Pantheon Report

Generated at 2018-09-05 22:43:38 (UTC).

Data path: India on em1 (*remote*) →AWS India 1 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.

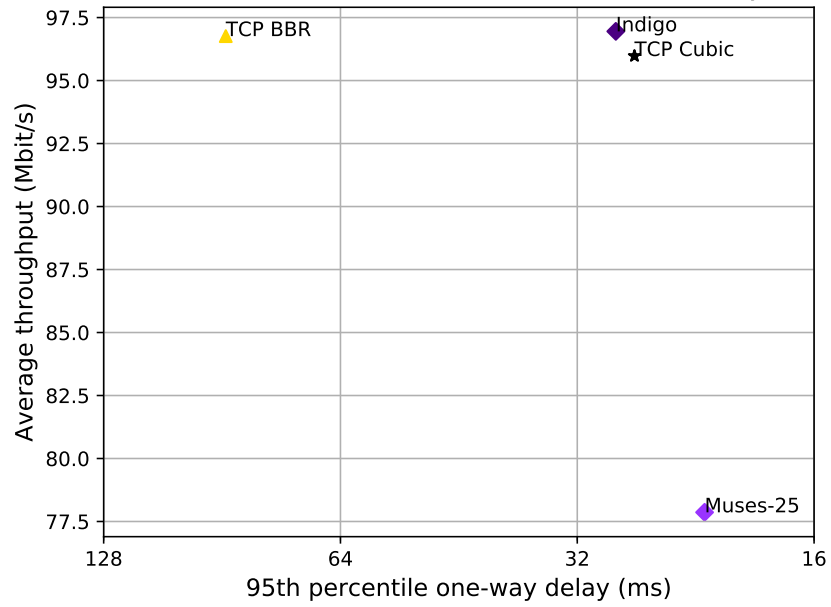NTP offsets were measured against `nets.org.sg` and have been applied to correct the timestamps in logs.

```
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
```
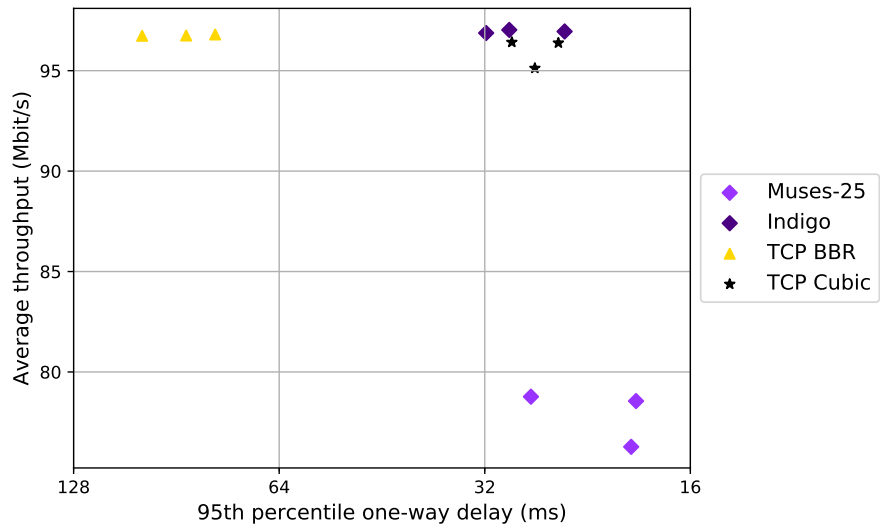
```
Git summary:
branch: muses @ 18b9165265c8ba2915c862e8713fd9ad82c1ac21
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436dbd4b834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbdfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0ecdbf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ a28d20fb82a95a965a3da65fd1eb71b8994e9b84
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 India to AWS India 1, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

TCP BBR

Indigo
TCP Cubic

Muses-25

Average throughput (Mbit/s)

95th percentile one-way delay (ms)

test from India to AWS India 1, 3 runs of 30s each per scheme
3 flows with 10s interval between flows

Average throughput (Mbit/s)

95th percentile one-way delay (ms)

- ◆ Muses-25
- ◆ Indigo
- ▲ TCP BBR
- ★ TCP Cubic

2

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	57.11	37.97	43.36	50.60	113.39	112.23	1.15	1.56	2.43
TCP Cubic	3	58.42	44.29	24.29	26.93	27.21	27.70	0.07	0.16	0.33
Indigo	3	61.24	39.13	29.52	25.53	27.31	29.11	0.07	0.13	0.60
Muses-25	3	44.75	29.49	40.85	21.34	22.36	25.10	0.03	0.10	0.26

```
Run 1: Statistics of TCP BBR

Start at: 2018-09-05 22:31:26
End at: 2018-09-05 22:31:56
Local clock offset: 3.65 ms
Remote clock offset: -2.228 ms


# Below is generated by plot.py at 2018-09-05 22:43:06
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.75 Mbit/s
95th percentile per-packet one-way delay: 87.578 ms
Loss rate: 1.28%
-- Flow 1:
Average throughput: 56.25 Mbit/s
95th percentile per-packet one-way delay: 51.206 ms
Loss rate: 0.93%
-- Flow 2:
Average throughput: 36.72 Mbit/s
95th percentile per-packet one-way delay: 115.334 ms
Loss rate: 1.88%
-- Flow 3:
Average throughput: 48.42 Mbit/s
95th percentile per-packet one-way delay: 85.071 ms
Loss rate: 1.57%
```

Run 1: Report of TCP BBR — Data Link

```
Run 2: Statistics of TCP BBR

Start at: 2018-09-05 22:36:11
End at: 2018-09-05 22:36:41
Local clock offset: 1.839 ms
Remote clock offset: -1.523 ms


