Holographic Type Communication

Delivering the Promise of Future Media by 2030

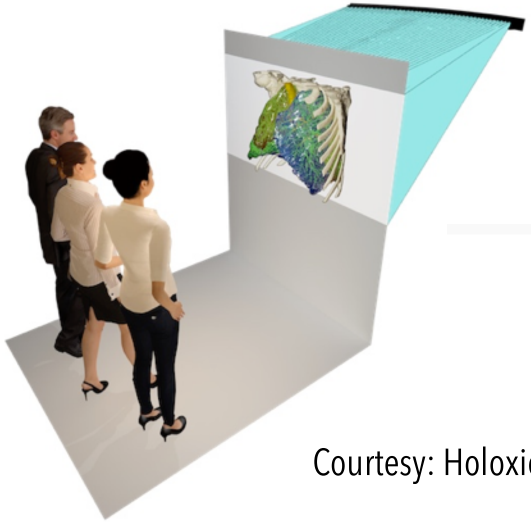
Kiran Makhijani, Future Networks, Futurewei

Fifth Workshop Network 2030
15 Oct 2019, Geneva

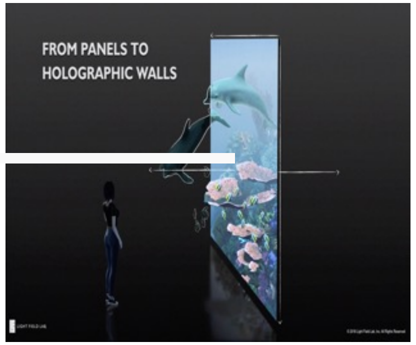
Majestic Era Of Hologram Display Technologies

Future Scenarios will Blend Virtual and Real Worlds Seamlessly.

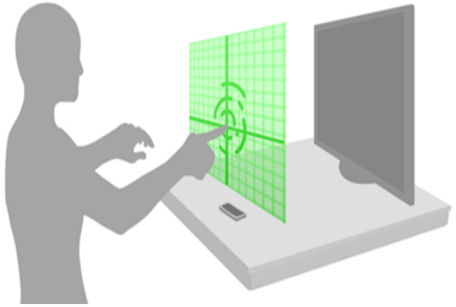
Courtesy: Microsoft, Hololens 2



Courtesy: Holoxica



Courtesy: Lightfield Lab, Holo-wall



Courtesy: LeapMotion

AR/VR HMDs prohibitive to natural experience.

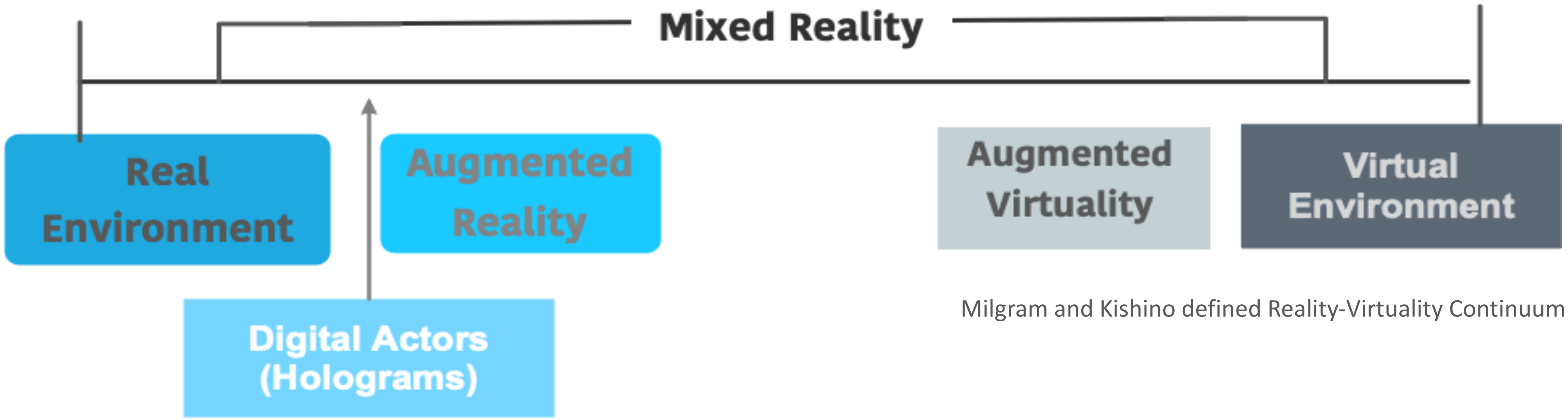
Holographic objects will be core Digital Actors

Beyond Visual Experiences – Touch, Interact & manipulate surrounding environments

Holographic Digital Actors

Start with
Inserting holograms in real environment

- Allow experiences to develop without having to use HMDs.
- First steps is to Focus on placement of Digital Actors in a Physical World

