



6G

FLAGSHIP

UNIVERSITY
OF OULU

XR in the 6G Age

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- 20+ years in Base Station R&D (NEC, Nokia)
- From R&D to Verticals, implementation and validation
- Research on 6G innovation with Extended Reality (XR)
 - Cyber Physical Fusion
 - Enhancing real environments with digital intelligence



Why XR in telecommunication?

Immersive Experiences → Remote Productivity.

Current communication focuses on connection, not collaboration

- Texts, video calls, screen sharing — all limited to **2D interfaces, one-way**.
- True collaboration happens through **motion, gesture, and presence**.

XR enables this new form of collaboration

- Merging digital and physical spaces for **co-creative work**.
- Integrating visual, motion, audio, and sensor data **in real time, in remote control**.

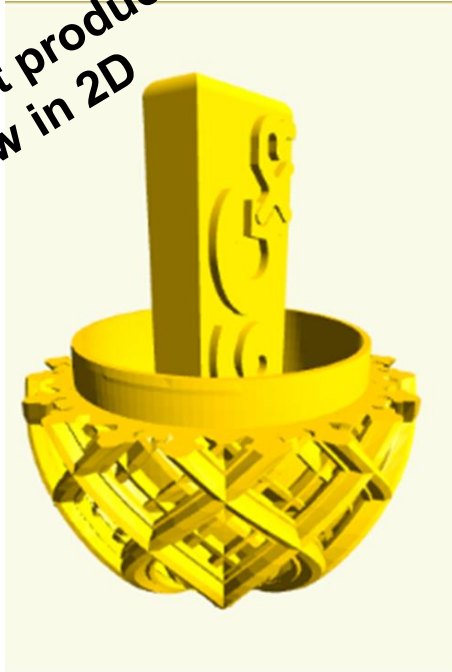
New network challenges

- These **heterogeneous, multimodal** data streams cannot be handled by conventional network QoS models.
- XR traffic is dynamic and interaction-driven requiring adaptive resource control through **network slicing**.

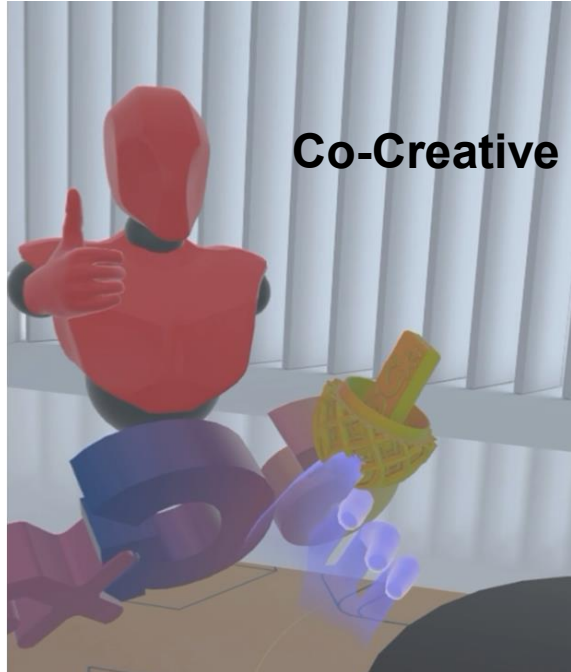


6G symposium in Levi Finland,
April 2024

Over night production
3D review in 2D



Co-Creative



Next generation remote work Co-Creative collaboration space



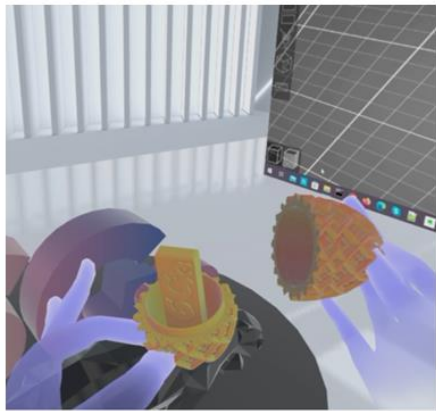
References:

- K. Komatsu et al., "Addressing 3D Digital Twin in XR Remote Fab Lab Over Sliced 5G Networks," EuCNC/6G Summit 2025, pp. 506–511, doi:10.1109/EuCNC/6GSummit63408.2025.11036986.
- 6G-XR Deliverable D6.2 — 3D Digital Twin XR Use Case Integration and Validation

