7th SG13 Regional Workshop for Africa on "ITU-T Standardization Work on Future Networks: Towards a Better Future for Africa" (Abuja, Nigeria, 3-4 February 2020)

New IP based Networks

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NOTE – This presentation is largely based on the tutorial given at Sept 2019 ITU-T TSAG meeting by Dr. Sheng Jiang (Huawei Technologies Co. Ltd., China)

Visionary network requirements

Imagine the Future

2030s

TODAY

1990s

1970s

Application

Holographic type communications

Smart Cities

Autonomous driving

AR/VR

Remote Surgery

Network

Need to DO SOMETHING
for the future networks

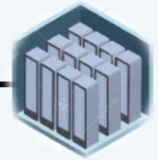
Connectivity

People

Things

Satellite Networks

Internet



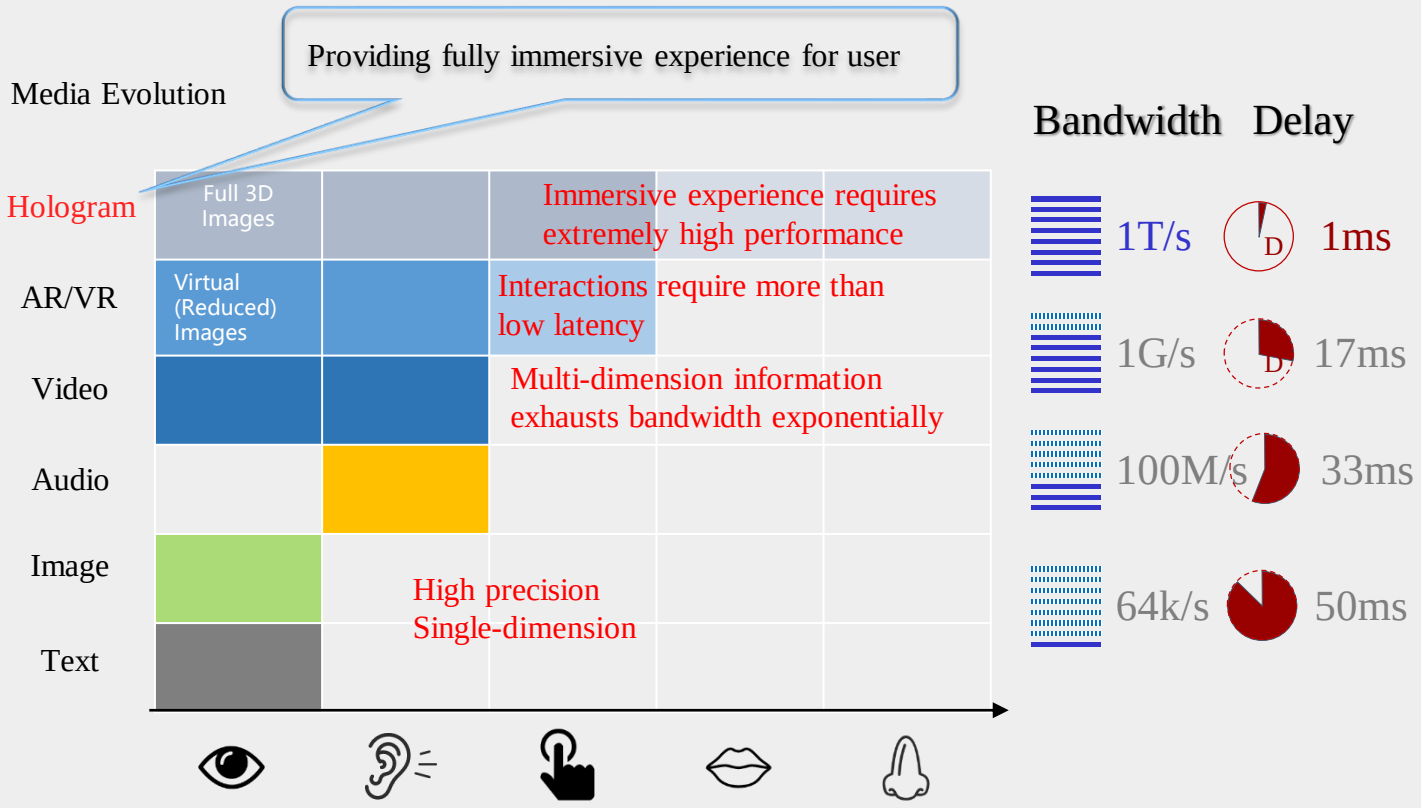
Datacenter Networks

Data

Computation

Interconnect
Everything
Every people
Every service

Evolution of Media Technologies for Future Immersive Experience



Multi-capturing scheme requires ultra-high bandwidth (as shown in the table). Furthermore, the interaction requires deterministic delay and ultra-high precision synchronization.

The loss tolerant feature also provides new opportunities for transport layer technologies.

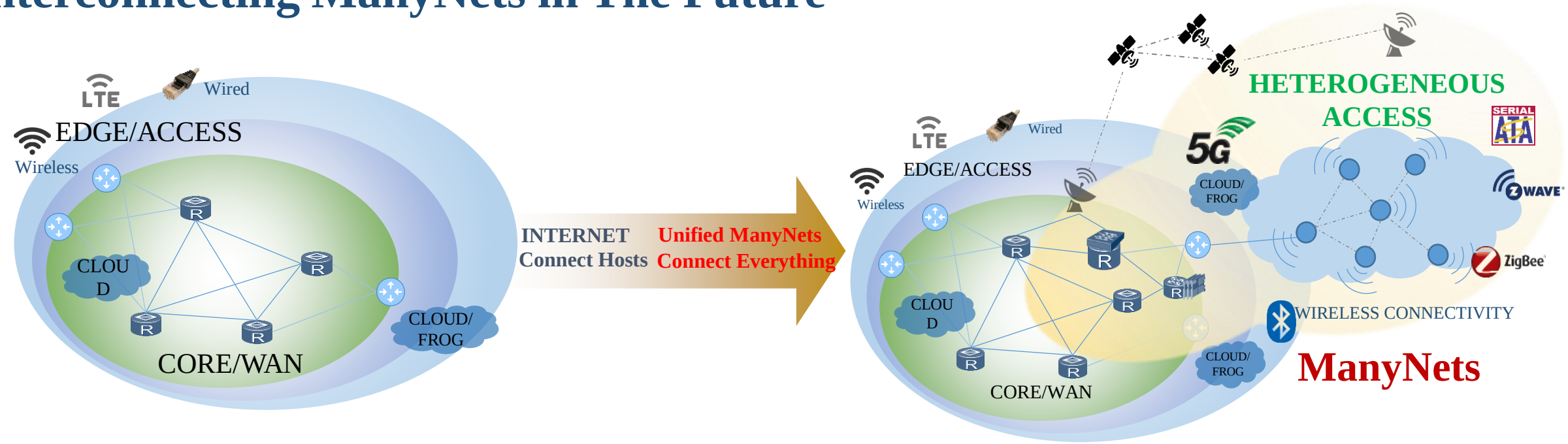
Holographic Type Communications (data size analysis)

Parameters	Hologram (5.9 inch)	Hologram (70 inch)
Resolution	124,800*70,200	1,536,000*864,000
Dot Pitch	1um	1um
Display Size	12.48 cm*7.02 cm	153.6 cm*86.4 cm
Bits per Pixel	24 bits/pixel	24 bits/pixel
Static Compression	40:1	40:1
Motion Compression	1000:1	1000:1
Static Image Size	**5.25 Gbits**	**796 Gbits**
Motion Image Size (at 60FPS)	**12.6 Gbps**	**1.9 Tbps**

New transport requirements for hologram communications

- **Ultra-high Throughput:** Along with the evolution of media technologies, the future applications, especially the holographic type communications, potentially require ultra-high throughput to the network.
- **Customizable Priority and Strategy:** Priorities and requirements of application data are diverse. Besides choosing the transport layer protocol, an application should have the capability to indicate the transport strategy.
- **Reduced Complexity and Indeterminacy:** Lossy transmission affects the quality of content, however (lossless) re-transmission potentially decreases the throughput. The new transport should consider the combination with new technologies, such as network coding, to deal with packet loss and provide better end-to-end capabilities.
- **Inherent Network Awareness:** Besides packet loss, more network parameters, such as bandwidth, delay and jitter, will influence the transport strategy. The new transport should be network-aware.

