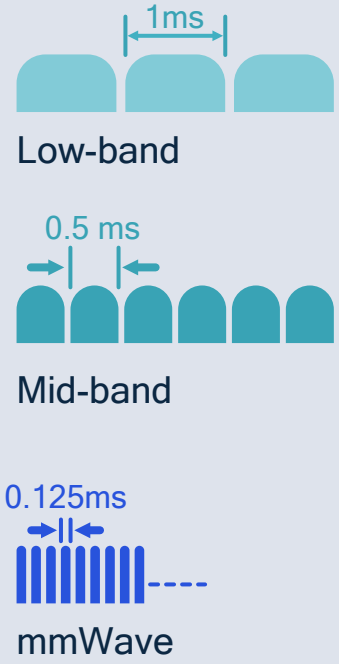
@QCOMResearch


Delivering on the 5G vision
Where virtually everyone and everything is intelligently connected
5G
5G Positioning
Advanced MIMO
Mobile mmWave
Wide-area IoT
Industrial 5G Networks
Industrial Precise Positioning
AI-enabled Air Interface
Automotive
Enabling the Metaverse
Green Networks

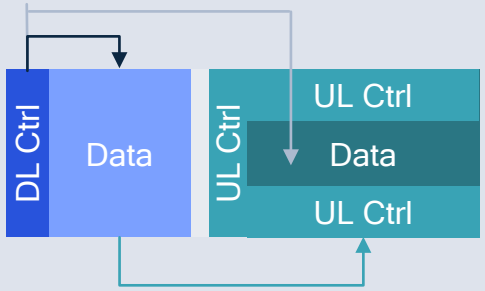
5G is built for low-latency and high reliability applications like XR

Our fundamental research has been contributed to 3GPP

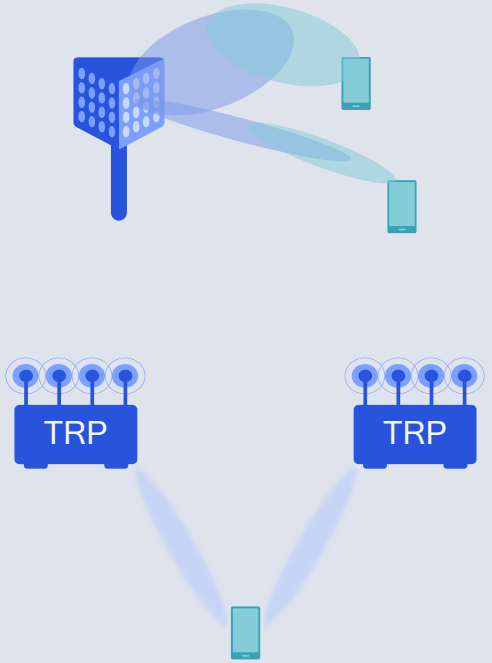
Shorter time slots



Fast processing times



Reliable beam forming



DL: downlink; UL: Uplink; TRP: Transmission and Reception Point

Consumer

VR

- Fitness
- Gaming
- Social
- Sports / concerts

- Entertainment
- Navigation
- Shopping

AR

- Corporate training
- Education
- Medical

- Infinite desktop
- Instructions
- Remote assistance

Enterprise

Metaverse

Persistent spatial internet with personalized digital experiences

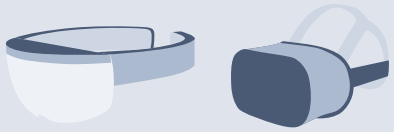
Spans both physical and virtual worlds

Shared virtual space in VR today, evolving to digitally enhanced physical space with AR & MR

Snapdragon

Your ticket to the metaverse

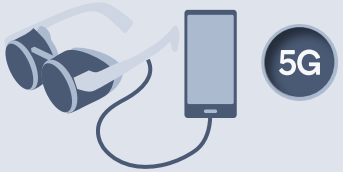
XR is evolving to be the next computing platform

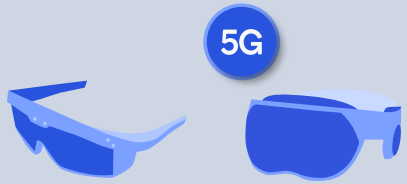


Standalone
VR and AR

Today

AR Viewer
Cabled





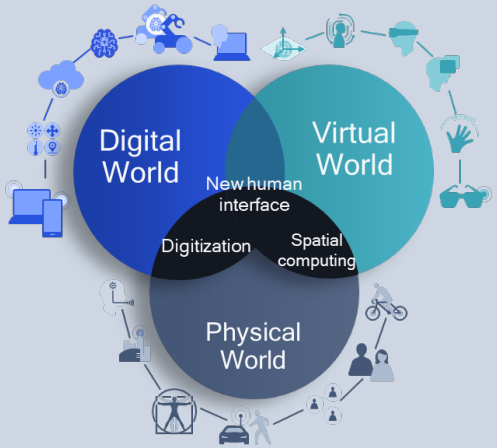
Standalone
VR and AR

1 - 4 years

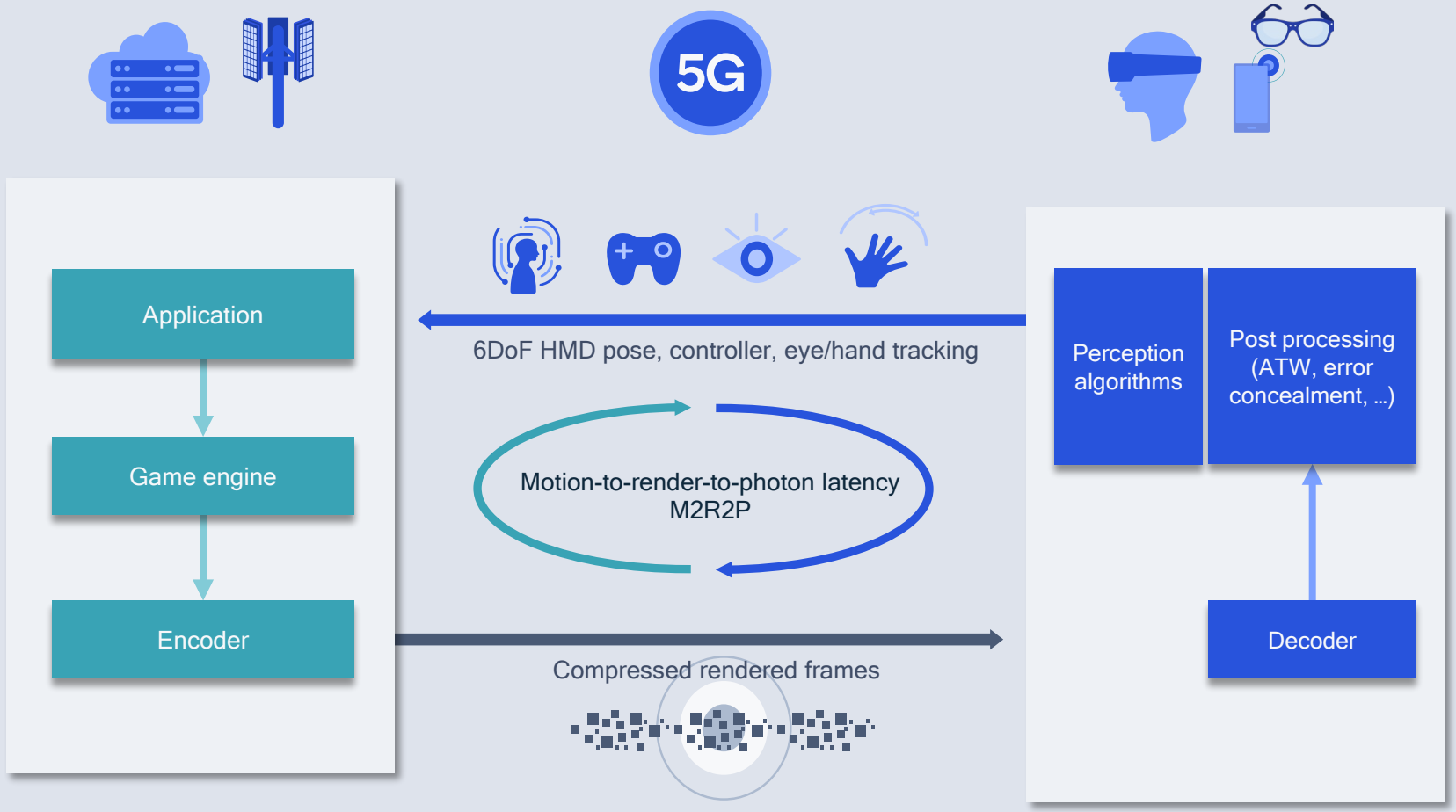
AR Viewer
Wireless

The
“Next Platform”

