Standards Developments FCC Gigabit Meas. WG

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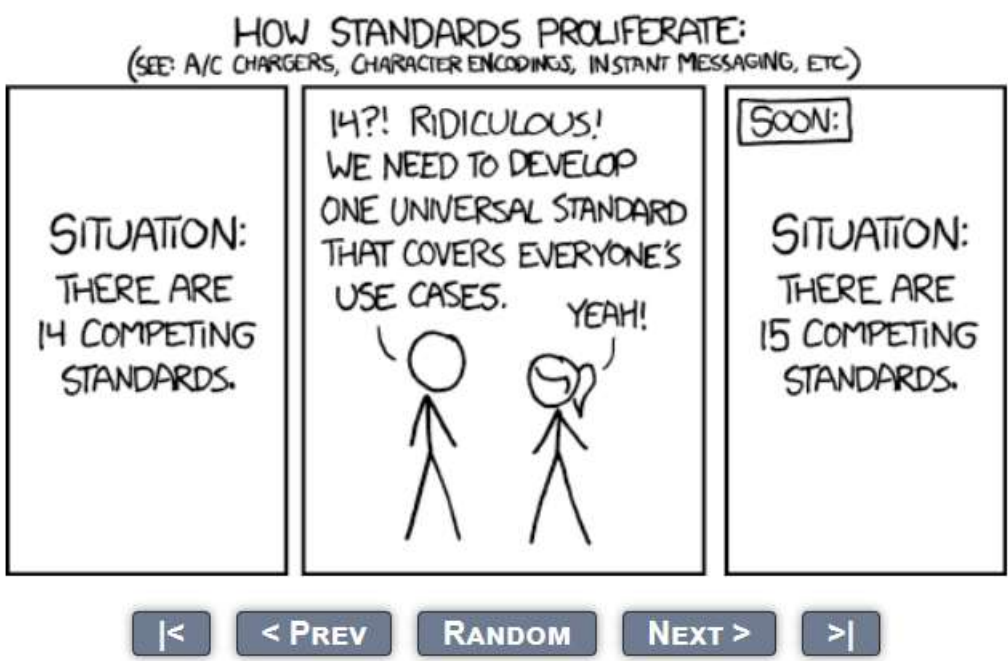
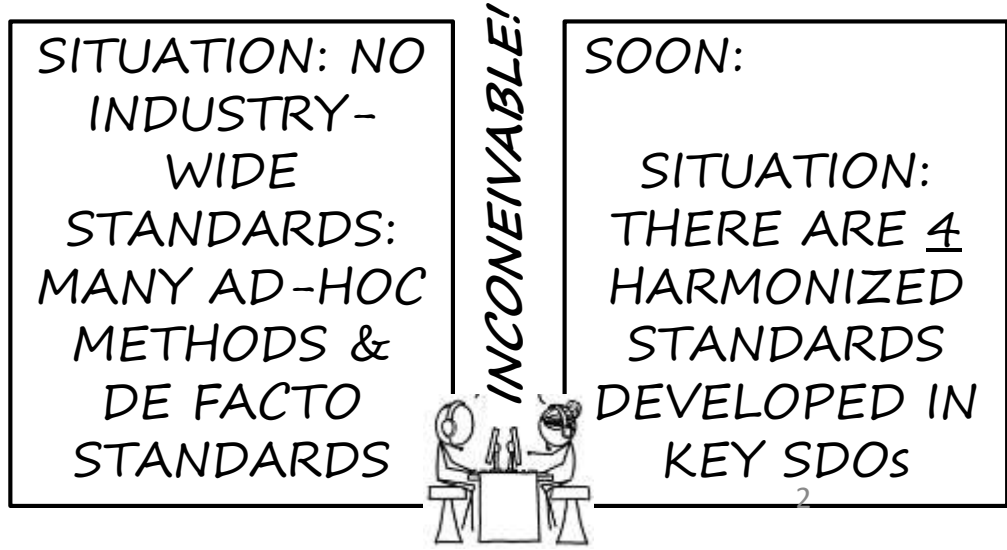
Where are we?

