Pantheon Report

Generated at 2018-08-31 13:18:03 (UTC).
Data path: GCE Sydney on ens4 (local) → GCE Tokyo on ens4 (remote).
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 @ e3c5aa19ca94c3066828fbb3f16a8fb6b2731e7a
third_party/fillp @ d47f4afa1b454a5e3c0537115c5a28436dbb4b834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143ceddfe58e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0e0ebf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaab4a906ce6bb7cf3cf
third_party/muses @ b59e0d118c50af3579569c462d33045741c65981
third_party/pantheon-tunnel @ cfbce6db5ff5740daef1771f813d646339e1952
third_party/pcc @ 1af9c958fa0d66d8b623c091a55f3c872b4981e1
M receiver/src/buffer.h
M receiver/src/core.cpp
M sender/src/buffer.h
M sender/src/core.cpp
third_party/pcc-experimental @ cd43e34e3f5f5613e8ac08fab92c4eb24f974ab
third_party/proto-quic @ 7796f1a82733a86b42f1bc8143ebc978f3c2f42
third_party/scream-reproduce @ f099118d1421aa3131bf11ff1964974e1da3b2b2
M src/ScreamClient
M src/ScreamServer
third_party/sprout @ 366e35c6178b01e31d4a6ad18c74f9415f19a26
third_party/verus @ d4b447ea74c6c60a261149af262956293f9a494
M src/verus.hpp
M tools/plot.py
third_party/vivace @ 2baf86211435ae071a32f96b7d8c504587f5d7f4
third_party/webrtc @ 3f0cc2a9061a41b6f9dd0e4735770d143a1fa2851
test from GCE Sydney to GCE Tokyo, 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

TCP BBR
TCP Cubic
Muses-25
Indigo
<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></td>
<td></td>
<td>flow 1</td>
<td>flow 2</td>
<td>flow 3</td>
</tr>
<tr>
<td>TCP BBR</td>
<td>2</td>
<td>547.85</td>
<td>529.26</td>
<td>426.38</td>
</tr>
<tr>
<td>TCP Cubic</td>
<td>2</td>
<td>555.89</td>
<td>526.86</td>
<td>461.19</td>
</tr>
<tr>
<td>Indigo</td>
<td>2</td>
<td>215.05</td>
<td>202.94</td>
<td>173.37</td>
</tr>
<tr>
<td>Muses-25</td>
<td>2</td>
<td>509.52</td>
<td>434.31</td>
<td>415.85</td>
</tr>
</tbody>
</table>
Run 1: Statistics of TCP BBR

Start at: 2018-08-31 12:49:56
End at: 2018-08-31 12:50:26
Local clock offset: 0.853 ms
Remote clock offset: 0.644 ms

# Below is generated by plot.py at 2018-08-31 13:17:01
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1070.67 Mbit/s
95th percentile per-packet one-way delay: 171.013 ms
Loss rate: 1.31%
-- Flow 1:
Average throughput: 545.72 Mbit/s
95th percentile per-packet one-way delay: 161.330 ms
Loss rate: 1.41%
-- Flow 2:
Average throughput: 573.38 Mbit/s
95th percentile per-packet one-way delay: 90.215 ms
Loss rate: 0.17%
-- Flow 3:
Average throughput: 430.37 Mbit/s
95th percentile per-packet one-way delay: 236.504 ms
Loss rate: 3.86%
Run 1: Report of TCP BBR — Data Link

![Graph showing network throughput and packet delay over time for different flows.](image1)

![Graph showing network throughput and packet delay over time for different flows.](image2)
Run 2: Statistics of TCP BBR

Start at: 2018-08-31 12:57:42
End at: 2018-08-31 12:58:12
Local clock offset: 0.56 ms
Remote clock offset: 0.773 ms

# Below is generated by plot.py at 2018-08-31 13:17:01
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 1013.61 Mbit/s
  95th percentile per-packet one-way delay: 165.521 ms
  Loss rate: 1.12%
-- Flow 1:
  Average throughput: 549.98 Mbit/s
  95th percentile per-packet one-way delay: 174.077 ms
  Loss rate: 1.56%
-- Flow 2:
  Average throughput: 485.15 Mbit/s
  95th percentile per-packet one-way delay: 147.543 ms
  Loss rate: 0.67%
-- Flow 3:
  Average throughput: 422.39 Mbit/s
  95th percentile per-packet one-way delay: 97.368 ms
  Loss rate: 0.41%
Run 2: Report of TCP BBR — Data Link

![Throughput Graph]

