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# Evaluating Network Buffer Size requirements for Very Large Data Transfers

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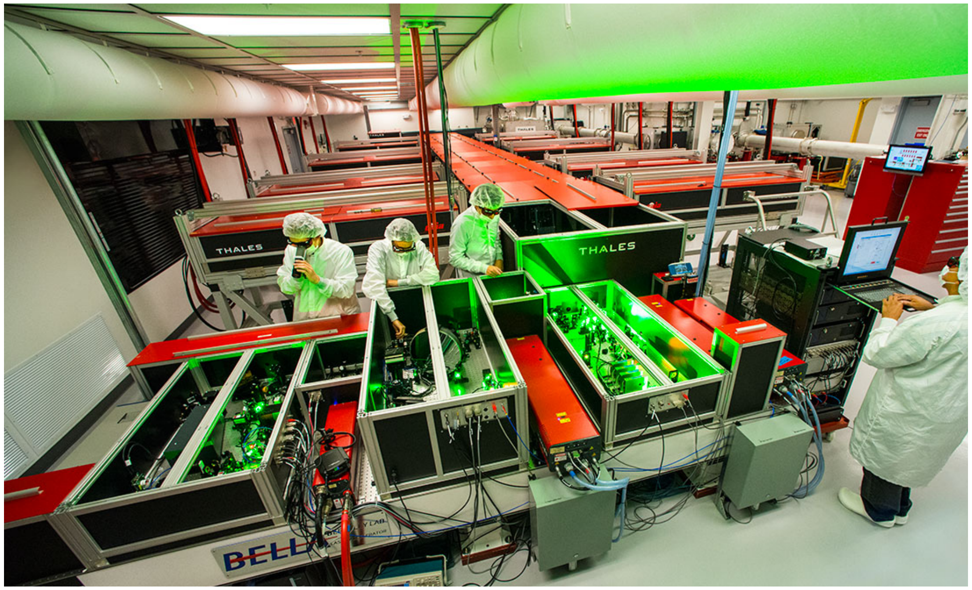
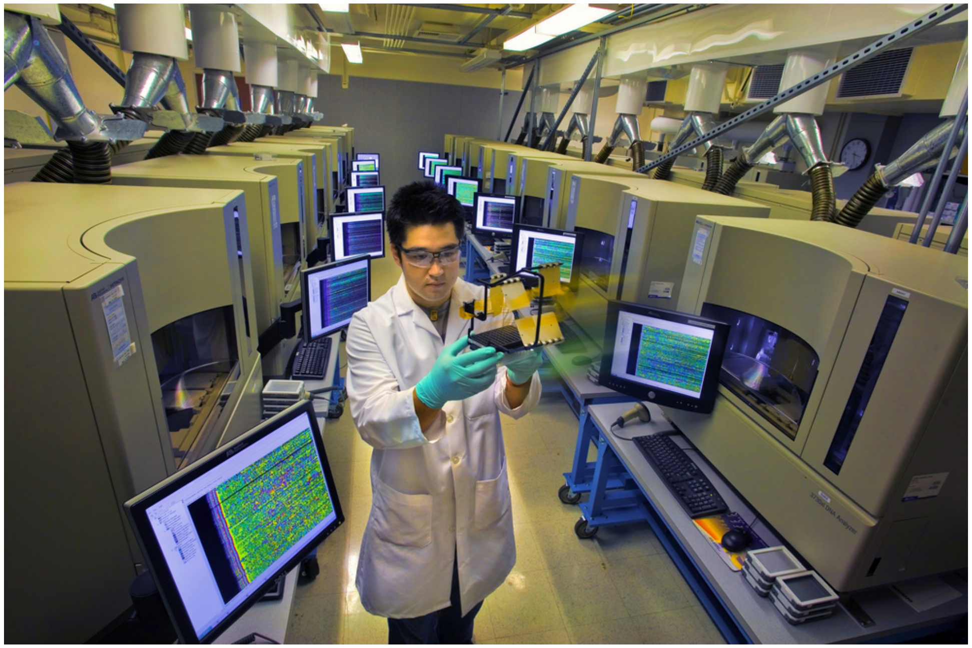
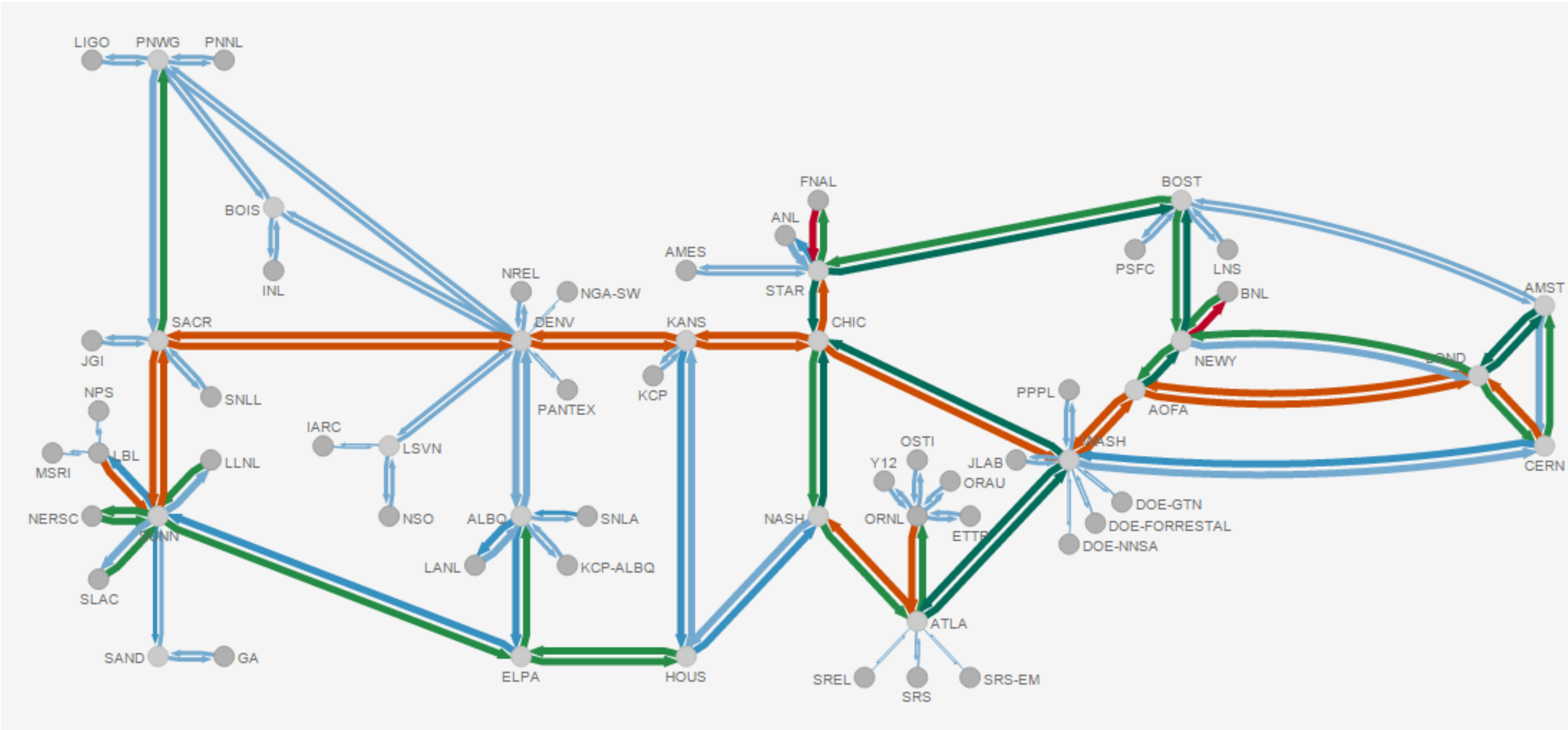
# Lawrence Berkeley National Laboratory



