Network 2030 and the Future of IP
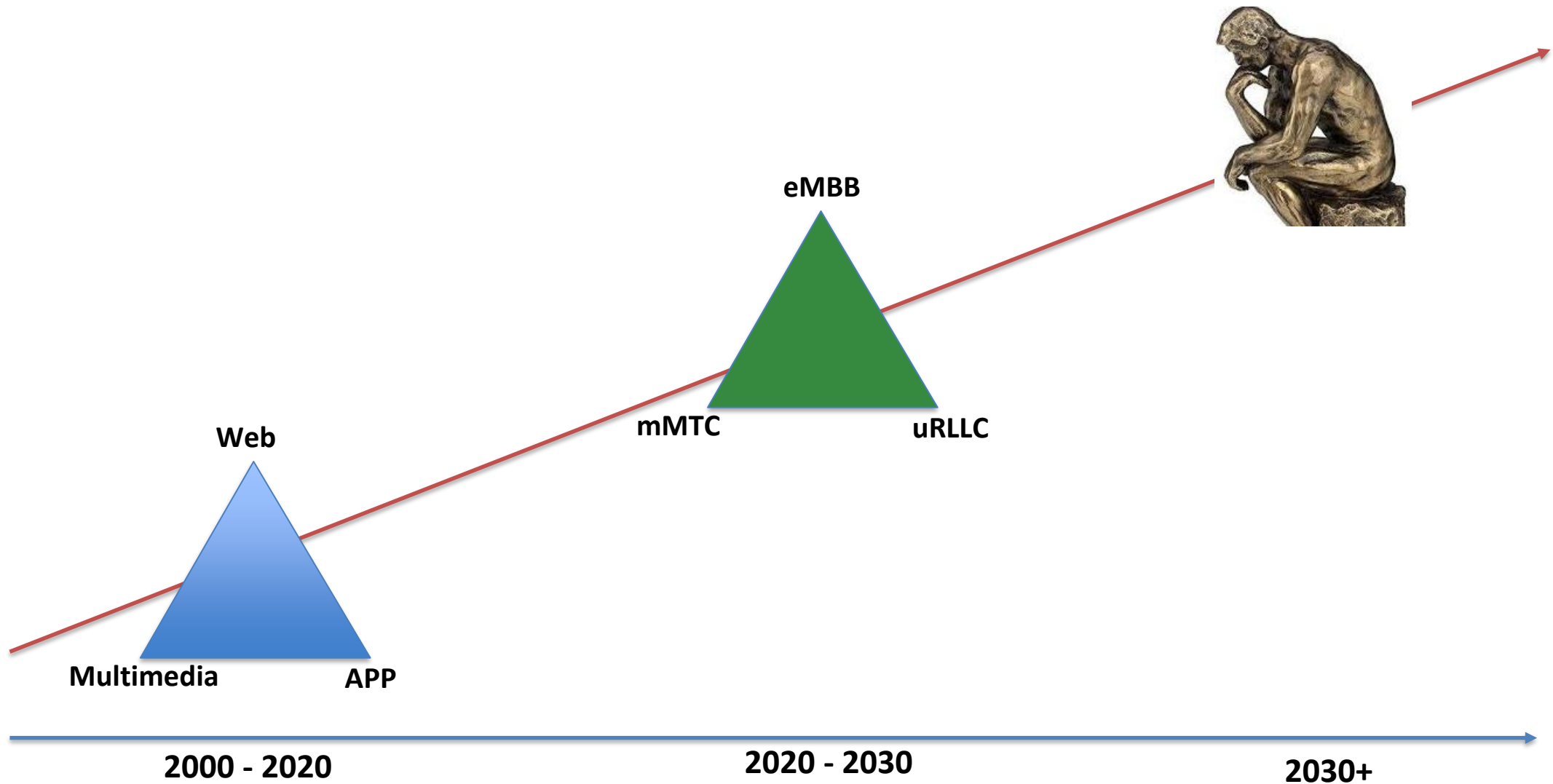
Agenda

- **Network 2030**
  - **ITU-T Initiative**
  - **Use Cases and Driving Forces**
- **A Research Proposal**

What will be the market drivers in the year 2030 and beyond?

eMBB

Web

mMTC   uRLLC

Multimedia   APP

2000 - 2020   **2020 - 2030**   **2030+**

ITU-T Focus Group on Network 2030

About ITU-T Study Groups Events All Groups Join ITU-T Standards Resources Regional Presence BSG

