Network 2030 Vision

Delivering the Promise of Future Media by 2030

Roller Coaster Presentation

>1 SPM (slide/minute)

CUSTOMER RELEASE, ASSUMPTION OF RISK, WAIVER OF LIABILITY, AND INDEMNIFICATION AGREEMENT

....
Sign above line

Toerless.Eckert, Kiran.Makhijani @futurewei.com,
Santa Clara, CA, USA

AWE EU pre conference Workshop: The Challenge of Spatial Computing
16 October 2019, München, Germany

Imagine applications in 2035

One fine day... Feb 2018

Hypothetically speaking,

Assume we want to design a new

Network and its protocols

that would support the world in 2035.

What would be your
Best use cases and market drivers?

Service Mashups
(that blend networking and other technologies, and that integrate the virtual and the physical world)

Multi-source, multi-destination
problem

Networked AR/~~VR?~~ Holograms with tactile sensors

Future Scenarios will Blend Virtual and Real Worlds Seamlessly.

AR/VR HMDs limiting to natural experience

See eg: failure of 3D@home.

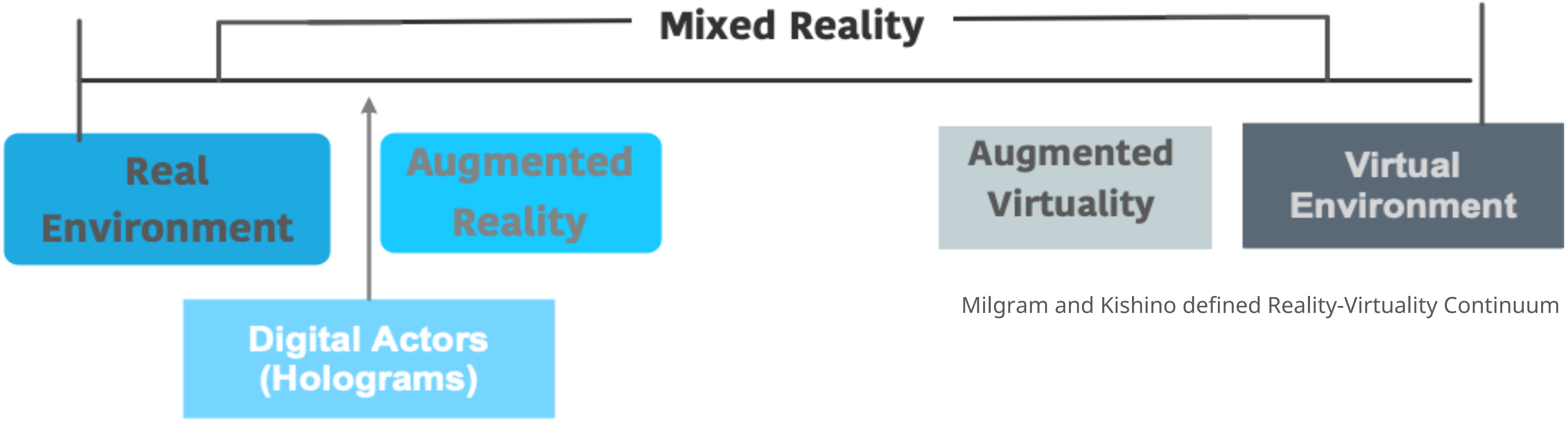
Holograms could become **Core Digital Actors**

What networks would Holograms need ?

Holographic Digital Actors

Start with
Insert holograms into real environments

Allow experiences to develop without having to use HMDs.
First steps: Placement of Digital Actors in a Physical World