# Energy Sciences Network




Connects Department of Energy National Laboratories to universities and research institutions around the world (LBNL's primary provider)

Many sites with 100G connections to ESnet today - Berkeley, Livermore, Stanford, Fermi, Brookhaven, Oakridge, Argonne

# ESnet / DOE National Lab Network Profile

Small-ish numbers of very large flows over very long distances:

Between California, Illinois, New York, Tennessee, Switzerland

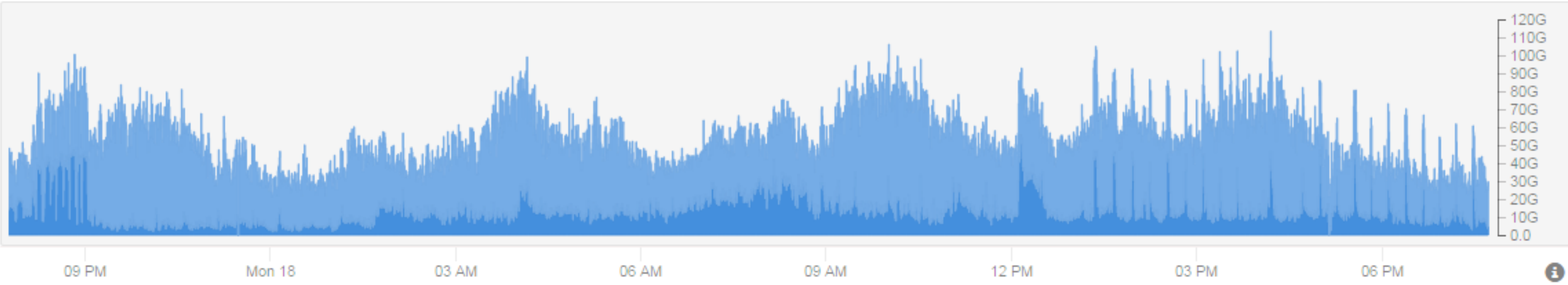
High-speed “Access” links - 100G sites connected to 100G core

Nx10G hosts, future Nx40G hosts, dedicated to Data Transfer

GridFTP / Globus Online / Parallel FTP

LHC detectors to data centers around the world (future 180Gbps)

Electron microscopes to supercomputers (20k – 100k FPS per camera)



# Buffer Bloat at a glance

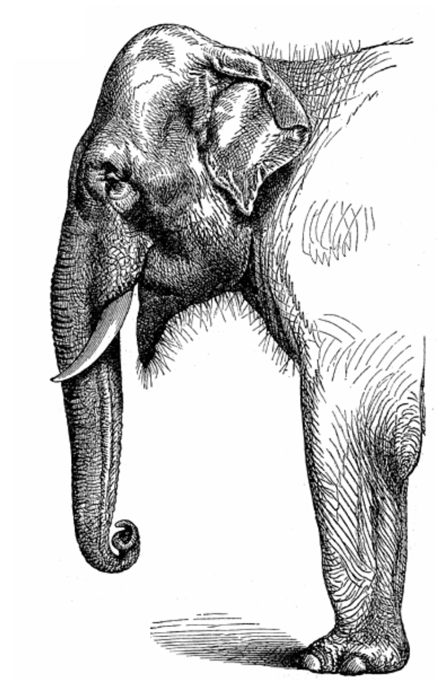
Premise: Big buffers = high latency, which is bad

