Immersive Media over 5G - What standards are needed?

Thomas Stockhammer
Director Technical Standards
Qualcomm Technologies, Inc.
September 2018

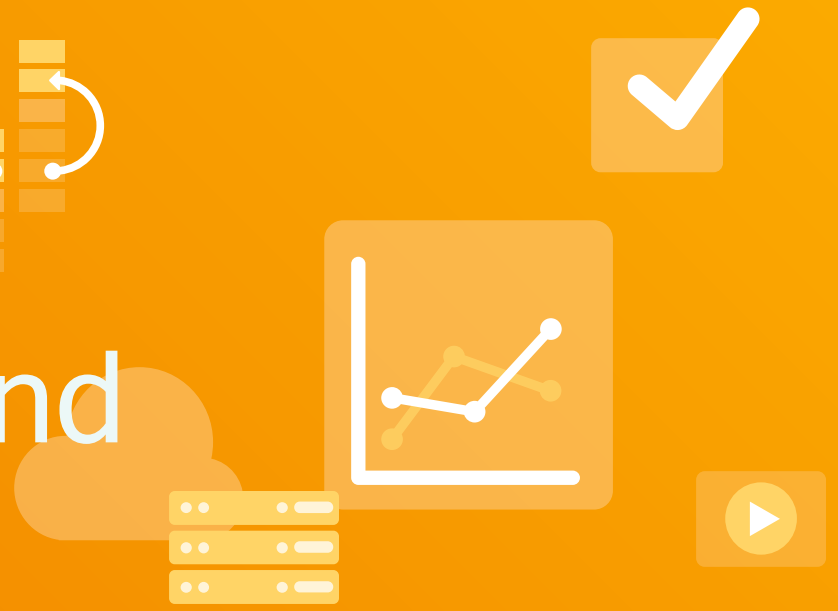
IBC 2018: 5G - “Are we nearly there yet”

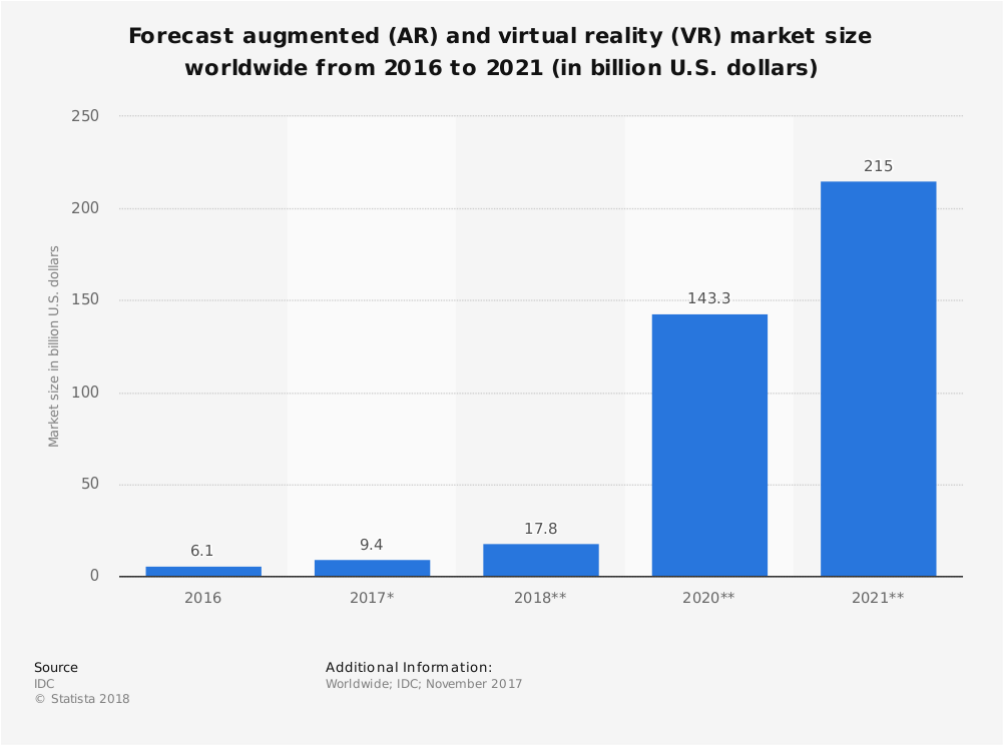
IMMERSIVE MEDIA OVER 5G - WHAT STANDARDS ARE NEEDED?

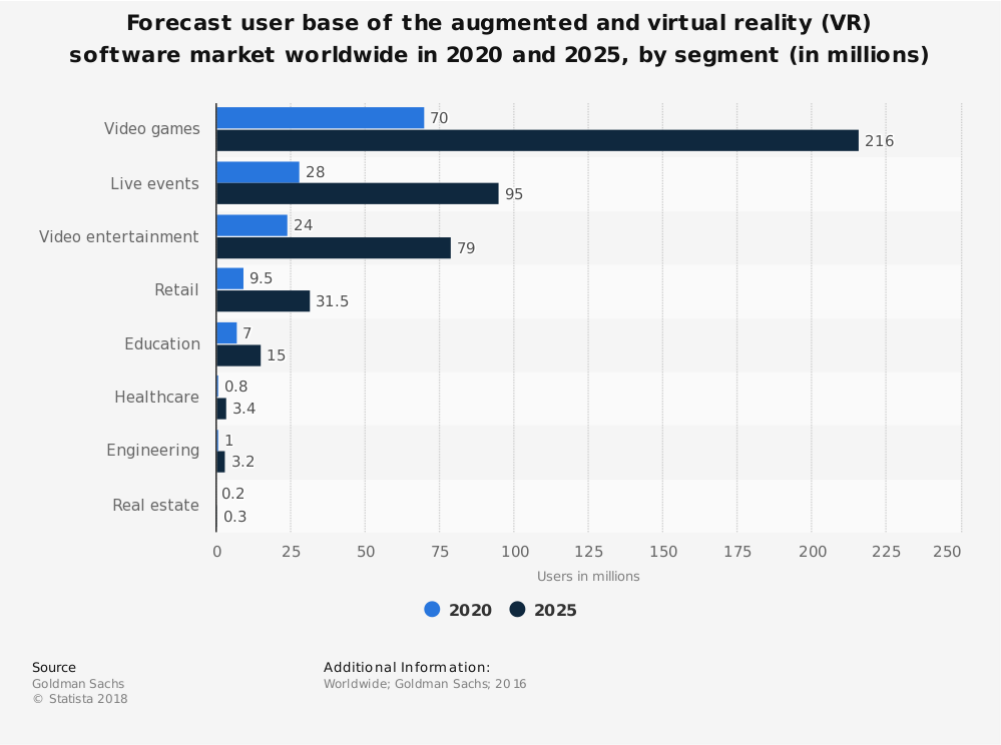
T. Stockhammer[1], I. Bouazizi[3], F. Gabin[2], G. Teniou[4]

[1] Qualcomm Incorporated, United States
[2]Ericsson, France
[3]Samsung, United States
[4]ORANGE, France

Introduction to AR/VR and Immersive Media







There seems to be a business case for VR/AR

Augmented reality vs. virtual reality

Similar underlying technologies but distinct experiences

Virtual reality

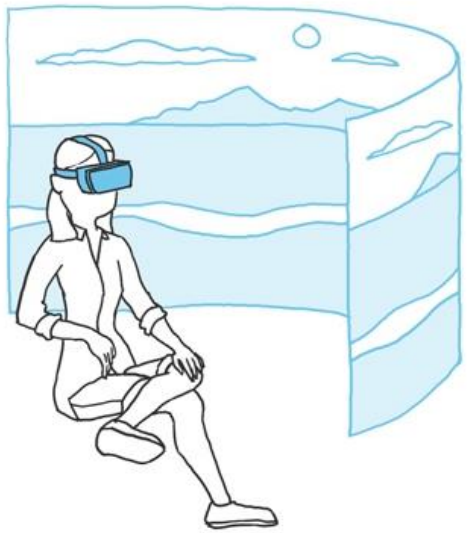
Simulates physical presence in real or imagined worlds, and enables the user to interact in that world

Augmented reality

Superimposes content over the real world such that the content appears to be part of the real-world scene

Evolution of user experience from VR to AR/XR

Today



VR: Mostly 3-DOF, lower resolution videos & games

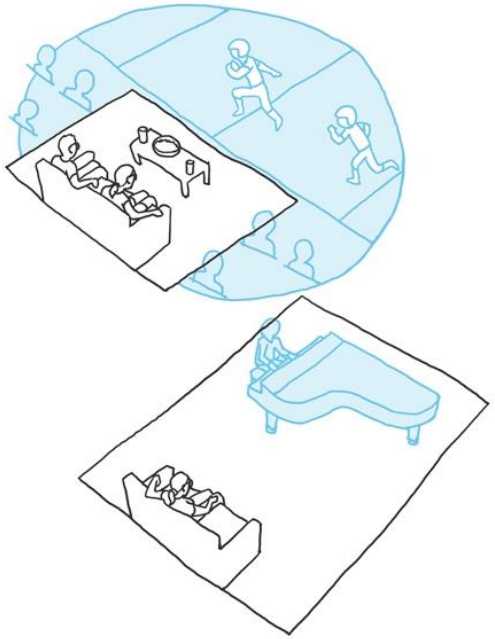
AR: Pokémon Go, Google Translate, Snapchat, and other rudimentary AR apps

Soon

VR: Ability to move around through live events, with better sense of “presence”

