

# Cloud X: CG Cloud VR Technical Specifications

(Revised Draft v1.0)



**VR**  
Virtual Reality

**X Labs**  
Wireless

## Background of CG Cloud VR

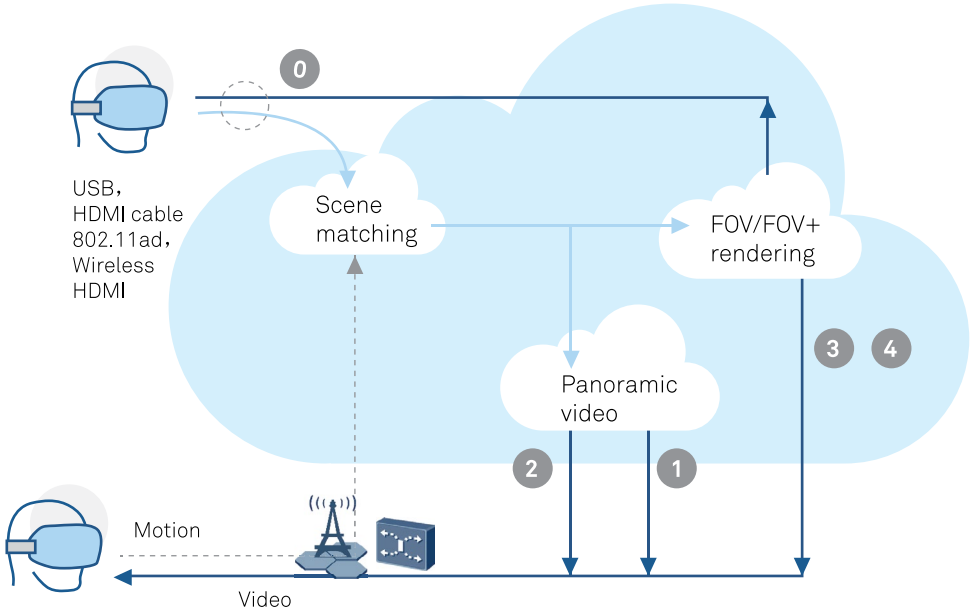
- Virtual reality (VR) uses three degrees of freedom (3DOF) panoramic videos or 6+DOF (Degree of Freedom) real-time computer graphic (CG) renders.
- Panoramic videos are used for on-demand and live streaming with 360-degree real-world videos, where the positions and visual angles in virtual scenes are fixed. CG renders are typically used for gaming, training, or collaboration, where the positions in virtual scenes are flexible, and different visual angles can be created. All of the CG-based virtual scenes are rendered using specialized graphics processing units (GPUs) in real time. They are highly immersive and are advanced forms of VR.
- The existing CG VR usually uses head-mounted displays (HMDs), HDMI or USB cables, and personal computers (PCs). Some vendors have replaced HDMI and USB cables with the 60GHz frequency and other IEEE 802.11 technologies to deliver wireless LAN connections between the HMD and PC, enabling them to provide multi-Gbps data rates.
- Panoramic video streaming has applied wireless WAN connections. However, whether CG VR can use wireless WAN connections has not yet been proven in the industry. CG VR systems and future WAN IP network capabilities would need to match with one another in order to produce a feasible solution.
- Our vision is to enable wireless WAN connections for CG VR and cloudify GPU resources to reduce user investment and enhance service iteration capabilities. We aim to make CG VR, the first high-value service of Enhanced Mobile Broadband (eMBB), everywhere.

### **Producing the world's first high-value eMBB service (100+ Mbps data rates and 5 ms latency).**

## Objectives of CG Cloud VR Technical Specifications (Draft)

- This draft aims at clarifying E2E industry capabilities of CG VR and aligning relevant understandings. This helps interworking among CG VR systems, WAN IP networks, and public clouds, and propels the initial ecosystem establishment.
- Use cases developed based on this draft shall be perceived intuitively and experienced in lab and field tests.
- Use cases are developed using experimental modeling and conjoint analysis to help optimize the CG Cloud VR protocol and mechanism. The use cases can provide the basis for the best match for the cloud, 4.5G and 5G networks, and other WAN IP networks.
- **The CG Cloud VR Technical Specifications** will eventually achieve an industry consensus and form a business ecosystem.