Typically talking about relatively low-speed flows over short distances

Or, highly-multiplexed core links… 10,000+ simultaneous flows

Case of **mouse** flows vs. **elephant** flows

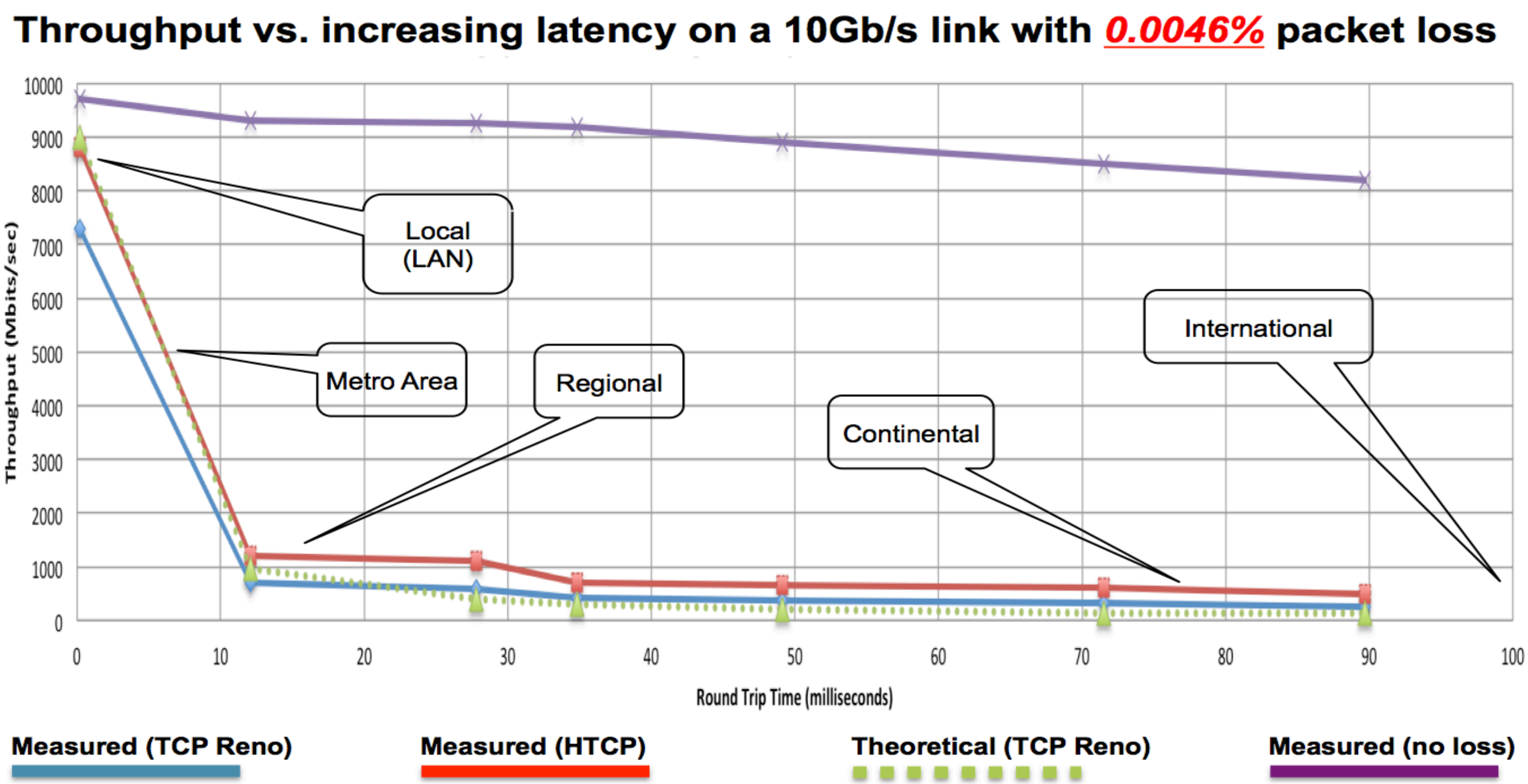
**vs.**



Bufferbloat: Dark Buffers in the Internet, CACM Vol 55
http://cacm.acm.org/magazines/2012/1/144810-bufferbloat

# On Elephants and Packet Loss

We need to send **lots of data** over **long distances**. Insufficient buffers cause us to drop packets frequently, which hinders our throughput.



# Then “Big” Buffers = good?

By “big” we’re still only talking **megabytes** of buffer per 10G port, not **gigabytes**.

Only addressing **very large data transfers** (TB, PB) + **large pipes** (10G & up) + **long distances** (50ms+) between small numbers of hosts.

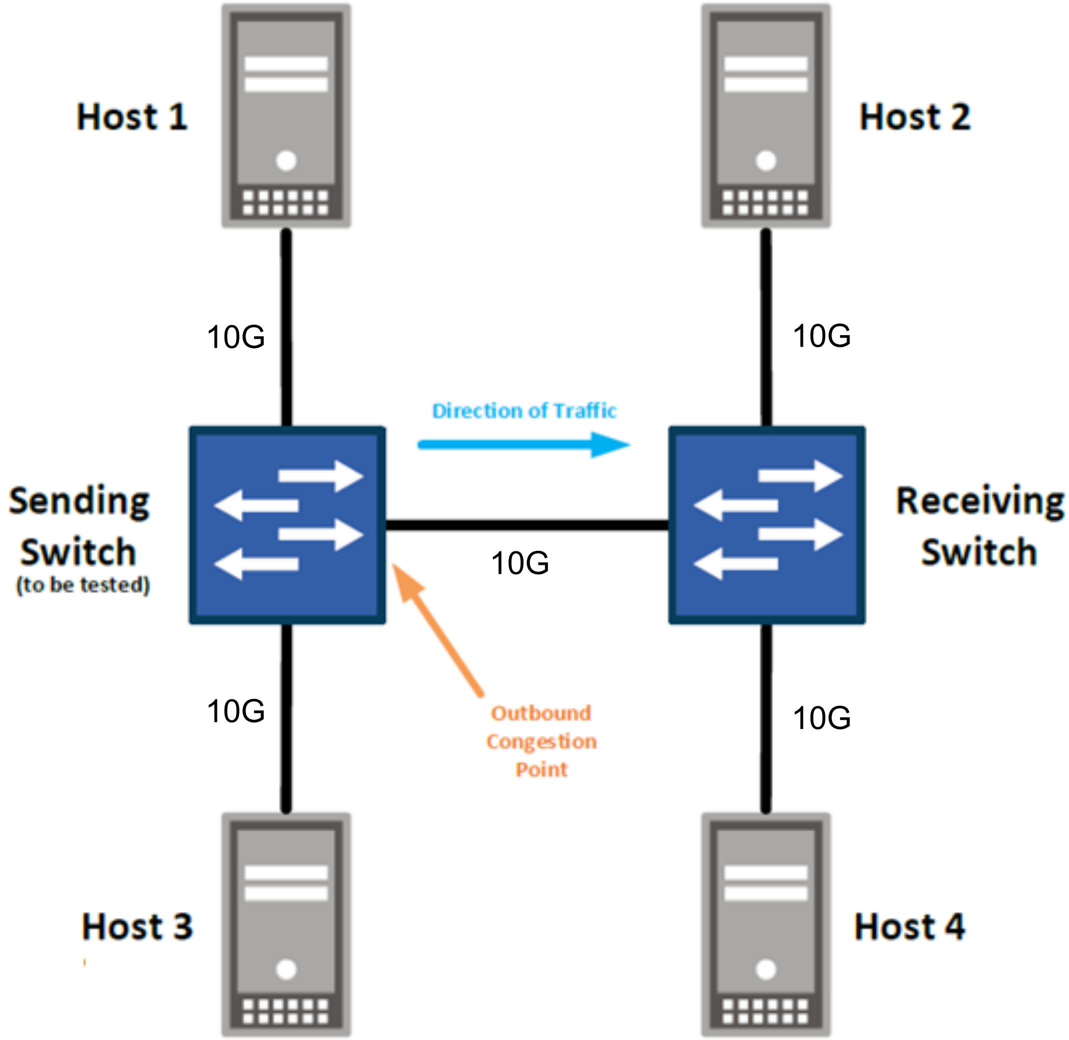
Important to have enough buffering to ride out micro-bursts. A TCP flow may need to drop a packet or two to fit itself to available capacity, but to maintain performance we need to keep TCP from getting stuck in loss recovery mode.

