Pantheon Report

Generated at 2018-09-05 02:58:38 (UTC).

Data path: AWS Korea on `ens5` (*local*) →China on `eno1` (*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.

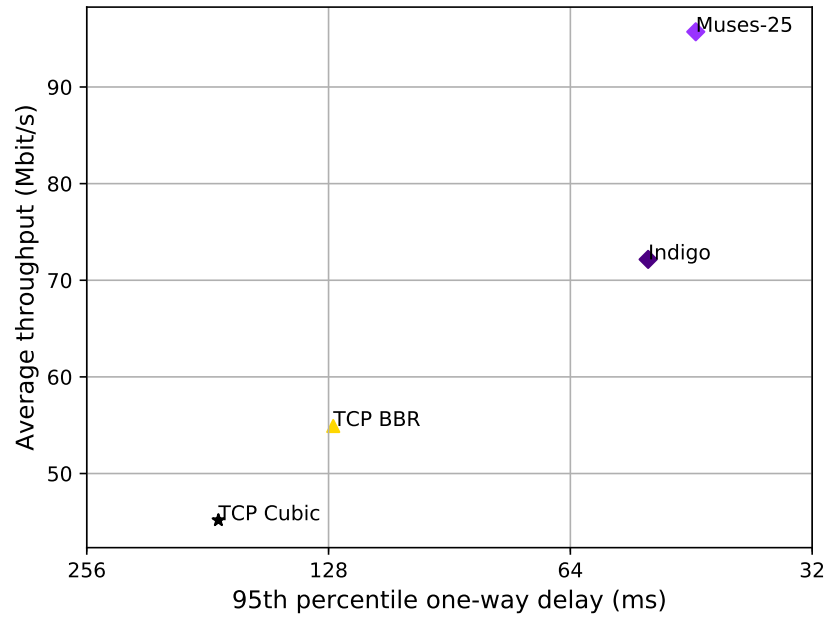NTP offsets were measured against `ntp.nict.jp` and have been applied to correct the timestamps in logs.

```
System info:
Linux 4.15.0-1010-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
```
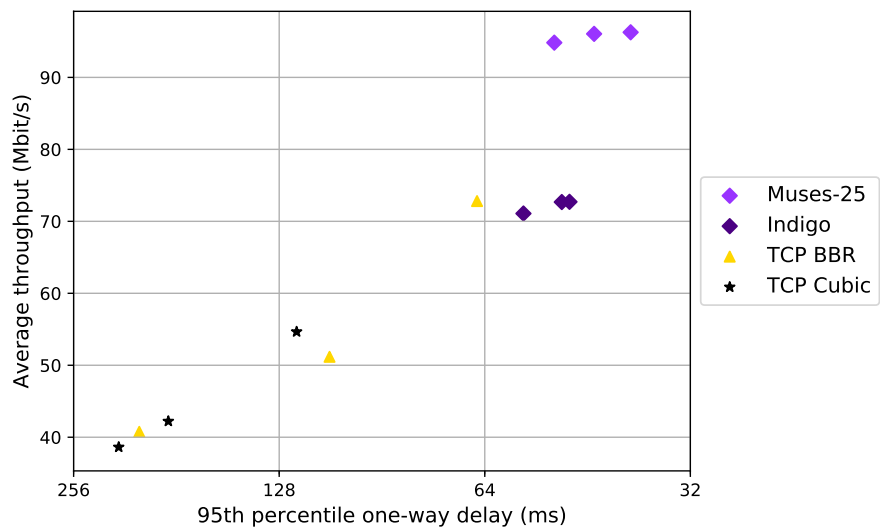
```
Git summary:
branch: muses @ 71e71e9a55b945431a7dea72180c1c9381097db9
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436dbd4b834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbdfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0ecdbf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ 96fbc95fb38373d71fbc80c5a105e62e7636623b
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 AWS Korea to China, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

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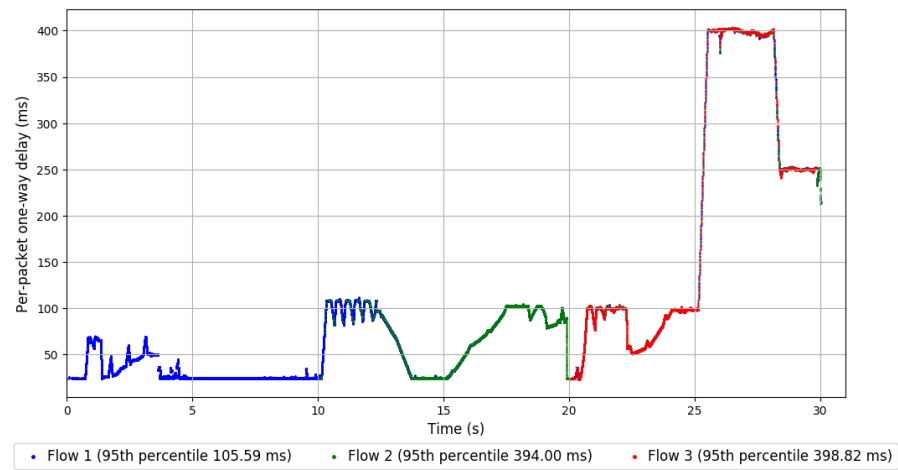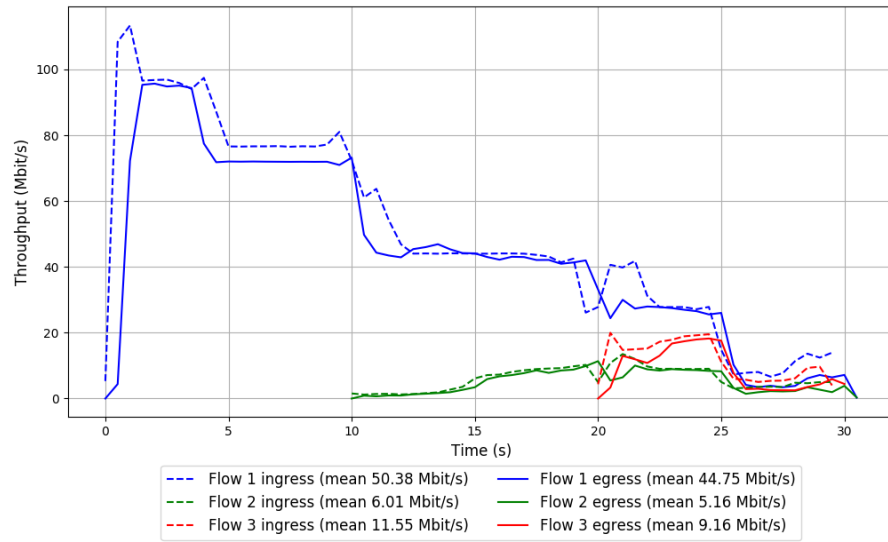3 flows with 10s interval between flows

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	39.33	14.59	17.72	110.74	231.63	206.53	14.32	18.23	17.99
TCP Cubic	3	34.30	12.62	7.41	171.38	181.95	161.44	1.91	1.00	1.00
Indigo	3	48.60	24.68	22.34	48.45	53.69	56.06	12.65	22.48	28.75
Muses-25	3	61.25	38.29	27.72	40.24	49.97	48.70	0.01	0.00	0.00

