# Pantheon Report

Generated at 2018-09-05 03:01:00 (UTC).

Data path: AWS California 1 on `ens5` (*local*) →Stanford on `eno1` (*remote*).

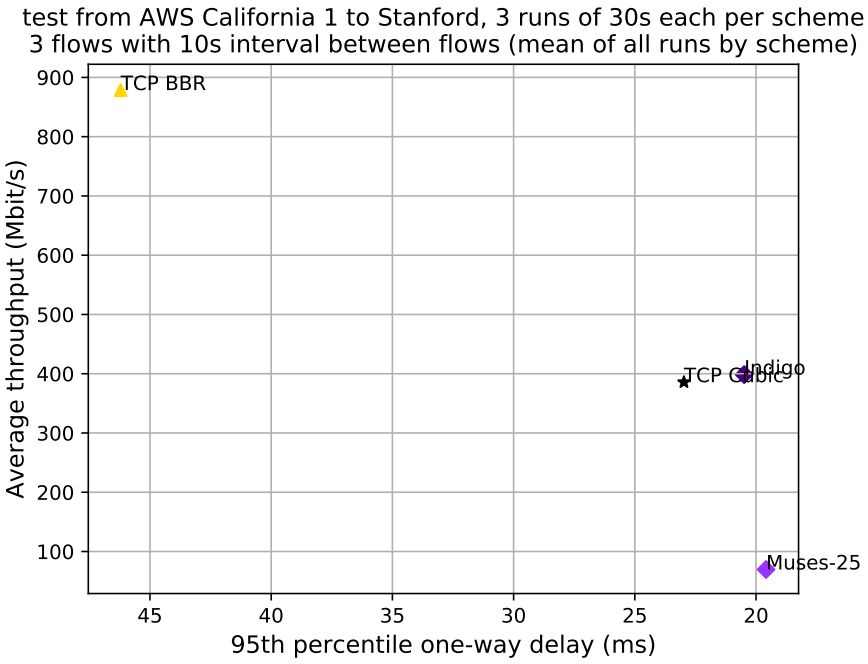
Repeated the test of 4 congestion control schemes 3 times.

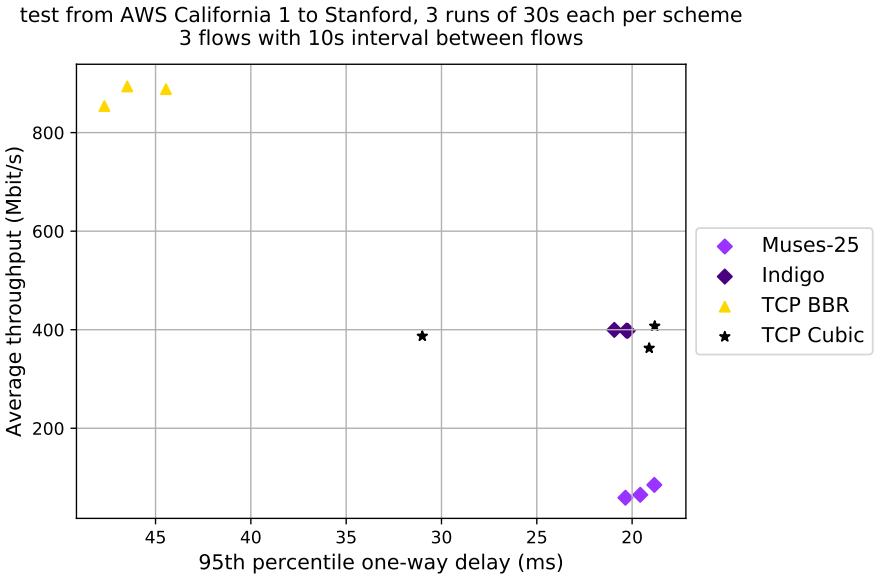
Each test lasted for 30 seconds running 3 flows with 10-second interval between two flows.

NTP offsets were measured against `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 @ 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 California 1 to Stanford, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)
TCP BBR
Indigo
TCP Cubic
Muses-25
Average throughput (Mbit/s)
95th percentile one-way delay (ms)
900
800
700
600
500
400
300
200
100
45
40
35
30
25
20


test from AWS California 1 to Stanford, 3 runs of 30s each per scheme
3 flows with 10s interval between flows
Muses-25
Indigo
TCP BBR
TCP Cubic
Average throughput (Mbit/s)
95th percentile one-way delay (ms)
800
600
400
200
45
40
35
30
25
20

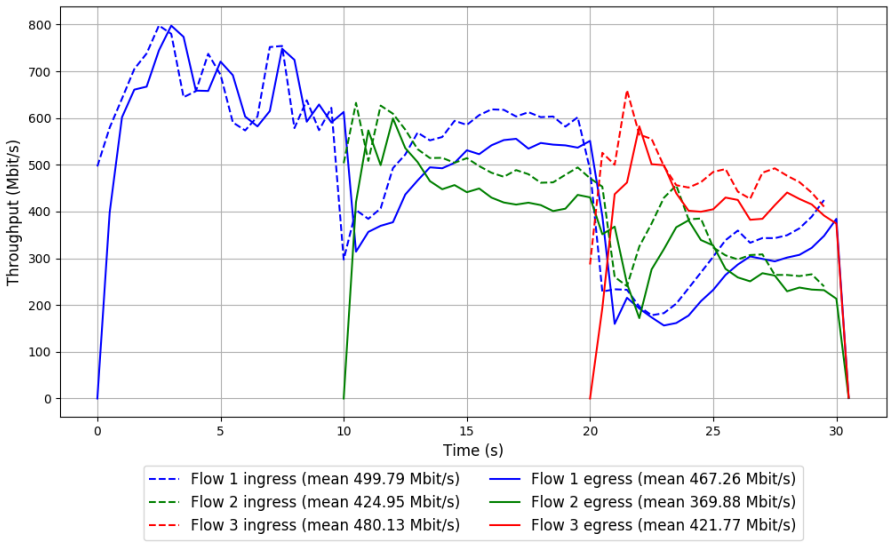
| scheme | # runs | mean avg tput (Mbit/s) | | | mean 95th-%ile delay (ms) | | | mean loss rate (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | flow 1 | flow 2 | flow 3 | flow 1 | flow 2 | flow 3 | flow 1 | flow 2 | flow 3 |
| TCP BBR | 3 | 495.75 | 377.75 | 394.45 | 47.87 | 28.37 | 23.70 | 6.70 | 12.17 | 12.41 |
| TCP Cubic | 3 | 187.48 | 207.92 | 179.55 | 26.35 | 18.18 | 19.10 | 0.05 | 0.05 | 0.04 |
| Indigo | 3 | 202.52 | 201.18 | 192.81 | 20.10 | 20.18 | 21.36 | 0.01 | 0.01 | 0.05 |
| Muses-25 | 3 | 24.08 | 50.38 | 36.93 | 19.32 | 19.76 | 20.10 | 0.06 | 0.02 | 0.04 |