6G Metaverse



A distributed compute architecture enables rich XR user experience



M2R2P = Edge processing + 5G round-trip time + Device processing

ATW: Asynchronous Time Warp

Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries. M2R2P: Motion-to-Render-to-Photon

Boundless VR 5G operator trials

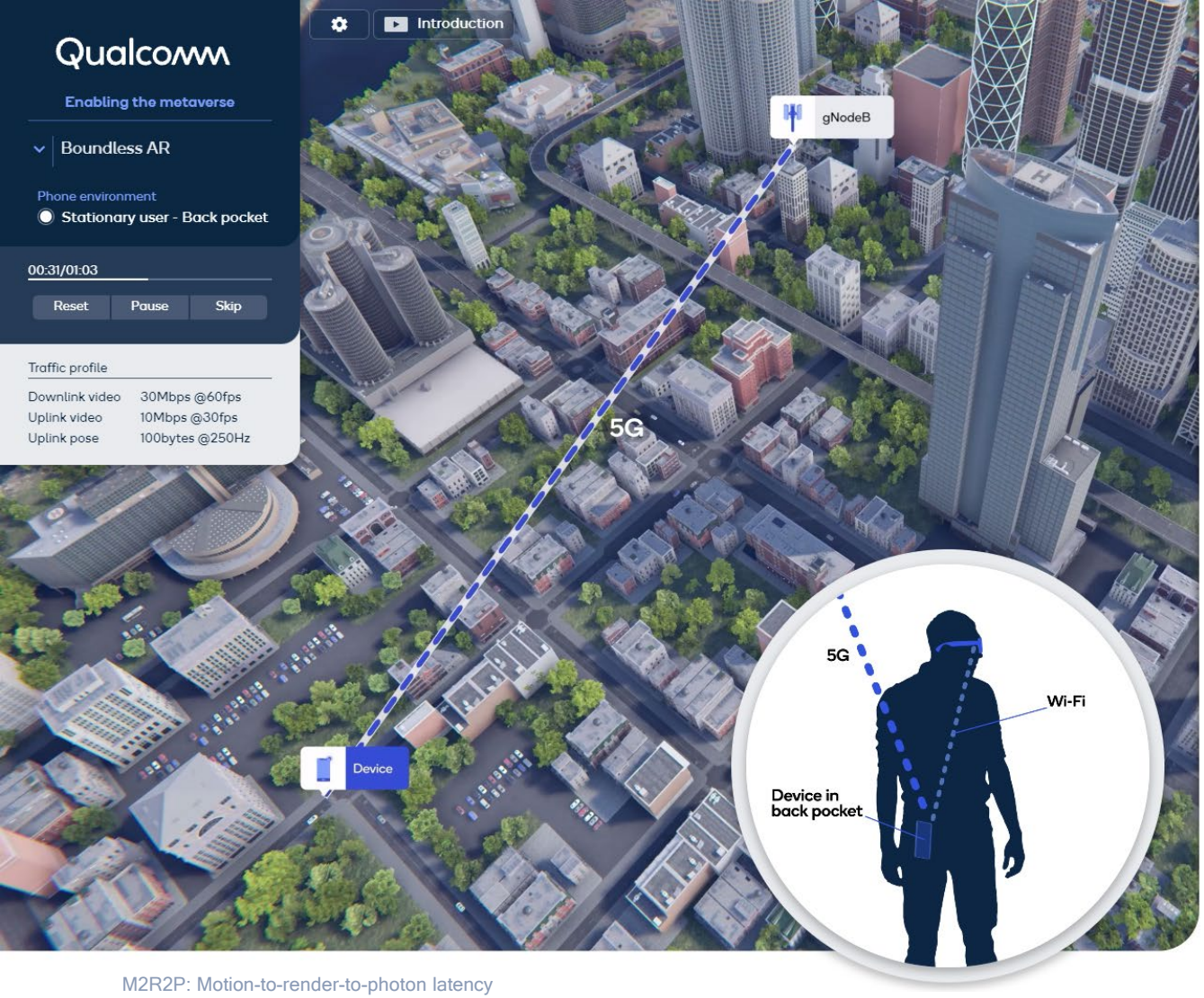
Ready for deployments in private networks

Device optimizations with 25% tail latency improvements

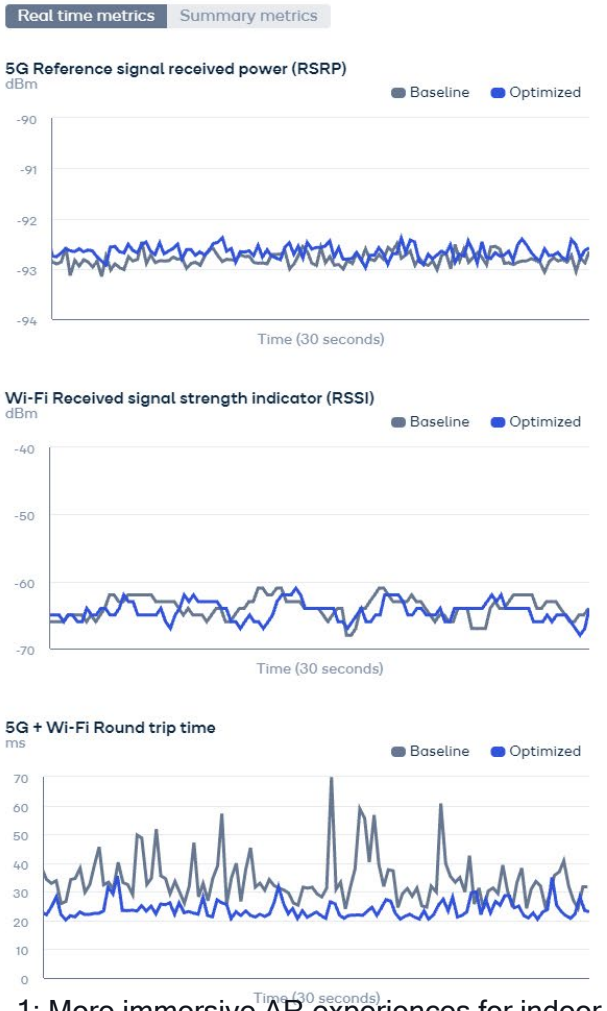
Less than 20ms 5G round-trip time

Less than 70ms M2R2P latency

Boundless AR



M2R2P: Motion-to-render-to-photon latency



Device optimizations with 38% tail latency improvements

Less than 30ms 5G + Wi-Fi round-trip times[1]