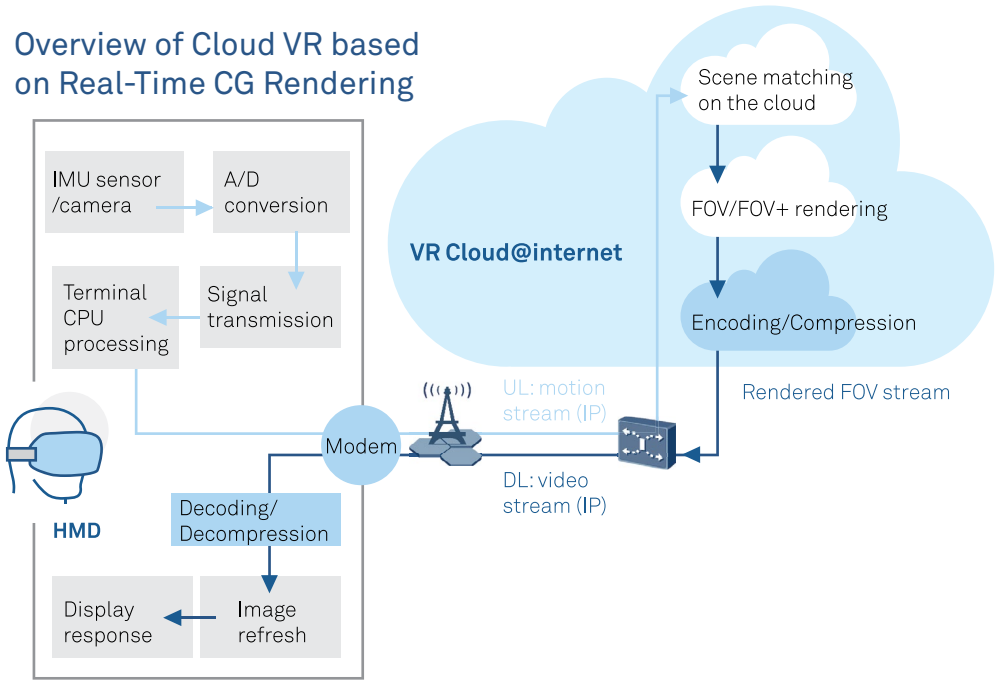
# Five-Step Development of Cloud VR



Future

0	1	2	3	4
<b>PC VR</b>	<b>Panoramic Video VR</b>	<b>FOV Video VR</b>	<b>CG Cloud VR</b>	<b>Extreme Experience</b>
Single FOV: 1080x1200p DOF: 6 Frame rate: 90 FPS Bit rate: 5.6 Gbps (24 bits) 2.8 Gbps (12 bits) (No compression or cellular network requirements)	Single FOV: 720p Round-trip time (RTT): 50 ms DOF: 3 Frame rate: 30 FPS Bit rate: 20–25 Mbps (12 bits) (for 4K panoramic video streaming, pseudo-3D)  Bit rate: 80–100 Mbps (12 bits) (for 8K panoramic video streaming, pseudo-3D, FOV 2K)	Single FOV: 1080x1200p RTT: 20 ms DOF: 3 Frame rate: 30 or 90 FPS Bit rate: 12 or 37 Mbps (12 bits)  Single FOV 4K, 80 or 240 Mbps (12 bits) Single FOV 6600x6600p, 0.4 or 1.2 Gbps (12 bits) (for prestored stereo panoramic video streaming, real 3D)	Single FOV: 1080x1200p RTT: 5–10 ms DOF: 6+ Frame rate: 60–90 FPS Bit rate: 100–150 Mbps (24 bits) (Compression ratio: 40:1) (for rendered FOV transmission, real 3D)  3.1: 3dof / 30FPS 3.3: 3dof / 60FPS 3.6: 6+dof / 60FPS	Single FOV: 6600x6600p (Entry-level retina experience) RTT: 5 ms DOF: N Frame rate: 90–120 FPS Bit rate: 9.4 Gbps (12 bits) (Compression ratio: 10:1) Bit rate: 4.7 Gbps (24 bits) (Compression ratio: 40:1) (for rendered FOV transmission, real 3D)

# Overview of Cloud VR based on Real-Time CG Rendering



## Flexible Deployments based on IP Cloud, Wi-Fi, and Cellular Networks

### IP Cloud (fixed)

The Luminance-Bandwidth-Chrominance (YUV) and Video Graphics Array (VGA) data generated from CG are encoded, compressed, and converted into IP packets.

