



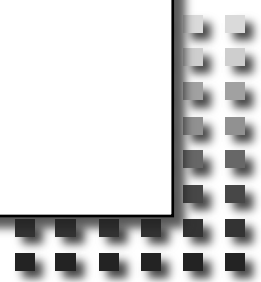
First L4S Interop Event *@* IETF Hackathon

IETF 114

23-26 July 2022

Philadelphia, Pennsylvania

Champions: Greg White (CableLabs), Jason Livingood (Comcast),
Sebnem Ozer (Comcast), Vidhi Goel (Apple), Neal Cardwell (Google)



Hackathon/Interop Plan

- L4S Congestion Control & AQM Architecture
 - draft-ietf-tsvwg-l4s-arch
 - draft-ietf-tsvwg-ecn-l4s-id
 - draft-ietf-tsvwg-aqm-dualq-coupled
- Accurate ECN for TCP (QUIC supports accurate ECN natively)
 - draft-ietf-tcpm-accurate-ecn
- L4S involves three components
 - Congestion control @ sender
 - Congestion marking @ bottleneck
 - Marking feedback @ receiver

Hackathon/Interop Plan – cont.

- Friday afternoon – CMTS & Network setup
- Saturday – Setup continues, initial testing
- Sunday – testing continues
- Monday – readout in TSVWG
- Tuesday – complete testing & wrap up

Hackathon Implementations

- Congestion control
 - Apple QUIC Prague
 - TCP Prague
 - Google BBRv2
 - NVIDIA GFN
 - Nokia RT-Prague
- Marking Feedback
 - PicoQUIC
 - Apple QUIC
 - Google AccECN/TCP
 - FreeBSD AccECN/TCP
 - NVIDIA GFN client

Hackathon Implementations

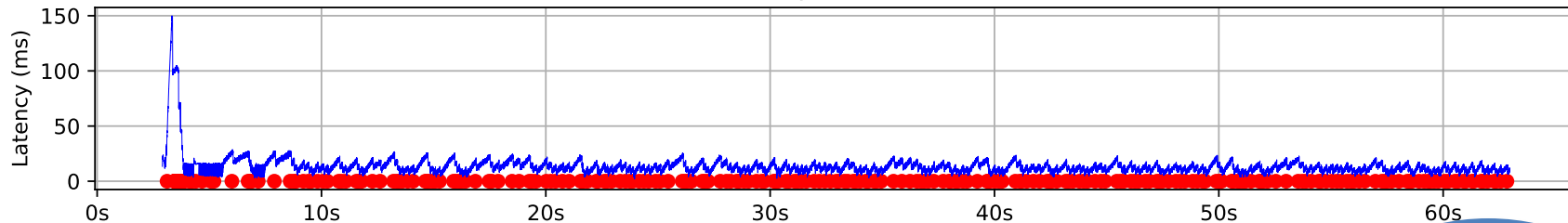
- Seven bottleneck link implementations
 - Four Low Latency DOCSIS implementations
 - 2 cable modem chipsets (Broadcom, Maxlinear)
 - 2 CMTS (Casa, Commscope)
 - Google Nest WiFi AP
 - Nokia Beacon 6 WiFi AP
 - Nokia 5G/Fixed Network Emulator

Initial Interoperability Testing

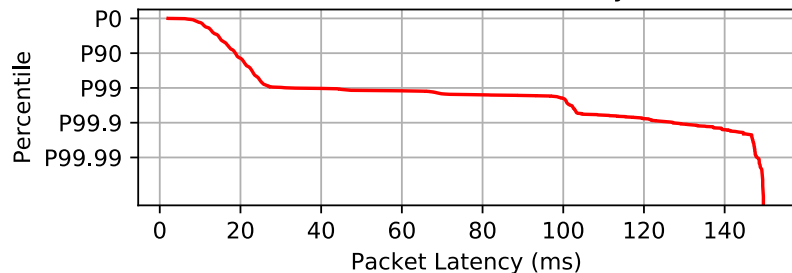
- AppleQUIC / CommscopeLLD
- AppleQUIC / CasaLLD
- AppleQUIC / BroadcomLLD
- AppleQUIC / MaxlinearLLD
- Google BBRv2 Linux / FreeBSD AccECN TCP
- NVIDIA / Nokia WiFi
- NVIDIA / NokiaRT / Nokia 5G RAN emulator
- NVIDIA / CasaLLD
- BBRv2 / TCP Prague / NokiaRT / Nokia 5G RAN emulator
- Meta Netesto / TCP Prague / Nokia WiFi
- AppleQUIC / NokiaRT / CasaLLD
- NVIDIA / AppleQUIC / CommscopeLLD
- NVIDIA / BBRv2 / CommscopeLLD
- More coming...