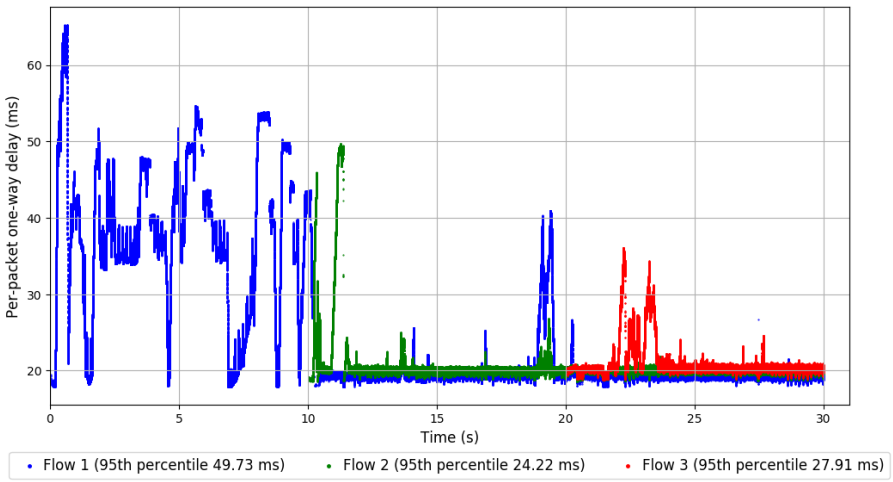
```
Run 1: Statistics of TCP BBR

Start at: 2018-09-05 02:33:25
End at: 2018-09-05 02:33:55
Local clock offset: -7.473 ms
Remote clock offset: -1.204 ms

# Below is generated by plot.py at 2018-09-05 03:00:55
# Datalink statistics
-- Total of 3 flows:
Average throughput: 853.82 Mbit/s
95th percentile per-packet one-way delay: 47.681 ms
Loss rate: 9.40%
-- Flow 1:
Average throughput: 467.26 Mbit/s
95th percentile per-packet one-way delay: 49.725 ms
Loss rate: 6.51%
-- Flow 2:
Average throughput: 369.88 Mbit/s
95th percentile per-packet one-way delay: 24.219 ms
Loss rate: 12.95%
-- Flow 3:
Average throughput: 421.77 Mbit/s
95th percentile per-packet one-way delay: 27.912 ms
Loss rate: 12.17%
```

Run 1: Report of TCP BBR — Data Link



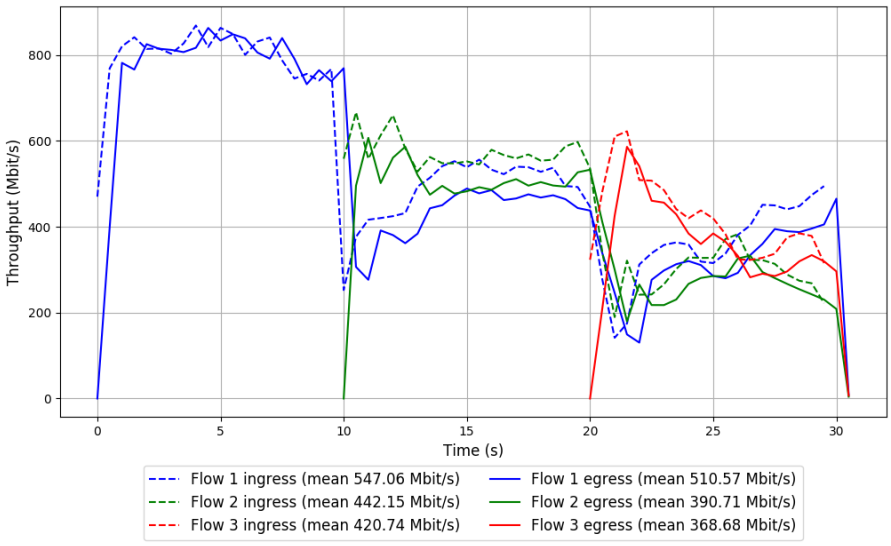



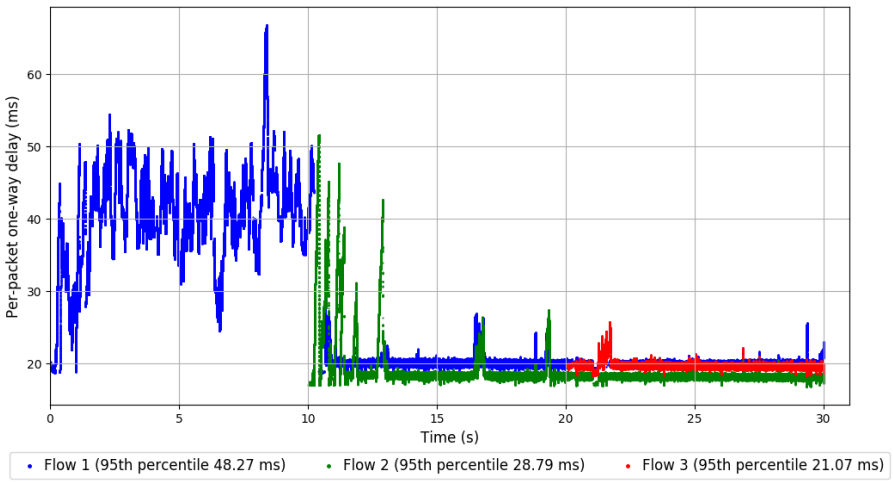
```
Run 2: Statistics of TCP BBR

Start at: 2018-09-05 02:39:54
End at: 2018-09-05 02:40:24
Local clock offset: -8.424 ms
Remote clock offset: -1.534 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 893.76 Mbit/s
95th percentile per-packet one-way delay: 46.483 ms
Loss rate: 8.98%
-- Flow 1:
Average throughput: 510.57 Mbit/s
95th percentile per-packet one-way delay: 48.271 ms
Loss rate: 6.67%
-- Flow 2:
Average throughput: 390.71 Mbit/s
95th percentile per-packet one-way delay: 28.792 ms
Loss rate: 11.63%
-- Flow 3:
Average throughput: 368.68 Mbit/s
95th percentile per-packet one-way delay: 21.066 ms
Loss rate: 12.38%
```

