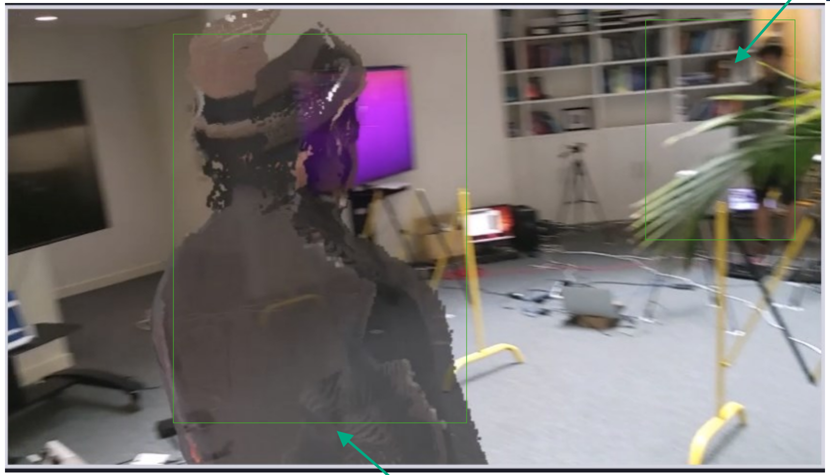
Enabling remote production and user intent-aware network adaptation for holographic video streaming

Peng Qian and Noa Zilberman

DEPARTMENT OF ENGINEERING SCIENCE
UNIVERSITY OF OXFORD

Holographic video streaming

Person captured by camera



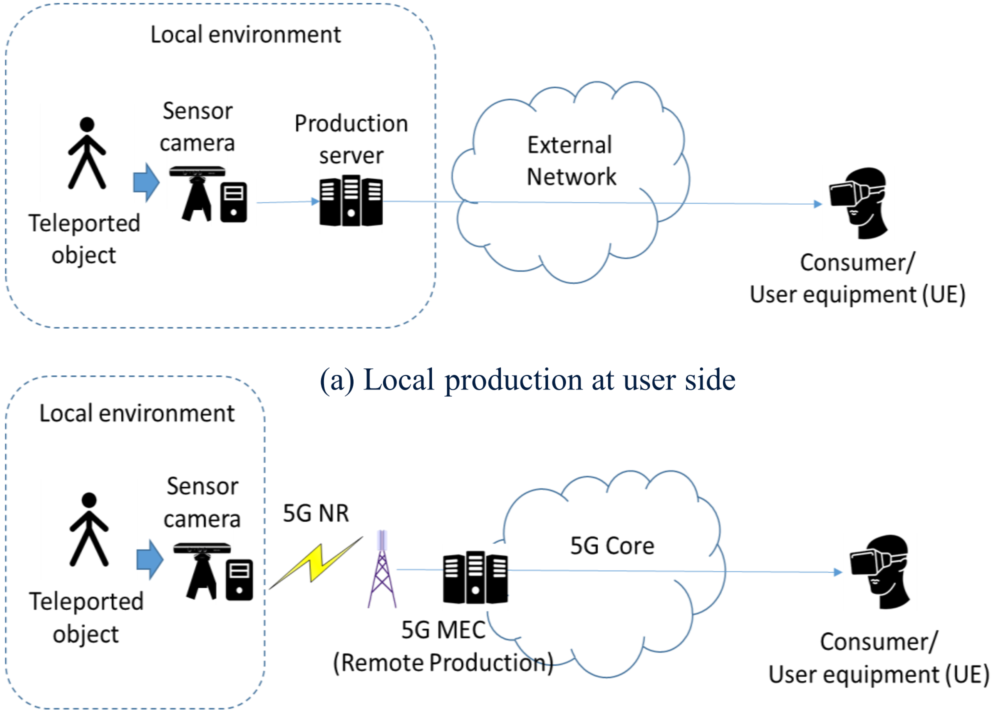
Holographic video in user' HoloLens 2

- **Large-scale point cloud**
- **Sensitive to network variation**
- **Diverse user interaction types**

Challenges

- Can this holographic video application be supported in a wireless network?
- How to mitigate the computation burden of high point density?
- How to understand and overcome the potential impact caused by user behavior?
- How to apply a proper network treatment to overcome inevitable network uncertainties?

