Pantheon Report

Generated at 2018-08-31 10:01:36 (UTC).
Data path: India on em1 (remote) → AWS India 1 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 nets.org.sg 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 @ e3c5aa19ca94c3066828fb83f16a8f6b2731e7a
third_party/fillp @ d47f4fa1b454a5e3c0537115c5a28436db4834
third_party/fillp-sheep @ daed0c84f98531712514b2231f43ec6901114ffe
third_party/genericCC @ d0153f8e594aa89e93b032143cedbf5e562f4
third_party/indigo @ 2601c92e4aa9d58d38dc4dfe0ecdf90c077e64d
third_party/libutp @ b3465b942e2826f2b179eaaab4a906ce6bb7cf3cf
third_party/muses @ b59e0d118c50af3579569c462d33045741c85981
third_party/pantheon-tunnel @ cbfcede6db5ff57404afe1771f813cd64639e1952
third_party/pcc @ 1af958fa0d661b623c091a55fec872b4981e1
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 @ 77961fa182733a86b42f1bc8143ebc978f3cf42
third_party/scream-reproduce @ f099118d1421aa3131bf11ff1964974e1da3b82
M src/ScreamClient
M src/ScreamServer
third_party/sprout @ 366e35c6178b01e31d4a66ad18c74f9415f19a26
third_party/verus @ 4b447ea74c6c6a261149af2629562939f9a494
M src/verus.hpp
M tools/plot.py
third_party/vivace @ 2ba86211435ae071a32f96b7d8c504587f57d7f
third_party/webrtc @ 3f0cc2a9061a41b6f9d8e4735770d143a1fa2851
test from India to AWS India 1, 3 runs of 30s each per scheme
3 flows with 10s interval between flows (mean of all runs by scheme)
<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>3</td>
<td>59.48</td>
<td>37.93</td>
<td>35.39</td>
</tr>
<tr>
<td>TCP Cubic</td>
<td>3</td>
<td>57.48</td>
<td>41.84</td>
<td>29.25</td>
</tr>
<tr>
<td>Indigo</td>
<td>3</td>
<td>52.86</td>
<td>40.62</td>
<td>34.55</td>
</tr>
<tr>
<td>Muses-25</td>
<td>3</td>
<td>13.28</td>
<td>13.57</td>
<td>10.77</td>
</tr>
</tbody>
</table>
Run 1: Statistics of TCP BBR

Start at: 2018-08-31 09:47:11
End at: 2018-08-31 09:47:41
Local clock offset: 3.005 ms
Remote clock offset: -3.547 ms

# Below is generated by plot.py at 2018-08-31 10:01:19
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.45 Mbit/s
95th percentile per-packet one-way delay: 69.782 ms
Loss rate: 4.13%
-- Flow 1:
Average throughput: 58.62 Mbit/s
95th percentile per-packet one-way delay: 49.255 ms
Loss rate: 3.39%
-- Flow 2:
Average throughput: 40.52 Mbit/s
95th percentile per-packet one-way delay: 96.774 ms
Loss rate: 5.35%
-- Flow 3:
Average throughput: 32.70 Mbit/s
95th percentile per-packet one-way delay: 88.508 ms
Loss rate: 5.02%
Run 1: Report of TCP BBR — Data Link

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

- **Throughput (Mbps):**
  - Flow 1 ingress (mean 60.63 Mbps)
  - Flow 1 egress (mean 58.62 Mbps)
  - Flow 2 ingress (mean 42.76 Mbps)
  - Flow 2 egress (mean 40.52 Mbps)
  - Flow 3 ingress (mean 34.34 Mbps)
  - Flow 3 egress (mean 32.70 Mbps)

- **Per-packet one-way delay (ms):**
  - Flow 1 (95th percentile 49.26 ms)
  - Flow 2 (95th percentile 96.77 ms)
  - Flow 3 (95th percentile 88.51 ms)
Run 2: Statistics of TCP BBR