Interconnecting ManyNets in The Future



Ubiquitous connection of a massive number of physical entities, such as smart terminals, sensors, wearables, vehicles, and industrial control devices

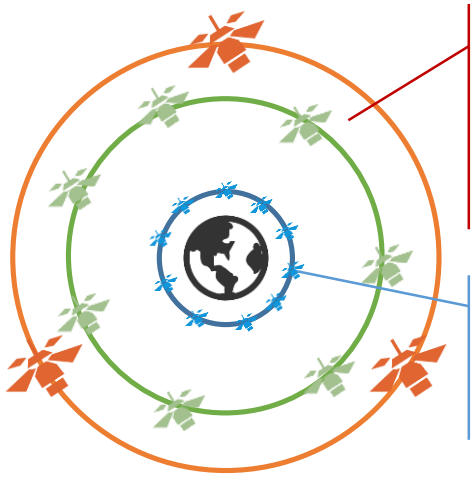
The popularization of in-network computing and AI technology will let the service resources, such as such as micro-services, processes and functions, become virtual communication entities

Interconnecting devices, services, contents, human beings, digitized entities, …

The content in the network acts as an independent communication entity and is no longer bound to specific locations or specific hosts

The network needs to provide specific QoS and security policies based on user identity, rather than mapping to something

Space-Terrestrial Integrated Network



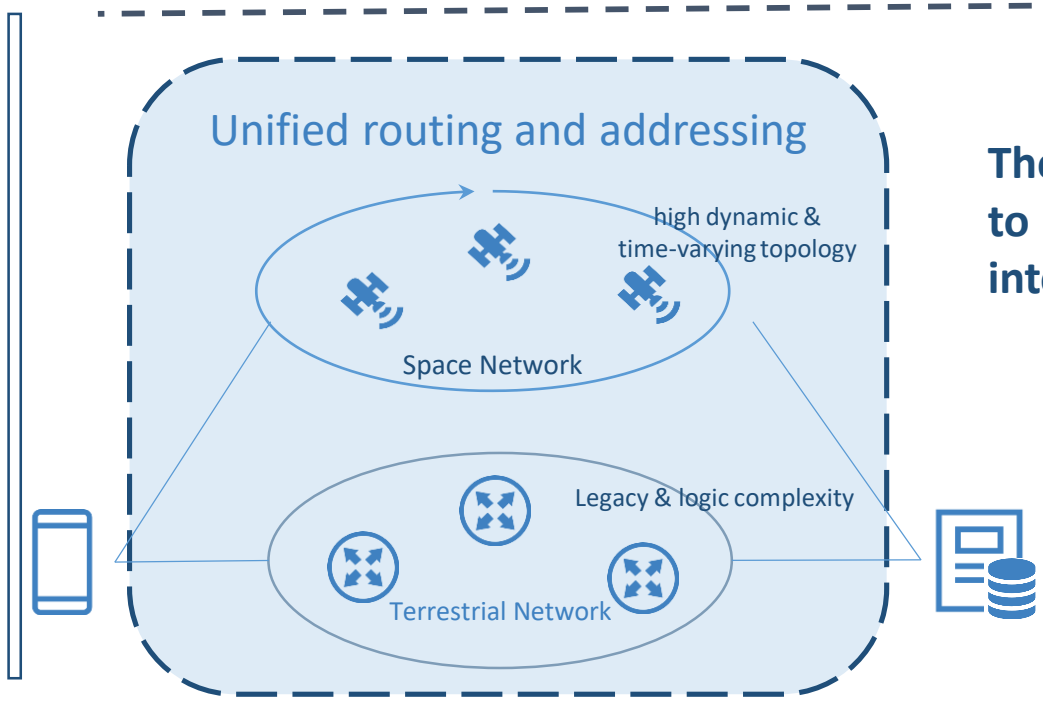
It is hard for GEO and MEO to provide low latency due to the physical restriction

LEO can provide end-to-end low latency

The high dynamicity challenges the traditional IP protocol, especially in networking and routing.

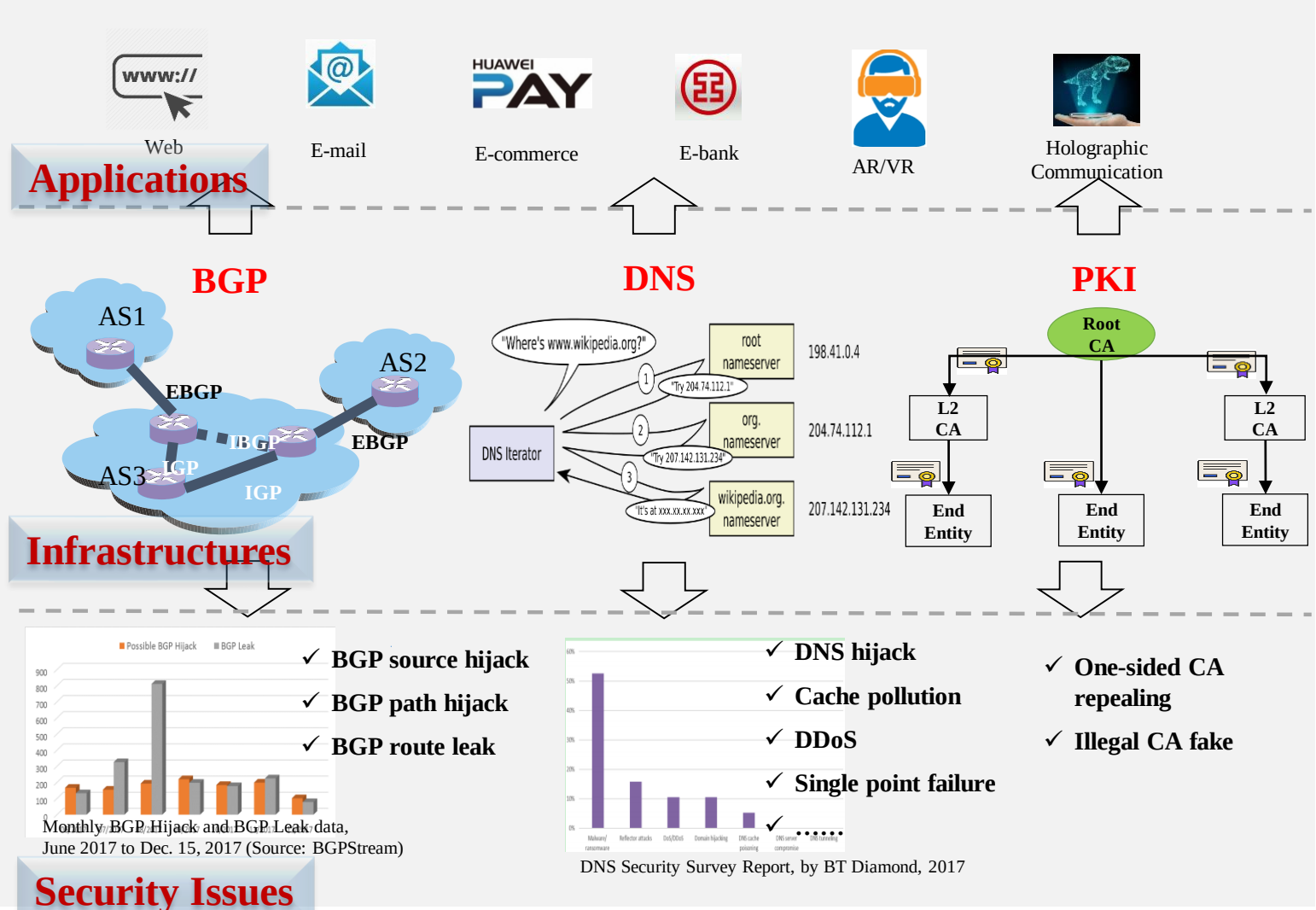
- Space network has the characteristics of **high dynamic and time-varying topology**
- The space network channel is **unstable**, the bit error rate could be high

Comparing with traditional optical fiber, space network can provide shorter end-to-end delay theoretically when the physical distance is more than 3000km [HotNets'18 paper]
Space networks can potentially play one of the most important roles in future data communications



There is a great opportunity to build a space-terrestrial integrated network

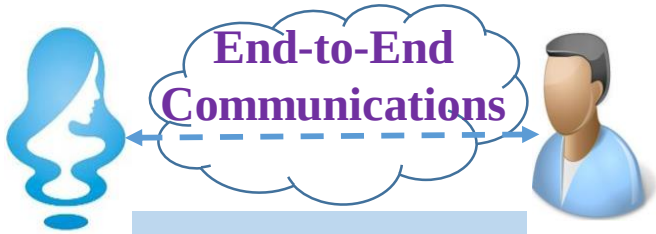
Trustworthy Foundation and Intrinsic Security for the Internet Infrastructure



Monthly BGP Hijack and BGP Leak data, June 2017 to Dec. 15, 2017 (Source: BGPStream)

DNS Security Survey Report, by BT Diamond, 2017

The Internet heavily relies on centralized infrastructures (e.g., BGP, DNS and PKI) and this has caused severe problems in the past.
Decentralized Trustworthy Network Infrastructure is then highly expected.