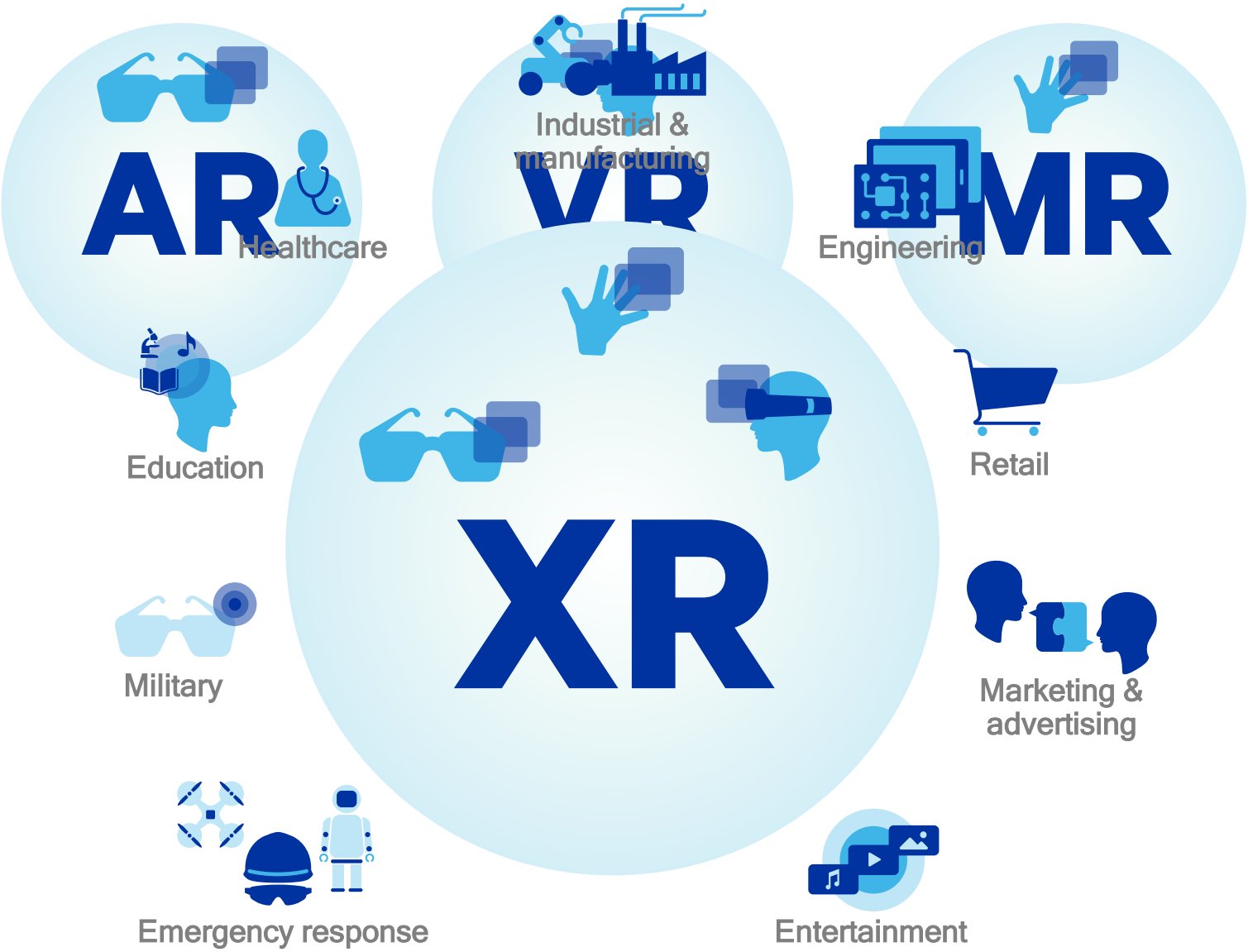
AR: Still rudimentary, yet more useful and immersive, streaming AR services, abled to be accessed on the go

The Future

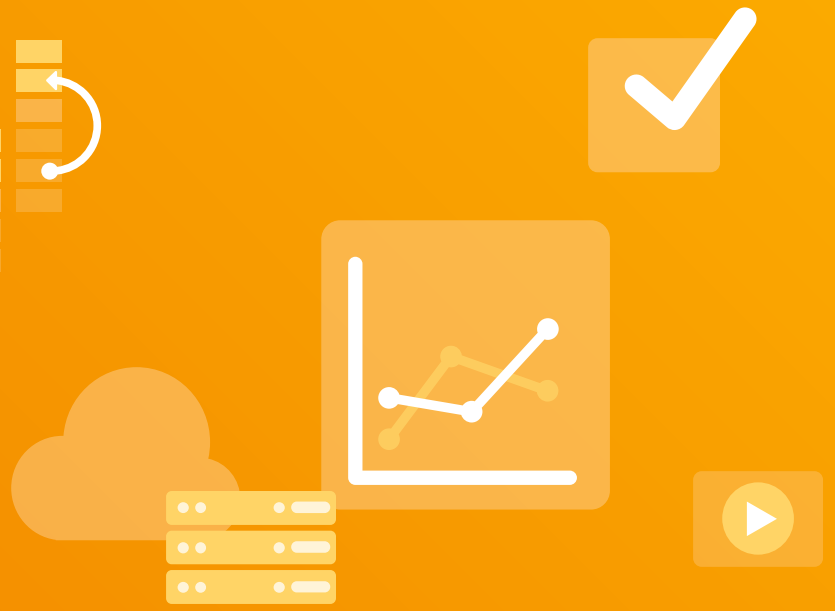


XR: Entire scenes, like entertainment events, can be accessed with your mobile AR device that are so realistic and interactive that they’ll be nearly indistinguishable from reality. VR becomes an occasionally used “mode” within AR/XR

Extended Reality (XR) is the next mobile computing platform

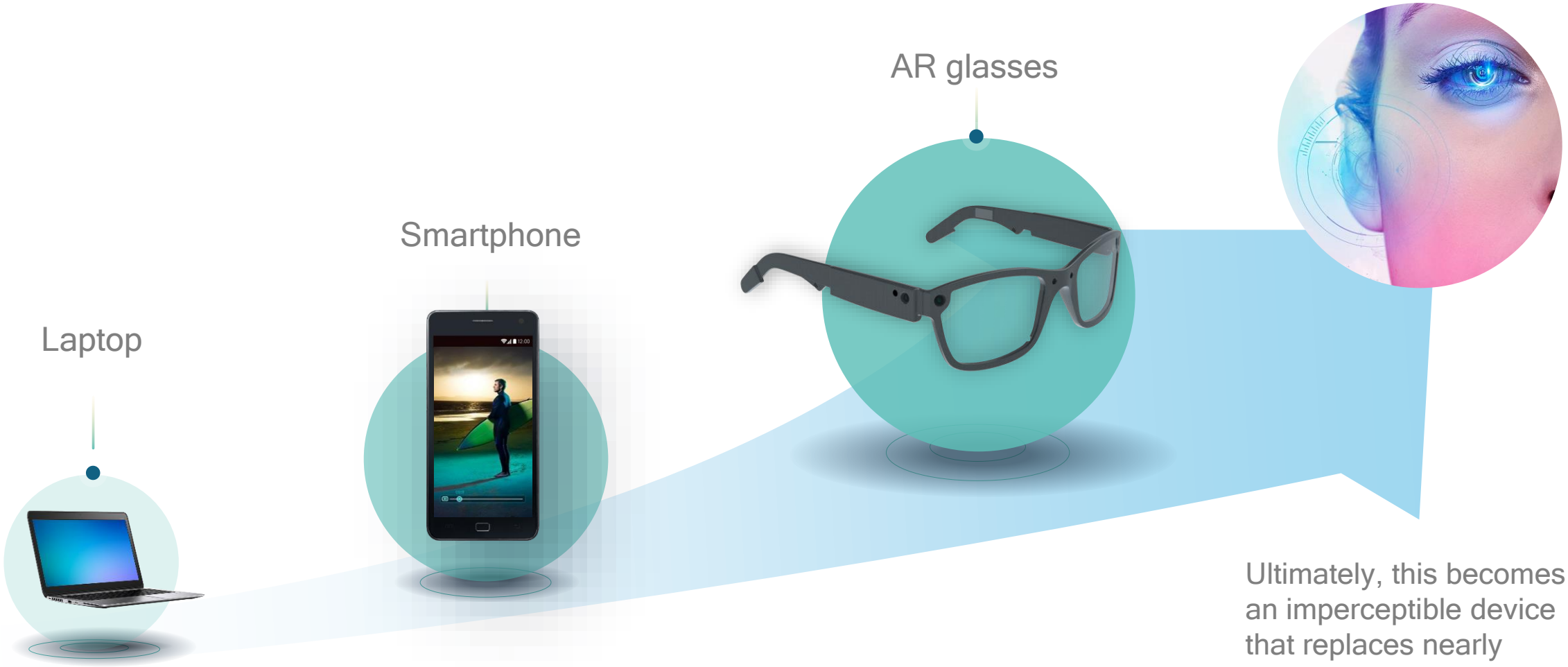


Evolution of XR from today to the future



AR is the next mobile computing platform

Nearly everything we've learned for smartphones will be used for AR



Ultimately, this becomes an imperceptible device that replaces nearly all others

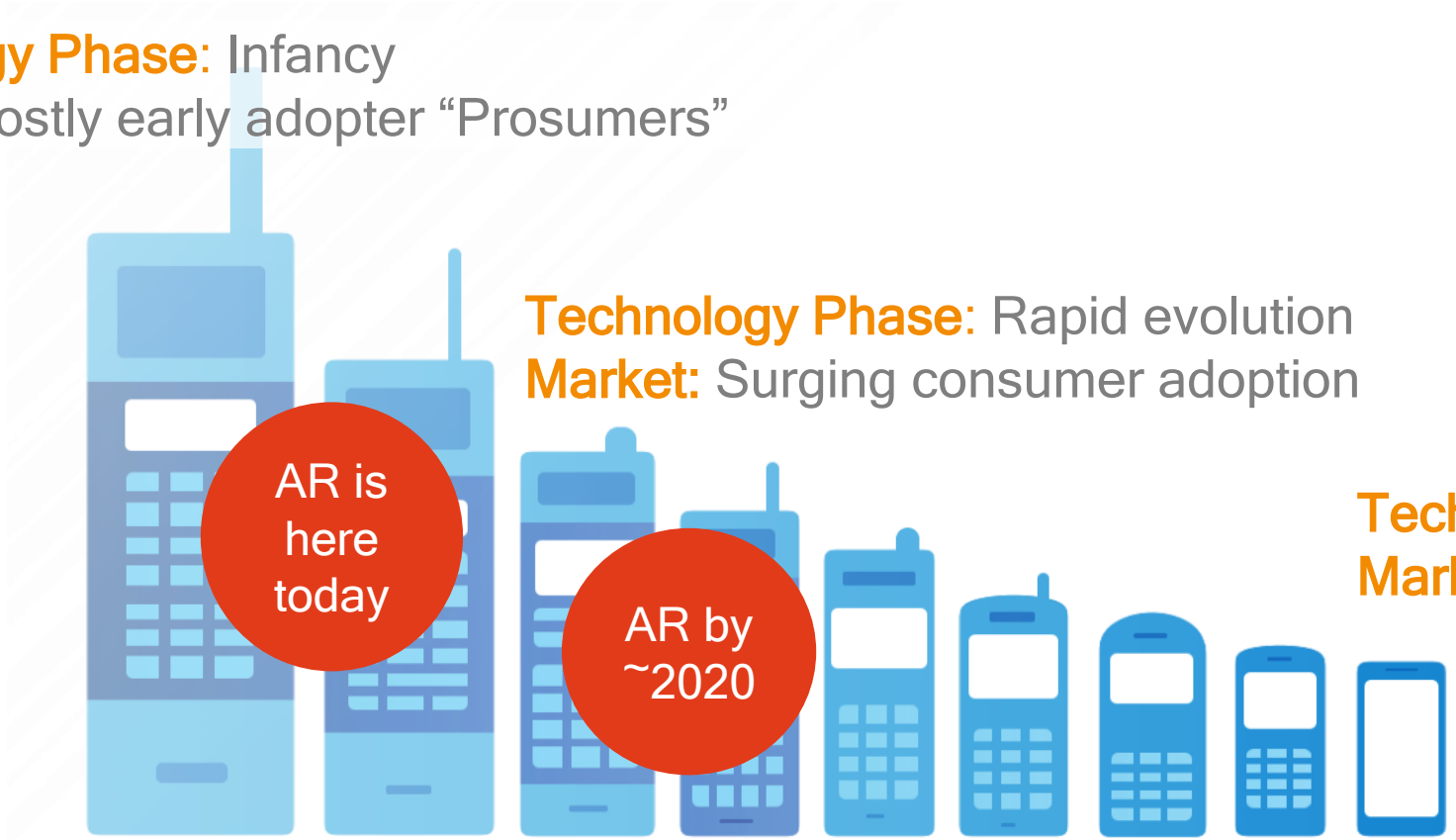
AR is here today, but it is still in its infancy