Target 50-100ms M2R2P

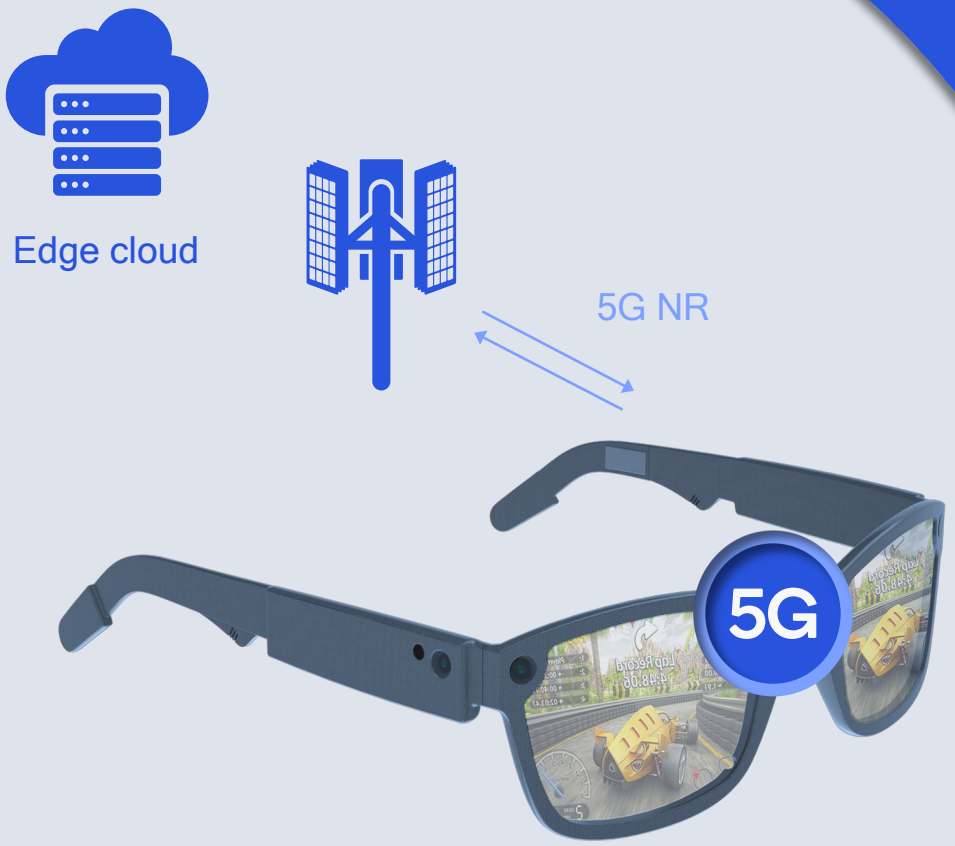
Demo video

1: More immersive AR experiences for indoor applications require less than 20 ms round-trip time.

Cloud-to-phone-to-AR glasses

Targets wide area deployments

Snapdragon XR2 platform Gen 1



Enabling 5G-powered AR glasses

1 For example, using Application Data Unit (ADU) Error Rate and Delay Budget vs. Packet Error Rate (PER) and Packet Delay Budget (PDB)

Optimized edge processing

Migration from central cloud to local edge

Improved Infra schedulers[1]

Delay aware schedulers to meet latency QoS

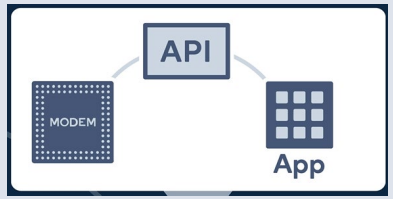
Low-power, low-latency 5G

3GPP based features

5G modem APIs

Enabling low latency on-device optimizations

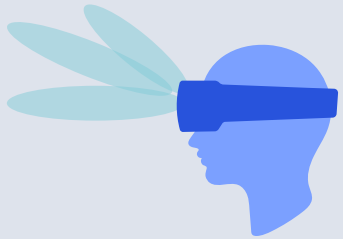
Enabling applications to adapt to RF/network conditions



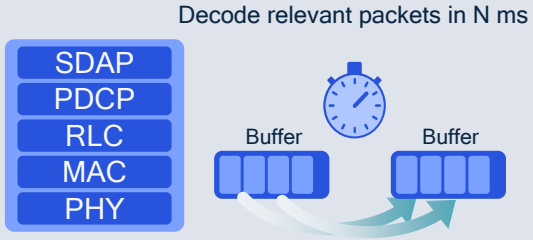
5G modem API to support low-latency application requirements

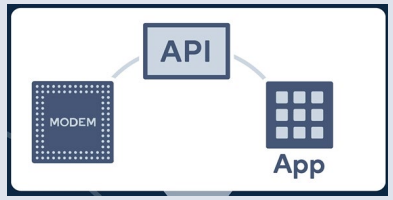
Packet prioritization

Better beam management for improved reliability



Dynamic packet processing on 5G protocol stack



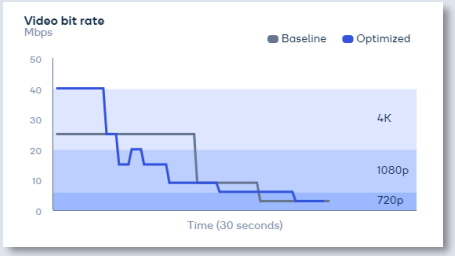


5G modem API for improved application adaptation and UX

Demo video

Improved video quality

Faster rate adaptation



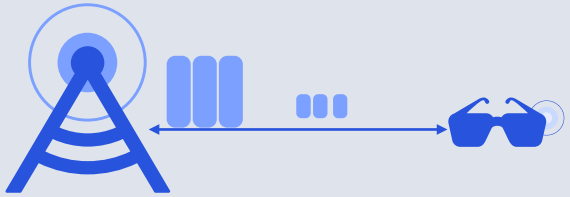
Less stuttering

3GPP is developing 5G Advanced on the path to 6G

3GPP

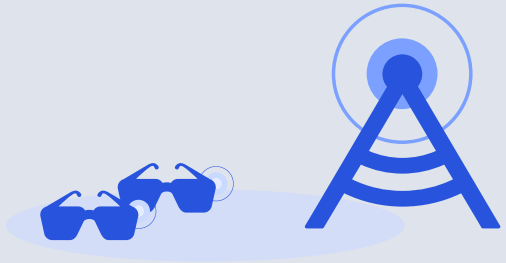
Release 15/16/17 XR techniques

Rel-15/16: Low power modes



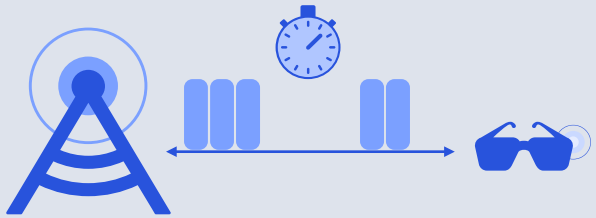
- **Bandwidth part:** Reduce BW if no/low data
- **Scell dormancy:** Switch to low power if no data
- **Cross-slot scheduling:** Gap between control and data for sleep.

Rel-16: Uplink enhancements



- **UL configured grant:** Handle periodic traffic
- **Slot aggregation:** Reduce HARQ latencies
- **UL skipping:** Save power if no data

Rel-17: XR burst handling



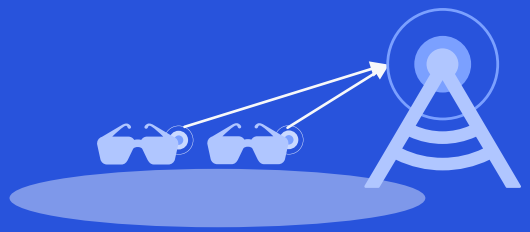
- **PDCCH skipping:** Faster transition to sleep after XR burst

