Pantheon Report

Generated at 2018-08-31 10:03:57 (UTC).

Data path: Mexico on `em1` (*remote*) →AWS California 2 on `ens5` (*local*).

Repeated the test of 4 congestion control schemes 3 times.

Each test lasted for 30 seconds running 3 flows with 10-second interval between two flows.

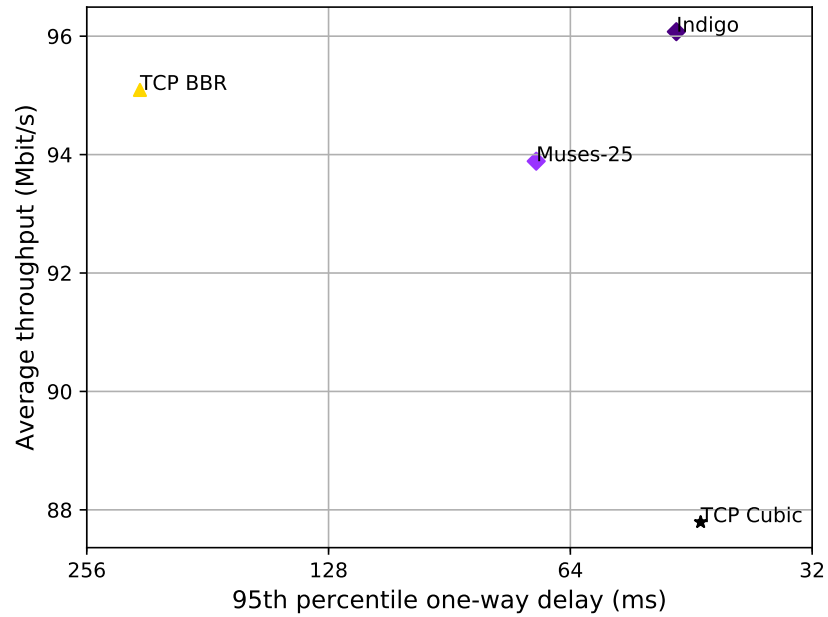NTP offsets were measured against `time.stanford.edu` and have been applied to correct the timestamps in logs.

```
System info:
Linux 4.15.0-1020-aws
net.core.default_qdisc = fq
net.core.rmem_default = 16777216
net.core.rmem_max = 536870912
net.core.wmem_default = 16777216
net.core.wmem_max = 536870912
net.ipv4.tcp_rmem = 4096 16777216 536870912
net.ipv4.tcp_wmem = 4096 16777216 536870912
net.ipv4.tcp_mem = 536870912 536870912 536870912
```
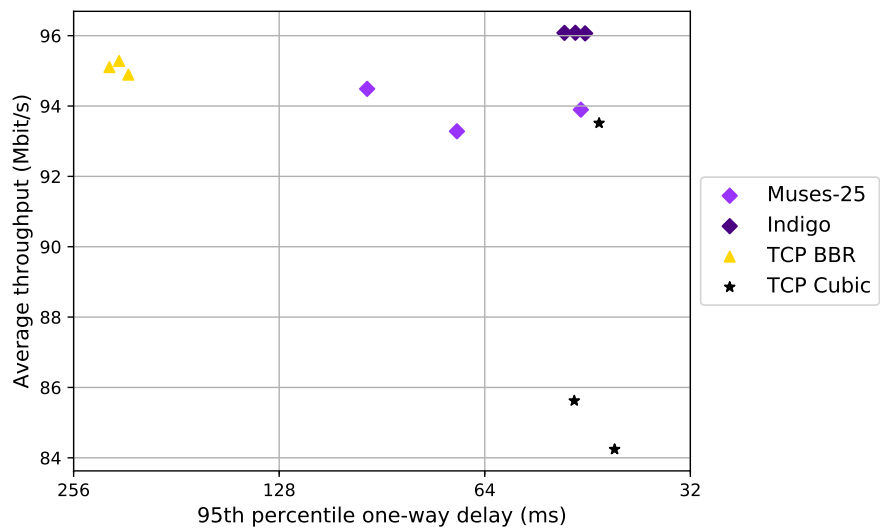
```
Git summary:
branch: muses @ e3c5aa19ca94c3066828fb83f16a8fb6b2731e7a
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436dbd4b834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbdfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0ecdbf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ b59e0d118c50af3579569c462d33045741c85981
third_party/pantheon-tunnel @ cbfce6db5ff5740dafe1771f813cd646339e1952
third_party/pcc @ 1afc958fa0d66d18b623c091a55fec872b4981e1
 M receiver/src/buffer.h
 M receiver/src/core.cpp
 M sender/src/buffer.h
 M sender/src/core.cpp
third_party/pcc-experimental @ cd43e34e3f5f5613e8acd08fab92c4eb24f974ab
third_party/proto-quic @ 77961f1a82733a86b42f1bc8143ebc978f3cff42
third_party/scream-reproduce @ f099118d1421aa3131bf11ff1964974e1da3bdb2
 M src/ScreamClient
 M src/ScreamServer
third_party/sprout @ 366e35c6178b01e31d4a46ad18c74f9415f19a26
third_party/verus @ d4b447ea74c6c60a261149af2629562939f9a494
 M src/verus.hpp
 M tools/plot.py
third_party/vivace @ 2baf86211435ae071a32f96b7d8c504587f5d7f4
third_party/webrtc @ 3f0cc2a9061a41b6f9dde4735770d143a1fa2851
```

test from Mexico to AWS California 2, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

