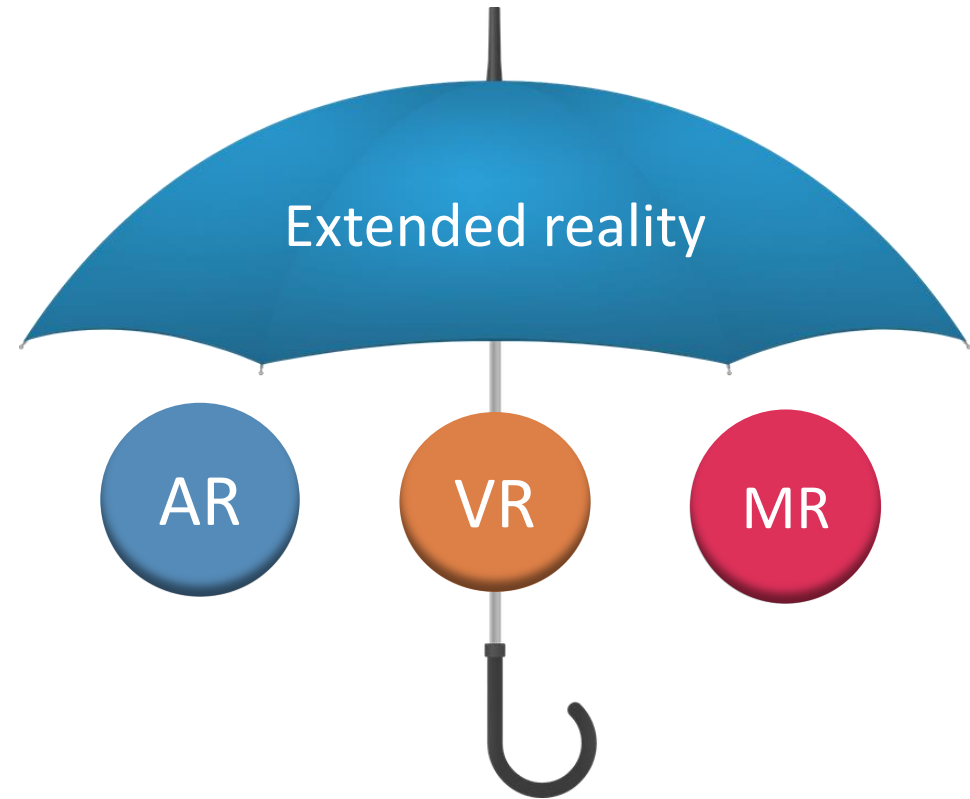


5G and Extended Reality

(XR)

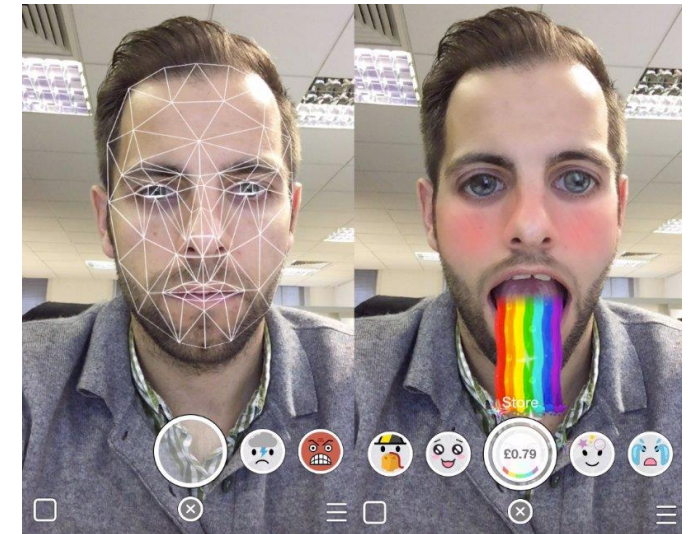
What is eXtended Reality (XR)?

XR is an umbrella term for all the immersive technologies.



Augmented reality (AR)

In augmented reality, virtual information and objects are overlaid on the real world. This experience enhances the real world with digital images, text, and animation. One can access the experience through AR glasses or via screens, tablets, and smartphones. This means users are not isolated from the real world and can still interact and see what's going on in front of them. The most well-known examples of AR are the Pokémon GO game that overlays digital creatures onto the real world or Snapchat filters that put digital objects such as hats or glasses onto your head.



LG U+ AR Dance-Off



Video [link](#)

Virtual Reality (VR)

In contrast to augmented reality, in a virtual reality experience, users are fully immersed in a simulated digital environment. Users must put on a VR headset or head-mounted display to get a 360 -degree view of an artificial world that fools their brain into believing they are, e.g., walking in Jurassic world, swimming with whales or stepping into whatever new world the VR developers created. The gaming and entertainment industry were early adopters of this technology; however, companies in several industries such as healthcare, construction, engineering, the military, and more are finding VR to be very useful.



NTT Docomo VR Example



Video [link](#)

Mixed Reality (MR)

In mixed reality, digital and real-world objects co-exist and can interact with one another in real-time. This is the latest immersive technology and is sometimes referred to as hybrid reality. It requires an MR headset and a lot more processing power than VR or AR. Microsoft's HoloLens is a great example that, e.g., allows you to place digital objects into the room you are standing in and give you the ability to spin it around or interact with the digital object in any way possible. Companies are exploring ways they can put mixed reality to work to solve problems, support initiatives, and make their businesses better.