# Below is generated by plot.py at 2018-09-05 22:43:06
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.74 Mbit/s
95th percentile per-packet one-way delay: 101.595 ms
Loss rate: 1.23%
-- Flow 1:
Average throughput: 56.22 Mbit/s
95th percentile per-packet one-way delay: 52.488 ms
Loss rate: 1.07%
-- Flow 2:
Average throughput: 36.66 Mbit/s
95th percentile per-packet one-way delay: 115.999 ms
Loss rate: 1.08%
-- Flow 3:
Average throughput: 48.57 Mbit/s
95th percentile per-packet one-way delay: 122.825 ms
Loss rate: 2.03%
```
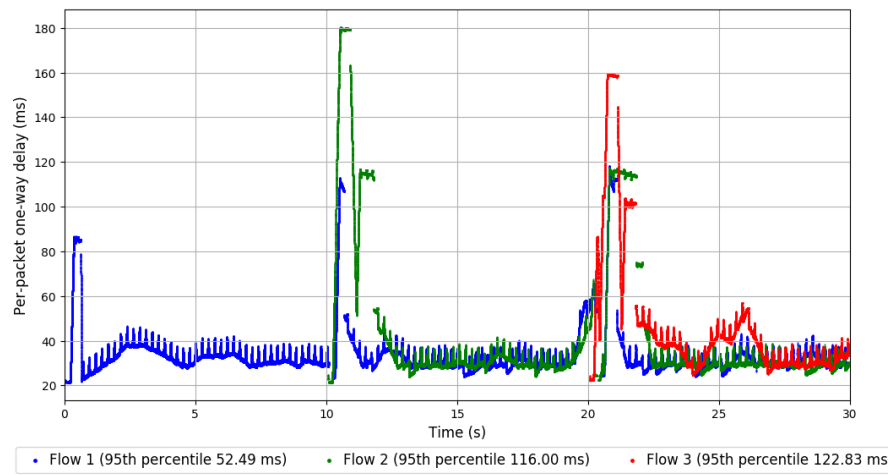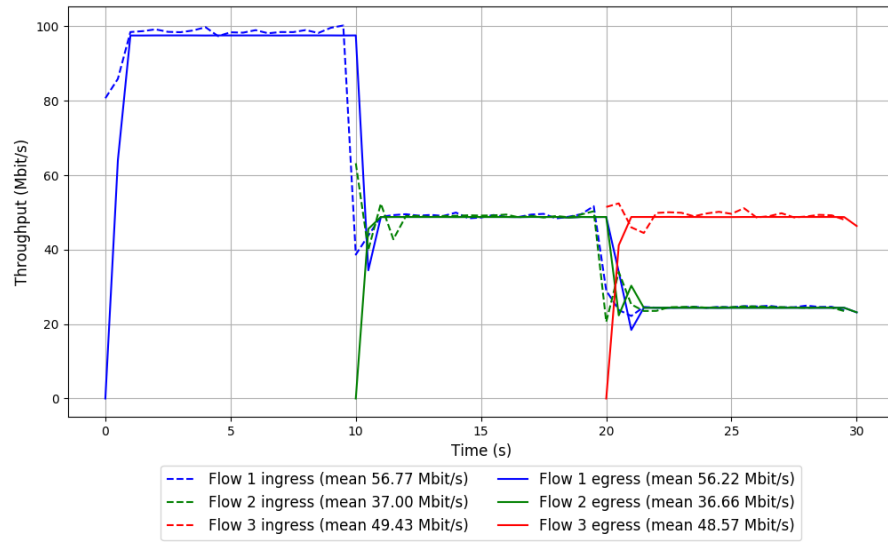
Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 56.77 Mbit/s)   Flow 1 egress (mean 56.22 Mbit/s)
Flow 2 ingress (mean 37.00 Mbit/s)   Flow 2 egress (mean 36.66 Mbit/s)
Flow 3 ingress (mean 49.43 Mbit/s)   Flow 3 egress (mean 48.57 Mbit/s)

Flow 1 (95th percentile 52.49 ms)   Flow 2 (95th percentile 116.00 ms)   Flow 3 (95th percentile 122.83 ms)
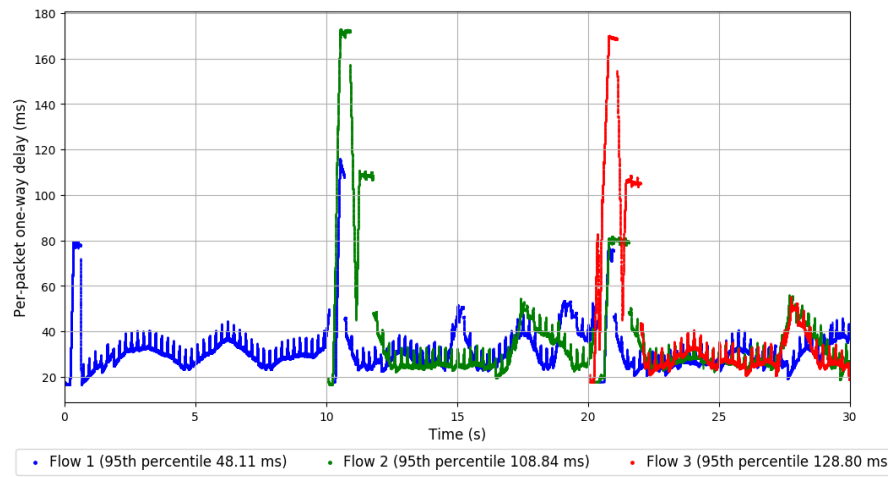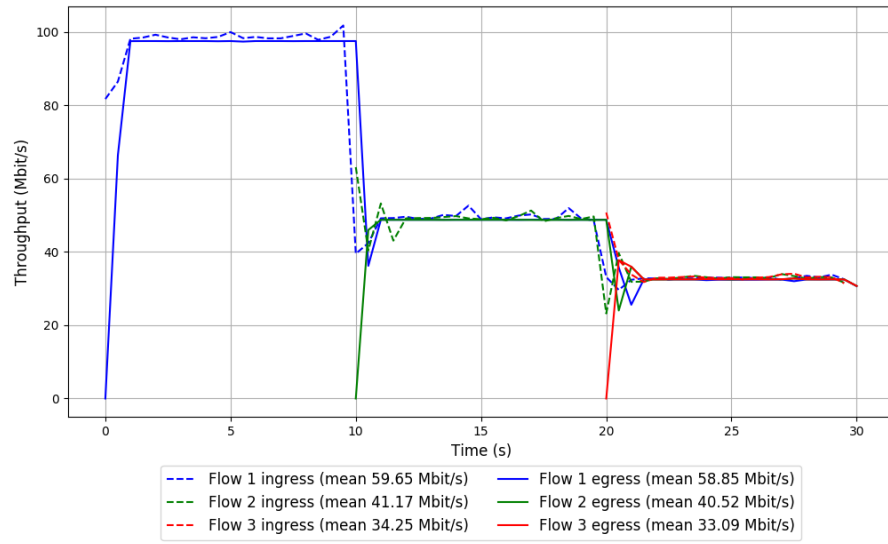
```
Run 3: Statistics of TCP BBR

