Pantheon Report

Generated at 2018-09-05 22:45:56 (UTC).

Data path: Mexico on `em1` (*remote*) →AWS California 2 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 `time.stanford.edu` 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 Mexico to AWS California 2, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)
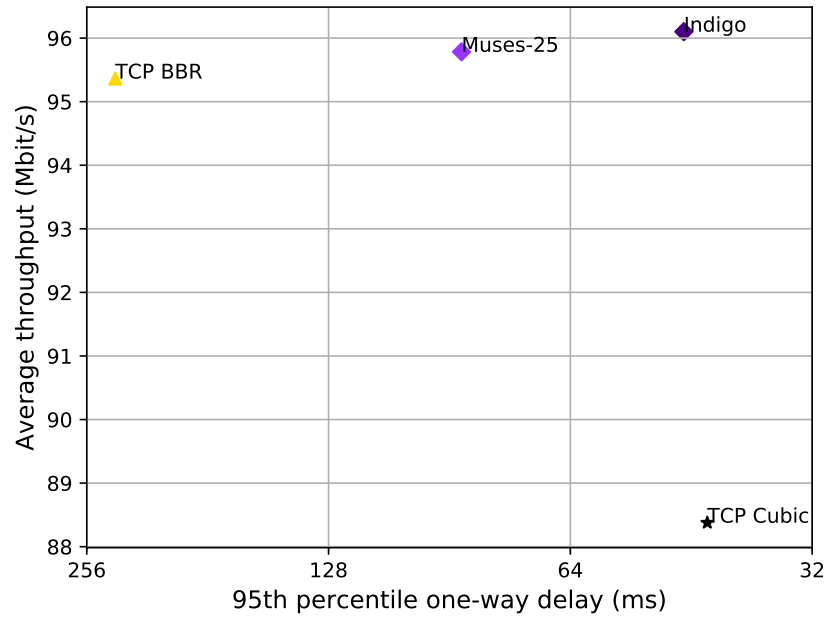
test from Mexico to AWS California 2, 3 runs of 30s each per scheme
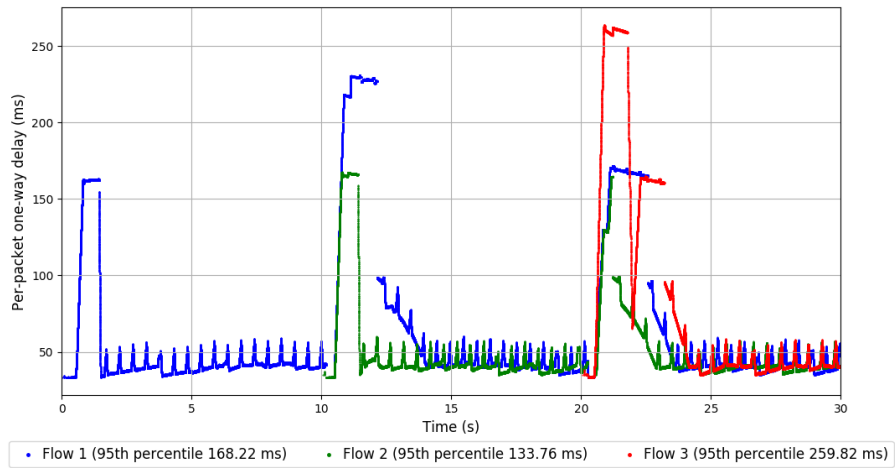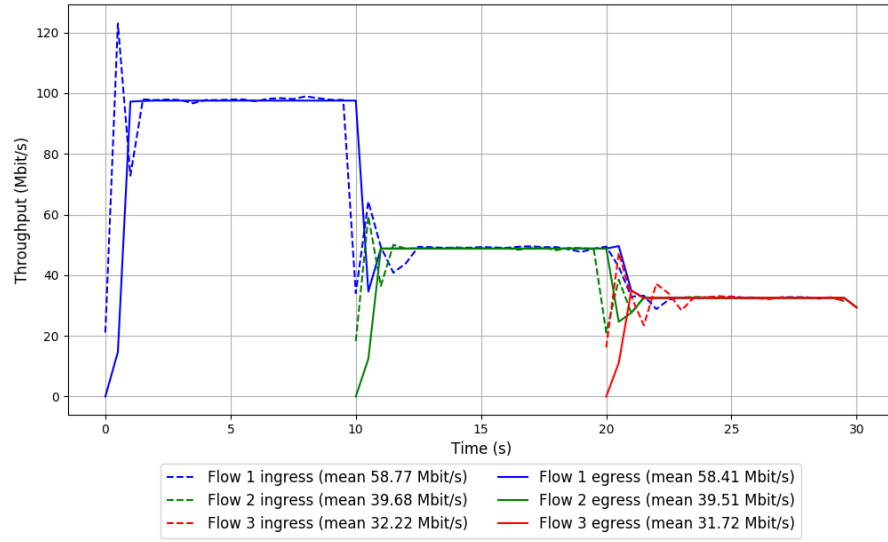### 3 flows with 10s interval between flows
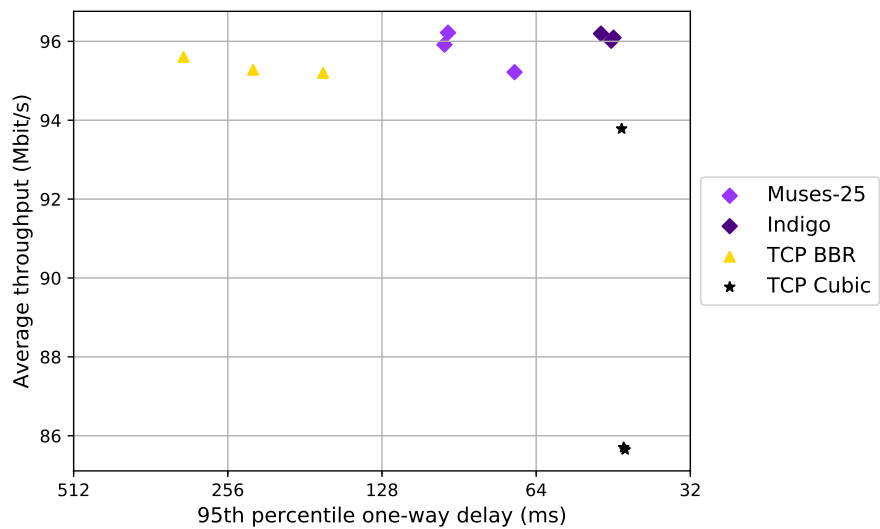
scheme	# runs	mean avg tput (Mbit/s)			mean 95th-%ile delay (ms)			mean loss rate (%)		
		flow 1	flow 2	flow 3	flow 1	flow 2	flow 3	flow 1	flow 2	flow 3
TCP BBR	3	57.33	38.41	37.69	182.41	218.00	383.76	0.89	1.43	2.67
TCP Cubic	3	52.82	37.09	32.83	45.93	42.79	42.97	0.17	0.39	0.60
Indigo	3	62.46	37.65	26.35	42.94	54.28	46.65	0.22	0.39	0.77
Muses-25	3	62.51	33.55	33.26	46.66	104.81	129.52	0.18	0.65	1.40

```
Run 1: Statistics of TCP BBR

Start at: 2018-09-05 22:29:26
End at: 2018-09-05 22:29:56
Local clock offset: 4.169 ms
Remote clock offset: -1.253 ms


# Below is generated by plot.py at 2018-09-05 22:45:19
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.20 Mbit/s
95th percentile per-packet one-way delay: 166.762 ms
Loss rate: 0.95%
-- Flow 1:
Average throughput: 58.41 Mbit/s
95th percentile per-packet one-way delay: 168.223 ms
Loss rate: 0.81%
-- Flow 2:
Average throughput: 39.51 Mbit/s
95th percentile per-packet one-way delay: 133.763 ms
Loss rate: 0.76%
-- Flow 3:
Average throughput: 31.72 Mbit/s
95th percentile per-packet one-way delay: 259.822 ms
Loss rate: 2.19%
```