Ethernet cables replace HDMI and USB cables for downlink data transmission and uplink feedback.

The HMD and rendering host are connected using the client-server model, allowing multiple users to share host resources.

### Wi-Fi-based

The IEEE 802.11 ac technology replaces Ethernet cables for downlink data transmission and uplink motion feedback, achieving local mobility.

Coding and compression algorithms are adapted for wireless signal and bandwidth fluctuations and certain bit errors.

Coding and compression algorithms can achieve balance between the latency and bandwidth.

Typical network requirements: 2 ms latency and 300 Mbps data rates

### Cellular-based (5G)

4.5G or 5G networks replace Wi-Fi to achieve wide-area mobility.

Algorithms are adapted for wireless signal and bandwidth fluctuations, certain bit errors, latency, and jitter.

Coding and compression algorithms achieve optimized balance between the latency and bandwidth.

Typical network requirements: 5 ms latency and 150 Mbps data rates



## WAN IP Network Capability Assumptions

### 4.5G network capabilities:

- E2E RTT: 10–15 ms; jitter: 10%; packet loss rate: less than 0.05%
- Downlink bandwidth: 50 Mbps,  $\pm$  20%
- Uplink bandwidth: 2 Mbps,  $\pm$  20%

### 5G network capabilities:

- E2E RTT: 5–8 ms; jitter: 10%; packet loss rate: less than 0.05%
- Downlink bandwidth: 100 Mbps,  $\pm$  20%
- Uplink bandwidth: 20Mbps,  $\pm$  20%

**Home Wi-Fi capabilities in developed regions can refer to 5G network capabilities.**

**Cloud rendering latency shall be less than 5 ms.**

## Experience Constraints

- Latency: Motion-to-Photon (MTP) < 20 ms
- Binocular resolution: > 2K (4.5G)  
> 3K (5G)
- Frame rate: > 60 FPS (4.5G)  
> 90 FPS (5G)

## Video Codec Capabilities

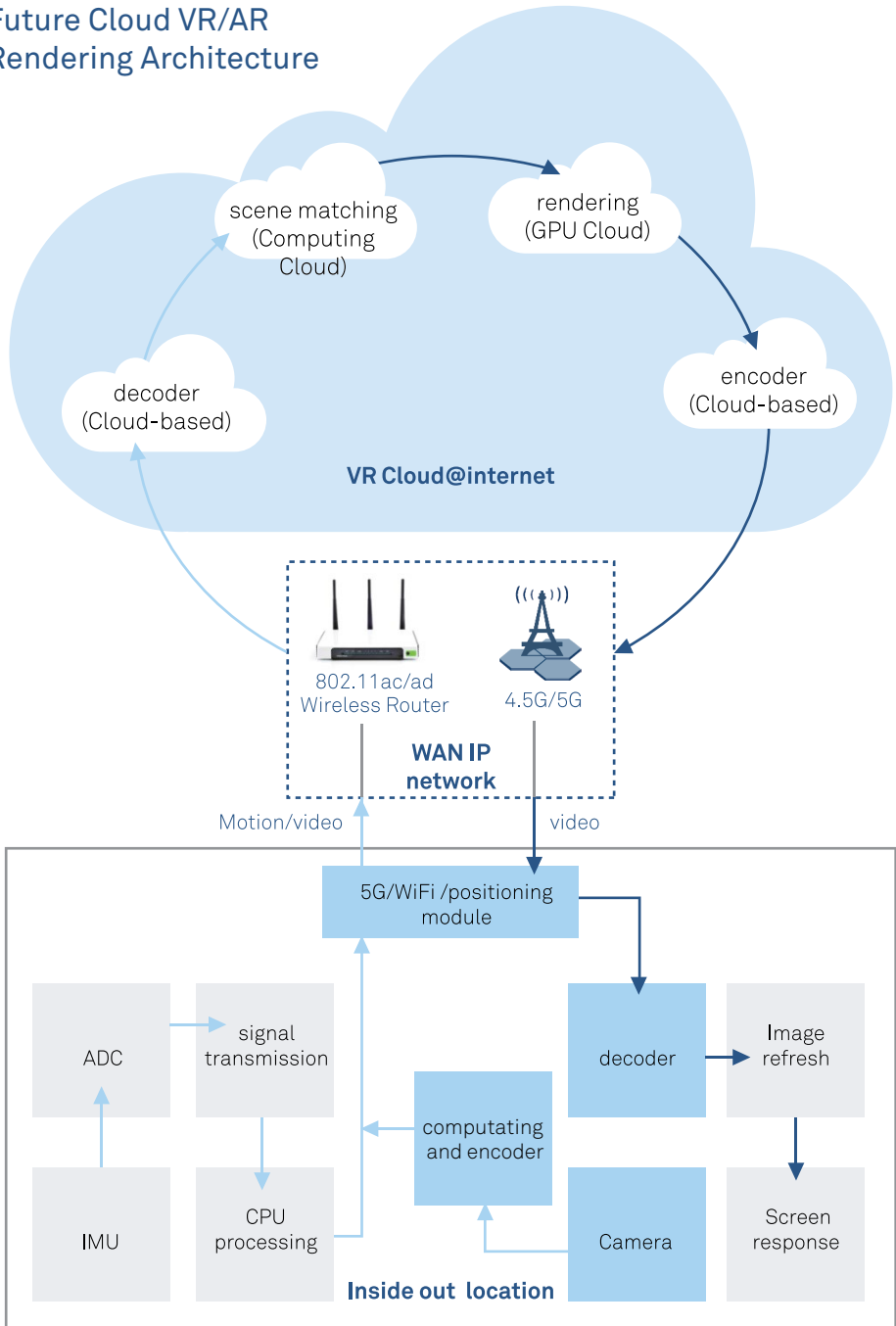
### Performance requirements:

