Pantheon Report

Generated at 2018-08-28 11:40:47 (UTC).

Data path: GCE Sydney on `ens4` (*local*) →GCE Tokyo on `ens4` (*remote*).

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.google.com` and have been applied to correct the timestamps in logs.
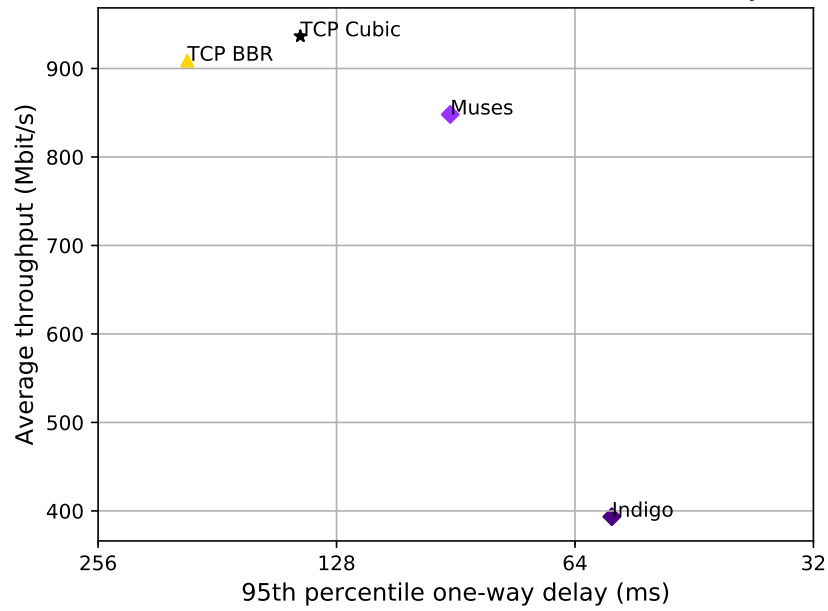
```
System info:
Linux 4.15.0-1015-gcp
net.core.default_qdisc = fq
net.core.rmem_default = 16777216
net.core.rmem_max = 536870912
net.core.wmem_default = 16777216
net.core.wmem_max = 536870912
net.ipv4.tcp_rmem = 4096 16777216 536870912
net.ipv4.tcp_wmem = 4096 16777216 536870912

Git summary:
branch: muses @ 86ef433b09b2f4ecae1186d6940af93bcf0969cd
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436dbd4b834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbdfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0ecdbf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ b261c9e99c63be452bc16f94ce0caa99a4c9d39a
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
```
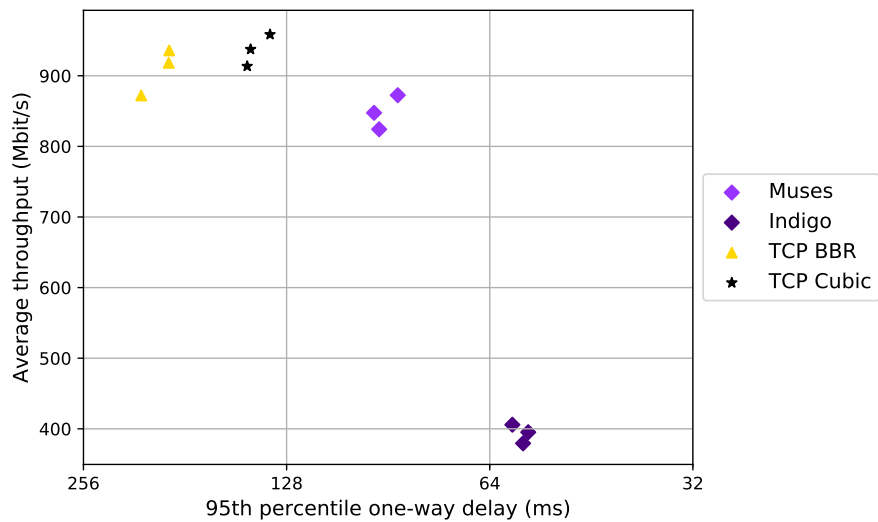
test from GCE Sydney to GCE Tokyo, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

test from GCE Sydney to GCE Tokyo, 3 runs of 30s each per scheme
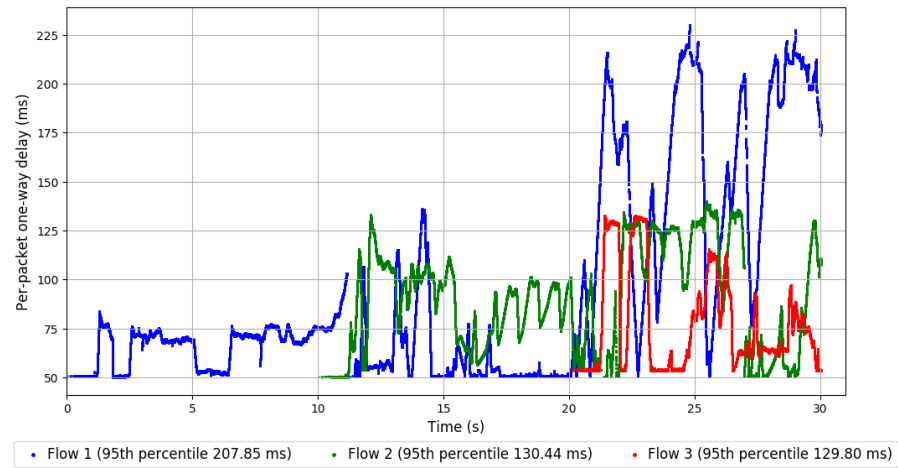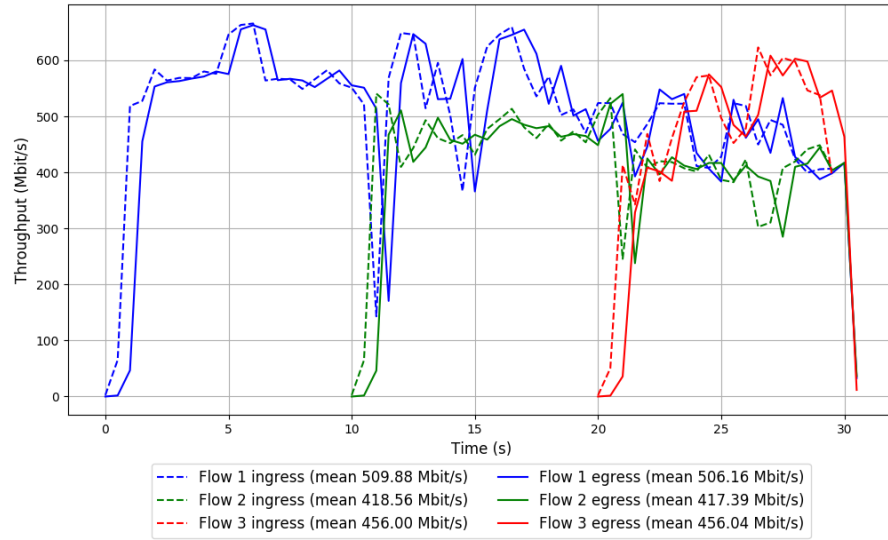### 3 flows with 10s interval between flows

