The Requirements for the Internet and the Internet Protocol in 2030

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Imagine the Future

1970s

1990s

Today

2030s

Application

Holographic Communication

Smart city

Auto-drive

AR/VR

Remote Surgery

Function

High Bandwidth

Deterministic Low Latency

Intrinsic Security

Virtualization

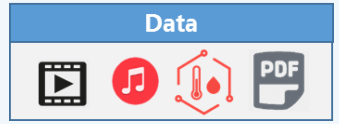
In-network Computing

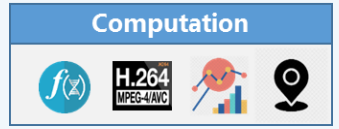
Connectivity

Satellite Networks

Internet

Datacenter Networks





Interconnect Everything

Nobody can predict the future precisely!

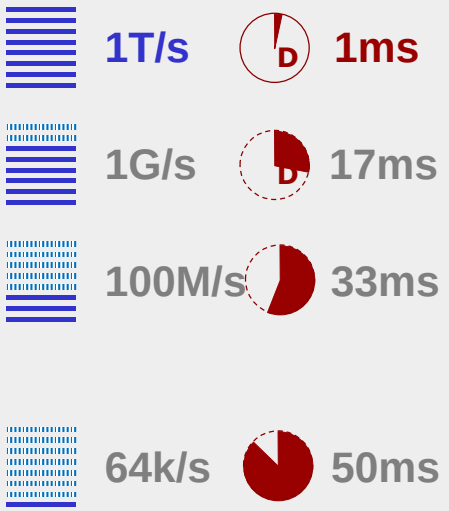
- **We have analyzed the issues in the current IP networks**
  - *"Observation of Current IP Network Issues and Innovation Requirements"* - Second ITU Workshop on Net2030, Hong Kong, 18 December 2018, https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20181218/Documents/Jiang_Sheng_Presentation.pdf
- **We can approach the future network according to the predictable applications and scenarios**
  - Holograph communication
  - Space network and integrating with the terrestrial Internet
  - Every object connects to the Internet
  - Secure communication and trustable network infrastructure