- Flow 1 ingress (mean 558.70 Mbit/s)
- Flow 1 egress (mean 549.98 Mbit/s)
- Flow 2 ingress (mean 488.43 Mbit/s)
- Flow 2 egress (mean 485.15 Mbit/s)
- Flow 3 ingress (mean 424.09 Mbit/s)
- Flow 3 egress (mean 422.39 Mbit/s)

![Round trip delay Graph]

- Flow 1 (95th percentile 174.08 ms)
- Flow 2 (95th percentile 147.54 ms)
- Flow 3 (95th percentile 97.37 ms)
Run 1: Statistics of TCP Cubic

Start at: 2018-08-31 12:47:56
End at: 2018-08-31 12:48:26
Local clock offset: 0.751 ms
Remote clock offset: 0.696 ms

# Below is generated by plot.py at 2018-08-31 13:17:01
# Datalink statistics
-- Total of 3 flows:
Average throughput: 1046.60 Mbit/s
95th percentile per-packet one-way delay: 109.720 ms
Loss rate: 0.06%
-- Flow 1:
Average throughput: 557.68 Mbit/s
95th percentile per-packet one-way delay: 61.106 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 532.07 Mbit/s
95th percentile per-packet one-way delay: 118.747 ms
Loss rate: 0.18%
-- Flow 3:
Average throughput: 405.34 Mbit/s
95th percentile per-packet one-way delay: 89.958 ms
Loss rate: 0.00%
Run 1: Report of TCP Cubic — Data Link

![Graph of TCP Cubic Data Link]

- **Flow 1 ingress** (mean 557.68 Mbit/s)
- **Flow 1 egress** (mean 557.68 Mbit/s)
- **Flow 2 ingress** (mean 533.69 Mbit/s)
- **Flow 2 egress** (mean 532.07 Mbit/s)
- **Flow 3 ingress** (mean 405.34 Mbit/s)
- **Flow 3 egress** (mean 405.34 Mbit/s)

![Graph of Per-packet one-way delay]

- **Flow 1** (95th percentile 61.11 ms)
- **Flow 2** (95th percentile 118.75 ms)
- **Flow 3** (95th percentile 89.96 ms)
Run 2: Statistics of TCP Cubic

End at: 2018-08-31 12:56:11
Local clock offset: 0.822 ms
Remote clock offset: 3.849 ms

# Below is generated by plot.py at 2018-08-31 13:17:06
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 1073.54 Mbit/s
  95th percentile per-packet one-way delay: 104.202 ms
  Loss rate: 0.05%
-- Flow 1:
  Average throughput: 554.10 Mbit/s
  95th percentile per-packet one-way delay: 86.880 ms
  Loss rate: 0.00%
-- Flow 2:
  Average throughput: 521.65 Mbit/s
  95th percentile per-packet one-way delay: 86.834 ms
  Loss rate: 0.01%
-- Flow 3:
  Average throughput: 517.04 Mbit/s
  95th percentile per-packet one-way delay: 120.609 ms
  Loss rate: 0.28%
Run 2: Report of TCP Cubic — Data Link

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

- Flow 1 ingress (mean 554.09 Mbit/s)
- Flow 1 egress (mean 554.10 Mbit/s)
- Flow 2 ingress (mean 521.79 Mbit/s)
- Flow 2 egress (mean 521.65 Mbit/s)
- Flow 3 ingress (mean 518.66 Mbit/s)
- Flow 3 egress (mean 517.04 Mbit/s)
Run 1: Statistics of Indigo

Start at: 2018-08-31 12:44:12
End at: 2018-08-31 12:44:42
Local clock offset: 0.796 ms
Remote clock offset: 0.607 ms

# Below is generated by plot.py at 2018-08-31 13:17:06
# Datalink statistics
-- Total of 3 flows:
Average throughput: 408.93 Mbit/s
95th percentile per-packet one-way delay: 54.041 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 217.26 Mbit/s
95th percentile per-packet one-way delay: 54.498 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 204.90 Mbit/s
95th percentile per-packet one-way delay: 52.273 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 172.41 Mbit/s
95th percentile per-packet one-way delay: 51.313 ms
Loss rate: 0.86%
Run 1: Report of Indigo — Data Link

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

- **Throughput:**
  - Flow 1 ingress (mean 217.26 Mbit/s)
  - Flow 1 egress (mean 217.26 Mbit/s)
  - Flow 2 ingress (mean 204.90 Mbit/s)
  - Flow 2 egress (mean 204.90 Mbit/s)
  - Flow 3 ingress (mean 174.45 Mbit/s)
  - Flow 3 egress (mean 174.45 Mbit/s)

