High-speed Networks, Cybersecurity, and Software-defined Networking Workshop

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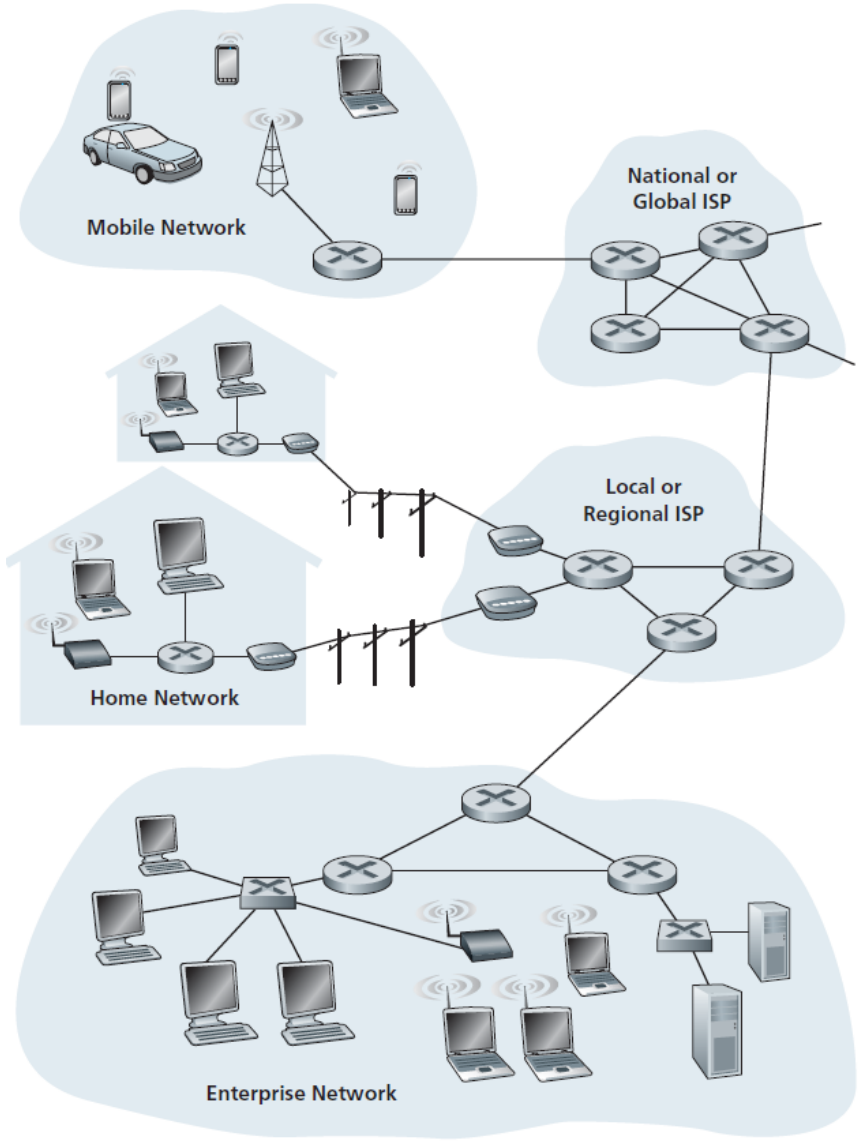
Lab 5: Setting WAN Bandwidth with Token Bucket Filter (TBF)

Token Bucket Filter

Introduction to Token Bucket Algorithm

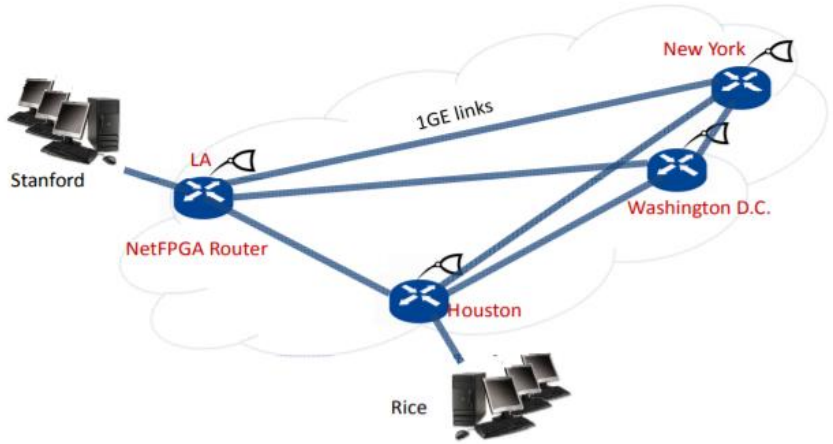
- When emulating networks, it is sometimes necessary to set the bandwidth of devices
- By manipulating the bandwidth / capacity of a link, the network behavior under different conditions can be observed