Focus Group on Technologies for Network 2030

Identify future use cases and new requirements

Study capabilities of networks for the year 2030 and beyond

Explore new concepts, principles, mechanisms, and architectures

Establish
July 16 – 27, 2018
Geneva

1st Meeting
October 2 – 4, 2018
New York

2nd Meeting
December 18 – 21, 2018
Hong Kong

3rd Meeting
18th Week, February 2019
London

4th Meeting
20th Week, May 2019
St. Petersburg

5th Meeting
October 2019
Geneva

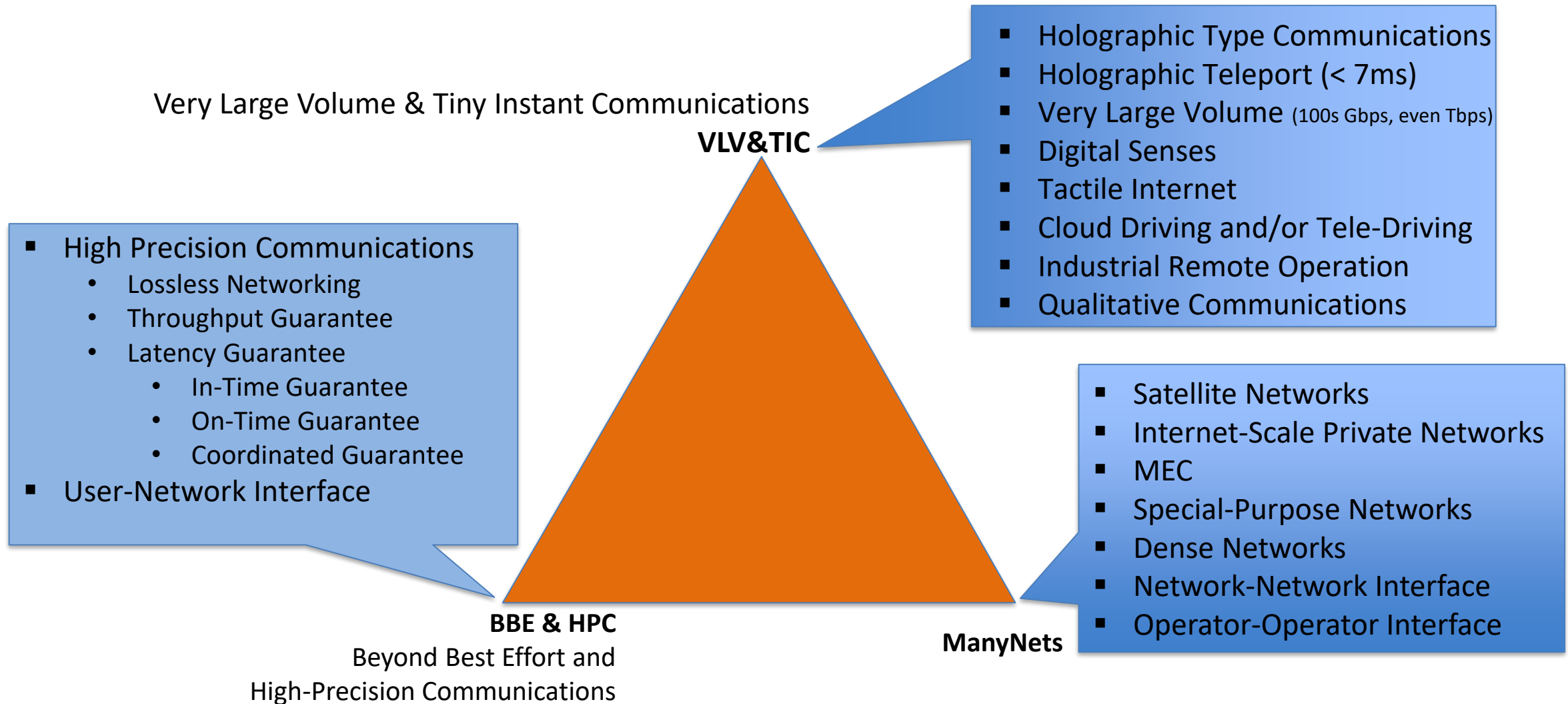https://www.itu.int/en/ITU-T/focusgroups/net2030/Pages/default.aspx

Output and Deliverables

A. *Network 2030 – A Blueprint of Technology, Applications, and Market Drivers towards the Year 2030 and Beyond*, a White Paper on Network 2030, ITU-T, May 2019 (Download)

B. *New Services and Capabilities for Network 2030: Description, Technical Gap and Performance Target Analysis*, ITU-T FG Network 2030, Oct 2019 (Download)