Run 2: Report of TCP BBR — Data Link



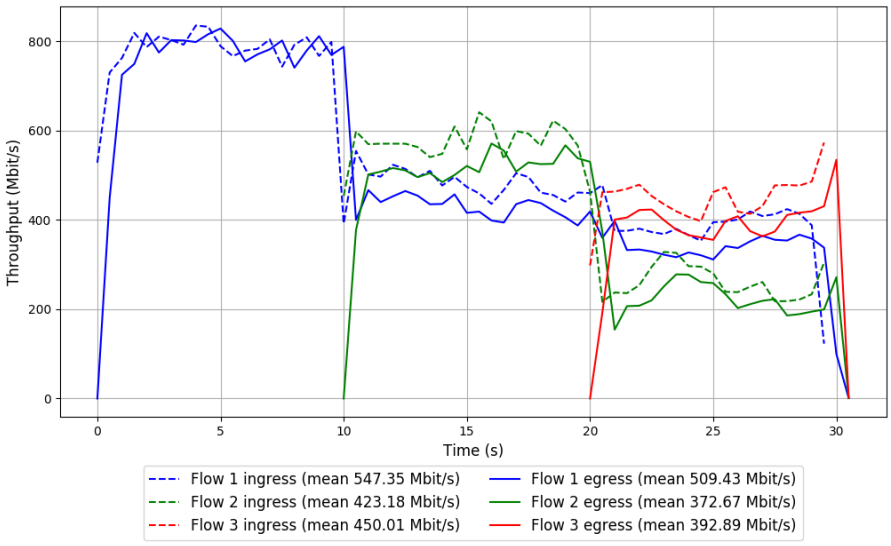



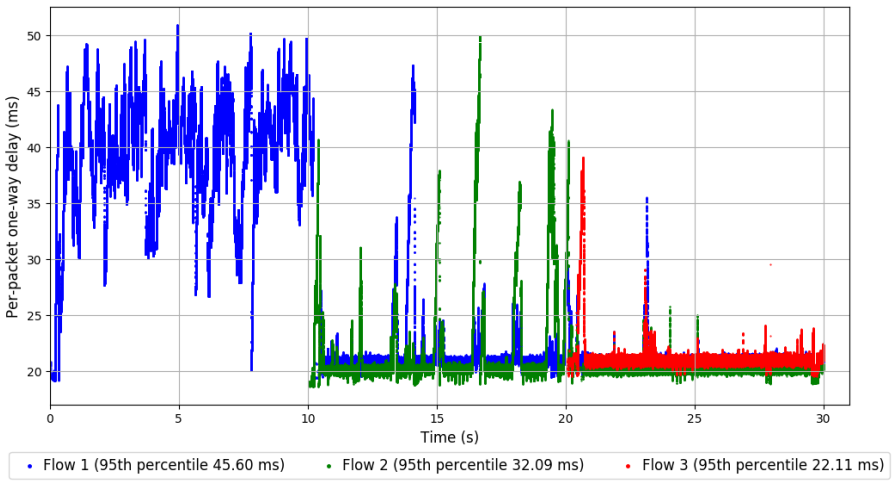
```
Run 3: Statistics of TCP BBR

Start at: 2018-09-05 02:46:26
End at: 2018-09-05 02:46:56
Local clock offset: -7.627 ms
Remote clock offset: 0.803 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 888.26 Mbit/s
95th percentile per-packet one-way delay: 44.452 ms
Loss rate: 9.25%
-- Flow 1:
Average throughput: 509.43 Mbit/s
95th percentile per-packet one-way delay: 45.599 ms
Loss rate: 6.92%
-- Flow 2:
Average throughput: 372.67 Mbit/s
95th percentile per-packet one-way delay: 32.085 ms
Loss rate: 11.93%
-- Flow 3:
Average throughput: 392.89 Mbit/s
95th percentile per-packet one-way delay: 22.108 ms
Loss rate: 12.69%
```

