Holographic Type Communication

Delivering the Promise of Future Media by 2030

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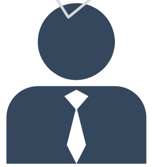
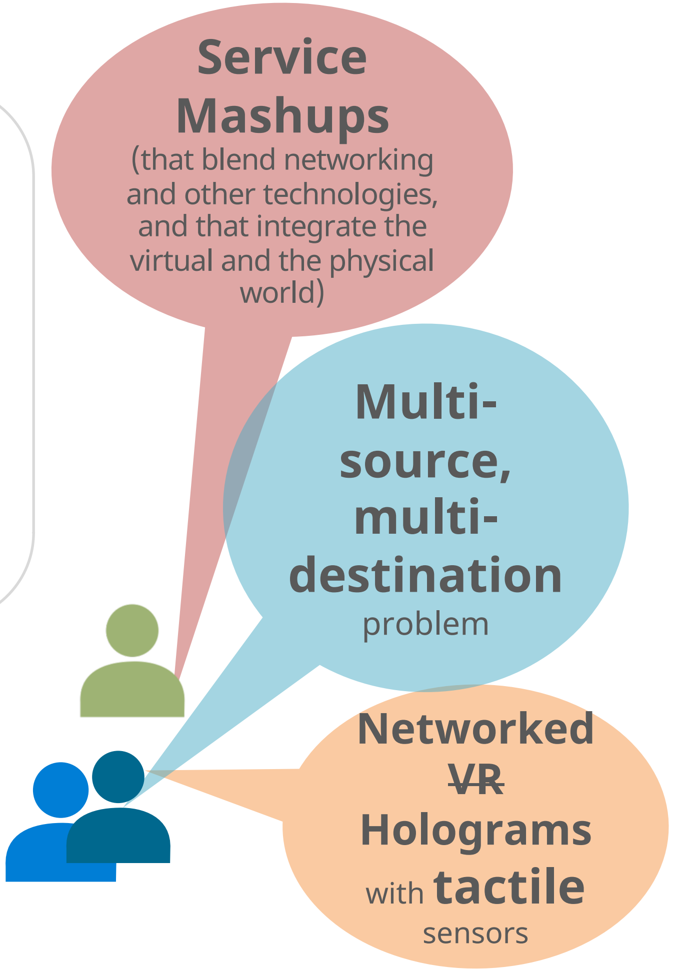
Year 2035 will be majestic year -☺

Future Scenarios will Blend Virtual and Real Worlds Seamlessly.

One fine day… Feb 2018

Hypothetically speaking, assume we want to design a new **network and its associated protocols** that would support future world in the year 2035.
What would be your best use cases and market drivers?



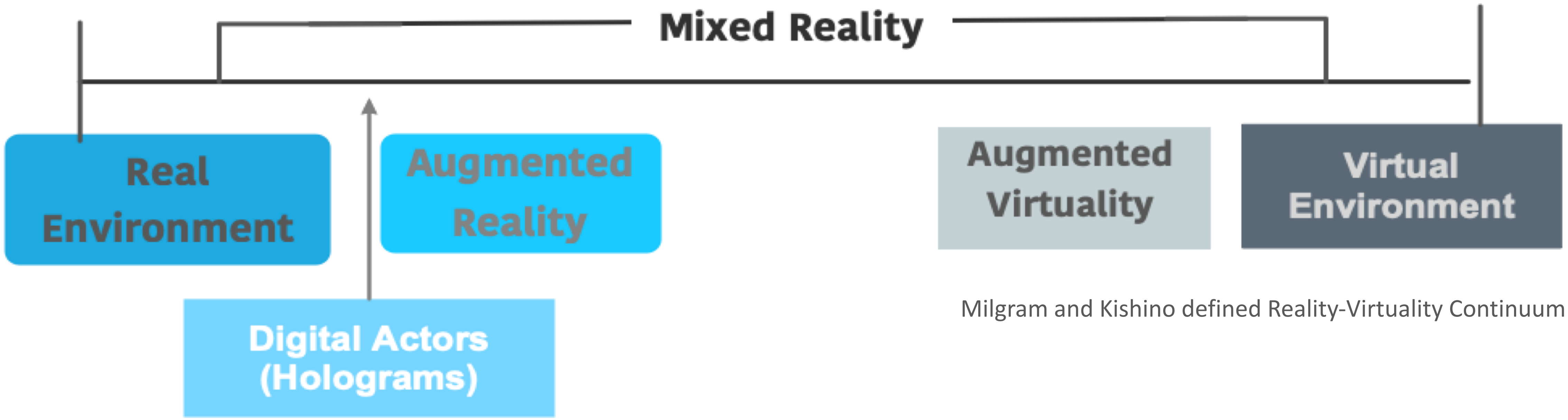


AR/VR HMDs prohibitive to natural experience.
Holograms will be core Digital Actors
Holograms always need network