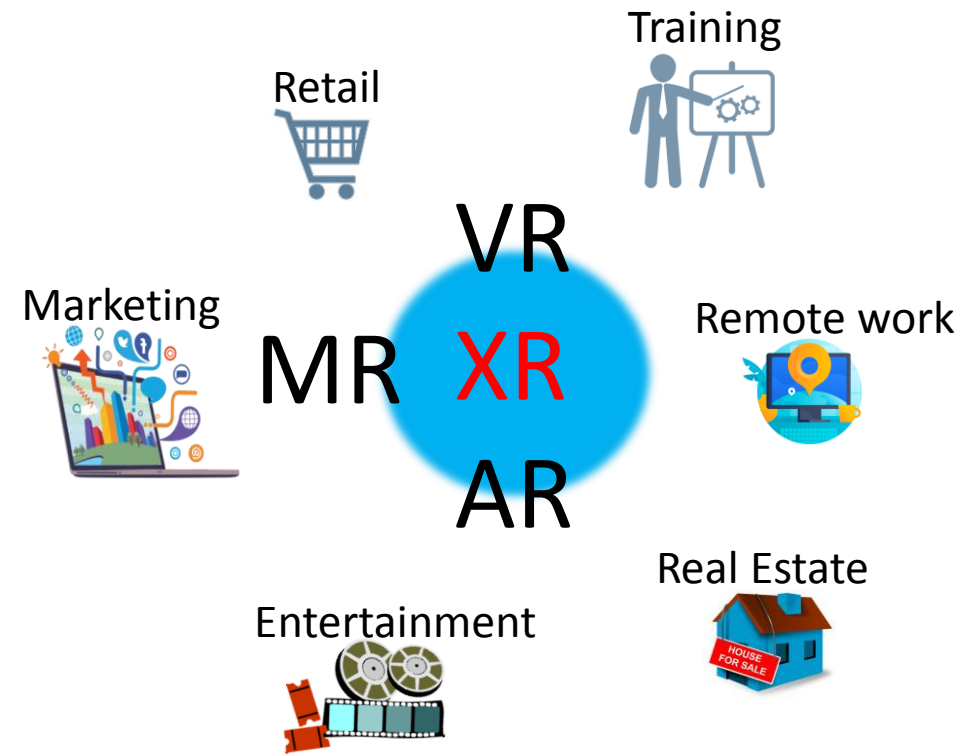
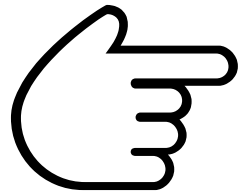
Microsoft HoloLens MR Example



Video [link](#)

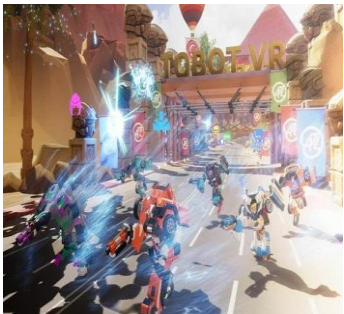
XR Applications for Business

There are many practical applications of XR as shown:



XR will impact everyone and everything

Transform how children learn and play



Children chasing virtual characters/immersive gaming, students using VR aids

Tourists exploring historical sites



Exploring historical sites through VR seeing them in their original state

Families communicating



Families brought together with life-like communication

Working Professionals



Engineers collaborating on shared design to improve efficiency

Health and Fitness



Virtual trainers to motivate fitness groups

People with disabilities



Experiences that might be impossible or unsafe for them in real life. They can run, ski, ride bikes, and climb mountains.

VIRTUAL REALITY HEAD MOUNTED DEVICES



OCULUS



HTC VIVE



SAMSUNG GEAR



GOOGLE
CARDBOARD



POWIS
CARDBOARD

AUGMENTED REALITY HEAD MOUNTED DEVICES



MICROSOFT
HOLOLENS



MAGIC LEAP



MIRA PRISM

A glimpse into the future — everyday AR glasses

Bone conduction transducers

Directional speakers

Tracking and recording cameras

Inertial, haptic,
and health sensors

Multiple high sensitivity
audio microphones

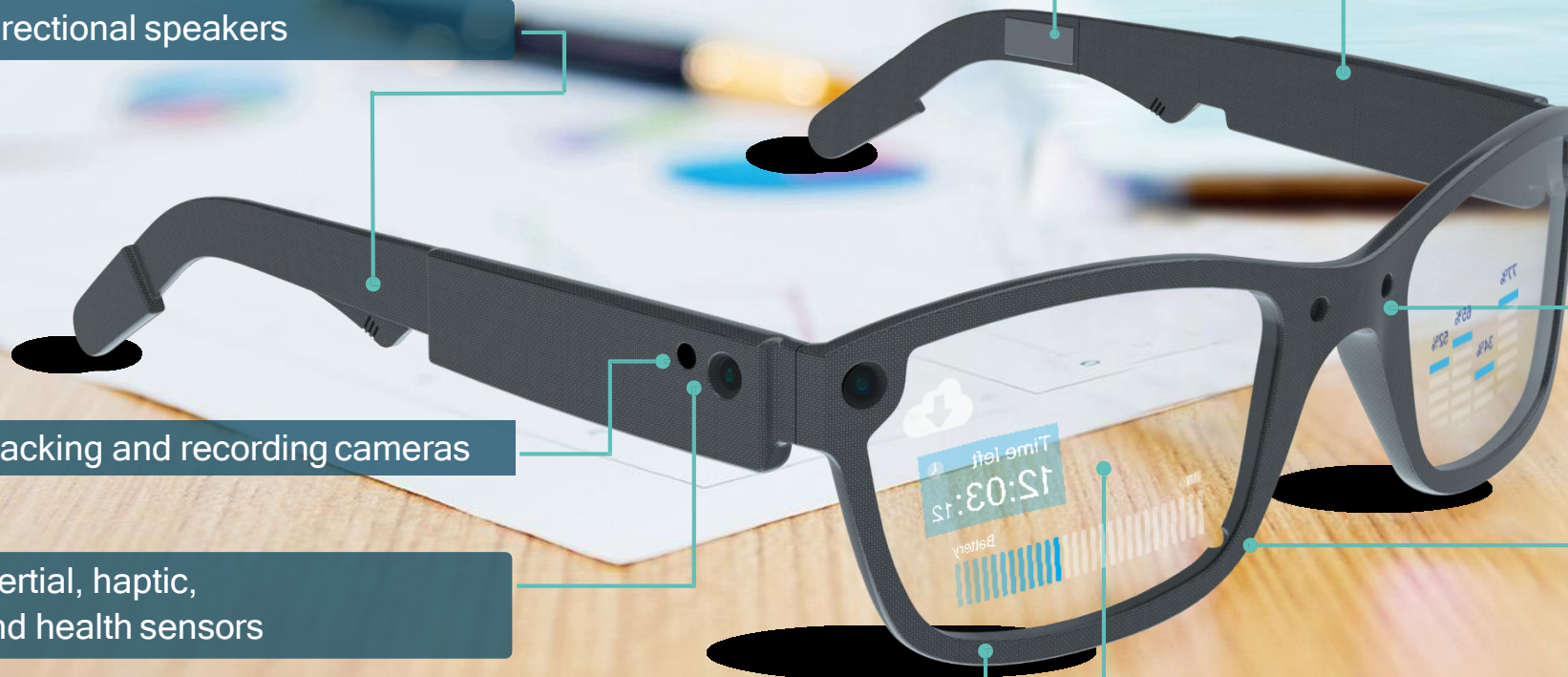
Multimode connectivity
(4G, 5G, etc.)

