Pantheon Report

Generated at 2018-08-28 10:15:18 (UTC).

Data path: GCE Tokyo on `ens4` (*remote*) →GCE Iowa on `ens4` (*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.google.com` and have been applied to correct the timestamps in logs.
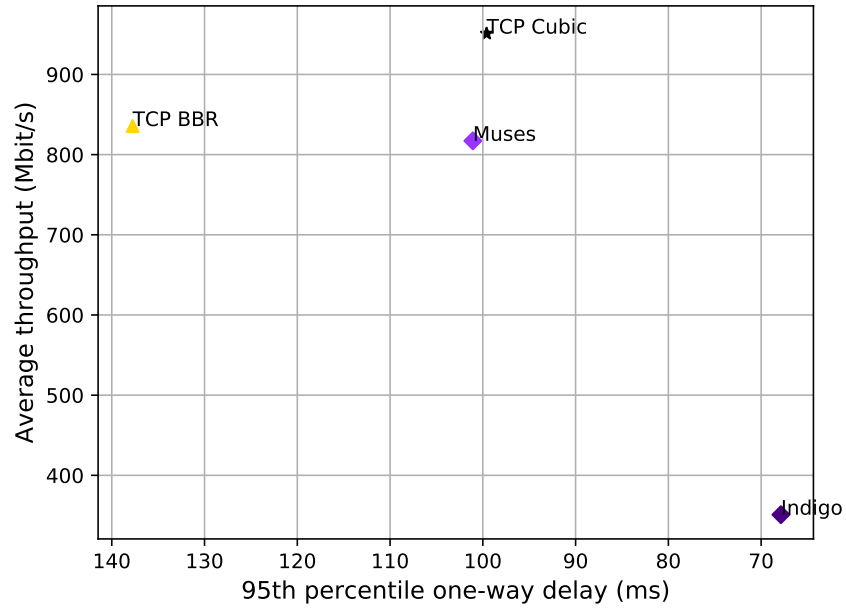
```
System info:
Linux 4.15.0-1017-gcp
net.core.default_qdisc = fq
net.core.rmem_default = 16777216
net.core.rmem_max = 536870912
net.core.wmem_default = 16777216
net.core.wmem_max = 536870912
net.ipv4.tcp_rmem = 4096 16777216 536870912
net.ipv4.tcp_wmem = 4096 16777216 536870912

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
```
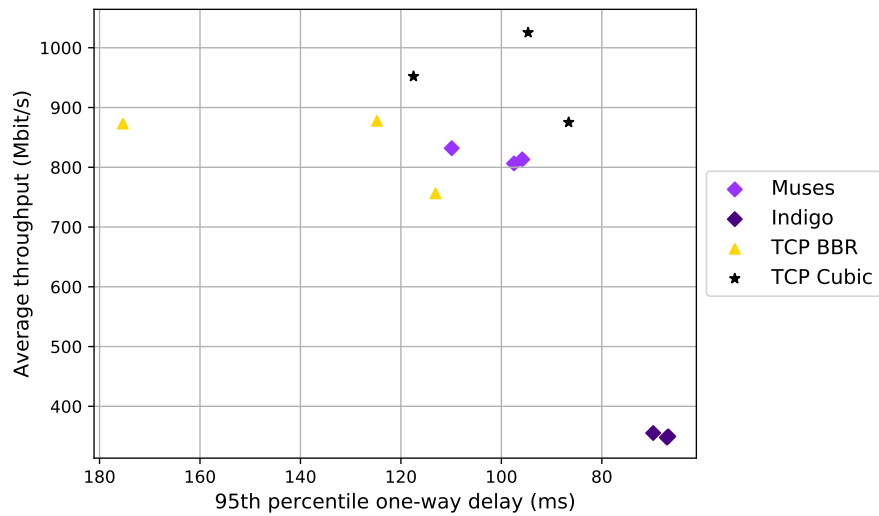
test from GCE Tokyo to GCE Iowa, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

