Pantheon Report

Generated at 2018-08-28 10:12:28 (UTC).

Data path: GCE London on ens4 (*remote*) →GCE Sydney 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.

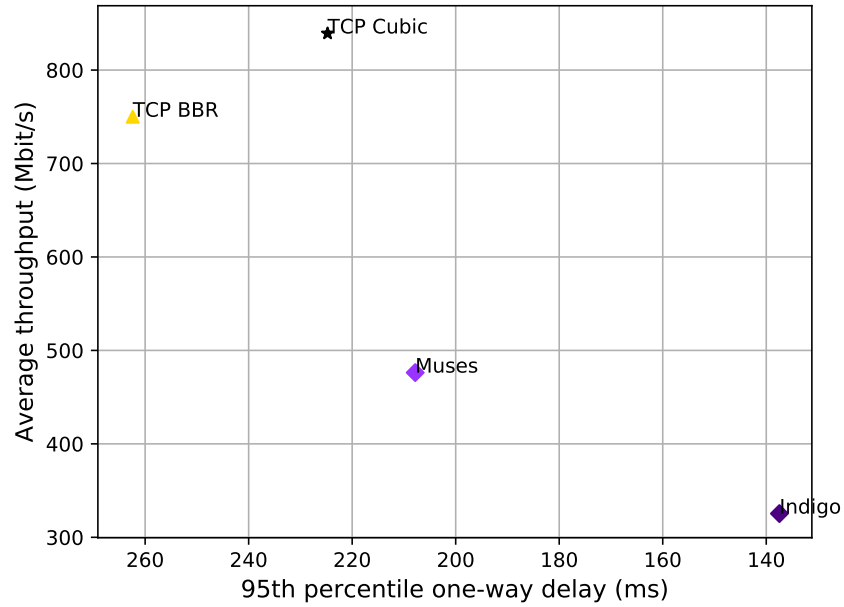```
System info:
Linux 4.15.0-1015-gcp
net.core.default_qdisc = fq
net.core.rmem_default = 16777216
net.core.rmem_max = 536870912
net.core.wmem_default = 16777216
net.core.wmem_max = 536870912
net.ipv4.tcp_rmem = 4096 16777216 536870912
net.ipv4.tcp_wmem = 4096 16777216 536870912

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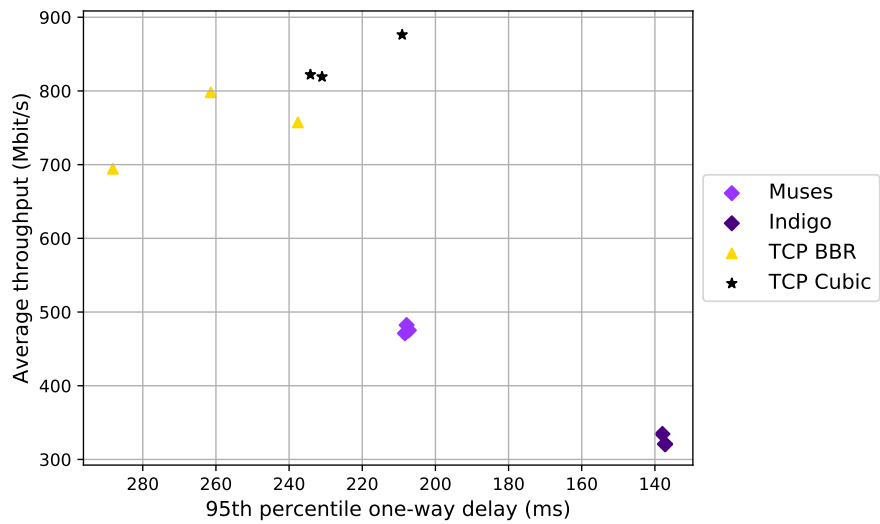
## test from GCE London to GCE Sydney, 3 runs of 30s each per scheme
### 3 flows with 10s interval between flows (mean of all runs by scheme)