Many passive and active cameras
with fisheye and telephoto lenses
Optoelectronic night vision
and thermal imaging sensors

Ambient light sensors

Eye tracking cameras

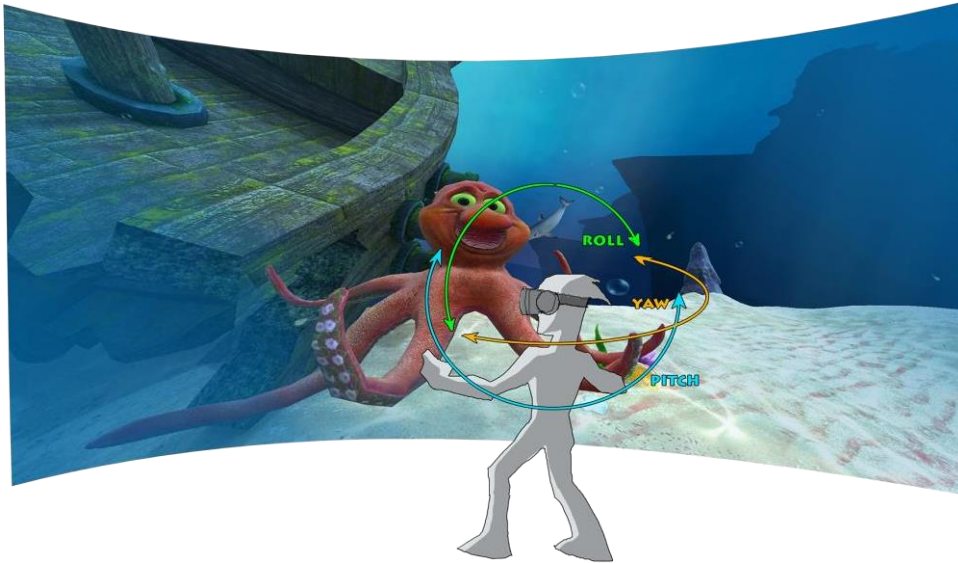
New optics and projection
technologies within a durable,
semitransparent display



6-DoF allows developers to bring the user into their story

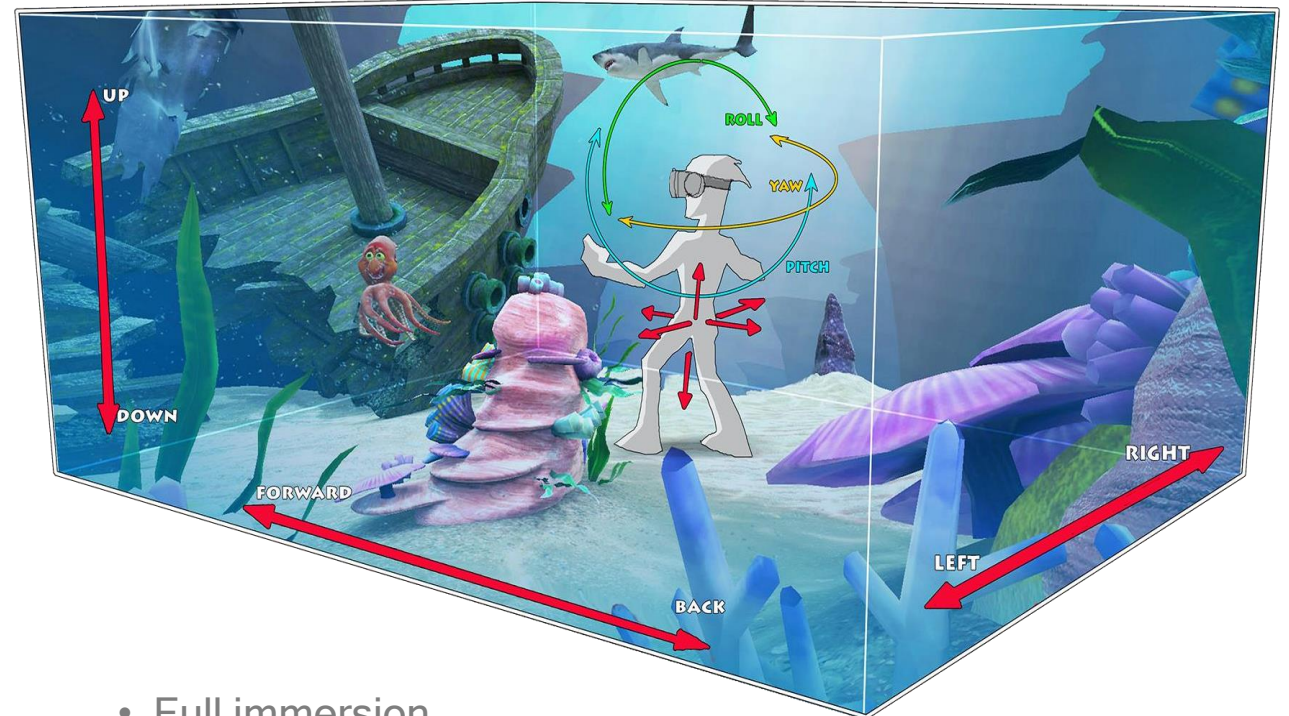
Source: Qualcomm

3 degrees of freedom (3-DoF)