Collaborative 3D Digital Twin Fab Lab

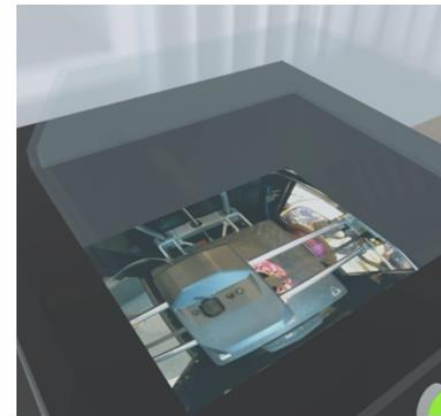
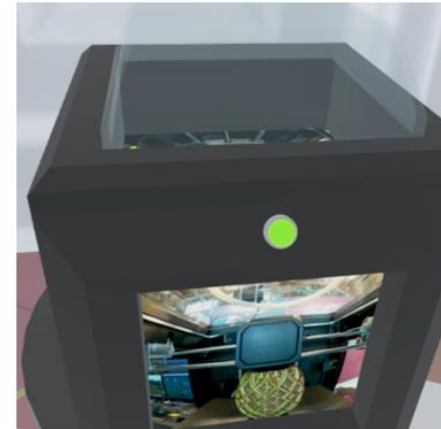
Telepresence Immersive Prototyping:

- Remote instructor and user review 3D design before fabrication
- Real-time interaction using voice and hand-tracked gestures
- Users can see and inspect the actual size and shape



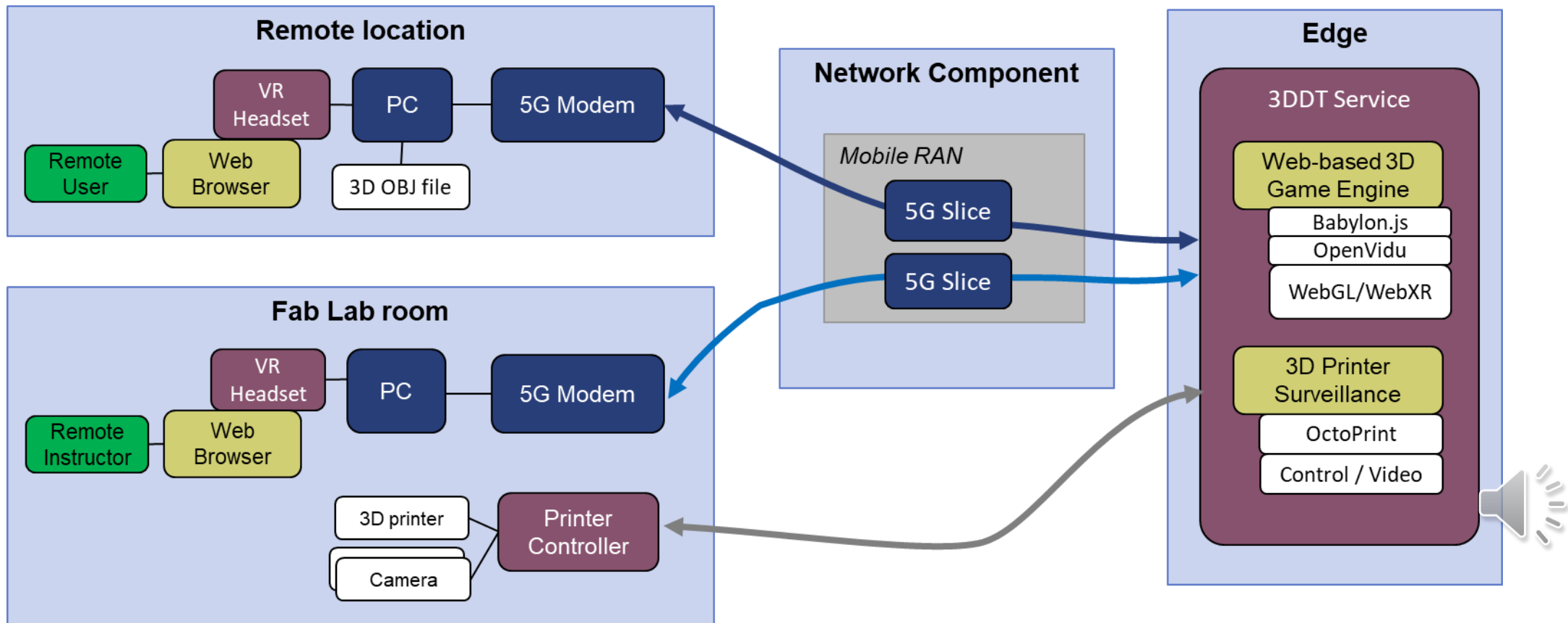
Machine remote control/surveillance:

- Remote control of 3D printer
- Live camera views integrated as 3D texture



3DDT Application for 5G network system

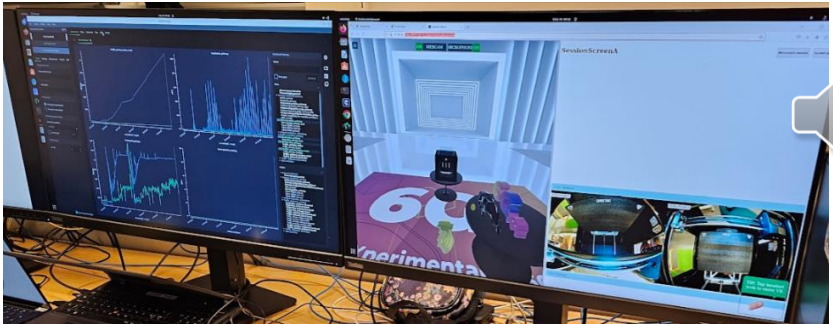
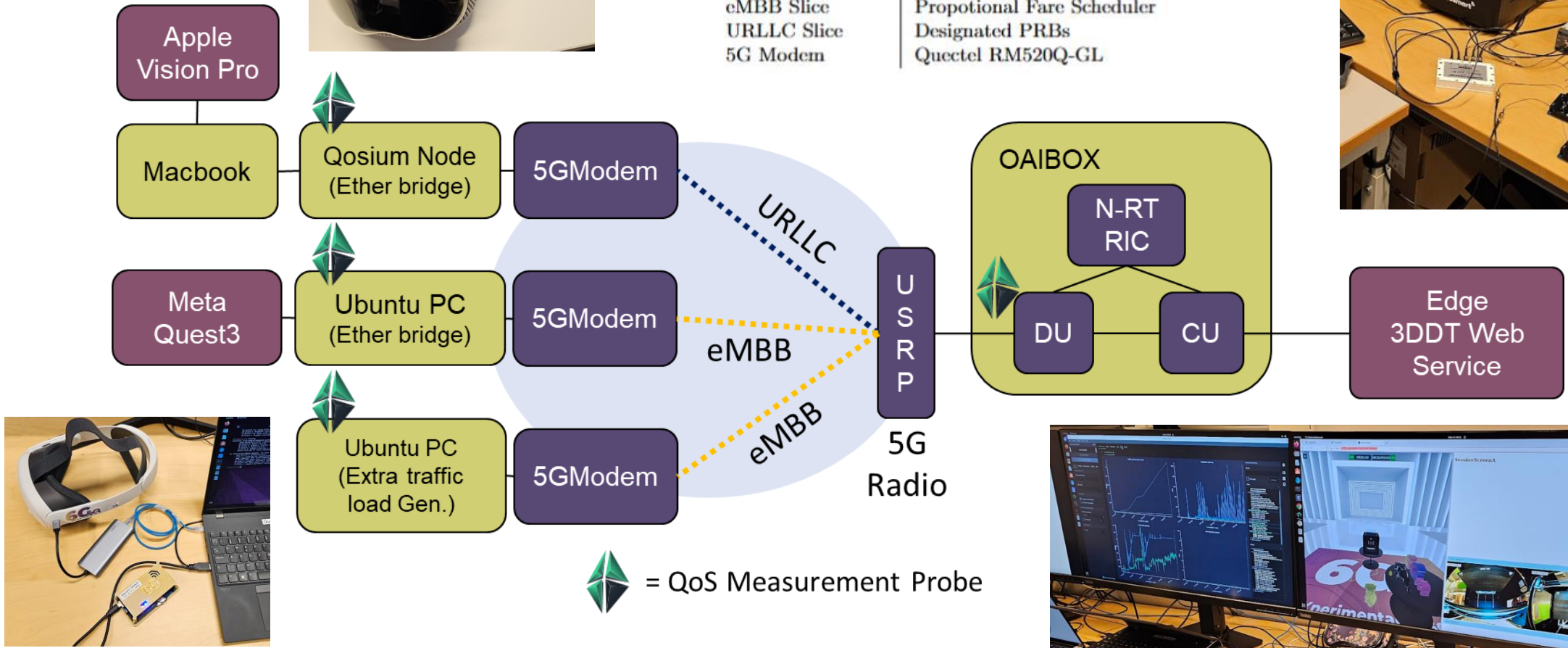
- A web-based edge service running on local 5G, optimized with 5G slicing.
- Open-sourced VR platform, WebGL/WebXR.
- IoT, remote control over VR platform.