- **Packet Delay:**
  - Flow 1 (95th percentile 54.50 ms)
  - Flow 2 (95th percentile 52.27 ms)
  - Flow 3 (95th percentile 51.31 ms)
Run 2: Statistics of Indigo

Start at: 2018-08-31 12:52:00
End at: 2018-08-31 12:52:30
Local clock offset: 0.944 ms
Remote clock offset: -2.139 ms

# Below is generated by plot.py at 2018-08-31 13:17:06
# Datalink statistics

-- Total of 3 flows:
Average throughput: 402.26 Mbit/s
95th percentile per-packet one-way delay: 51.001 ms
Loss rate: 0.00%

-- Flow 1:
Average throughput: 212.83 Mbit/s
95th percentile per-packet one-way delay: 48.102 ms
Loss rate: 0.00%

-- Flow 2:
Average throughput: 200.99 Mbit/s
95th percentile per-packet one-way delay: 51.733 ms
Loss rate: 0.00%

-- Flow 3:
Average throughput: 174.33 Mbit/s
95th percentile per-packet one-way delay: 51.238 ms
Loss rate: 0.00%
Run 2: Report of Indigo — Data Link

![Data Link Performance Graph]

Throughput (Mbps)

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Flow 1 Ingress (mean 212.83 Mbps)</th>
<th>Flow 1 Egress (mean 212.83 Mbps)</th>
</tr>
</thead>
<tbody>
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<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Per-packet one-way delay (ms)

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Flow 1 (95th percentile 48.10 ms)</th>
<th>Flow 2 (95th percentile 51.73 ms)</th>
<th>Flow 3 (95th percentile 51.24 ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
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<tr>
<td>30</td>
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</tbody>
</table>
Run 1: Statistics of Muses-25

Start at: 2018-08-31 12:45:57
End at: 2018-08-31 12:46:27
Local clock offset: 0.719 ms
Remote clock offset: 0.628 ms

# Below is generated by plot.py at 2018-08-31 13:18:00
# Datalink statistics
-- Total of 3 flows:
Average throughput: 965.70 Mbit/s
95th percentile per-packet one-way delay: 62.165 ms
Loss rate: 0.00%
-- Flow 1:
Average throughput: 504.71 Mbit/s
95th percentile per-packet one-way delay: 62.200 ms
Loss rate: 0.00%
-- Flow 2:
Average throughput: 462.10 Mbit/s
95th percentile per-packet one-way delay: 62.842 ms
Loss rate: 0.00%
-- Flow 3:
Average throughput: 470.44 Mbit/s
95th percentile per-packet one-way delay: 60.970 ms
Loss rate: 0.01%
Run 1: Report of Muses-25 — Data Link

![Graph 1: Throughput vs. Time]

- **Flow 1 ingress** (mean 504.73 Mbit/s)
- **Flow 1 egress** (mean 504.71 Mbit/s)
- **Flow 2 ingress** (mean 462.15 Mbit/s)
- **Flow 2 egress** (mean 462.10 Mbit/s)
- **Flow 3 ingress** (mean 470.54 Mbit/s)
- **Flow 3 egress** (mean 470.44 Mbit/s)

![Graph 2: Per-packet one-way delay vs. Time]

- **Flow 1** (95th percentile 62.20 ms)
- **Flow 2** (95th percentile 62.84 ms)
- **Flow 3** (95th percentile 60.97 ms)
Run 2: Statistics of Muses-25

Start at: 2018-08-31 12:53:45
End at: 2018-08-31 12:54:15
Local clock offset: 0.756 ms
Remote clock offset: 3.671 ms

# Below is generated by plot.py at 2018-08-31 13:18:00
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 902.11 Mbit/s
  95th percentile per-packet one-way delay: 63.499 ms
  Loss rate: 0.03%
-- Flow 1:
  Average throughput: 514.34 Mbit/s
  95th percentile per-packet one-way delay: 63.455 ms
  Loss rate: 0.00%
-- Flow 2:
  Average throughput: 406.51 Mbit/s
  95th percentile per-packet one-way delay: 64.563 ms
  Loss rate: 0.01%
-- Flow 3:
  Average throughput: 361.25 Mbit/s
  95th percentile per-packet one-way delay: 62.039 ms
  Loss rate: 0.21%
Run 2: Report of Muses-25 — Data Link

![Graph 1: Throughput vs Time](image1)

![Graph 2: Per-packet error rate vs Time](image2)