Broadband QoS and QoE Assessment, 5-years-on: Major Changes!

Al Morton

Note: "Assessment" not equal to "Regulation"!

Outline

- Turn-back the clock
  - What were our assumptions 5 years ago?

- Communication Evolution:
  - Topology & Architecture

- Application Evolution:
  - New Apps and requirements

- Measurement Evolution:
  - New Metrics and Reference Paths

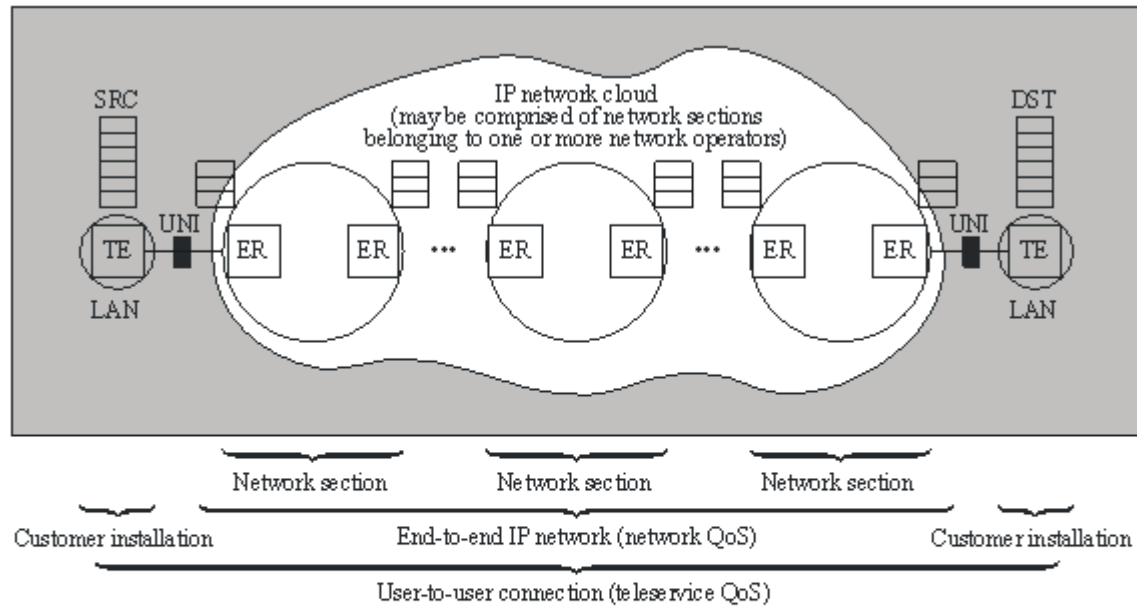"Improved Internet speed tests can enhance QoS and QoE",

Proceedings of the 4th International Workshop on Perceptual Quality of Systems (PQS 2013), held in Vienna, Austria, 2-4 September, 2013. (Available from the author)

>>User Measurement affects QoE

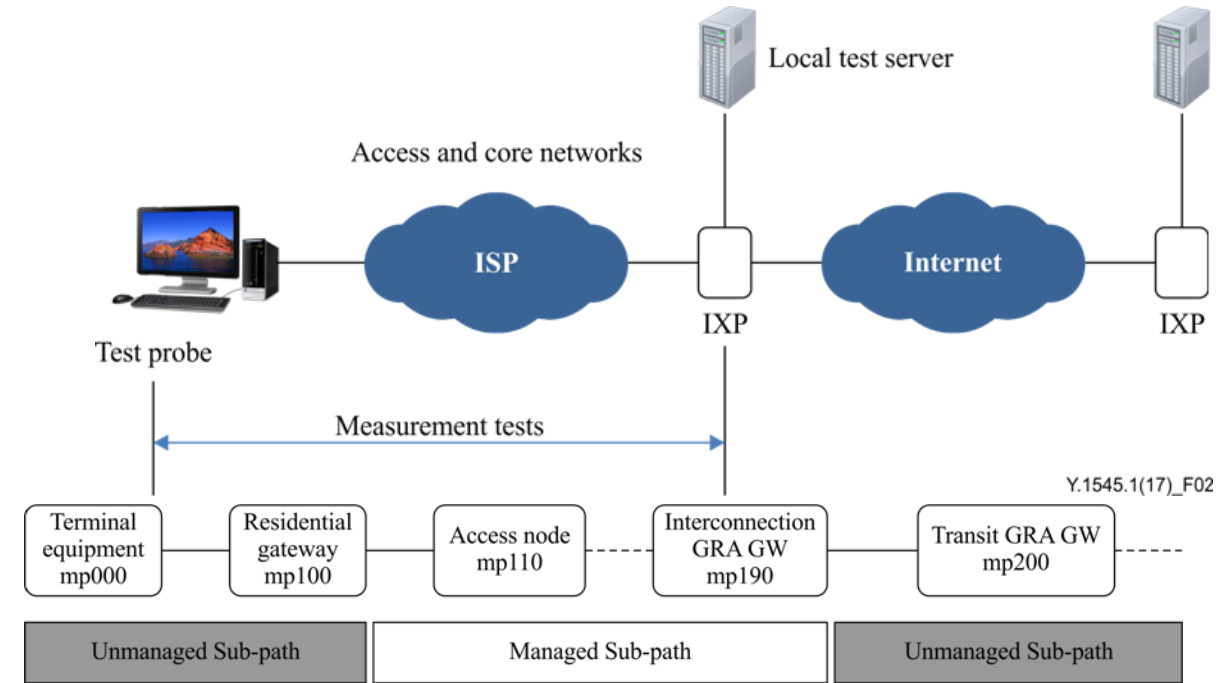# Designing Measurements: Past Assumptions