- Can only watch

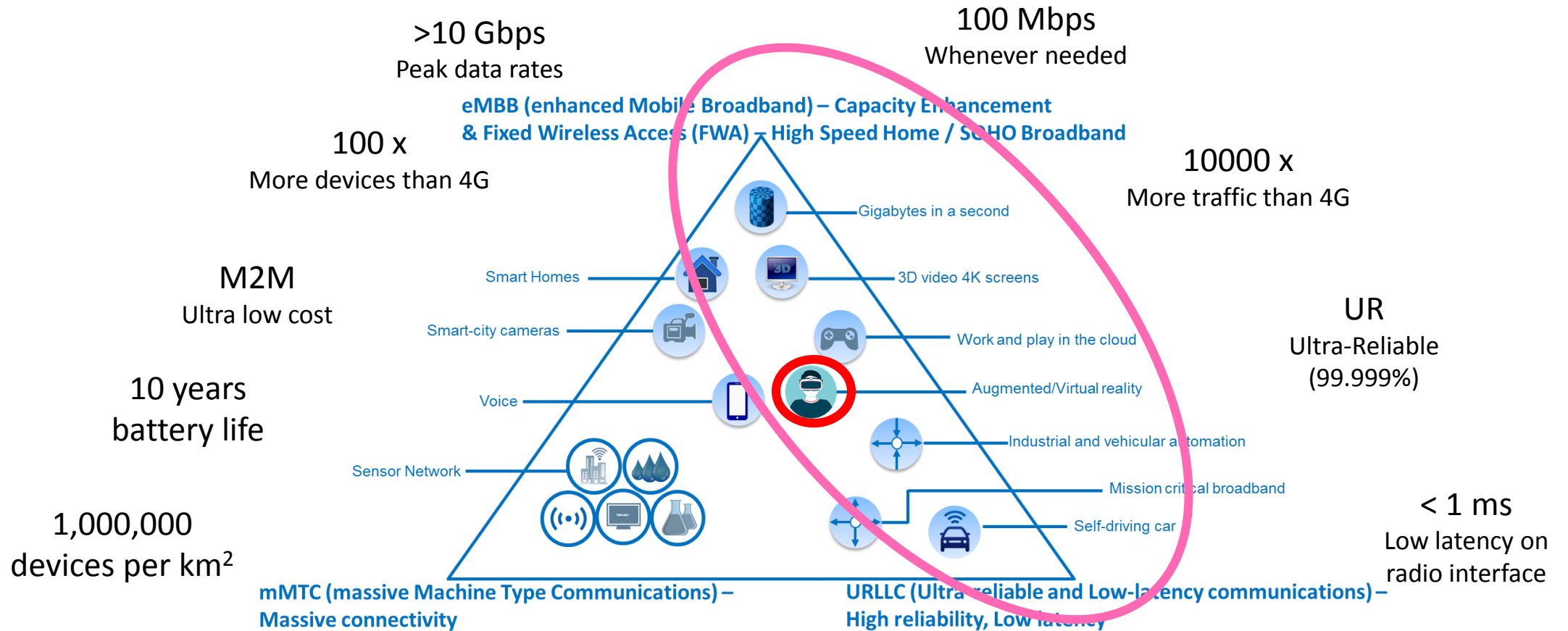
6 degrees of freedom (6-DoF)



- Full immersion
- Can become part of the story
- Can now interact and change the story

5G (IMT-2020) Requirements

ITU-R IMT-2020 requirements



3GPP SA1 service requirements

- In June 2016, SA1 finalized service requirements for 5G called *New Services and Markets Technology Enablers (SMARTER)*
- They are documented in the **TS 22.261 service requirements for the 5G system** ([link](#))
- VR aspects are addressed under ***efficient content delivery*** and ***Low latency and high reliability*** sections.
 - Requirements on the data rate : 250 Mbps
 - Requirements on motion-to sound and motion-to-photon latencies
 - Requirements on audio/video synchronization

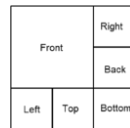
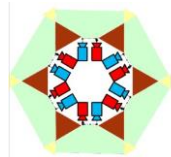
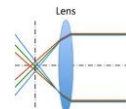
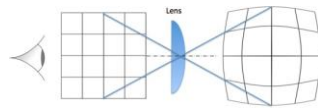
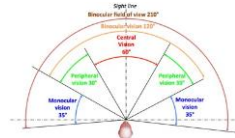
Source: 3GPP Presentation

Checkpoint on VR (360)

April 2016 - June 2017: Study on Virtual reality

Video systems

- Human factors
- FOV and lenses
- Optical aberrations

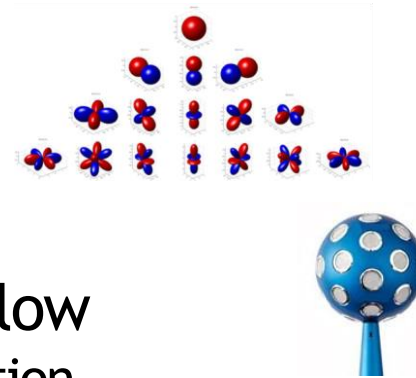


VR Video Workflow

- Capture
- Stitching
- Projection
- Packing
- Encoding/decoding
- Rendering

Audio systems

- Channel based
- Object based
- Scene based



VR Audio Workflow

- Content production
- Audio production formats
- Rendering systems
- Data exchange
- Ambisonics analysis
- Rendering



3GPP
TR 26.918

Virtual Reality
(VR)
media services
over 3GPP

Source: 3GPP Presentation

Checkpoint on VR (360)