- Compression ratio (uplink and downlink): > 40:1
- Encoding and decoding latency (unidirectional): < 1 ms
- Gyroscope/Motion refresh frequency: > 1 kHz

### Deployment requirements:

- Hardware or software coding can be applied.
- Parameter negotiation works between codecs.
- Network bandwidth, latency, and modes can be perceived through communication with the Modem.
- The bandwidth and delay can be balanced. Policies can be set manually and adjusted adaptively.

# Future Cloud VR/AR Rendering Architecture



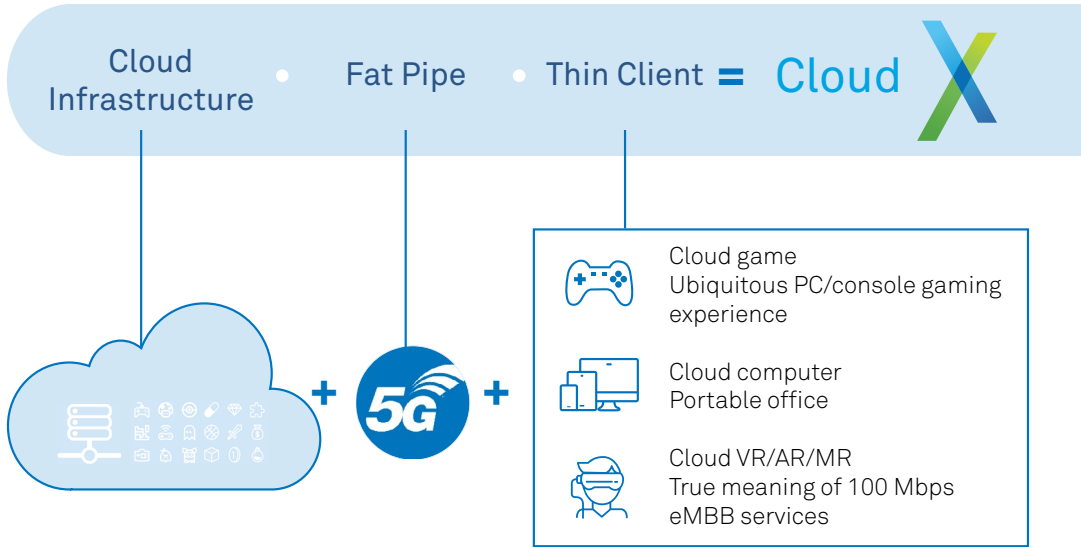
Future HMD (with built-in wireless module, GPS, and inside-out positioning camera)