Analogy to cell phones: AR evolution will take years…opportunity will be immense

Technology Phase: Infancy
Market: Mostly early adopter "Prosumers"

Technology Phase: Rapid evolution
Market: Surging consumer adoption

Technology Phase: Maturity
Market: Worldwide, ubiquitous use



AR will follow a similar ~30 year cycle of sleeker designs, with tremendously increasing functionality

AR is here today, but it is still in its infancy

Currently shipping devices that use Qualcomm® Snapdragon™ processors

Today's Smartphones and Phablets

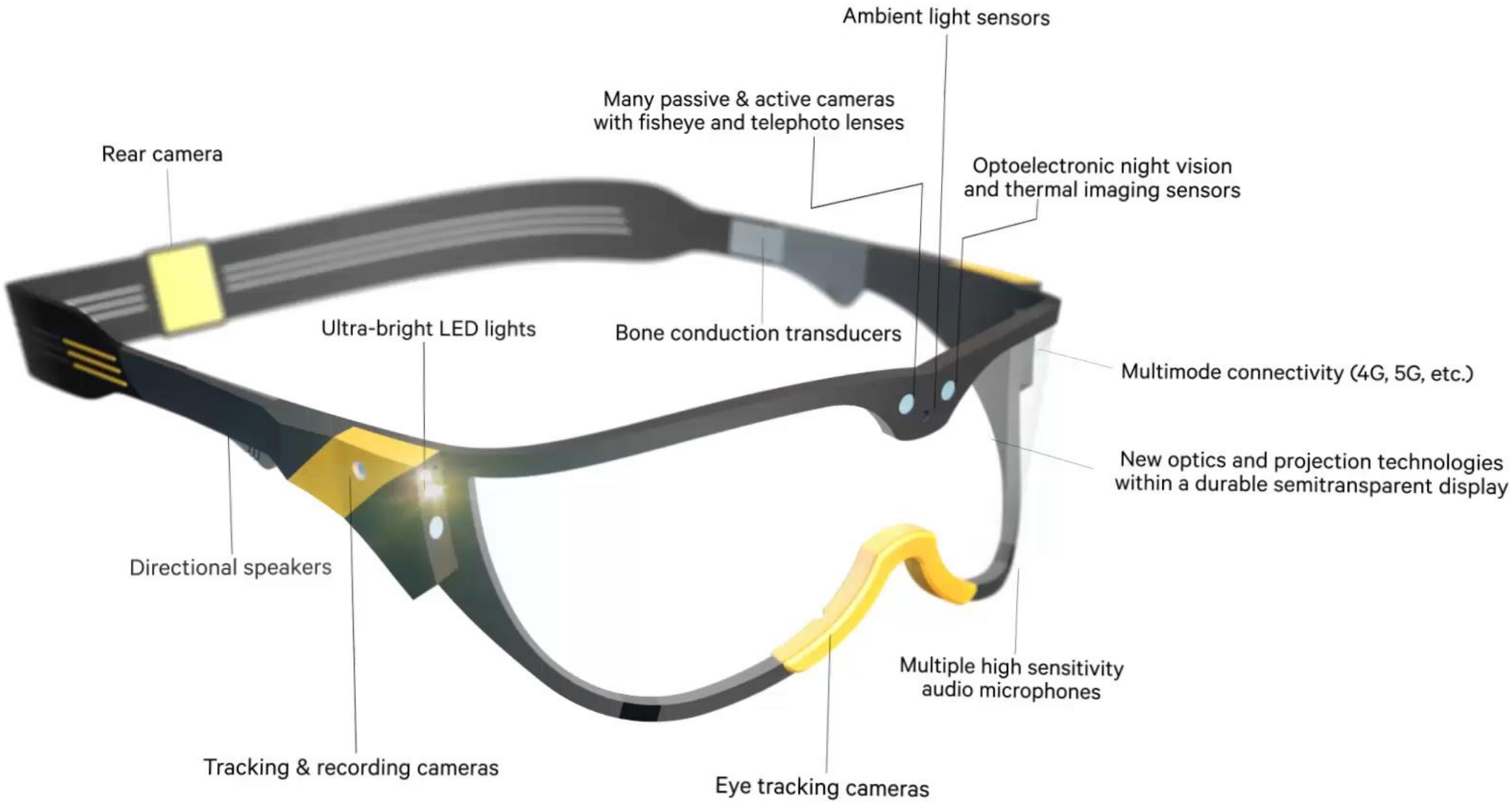
Tango

Glasses

ODG
OSTERHOUT DESIGN GROUP

Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc.

Will the smartphone become an AR wearable?


Ambient light sensors
Many passive & active cameras
with fisheye and telephoto lenses
Rear camera
Optoelectronic night vision
and thermal imaging sensors
Ultra-bright LED lights
Bone conduction transducers
Multimode connectivity (4G, 5G, etc.)
New optics and projection technologies
within a durable semitransparent display
Directional speakers
Multiple high sensitivity
audio microphones
Tracking & recording cameras
Eye tracking cameras

Challenges and Requirements for AR

New technologies for future AR requirements

Providing an always-on experience that intelligently enhances our lives

Immersive

The visuals, sounds, and interactions are so realistic that they are true to life

Cognitive

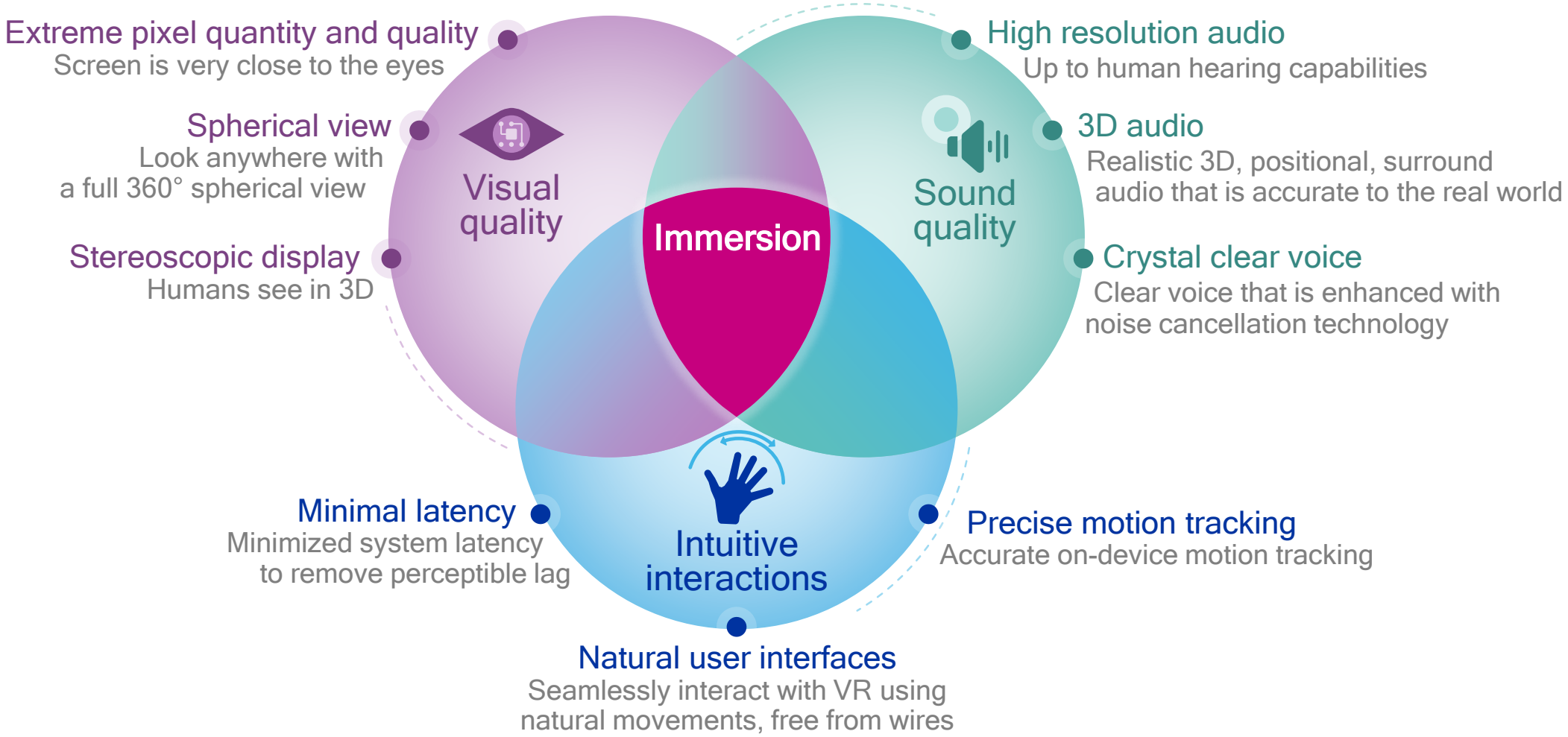
It understands the real world, learns personal preferences, and provides security & privacy