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



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| 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 | 460.17 | 313.82 | 251.96 | 257.85 | 280.88 | 187.59 | 3.65 | 5.00 | 5.87 |
| TCP Cubic | 3 | 470.69 | 420.32 | 275.16 | 226.77 | 214.27 | 175.04 | 1.09 | 1.62 | 4.66 |
| Indigo | 3 | 166.51 | 171.87 | 141.12 | 136.94 | 137.55 | 138.67 | 0.83 | 1.33 | 3.52 |
| Muses | 3 | 359.55 | 174.95 | 2.69 | 208.30 | 207.59 | 136.43 | 4.24 | 4.96 | 32.39 |

```
Run 1: Statistics of TCP BBR

Start at: 2018-08-28 09:34:11
End at: 2018-08-28 09:34:41
Local clock offset: -0.062 ms
Remote clock offset: 0.483 ms

Below is generated by plot.py at 2018-08-28 10:07:52
Datalink statistics
-- Total of 3 flows:
Average throughput: 798.23 Mbit/s
95th percentile per-packet one-way delay: 261.406 ms
Loss rate: 4.63%
-- Flow 1:
Average throughput: 475.58 Mbit/s
95th percentile per-packet one-way delay: 258.875 ms
Loss rate: 3.74%
-- Flow 2:
Average throughput: 334.44 Mbit/s
95th percentile per-packet one-way delay: 283.708 ms
Loss rate: 5.09%
-- Flow 3:
Average throughput: 309.38 Mbit/s
95th percentile per-packet one-way delay: 256.421 ms
Loss rate: 7.68%
```
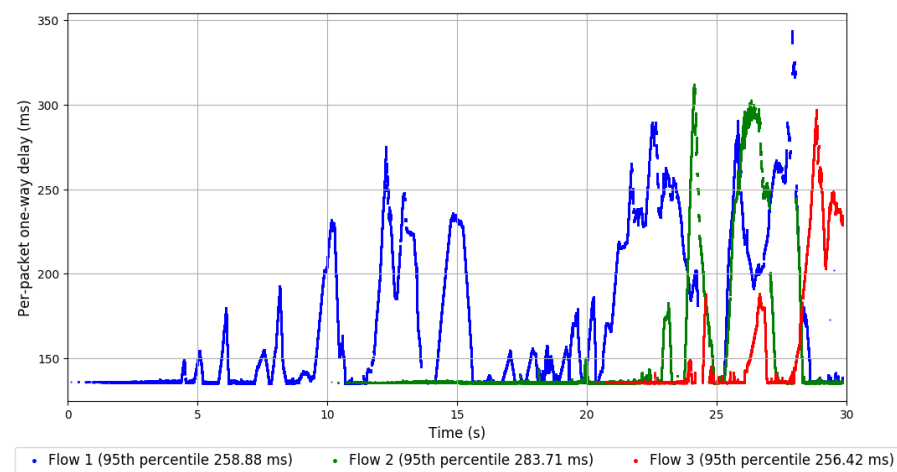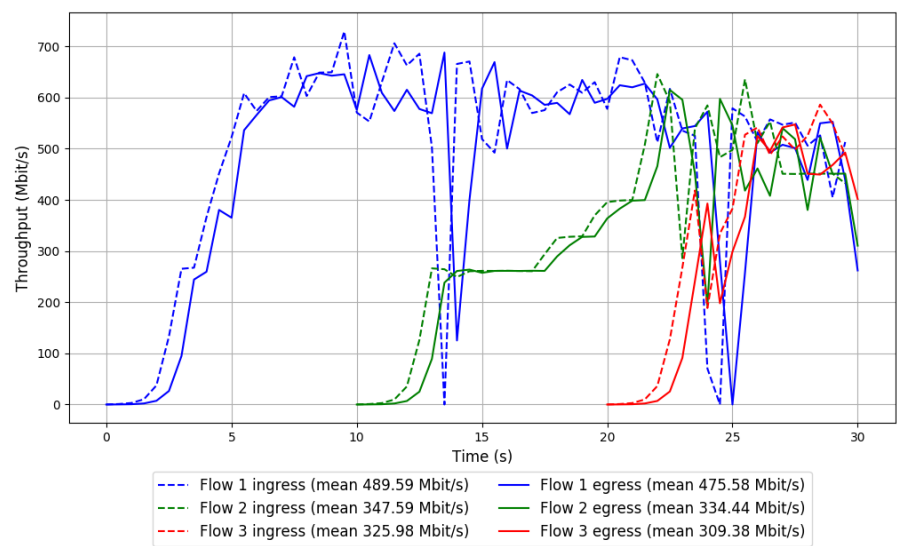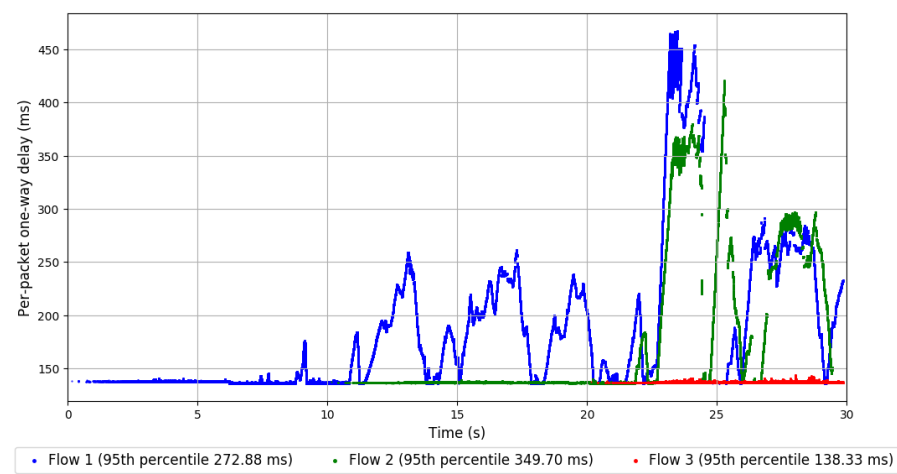
Run 1: Report of TCP BBR — Data Link



Flow 1 ingress (mean 489.59 Mbit/s)    Flow 1 egress (mean 475.58 Mbit/s)
Flow 2 ingress (mean 347.59 Mbit/s)    Flow 2 egress (mean 334.44 Mbit/s)
Flow 3 ingress (mean 325.98 Mbit/s)    Flow 3 egress (mean 309.38 Mbit/s)



Flow 1 (95th percentile 258.88 ms)    Flow 2 (95th percentile 283.71 ms)    Flow 3 (95th percentile 256.42 ms)
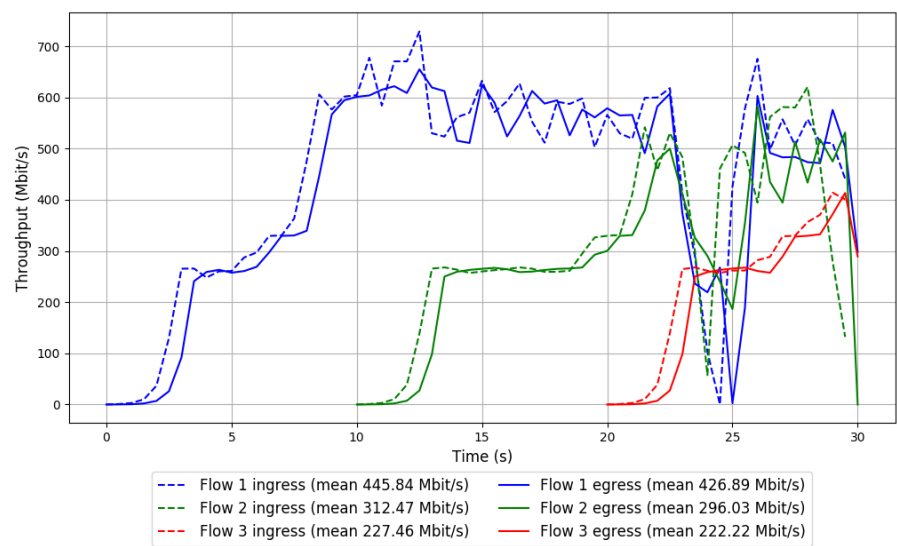
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```
Run 2: Statistics of TCP BBR

Start at: 2018-08-28 09:42:20
End at: 2018-08-28 09:42:50
Local clock offset: -0.151 ms
Remote clock offset: -0.471 ms


