Deterministic Service Delivery with IP 2020 - The Next Generation Internet

Discussion on the state of the services and mechanism to achieve next stage

Kiran Makhijani
Principal Engineer, Future Networks
Huawei USA
Kiran.Makhijani@huawei.com

HUAWEI

Purpose of This Talk

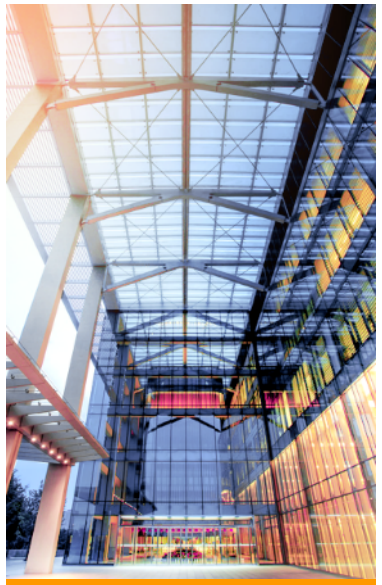
- The state of service delivery in the Internet
- The notion of service experience
- Identify requirements to help us design the future networks
- Current research directions with our perspective

Huawei at a Glance

180,000
Employees

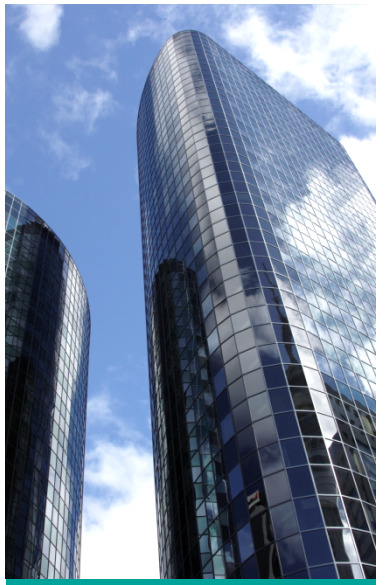
80,000
R&D employees

170+
Countries



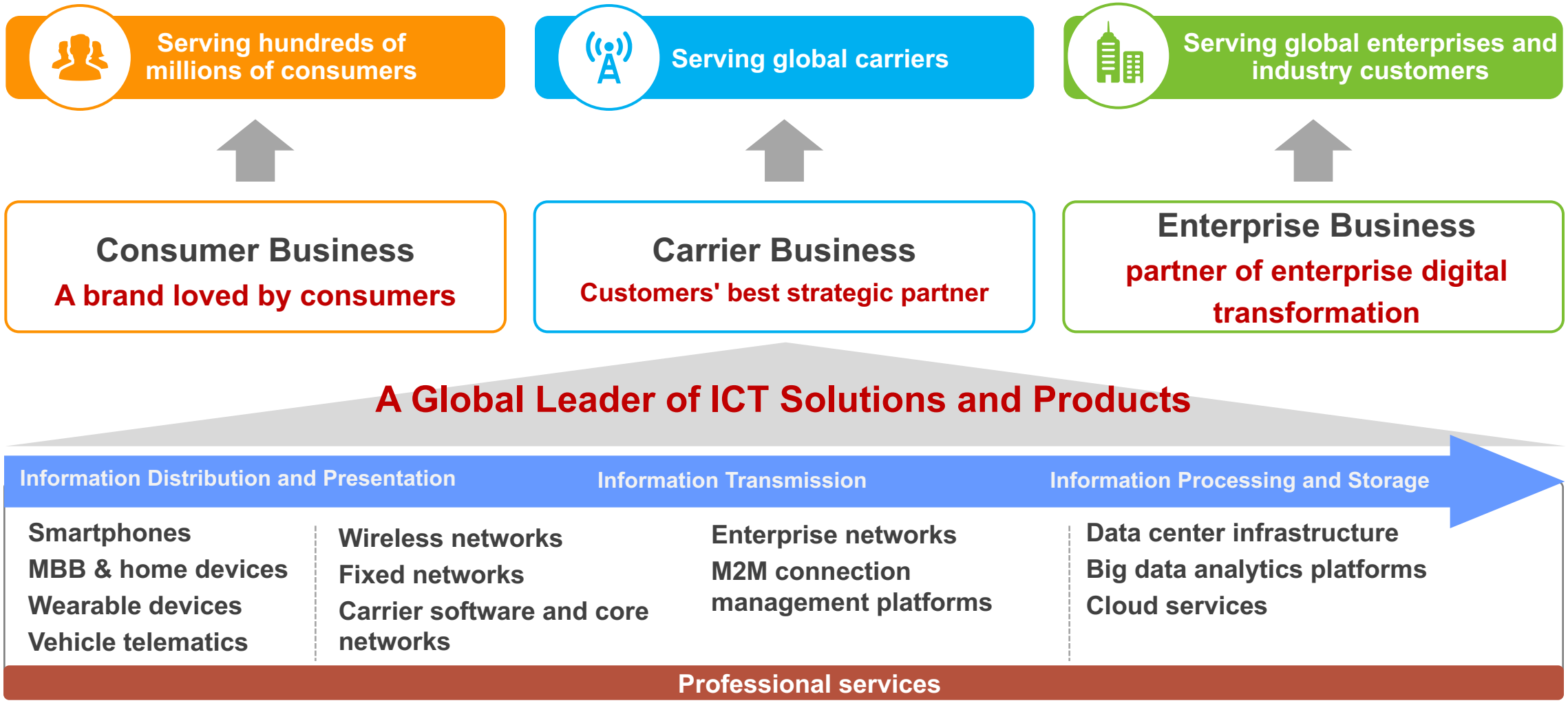
15
R&D institute and centers

No. 72
Interbrand's Top 100 Best Global Brands

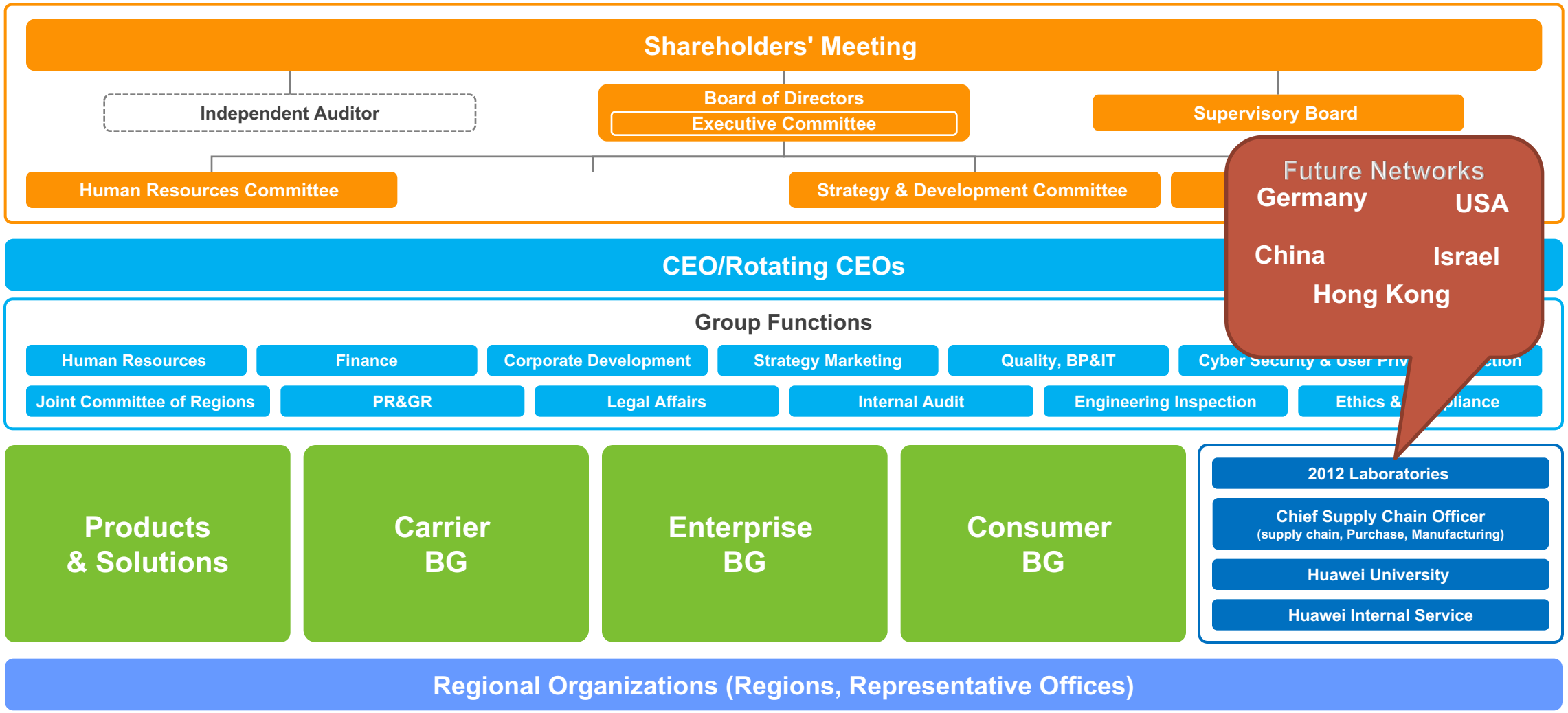


No. 129
Fortune Global 500

Provide ICT Solutions and Services for Three Customer Groups



Corporate Governance Structure



Research at Huawei's

- Huawei has consistently invested over 10% of its revenue in R&D every year.
- In 2015, 45% of total workforce were engaged in R&D.
- The Huawei Innovation Research Program (HIRP)
  - An Open program that offers funding opportunities leading universities and research institutes
  - Conducting innovative research in the field of communication technologies and computer science
  - http://innovationresearch.huawei.com/IPD/hirp/portal/index.html
- Active Collaboration with many universities in the US

University Of Maryland

Harvard

Winlab @Rutgers

MIT

University Of California Riverside

University Of California Berkley

Stanford

Agenda

Evolution Of Services

Service Fidelity

Limitations with current mechanisms

IP200 Initiative - Strategic Project

ID Oriented Networks and Service Fidelity

Intelligence Driven Networks

Service Evolution – Growing Resource Demands

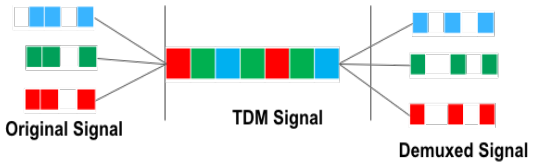
Now - 3

Analog Voice

Dedicated line

Now -2

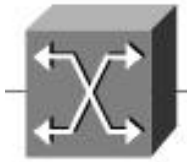
IP Voice, Data



Same data network for text and voice

Now -1

Diverse



E-commerce, Social media, YouTube, Netflix, VoD, web conference

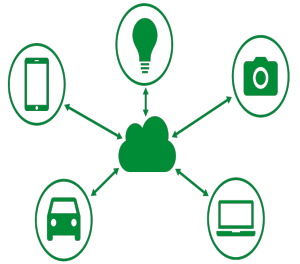
Now

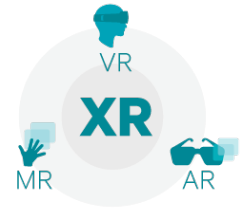
Diverse and Adaptive

Adaptive broadcast streams for Mobile /fixed/home devices.