test from GCE Tokyo to GCE Iowa, 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	399.13	450.78	416.80	103.60	156.34	142.47	0.67	1.31	2.91
TCP Cubic	3	493.62	486.66	406.02	73.34	88.37	120.97	0.38	0.69	1.32
Indigo	3	191.12	165.16	154.91	66.14	66.19	66.29	0.35	0.57	1.44
Muses	3	471.77	396.47	252.84	103.37	97.01	87.76	0.51	0.92	2.63

```
Run 1: Statistics of TCP BBR

Start at: 2018-08-28 09:28:19
End at: 2018-08-28 09:28:49
Local clock offset: 0.452 ms
Remote clock offset: 2.801 ms


# Below is generated by plot.py at 2018-08-28 10:08:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 877.59 Mbit/s
95th percentile per-packet one-way delay: 124.780 ms
Loss rate: 1.08%
-- Flow 1:
Average throughput: 435.08 Mbit/s
95th percentile per-packet one-way delay: 84.807 ms
Loss rate: 0.47%
-- Flow 2:
Average throughput: 463.31 Mbit/s
95th percentile per-packet one-way delay: 161.703 ms
Loss rate: 1.49%
-- Flow 3:
Average throughput: 412.85 Mbit/s
95th percentile per-packet one-way delay: 128.469 ms
Loss rate: 2.08%
```
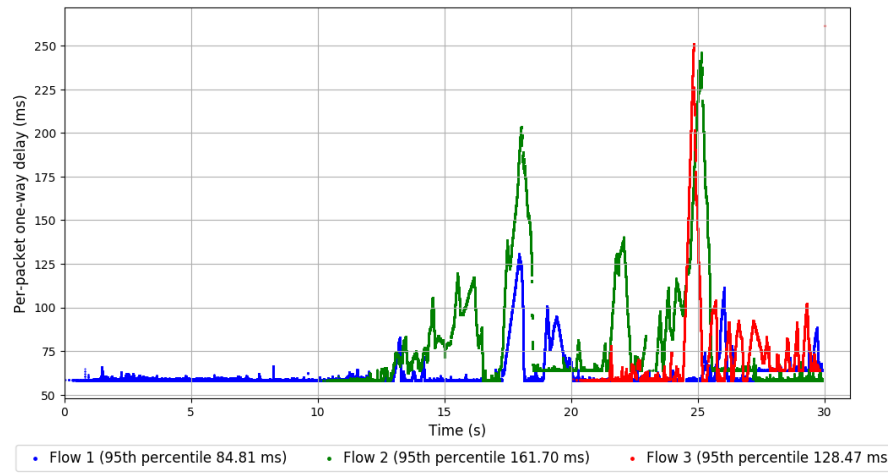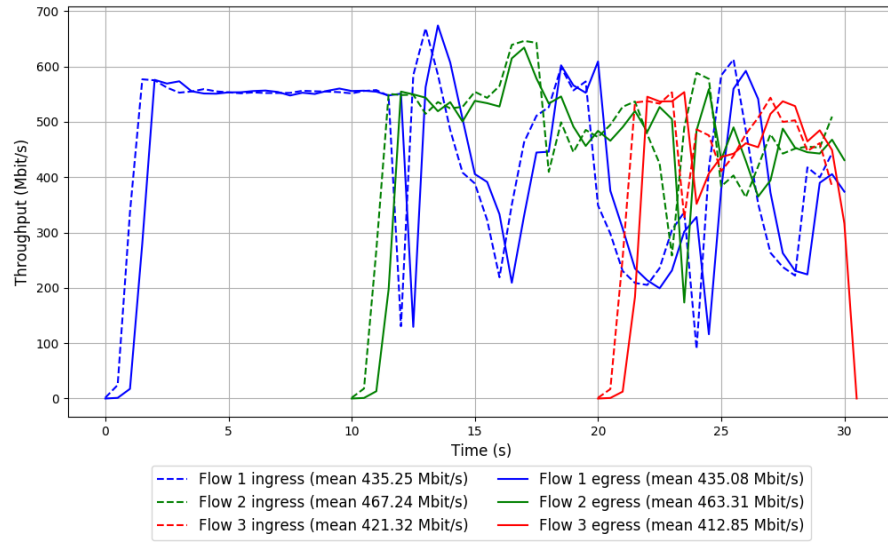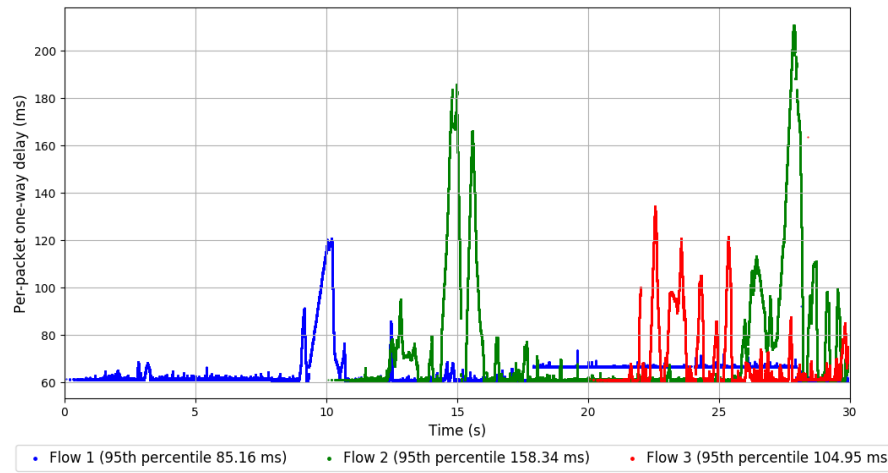
Run 1: Report of TCP BBR — Data Link

Flow 1 ingress (mean 435.25 Mbit/s) --- Flow 1 egress (mean 435.08 Mbit/s)
Flow 2 ingress (mean 467.24 Mbit/s) --- Flow 2 egress (mean 463.31 Mbit/s)
Flow 3 ingress (mean 421.32 Mbit/s) --- Flow 3 egress (mean 412.85 Mbit/s)