- User <u>access</u> to the Internet was <u>the principle bottleneck</u> that limited their experience;

- The main emphasis on characteristics of IP-based transport service was <u>Speed</u>;

- TCP was *the* dominant form of reliable transport;

- There was considerable interest to <u>measure multi-operator paths</u> from user to content, and

- There was also interest to measure performance across <u>Gateways</u> between Tier 1 Operators.
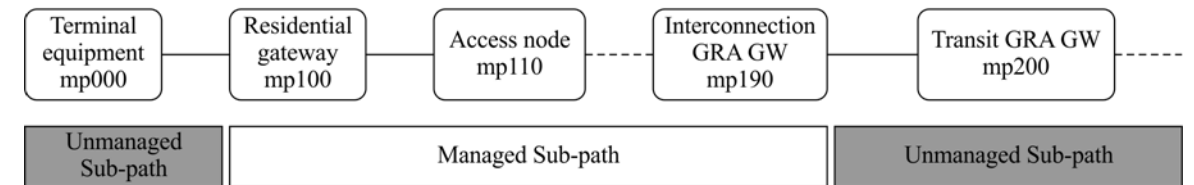
Reference Paths for IP Networks (Y.1541, Y.1545.1)

SRC

IP network cloud
(may be comprised of network sections
belonging to one or more network operators)

DST

TE — UNI — ER — ER ••• ER — ER ••• ER — ER — UNI — TE

LAN

LAN

Network section   Network section   Network section

Customer installation   End-to-end IP network (network QoS)   Customer installation

User-to-user connection (teleservice QoS)

| TE | Terminal equipment |
| ER | Edge router |

Protocol stack

UNI — User network interface

Y.1541 (11)_F01

NOTE – Customer Installation equipment (shaded area) is for illustrative purposes only.

Local test server

Access and core networks

ISP   Internet

IXP   IXP

Test probe

Measurement tests

Y.1545.1(17)_F02

| Terminal equipment mp000 | Residential gateway mp100 | Access node mp110 | Interconnection GRA GW mp190 | Transit GRA GW mp200 |

| Unmanaged Sub-path | Managed Sub-path | Unmanaged Sub-path |

a) Subscriber managed residential gateway (unmanaged from CICP point of view)

| Terminal equipment mp000 | Residential gateway mp100 | Access node mp110 | Interconnection GRA GW mp190 | Transit GRA GW mp200 |