Run 1: Report of TCP BBR — Data Link

Flow 1 ingress (mean 58.77 Mbit/s) --- Flow 1 egress (mean 58.41 Mbit/s)
Flow 2 ingress (mean 39.68 Mbit/s) --- Flow 2 egress (mean 39.51 Mbit/s)
Flow 3 ingress (mean 32.22 Mbit/s) --- Flow 3 egress (mean 31.72 Mbit/s)

Flow 1 (95th percentile 168.22 ms) · Flow 2 (95th percentile 133.76 ms) · Flow 3 (95th percentile 259.82 ms)
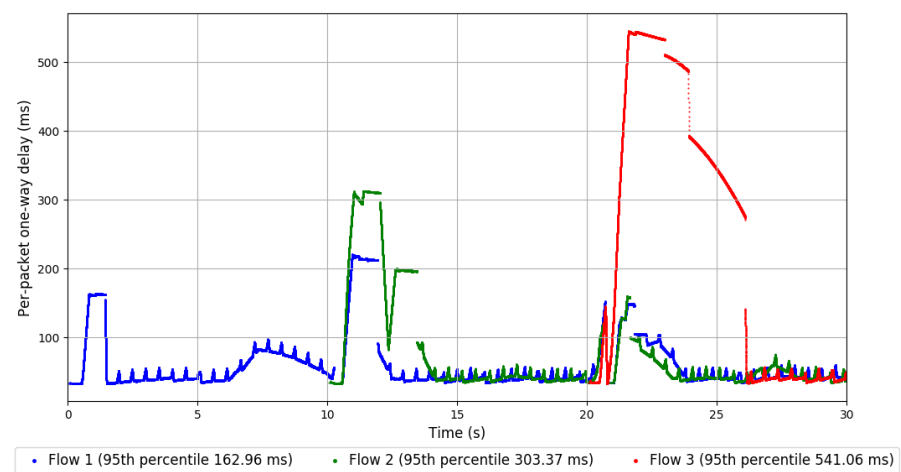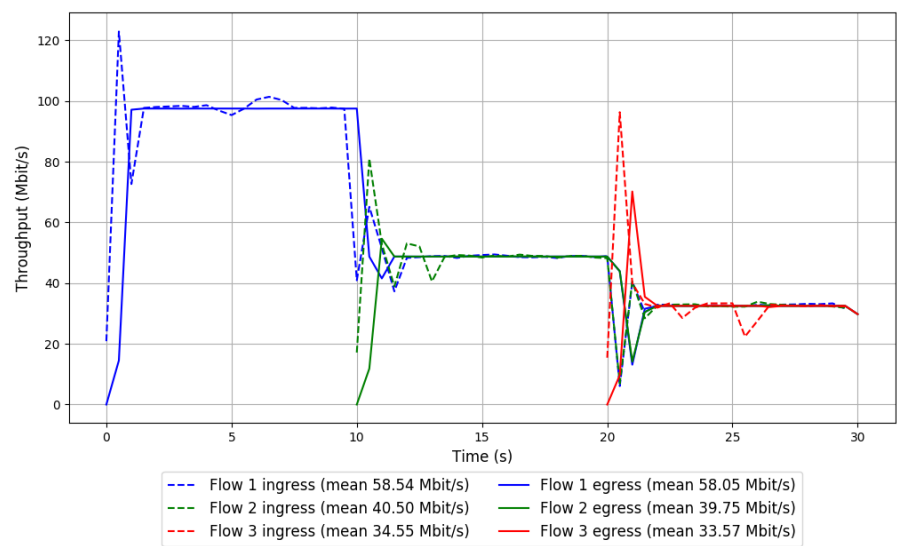
5

```
Run 2: Statistics of TCP BBR

Start at: 2018-09-05 22:34:58
End at: 2018-09-05 22:35:28
Local clock offset: 3.051 ms
Remote clock offset: -1.306 ms


# Below is generated by plot.py at 2018-09-05 22:45:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.61 Mbit/s
95th percentile per-packet one-way delay: 312.448 ms
Loss rate: 1.65%
-- Flow 1:
Average throughput: 58.05 Mbit/s
95th percentile per-packet one-way delay: 162.959 ms
Loss rate: 1.06%
-- Flow 2:
Average throughput: 39.75 Mbit/s
95th percentile per-packet one-way delay: 303.365 ms
Loss rate: 2.18%
-- Flow 3:
Average throughput: 33.57 Mbit/s
95th percentile per-packet one-way delay: 541.057 ms
Loss rate: 3.45%
```

Run 2: Report of TCP BBR — Data Link

Flow 1 ingress (mean 58.54 Mbit/s) --- Flow 1 egress (mean 58.05 Mbit/s)
Flow 2 ingress (mean 40.50 Mbit/s) --- Flow 2 egress (mean 39.75 Mbit/s)
Flow 3 ingress (mean 34.55 Mbit/s) --- Flow 3 egress (mean 33.57 Mbit/s)