Flow 1 (95th percentile 84.81 ms)   Flow 2 (95th percentile 161.70 ms)   Flow 3 (95th percentile 128.47 ms)
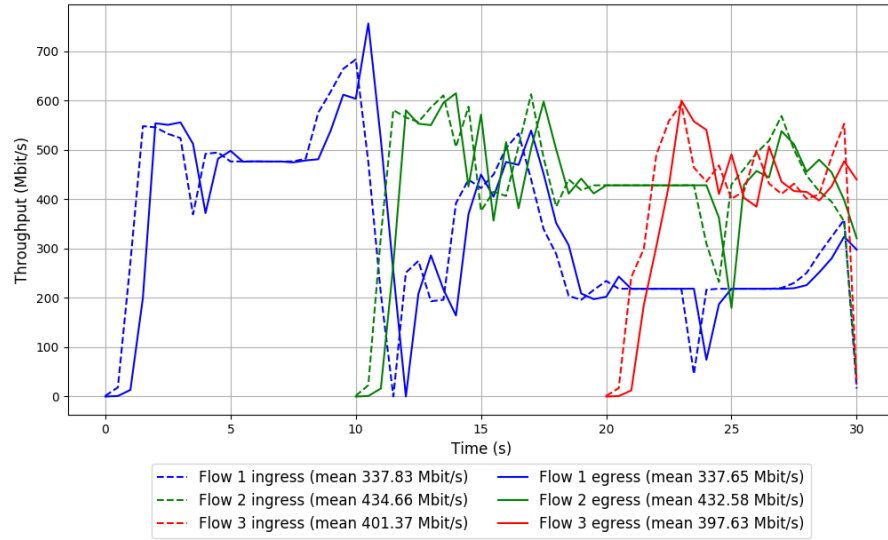
5

```
Run 2: Statistics of TCP BBR

Start at: 2018-08-28 09:35:48
End at: 2018-08-28 09:36:18
Local clock offset: 0.447 ms
Remote clock offset: -0.058 ms


# Below is generated by plot.py at 2018-08-28 10:08:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 756.31 Mbit/s
95th percentile per-packet one-way delay: 113.114 ms
Loss rate: 1.19%
-- Flow 1:
Average throughput: 337.65 Mbit/s
95th percentile per-packet one-way delay: 85.157 ms
Loss rate: 0.58%
-- Flow 2:
Average throughput: 432.58 Mbit/s
95th percentile per-packet one-way delay: 158.336 ms
Loss rate: 1.27%
-- Flow 3:
Average throughput: 397.63 Mbit/s
95th percentile per-packet one-way delay: 104.951 ms
Loss rate: 2.52%
```
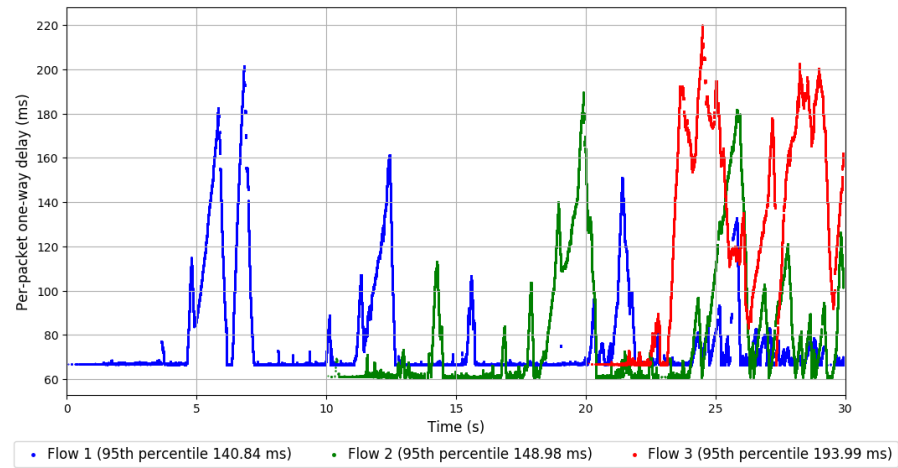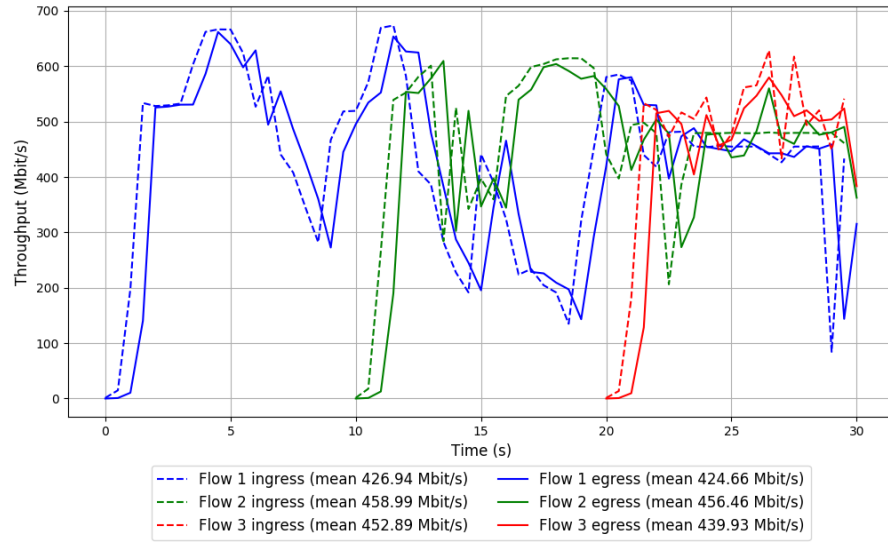
Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 337.83 Mbit/s)   Flow 1 egress (mean 337.65 Mbit/s)
Flow 2 ingress (mean 434.66 Mbit/s)   Flow 2 egress (mean 432.58 Mbit/s)
Flow 3 ingress (mean 401.37 Mbit/s)   Flow 3 egress (mean 397.63 Mbit/s)

Flow 1 (95th percentile 85.16 ms)   Flow 2 (95th percentile 158.34 ms)   Flow 3 (95th percentile 104.95 ms)

```
Run 3: Statistics of TCP BBR

Start at: 2018-08-28 09:43:12
End at: 2018-08-28 09:43:42
Local clock offset: 0.51 ms
Remote clock offset: -0.048 ms


# Below is generated by plot.py at 2018-08-28 10:08:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 873.04 Mbit/s
95th percentile per-packet one-way delay: 175.352 ms
Loss rate: 1.57%
-- Flow 1:
Average throughput: 424.66 Mbit/s
95th percentile per-packet one-way delay: 140.841 ms
Loss rate: 0.96%
-- Flow 2:
Average throughput: 456.46 Mbit/s
95th percentile per-packet one-way delay: 148.983 ms
Loss rate: 1.16%
-- Flow 3:
Average throughput: 439.93 Mbit/s
95th percentile per-packet one-way delay: 193.993 ms
Loss rate: 4.12%
```
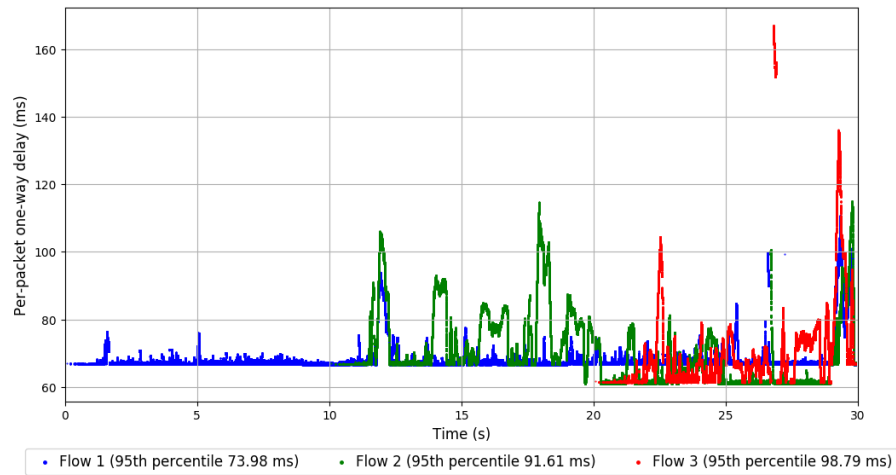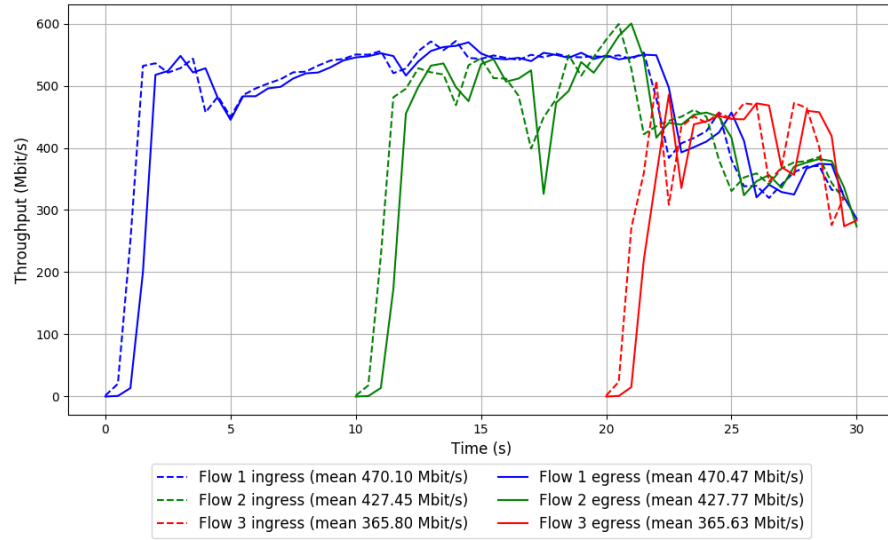
Run 3: Report of TCP BBR — Data Link