- Clearly defined, Repeatable Measurements have never been more important in this context.
  - Industry succeeded with ad hoc methods in closed systems at lower rates.
- The need for change recognized ~2 years ago
  - Anticipation of needs in Standards work? Inconceivable!
- Motivations for measurement are many, but most important is to:
  - understand what matters, and
  - be clear about WHAT will be measured





Designing Measurements: Today's clear trends

6 years ago:

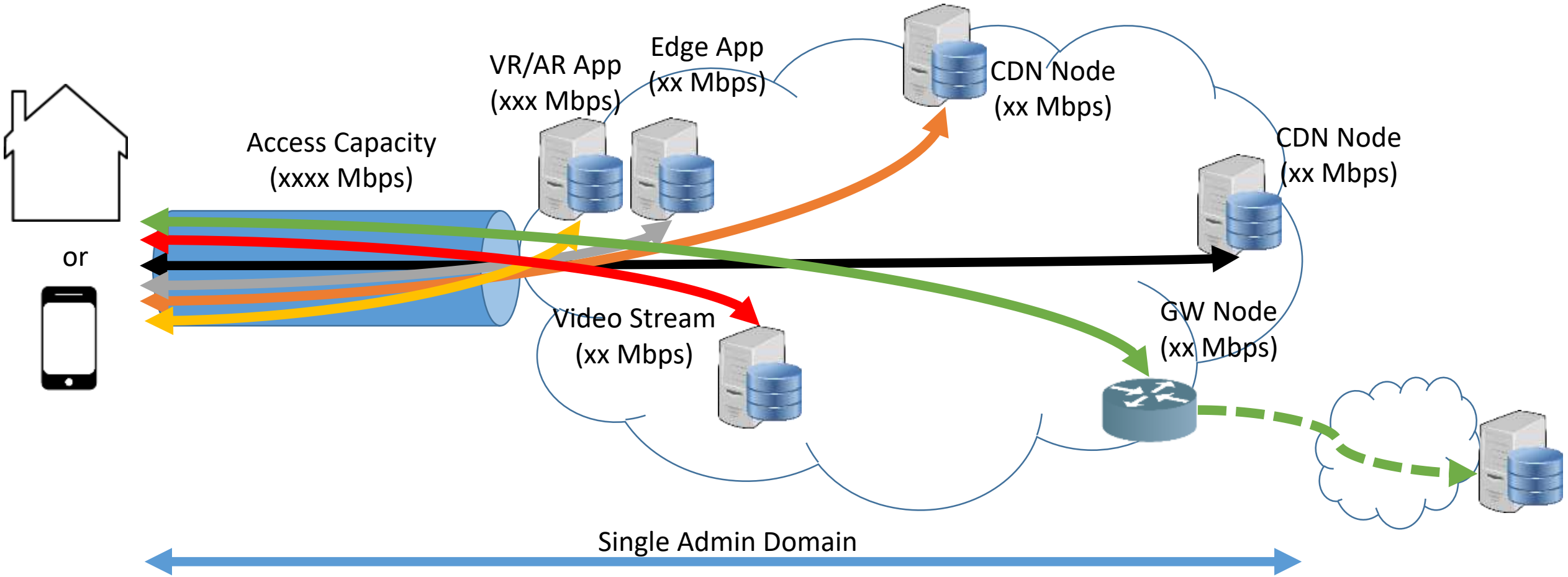
- User access was the bottleneck;
- The main emphasis on Speed;
- TCP was *the*reliable transport;
- Measure multi-operator paths from user to content, and
- Measure performance across Gateways between Tier 1 Ops

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 one changes the game**!