C. Use Cases and Requirements for Network 2030 (In Progress)

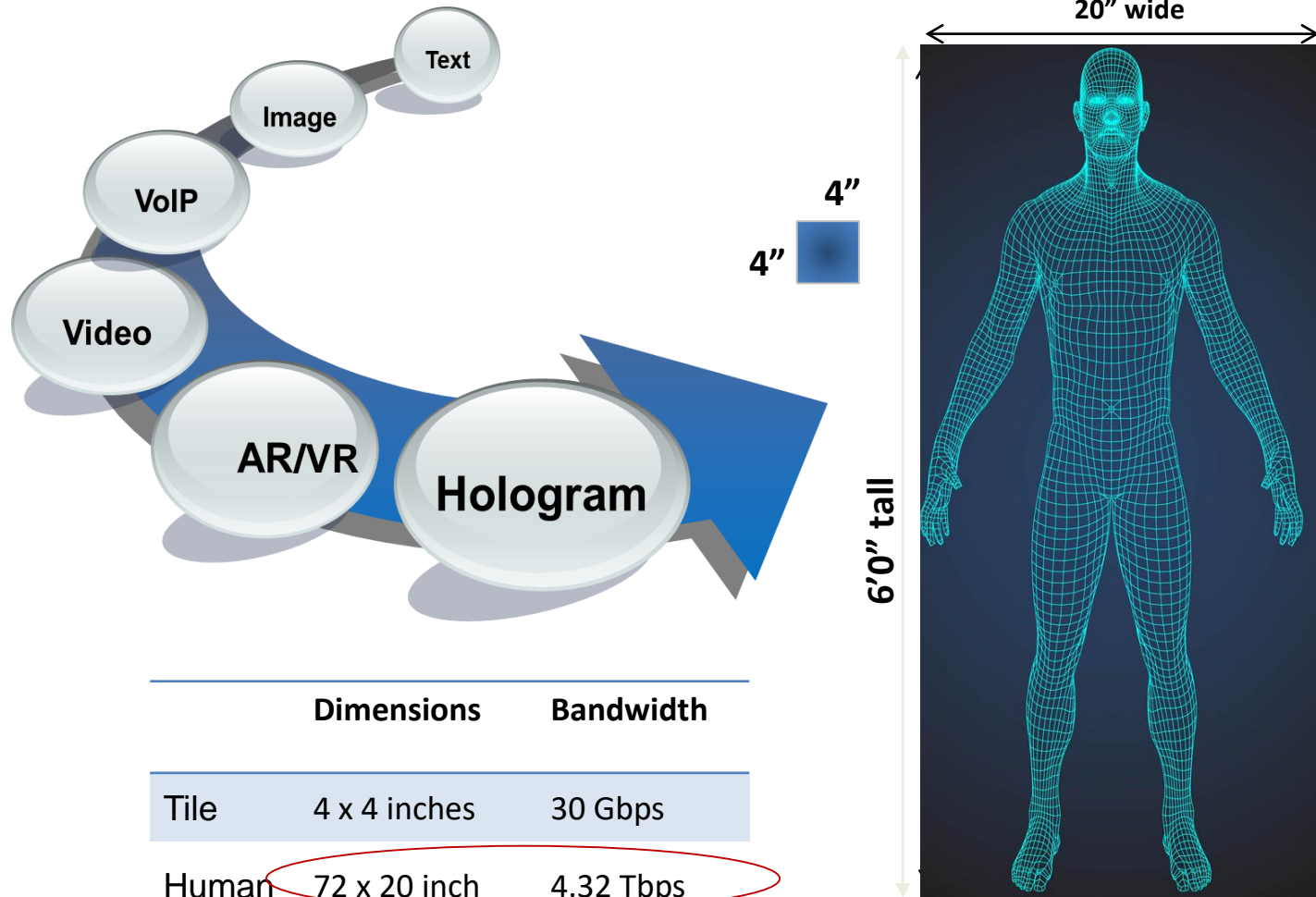D. Architecture and Framework for Network 2030 (In Progress)

Use Cases being discussed

- Holographic type communications (HTC)
- Tele-driving, cloud driving and integrated driving
- Space-terrestrial integrated network (STIN)
- Industrial IoT (IIoT) with fully cloudified PLC
- Intelligent operation network (ION)
- Light-field 3D communications (LF3D)
- Tactile internet (TAC)
- Network computing convergence (NCC)
- Digital Twin and Holographic Twin (DT/HT)
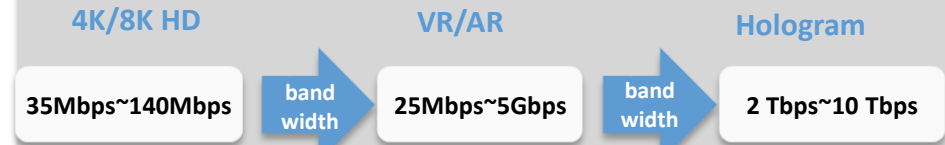
New IP Frontier – Market and Business Drivers