Holographic Digital Actors

Start with
Inserting holograms in real environment

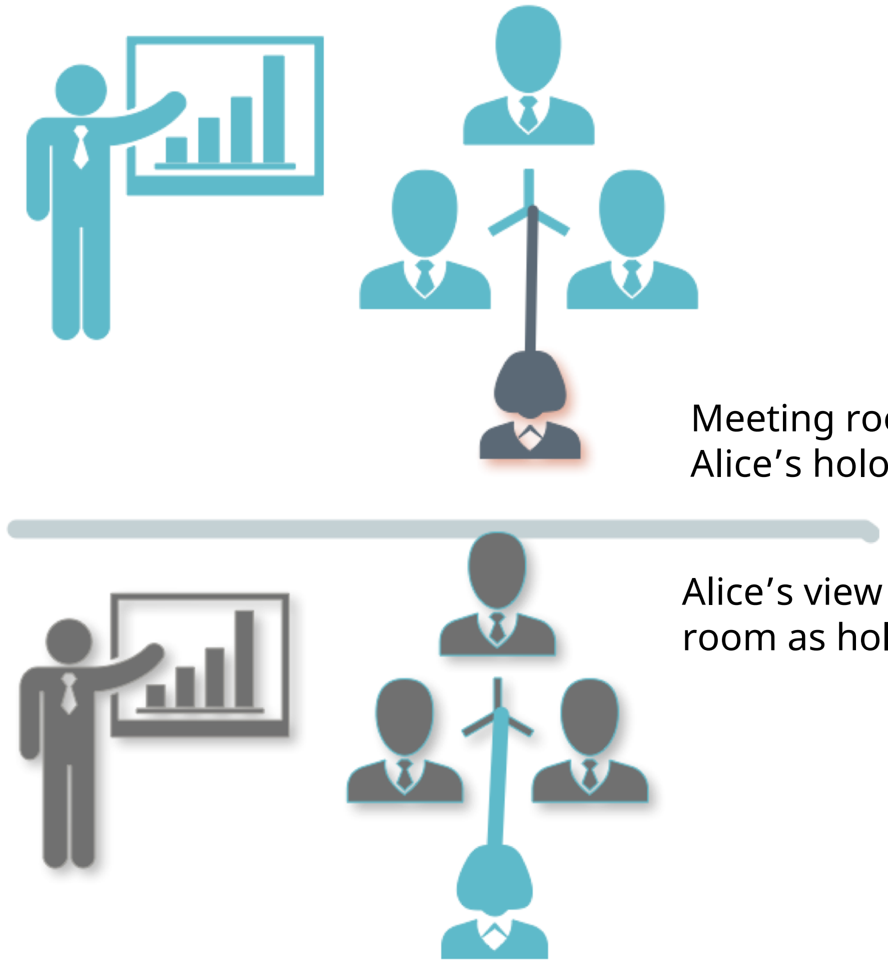
- Allow experiences to develop without having to use HMDs.
- First steps is to Focus on placement of Digital Actors in a Physical World



Milgram and Kishino defined Reality-Virtuality Continuum

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

Holographic Communication Use case



Meeting room view + Alice's hologram

Alice's view with Meeting room as hologram

Digital Actor

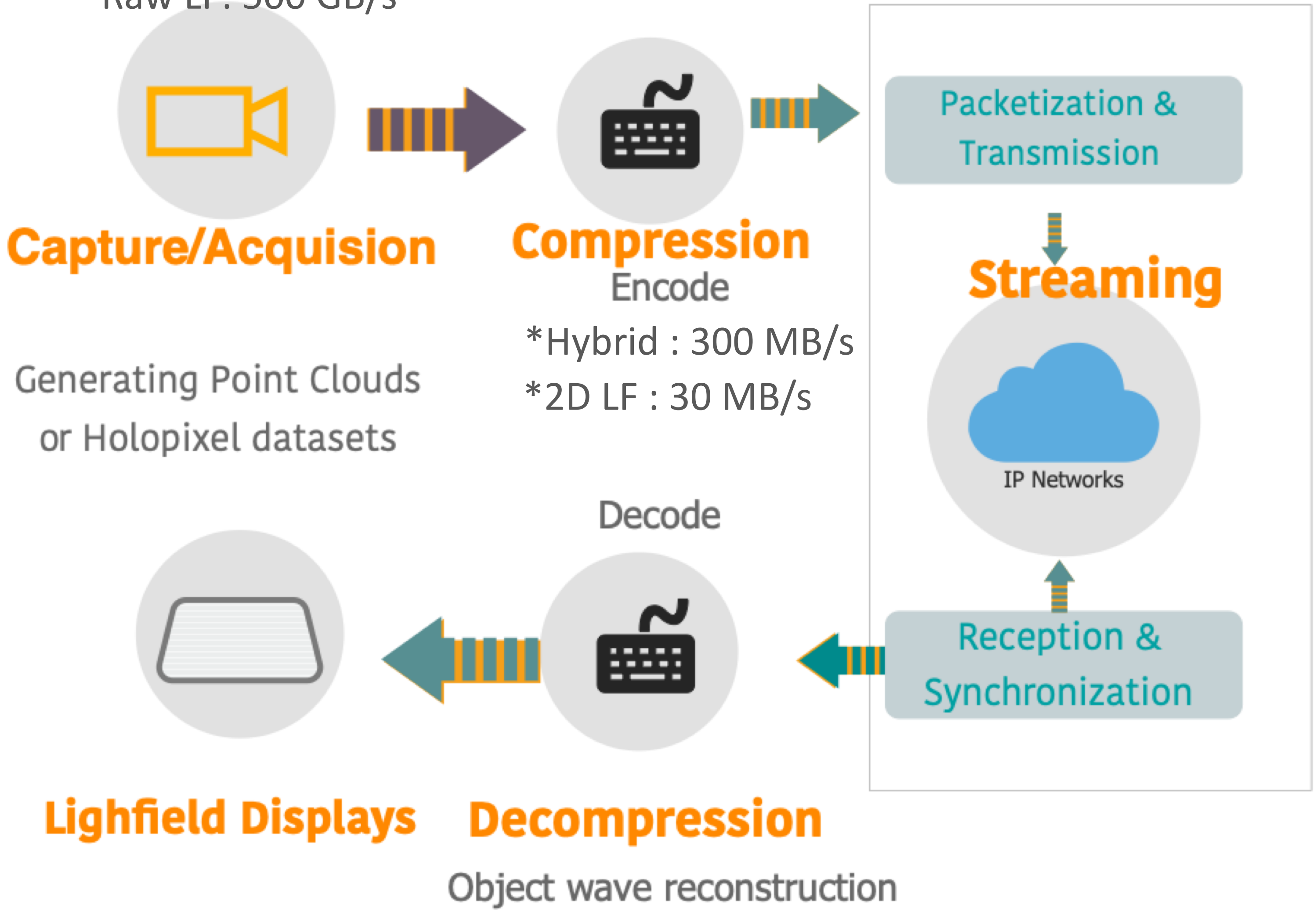
Single point cloud holographic object in a real scene