Release 15 Technical specification for streaming services

- Definition of **client architecture** and **API** for VR streaming services
- Set of **operating points** covering the large range of device capabilities from Carboards to high-end tethered HMDs.
- Definition of **Media profiles**: mapping of operating points to DASH delivery
- **System metadata** is added to support rendering of 360 experiences on 2D screens, including the aspects of rendering without pose information



Source: 3GPP Presentation

XR over 5G

- XR use cases including AR are further discussed in detail in the 3GPP SA4 study item Extended Reality (XR) in 5G (TR 26.928). The following classification of use cases is identified in the document:
 - Offline Sharing of 3D Objects
 - Real-time XR Sharing
 - XR Multimedia Streaming
 - Online XR Gaming
 - Industrial Services
 - XR Mission Critical
 - XR Conference
 - Spatial Audio Multiparty Call

Source: 5G Americas Whitepaper

XR Devices and Form Factors

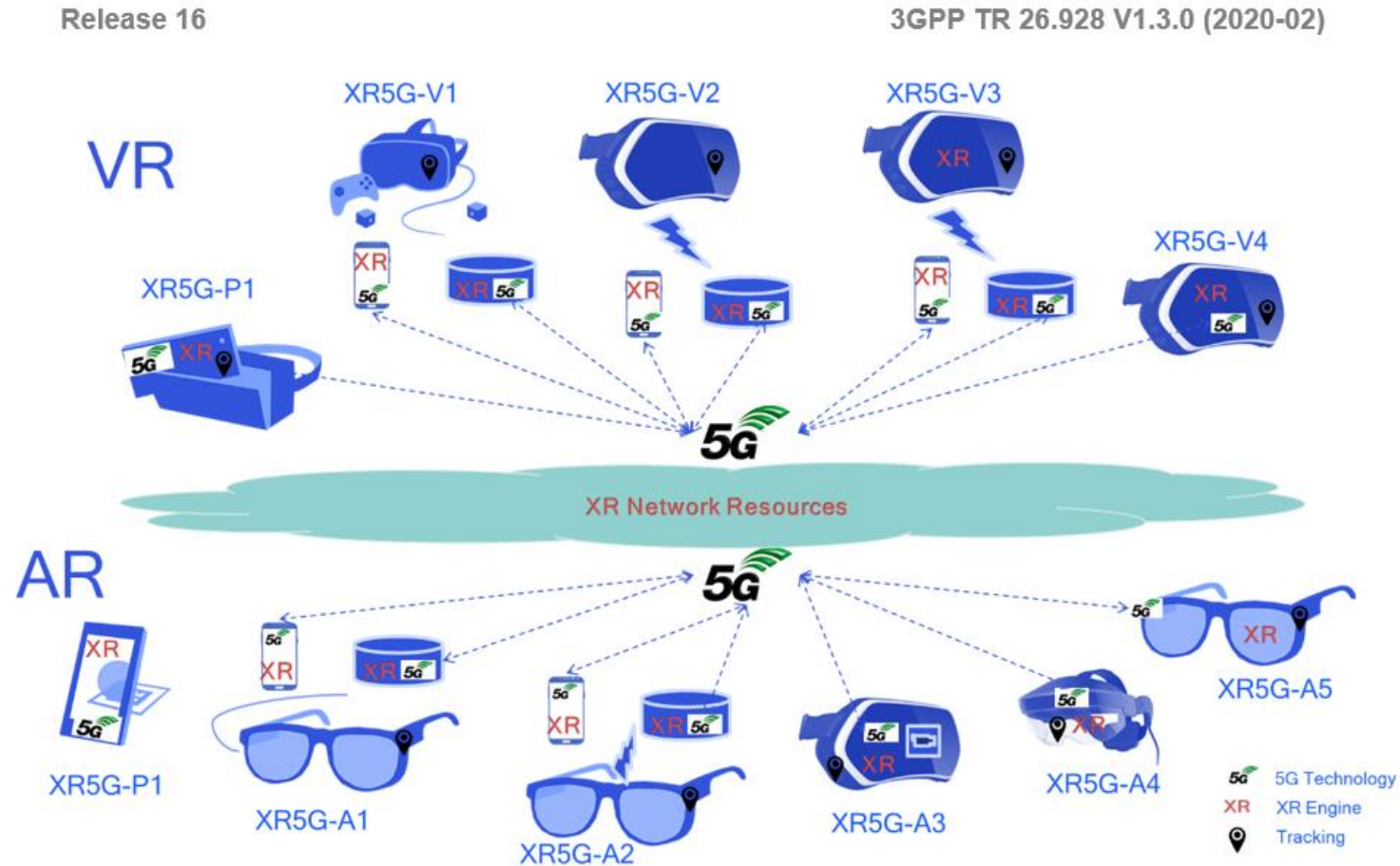


Figure 4.8-1: XR Form Factors

Summary of XR Device Types (3GPP TR 26.928)

XR Type Number	XR Device Type Name	Tethering Examples	5G Uu Modem	XR Engine Localization	Power Supply	Typical Max Avail Power
XR5G-P1	Phone	n/a	XR device	XR device or split	Internal	3-5 W
XR5G-V1	Simple VR Viewer wired tethering	USB-C	External	External	External	2-5 W
XR5G-V2	Simple VR Viewer wireless tethering	802.11ad/y, 5G sidelink, etc.	External	External	Internal	2-3 W
XR5G-V3	Smart VR Viewer wireless tethering	802.11ad/y, 5G sidelink, etc.	External	XR device or Split	Internal	2-3 W
XR5G-V4	VR HMD Standalone	n/a	XR device	XR device or Split	Internal	3-7 W
XR5G-A1	Simple AR Wearable Glass wired tethering	USB-C	External	External	External	1-3 W
XR5G-A2	Simple AR Wearable Glass wireless tethering	802.11ad/y, 5G sidelink. etc.	External	External	Internal	0.5 – 2 W
XR5G-A3	Smart AR HMD see-through standalone	n/a	XR device	XR device or Split	Internal	3-7 W
XR5G-A4	AR Wearable Glass standalone	n/a	XR device	XR device or Split	Internal	2 - 4 W
XR5G-A5	Smart AR Wearable Glass wireless tethering	802.11ad/y, 5G sidelink. etc.	External	XR device or Split	Internal	0.5 – 2 W