Now +1

Diverse, Adaptive and Accuracy





Service Fidelity

Icon credits: FlatIcon, Robot icon credits , Extended Reality, Artificial Intelligence

Service Fidelity = Delivery + Experience

Immersive content consumption is cool! But demanding

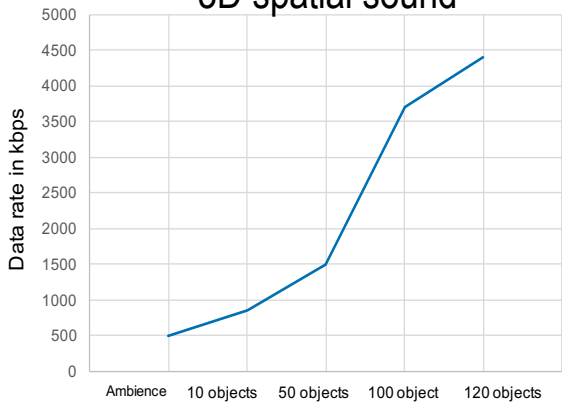
Sound	Speech	Video	Touch

5,644,8 kbps Super Audio

6,144 kbps AC3

9.6 Mbps DVD-Audio

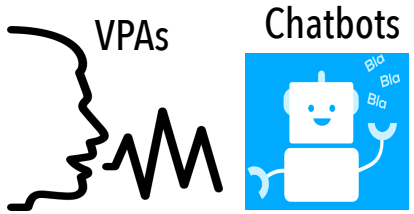
3D spatial sound



Object Based Representation (Dolby)

50% - Voice based search

85% customer service - chatbots



Speech to text translations

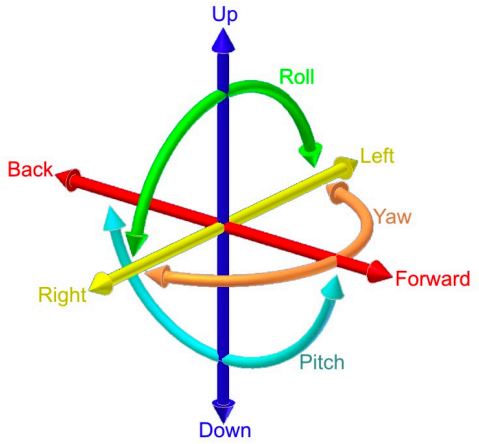
30 fps, 100 Mbps - Basic VR

60 fps, 400 Mbps – Adv. VR

120 fps, 1000 Mbps – Ult. VR

1: MTP < 20ms

2: Throughput > Gbps



Provide the medium for transporting touch and actuation in real-time

Sampled at 1 kHz leading to 1000 packets per second

Joystick, Haptic wearables, vibrations

Tradeoffs Between Six Degrees Of Freedom

Latency 5-20ms – 400-600 Mbps

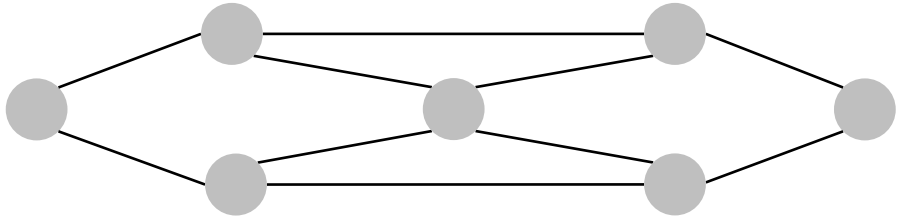
Latency 1- 5ms – 100-200 Mbps

Source Qualcomm-AR-VR

Network specific needs to deliver services

Spatial audio	VPAs	AR/VR	Haptics	M2M
Reasonable Latency	No Packet Loss Low/ Near zero Jitter	High Bandwidth Reliable	Low Bandwidth, Ultra reliable, Deterministic Round trip	Reliable, Low overheads

Application



Immersive service

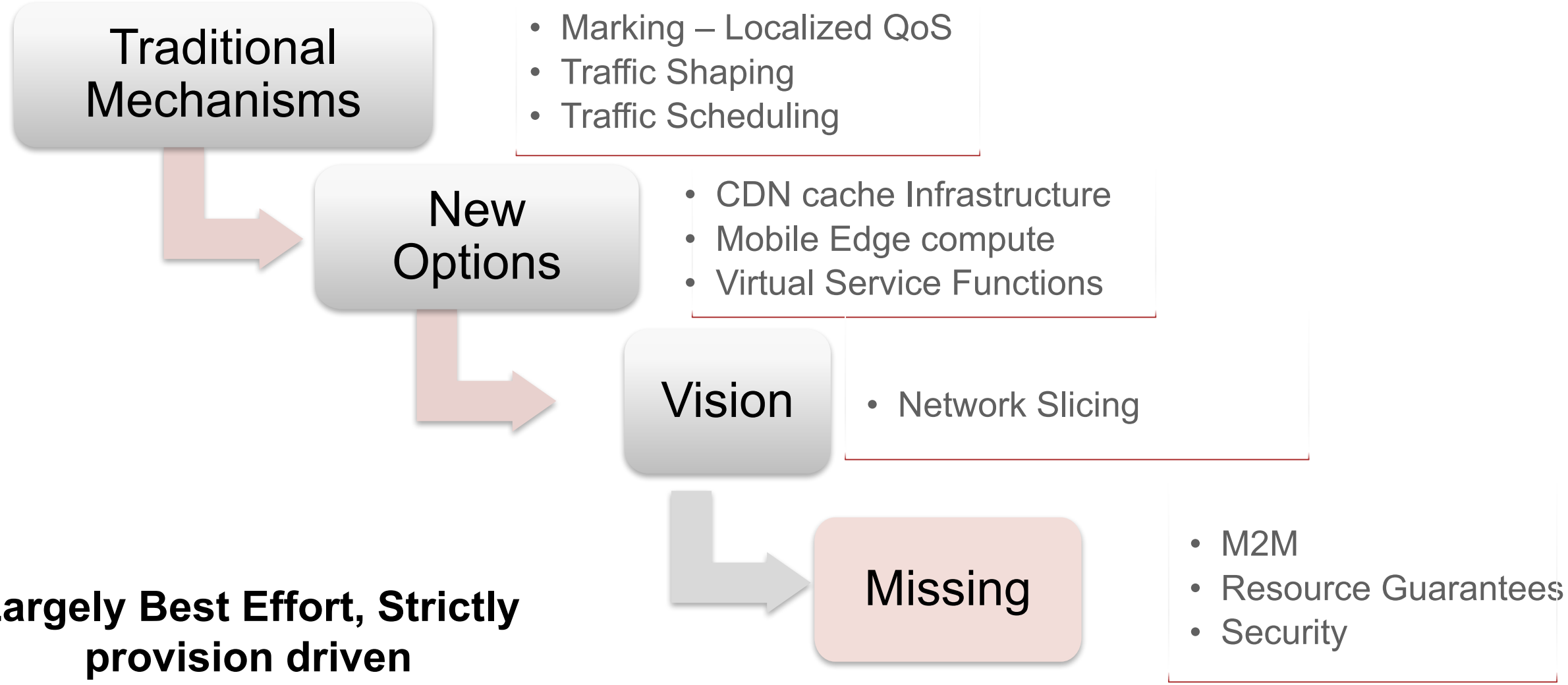
1. Diverse quality requirements from network