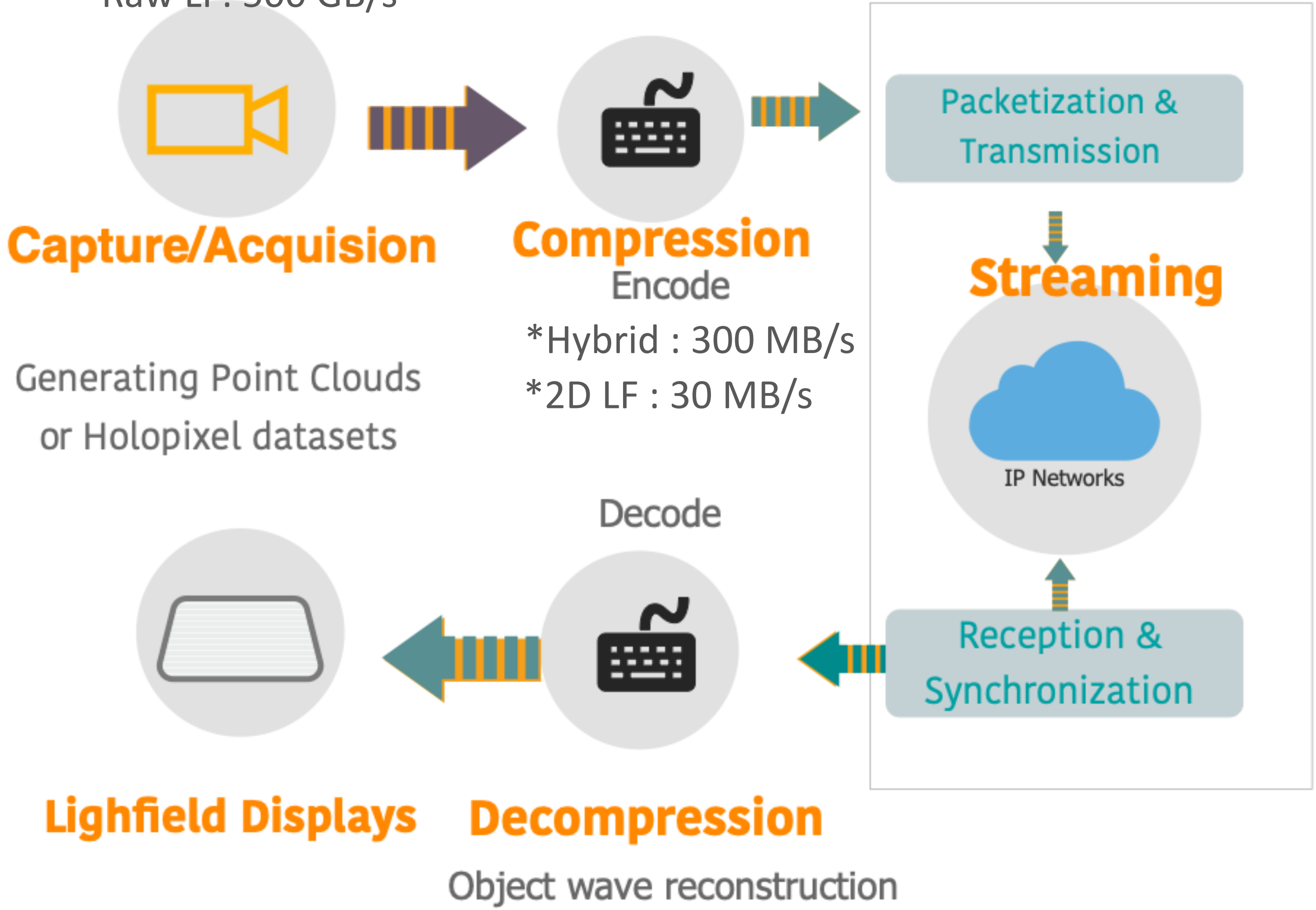


Milgram and Kishino defined Reality-Virtuality Continuum

Naturally, grounded in the real world., Can be life sized or resizable , Responsive, but not alive.

Holographic* Media Engine

**800K points = 1000 Mbps.
*Raw LF: 500 GB/s



Evolution of Holograms
from Diffraction patterns to Light field models.

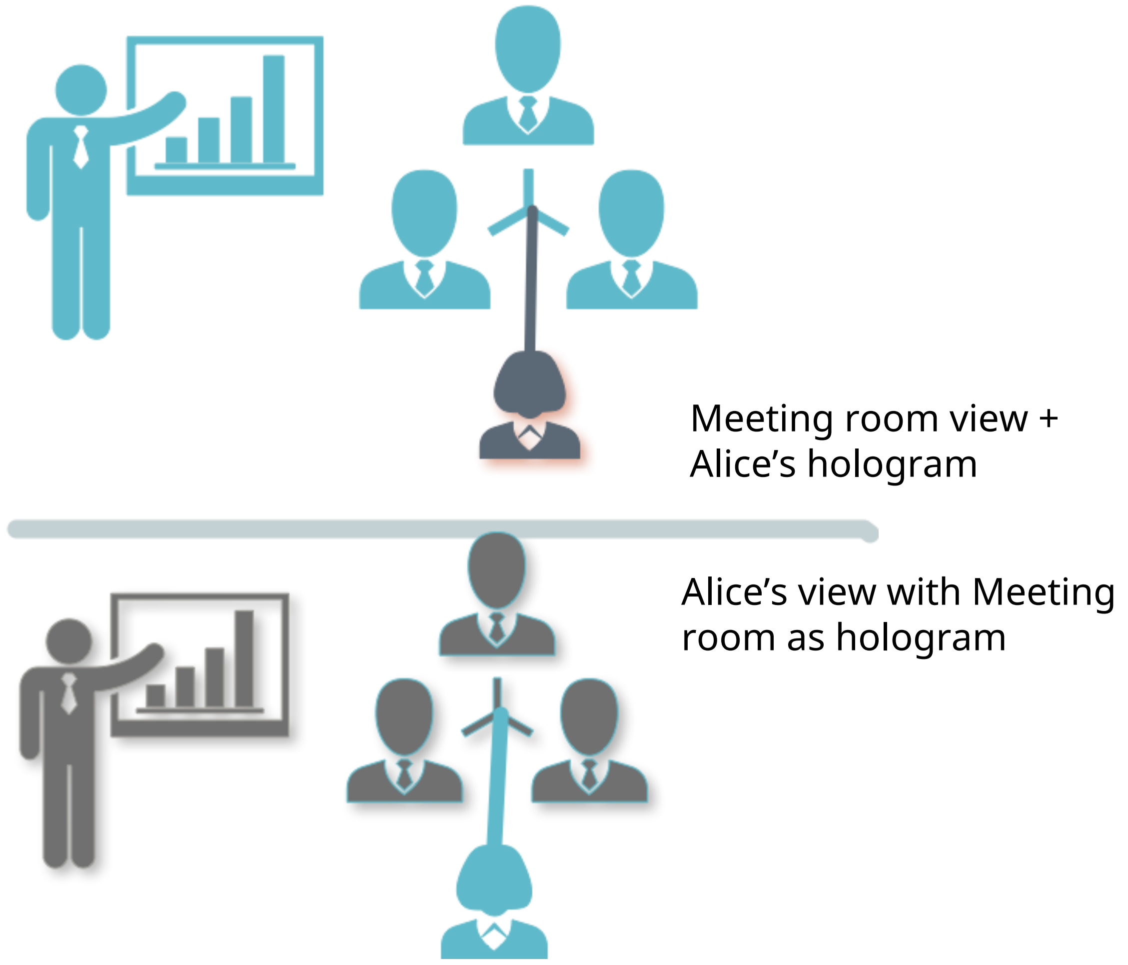
Still Holographic datasets comprise of giga (or tera) bytes of uncompressed data.

Computation times for codecs can be restrictively high (~50ms)

*Holographic ➔ H-

source: *https://mpeg.chiariglione.org/sites/default/files/events/08_KARAFIN_LightFieldLab_MPEGWorkshopLB_v01.pdf
**https://mpeg.chiariglione.org/sites/default/files/events/05_MP20%20PPC%20Preda%202017.pdf

H-Telepresence



Digital Actor

Single point cloud holographic object in a real scene

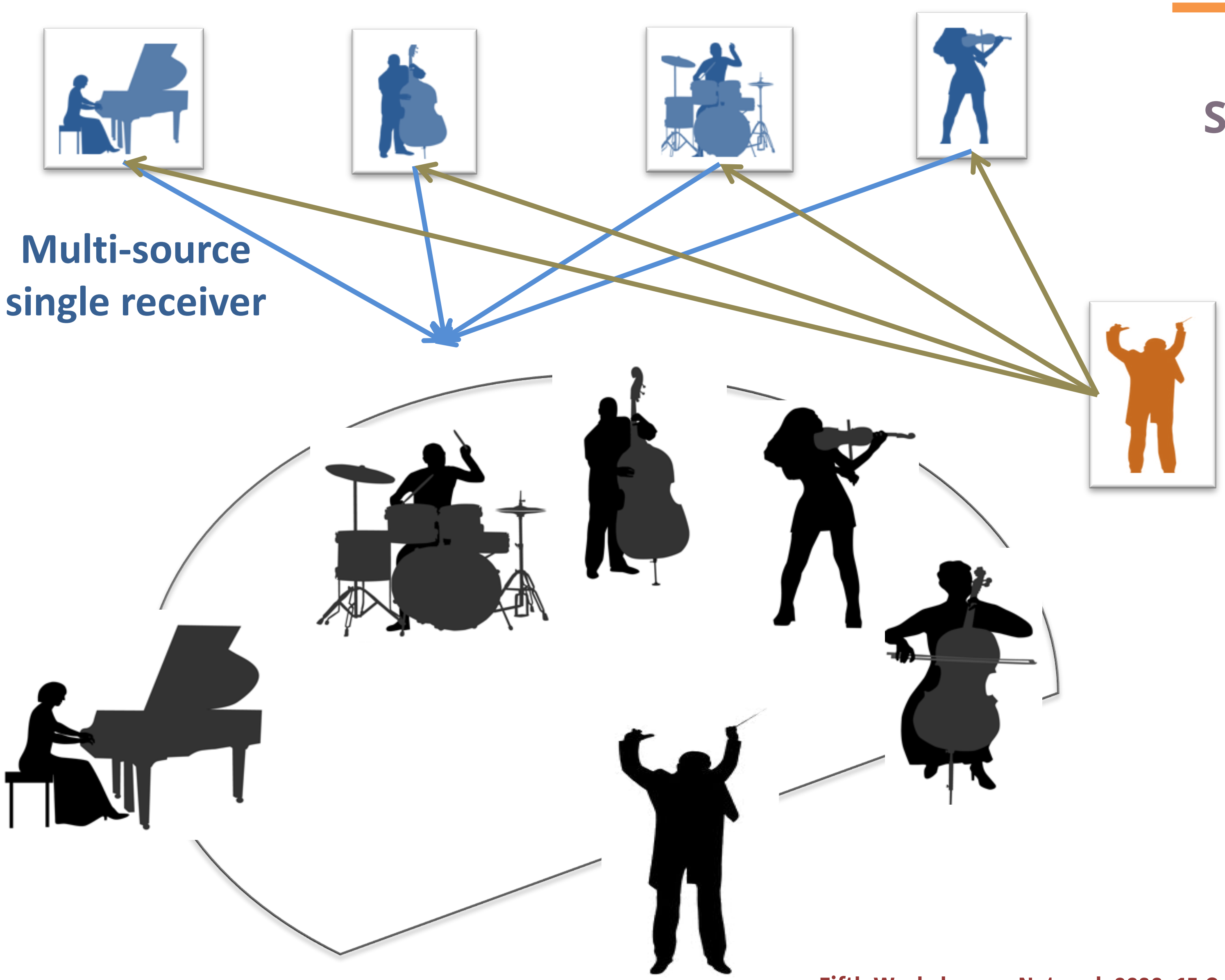
Telepresence using Hologram. It is the only digital object in the scene.