Very Large Volume & Tiny Instant Communications

VLV&TIC

- Holographic Type Communications
- Holographic Teleport (< 7ms)
- Very Large Volume (100s Gbps, even Tbps)
- Digital Senses
- Tactile Internet
- Cloud Driving and/or Tele-Driving
- Industrial Remote Operation
- Qualitative Communications

- High Precision Communications
  - Lossless Networking
  - Throughput Guarantee
  - Latency Guarantee
    - In-Time Guarantee
    - On-Time Guarantee
    - Coordinated Guarantee
- User-Network Interface

BBE & HPC
Beyond Best Effort and
High-Precision Communications

ManyNets

- Satellite Networks
- Internet-Scale Private Networks
- MEC
- Special-Purpose Networks
- Dense Networks
- Network-Network Interface
- Operator-Operator Interface

Media Evolution: Holograms and Holographic Type Communications

Text

Image

VoIP

Video

AR/VR

Hologram

20" wide

4"

4"

6'0" tall

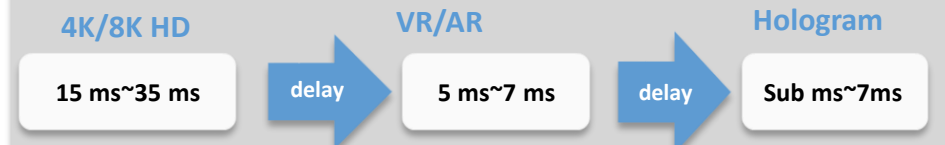|	Dimensions	Bandwidth
Tile	4 x 4 inches	30 Gbps
Human	72 x 20 inch	4.32 Tbps

- Raw data; no optimization or compression.
- color, FP (full parallax), 30 fps

(reference: 3D Holographic Display and Its Data Transmission Requirement, 10.1109/IPOC.2011.6122872), derived from for 'Holographic three-dimensional telepresence'; N. Peyghambarian, University of Arizona)
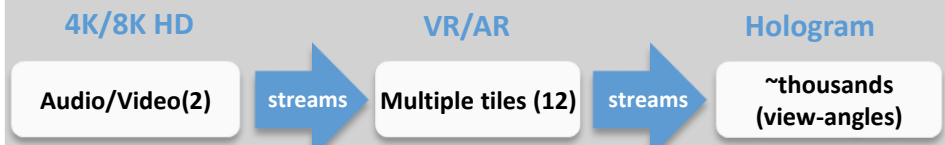
Throughput goes up

4K/8K HD		VR/AR		Hologram
35Mbps~140Mbps	band width	25Mbps~5Gbps	band width	2 Tbps~10 Tbps

Holographic Twin: Latency falls down

4K/8K HD		VR/AR		Hologram
15 ms~35 ms	delay	5 ms~7 ms	delay	Sub ms~7ms

Synchronization of parallel streams

4K/8K HD		VR/AR		Hologram
Audio/Video(2)	streams	Multiple tiles (12)	streams	~thousands (view-angles)

Attaching Digital Senses to Holographic Type Communications

Media Evolution

	👁	👂	👆	👄	👃
Hologram	🟥	🟥	🟥	🟥	🟥
AR/VR	🟦	🟦	🟦		
Video	🟧	🟧			
Audio		🟨			
Image	🟩				
Text	⬛				