Flow 1 ingress (mean 426.94 Mbit/s)   Flow 1 egress (mean 424.66 Mbit/s)
Flow 2 ingress (mean 458.99 Mbit/s)   Flow 2 egress (mean 456.46 Mbit/s)
Flow 3 ingress (mean 452.89 Mbit/s)   Flow 3 egress (mean 439.93 Mbit/s)

Flow 1 (95th percentile 140.84 ms)   Flow 2 (95th percentile 148.98 ms)   Flow 3 (95th percentile 193.99 ms)

```
Run 1: Statistics of TCP Cubic

Start at: 2018-08-28 09:30:17
End at: 2018-08-28 09:30:47
Local clock offset: 0.474 ms
Remote clock offset: -0.107 ms


# Below is generated by plot.py at 2018-08-28 10:08:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 875.22 Mbit/s
95th percentile per-packet one-way delay: 86.605 ms
Loss rate: 0.56%
-- Flow 1:
Average throughput: 470.47 Mbit/s
95th percentile per-packet one-way delay: 73.979 ms
Loss rate: 0.35%
-- Flow 2:
Average throughput: 427.77 Mbit/s
95th percentile per-packet one-way delay: 91.615 ms
Loss rate: 0.59%
-- Flow 3:
Average throughput: 365.63 Mbit/s
95th percentile per-packet one-way delay: 98.792 ms
Loss rate: 1.32%
```