```
Run 1: Statistics of TCP BBR

Start at: 2018-09-05 02:46:05
End at: 2018-09-05 02:46:35
Local clock offset: 11.797 ms
Remote clock offset: 24.763 ms


# Below is generated by plot.py at 2018-09-05 02:57:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 51.18 Mbit/s
95th percentile per-packet one-way delay: 108.015 ms
Loss rate: 12.09%
-- Flow 1:
Average throughput: 44.75 Mbit/s
95th percentile per-packet one-way delay: 105.593 ms
Loss rate: 11.17%
-- Flow 2:
Average throughput: 5.16 Mbit/s
95th percentile per-packet one-way delay: 393.998 ms
Loss rate: 14.17%
-- Flow 3:
Average throughput: 9.16 Mbit/s
95th percentile per-packet one-way delay: 398.816 ms
Loss rate: 22.04%
```

Run 1: Report of TCP BBR — Data Link

Flow 1 ingress (mean 50.38 Mbit/s) -- -- -- Flow 1 egress (mean 44.75 Mbit/s) ——
Flow 2 ingress (mean 6.01 Mbit/s) -- -- -- Flow 2 egress (mean 5.16 Mbit/s) ——
Flow 3 ingress (mean 11.55 Mbit/s) -- -- -- Flow 3 egress (mean 9.16 Mbit/s) ——

• Flow 1 (95th percentile 105.59 ms)   • Flow 2 (95th percentile 394.00 ms)   • Flow 3 (95th percentile 398.82 ms)
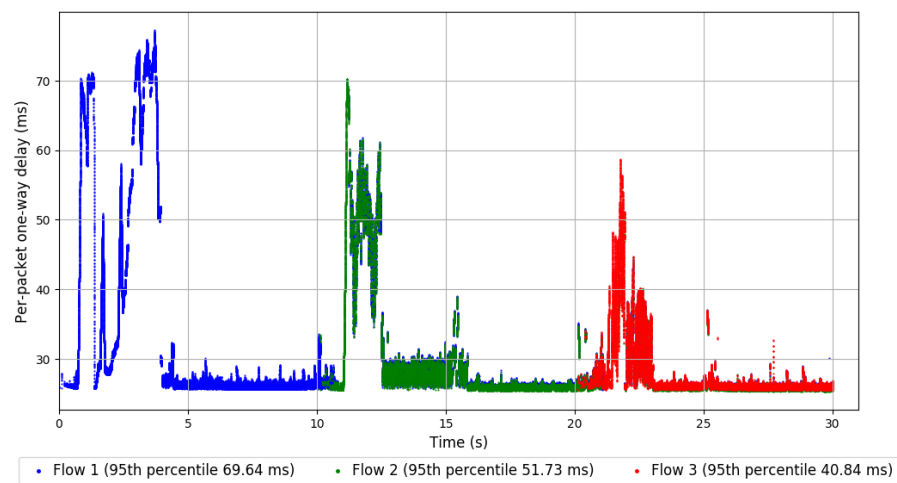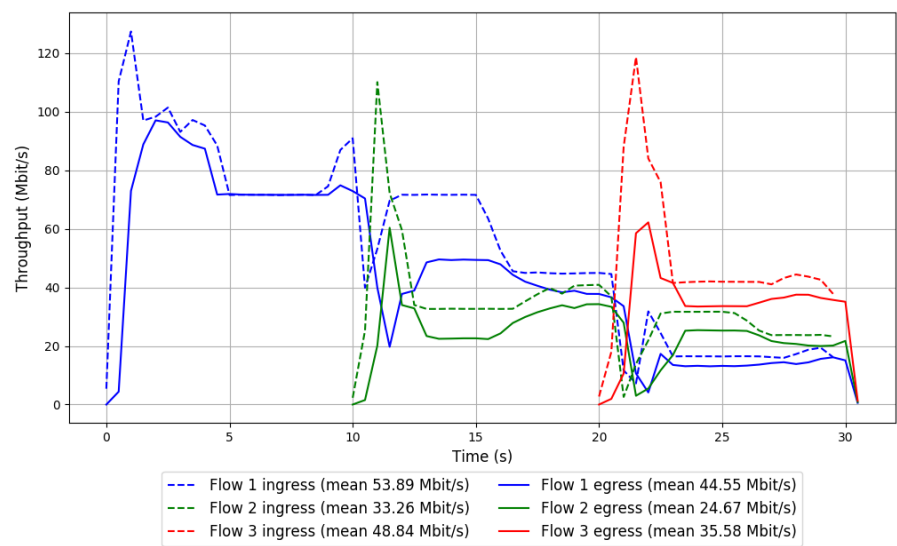
5