Upstream Classic (DOCSIS & AppleQUIC)

Latency Timeseries



CCDF of Packet Latency



Packet Delay Statistics

P0	2.051 ms
P90	18.728 ms
P99	32.073 ms
P99.9	127.196 ms
Drops	278 Packets
Missing	0 Packets

Data Rate Statistics

Mean data rate	20.8 Mbps
P10 of data rate	18.4 Mbps
P10 % of mean	88.5%
Ramp time to 90%	200 ms

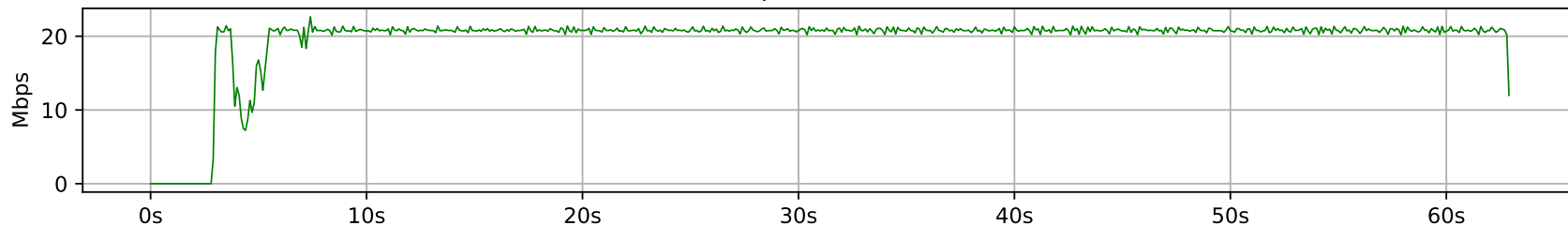
PDV Statistics

P99	30.022 ms
P99.9	125.145 ms

DSCP and ECN Counts

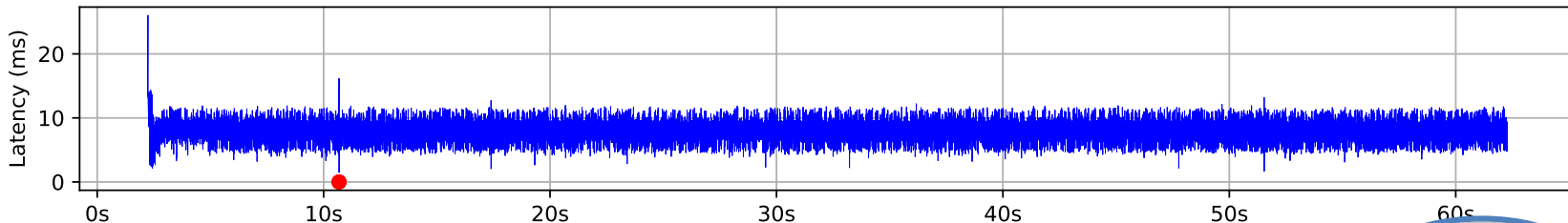
DSCP 3	132320
Not ECT	2
ECT0	132318
Total	132320

Mbps Timeseries

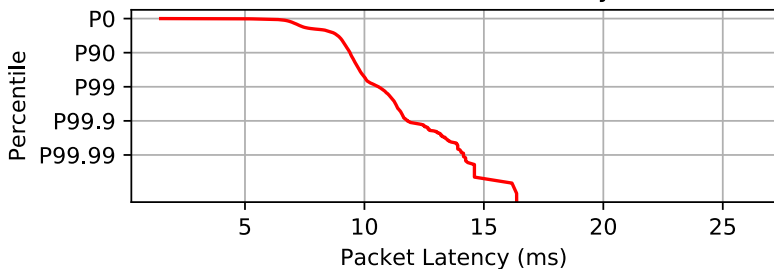


Upstream L4S (DOCSIS & AppleQUIC)

Latency Timeseries



CCDF of Packet Latency



Packet Delay Statistics

P0	1.470 ms
P90	9.396 ms
P99	10.588 ms
P99.9	11.811 ms
Drops	4 Packets
Missing	4 Packets

Data Rate Statistics

Mean data rate	20.6 Mbps
P10 of data rate	6.6 Mbps
P10 % of mean	32.0%
Ramp time to 90%	300 ms