Connected

An always-on, low power wearable with fast wireless cloud connectivity anywhere

AR shares requirements similar to VR for immersion

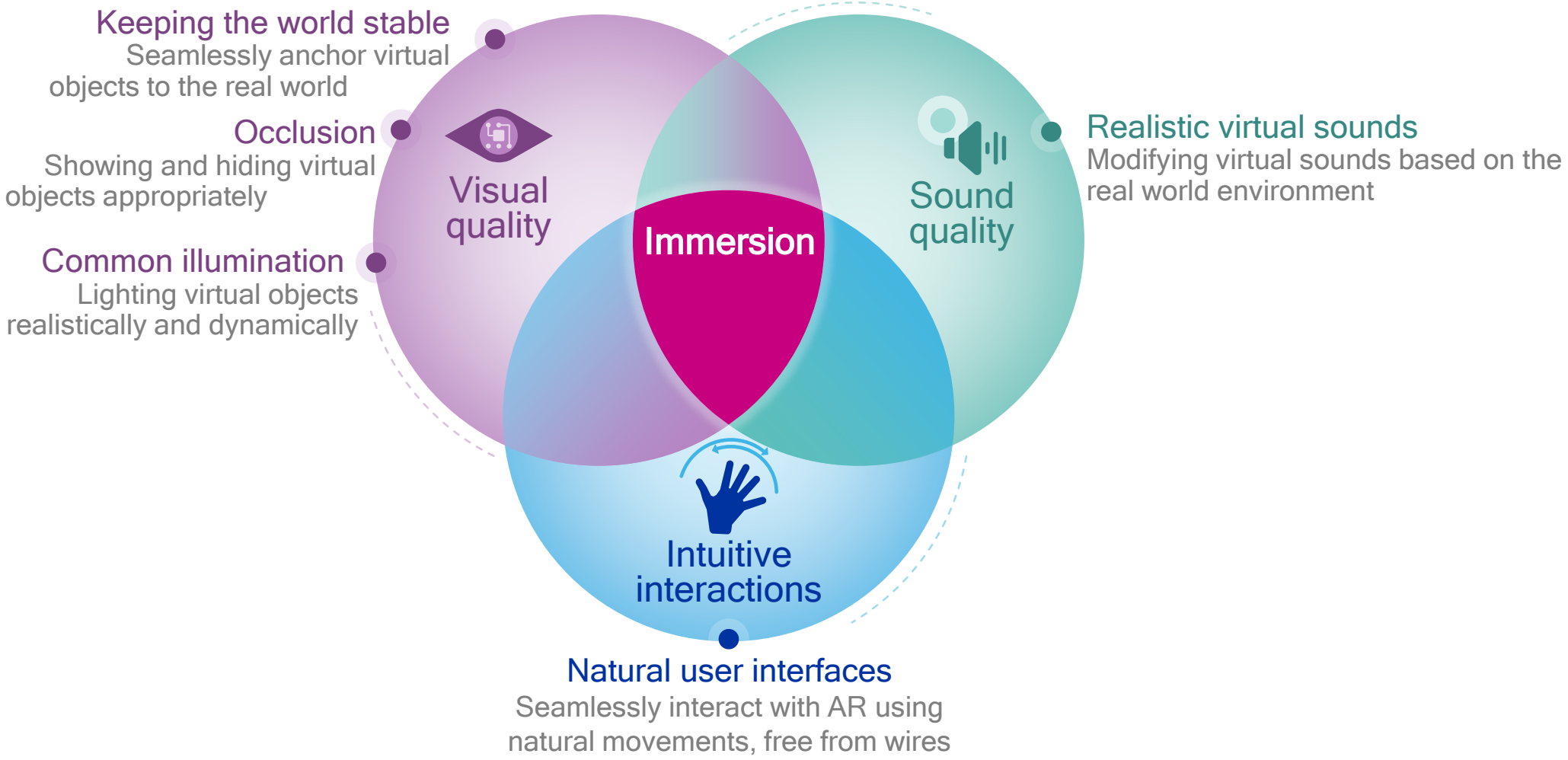
Achieving realistic AR at low power to enable a comfortable, sleek form factor



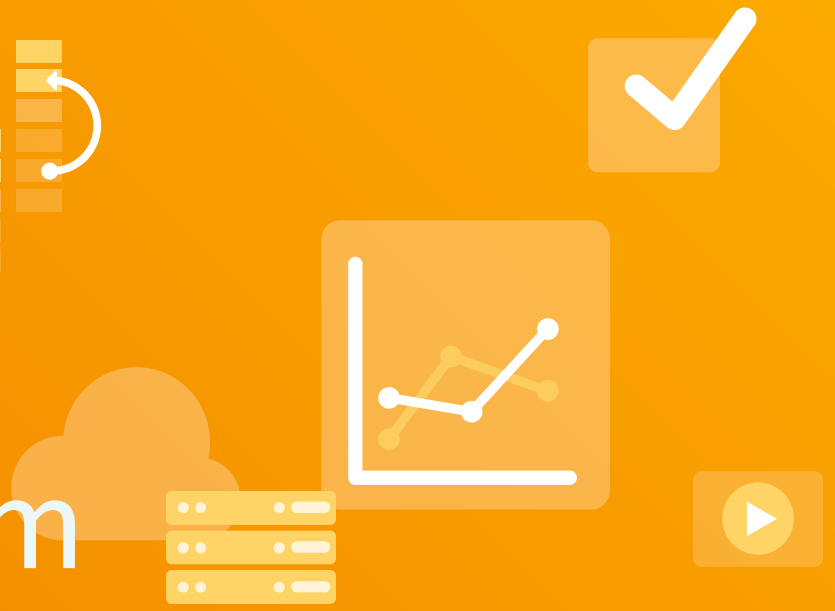
Learn more about our vision for the future of VR: www.qualcomm.com/VR

AR introduces additional requirements for immersion

Seamlessly integrating virtual objects with the real world



Technical Enablers: Mobile Compute Platform



Mobile XR is advancing in every generation

Qualcomm® Snapdragon™ 820

3DoF

1K x 1K @ 60 fps

Snapdragon 835

6DoF

1.5K x 1.5K @ 60 fps

Snapdragon 845

Room-Scale 6DoF

SLAM

2K x 2K @ 120fps

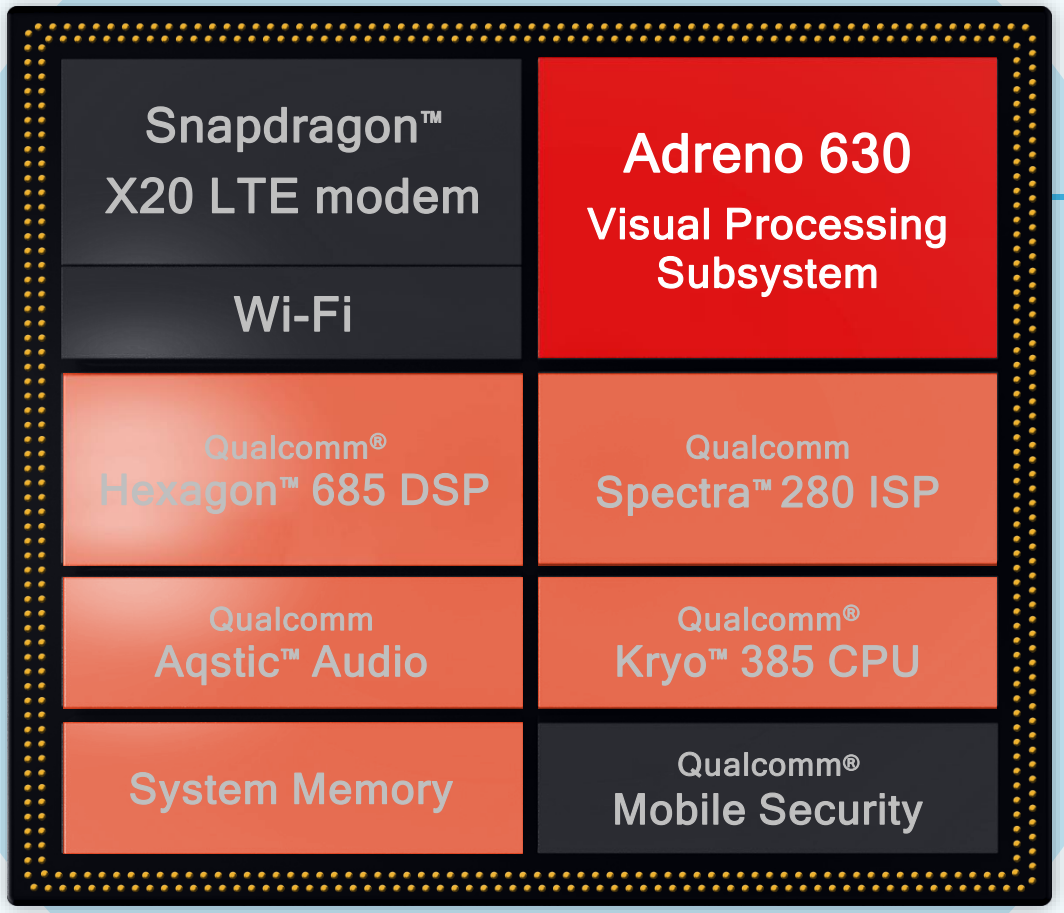
Snapdragon 845

XR/AR

Computer vision, image processing, sensor processing, graphics, video processing, location, and cloud interaction

Benefits

- Integrated and optimized
- Enhanced battery life
- Thermal efficiency
- Standardized implementation
- Mass market cost
- Variety of use cases and industry support



Entire SoC is used!