Run 3: Report of TCP BBR — Data Link



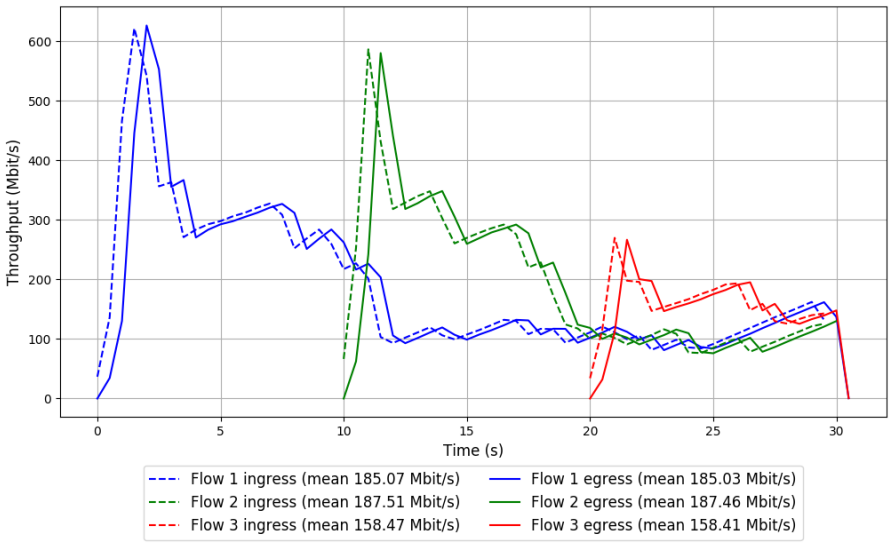



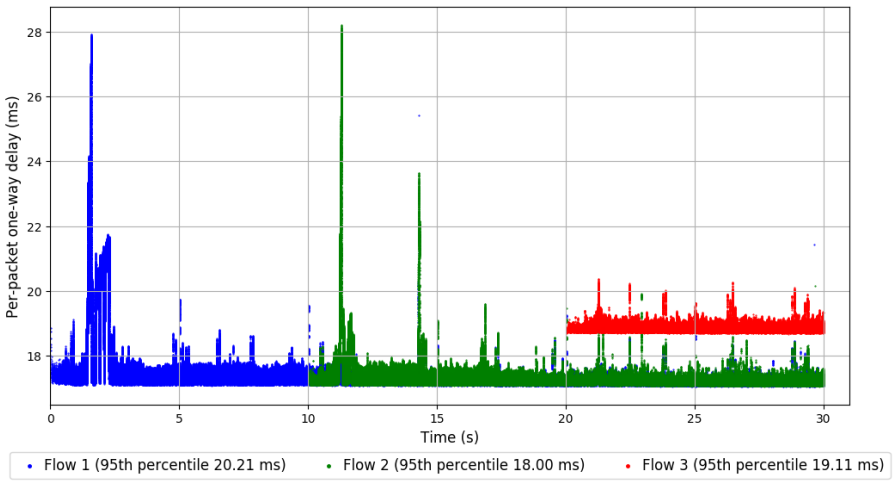
```
Run 1: Statistics of TCP Cubic

Start at: 2018-09-05 02:35:22
End at: 2018-09-05 02:35:52
Local clock offset: -7.647 ms
Remote clock offset: -1.316 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 362.67 Mbit/s
95th percentile per-packet one-way delay: 19.103 ms
Loss rate: 0.03%
-- Flow 1:
Average throughput: 185.03 Mbit/s
95th percentile per-packet one-way delay: 20.213 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 187.46 Mbit/s
95th percentile per-packet one-way delay: 18.002 ms
Loss rate: 0.03%
-- Flow 3:
Average throughput: 158.41 Mbit/s
95th percentile per-packet one-way delay: 19.106 ms
Loss rate: 0.03%
```

Run 1: Report of TCP Cubic — Data Link



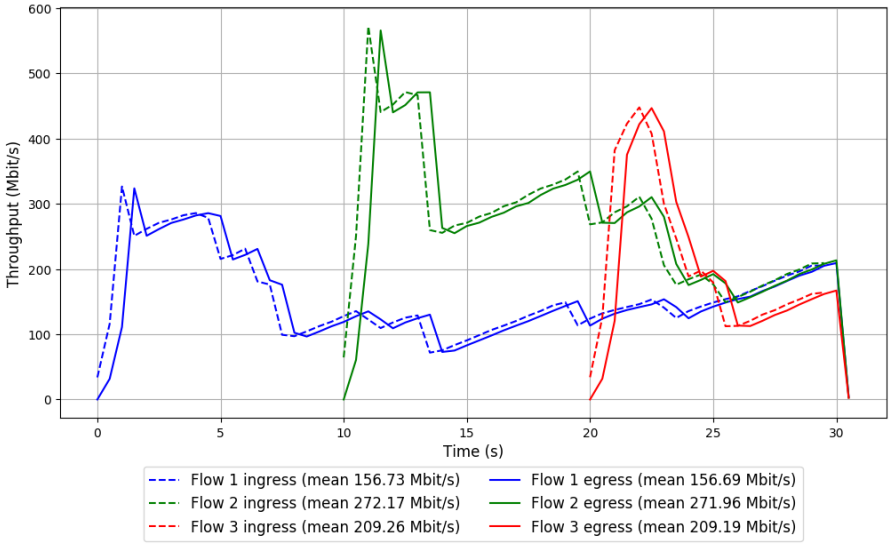



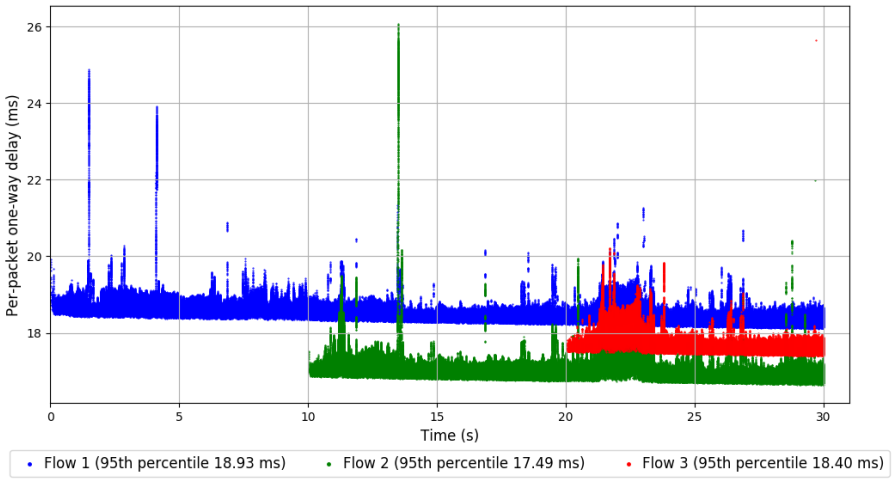
```
Run 2: Statistics of TCP Cubic

Start at: 2018-09-05 02:41:53
End at: 2018-09-05 02:42:23
Local clock offset: -8.852 ms
Remote clock offset: -0.727 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 407.43 Mbit/s
95th percentile per-packet one-way delay: 18.815 ms
Loss rate: 0.05%
-- Flow 1:
Average throughput: 156.69 Mbit/s
95th percentile per-packet one-way delay: 18.928 ms
Loss rate: 0.03%
-- Flow 2:
Average throughput: 271.96 Mbit/s
95th percentile per-packet one-way delay: 17.491 ms
Loss rate: 0.08%
-- Flow 3:
Average throughput: 209.19 Mbit/s
95th percentile per-packet one-way delay: 18.397 ms
Loss rate: 0.04%
```