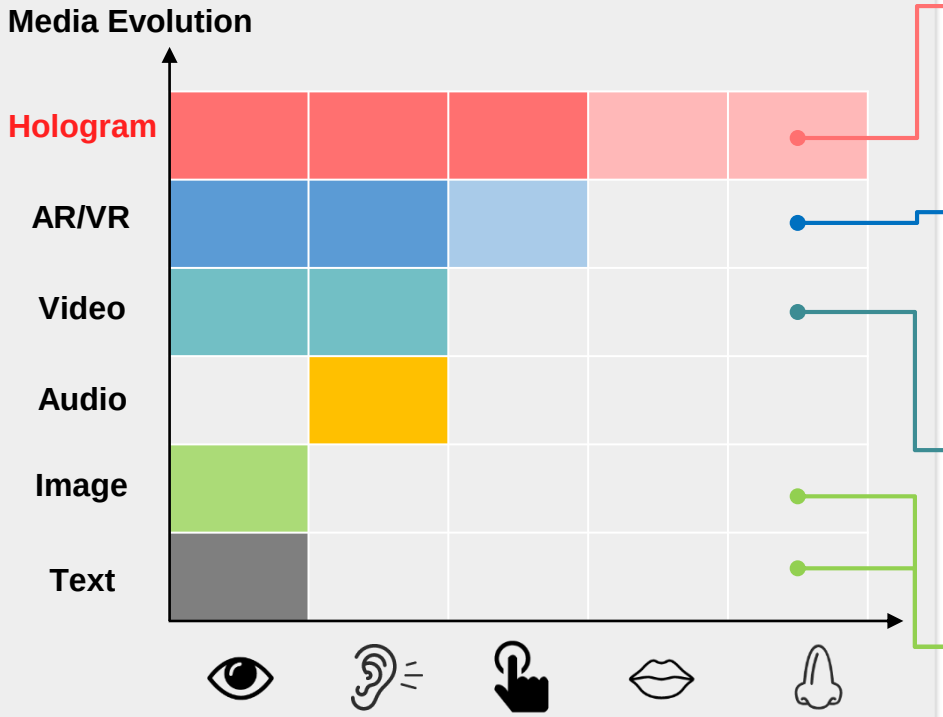
Evolution of Media Technologies





New types of MEDIA continuously fulfill sensory experience

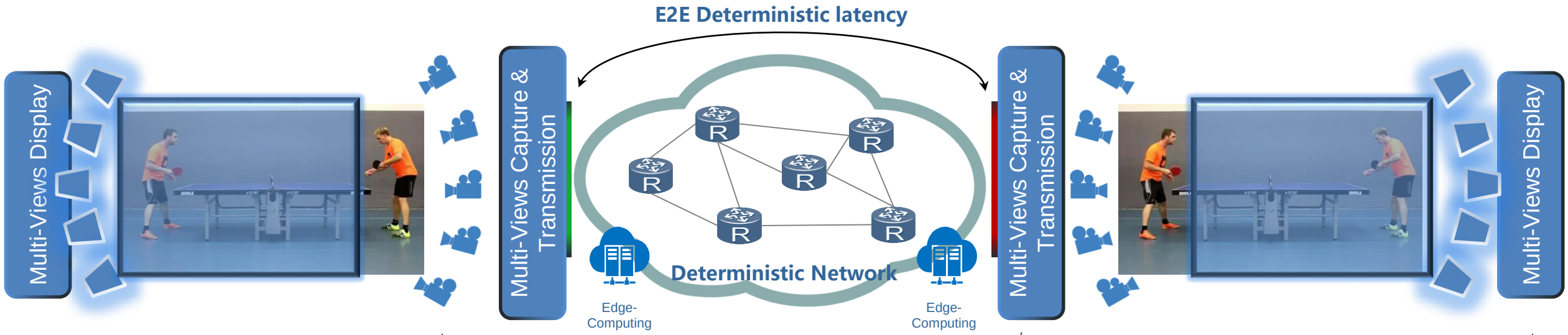




MORE Requirements for Network

- Immersive experience requires extremely high performance.
- Interoperability requires more beyond low latency
- Multi-dimension information exhaust bandwidth exponentially
- High precision Single-dimension

Holographic transmission



Ultra-high bandwidth requirement from Multi-Views capture

Deterministic latency requirement from interactions

High-sync and loss tolerant features require new transport technologies

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

New Transport Protocols for Holographic Communication

- **Differential Priorities for data**

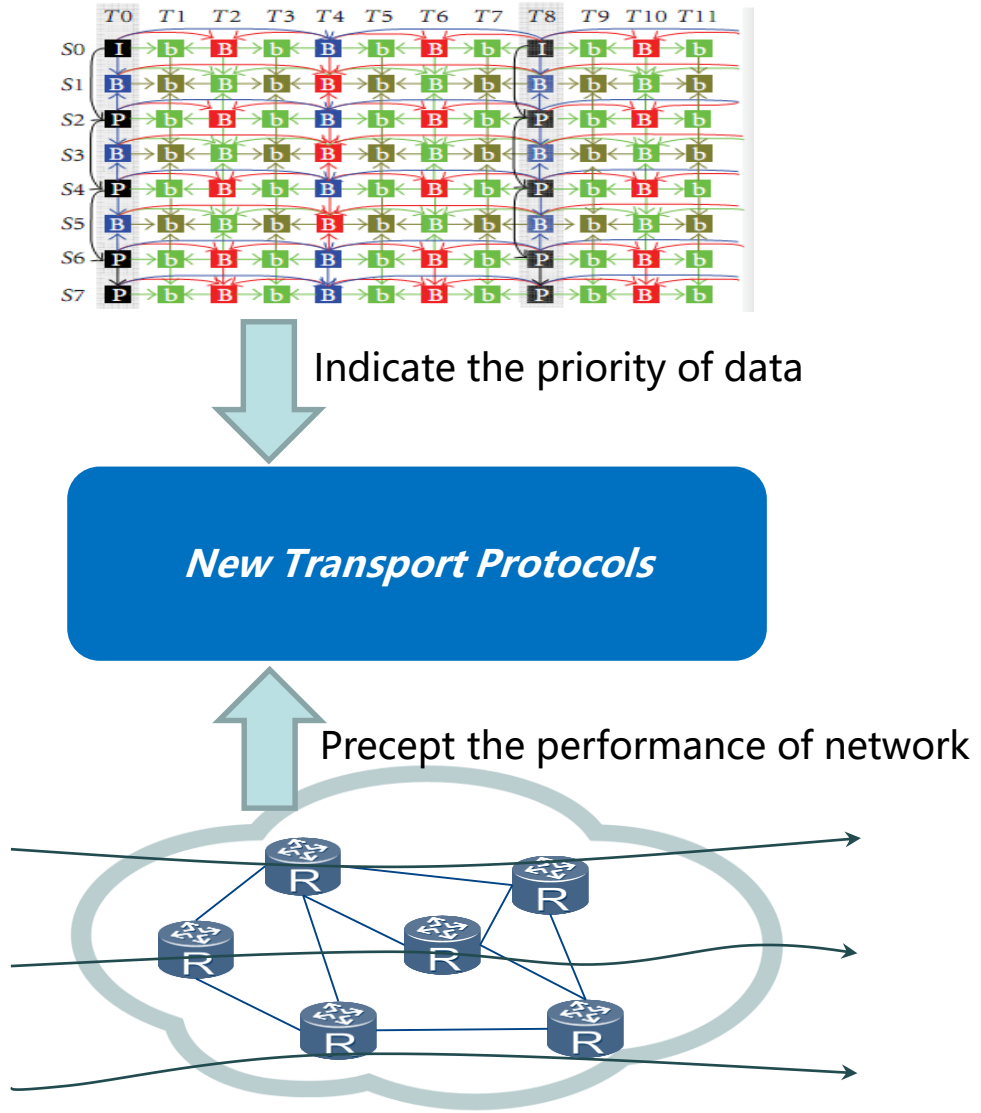
  The video data have different priorities natively however the current transport protocols see them equal.