Flow 1 (95th percentile 162.96 ms)   Flow 2 (95th percentile 303.37 ms)   Flow 3 (95th percentile 541.06 ms)
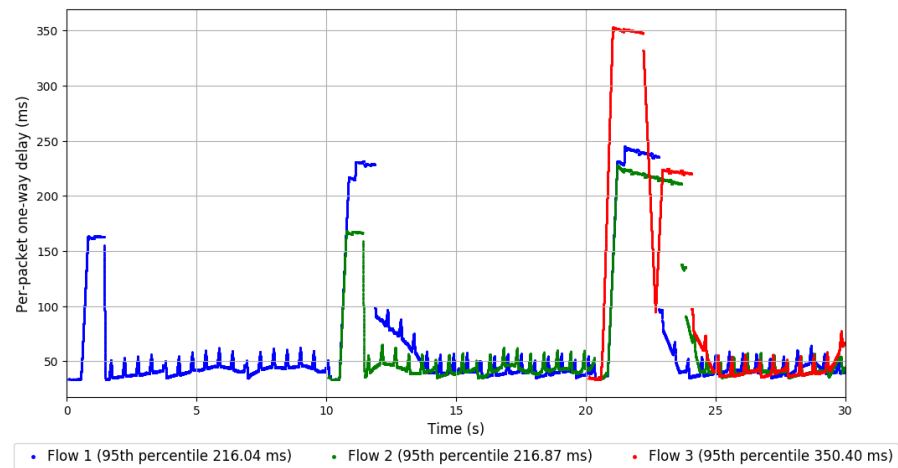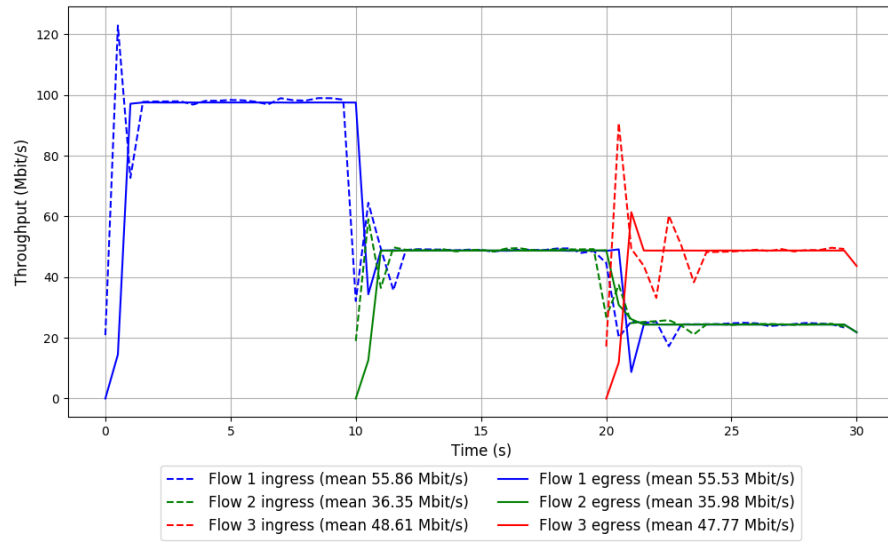
7

```
Run 3: Statistics of TCP BBR

Start at: 2018-09-05 22:40:30
End at: 2018-09-05 22:41:00
Local clock offset: 2.265 ms
Remote clock offset: -1.534 ms


# Below is generated by plot.py at 2018-09-05 22:45:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.28 Mbit/s
95th percentile per-packet one-way delay: 228.500 ms
Loss rate: 1.20%
-- Flow 1:
Average throughput: 55.53 Mbit/s
95th percentile per-packet one-way delay: 216.039 ms
Loss rate: 0.80%
-- Flow 2:
Average throughput: 35.98 Mbit/s
95th percentile per-packet one-way delay: 216.872 ms
Loss rate: 1.34%
-- Flow 3:
Average throughput: 47.77 Mbit/s
95th percentile per-packet one-way delay: 350.396 ms
Loss rate: 2.36%
```

Run 3: Report of TCP BBR — Data Link

Flow 1 ingress (mean 55.86 Mbit/s) --- Flow 1 egress (mean 55.53 Mbit/s)
Flow 2 ingress (mean 36.35 Mbit/s) --- Flow 2 egress (mean 35.98 Mbit/s)
Flow 3 ingress (mean 48.61 Mbit/s) --- Flow 3 egress (mean 47.77 Mbit/s)

Flow 1 (95th percentile 216.04 ms)   Flow 2 (95th percentile 216.87 ms)   Flow 3 (95th percentile 350.40 ms)
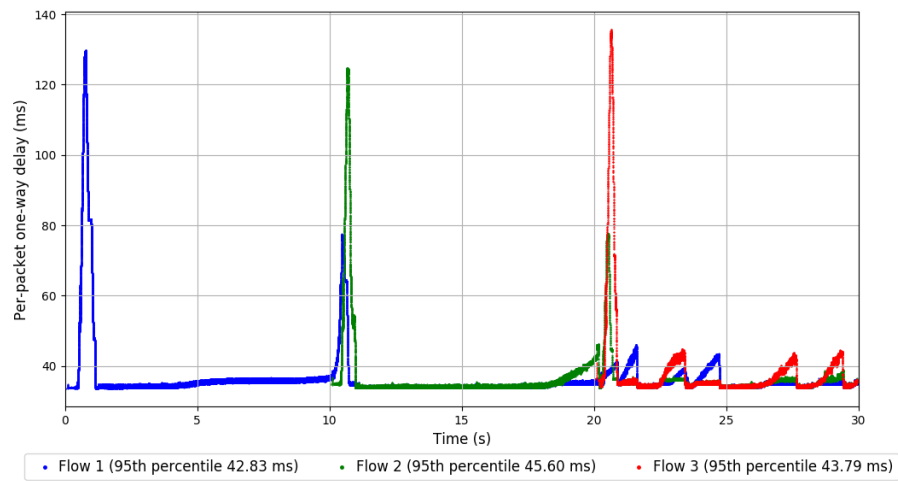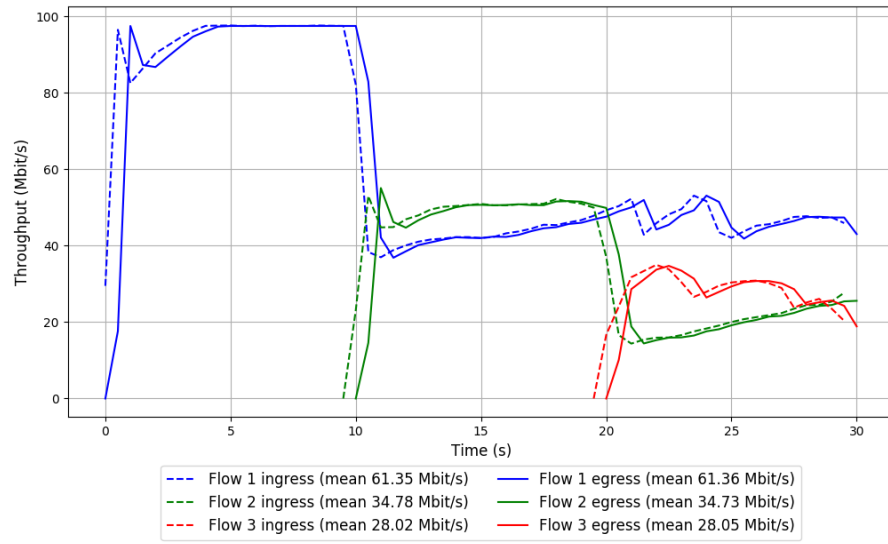
```
Run 1: Statistics of TCP Cubic

Start at: 2018-09-05 22:30:49
End at: 2018-09-05 22:31:19
Local clock offset: 4.394 ms
Remote clock offset: -1.293 ms


# Below is generated by plot.py at 2018-09-05 22:45:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 93.78 Mbit/s
95th percentile per-packet one-way delay: 43.585 ms
Loss rate: 0.28%
-- Flow 1:
Average throughput: 61.36 Mbit/s
95th percentile per-packet one-way delay: 42.834 ms
Loss rate: 0.18%
-- Flow 2:
Average throughput: 34.73 Mbit/s
95th percentile per-packet one-way delay: 45.604 ms
Loss rate: 0.45%
-- Flow 3:
Average throughput: 28.05 Mbit/s
95th percentile per-packet one-way delay: 43.789 ms
Loss rate: 0.54%
```

