TSAG Information Session

Network 2030

Richard Li

ITU, Geneva
February 11 2020

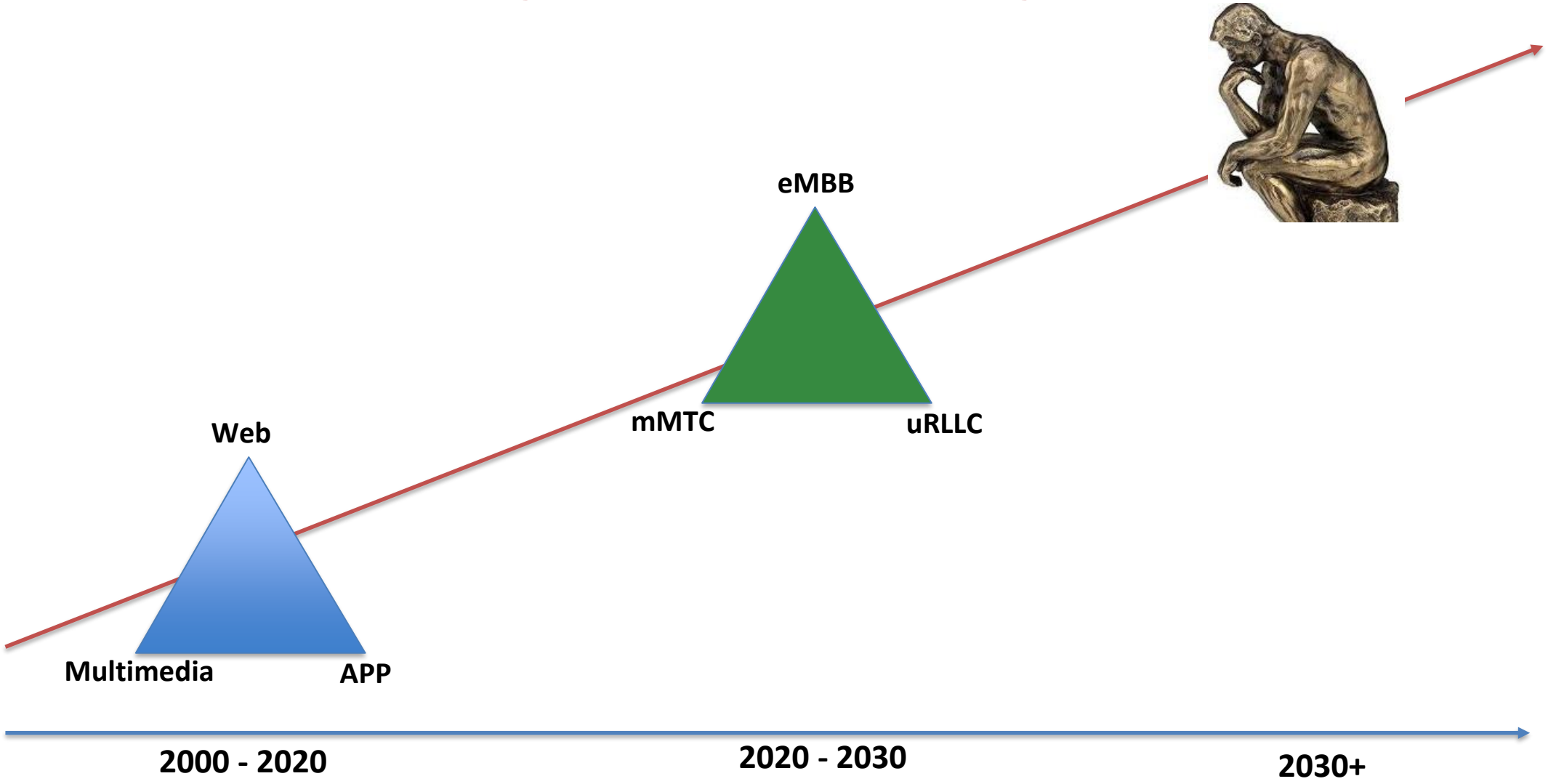
Highlights

- Network 2030 and New IP are related, but two independent streams of work
- Network 2030 identifies use cases, analyzes technical gaps, finds requirements, and studies new capabilities of networks for the year 2030 and beyond.
- New IP enables new network capabilities needed by
  - ✓ Advanced IP Backhaul Transport for 5G, B5G, and 6G
  - ✓ Requirements and New Capabilities for Network 2030 in particular and Future Networks in general
  - ✓ Emerging industry verticals, for example, remote driving, cloudified PLC, industrial IoT, industrial control, intelligent operation networks
  - ✓ Technical Aspects of Privacy, Trust and Intrinsic Security

Part I

Network 2030

What will be in the year 2030 and beyond?



Focus Group on Network 2030

Identify **future use cases** and new requirements

Study **new capabilities** of networks for the year 2030 and beyond

Explore **new concepts,** principles, mechanisms, and architectures

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

Establish

July 16 – 27, 2018
Geneva

1st Meeting

October 2 – 4, 2018
New York

2nd Meeting

December 18 – 21, 2018
Hong Kong

3rd Meeting

February 18-20, 2019
London

4th Meeting

May 21-23, 2019
St. Petersburg

5th Meeting

October 14-18, 2019
Geneva

6th Meeting

January 13-15, 2020
Lisbon

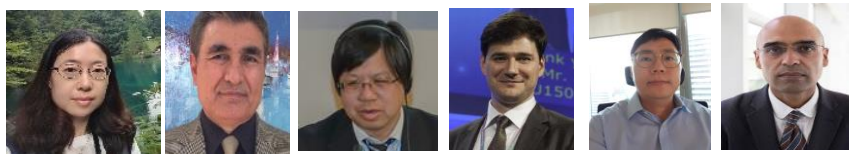
FG NET-2030 leadership

Chair:

Richard Li

Vice Chairs:

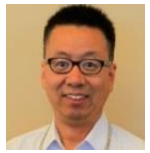
Sophie Zhang (CT), Mehmet Toy (Verizon), Yutaka Miyake (KDDI Research), Alexey Borodin (Rostelecom), Dong-Hi Sim (SK Telecom), Sundeep Bhandari (NPL)



Sub-G1 Chair:
Mostafa Essa (Vodafone)

Sub-G2 Chair:

Richard Li (Acting)



Sub-G3 Chairs:

Mehmet Toy (Verizon)
David Dai (Fiberhome)

Output and Deliverables

A. [WP] *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. [PDT] + [GAP] *New Services and Capabilities for Network 2030: Description, Technical Gap and Performance Target Analysis*, ITU-T FG Network 2030, Oct 2019 (Download)

- **Gaps to extracted out from this release.**

C. [UC] Use Cases and Requirements for Network 2030

- Summary report "Representative use cases and key network requirements for Network 2030" (TR approved in the Jan 2020 meeting – available on the FG's website, and also submitted to the SG13)
- "Use Cases and Requirements for Future Networks towards 2030" (ongoing, May 2020 target)

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

- **Target TBC [May 2020])**
- **Multiple Sub-G3 teams are working on different architectural aspects: team-specific deliverables might be possible produced**

Cross Sub-Group Deliverables

1. [TERM] “Terms and Definitions” – TR initial draft at Jan 2020 FG meeting

2. [Demo] “Description of Demonstrations for Network 2030 on Sixth ITU Workshop on Network 2030 and Demo Day” – TR launch approved at Jan 2020 FG meeting

Sub-G1: Use cases for Network 2030

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7 representative use cases:

1) Holographic-type communications (HTC)
2) Tactile Internet for Remote Operations (TIRO)
3) Intelligent Operation Network (ION)
4) Network and Computing Convergence (NCC)
5) Digital Twin (DT)
6) Space-Terrestrial Integrated Network (STIN)
7) Industrial IoT (IIoT) with cloudification

Source: Marco Carugi and Bin Da, Co-Editors, Sub-G1

Sub-G1: Requirement and Gaps Analysis of the use cases

a) Analysis of the use cases for different requirements dimensions and identification of gaps with respect to current network vision and/or existing capabilities