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



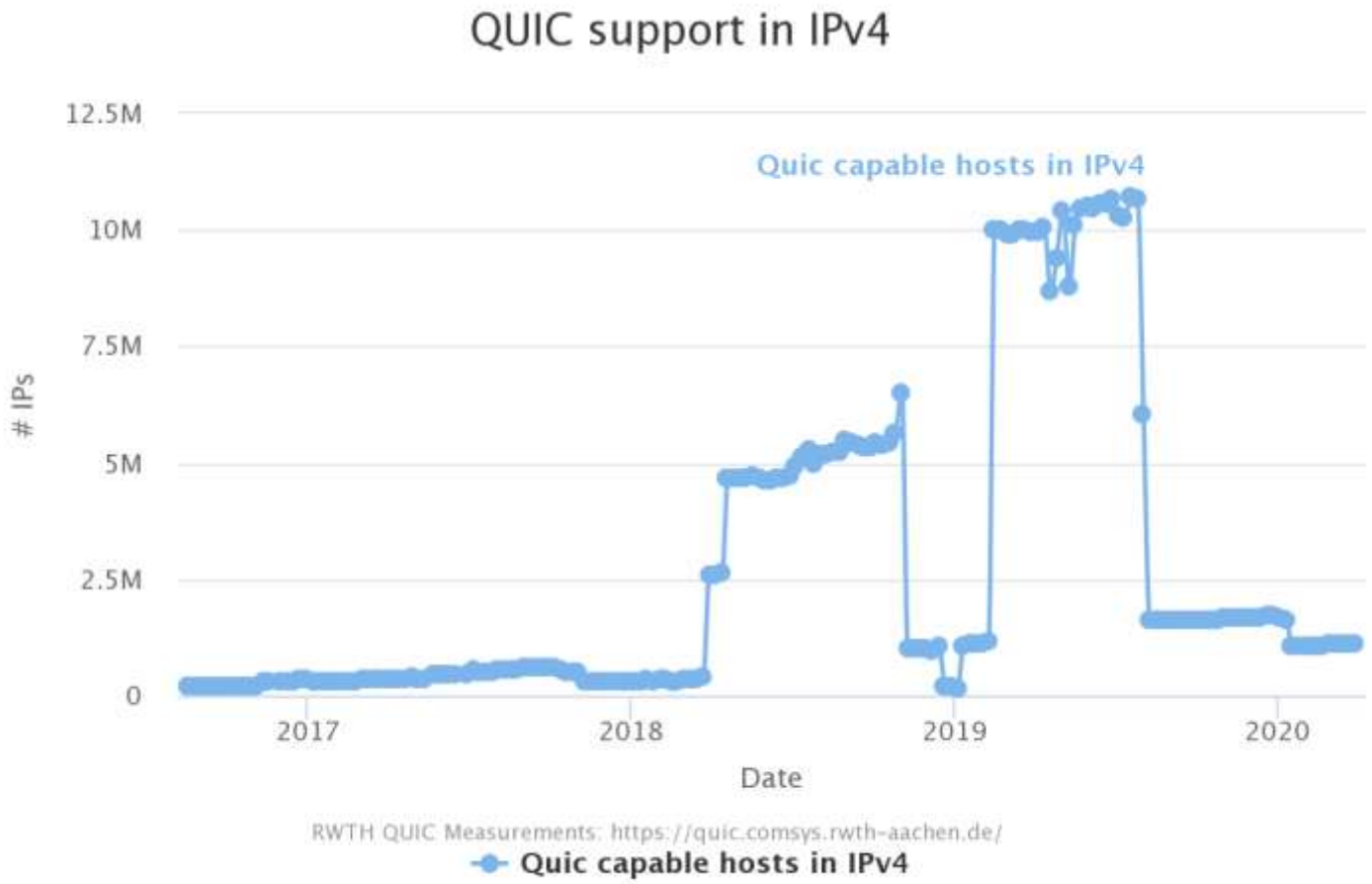
Example indications of High Performance needs Hint Latency too!