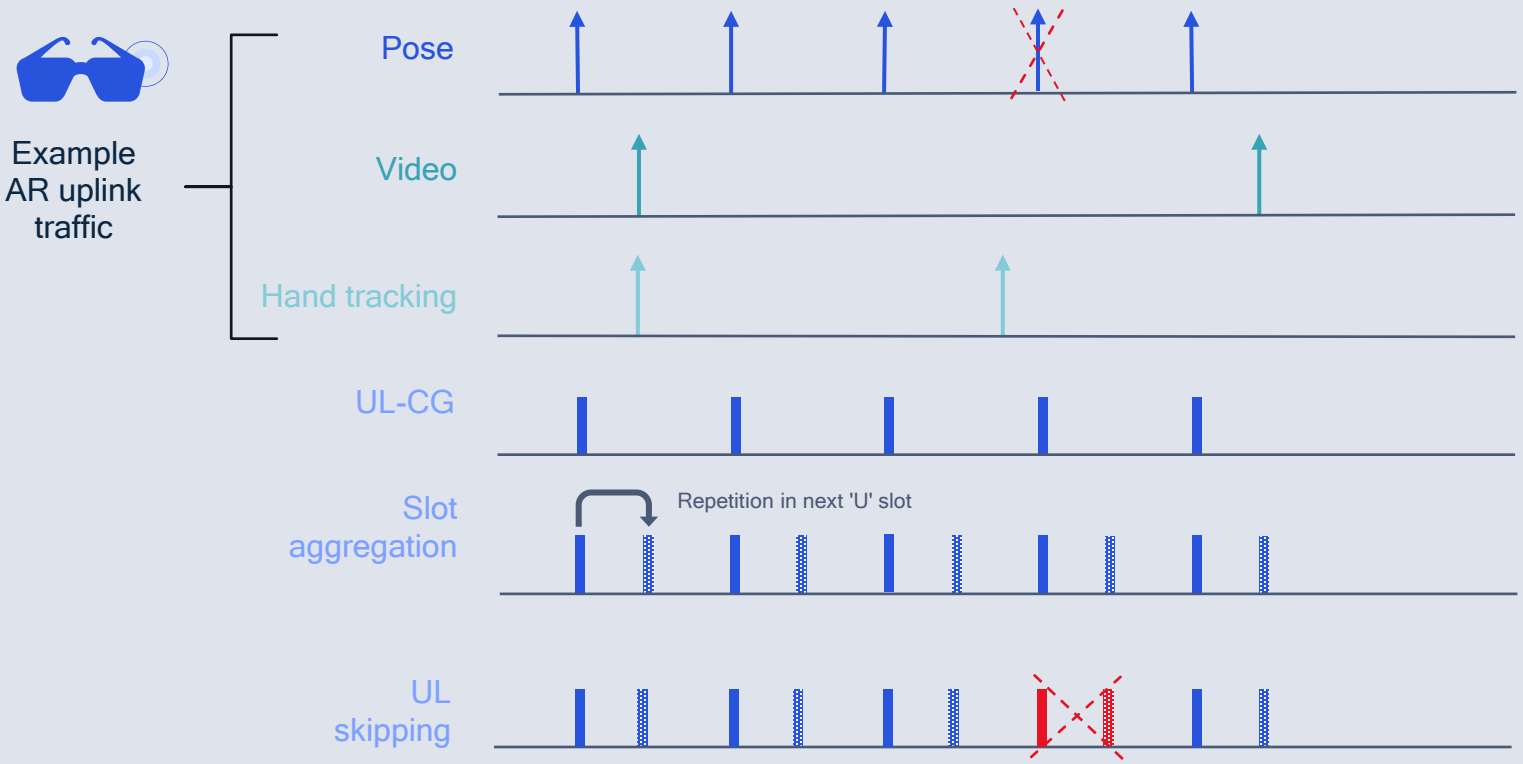
PDCCH: Physical Downlink Control Channel; UL: Uplink; Scell: Secondary cell; HARQ: Hybrid Automatic Repeat Request

3GPP enhancements for XR device latency and power efficiency

Rel-16 provides better handling of uplink XR traffic

Reduces latency and device power consumption





UL Configured Grant (UL-CG)

Periodic resources for low latency traffic

Slot aggregation

Improves reliability and reduces HARQ latencies

Uplink skipping

Skip UL grants when no data and save power

MCS: Modulation and Coding Scheme; HARQ: Hybrid Automatic Repeat reQuest; BSR: Buffer Status Reporting

Rel-17 Reduced Capability (NR-Light) can enable a category of low-power AR glasses

- Lower data rates
- Reduced power consumption
- Lower device complexity

- Narrower bandwidths
  20 MHz in sub-7
- Fewer receive antennas
  1-2 Rx
- No carrier aggregation or dual connectivity
- Lower order modulation
  (256-QAM optional)
- Half-duplex

Source: RP-211574 (Support of reduced capability NR devices)

Further improving XR experience with 5G Advanced

Align transmission to multimedia cadence

Enhanced CDRX and configured grant

Sleep after low latency uplink transmission

Retransmission-less configured grant

QoS based on multimedia payload

Define QoS based on PDU sets

Staggering UE traffic arrivals at gNodeB

Improved scheduler

Low latency mobility

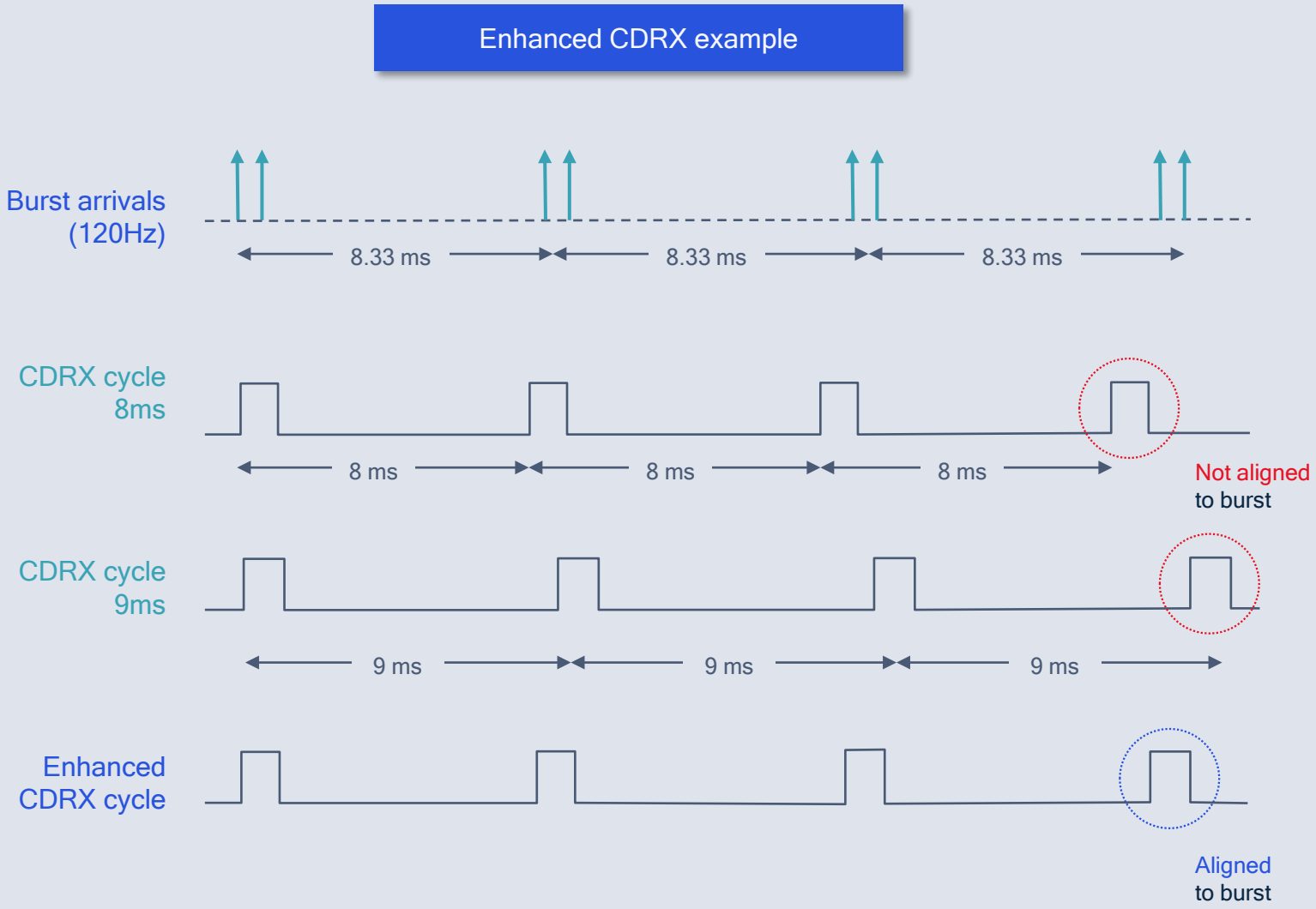
Using L1/L2 signaling for handoffs

Rel-18 aligns transmission times to the multimedia cadence

Enhanced CDRX eliminates drift between DRX-ON and XR traffic

Enhanced CG eliminates drift between CG and XR traffic

Reduces latencies and device power consumption



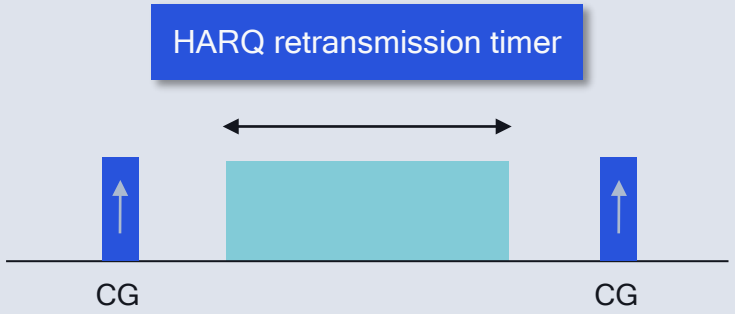
CG: Configured Grant; CDRX: Connected-mode Discontinuous Reception