# Below is generated by plot.py at 2018-08-28 10:07:52
# Datalink statistics
-- Total of 3 flows:
Average throughput: 694.46 Mbit/s
95th percentile per-packet one-way delay: 288.170 ms
Loss rate: 5.70%
-- Flow 1:
Average throughput: 426.89 Mbit/s
95th percentile per-packet one-way delay: 272.885 ms
Loss rate: 5.12%
-- Flow 2:
Average throughput: 296.03 Mbit/s
95th percentile per-packet one-way delay: 349.699 ms
Loss rate: 7.20%
-- Flow 3:
Average throughput: 222.22 Mbit/s
95th percentile per-packet one-way delay: 138.328 ms
Loss rate: 4.97%
```

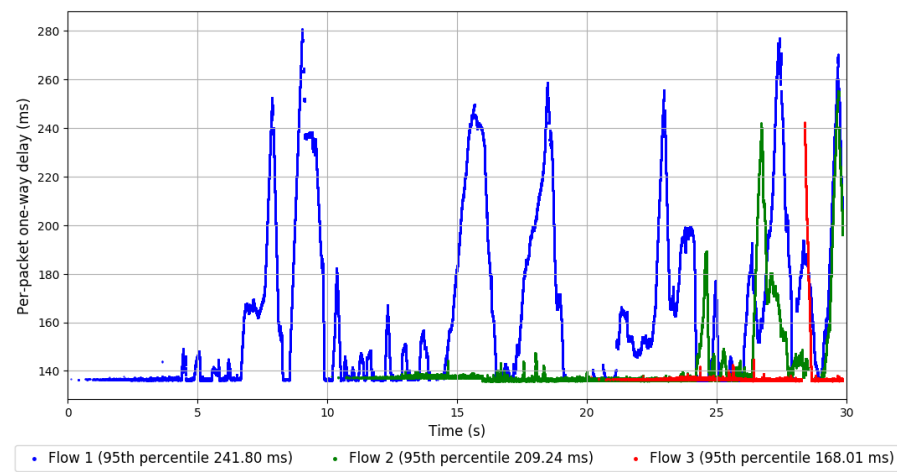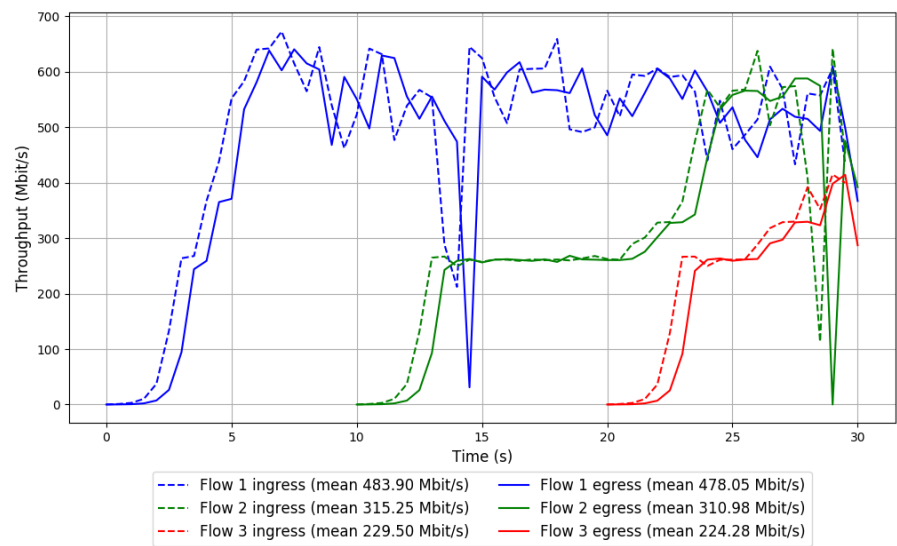Run 2: Report of TCP BBR — Data Link

```
Run 3: Statistics of TCP BBR

Start at: 2018-08-28 09:50:10
End at: 2018-08-28 09:50:40
Local clock offset: -0.459 ms
Remote clock offset: -0.469 ms


# Below is generated by plot.py at 2018-08-28 10:07:52
# Datalink statistics
-- Total of 3 flows:
Average throughput: 757.38 Mbit/s
95th percentile per-packet one-way delay: 237.593 ms
Loss rate: 2.55%
-- Flow 1:
Average throughput: 478.05 Mbit/s
95th percentile per-packet one-way delay: 241.798 ms
Loss rate: 2.10%
-- Flow 2:
Average throughput: 310.98 Mbit/s
95th percentile per-packet one-way delay: 209.244 ms
Loss rate: 2.70%
-- Flow 3:
Average throughput: 224.28 Mbit/s
95th percentile per-packet one-way delay: 168.013 ms
Loss rate: 4.95%
```

Run 3: Report of TCP BBR — Data Link

Flow 1 ingress (mean 483.90 Mbit/s)   Flow 1 egress (mean 478.05 Mbit/s)
Flow 2 ingress (mean 315.25 Mbit/s)   Flow 2 egress (mean 310.98 Mbit/s)
Flow 3 ingress (mean 229.50 Mbit/s)   Flow 3 egress (mean 224.28 Mbit/s)

Flow 1 (95th percentile 241.80 ms)   Flow 2 (95th percentile 209.24 ms)   Flow 3 (95th percentile 168.01 ms)

```
Run 1: Statistics of TCP Cubic

Start at: 2018-08-28 09:32:02
End at: 2018-08-28 09:32:32
Local clock offset: -0.246 ms
Remote clock offset: 0.012 ms