- **Network-aware is important**

  Multipath transmission needs high-precision synchronization. The performance of different paths should be considered

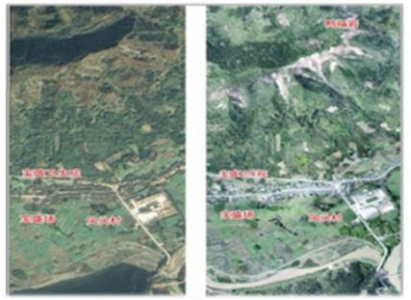
- **New tech for less re-transmission**

  Lossy transmission affects quality however re-transmission potentially enlarges the latency. Network coding technologies are considered to provide reliability



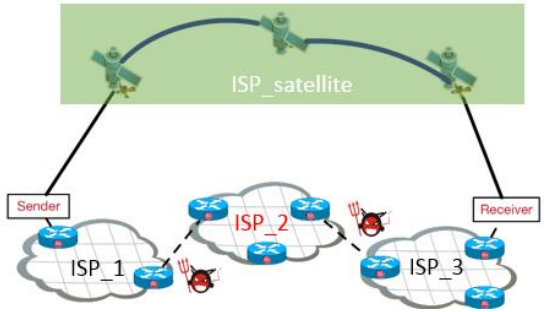
Motivations and Requirements of Terrestrial and Space Internets

- The existing Internet architecture cannot cover the growing network requirements



Emergency relief

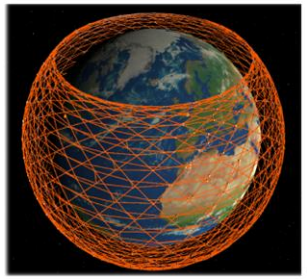
High-speed aviation and navigation broadband



Cross-border secure transmission

- Many giant companies are building the space network

- Study [1] shows that the space network can provide lower latency communications than any possible terrestrial optical fiber network over distances greater than about 3000km



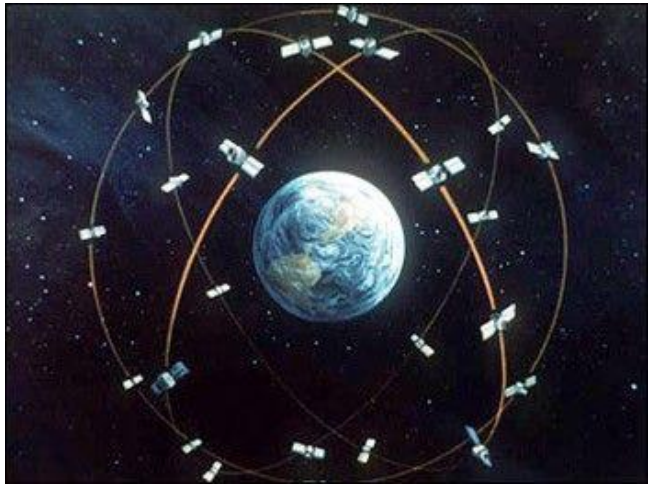
[1] Mark Handley. 2018. Delay is Not an Option: Low Latency Routing in Space. In Proceedings of the 17th ACM Workshop on Hot Topics in Networks(HotNets '18). ACM, New York, NY, USA, 85-91. DOI: https://doi.org/10.1145/3286062.3286075