Rel-18 enables devices to sleep after uplink transmission

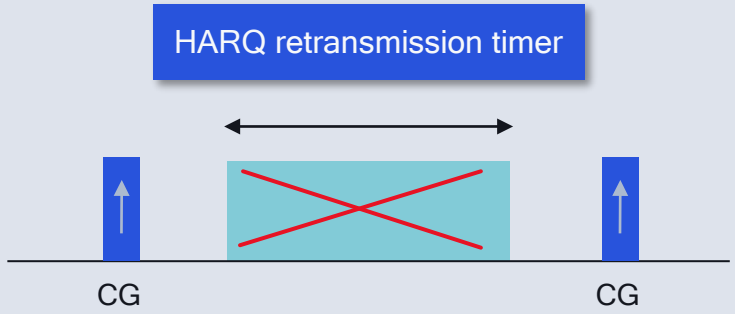
Retransmission-less Configured Grant:

1. Uses conservative MCS to improve reliability of first transmission
2. Avoids the need for the UE to monitor control channel after CG
3. Allows longer sleep cycles reducing device power consumption

Legacy device is ON for potential retransmissions



Rel-18 device can sleep



Low-latency, low-bandwidth transmissions

(e.g., 100-byte pose)

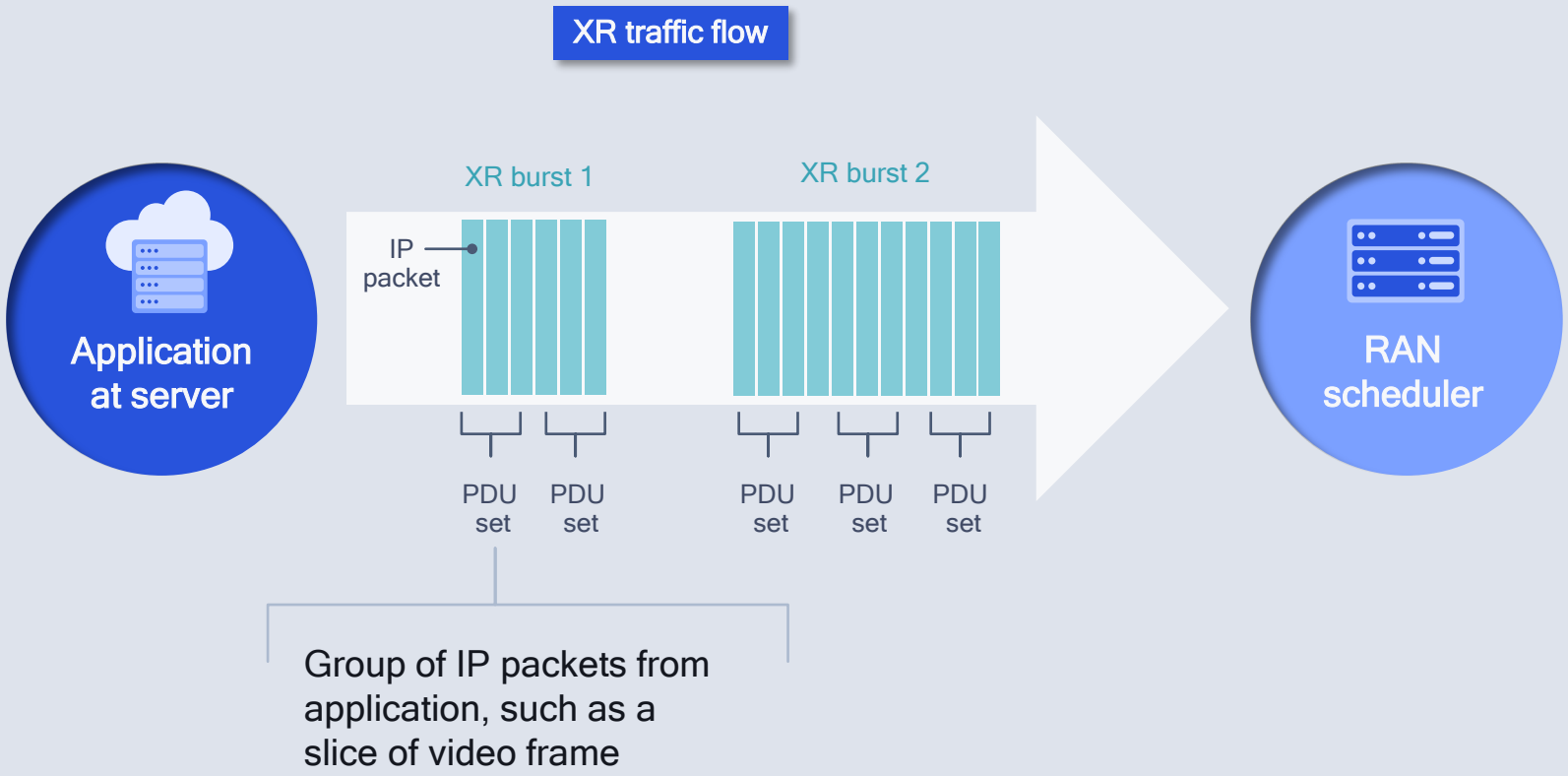
HARQ: Hybrid Automatic Repeat Request; MCS: Modulation and Coding Scheme; CG: Configured Grant

Rel-18 enables QoS based on multimedia traffic payloads instead of IP packets

QoS defined for PDU-sets

QoS parameters include error rate and delay

Enables RAN schedulers to satisfy multimedia QoS requirements

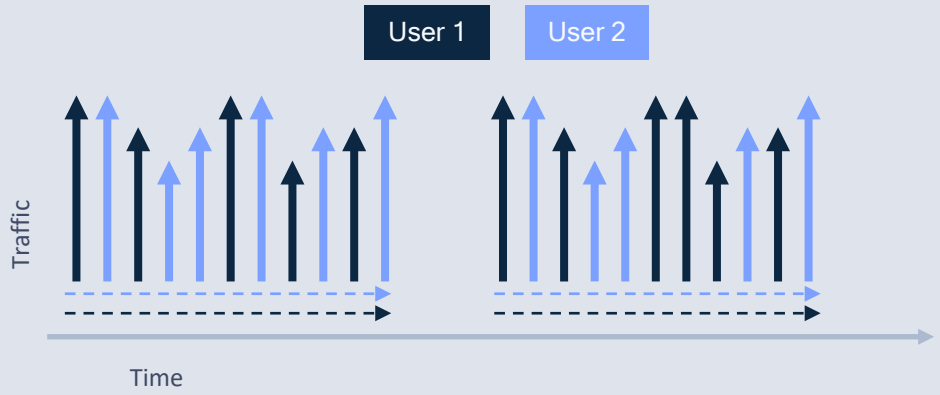


Rel-18 staggers UE application traffic arrivals from the server to the base station