Table 1: Exemplary use case analysis

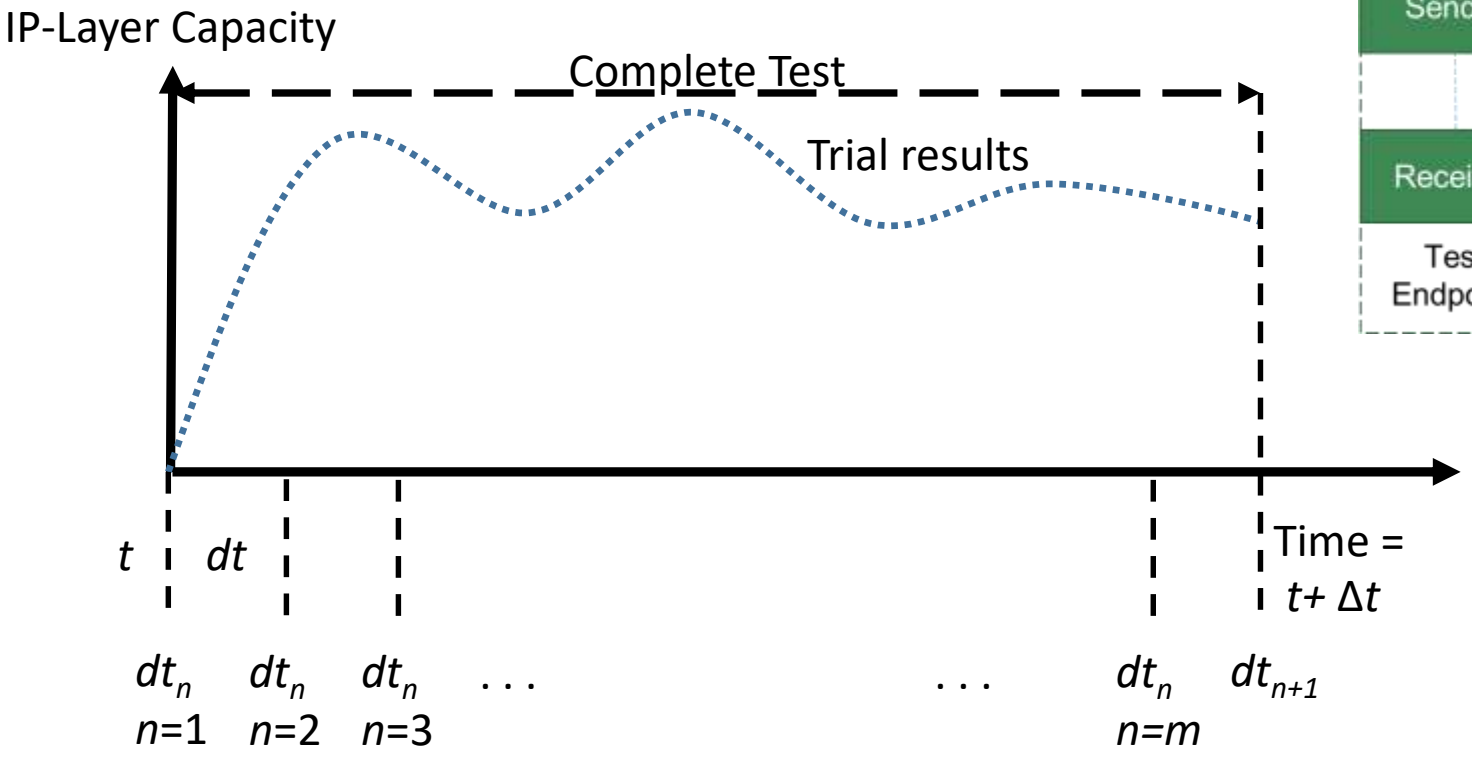
Service	Content Sever	Characteristic			Cloud-Edge Coordination	Possible Location
		Latency	Bandwidth	Privacy		
AR/VR	Local	<5ms	100Mbps~ 9.4Gbps	No	Sync but not real-time	Access ring (Edge DC)
V2X	Local	<10ms	>100Mbps	No	Processed data real-time Sync	Access ring (Edge DC)
Video Surveillance	Local	Variable	>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)