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	479.37	441.09	407.84	175.34	172.93	190.51	0.74	0.86	2.29
TCP Cubic	3	493.32	462.79	405.97	135.91	108.20	157.78	0.29	0.09	0.55
Indigo	3	205.22	196.91	178.39	57.39	56.71	57.74	0.00	0.00	0.00
Muses	3	472.59	416.81	301.98	93.91	91.00	89.26	0.06	0.03	0.41

```
Run 1: Statistics of TCP BBR

Start at: 2018-08-28 10:55:37
End at: 2018-08-28 10:56:07
Local clock offset: -0.016 ms
Remote clock offset: -0.066 ms


# Below is generated by plot.py at 2018-08-28 11:33:01
# Datalink statistics
-- Total of 3 flows:
Average throughput: 935.91 Mbit/s
95th percentile per-packet one-way delay: 191.038 ms
Loss rate: 0.47%
-- Flow 1:
Average throughput: 506.16 Mbit/s
95th percentile per-packet one-way delay: 207.846 ms
Loss rate: 0.72%
-- Flow 2:
Average throughput: 417.39 Mbit/s
95th percentile per-packet one-way delay: 130.437 ms
Loss rate: 0.26%
-- Flow 3:
Average throughput: 456.04 Mbit/s
95th percentile per-packet one-way delay: 129.797 ms
Loss rate: 0.00%
```

Run 1: Report of TCP BBR — Data Link

Legend:
- Flow 1 ingress (mean 509.88 Mbit/s) — Flow 1 egress (mean 506.16 Mbit/s)
- Flow 2 ingress (mean 418.56 Mbit/s) — Flow 2 egress (mean 417.39 Mbit/s)
- Flow 3 ingress (mean 456.00 Mbit/s) — Flow 3 egress (mean 456.04 Mbit/s)

- Flow 1 (95th percentile 207.85 ms)
- Flow 2 (95th percentile 130.44 ms)
- Flow 3 (95th percentile 129.80 ms)

```
Run 2: Statistics of TCP BBR

Start at: 2018-08-28 11:03:08
End at: 2018-08-28 11:03:38
Local clock offset: 0.108 ms
Remote clock offset: 2.742 ms


# Below is generated by plot.py at 2018-08-28 11:33:01
# Datalink statistics
-- Total of 3 flows:
Average throughput: 872.16 Mbit/s
95th percentile per-packet one-way delay: 210.219 ms
Loss rate: 1.27%
-- Flow 1:
Average throughput: 446.27 Mbit/s
95th percentile per-packet one-way delay: 126.706 ms
Loss rate: 0.20%
-- Flow 2:
Average throughput: 457.50 Mbit/s
95th percentile per-packet one-way delay: 201.762 ms
Loss rate: 0.98%
-- Flow 3:
Average throughput: 364.47 Mbit/s
95th percentile per-packet one-way delay: 245.707 ms
Loss rate: 5.64%
```
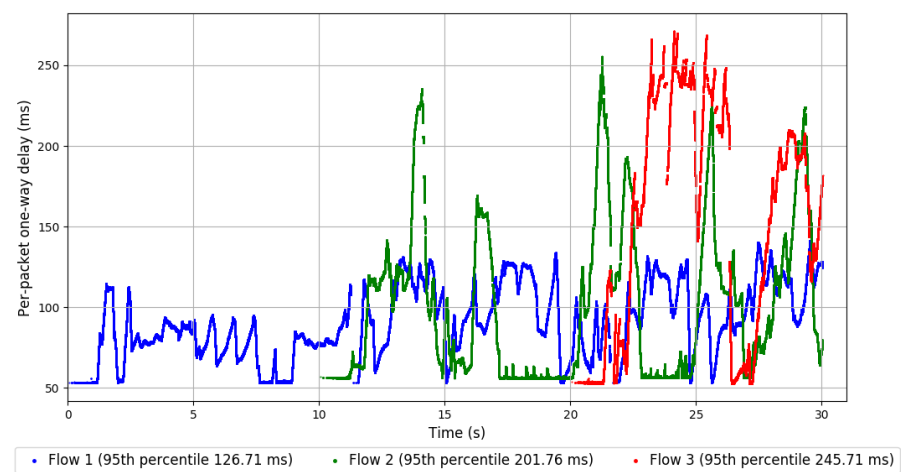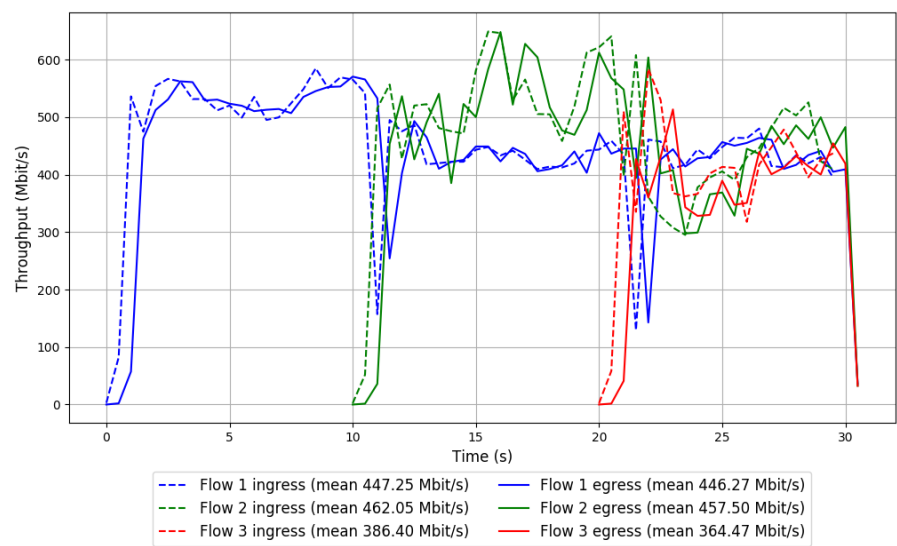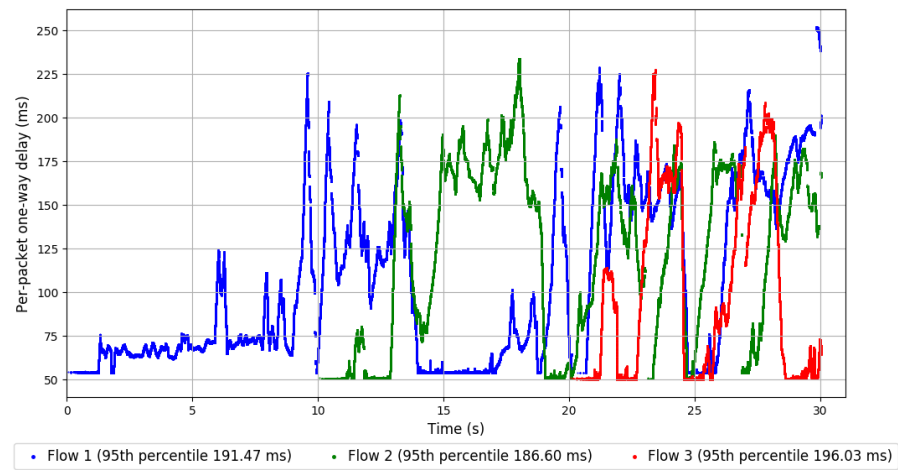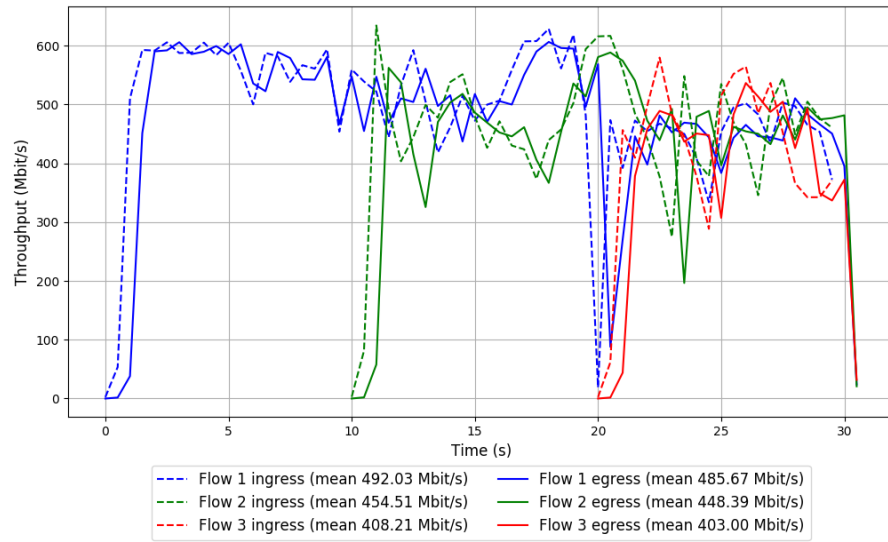
Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 447.25 Mbit/s)   Flow 1 egress (mean 446.27 Mbit/s)
Flow 2 ingress (mean 462.05 Mbit/s)   Flow 2 egress (mean 457.50 Mbit/s)
Flow 3 ingress (mean 386.40 Mbit/s)   Flow 3 egress (mean 364.47 Mbit/s)