Run 2: Report of TCP Cubic — Data Link



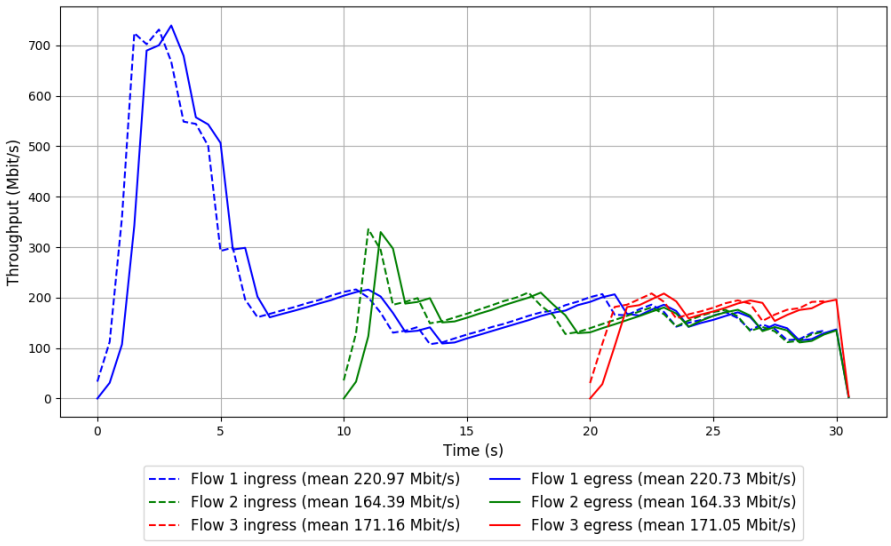



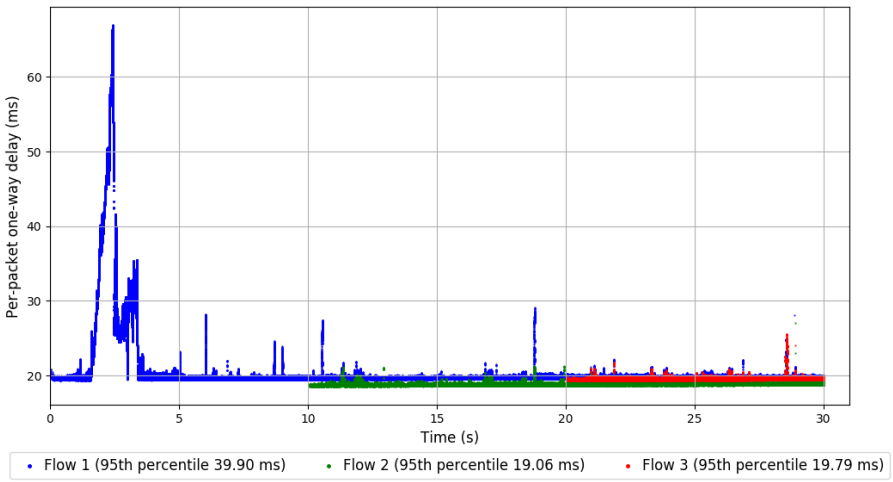
```
Run 3: Statistics of TCP Cubic

Start at: 2018-09-05 02:48:24
End at: 2018-09-05 02:48:54
Local clock offset: -5.72 ms
Remote clock offset: 1.379 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 387.09 Mbit/s
95th percentile per-packet one-way delay: 31.005 ms
Loss rate: 0.08%
-- Flow 1:
Average throughput: 220.73 Mbit/s
95th percentile per-packet one-way delay: 39.895 ms
Loss rate: 0.11%
-- Flow 2:
Average throughput: 164.33 Mbit/s
95th percentile per-packet one-way delay: 19.061 ms
Loss rate: 0.04%
-- Flow 3:
Average throughput: 171.05 Mbit/s
95th percentile per-packet one-way delay: 19.788 ms
Loss rate: 0.06%
```