1T/s	D	**1ms**
1G/s		17ms
100M/s		33ms
64k/s		50ms
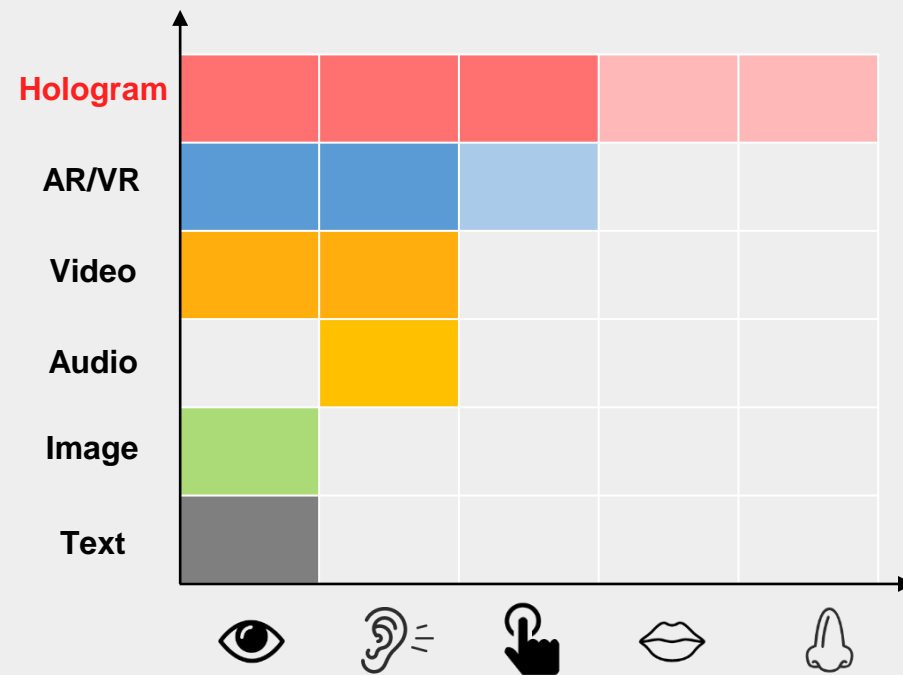
IEEE Digital Senses Initiative
Coverage Model

Transforming industries

Privacy — Public awareness
Identity — User acceptance
Security — Content richness
Trust — Ecosystem readiness
Ethics

Virtual Reality · Augmented Reality · Human Augmentation · Consumer Healthcare · Smart Robots · Wearables · and more...

Capture · Reproduce · Synthesize · Understand · Respond

Sight · Hearing · Touch · Smell · Taste · Other senses · Human or Machine

IEEE — Advancing Technology for Humanity

Packet loss and latency are safety of life KPIs

UC, Berkeley
Pizza Delivery
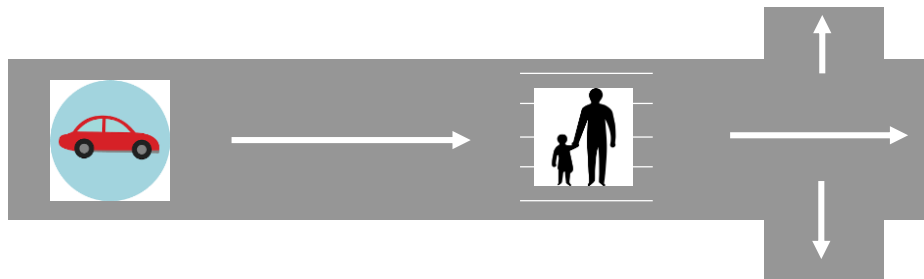
Sensory Image Capture: 40ms
Framing + Encoding: 120 ms
Decoding + Display: 100ms
RTT between Colombia to San Francisco: 200 – 400ms

Total: 460 – 660 ms

Extrapolation:
1) 5 km/hour = 1.4m/sec. Crash-Avoidance distance = 1.4m/sec x 660ms = 0.92m
2) 30 km/hour = 8.4m/sec. Crash-Avoidance distance = 8.4m/sec x 660ms = 5.54m
3) 60 km/hour = 16.8m/sec. Crash-Avoidance distance = 16.8m/sec x 660ms = 11.08m

# Convergence of Satellite Networks and Terrestrial Networks

Co.	Support (Data are from the Internet, not yet verified)	Scale
Starlink	SpaceX (Elon Musk)	4K by 2019, the 12K
Oneweb	Softbank	650 by 2019
Boeing	Apple (spec)	2956, 1350 in 6 yrs
O3Nb	Virgin group, SES	400
CASIC	China	300 (54 trial)

Distances	Bandwidth	delay
(LEO) 900-1200 KM	1—200 Gbps	35ms
(MEO) ~2000 KM	1-200 Gbps	~60ms
Space to space	~100 KM – ~Tbps ~1000 KM ~10 Gbps	

On-board Cache

Moving platform

Moving platform

LEO satellite network

- Seamlessly integrated addressing/routing framework
- Holistic path control policies
- Coordinated management and admission control mechanisms

User device

Terrestrial service resources (e.g. Content servers)