5G-XR Functions in 5GS

Release 16

3GPP TR 26.928 V2.0.0 (2020-03)

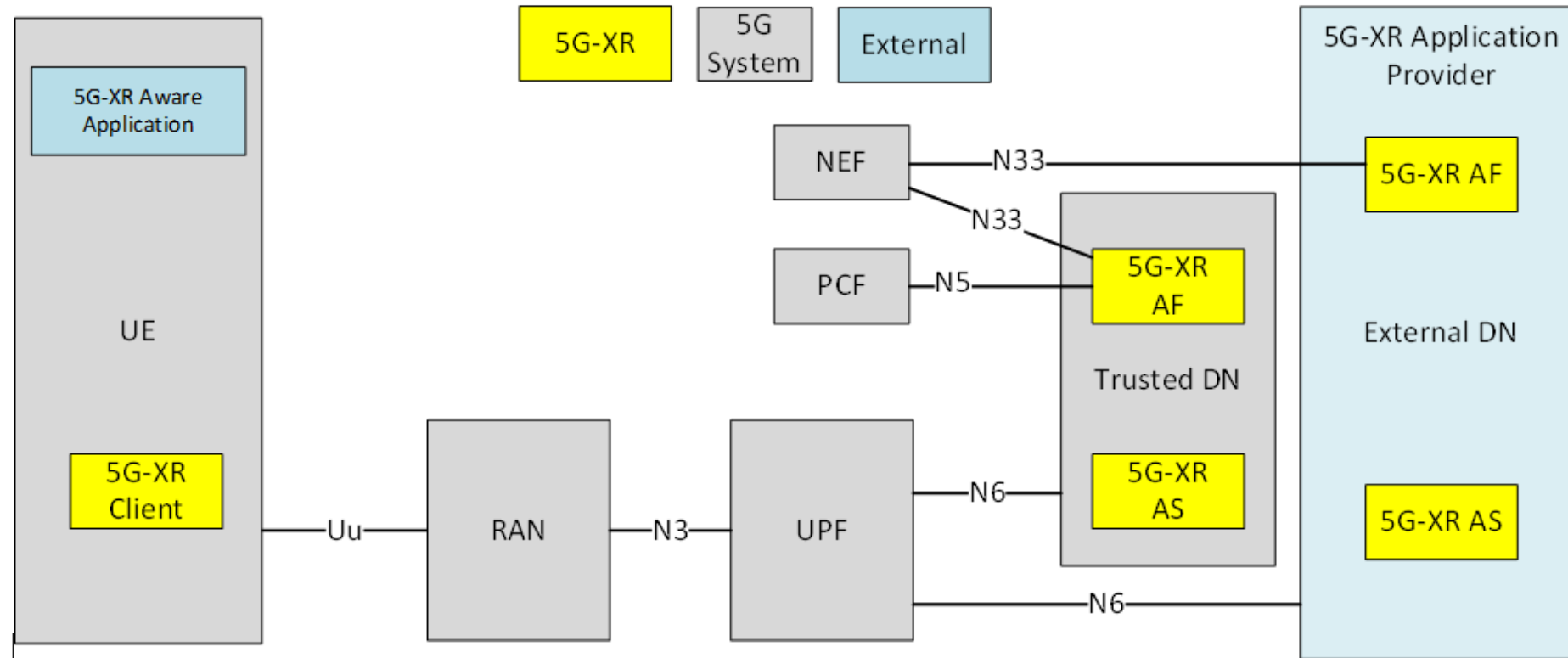


Figure 4.3.2-1: 5G-XR functions integrated in 5G System

XR & Edge Computing

Release 16

3GPP TR 26.928 V2.0.0 (2020-03)

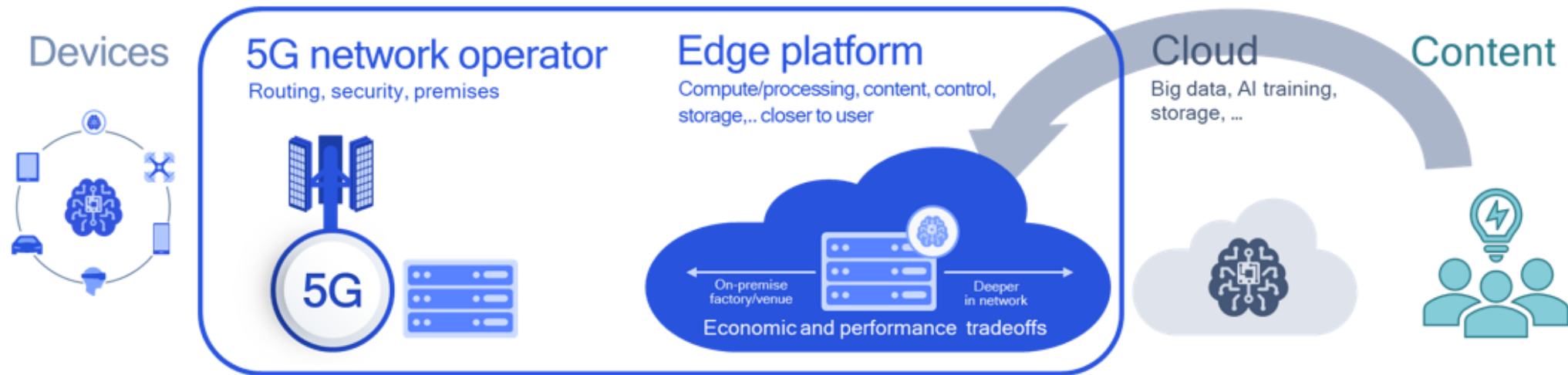




Figure 4.3.5-1 Cloud and Edge Processing

Examples of XR Traffic Requirements

XR Use Case and Architecture		XR gaming with generalized XR architecture	360° XR streaming with Device-based architecture
Uplink requirements	Bitrate	Flow 1: 640 Kbps Flow 2: 16 Mbps	<<640 Kbps
	Packet format	UDP	TCP
	Packet Error Rate (PER)	Flow 1: 1e-3, 1.25 ms Flow 2: 1e-3, 100 ms	1e-6
	Packet Delay Budget (PDB)	Flow 1: 1.25 ms Flow 2: 100 ms	300 ms
Downlink requirements	Bitrate	100-150 Mbps	10-25 Mbps
	Packet format	RTP-UDP	TCP
	Packet Error Rate (PER)	1e-3	1e-6
	Packet Delay Budget (PDB)	10 ms	300 ms