| Unmanaged Sub-path | Managed Sub-path | Unmanaged Sub-path |

Y.1545.1(17)_F03

b) Residential gateway managed by CICP

Passive Optical Networks

Optical Network Market: TDM PON Network

All ONUs receive all traffic

ONT

ONT

ONT

ONT

Splitter

Only one wavelength is transmitted

OLT

Source: Frost & Sullivan
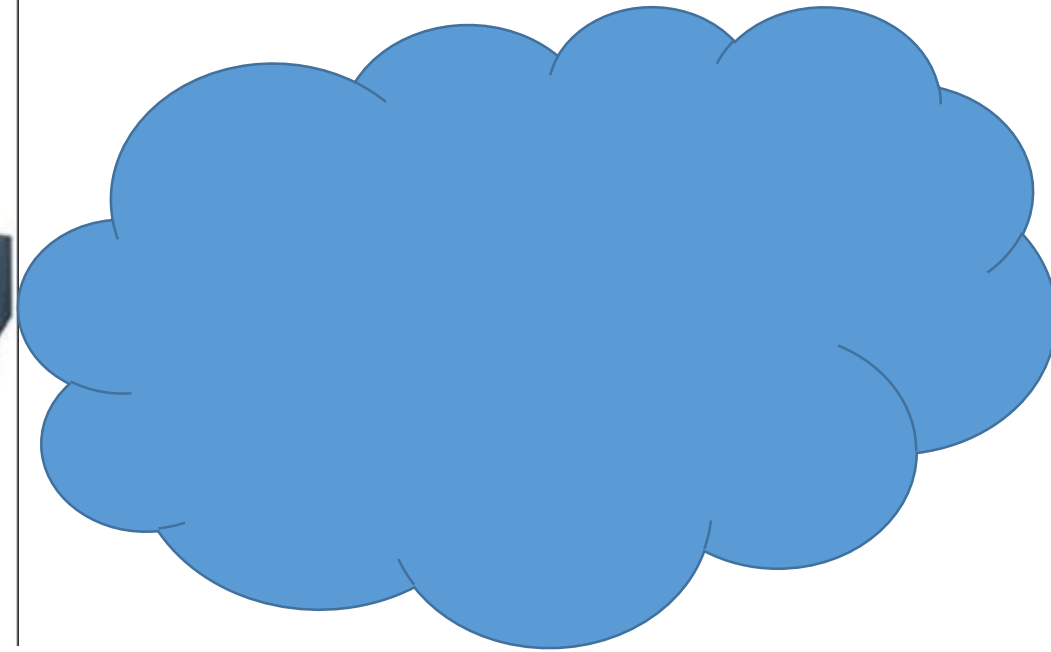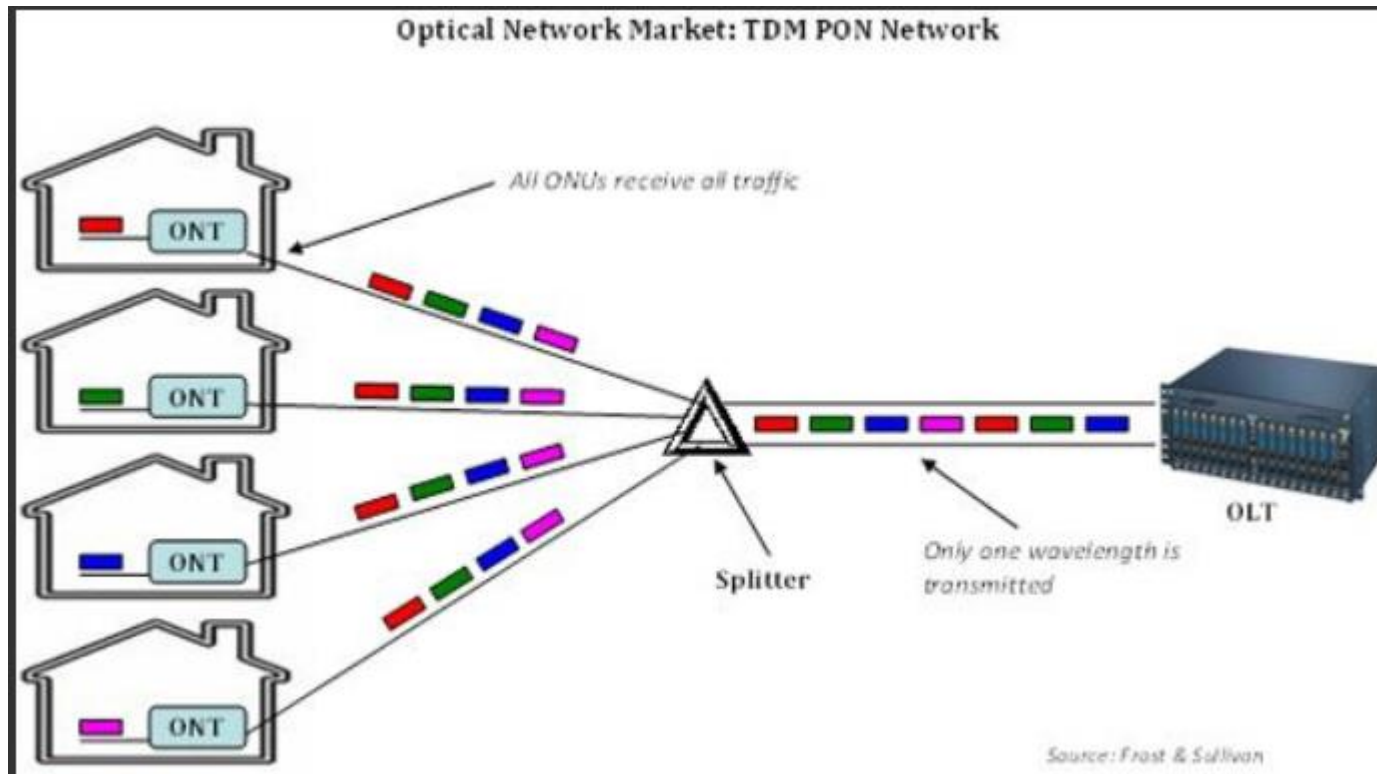
MEC in 5G networks