test from Mexico to AWS California 2, 3 runs of 30s each per scheme
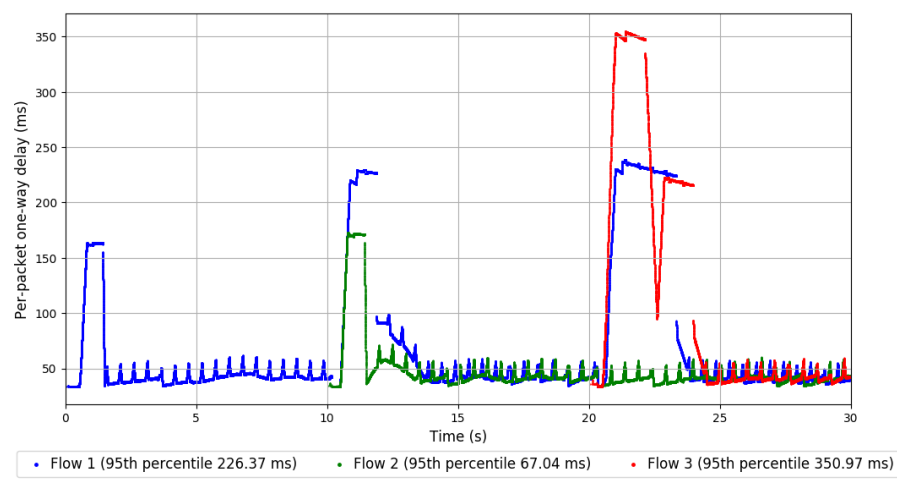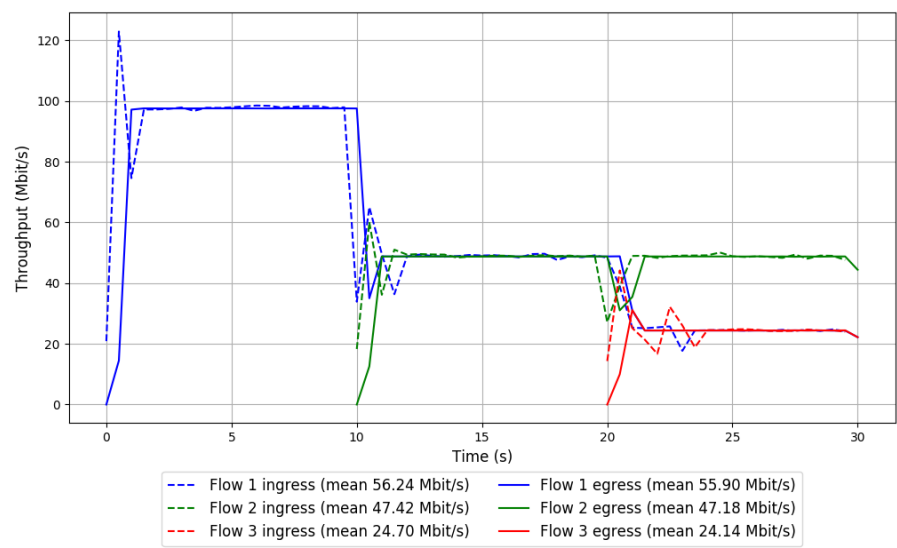3 flows with 10s interval between flows

scheme	# runs	mean avg tput (Mbit/s)			mean 95th-%ile delay (ms)			mean loss rate (%)		
		flow 1	flow 2	flow 3	flow 1	flow 2	flow 3	flow 1	flow 2	flow 3
TCP BBR	3	55.61	39.66	39.56	224.47	166.36	279.78	0.76	0.99	2.15
TCP Cubic	3	51.73	36.13	36.28	46.26	41.27	46.44	0.16	0.26	0.73
Indigo	3	59.01	40.17	31.67	47.48	47.24	45.81	0.22	0.40	0.74
Muses-25	3	57.20	38.86	32.91	43.06	82.99	90.70	0.19	0.28	0.70

```
Run 1: Statistics of TCP BBR

Start at: 2018-08-31 09:50:19
End at: 2018-08-31 09:50:49
Local clock offset: -9.81 ms
Remote clock offset: -0.821 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.28 Mbit/s
95th percentile per-packet one-way delay: 219.608 ms
Loss rate: 1.00%
-- Flow 1:
Average throughput: 55.90 Mbit/s
95th percentile per-packet one-way delay: 226.369 ms
Loss rate: 0.81%
-- Flow 2:
Average throughput: 47.18 Mbit/s
95th percentile per-packet one-way delay: 67.038 ms
Loss rate: 0.84%
-- Flow 3:
Average throughput: 24.14 Mbit/s
95th percentile per-packet one-way delay: 350.968 ms
Loss rate: 2.90%
```

Run 1: Report of TCP BBR — Data Link

Flow 1 ingress (mean 56.24 Mbit/s) --- Flow 1 egress (mean 55.90 Mbit/s)
Flow 2 ingress (mean 47.42 Mbit/s) --- Flow 2 egress (mean 47.18 Mbit/s)
Flow 3 ingress (mean 24.70 Mbit/s) --- Flow 3 egress (mean 24.14 Mbit/s)

Flow 1 (95th percentile 226.37 ms)   Flow 2 (95th percentile 67.04 ms)   Flow 3 (95th percentile 350.97 ms)

5

```
Run 2: Statistics of TCP BBR

Start at: 2018-08-31 09:55:45
End at: 2018-08-31 09:56:15
Local clock offset: -9.38 ms
Remote clock offset: -0.797 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.11 Mbit/s
95th percentile per-packet one-way delay: 226.907 ms
Loss rate: 1.09%
-- Flow 1:
Average throughput: 55.52 Mbit/s
95th percentile per-packet one-way delay: 226.143 ms
Loss rate: 0.80%
-- Flow 2:
Average throughput: 35.90 Mbit/s
95th percentile per-packet one-way delay: 215.317 ms
Loss rate: 1.19%
-- Flow 3:
Average throughput: 47.40 Mbit/s
95th percentile per-packet one-way delay: 315.478 ms
Loss rate: 1.97%
```
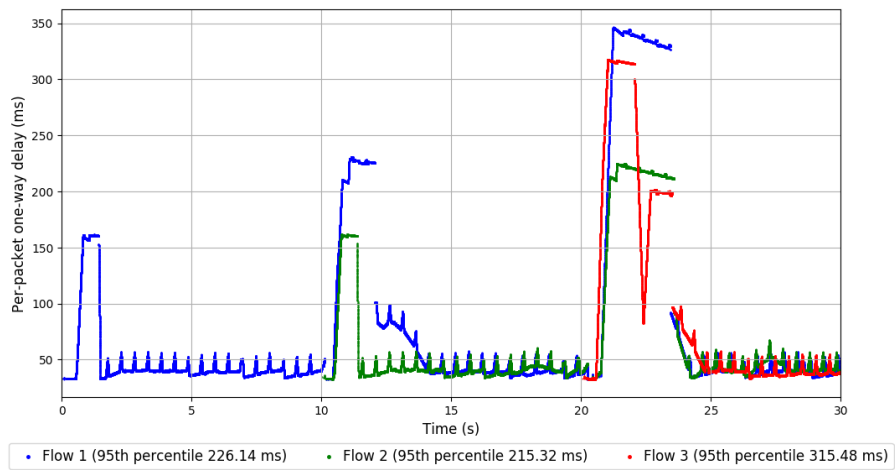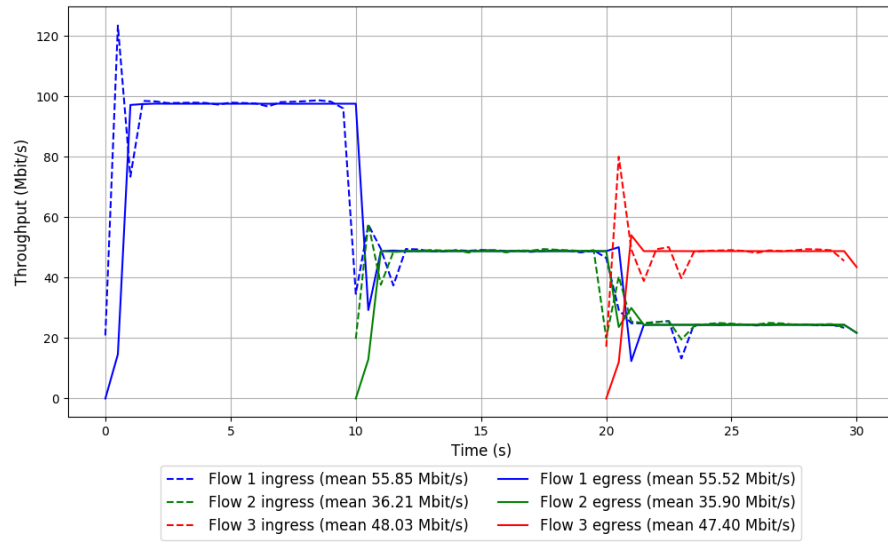
Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 55.85 Mbit/s) ----- Flow 1 egress (mean 55.52 Mbit/s)
Flow 2 ingress (mean 36.21 Mbit/s) ----- Flow 2 egress (mean 35.90 Mbit/s)
Flow 3 ingress (mean 48.03 Mbit/s) ----- Flow 3 egress (mean 47.40 Mbit/s)