Remaining entities are real.

H-Virtual Stage

Use case:

Synchronizing single virtual world among multiple users



Rendering virtual stage from multiple actors over heterogeneous network conditions.

Current networks do not make effort to synchronize

New Media over Traditional Stack

client

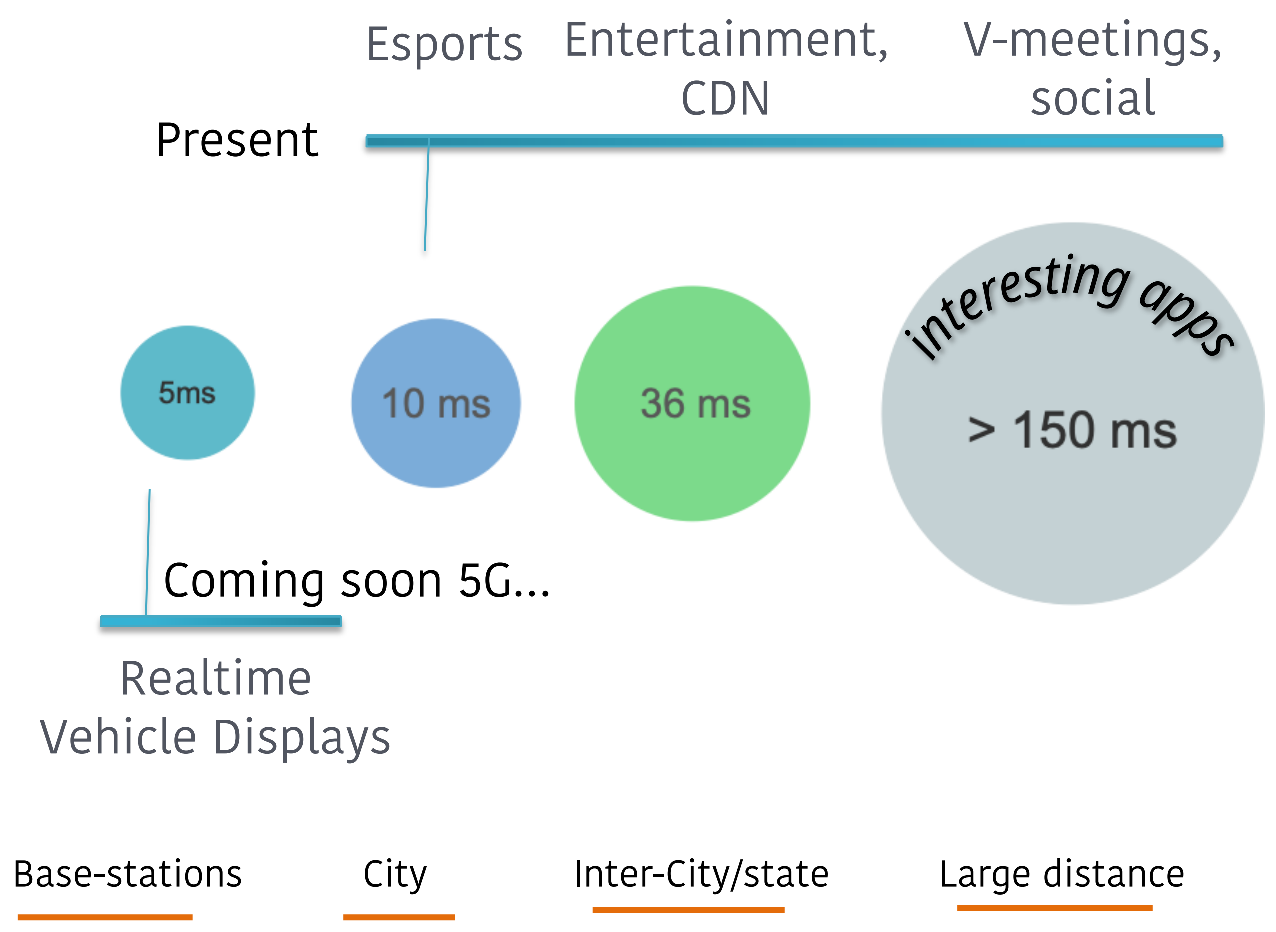
H-APP	Create virtual worlds, translate to point clouds
Transport	High throughput, end to end congestion
Network	QoS: high-volume resource-reservation
Access	framing

Finding more and more resources using old means to guarantee Holo-scale performance

Minimize rendering is far more expensive than traditional applications
Uninterrupted fast packetization
Control delays over the network

Do traditional approaches even apply?

Streaming Boundaries



Tolerating Delays

Not all holographic applications can catch up with the distance

Quest for realistic experience and instantaneous reactions are not only challenging but limited by how fast can we transmit.

<u>Alternate</u> means to manage delays.

Throughput

Use case:
Minimize Throughput fluctuations

$$T \le \frac{MSS}{RTT * \sqrt{\rho}} \Rightarrow \rho \le \left(\frac{MSS}{RTT * T}\right)^2$$

There's a threshold to packet loss, beyond which user experience degrades (U-vMOS*)

Higher vMOS meant low tolerance to PLR
*(vMOS 4.5, 4K video, PLR 3.5×10^{-5})

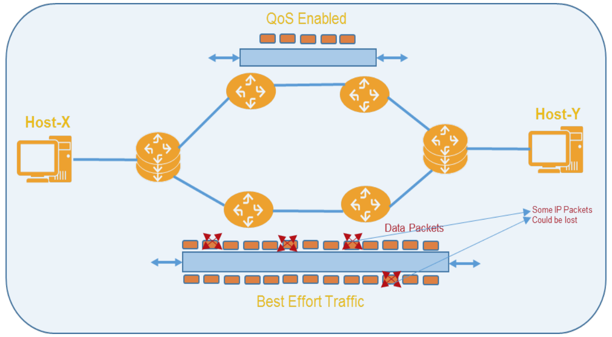
Can packet losses be always prevented?
Or How to mitigate effects of Packet loss.