Start at: 2018-09-05 22:40:57
End at: 2018-09-05 22:41:27
Local clock offset: -3.742 ms
Remote clock offset: -1.836 ms


# Below is generated by plot.py at 2018-09-05 22:43:07
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.80 Mbit/s
95th percentile per-packet one-way delay: 79.418 ms
Loss rate: 1.78%
-- Flow 1:
Average throughput: 58.85 Mbit/s
95th percentile per-packet one-way delay: 48.110 ms
Loss rate: 1.44%
-- Flow 2:
Average throughput: 40.52 Mbit/s
95th percentile per-packet one-way delay: 108.836 ms
Loss rate: 1.71%
-- Flow 3:
Average throughput: 33.09 Mbit/s
95th percentile per-packet one-way delay: 128.801 ms
Loss rate: 3.68%
```

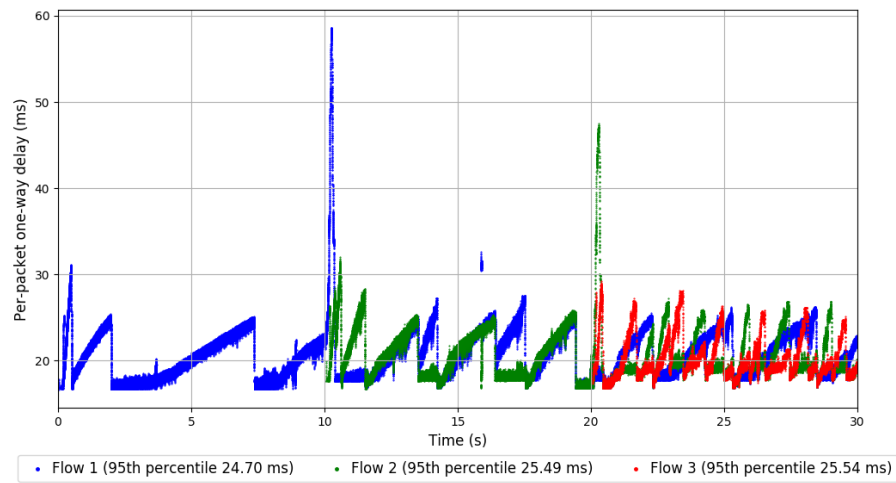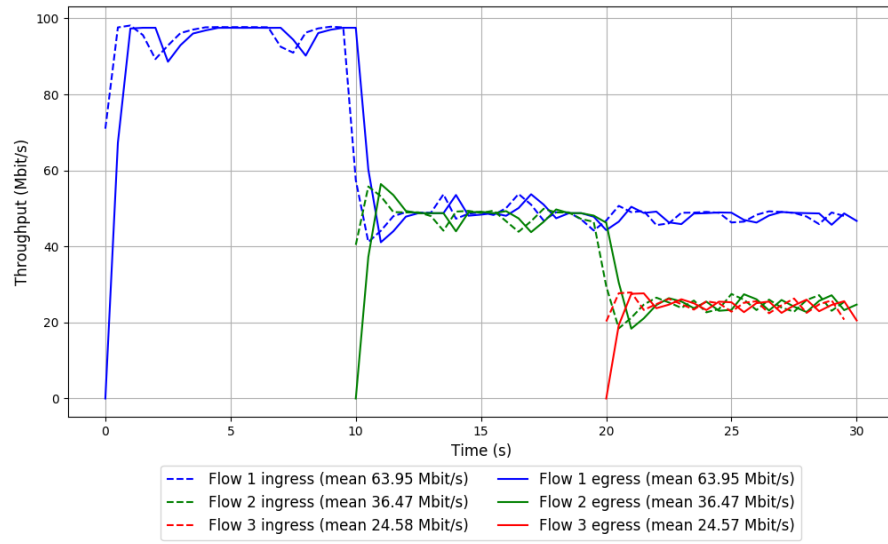# Run 3: Report of TCP BBR — Data Link

```
Run 1: Statistics of TCP Cubic

Start at: 2018-09-05 22:30:15
End at: 2018-09-05 22:30:45
Local clock offset: -1.169 ms
Remote clock offset: -1.406 ms