Flow 1 (95th percentile 226.14 ms)　Flow 2 (95th percentile 215.32 ms)　Flow 3 (95th percentile 315.48 ms)
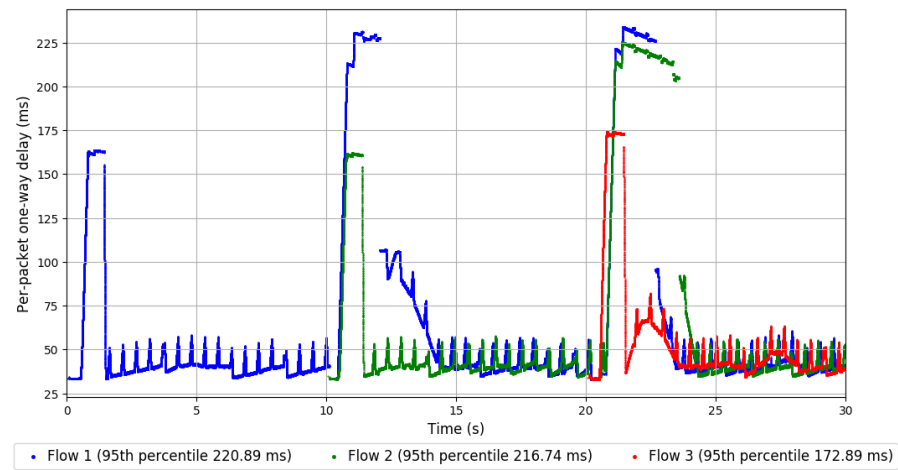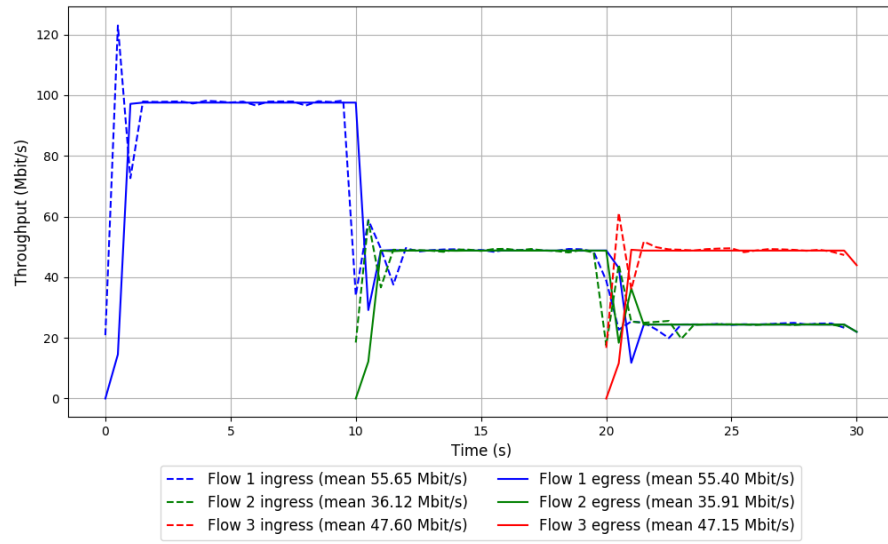
```
Run 3: Statistics of TCP BBR

Start at: 2018-08-31 10:01:11
End at: 2018-08-31 10:01:41
Local clock offset: -4.392 ms
Remote clock offset: -0.814 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 94.89 Mbit/s
95th percentile per-packet one-way delay: 212.839 ms
Loss rate: 0.89%
-- Flow 1:
Average throughput: 55.40 Mbit/s
95th percentile per-packet one-way delay: 220.893 ms
Loss rate: 0.67%
-- Flow 2:
Average throughput: 35.91 Mbit/s
95th percentile per-packet one-way delay: 216.738 ms
Loss rate: 0.93%
-- Flow 3:
Average throughput: 47.15 Mbit/s
95th percentile per-packet one-way delay: 172.893 ms
Loss rate: 1.58%
```

Run 3: Report of TCP BBR — Data Link

Flow 1 ingress (mean 55.65 Mbit/s) --- Flow 1 egress (mean 55.40 Mbit/s)
Flow 2 ingress (mean 36.12 Mbit/s) --- Flow 2 egress (mean 35.91 Mbit/s)
Flow 3 ingress (mean 47.60 Mbit/s) --- Flow 3 egress (mean 47.15 Mbit/s)