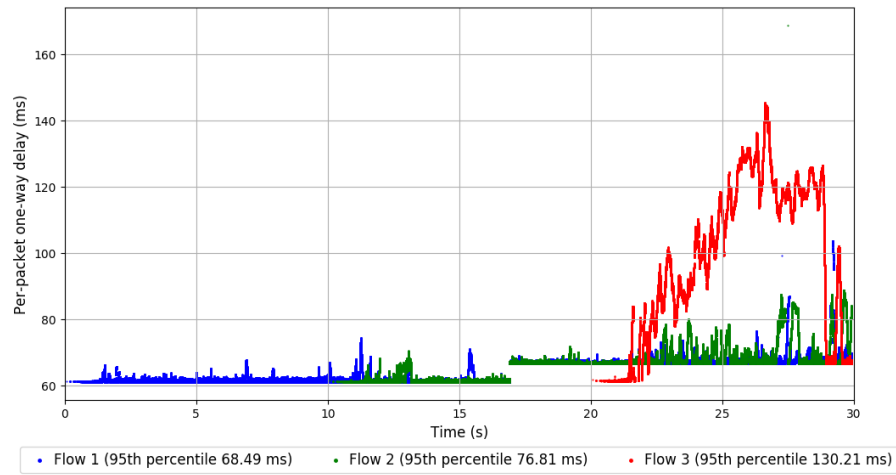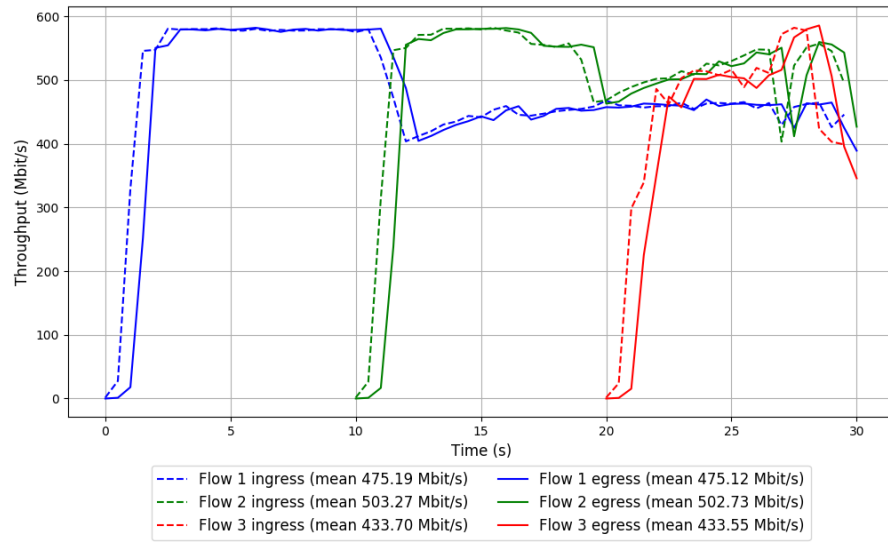Run 1: Report of TCP Cubic — Data Link

```
Run 2: Statistics of TCP Cubic

Start at: 2018-08-28 09:37:39
End at: 2018-08-28 09:38:09
Local clock offset: 0.472 ms
Remote clock offset: -0.021 ms


# Below is generated by plot.py at 2018-08-28 10:08:58
# Datalink statistics
-- Total of 3 flows:
Average throughput: 952.17 Mbit/s
95th percentile per-packet one-way delay: 117.499 ms
Loss rate: 0.65%
-- Flow 1:
Average throughput: 475.12 Mbit/s
95th percentile per-packet one-way delay: 68.494 ms
Loss rate: 0.42%
-- Flow 2:
Average throughput: 502.73 Mbit/s
95th percentile per-packet one-way delay: 76.805 ms
Loss rate: 0.72%
-- Flow 3:
Average throughput: 433.55 Mbit/s
95th percentile per-packet one-way delay: 130.210 ms
Loss rate: 1.27%
```
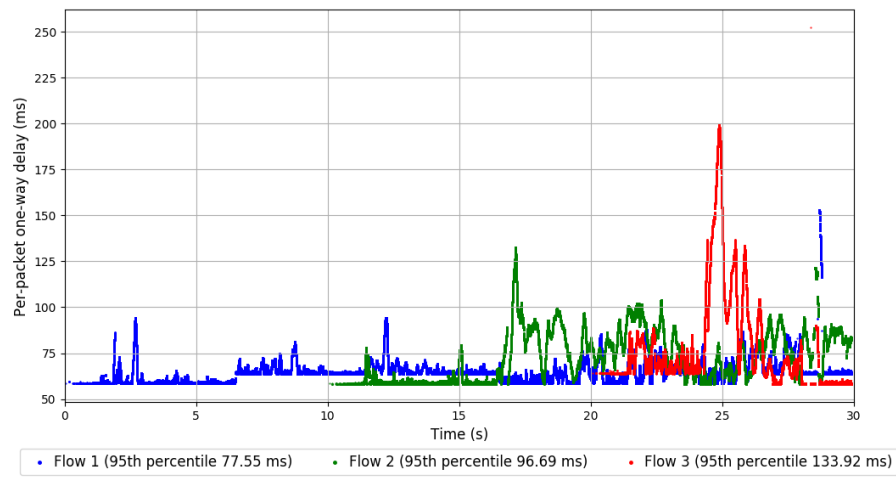
Run 2: Report of TCP Cubic — Data Link

```
Run 3: Statistics of TCP Cubic

Start at: 2018-08-28 09:45:10
End at: 2018-08-28 09:45:40
Local clock offset: 0.497 ms
Remote clock offset: 2.752 ms


# Below is generated by plot.py at 2018-08-28 10:09:36
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1025.39 Mbit/s
95th percentile per-packet one-way delay: 94.678 ms
Loss rate: 0.63%
-- Flow 1:
Average throughput: 535.26 Mbit/s
95th percentile per-packet one-way delay: 77.548 ms
Loss rate: 0.36%
-- Flow 2:
Average throughput: 529.48 Mbit/s
95th percentile per-packet one-way delay: 96.692 ms
Loss rate: 0.75%
-- Flow 3:
Average throughput: 418.89 Mbit/s
95th percentile per-packet one-way delay: 133.920 ms
Loss rate: 1.38%
```
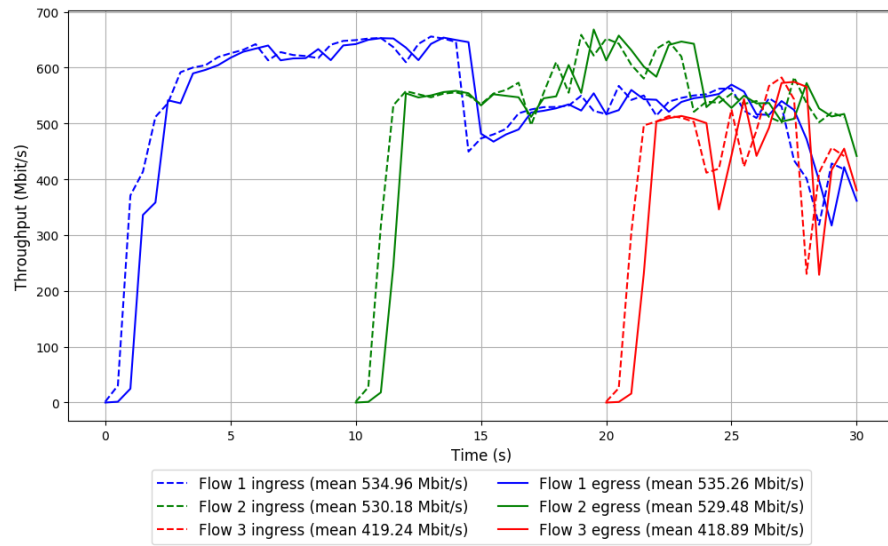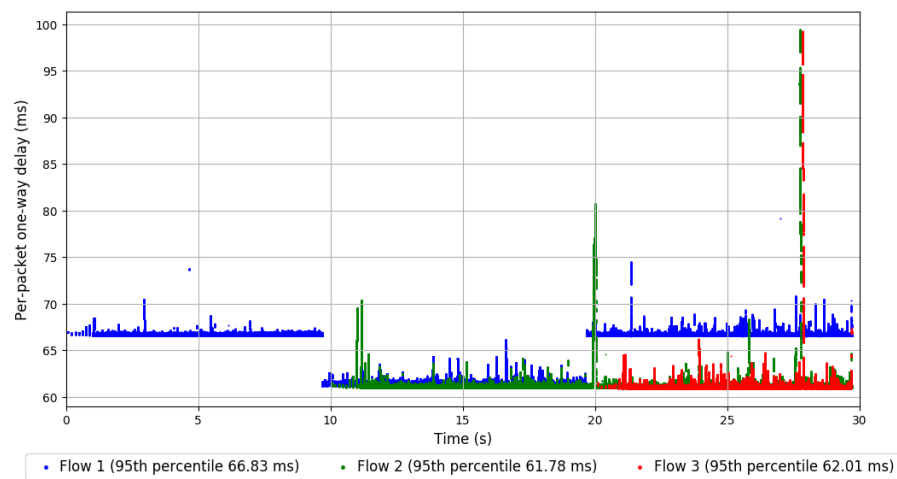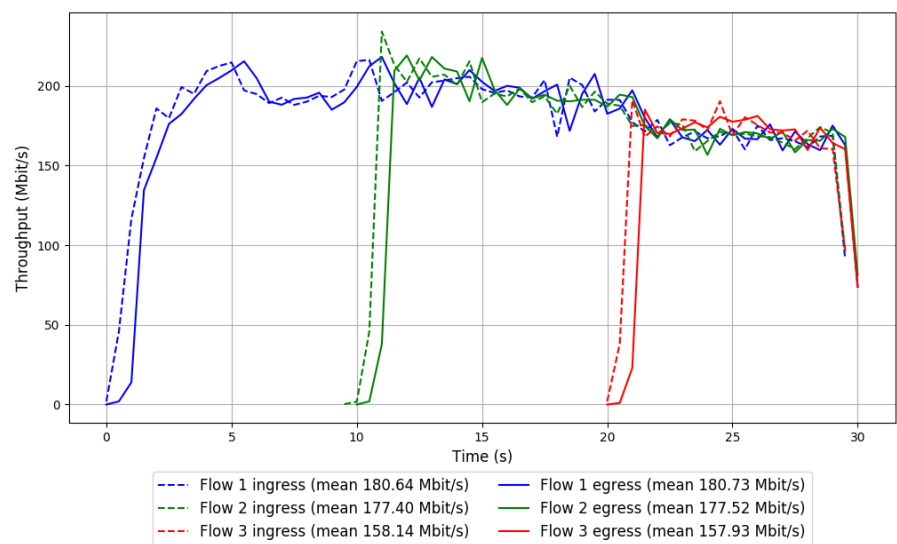
Run 3: Report of TCP Cubic — Data Link