Room-Scale 6DOF with SLAM

Adreno Foveation

2K x 2K @ 120 fps XR

30% Faster Graphics and Video*

30% Power Reduction*

Improved 6DOF Hand Tracking and Controller support*

Iris Authentication

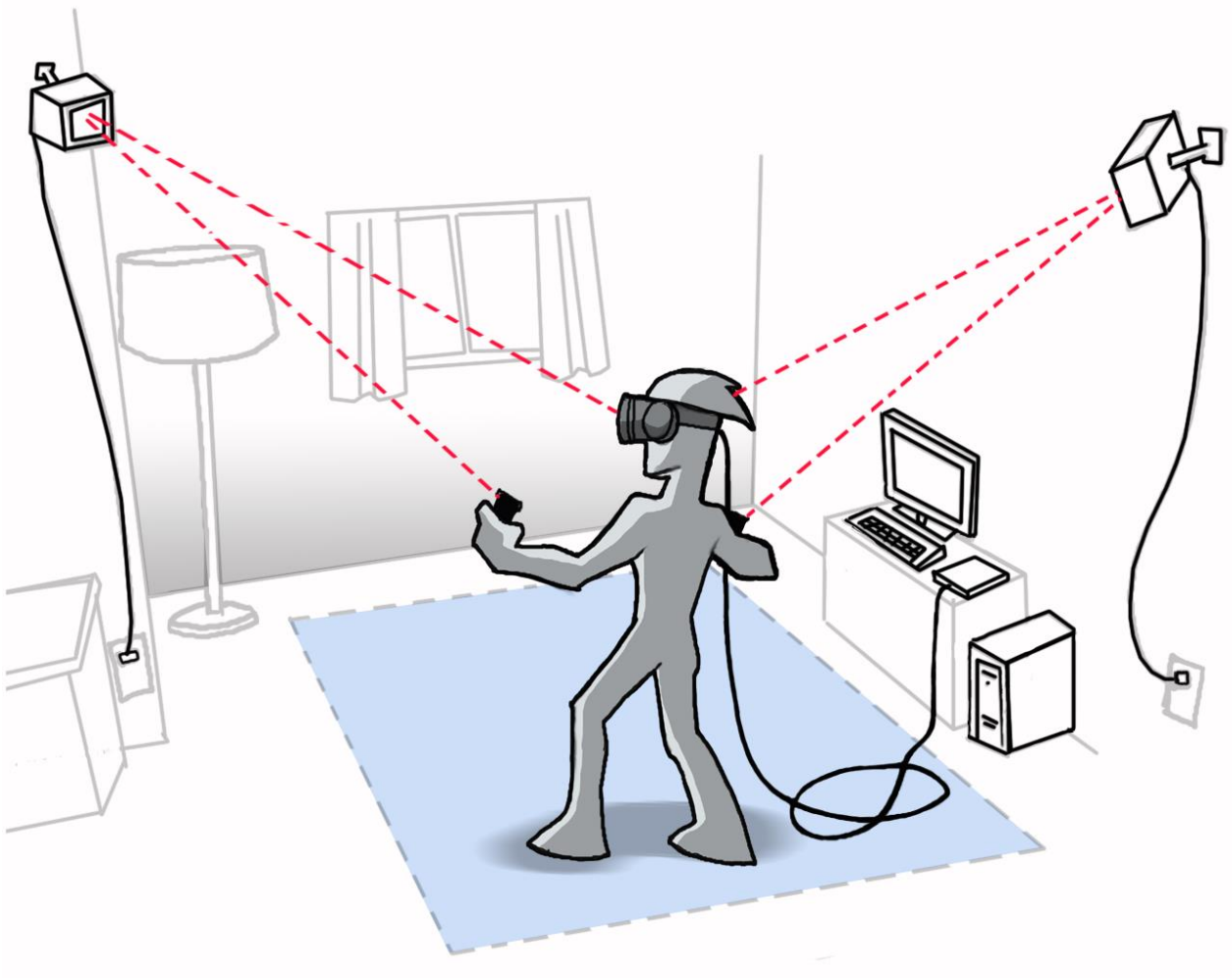
Voice UI with custom keyword

Qualcomm 3D Audio SDK for Unity

*Compared to Snapdragon 835

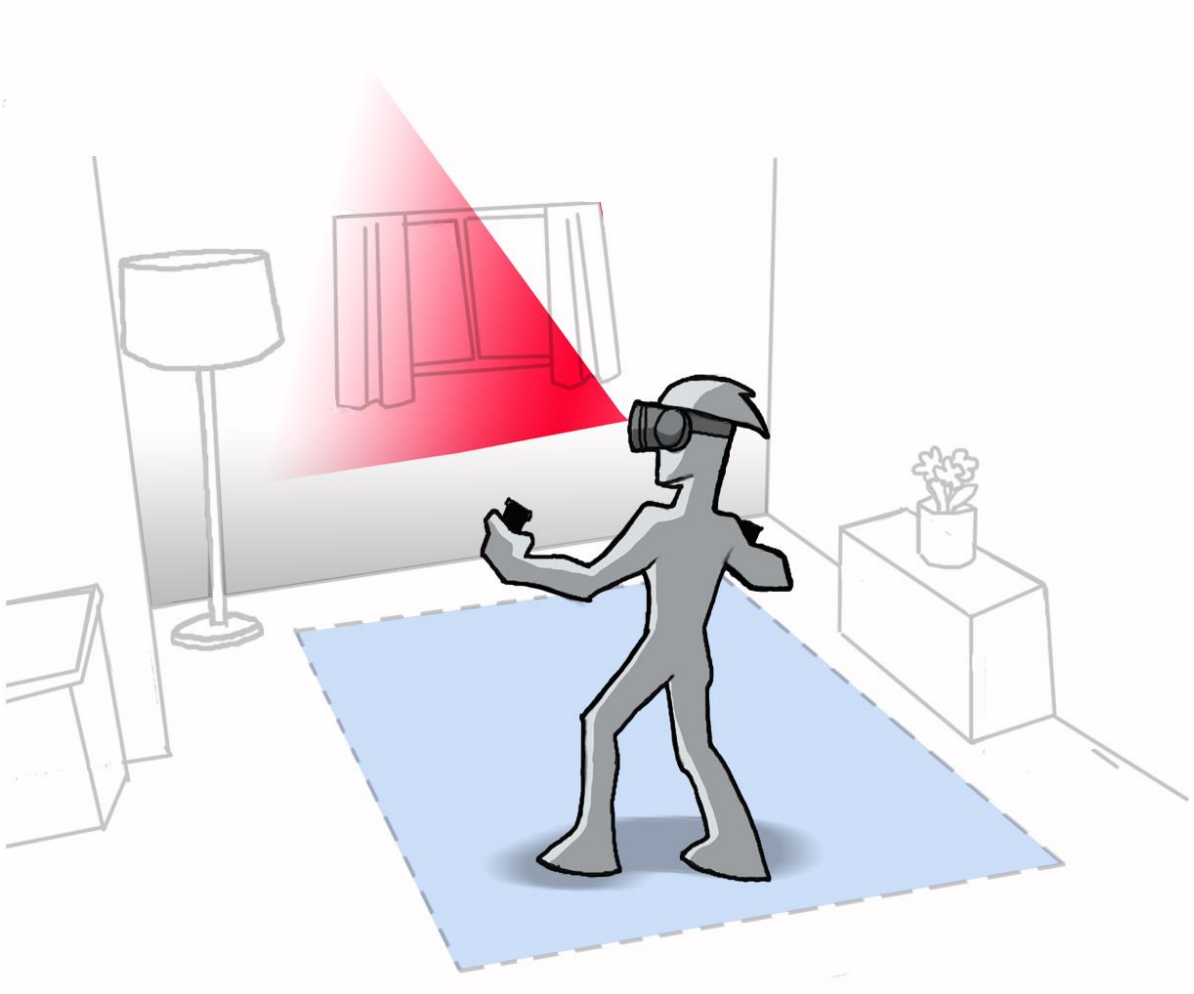
Conventional 6-DoF: “Outside-in” tracking

External sensors determine the user’s position and orientation



Mobile 6-DoF: “Inside-out” tracking

Visual inertial odometry (VIO) for rapid and accurate 6-DoF pose



Device Architecture / Technology Enablers for XR

Optimizations needed across the SoC and system SW

HW streaming interfaces

- Bypass DRAM with engine to engine communication
  - ISP to DSP
  - Sensors to DSP

Global time stamps

- Maintain synchronization across various processing engines

Accurate motion tracking

- Fast and accurate 6-DOF
- Accurate predictive 6-DOF for a small future window

Late latching

- Using the latest pose
- Asynchronous threads for consistent frame rate

Multiview stereoscopic rendering

- Single pass render of left and right eye

High frame rate

- 90 FPS for reduced frame latency

Foveated rendering

- Reduce pixel generation workload while maintaining high image quality

Direct access to VR features

- Bypass Android latency

Fast connectivity

- Low latency connectivity
- High bandwidth

Single buffer

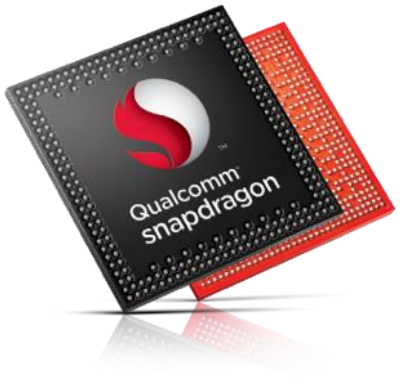
- Low latency connectivity
- High bandwidth

Display Technology

- Resolution, Frame rate, colors, etc.
- Robust, flexible, light

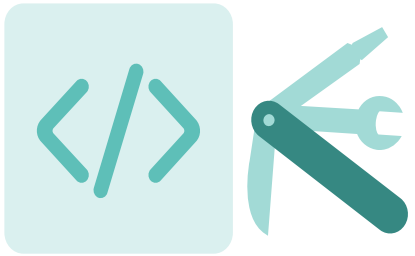
Supporting Tangible Efforts

Qualcomm® Snapdragon™ 835/845 Mobile VR Platform



Snapdragon 835/845

Purpose-built mobile processor for superior XR experiences

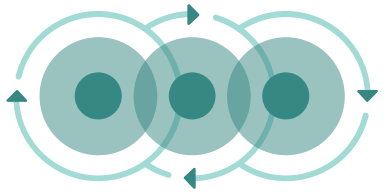


Snapdragon VR SDK

Easy developer access to Snapdragon accelerated XR libraries that simplify application development

HMD Accelerator Program

Reference designs, working with ODMs and technical support to commercialize XR HMDs quickly