Security Issues

Authenticity
Source IP spoofing

Accountability vs. Privacy
Tradeoff: exposing IP, port & TTL on wire impacts privacy, but their anonymization impacts accountability

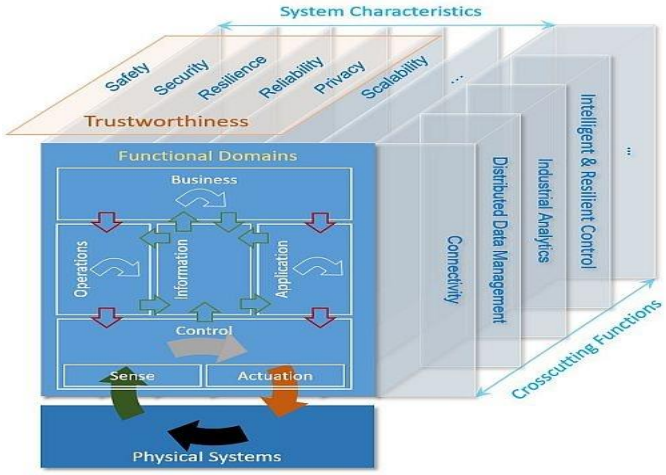
Confidentiality & Integrity
IPSec & TLS can protect confidentiality and integrity of data communication, but security of the key exchanges with the root has still to be guaranteed

Availability
It is required to avoid the unavailability of the target resources (network, computing and storage) caused by DDoS attacks

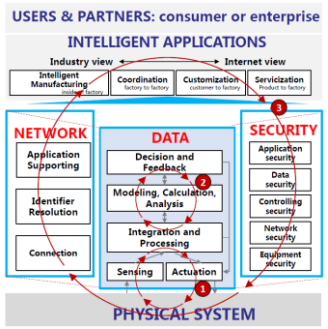
Intrinsic Security is desired to address these issues

More Network Requirements come from Verticals

Industrial Internet (IIoT)



IIC: Connectivity Framework for the Industrial Internet



AII: IIoT White Paper 2018

Key Network Metrics for Industrial Internet:

- Extremely low latency: *ms* level (with *us* level jittering)
- Ultra-high reliability: *>99.999%* system uptime
- Precise synchronization
- Super-massive connections
- Energy efficiency
- Ultra-high bandwidth for particular applications

Industrial fieldbus is merging with outside networks to form the Industrial Internet, which requires large-scale synchronization with deterministic data transmission, and ultra-high reliability

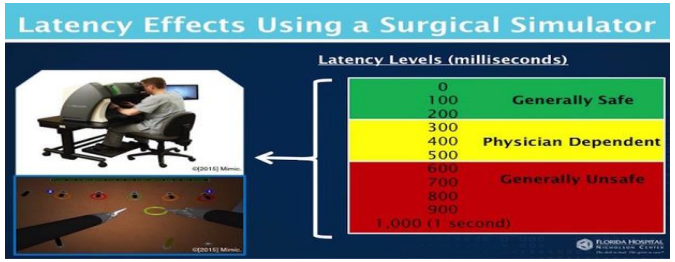
Tele-Medical Applications

Direct tele-medical application (2001~2020)

MiroSurge system developed at German Aerospace Center (DLR Institute) with table-mounted manipulators.

Synchronization via human + machine (~2025)

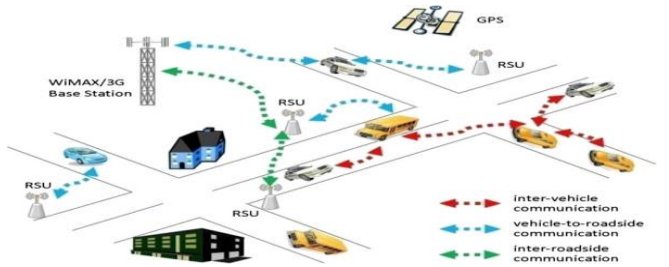
Two surgeons in remote synchronization via **Raven II** platform



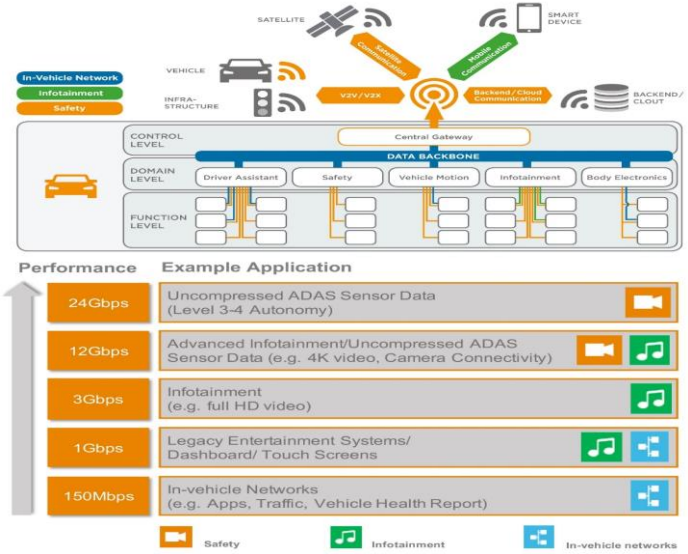
Source: Hospital tests lag time for robotic surgery 1,200 miles away from doctor, 2015

Tele-medical applications are emerging with requirements of high-precision coordination and low latency signaling