```
Run 2: Statistics of TCP BBR

Start at: 2018-09-05 02:51:14
End at: 2018-09-05 02:51:44
Local clock offset: 8.231 ms
Remote clock offset: 27.049 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 72.82 Mbit/s
95th percentile per-packet one-way delay: 65.692 ms
Loss rate: 21.11%
-- Flow 1:
Average throughput: 44.55 Mbit/s
95th percentile per-packet one-way delay: 69.644 ms
Loss rate: 17.35%
-- Flow 2:
Average throughput: 24.67 Mbit/s
95th percentile per-packet one-way delay: 51.728 ms
Loss rate: 25.82%
-- Flow 3:
Average throughput: 35.58 Mbit/s
95th percentile per-packet one-way delay: 40.837 ms
Loss rate: 27.15%
```

Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 53.89 Mbit/s) Flow 1 egress (mean 44.55 Mbit/s)
Flow 2 ingress (mean 33.26 Mbit/s) Flow 2 egress (mean 24.67 Mbit/s)
Flow 3 ingress (mean 48.84 Mbit/s) Flow 3 egress (mean 35.58 Mbit/s)

Flow 1 (95th percentile 69.64 ms) Flow 2 (95th percentile 51.73 ms) Flow 3 (95th percentile 40.84 ms)
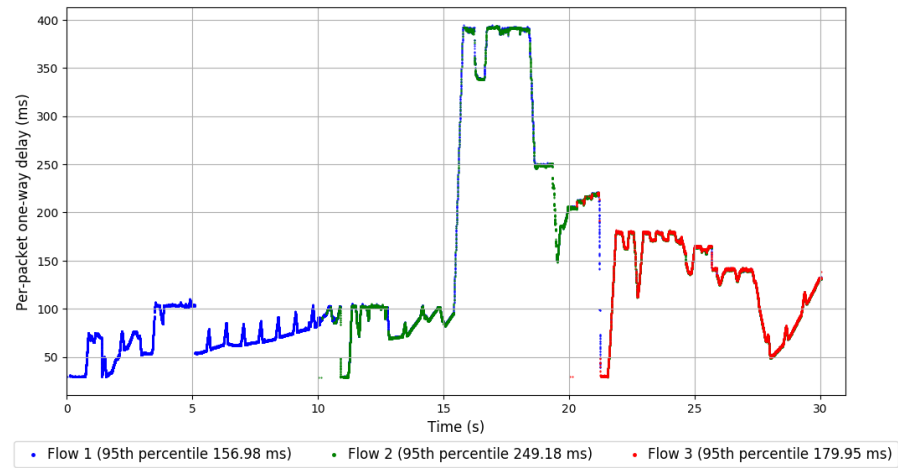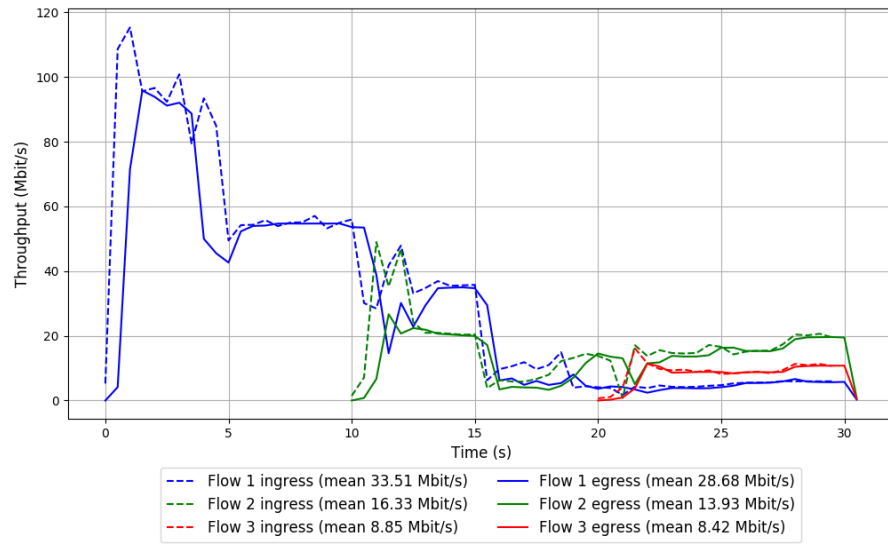
7

```
Run 3: Statistics of TCP BBR

Start at: 2018-09-05 02:56:30
End at: 2018-09-05 02:57:00
Local clock offset: 6.517 ms
Remote clock offset: 30.889 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 40.76 Mbit/s
95th percentile per-packet one-way delay: 205.165 ms
Loss rate: 13.89%
-- Flow 1:
Average throughput: 28.68 Mbit/s
95th percentile per-packet one-way delay: 156.976 ms
Loss rate: 14.43%
-- Flow 2:
Average throughput: 13.93 Mbit/s
95th percentile per-packet one-way delay: 249.178 ms
Loss rate: 14.69%
-- Flow 3:
Average throughput: 8.42 Mbit/s
95th percentile per-packet one-way delay: 179.946 ms
Loss rate: 4.78%
```
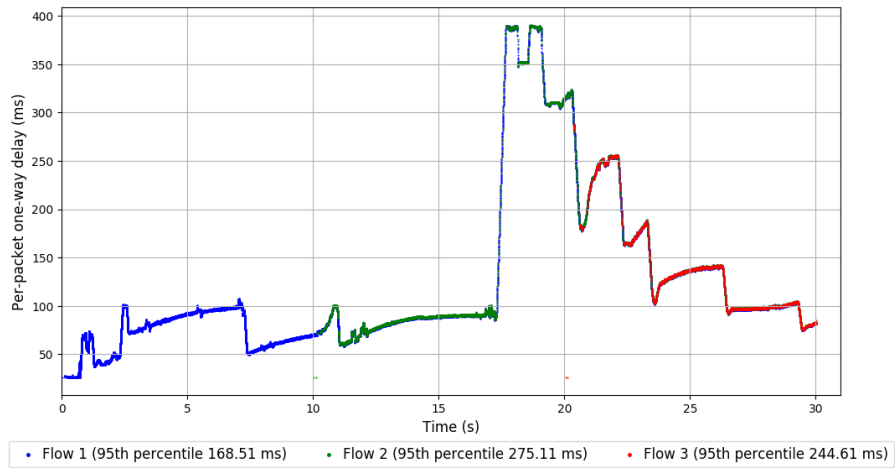
Run 3: Report of TCP BBR — Data Link

Flow 1 ingress (mean 33.51 Mbit/s) --- Flow 1 egress (mean 28.68 Mbit/s)
Flow 2 ingress (mean 16.33 Mbit/s) --- Flow 2 egress (mean 13.93 Mbit/s)
Flow 3 ingress (mean 8.85 Mbit/s) --- Flow 3 egress (mean 8.42 Mbit/s)

Flow 1 (95th percentile 156.98 ms) Flow 2 (95th percentile 249.18 ms) Flow 3 (95th percentile 179.95 ms)
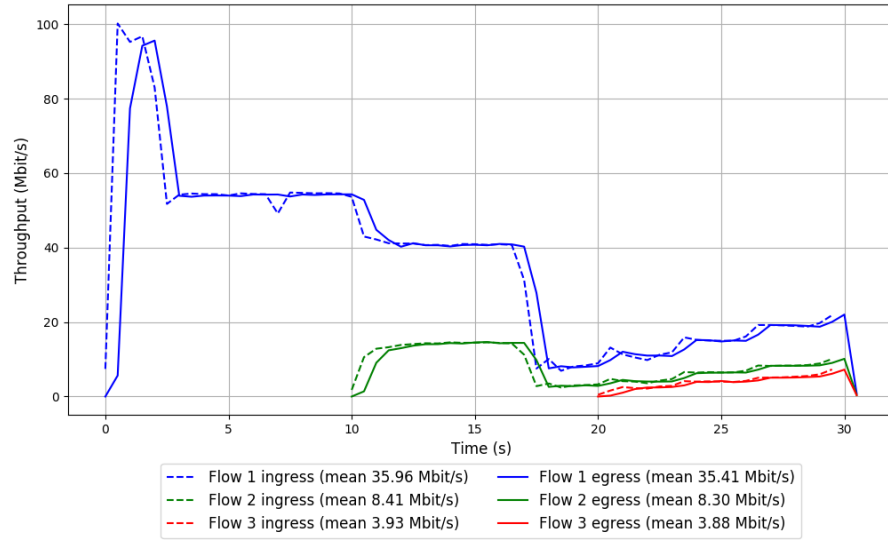
9