Dimensions from requirements gaps perspective	Current vision and/or existing capabilities (e.g. expected to be supported by existing networks)	Network 2030 goals (Matching ToR)	Gaps for network requirements (where applicable)

b) Association of the representative use cases (use cases having some prominent requirements) to the different dimensions

DIMENSIONS AND ASSOCIATED USE CASES - ONGOING SUB-G1 DELIVERABLE DRAFT
Extremely high bandwidth and capacity: HOL, LF3D, Tactile Internet, Deep Edge service access
Extremely low latency: HOL, LF3D, Tactile Internet, Cloud PLC, Deep Edge service access
Bounded latency and jitter: HOL, LF3D, Tactile Internet, Cloud PLC, Deep Edge service access
Timing accuracy and synchronization: Cloud PLC
Geolocation accuracy (network related dimension)
Consistent QoE
Flexible QoS support
High programmability (and softwarization): Space Terrestrial Integrated Networking, Network intelligence based operations
Data computing, storage, collection and analytics: Space Terrestrial Integrated Networking, Network intelligence based operations
Autonomy: Network intelligence based operations
Network security (incl. in network security/DDoS prevention)
Privacy
Trustworthiness
Resilience: Space Terrestrial Integrated Networking
Traceability
Enahced lawful intercept
New transport
Flexibility of Addressing: Space Terrestrial Integrated Networking
Edge capabilities
Aggregation
Mobility: Space Terrestrial Integrated Networking
User network interface: Space Terrestrial Integrated Networking

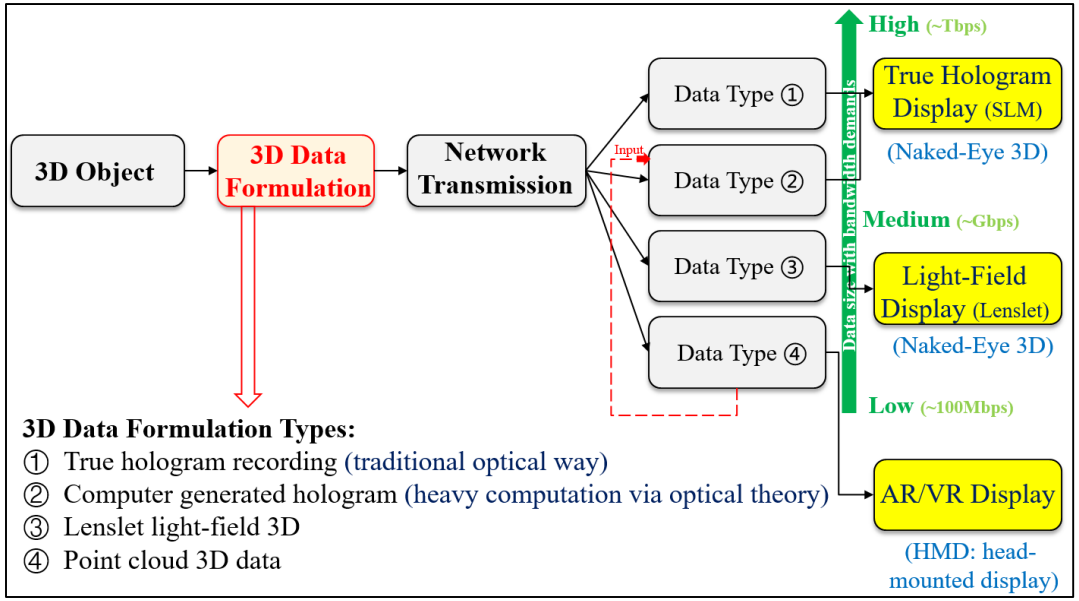
Ongoing draft to be revisited and aligned (terminology, use cases and requirements) with Jan 2020 approved Sub-G1 Summary report

Sub-G1 Use Case examples [from Sub-G1 Summary Report]

Holographic-type communications (HTC)

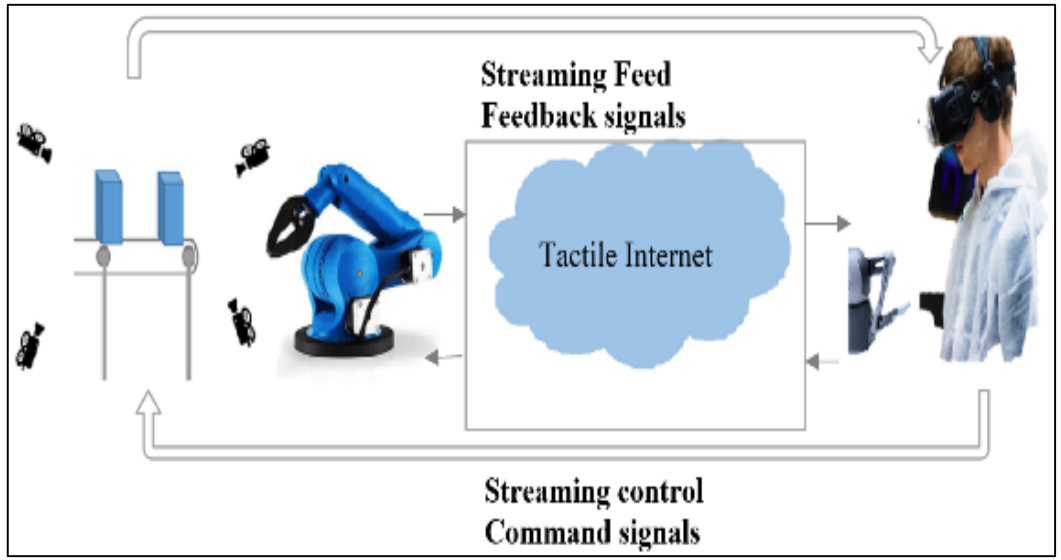
Key network requirements

- *Ultra high bandwidth* (up to Tbps)
- *Ultra-low latency* (up to sub-ms)
- *Multi-stream synchronization*
- *Complete security*
- *Reliability*
- *Edge computation*



Types of 3D data transmission in HTC

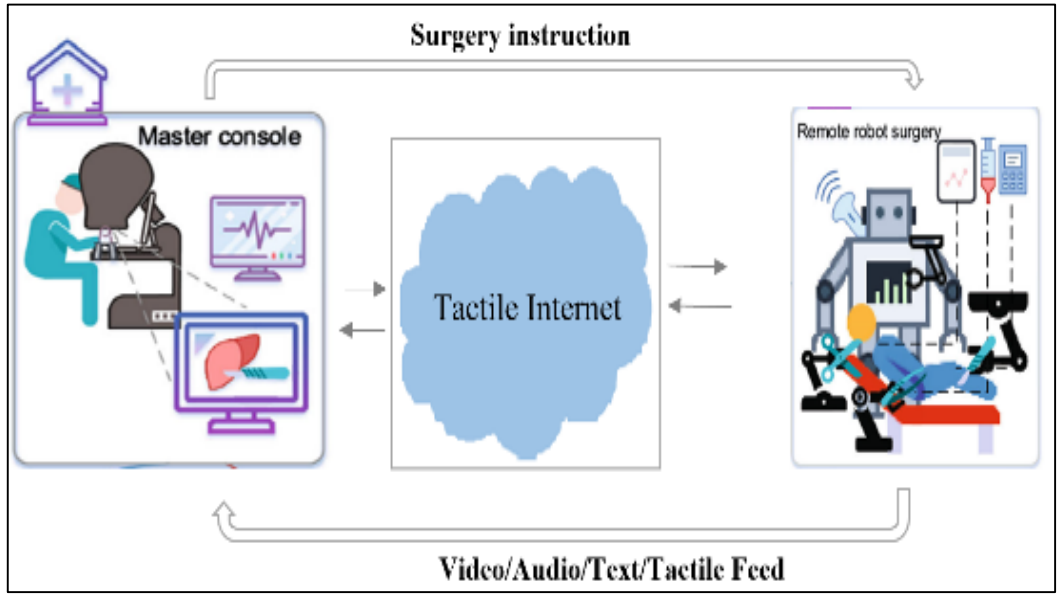
Sub-G1 Use Case examples [from Sub-G1 Summary Report]
Tactile Internet for Remote Operations (TIRO)