Platform and Ecosystem support

Working with multiple content, technology and platform companies

Standardization Efforts

Global, Optimized HW Implementation, Interoperability

We need alignment in several key areas

Creating immersive XR experiences through standards-based technologies

Professional production & user generation

Video and audio compression

Transport: Content delivery

Access network

Apps

Display and rendering

ITU

3GPP A GLOBAL INITIATIVE

SMPTE

MPEG

DASH Industry Forum

DVB

ATSC 3.0

IETF

3GPP A GLOBAL INITIATIVE

IEEE

W3C WebVR

OpenXR

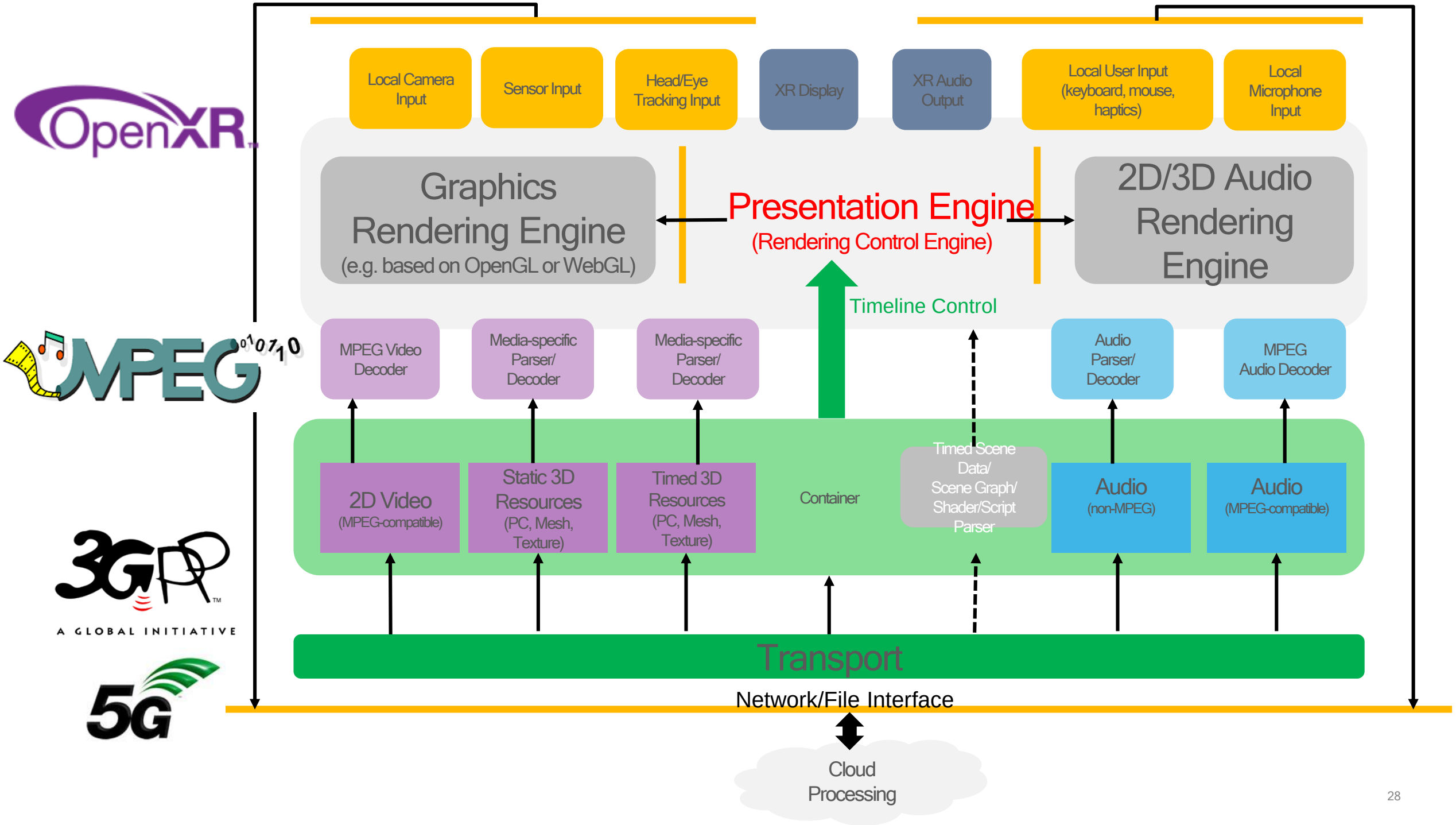
Java

VESA

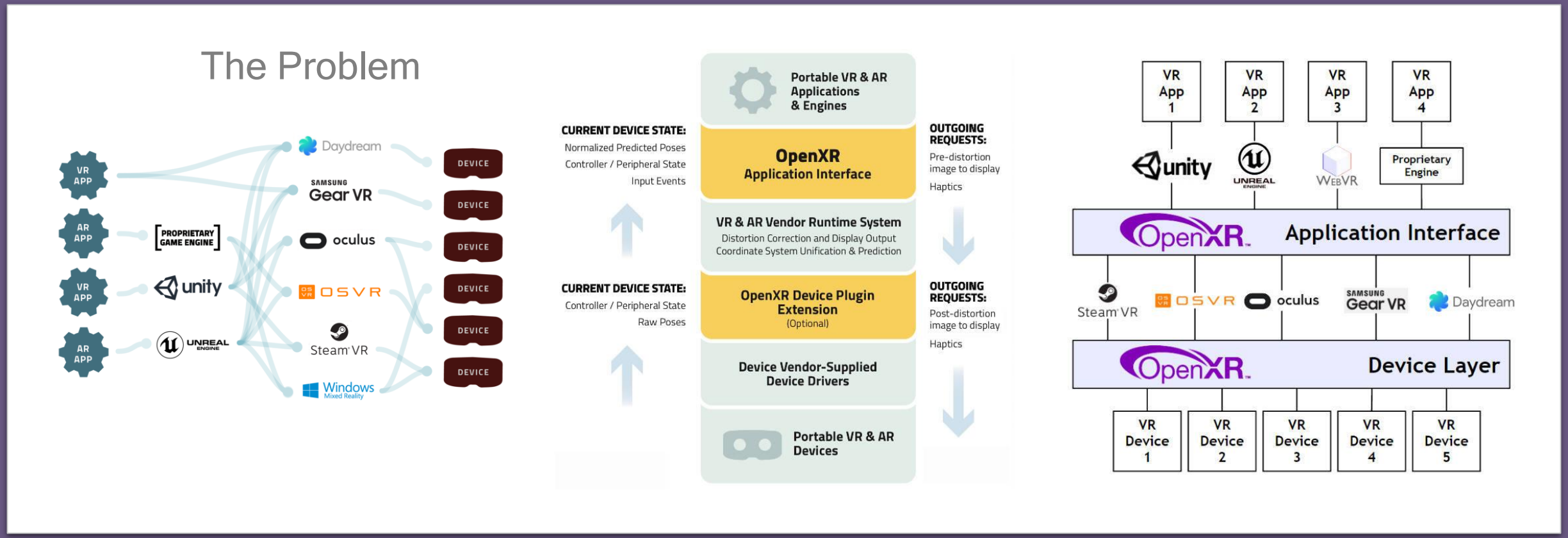
Consumer Technology Association

ITU

VR INDUSTRY FORUM


OpenXR
Local Camera Input
Sensor Input
Head/Eye Tracking Input
XR Display
XR Audio Output
Local User Input (keyboard, mouse, haptics)
Local Microphone Input
Graphics Rendering Engine
(e.g. based on OpenGL or WebGL)
Presentation Engine
(Rendering Control Engine)
2D/3D Audio Rendering Engine
Timeline Control
MPEG
MPEG Video Decoder
Media-specific Parser/ Decoder
Media-specific Parser/ Decoder
Audio Parser/ Decoder
MPEG Audio Decoder
2D Video
(MPEG-compatible)
Static 3D Resources
(PC, Mesh, Texture)
Timed 3D Resources
(PC, Mesh, Texture)
Container
Timed Scene Data/ Scene Graph/ Shader/Script Parser
Audio
(non-MPEG)
Audio
(MPEG-compatible)
3GPP
A GLOBAL INITIATIVE
Transport
5G
Network/File Interface
Cloud Processing

Khronos/OpenXR



OpenXR™ is creating an open standard for VR and AR applications and devices

OpenXR Philosophies

1

Enable both VR and AR applications

The OpenXR standard unified common VR and AR functionality to streamline software and hardware development for a wide variety of products and platforms

2

Be future-proof

While OpenXR 1.0 is focused on enabling the current state-of-the-art, the standard is built around a flexible architecture and extensibility to support rapid innovation in the software and hardware spaces for years to come

3

Do not try to predict the future of XR technology

While trying to predict the future details of XR would be foolhardy, OpenXR uses forward-looking API design techniques to enable designers to easily harness new and emerging technologies

4

Unify performance-critical concepts in XR application development

Developers can optimize to a single, predictable, universal target rather than add application complexity to handle a variety of target platforms

KHRONOS™ GROUP

MPEG-i

MPEG-I

- In October 2016, MPEG initiated a new project on “Coded Representation of Immersive Media”, referred to as MPEG-I based on a survey.
- After the launch of the project, several phases, activities, and projects have been launched that enable services considered in MPEG-i.
- Core technologies as well as additional enablers are implemented in parts of the MPEG-I standard.
- Currently 8 parts are under development.
  - Part 1 - Immersive Media Architectures
  - Part 2 - Omnidirectional MediA Format
  - Part 3 - Versatile Video Coding
  - Part 4 - Immersive Audio Coding
  - Part 5 - Point Cloud Coding
  - Part 6 - Immersive Media Metrics
  - Part 7 - Immersive Media Metadata
  - Part 8 - Network-Based Media Processing

Different Track Activities

3DoF
V1 12/2017

- System: OMAF (File Format, DASH, Metadata)
- Video: HEVC or AVC + SEI
- Audio: MPEG-H Audio or simple AAC

3DoF+
12/2019

- System: OMAF (File Format, DASH, Metadata)
- Video: HEVC or AVC + Metadata
- Audio no updates

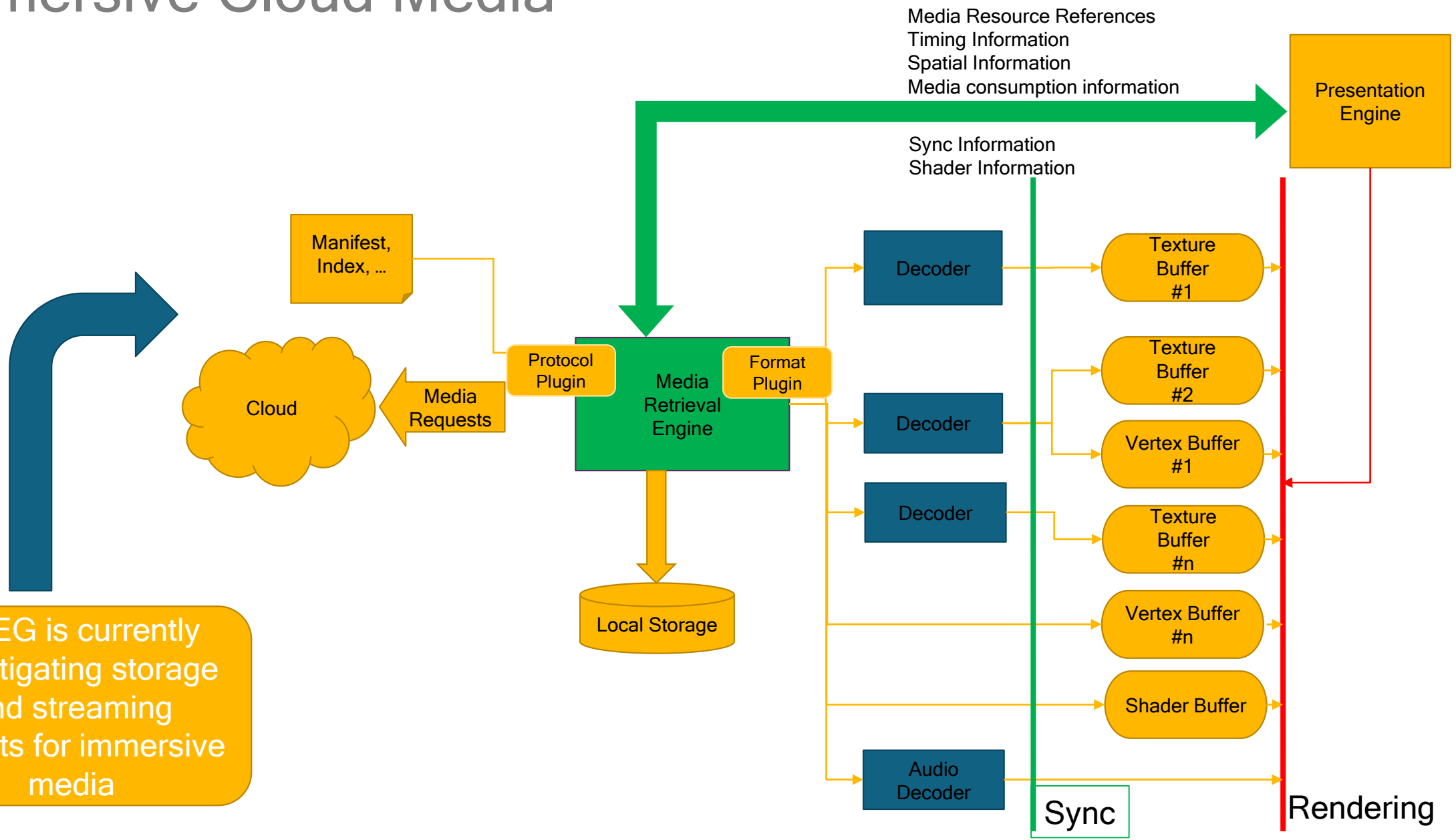
6DoF
Different tracks

- System: Rendering Centric, Scene Description
- Video: PCC, Dense Light Field, others
- Audio: Rendering centric audio architecture