Base station signals the user burst arrival time offset to the server

Server staggers user traffic to the base station

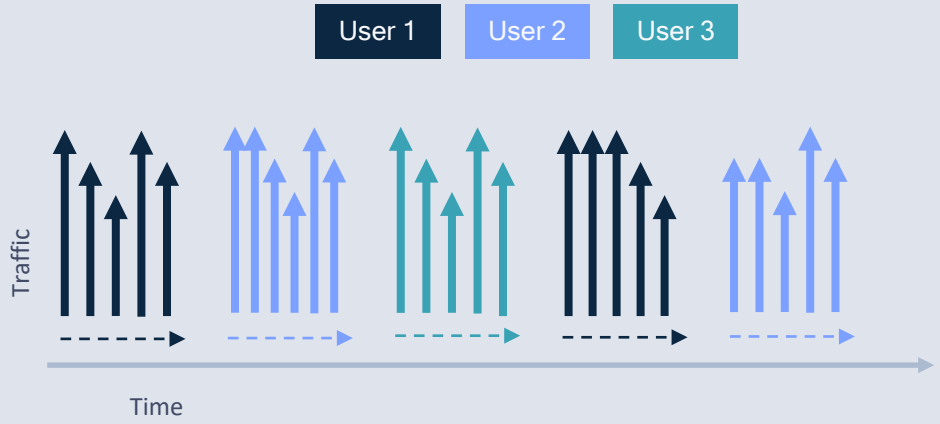
Improves base station scheduler



No UE application traffic staggering

Inefficient scheduler

- Higher latencies
- Higher power / device ON-time
- Lower capacity



UE application traffic staggering

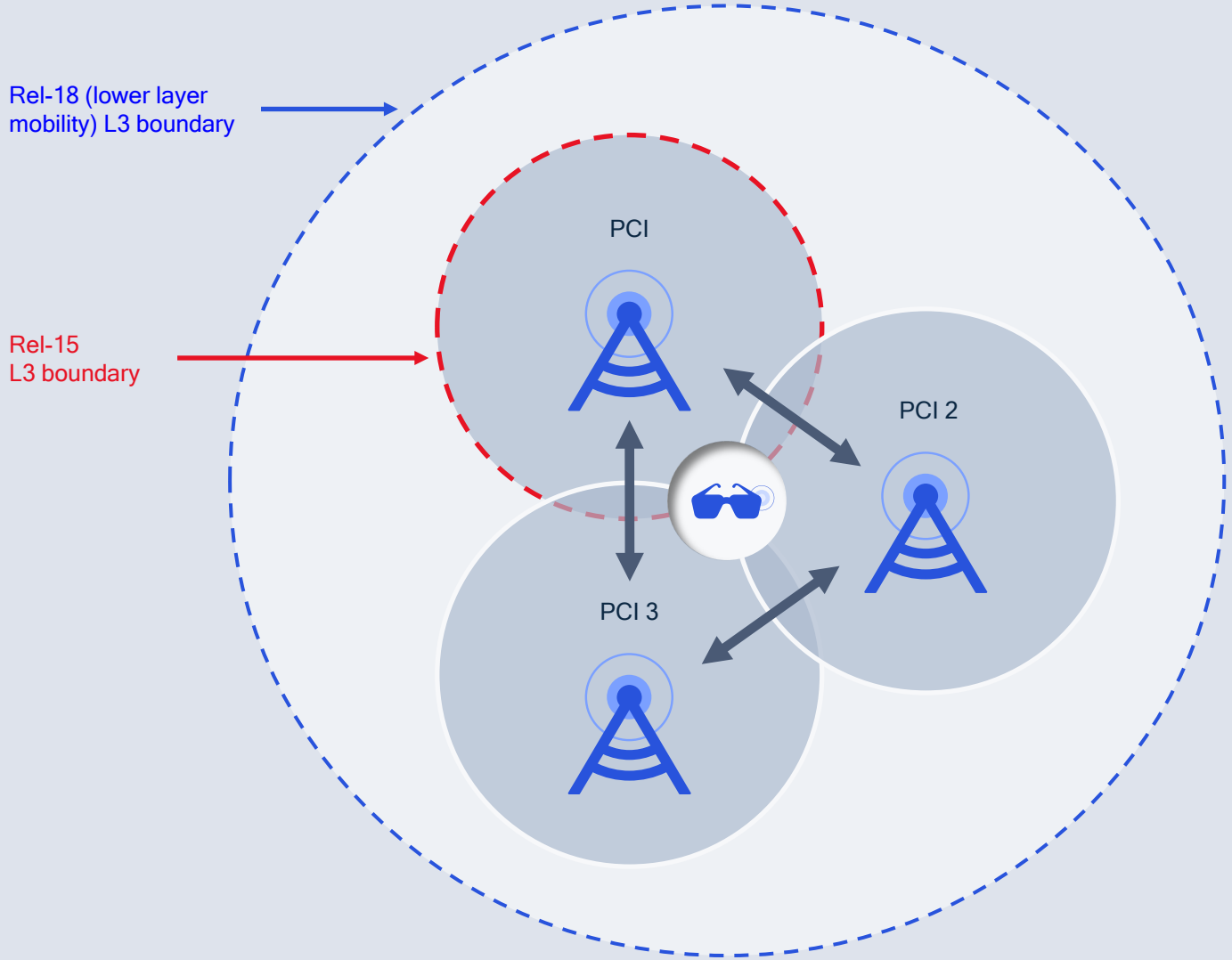
Improved scheduler

+ Lower latencies
+ Lower power / device ON-time
+ Higher capacity

Rel-18 improves mobility management with better cell handovers

Rel-15 uses RRC (L3) signaling, leading to handoff delays

Rel-18 uses L1/L2 signaling for fast Pcell updates, reducing handoff delays and extending coverage



RRC: Radio Resource Control; Pcell: Personal cell

6G will enable the merging of our worlds

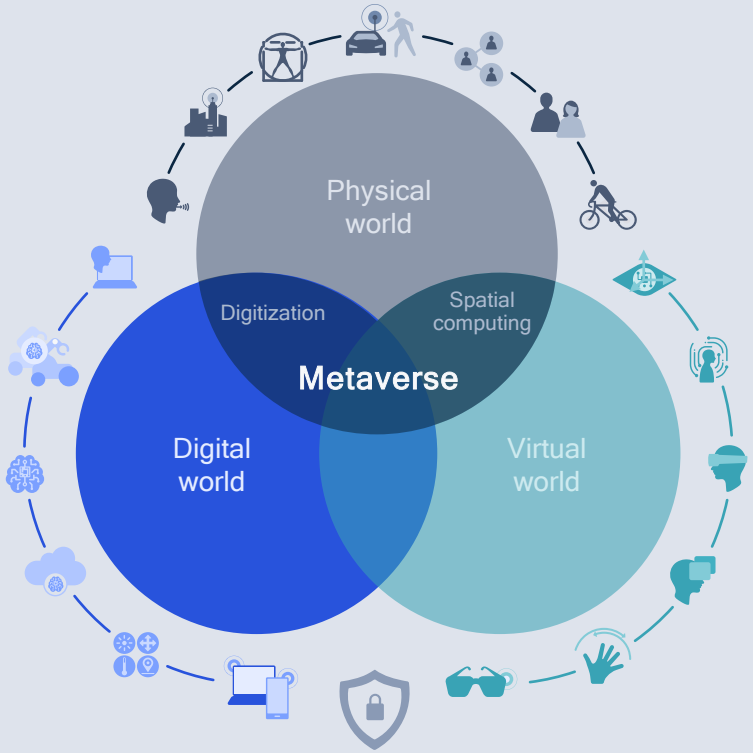
Physical, digital, virtual, immersive interactions taking human augmentation to next level via ubiquitous, low-power joint communication and sensing

AI-native E2E communications

Data-driven communication and network design, with joint training, model sharing and distributed inference across networks and devices

Air interface innovations

Waveform/coding from MHz to THz, advanced duplexing, Giga-MIMO, mmWave evolution, passive MIMO, satellite comm., system energy efficiency



Spectrum expansion and sharing

Expanding to THz, wide-area expansion to higher bands, new spectrum sharing paradigm, dynamic coordination with environmental awareness