2. Interface is on user side

3. IP based E2E Transport

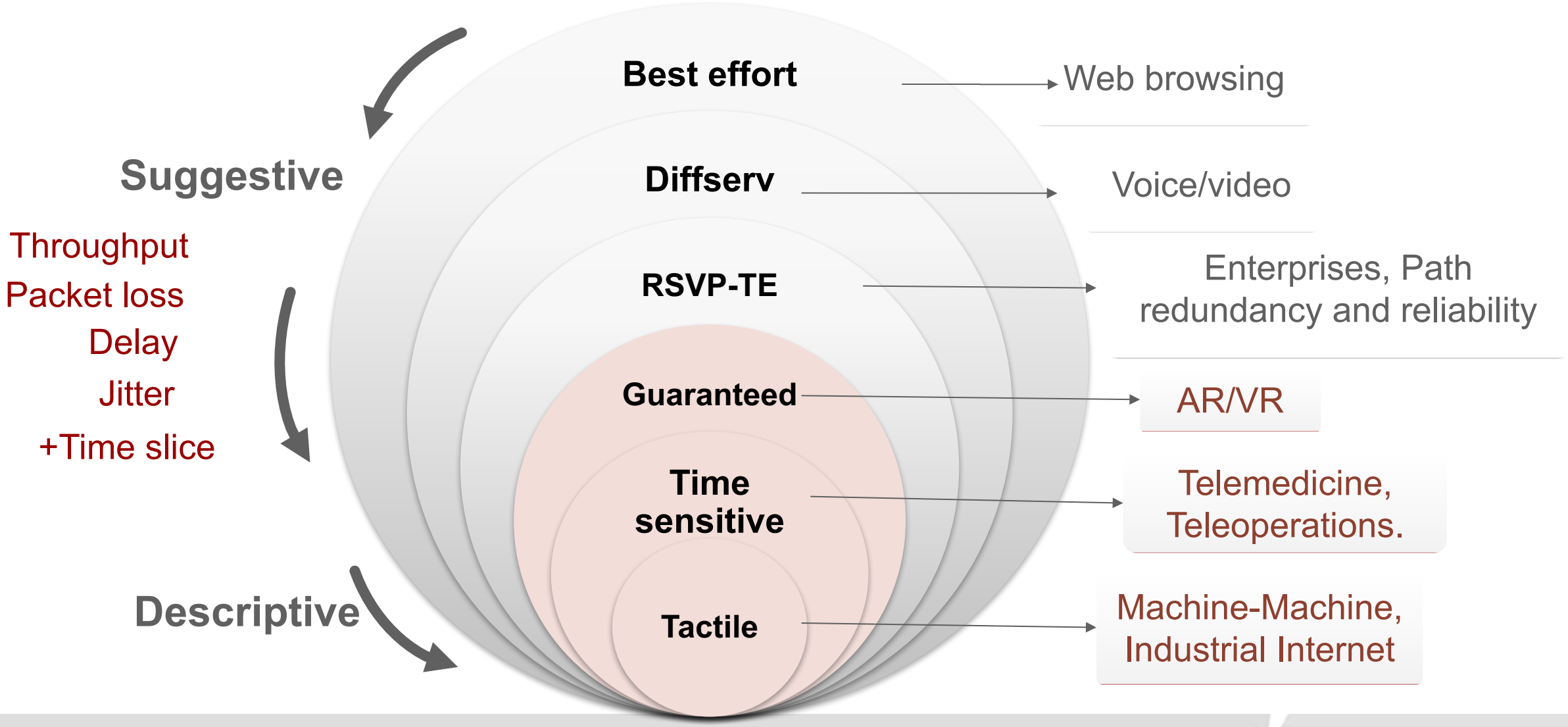
4. Intelligence is distributed, towards service; cloud based

How can we meet service requirements?

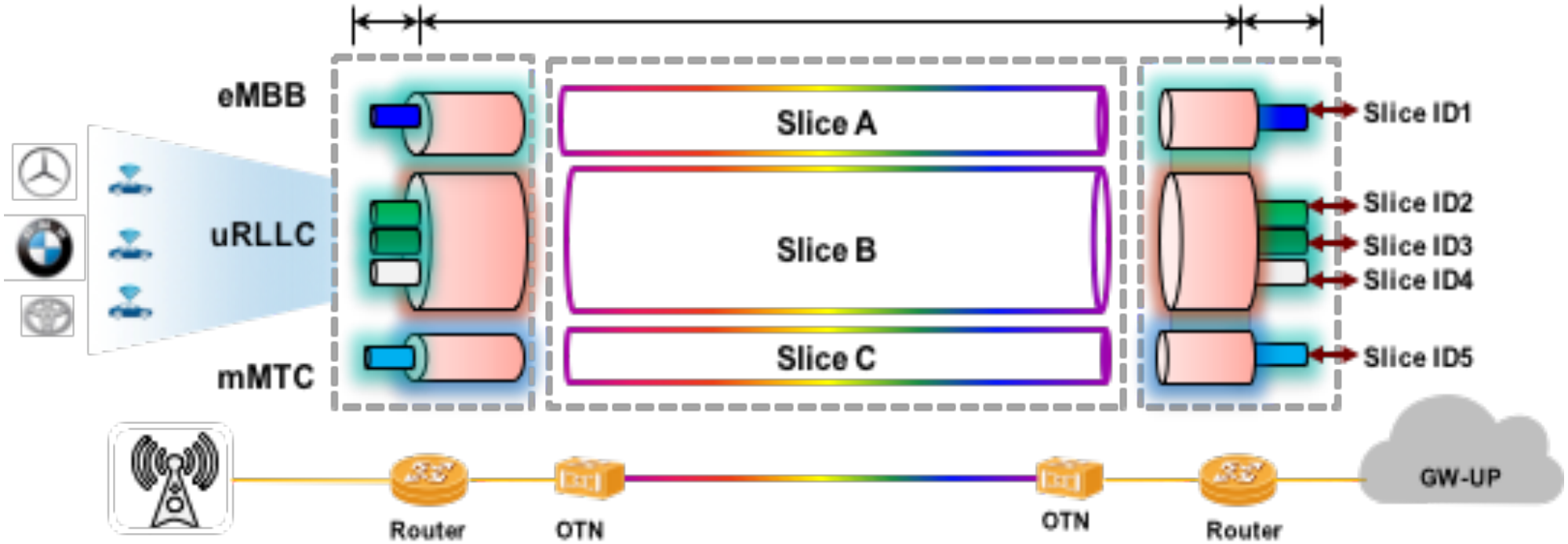


Largely Best Effort, Strictly provision driven

Traditional Mechanism: How networks deliver services



Vision of network slices – how to realize it?



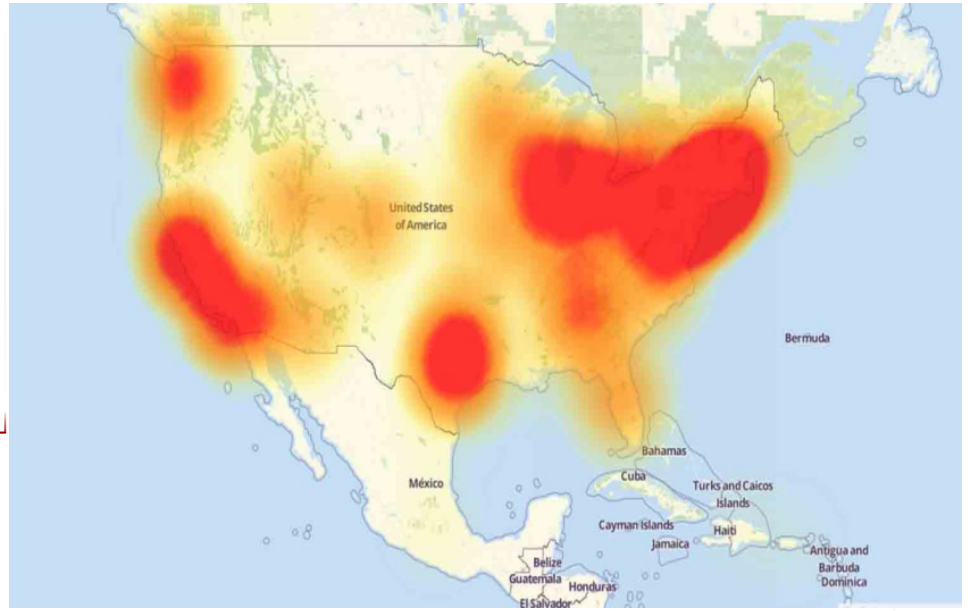
Mostly Orchestration and Management.
No fundamental change to resource guarantees
Slicing makes it essential to add deterministic service guarantees

Missing – Security. Internet Is Fragile

Uncontrollable Malware Spread At The Scale Of IoT

21 Oct 2016 DDoS Attach at Dyn.
Up to 10,000 IoT Devices involved

First [7 AM]
Second [noon]
Third [4 PM][4]



Massive Outages Due To Configuration Errors

Amazon Outage of 28th Feb 2017 (Typo Error)[5]

"Unfortunately, one of the inputs to the command was entered incorrectly and a larger set of servers was removed than intended," the Amazon note states.

Identity Thefts and Data Breaches

Between 2013 and 2016 Billion accounts were hacked – thrice.[6]

Yahoo hit in worst hack ever, 500 million accounts swiped

4:[DDoS] : http://money.cnn.com/2016/10/21/technology/ddos-attack-popular-sites/

5. http://money.cnn.com/2017/03/02/technology/amazon-s3-outage-human-error/

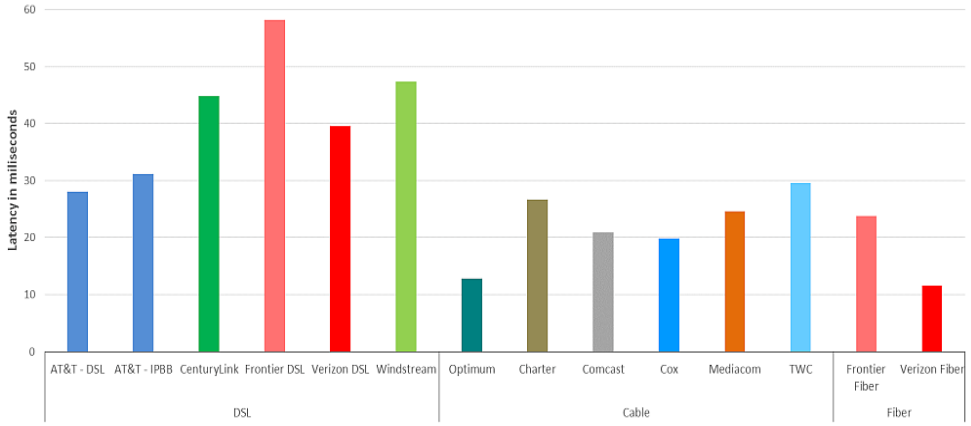
6 http://www.cnbc.com/2017/02/15/yahoo-sends-new-warning-to-customers-about-data-breach.html

Missing – Service guarantees

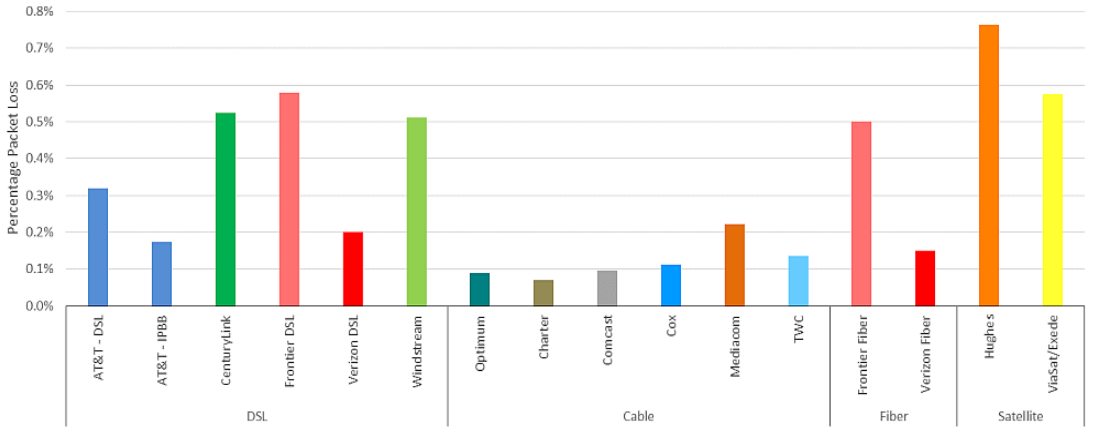
Non-existent Service Level Agreements for Residential Users