```
Run 1: Statistics of TCP Cubic

Start at: 2018-09-05 02:43:28
End at: 2018-09-05 02:43:58
Local clock offset: 13.062 ms
Remote clock offset: 25.955 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 42.22 Mbit/s
95th percentile per-packet one-way delay: 186.004 ms
Loss rate: 1.49%
-- Flow 1:
Average throughput: 35.41 Mbit/s
95th percentile per-packet one-way delay: 168.514 ms
Loss rate: 1.53%
-- Flow 2:
Average throughput: 8.30 Mbit/s
95th percentile per-packet one-way delay: 275.113 ms
Loss rate: 1.33%
-- Flow 3:
Average throughput: 3.88 Mbit/s
95th percentile per-packet one-way delay: 244.607 ms
Loss rate: 1.10%
```
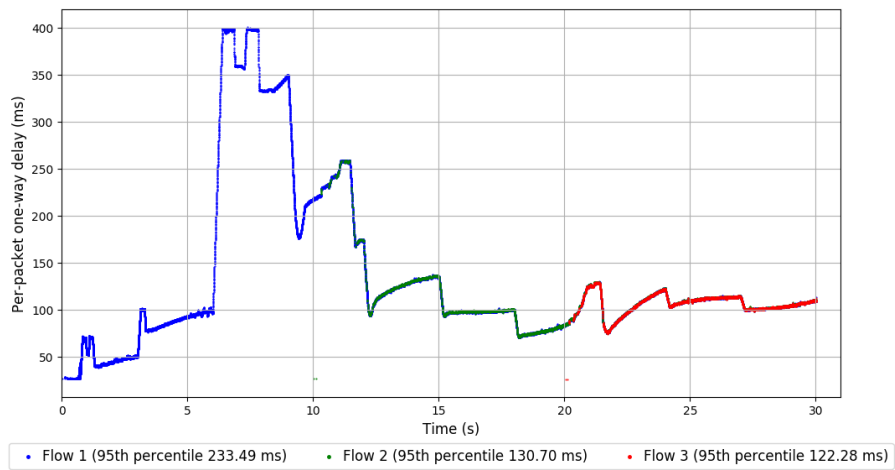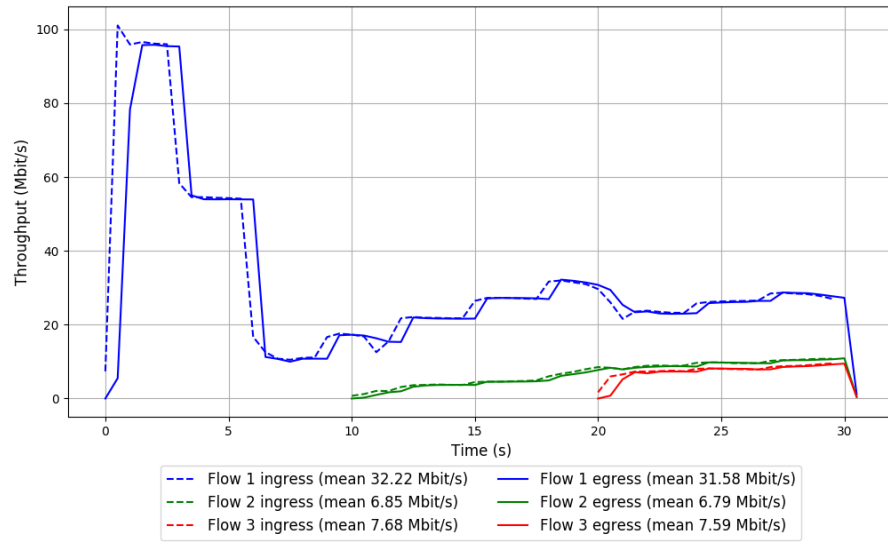
Run 1: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 35.96 Mbit/s) — — — Flow 1 egress (mean 35.41 Mbit/s)
Flow 2 ingress (mean 8.41 Mbit/s) — — — Flow 2 egress (mean 8.30 Mbit/s)
Flow 3 ingress (mean 3.93 Mbit/s) — — — Flow 3 egress (mean 3.88 Mbit/s)

Flow 1 (95th percentile 168.51 ms) • Flow 2 (95th percentile 275.11 ms) • Flow 3 (95th percentile 244.61 ms)