Scalable network architecture

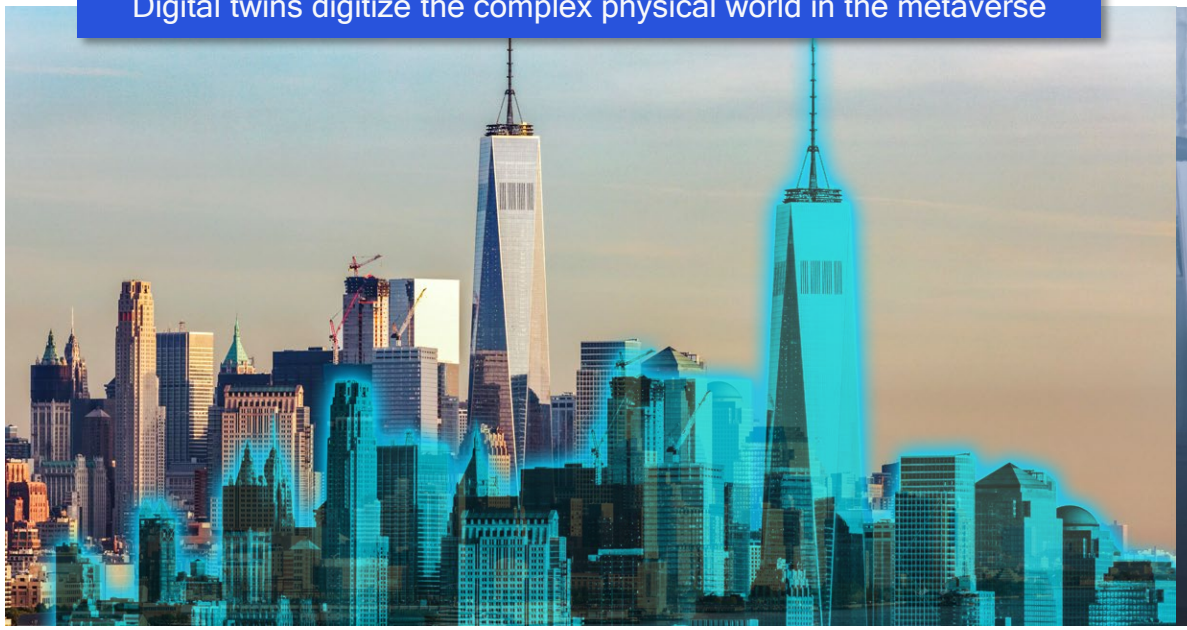
Disaggregation and virtualization at the Connected Intelligent Edge, use of advanced topologies to address growing demand

Communications resiliency

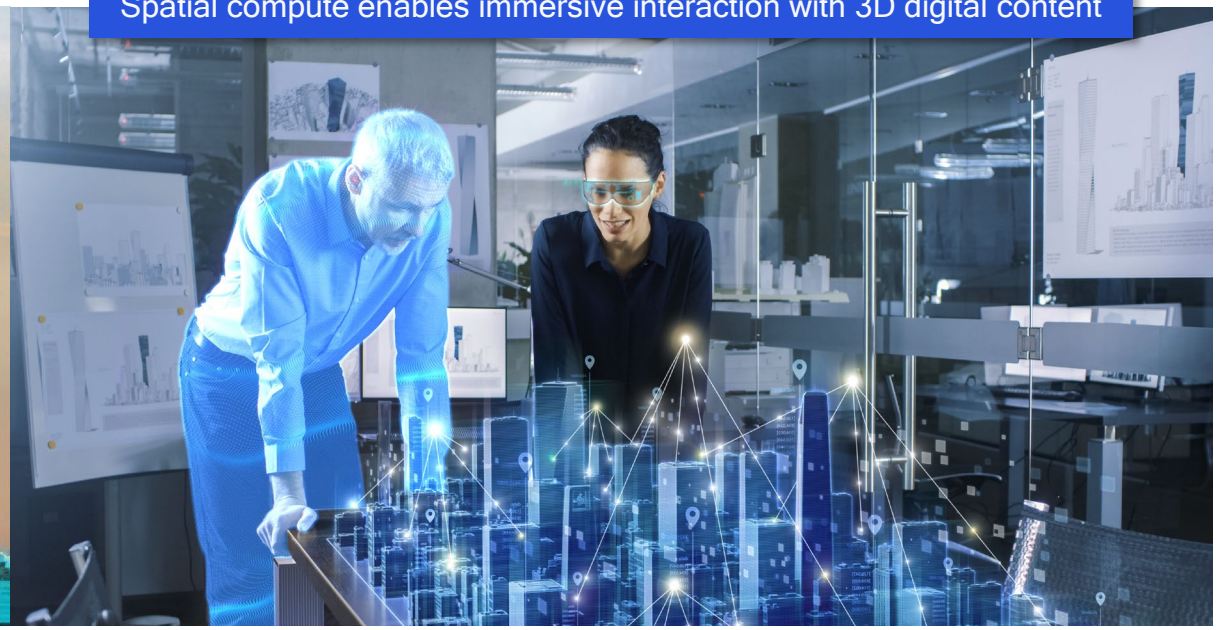
Multifaceted trust and configurable security post quantum security, robust networks tolerant to failures and attacks

6G XR requirements fueled by digital twins and spatial compute

Digital twins digitize the complex physical world in the metaverse



Spatial compute enables immersive interaction with 3D digital content



100x network capacity

0.1-10 Gbps per user

Use multiple frequency bands

(sub-THz, mmW, sub 7GHz, 7-24GHz, unlicensed, shared spectrum)

6G protocols can natively support distributed compute

Dynamically distributing workloads

Delivering low power and low latencies

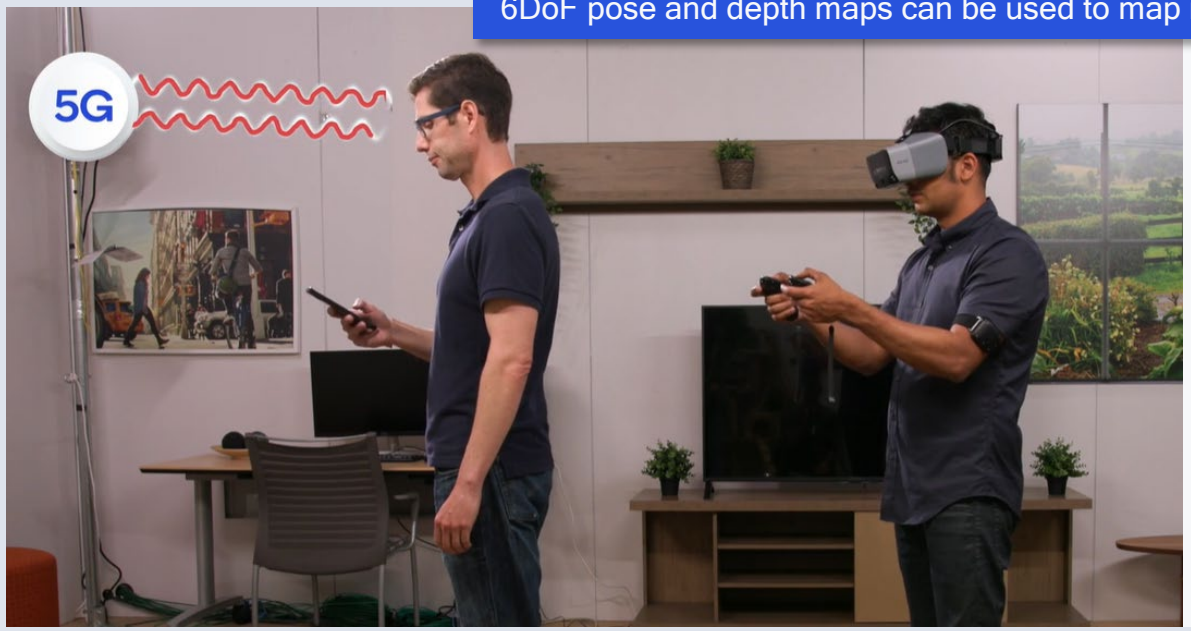
Incorporating e2e QoS and session handling