Run 1: Report of TCP Cubic — Data Link

- - - Flow 1 ingress (mean 61.35 Mbit/s) ——— Flow 1 egress (mean 61.36 Mbit/s)
- - - Flow 2 ingress (mean 34.78 Mbit/s) ——— Flow 2 egress (mean 34.73 Mbit/s)
- - - Flow 3 ingress (mean 28.02 Mbit/s) ——— Flow 3 egress (mean 28.05 Mbit/s)

• Flow 1 (95th percentile 42.83 ms)   • Flow 2 (95th percentile 45.60 ms)   • Flow 3 (95th percentile 43.79 ms)
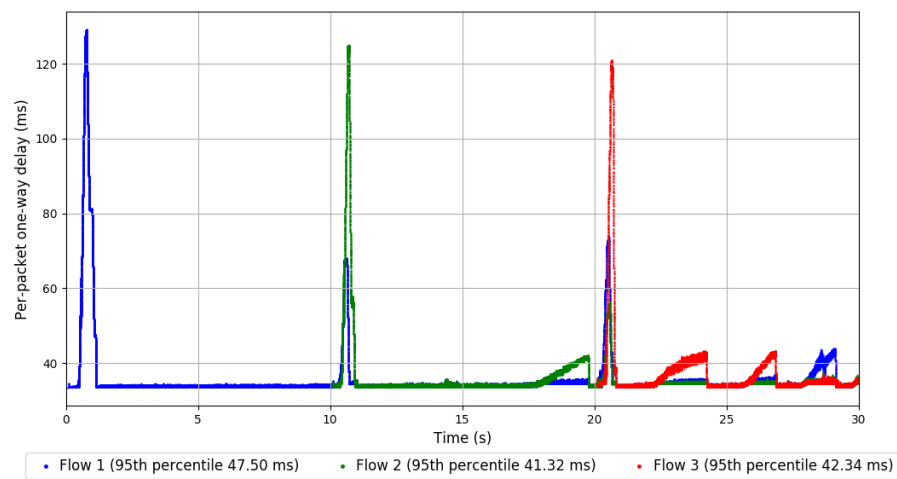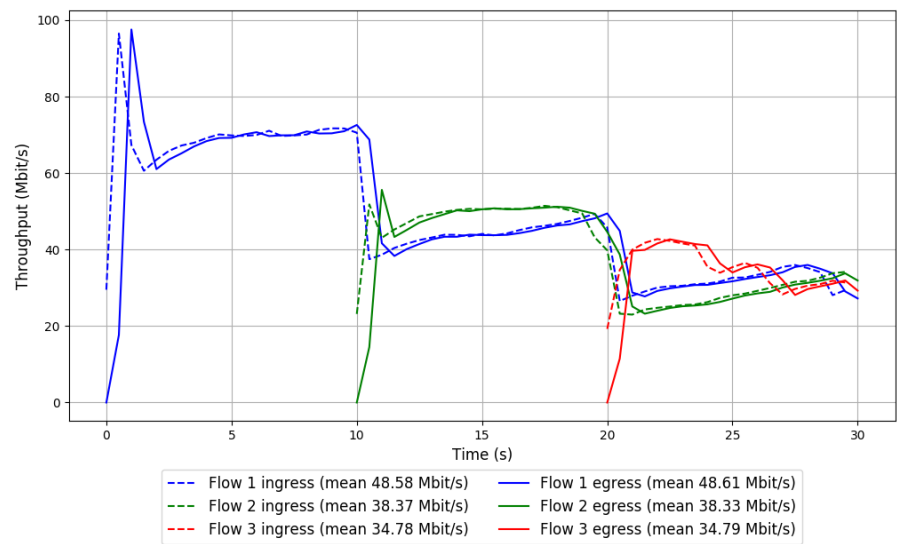
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```
Run 2: Statistics of TCP Cubic

Start at: 2018-09-05 22:36:21
End at: 2018-09-05 22:36:51
Local clock offset: 2.831 ms
Remote clock offset: -1.402 ms