## Potential cooperation direction



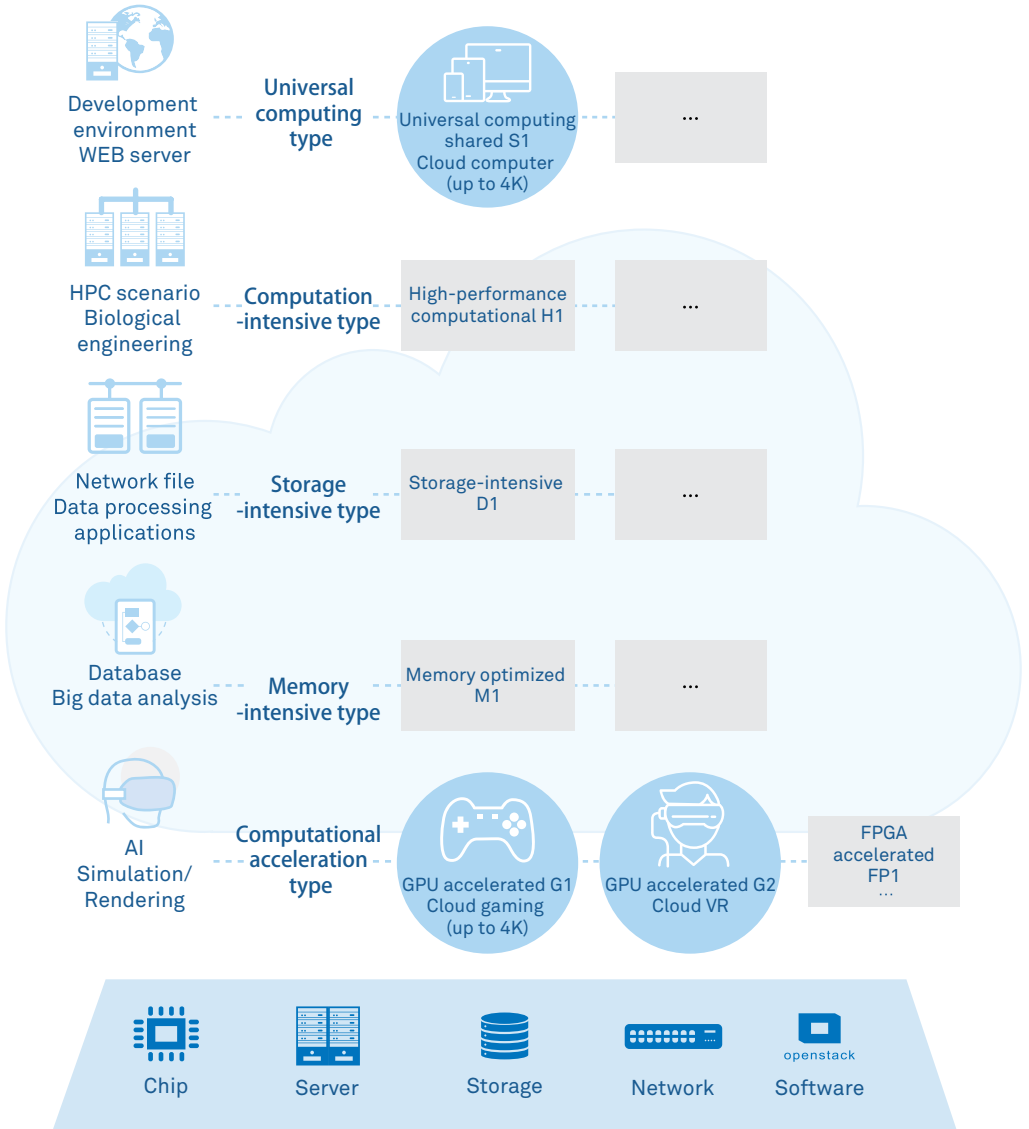
- Low-latency video encoding compression and decoding
- CG cloud VR application-layer transmission protocol
- Low-latency GPU rendering cloud
- AR/VR HMD integrated with 4.5G/5G communication module, low-latency video encoding and decoding module, and wide-area locating/tracing module
- VR content operation management platform (user management, dynamic resource allocation, and so on)
- Outdoor innovative applications based on real-time cloud rendering VR/AR
- E2E solution innovations oriented to CG cloud VR application