# How can we tell what's sufficient?

**Test with tools that are:**

- Readily Available
- Open Source
- Easy to Use
- Free

# iperf3 in a simulated WAN




**Add latency on hosts 1 and 2:** tc qdisc add dev EthN root netem delay 25ms

# Test Procedures:

Add a 25ms delay to each of hosts **1** and **2**:

```
host1# tc qdisc add dev ethN root netem delay 25ms
host2# tc qdisc add dev ethN root netem delay 25ms
```

Start the iperf3 server on hosts **2** and **4**:

```
host2# iperf3 –s
host4# iperf3 –s
```

On host 3, begin a 2Gbps UDP transfer to host **4** to add congestion:

```
host3# iperf3 -c host4 -u -b2G -t3000
```

On host **1**, begin a 10Gbps TCP transfer, 2 parallel streams for 30 seconds (first 5s omitted from results):

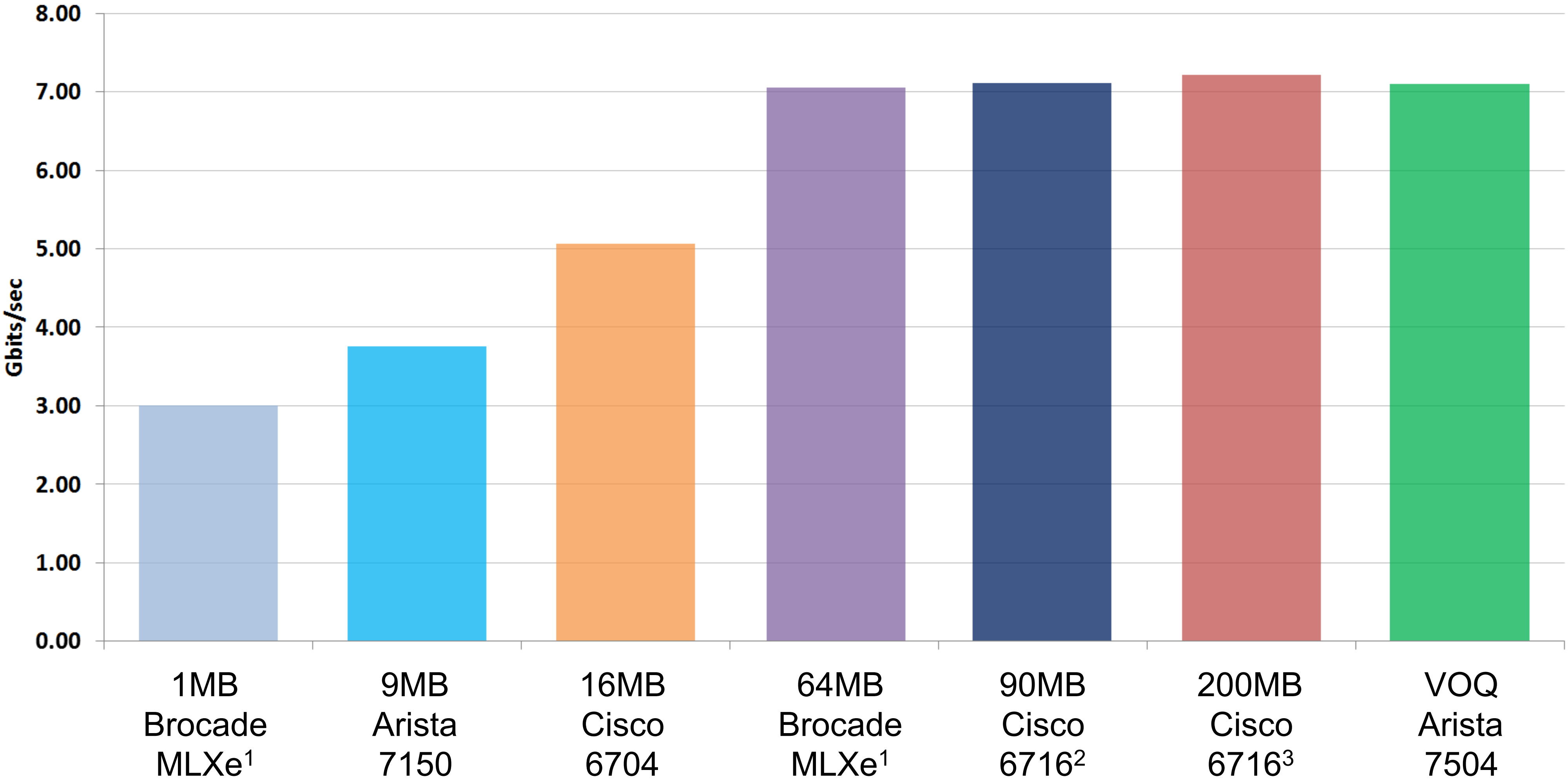
```
host1# iperf3 -c host2 -P2 -t30 -O5
```

# Test Results (example):

```
[  4]  27.00-28.00  sec   276 MBytes  2.32 Gbits/sec    0   15.4 MBytes
[  6]  27.00-28.00  sec   145 MBytes  1.22 Gbits/sec    0   8.66 MBytes
[SUM]  27.00-28.00  sec   421 MBytes  3.53 Gbits/sec    0
- - - - - - - - - - - - - - - - - - - - - - - - -
[  4]  28.00-29.00  sec   324 MBytes  2.72 Gbits/sec    5   12.5 MBytes
[  6]  28.00-29.00  sec   195 MBytes  1.64 Gbits/sec    7   9.61 MBytes
[SUM]  28.00-29.00  sec   519 MBytes  4.35 Gbits/sec   12
- - - - - - - - - - - - - - - - - - - - - - - - -
[  4]  29.00-30.00  sec   201 MBytes  1.69 Gbits/sec    0   9.54 MBytes
[  6]  29.00-30.00  sec   126 MBytes  1.06 Gbits/sec    0   6.05 MBytes
[SUM]  29.00-30.00  sec   328 MBytes  2.75 Gbits/sec    0
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  4]   0.00-30.00  sec  5.85 GBytes  1.68 Gbits/sec   40             sender
[  4]   0.00-30.00  sec  5.83 GBytes  1.67 Gbits/sec                  receiver
[  6]   0.00-30.00  sec  4.04 GBytes  1.16 Gbits/sec   39             sender
[  6]   0.00-30.00  sec  4.01 GBytes  1.15 Gbits/sec                  receiver
[SUM]   0.00-30.00  sec  9.89 GBytes  2.83 Gbits/sec   79             sender
[SUM]   0.00-30.00  sec  9.85 GBytes  2.82 Gbits/sec                  receiver
```