Typical use case A: remote industrial management (involves real-time monitoring and control of industrial infrastructure operations)

Key network requirements

- ***Ultra high bandwidth*** **(up to Tbps)**
- ***Ultra-low latency*** **(up to ms)**
- ***Sensory input synchronization***
- ***Security***
- ***Reliability***
- ***Differentiated prioritization levels***



Typical use case B: remote robotic surgery

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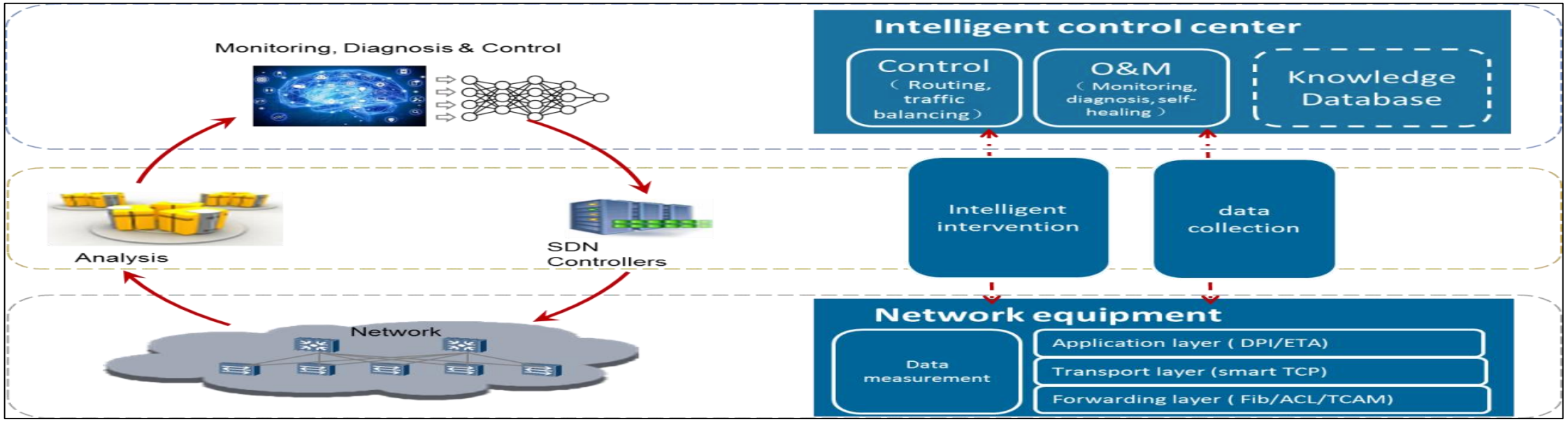
Sub-G1 Use Case examples [from Sub-G1 Summary Report]
Intelligent Operation Network (ION)

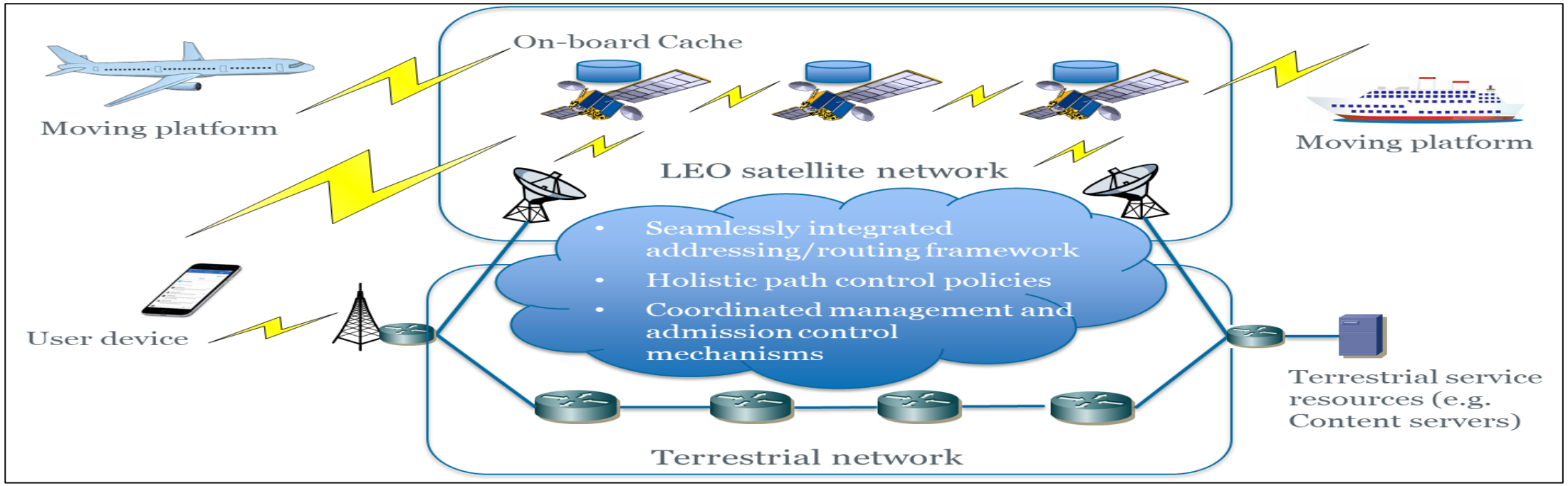


Example framework for fully automated and intelligent closed-loop control for ION-type applications

Key network requirements

- ***High bandwidth (instantaneous high-volume data collection)***
- ***Ultra-low latency*** **up to sub-ms** ***(intelligent closed-loop control)***
- ***Programmability and softwarization***

Sub-G1 Use Case examples [from Sub-G1 Summary Report]
Space-Terrestrial Integrated Network (STIN)