- The commercial prospect of space network is enormous
- The cost of a satellite communication system is about (2000 satellites):
  -50w*2000 + 500w*100 = 1.5 billion dollars
  (50w/per satellite, 500w/launching a rocket)
- The revenue only from airline broadband is about:
  -1190w*20*365 = 90 billion dollars
  (0.1 discount is 0.9 billion dollars)
- It takes about two years to recover the cost, and three years to profit

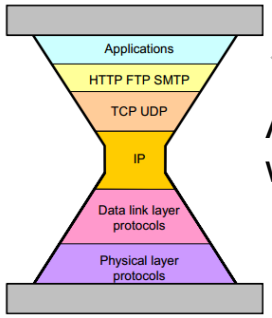
Space Network should use Unified Protocols with Terrestrial Internet

Terrestrial Internet and space network are heterogeneous

- 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

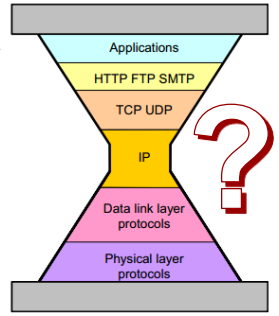


The TCP/IP protocol is mature for the terrestrial Internet



Addressing differences and protocol conversion will bring huge network operation cost

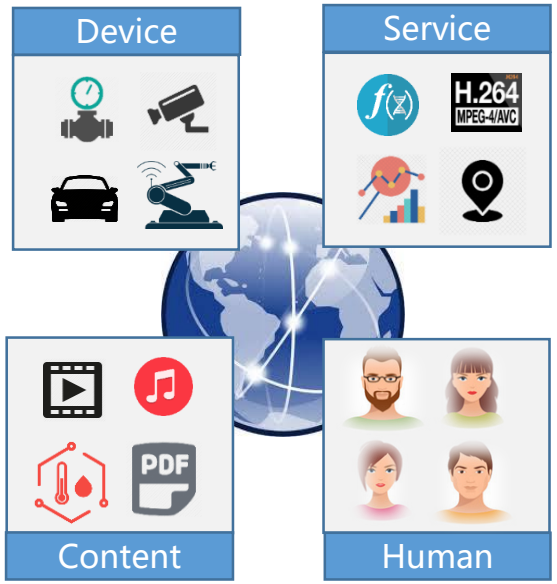
The current TCP/IP protocol must be modified/enhanced to satisfy the space network



- **It is a great opportunity to build an integrated network of space and ground**
- **The architecture of the terrestrial Internet should be extended, and the new architecture of the space network should be proposed according to its particularity**
- **The uniform architecture and protocol for the integrated network of space and ground are necessary (including addressing, routing, forwarding and transport technologies)**

Every Object/Entities in the World Connects to the Internet

All devices in our life, e.g. hosts, smart things, sensors, actuators, connect to each other and Internet



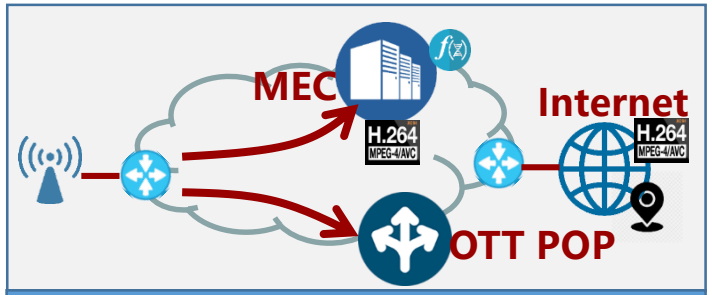
On-line services are much more richer, which includes micro service, function, computing resource like AI and so on

Content is independent communication entity which does not adhere to hosts any more