```
Run 2: Statistics of TCP Cubic

Start at: 2018-09-05 02:48:39
End at: 2018-09-05 02:49:09
Local clock offset: 9.505 ms
Remote clock offset: 27.663 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 38.63 Mbit/s
95th percentile per-packet one-way delay: 219.891 ms
Loss rate: 1.79%
-- Flow 1:
Average throughput: 31.58 Mbit/s
95th percentile per-packet one-way delay: 233.489 ms
Loss rate: 1.98%
-- Flow 2:
Average throughput: 6.79 Mbit/s
95th percentile per-packet one-way delay: 130.702 ms
Loss rate: 0.83%
-- Flow 3:
Average throughput: 7.59 Mbit/s
95th percentile per-packet one-way delay: 122.276 ms
Loss rate: 1.11%
```
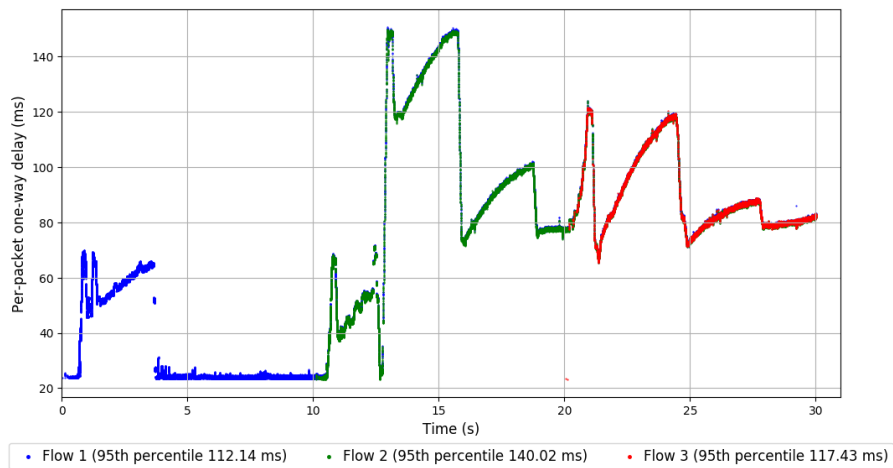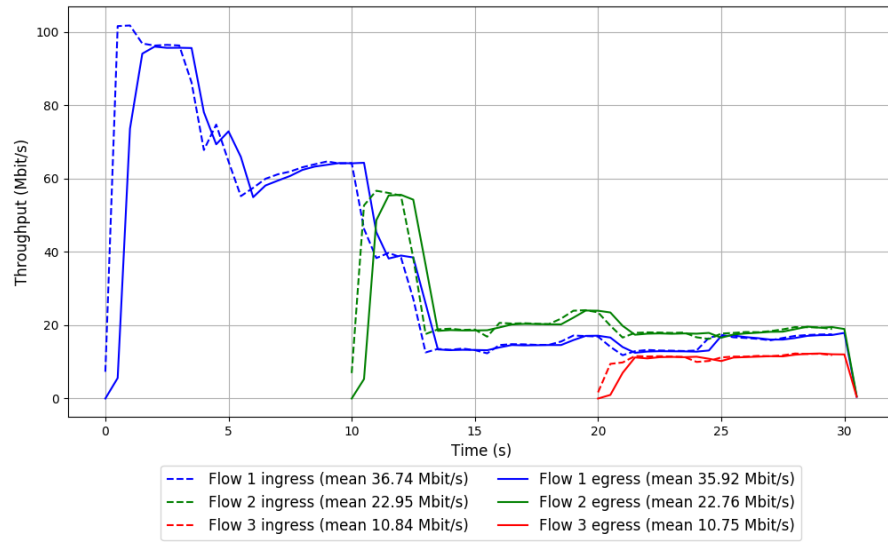
Run 2: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 32.22 Mbit/s) — Flow 1 egress (mean 31.58 Mbit/s)
Flow 2 ingress (mean 6.85 Mbit/s) — Flow 2 egress (mean 6.79 Mbit/s)
Flow 3 ingress (mean 7.68 Mbit/s) — Flow 3 egress (mean 7.59 Mbit/s)

Flow 1 (95th percentile 233.49 ms) • Flow 2 (95th percentile 130.70 ms) • Flow 3 (95th percentile 122.28 ms)

```
Run 3: Statistics of TCP Cubic

Start at: 2018-09-05 02:53:53
End at: 2018-09-05 02:54:23
Local clock offset: 6.95 ms
Remote clock offset: 24.634 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 54.65 Mbit/s
95th percentile per-packet one-way delay: 120.700 ms
Loss rate: 1.76%
-- Flow 1:
Average throughput: 35.92 Mbit/s
95th percentile per-packet one-way delay: 112.138 ms
Loss rate: 2.23%
-- Flow 2:
Average throughput: 22.76 Mbit/s
95th percentile per-packet one-way delay: 140.021 ms
Loss rate: 0.85%
-- Flow 3:
Average throughput: 10.75 Mbit/s
95th percentile per-packet one-way delay: 117.426 ms
Loss rate: 0.78%
```

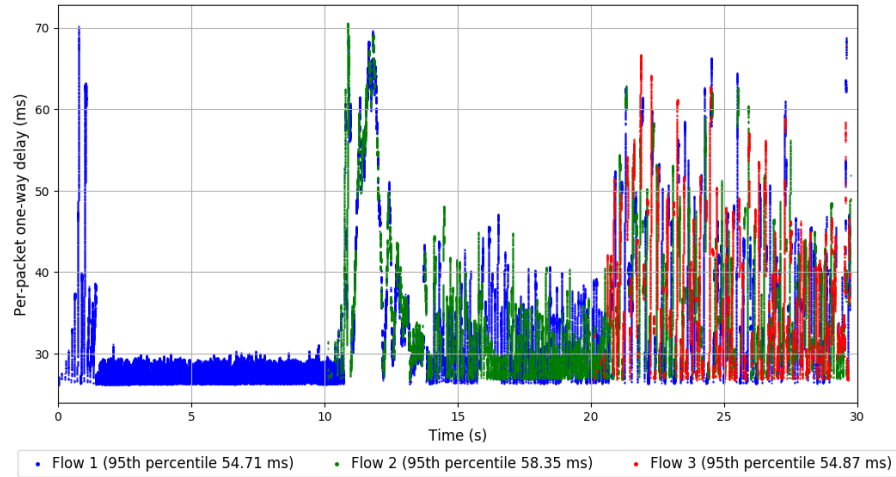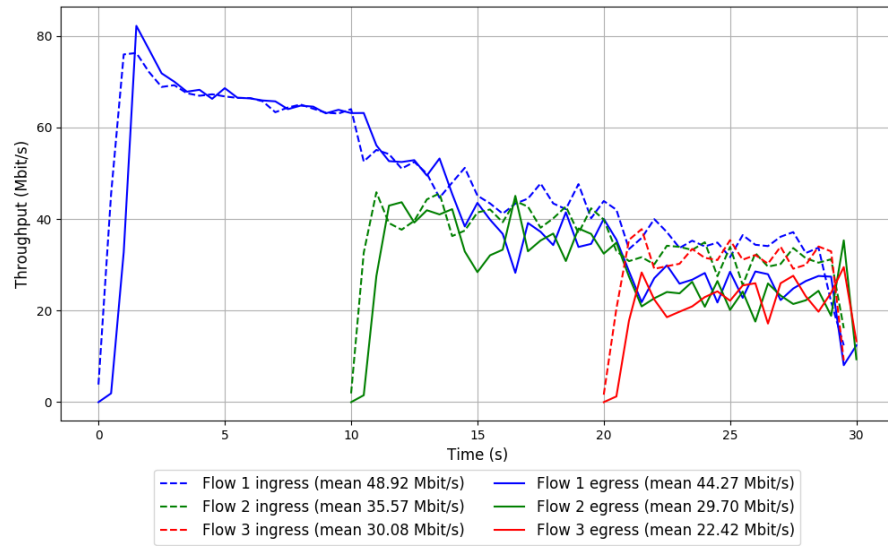Run 3: Report of TCP Cubic — Data Link