J. Kurose, K. Ross, Computer Networking: A Top-Down Approach, 7th Edition, Pearson, 2017

Introduction to Token Bucket Algorithm

- Example: what is the ideal buffer size in a router, so that the utilization of a bottleneck link is maximized?



2009 Hardware experiment

N. Beheshti, “Tiny Buffers for Electronic and Optical Routers,” 2009. Online” https://tinyurl.com/y8uug534

Introduction to Token Bucket Algorithm

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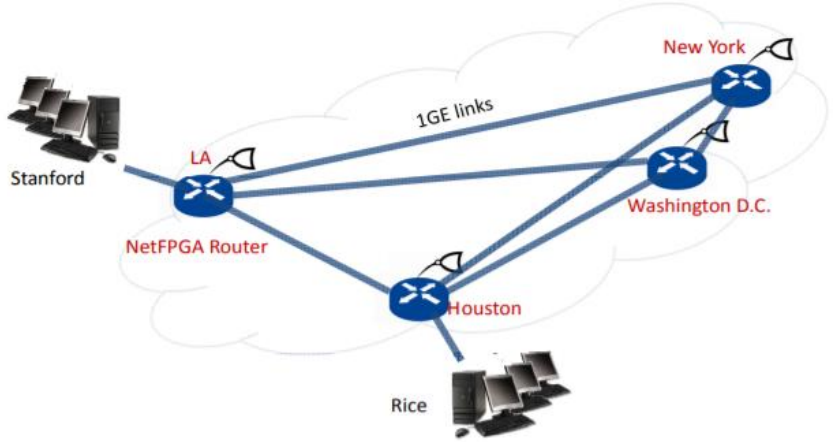
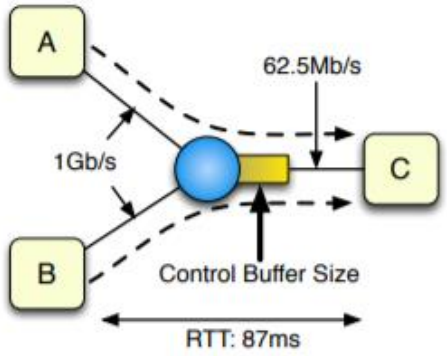
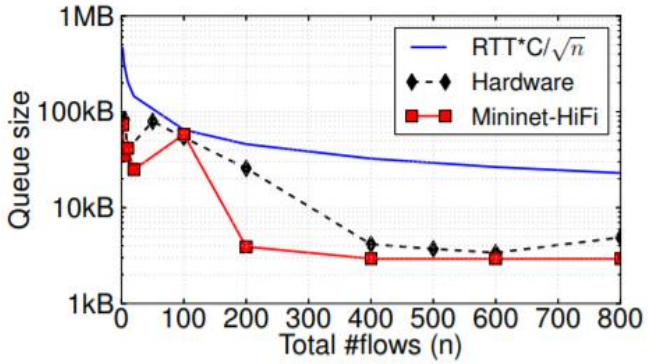


2009 Hardware experiment



2012 Mininet Experiment



Red: Mininet results (2012, after Mininet was created)
Black: Internet2 backbone results (Los Angeles – Houston)
Blue: Theoretical upper bound