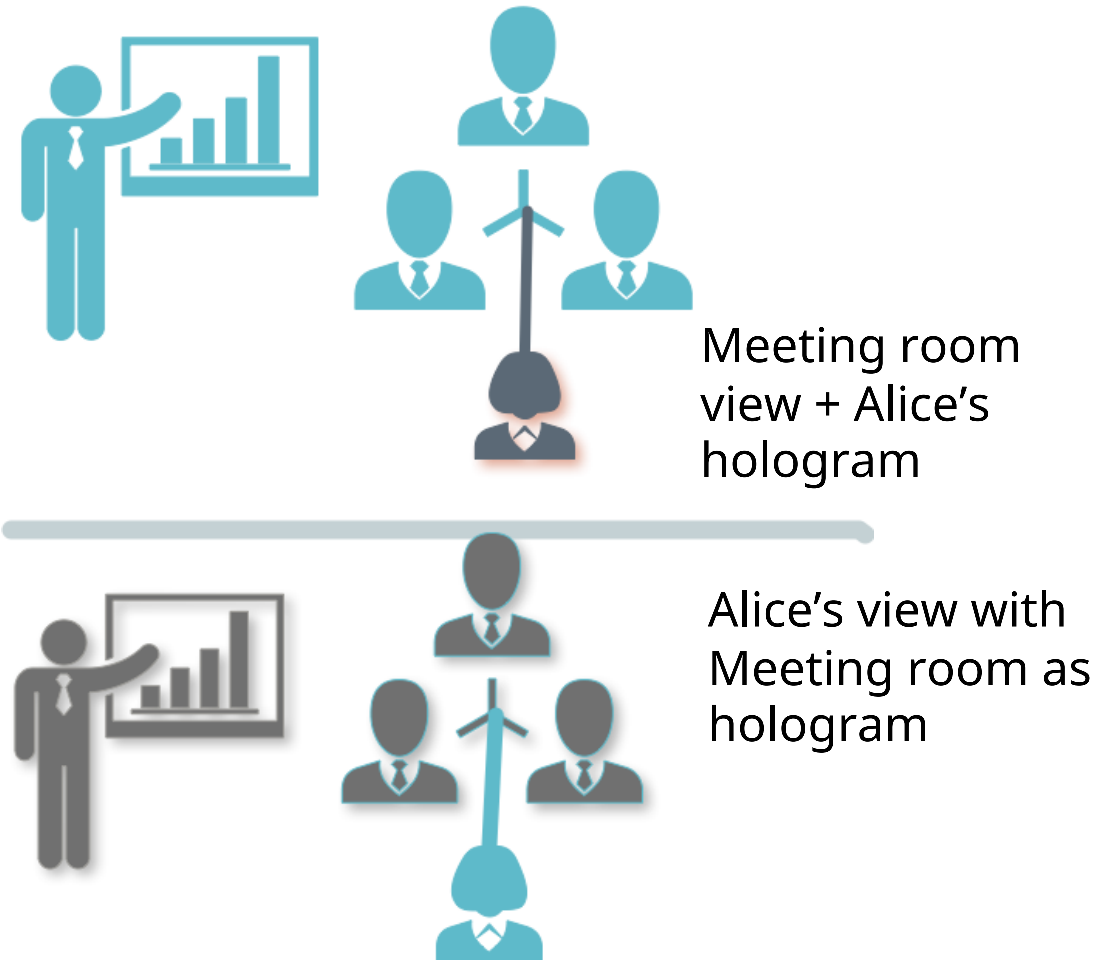


Milgram and Kishino defined Reality-Virtuality Continuum

Holographic Digital Actors: Naturally - grounded in the real world - Life sized or resizable - Responsive, but not alive

Holo-presence

Holographic Communication Use case



Use-case: Digital Actor Single point cloud holographic object in a real scene

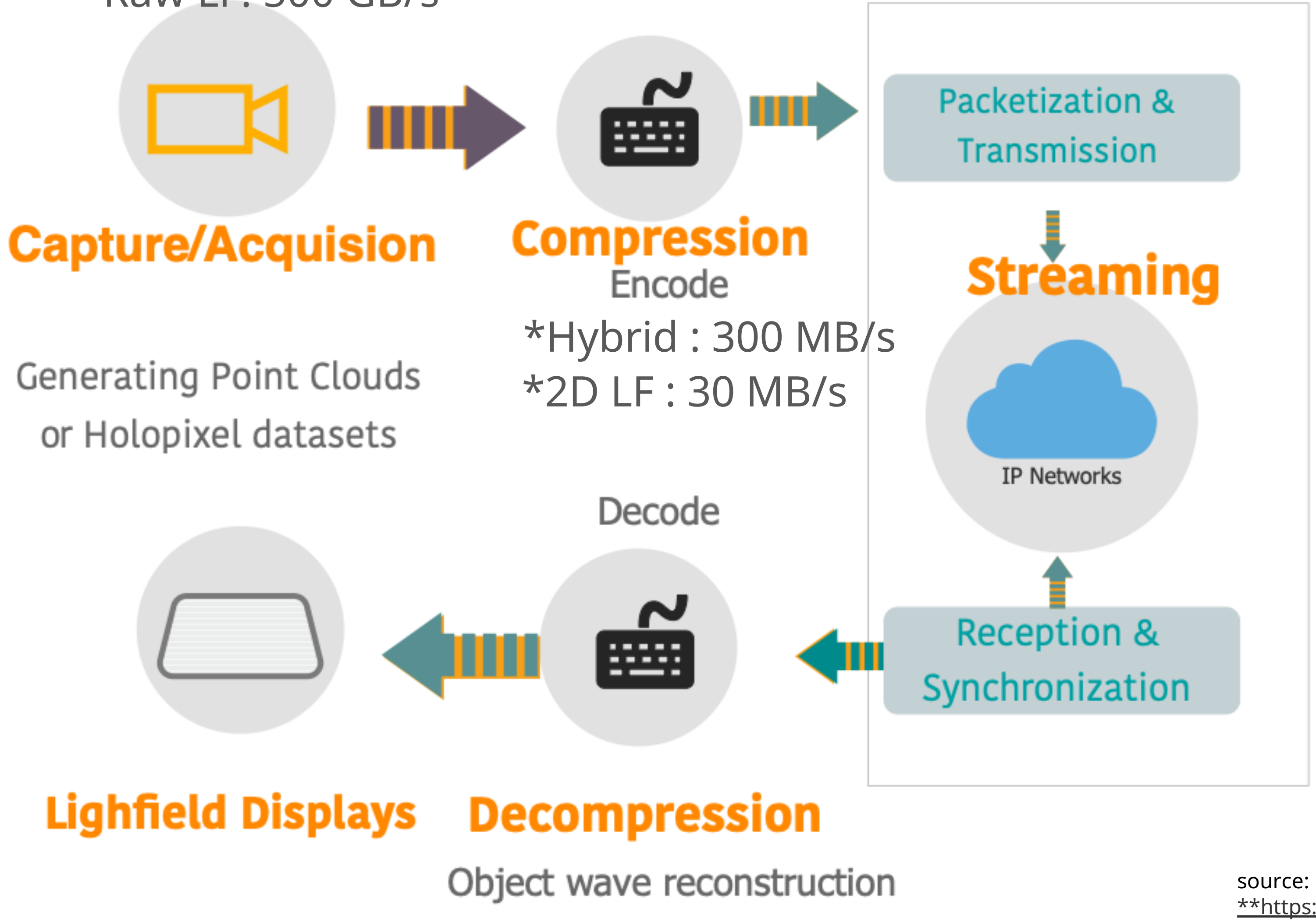
Telepresence using Hologram.

It is the only digital object in the scene,
remaining entities are real.

Ideally, Alice has respective setup.

Holographic Media Engine

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



Evolution of Holograms
from Diffraction patterns to Light field models.

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

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

Compression schemes known to improve with adoption, but no good predictions for "final" rates.