Flow 1 (95th percentile 126.71 ms)   Flow 2 (95th percentile 201.76 ms)   Flow 3 (95th percentile 245.71 ms)

```
Run 3: Statistics of TCP BBR

Start at: 2018-08-28 11:10:32
End at: 2018-08-28 11:11:02
Local clock offset: -0.113 ms
Remote clock offset: -0.019 ms


# Below is generated by plot.py at 2018-08-28 11:33:01
# Datalink statistics
-- Total of 3 flows:
Average throughput: 918.32 Mbit/s
95th percentile per-packet one-way delay: 191.377 ms
Loss rate: 1.30%
-- Flow 1:
Average throughput: 485.67 Mbit/s
95th percentile per-packet one-way delay: 191.475 ms
Loss rate: 1.29%
-- Flow 2:
Average throughput: 448.39 Mbit/s
95th percentile per-packet one-way delay: 186.602 ms
Loss rate: 1.33%
-- Flow 3:
Average throughput: 403.00 Mbit/s
95th percentile per-packet one-way delay: 196.031 ms
Loss rate: 1.23%
```

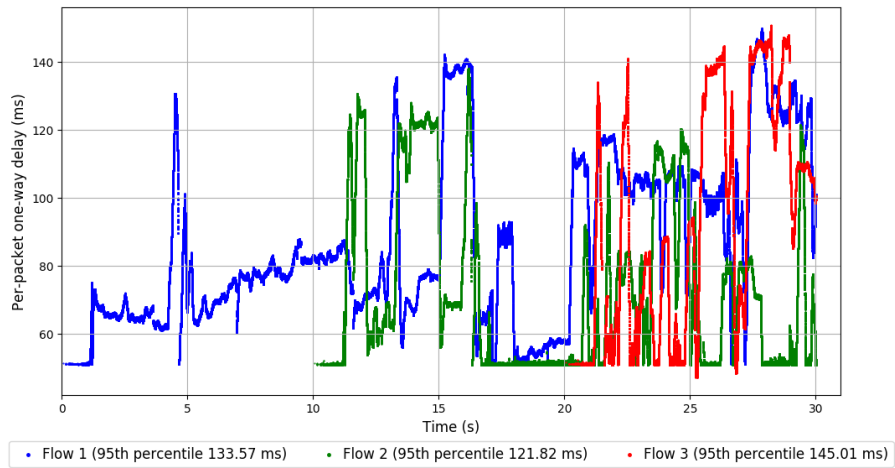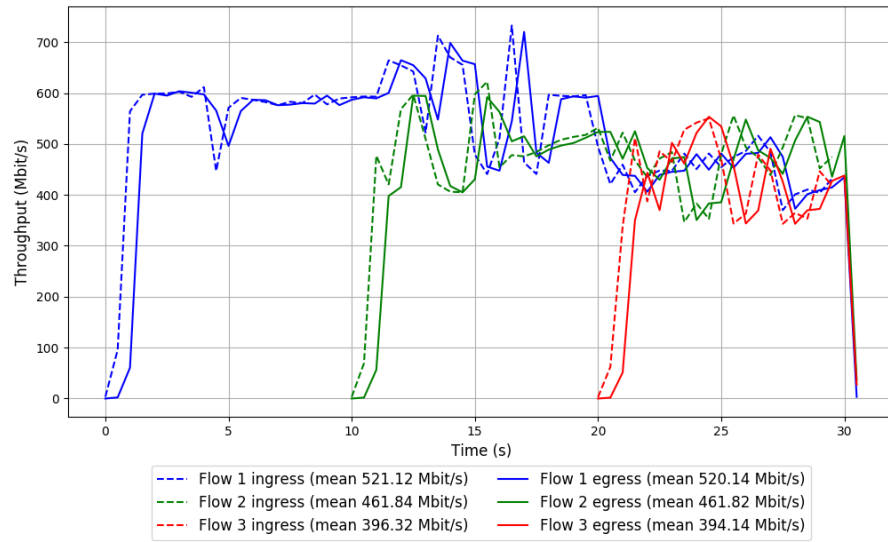Run 3: Report of TCP BBR — Data Link

```
Run 1: Statistics of TCP Cubic

Start at: 2018-08-28 10:57:33
End at: 2018-08-28 10:58:03
Local clock offset: -0.078 ms
Remote clock offset: -2.885 ms


# Below is generated by plot.py at 2018-08-28 11:33:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 958.45 Mbit/s
95th percentile per-packet one-way delay: 135.441 ms
Loss rate: 0.24%
-- Flow 1:
Average throughput: 520.14 Mbit/s
95th percentile per-packet one-way delay: 133.571 ms
Loss rate: 0.28%
-- Flow 2:
Average throughput: 461.82 Mbit/s
95th percentile per-packet one-way delay: 121.824 ms
Loss rate: 0.02%
-- Flow 3:
Average throughput: 394.14 Mbit/s
95th percentile per-packet one-way delay: 145.008 ms
Loss rate: 0.58%
```
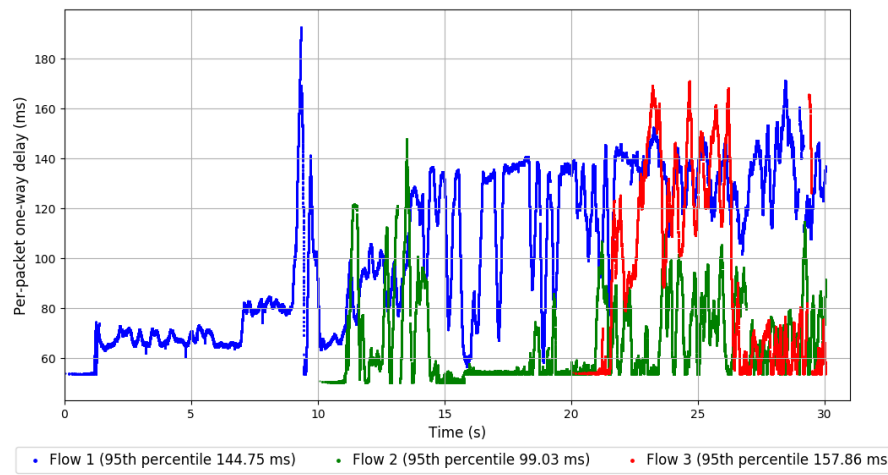
Run 1: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 521.12 Mbit/s)   Flow 1 egress (mean 520.14 Mbit/s)
Flow 2 ingress (mean 461.84 Mbit/s)   Flow 2 egress (mean 461.82 Mbit/s)
Flow 3 ingress (mean 396.32 Mbit/s)   Flow 3 egress (mean 394.14 Mbit/s)

Flow 1 (95th percentile 133.57 ms)   Flow 2 (95th percentile 121.82 ms)   Flow 3 (95th percentile 145.01 ms)