Residential Services have no SLA [REPORT][3]

Shared bandwidth with other customers that may degrade some application performance



packet loss = latency exceeds 3 second. Cable: 0.1%



Latency : 12ms-58ms

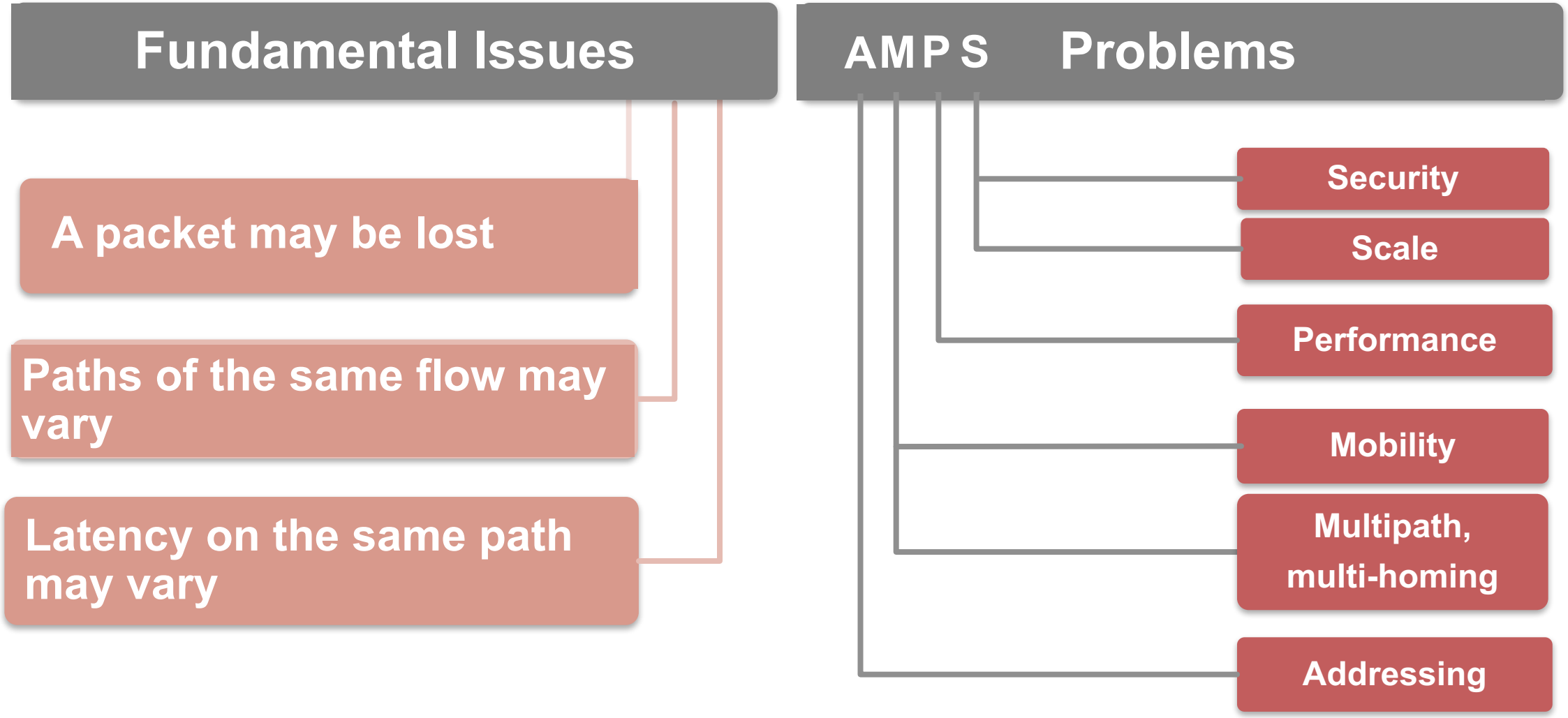
Effects of Over Subscription upon congestion

- Saving Cost: Divert traffic on already optimally used paths ➔ may cause congestions on existing flow
- Heavy Investments: Fully redundant systems.

3. [REPORT] https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-report-2016

Traditional mechanisms can not provide service fidelity

Because…


Fundamental Issues
A packet may be lost
Paths of the same flow may vary
Latency on the same path may vary
AMPS Problems
Security
Scale
Performance
Mobility
Multipath, multi-homing
Addressing

Goal of IP2020

Our networks have to be **Open, Smart and Deterministic**

Mobility
- Across different accesses with continuity

Multihoming, Multipath
- Always reachable and discoverable
- Same device different paths per flow basis or load balanced

Addressing
- Favorable to diverse category of end points

Scale & Security

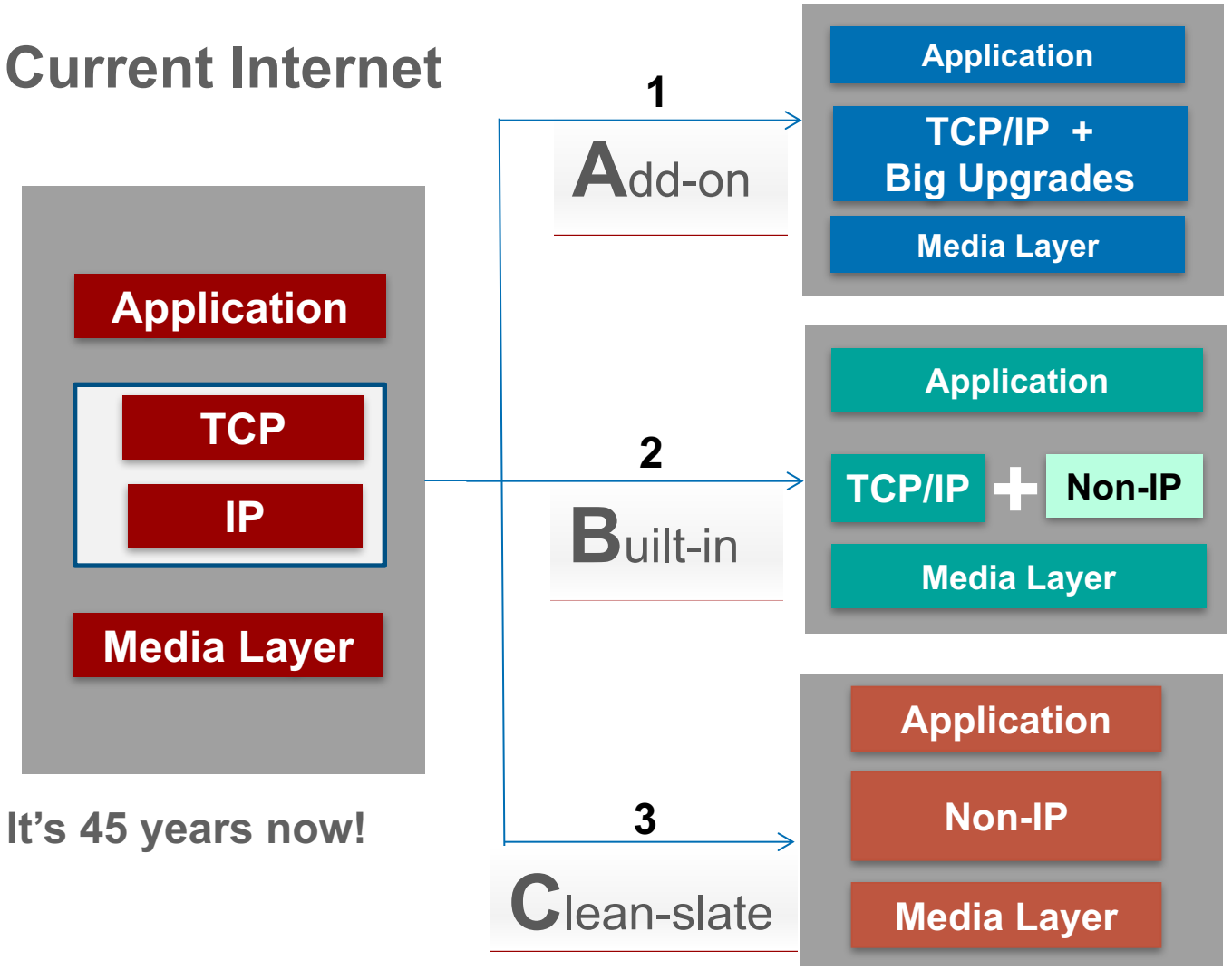
Path Consistency
Economy of path taken
Eg. BGP path distribution