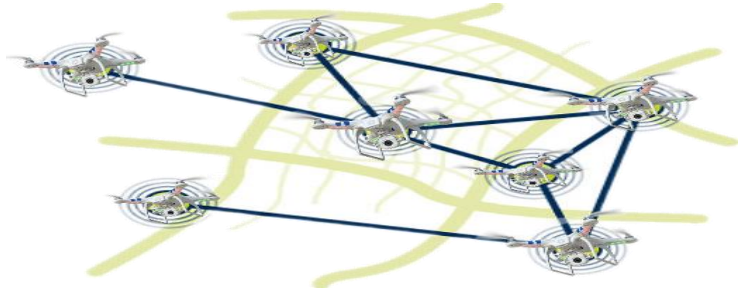
Human is the Communication Entities and subject. It should be visible directly in the network rather than mapping through devices into IP addr.

Application sessions should not be broken by mobility, increasing user experience

Ubiquitous Mobility of Physical Things

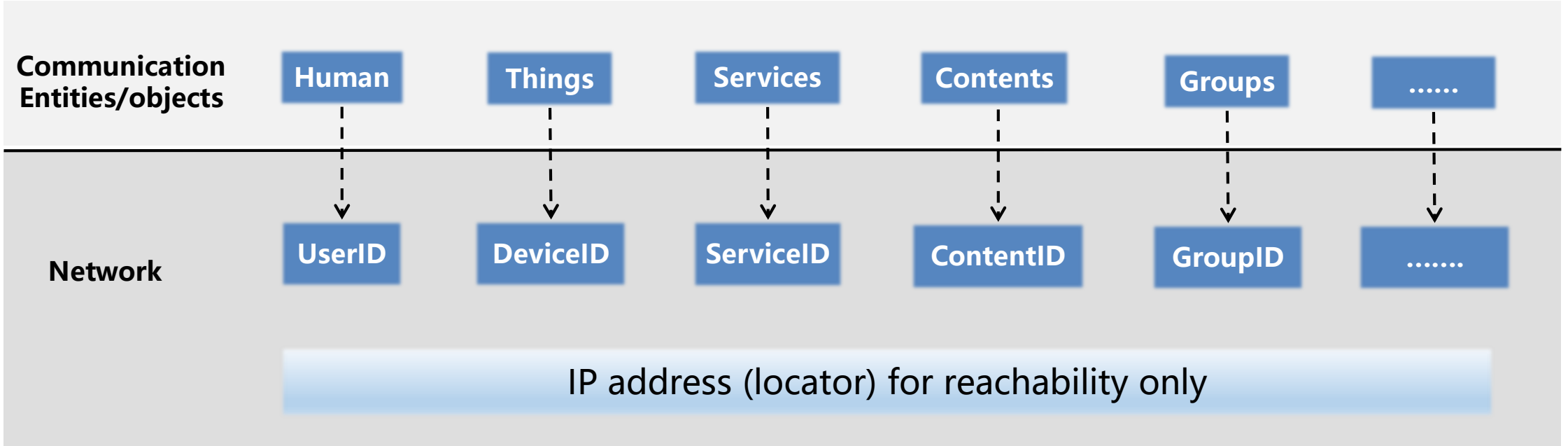


Migration of Micro Services (Functions)



Things are grouped accordingly. Broadcast should be supported dynamically

Using Identifiers to Represent Entities/Objects Directly



The network could implement routing/forwarding and policies based on real communicating entities. It would be direct and efficient.

Computing Resources are Widespread in Networks

Trend 1: Ubiquitous computing power, at different distances & different scales

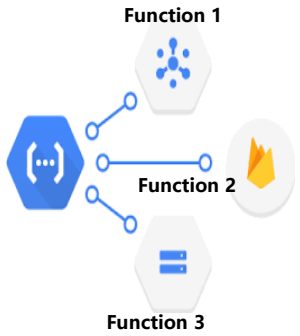
100s billions of smart terminals (mobile phones and wearable devices)