11

```
Run 2: Statistics of TCP Cubic

Start at: 2018-08-28 11:05:02
End at: 2018-08-28 11:05:32
Local clock offset: -0.013 ms
Remote clock offset: 0.14 ms


# Below is generated by plot.py at 2018-08-28 11:33:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 937.49 Mbit/s
95th percentile per-packet one-way delay: 144.741 ms
Loss rate: 0.26%
-- Flow 1:
Average throughput: 492.02 Mbit/s
95th percentile per-packet one-way delay: 144.754 ms
Loss rate: 0.34%
-- Flow 2:
Average throughput: 463.14 Mbit/s
95th percentile per-packet one-way delay: 99.031 ms
Loss rate: 0.24%
-- Flow 3:
Average throughput: 411.50 Mbit/s
95th percentile per-packet one-way delay: 157.861 ms
Loss rate: 0.00%
```
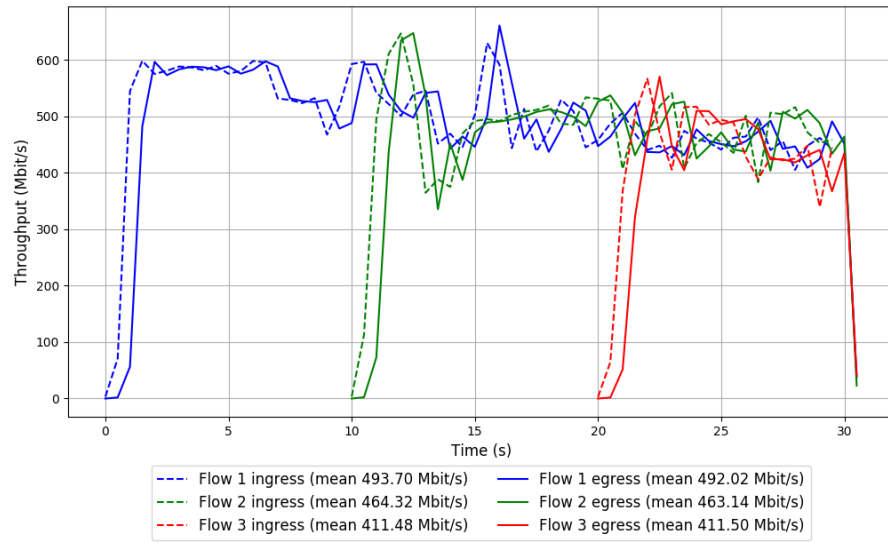
Run 2: Report of TCP Cubic — Data Link

```
Run 3: Statistics of TCP Cubic

Start at: 2018-08-28 11:12:30
End at: 2018-08-28 11:13:00
Local clock offset: -0.111 ms
Remote clock offset: 0.084 ms


# Below is generated by plot.py at 2018-08-28 11:33:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 913.47 Mbit/s
95th percentile per-packet one-way delay: 146.414 ms
Loss rate: 0.29%
-- Flow 1:
Average throughput: 467.80 Mbit/s
95th percentile per-packet one-way delay: 129.405 ms
Loss rate: 0.24%
-- Flow 2:
Average throughput: 463.41 Mbit/s
95th percentile per-packet one-way delay: 103.741 ms
Loss rate: 0.02%
-- Flow 3:
Average throughput: 412.27 Mbit/s
95th percentile per-packet one-way delay: 170.459 ms
Loss rate: 1.07%
```
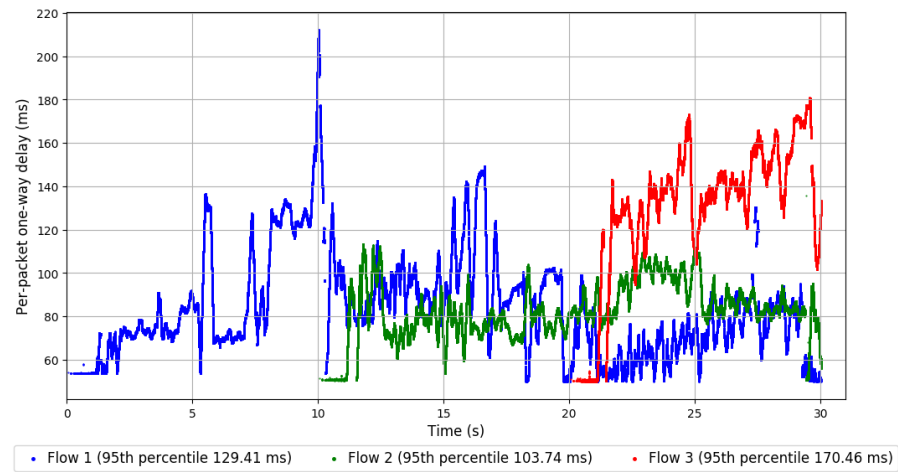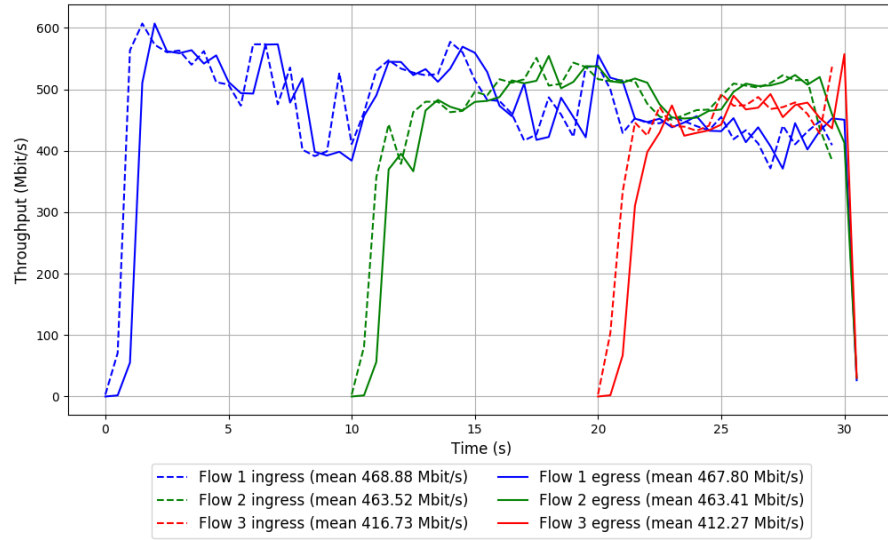
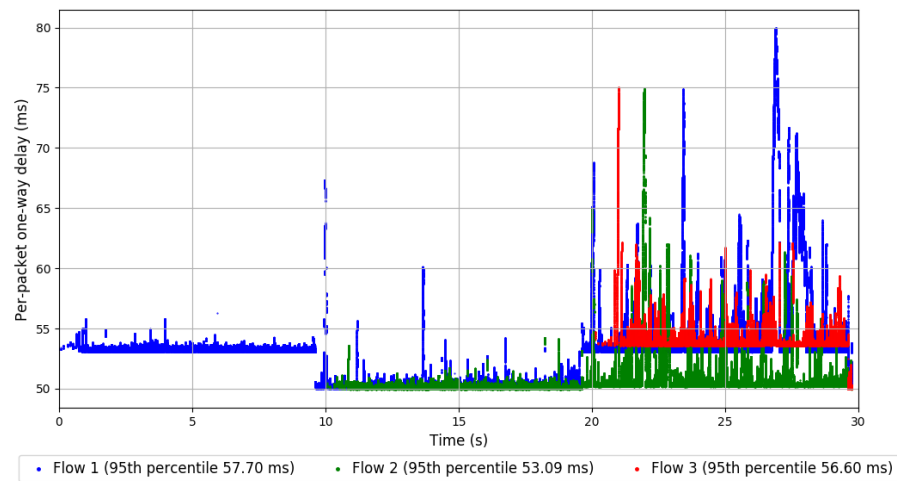Run 3: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 468.88 Mbit/s) ---- Flow 1 egress (mean 467.80 Mbit/s) ——
Flow 2 ingress (mean 463.52 Mbit/s) ---- Flow 2 egress (mean 463.41 Mbit/s) ——
Flow 3 ingress (mean 416.73 Mbit/s) ---- Flow 3 egress (mean 412.27 Mbit/s) ——