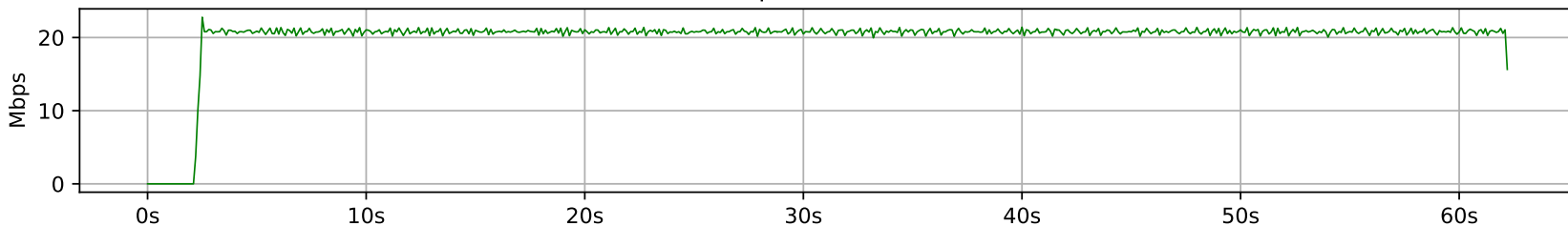
PDV Statistics

P99	9.117 ms
P99.9	10.341 ms

DSCP and ECN Counts

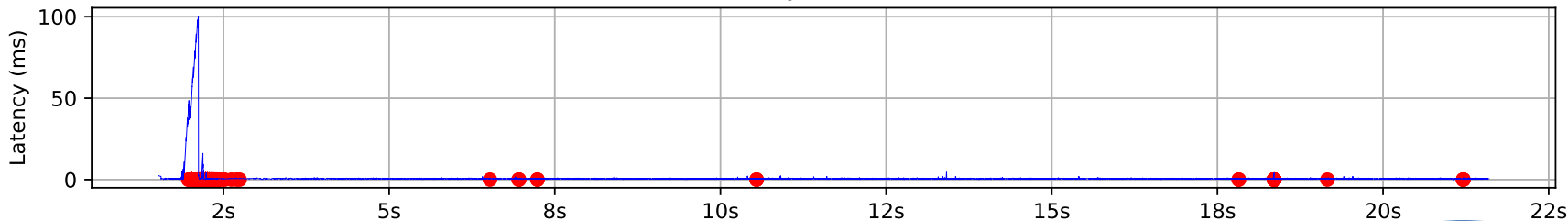
DSCP 3	2
DSCP 0	133760
Not ECT	2
ECT1	127643
CE	6117
Total	133762

Mbps Timeseries

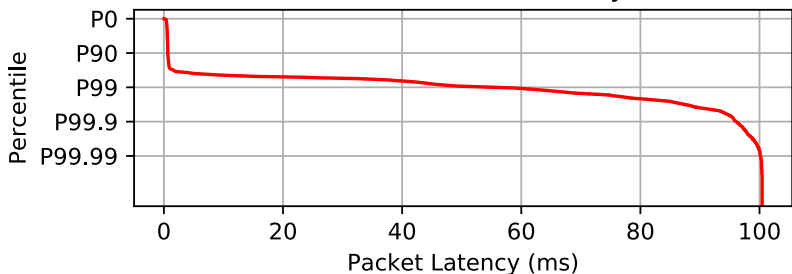


Downstream Classic (DOCSIS & AppleQUIC)

Latency Timeseries



CCDF of Packet Latency



Packet Delay Statistics

P0	0.018 ms
P90	0.664 ms
P99	55.671 ms
P99.9	96.125 ms
Drops	1044 Packets
Missing	304 Packets

Data Rate Statistics

Mean data rate	98.4 Mbps
P10 of data rate	40.6 Mbps
P10 % of mean	41.3%
Ramp time to 90%	200 ms