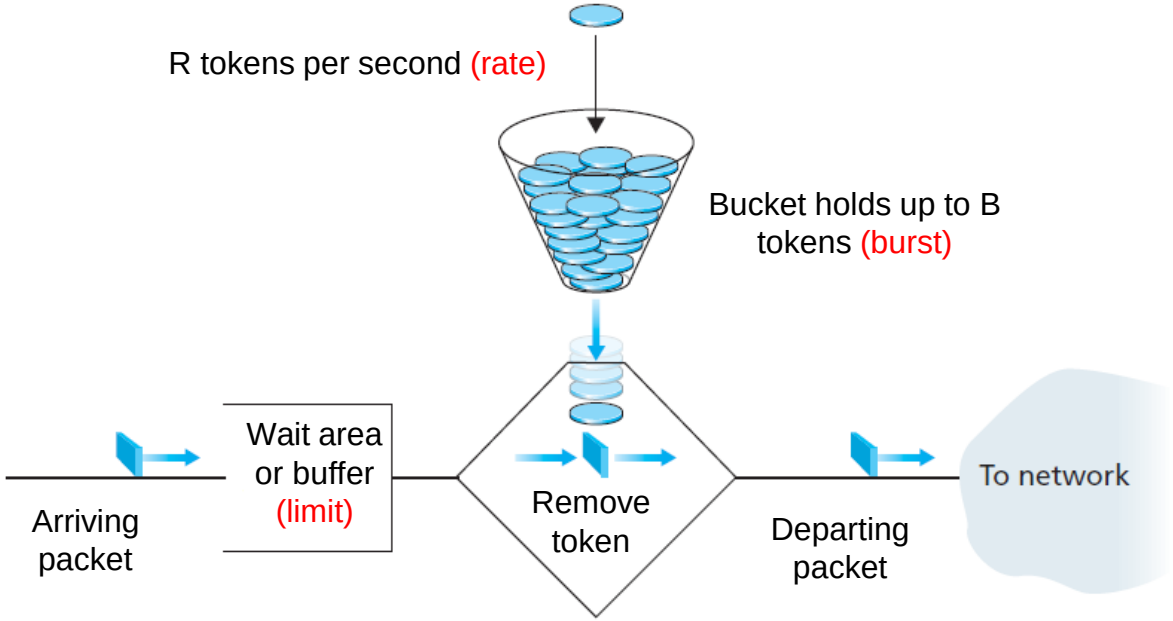
N. Beheshti, “Tiny Buffers for Electronic and Optical Routers,” 2009. Online” https://tinyurl.com/y8uug534
Nikhil Handigo et al., “Reproducible Network Experiments Using Container-Based Emulation,” 2012. Online: https://tinyurl.com/ybeebb4v
Reproducing Network Research Website. Online: https://reproducingnetworkresearch.wordpress.com/

Introduction to Token Bucket Algorithm

- The Token Bucket algorithm is used to limit the average rate (bps) and burst size of packets (or bits/bytes) on a link
  - Average rate gives the bps at which a traffic can be sent into the link
  - Burst size gives the maximum bps (the “burst”) that can be sent into the link over an extremely short interval of time

Introduction to Token Bucket Algorithm

- The Token Bucket algorithm is used to limit the average rate (bps) and burst size of packets (or bits/bytes) on a link
  - R tokens are generated at a constant rate
  - A leaky bucket holds up to B tokens
  - A packet is sent to the network only if a token is available; one token is then removed from the bucket
  - If no token is available, the packet must wait in the buffer, until a token is available