Flow 1 (95th percentile 129.41 ms)   Flow 2 (95th percentile 103.74 ms)   Flow 3 (95th percentile 170.46 ms)
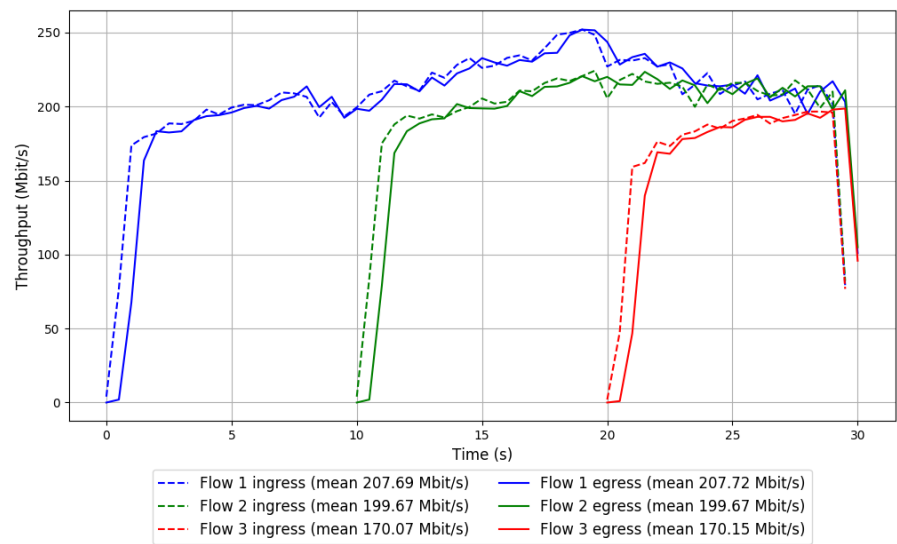
15

```
Run 1: Statistics of Indigo

Start at: 2018-08-28 10:51:58
End at: 2018-08-28 10:52:28
Local clock offset: -0.033 ms
Remote clock offset: -0.206 ms


# Below is generated by plot.py at 2018-08-28 11:33:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 395.19 Mbit/s
95th percentile per-packet one-way delay: 56.122 ms
Loss rate: 0.00%
-- Flow 1:
Average throughput: 207.72 Mbit/s
95th percentile per-packet one-way delay: 57.702 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 199.67 Mbit/s
95th percentile per-packet one-way delay: 53.090 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 170.15 Mbit/s
95th percentile per-packet one-way delay: 56.600 ms
Loss rate: 0.00%
```

Run 1: Report of Indigo — Data Link

```
Run 2: Statistics of Indigo

Start at: 2018-08-28 10:59:28
End at: 2018-08-28 10:59:58
Local clock offset: 0.198 ms
Remote clock offset: 2.858 ms


# Below is generated by plot.py at 2018-08-28 11:33:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 405.84 Mbit/s
95th percentile per-packet one-way delay: 59.246 ms
Loss rate: 0.01%
-- Flow 1:
Average throughput: 216.18 Mbit/s
95th percentile per-packet one-way delay: 58.932 ms
Loss rate: 0.01%
-- Flow 2:
Average throughput: 199.73 Mbit/s
95th percentile per-packet one-way delay: 60.209 ms
Loss rate: 0.01%
-- Flow 3:
Average throughput: 176.33 Mbit/s
95th percentile per-packet one-way delay: 56.105 ms
Loss rate: 0.00%
```
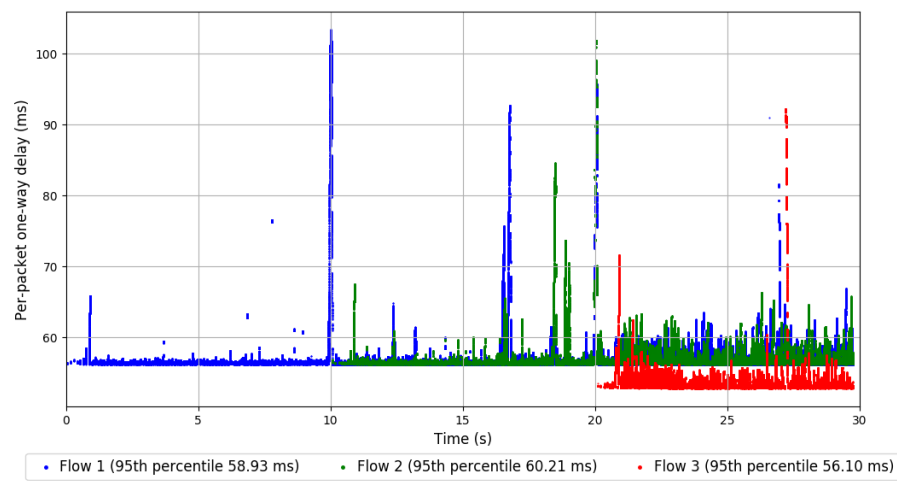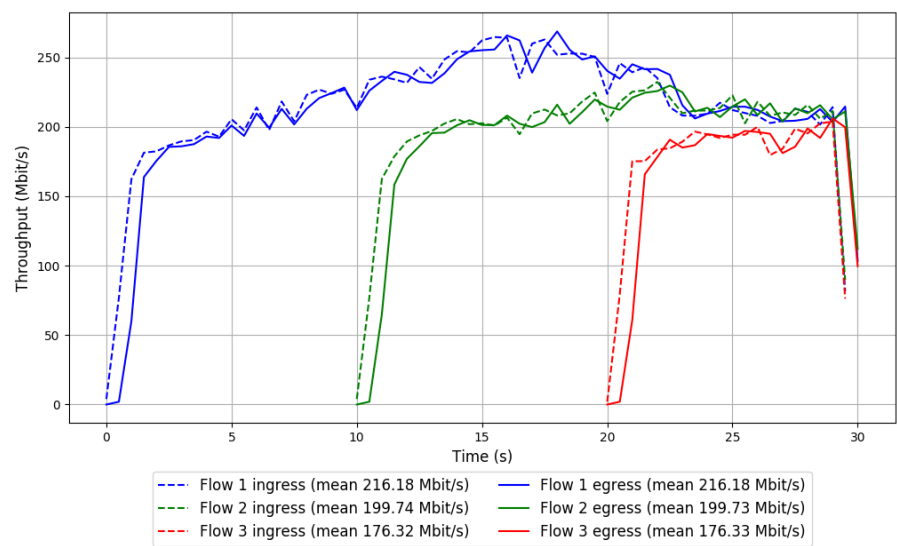
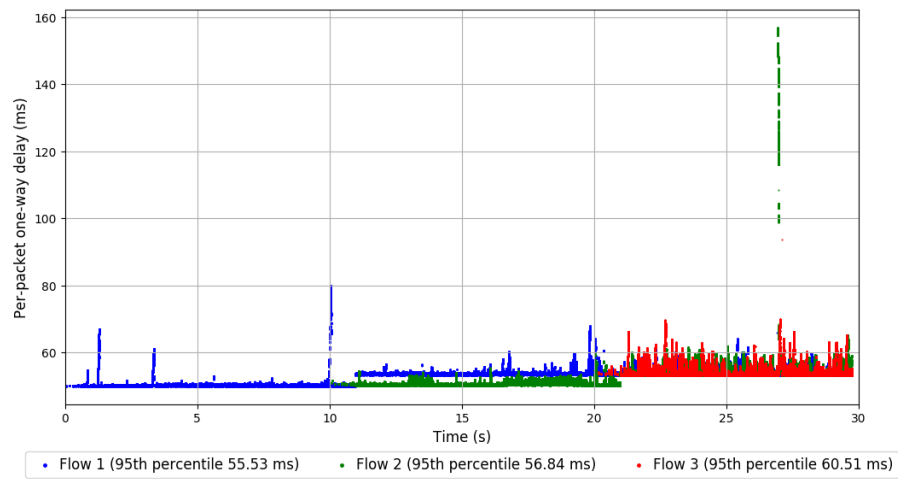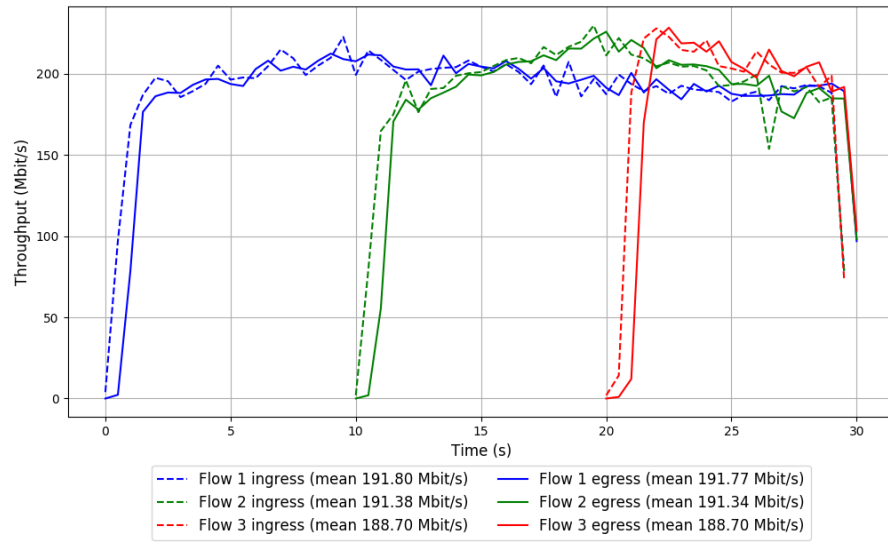Run 2: Report of Indigo — Data Link

```
Run 3: Statistics of Indigo

Start at: 2018-08-28 11:06:57
End at: 2018-08-28 11:07:27
Local clock offset: 0.163 ms
Remote clock offset: -0.032 ms


# Below is generated by plot.py at 2018-08-28 11:36:42
# Datalink statistics
-- Total of 3 flows:
Average throughput: 379.41 Mbit/s
95th percentile per-packet one-way delay: 57.124 ms
Loss rate: 0.00%
-- Flow 1:
Average throughput: 191.77 Mbit/s
95th percentile per-packet one-way delay: 55.532 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 191.34 Mbit/s
95th percentile per-packet one-way delay: 56.838 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 188.70 Mbit/s
95th percentile per-packet one-way delay: 60.511 ms
Loss rate: 0.00%
```