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

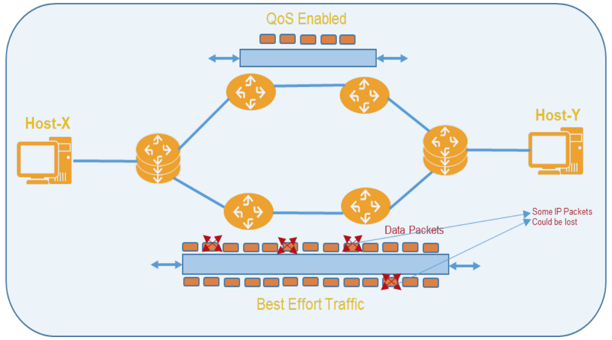
1. How much can we transmit?
2. The resolution or quality?
3. How much latency is acceptable?

But there’s a limit:

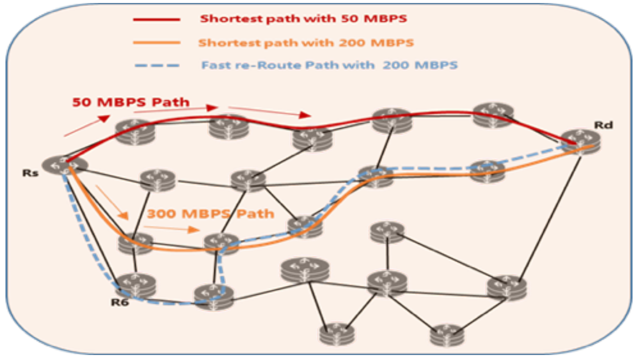
1. Throughput is not exactly bandwidth.
2. E2E Latency > network propagation delay.

(Beyond) Internet Capabilities Today

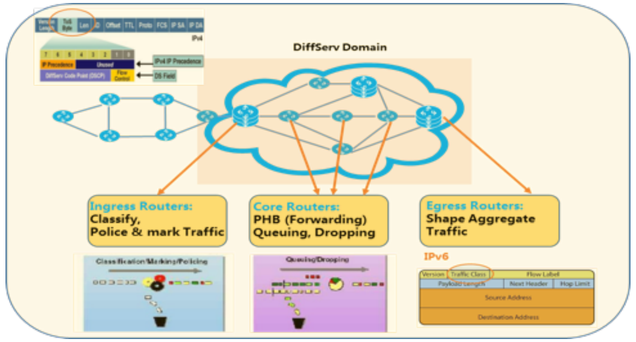
Internet: Best Effort



Traffic Engineering ==
Capacity Engineering



Beyond Internet:
Differentiated / (Integrated) Services



Available Services Internet
Streaming == Abuse of web-caches

- ✓ “Best Effort” Per-Hop Behavior (PHB)
- ✓ ECN / AQM (maybe)
- ✓ “Shortest Path” routing

- × Throughput / Priority Guarantees
- × Latency Guarantee (path/queuing)
- × No-Loss guarantees
- × Jitter

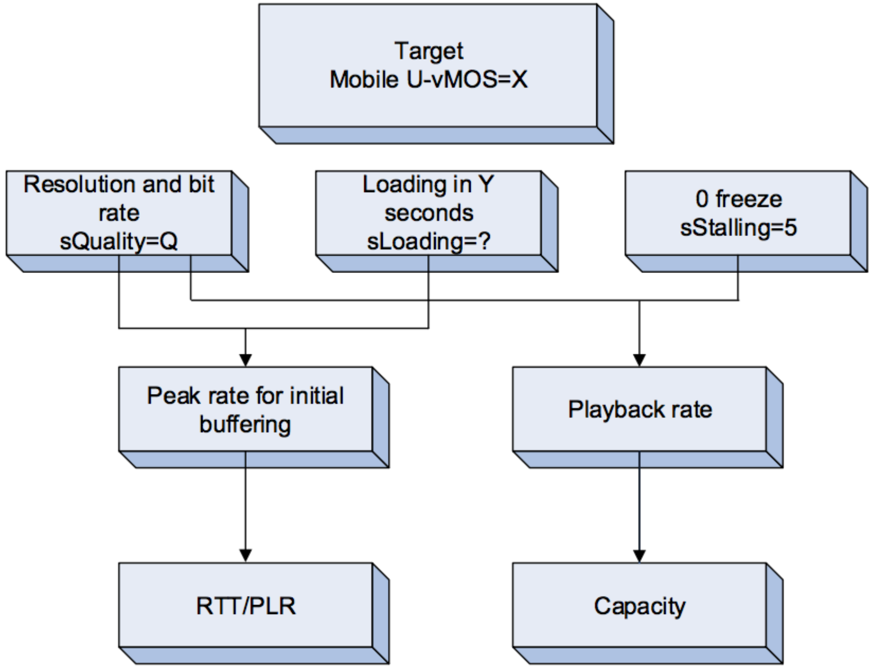
Beyond Internet

Fragmented, non-ubiquitous, ONE-OFF peer2peer maze of not-well-working services options. E.G.: biggest OTT provider get preferential treatments in network.

Mean Opinion Scores (MOS)

"User experience" vs. Application/codec vs. network behavior (throughput, loss, latency)

Use case:
On-demand, High Resolution Home/Mobile Video



Example, Simple Mean Opinion Score

Initial , intermittent buffering

Probability / periodicity of non-congestion loss (NCL)
Random (bit /packet errors) vs. Burst (outage) loss

Likelihood to conceal NCL (codec dependent)
Ability to correct NCL (FEC, retransmissions)

Normal/Ideal quality (throughput)

Quality Variation (throughput variation)
Frequency, fine-grained (concealed)

Congestion Loss (*YUCK*), Self-Friendly-ness

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

The troubles with throughput

Use case: Any Application

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

Higher the Better ?!

What is (Internet) throughput fairness ?

~~“all flows are created equal” ???~~

E.g.: competing 4K TV and Smartphone

How to achieve fairness ?

Path-RTT, transport-protocol-aggressivness

Guarantees ?