```
Run 1: Statistics of Indigo

Start at: 2018-09-05 02:33:19
End at: 2018-09-05 02:33:49
Local clock offset: 10.574 ms
Remote clock offset: 25.825 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 71.08 Mbit/s
95th percentile per-packet one-way delay: 56.175 ms
Loss rate: 13.38%
-- Flow 1:
Average throughput: 44.27 Mbit/s
95th percentile per-packet one-way delay: 54.708 ms
Loss rate: 9.46%
-- Flow 2:
Average throughput: 29.70 Mbit/s
95th percentile per-packet one-way delay: 58.349 ms
Loss rate: 16.46%
-- Flow 3:
Average throughput: 22.42 Mbit/s
95th percentile per-packet one-way delay: 54.865 ms
Loss rate: 25.63%
```
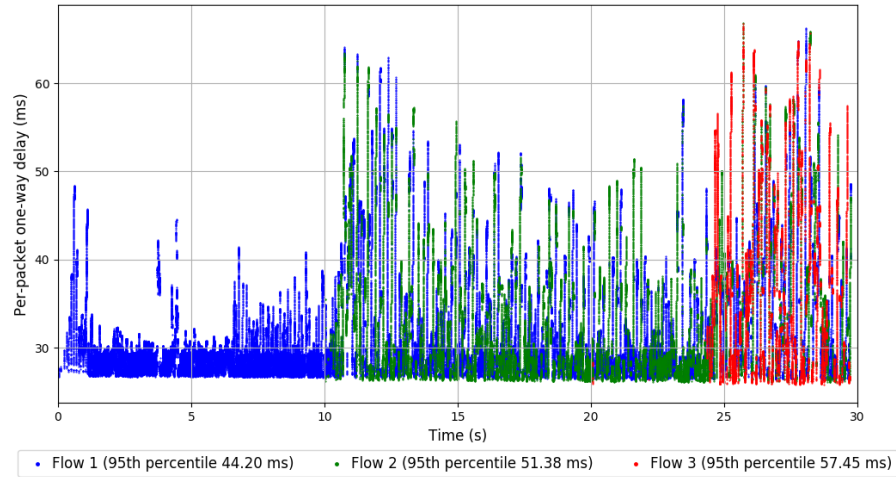
Run 1: Report of Indigo — Data Link

Flow 1 ingress (mean 48.92 Mbit/s) — — —   Flow 1 egress (mean 44.27 Mbit/s)
Flow 2 ingress (mean 35.57 Mbit/s) — — —   Flow 2 egress (mean 29.70 Mbit/s)
Flow 3 ingress (mean 30.08 Mbit/s) — — —   Flow 3 egress (mean 22.42 Mbit/s)

Flow 1 (95th percentile 54.71 ms)   Flow 2 (95th percentile 58.35 ms)   Flow 3 (95th percentile 54.87 ms)
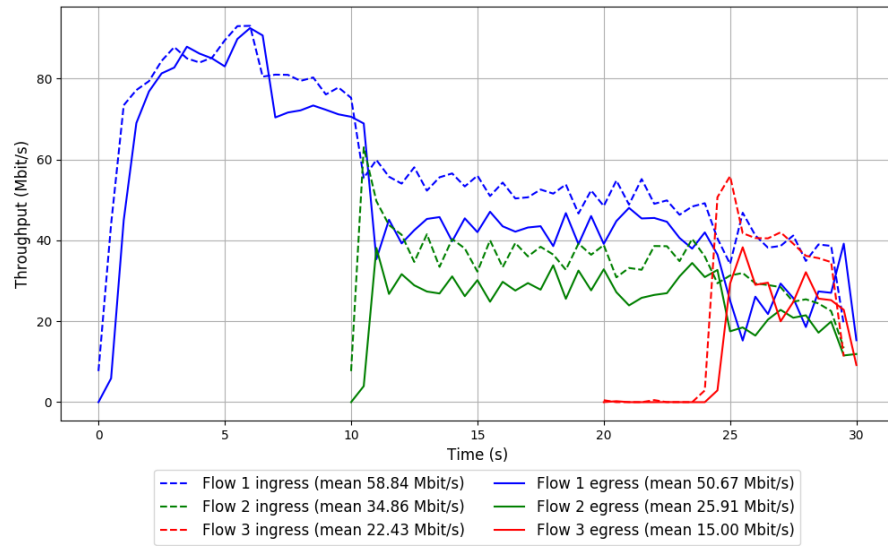
```
Run 2: Statistics of Indigo

Start at: 2018-09-05 02:47:21
End at: 2018-09-05 02:47:51
Local clock offset: 10.439 ms
Remote clock offset: 27.251 ms