Flow 1 (95th percentile 220.89 ms) · Flow 2 (95th percentile 216.74 ms) · Flow 3 (95th percentile 172.89 ms)
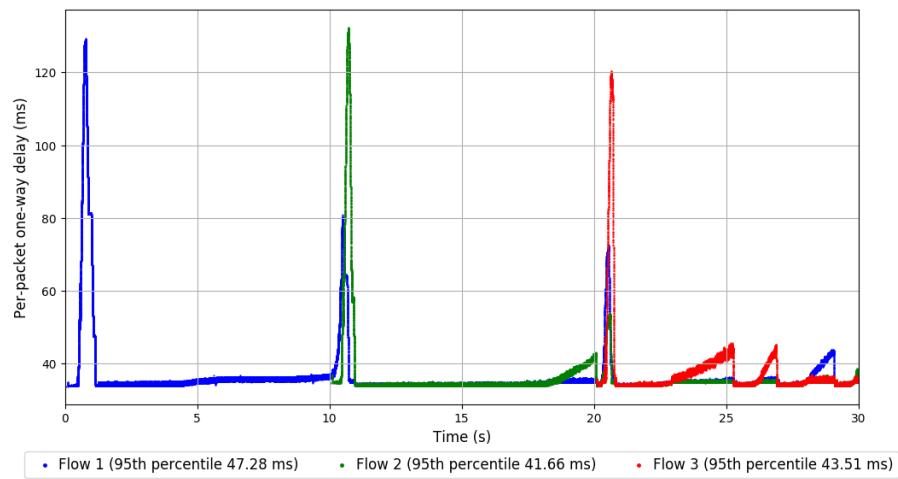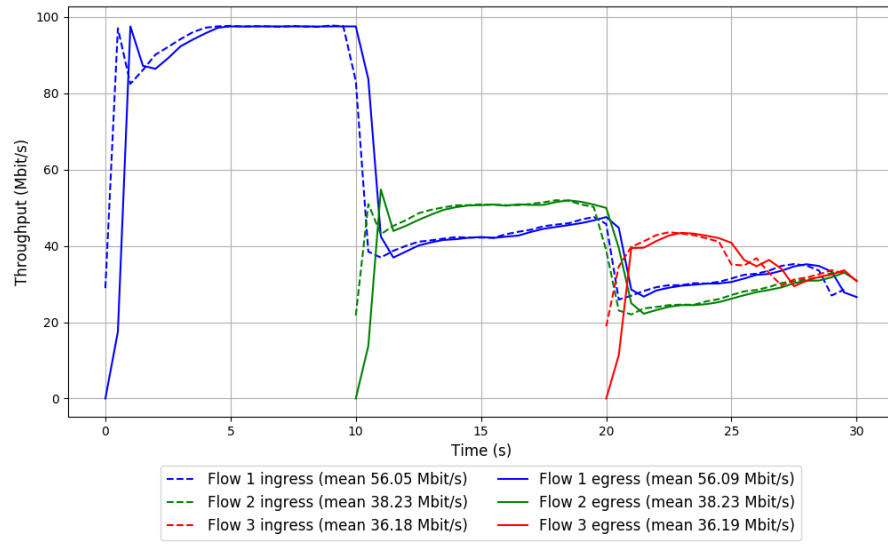
9

```
Run 1: Statistics of TCP Cubic

Start at: 2018-08-31 09:47:37
End at: 2018-08-31 09:48:07
Local clock offset: -9.066 ms
Remote clock offset: -1.039 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 93.51 Mbit/s
95th percentile per-packet one-way delay: 43.525 ms
Loss rate: 0.25%
-- Flow 1:
Average throughput: 56.09 Mbit/s
95th percentile per-packet one-way delay: 47.284 ms
Loss rate: 0.13%
-- Flow 2:
Average throughput: 38.23 Mbit/s
95th percentile per-packet one-way delay: 41.662 ms
Loss rate: 0.32%
-- Flow 3:
Average throughput: 36.19 Mbit/s
95th percentile per-packet one-way delay: 43.509 ms
Loss rate: 0.63%
```

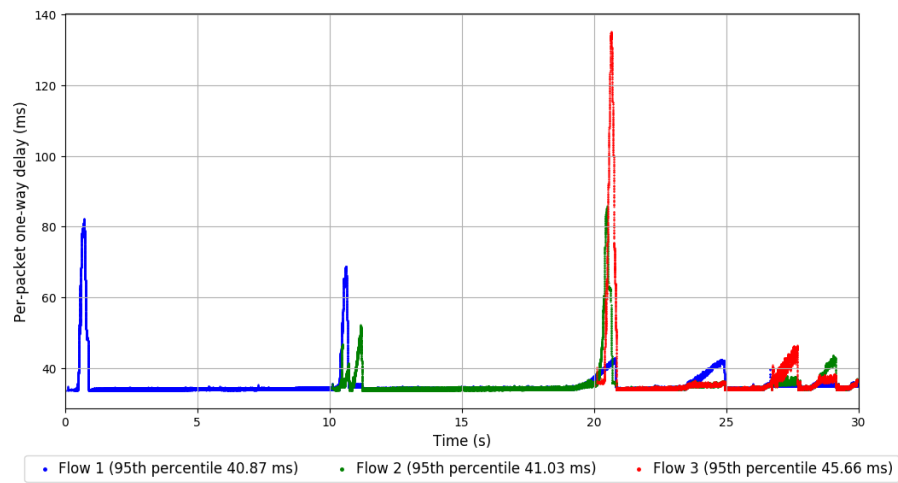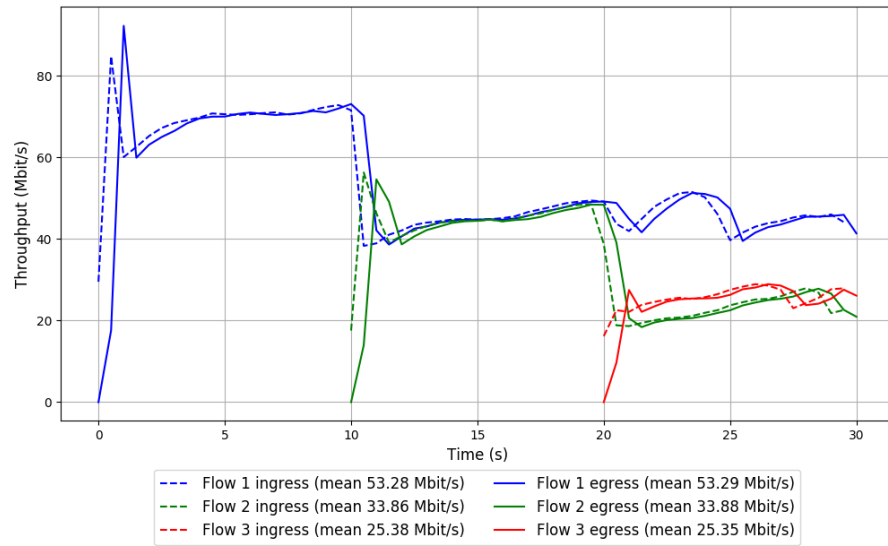Run 1: Report of TCP Cubic — Data Link

```
Run 2: Statistics of TCP Cubic

Start at: 2018-08-31 09:53:03
End at: 2018-08-31 09:53:33
Local clock offset: -10.527 ms
Remote clock offset: -0.827 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 84.24 Mbit/s
95th percentile per-packet one-way delay: 41.315 ms
Loss rate: 0.27%
-- Flow 1:
Average throughput: 53.29 Mbit/s
95th percentile per-packet one-way delay: 40.871 ms
Loss rate: 0.19%
-- Flow 2:
Average throughput: 33.88 Mbit/s
95th percentile per-packet one-way delay: 41.026 ms
Loss rate: 0.25%
-- Flow 3:
Average throughput: 25.35 Mbit/s
95th percentile per-packet one-way delay: 45.663 ms
Loss rate: 0.80%
```
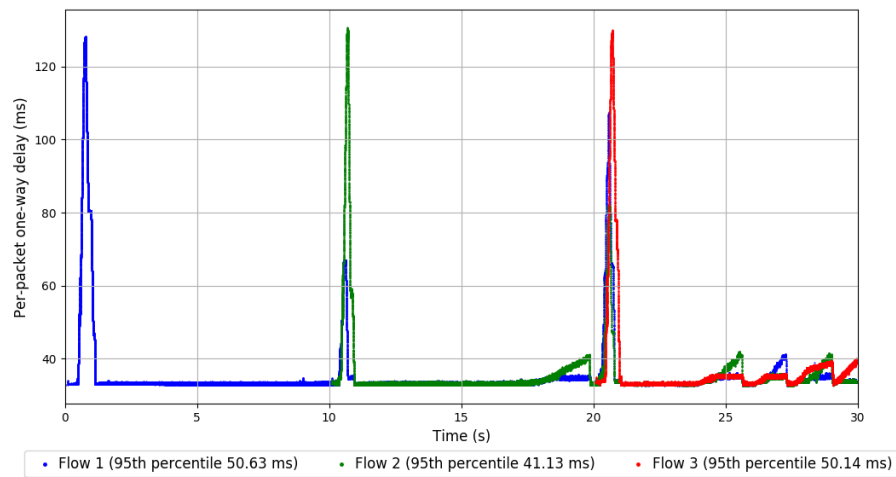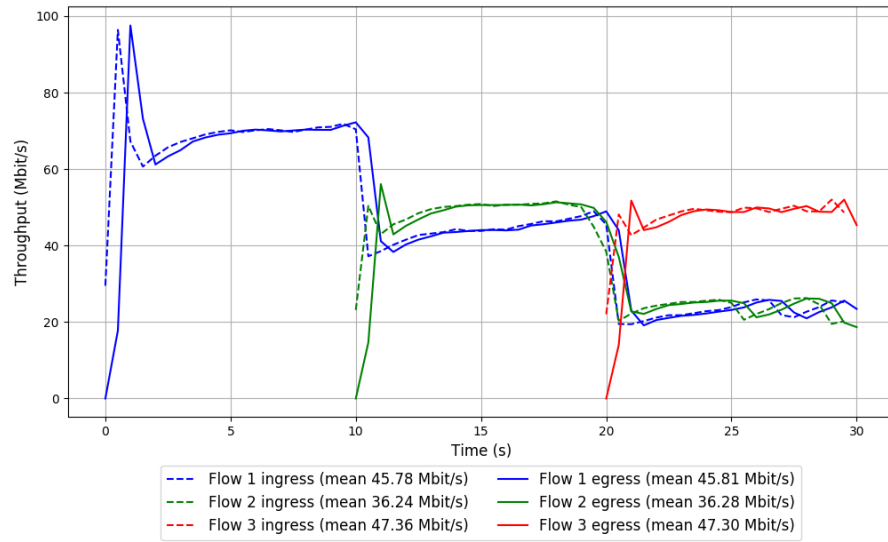
Run 2: Report of TCP Cubic — Data Link

```
Run 3: Statistics of TCP Cubic

Start at: 2018-08-31 09:58:29
End at: 2018-08-31 09:58:59
Local clock offset: -6.4 ms
Remote clock offset: -0.758 ms


# Below is generated by plot.py at 2018-08-31 10:03:15
# Datalink statistics
-- Total of 3 flows:
Average throughput: 85.62 Mbit/s
95th percentile per-packet one-way delay: 47.326 ms
Loss rate: 0.28%
-- Flow 1:
Average throughput: 45.81 Mbit/s
95th percentile per-packet one-way delay: 50.632 ms
Loss rate: 0.15%
-- Flow 2:
Average throughput: 36.28 Mbit/s
95th percentile per-packet one-way delay: 41.126 ms
Loss rate: 0.22%
-- Flow 3:
Average throughput: 47.30 Mbit/s
95th percentile per-packet one-way delay: 50.143 ms
Loss rate: 0.77%
```