# Below is generated by plot.py at 2018-08-28 10:08:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 876.23 Mbit/s
95th percentile per-packet one-way delay: 209.092 ms
Loss rate: 1.83%
-- Flow 1:
Average throughput: 501.92 Mbit/s
95th percentile per-packet one-way delay: 216.610 ms
Loss rate: 1.13%
-- Flow 2:
Average throughput: 405.29 Mbit/s
95th percentile per-packet one-way delay: 200.051 ms
Loss rate: 1.72%
-- Flow 3:
Average throughput: 323.62 Mbit/s
95th percentile per-packet one-way delay: 235.140 ms
Loss rate: 5.34%
```
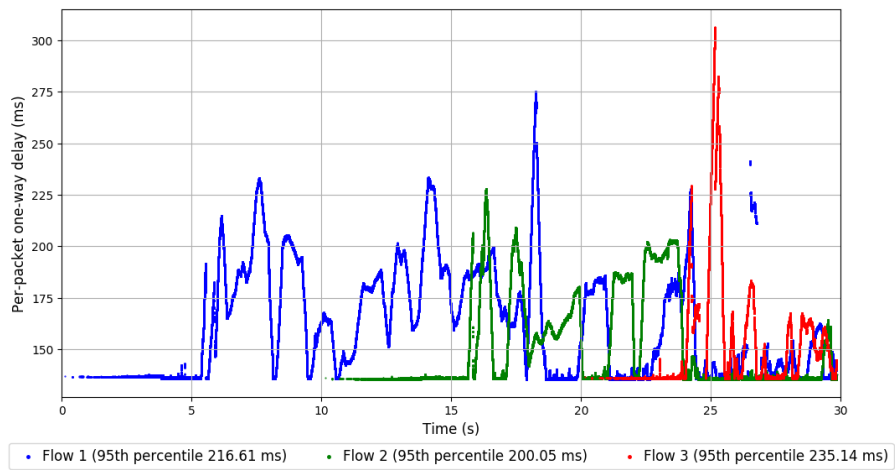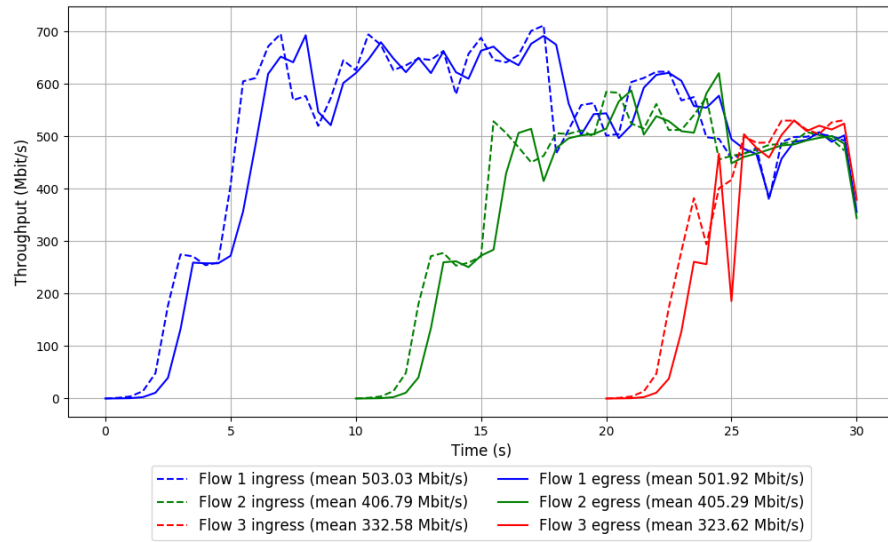
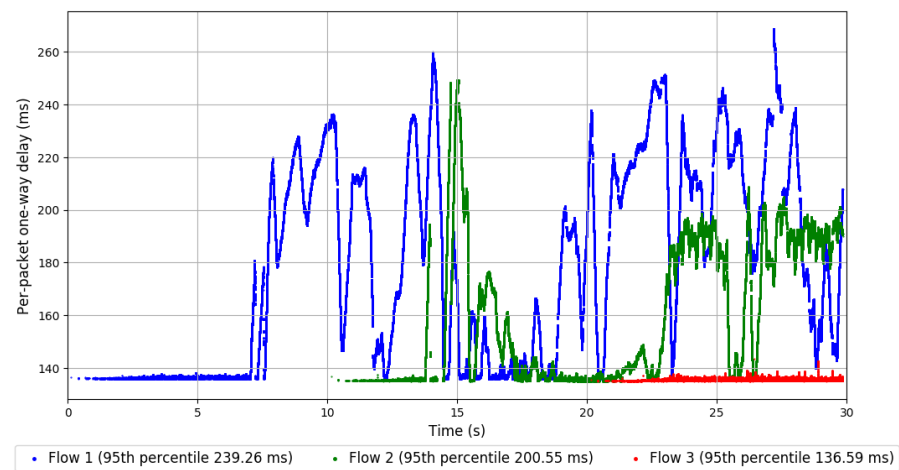Run 1: Report of TCP Cubic — Data Link

- - - Flow 1 ingress (mean 503.03 Mbit/s) —— Flow 1 egress (mean 501.92 Mbit/s)
- - - Flow 2 ingress (mean 406.79 Mbit/s) —— Flow 2 egress (mean 405.29 Mbit/s)
- - - Flow 3 ingress (mean 332.58 Mbit/s) —— Flow 3 egress (mean 323.62 Mbit/s)

• Flow 1 (95th percentile 216.61 ms)   • Flow 2 (95th percentile 200.05 ms)   • Flow 3 (95th percentile 235.14 ms)
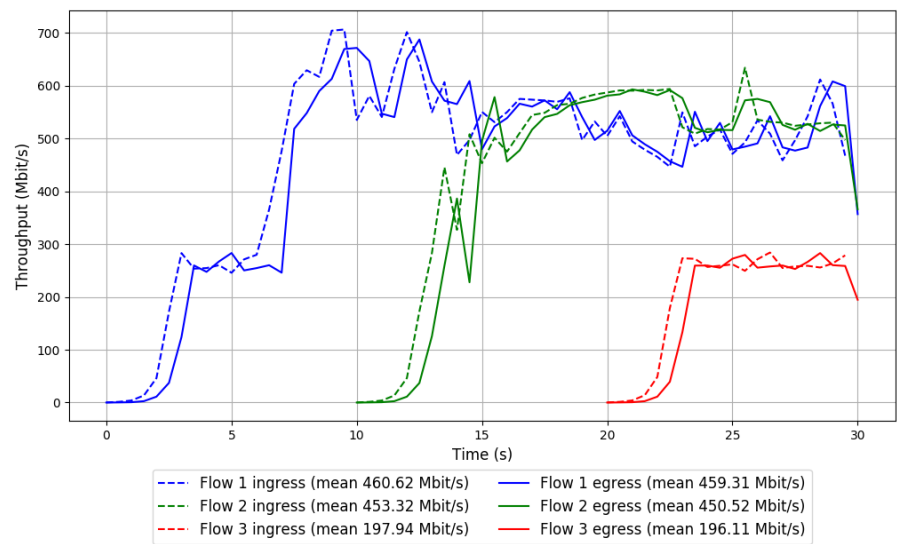
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```
Run 2: Statistics of TCP Cubic

Start at: 2018-08-28 09:40:14
End at: 2018-08-28 09:40:44
Local clock offset: -0.319 ms
Remote clock offset: -0.093 ms


# Below is generated by plot.py at 2018-08-28 10:08:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 822.10 Mbit/s
95th percentile per-packet one-way delay: 234.171 ms
Loss rate: 1.67%
-- Flow 1:
Average throughput: 459.31 Mbit/s
95th percentile per-packet one-way delay: 239.258 ms
Loss rate: 1.19%
-- Flow 2:
Average throughput: 450.52 Mbit/s
95th percentile per-packet one-way delay: 200.548 ms
Loss rate: 1.97%
-- Flow 3:
Average throughput: 196.11 Mbit/s
95th percentile per-packet one-way delay: 136.591 ms
Loss rate: 3.61%
```