Billions of home gateway and/Wifi AP

MEC for mobile net

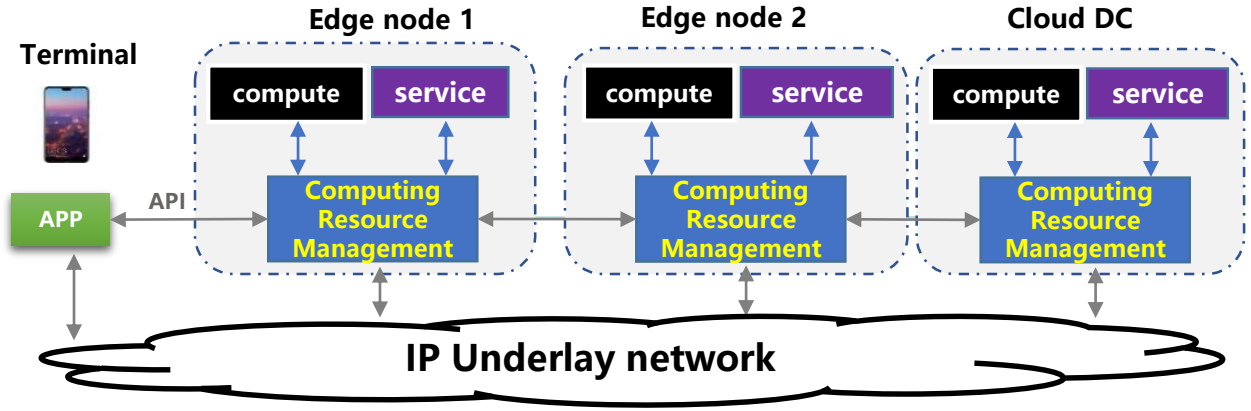
CloudCO for fixed net

Trend 2: Ubiquitous functions: Micro-service and Serverless



- **Client side: Focus on service logic without sensing computing locations and resources.**
- **Server side: The event trigger function component can be used immediately after it is used up.**

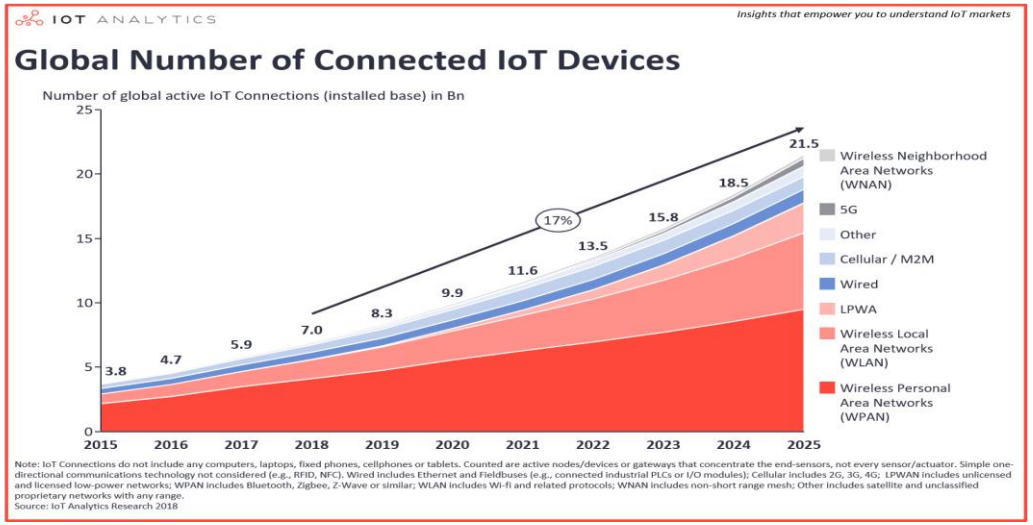
The latency to reach the computing resource are critical. In order to choose the computing resources efficiently and reduce the time consumption from the service mapping, a generic computing resource management functions is needed.

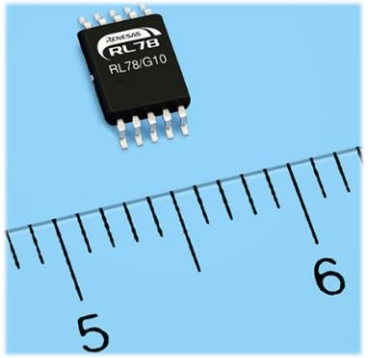


The dynamic network status and the availability of the computing resources would be advertised to the network as part of routing information. The network forwards the packets to the corresponding compute nodes based on the function or service ID, achieving optimal user experience and optimal computing and network resource utilization.