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

Remaining entities are real.

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)

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

Streaming

THROUGHPUT

Higher the Better

LATENCY

Shorter the Better

Traditional Networking

With end to end intelligence in order to support holographic streams.

Trade offs between

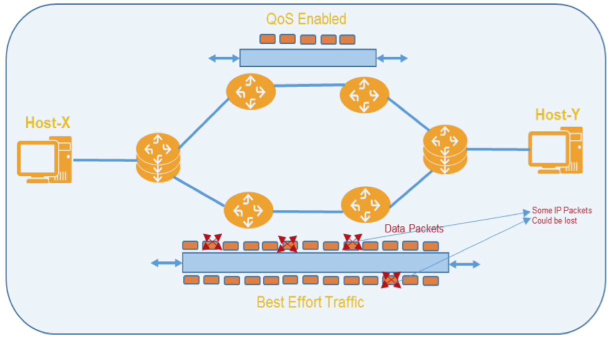
1. How much can we transmit?
2. The resolution or quality?
3. How much delay is acceptable?

But there's a limit:

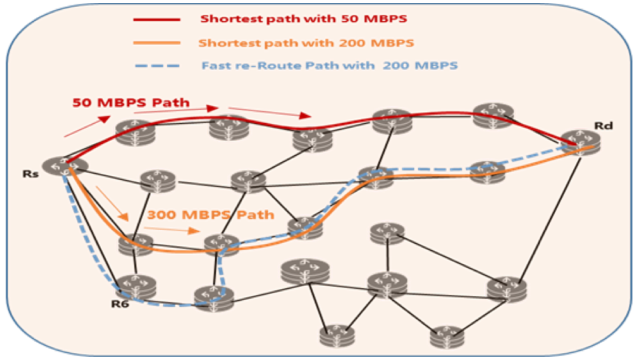
1. Throughput is not exactly bandwidth.
2. Latency is not same as in-network delay.

Capabilities Today

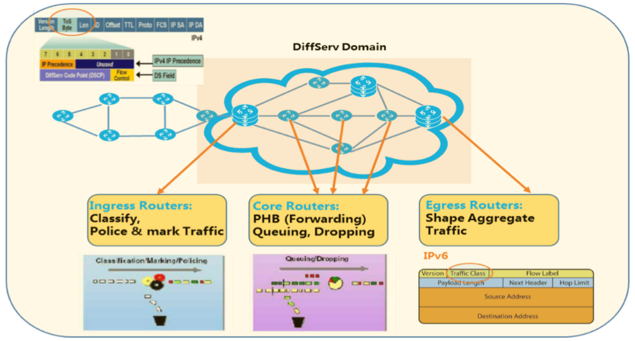
Best Effort



Traffic Engineering



Differentiated Services



Available Guarantees

- ✓ Per-Hop Behavior
- ✓ Forwarding Path (Source Routing)
- ✓ Minimal Bandwidth

- × Throughput Guarantee
- × Latency Guarantee
- × Being Lossless
- × Zero Jitter