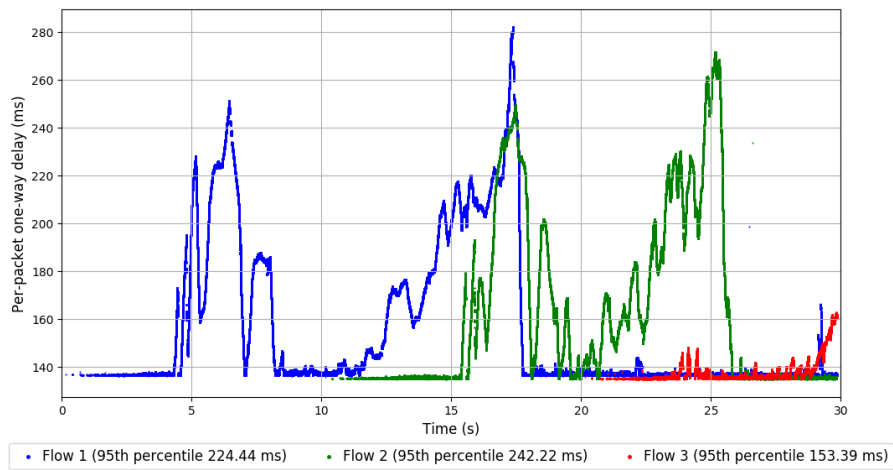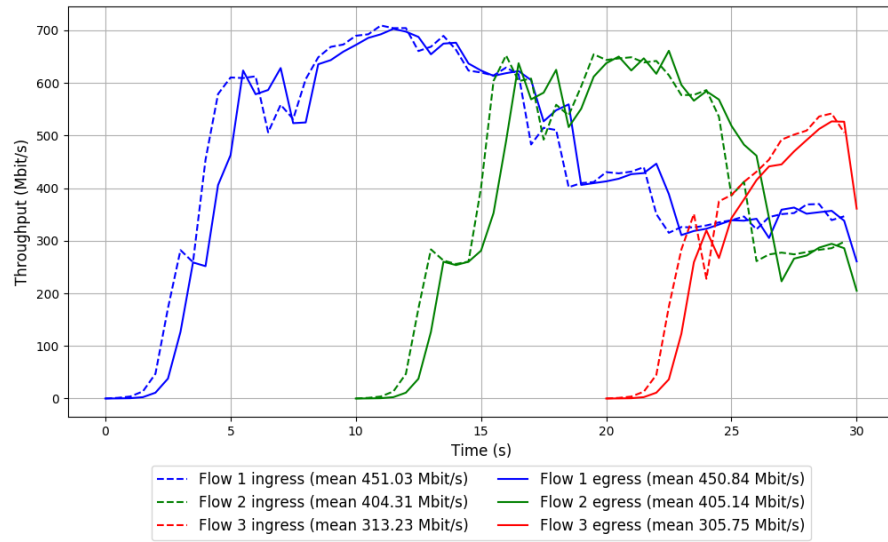Run 2: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 460.62 Mbit/s) --- Flow 1 egress (mean 459.31 Mbit/s) ---
Flow 2 ingress (mean 453.32 Mbit/s) --- Flow 2 egress (mean 450.52 Mbit/s) ---
Flow 3 ingress (mean 197.94 Mbit/s) --- Flow 3 egress (mean 196.11 Mbit/s) ---

Flow 1 (95th percentile 239.26 ms)   Flow 2 (95th percentile 200.55 ms)   Flow 3 (95th percentile 136.59 ms)

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```
Run 3: Statistics of TCP Cubic

Start at: 2018-08-28 09:48:04
End at: 2018-08-28 09:48:34
Local clock offset: -0.286 ms
Remote clock offset: 0.284 ms


# Below is generated by plot.py at 2018-08-28 10:08:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 819.21 Mbit/s
95th percentile per-packet one-way delay: 230.992 ms
Loss rate: 1.54%
-- Flow 1:
Average throughput: 450.84 Mbit/s
95th percentile per-packet one-way delay: 224.443 ms
Loss rate: 0.95%
-- Flow 2:
Average throughput: 405.14 Mbit/s
95th percentile per-packet one-way delay: 242.218 ms
Loss rate: 1.16%
-- Flow 3:
Average throughput: 305.75 Mbit/s
95th percentile per-packet one-way delay: 153.392 ms
Loss rate: 5.04%
```

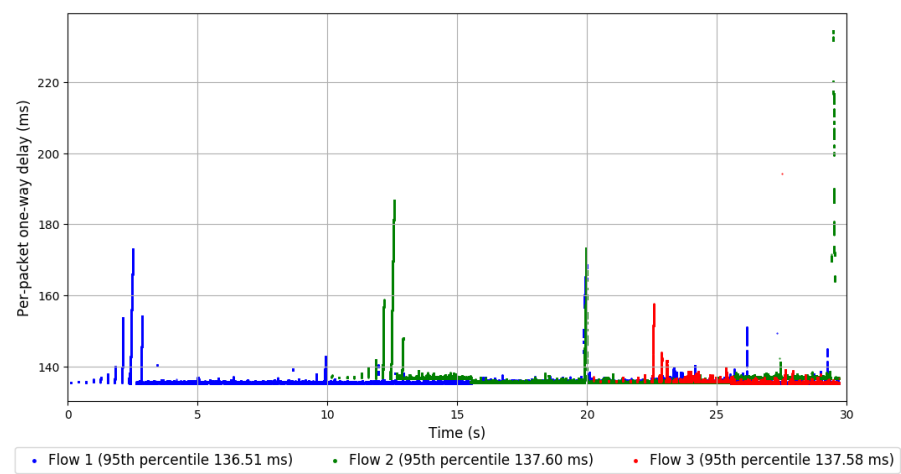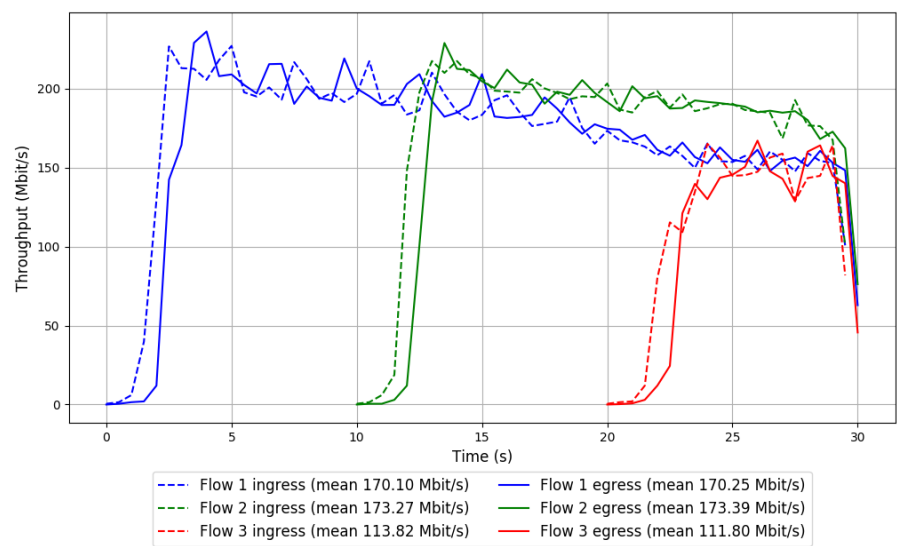Run 3: Report of TCP Cubic — Data Link