Run 3: Report of TCP Cubic — Data Link

- - - - Flow 1 ingress (mean 45.78 Mbit/s) ——— Flow 1 egress (mean 45.81 Mbit/s)
- - - - Flow 2 ingress (mean 36.24 Mbit/s) ——— Flow 2 egress (mean 36.28 Mbit/s)
- - - - Flow 3 ingress (mean 47.36 Mbit/s) ——— Flow 3 egress (mean 47.30 Mbit/s)

• Flow 1 (95th percentile 50.63 ms)　　• Flow 2 (95th percentile 41.13 ms)　　• Flow 3 (95th percentile 50.14 ms)
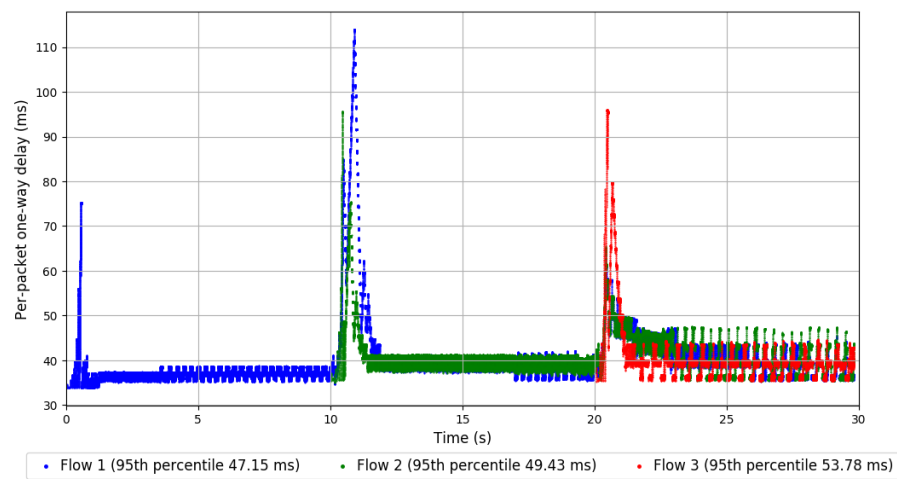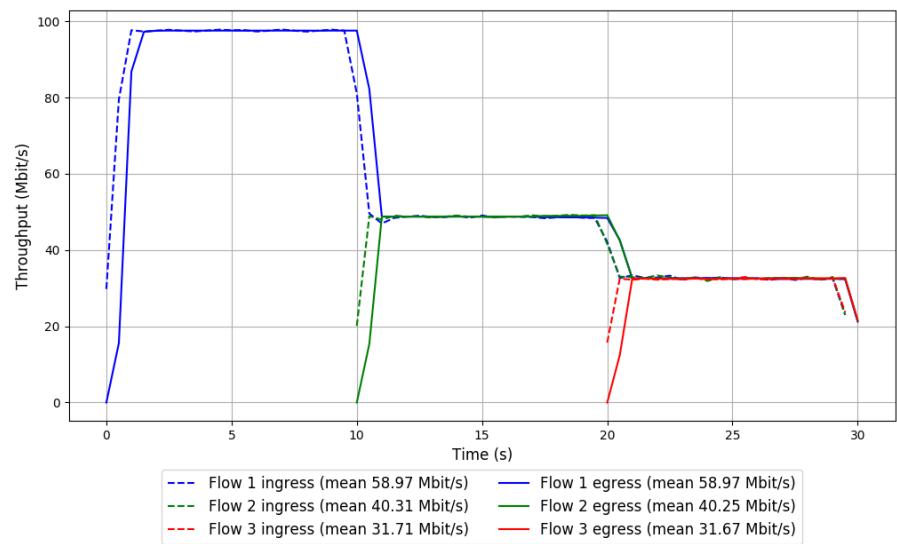
```
Run 1: Statistics of Indigo

Start at: 2018-08-31 09:46:15
End at: 2018-08-31 09:46:45
Local clock offset: -8.638 ms
Remote clock offset: -0.989 ms


# Below is generated by plot.py at 2018-08-31 10:03:16
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.08 Mbit/s
95th percentile per-packet one-way delay: 48.921 ms
Loss rate: 0.35%
-- Flow 1:
Average throughput: 58.97 Mbit/s
95th percentile per-packet one-way delay: 47.149 ms
Loss rate: 0.22%
-- Flow 2:
Average throughput: 40.25 Mbit/s
95th percentile per-packet one-way delay: 49.432 ms
Loss rate: 0.46%
-- Flow 3:
Average throughput: 31.67 Mbit/s
95th percentile per-packet one-way delay: 53.781 ms
Loss rate: 0.79%
```