Vehicular Networks



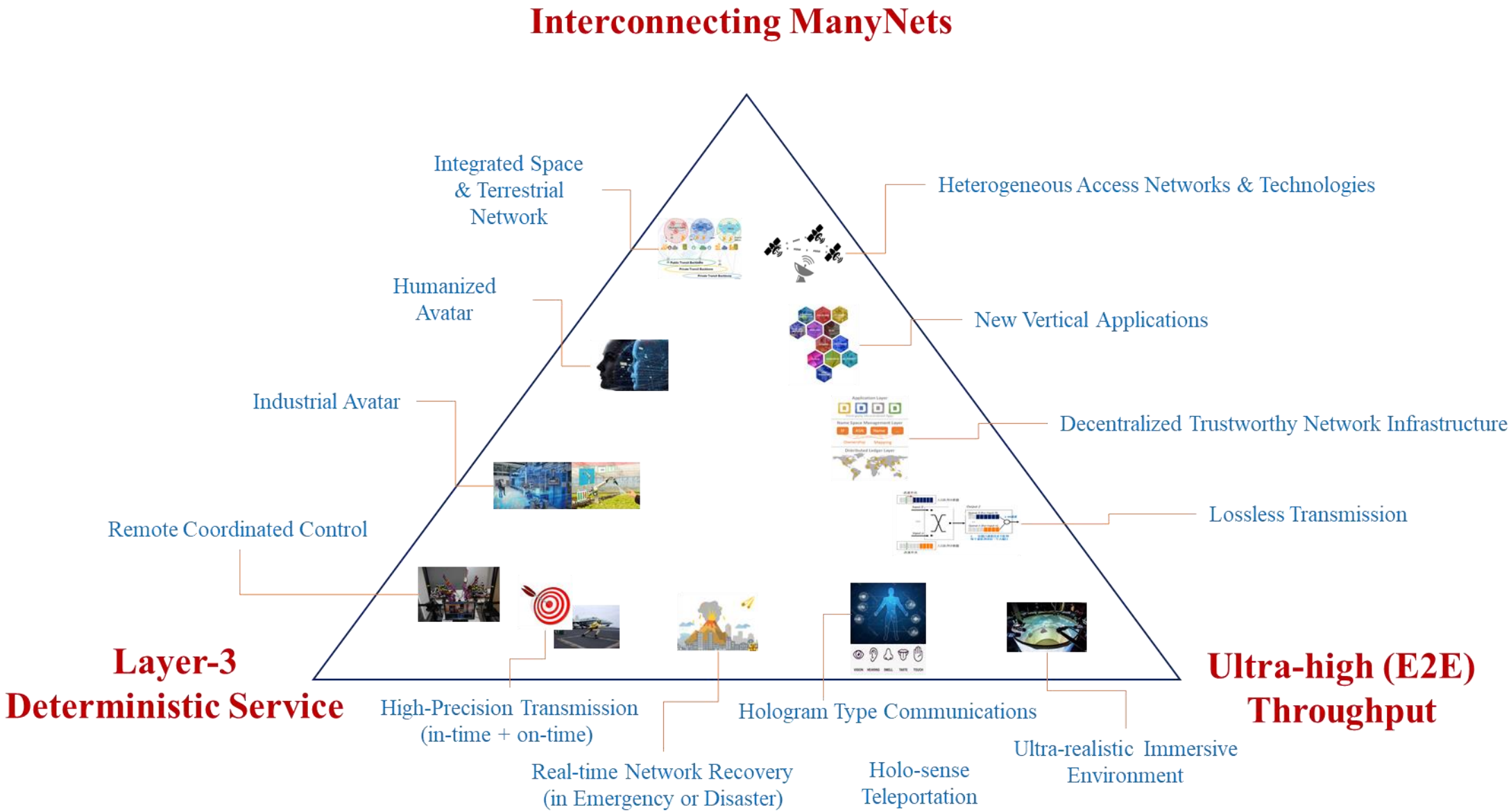
Source: Vehicular Networks



Autonomous Intersection Management (Austin University)

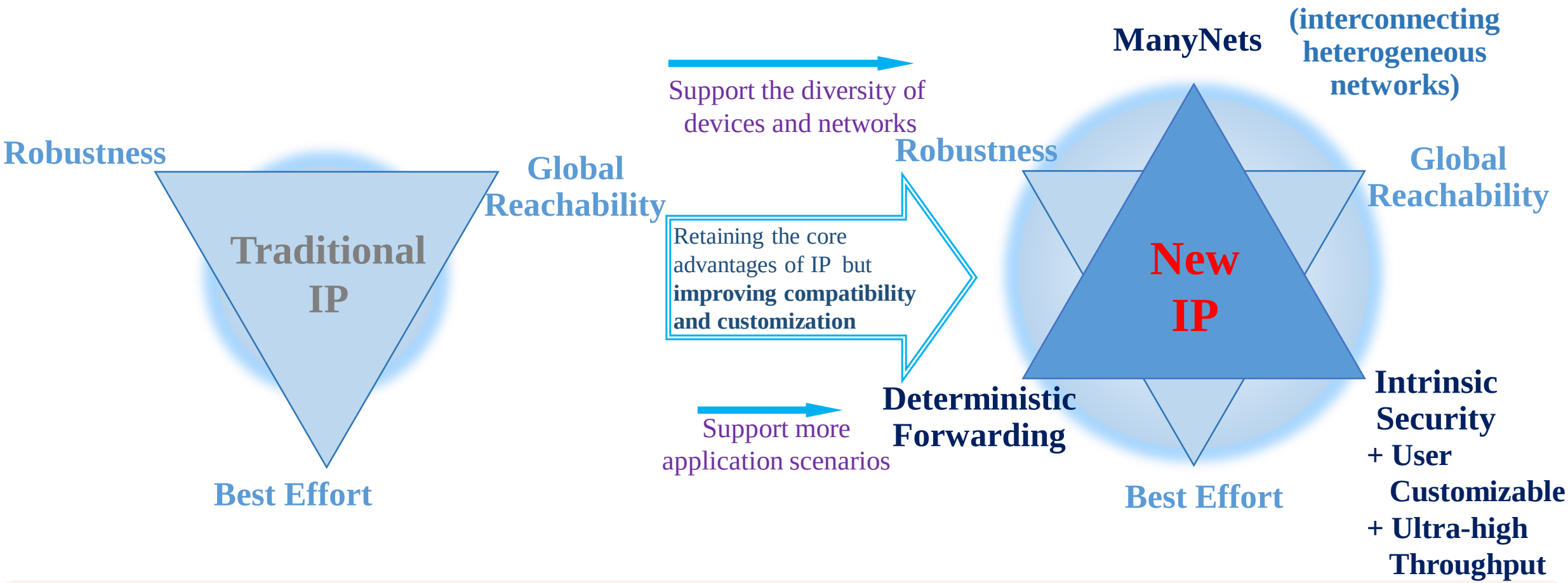
Vehicle-to-X networks enable new communications, while in-vehicle data is expected to be boosted dramatically. Vehicular safety also requires ultra-low latency and large-scale synchronization.

Future Network Scenarios and Requirements Towards 2030



New IP based Networks

New IP based Networks: Enhanced, Stronger, Unified, Flexible and Secure



New Connecting:

- (a) Unified Internet by connecting heterogeneous address spaces and variable length IP addresses directly.

  Supporting new kinds of devices, services, capabilities and objects in the future network diversity.

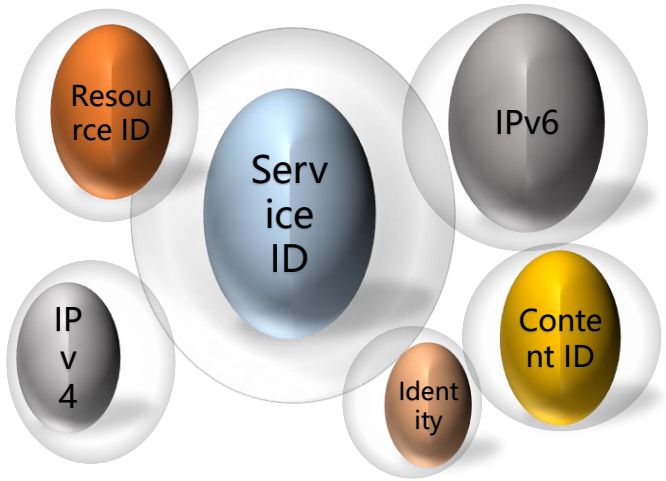
New Services:

- (a) Providing deterministic network service for the upper layer applications, especially for those requiring determinacy
- (b) Dynamic cooperation of the new transport layer with the network layer, providing ultra-high throughput capability

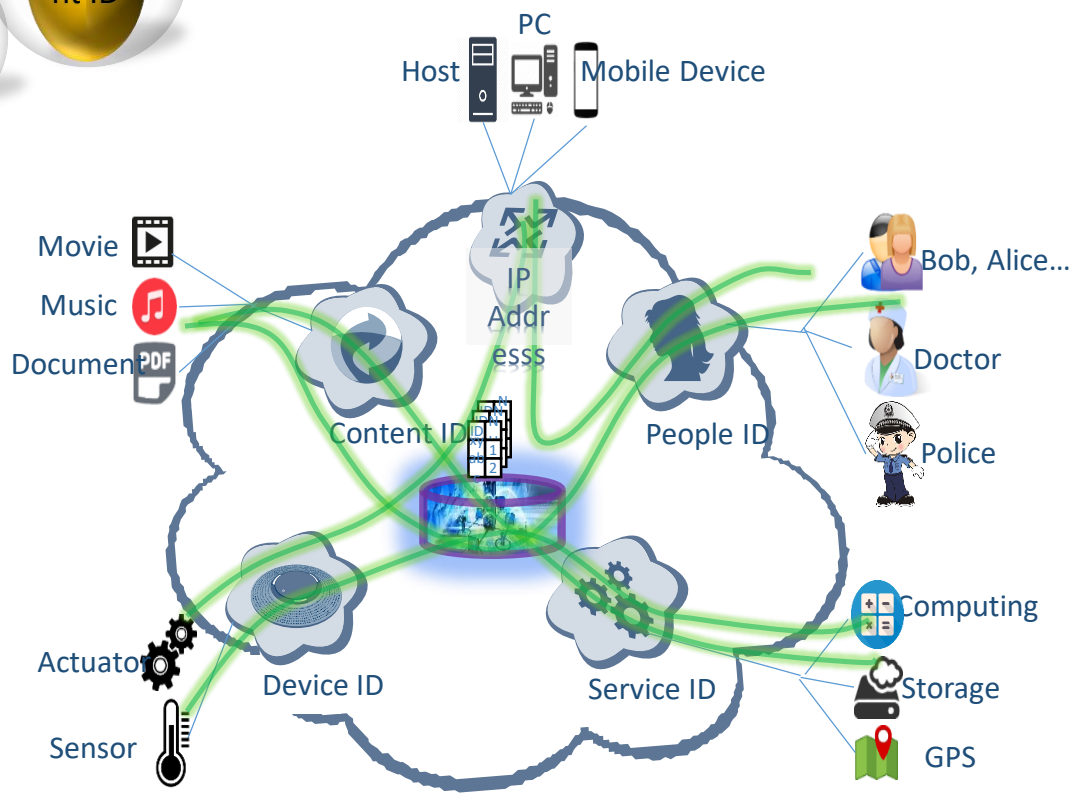
New Capabilities:

- (a) Providing intrinsic security
- (b) Providing user customizable capability. The network protocol can carry more information, requirements and functions from user/application

Flexible and Multi-Semantic Addressing, Service-Oriented Routing

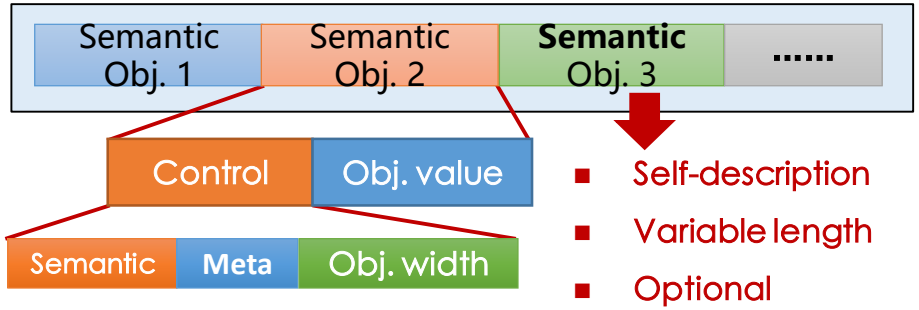


Heterogeneous address spaces should be able to communicate with each other



Instead of mapping all information into network address, **diverse IDs can be used to indicate the destination**, improving the routing capabilities.

Service-oriented routing (direct routing based on diverse IDs, maintaining diverse ID routing tables in the network

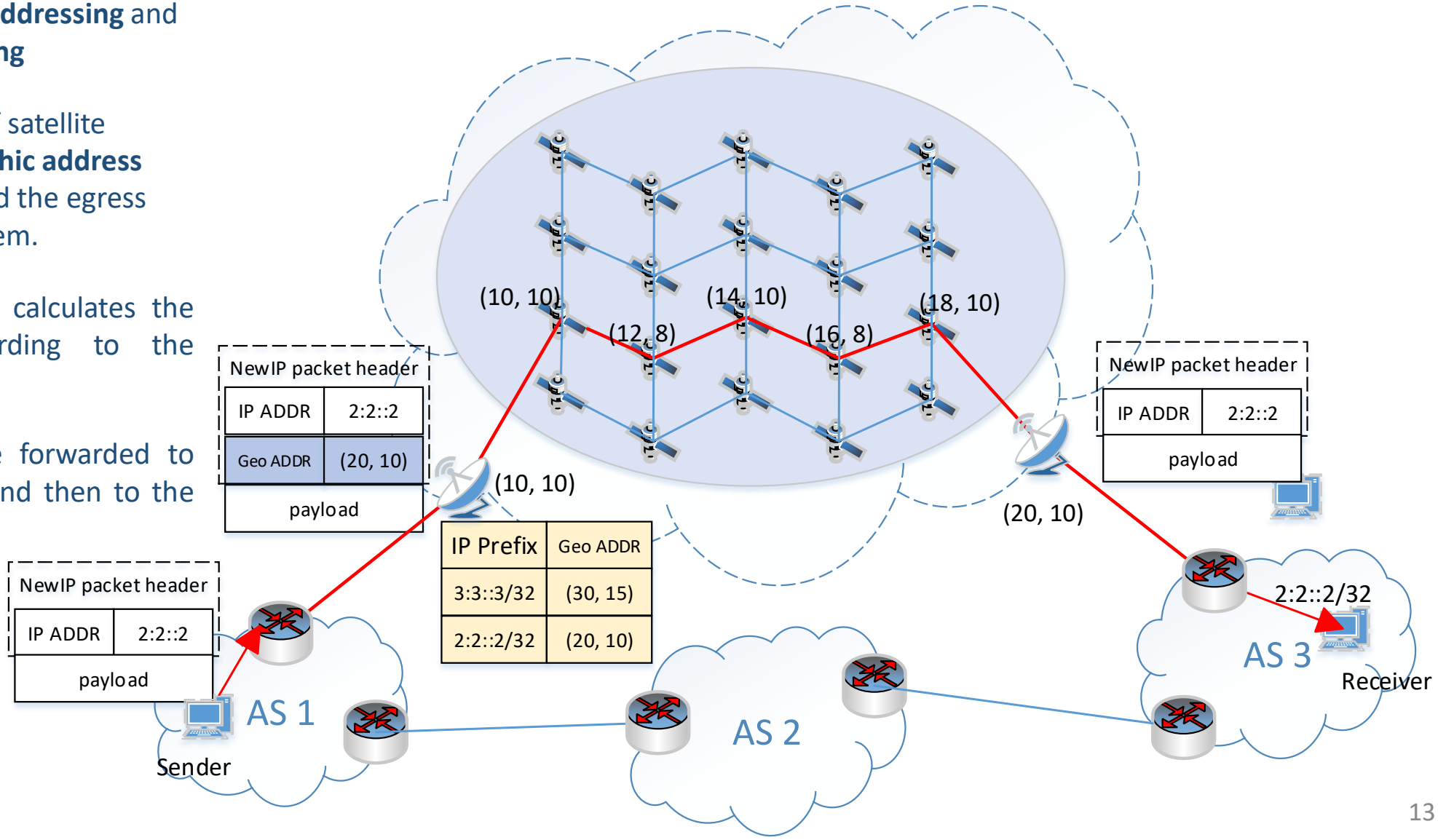


From fixed-length (32/128 bits) to variable-length addresses (can be longer or shorter)

Furthermore, the **semantic fields can be changed** to satisfy a variety of communication scenarios.