```
Run 1: Statistics of Indigo

Start at: 2018-08-28 09:30:10
End at: 2018-08-28 09:30:40
Local clock offset: -0.169 ms
Remote clock offset: 0.115 ms


# Below is generated by plot.py at 2018-08-28 10:08:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 320.49 Mbit/s
95th percentile per-packet one-way delay: 137.197 ms
Loss rate: 1.32%
-- Flow 1:
Average throughput: 170.25 Mbit/s
95th percentile per-packet one-way delay: 136.512 ms
Loss rate: 0.82%
-- Flow 2:
Average throughput: 173.39 Mbit/s
95th percentile per-packet one-way delay: 137.601 ms
Loss rate: 1.31%
-- Flow 3:
Average throughput: 111.80 Mbit/s
95th percentile per-packet one-way delay: 137.584 ms
Loss rate: 3.67%
```

Run 1: Report of Indigo — Data Link

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```
Run 2: Statistics of Indigo

Start at: 2018-08-28 09:38:21
End at: 2018-08-28 09:38:51
Local clock offset: -0.218 ms
Remote clock offset: 0.678 ms


# Below is generated by plot.py at 2018-08-28 10:08:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 321.11 Mbit/s
95th percentile per-packet one-way delay: 137.227 ms
Loss rate: 1.43%
-- Flow 1:
Average throughput: 157.95 Mbit/s
95th percentile per-packet one-way delay: 136.660 ms
Loss rate: 0.86%
-- Flow 2:
Average throughput: 171.53 Mbit/s
95th percentile per-packet one-way delay: 136.892 ms
Loss rate: 1.32%
-- Flow 3:
Average throughput: 154.94 Mbit/s
95th percentile per-packet one-way delay: 139.005 ms
Loss rate: 3.43%
```
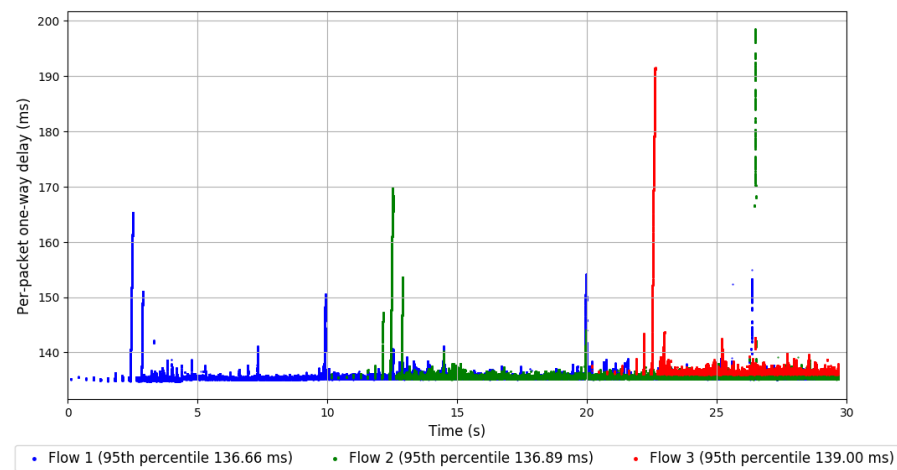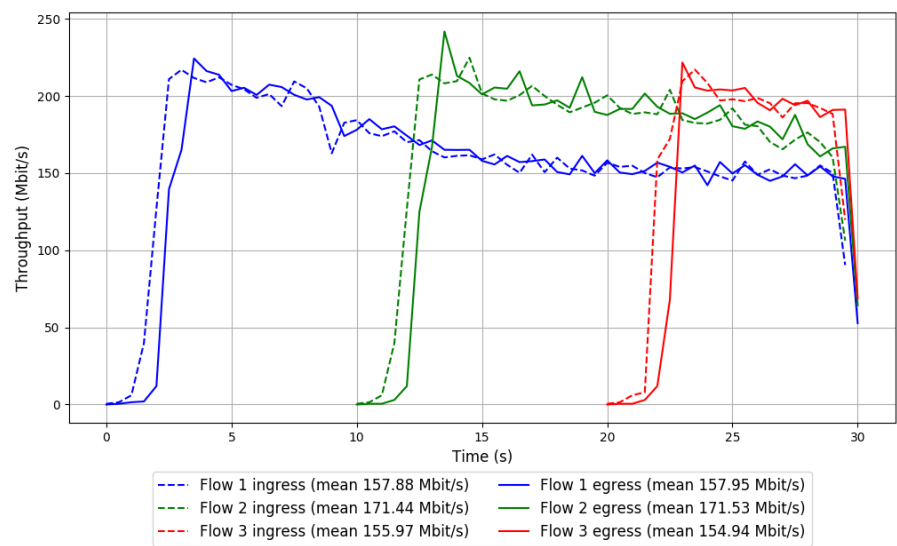
Run 2: Report of Indigo — Data Link

```
Run 3: Statistics of Indigo

Start at: 2018-08-28 09:46:11
End at: 2018-08-28 09:46:41
Local clock offset: -0.177 ms
Remote clock offset: 0.02 ms


# Below is generated by plot.py at 2018-08-28 10:11:35
# Datalink statistics
-- Total of 3 flows:
Average throughput: 334.58 Mbit/s
95th percentile per-packet one-way delay: 137.945 ms
Loss rate: 1.40%
-- Flow 1:
Average throughput: 171.33 Mbit/s