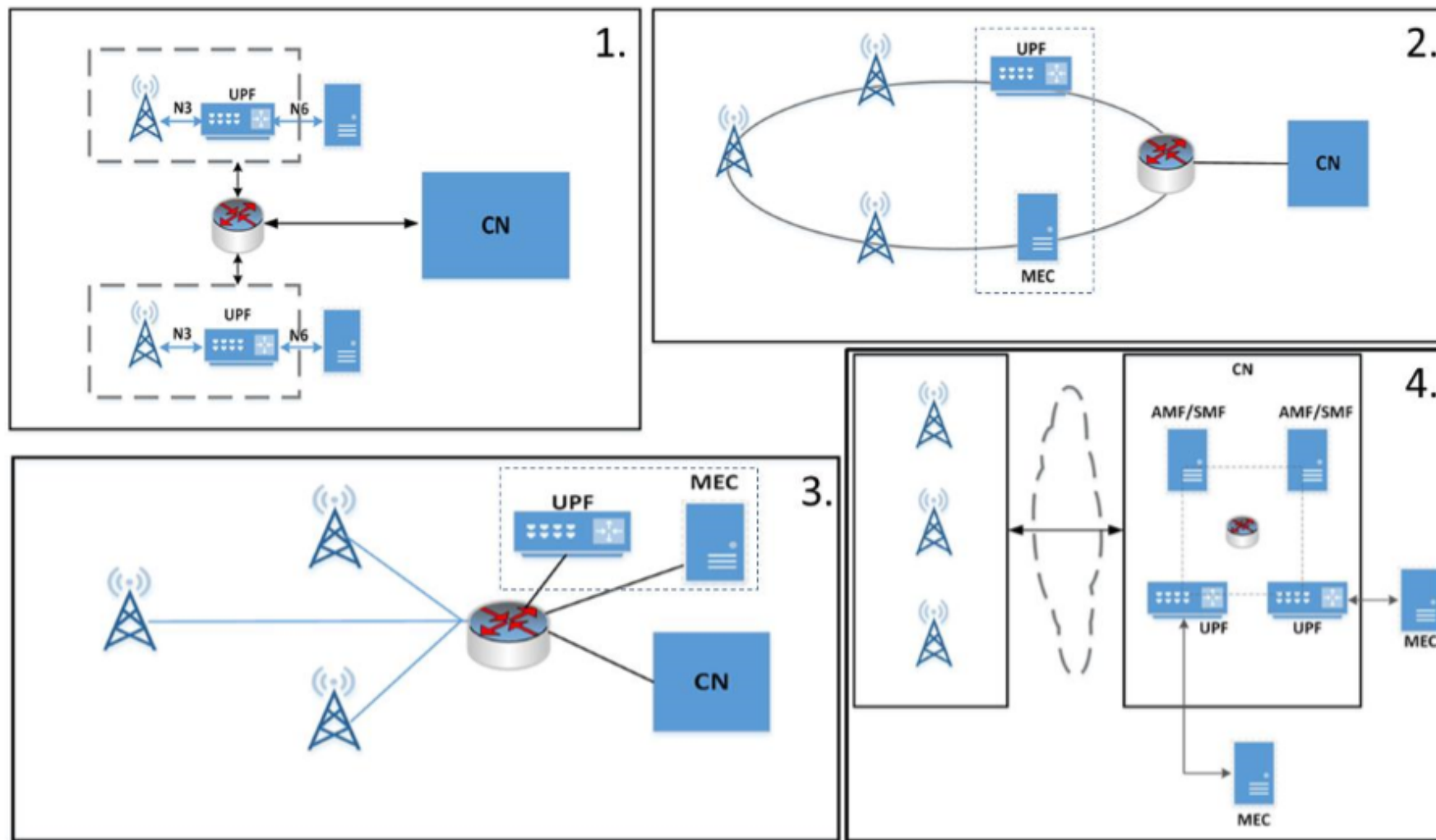UPF = User Plane Function
MEC = Mobile Edge Compute

Figure 3. Examples of the physical deployment of MEC.

1. MEC and the local UPF collocated with the Base Station.

2. MEC collocated with a transmission node, possibly with a local UPF

3. MEC and the local UPF collocated with a network aggregation point

4. MEC collocated with the Core Network functions (i.e. in the same data centre)

Example indications of High Performance needs Hint Latency too!