Run 1: Report of Indigo — Data Link

Flow 1 ingress (mean 58.97 Mbit/s) --- Flow 1 egress (mean 58.97 Mbit/s)
Flow 2 ingress (mean 40.31 Mbit/s) --- Flow 2 egress (mean 40.25 Mbit/s)
Flow 3 ingress (mean 31.71 Mbit/s) --- Flow 3 egress (mean 31.67 Mbit/s)

Flow 1 (95th percentile 47.15 ms)   Flow 2 (95th percentile 49.43 ms)   Flow 3 (95th percentile 53.78 ms)
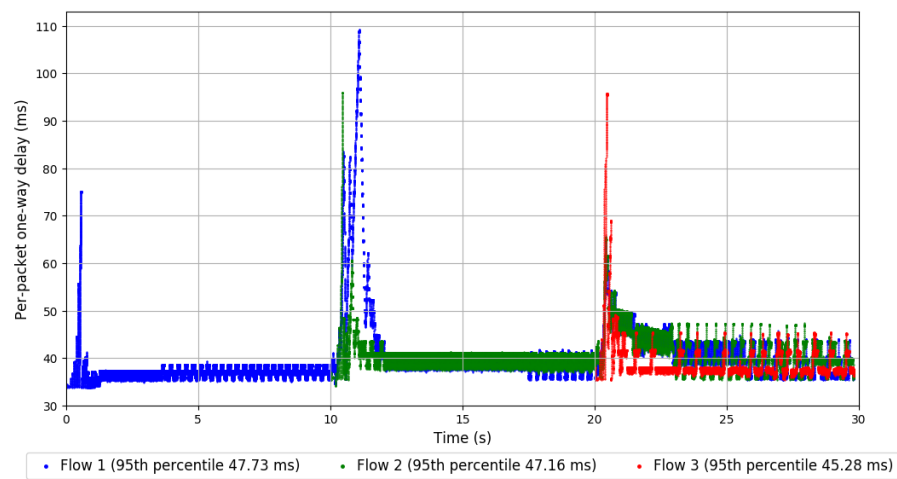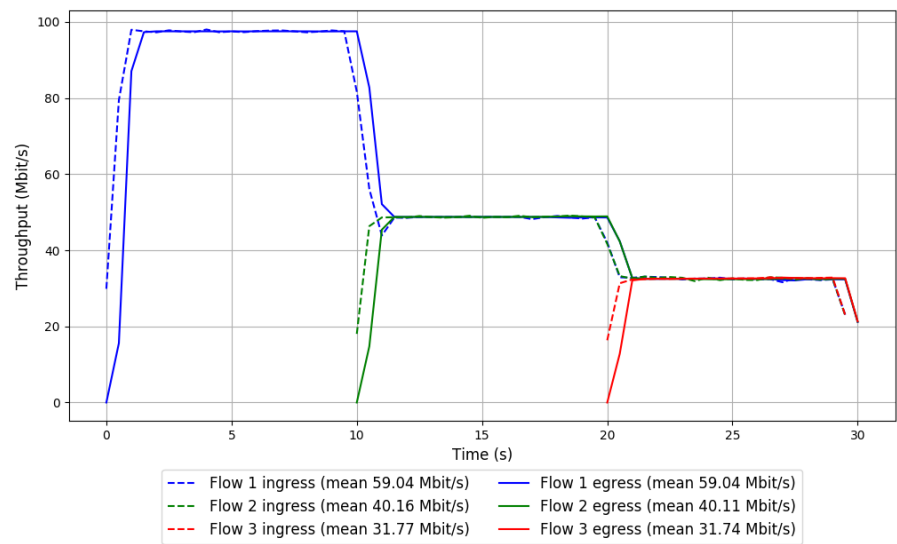
17

```
Run 2: Statistics of Indigo

Start at: 2018-08-31 09:51:41
End at: 2018-08-31 09:52:11
Local clock offset: -10.168 ms
Remote clock offset: -0.986 ms


# Below is generated by plot.py at 2018-08-31 10:03:16
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.08 Mbit/s
95th percentile per-packet one-way delay: 47.157 ms
Loss rate: 0.33%
-- Flow 1:
Average throughput: 59.04 Mbit/s
95th percentile per-packet one-way delay: 47.732 ms
Loss rate: 0.22%
-- Flow 2:
Average throughput: 40.11 Mbit/s
95th percentile per-packet one-way delay: 47.157 ms
Loss rate: 0.43%
-- Flow 3:
Average throughput: 31.74 Mbit/s
95th percentile per-packet one-way delay: 45.278 ms
Loss rate: 0.73%
```
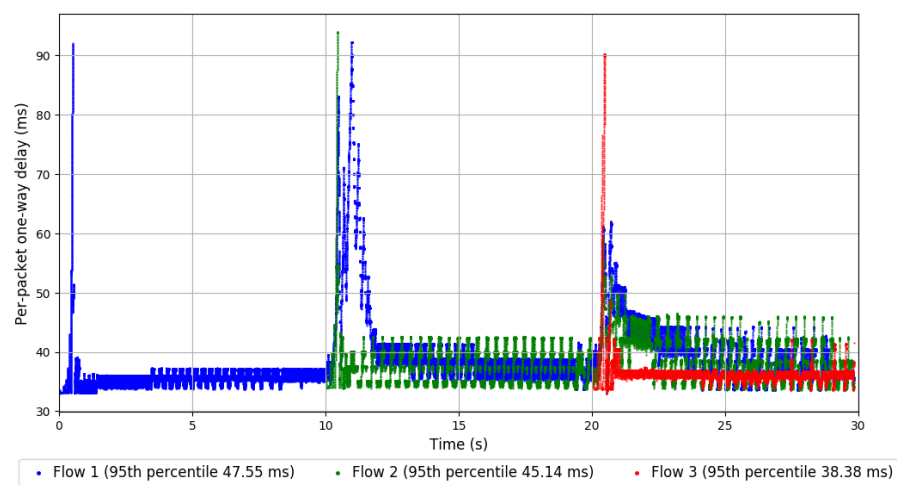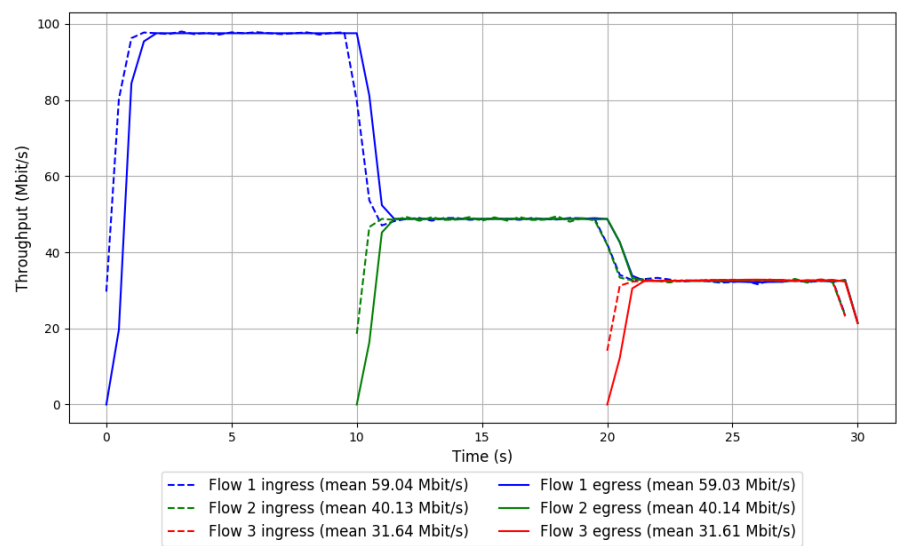
Run 2: Report of Indigo — Data Link

```
Run 3: Statistics of Indigo

Start at: 2018-08-31 09:57:07
End at: 2018-08-31 09:57:37
Local clock offset: -7.735 ms
Remote clock offset: -0.954 ms


# Below is generated by plot.py at 2018-08-31 10:03:42
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.07 Mbit/s
95th percentile per-packet one-way delay: 45.624 ms
Loss rate: 0.30%
-- Flow 1:
Average throughput: 59.03 Mbit/s
95th percentile per-packet one-way delay: 47.549 ms
Loss rate: 0.22%
-- Flow 2:
Average throughput: 40.14 Mbit/s
95th percentile per-packet one-way delay: 45.136 ms
Loss rate: 0.31%
-- Flow 3:
Average throughput: 31.61 Mbit/s
95th percentile per-packet one-way delay: 38.377 ms
Loss rate: 0.71%
```