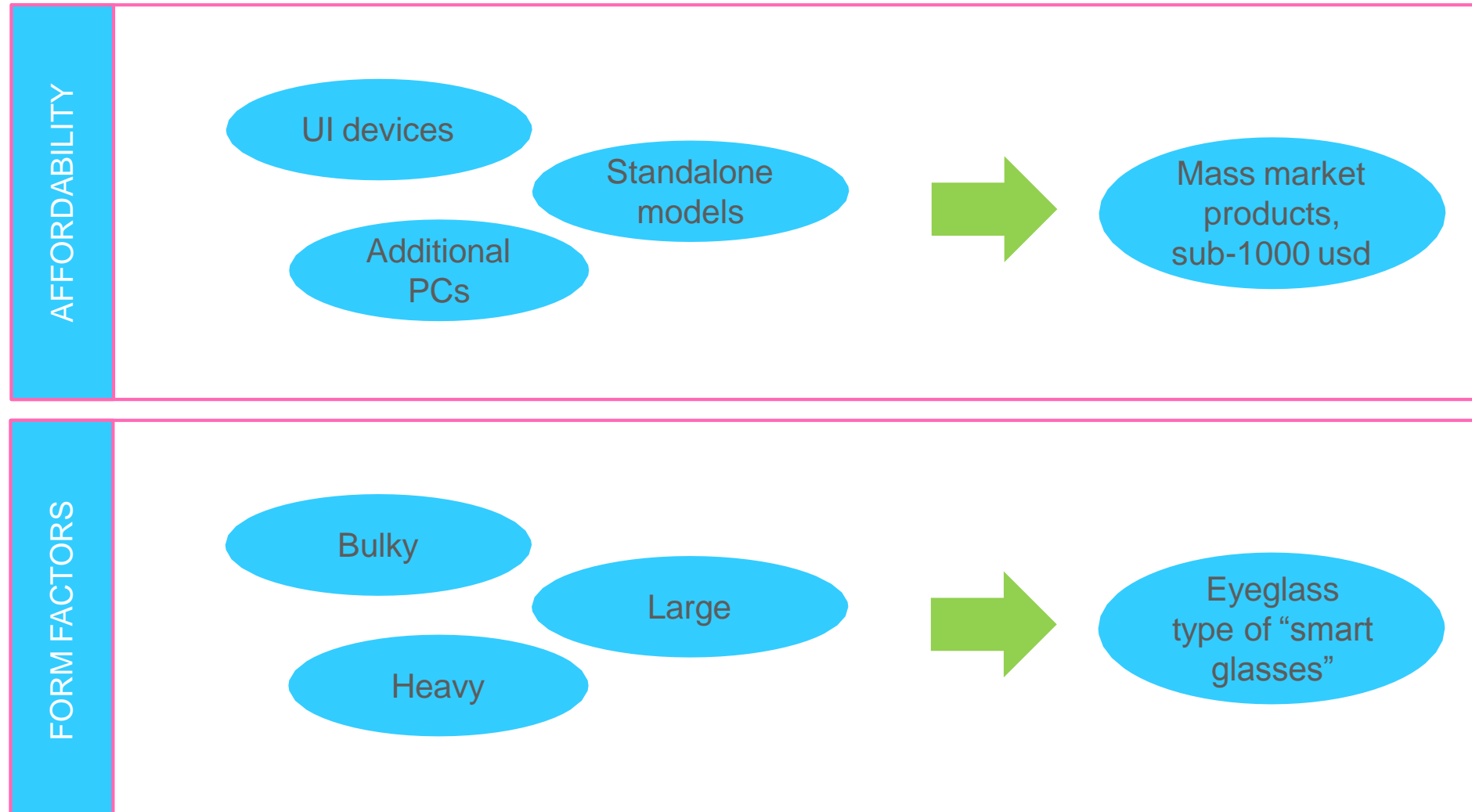
Source: 5G Americas Whitepaper

Telecom VR service 5G network construction standards

ServiceType	Service Scenario				Network Requirement					
	Sub-Scenario	Resolution ratio	Bit rate (Mbps)	Frame rate(fps)	Bandwidth (TCP DL)	Bandwidth (TCP UL)	Network RTT Delay	Minimum RSRP (dBm)	Minimum SINR(dB)	
 Video	VR Panoramic	180° 3D	4K	100	30	150Mbps	1Mbps	≤35ms	-105 dBm	3dB
		360° 2D	4K	40	30	60Mbps	1Mbps	≤35ms	-108 dBm	3dB
		360° 3D	4K	40	30	60Mbps	1Mbps	≤35ms	-108 dBm	3dB
		8K 2D(FOV)	8K	60	30	90Mbps	1Mbps	≤35ms	-110 dBm	2dB
	3D cinema	4K	30	30	45Mbps	1Mbps	≤35ms	-110 dBm	2dB	
	Giant screen cinema	4K	30	30	45Mbps	1Mbps	≤35ms	-110 dBm	2dB	
 Game	VR game (high latency sensitivity)	3K	40	60	80Mbps	4Mbps	≤20ms	-108 dBm	3dB	
	VR game (Medium latency sensitivity)	3K	40	60	80Mbps	4Mbps	≤40ms	-110 dBm	2dB	
	VR game (Low latency sensitivity)	3K	40	60	80Mbps	4Mbps	≤60ms	-110 dBm	2dB	