Absolute Reservation == scale issues

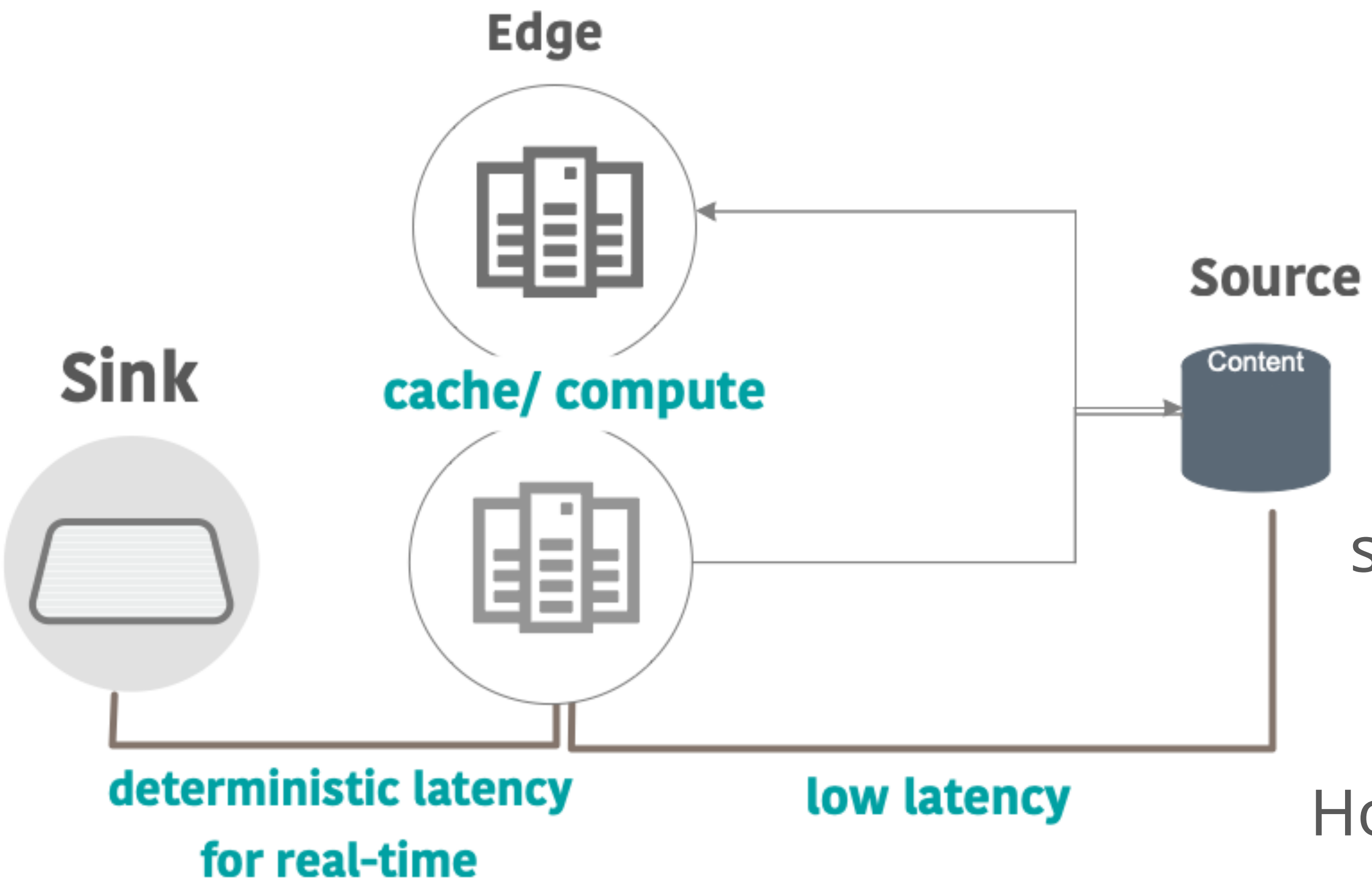
Relative throughput easier !!

Limited by Loss and Capacity:

Higher performance requires lower loss or higher overhead

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

The Edge: Scale, Latency and Control Loops



Use case:
Live event feed/Real-time interactive,
immersive gaming / remote-operations

Shorten control loop RTT.

Improve interactive experience (MOS!).

scale computational power for decoding / rendering (eg: different views)

How to control variability (throughput/latency)

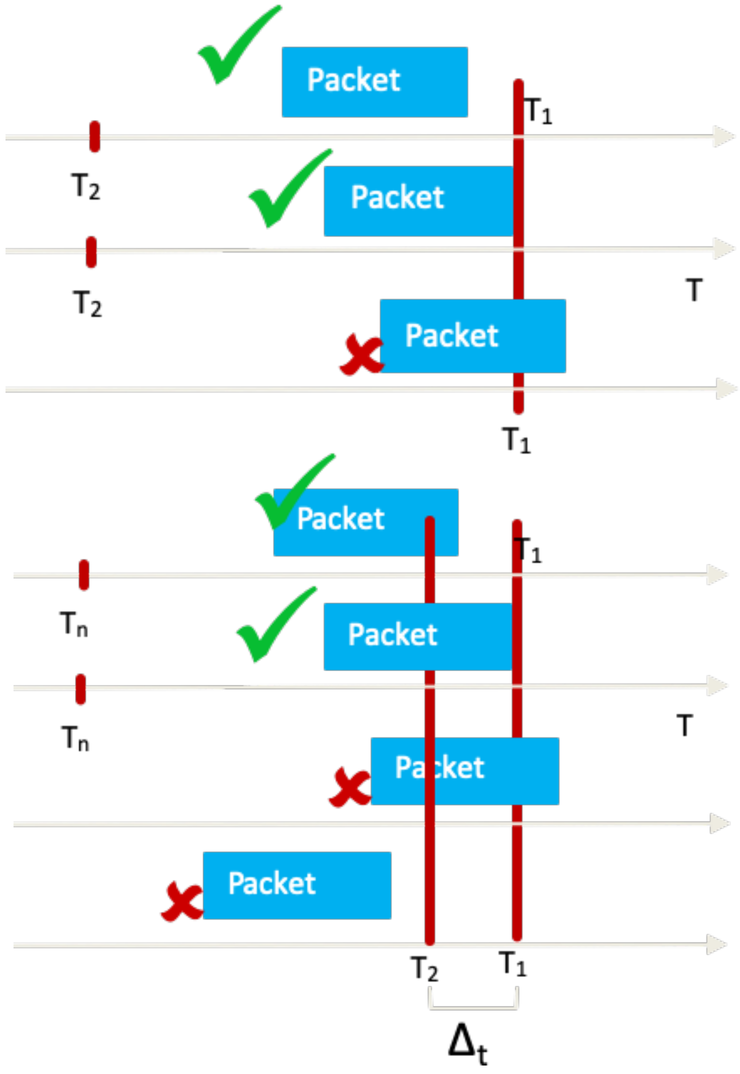
Deterministic ?