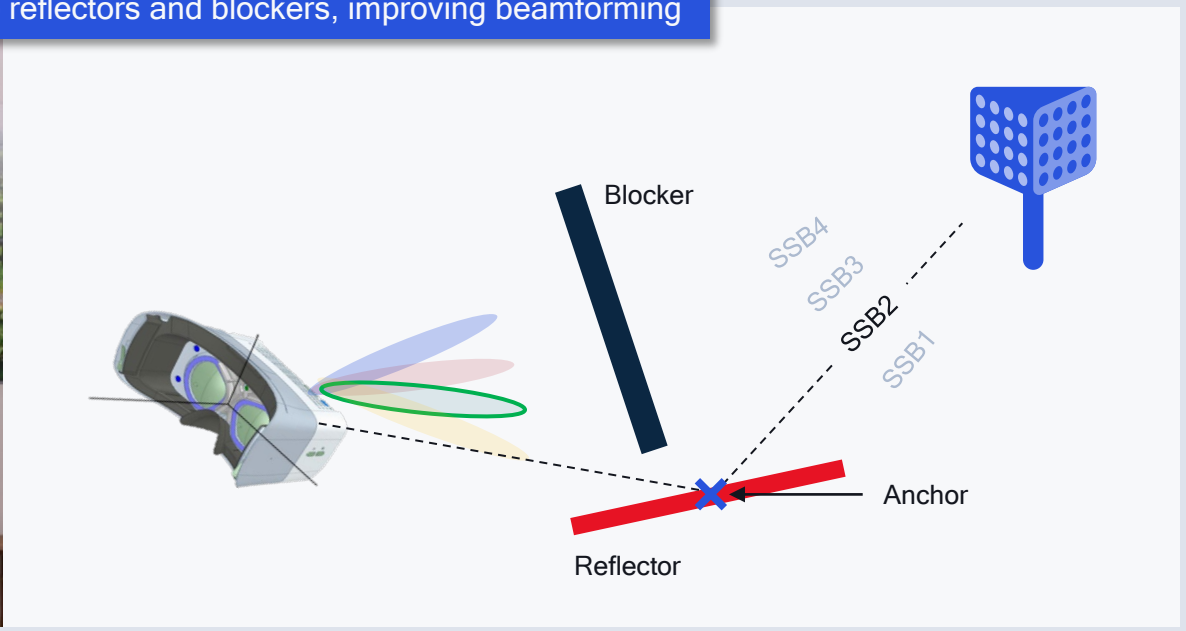
- 6DoF/SLAM
- Hand Tracking
- Facial Expression
- Eye Tracking
- 3D Graphics Rendering
- Scene Understanding
- Objected Rec and Tracking
- Camera Processing

6G can fuse perception and wireless to improve performance

We demonstrated that perception inputs can improve mmWave beamforming accuracy

6DoF pose and depth maps can be used to map reflectors and blockers, improving beamforming





SSB: Synchronization Signal Block

6G protocols can enable network and device perception services

Platforms

Snapdragon
XR2+ platform
Gen 1

Snapdragon
XR2 platform
Gen 1

Snapdragon
XR1 platform
Gen 1

Software & algorithms

6DoF/SLAM

Object Rec
& Tracking

Eye
Tracking

Pass Through
(video see through)

Hand
Tracking

3D
Reconstruction

Reference designs

Ecosystem

Snapdragon
spaces

Qualcomm Technologies is enabling the XR industry

Snapdragon powers key XR platforms

Snapdragon
XR2+ platform
Gen 1

Snapdragon
XR2 platform
Gen 1

Snapdragon
XR1 platform
Gen 1


Google Glass Enterprise Edition 2


ThirdEye X2


Vuzix M400


Microsoft Hololens 2


Nreal light


Lenovo ThinkReality A6


Lenovo Mirage Solo


Realmax Qian


Shadow Creator Action One


Shadow Creator Shadow VR


Shadow Creator Jimo


iQiyi 3


Shadow Creator HONGHU


Ximmerse Rhino X


Oculus Go


Oculus Quest


Meta Quest Pro


Pico G2 4K


Realwear HMT-1


iQiyi QiYu 2S


Lenovo Think Reality A3


Rokid Glass


Pic Neo


HTC VIVE Focus 3


Oculus Quest 2


HTC Vive Focus Plus


3Glasses X1


XRSpace Mova


HTC Vive Cosmos

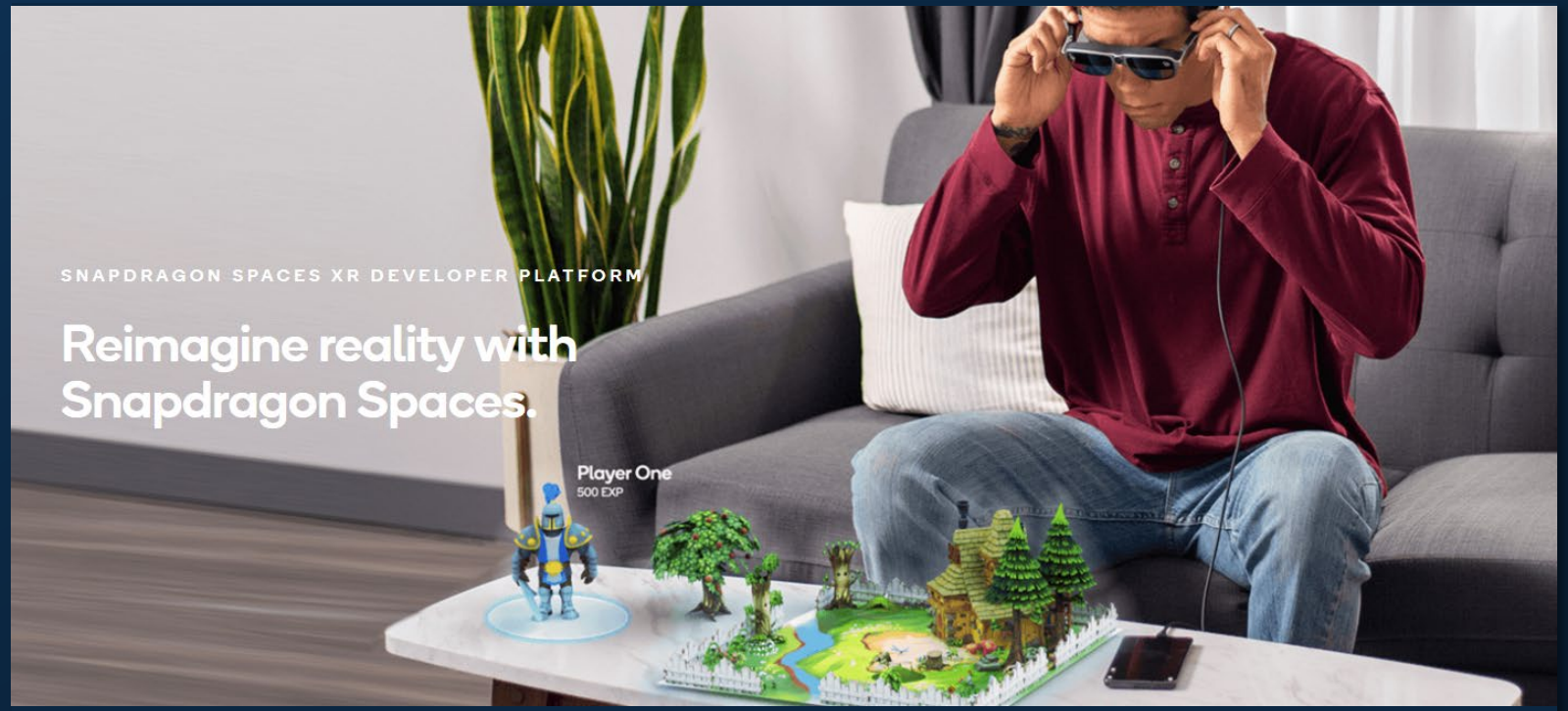

DPVR P1 Pro


Xiaomi Mi VR

60+
Devices launched

Snapdragon Spaces™ XR Developer Platform

Empowering developers to create immersive experience for AR Glasses



- Open platform and open ecosystem
- Paves the way to a new Frontier of Spatial Computing

Qualcomm launches

up to $100M

Snapdragon™ Metaverse Fund

Qualcomm

5G enables boundless XR at scale and is ready for commercialization

Device APIs with 5G optimizations enable richer user experience and more efficient deployments

5G standards have a strong evolution path for enhanced XR experiences, leading into 6G.

We are making boundless XR possible by enabling the industry with 5G modem APIs, XR platforms, XR SDKs, and XR reference designs

Questions?

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