Throughput

Use case:
On-demand High Resolution HV

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

Higher the Better

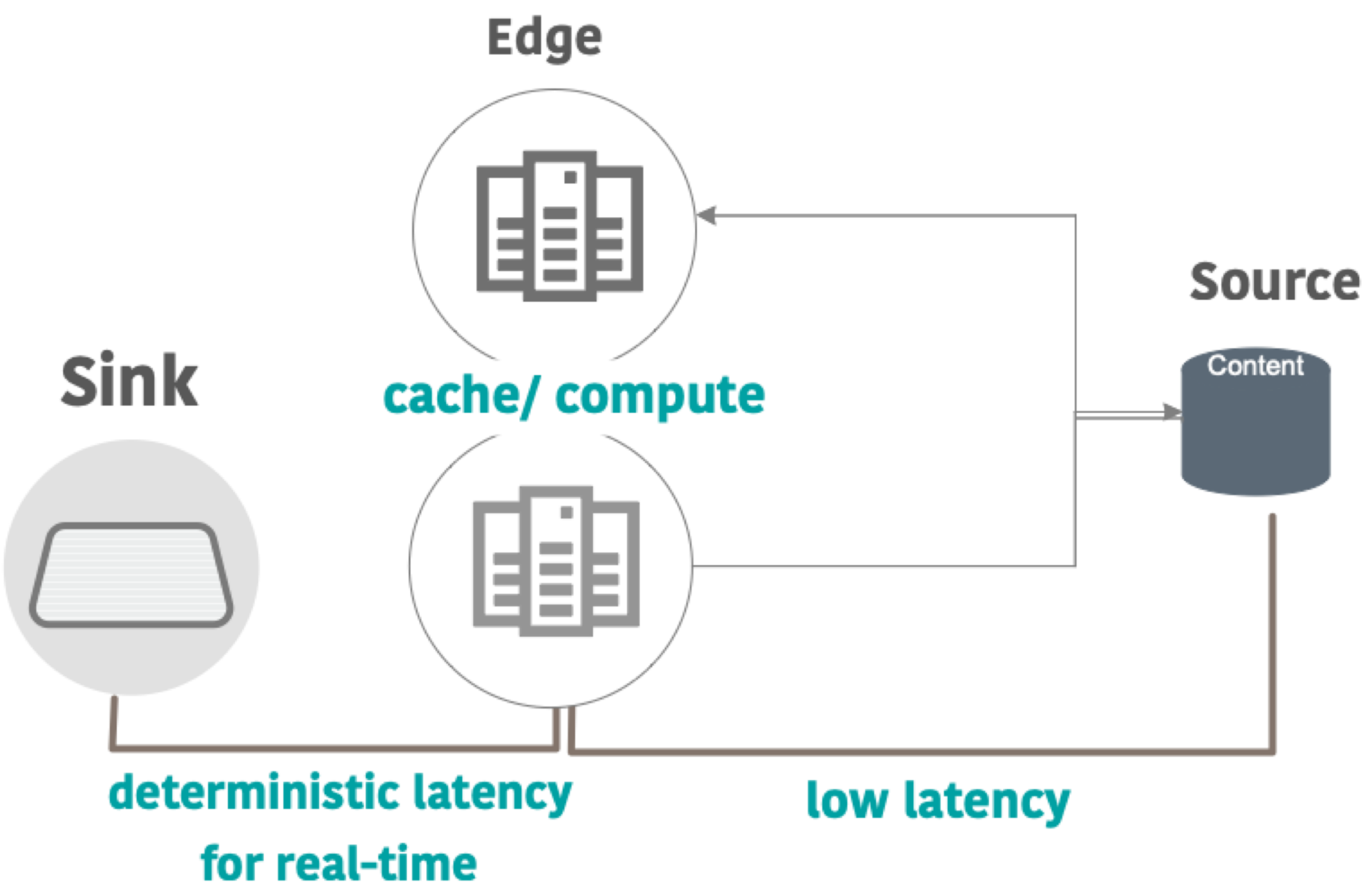
There's a threshold to packet loss, beyond which user experience degrades (U-vMOS*)

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.

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

Latency



Use case:
Live event feed/Real-time interactive and immersive gaming

Lots of computational power for decoding and rendering different views.

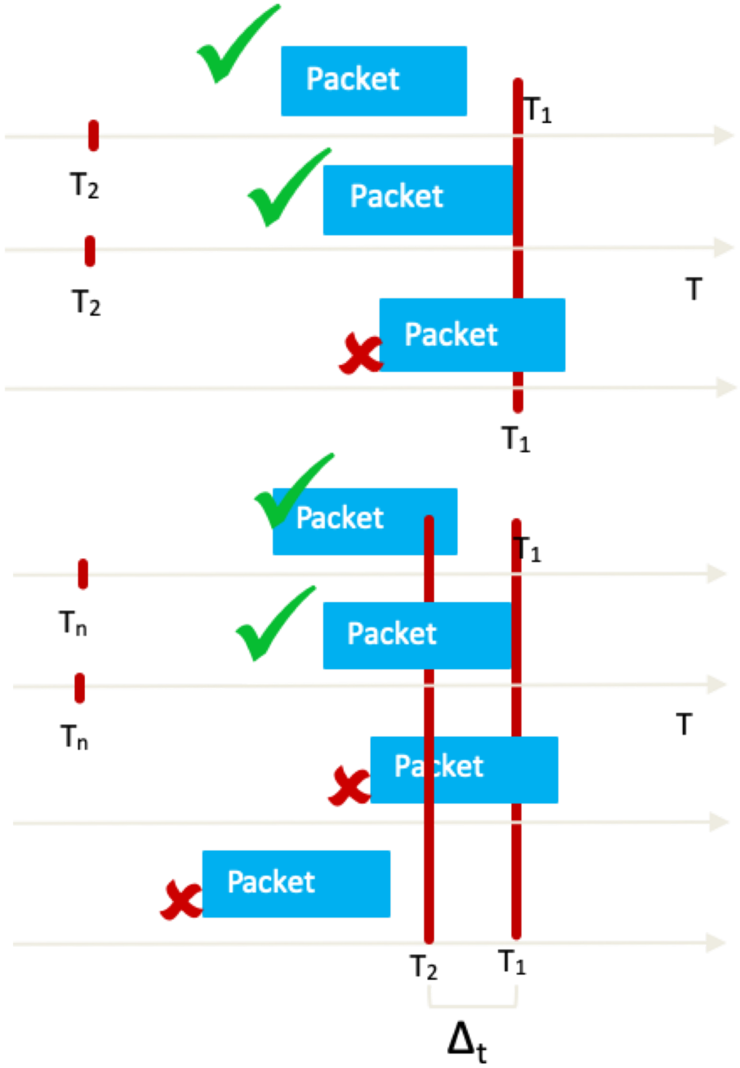
Utilize edge for distance.

Can we still guarantee High-precision communications for real-time interactions?