# More Cloud 'X' Services



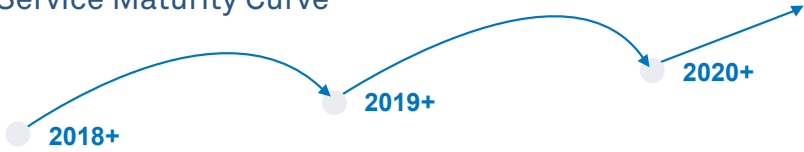


# On-demand Service Cloud Capability Adapting to Diversified Service Requirements



Cloud services will evolve from IaaS to IaaS+PaaS+BigData+IoT+AI. Relying on the rapid and iterative cloud capabilities, individuals, families, and enterprises can continue to use the latest services. For example, by means of computationally accelerated cloud services, PC gaming and VR that require complicated graphics processing can be moved to the cloud, enabling cloud resource sharing and rapid content delivery.

# Cloud X @ eMBB Network Capability and Service Maturity Curve



Virtual machine (AI inside):  
 CPU: like Intel Core i3 +  
 RAM: 2+ GB  
 GPU: integrated graphics card

Network:  
 Bandwidth: 20+ Mbps  
 Latency: < 30 ms  
 Jitter: < 20%

Terminal:  
 Large-screen terminal  
 TC+Screen

Virtual machine (AI inside):  
 CPU: like Intel Core i5 + RAM: 4+ GB  
 GPU: like NVIDIA GTX 745+

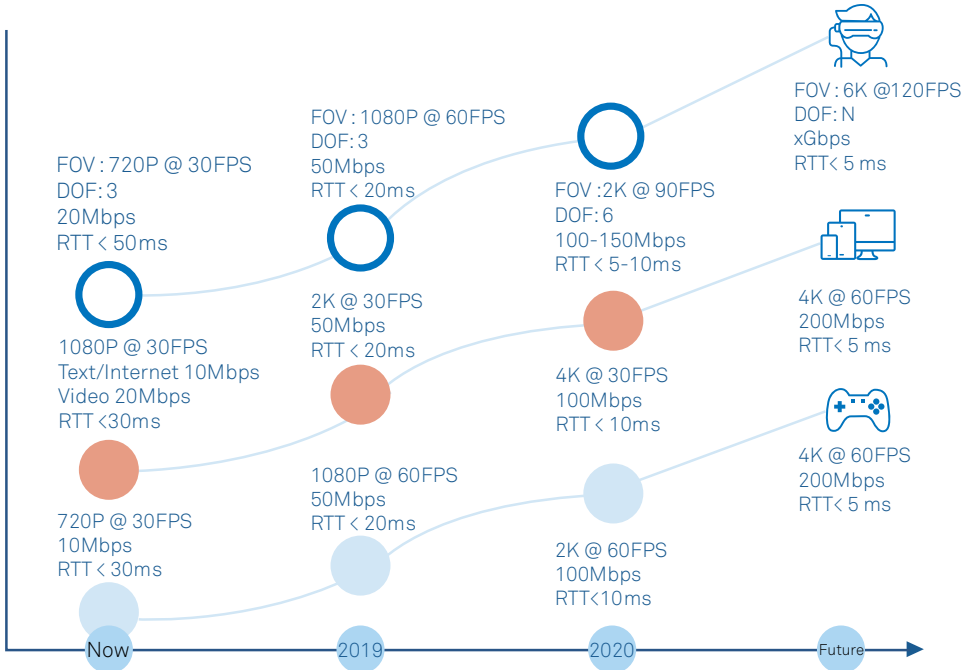
Network:  
 Bandwidth: 50+ Mbps  
 Latency: < 20 ms  
 Jitter: < 15%

Terminal:  
 Large-screen terminal  
 TC+Screen

Virtual machine (AI inside):  
 CPU: like Intel Core i7 +  
 RAM: 8+ GB  
 GPU: like NVIDIA GTX 1060+