# Below is generated by plot.py at 2018-09-05 02:58:14
# Datalink statistics
-- Total of 3 flows:
Average throughput: 72.71 Mbit/s
95th percentile per-packet one-way delay: 48.098 ms
Loss rate: 18.48%
-- Flow 1:
Average throughput: 50.67 Mbit/s
95th percentile per-packet one-way delay: 44.201 ms
Loss rate: 13.89%
-- Flow 2:
Average throughput: 25.91 Mbit/s
95th percentile per-packet one-way delay: 51.381 ms
Loss rate: 25.58%
-- Flow 3:
Average throughput: 15.00 Mbit/s
95th percentile per-packet one-way delay: 57.445 ms
Loss rate: 33.14%
```

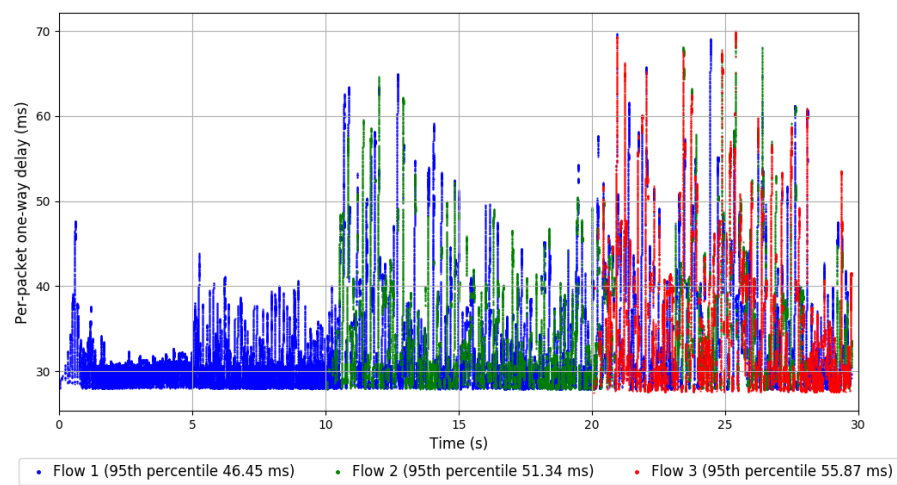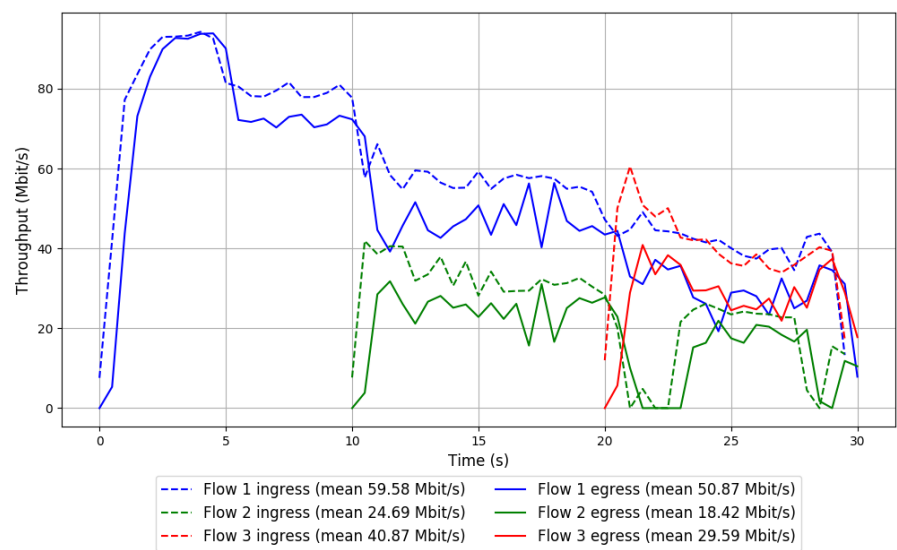Run 2: Report of Indigo — Data Link

```
Run 3: Statistics of Indigo

Start at: 2018-09-05 02:52:33
End at: 2018-09-05 02:53:03
Local clock offset: 7.497 ms
Remote clock offset: 29.187 ms

# Below is generated by plot.py at 2018-09-05 02:58:29
# Datalink statistics
-- Total of 3 flows:
Average throughput: 72.68 Mbit/s
95th percentile per-packet one-way delay: 49.362 ms
Loss rate: 18.50%
-- Flow 1:
Average throughput: 50.87 Mbit/s
95th percentile per-packet one-way delay: 46.453 ms
Loss rate: 14.61%
-- Flow 2:
Average throughput: 18.42 Mbit/s
95th percentile per-packet one-way delay: 51.344 ms
Loss rate: 25.40%
-- Flow 3:
Average throughput: 29.59 Mbit/s
95th percentile per-packet one-way delay: 55.871 ms
Loss rate: 27.48%
```

Run 3: Report of Indigo — Data Link

```
Run 1: Statistics of Muses-25

Start at: 2018-09-05 02:44:46
End at: 2018-09-05 02:45:16
Local clock offset: 13.084 ms
Remote clock offset: 27.591 ms