# Below is generated by plot.py at 2018-09-05 22:45:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 85.65 Mbit/s
95th percentile per-packet one-way delay: 42.898 ms
Loss rate: 0.30%
-- Flow 1:
Average throughput: 48.61 Mbit/s
95th percentile per-packet one-way delay: 47.496 ms
Loss rate: 0.16%
-- Flow 2:
Average throughput: 38.33 Mbit/s
95th percentile per-packet one-way delay: 41.324 ms
Loss rate: 0.41%
-- Flow 3:
Average throughput: 34.79 Mbit/s
95th percentile per-packet one-way delay: 42.343 ms
Loss rate: 0.62%
```

Run 2: Report of TCP Cubic — Data Link

Flow 1 ingress (mean 48.58 Mbit/s) --- Flow 1 egress (mean 48.61 Mbit/s)
Flow 2 ingress (mean 38.37 Mbit/s) --- Flow 2 egress (mean 38.33 Mbit/s)
Flow 3 ingress (mean 34.78 Mbit/s) --- Flow 3 egress (mean 34.79 Mbit/s)

Flow 1 (95th percentile 47.50 ms)   Flow 2 (95th percentile 41.32 ms)   Flow 3 (95th percentile 42.34 ms)
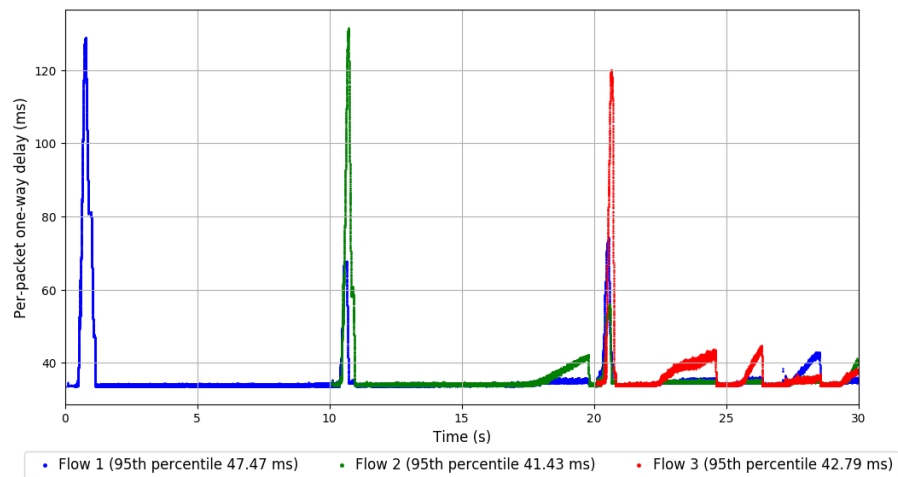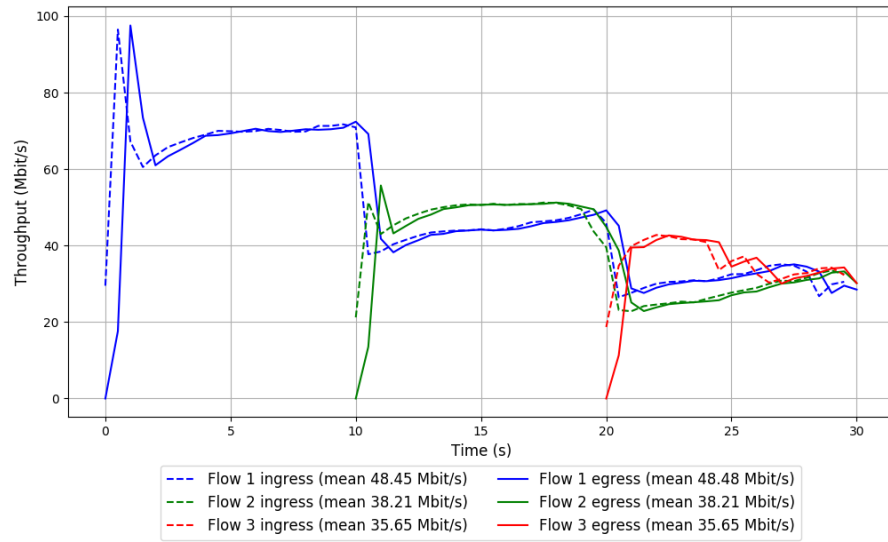
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```
Run 3: Statistics of TCP Cubic

Start at: 2018-09-05 22:41:53
End at: 2018-09-05 22:42:23
Local clock offset: 2.159 ms
Remote clock offset: -1.603 ms


# Below is generated by plot.py at 2018-09-05 22:45:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 85.70 Mbit/s
95th percentile per-packet one-way delay: 43.188 ms
Loss rate: 0.28%
-- Flow 1:
Average throughput: 48.48 Mbit/s
95th percentile per-packet one-way delay: 47.469 ms
Loss rate: 0.16%
-- Flow 2:
Average throughput: 38.21 Mbit/s
95th percentile per-packet one-way delay: 41.430 ms
Loss rate: 0.32%
-- Flow 3:
Average throughput: 35.65 Mbit/s
95th percentile per-packet one-way delay: 42.788 ms
Loss rate: 0.65%
```

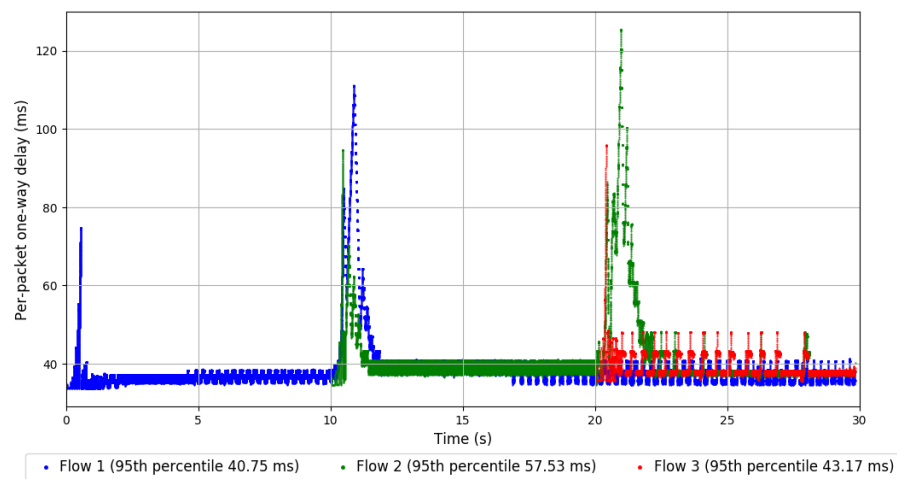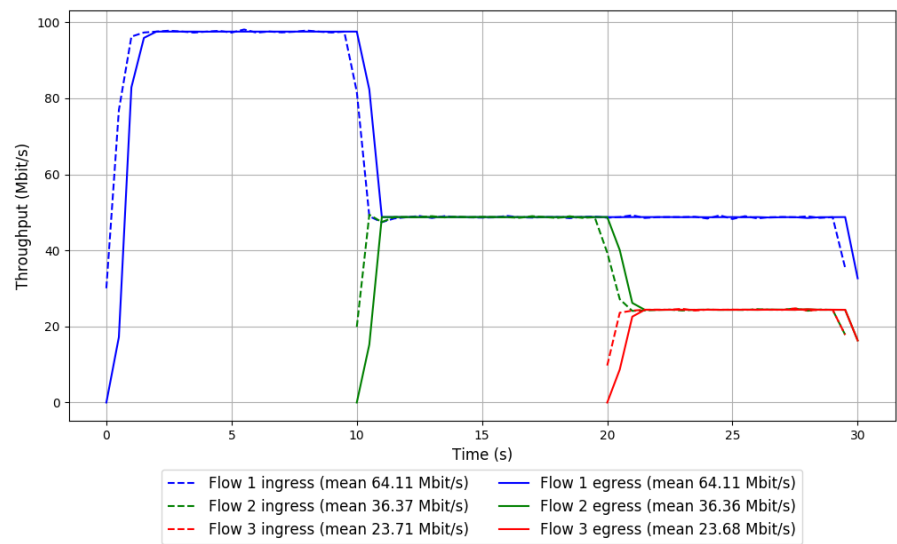Run 3: Report of TCP Cubic — Data Link

```
Run 1: Statistics of Indigo

Start at: 2018-09-05 22:28:01
End at: 2018-09-05 22:28:31
Local clock offset: 4.065 ms
Remote clock offset: -1.365 ms


# Below is generated by plot.py at 2018-09-05 22:45:21
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.02 Mbit/s
95th percentile per-packet one-way delay: 45.667 ms
Loss rate: 0.29%
-- Flow 1:
Average throughput: 64.11 Mbit/s
95th percentile per-packet one-way delay: 40.747 ms
Loss rate: 0.20%
-- Flow 2:
Average throughput: 36.36 Mbit/s
95th percentile per-packet one-way delay: 57.535 ms
Loss rate: 0.36%
-- Flow 3:
Average throughput: 23.68 Mbit/s
95th percentile per-packet one-way delay: 43.168 ms
Loss rate: 0.79%
```