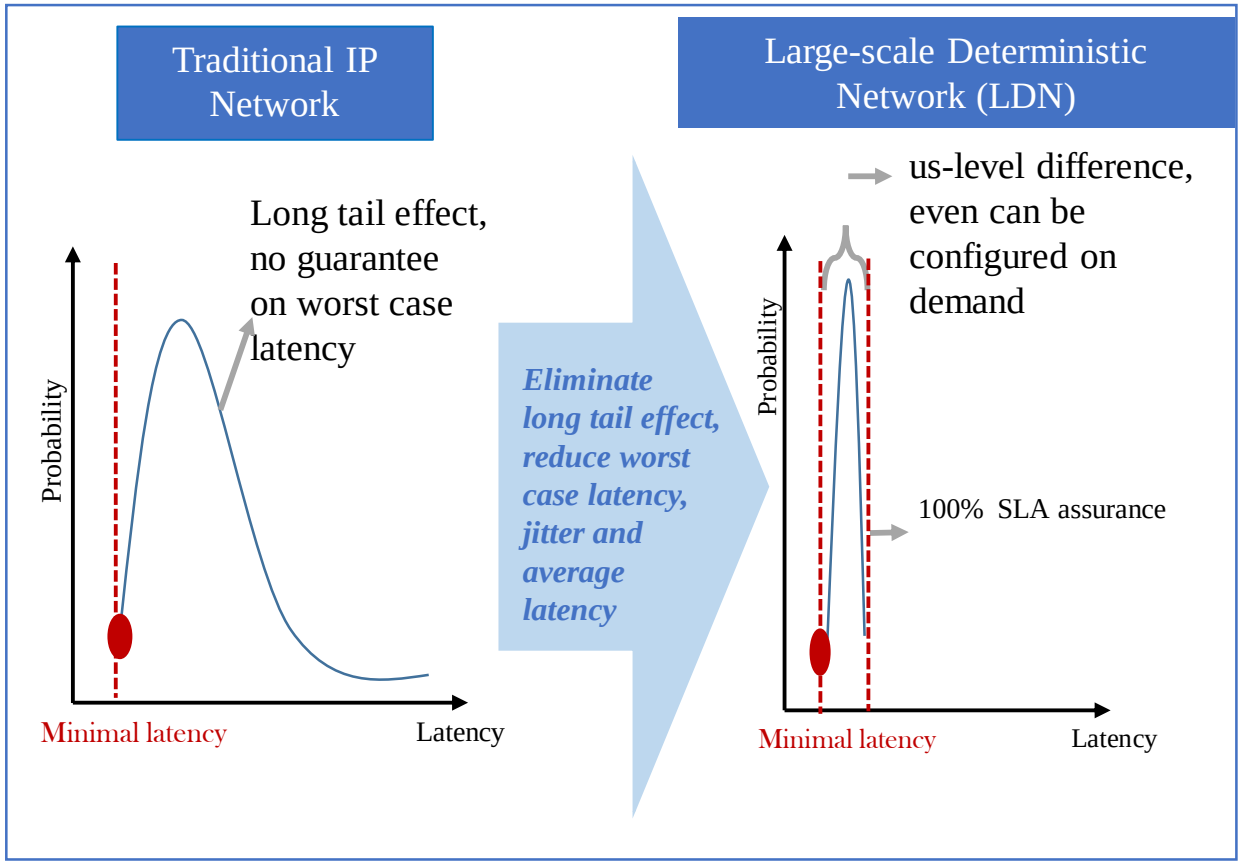
Support of Space-Terrestrial Integrated Network and Diversity of Addressing

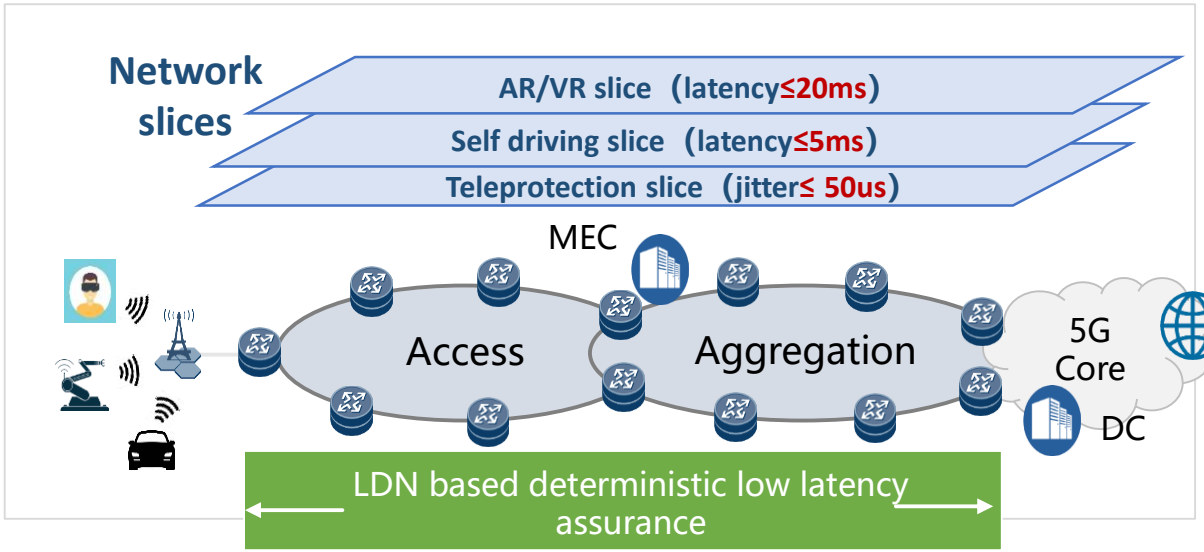
- Supports **topological addressing** and **geographical addressing**
- The ingress gateway of satellite network adds **geographic address** into New IP header and the egress gateway deletes the item.
- The satellite network calculates the shortest path according to the coordinate.
- The data packets are forwarded to the nearest satellite and then to the destination.



Deterministic Forwarding for End-to-End High-Precision and Deterministic Latency Services

Enablement of network layer deterministic forwarding to satisfy future scenarios





New applications require both "in-time" and "on-time"

User-Defined Customized Request for the Network

Packet Level Network Programming

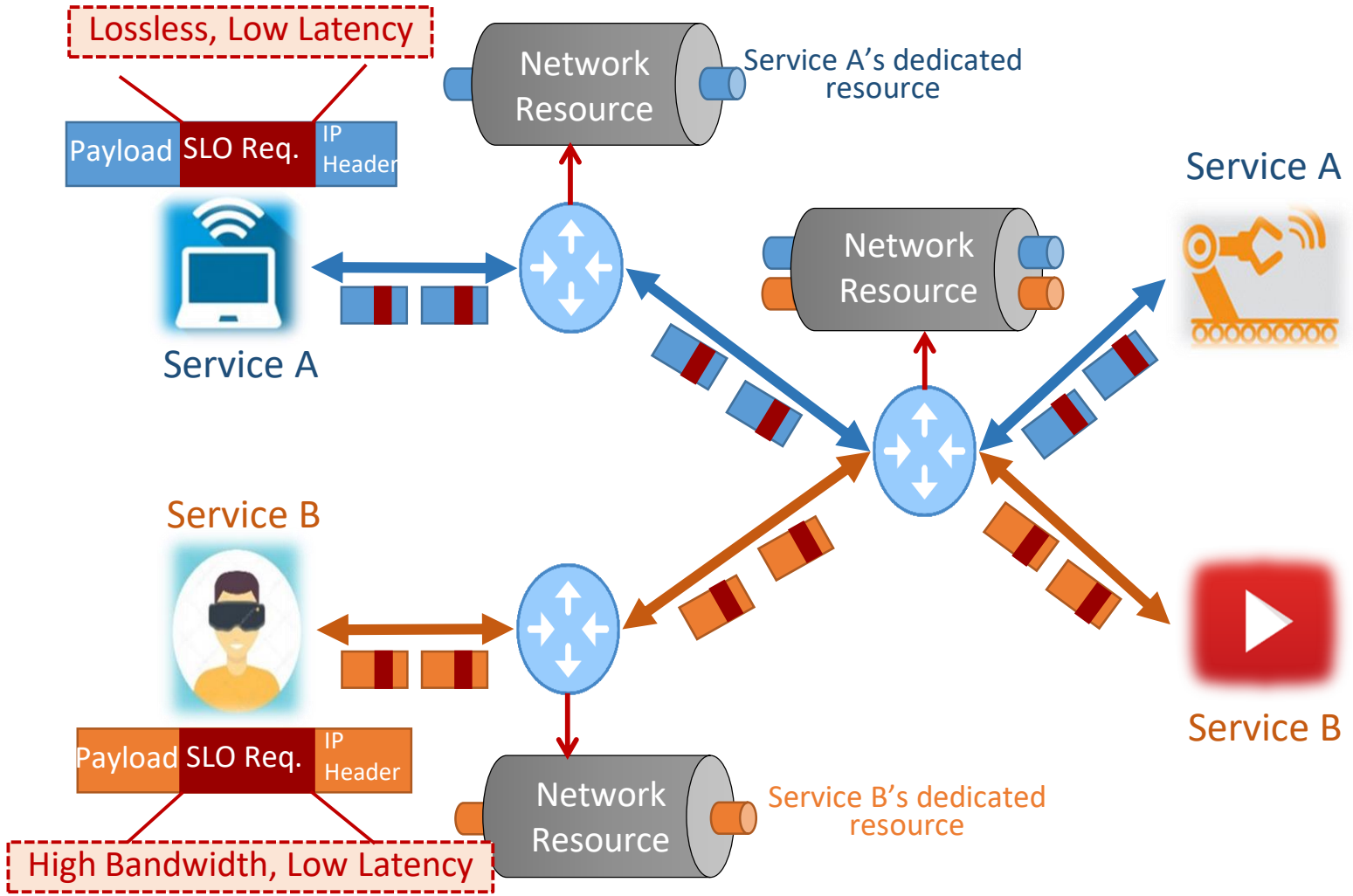
- Packet carrying instructions, metadata and execution permission to program the network behaviors