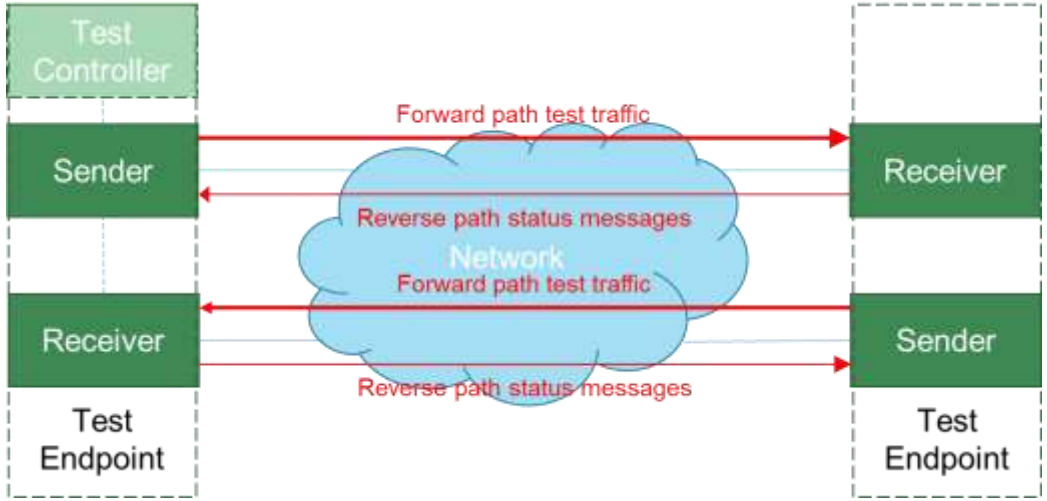
UDP-based Google QUIC Traffic: Host Support

- 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…" (Akamai is a Cache/CDN) [Current Results]



High-level View of the Metric and Method





$$Maximum\_C(t, \Delta t) = \frac{\max_{[t,\Delta t]}\left(n_0(dt_n, dt_{n+1})\right)}{dt}$$