Run 1: Report of Indigo — Data Link

Flow 1 ingress (mean 64.11 Mbit/s)   Flow 1 egress (mean 64.11 Mbit/s)
Flow 2 ingress (mean 36.37 Mbit/s)   Flow 2 egress (mean 36.36 Mbit/s)
Flow 3 ingress (mean 23.71 Mbit/s)   Flow 3 egress (mean 23.68 Mbit/s)

Flow 1 (95th percentile 40.75 ms)   Flow 2 (95th percentile 57.53 ms)   Flow 3 (95th percentile 43.17 ms)
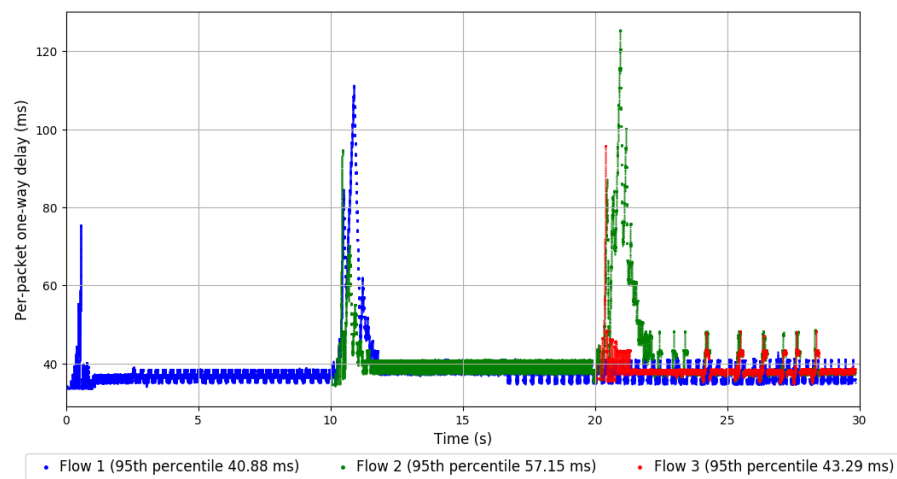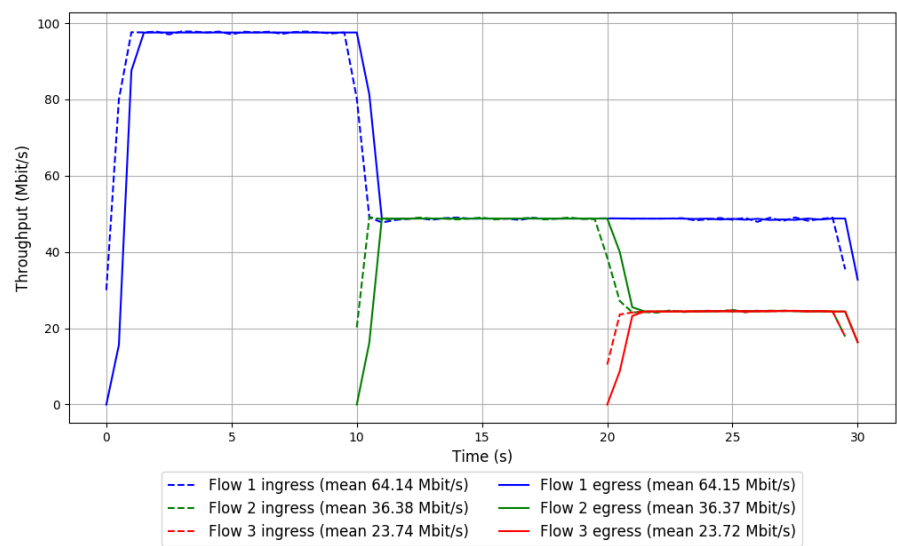
```
Run 2: Statistics of Indigo

Start at: 2018-09-05 22:33:34
End at: 2018-09-05 22:34:04
Local clock offset: 3.378 ms
Remote clock offset: -1.382 ms


# Below is generated by plot.py at 2018-09-05 22:45:21
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.09 Mbit/s
95th percentile per-packet one-way delay: 45.204 ms
Loss rate: 0.28%
-- Flow 1:
Average throughput: 64.15 Mbit/s
95th percentile per-packet one-way delay: 40.879 ms
Loss rate: 0.20%
-- Flow 2:
Average throughput: 36.37 Mbit/s
95th percentile per-packet one-way delay: 57.153 ms
Loss rate: 0.36%
-- Flow 3:
Average throughput: 23.72 Mbit/s
95th percentile per-packet one-way delay: 43.293 ms
Loss rate: 0.76%
```

Run 2: Report of Indigo — Data Link

- - - Flow 1 ingress (mean 64.14 Mbit/s)   —— Flow 1 egress (mean 64.15 Mbit/s)
- - - Flow 2 ingress (mean 36.38 Mbit/s)   —— Flow 2 egress (mean 36.37 Mbit/s)
- - - Flow 3 ingress (mean 23.74 Mbit/s)   —— Flow 3 egress (mean 23.72 Mbit/s)