Table 1: Exemplary use case analysis

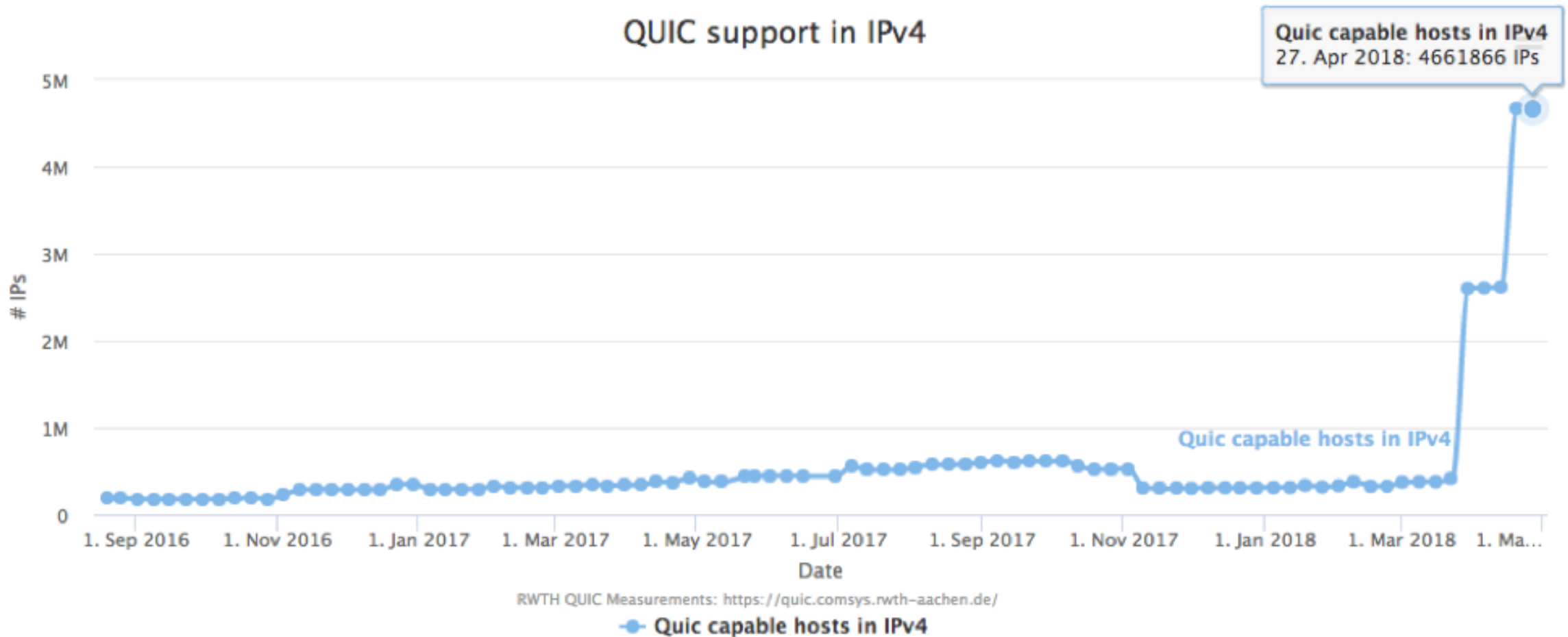| Service	Content Sever	Characteristic			Cloud-Edge Coordination	Possible Location
		Latency	Bandwidth	Privacy		
AR/VR	Local	<5ms	100Mbps~9.4Gbps	No	Sync but not real-time	Access ring (Edge DC)
V2X	Local	<10ms	>100Mbps	No	Processed data real-time Sync	Access ring (Edge DC)
Video Surveillance	Local	Variable	>20Mbps	No	Processed data real-time Sync	Access ring (Edge DC)
Smart factory	Local	<10ms	Variable	Yes	Only in private Cloud	Factory (Edge DC)
Enterprise Cloud (e-health)	Local	<10ms	Variable	Yes	Only in private Cloud	Enterprise (Edge DC)
IOT management	Local /Cloud	Variable	Variable	No	Processed data but not real-time Sync	Access ring or Collector ring (Edge DC or Local DC)
Entertainment (8K TV and Gaming)	Cloud	10ms	>100Mbps	No	Local caching	Collector ring (Local DC)

