Pantheon Report

Generated at 2018-08-31 14:19:56 (UTC).
Data path: GCE Tokyo on ens4 (remote) → GCE Sydney on ens4 (local).
Repeated the test of 4 congestion control schemes twice.
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 4.15.0-1018-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
net.ipv4.tcp_mem = 536870912 536870912 536870912

Git summary:
branch: muses @ e3c5aa19ca94c3066828fb83f16a8fb6b2731e7a
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436db48834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38cd4fde0ecdbf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ b59e0d118c50af3579569c462d33045741c85981
third_party/pantheon-tunnel @ cbfcee6db5ff5740dafe1771f813cd646339e1952
third_party/pcc @ 1af9c958fa0d6d18623c091a55fec872b4981e1
M receiver/src/buffer.h
M receiver/src/core.cpp
M sender/src/buffer.h
M sender/src/core.cpp
third_party/pcc-experimental @ cd43e703e3f5f5613e8adco8fab92c4eb24f974ab
third_party/proto-quic @ 77961f1a82733a86b42f1bc8143e9c978f3c3f42
third_party/scream-reproduce @ f099118d1421aa3131bf11ff1964974e1da3b3b2
M src/ScreamClient
M src/ScreamServer
third_party/sprout @ 366e35c6788b01e31d4a6ad18c74f9415f19a26
third_party/verus @ d4b447ea74c6c60a261149af2629562939f9a494
M src/verus.hpp
M tools/plot.py
third_party/vivace @ 2baf86211435ae071a32f96b7d8c504587f5d7f4
third_party/webrtc @ 3f0cc2a9061a41b6f9ddee4735770d143a1fa2851
test from GCE Tokyo to GCE Sydney, 2 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)

Average throughput (Mbit/s)

95th percentile one-way delay (ms)

TCP BBR

TCP Cubic

Muses-25

Indigo

32 64 128 256

400 500 600 700 800 900 1000 1100

256 128 64 32

95th percentile one-way delay (ms)

Average throughput (Mbit/s)

32 64 128 256

400 500 600 700 800 900 1000 1100

256 128 64 32

95th percentile one-way delay (ms)
<table>
<thead>
<tr>
<th>scheme</th>
<th># runs</th>
<th>mean avg tput (Mbit/s)</th>
<th>mean 95th-%ile delay (ms)</th>
<th>mean loss rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP BBR</td>
<td>2</td>
<td>544.27, 507.92, 499.26</td>
<td>187.72, 148.89, 141.74</td>
<td>1.89, 1.16, 2.81</td>
</tr>
<tr>
<td>TCP Cubic</td>
<td>2</td>
<td>584.36, 534.01, 464.42</td>
<td>109.76, 114.52, 98.28</td>
<td>0.47, 0.69, 1.22</td>
</tr>
<tr>
<td>Indigo</td>
<td>2</td>
<td>217.41, 203.08, 176.00</td>
<td>53.57, 55.15, 55.32</td>
<td>0.34, 0.55, 1.27</td>
</tr>
<tr>
<td>Muses-25</td>
<td>2</td>
<td>482.39, 484.23, 406.52</td>
<td>64.59, 61.92, 66.51</td>
<td>0.20, 0.34, 1.55</td>
</tr>
</tbody>
</table>
Run 1: Statistics of TCP BBR

Start at: 2018-08-31 13:46:42
End at: 2018-08-31 13:47:12
Local clock offset: 0.089 ms
Remote clock offset: -0.188 ms

# Below is generated by plot.py at 2018-08-31 14:18:42
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 1054.14 Mbit/s
  95th percentile per-packet one-way delay: 173.686 ms
  Loss rate: 2.08%
  -- Flow 1:
  Average throughput: 540.58 Mbit/s
  95th percentile per-packet one-way delay: 194.901 ms
  Loss rate: 2.49%
  -- Flow 2:
  Average throughput: 521.31 Mbit/s
  95th percentile per-packet one-way delay: 114.611 ms
  Loss rate: 0.68%
  -- Flow 3:
  Average throughput: 506.17 Mbit/s
  95th percentile per-packet one-way delay: 130.251 ms
  Loss rate: 3.59%
Run 1: Report of TCP BBR — Data Link
Run 2: Statistics of TCP BBR

Start at: 2018-08-31 13:54:33
End at: 2018-08-31 13:55:03
Local clock offset: -0.27 ms
Remote clock offset: -2.833 ms