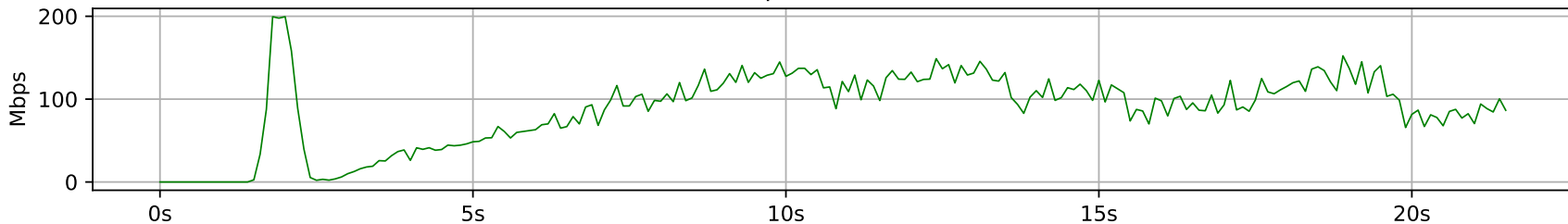
PDV Statistics

P99	55.653 ms
P99.9	96.107 ms

DSCP and ECN Counts

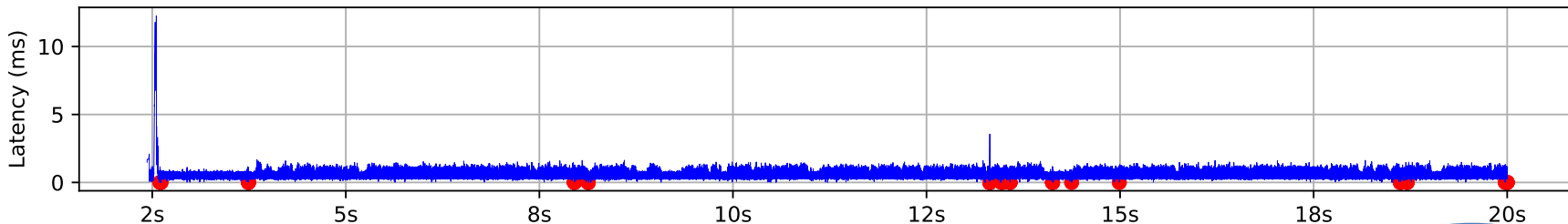
DSCP 3	160268
ECT0	160267
Not ECT	1
Total	160268

Mbps Timeseries

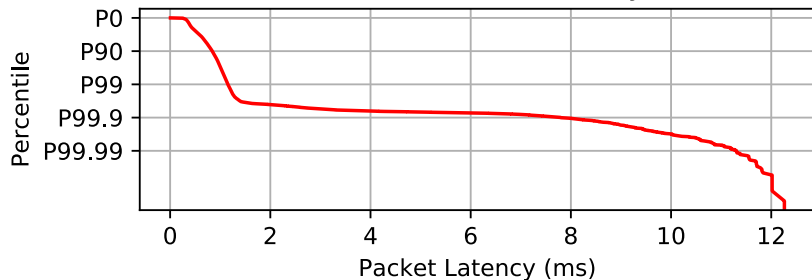


Downstream L4S (DOCSIS & AppleQUIC)

Latency Timeseries



CCDF of Packet Latency



Packet Delay Statistics

P0	0.006 ms
P90	0.841 ms
P99	1.154 ms
P99.9	7.800 ms
Drops	96 Packets
Missing	86 Packets

Data Rate Statistics

Mean data rate	199.4 Mbps
P10 of data rate	199.1 Mbps
P10 % of mean	99.8%
Ramp time to 90%	100 ms

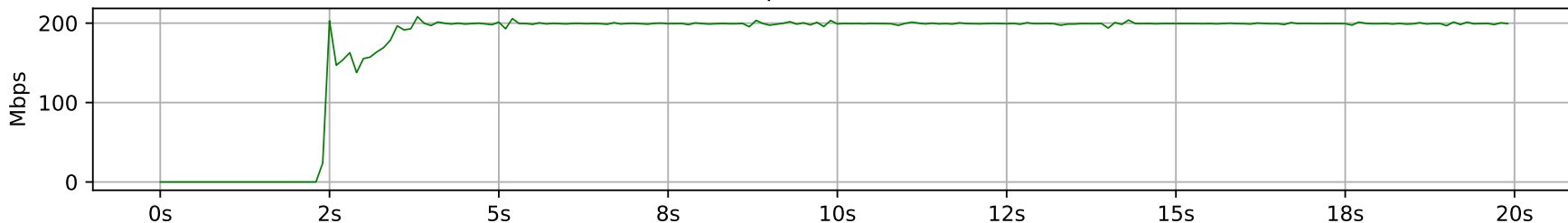
PDV Statistics

P99	1.148 ms
P99.9	7.794 ms

DSCP and ECN Counts

DSCP 43	322777
DSCP 3	1
ECT1	320048
Not ECT	1
CE	2729
Total	322778

Mbps Timeseries



Participating Organizations (15)

Apple

CableLabs

Casa

Charter

Comcast

Commscope

Google

Independent

Kyrio

Meta

Nokia

Netapp

Netflix

NVIDIA

ETH Zurich

Participants (32)

Shamim Akhtar

Radhouan Allani

Chris Box

Bob Briscoe

Justin Cardones

Neal Cardwell

Chia-Yu Chang

Stuart Cheshire

Koen De Schepper

Glenn Deen

Wesley Eddy

Bilgehan Erman

Vidhi Goel

Edward Grinshpun

Milap Rajeshkumar Joshi

Carl Klatsky

Jason Livingood

Colin McIntosh

Charles Moyer

Murat Mugan

Sebnem Ozer

Ram Ranganathan

Nicola Rustignoli

Dan Rice

Ermin Sakic

Richard Scheffenegger

Greg White

Max White

Guoye Zhang

Hongbiao Zhang

Shawn Zhang

Lei Zhou