UDP-based QUIC Traffic Growth
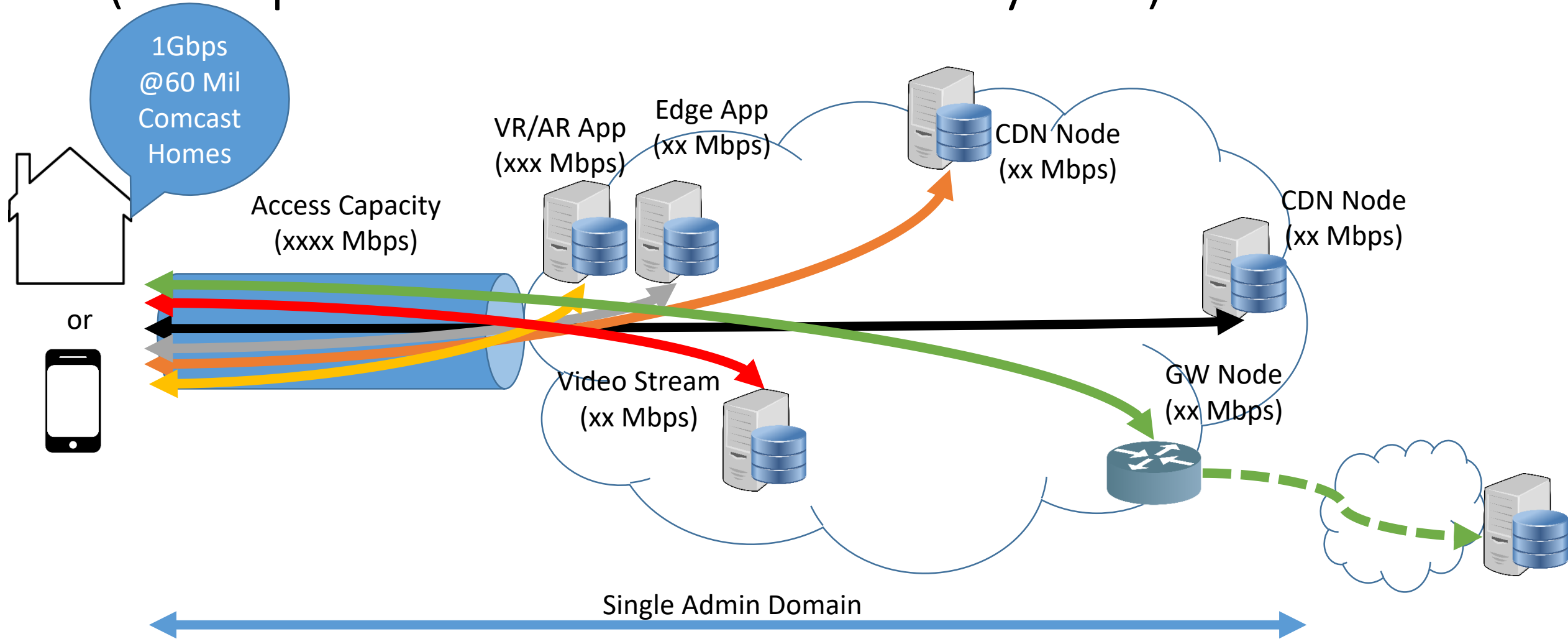
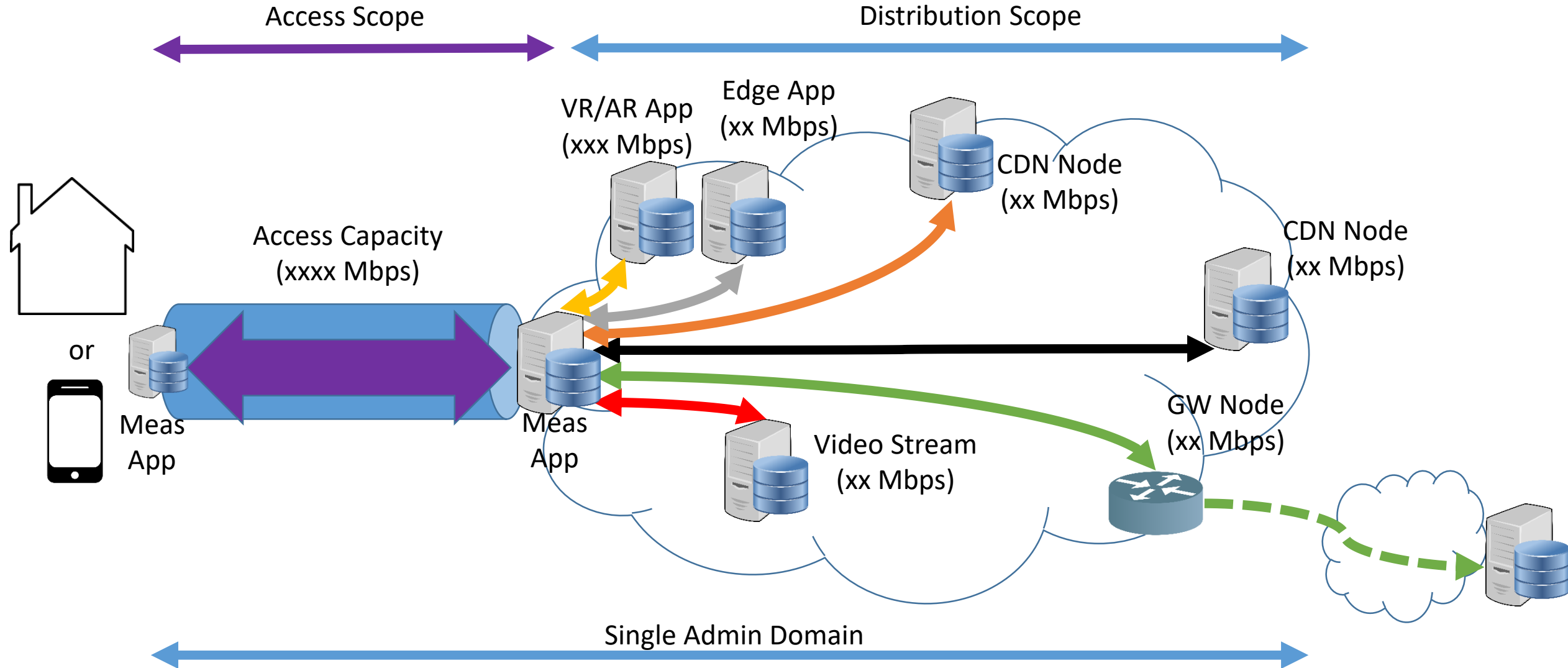- Openwave Mobility's Mobile Video Index (MVI)
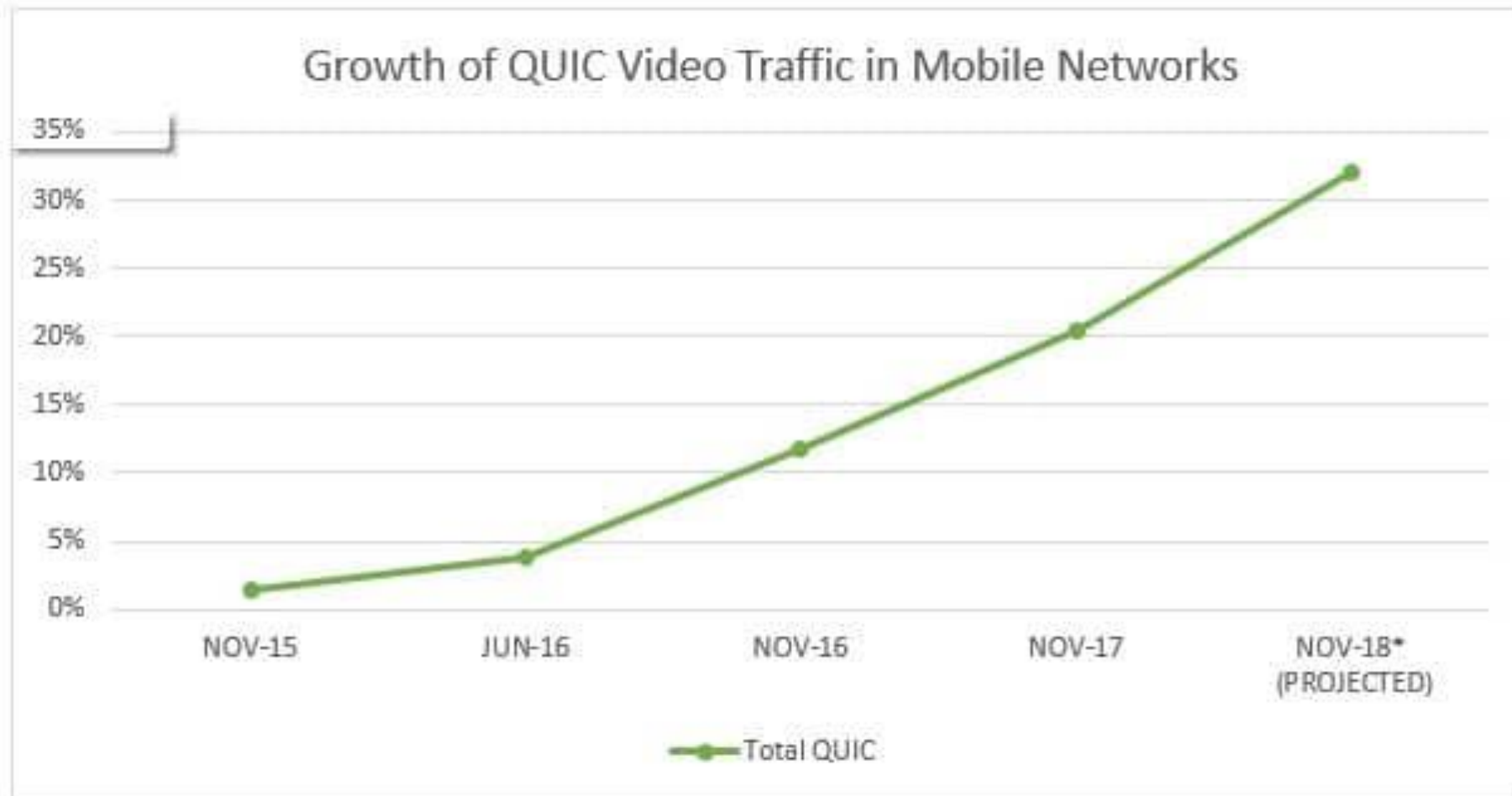
UDP-based QUIC Traffic Growth