High-Precision

In-time Guarantees

On-time Guarantees



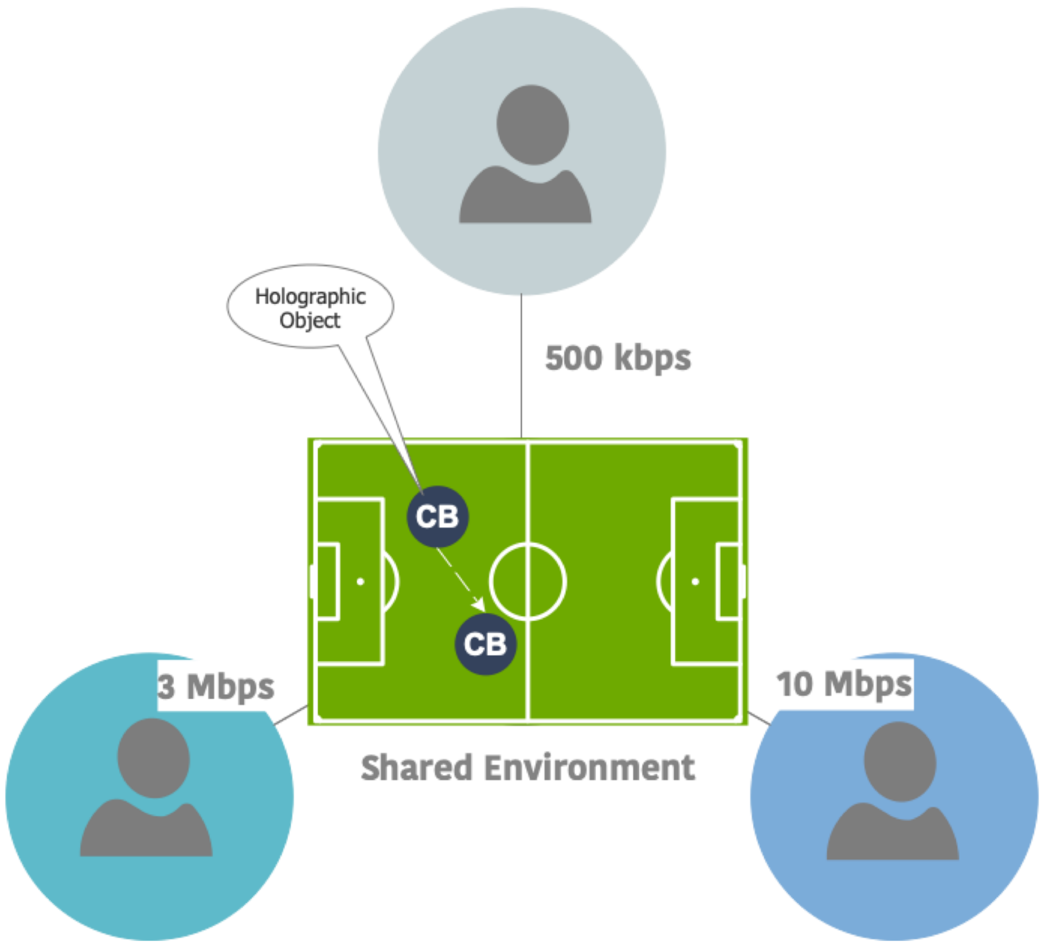
Use case:

Extremely low latencies for critical events such as accident avoidance

Provide Network with attributes to handle delays due to Transmission, Propagation, Processing and Queuing