Terrestrial network

Use Cases

- Satellite as access, and terrestrial networks as backhaul
- Satellite as transport
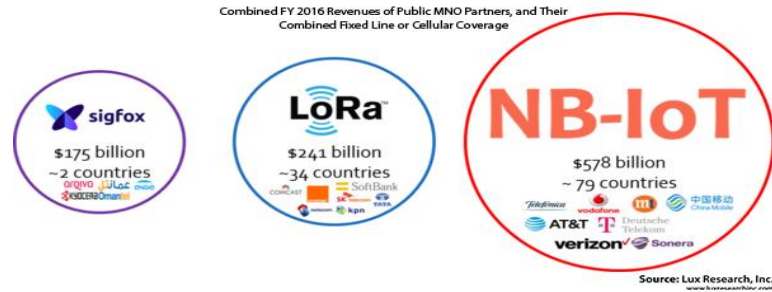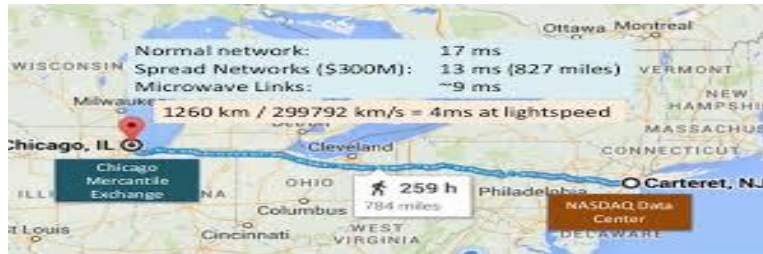- Hybrid and Integrated
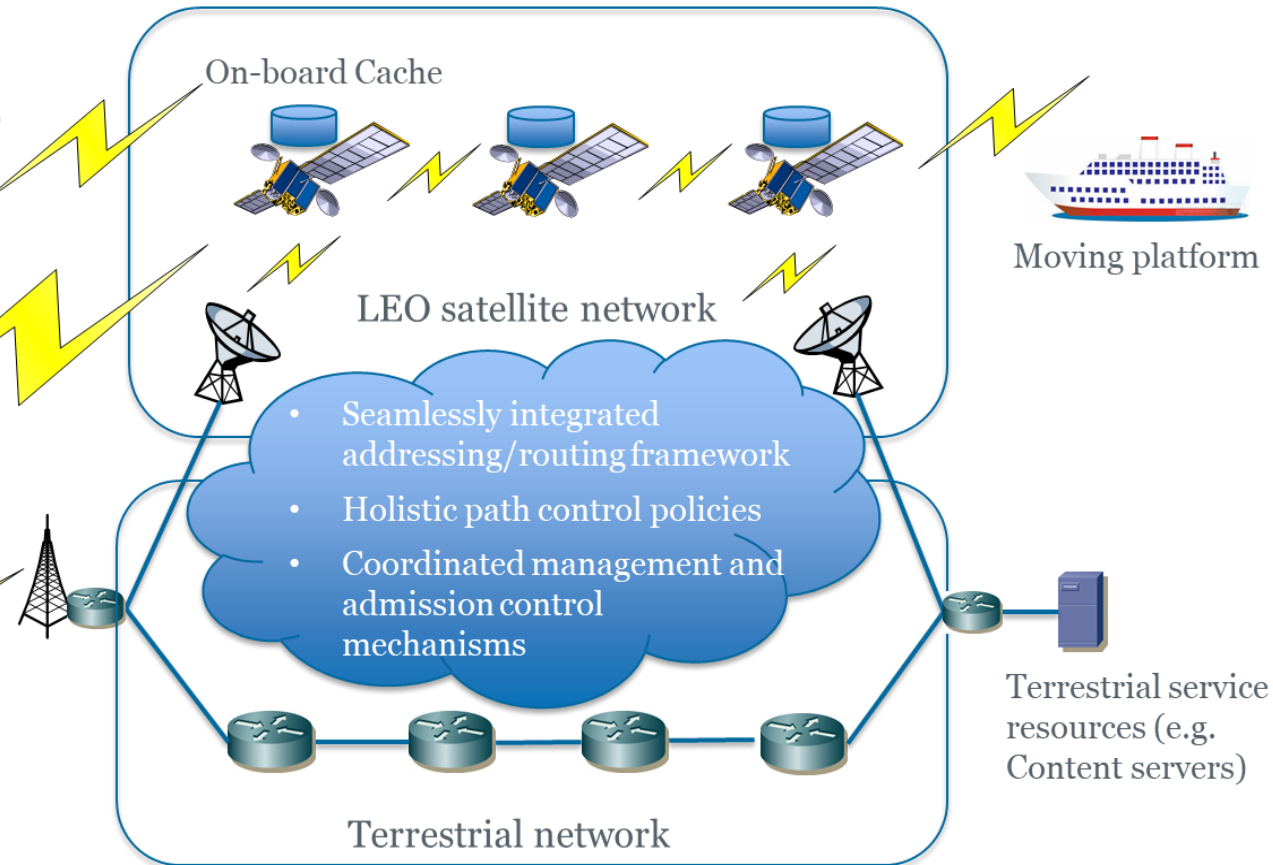
Requirements