Reliability

Service Fidelity

Latency
Predictable & Measurable

How to make it open, smart and deterministic in Data Plane



Example: IAB IP Stack Evolution

- QUIC
- MPTCP
- L4S, PLUS

Example: Vendor/US NSF

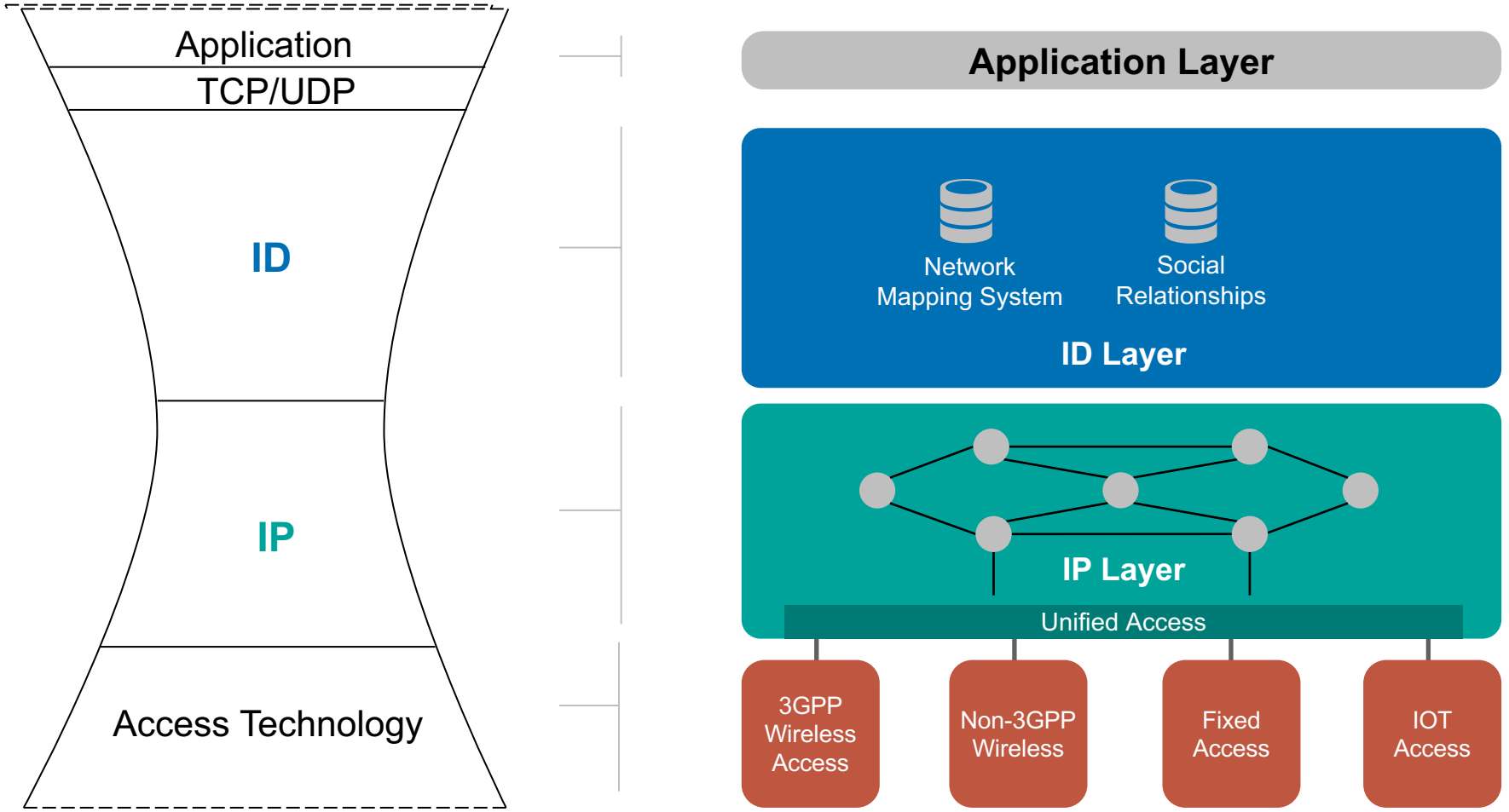
- IP 2020
- MobilityFirst *
- NDN *, CCN, ICN,
- XIA *

* FIA: Future Internet Architecture

Example: Mostly Academia or history

- ICN, Scion
- RINA
- ATM, Frame Relay

ID Oriented Networking (ION) Paradigm



Complete ION Ecosystem in IP2020

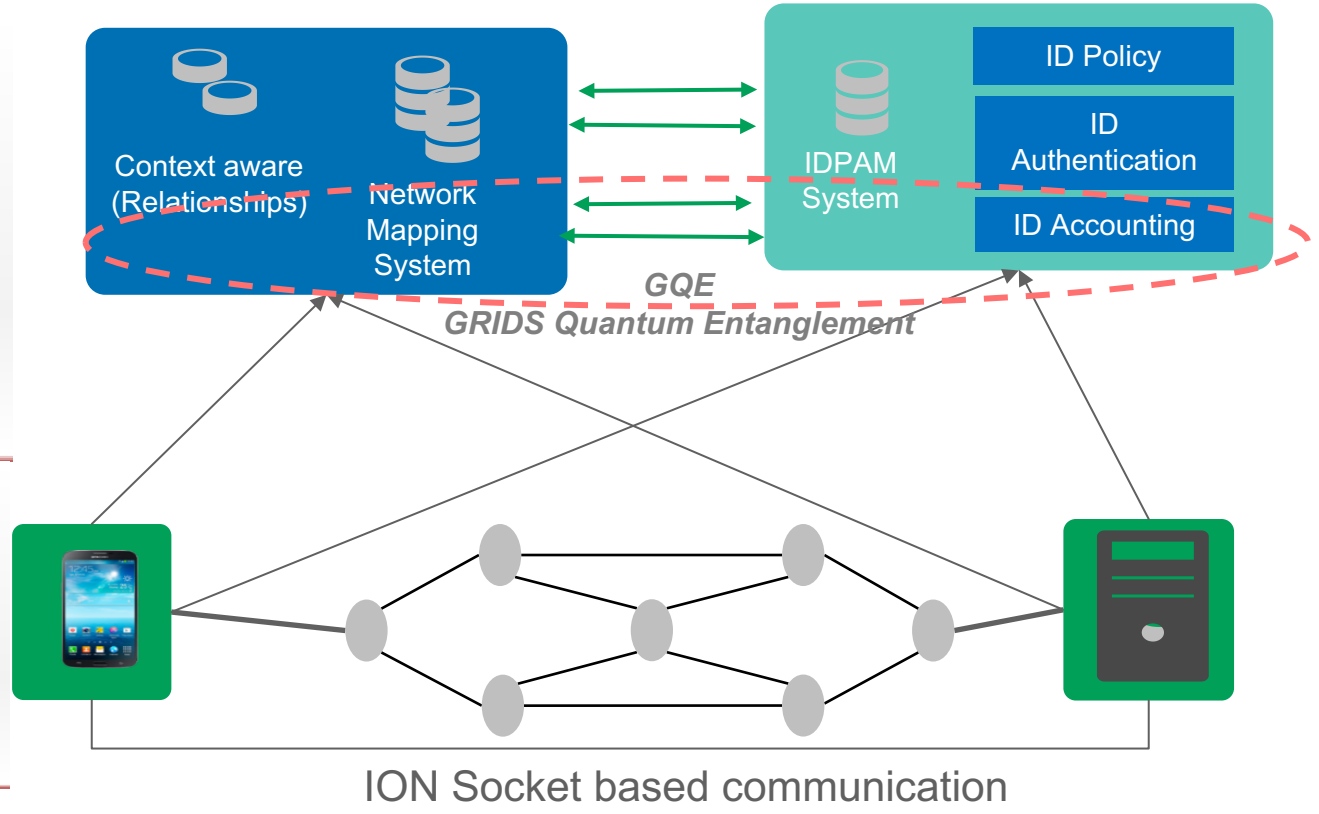
Control Plane | **Data Plane** | **O/S Socket Interface** | **ION Applications**

Control Plane

Realized via Mapping System
Dynamic, Scalable, ID Aware
IETF IDEAS WG
GRIDS – Generic Resilient IDentity System