Mitigating the computation cost with remote production



(b) Remote production at 5G MEC

Fig. Remote production at 5G edge computing network

- Experiment on real 5G radio and core network, in 5G/6GIC, University of Surrey.
- Low resolution level can reach 25 FPS with less than 100 ms frame delay.
- Full High Definition (FHD) resolution experiences bandwidth bottleneck, leading to 15 FPS and less than 200ms frame delay.
- For higher resolution like Ultra HD (UHD), the FPS is only 5, which is limited by the data transmission ability at user side.

Remote production: Transmitting raw data via 5G uplink and offloading computation tasks to mobile edge server.

User intent in holographic video streaming

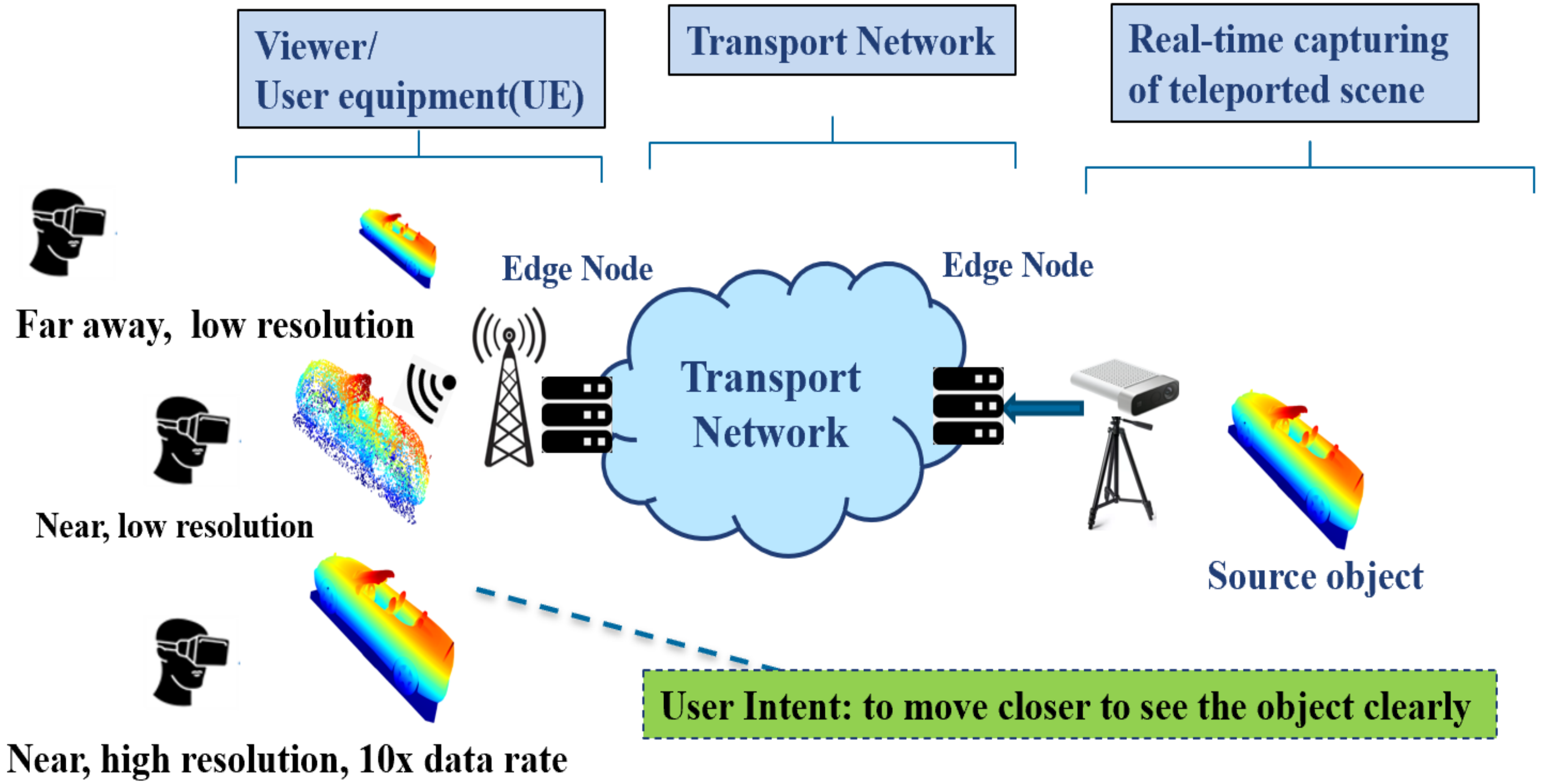


Fig. User intent in holographic video streaming

User intent-aware network adaptation

A person holding a notice board

Intent-aware SDN Framework

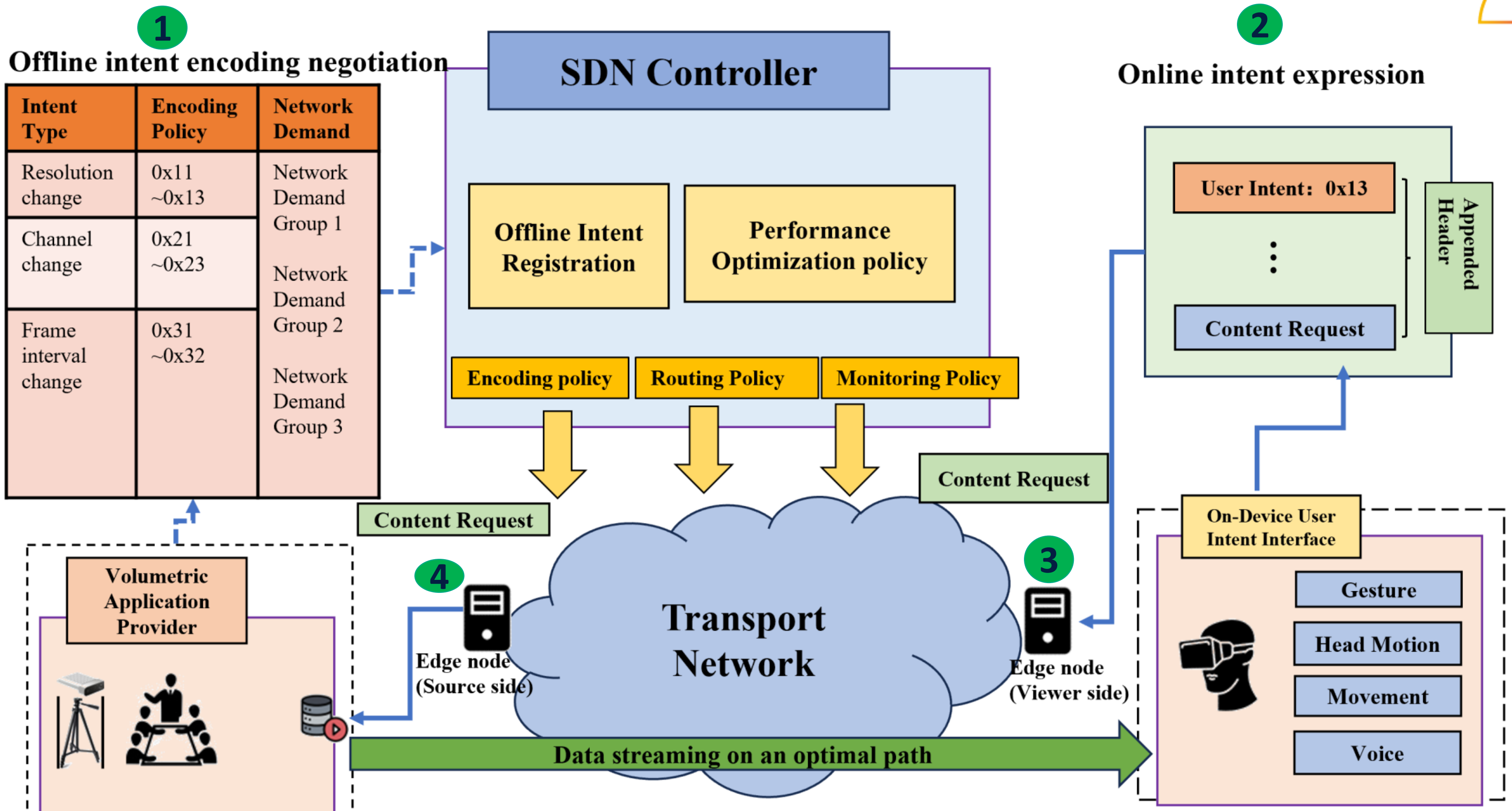


Fig. Intent-aware SDN framework with network adaptation

- Step 1: Offline intent registration from application
- Step 2: Online intent expression at viewer side
- Step 3: Online intent capture at edge node
- Step 4: Online path adaptation at edge node