- APNIC blog: How much of the Internet is using QUIC? By Jan Rüth on 15 May 2018: "… Akamai officially announced its QUIC rollout, we noticed a drastic increase…" (and Akamai is a Cache/CDN)

QUIC support in IPv4

RWTH QUIC Measurements: https://quic.comsys.rwth–aachen.de/

Service Capacity has Access Scope (user paths become diverse beyond)

1Gbps @60 Mil Comcast Homes

or

Access Capacity (xxxx Mbps)

VR/AR App (xxx Mbps)

Edge App (xx Mbps)

CDN Node (xx Mbps)

CDN Node (xx Mbps)

Video Stream (xx Mbps)

GW Node (xx Mbps)

Single Admin Domain

Separate Measurements for Access and Distribution

Access Scope

Distribution Scope

VR/AR App (xxx Mbps)

Edge App (xx Mbps)

CDN Node (xx Mbps)

CDN Node (xx Mbps)

Access Capacity (xxxx Mbps)

or

Meas App

Meas App

GW Node (xx Mbps)

Video Stream (xx Mbps)

Single Admin Domain

ITU-T SG12 Q17 Evaluation Phase 1:
IETF Benchmarking & IP Access Meas. Cross-over

- Access moving to Gbps & Low Latency

- Benchmark Methods: UDP & new Robust Search alg.