High-Precision-Communications ?

High-Precision Communications

In-time Guarantees

On-time Guarantees



Use case:
Latency sensitive streaming, control-loops

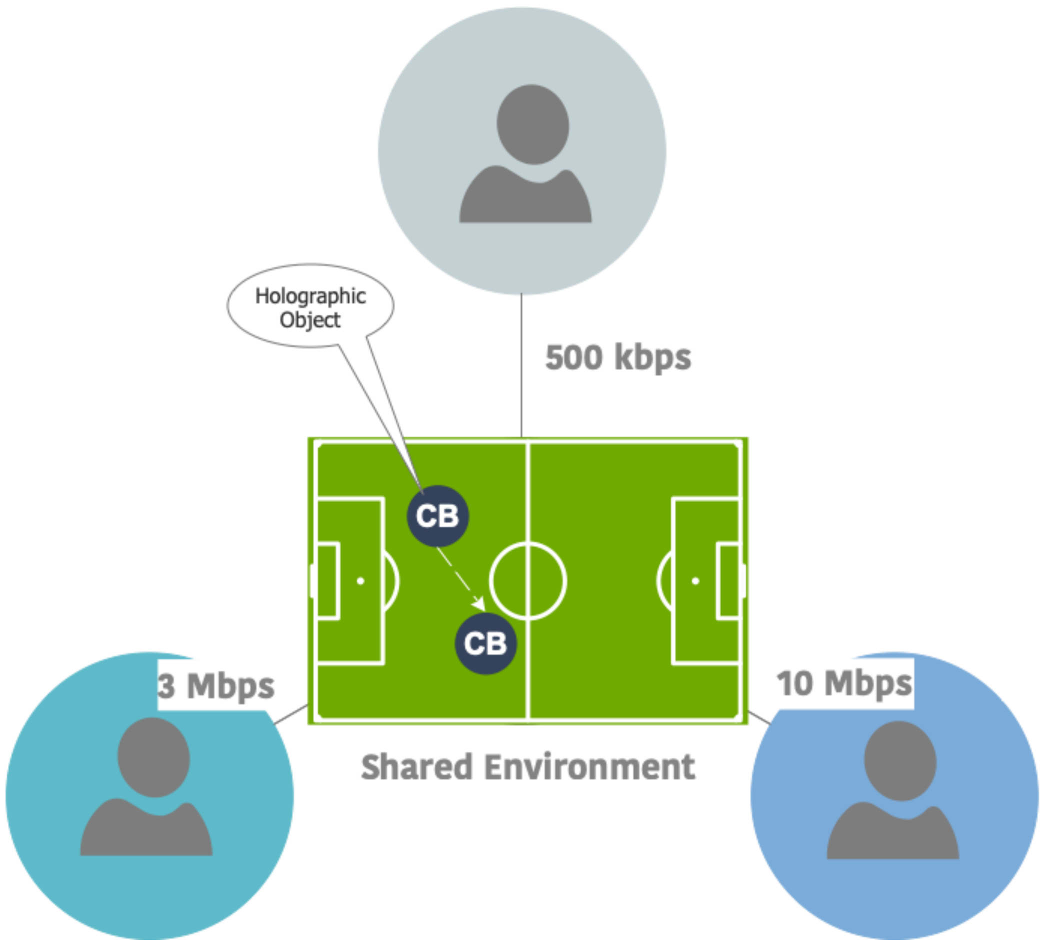
Let applications manage network latency (queuing, buffering)
End-to-end min..max latency control