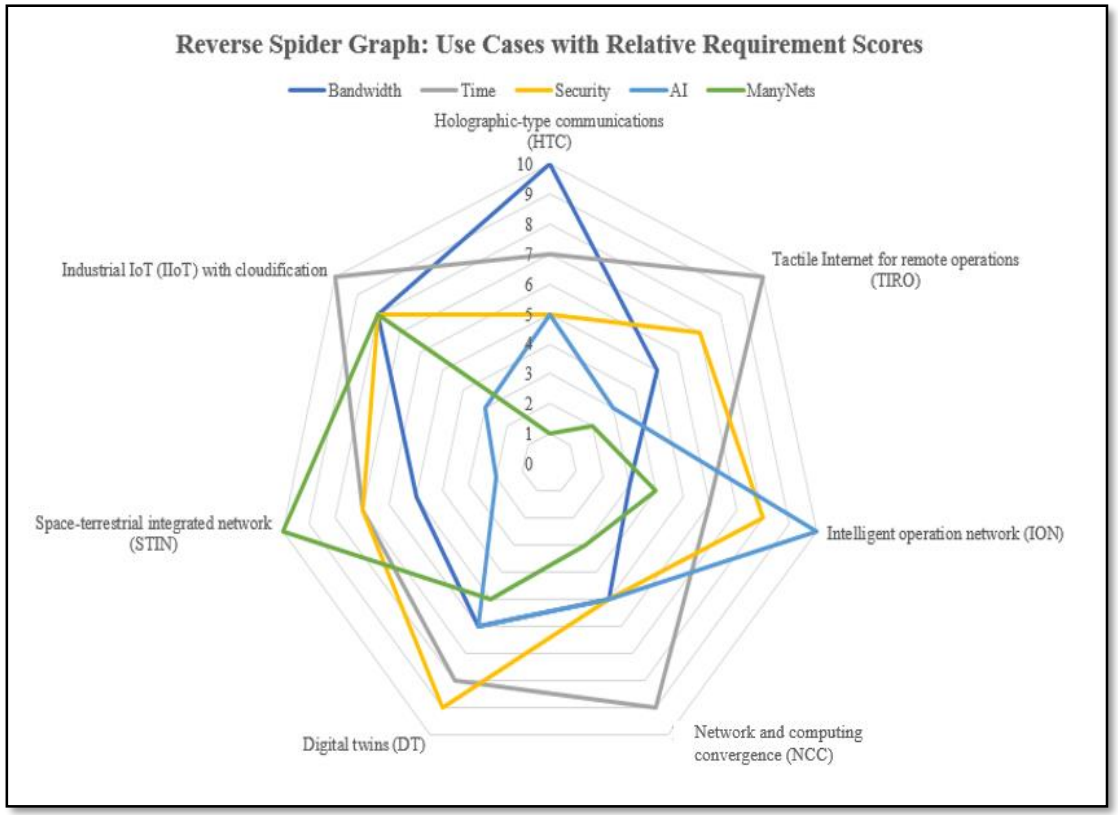


The trend of satellite and terrestrial Internet integration

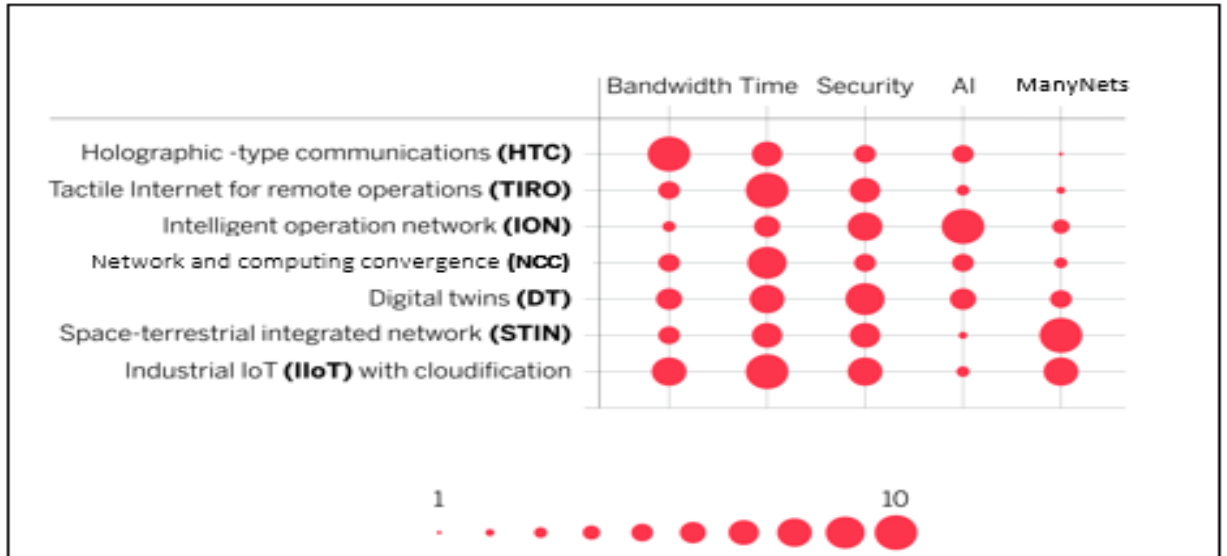
Key network requirements

- ***Flexible addressing and routing mechanisms***
- ***Bandwidth capacity at the satellite side***
- ***Admission control by satellites***
- ***Edge computing and storage***

Sub-G1 Use Case Clustering



Reverse Spider Graph



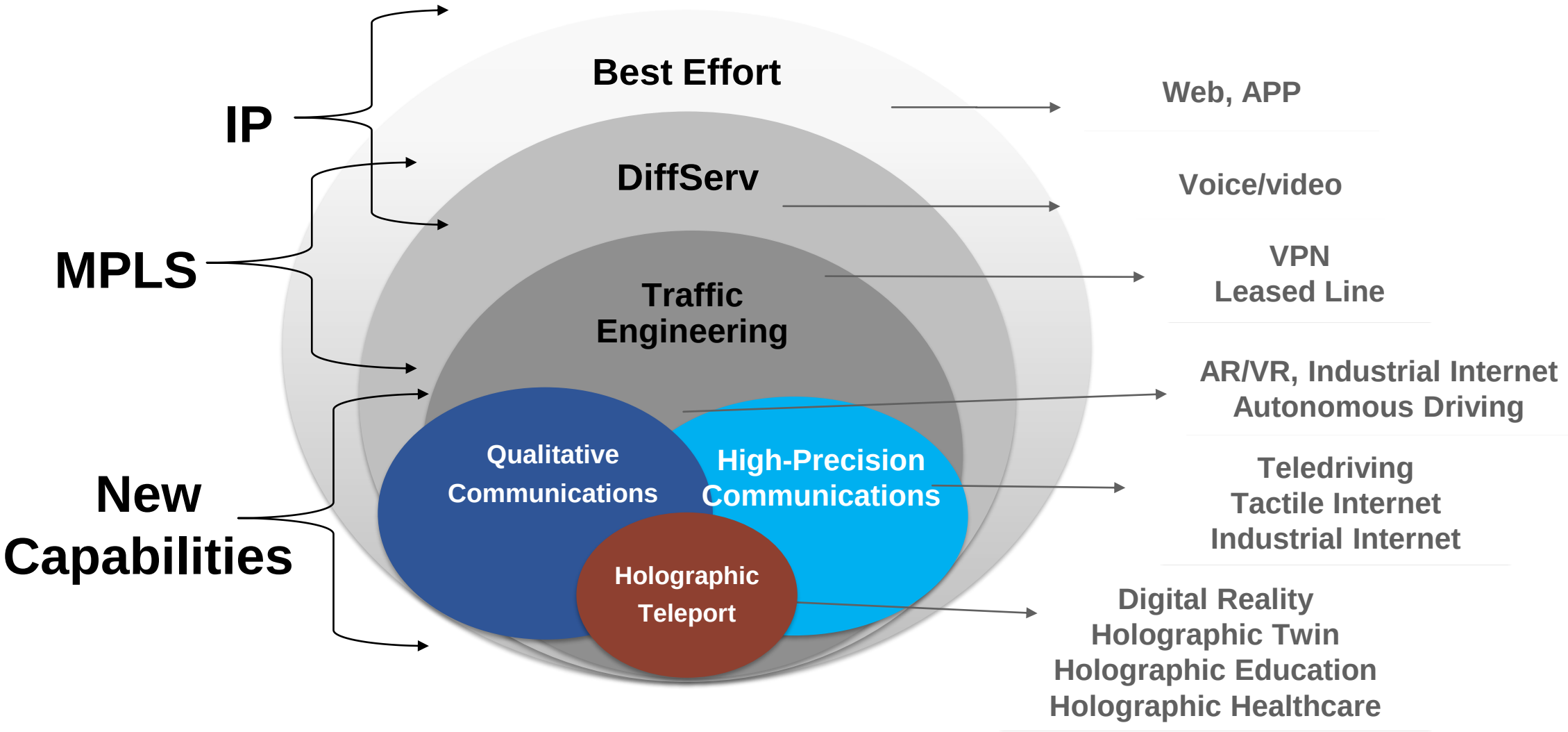
Ball Diameter Graph

5 ABSTRACT NETWORK REQUIREMENT DIMENSIONS

- Bandwidth, Time, Security, Artificial Intelligence (AI), ManyNets (*)
- abstracted over more than 20 network requirement dimensions considered within Sub-G1
- scored according to relative importance of specific network requirement [1 to 3 (low), 4 to 6 (medium), 7 to 9 (high), 10 (extremely high)]

(*) ManyNets: seamless coexistence of heterogeneous network infrastructures

Sub-G2: New Capabilities and Services



Sub-G2: New Network Capabilities (PDT)

Time Engineered Services

Time centric	Criteria	Use cases	Time scales
In-time service	no later than requested time	Manufacturing automation Remote surgery	t ~ 1-10 ms
On-time service	at a requested time	Instantaneous response to emergency situation Synchronized operations such as drone swarms	Δt ~ 1 ms
Coordinated service	Relative time	Multi-sense communication Autonomous Traffic communication	t < 5ms