Run 3: Report of TCP Cubic — Data Link



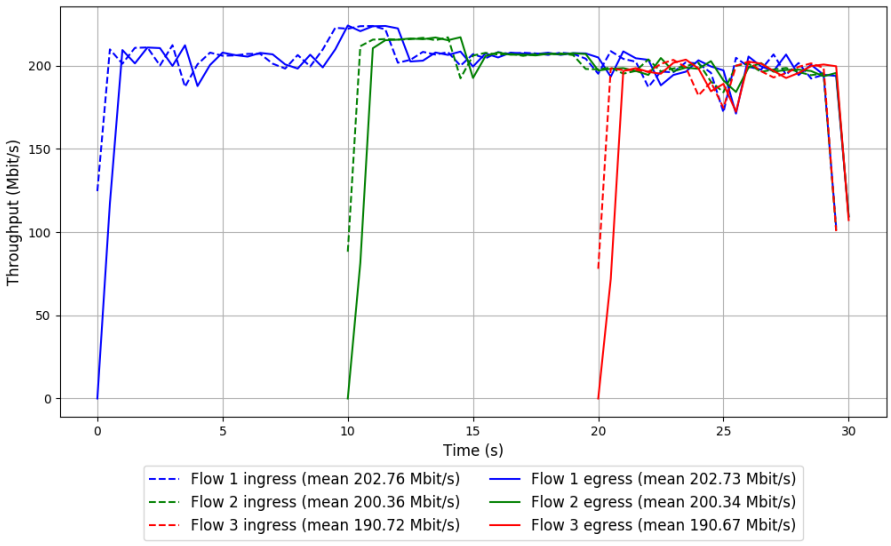



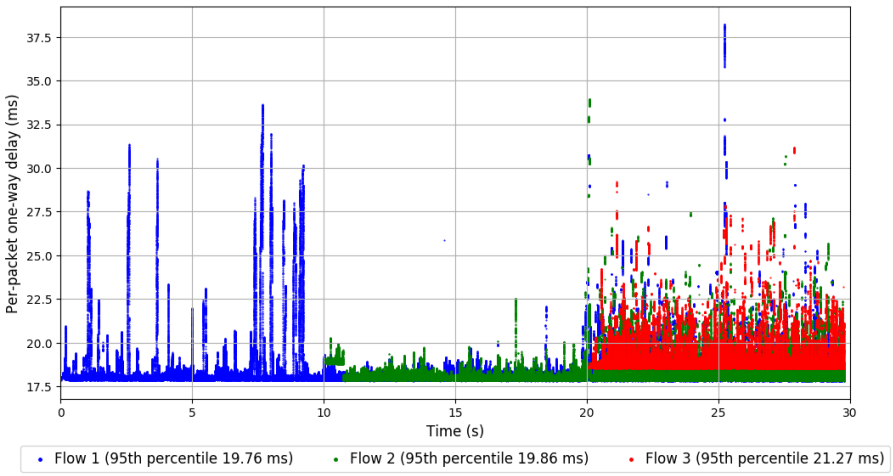
```
Run 1: Statistics of Indigo

Start at: 2018-09-05 02:36:54
End at: 2018-09-05 02:37:24
Local clock offset: -7.89 ms
Remote clock offset: -1.38 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 397.74 Mbit/s
95th percentile per-packet one-way delay: 20.230 ms
Loss rate: 0.01%
-- Flow 1:
Average throughput: 202.73 Mbit/s
95th percentile per-packet one-way delay: 19.756 ms
Loss rate: 0.01%
-- Flow 2:
Average throughput: 200.34 Mbit/s
95th percentile per-packet one-way delay: 19.859 ms
Loss rate: 0.01%
-- Flow 3:
Average throughput: 190.67 Mbit/s
95th percentile per-packet one-way delay: 21.269 ms
Loss rate: 0.02%
```

Run 1: Report of Indigo — Data Link



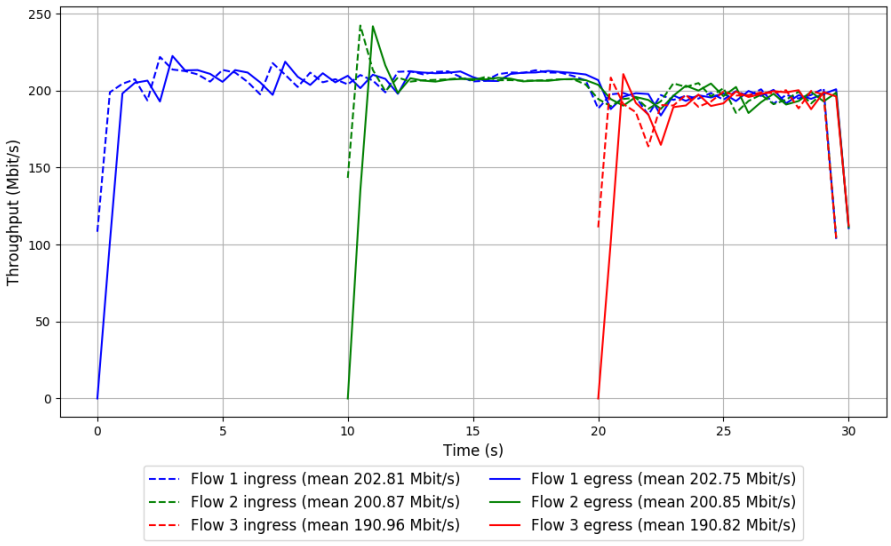



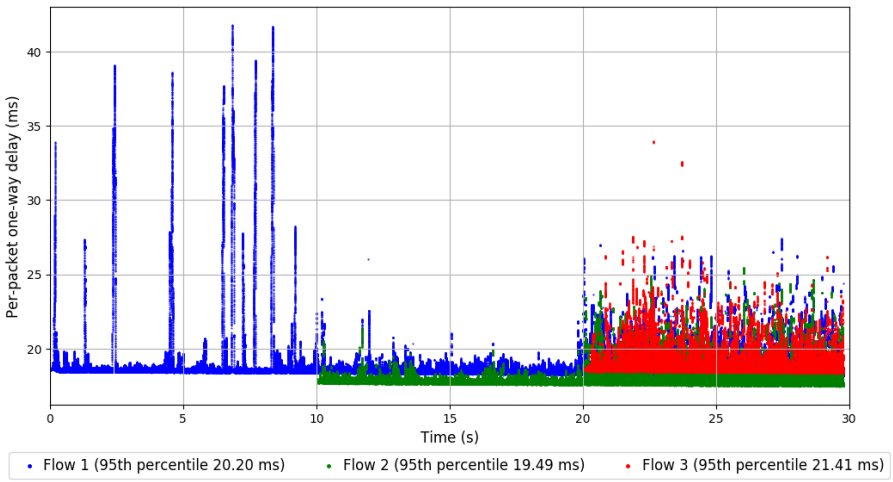
```
Run 2: Statistics of Indigo

Start at: 2018-09-05 02:43:27
End at: 2018-09-05 02:43:57
Local clock offset: -9.242 ms
Remote clock offset: -0.106 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 398.12 Mbit/s
95th percentile per-packet one-way delay: 20.302 ms
Loss rate: 0.02%
-- Flow 1:
Average throughput: 202.75 Mbit/s
95th percentile per-packet one-way delay: 20.199 ms
Loss rate: 0.01%
-- Flow 2:
Average throughput: 200.85 Mbit/s
95th percentile per-packet one-way delay: 19.492 ms
Loss rate: 0.01%
-- Flow 3:
Average throughput: 190.82 Mbit/s
95th percentile per-packet one-way delay: 21.410 ms
Loss rate: 0.05%
```