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

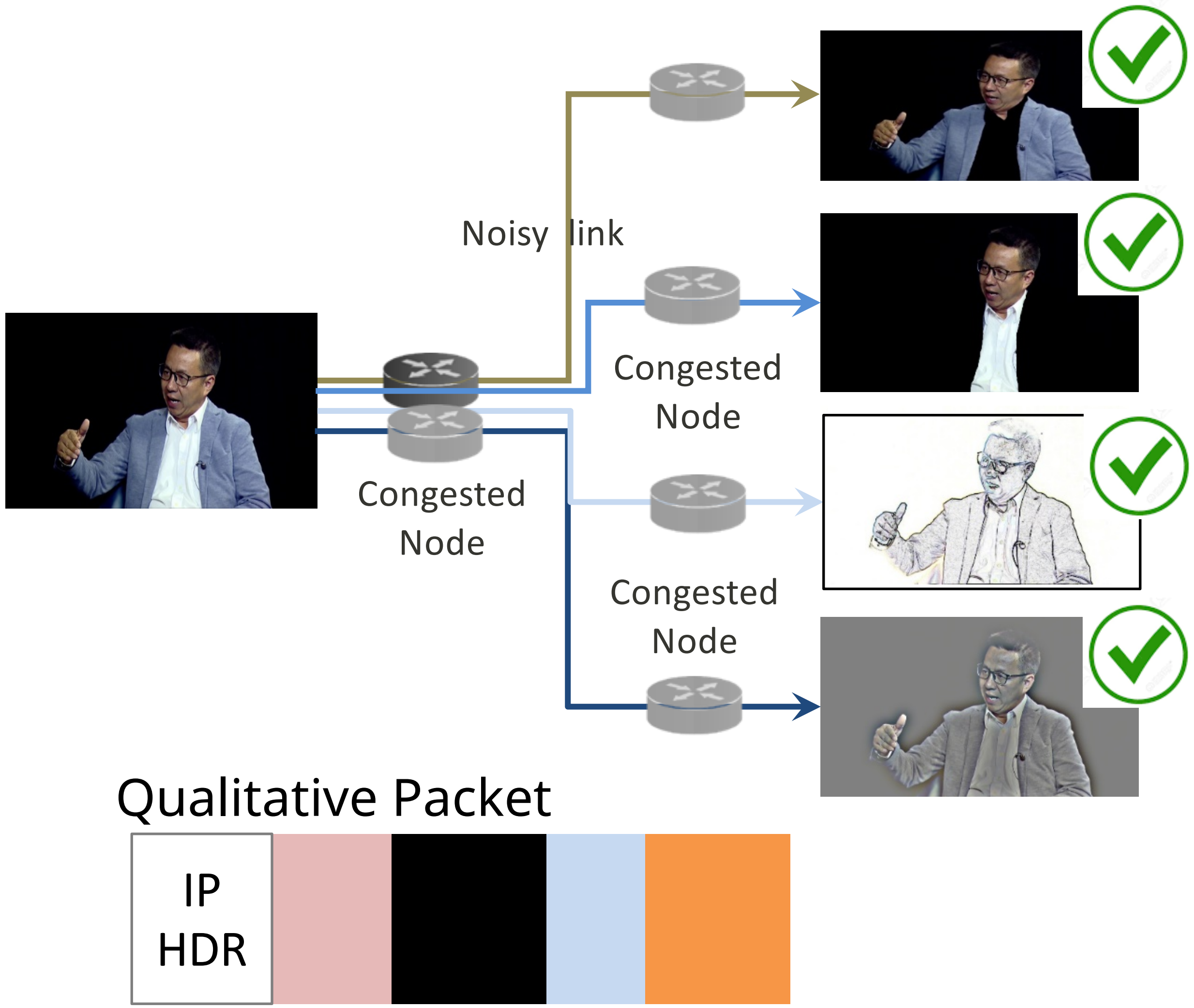
Coordinated



Use case:
Synchronized Remote Collaboration

- 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.

Qualitative

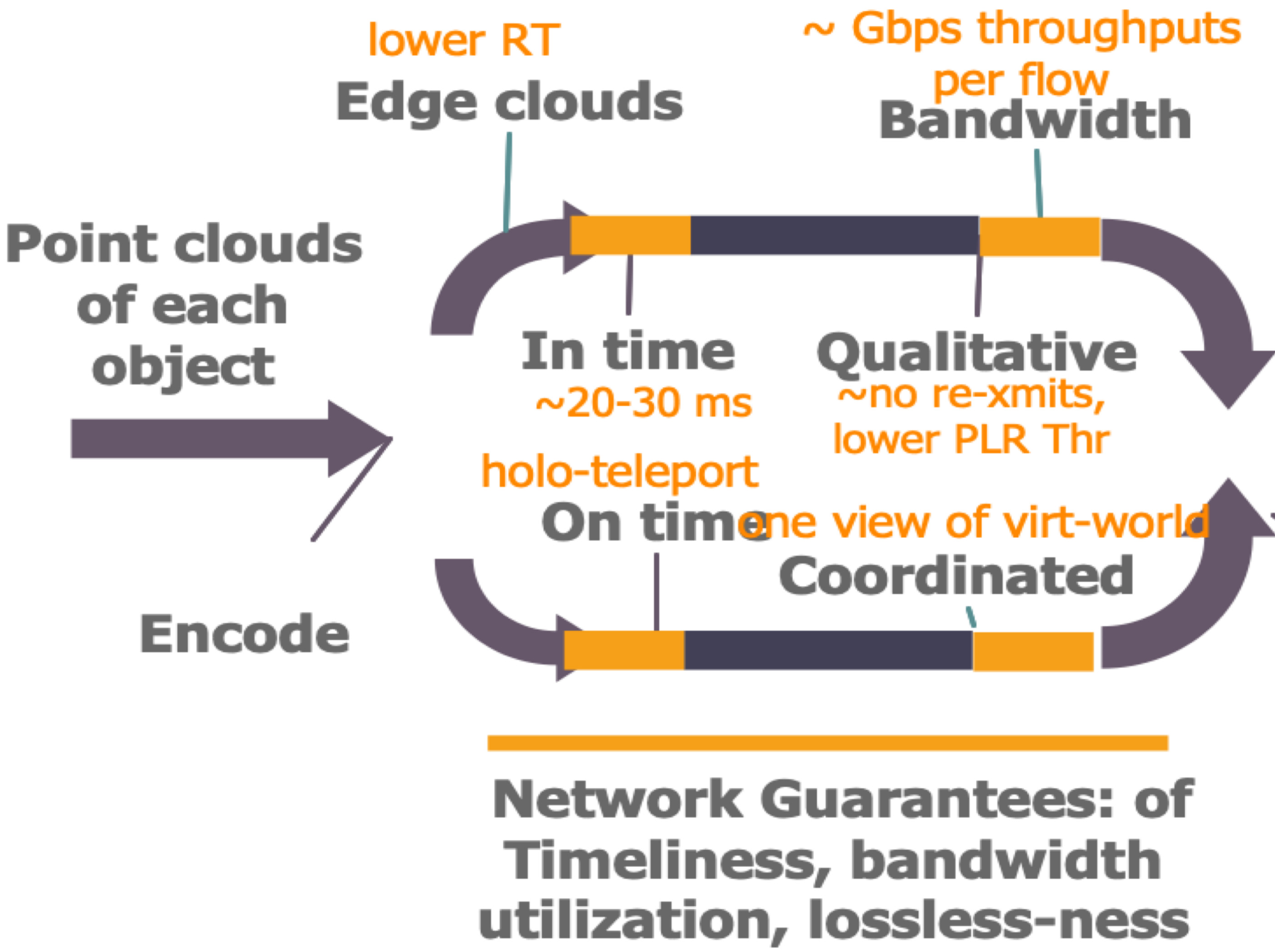


Use case:

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.