Higher and Consistent

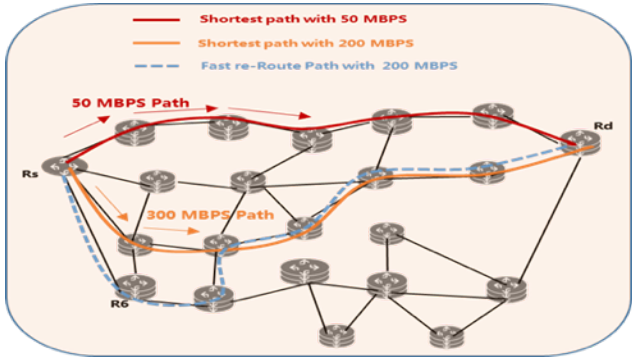
*Source: https://www.huawei.com/~/media/CORPORATE/PDF/white%20paper/Technical-White-Paper-on-Mobile-Bearer-Network-Requirements-for-Mobile-Video-Services

Network QoS

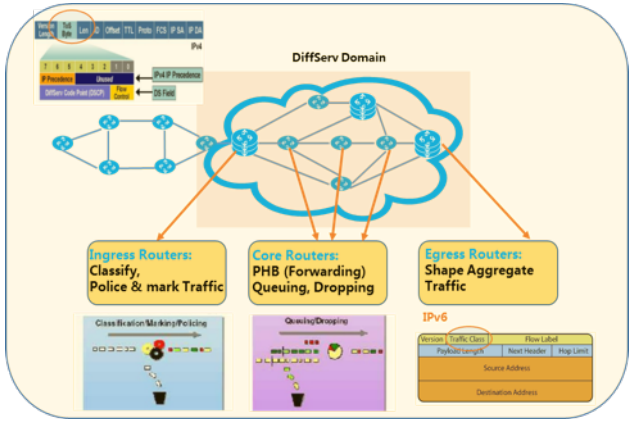
Best Effort



Traffic Engineering



Differentiated Services



Resource Guarantees

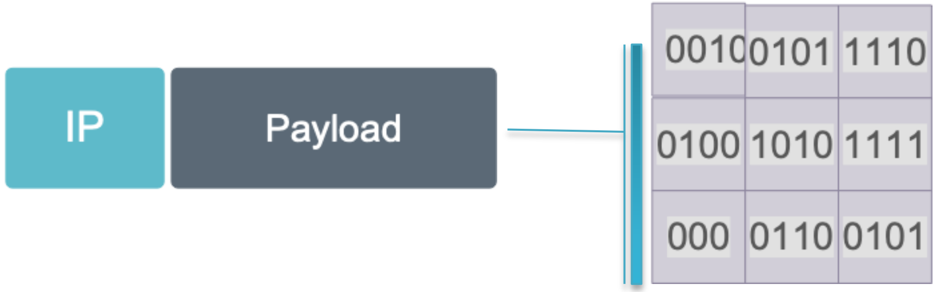
Statistical methods for traffic engineering will lead to **large delay variations**. Not suitable for operating in a digital replica of a scene.

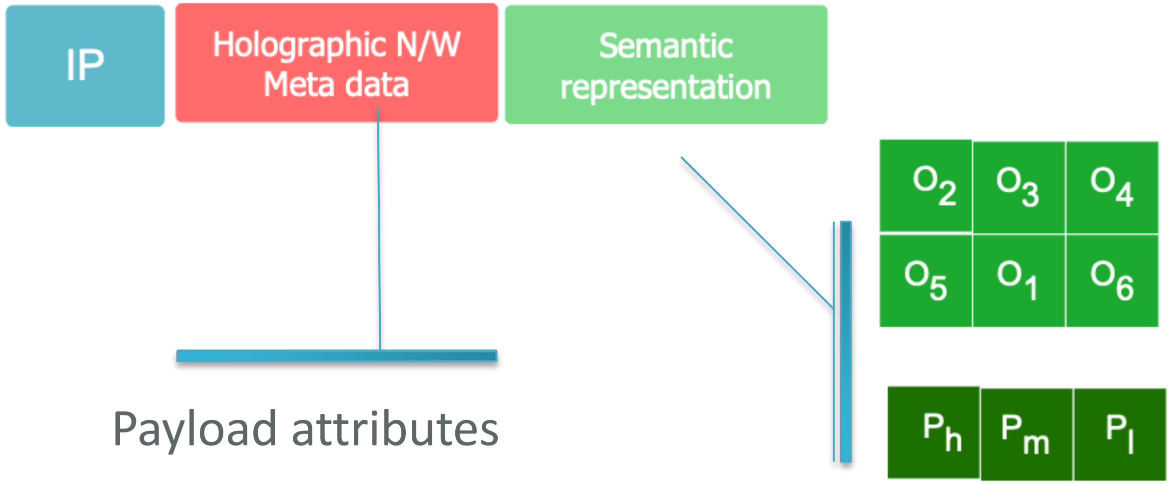
Synchronization guarantees for multi- party communication in a virtual scene.

How should network treat holographic data?

Building Blocks for Holographic Type Communications

Packetization





Payload attributes

Object map location changes

Delay budget

Start with new means of sending data. Capture semantics not syntax

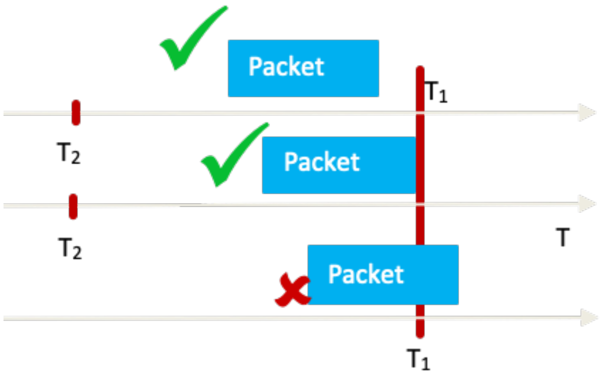
Provide Network with clues to what to do with the data?

Paradigm shift to per packet delivery guarantee (instead of flow levels).

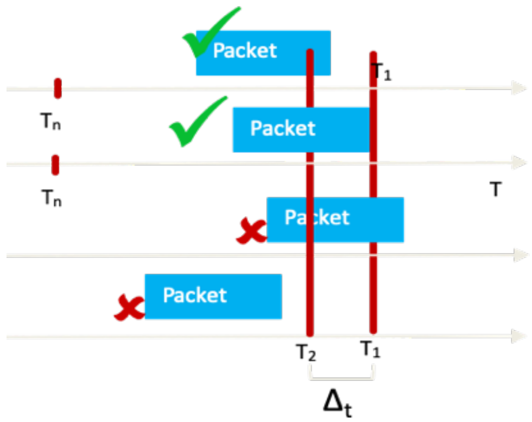
Opens up new means to Transmit, process and Schedule in networks