- - - Flow 1 ingress (mean 534.96 Mbit/s) —— Flow 1 egress (mean 535.26 Mbit/s)
- - - Flow 2 ingress (mean 530.18 Mbit/s) —— Flow 2 egress (mean 529.48 Mbit/s)
- - - Flow 3 ingress (mean 419.24 Mbit/s) —— Flow 3 egress (mean 418.89 Mbit/s)

• Flow 1 (95th percentile 77.55 ms)   • Flow 2 (95th percentile 96.69 ms)   • Flow 3 (95th percentile 133.92 ms)

15

```
Run 1: Statistics of Indigo

Start at: 2018-08-28 09:34:06
End at: 2018-08-28 09:34:36
Local clock offset: 0.488 ms
Remote clock offset: -0.044 ms

# Below is generated by plot.py at 2018-08-28 10:09:36
# Datalink statistics
-- Total of 3 flows:
Average throughput: 349.68 Mbit/s
95th percentile per-packet one-way delay: 66.766 ms
Loss rate: 0.59%
-- Flow 1:
Average throughput: 180.73 Mbit/s
95th percentile per-packet one-way delay: 66.827 ms
Loss rate: 0.38%
-- Flow 2:
Average throughput: 177.52 Mbit/s
95th percentile per-packet one-way delay: 61.780 ms
Loss rate: 0.56%
-- Flow 3:
Average throughput: 157.93 Mbit/s
95th percentile per-packet one-way delay: 62.010 ms
Loss rate: 1.38%
```
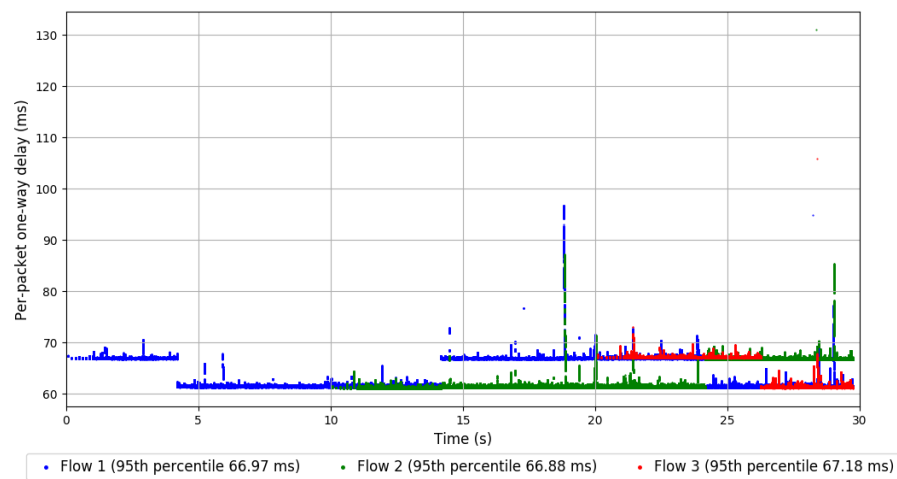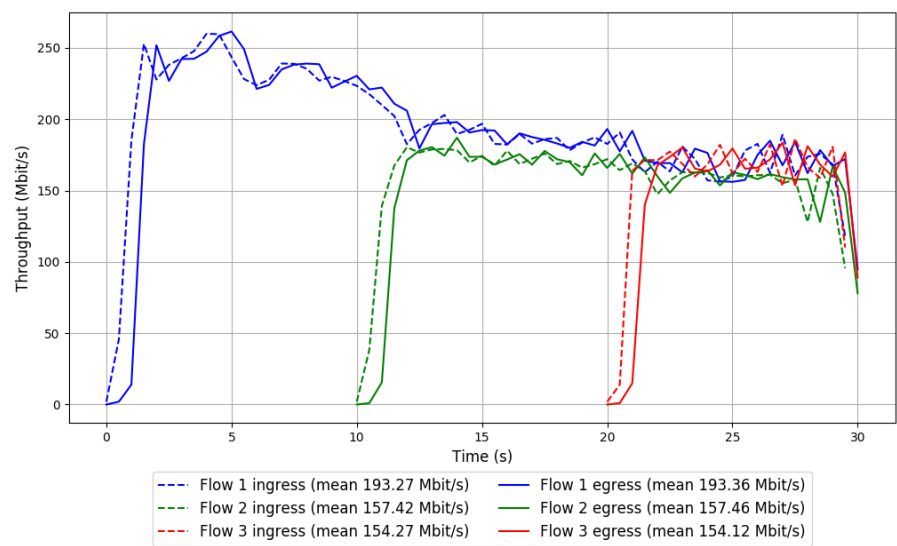
Run 1: Report of Indigo — Data Link

```
Run 2: Statistics of Indigo

Start at: 2018-08-28 09:41:30
End at: 2018-08-28 09:42:00
Local clock offset: 0.638 ms
Remote clock offset: -0.003 ms

# Below is generated by plot.py at 2018-08-28 10:09:36
# Datalink statistics
-- Total of 3 flows:
Average throughput: 347.73 Mbit/s
95th percentile per-packet one-way delay: 67.057 ms
Loss rate: 0.61%
-- Flow 1:
Average throughput: 193.36 Mbit/s
95th percentile per-packet one-way delay: 66.975 ms
Loss rate: 0.39%
-- Flow 2:
Average throughput: 157.46 Mbit/s
95th percentile per-packet one-way delay: 66.878 ms
Loss rate: 0.59%
-- Flow 3:
Average throughput: 154.12 Mbit/s
95th percentile per-packet one-way delay: 67.184 ms
Loss rate: 1.48%
```