Data plane

Enables packet transmissions in IP core network



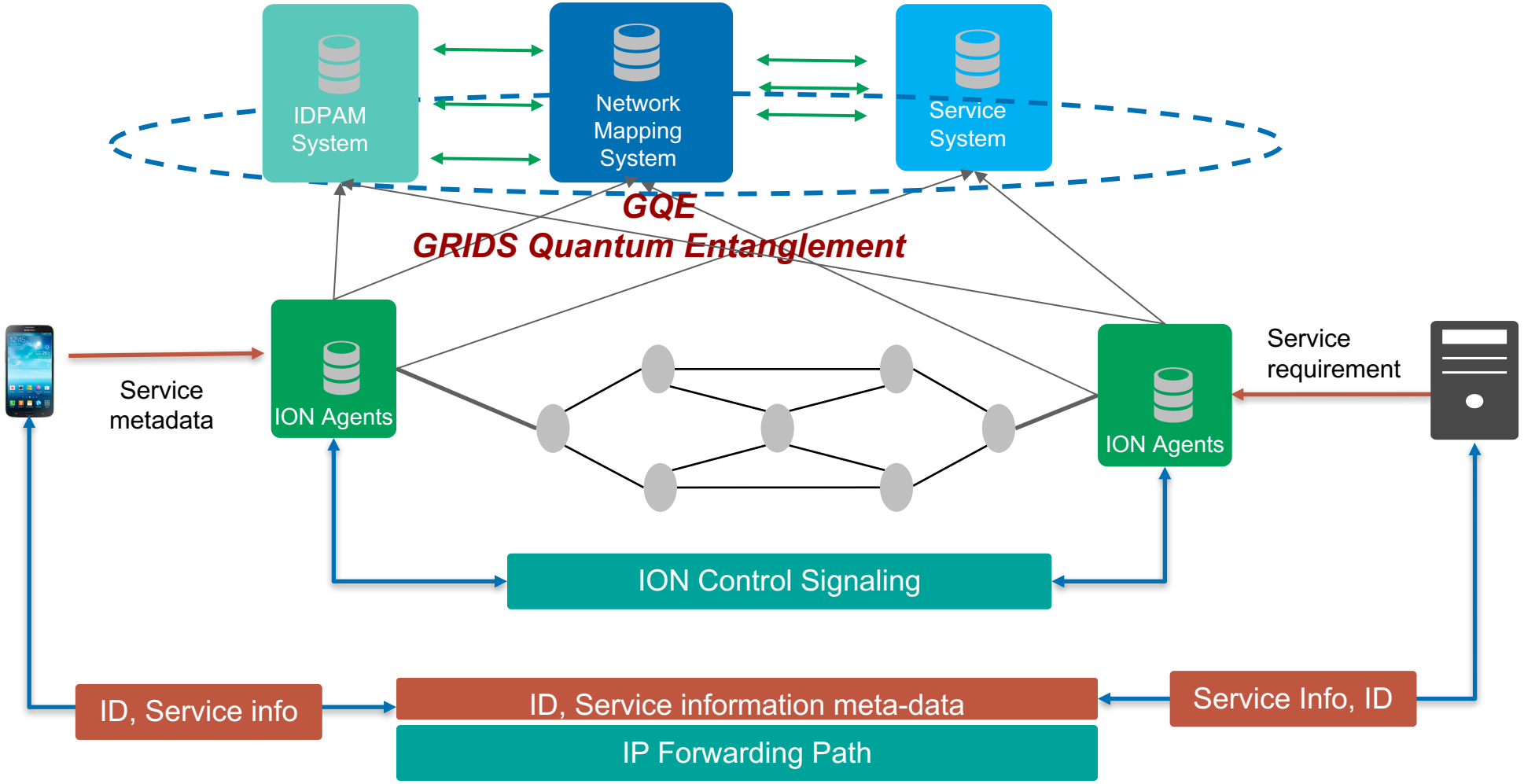
Applications with ION

For Example Mobility, Scalability and Social IoT solutions simplified with ION

Operating System ID socket Interface

End to end ID based connection setup that doesn't depend on IP

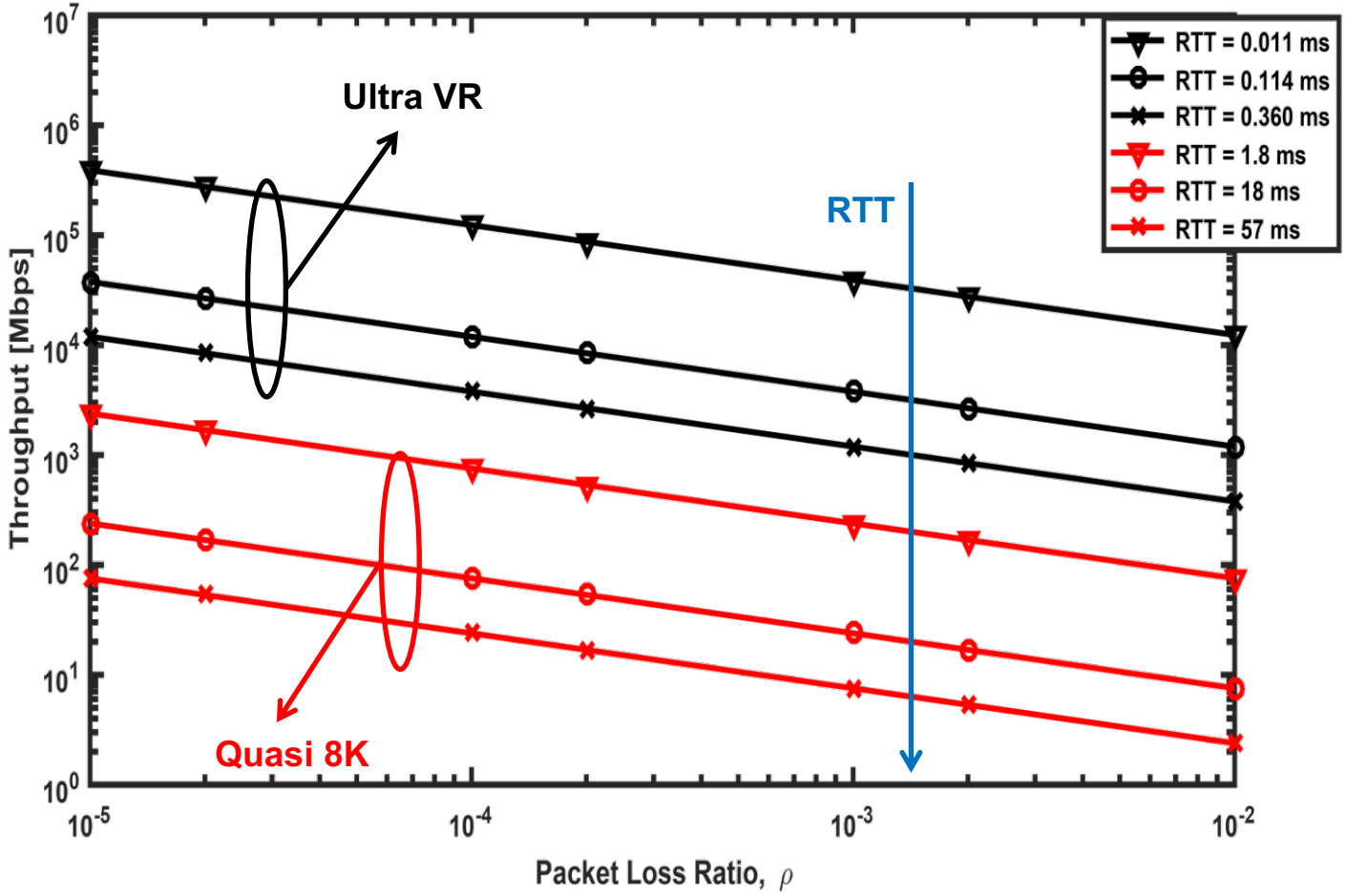
But what has service got to do in ION?



So that was the service requirement distribution.
Well! how about deterministic part?
Or experience for that matter…

TCP Throughput Law

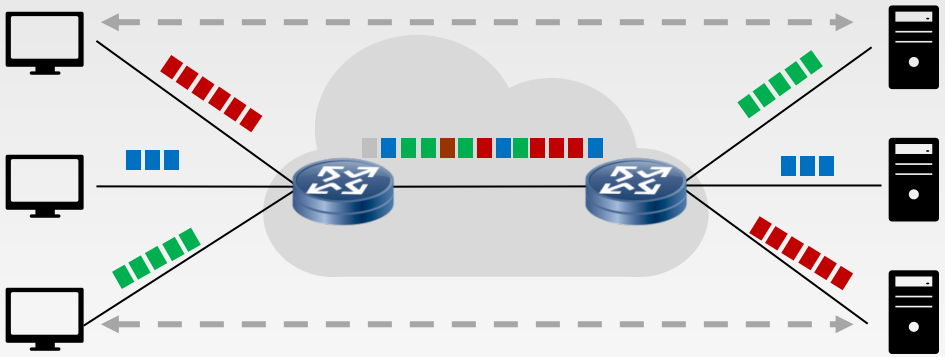
Relationship between Throughput, Packet Loss and Delay



$$\text{TCP Throughput} \le \min\left(BW, \frac{\text{WindowSize}}{RTT}, \frac{MSS}{RTT} \times \frac{C}{\sqrt{\rho}}\right)$$

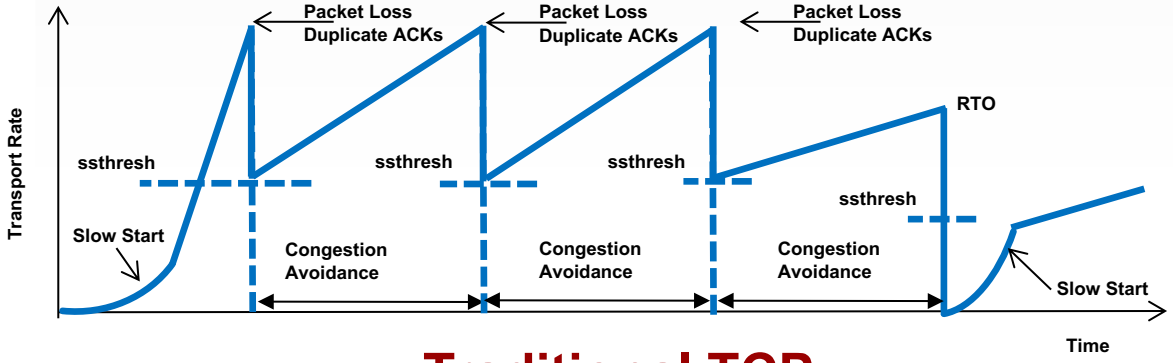
- The TCP throughput is inversely proportional to its packet loss ratio and round-trip time delay.
- Example: For throughput 12 gbps and packet loss ratio 1/10,000, the end-to-end delay is 0.114 ms.

Deterministic TCP (DTCP)

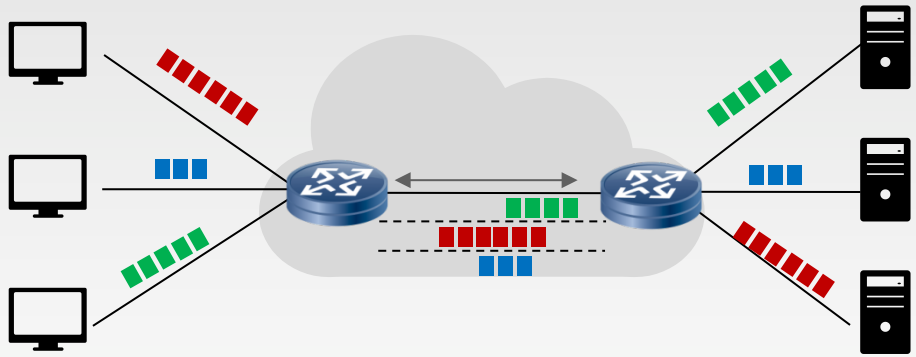


TCP Requirement:
- Avoid congestion
- Higher bandwidth utilization

Method:
- Sliding window mechanism



Traditional TCP

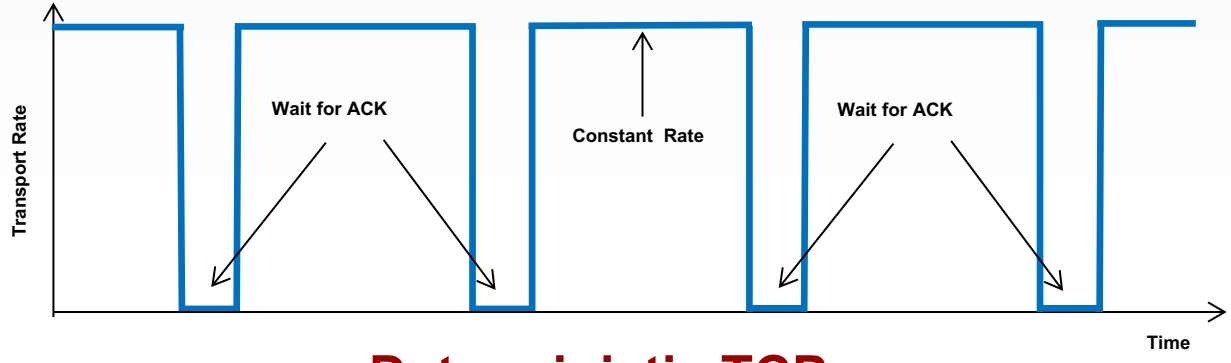


Flow control for DTCP:
- Leaky bucket: rate limit
- Token bucket: allow burs

Retransmission mechanism:
- FIFO

DTCP:
- Signaling by TCP
- Provide guaranteed network resource

Transport benefits:
- TCP does not need to use different congestion avoid mechanism to reach target rate
- Higher bandwidth utilization due to no packet loss signaling