# Average TCP results, various switches

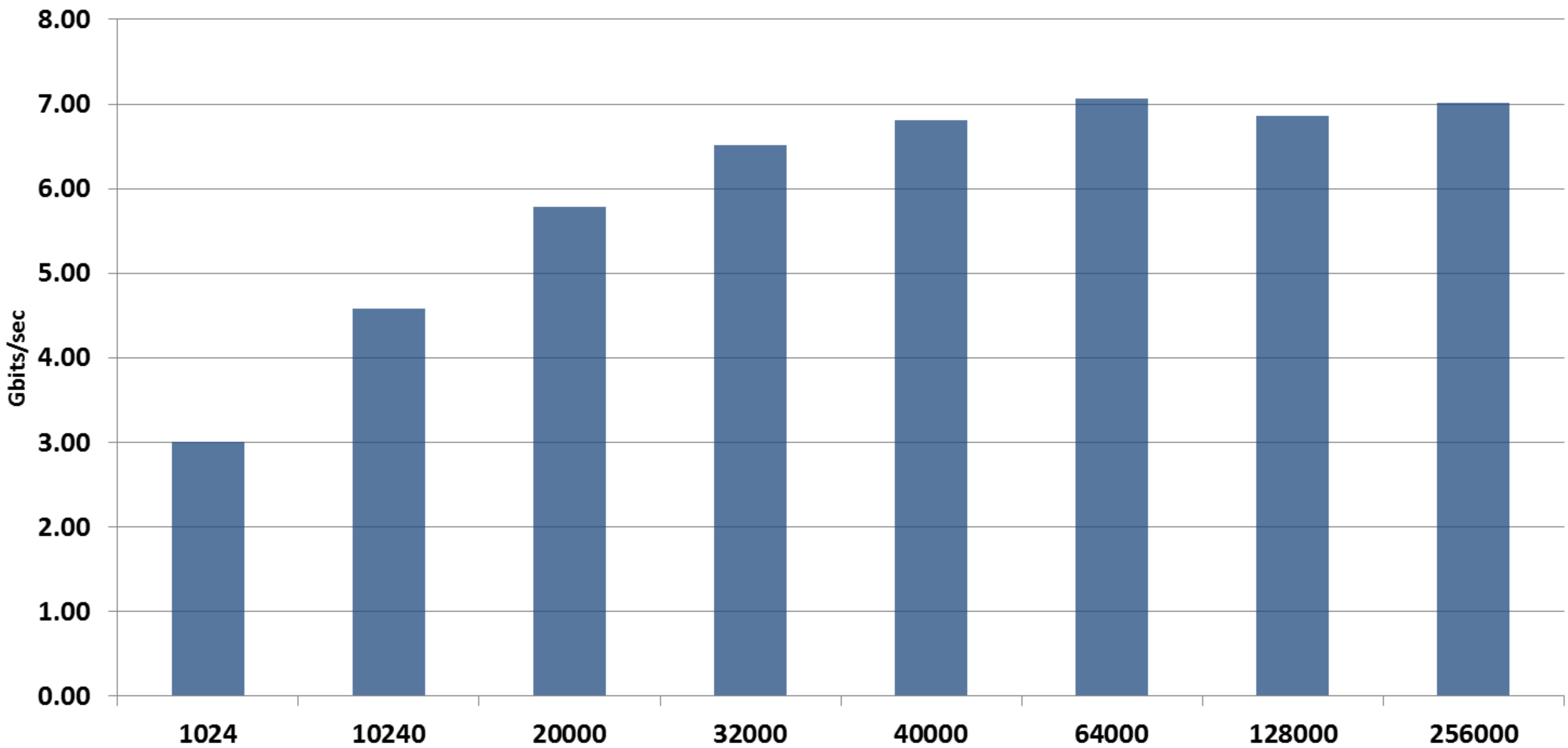
## Buffers per 10G egress port, 2x parallel TCP streams, 50ms simulated RTT, 2Gbps UDP background traffic