• Flow 1 (95th percentile 40.88 ms)   • Flow 2 (95th percentile 57.15 ms)   • Flow 3 (95th percentile 43.29 ms)
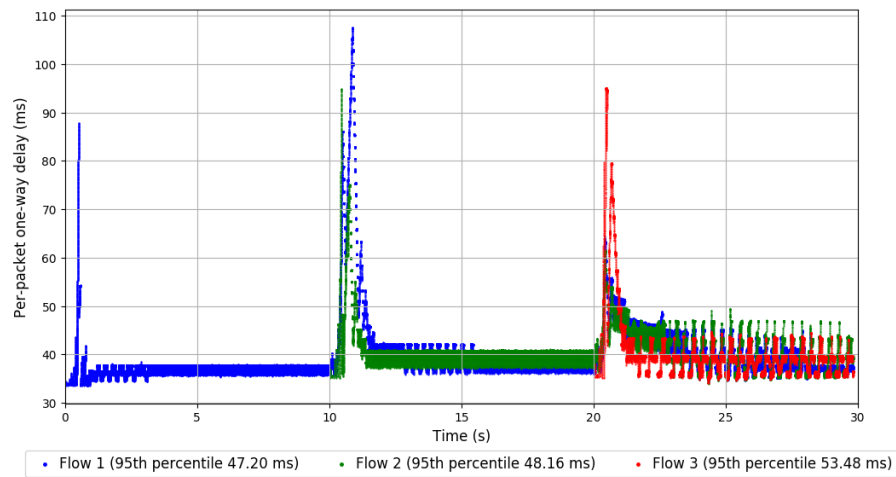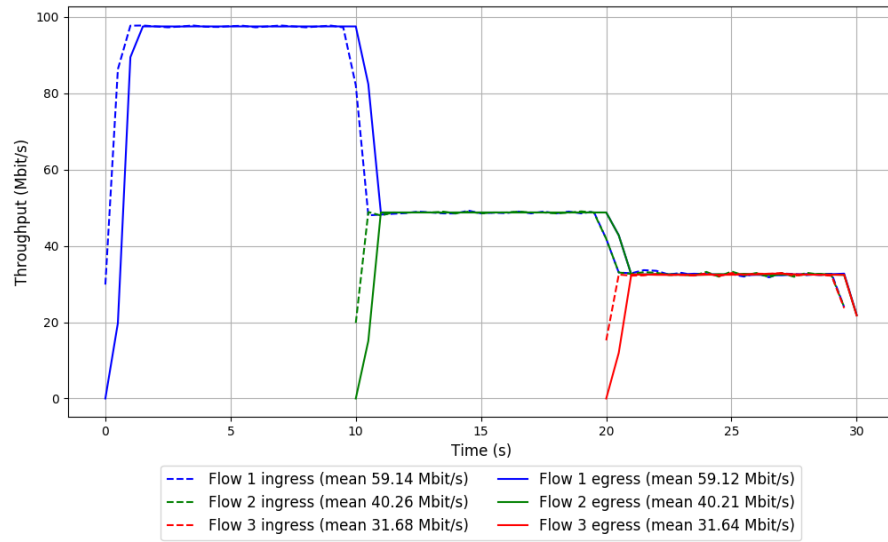
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```
Run 3: Statistics of Indigo

Start at: 2018-09-05 22:39:06
End at: 2018-09-05 22:39:36
Local clock offset: 2.405 ms
Remote clock offset: -1.554 ms


# Below is generated by plot.py at 2018-09-05 22:45:51
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.19 Mbit/s
95th percentile per-packet one-way delay: 47.829 ms
Loss rate: 0.36%
-- Flow 1:
Average throughput: 59.12 Mbit/s
95th percentile per-packet one-way delay: 47.198 ms
Loss rate: 0.25%
-- Flow 2:
Average throughput: 40.21 Mbit/s
95th percentile per-packet one-way delay: 48.161 ms
Loss rate: 0.44%
-- Flow 3:
Average throughput: 31.64 Mbit/s
95th percentile per-packet one-way delay: 53.475 ms
Loss rate: 0.76%
```

Run 3: Report of Indigo — Data Link

Flow 1 ingress (mean 59.14 Mbit/s) --- Flow 1 egress (mean 59.12 Mbit/s)
Flow 2 ingress (mean 40.26 Mbit/s) --- Flow 2 egress (mean 40.21 Mbit/s)
Flow 3 ingress (mean 31.68 Mbit/s) --- Flow 3 egress (mean 31.64 Mbit/s)

Flow 1 (95th percentile 47.20 ms)   Flow 2 (95th percentile 48.16 ms)   Flow 3 (95th percentile 53.48 ms)
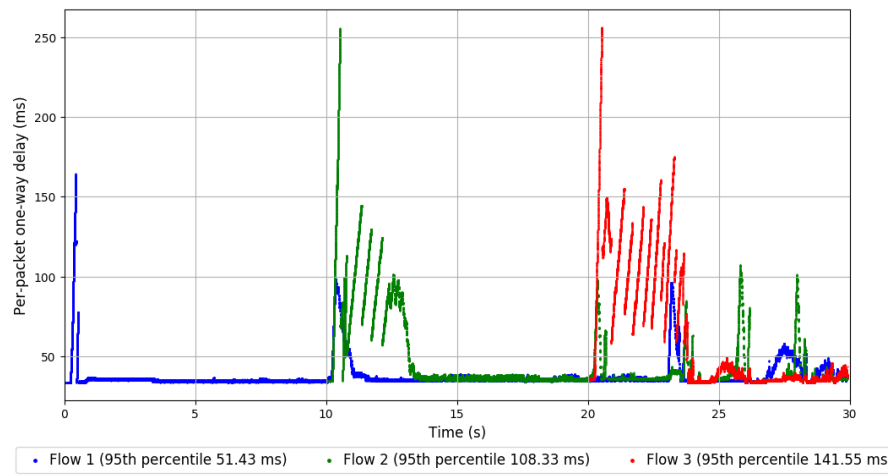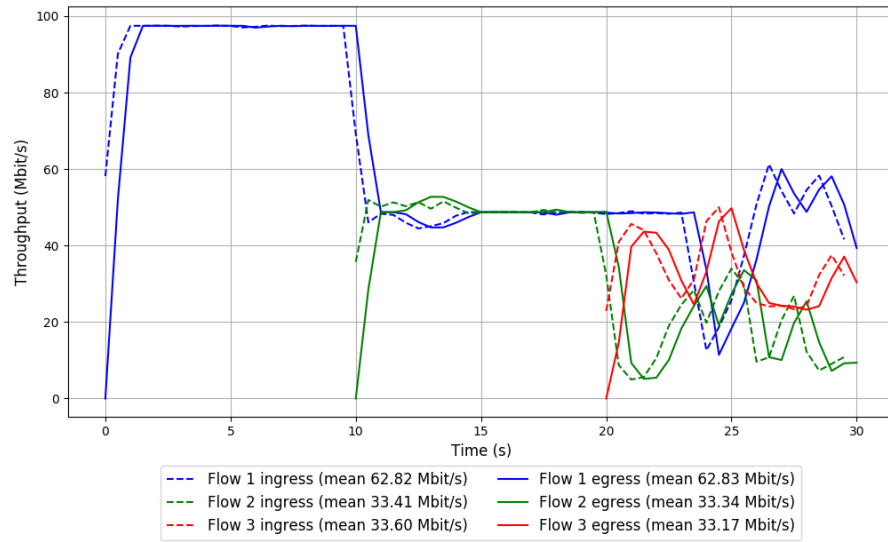
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```
Run 1: Statistics of Muses-25

Start at: 2018-09-05 22:32:11
End at: 2018-09-05 22:32:41
Local clock offset: 3.908 ms
Remote clock offset: -1.291 ms


# Below is generated by plot.py at 2018-09-05 22:45:53
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.92 Mbit/s
95th percentile per-packet one-way delay: 96.653 ms
Loss rate: 0.48%
-- Flow 1:
Average throughput: 62.83 Mbit/s
95th percentile per-packet one-way delay: 51.433 ms
Loss rate: 0.21%
-- Flow 2:
Average throughput: 33.34 Mbit/s
95th percentile per-packet one-way delay: 108.335 ms
Loss rate: 0.53%
-- Flow 3:
Average throughput: 33.17 Mbit/s
95th percentile per-packet one-way delay: 141.549 ms
Loss rate: 1.90%
```