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

Coordinated Communications



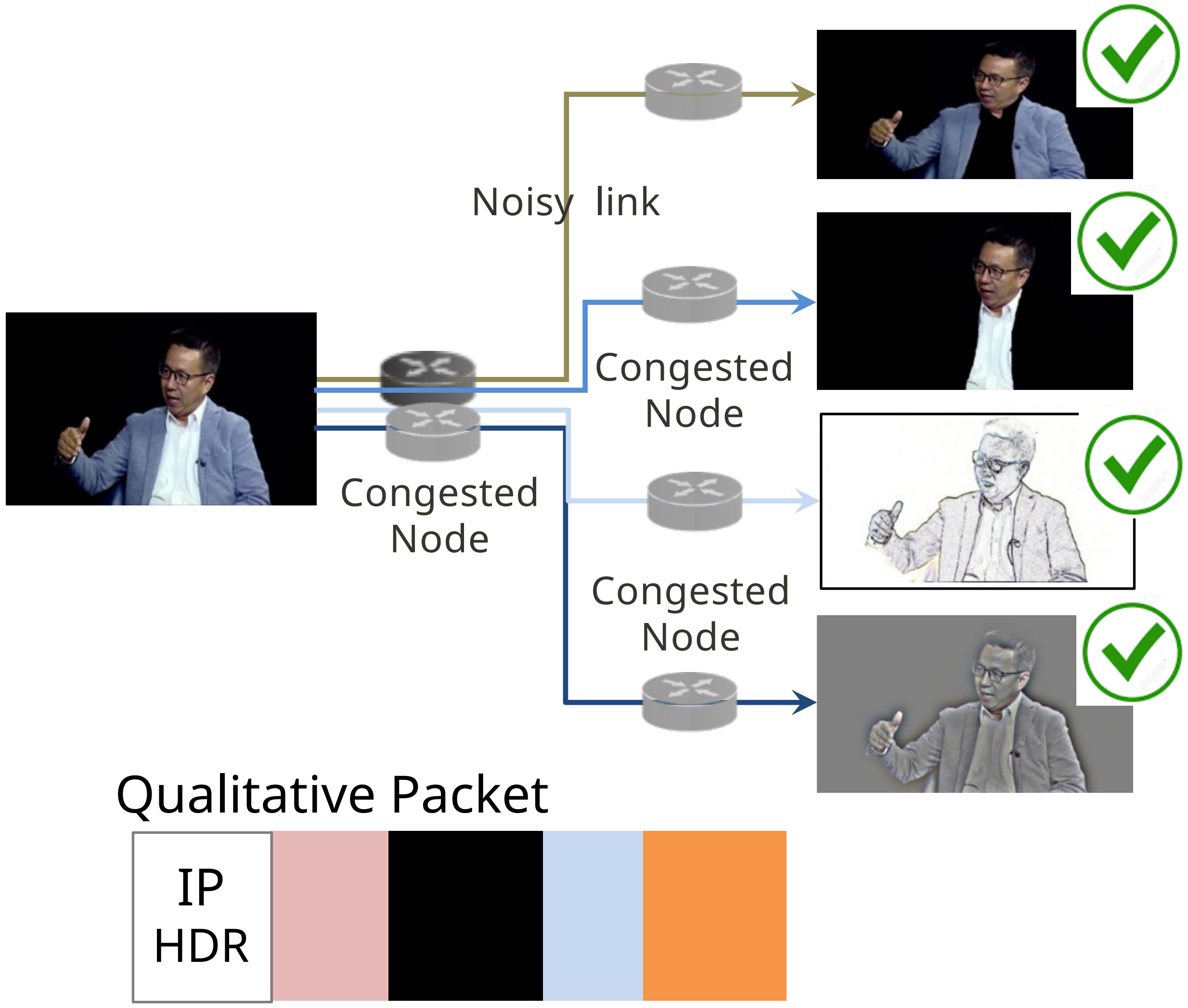
Use case:
Synchronized Multi-Part Remote Collaboration

Synchronized latency experience
"Why can player 3 shoot /kill faster?"
(lowest RTT to server)
In-network latency fairness (vs. clients faking RTT)

Aggregate Network Resource Management
"Get N Gbps for 2 hours, split across parties as you like"

Scale optimizations with guarantees
Multicast: in-network replication to parties
Incast: Many to "virtual/cluster" one

Qualitative Communications



Use case: Scalable Gradual management of quality

Layered/Object media codecs (e.g.: MPEG SVC)

Network awareness of Quality
Mapping to different per-packet network resources
E.g.: congest/(discard) highest-quality level first

Redundancy:
L3 In-network redundancy (FEC) insert/remove

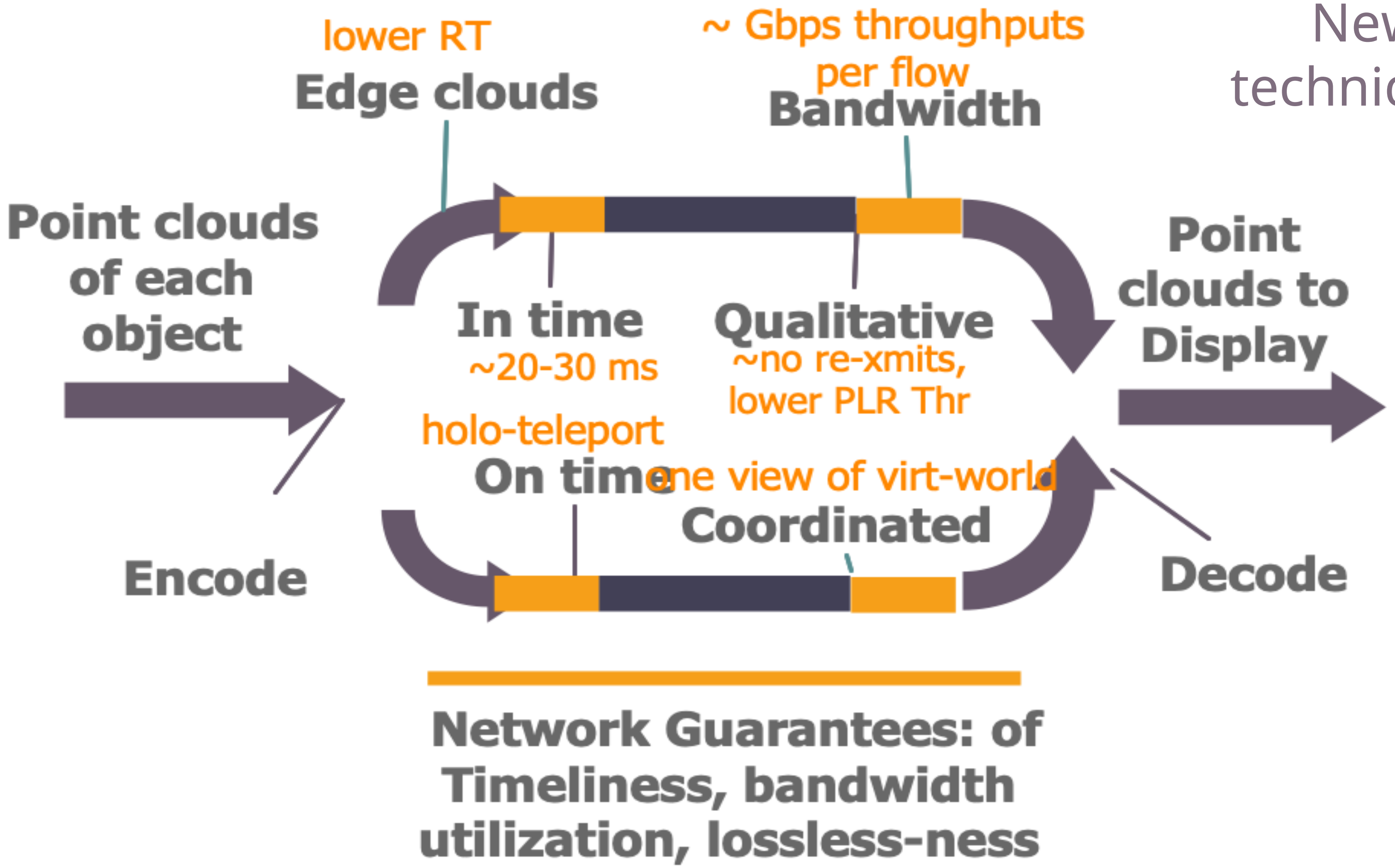
From flows to packets:
When bitrates increase but not packet rates
E.g.: Optical Switched Networks => huge packets