Start at: 2018-08-31 09:51:57
End at: 2018-08-31 09:52:27
Local clock offset: 2.467 ms
Remote clock offset: -3.874 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.61 Mbit/s
95th percentile per-packet one-way delay: 75.911 ms
Loss rate: 4.14%
-- Flow 1:
Average throughput: 63.83 Mbit/s
95th percentile per-packet one-way delay: 48.629 ms
Loss rate: 3.80%
-- Flow 2:
Average throughput: 36.76 Mbit/s
95th percentile per-packet one-way delay: 99.931 ms
Loss rate: 4.85%
-- Flow 3:
Average throughput: 25.05 Mbit/s
95th percentile per-packet one-way delay: 101.384 ms
Loss rate: 4.63%
Run 2: Report of TCP BBR — Data Link
Run 3: Statistics of TCP BBR

Start at: 2018-08-31 09:56:51
End at: 2018-08-31 09:57:21
Local clock offset: 2.197 ms
Remote clock offset: -3.636 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 96.37 Mbit/s
95th percentile per-packet one-way delay: 73.271 ms
Loss rate: 3.81%
-- Flow 1:
Average throughput: 55.98 Mbit/s
95th percentile per-packet one-way delay: 45.543 ms
Loss rate: 3.39%
-- Flow 2:
Average throughput: 36.51 Mbit/s
95th percentile per-packet one-way delay: 105.359 ms
Loss rate: 4.20%
-- Flow 3:
Average throughput: 48.42 Mbit/s
95th percentile per-packet one-way delay: 93.779 ms
Loss rate: 4.65%
Run 3: Report of TCP BBR — Data Link

![Graph showing throughput and per-packet one-way delay](image-url)
Run 1: Statistics of TCP Cubic

Start at: 2018-08-31 09:49:39
End at: 2018-08-31 09:50:09
Local clock offset: -2.846 ms
Remote clock offset: -9.189 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 95.00 Mbit/s
95th percentile per-packet one-way delay: 28.464 ms
Loss rate: 0.12%
-- Flow 1:
Average throughput: 57.55 Mbit/s
95th percentile per-packet one-way delay: 27.436 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 40.60 Mbit/s
95th percentile per-packet one-way delay: 29.169 ms
Loss rate: 0.15%
-- Flow 3:
Average throughput: 31.41 Mbit/s
95th percentile per-packet one-way delay: 29.767 ms
Loss rate: 0.34%
Run 2: Statistics of TCP Cubic

Start at: 2018-08-31 09:54:27
End at: 2018-08-31 09:54:57
Local clock offset: 1.947 ms
Remote clock offset: -2.61 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
  Average throughput: 95.99 Mbit/s
  95th percentile per-packet one-way delay: 24.870 ms
  Loss rate: 0.12%
-- Flow 1:
  Average throughput: 58.31 Mbit/s
  95th percentile per-packet one-way delay: 24.756 ms
  Loss rate: 0.06%
-- Flow 2:
  Average throughput: 44.45 Mbit/s
  95th percentile per-packet one-way delay: 24.352 ms
  Loss rate: 0.18%
-- Flow 3:
  Average throughput: 24.39 Mbit/s
  95th percentile per-packet one-way delay: 27.410 ms
  Loss rate: 0.37%
Run 2: Report of TCP Cubic — Data Link
Run 3: Statistics of TCP Cubic

Start at: 2018-08-31 09:59:17
End at: 2018-08-31 09:59:47
Local clock offset: 1.468 ms
Remote clock offset: -4.096 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 94.13 Mbit/s
95th percentile per-packet one-way delay: 28.265 ms
Loss rate: 0.13%
-- Flow 1:
Average throughput: 56.57 Mbit/s
95th percentile per-packet one-way delay: 27.664 ms
Loss rate: 0.07%
-- Flow 2:
Average throughput: 40.48 Mbit/s
95th percentile per-packet one-way delay: 28.793 ms
Loss rate: 0.16%
-- Flow 3:
Average throughput: 31.96 Mbit/s
95th percentile per-packet one-way delay: 29.824 ms
Loss rate: 0.34%
Run 3: Report of TCP Cubic — Data Link
Run 1: Statistics of Indigo