# Below is generated by plot.py at 2018-08-31 14:18:42
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1039.48 Mbit/s
95th percentile per-packet one-way delay: 175.639 ms
Loss rate: 1.51%
-- Flow 1:
Average throughput: 547.96 Mbit/s
95th percentile per-packet one-way delay: 180.534 ms
Loss rate: 1.28%
-- Flow 2:
Average throughput: 494.53 Mbit/s
95th percentile per-packet one-way delay: 183.164 ms
Loss rate: 1.64%
-- Flow 3:
Average throughput: 492.35 Mbit/s
95th percentile per-packet one-way delay: 153.238 ms
Loss rate: 2.04%
Run 2: Report of TCP BBR — Data Link

![Graph showing network performance metrics over time](image-url)

Legend:
- Flow 1 ingress (mean 553.08 Mbit/s)
- Flow 1 egress (mean 547.96 Mbit/s)
- Flow 2 ingress (mean 500.08 Mbit/s)
- Flow 2 egress (mean 494.53 Mbit/s)
- Flow 3 ingress (mean 497.38 Mbit/s)
- Flow 3 egress (mean 492.35 Mbit/s)

![Graph showing packet delay over time](image-url)

Legend:
- Flow 1 (95th percentile 180.53 ms)
- Flow 2 (95th percentile 183.16 ms)
- Flow 3 (95th percentile 153.24 ms)
Run 1: Statistics of TCP Cubic

Start at: 2018-08-31 13:50:44
End at: 2018-08-31 13:51:14
Local clock offset: -0.112 ms
Remote clock offset: -0.053 ms

# Below is generated by plot.py at 2018-08-31 14:18:57
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1103.34 Mbit/s
95th percentile per-packet one-way delay: 114.649 ms
Loss rate: 0.60%
-- Flow 1:
Average throughput: 591.60 Mbit/s
95th percentile per-packet one-way delay: 103.603 ms
Loss rate: 0.46%
-- Flow 2:
Average throughput: 531.27 Mbit/s
95th percentile per-packet one-way delay: 120.763 ms
Loss rate: 0.61%
-- Flow 3:
Average throughput: 480.02 Mbit/s
95th percentile per-packet one-way delay: 88.346 ms
Loss rate: 1.07%
Run 1: Report of TCP Cubic — Data Link

![Graph of throughput and delay over time for three flows.](image)

- **Throughput (Mbps):**
  - Flow 1 ingress (mean 592.26 Mbps)
  - Flow 1 egress (mean 591.60 Mbps)
  - Flow 2 ingress (mean 531.76 Mbps)
  - Flow 2 egress (mean 531.27 Mbps)
  - Flow 3 ingress (mean 480.14 Mbps)
  - Flow 3 egress (mean 480.02 Mbps)

- **Per-packet one-way delay (ms):**
  - Flow 1 (95th percentile 103.60 ms)
  - Flow 2 (95th percentile 120.76 ms)
  - Flow 3 (95th percentile 88.35 ms)
Run 2: Statistics of TCP Cubic

Start at: 2018-08-31 13:58:33
End at: 2018-08-31 13:59:03
Local clock offset: -0.08 ms
Remote clock offset: -0.219 ms

# Below is generated by plot.py at 2018-08-31 14:18:57
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1082.48 Mbit/s
95th percentile per-packet one-way delay: 110.743 ms
Loss rate: 0.70%
-- Flow 1:
Average throughput: 577.11 Mbit/s
95th percentile per-packet one-way delay: 115.918 ms
Loss rate: 0.48%
-- Flow 2:
Average throughput: 536.76 Mbit/s
95th percentile per-packet one-way delay: 108.268 ms
Loss rate: 0.77%
-- Flow 3:
Average throughput: 448.83 Mbit/s
95th percentile per-packet one-way delay: 108.210 ms
Loss rate: 1.37%
Run 2: Report of TCP Cubic — Data Link

![Graph of throughputs and round-trip delays for different flows.](image-url)
Run 1: Statistics of Indigo

Start at: 2018-08-31 13:44:57
End at: 2018-08-31 13:45:27
Local clock offset: 0.031 ms
Remote clock offset: -0.146 ms

# Below is generated by plot.py at 2018-08-31 14:18:57
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 406.59 Mbit/s
  95th percentile per-packet one-way delay: 55.032 ms
  Loss rate: 0.56%
-- Flow 1:
  Average throughput: 213.10 Mbit/s
  95th percentile per-packet one-way delay: 51.854 ms
  Loss rate: 0.35%
-- Flow 2:
  Average throughput: 206.07 Mbit/s
  95th percentile per-packet one-way delay: 55.657 ms
  Loss rate: 0.59%
-- Flow 3:
  Average throughput: 176.00 Mbit/s
  95th percentile per-packet one-way delay: 56.156 ms
  Loss rate: 1.28%
Run 1: Report of Indigo — Data Link

![Graph showing throughput and per-packet delay over time for different flows.]