- Enhanced HoloLen2 application and point cloud streaming application
- Segment routing over IPv6 to encap/decap user intent header
- Path probing between edge nodes
- Customizable Multi-Arm Bandit path selection algorithm

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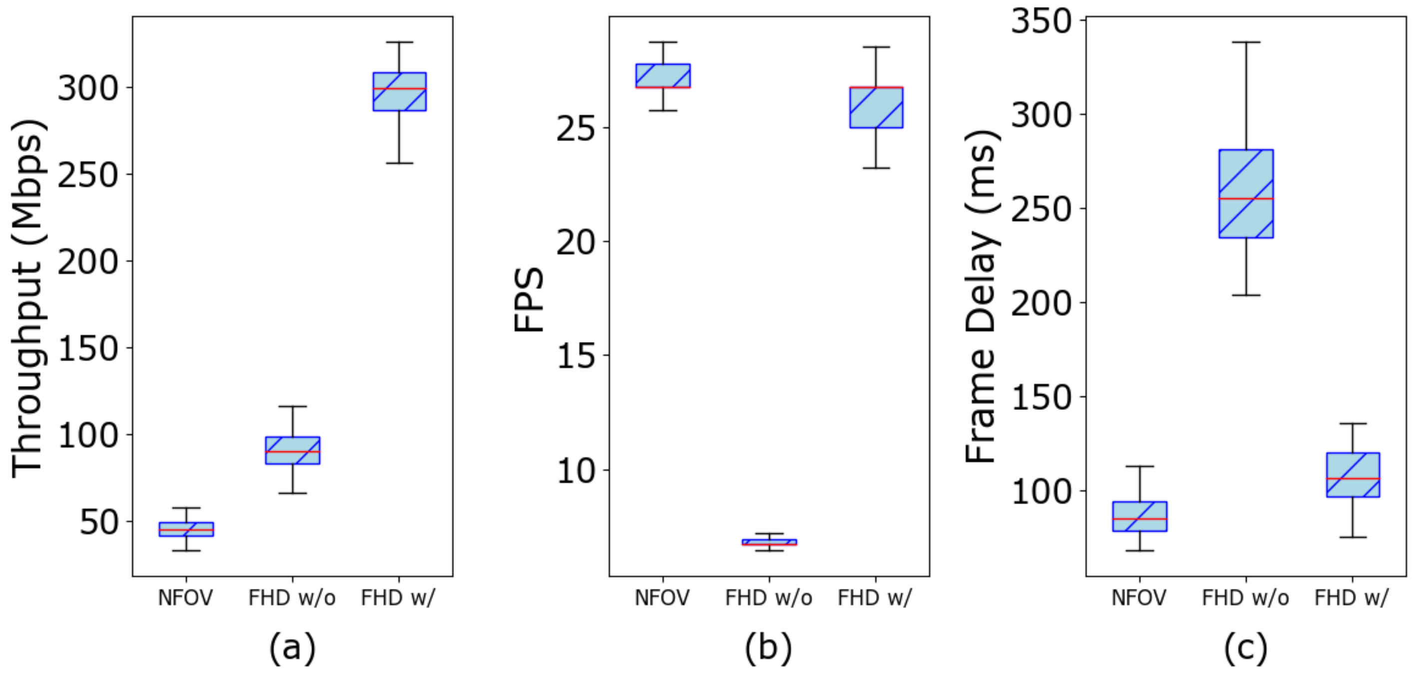
Key result – User intent requiring FHD resolution level



- ➢ User requests to switch resolution level from Near-Field-Of-View (NFOV) to FHD.
- ➢ User intents can be successfully expressed and captured.
- ➢ User perceived performance can be significantly improved.

Future work

- Point cloud as LiDAR streaming in vehicle perception.

- Joint challenges from computation and network transmission.

- Edge intelligence with Data Processing Units (DPUs), and In-Network Machine Learning (e.g., Planter [1])

Contact: peng.qian@eng.ox.ac.uk, noa.zilberman@eng.ox.ac.uk

[1] Zheng, Changgang, et al. "Planter: Rapid Prototyping of In-Network Machine Learning Inference." *ACM SIGCOMM Computer Communication Review* (2024).

Thank you

Presentation outline

- Background and challenges
- Remote production at 5G mobile edge
- User intent aware network adaptation framework
- Future work and conclusion