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. Lost 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…

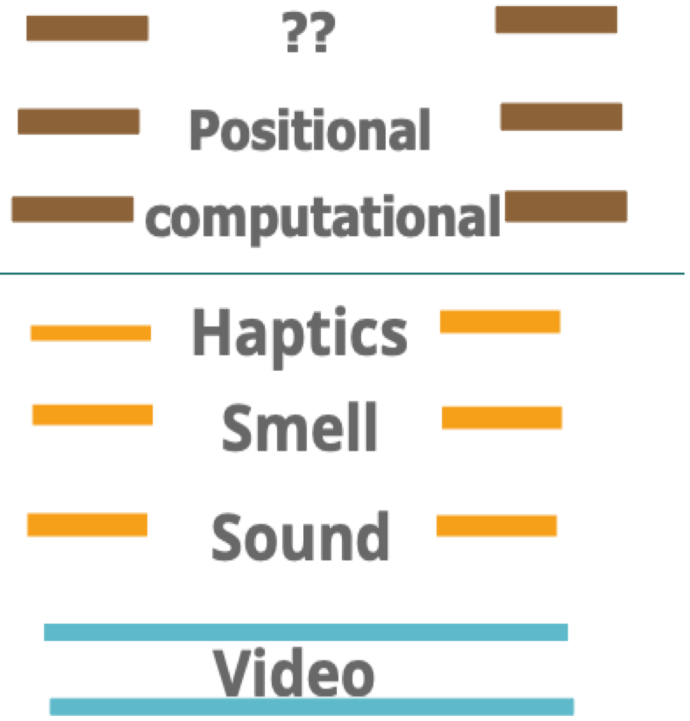
In-network capabilities

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. different planes as different flows.
5. Coordinate fairness over heterogeneous links.

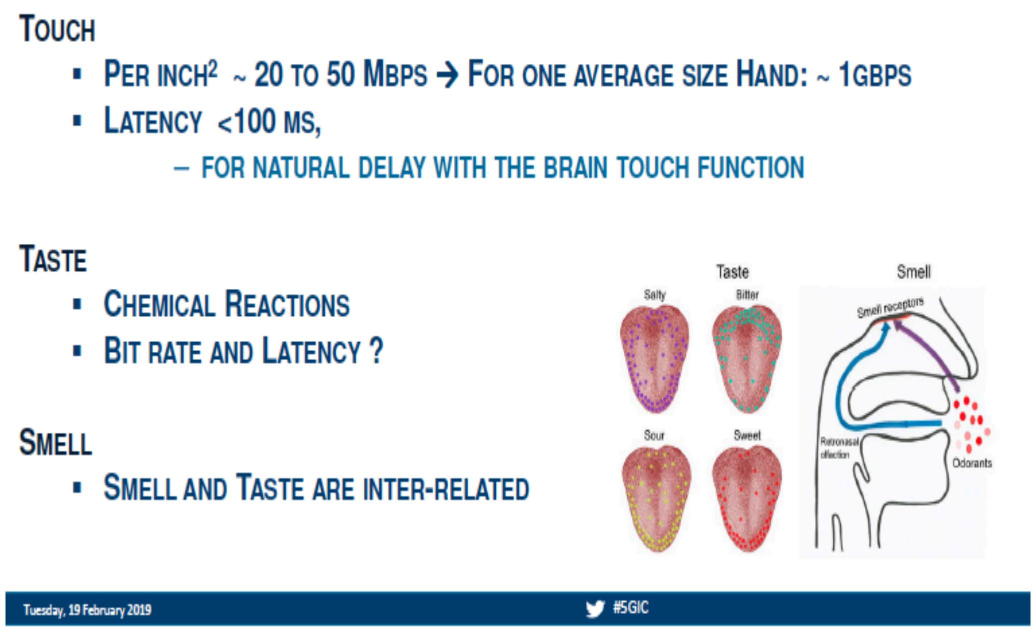
Future Media

Intuitive interactions (Spatial Compute)

Natural interactions (Teleportation)



Teleportation = Holoportation + Sensual Information



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

Are we ready for the year 2030+?

No, absolutely not!

Precision of time in services	Industrial Control Autonomous Driving Tactile Internet
Holographic Media	Real-time high-throughput streaming Coordination of different streams
ManyNets Infrastructure	Space Internets Private Internet Unresolved Regulatory barriers
Moving beyond best effort	Premium Services Lossless networking
Rich Access Technology	Gbps/Tbps access enabled by 5G/B5G and Surface Wave

Networking 101:
No significant fundamental change necessary for networks.