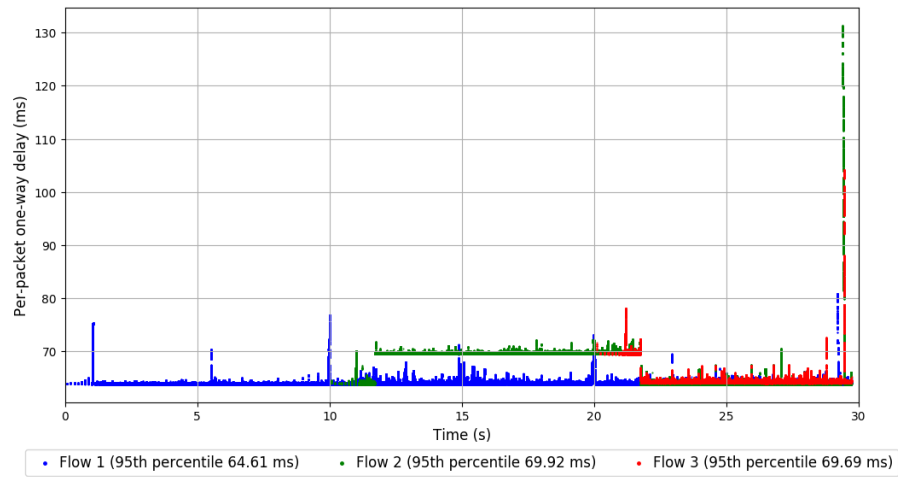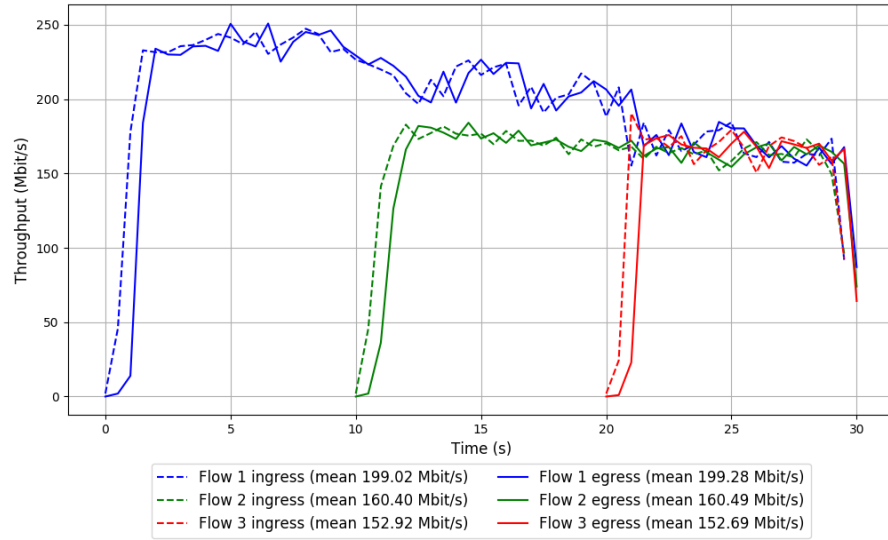Run 2: Report of Indigo — Data Link

```
Run 3: Statistics of Indigo

Start at: 2018-08-28 09:49:04
End at: 2018-08-28 09:49:34
Local clock offset: 0.532 ms
Remote clock offset: -2.849 ms


# Below is generated by plot.py at 2018-08-28 10:11:31
# Datalink statistics
-- Total of 3 flows:
Average throughput: 355.28 Mbit/s
95th percentile per-packet one-way delay: 69.777 ms
Loss rate: 0.53%
-- Flow 1:
Average throughput: 199.28 Mbit/s
95th percentile per-packet one-way delay: 64.614 ms
Loss rate: 0.28%
-- Flow 2:
Average throughput: 160.49 Mbit/s
95th percentile per-packet one-way delay: 69.923 ms
Loss rate: 0.57%
-- Flow 3:
Average throughput: 152.69 Mbit/s
95th percentile per-packet one-way delay: 69.689 ms
Loss rate: 1.47%
```