95th percentile per-packet one-way delay: 137.635 ms
Loss rate: 0.80%
-- Flow 2:
Average throughput: 170.68 Mbit/s
95th percentile per-packet one-way delay: 138.169 ms
Loss rate: 1.35%
-- Flow 3:
Average throughput: 156.63 Mbit/s
95th percentile per-packet one-way delay: 139.413 ms
Loss rate: 3.45%
```
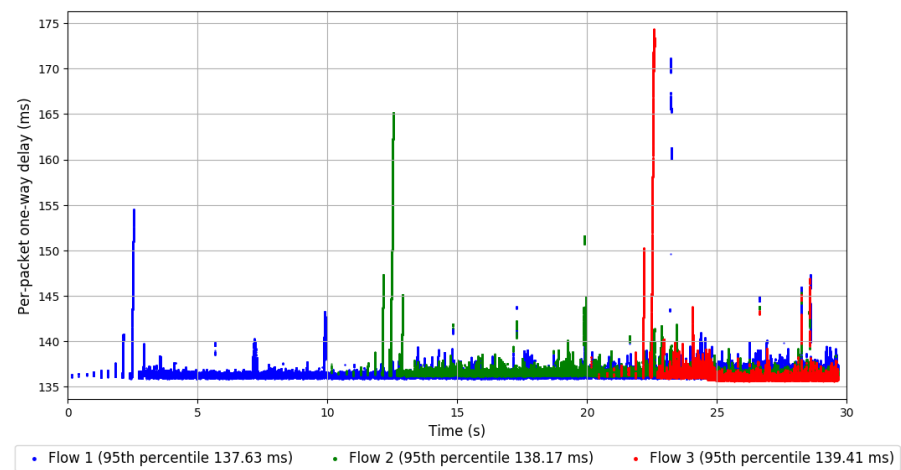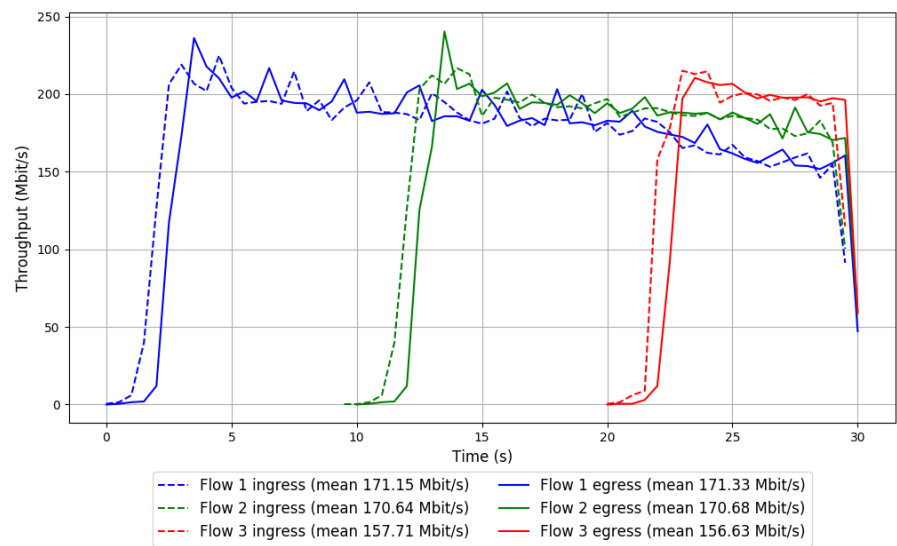
Run 3: Report of Indigo — Data Link

```
Run 1: Statistics of Muses

Start at: 2018-08-28 09:28:21
End at: 2018-08-28 09:28:51
Local clock offset: -0.286 ms
Remote clock offset: 0.028 ms

# Below is generated by plot.py at 2018-08-28 10:12:08
# Datalink statistics
-- Total of 3 flows:
Average throughput: 482.32 Mbit/s
95th percentile per-packet one-way delay: 207.866 ms
Loss rate: 3.90%
-- Flow 1:
Average throughput: 363.63 Mbit/s
95th percentile per-packet one-way delay: 207.025 ms
Loss rate: 3.49%
-- Flow 2:
Average throughput: 177.71 Mbit/s
95th percentile per-packet one-way delay: 216.651 ms
Loss rate: 4.76%
-- Flow 3:
Average throughput: 3.40 Mbit/s
95th percentile per-packet one-way delay: 135.928 ms
Loss rate: 32.50%
```
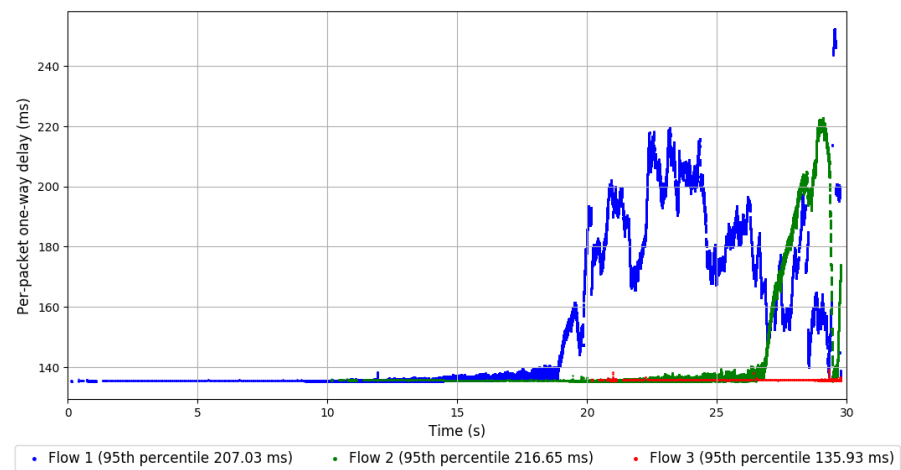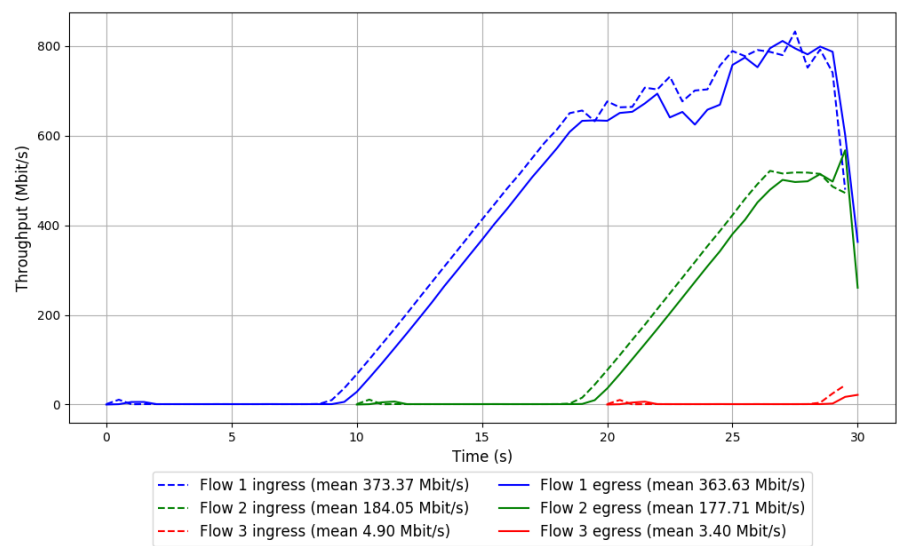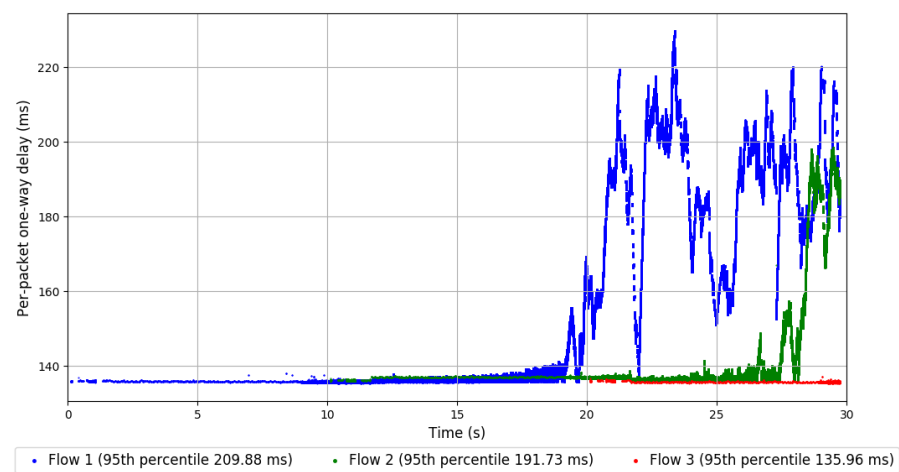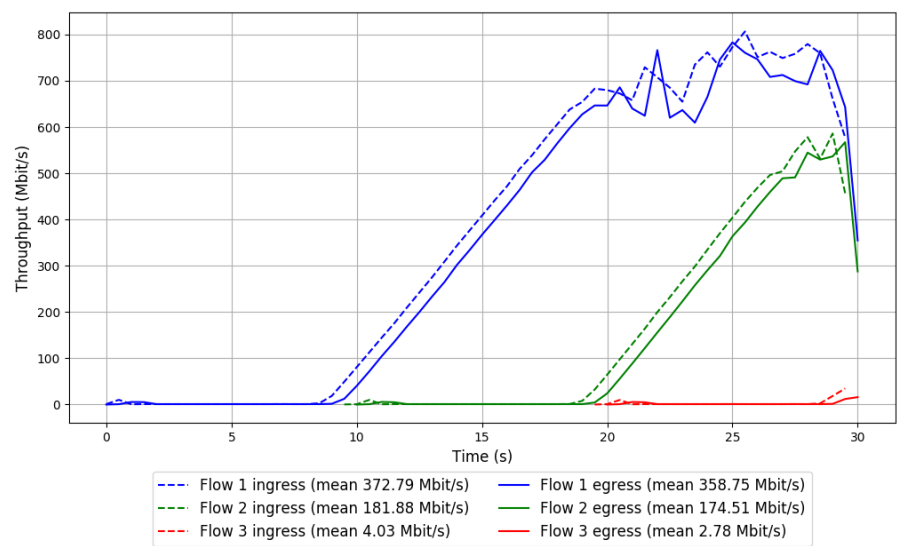
Run 1: Report of Muses — Data Link

```
Run 2: Statistics of Muses

Start at: 2018-08-28 09:36:34
End at: 2018-08-28 09:37:04
Local clock offset: -0.209 ms
Remote clock offset: 0.284 ms


# Below is generated by plot.py at 2018-08-28 10:12:21
# Datalink statistics
-- Total of 3 flows:
Average throughput: 475.27 Mbit/s
95th percentile per-packet one-way delay: 207.262 ms
Loss rate: 4.89%
-- Flow 1:
Average throughput: 358.75 Mbit/s
95th percentile per-packet one-way delay: 209.876 ms
Loss rate: 4.64%
-- Flow 2:
Average throughput: 174.51 Mbit/s
95th percentile per-packet one-way delay: 191.734 ms
Loss rate: 5.36%
-- Flow 3:
Average throughput: 2.78 Mbit/s
95th percentile per-packet one-way delay: 135.961 ms
Loss rate: 33.04%
```