[1] NI-MLX-10Gx8-M
[2] Over-subscription Mode
[3] Performance Mode

# Tunable Buffers with a Brocade MLXe[1]

## Buffers per 10G egress port, 2x parallel TCP streams, 50ms simulated RTT, 2Gbps UDP background traffic




[1] NI-MLX-10Gx8-M Linecard



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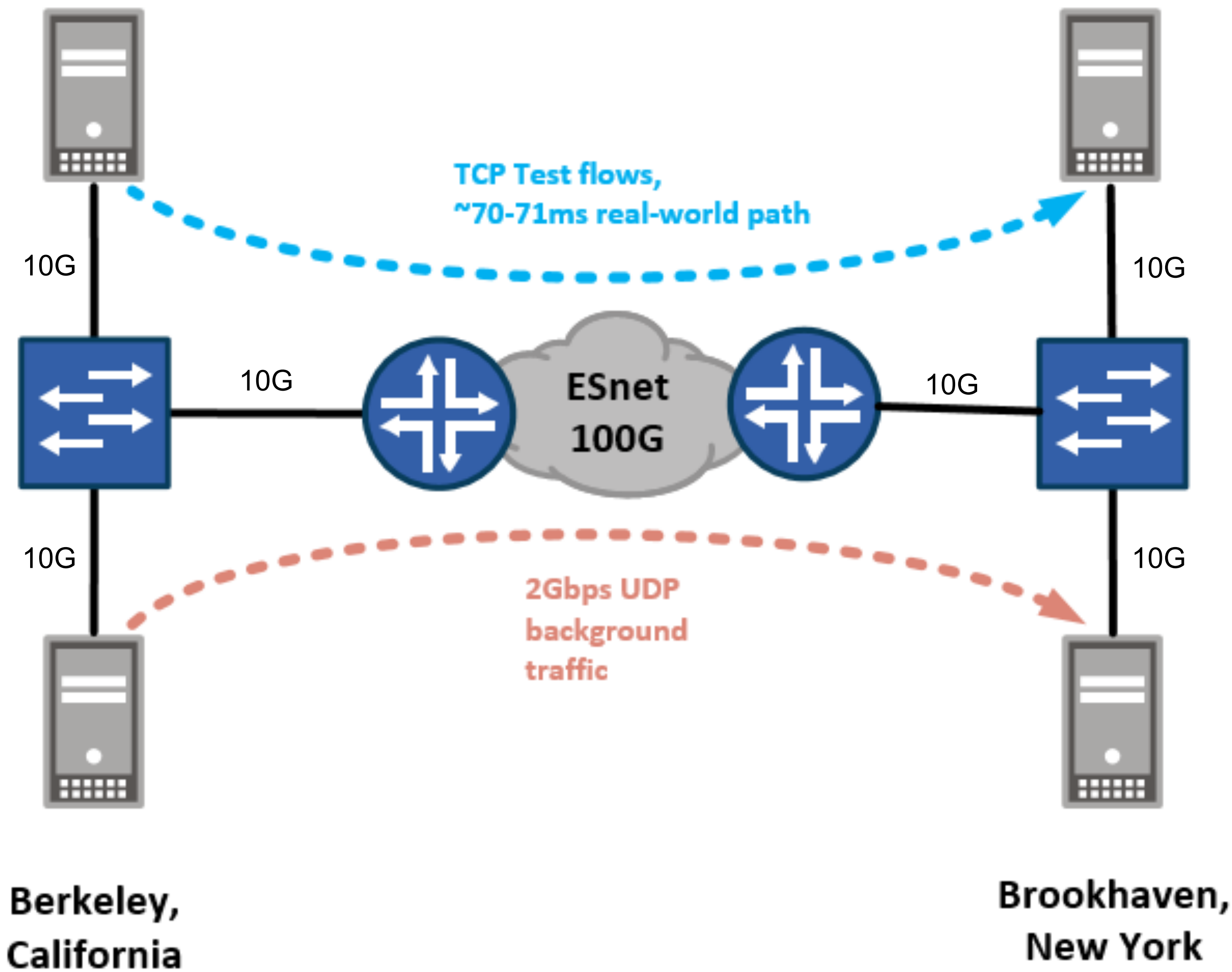
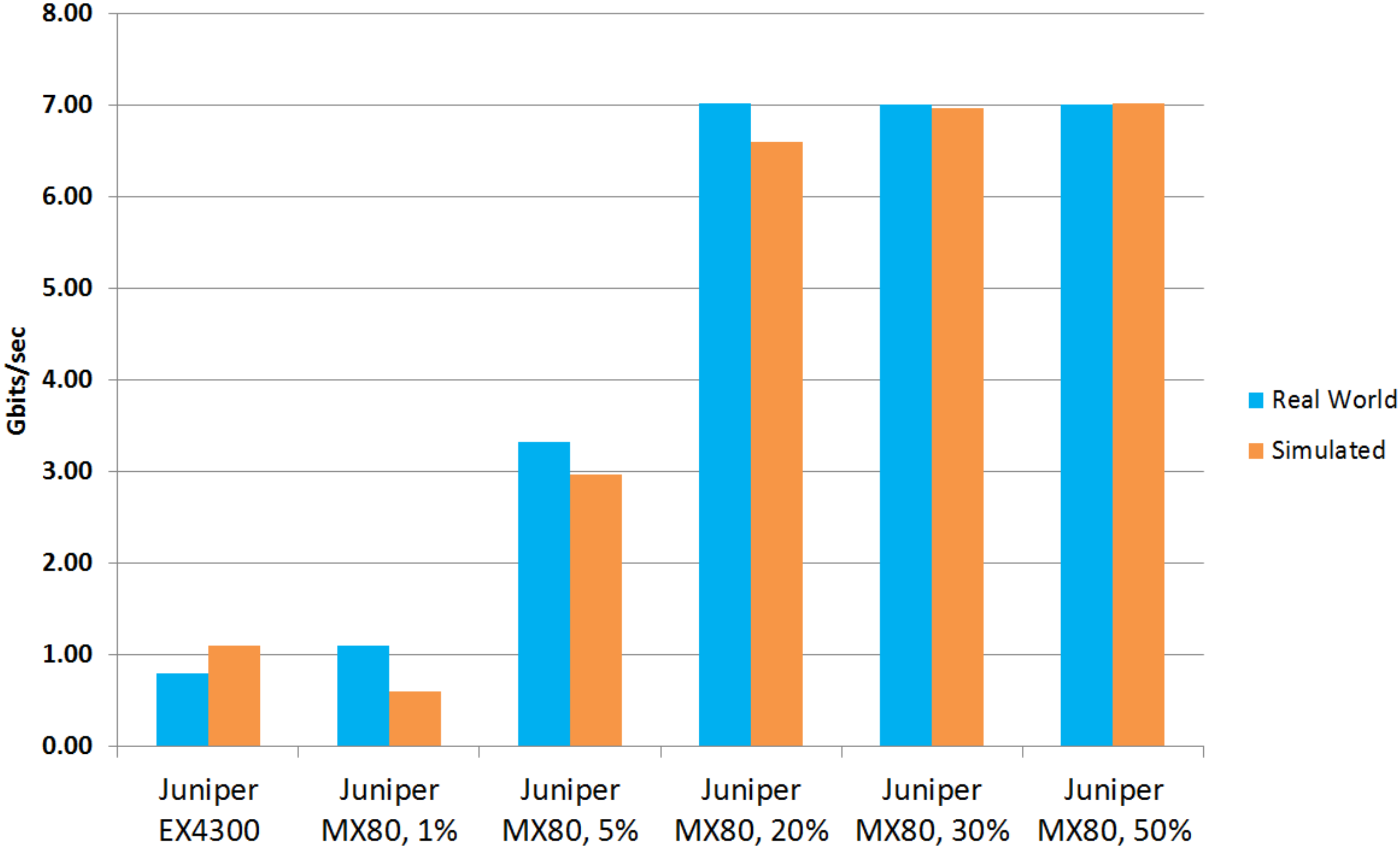
# In the Real World @ 70ms RTT