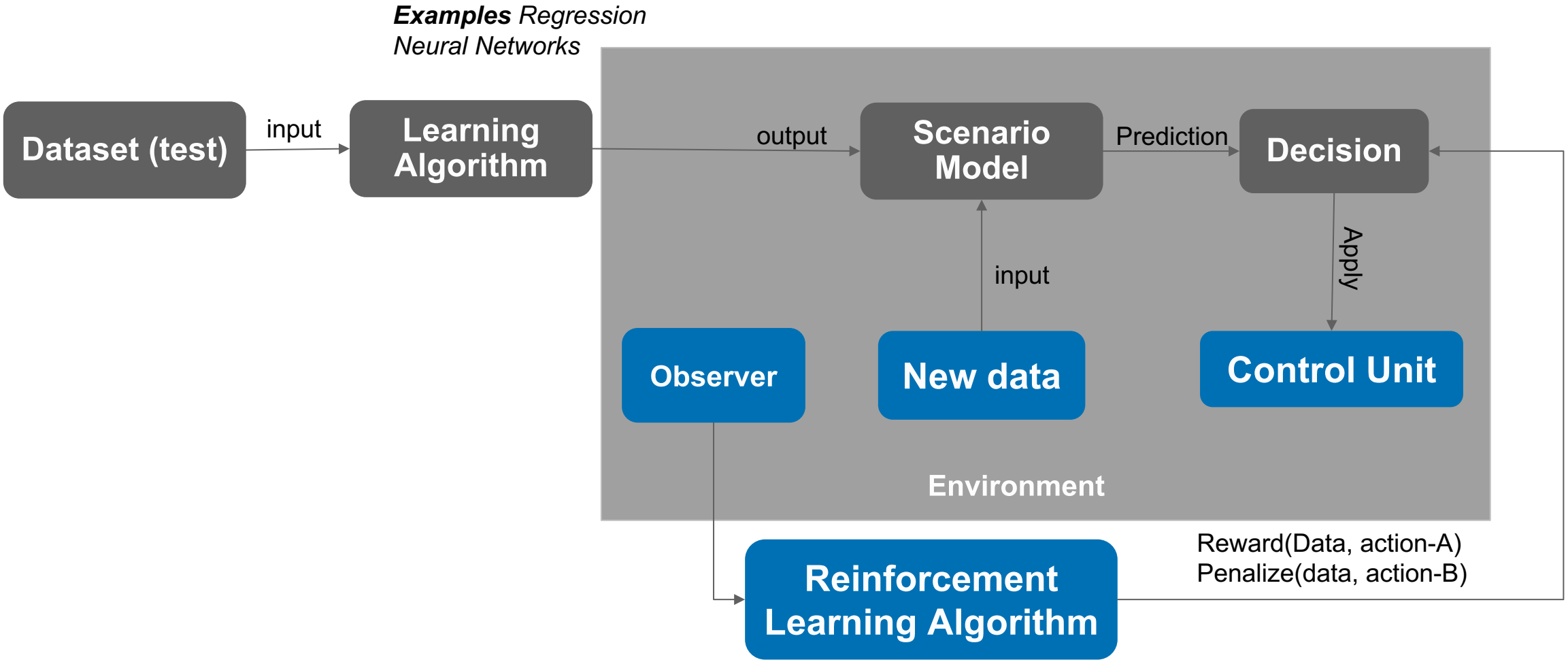
Deterministic TCP

Ok, Service Fidelity makes sense.
What else?

Services involve provisioning, monitoring, upgrades…

	Provisioning	Network Path Engineering	Network Operations
	Instruction to a network node about what to do	Distributed Routing protocols and polices	Monitor Runtime State
Today	Templates, Yang models, 0-touch configs	Route policies, traffic engineering, alternate paths are provisioned. Route convergence is reactive	Thresholds set different levels of alarms or events
ML/AI Trends	Learning not configure	Predict network path and topology issues Proactive route changes Activate fibs based on flow duration predictions	Forecast traffic behavior and re-adjust resources through learnt models

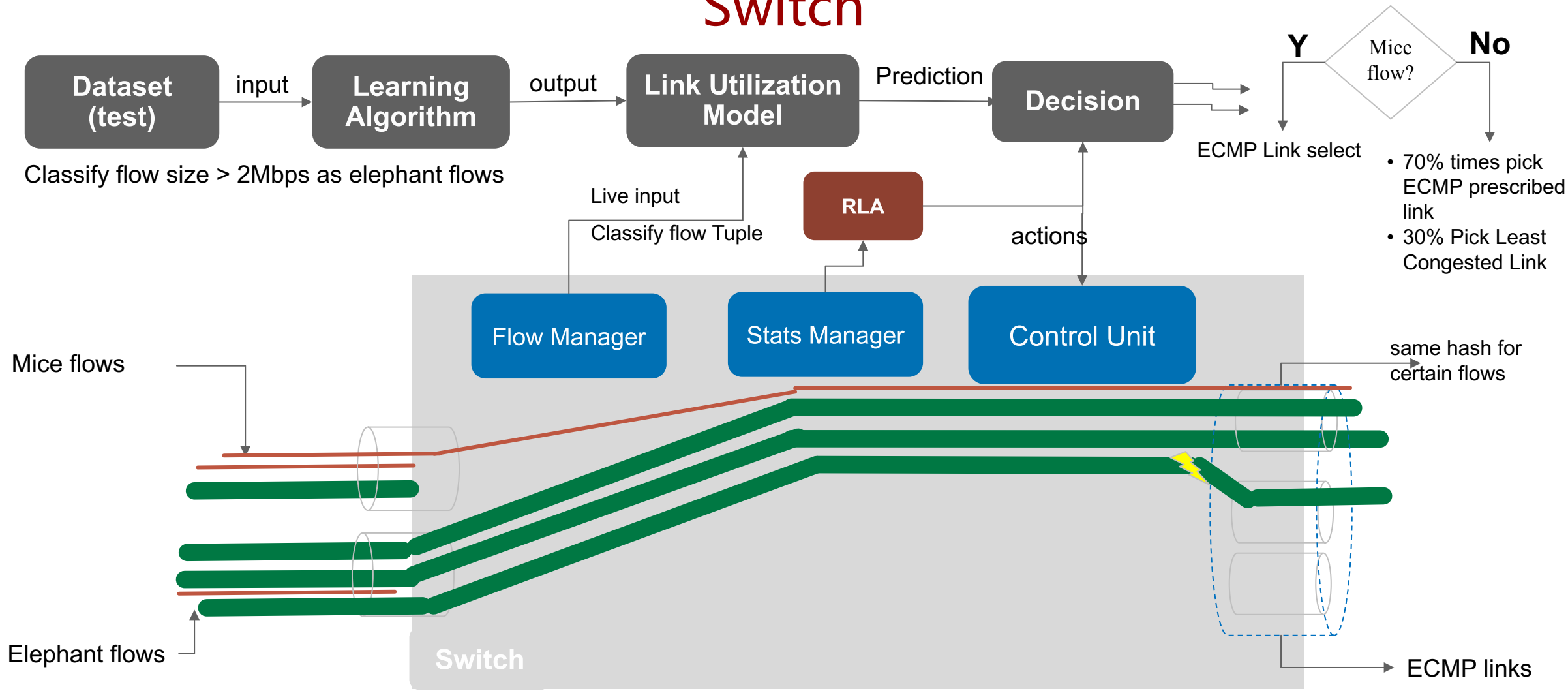
Generalized Machine Learning Pipeline



ECMP Based Link Utilization Problem In A Switch

- **Massive Scale DCs use fixed spine-leaf topology**
- **ECMP distributes traffic across multiple paths**
- **ECMP uses Hash computation to balance similar flows over multiple links**
- **However, the flows are not evenly balanced**
  - Low-bandwidth (Mice) flows: Majority of flows. Are short-lived and latency sensitive.
    - Example: Web, email, chat applications
  - High-bandwidth (Elephant) flows consume majority bandwidth and are long-lived.
    - Example Storage-intensive big-data, data-replication and backup applications
- **Problem**
  - Variance in the amount of bandwidth used between long-lived vs short-lived flows does not ensure that traffic is balanced across all the links.
  - Increase in Mean-time-to completion for mice flows
  - Reduced data-rate for elephant flows due to congestion control