High-Precision

In-time Guarantees



On-time Guarantees



Scenario 1:
Latency sensitive streaming, control-loops

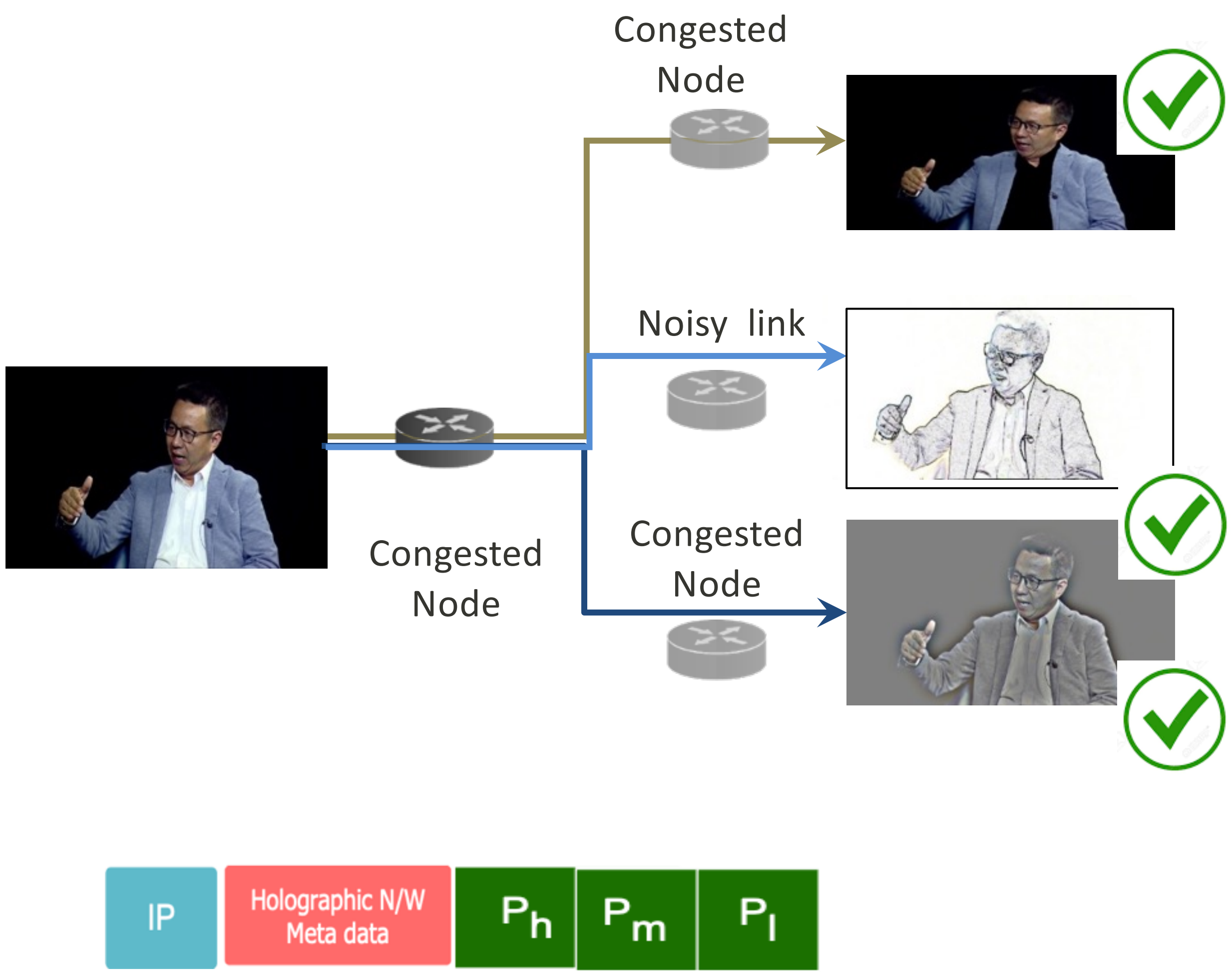
Let applications manage network latency (queuing, buffering)
End-to-end min..max latency control

Stateless == per-packet
Avoid scale limits of network flow-awareness

With/without (bandwidth) reservations
E.g: dynamic adjust throughput, but keep low-latency

On-time: Delay early packets
Reduces application side buffering / jitter

Qualitative

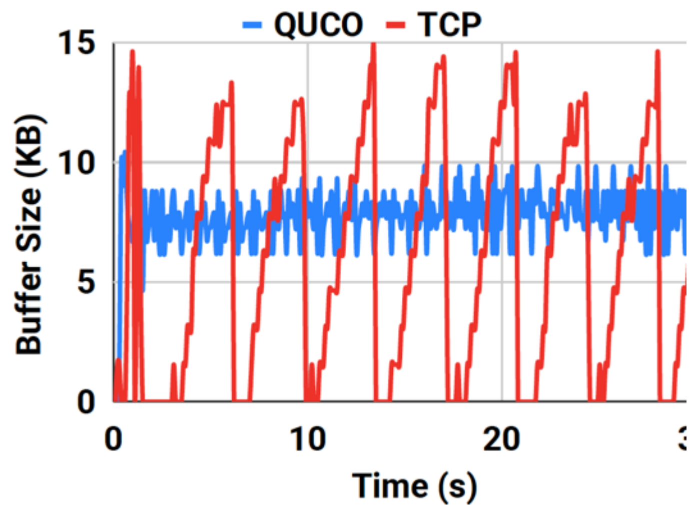


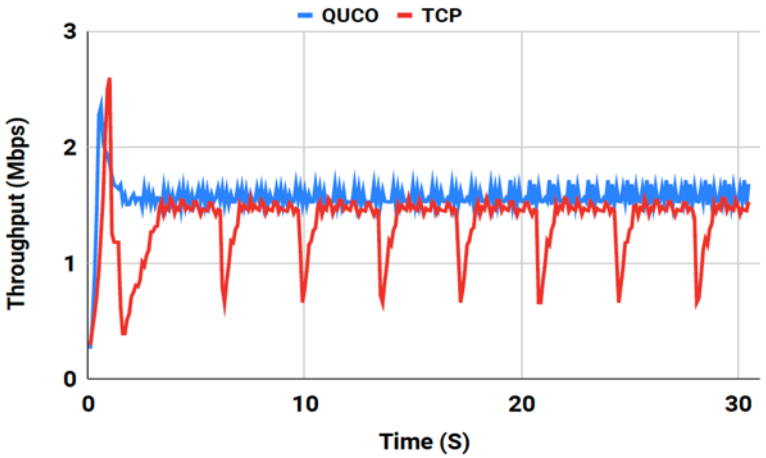
Use case:

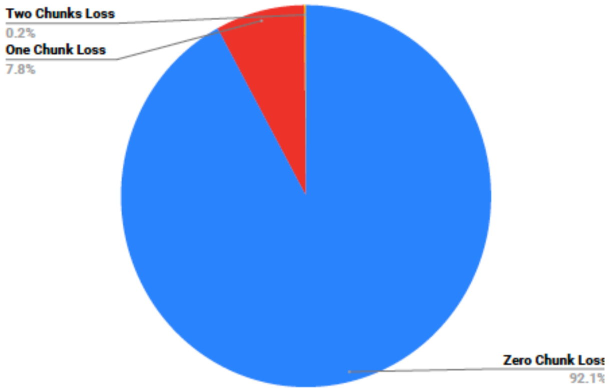
When packet loss is not acceptable;
Tolerance to errors

- Adverse network conditions lead to entire packet dropped.
- Bit-level information is too-fine grained and packet is coarse grained.
- Assign different weights to parts of packets and drop less-important data in favor of guaranteed delivery of useful packets
- Provide artefacts to repair or recover lost data at a later node.