In-Band Signaling

- Combining together control plane and data plane capabilities

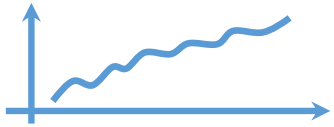
User/Application Granularity In-Band OAM

- Enabling fine-grained and accurate performance monitoring to allow end-user to further adjust Service Level Objectives (SLOs) depending on monitored network metrics

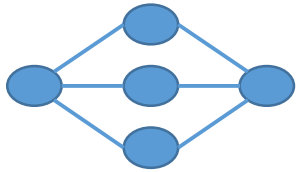


New Transport capabilities

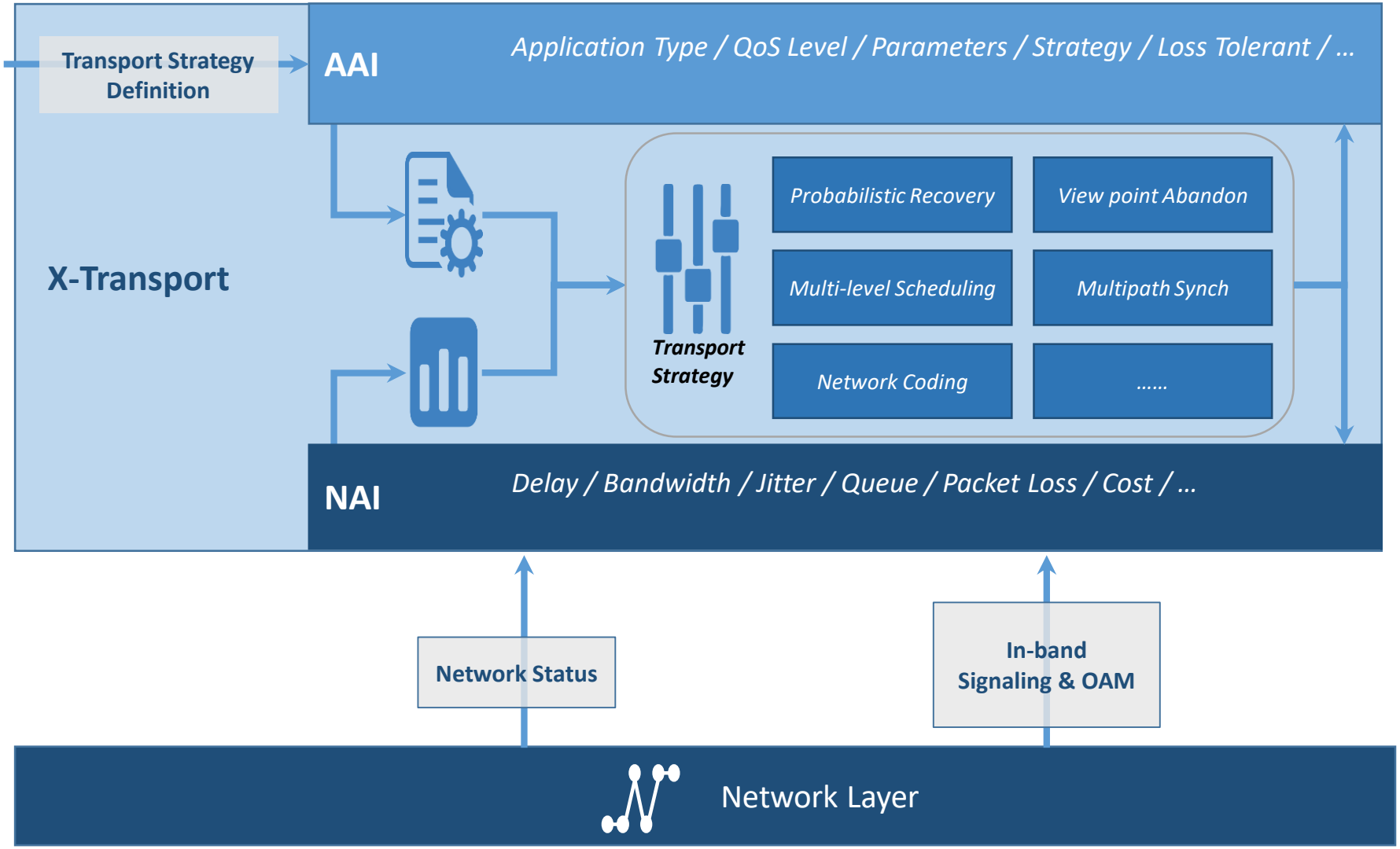
- **Ultra-high throughput**: the new transport can satisfy complex network environment and improve transmission efficiency (usage of network coding)



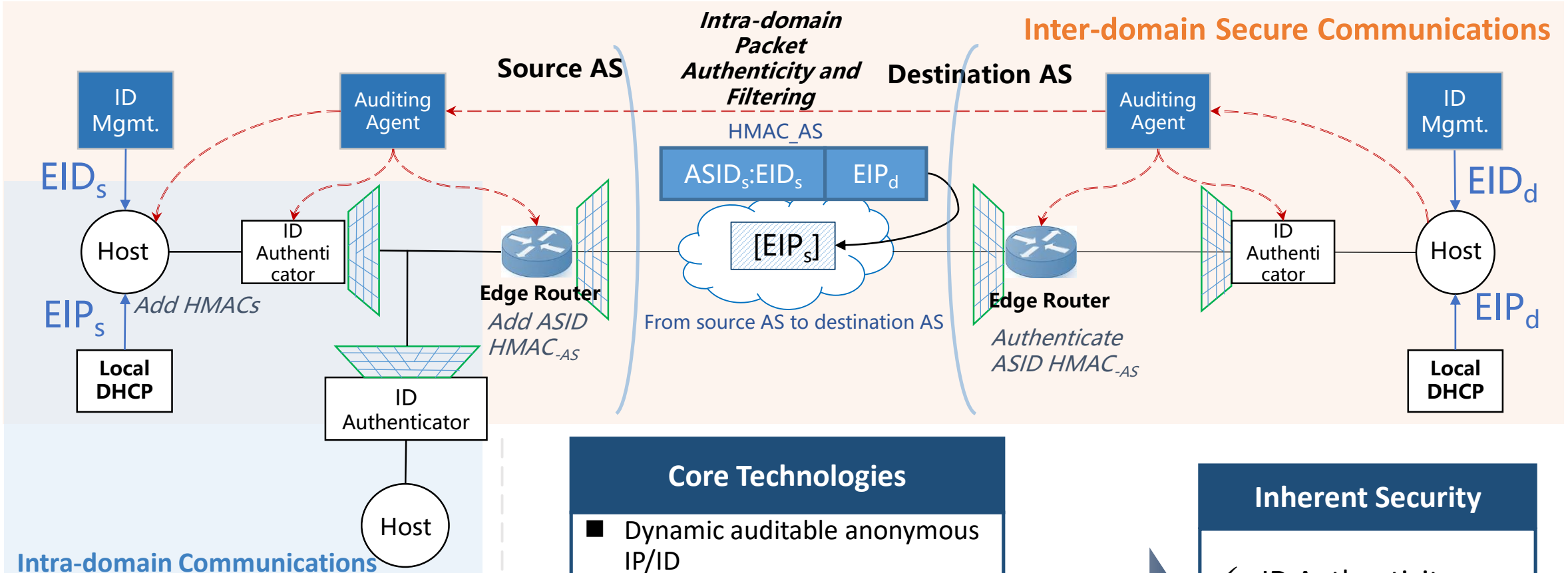
- **Network-aware:** by cooperation of in-band signaling, out of band signaling and network devices, the new transport can optimize transport strategy and scheduling



- **Transport customized**: according to the description from applications, the new transport can plan the matched transport strategy



Intrinsic Security for Privacy Protection in the Network



Core Technologies

- Dynamic auditable anonymous IP/ID
- Decentralized ID-based Intrinsic Key
- Authenticity for Zero Trust Test
- Joint Inter-AS Auditing and Attack Prevention