# Below is generated by plot.py at 2018-09-05 22:43:07
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.38 Mbit/s
95th percentile per-packet one-way delay: 24.965 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 63.95 Mbit/s
95th percentile per-packet one-way delay: 24.696 ms
Loss rate: 0.09%
-- Flow 2:
Average throughput: 36.47 Mbit/s
95th percentile per-packet one-way delay: 25.494 ms
Loss rate: 0.14%
-- Flow 3:
Average throughput: 24.57 Mbit/s
95th percentile per-packet one-way delay: 25.537 ms
Loss rate: 0.31%
```

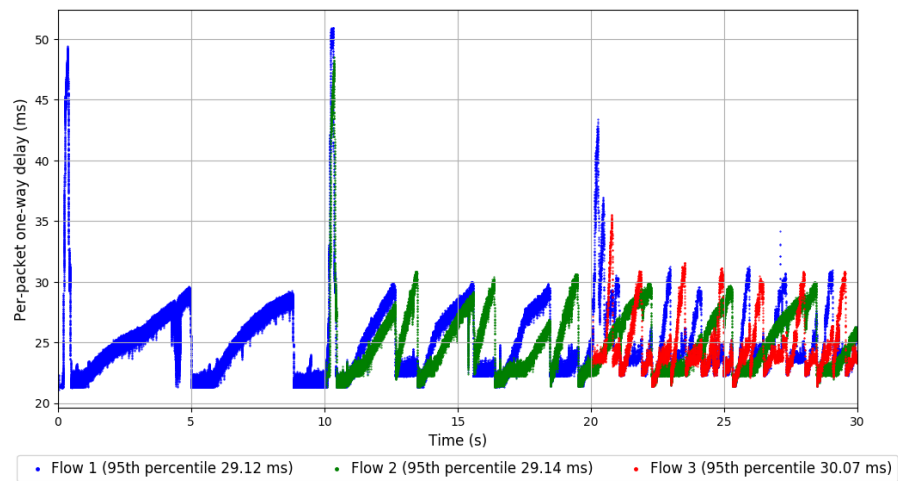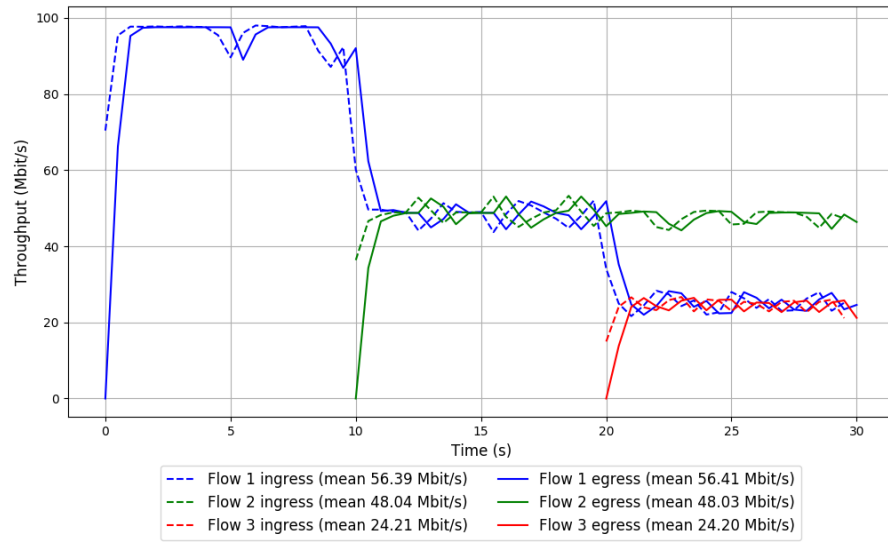Run 1: Report of TCP Cubic — Data Link

```
Run 2: Statistics of TCP Cubic

Start at: 2018-09-05 22:35:00
End at: 2018-09-05 22:35:30
Local clock offset: 2.512 ms
Remote clock offset: -0.909 ms


# Below is generated by plot.py at 2018-09-05 22:43:07
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.42 Mbit/s
95th percentile per-packet one-way delay: 29.210 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 56.41 Mbit/s
95th percentile per-packet one-way delay: 29.116 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 48.03 Mbit/s
95th percentile per-packet one-way delay: 29.141 ms
Loss rate: 0.18%
-- Flow 3:
Average throughput: 24.20 Mbit/s
95th percentile per-packet one-way delay: 30.071 ms
Loss rate: 0.33%
```

Run 2: Report of TCP Cubic — Data Link

- - - - Flow 1 ingress (mean 56.39 Mbit/s)   —— Flow 1 egress (mean 56.41 Mbit/s)
- - - - Flow 2 ingress (mean 48.04 Mbit/s)   —— Flow 2 egress (mean 48.03 Mbit/s)
- - - - Flow 3 ingress (mean 24.21 Mbit/s)   —— Flow 3 egress (mean 24.20 Mbit/s)

- Flow 1 (95th percentile 29.12 ms)   • Flow 2 (95th percentile 29.14 ms)   • Flow 3 (95th percentile 30.07 ms)
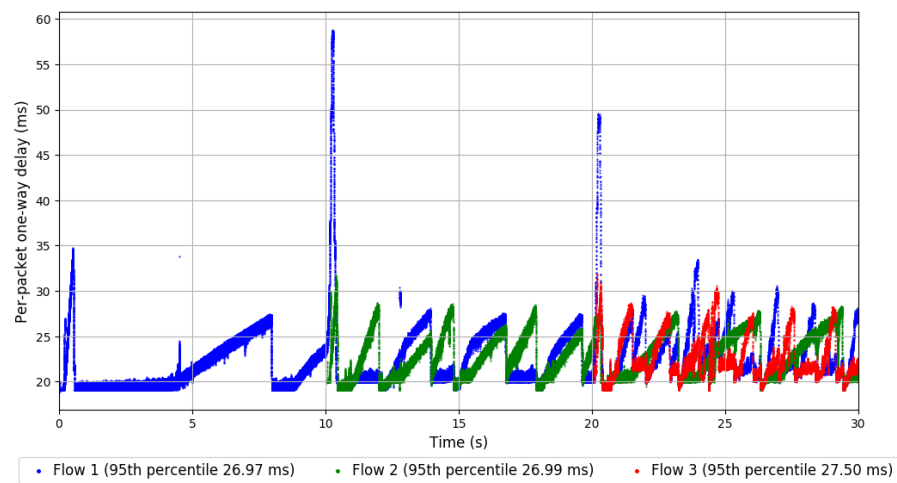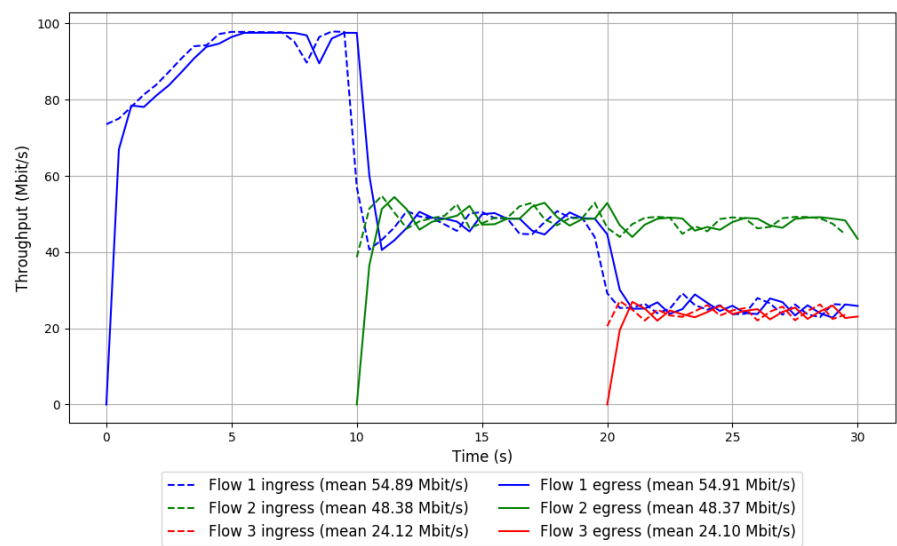
13