Compound Services

Table 2: Compound Services

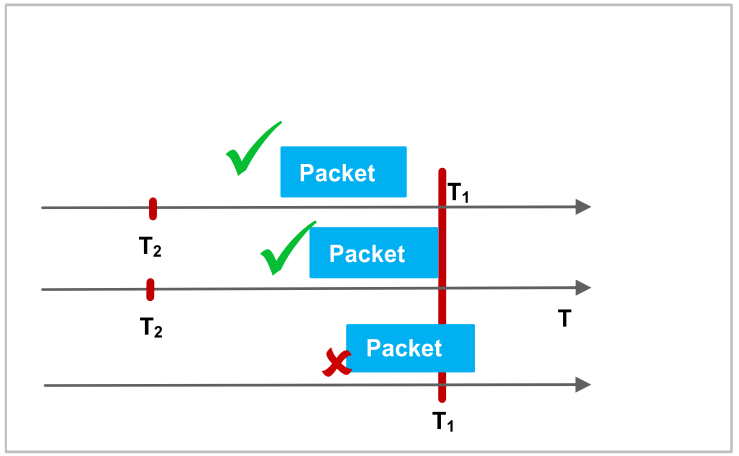
Compound Service	Criteria	Use cases	Time scales*
Qualitative Service	Conditional to network state	High throughput multimedia such as Holographic applications	~ 40 ms
Holographic Type Communications	Coordinated, time dependence and high bandwidth	High bandwidth requirements, different encoding for teleconferencing vs 3D medical imaging	~30 ms
Digital Teleportation	Coordinated, synchronized,	Digital replicated live-environment	~30ms
Tactile communications	Time dependence and reliability (zero packet-loss)	Variable encodings of haptics, optionally high bandwidth requirements, fast responses.	< 10ms

*note: Time scales depend on physical distances between the end points; numbers here represent general guidelines

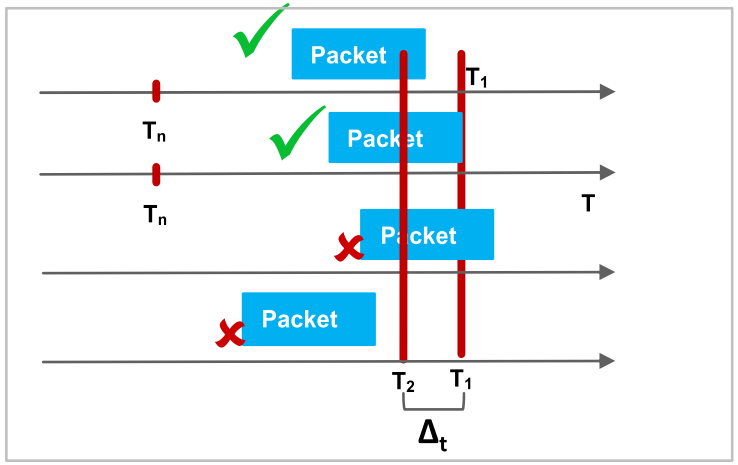
Sub-G2: Time-Engineered Services

Time Engineered Services

Intime Guarantees



On-time Guarantees



Coordinated Guarantees

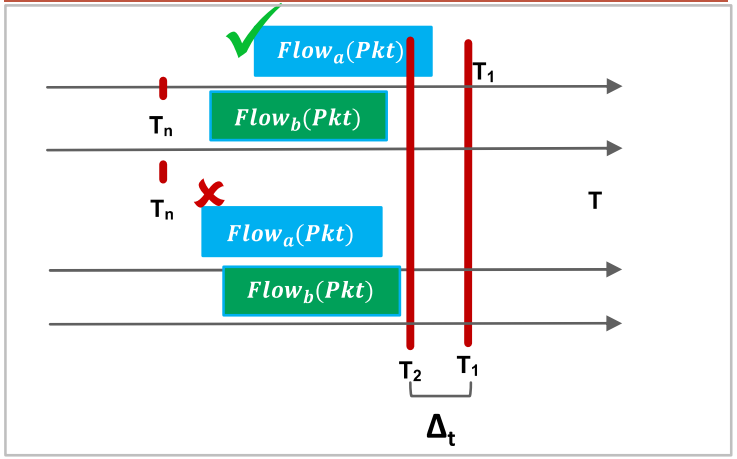


Table 1: Time-engineered

Time Engineered service criteria

Time centric	Criteria	Use cases	Time scales
In-time service	no later than requested time	Manufacturing automation Remote surgery	t ~ 1-10 ms
On-time service	at a requested time	Instantaneous response to emergency situation Synchronized operations such as drone swarms	Δt ~ 1 ms
Coordinated service	Relative time	Multi-sense communication Autonomous Traffic communication	t < 5ms

Coordinated guarantees based services:

- ✓ Source aggregation cooperative transmission service
- ✓ Challenge: time synchronization, resource synchronization, network assurance

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Sub-G3: Network2030 Architecture Framework

Document Outline

- Terminologies
- Introduction
- Architectural Principles
- Characteristics of Future Integrated Architecture
- Interfaces
- Connections and Connection End Points
- Management Architecture for Future Integrated Network Architecture
- Access Network and Edge
- Space Networking
- Addressing
- Routing
- Security
- Mobility
- QoS
- High Availability
- References

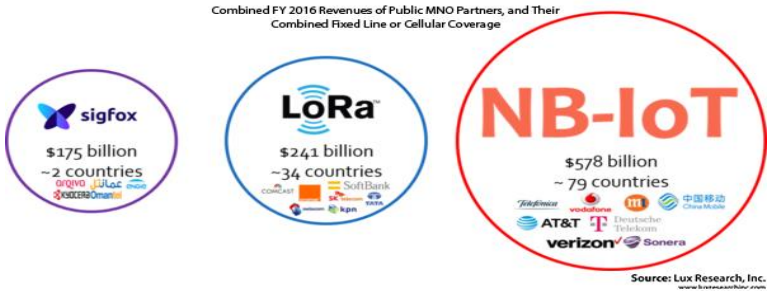
Work Plan

- We will continue to work to have a preliminary draft in 2Q2020.
- After the preliminary draft, we will work on refining the document till November 2020.
- We are missing contributors in multiple areas. Some sections such as “Mobility” will be left empty.

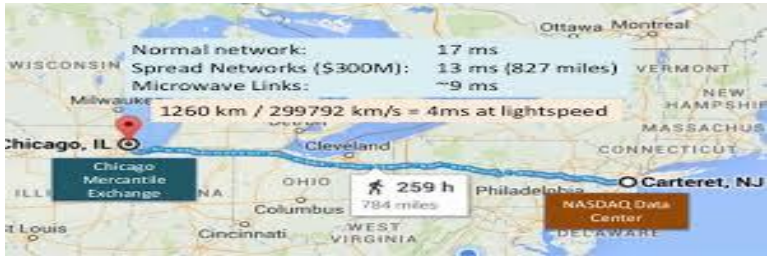
Source: Dr. Mehmet Toy, Vice-Chair of FG and Co-Chair of Sub-G3

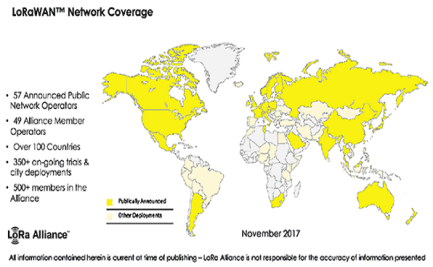
Sub-G3 ManyNets: Embracing Diversity, Variety, and Economy

Non-IP Networks
(Growing market segment)