Qualitative Experiment





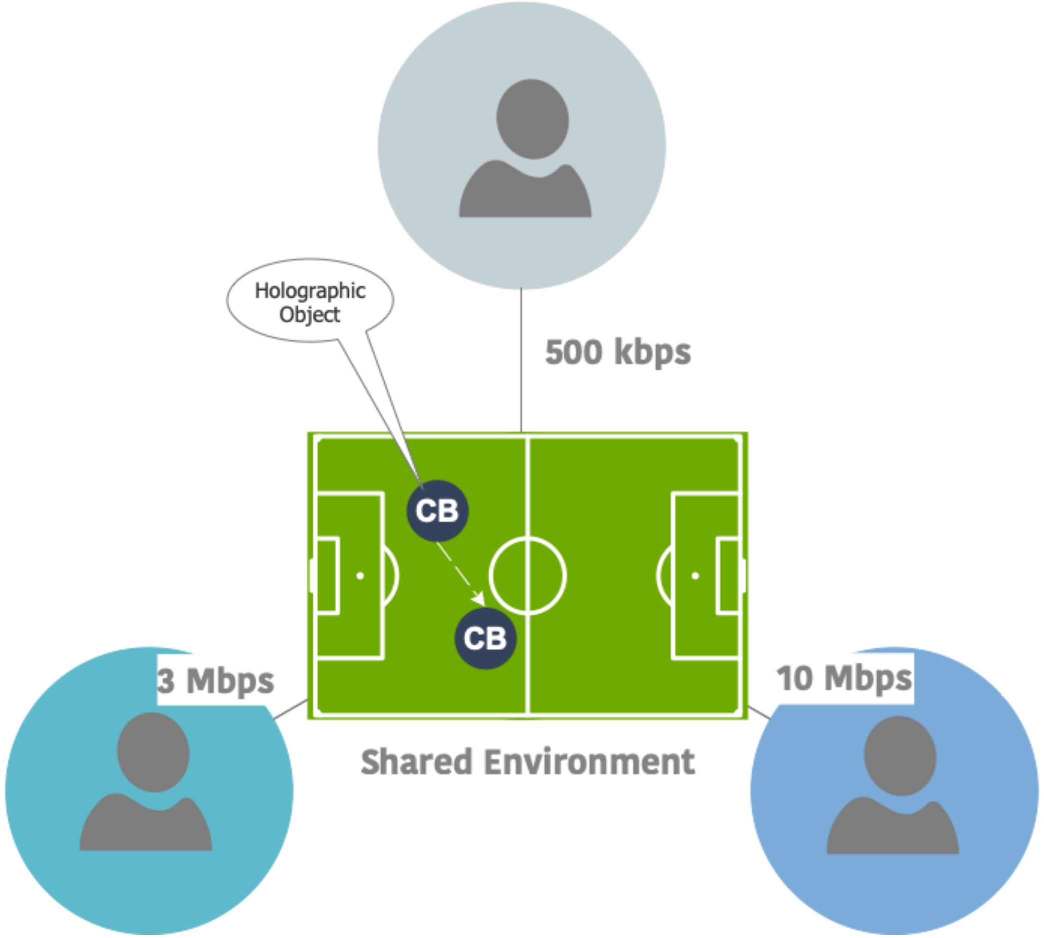


Use case:

When router queues start filling up, trim packets but don't compromise throughput

- With new packetization scheme, Q-packets: fixed rate throughput on senders side.
- Flat queue buffer fluctuations on network node
- Low drop rate: but not expressed in throughput – Better MoS.

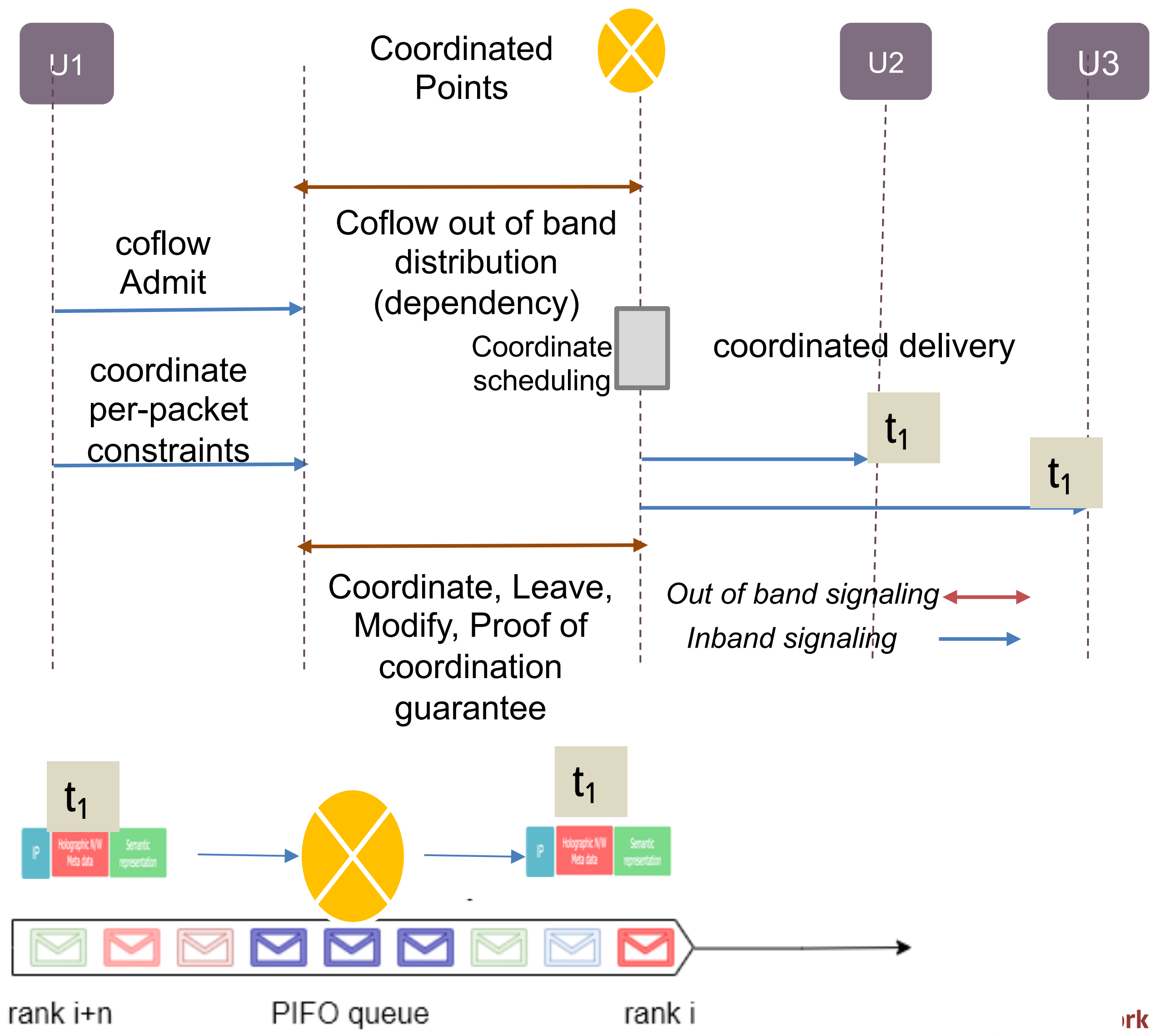
Coordinated



Use case:
One view multi-party holographic communications

- Remote collaborations strive for natural experiences . Same instance of virtual environment (not sooner or later).
- Match timeliness when changes about things appear for each receiver.
- Guaranteed multicast, incast and multi-party communications.