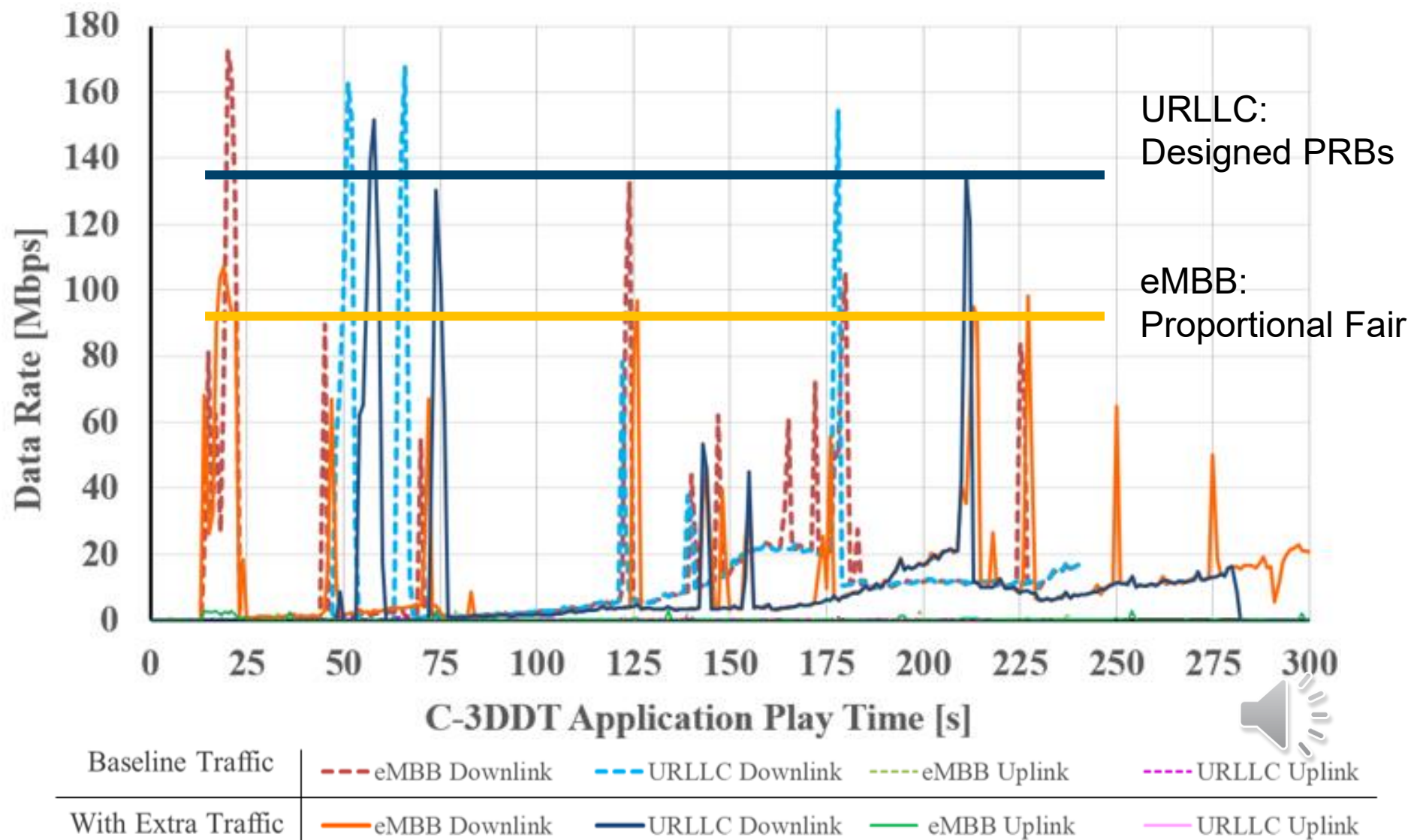
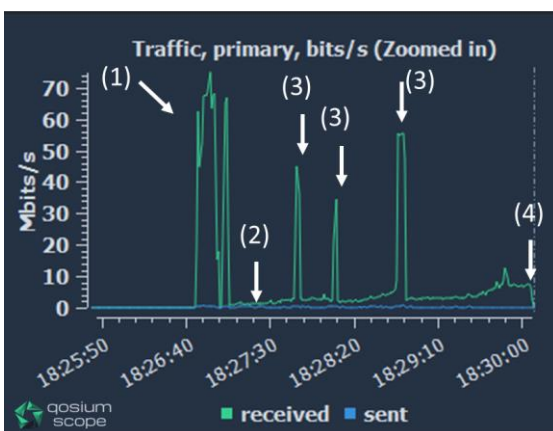
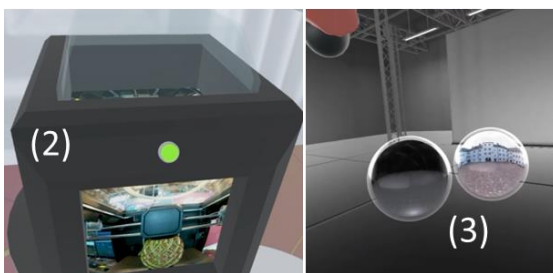
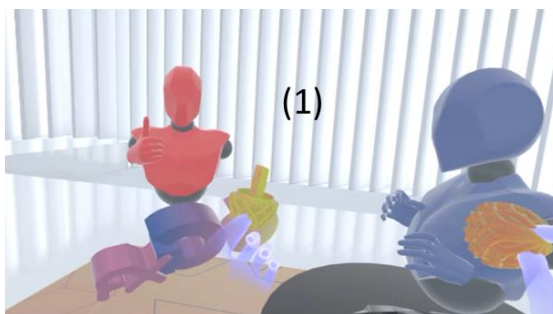
5G Testbed Measurement set up