Massive Constrained Devices in the Internet

Tremendous number of IoT devices

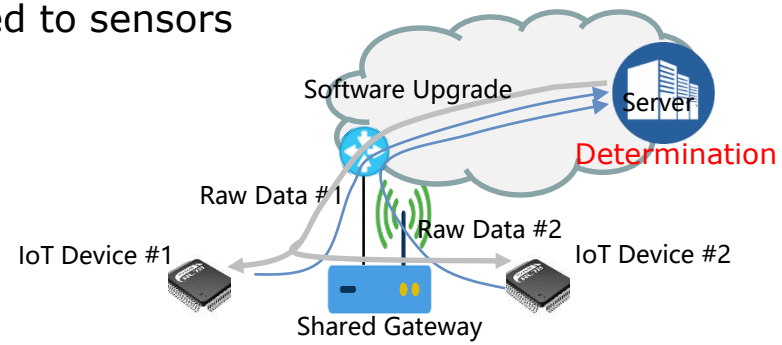




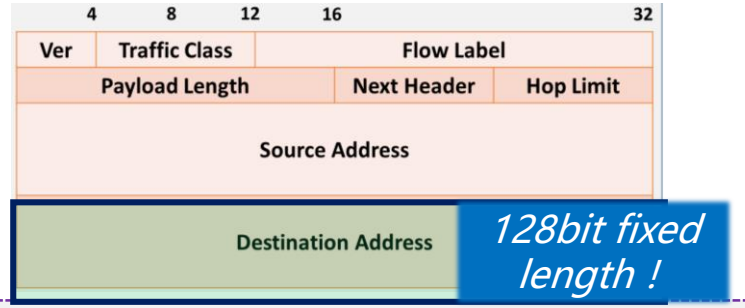
RENESAS RL78/G10 Module

An example of a such device:
Program Flash: 128KB
Data Flash: 8KB
SRAM: 12KB
System Clock (RF side): 32MHz
Size: 3mm*3.5 mm

These constrained devices also have the need to inter-connect to global resources: raw sensor data is sent to server for determination and software upgrade data is pushed to sensors



Lower overhead of packet is required, improving network protocol efficiency. However, the length of network addresses could not be compressed as required...



Unmodified IPv6 address is too long to fit those scenarios, and many field are not in use.

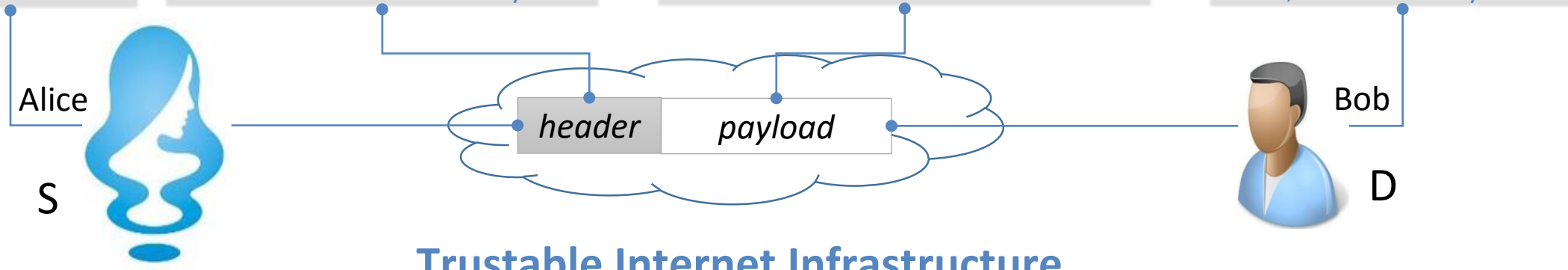
Security Communication over Trustable Internet Infrastructure