Coordinated Experiment



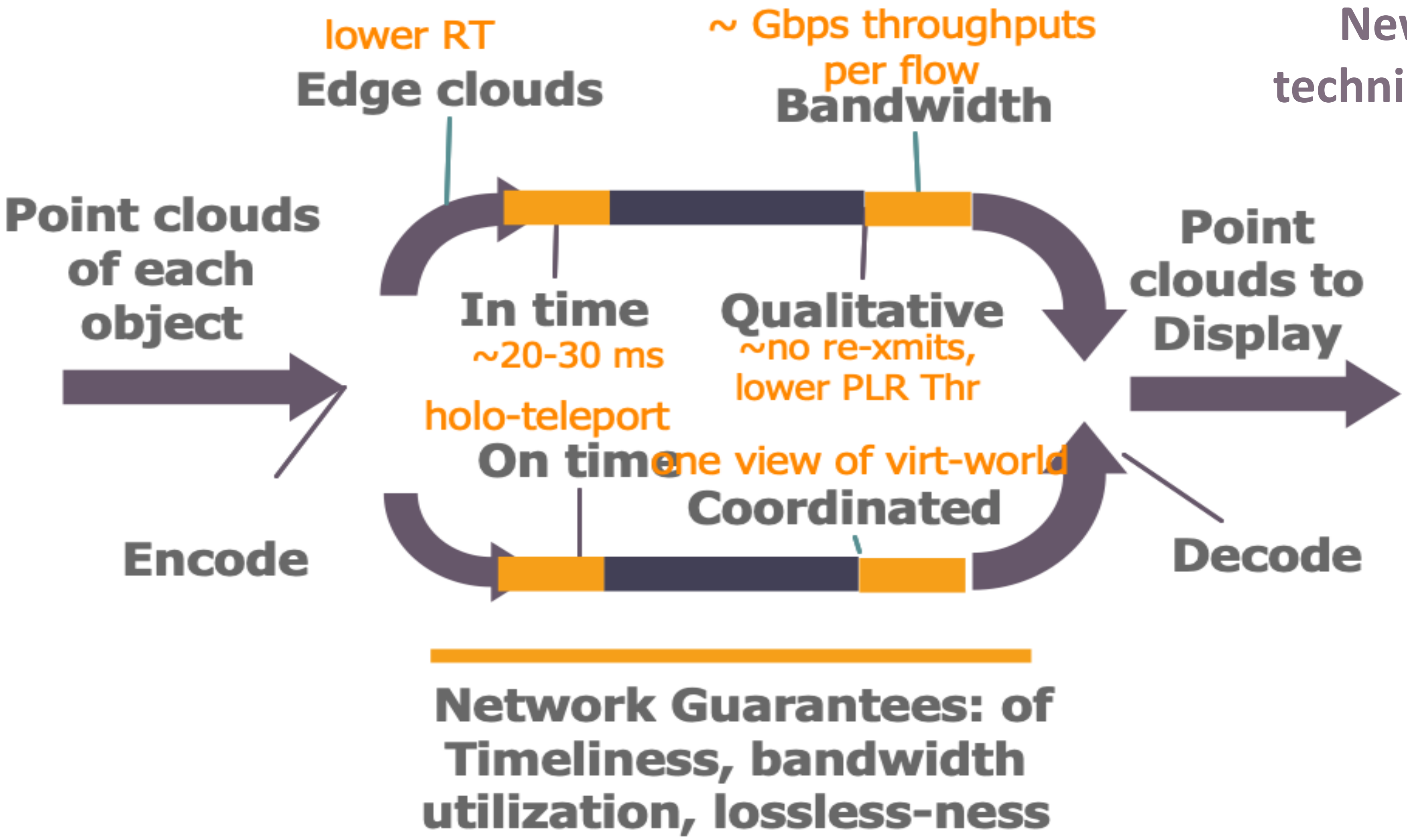
Use case:

Coflow in-network processing

- Cooperation, Consistency, Constraint, completeness
- Combination of in-band and out-of-band signaling

Work-in-progress, poster presentation at ICNP.

Holographic Streaming



New network services

New service aware packetization techniques, perhaps supported by new media formats

With new capabilities available, new formats for huge data sets can be modeled based on network-friendly metadata.

Necessary Full Stack Collaboration

Challenges

1. Lots of bandwidth
2. Trade offs between how much to compress and affordable delays.
3. Metadata to identify key pieces of environmental data.
4. FOV is only 1/5 of the scene. Bandwidth is wasted.
5. Currently no way to measure Quality (MoS) etc…

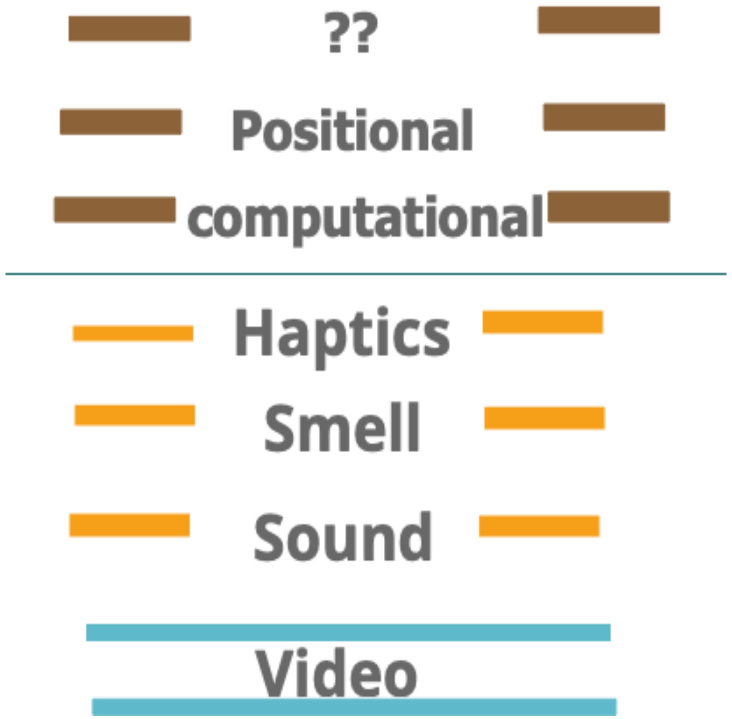
In-network capabilities

1. Provide metadata to network to receive desired experience.
2. Provide indication of time information.
3. Enabling in network qualitative techniques to resize, adapt surface textures.
4. Disaggregate key pieces of environmental data, e.g. object based semantics.
5. Coordinate fairness over heterogeneous links.