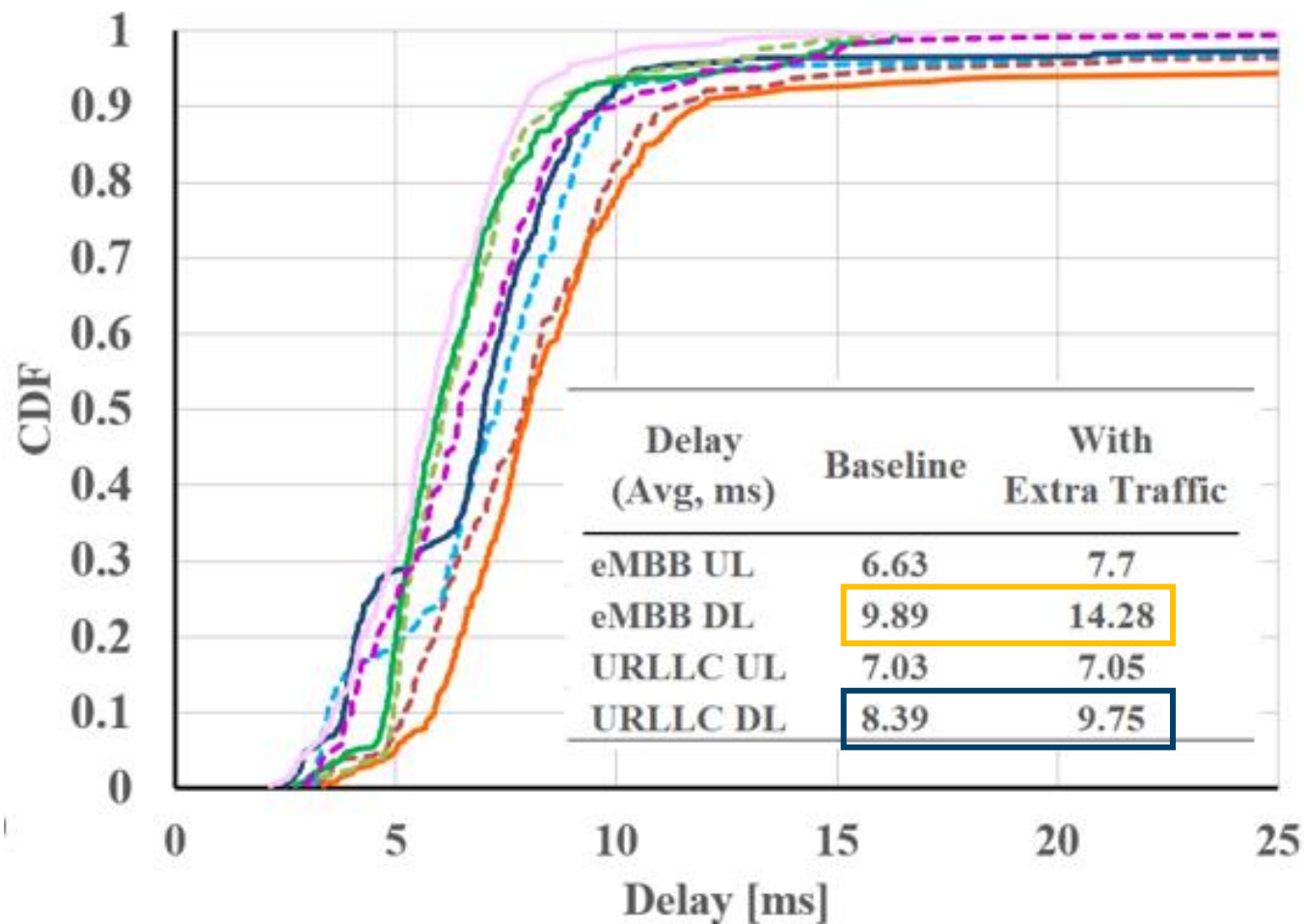
Parameter	O-RAN based System
Radio Hardware	USRP X410
Radio Band	n77 (3850.0 MHz)
Bandwidth	100 MHz
TDD Pattern	DDDFU
Antenna Config.	2x2 MIMO
Slice Enabler	xAPP in N-RT RIC
eMBB Slice	Proportional Fair Scheduler
URLLC Slice	Designated PRBs
5G Modem	Quectel RM520Q-GL