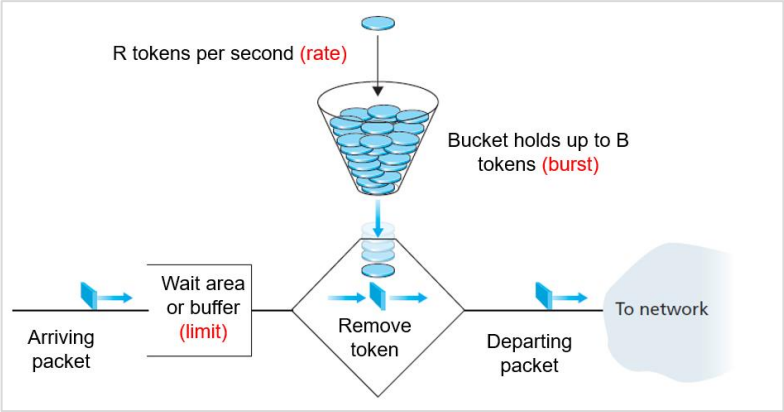


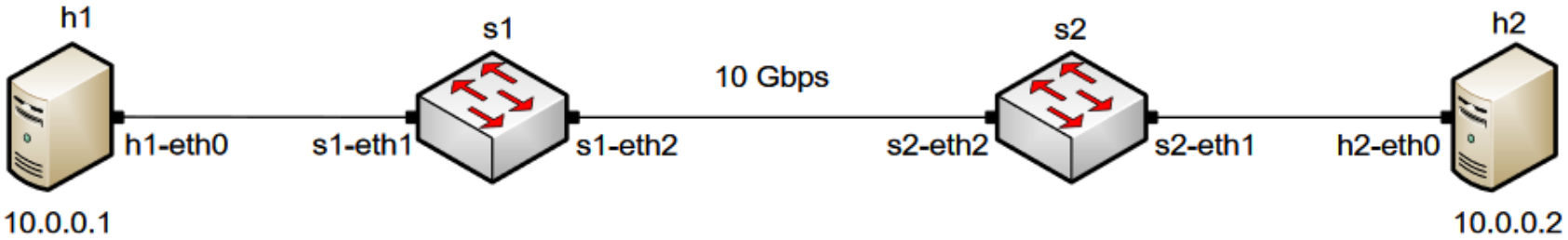
Rate Limit on Switches

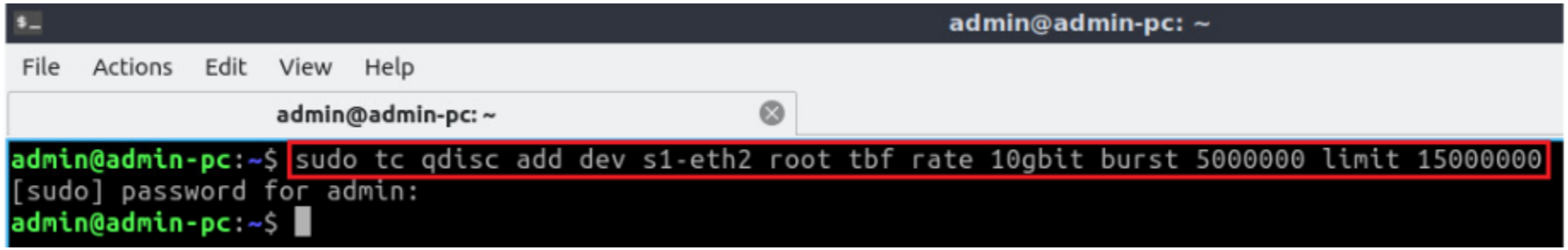
Rate Limiting on Switches

- The first figure shows the network topology
- The *tbf* parameters are the following:
  - rate: 10gbit (in bits per seconds)
  - burst: 5,000,000 (in bytes)
  - limit: 15,000,000 (in bytes)