```
Run 3: Statistics of TCP Cubic

Start at: 2018-09-05 22:39:45
End at: 2018-09-05 22:40:15
Local clock offset: -0.795 ms
Remote clock offset: -1.226 ms


# Below is generated by plot.py at 2018-09-05 22:43:07
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.12 Mbit/s
95th percentile per-packet one-way delay: 27.027 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 54.91 Mbit/s
95th percentile per-packet one-way delay: 26.970 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 48.37 Mbit/s
95th percentile per-packet one-way delay: 26.990 ms
Loss rate: 0.16%
-- Flow 3:
Average throughput: 24.10 Mbit/s
95th percentile per-packet one-way delay: 27.498 ms
Loss rate: 0.35%
```

Run 3: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 54.89 Mbit/s) — — — Flow 1 egress (mean 54.91 Mbit/s)
Flow 2 ingress (mean 48.38 Mbit/s) — — — Flow 2 egress (mean 48.37 Mbit/s)
Flow 3 ingress (mean 24.12 Mbit/s) — — — Flow 3 egress (mean 24.10 Mbit/s)

Flow 1 (95th percentile 26.97 ms)   Flow 2 (95th percentile 26.99 ms)   Flow 3 (95th percentile 27.50 ms)
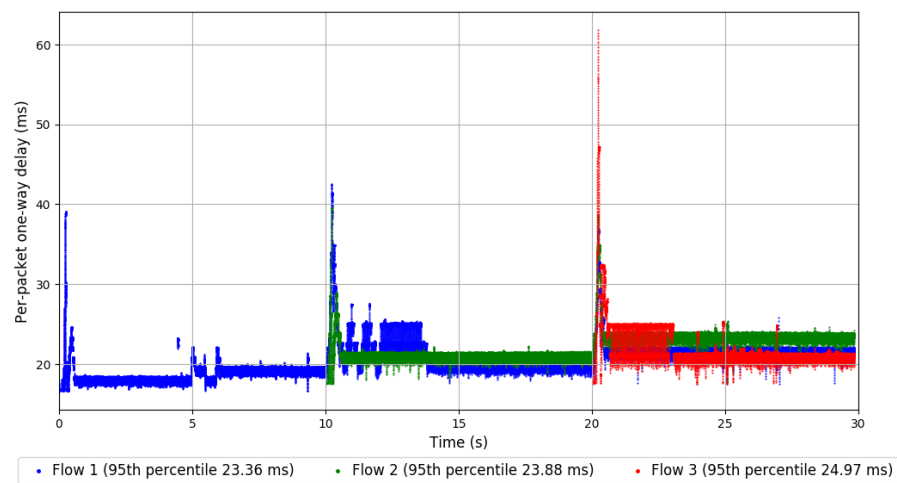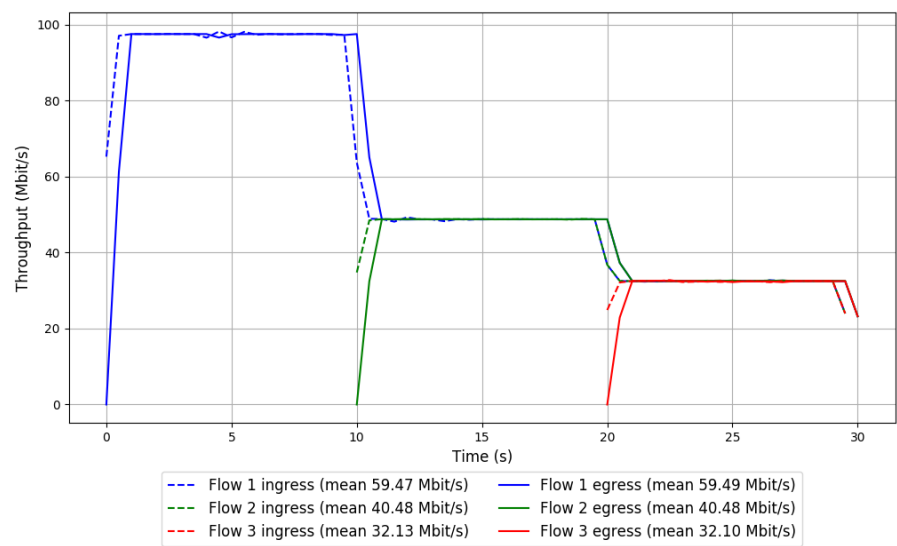
15

```
Run 1: Statistics of Indigo

Start at: 2018-09-05 22:29:02
End at: 2018-09-05 22:29:32
Local clock offset: -1.374 ms
Remote clock offset: -1.429 ms