Packet-Chunks, tail-discard / congest / recover

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.

Full Stack Composition / Collaboration

Challenges (examples)

1. Variability bandwidth
2. Loss of connectivity
3. Trade offs between how much to compress and affordable delays.
4. Metadata to identify key pieces of environmental data.
5. FOV is only 1/5 of the scene. Bandwidth is wasted.
6. 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 / Senses

Teleportation =
Holopresence + Sensual Information

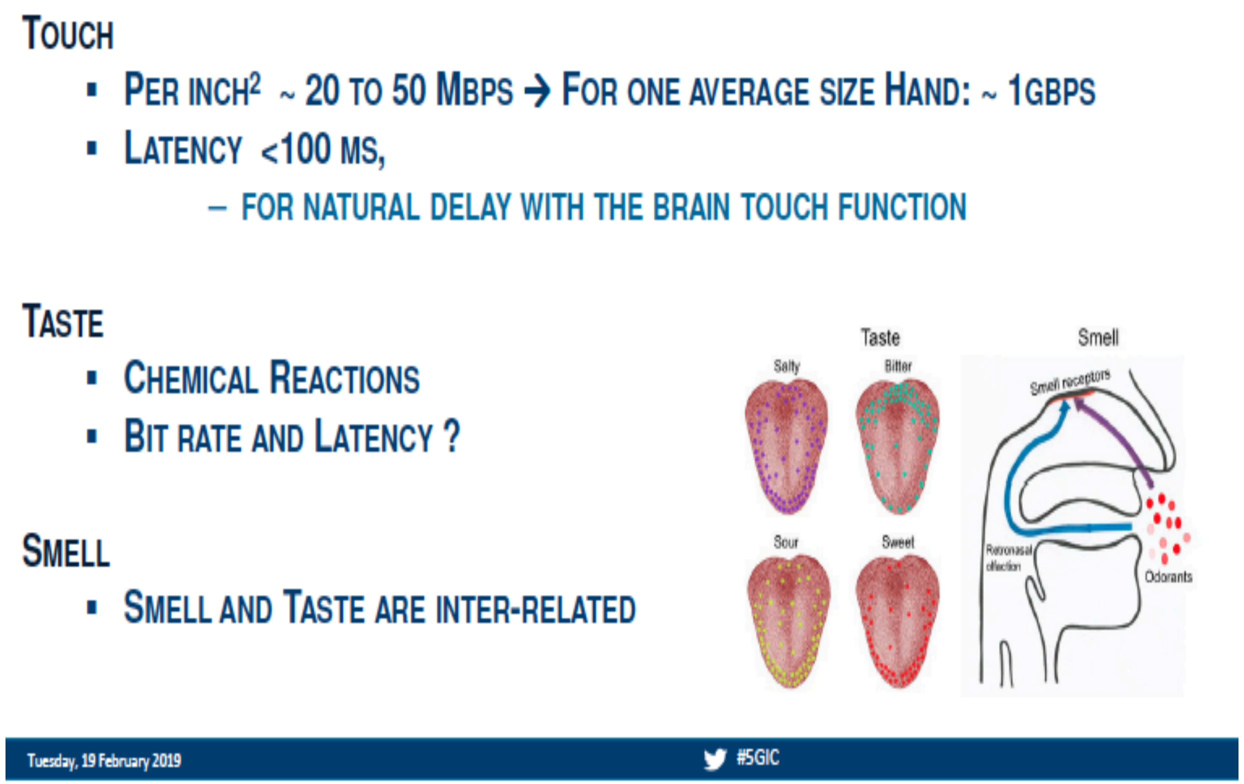
Intuitive interactions
(Spatial Compute)

??
Positional
computational

Natural
interactions
(Teleportation)

Haptics
Smell
Sound

Video



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 changes for networks beyond "Best Effort"

1) MPLS ~= traffic engineering and VPN
   RSVP-TE can provide guaranteed services

2) IPv6/SRv6 increase the addressing space/overhead
   No change to QoS over IPv4

3) SR-MPLS/SR-v6 revives 1980'th source routing
   Optimized for capacity management

4) SDN is a new word for network management (provisioning/monitoring/validation)