Reference

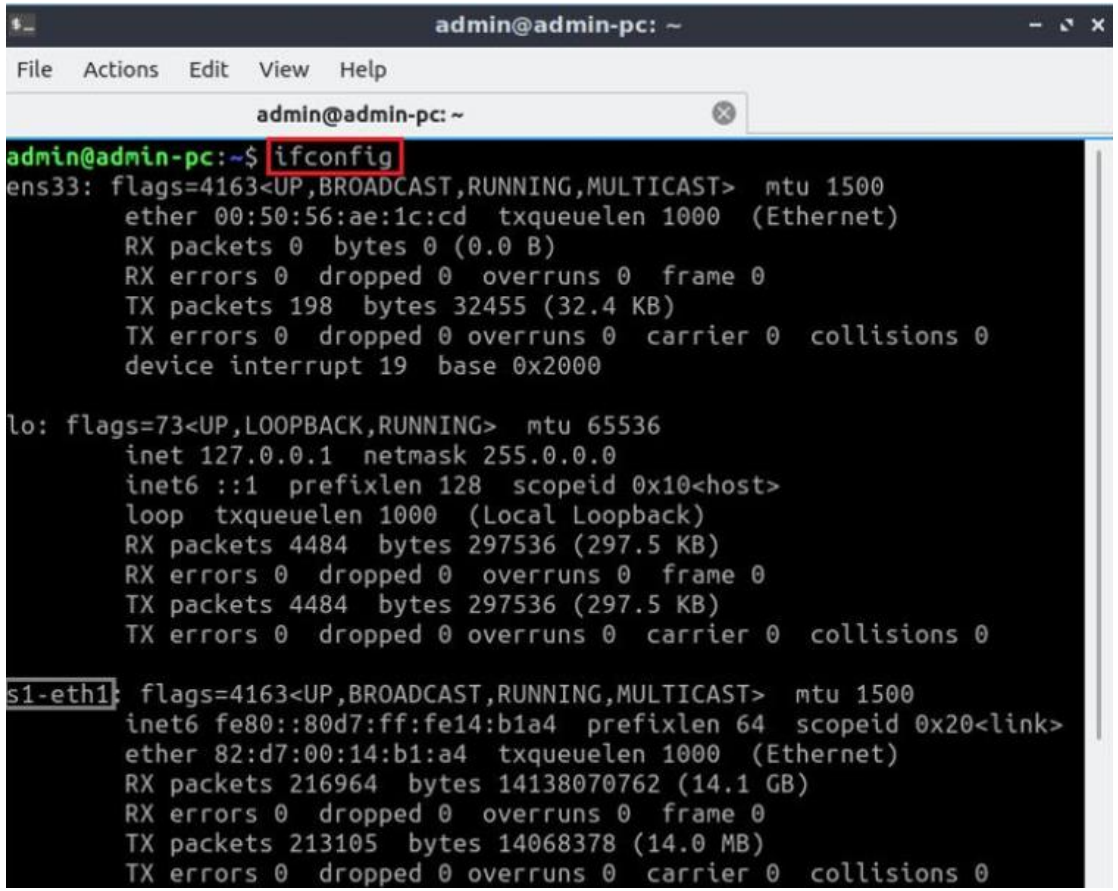


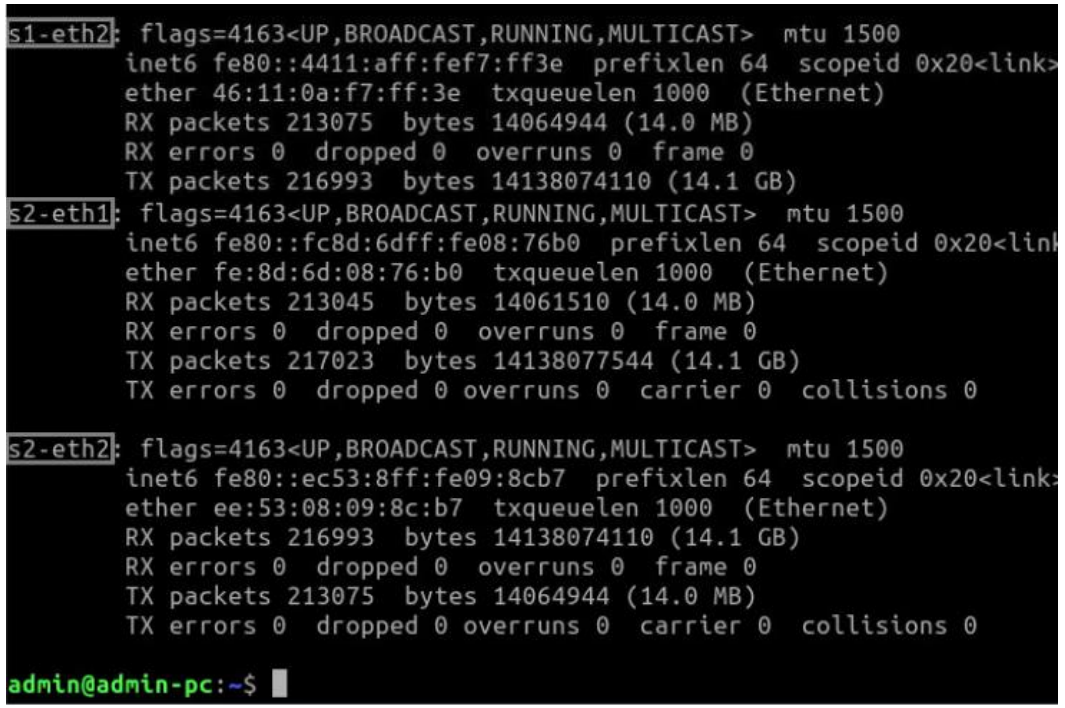




Identify Switch Interfaces

- The *ifconfig* command is used to display information related to network interfaces