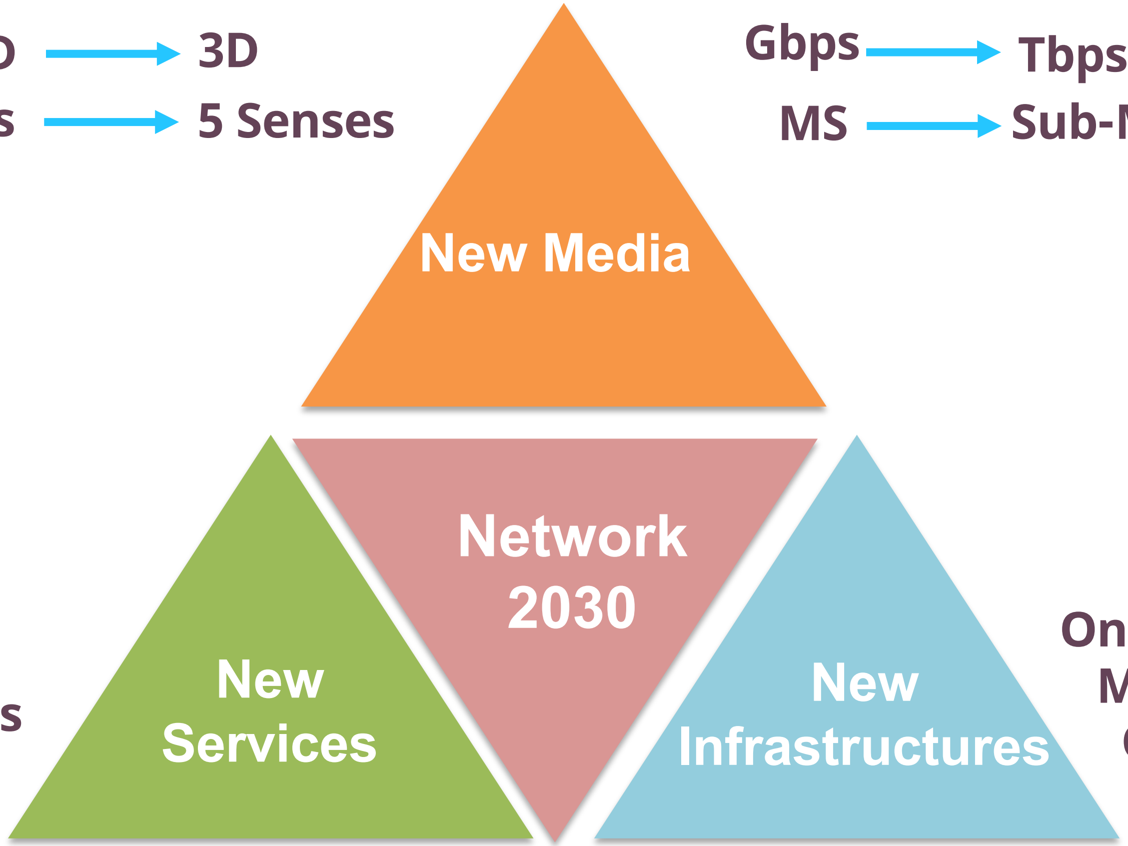
1) MPLS provides a switching way to implement traffic engineering and VPN services
2) IPv6 changes the addressing scheme,
3) while SRv6 reformats source routing
4) SDN changes the way to control networks
5) NFV changes the way to implement network functions

Vision Network 2030

Holographic Society and Industry

2D → 3D
2 Senses → 5 Senses

Gbps → Tbps
MS → Sub-MS Latency



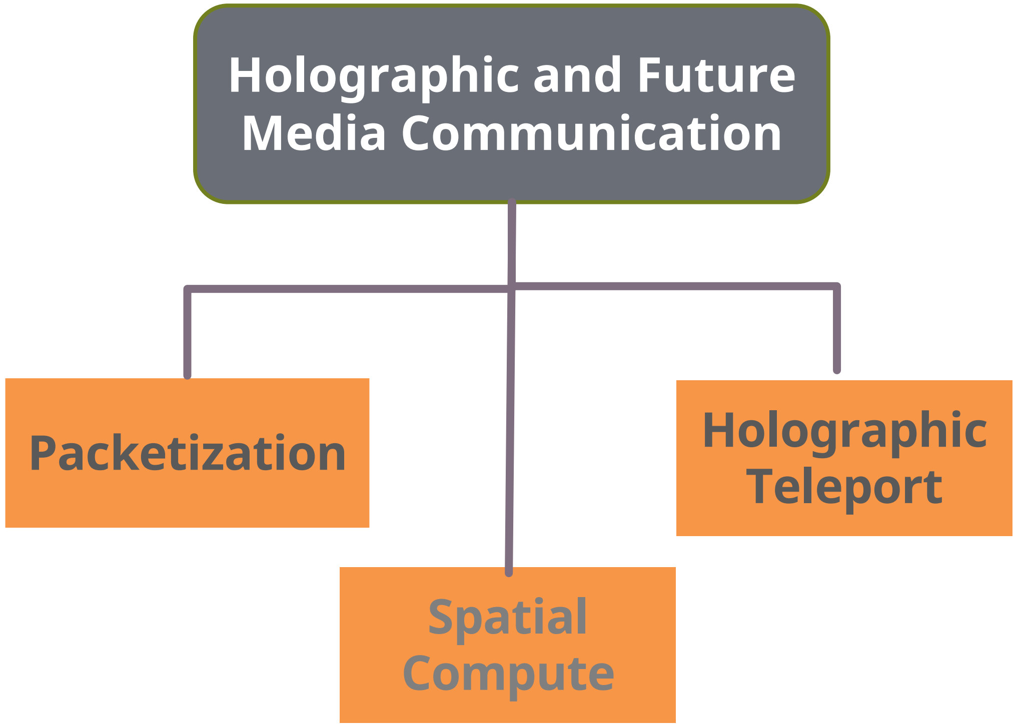
Next wave of
Internet Innovations

OneNet → ManyNets
Mbps → Gbps/Tbps Access
Computing in Networks

Lossless Networking
High-Precision Communications
Holographic Type Communications

Converged Terrestrial and Space
Fidelity and Trust
Federated Networks

Summary



New Network Capabilities

- 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
- Lots of metadata support.

Future Media Enablers/Market Drivers

- Multi-sensory
- Teleportation
- Spatial Compute

Elements of Network 2030

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, Questions?

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ITU-T FG-NET-2030

https://www.itu.int/en/ITU-T/focusgroups/net2030/Pages/default.aspx