- Today's Access Test Methods: N x TCP conn.

- Test using **Calibrated DUT**

- Results: UDP found Cap Limits! Best perf using MTU

- TCP methods have variable results and a tendency to under-estimate Cap limits
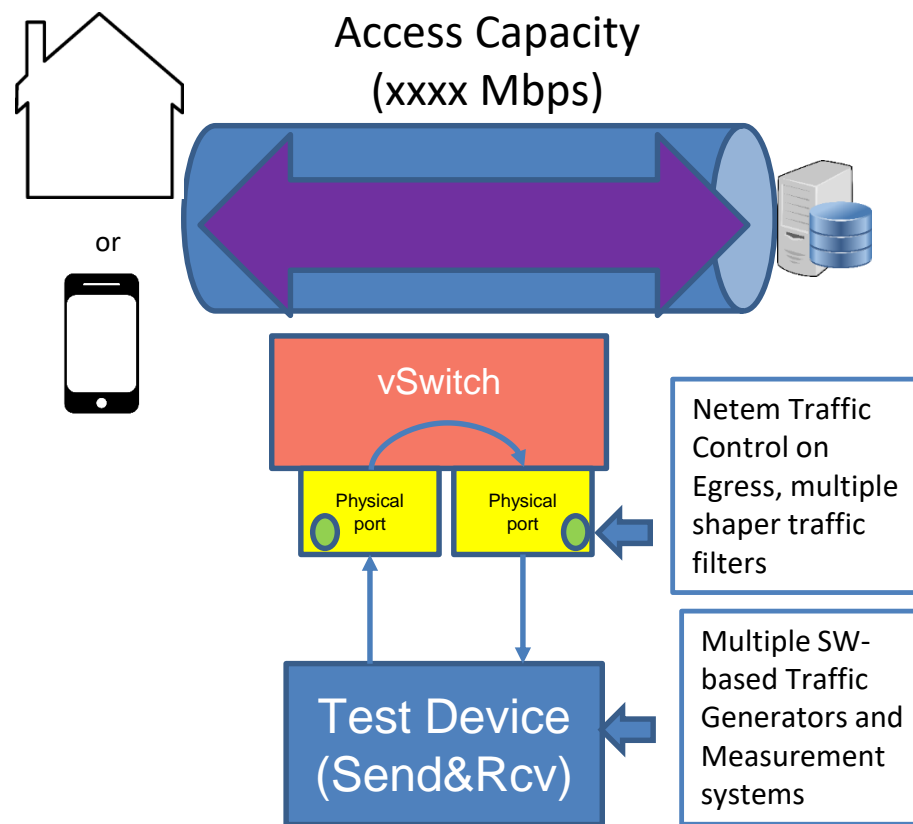
There is a clear application for the Q17 work to Harmonize IP Network Measurements in [EC: Meas for Fixed/Mobile/5G]

Access Capacity
(xxxx Mbps)

or

vSwitch

Physical port   Physical port

Netem Traffic Control on Egress, multiple shaper traffic filters

Test Device (Send&Rcv)

Multiple SW-based Traffic Generators and Measurement systems

Designing Measurements: Today's clear trends

5 years ago:

- User access was the bottleneck;

- The main emphasis on Speed;

- TCP was *the*reliable transport;

- Measure multi-operator paths from user to content, and

- Measure performance across Gateways between Tier 1 Ops

Today's trends:

- Mob. Carrier Agg & Gbps access

- Latency also/more critical

- UDP with QUIC large & growing

- Content moving to the user: CDNs, Mobile Edge Compute

- Content everywhere, Less traffic & less congestion at Gateways

You might not see ALL these trends happening in your region today, but **arrival of any change the game**!

References

- MEC White Paper, "MEC in 5G networks", https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp28_mec_in_5G_FINAL.pdf
- Growth of Google QUIC traffic on Mobile https://owmobility.com/blog/meteoric-rise-google-quic-worrying-mobile-operators/
- How much of the Internet is using Google QUIC? https://blog.apnic.net/2018/05/15/how-much-of-the-internet-is-using-quic/
- 5G Unlocks … https://www.huawei.com/us/industry-insights/outlook/mobile-broadband/insights-reports/5g-unlocks-a-world-of-opportunities
- [EC: Meas for Fixed/Mobile/5G] European Commission: Fixed and Mobile Convergence in Europe: Quality Measurements for 5G and Network Densification