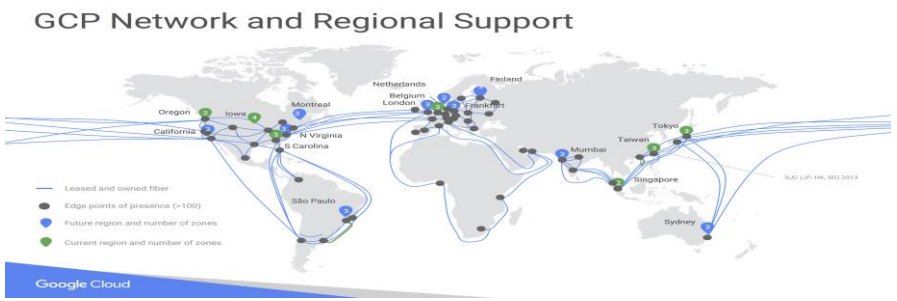
Spread Networks

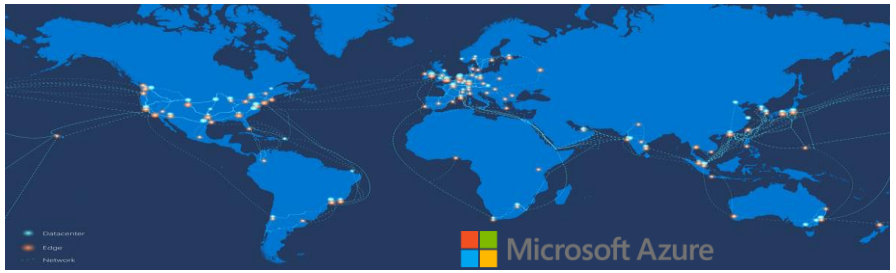




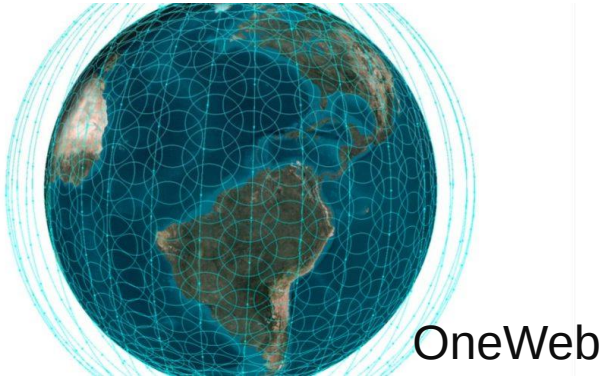
FirstNet®

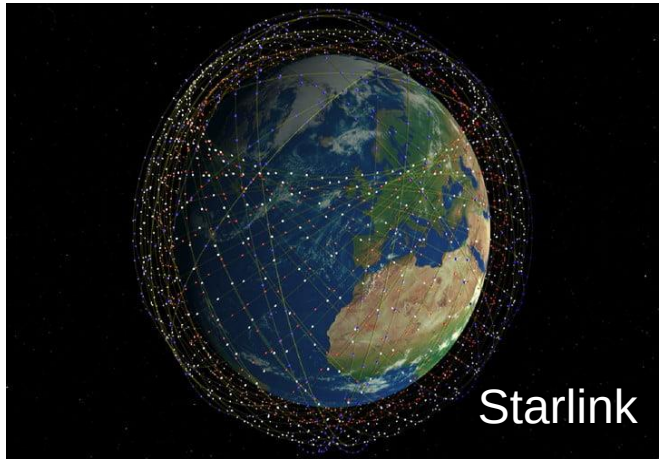
Private Global Backbones
(Death of Internet Transit, Geoff Huston's Presentation)



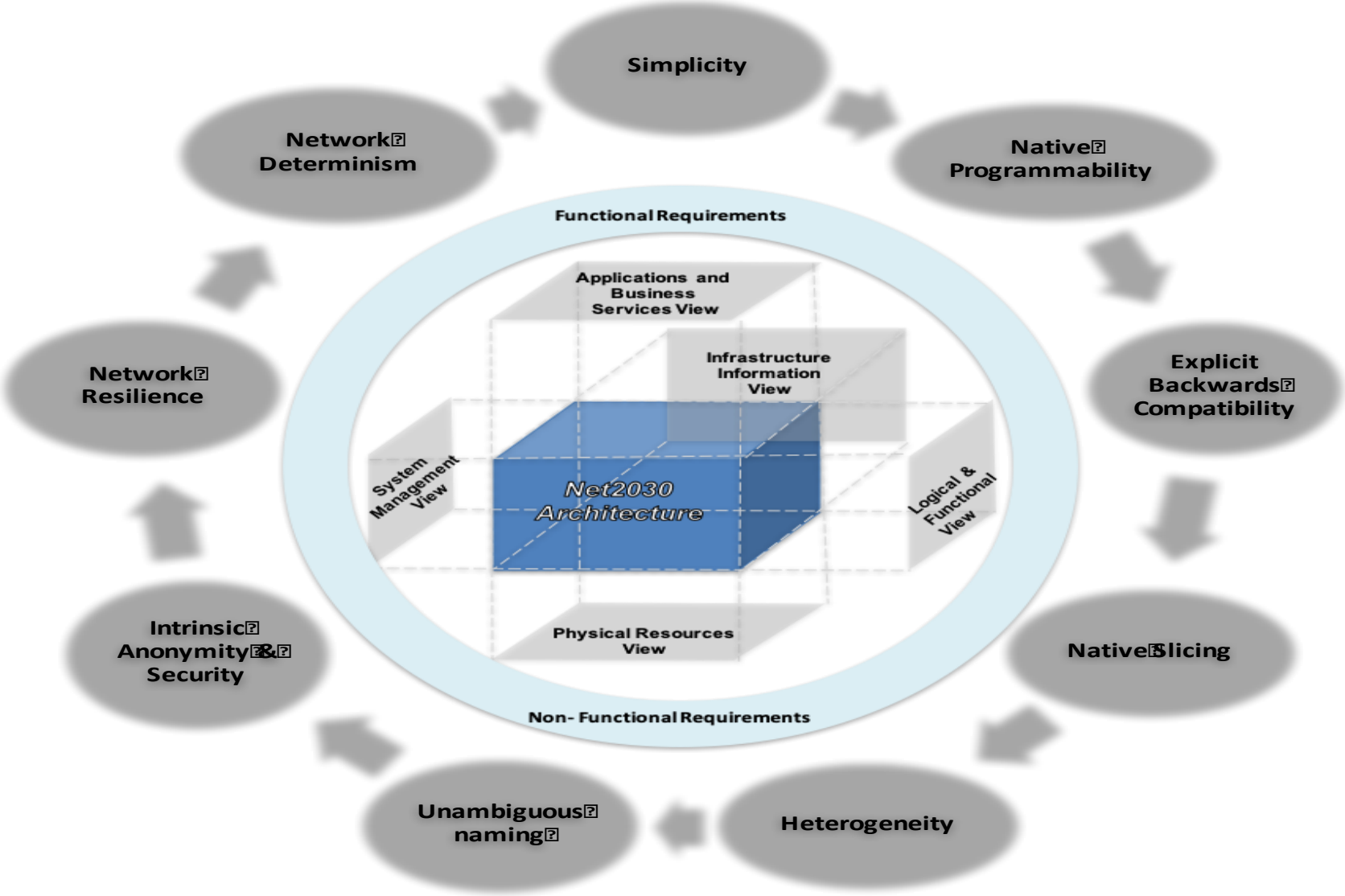


Emerging Satellite Constellations
(Global Broadband connectivity for 4 billion people who are not connected to any network today)





Sub-G3 Network 2030 Architecture Framework (1/3)

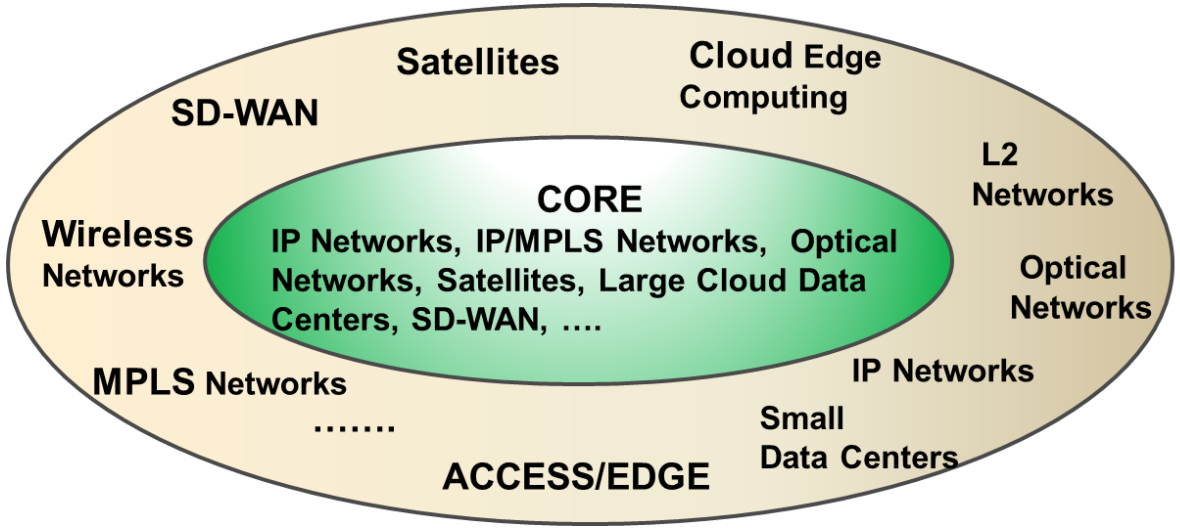


Relationships between Network 2030 principles, requirements and architecture(s)