Run 3: Report of Indigo — Data Link

```
Run 1: Statistics of Muses

Start at: 2018-08-28 09:32:11
End at: 2018-08-28 09:32:41
Local clock offset: 0.525 ms
Remote clock offset: 2.73 ms

# Below is generated by plot.py at 2018-08-28 10:14:47
# Datalink statistics
-- Total of 3 flows:
Average throughput: 831.88 Mbit/s
95th percentile per-packet one-way delay: 109.887 ms
Loss rate: 0.85%
-- Flow 1:
Average throughput: 477.82 Mbit/s
95th percentile per-packet one-way delay: 114.293 ms
Loss rate: 0.50%
-- Flow 2:
Average throughput: 422.91 Mbit/s
95th percentile per-packet one-way delay: 93.996 ms
Loss rate: 0.91%
-- Flow 3:
Average throughput: 225.18 Mbit/s
95th percentile per-packet one-way delay: 80.570 ms
Loss rate: 2.91%
```
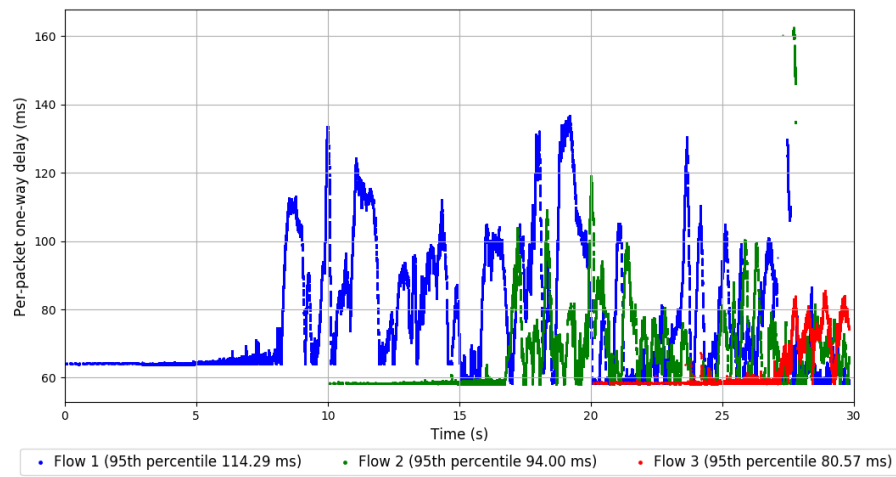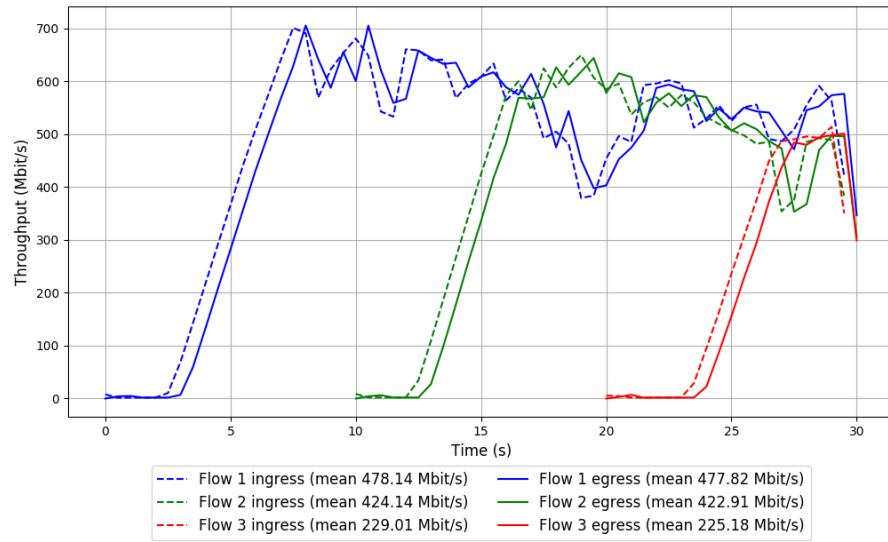
Run 1: Report of Muses — Data Link

```
Run 2: Statistics of Muses

Start at: 2018-08-28 09:39:37
End at: 2018-08-28 09:40:07
Local clock offset: 0.527 ms
Remote clock offset: 2.734 ms


# Below is generated by plot.py at 2018-08-28 10:15:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 806.46 Mbit/s
95th percentile per-packet one-way delay: 97.486 ms
Loss rate: 0.85%
-- Flow 1:
Average throughput: 460.51 Mbit/s
95th percentile per-packet one-way delay: 100.793 ms
Loss rate: 0.54%
-- Flow 2:
Average throughput: 391.92 Mbit/s
95th percentile per-packet one-way delay: 93.338 ms
Loss rate: 0.87%
-- Flow 3:
Average throughput: 263.76 Mbit/s
95th percentile per-packet one-way delay: 91.996 ms
Loss rate: 2.46%
```
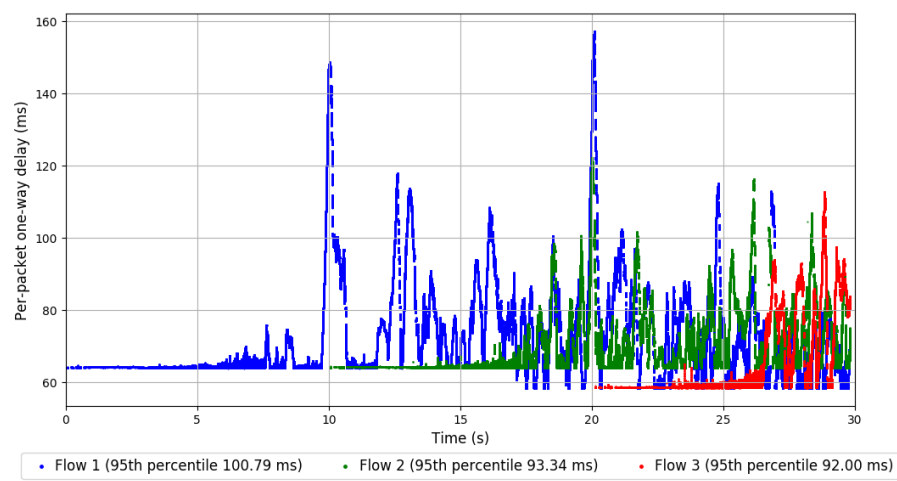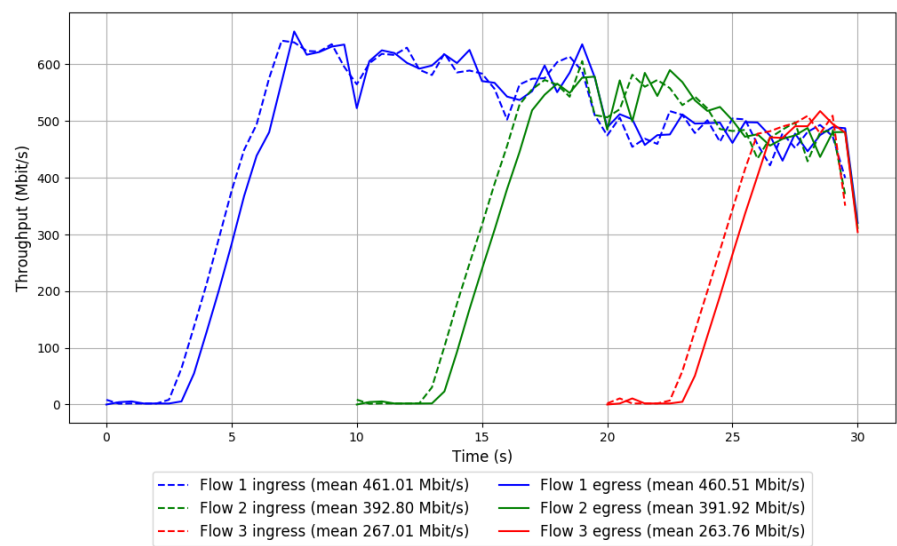
Run 2: Report of Muses — Data Link

```
Run 3: Statistics of Muses

Start at: 2018-08-28 09:47:11
End at: 2018-08-28 09:47:41
Local clock offset: 0.494 ms
Remote clock offset: -0.003 ms

# Below is generated by plot.py at 2018-08-28 10:15:16
# Datalink statistics
-- Total of 3 flows:
Average throughput: 813.23 Mbit/s
95th percentile per-packet one-way delay: 95.841 ms
Loss rate: 0.86%
-- Flow 1:
Average throughput: 476.98 Mbit/s
95th percentile per-packet one-way delay: 95.024 ms
Loss rate: 0.49%
-- Flow 2:
Average throughput: 374.59 Mbit/s
95th percentile per-packet one-way delay: 103.685 ms
Loss rate: 0.97%
-- Flow 3:
Average throughput: 269.58 Mbit/s
95th percentile per-packet one-way delay: 90.701 ms
Loss rate: 2.52%
```

Run 3: Report of Muses — Data Link