# Below is generated by plot.py at 2018-09-05 02:58:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.05 Mbit/s
95th percentile per-packet one-way delay: 44.267 ms
Loss rate: 0.00%
-- Flow 1:
Average throughput: 63.66 Mbit/s
95th percentile per-packet one-way delay: 36.294 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 36.29 Mbit/s
95th percentile per-packet one-way delay: 53.677 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 25.28 Mbit/s
95th percentile per-packet one-way delay: 51.423 ms
Loss rate: 0.00%
```
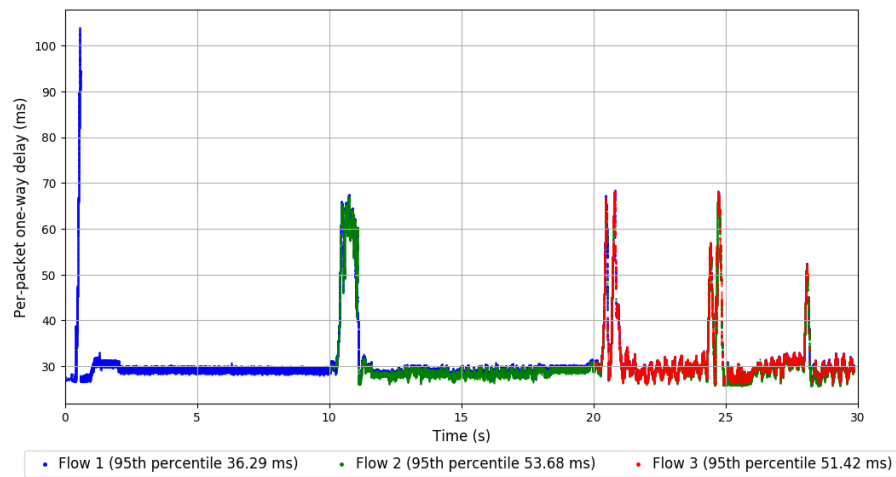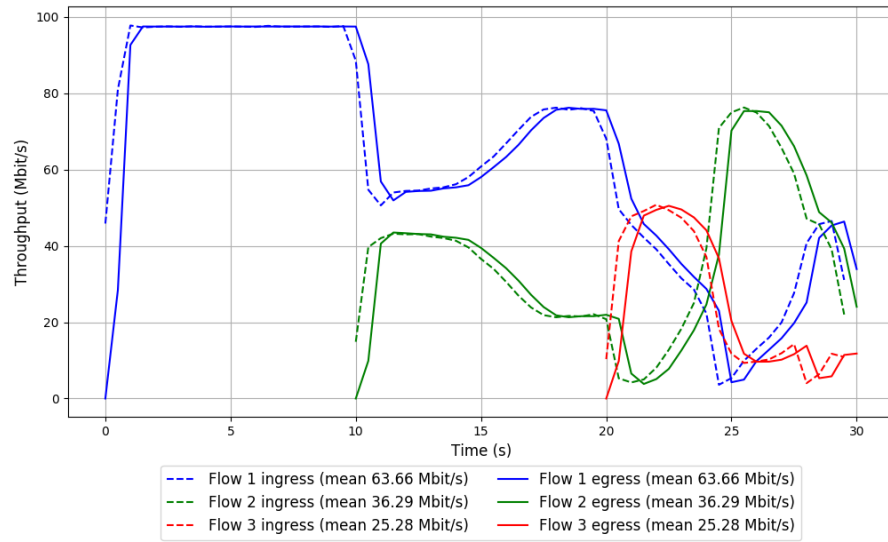
Run 1: Report of Muses-25 — Data Link

Flow 1 ingress (mean 63.66 Mbit/s) --- Flow 1 egress (mean 63.66 Mbit/s)
Flow 2 ingress (mean 36.29 Mbit/s) --- Flow 2 egress (mean 36.29 Mbit/s)
Flow 3 ingress (mean 25.28 Mbit/s) --- Flow 3 egress (mean 25.28 Mbit/s)

Flow 1 (95th percentile 36.29 ms)   Flow 2 (95th percentile 53.68 ms)   Flow 3 (95th percentile 51.42 ms)
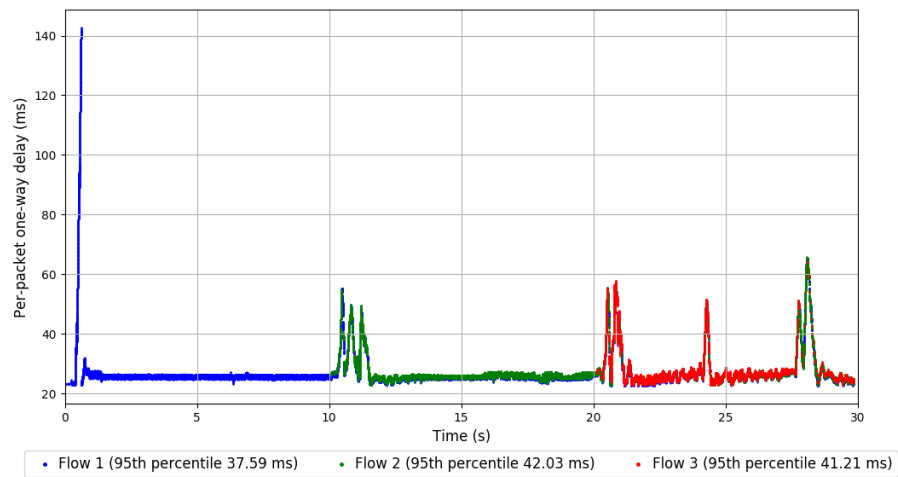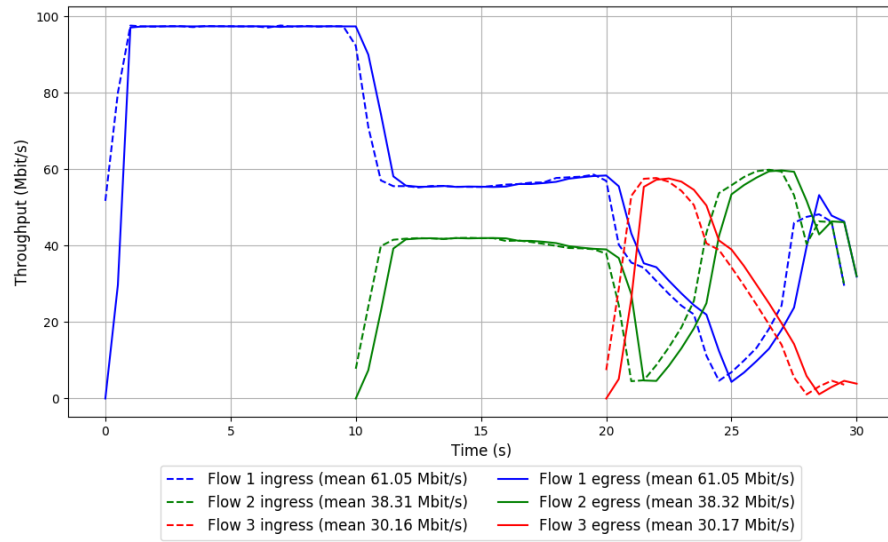
23

```
Run 2: Statistics of Muses-25

Start at: 2018-09-05 02:49:54
End at: 2018-09-05 02:50:24
Local clock offset: 8.7 ms
Remote clock offset: 23.974 ms

# Below is generated by plot.py at 2018-09-05 02:58:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.27 Mbit/s
95th percentile per-packet one-way delay: 39.136 ms
Loss rate: 0.00%
-- Flow 1:
Average throughput: 61.05 Mbit/s
95th percentile per-packet one-way delay: 37.593 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 38.32 Mbit/s
95th percentile per-packet one-way delay: 42.026 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 30.17 Mbit/s
95th percentile per-packet one-way delay: 41.210 ms
Loss rate: 0.00%
```

Run 2: Report of Muses-25 — Data Link

```
Run 3: Statistics of Muses-25

Start at: 2018-09-05 02:55:10
End at: 2018-09-05 02:55:40
Local clock offset: 6.7 ms
Remote clock offset: 30.223 ms

# Below is generated by plot.py at 2018-09-05 02:58:37
# Datalink statistics
-- Total of 3 flows:
Average throughput: 94.83 Mbit/s
95th percentile per-packet one-way delay: 50.627 ms
Loss rate: 0.01%
-- Flow 1:
Average throughput: 59.05 Mbit/s
95th percentile per-packet one-way delay: 46.824 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 40.25 Mbit/s
95th percentile per-packet one-way delay: 54.215 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 27.70 Mbit/s
95th percentile per-packet one-way delay: 53.480 ms
Loss rate: 0.00%
```

Run 3: Report of Muses-25 — Data Link