Start at: 2018-08-31 09:48:25
End at: 2018-08-31 09:48:56
Local clock offset: 1.589 ms
Remote clock offset: -3.924 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 91.65 Mbit/s
95th percentile per-packet one-way delay: 24.112 ms
Loss rate: 0.10%
-- Flow 1:
Average throughput: 53.86 Mbit/s
95th percentile per-packet one-way delay: 24.396 ms
Loss rate: 0.05%
-- Flow 2:
Average throughput: 45.66 Mbit/s
95th percentile per-packet one-way delay: 22.458 ms
Loss rate: 0.13%
-- Flow 3:
Average throughput: 25.21 Mbit/s
95th percentile per-packet one-way delay: 26.922 ms
Loss rate: 0.37%
Run 1: Report of Indigo — Data Link

**Graph 1:**
- **Y-axis:** Throughput (Mbps/s)
- **X-axis:** Time (s)
- Data points indicate the throughput for different flows over time. The legend specifies the mean throughput for each flow.

**Graph 2:**
- **Y-axis:** Per-packet round-trip delay (ms)
- **X-axis:** Time (s)
- The graph shows the round-trip delay for different flows, with the legend indicating the 95th percentile delays for each flow.
Run 2: Statistics of Indigo

Start at: 2018-08-31 09:53:14
End at: 2018-08-31 09:53:44
Local clock offset: 2.742 ms
Remote clock offset: -3.277 ms

# Below is generated by plot.py at 2018-08-31 10:01:20
# Datalink statistics
-- Total of 3 flows:
Average throughput: 93.44 Mbit/s
95th percentile per-packet one-way delay: 24.284 ms
Loss rate: 0.10%
-- Flow 1:
Average throughput: 53.51 Mbit/s
95th percentile per-packet one-way delay: 22.313 ms
Loss rate: 0.05%
-- Flow 2:
Average throughput: 36.65 Mbit/s
95th percentile per-packet one-way delay: 26.031 ms
Loss rate: 0.10%
-- Flow 3:
Average throughput: 47.29 Mbit/s
95th percentile per-packet one-way delay: 24.148 ms
Loss rate: 0.30%
Run 2: Report of Indigo — Data Link
Run 3: Statistics of Indigo

Start at: 2018-08-31 09:58:04  
End at: 2018-08-31 09:58:34  
Local clock offset: 2.1 ms  
Remote clock offset: -3.664 ms

# Below is generated by plot.py at 2018-08-31 10:01:35  
# Datalink statistics
-- Total of 3 flows:
Average throughput: 87.76 Mbit/s
95th percentile per-packet one-way delay: 22.267 ms
Loss rate: 0.11%
-- Flow 1:
Average throughput: 51.22 Mbit/s
95th percentile per-packet one-way delay: 21.854 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 39.56 Mbit/s
95th percentile per-packet one-way delay: 22.513 ms
Loss rate: 0.12%
-- Flow 3:
Average throughput: 31.15 Mbit/s
95th percentile per-packet one-way delay: 23.010 ms
Loss rate: 0.31%
Run 3: Report of Indigo — Data Link
Run 1: Statistics of Muses-25

Start at: 2018-08-31 09:46:04
End at: 2018-08-31 09:46:34
Local clock offset: 2.916 ms
Remote clock offset: -2.673 ms