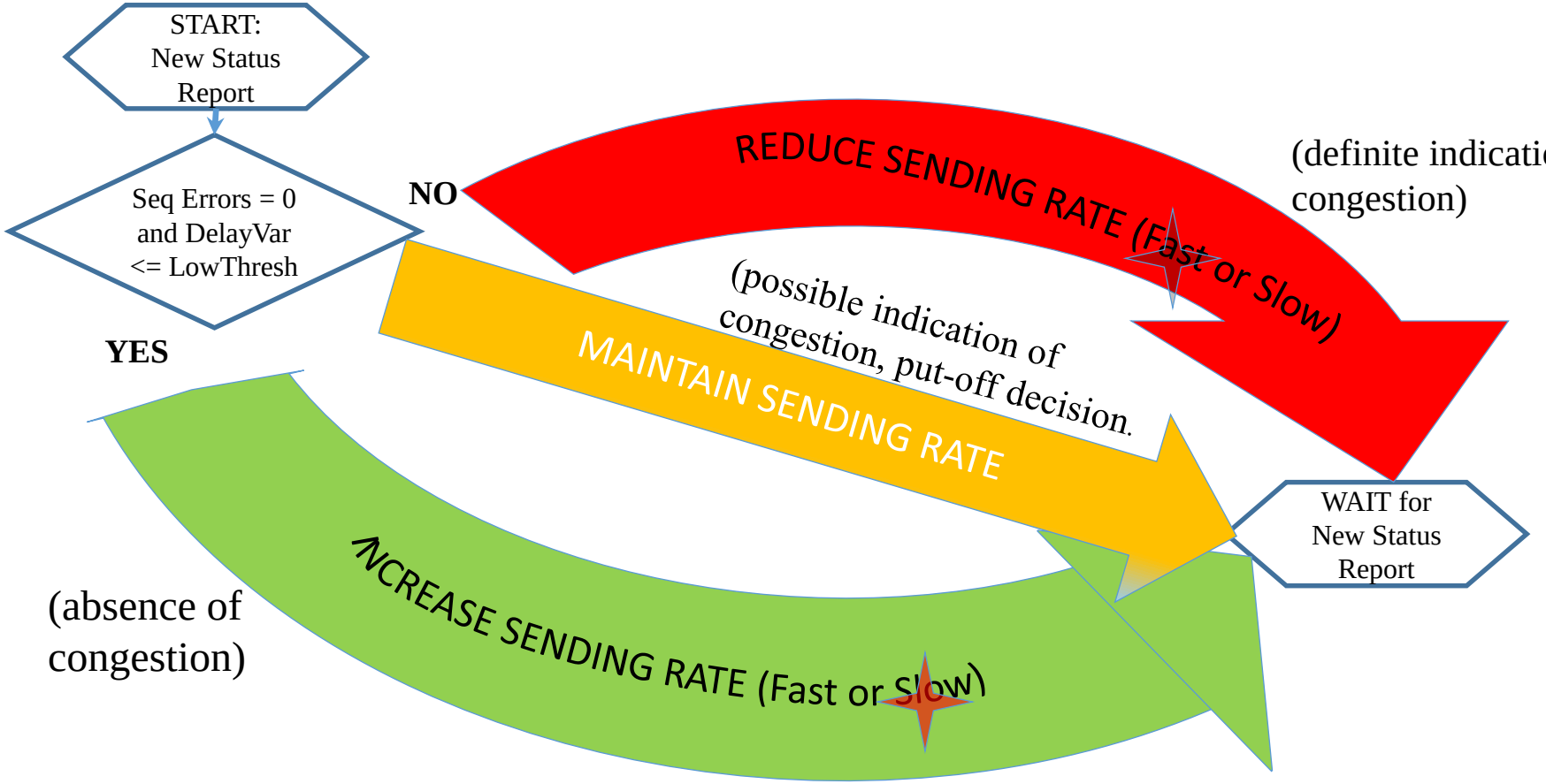
Standards High-Level Status: IP-Layer Capacity Metric and Measurements

- ITU-T Study Group 12 - **Approved**
  - Question 17 on Packet Network Performance the Metric and Method of Measurement to Recommendation **Y.1540 - 2019 (Annexes A and B)**
    - Considerable background (test results; research) in Appendices X through XIII
- ETSI TC Speech and Multimedia Transmission Quality (STQ)
  - **Approved** the Metric in **TS 103 222 Part 2** on High Speed Internet KPIs
  - Reference to Rec Y.1540 for all other material
- Broadband Forum (BBF) – Project **Approved**: **WT-471**
  - Standardize the identical Metric and Methods with additional details on Measurement Points and Information Model for control and reporting.
- IETF IP Performance Measurements (IPPM) Working Group
  - **Internet Draft** **Adopted** by WG, adding Metric details, Measurement Considerations, and Results presentation formats