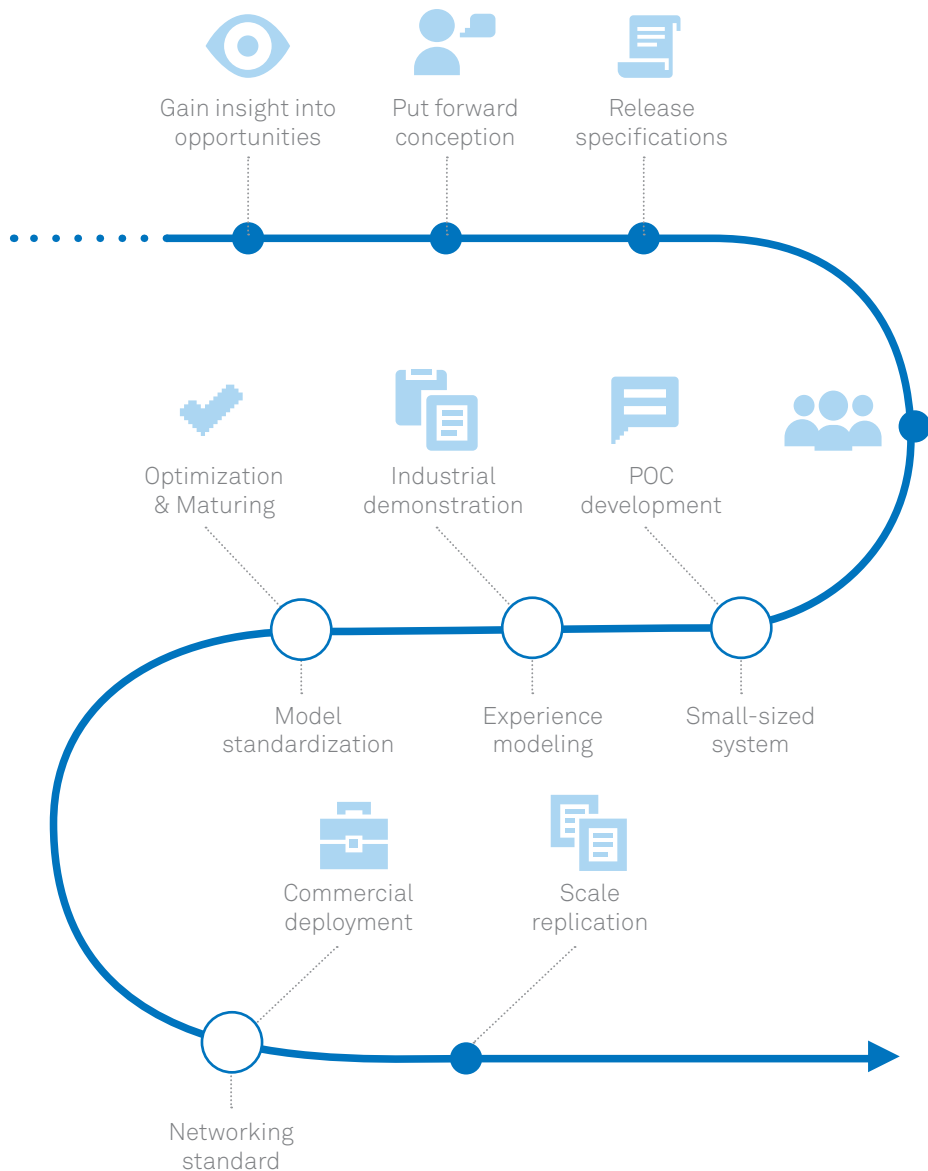
Network:  
 Bandwidth: 100+ Mbps  
 Latency: < 5 ms  
 Jitter: < 10%

Terminal:  
 HMD/Glass



On-demand service delivery capability based on cloud and scale deployment of 4.5G/5G network, together with cloud virtual machine (AI inside)+wide-area IP network bus+new terminals, will reshape the ICT industry and require readaptation among standards, protocols, and network architecture.

# Cloud X @ eMBB Service Incubation Path



Together with our industry partners, we have started with opportunity insight and conception formation. We will make small-sized system prototypes and industry demonstrations as short-term goals, and ultimately incubate eMBB services for scale commercial use.

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