- **Throughput (Mbps):**
  - **Flow 1 ingress** (mean 213.10 Mbps)
  - **Flow 1 egress** (mean 213.10 Mbps)
  - **Flow 2 ingress** (mean 206.16 Mbps)
  - **Flow 2 egress** (mean 206.07 Mbps)
  - **Flow 3 ingress** (mean 176.35 Mbps)
  - **Flow 3 egress** (mean 176.00 Mbps)

- **Per-packet delay (ms):**
  - **Flow 1** (95th percentile 51.85 ms)
  - **Flow 2** (95th percentile 55.66 ms)
  - **Flow 3** (95th percentile 56.16 ms)
Run 2: Statistics of Indigo

Start at: 2018-08-31 13:52:46
End at: 2018-08-31 13:53:16
Local clock offset: 0.129 ms
Remote clock offset: -0.146 ms

# Below is generated by plot.py at 2018-08-31 14:18:57
# Datalink statistics
-- Total of 3 flows:
Average throughput: 411.73 Mbit/s
95th percentile per-packet one-way delay: 55.050 ms
Loss rate: 0.52%
-- Flow 1:
Average throughput: 221.73 Mbit/s
95th percentile per-packet one-way delay: 55.278 ms
Loss rate: 0.33%
-- Flow 2:
Average throughput: 200.09 Mbit/s
95th percentile per-packet one-way delay: 54.650 ms
Loss rate: 0.51%
-- Flow 3:
Average throughput: 175.99 Mbit/s
95th percentile per-packet one-way delay: 54.492 ms
Loss rate: 1.26%
Run 2: Report of Indigo — Data Link

Graph 1: Throughput (Mbit/s) vs Time (s)

Graph 2: Per-packet round trip delay (ms) vs Time (s)

Legend:
- Flow 1 ingress (mean 221.65 Mbit/s)
- Flow 1 egress (mean 221.73 Mbit/s)
- Flow 2 ingress (mean 200.02 Mbit/s)
- Flow 2 egress (mean 200.09 Mbit/s)
- Flow 3 ingress (mean 176.35 Mbit/s)
- Flow 3 egress (mean 175.99 Mbit/s)
Run 1: Statistics of Muses-25

Start at: 2018-08-31 13:48:45
End at: 2018-08-31 13:49:15
Local clock offset: -0.106 ms
Remote clock offset: -3.116 ms

# Below is generated by plot.py at 2018-08-31 14:19:53
# Datalink statistics
-- Total of 3 flows:
Average throughput: 963.11 Mbit/s
95th percentile per-packet one-way delay: 65.831 ms
Loss rate: 0.45%
-- Flow 1:
Average throughput: 480.34 Mbit/s
95th percentile per-packet one-way delay: 67.555 ms
Loss rate: 0.19%
-- Flow 2:
Average throughput: 533.14 Mbit/s
95th percentile per-packet one-way delay: 61.460 ms
Loss rate: 0.34%
-- Flow 3:
Average throughput: 394.26 Mbit/s
95th percentile per-packet one-way delay: 71.669 ms
Loss rate: 1.72%
Run 1: Report of Muses-25 — Data Link

![Graph 1: Throughput (Mbps)]

![Graph 2: Per-packet one-way delay (ms)]
Run 2: Statistics of Muses-25

Start at: 2018-08-31 13:56:36
End at: 2018-08-31 13:57:06
Local clock offset: -0.317 ms
Remote clock offset: -0.117 ms

# Below is generated by plot.py at 2018-08-31 14:19:53
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 910.32 Mbit/s
  95th percentile per-packet one-way delay: 61.857 ms
  Loss rate: 0.42%
-- Flow 1:
  Average throughput: 484.45 Mbit/s
  95th percentile per-packet one-way delay: 61.635 ms
  Loss rate: 0.20%
-- Flow 2:
  Average throughput: 435.31 Mbit/s
  95th percentile per-packet one-way delay: 62.372 ms
  Loss rate: 0.33%
-- Flow 3:
  Average throughput: 418.79 Mbit/s
  95th percentile per-packet one-way delay: 61.358 ms
  Loss rate: 1.39%
Run 2: Report of Muses-25 — Data Link