Run 3: Report of Indigo — Data Link

- - - Flow 1 ingress (mean 191.80 Mbit/s) —— Flow 1 egress (mean 191.77 Mbit/s)
- - - Flow 2 ingress (mean 191.38 Mbit/s) —— Flow 2 egress (mean 191.34 Mbit/s)
- - - Flow 3 ingress (mean 188.70 Mbit/s) —— Flow 3 egress (mean 188.70 Mbit/s)

• Flow 1 (95th percentile 55.53 ms)   • Flow 2 (95th percentile 56.84 ms)   • Flow 3 (95th percentile 60.51 ms)
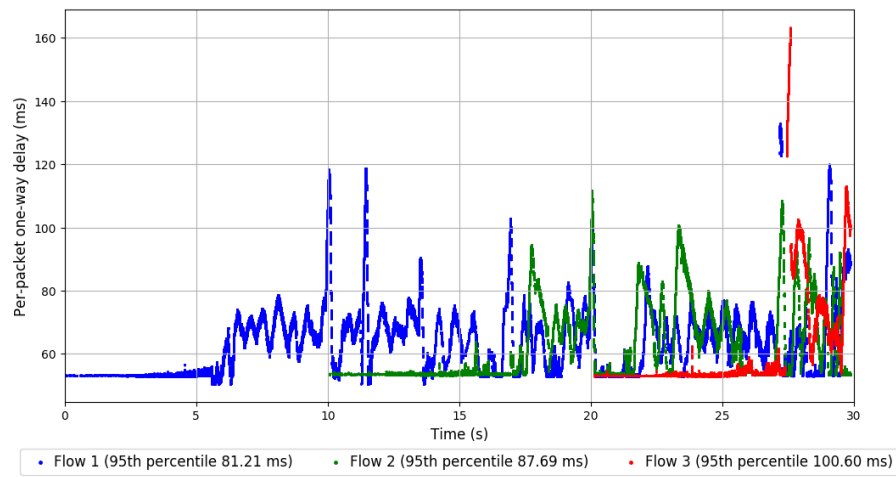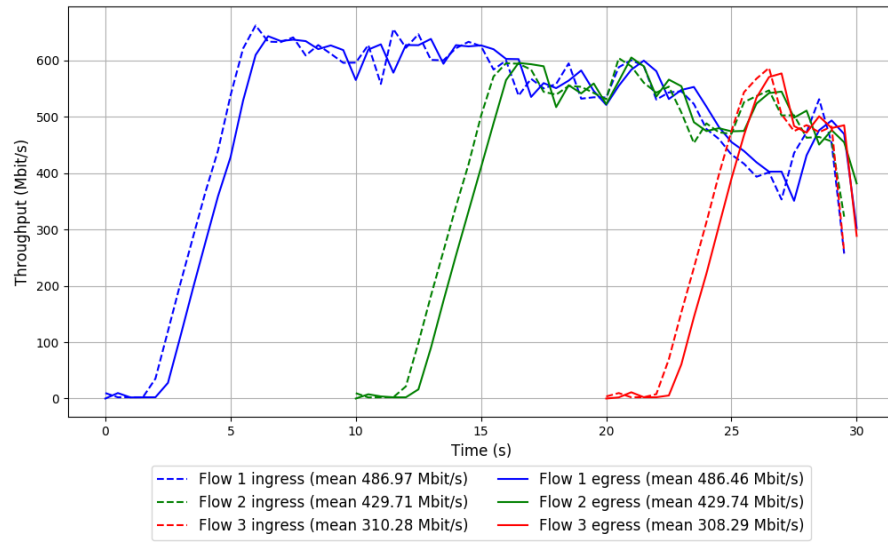
21

```
Run 1: Statistics of Muses

Start at: 2018-08-28 10:53:42
End at: 2018-08-28 10:54:12
Local clock offset: 0.211 ms
Remote clock offset: -0.039 ms


# Below is generated by plot.py at 2018-08-28 11:40:24
# Datalink statistics
-- Total of 3 flows:
Average throughput: 872.47 Mbit/s
95th percentile per-packet one-way delay: 87.592 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 486.46 Mbit/s
95th percentile per-packet one-way delay: 81.214 ms
Loss rate: 0.09%
-- Flow 2:
Average throughput: 429.74 Mbit/s
95th percentile per-packet one-way delay: 87.686 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 308.29 Mbit/s
95th percentile per-packet one-way delay: 100.602 ms
Loss rate: 0.64%
```