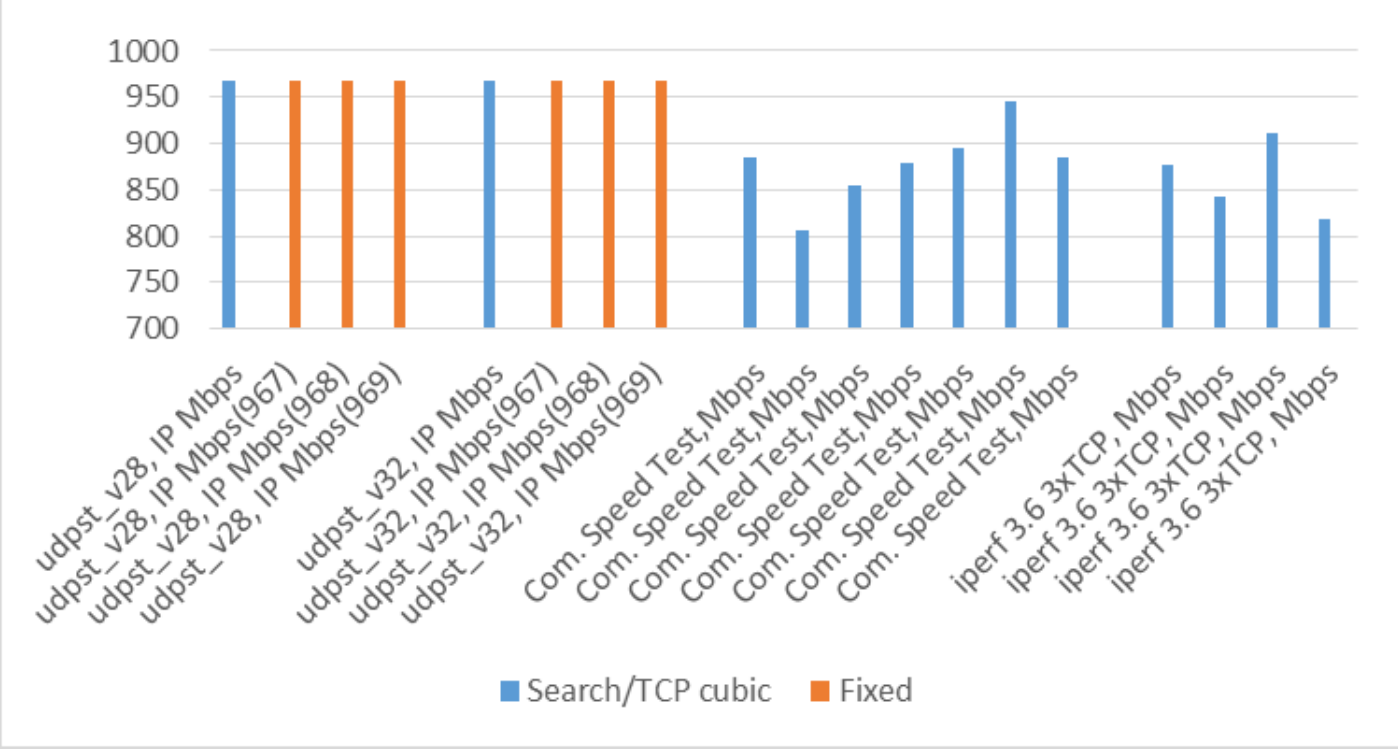
Search algorithm at high level

Three Alternatives: reaction to measurements returned in Status Messages

- ability to control its actions directly (tuning specific parameters)
- More flexible than in CCA with TCP: CUBIC and BBR



1 Gbps Downlink Meas. Comparison, Mbps



udpst, Common Speed Test Web Sockets Clients and iPerf 3.6 with TCP Cubic (default), in NJ

udpst, Common Web Sockets, and iPerf 3.6 Servers

Summary of SG 12 testing (tests continue)

The consensus on Lab and Field measurement results was that UDP is the preferred transport protocol for capacity assessment:

- UDP indicated accurate “ground truth” assessment (lab) and more consistent (field) results for Max IP-Layer Capacity
- UDP tools were able to measure loss, delay, delay variation and reordering.
- TCP registered lower rates than UDP tests and greater rate variability under various challenging circumstances (RTT, competing traffic, etc.).
- TCP measurements on 1 Gbps PON exhibit a significant underestimation of capacity.
- Laboratory conclusions on UDP as the benchmark, and TCP as underestimating capacity were supported by the field measurements.
- Tests of stationary LTE access indicated inherent variability, as expected.