Throughput: 3DDT Application over 5G O-RAN Slicing



Latency: 3DDT Application over 5G O-RAN Slicing



Baseline Traffic	eMBB Downlink	URLLC Downlink	eMBB Uplink	URLLC Uplink
With Extra Traffic	eMBB Downlink	URLLC Downlink	eMBB Uplink	URLLC Uplink



Experiential KVIs feedback

EUCNC/6G Summit 2024 in Antwerp	Researcher's night at University of Oulu
QoE	KVIs
40 experts	94 non-experts



Usability	Participants (%)
Difficult	2 (5%)
Neutral	4 (10%)
Easy	20 (50%)
Very Easy	14 (35%)

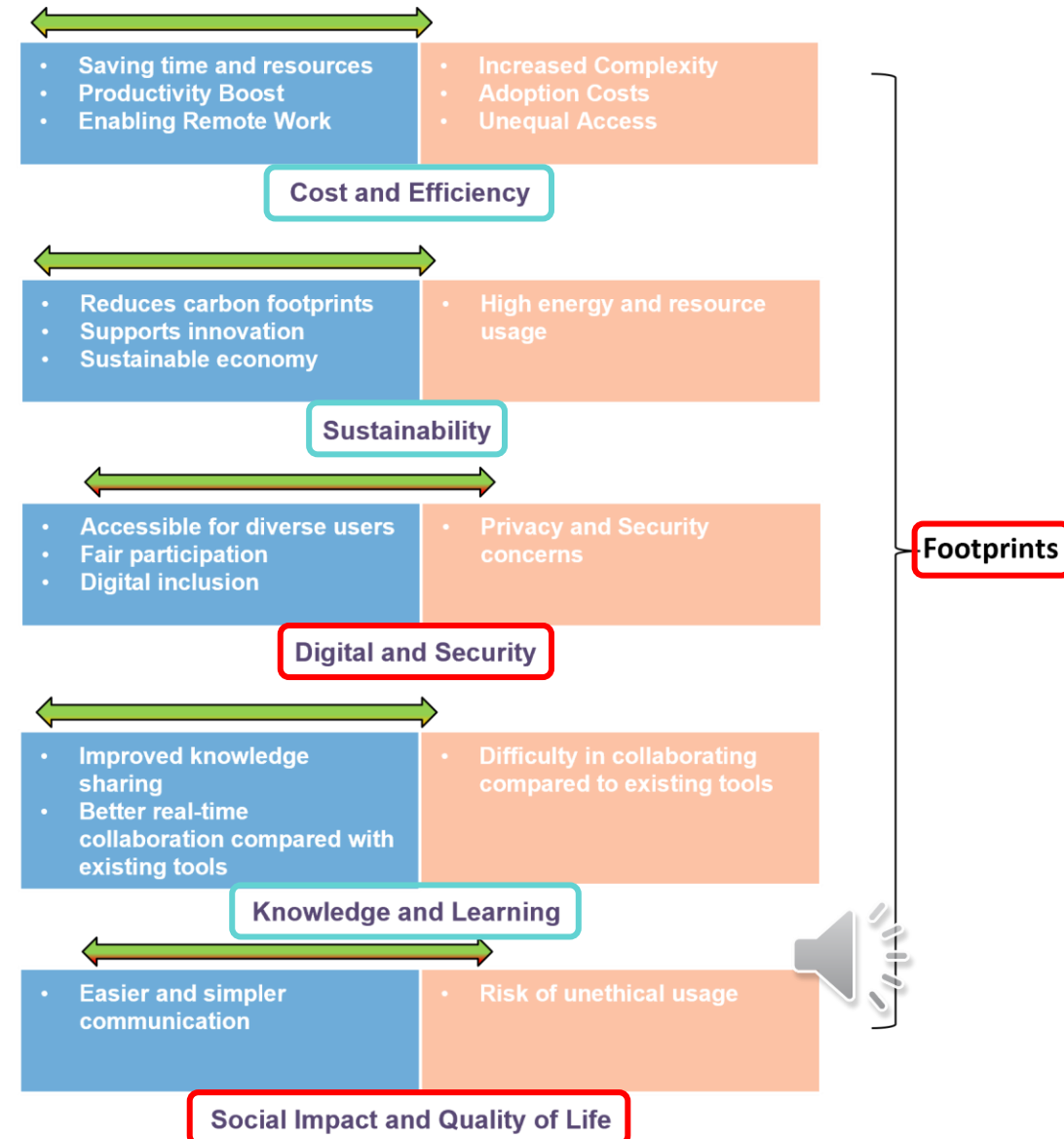
Latency Experience	Participants (%)
Occasionally	2 (5%)
Rarely	17 (42.5%)
Never	21 (52.5%)

85%
ease to use

95%
no noticeable
latency



Handprints



Key Insights and Next Direction



Implications

- Collaborative 3DDT enables **low-latency** and **stable** remote collaboration through **5G slicing**.
- Confirms technical **reliability** and user **acceptance** in real 5G testbed validation and demonstrations.

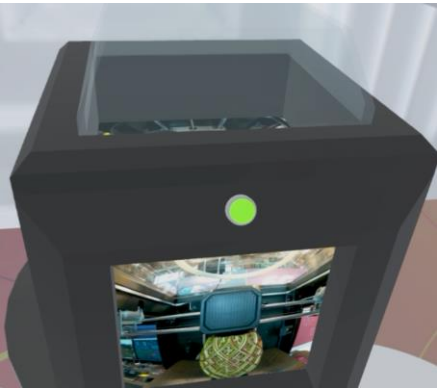
Solid foundation for cyber–physical fusion toward 6G