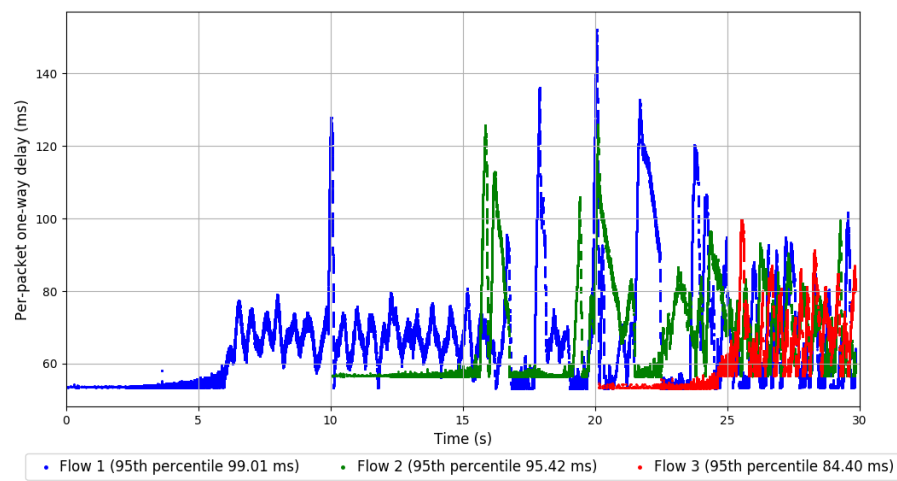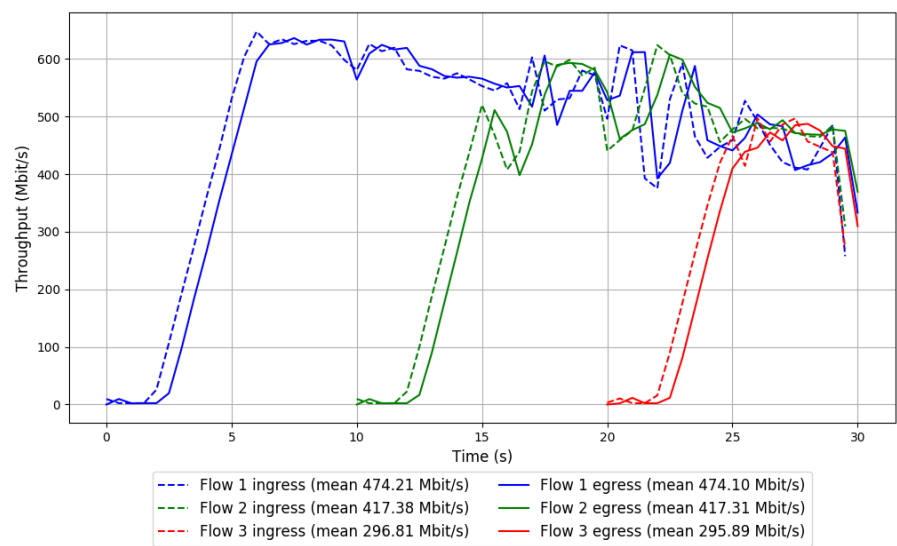Run 1: Report of Muses — Data Link

```
Run 2: Statistics of Muses

Start at: 2018-08-28 11:01:13
End at: 2018-08-28 11:01:43
Local clock offset: -0.043 ms
Remote clock offset: 2.818 ms


# Below is generated by plot.py at 2018-08-28 11:40:42
# Datalink statistics
-- Total of 3 flows:
Average throughput: 847.50 Mbit/s
95th percentile per-packet one-way delay: 94.970 ms
Loss rate: 0.04%
-- Flow 1:
Average throughput: 474.10 Mbit/s
95th percentile per-packet one-way delay: 99.009 ms
Loss rate: 0.01%
-- Flow 2:
Average throughput: 417.31 Mbit/s
95th percentile per-packet one-way delay: 95.423 ms
Loss rate: 0.01%
-- Flow 3:
Average throughput: 295.89 Mbit/s
95th percentile per-packet one-way delay: 84.398 ms
Loss rate: 0.27%
```

Run 2: Report of Muses — Data Link

```
Run 3: Statistics of Muses

Start at: 2018-08-28 11:08:40
End at: 2018-08-28 11:09:10
Local clock offset: 0.113 ms
Remote clock offset: -0.044 ms


# Below is generated by plot.py at 2018-08-28 11:40:45
# Datalink statistics
-- Total of 3 flows:
Average throughput: 824.23 Mbit/s
95th percentile per-packet one-way delay: 93.335 ms
Loss rate: 0.11%
-- Flow 1:
Average throughput: 457.22 Mbit/s
95th percentile per-packet one-way delay: 101.492 ms
Loss rate: 0.09%
-- Flow 2:
Average throughput: 403.38 Mbit/s
95th percentile per-packet one-way delay: 89.882 ms
Loss rate: 0.08%
-- Flow 3:
Average throughput: 301.75 Mbit/s
95th percentile per-packet one-way delay: 82.774 ms
Loss rate: 0.31%
```

Run 3: Report of Muses — Data Link