Run 2: Report of Muses — Data Link

```
Run 3: Statistics of Muses

Start at: 2018-08-28 09:44:24
End at: 2018-08-28 09:44:54
Local clock offset: -0.273 ms
Remote clock offset: -0.268 ms

# Below is generated by plot.py at 2018-08-28 10:12:27
# Datalink statistics
-- Total of 3 flows:
Average throughput: 471.15 Mbit/s
95th percentile per-packet one-way delay: 208.331 ms
Loss rate: 4.67%
-- Flow 1:
Average throughput: 356.28 Mbit/s
95th percentile per-packet one-way delay: 208.001 ms
Loss rate: 4.58%
-- Flow 2:
Average throughput: 172.64 Mbit/s
95th percentile per-packet one-way delay: 214.387 ms
Loss rate: 4.77%
-- Flow 3:
Average throughput: 1.90 Mbit/s
95th percentile per-packet one-way delay: 137.390 ms
Loss rate: 31.63%
```

Run 3: Report of Muses — Data Link

- - - - Flow 1 ingress (mean 369.97 Mbit/s) ——— Flow 1 egress (mean 356.28 Mbit/s)
- - - - Flow 2 ingress (mean 178.82 Mbit/s) ——— Flow 2 egress (mean 172.64 Mbit/s)
- - - - Flow 3 ingress (mean 2.70 Mbit/s) ——— Flow 3 egress (mean 1.90 Mbit/s)

• Flow 1 (95th percentile 208.00 ms)   • Flow 2 (95th percentile 214.39 ms)   • Flow 3 (95th percentile 137.39 ms)