Further investigations

- Mobile endpoint testing
- DoH may cause issues for some crowd-sourced measurements
  - Current method is almost insensitive to RTT (unlike TCP).
- Suggestions?

```
12733 Server: EastCoast, Protocol: UDP
12734 UDP Speed Test, Copyright (C) 2019, All Rights Reserved
12735 Software Rev: 4.0, Built: Jul 28 2019 20:09:20
12736 Mode: Client, Protocol Version: 40
12737 Downstream Test Time(sec): 10, DelayLimits(ms): 30-90, StatusFeedback(ms): 50, JumboSizes: Enabled, LoadRateIndex: -1
12738 -Time(sec): 1.001    PktLossRatio: 0.00E+00, Loss/OoO: 0/0, DelayVar(ms): 0/0/2, SampledRTT(ms): 8-10, Mbps(L3/IP): 293.06
12739 -Time(sec): 2.002    PktLossRatio: 0.00E+00, Loss/OoO: 0/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-10, Mbps(L3/IP): 493.08
12740 -Time(sec): 3.003    PktLossRatio: 0.00E+00, Loss/OoO: 0/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-10, Mbps(L3/IP): 693.10
12741 -Time(sec): 4.004    PktLossRatio: 5.57E-03, Loss/OoO: 487/0, DelayVar(ms): 0/0/8, SampledRTT(ms): 8-16, Mbps(L3/IP): 867.66
12742 -Time(sec): 5.005    PktLossRatio: 5.45E-05, Loss/OoO: 5/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-10, Mbps(L3/IP): 912.71
12743 -Time(sec): 6.006    PktLossRatio: 1.71E-04, Loss/OoO: 16/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-10, Mbps(L3/IP): 927.89
12744 -Time(sec): 7.007    PktLossRatio: 1.47E-04, Loss/OoO: 14/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-11, Mbps(L3/IP): 943.54
12745 -Time(sec): 8.008    PktLossRatio: 9.09E-04, Loss/OoO: 88/0, DelayVar(ms): 0/0/1, SampledRTT(ms): 8-10, Mbps(L3/IP): 961.89
12746 -Time(sec): 9.009    PktLossRatio: 1.81E-03, Loss/OoO: 176/0, DelayVar(ms): 0/0/2, SampledRTT(ms): 9-12, Mbps(L3/IP): 966.38
12747 -Time(sec): 10.010   PktLossRatio: 3.31E-03, Loss/OoO: 323/0, DelayVar(ms): 0/1/2, SampledRTT(ms): 8-12, Mbps(L3/IP): 965.60
12748 Downstream Summary-> PktLossRatio: 1.20E-03, Loss/OoO: 1109/0, DelayVar(ms): 0/0/8, SampledRTT(ms): 8-16, Mbps(L3/IP): 802.49
12749 Downstream Maximum--> Mbps(L3/IP): 966.38, Mbps(L2/Eth): 980.34, Mbps(L1/Eth): 995.87, Mbps(L1/Eth+VLAN): 998.97
12750 04:15:13
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SELECTED REFERENCES (Standards/Drafts on Slide 11)

- Hackfest 106 Slides: Test Results
- Hackfest 105 Slides: Test Results
- Liaisons from ITU-T SG 12 and ETSI TC STQ – see email for links, or
- https://datatracker.ietf.org/liaison/1645/
- https://datatracker.ietf.org/liaison/1643/
- https://datatracker.ietf.org/liaison/1634/
- https://datatracker.ietf.org/liaison/1632/
- More Test results in the Liaison attachments

References (Standards/Drafts on Slide 11)

- “Improved Internet speed tests can enhance QoS and QoE”, PQS 2013, https://irtf.org/raim-2015-papers/raim-2015-paper1.pdf
- 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