# Below is generated by plot.py at 2018-09-05 22:43:08
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.95 Mbit/s
95th percentile per-packet one-way delay: 24.447 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 59.49 Mbit/s
95th percentile per-packet one-way delay: 23.360 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 40.48 Mbit/s
95th percentile per-packet one-way delay: 23.883 ms
Loss rate: 0.14%
-- Flow 3:
Average throughput: 32.10 Mbit/s
95th percentile per-packet one-way delay: 24.969 ms
Loss rate: 0.38%
```

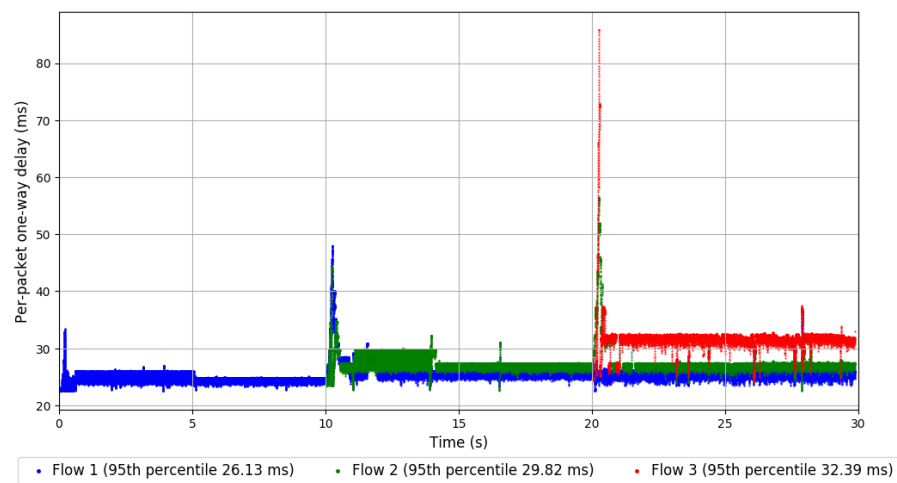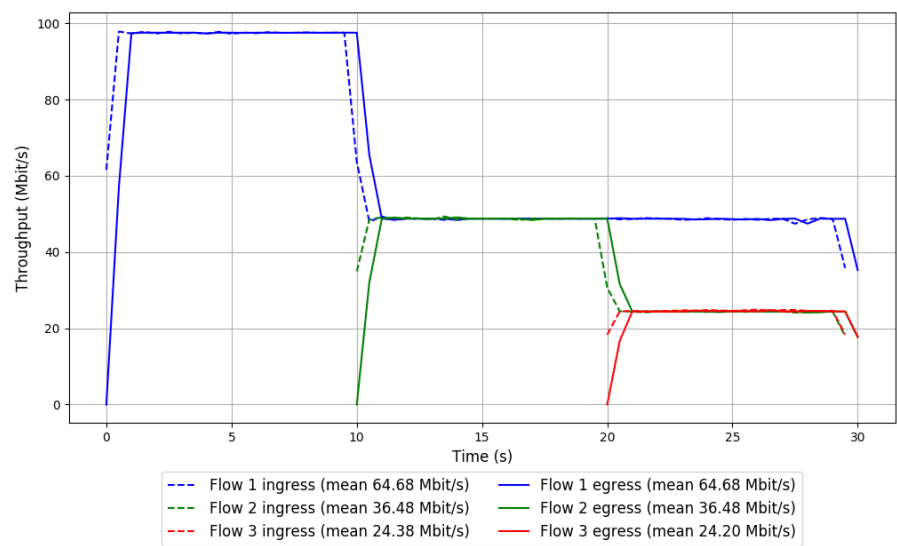Run 1: Report of Indigo — Data Link

```
Run 2: Statistics of Indigo

Start at: 2018-09-05 22:33:48
End at: 2018-09-05 22:34:18
Local clock offset: 2.694 ms
Remote clock offset: -2.215 ms


# Below is generated by plot.py at 2018-09-05 22:43:08
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.88 Mbit/s
95th percentile per-packet one-way delay: 31.851 ms
Loss rate: 0.17%
-- Flow 1:
Average throughput: 64.68 Mbit/s
95th percentile per-packet one-way delay: 26.134 ms
Loss rate: 0.09%
-- Flow 2:
Average throughput: 36.48 Mbit/s
95th percentile per-packet one-way delay: 29.825 ms
Loss rate: 0.12%
-- Flow 3:
Average throughput: 24.20 Mbit/s
95th percentile per-packet one-way delay: 32.391 ms
Loss rate: 1.04%
```

Run 2: Report of Indigo — Data Link

Flow 1 ingress (mean 64.68 Mbit/s)   Flow 1 egress (mean 64.68 Mbit/s)
Flow 2 ingress (mean 36.48 Mbit/s)   Flow 2 egress (mean 36.48 Mbit/s)
Flow 3 ingress (mean 24.38 Mbit/s)   Flow 3 egress (mean 24.20 Mbit/s)

Flow 1 (95th percentile 26.13 ms)   Flow 2 (95th percentile 29.82 ms)   Flow 3 (95th percentile 32.39 ms)

```
Run 3: Statistics of Indigo

Start at: 2018-09-05 22:38:33
End at: 2018-09-05 22:39:03
Local clock offset: 2.593 ms
Remote clock offset: -1.22 ms