Run 1: Report of Muses-25 — Data Link

Flow 1 ingress (mean 62.82 Mbit/s) ----   Flow 1 egress (mean 62.83 Mbit/s) ——
Flow 2 ingress (mean 33.41 Mbit/s) ----   Flow 2 egress (mean 33.34 Mbit/s) ——
Flow 3 ingress (mean 33.60 Mbit/s) ----   Flow 3 egress (mean 33.17 Mbit/s) ——

Flow 1 (95th percentile 51.43 ms)   Flow 2 (95th percentile 108.33 ms)   Flow 3 (95th percentile 141.55 ms)
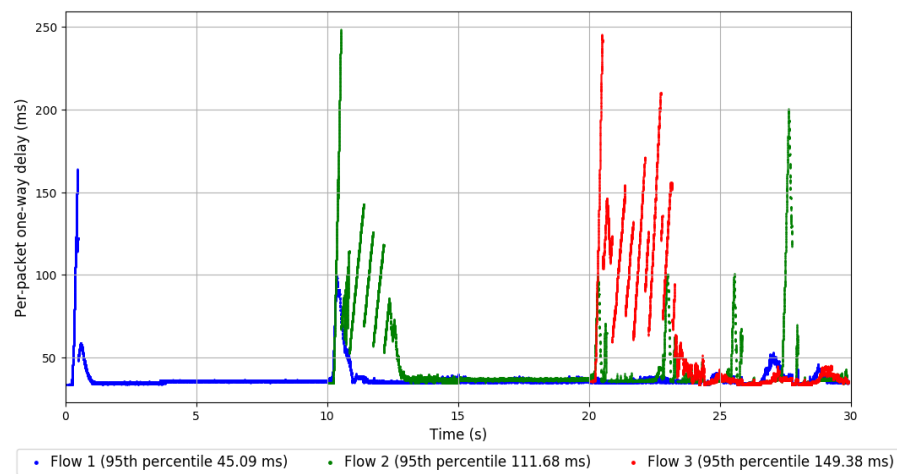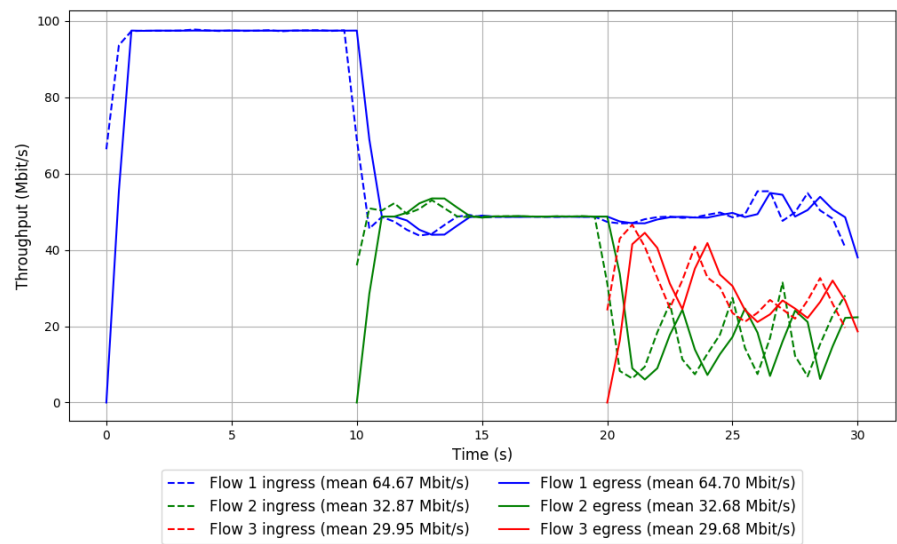
23

```
Run 2: Statistics of Muses-25

Start at: 2018-09-05 22:37:43
End at: 2018-09-05 22:38:13
Local clock offset: 2.583 ms
Remote clock offset: -1.634 ms


# Below is generated by plot.py at 2018-09-05 22:45:54
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.22 Mbit/s
95th percentile per-packet one-way delay: 95.118 ms
Loss rate: 0.48%
-- Flow 1:
Average throughput: 64.70 Mbit/s
95th percentile per-packet one-way delay: 45.095 ms
Loss rate: 0.18%
-- Flow 2:
Average throughput: 32.68 Mbit/s
95th percentile per-packet one-way delay: 111.679 ms
Loss rate: 0.91%
-- Flow 3:
Average throughput: 29.68 Mbit/s
95th percentile per-packet one-way delay: 149.383 ms
Loss rate: 1.56%
```

Run 2: Report of Muses-25 — Data Link

Flow 1 ingress (mean 64.67 Mbit/s)   Flow 1 egress (mean 64.70 Mbit/s)
Flow 2 ingress (mean 32.87 Mbit/s)   Flow 2 egress (mean 32.68 Mbit/s)
Flow 3 ingress (mean 29.95 Mbit/s)   Flow 3 egress (mean 29.68 Mbit/s)

Flow 1 (95th percentile 45.09 ms)   Flow 2 (95th percentile 111.68 ms)   Flow 3 (95th percentile 149.38 ms)

```
Run 3: Statistics of Muses-25

Start at: 2018-09-05 22:43:15
End at: 2018-09-05 22:43:45
Local clock offset: 2.081 ms
Remote clock offset: -1.567 ms


# Below is generated by plot.py at 2018-09-05 22:45:54
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.22 Mbit/s
95th percentile per-packet one-way delay: 70.516 ms
Loss rate: 0.31%
-- Flow 1:
Average throughput: 60.01 Mbit/s
95th percentile per-packet one-way delay: 43.466 ms
Loss rate: 0.15%
-- Flow 2:
Average throughput: 34.64 Mbit/s
95th percentile per-packet one-way delay: 94.431 ms
Loss rate: 0.50%
-- Flow 3:
Average throughput: 36.93 Mbit/s
95th percentile per-packet one-way delay: 97.625 ms
Loss rate: 0.74%
```

Run 3: Report of Muses-25 — Data Link

- - - - Flow 1 ingress (mean 59.97 Mbit/s) ——— Flow 1 egress (mean 60.01 Mbit/s)
- - - - Flow 2 ingress (mean 34.70 Mbit/s) ——— Flow 2 egress (mean 34.64 Mbit/s)
- - - - Flow 3 ingress (mean 36.96 Mbit/s) ——— Flow 3 egress (mean 36.93 Mbit/s)

- Flow 1 (95th percentile 43.47 ms)   - Flow 2 (95th percentile 94.43 ms)   - Flow 3 (95th percentile 97.62 ms)