Source: GSMA Whitepaper 5G Use Cases for Verticals China 2020


Challenge #1: Form factor and high cost barriers




Source: GSMA presentation, see references

Challenge #2: High computing is indispensable

CURRENT HMD COMPUTING NEEDS















+

Additional PC with 

CPU: INTEL i5 – 4590 or higher
GPU: NVIDIA GTX 970 / AMD R9 290

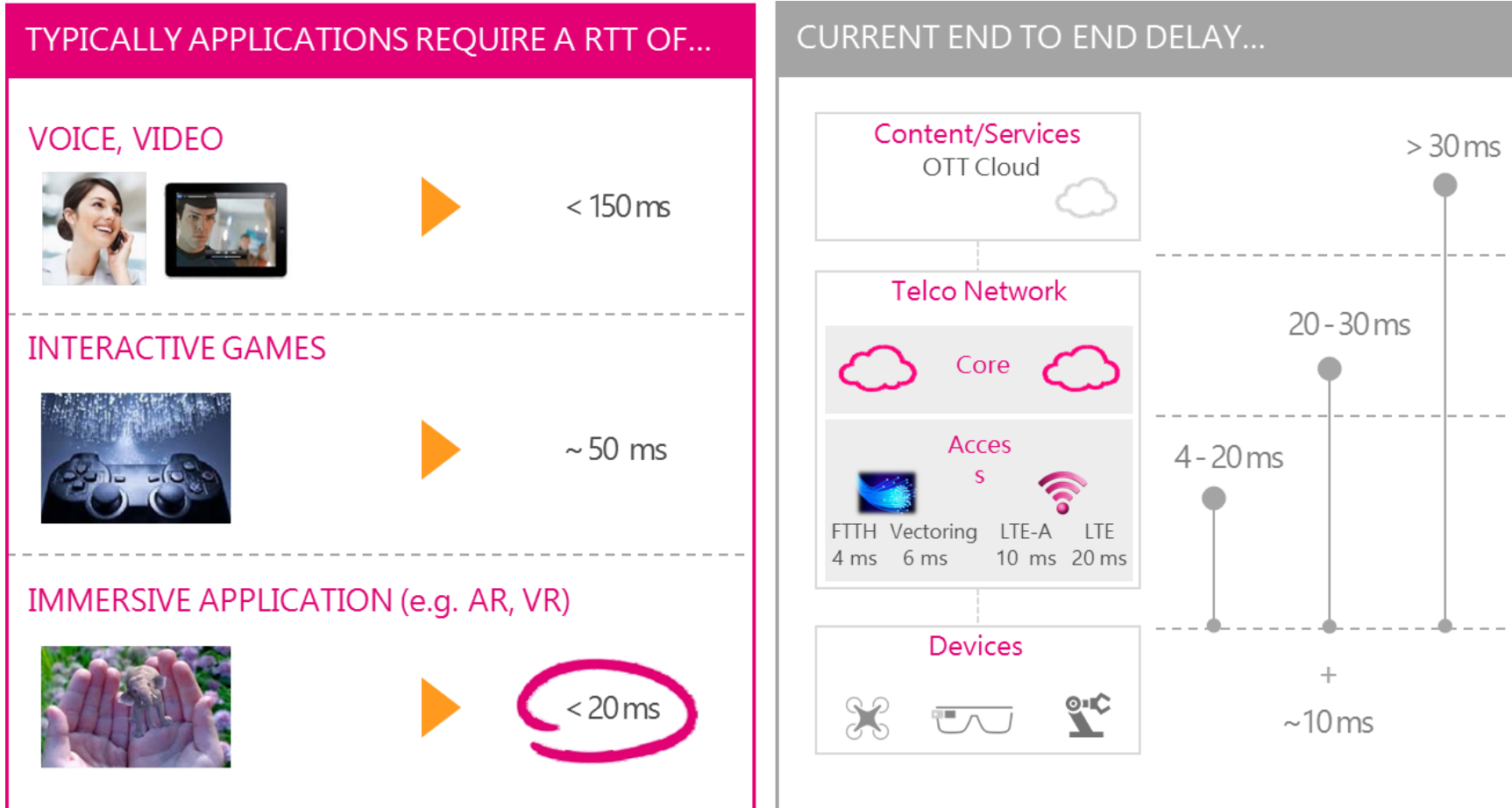
≈ 5000 GFLOPS

COMPUTING POWER COMPARISON

Smartphone  Samsung S7 GPU: ≈ 400 Gflops Cost: €800	 Serves 1 User	 Battery Powered
Consoles  Router, PS4 / XBox ² GPU: <2000 Gflops Cost: €400	 Serves 1 - 3 users	 Grid Powered
Network Edge  Blade Server X Tflops Cost: €20 - 50k		 Grid Powered
Central Data Center  Blade Servers Y Exa-Pflops Cost: €1 - 5mn		 Grid Powered

Source: GSMA presentation, see references

Challenge #3: Latency is the key



Source: Graphical Processing for Immersive VR, AMD; Expert estimation, two way delay/network performance, Deutsche Telekom

Source: GSMA presentation, see references

References

- 3GPP TR 26.928: Extended Reality (XR) in 5G (Release 16) ([link](#))
- Qualcomm: VR and AR pushing connectivity limits ([link](#))
- 5G Americas: 5G Services Innovation Whitepaper, November 2019 ([link](#))
- Qualcomm: VR Device/hardware Ecosystem ([link](#))
- 3GPP achievements on VR & ongoing developments on XR over 5G - Gilles Teniou, 3GPP SA4 Vice-Chairman, Orange ([link](#))
- 3GPP activities around Virtual Reality - Gilles Teniou – 3GPP SA4 Vice Chair / VIDEO SWG Chairman ([link](#))
- The activities of GSMA on 5G and Cloud AR/VR ([link](#))
- China Mobile: Cloud AR in 5G Era ([link](#))

Thank You

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