Complementary

- Network-based Media Processing
- Metrics

Immersive Cloud Media

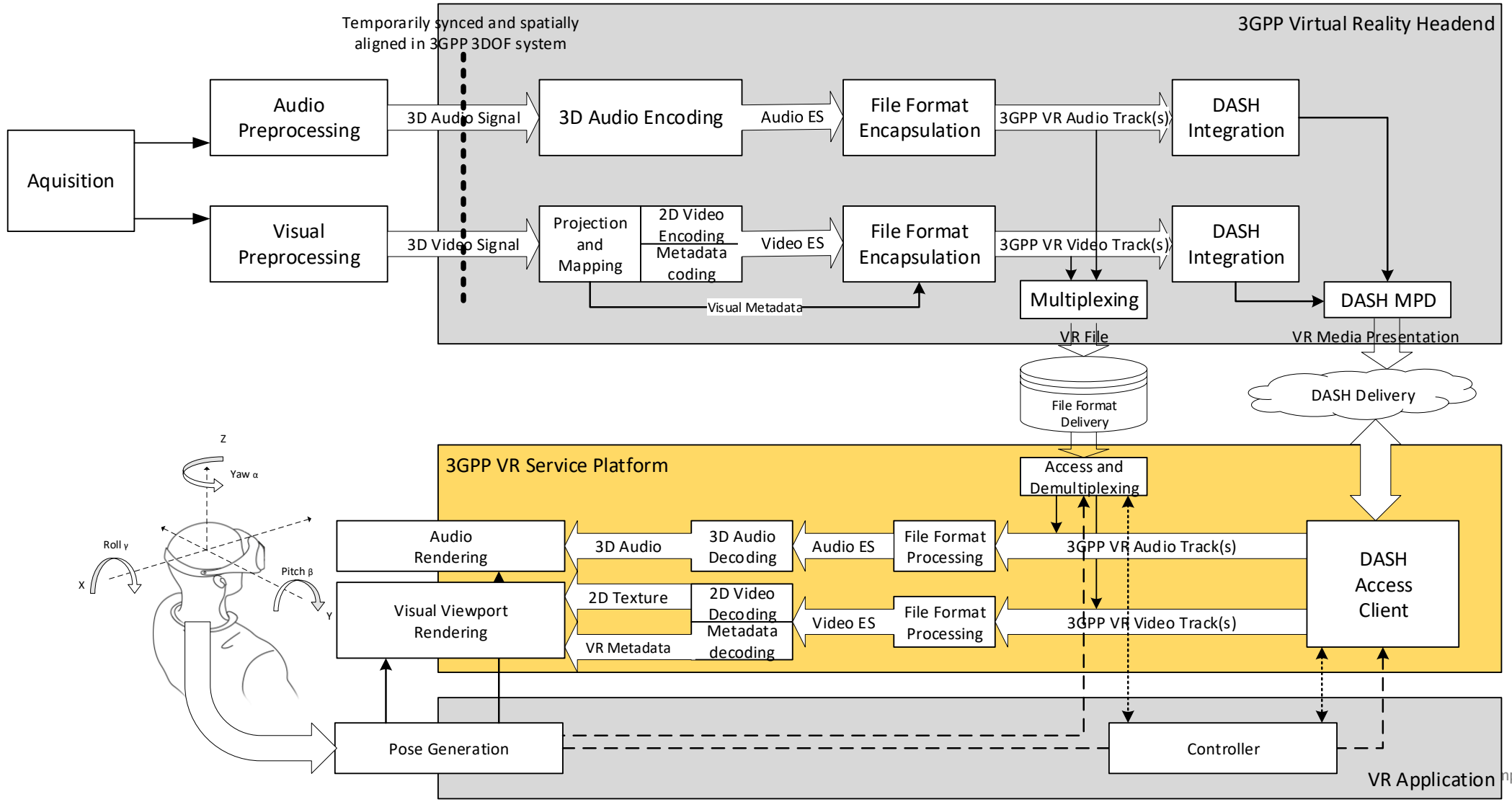


MPEG is currently investigating storage and streaming formats for immersive media

3GPP

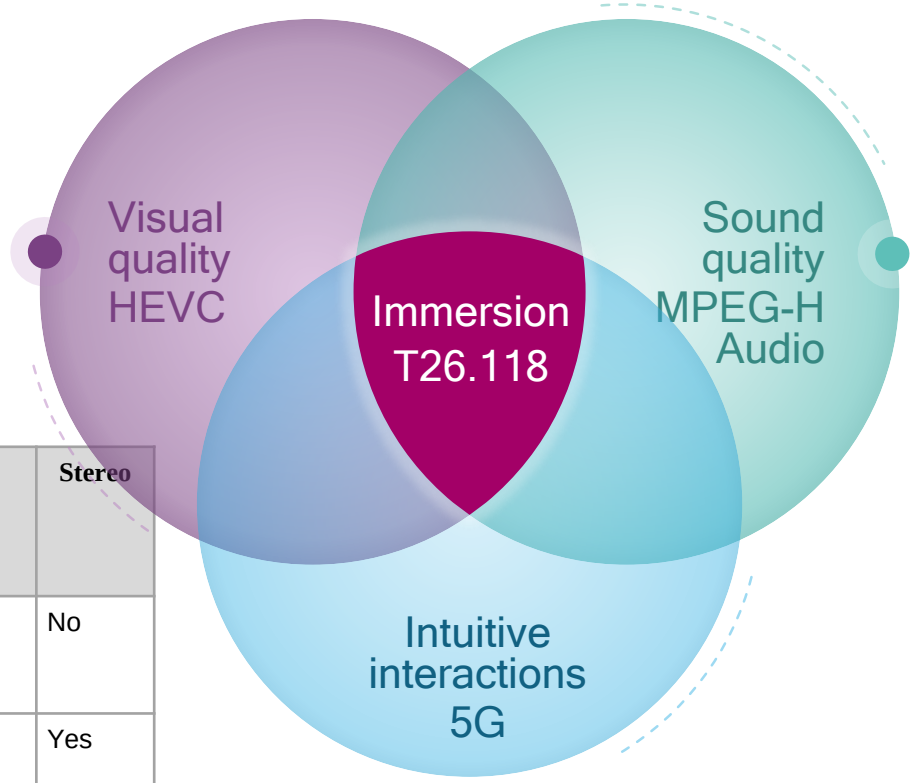
Virtual Reality in 5G

The first set of enablers for VR over 5G - approved in Sep 2018



VRStream

Technical Specification TS26.118



Operation Points Video

Operation Point name	Decoder	Bit depth	Typical Original Spatial Resolution	Frame Rate	Colour space format	Transfer Characteristics	Projection	RWP	Stereo
Basic H.264/AVC	H.264/AVC HP@L5.1	8	Up to 4k	Up to 60 Hz	BT.709	BT.709	ERP w/o padding	No	No
Main H.265/HEVC	H.265/HEVC MP10@L5.1	8, 10	Up to 6k in mono and 3k in stereo	Up to 60 Hz	BT.709 BT.2020	BT.709	ERP w/o padding	Yes	Yes
Flexible H.265/HEVC	H.265/HEVC MP10@L5.1	8, 10	Up to 8k in mono and 3k in stereo	Up to 120 Hz	BT.709 BT.2020	BT.709, BT.2100 PQ	ERP w/o padding CMP	Yes	Yes

Media Profiles Video

Media Profile	Operation Point	Sample Entry	DASH Integration
Basic Video	Basic H.264/AVC	`resv` `avc1`	Single Adaptation Set Single Representation streaming
Main Video	Main H.265/HEVC	`resv` `hvc1`	Single or Multiple independent Adaptation Sets offered Single Representation streaming
Advanced Video	Flexible H.265/HEVC	`resv` `hvc1, hvc2`	Single or Multiple dependent Adaptation Sets offered Single or Multiple representation streaming

- 3GPP selected MPEG-H audio as the only recommended option for audio media profile
- Additional enablers for metadata and synchronized presentations are available

Confidential and Proprietary – Qualcomm Technologies, Inc. and/or its affiliated companies.

Beyond Rel-15 – beyond VR360 3DoF Streaming

Extended Reality (XR), 6DoF, Split rendering, …

E-FLUS

- Framework for Live Uplink Streaming
- QoS supported "Facebook live“
- User Generated and Professional content
- Immersive Media included

XR-5G

- Study on Use Cases and Requirements for media capabilities for XR over 5G
- Addresses AR, 6DoF, different media types
- Expected to prepare normative work

NCIS

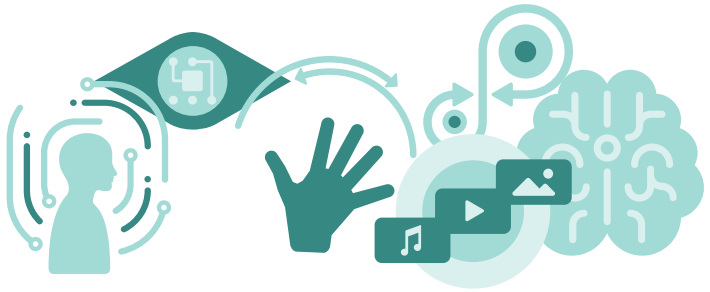
- Study on network requirements for interactive immersive services
- Inclusion of network-based rendering
- Expected to prepare normative work

AVPROD

- Study on AV Service production
- Remote audio and video production
- Studio based production
- Remote editing
- Stage Performers

Confidential and Proprietary – Qualcomm Technologies, Inc. and/or its affiliated companies.