Run 2: Report of Indigo — Data Link



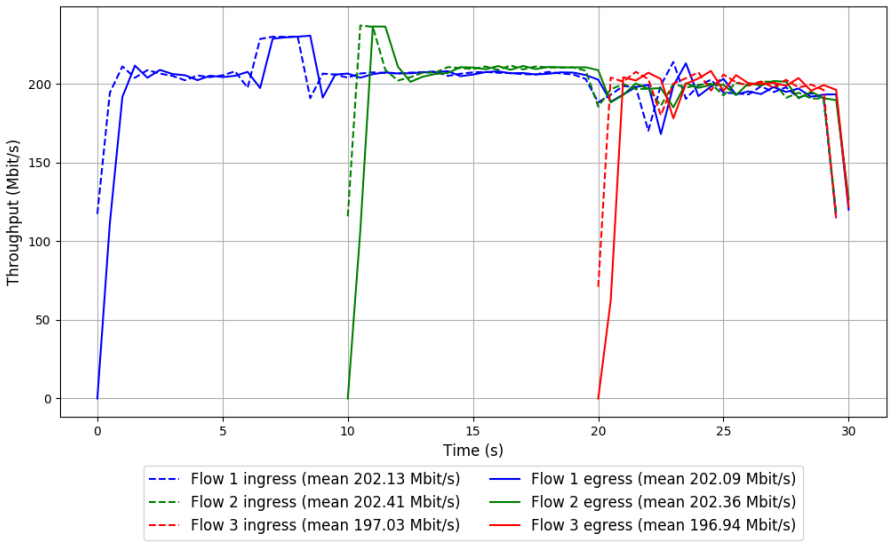



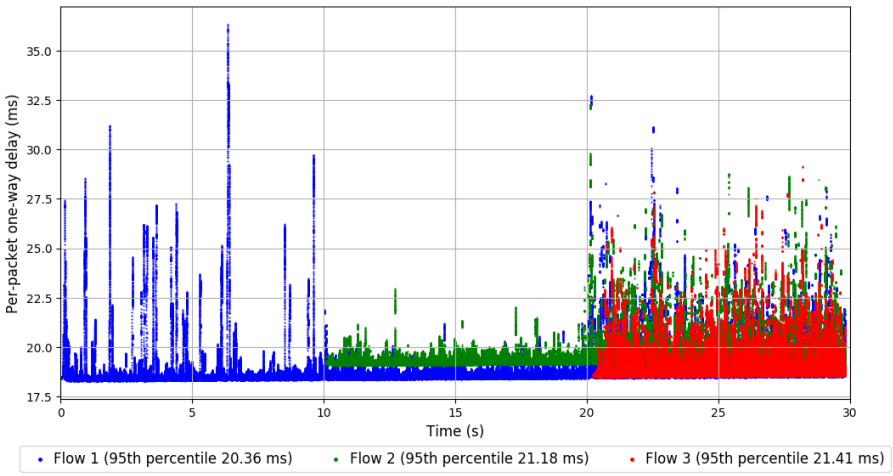
```
Run 3: Statistics of Indigo

Start at: 2018-09-05 02:49:57
End at: 2018-09-05 02:50:27
Local clock offset: -4.463 ms
Remote clock offset: 1.68 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 399.62 Mbit/s
95th percentile per-packet one-way delay: 20.934 ms
Loss rate: 0.03%
-- Flow 1:
Average throughput: 202.09 Mbit/s
95th percentile per-packet one-way delay: 20.359 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 202.36 Mbit/s
95th percentile per-packet one-way delay: 21.177 ms
Loss rate: 0.02%
-- Flow 3:
Average throughput: 196.94 Mbit/s
95th percentile per-packet one-way delay: 21.408 ms
Loss rate: 0.07%
```