Future Media

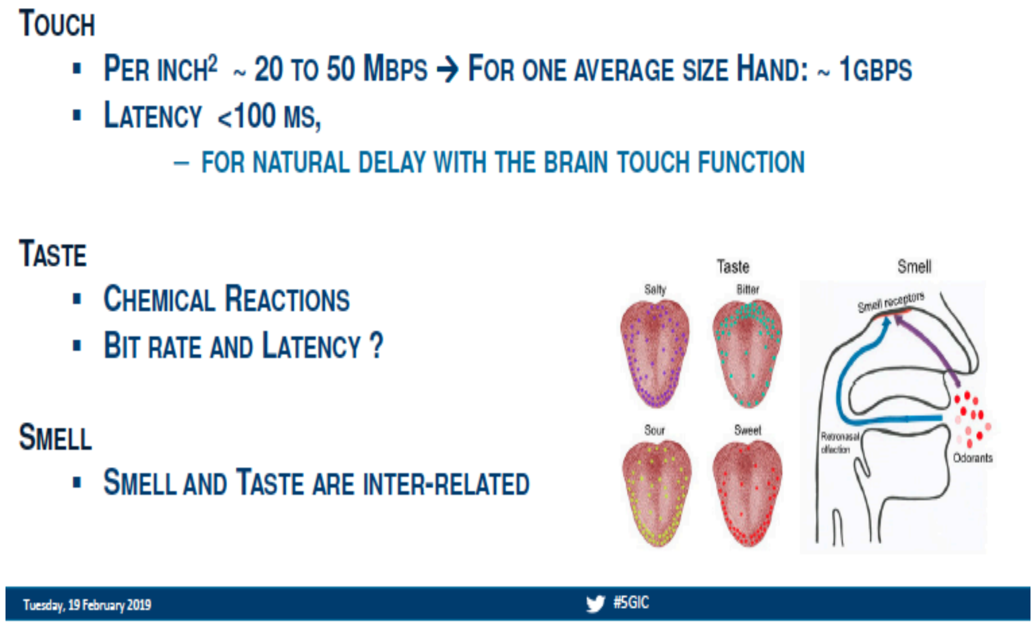
Intuitive interactions (Spatial Compute)

Natural interactions (Teleportation)



Teleportation =

Holoportation + Sensual Information



TOUCH

- PER INCH^2 ~ 20 TO 50 MBPS → FOR ONE AVERAGE SIZE HAND: ~ 1GBPS
- LATENCY <100 MS,
  - FOR NATURAL DELAY WITH THE BRAIN TOUCH FUNCTION

TASTE

- CHEMICAL REACTIONS
- BIT RATE AND LATENCY ?

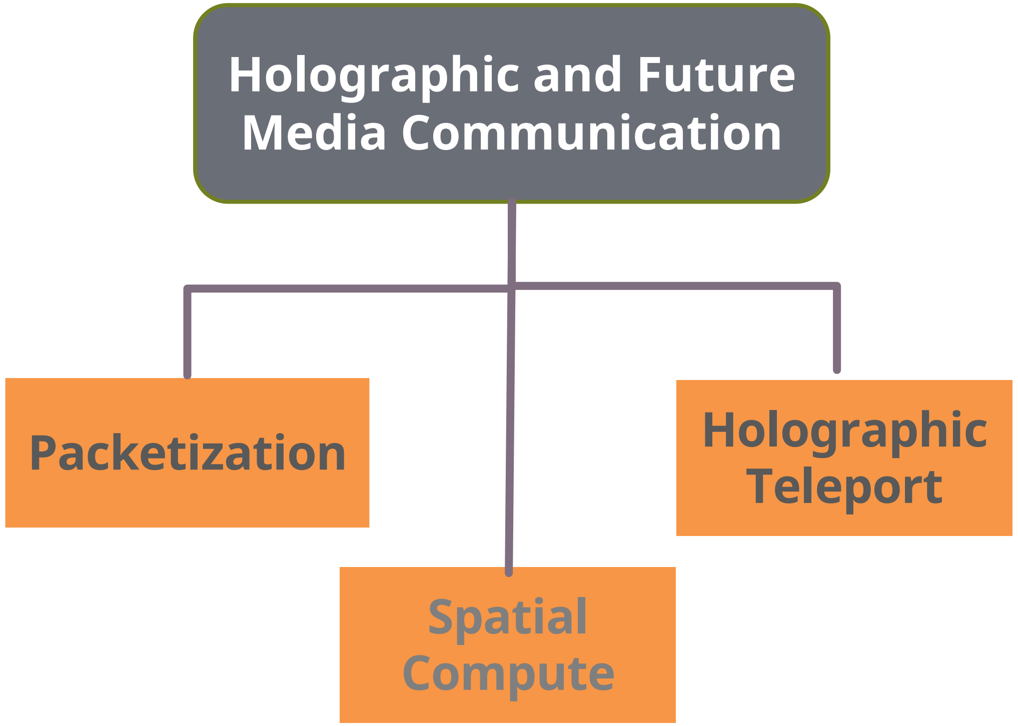
SMELL

- SMELL AND TASTE ARE INTER-RELATED

Tuesday, 19 February 2019 #5GIC

Source: *https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20190218/Documents/Rahim_Tafazolli_Presentation.pdf

Summary



New Packetization motivation
- High-Precision (time-based services)
- Qualitative service to manage throughputs
- Coordinated services for single view of virtual worlds

Collaboration for new network-friendly media formats
- Mechanisms to disaggregate volumetric data sets to object centric approach
- Lots of metadata support.

Future Media Enablers/Market Drivers
- Multi-sensory for Spatial compute
- Teleportation
- Spatial Compute

Publications and Talks

Concepts

- A New Way to Evolve the Internet, A Keynote Speech at IEEE NetSoft 2018, Montreal, Canada, June 2018
- What if we reimagine the Internet?, A Keynote Speech at IEEE ICII 2018, Bellevue, Washington, USA, Oct 2018

Framework and Architecture

- A New Framework and Protocol for Future Networking, ACM Sigcomm 2018 NEAT Workshop, Budapest, August 20, 2018
- New IP: Design for Future Internet with New Service Capabilities Envisioned, IEEE ICC Industry Tutorial, 2019

Market Drivers and Requirements

- Towards a New Internet for the Year 2030 and Beyond, ITU IMT-2020/5G Workshop, Geneva, Switzerland, July 2018
- Network 2030: Market Drivers and Prospects, ITU-T 1st Workshop on Network 2030, New York City, New York, October 2018
- Next Generation Networks: Requirements and Research Directions, ETSI New Internet Forum, the Hague, the Netherlands, October 2018
- The Requirements for the Internet and the Internet Protocol in 2030, ITU-T 3rd Workshop on Network 2030, London, Feb 2019

New Technologies

- Preferred Path Routing – A Next-Generation Routing Framework beyond Segment Routing, IEEE Globecom 2018, December 2018
- Flow-Level QoS Assurance via In-Band Signaling, 27th IEEE WOCC 2018 , 2018
- Using Big Packet Protocol Framework to Support Low Latency based Large Scale Networks, ICNS 2019, Athens, 2019

Use Cases and Verticals

- A Novel Multi-Factored Replacement Algorithm for In-Network Content Caching, EUCNC 2019, Valencia, Spain
- Distributed Mechanism for Computation Offloading Task Routing in Mobile Edge Cloud Network, ICNC 2019, Honolulu, USA
- Enhance Information Derivation by In-Network Semantic Mashup for IoT Applications, EUCNC 2018, Ljubljana, Slovenia
- Latency Guarantee for Multimedia Streaming Service to Moving Subscriber with 5G Slicing, ISNCC 2018, Rome, Italy

References

- Holographic content considerations methods for efficient data transmission and content creation methodologies
- Point Cloud Compression in MPEG MP20 Workshop Hong kong 2017
- Keynote: the near future of immersive experiences: where we are on the journey, what lies ahead, and what it takes to get there.
- Architectures and codecs for real-time light field streaming journal of imaging science and Technology , January 2017
- A Dynamic Compression Technique for Streaming Kinect-Based Point Cloud Data (2017 International Conference on Computing, Networking and Communications (ICNC): Multimedia Computing and Communications)
- Technical White Paper on Mobile Bearer Network Requirements for Mobile Video Services.
- On the Support of Light Field and Holographic Video Display Technology, Light Field Lab, Inc., San Jose, CA. “The road to immersive communication,” Proceedings of the IEEE, vol. 100, Apr. 2012.

Thank You

Comments, Curious?

kiranm@Futurewei.com