- Uniform Addressing and Converged Routing
- Bandwidth capacity at the satellite side
- Admission control by satellites
- Edge storage and computing

Many Nets: Diversity, Variety, and Economy

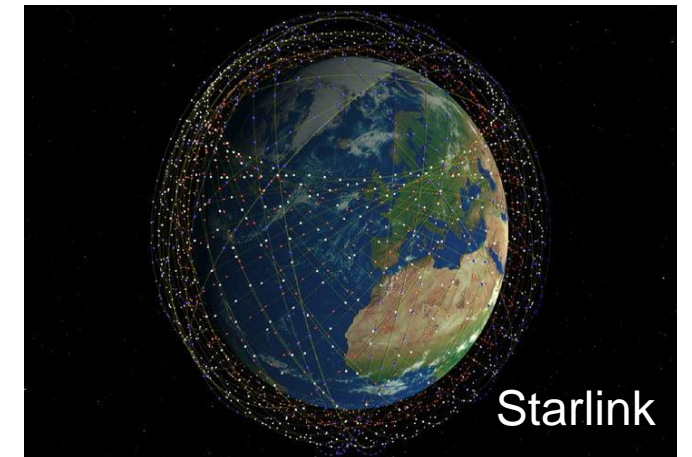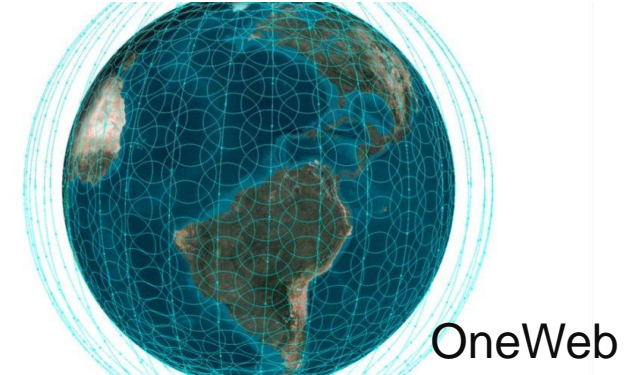## Non-IP Networks
(Growing market segment)