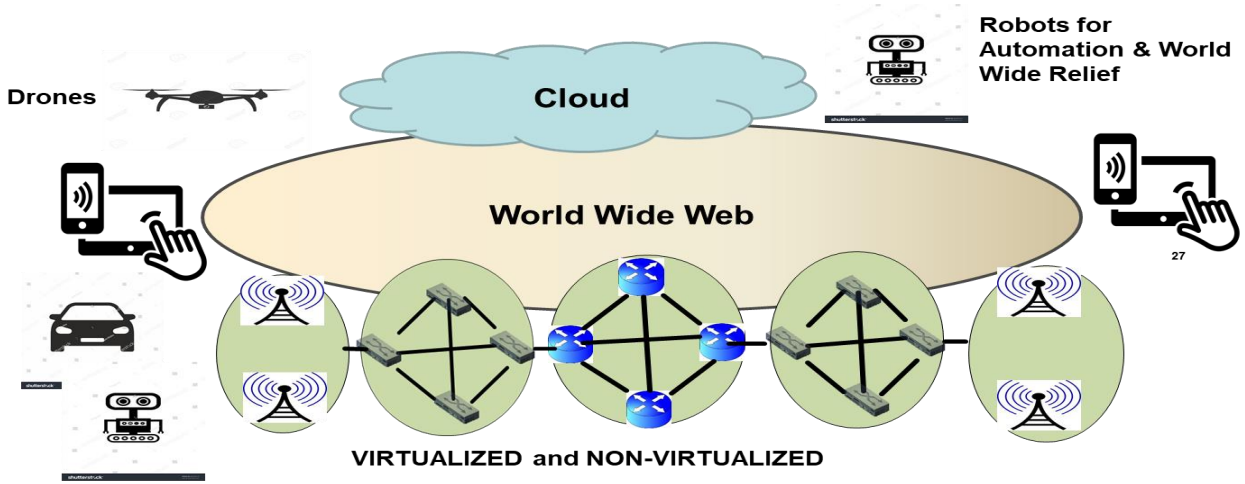
Extract from Sub-G3 ongoing draft

Sub-G3 Network 2030 Architecture Framework (2/3)

Network 2030 infrastructure is expected to include fixed and wireless networks, cloud and space communications infrastructures



Network 2030 is expected to be used by various devices including robots, self-driven cars, and drones

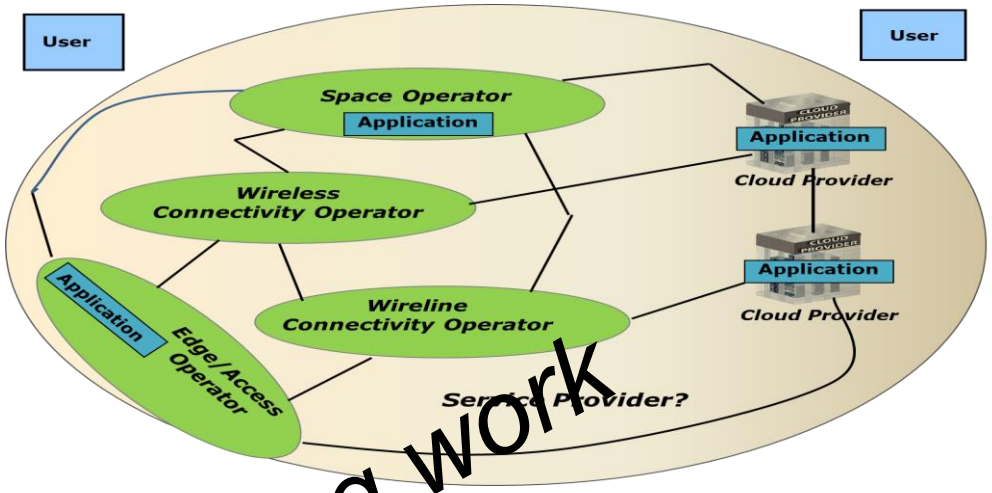


Example of future network infrastructure and end devices

Sub-G3 Network 2030 Architecture Framework (3/3)

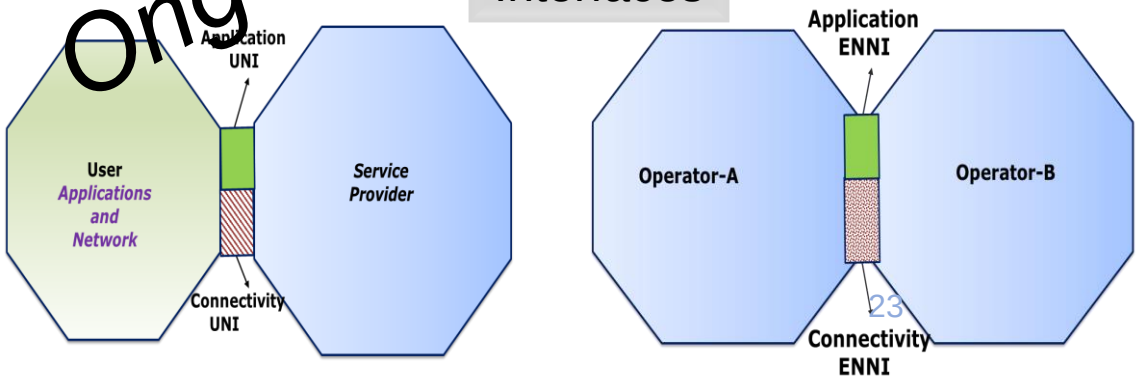
The future integrated network will comprise highly automated and intelligent one or more Operator networks supporting compute, storage, and applications, and connectivity among them, that may be accessed by a user from one or more locations

Actors of future integrated network



Ongoing work

Interfaces



Sub-G3 architectural teams:

- Principles
- Addressing
- Security, Privacy and Trust
- Mobility
- Resiliency, Reliability, High Availability and QoS
- Access Network and Edge Computing
- Network Management and Orchestration (incl. Application Management)
- Space Networking
- *Microservices and Control Plane*
- *Softwarization*

Part II

New IP

Network 2030 and New IP are related, but independent tracks

Network 2030

a. A study of the long-term market drivers fueled by emerging applications and industry verticals
b. It identifies use cases, analyzes technical gaps, finds requirements, and studies new capabilities of networks
c. No overlaps – it excludes work considered by other FGs e.g. security, quantum, AI, to name a few.