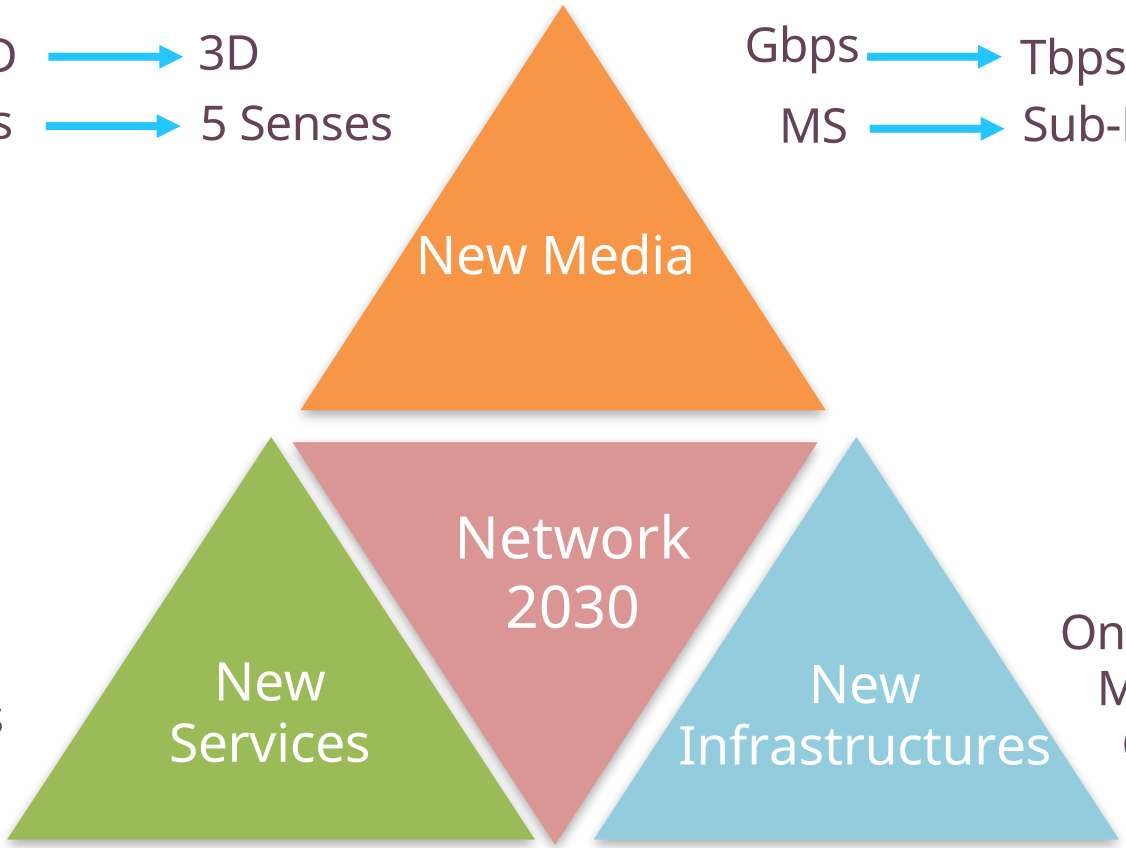
5) VNF/NFV are software-ized routers/switches
   Rarely micro-services/cloud-native

Vision Network 2030

Holographic Society and Industry

2D → 3D
2 Senses → 5 Senses

Gbps → Tbps
MS → Sub-MS Latency



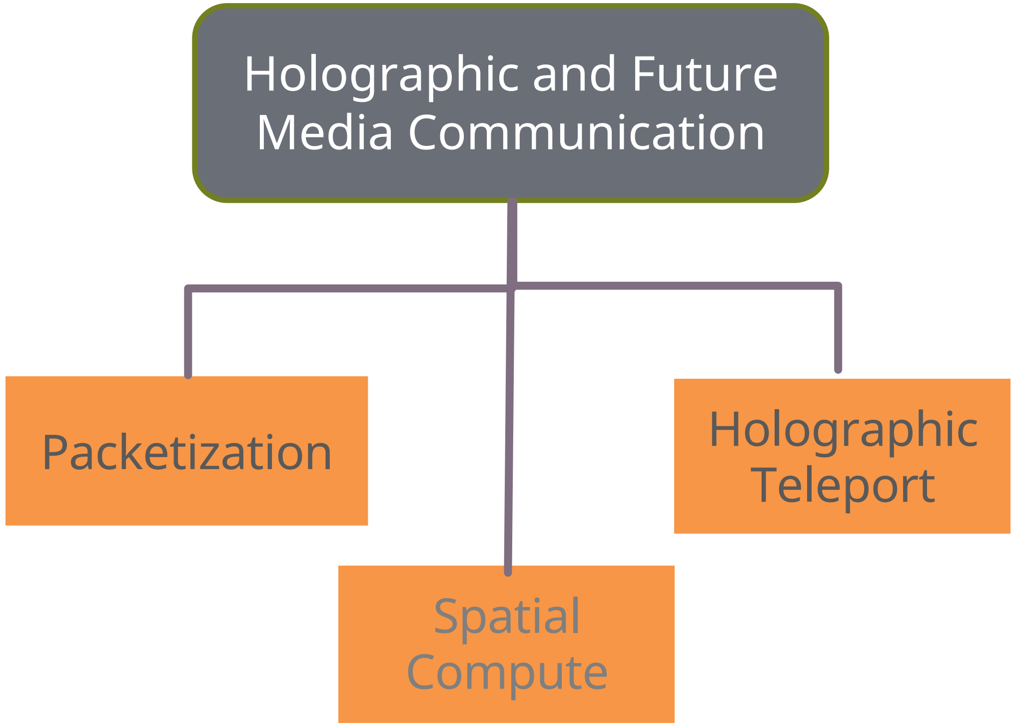
Next wave of Internet Innovations

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?

toerless.eckert, kiran.makhijani @Futurewei.com

ITU-T FG-NET-2030

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