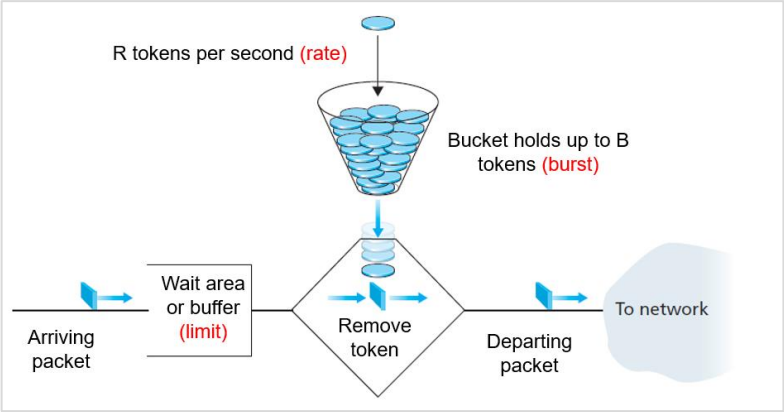


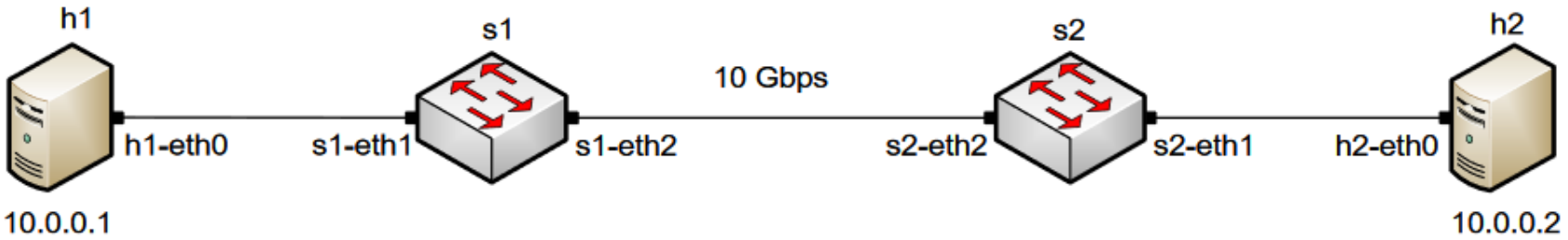
Rate Limit on End Devices

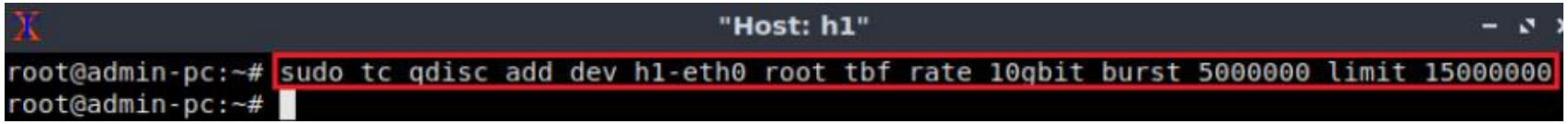
Rate Limiting on End-hosts

- The first figure shows the network topology
- The *tbf* parameters are the following:
  - rate: 10gbit (in bits per seconds)
  - burst: 5,000,000 (in bytes)
  - limit: 15,000,000 (in bytes)