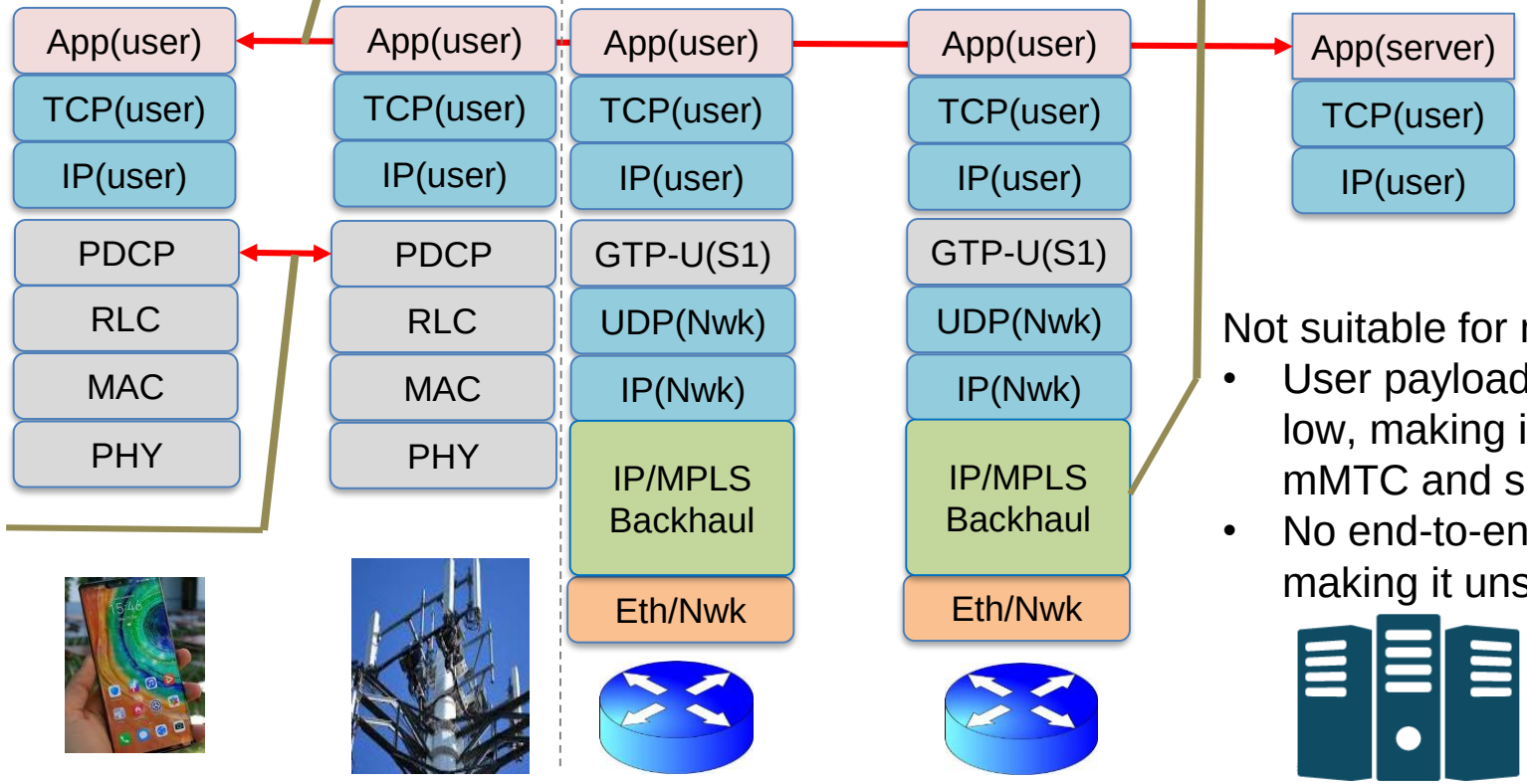
New IP

a. Advanced IP Backhaul Transport for 5G, B5G, and even 6G
b. Requirements and New Capabilities from Network 2030
c. Emerging industry verticals, for example, remote driving and operation, cloudified PLC, industrial IoT, industrial control and intelligent operation network
d. Technical Aspects of Privacy, Trust and Intrinsic Security

New IP Solves Problems with End-to-End Guarantees of Throughput, Latency, Lossless Networking

Throughput and latency are not guaranteed by the current end-to-end TCP/IP

Inefficient use of protocols
- Tunnels over tunnels
- Some header fields repeat each other



Delay variations: Radio retransmissions are not synchronized with TCP flow control, causing TCP to wastefully retransmit packets

Not suitable for mMTC and uRLLC
- User payload efficiency is too low, making it unsuitable for mMTC and short messages
- No end-to-end delay guarantee, making it unsuitable for uRLLC

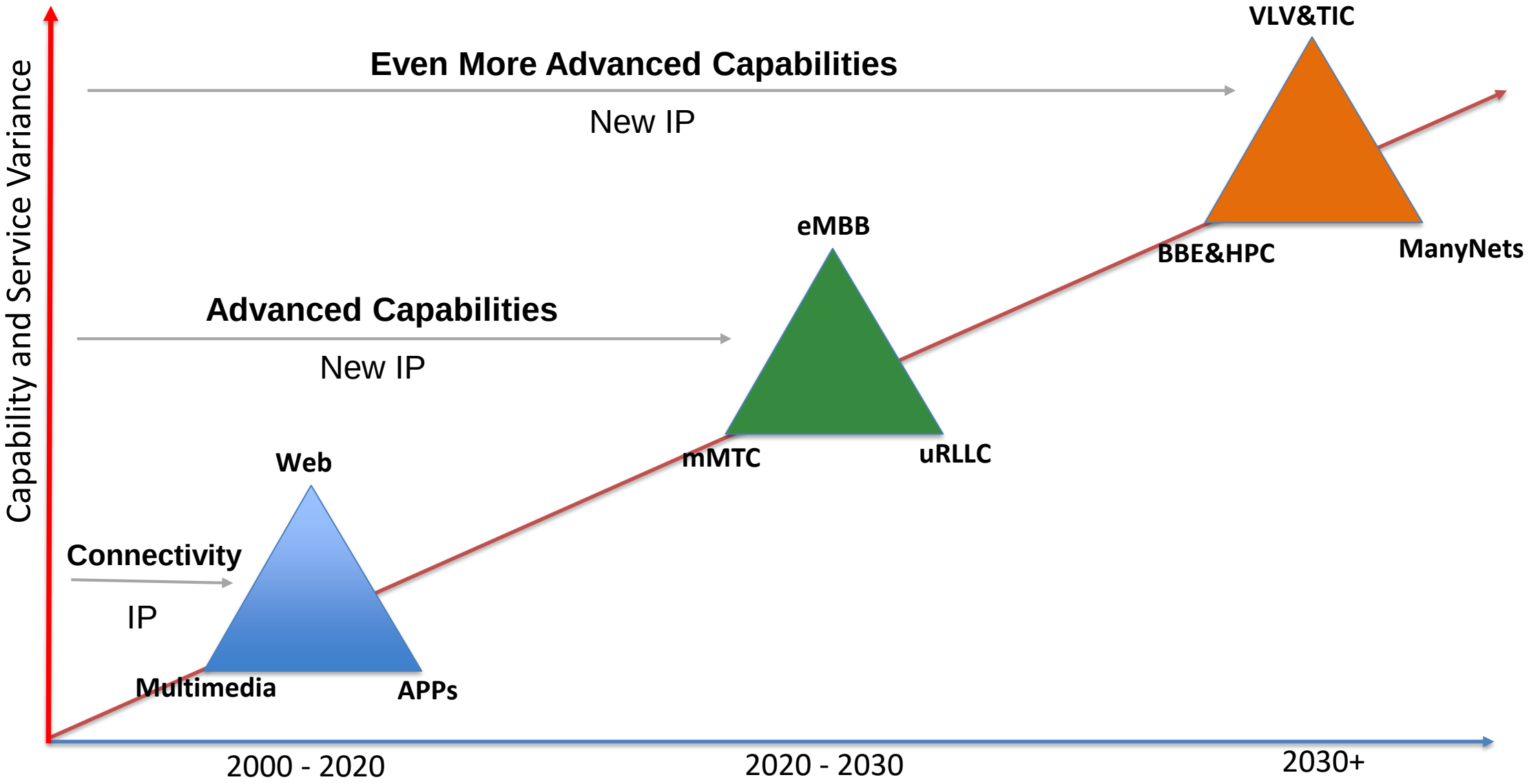
Cellular network

Fixed, IP based wireline network

New IP Supports Industry Verticals

For Example: Driverless Vehicles and Remote Operations

New IP Bridges the Technical Gaps in both Mobile Backhaul and Network 2030



New IP Status

- New IP is currently under work by engineers and research scientists from both industry and academia across multiple countries
- Some prototypes have been presented in public
- Some operators/service providers have shown strong interest in New IP to support new applications
- Standardization of New IP has not yet started

Thank you