# Below is generated by plot.py at 2018-09-05 22:43:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 97.03 Mbit/s
95th percentile per-packet one-way delay: 29.463 ms
Loss rate: 0.11%
-- Flow 1:
Average throughput: 59.56 Mbit/s
95th percentile per-packet one-way delay: 27.107 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 40.42 Mbit/s
95th percentile per-packet one-way delay: 28.234 ms
Loss rate: 0.12%
-- Flow 3:
Average throughput: 32.26 Mbit/s
95th percentile per-packet one-way delay: 29.960 ms
Loss rate: 0.37%
```
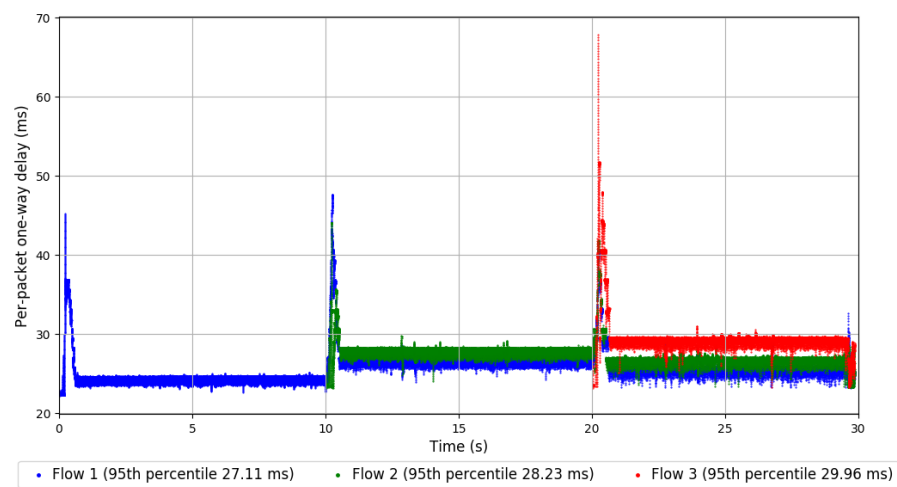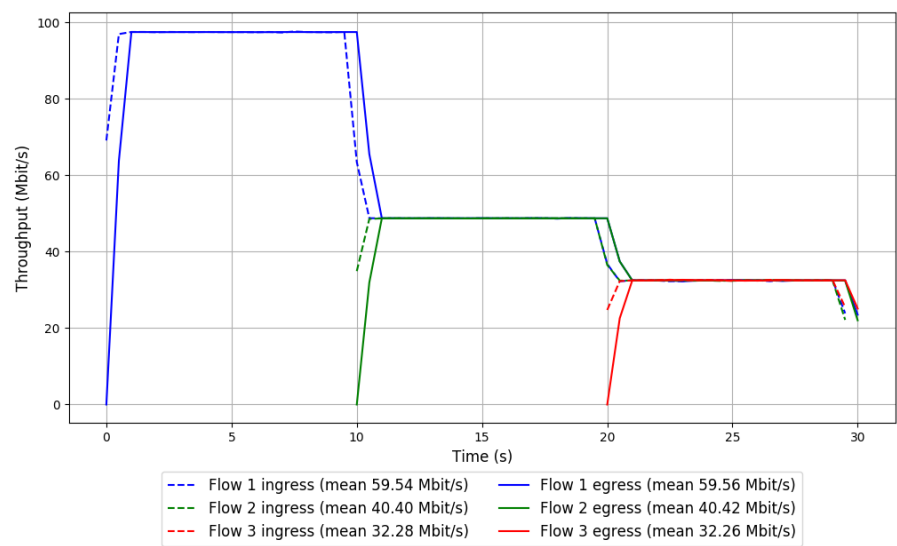
Run 3: Report of Indigo — Data Link

Flow 1 ingress (mean 59.54 Mbit/s)   Flow 1 egress (mean 59.56 Mbit/s)
Flow 2 ingress (mean 40.40 Mbit/s)   Flow 2 egress (mean 40.42 Mbit/s)
Flow 3 ingress (mean 32.28 Mbit/s)   Flow 3 egress (mean 32.26 Mbit/s)

Flow 1 (95th percentile 27.11 ms)   Flow 2 (95th percentile 28.23 ms)   Flow 3 (95th percentile 29.96 ms)
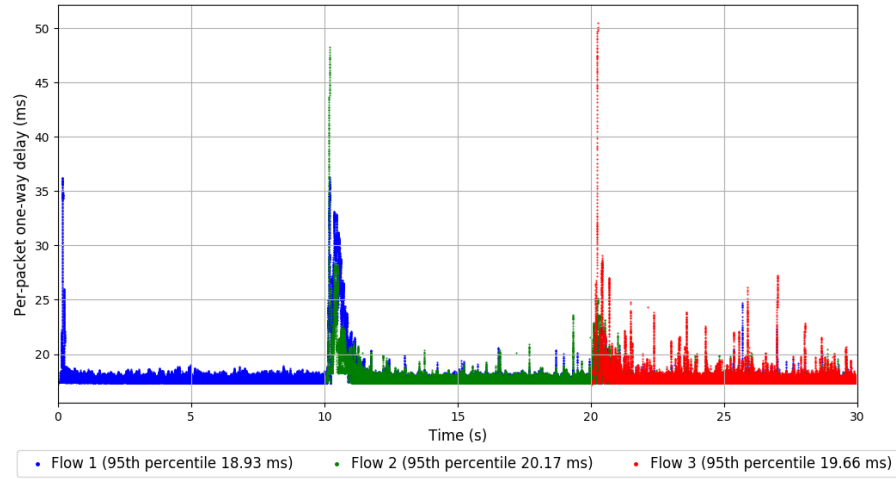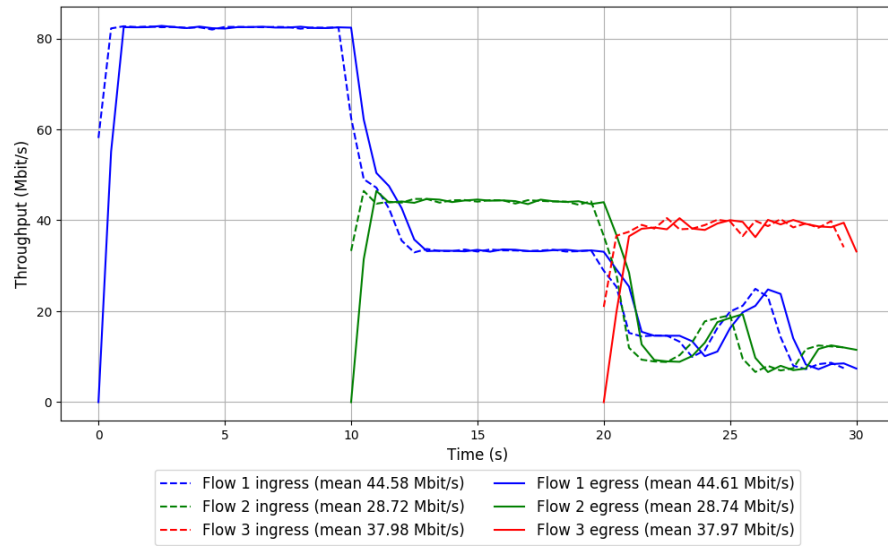
```
Run 1: Statistics of Muses-25