Next steps

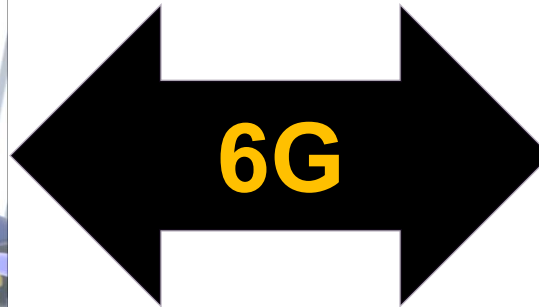
- Enable **intelligence** with 3DDT and slicing
 - **AI-driven adaptive networks** for **real-time optimization** across network and application layers.
- Addresses KVs concerns on **data security** and **social ethical concern**
 - Not only isolated XR/DT system, **interoperability**, multi access digital twin.
 - Secure **authentication** and blockchain, **ontology-based** localized database



Immersive, Realism



Cyber World

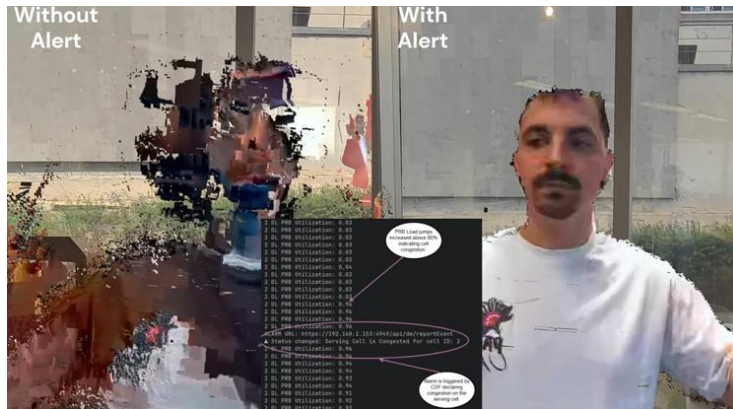


Physical World

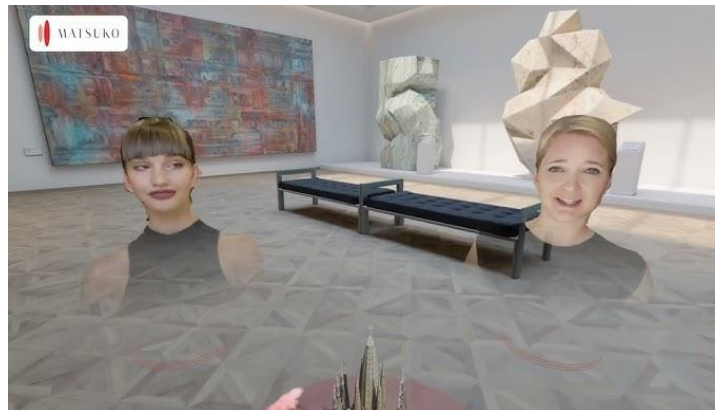
Intelligence, Value



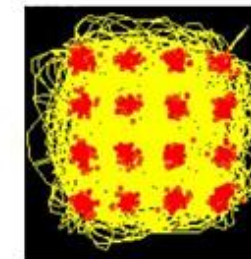
6GXR



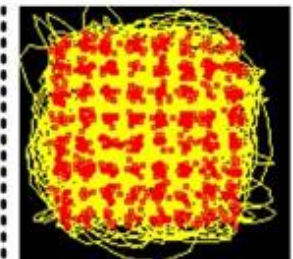
Adaptive holographic calls with congestion awareness



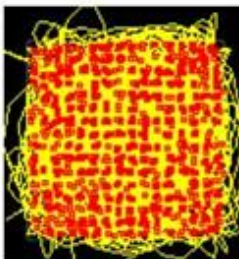
Holographic call in the IMS data channel



Modulation: 16 QAM
BW: 4 GHz
SNR: 19.13 dB
EVM: 8.2 %



Modulation: 64 QAM
BW: 2 GHz
SNR: 21.3 dB
EVM: 5.5 %



Modulation: 256 QAM
BW: 0.5 GHz
SNR: 26.3 dB
EVM: 2.7 %

300GHz receiver performance evaluation



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6G SNS

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