Run 3: Report of Indigo — Data Link



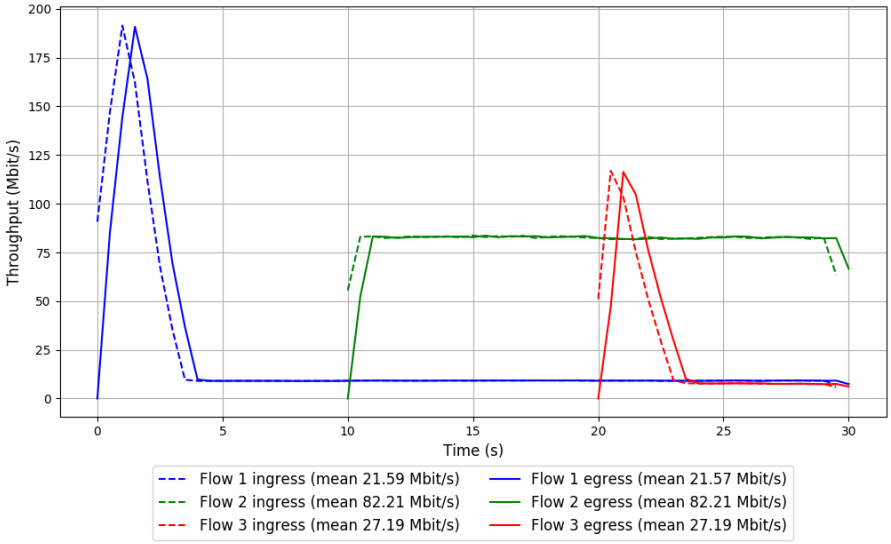



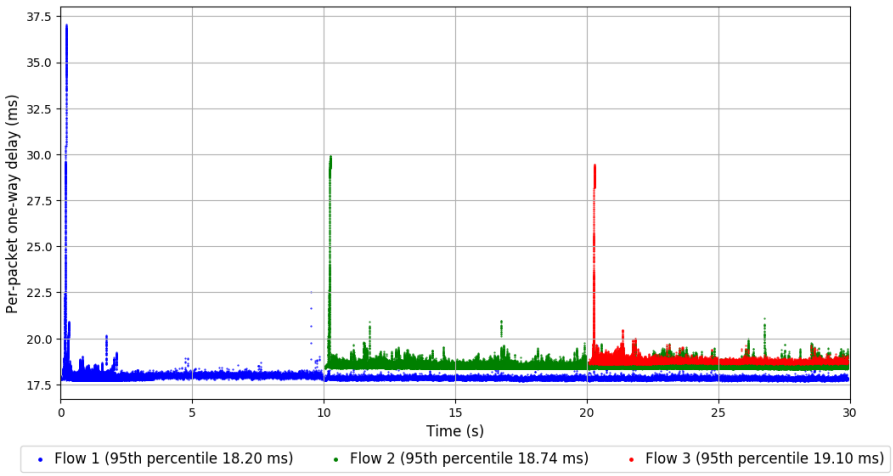
```
Run 1: Statistics of Muses-25

Start at: 2018-09-05 02:38:32
End at: 2018-09-05 02:39:02
Local clock offset: -8.155 ms
Remote clock offset: -1.583 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 85.08 Mbit/s
95th percentile per-packet one-way delay: 18.835 ms
Loss rate: 0.04%
-- Flow 1:
Average throughput: 21.57 Mbit/s
95th percentile per-packet one-way delay: 18.199 ms
Loss rate: 0.13%
-- Flow 2:
Average throughput: 82.21 Mbit/s
95th percentile per-packet one-way delay: 18.742 ms
Loss rate: 0.01%
-- Flow 3:
Average throughput: 27.19 Mbit/s
95th percentile per-packet one-way delay: 19.102 ms
Loss rate: 0.01%
```

Run 1: Report of Muses-25 — Data Link



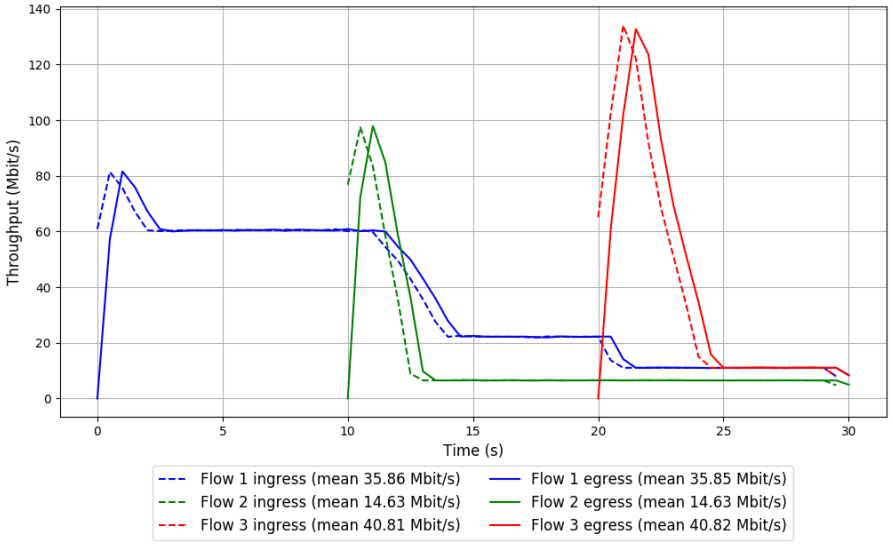



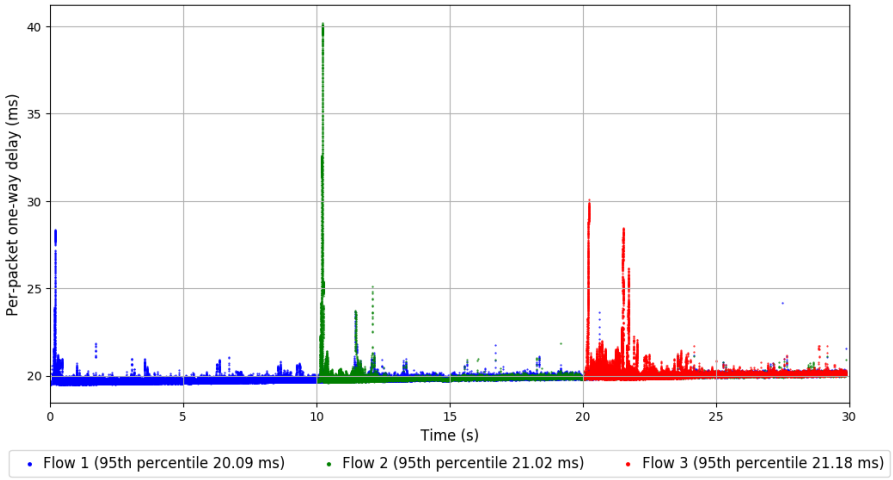
```
Run 2: Statistics of Muses-25

Start at: 2018-09-05 02:45:04
End at: 2018-09-05 02:45:34
Local clock offset: -9.159 ms
Remote clock offset: 0.453 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 59.02 Mbit/s
95th percentile per-packet one-way delay: 20.350 ms
Loss rate: 0.02%
-- Flow 1:
Average throughput: 35.85 Mbit/s
95th percentile per-packet one-way delay: 20.095 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 14.63 Mbit/s
95th percentile per-packet one-way delay: 21.016 ms
Loss rate: 0.04%
-- Flow 3:
Average throughput: 40.82 Mbit/s
95th percentile per-packet one-way delay: 21.178 ms
Loss rate: 0.01%
```

Run 2: Report of Muses-25 — Data Link



```
Run 3: Statistics of Muses-25

Start at: 2018-09-05 02:51:34
End at: 2018-09-05 02:52:04
Local clock offset: -3.499 ms
Remote clock offset: 1.904 ms

# Below is generated by plot.py at 2018-09-05 03:00:59
# Datalink statistics
-- Total of 3 flows:
Average throughput: 64.98 Mbit/s
95th percentile per-packet one-way delay: 19.573 ms
Loss rate: 0.02%
-- Flow 1:
Average throughput: 14.81 Mbit/s
95th percentile per-packet one-way delay: 19.659 ms
Loss rate: 0.02%
-- Flow 2:
Average throughput: 54.29 Mbit/s
95th percentile per-packet one-way delay: 19.532 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 42.78 Mbit/s
95th percentile per-packet one-way delay: 20.014 ms
Loss rate: 0.09%
```

Run 3: Report of Muses-25 — Data Link