Boundless photorealistic mobile XR over 5G

Qualcomm Technologies, Inc.
XR is meant to be mobile
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A glimpse into the future — sleek and stylish XR glasses

How do we get there?

- Bone conduction transducers
- Directional speakers
- Tracking and recording cameras
- Inertial, haptic, and health sensors
- Multiple high sensitivity audio microphones
- Multimode connectivity (4G, 5G, etc.)
- Many passive and active cameras with fisheye and telephoto lenses
- Optoelectronic night vision and thermal imaging sensors
- Ambient light sensors
- Eye tracking cameras
- New optics and projection technologies within a durable, semitransparent display
Split-rendering over 5G brings best of both worlds – boundless photorealistic mobile XR in a sleek, affordable headset.

Mobile XR
- Reliable, anywhere anytime usage
- Ease of use with no setup
- Battery powered sleek, ultra-light design
- Leverages mobile ecosystem scale

PC-tethered XR
- Not limited by power and thermal constraints
- Expensive and niche for high-end experiences
- Wires limit intuitive actions and immersion
- Usage limited to a fixed location

The best of both worlds
Boundless mobile XR – the best possible XR anywhere

**Premium XR anywhere**
Efficient on-device processing to deliver immersive XR
Utilize connectivity for less time-sensitive content and downloads
We are doing this today

**Photorealistic graphics and visuals**
Enhanced experience where possible with new split-rendering architecture
On-device processing augmented by compute located at cloud edge over 5G connectivity
A new era in distributed processing

Essential on-device processing
- Optimized under strict power, thermal, size constraints
- Premium experiences today that continuously improve

Split rendering
- Low latency
- High capacity
- Reliable link

Augment by edge cloud processing
- Significantly higher power envelope—beyond PC class
- Augment on-device rendering with edge cloud rendering

Complex XR workloads
- Compute intensive
- Complex concurrencies
- Real-time
- Always-on
- Latency sensitive

Challenging XR form factor
- Thermally efficient for sleek and ultra-light
- Long battery life for all-day use
- Storage/memory bandwidth
Achieving immersive mobile XR is challenging

- **Visual quality**
  - High resolution audio
    - Up to human hearing capabilities
  - 3D audio
    - Realistic 3D, positional, surround audio that is accurate to the real world

- **Sound quality**
  - Precise motion tracking
    - Accurate on-device motion tracking

- **Immersion**
  - Intuitive interactions
    - Natural user interfaces
      - Seamlessly interact with VR using natural movements, free from wires

- **Minimal latency**
  - Minimized system latency to remove perceptible lag

- **Spherical view**
  - Look anywhere with a full 360° spherical view

- **Stereoscopic display**
  - Humans see in 3D

- **Extreme pixel quantity and quality**
  - Screen is very close to the eyes

- **Natural user interfaces**
  - Seamlessly interact with VR using natural movements, free from wires
Minimizing motion to photon latency is crucial for immersion

Lag prevents immersion and can cause discomfort
Workloads must run efficiently on-device at low latency

- Motion detection
  - Sensor sampling and fusion
  - Head pose generation

- Visual processing
  - View generation
  - Render / decode

- Display
  - Adjustment to latest pose (time warp)
  - Quality enhancement and display

5G

Opportunity for split rendering

Enhanced rendering

“Motion” Total time (motion to photon latency) for steps must be less than 20 milliseconds

“Photon” (new pixels’ light emitted from the screen)
Augment on-device processing for boundless photorealistic mobile XR

1. Asynchronous time warp reduces Motion to Photon (MTP) latency by using on-device processing based on the latest available pose. MTP below 20 ms generally avoids discomfort – has to be processed on the device.

Cloud

Less latency sensitive content (e.g. recorded streaming video)

Edge Cloud with rendering

Deeper in network

On-premise, e.g. venue

XR headset with on-device processing

5G

6-DoF head pose

Encoded data

On-device adjustment to latest pose

Today’s latency is unpredictable

Partial rendering offload possible with 5G’s low latency, capacity and quality of service

Power-efficient, latency sensitive on-device rendering and tracking

1. Asynchronous time warp reduces Motion to Photon (MTP) latency by using on-device processing based on the latest available pose. MTP below 20 ms generally avoids discomfort – has to be processed on the device.
The wireless edge transformation realizes the full potential of 5G

- New experiences with new levels of immersion, immediacy, personalization and privacy
- Creating new industries and transforming existing industries in the new era of distributed autonomy
- Essential on-device capabilities augmented with processing/compute, content, control,... at edge cloud
Our technologies are transforming the wireless edge today

Inventing technology at scale to realize the promise of massive on-device AI

Providing the connectivity fabric with LTE, Wi-Fi, Bluetooth today
Distribute functions based on economic and performance tradeoffs for use case

Cloud
- Big data, AI training, less delay sensitive content, storage,…

Edge cloud
- Compute/processing, content, control, storage,… closer to user

Economic and performance tradeoffs

On-premise control for ultra-low latency in the reconfigurable factory
On-car intelligence for immediacy, edge cloud e.g. for local HD maps
Distribute processing across device and edge cloud for boundless XR
New services through distributed/split functions over 5G
Content/control closer to user for instant access, real-time online gaming, etc.
On-device virtual assistant for privacy and personalization—assistance from cloud

Latency as low as 1 ms

Latency could be over 100s ms today

Distribute functions depending on use case e.g. to reach required latency

1. Such as distributed/virtualized core, distributed packet gateway functionality for low latency, mobile edge compute, related to MEC Multi Access Edge Computing as defined by ETSI
Opportunity for operators to take advantage of the wireless edge transformation for XR

Enhanced mobile broadband with 5G

- Enhanced XR experiences through increased capacity, lower latency, and uniform experience
- Rich visual content
- Interactive content
- Frequent upload and download of XR content, virtually anywhere

Services platform at edge cloud

- Content processing, storage, and distribution as a service
- Even lower latency with content closer to devices
- Business and consumer applications for boundless XR

Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.
Synergy from the XR ecosystem working together

XR Industry benefits from increased consumer adoption
Real-time interactive collaboration
Multi-player gaming with photorealistic graphics
Next-gen 6-DoF video

*6 DoF: Six degrees of freedom*
Our mobile office or living room, virtually anywhere
Shopping like never before
Supporting boundless mobile XR experiences

Split-rendering with 5G as the connectivity fabric

Edge cloud
XR content partially rendered on powerful compute resources in the network

5G
Compressed content delivered via high-bandwidth, low-latency air interface

On-device processing
Power-efficient, high-performance, latency-sensitive on-device rendering and tracking
XR is meant to be mobile, and our superior on-device processing powers immersive experiences today.

Boundless XR with photorealistic visuals is possible by augmenting on-device processing with edge cloud rendering over 5G.

Our leadership in on-device processing and 5G at the wireless edge is helping drive the industry to boundless XR.

The wireless edge transformation realizes full potential of 5G for a plethora of other applications.
Thank you

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