Run 3: Report of Indigo — Data Link

Flow 1 ingress (mean 59.04 Mbit/s)   Flow 1 egress (mean 59.03 Mbit/s)
Flow 2 ingress (mean 40.13 Mbit/s)   Flow 2 egress (mean 40.14 Mbit/s)
Flow 3 ingress (mean 31.64 Mbit/s)   Flow 3 egress (mean 31.61 Mbit/s)

Flow 1 (95th percentile 47.55 ms)   Flow 2 (95th percentile 45.14 ms)   Flow 3 (95th percentile 38.38 ms)
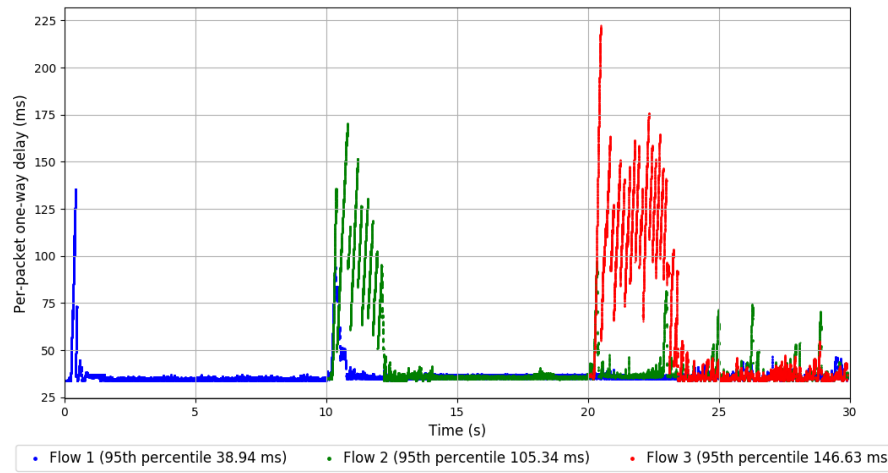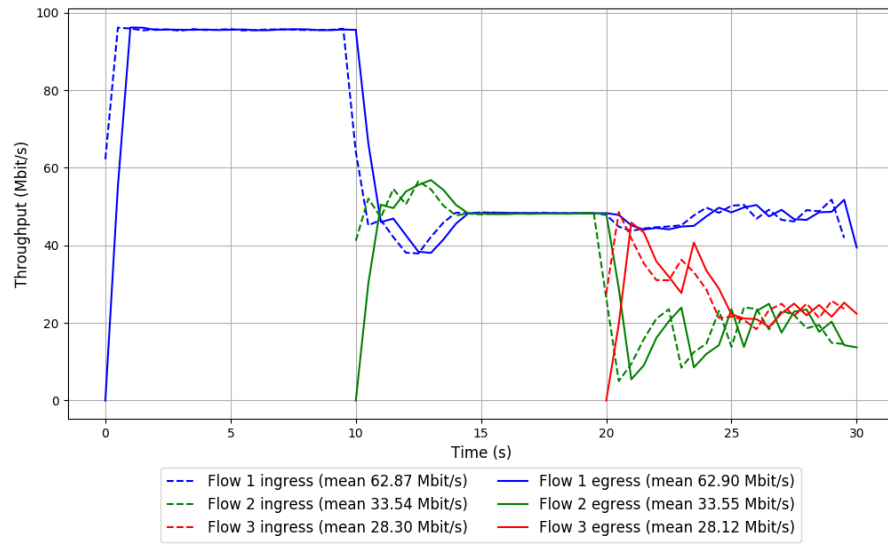
```
Run 1: Statistics of Muses-25

Start at: 2018-08-31 09:48:58
End at: 2018-08-31 09:49:28
Local clock offset: -9.327 ms
Remote clock offset: -0.832 ms


# Below is generated by plot.py at 2018-08-31 10:03:54
# Datalink statistics
-- Total of 3 flows:
Average throughput: 94.49 Mbit/s
95th percentile per-packet one-way delay: 95.158 ms
Loss rate: 0.30%
-- Flow 1:
Average throughput: 62.90 Mbit/s
95th percentile per-packet one-way delay: 38.941 ms
Loss rate: 0.17%
-- Flow 2:
Average throughput: 33.55 Mbit/s
95th percentile per-packet one-way delay: 105.336 ms
Loss rate: 0.29%
-- Flow 3:
Average throughput: 28.12 Mbit/s
95th percentile per-packet one-way delay: 146.628 ms
Loss rate: 1.25%
```