The XR Challenge



XR workloads

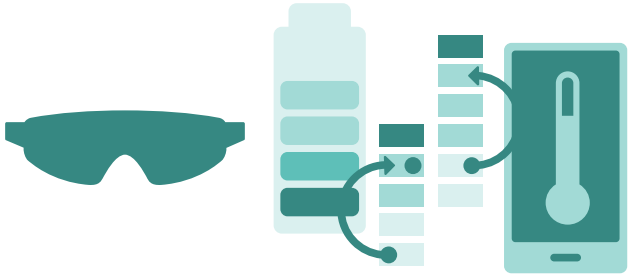
Compute intensive

Complex concurrencies

Always-on

Real-time

Latency Sensitive



Constrained mobile wearable environment

Thermally efficient for sleek, ultra-light designs

Long battery life for all-day use

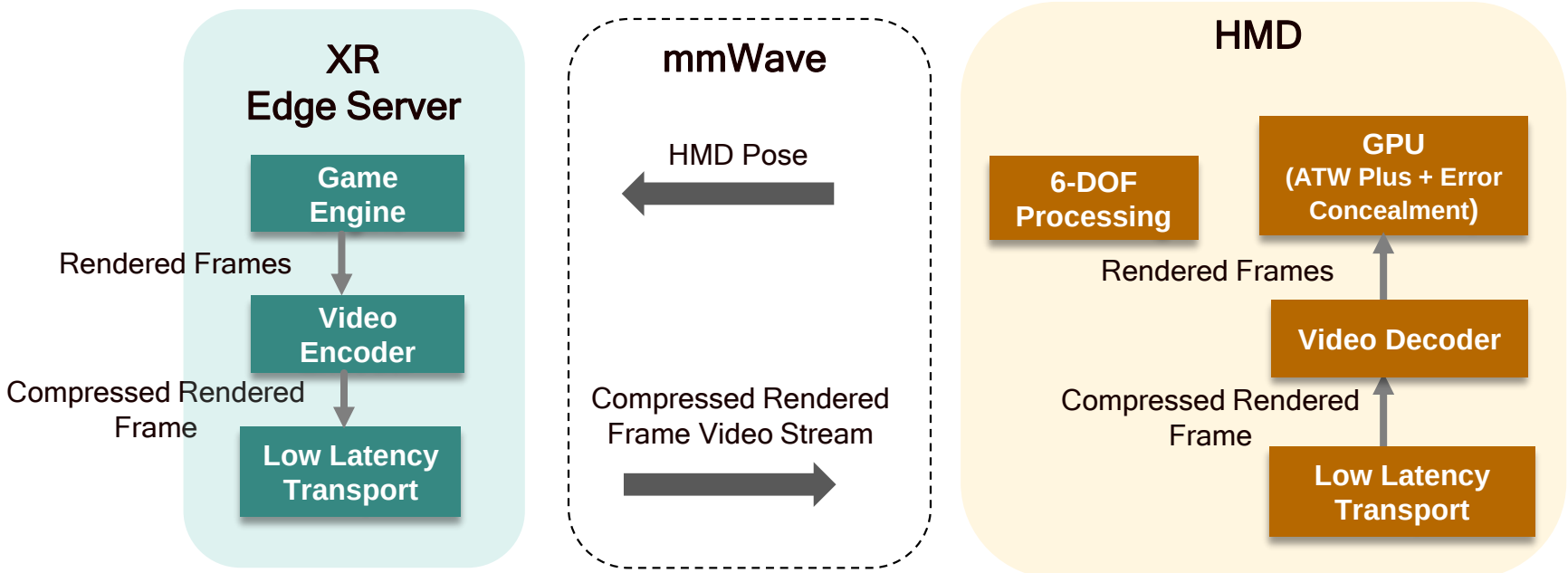
Approach: Split Rendering

Pixel Streaming Overview

VR graphics workload split into rendering workload on powerful XR server and ATW on device

Low motion-to-photon latency preserved via on device Asynchronuous Time Warping (ATW)

System Architecture



Example Implementation

Snapdragon HMD

- Chipset: SD 835
- Monocular 6-DOF Head tracking
- Display Rate: 70Hz
- Display Resolution: 2560x1440
- Downlink: 802.11ad (60GHz), 32 element antenna
- Uplink: 802.11 n(5GHz),2x2 MIMO

Rendering Server

- Content: Unity Adam Demo*
- Eye Buffer : 1440x1440
- Frame Rate: 60fps
- Codec: H264
- Avg/Peak Encoded Rate: 100/120 Mbps

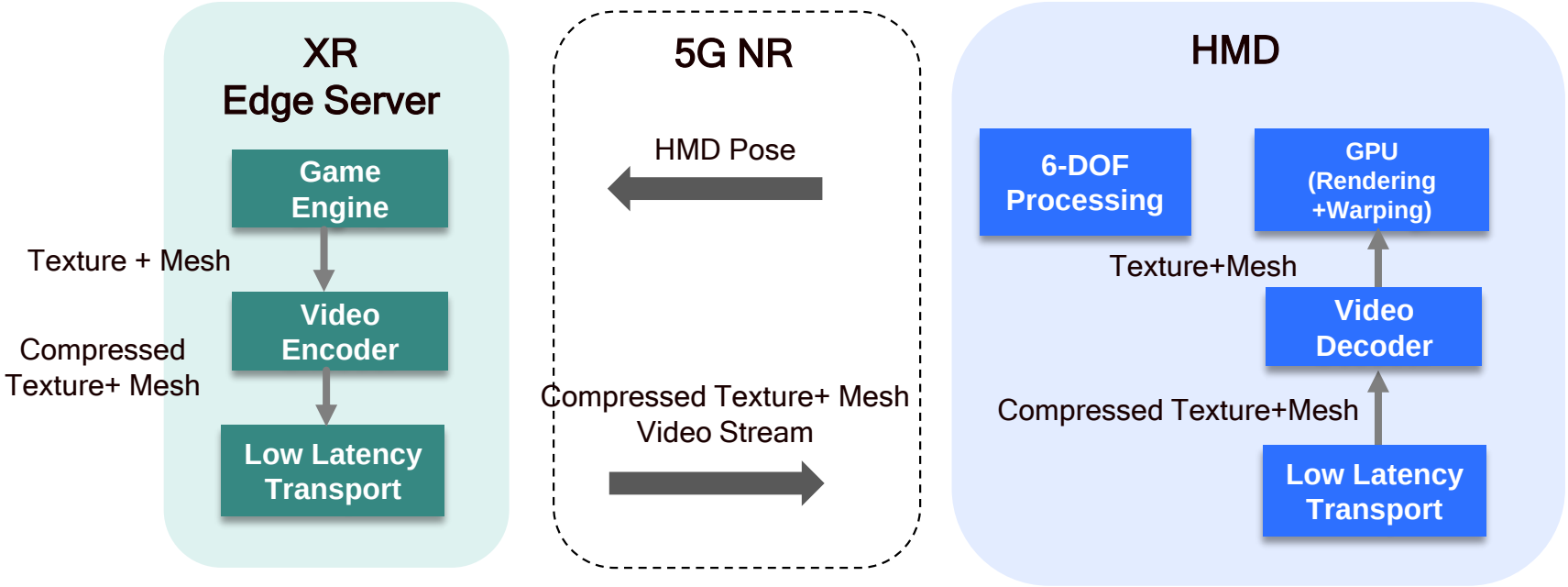
Qualcomm Confidential and Proprietary

Phase 2: Vector Streaming

Split rendering framework based on generating textures and meshes (geometry) for even XR graphics quality

Seamless support for enhanced XR rendering optimizations (e.g. foveated rendering, asynchronous space warp)

System Architecture



Wireless Split Rendering Research

Leveraging 5G to deliver next gen VR/AR Experiences

Mobile Edge Compute

XR content partially rendered on powerful compute resources

5G Wireless

Compressed content delivered via multi-Gbps, sub ms latency wireless link

XR Platform

Power-efficient, latency sensitive rendering and 6-DOF processing

Recap

Recap

What is the state of the art for AR capabilities?
What are the device requirements for the optimal user experience?

Latency, Resolution, Frame Rate,
Video Decode, Power, Connectivity

What is expected to hit the market over the next few years?

New Displays, Neural Network Processors,
VR Hardware Blocks, Connectivity, Immersive Streams

What does the device architecture look like?

XR Optimized Hardware Blocks

Where do you see needs for standards?

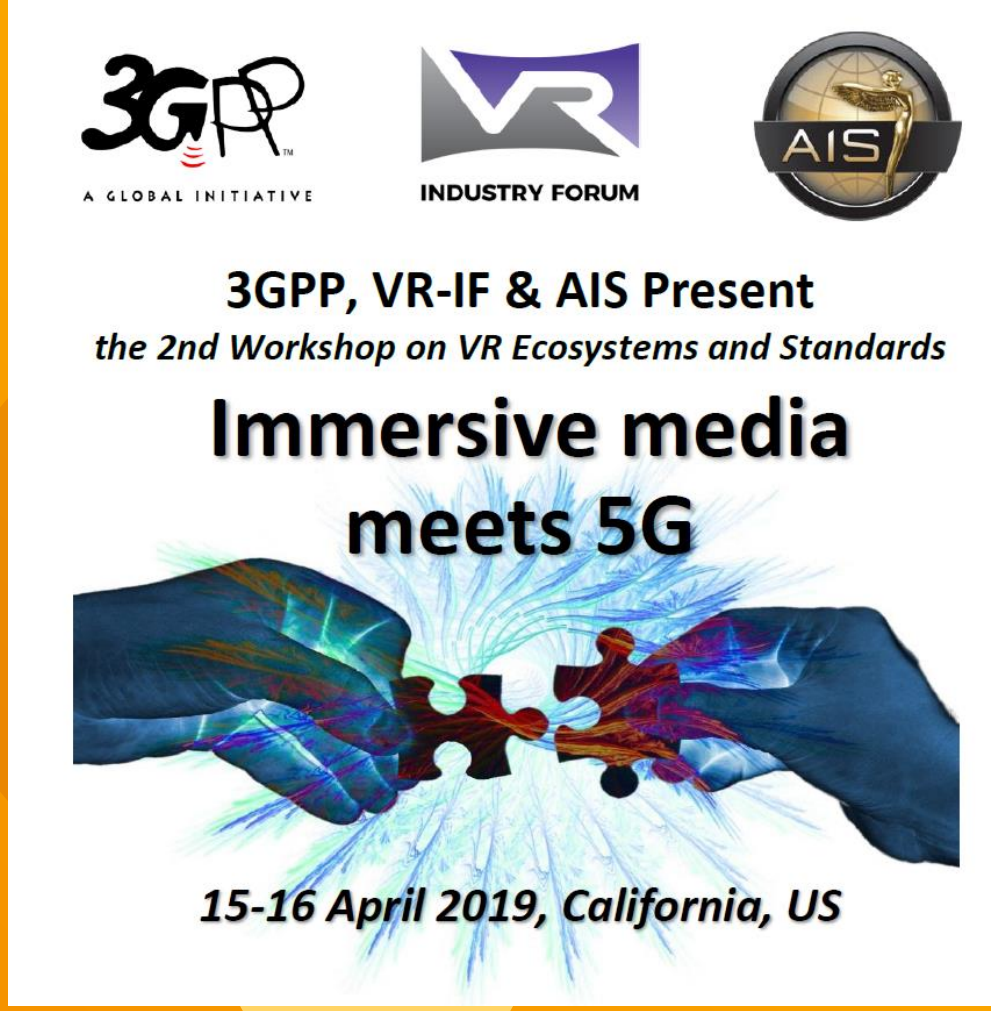
Application / Device APIs (Khronos OpenXR)
Immersive Streaming Content (MPEG-I)
Low Latency Networks (3GPP)

Thank you

Follow us on:

For more information, visit us at:

www.qualcomm.com & www.qualcomm.com/blog



All data and information contained in or disclosed by this document is confidential and proprietary information of Qualcomm Technologies, Inc. and/or its affiliated companies and all rights therein are expressly reserved. By accepting this material the recipient agrees that this material and the information contained therein is to be held in confidence and in trust and will not be used, copied, reproduced in whole or in part, nor its contents revealed in any manner to others without the express written permission of Qualcomm Technologies, Inc. Nothing in these materials is an offer to sell any of the components or devices referenced herein.

©2016 Qualcomm Technologies, Inc. and/or its affiliated companies. All Rights Reserved.

Qualcomm and Snapdragon are trademarks of Qualcomm Incorporated, registered in the United States and other countries. Other products and brand names may be trademarks or registered trademarks of their respective owners.

References in this presentation to "Qualcomm" may mean Qualcomm Incorporated, Qualcomm Technologies, Inc., and/or other subsidiaries or business units within the Qualcomm corporate structure, as applicable. Qualcomm Incorporated includes Qualcomm's licensing business, QTL, and the vast majority of its patent portfolio. Qualcomm Technologies, Inc., a wholly-owned subsidiary of Qualcomm Incorporated, operates, along with its subsidiaries, substantially all of Qualcomm's engineering, research and development functions, and substantially all of its product and services businesses, including its semiconductor business, QCT.