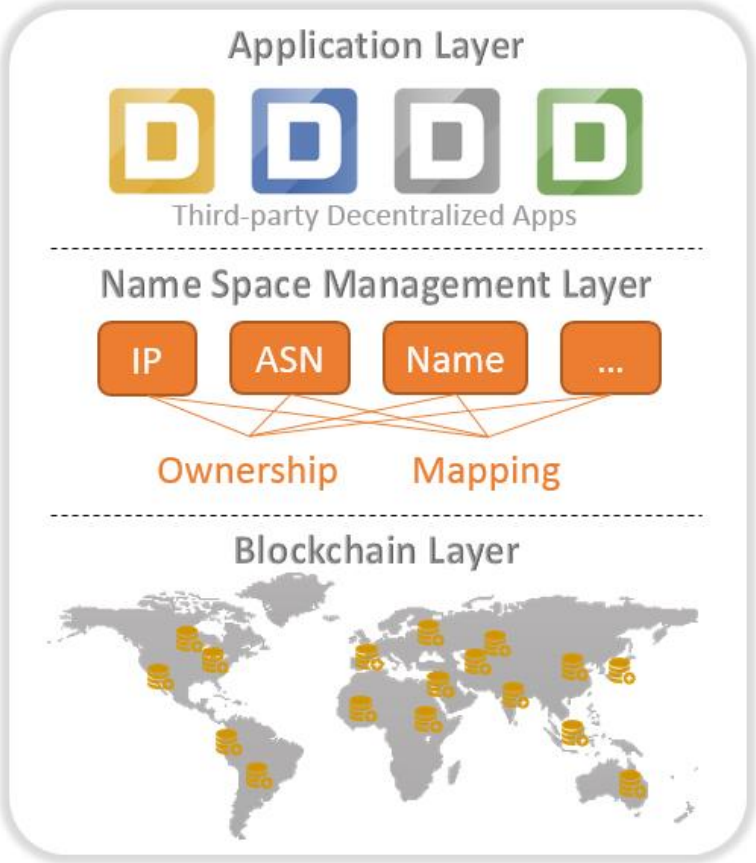
Inherent Security

- ✓ ID Authenticity
- ✓ Guaranteed Privacy
- ✓ Immune to DDoS

Decentralized Trustworthy Network Infrastructure

- **Goal**
  - To use decentralized technology for implementation of management of network resource and ownership, instead of single trust anchor and tree-like system.
  - To build up a universal trustworthy network architecture and provide powerful secure and trustworthy infrastructure for applications.

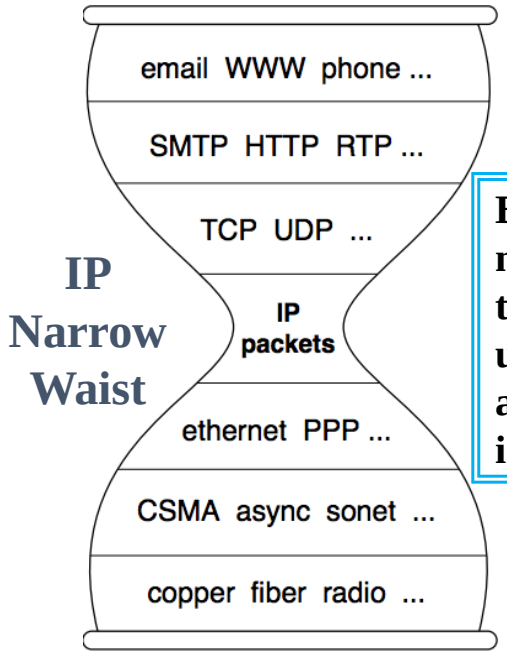
- **Architectural framework**
  - **Application Layer**
    - Based on the layers below, it provides 3rd party open API to implement more trustworthy and secure services
  - **Name Space Management Layer**
  - **Blockchain Layer**
    - It provides decentralized trustworthy infrastructure for the upper layers



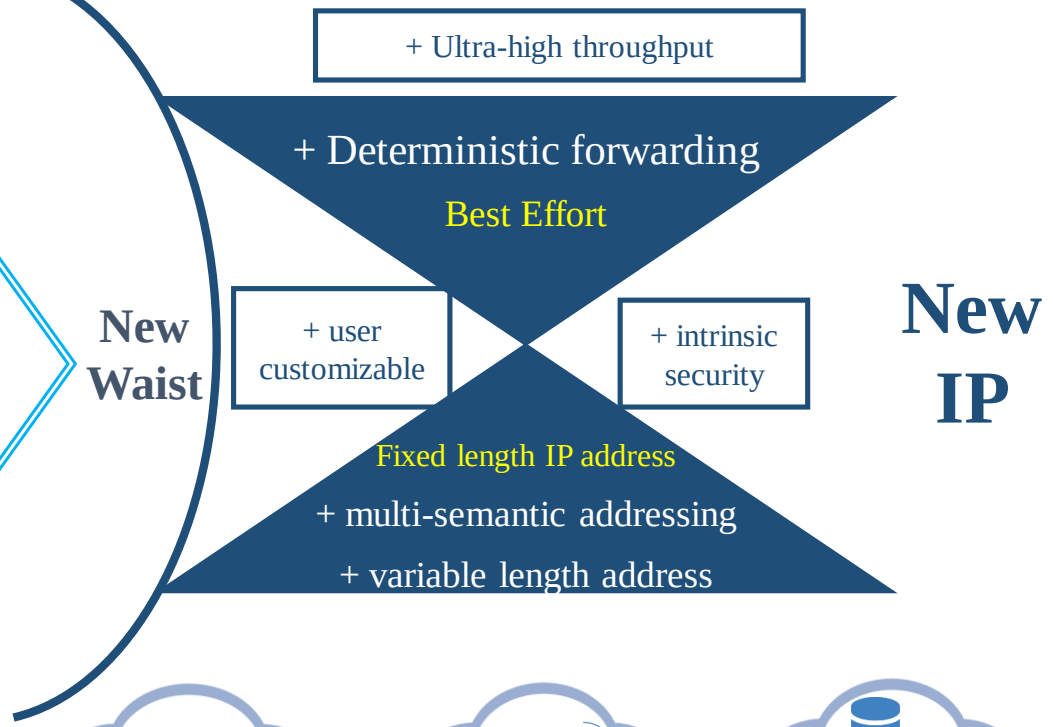
Work item in progress within ITU-T Q2/13 *(Y.DNI-fr "*Framework and Requirements of Decentralized Trustworthy Network Infrastructure")

Inheriting the Successful Gene of IP and Move Forward to a New IP

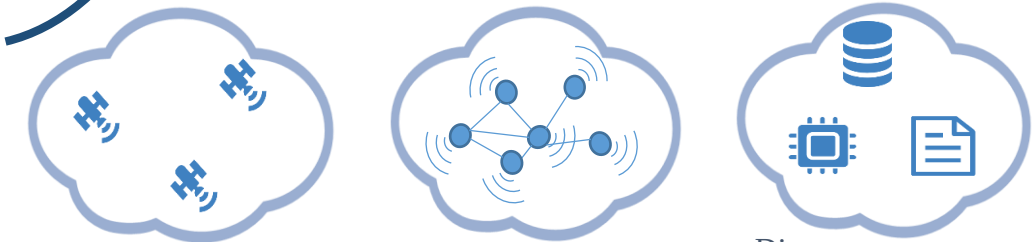
Support more applications



By preserving the advantages of statistical multiplexing and compatibility from traditional IP networks, New IP aims to upgrade the fundamental network capabilities and let then the network becoming the incubator of future services.



Compatible with the diversity of network elements



Huawei is committed to New IP

- New IP for Networks aims to design and implement a fundamental comprehensive solution to enable the evolution of the network in order to support emerging and future applications (towards 2030) – with benefits from both economic and social viewpoints
- New IP is not only a novel Internet Protocol, but rather a new architecture with associated signaling, control, management and transport capabilities
- New IP brings concrete and future-proof vision for the Next Study Period for several ITU-T Study Groups
- Huawei is committed to work out New IP based Networks and promote usage in the industry together with academic partners, industrial partners and customers

Thank you very much for your attention