Run 1: Report of Muses-25 — Data Link

Flow 1 ingress (mean 62.87 Mbit/s) — Flow 1 egress (mean 62.90 Mbit/s)
Flow 2 ingress (mean 33.54 Mbit/s) — Flow 2 egress (mean 33.55 Mbit/s)
Flow 3 ingress (mean 28.30 Mbit/s) — Flow 3 egress (mean 28.12 Mbit/s)

Flow 1 (95th percentile 38.94 ms) • Flow 2 (95th percentile 105.34 ms) • Flow 3 (95th percentile 146.63 ms)
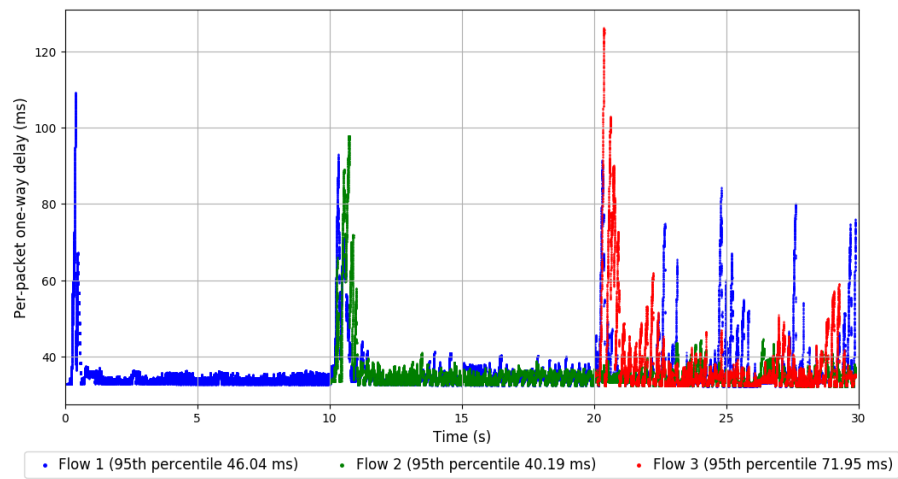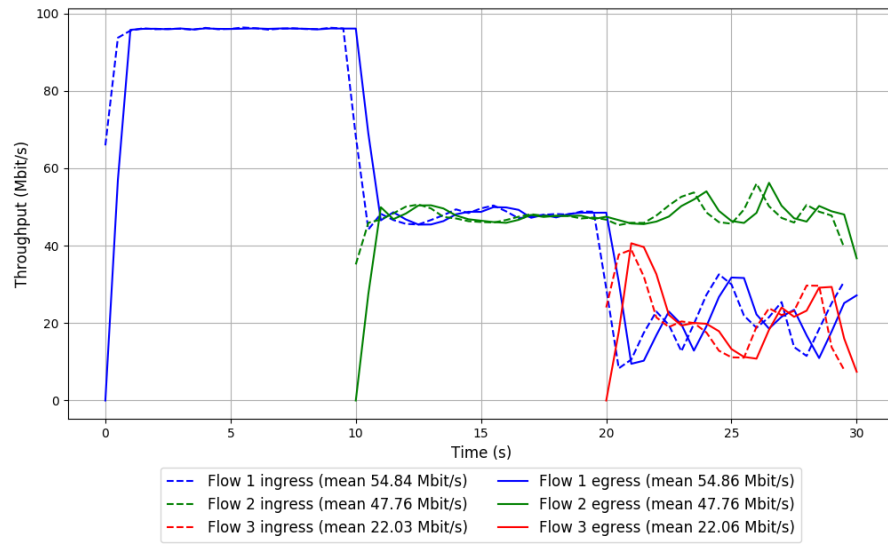
23

```
Run 2: Statistics of Muses-25

Start at: 2018-08-31 09:54:24
End at: 2018-08-31 09:54:54
Local clock offset: -10.997 ms
Remote clock offset: -0.726 ms

# Below is generated by plot.py at 2018-08-31 10:03:56
# Datalink statistics
-- Total of 3 flows:
Average throughput: 93.90 Mbit/s
95th percentile per-packet one-way delay: 46.289 ms
Loss rate: 0.22%
-- Flow 1:
Average throughput: 54.86 Mbit/s
95th percentile per-packet one-way delay: 46.039 ms
Loss rate: 0.16%
-- Flow 2:
Average throughput: 47.76 Mbit/s
95th percentile per-packet one-way delay: 40.192 ms
Loss rate: 0.32%
-- Flow 3:
Average throughput: 22.06 Mbit/s
95th percentile per-packet one-way delay: 71.947 ms
Loss rate: 0.24%
```

Run 2: Report of Muses-25 — Data Link

Flow 1 ingress (mean 54.84 Mbit/s) ---- Flow 1 egress (mean 54.86 Mbit/s)
Flow 2 ingress (mean 47.76 Mbit/s) ---- Flow 2 egress (mean 47.76 Mbit/s)
Flow 3 ingress (mean 22.03 Mbit/s) ---- Flow 3 egress (mean 22.06 Mbit/s)

Flow 1 (95th percentile 46.04 ms)   Flow 2 (95th percentile 40.19 ms)   Flow 3 (95th percentile 71.95 ms)

```
Run 3: Statistics of Muses-25

Start at: 2018-08-31 09:59:49
End at: 2018-08-31 10:00:19
Local clock offset: -5.168 ms
Remote clock offset: -0.68 ms


# Below is generated by plot.py at 2018-08-31 10:03:56
# Datalink statistics
-- Total of 3 flows:
Average throughput: 93.28 Mbit/s
95th percentile per-packet one-way delay: 70.298 ms
Loss rate: 0.30%
-- Flow 1:
Average throughput: 53.83 Mbit/s
95th percentile per-packet one-way delay: 44.187 ms
Loss rate: 0.23%
-- Flow 2:
Average throughput: 35.27 Mbit/s
95th percentile per-packet one-way delay: 103.451 ms
Loss rate: 0.24%
-- Flow 3:
Average throughput: 48.56 Mbit/s
95th percentile per-packet one-way delay: 53.523 ms
Loss rate: 0.62%
```

Run 3: Report of Muses-25 — Data Link

Flow 1 ingress (mean 53.84 Mbit/s)   Flow 1 egress (mean 53.83 Mbit/s)
Flow 2 ingress (mean 35.24 Mbit/s)   Flow 2 egress (mean 35.27 Mbit/s)
Flow 3 ingress (mean 48.55 Mbit/s)   Flow 3 egress (mean 48.56 Mbit/s)

Flow 1 (95th percentile 44.19 ms)   Flow 2 (95th percentile 103.45 ms)   Flow 3 (95th percentile 53.52 ms)

27