# Below is generated by plot.py at 2018-08-31 10:01:35
# Datalink statistics
-- Total of 3 flows:
Average throughput: 24.28 Mbit/s
95th percentile per-packet one-way delay: 18.082 ms
Loss rate: 0.08%
-- Flow 1:
Average throughput: 11.99 Mbit/s
95th percentile per-packet one-way delay: 17.800 ms
Loss rate: 0.06%
-- Flow 2:
Average throughput: 13.66 Mbit/s
95th percentile per-packet one-way delay: 18.442 ms
Loss rate: 0.07%
-- Flow 3:
Average throughput: 9.68 Mbit/s
95th percentile per-packet one-way delay: 18.312 ms
Loss rate: 0.21%
Run 1: Report of Muses-25 — Data Link

[Graph showing throughput and per-packet one-way delay for different flows over time]
Run 2: Statistics of Muses-25

Start at: 2018-08-31 09:50:50  
End at: 2018-08-31 09:51:20  
Local clock offset: 2.919 ms  
Remote clock offset: -4.167 ms

# Below is generated by plot.py at 2018-08-31 10:01:35  
# Datalink statistics
-- Total of 3 flows:  
Average throughput: 24.49 Mbit/s  
95th percentile per-packet one-way delay: 19.337 ms  
Loss rate: 0.10%  
-- Flow 1:  
Average throughput: 12.84 Mbit/s  
95th percentile per-packet one-way delay: 19.060 ms  
Loss rate: 0.05%  
-- Flow 2:  
Average throughput: 12.25 Mbit/s  
95th percentile per-packet one-way delay: 19.726 ms  
Loss rate: 0.10%  
-- Flow 3:  
Average throughput: 10.58 Mbit/s  
95th percentile per-packet one-way delay: 20.000 ms  
Loss rate: 0.24%
Run 2: Report of Muses-25 — Data Link

![Graph of throughput and per-packet end-to-end delay](image.png)

- **Throughput (Mbps)**: The graph shows the throughput over time for different flows. Flow 1 has a throughput of 12.84 Mbps, Flow 2 has 12.25 Mbps, and Flow 3 has 10.57 Mbps.
- **Per-packet end-to-end delay (ms)**: The graph shows the per-packet end-to-end delay for different flows. Flow 1 has a 95th percentile of 19.06 ms, Flow 2 has 19.73 ms, and Flow 3 has 20.00 ms.
Run 3: Statistics of Muses-25

Start at: 2018-08-31 09:55:44
End at: 2018-08-31 09:56:14
Local clock offset: 1.745 ms
Remote clock offset: -3.03 ms

# Below is generated by plot.py at 2018-08-31 10:01:35
# Datalink statistics
-- Total of 3 flows:
Average throughput: 28.85 Mbit/s
95th percentile per-packet one-way delay: 16.814 ms
Loss rate: 0.07%
-- Flow 1:
Average throughput: 15.01 Mbit/s
95th percentile per-packet one-way delay: 16.625 ms
Loss rate: 0.04%
-- Flow 2:
Average throughput: 14.81 Mbit/s
95th percentile per-packet one-way delay: 17.147 ms
Loss rate: 0.08%
-- Flow 3:
Average throughput: 12.06 Mbit/s
95th percentile per-packet one-way delay: 16.950 ms
Loss rate: 0.17%
Run 3: Report of Muses-25 — Data Link

```
<table>
<thead>
<tr>
<th></th>
<th>Throughput (Mbit/s)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow 1</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Flow 2</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>Flow 3</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

- Flow 1 ingress (mean 15.00 Mbit/s)
- Flow 1 egress (mean 15.01 Mbit/s)
- Flow 2 ingress (mean 14.80 Mbit/s)
- Flow 2 egress (mean 14.81 Mbit/s)
- Flow 3 ingress (mean 12.06 Mbit/s)
- Flow 3 egress (mean 12.06 Mbit/s)

```

```
<table>
<thead>
<tr>
<th></th>
<th>Per packet one-way delay (ms)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow 1</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Flow 2</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Flow 3</td>
<td>18</td>
<td>10</td>
</tr>
</tbody>
</table>

- Flow 1 (95th percentile 16.62 ms)
- Flow 2 (95th percentile 17.15 ms)
- Flow 3 (95th percentile 16.95 ms)

```