Start at: 2018-09-05 22:27:51
End at: 2018-09-05 22:28:21
Local clock offset: -1.485 ms
Remote clock offset: -2.169 ms

# Below is generated by plot.py at 2018-09-05 22:43:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 76.27 Mbit/s
95th percentile per-packet one-way delay: 19.532 ms
Loss rate: 0.09%
-- Flow 1:
Average throughput: 44.61 Mbit/s
95th percentile per-packet one-way delay: 18.927 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 28.74 Mbit/s
95th percentile per-packet one-way delay: 20.171 ms
Loss rate: 0.09%
-- Flow 3:
Average throughput: 37.97 Mbit/s
95th percentile per-packet one-way delay: 19.665 ms
Loss rate: 0.31%
```
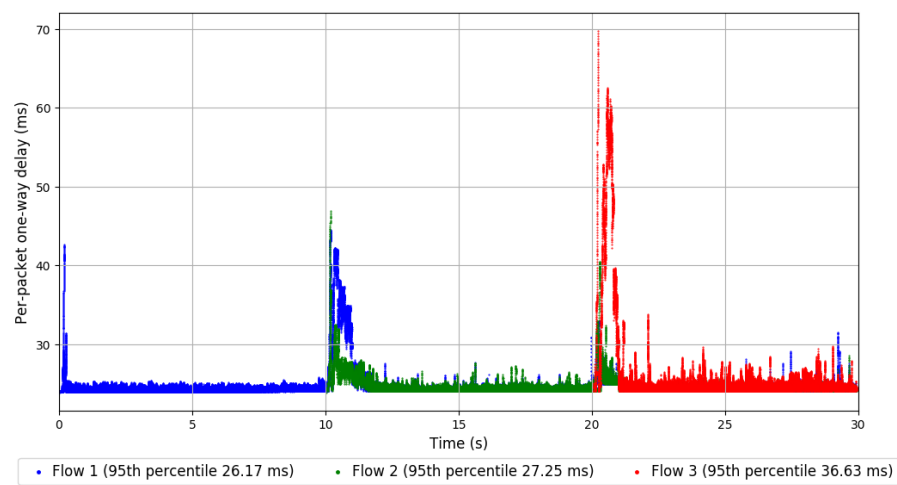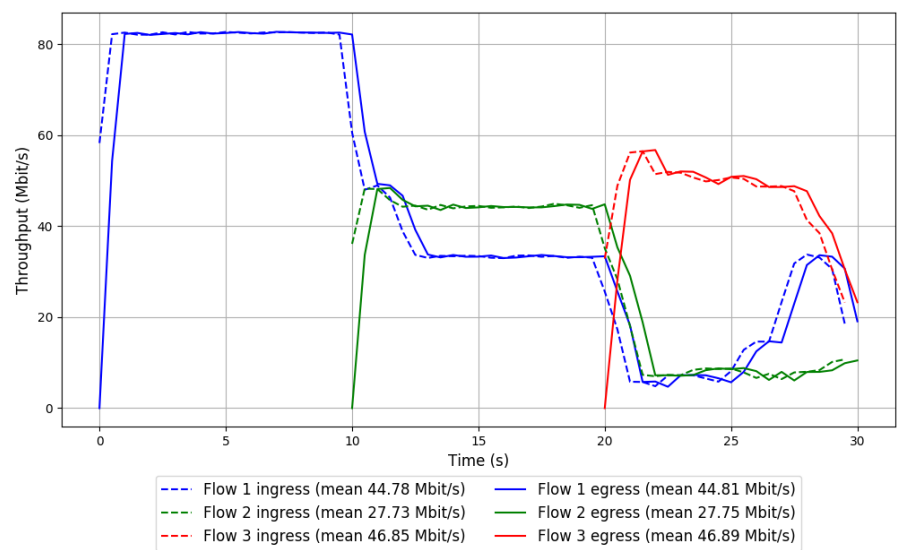
Run 1: Report of Muses-25 — Data Link

```
Run 2: Statistics of Muses-25

Start at: 2018-09-05 22:32:38
End at: 2018-09-05 22:33:08
Local clock offset: 4.896 ms
Remote clock offset: -1.838 ms


# Below is generated by plot.py at 2018-09-05 22:43:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 78.77 Mbit/s
95th percentile per-packet one-way delay: 27.387 ms
Loss rate: 0.08%
-- Flow 1:
Average throughput: 44.81 Mbit/s
95th percentile per-packet one-way delay: 26.168 ms
Loss rate: 0.04%
-- Flow 2:
Average throughput: 27.75 Mbit/s
95th percentile per-packet one-way delay: 27.250 ms
Loss rate: 0.08%
-- Flow 3:
Average throughput: 46.89 Mbit/s
95th percentile per-packet one-way delay: 36.630 ms
Loss rate: 0.19%
```

Run 2: Report of Muses-25 — Data Link

```
Run 3: Statistics of Muses-25

Start at: 2018-09-05 22:37:23
End at: 2018-09-05 22:37:53
Local clock offset: -2.504 ms
Remote clock offset: -1.501 ms


# Below is generated by plot.py at 2018-09-05 22:43:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 78.55 Mbit/s
95th percentile per-packet one-way delay: 19.215 ms
Loss rate: 0.10%
-- Flow 1:
Average throughput: 44.82 Mbit/s
95th percentile per-packet one-way delay: 18.924 ms
Loss rate: 0.04%
-- Flow 2:
Average throughput: 31.97 Mbit/s
95th percentile per-packet one-way delay: 19.655 ms
Loss rate: 0.13%
-- Flow 3:
Average throughput: 37.69 Mbit/s
95th percentile per-packet one-way delay: 19.011 ms
Loss rate: 0.28%
```

Run 3: Report of Muses-25 — Data Link