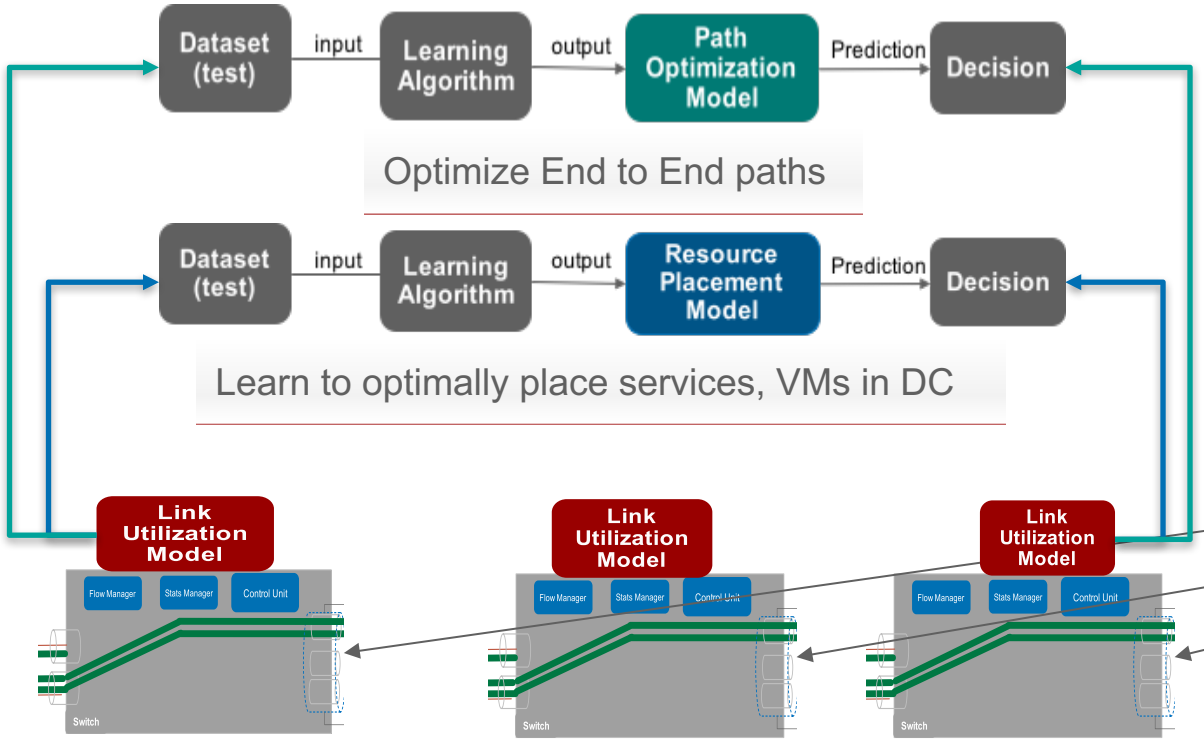
Machine Learning For ECMP Link Utilization in a Switch

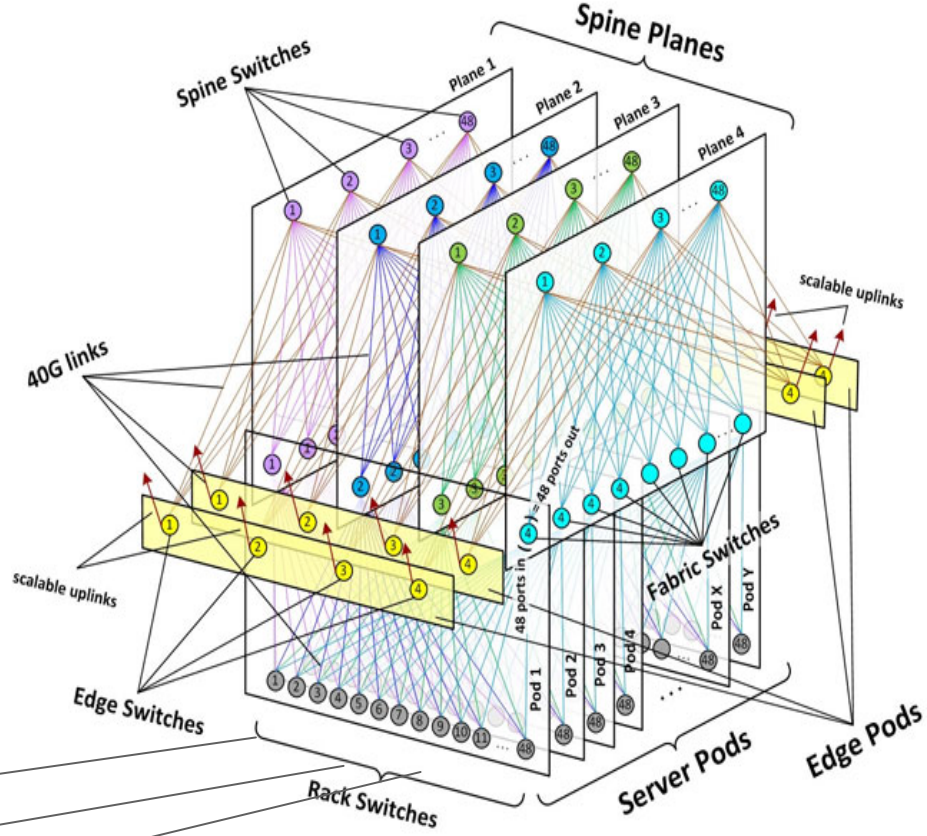


RLA – Reinforcement Learning Algorithm

Intelligence Driven Networking – DC Scenarios with Global Scope

- Extend to wider scoped learning - global models across multiple switches
- Different learning models for different scenarios together

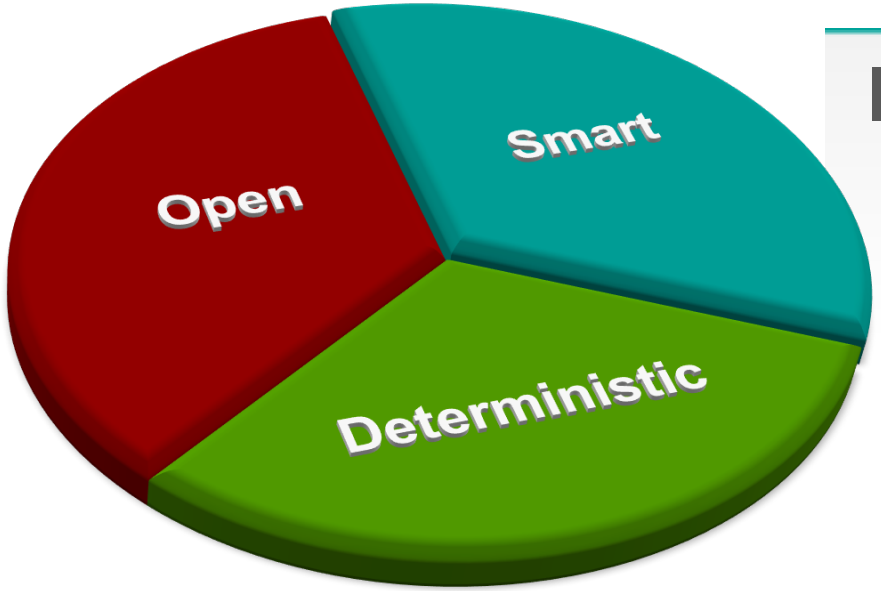




Src: Facebook data center

Summing It Up - IP2020 Delivers Next Generation Networks

Identity **O**riented **N**etworking (ION)



Intelligence **D**riven **N**etworks (IDN)

Wearable WSN

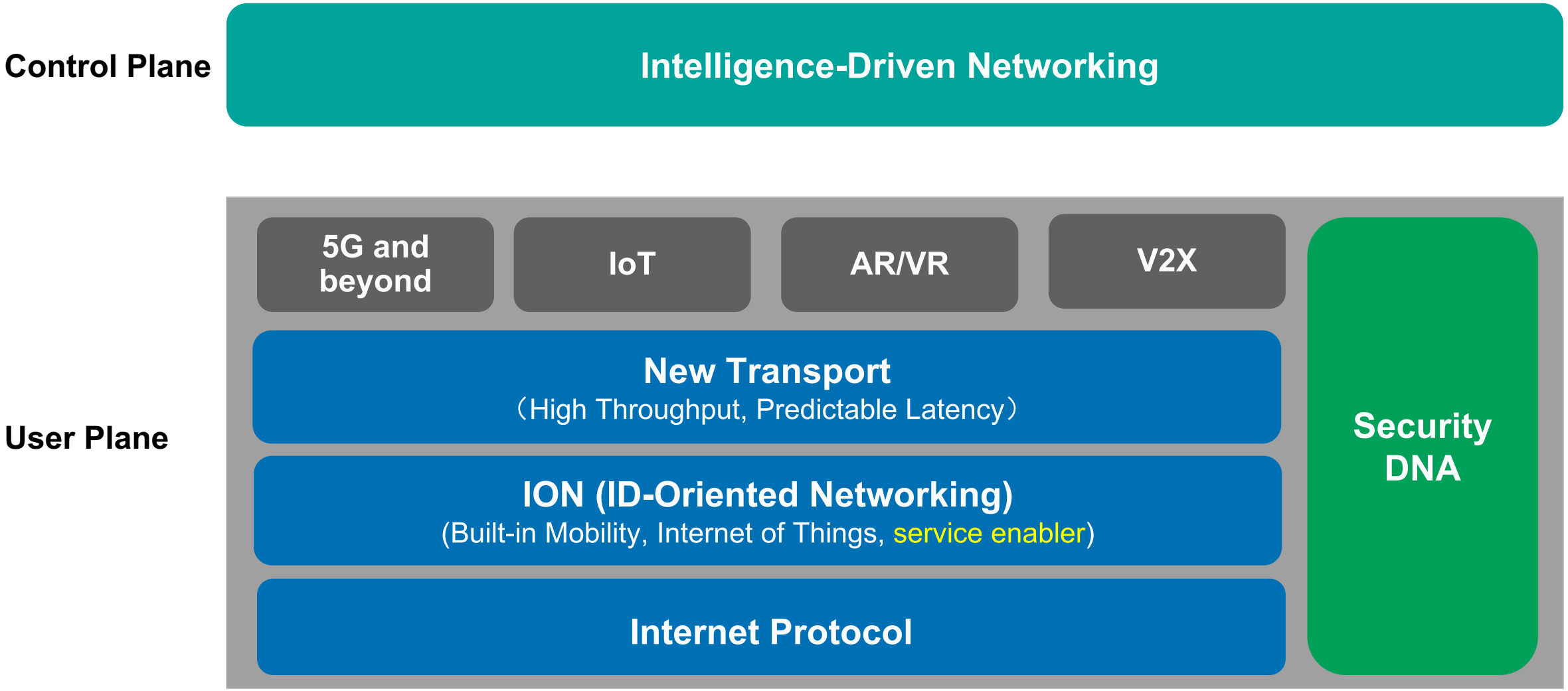
Smart Home

Next-**G**en **T**ransport (NG-T)

Autonomous Driving

Smart Cities

IP 2020 Protocol Stack



Service Fidelity is important, when even a little wait is too late

Thank you

www.huawei.com