Private Global Backbones
(Death of Internet Transit)
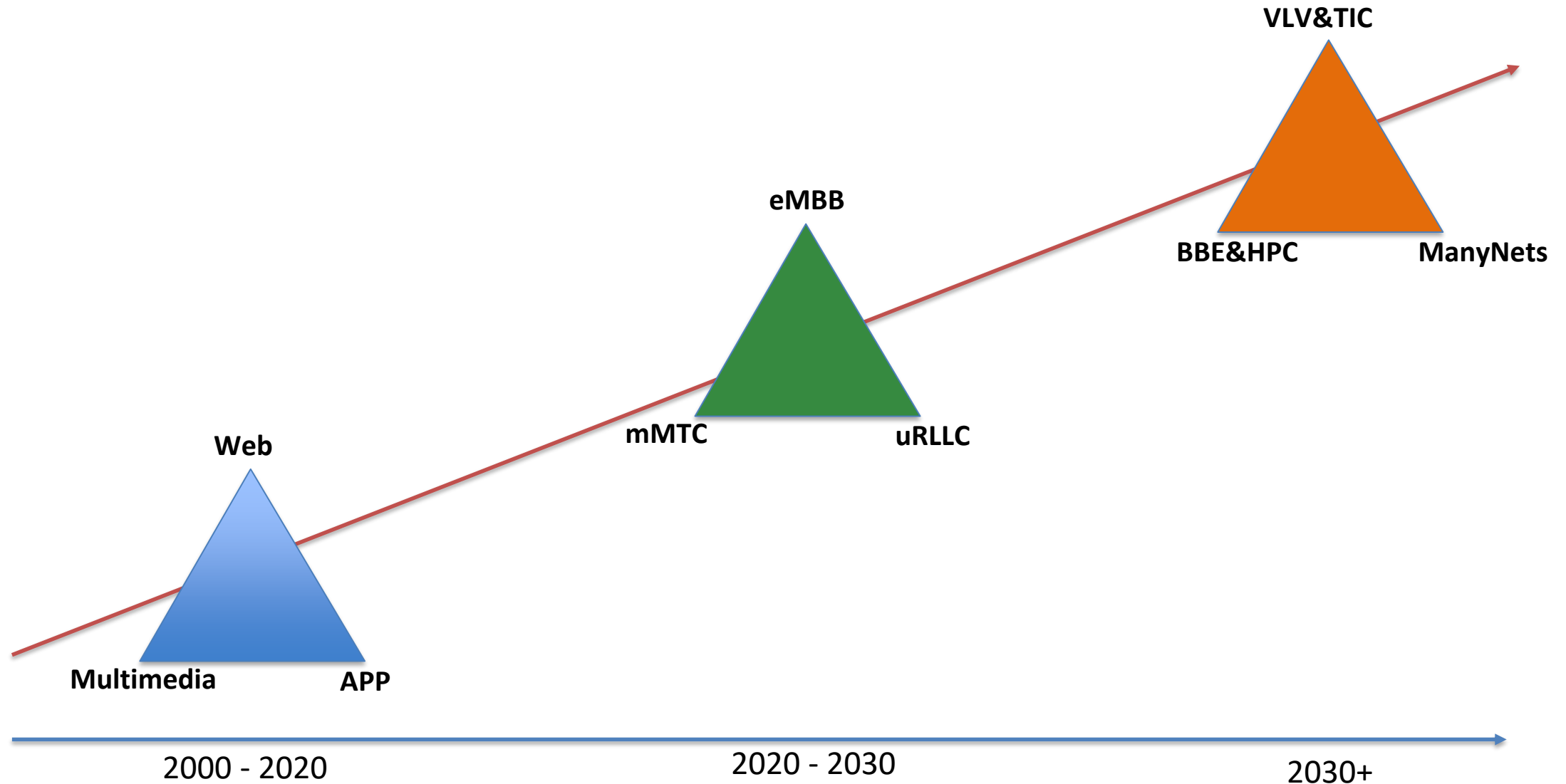
Emerging Satellite Constellations
(Global Broadband connectivity for 4 billion people who are not connected to any network today)

Combined FY 2016 Revenues of Public MNO Partners, and Their Combined Fixed Line or Cellular Coverage

sigfox — $175 billion ~2 countries

LoRa — $241 billion ~34 countries

NB-IoT — $578 billion ~79 countries

Source: Lux Research, Inc.

Spread Networks

Normal network: 17 ms
Spread Networks ($300M): 13 ms (827 miles)
Microwave Links: ~9 ms
1260 km / 299792 km/s = 4ms at lightspeed

LoRaWAN™ Network Coverage

- 57 Announced Public Network Operators
- 49 Alliance Member Operators
- Over 100 Countries
- 350+ on-going trials & city deployments
- 500+ members in the Alliance

November 2017

FirstNet®

Amazon Global Network
- All traffic between AWS Regions makes use of the Amazon Global Network

aws reInvent

GCP Network and Regional Support

Google Cloud

Microsoft Azure

OneWeb

Starlink

Ref: Geoff Huston and Mostafa Ammar's Talk at Network 2030

Past, Present and Future: Market Drivers

Proposal: Set up a new research group

- Provide a venue for the IETFers who are interested in the future of IP
- Make sure that its progress and changes keep the key attributes of the Internet that have allowed the Internet to thrive so far
- Collaborate with other organizations to synchronize the research
  - Workshop
  - Liaison

Jobs of the RG

1) Review output from the ITU-T Network 2030 and identify new services and applications which are of significant importance but which cannot be implemented on the current Internet as it is today.

2) Assess the capabilities of the current Internet as it has actually evolved to versus in regards to the needs of those upcoming applications.

3) Derive relevant requirements, if any, that have not been considered or adequately addressed in existing Internet designs

4) Explore the impact of applications-at-the-horizon to the Internet architecture and protocols

5) Investigate the implications of evolving infrastructures for the Internet architecture and protocols

6) Establish critical forwarding and operational characteristics of the data plane needed to support those new applications. (control plane and management plane initially not in focus.)

Discussions

1) Does it make any sense to have a RG? Shall we do it?
2) Assuming we set up such a RG,
    1) How do we call this RG? We need a name
    2) What is its scope? Does the job list look good?
    3) What would be the requirements of the future IP?
    4) Should it be transverse to Network/Transport layers? Or even more?
    5) What are the major technological bottlenecks today for future applications? Why?
3) If we set up a RG, would you like to make contributions?
4) Planning for IETF 107 at Vancouver

Thank you