Authenticity
Source IP spoofing

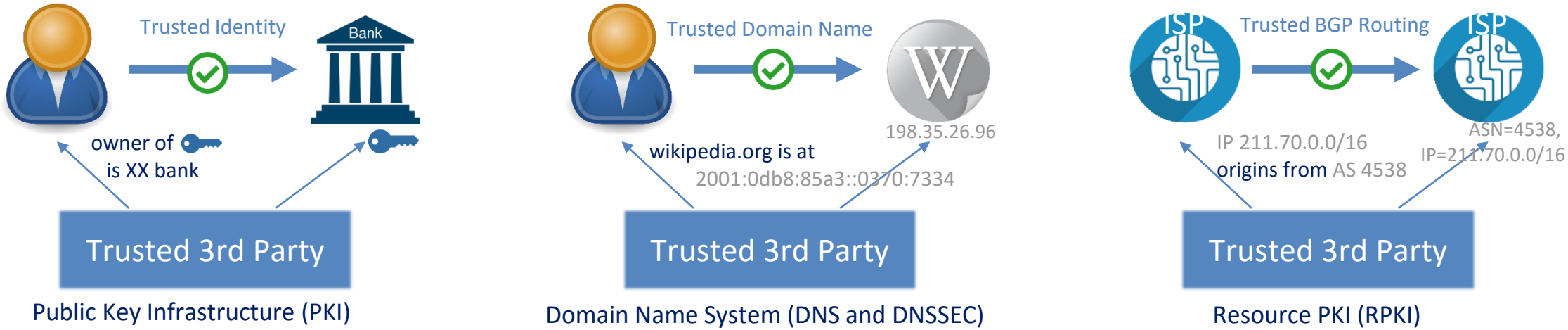
Accountability vs. Privacy
Exposing IP, port & TTL on wire decreases privacy, but anonymizing them decreases accountability

Confidentiality & Integrity
IPSec & TLS can protect payload sniffing or tampering. But the key exchange process has vulnerabilities.

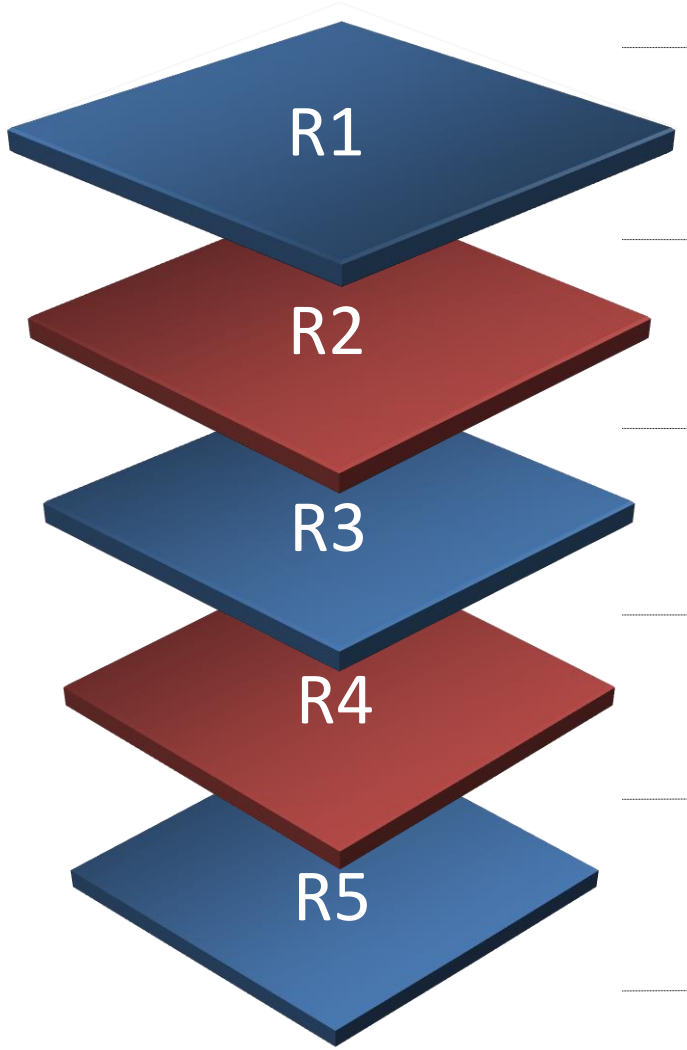
Availability
Anyone can send DDoS traffic to overwhelm targets' bandwidth, CPU or memory.



Trustable Internet Infrastructure



Requirements for the Internet Protocol in 2030



- **Differentiated Service for Various User Requests**
  - ✓ deterministic on latency and jitter
- **IP Address Namespace and Fields Flexibility**
  - ✓ Address length and fields on demand
- **Routing Directly Based on Multiple-semantic IDs**
  - ✓ Separating ID semantic out of IP address
- **New Efficient and Reliable Transport Protocols**
  - ✓ Based on the unique feature of holographic communication, but beyond
- **Secure Communication for All Applications**
  - ✓ Intrinsic security and trustable network infrastructure

Acknowledgement

- This slide is an output of team work
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Thank you

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