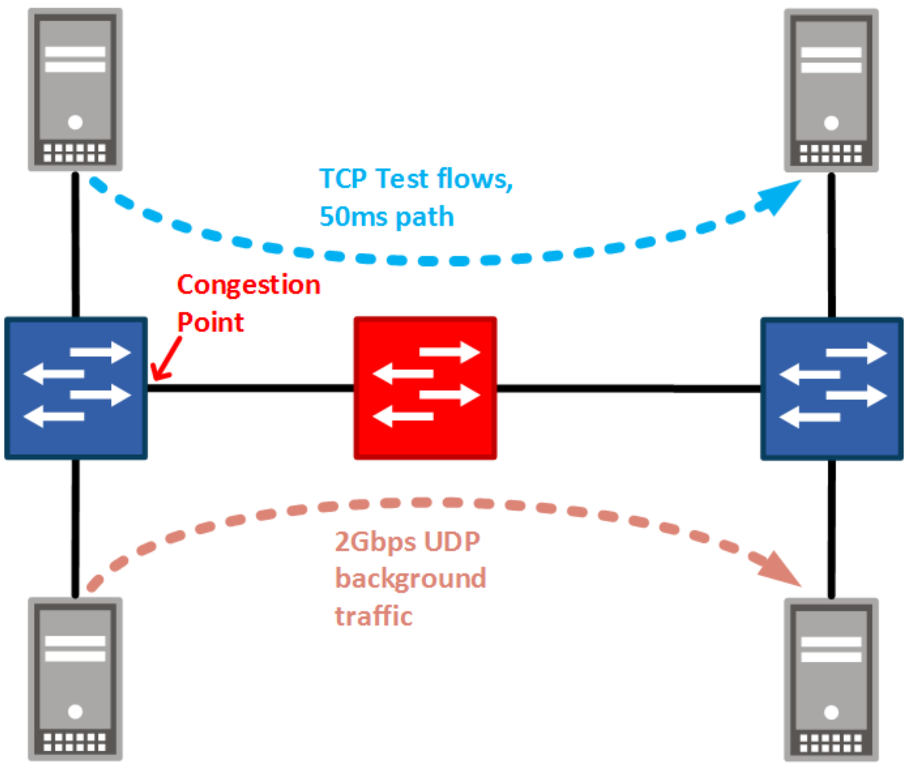

Special thanks to Mark Lukasczyk at Brookhaven National Laboratory for providing far-end test servers

# Real World vs Simulated

70ms RTT, 2x parallel TCP streams,
2Gbps UDP background traffic

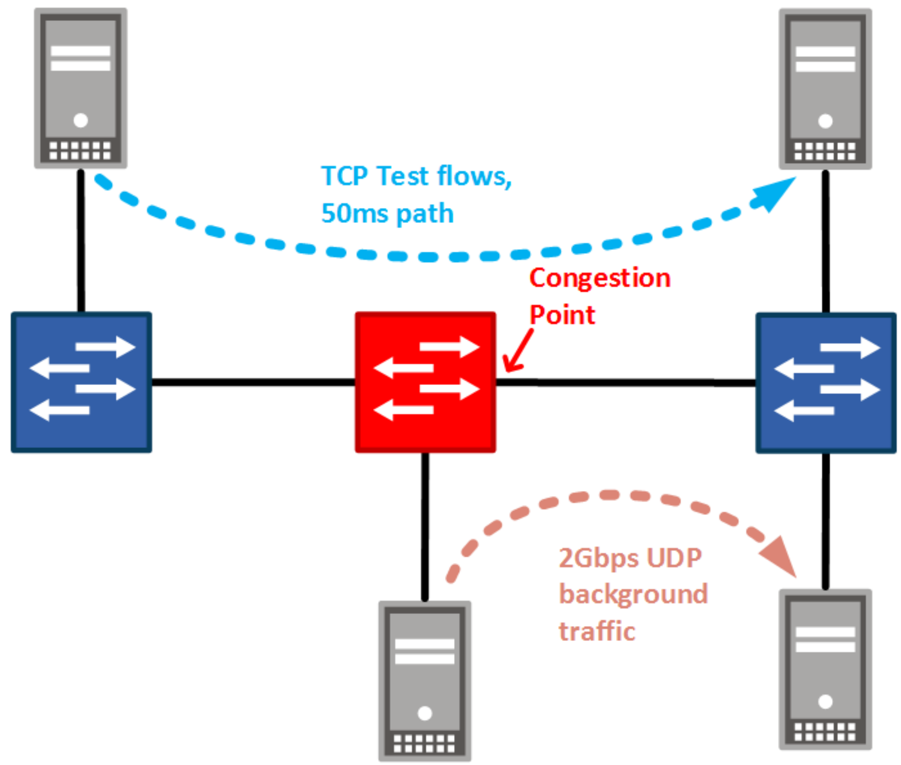


# Can we detect insufficient buffers?




Congestion at

first hop




Congestion at

second hop

# nuttcp test procedures

Simulate WAN connectivity by adding 25ms delay to each

```
host1# tc qdisc add dev eth1 root netem delay 25ms
host2# tc qdisc add dev eth1 root netem delay 25ms
```

Add 2Gbps UDP background traffic on link:

```
host4# iperf3 –s
host3# iperf3 -c host4 -u -b2G -t3000
```

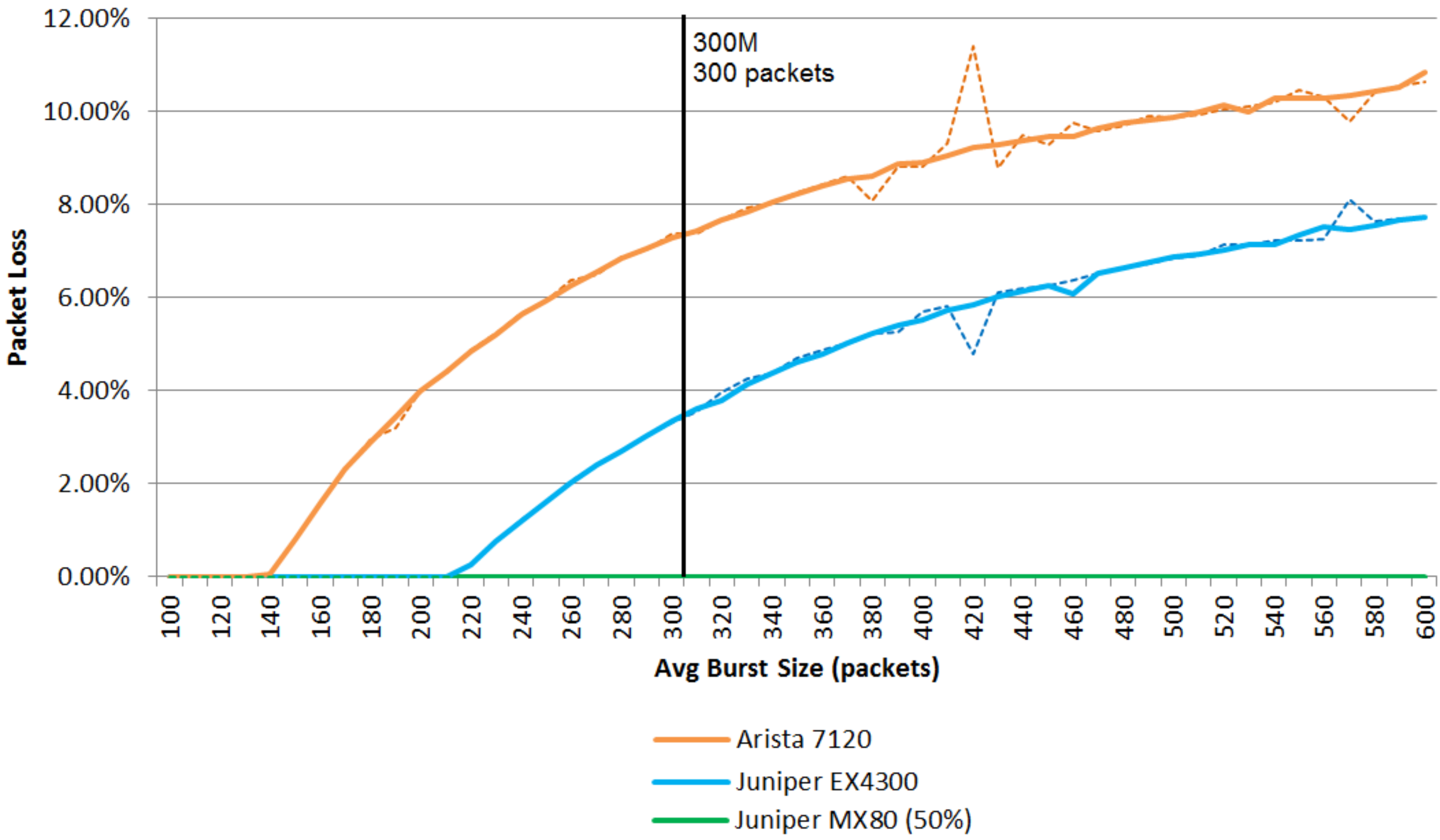
Basic test parameters[1]:

```
host2# nuttcp -S
host1# nuttcp -l8972 -T30 -u -w4m –Ri300m/X –i1 host2
```

X= Burst Size (# of packets)

[1] https://fasterdata.es.net/performance-testing/network-troubleshooting-tools/nuttcp/

# nuttcp results over various burst sizes




Deviations likely due to network emulation.



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# nuttcp conclusion

**This will probably have no packet loss on smaller buffer switches:**

```
nuttcp -l8972 -T30 -u -w4m -Ri300m/65 -i1
```

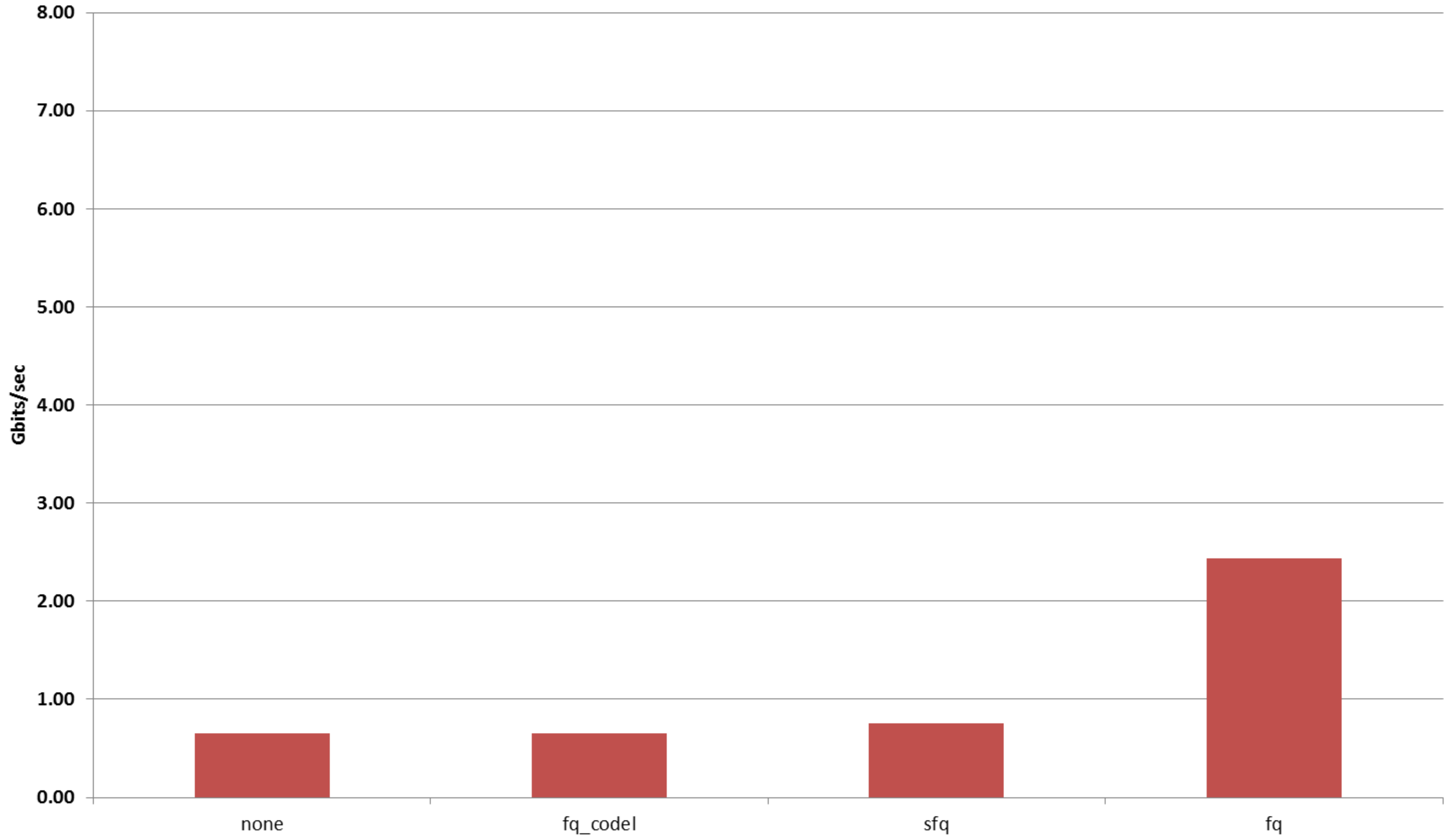
**While this will probably have some:**

```
nuttcp -l8972 -T30 -u -w4m -Ri300m/300 -i1
```

**BUT** only applies to where there is congestion. A small buffer switch that isn't congested won't be detectable with this method.

# Host Queuing Alternatives in Linux kernel 3.11+[1]
# Real World ~70ms RTT, ~9-12MB buffers

```
tc qdisc add dev EthN root [ fq_codel | sfq | fq ]
```




[1] These tests performed in Fedora, FC21/3.19.5-200
No tweaks or tuning to FQ_CoDel, SFQ or FQ

# Additional Information

- **A History of Buffer Sizing**
  http://people.ucsc.edu/~warner/Bufs/buffer-requirements
- **Jim Warner's Packet Buffer Page**
  http://people.ucsc.edu/~warner/buffer.html
- **Faster Data @ ESnet**
  http://fasterdata.es.net
- **Cisco Buffers, Queues & Thresholds on Cat 6500 Ethernet Modules**
  http://goo.gl/gTyryX

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