Reference

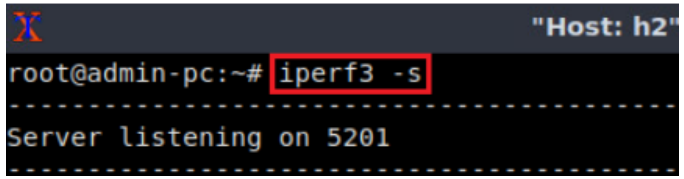




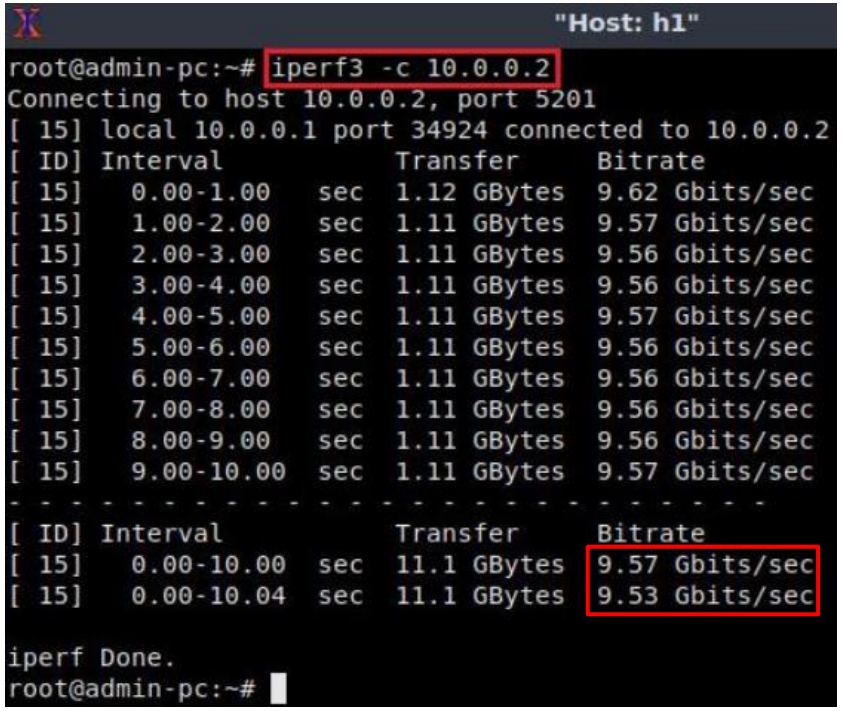


Verification

- The user can now verify the previous configuration by using the iperf3tool to measure throughput



Server (h2)

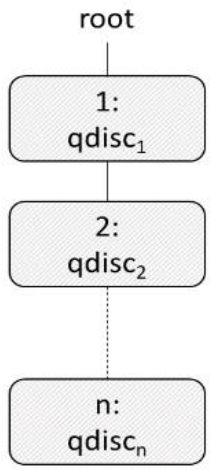


Client (h1)

Combining NETEM and TBF

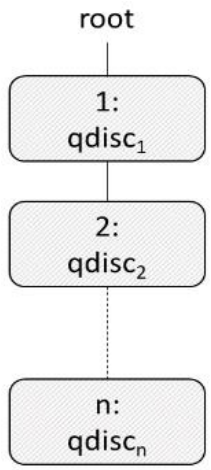
Combining Qdiscs

- The first qdisc (qdisc1) is attached to the root label
- Then, subsequent qdiscs can be attached to their parents by specifying the correct label



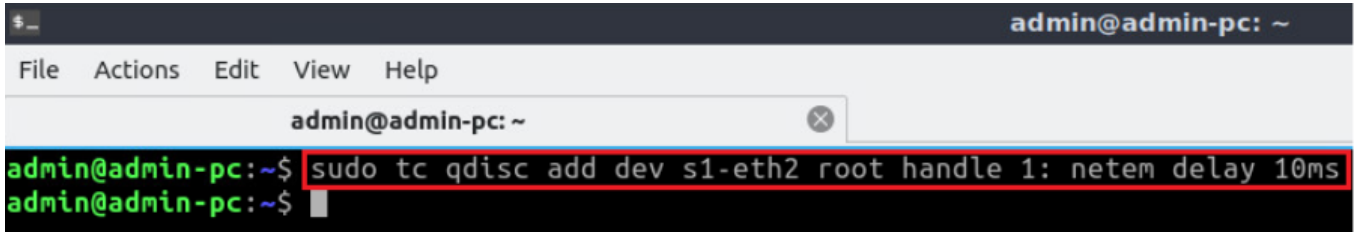
Combining NETEM and TBF

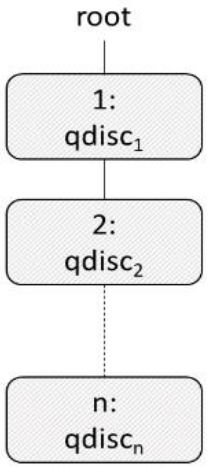
- NETEM is used to introduce delay, jitter, packet corruption, etc.
- TBF is used to limit the rate
- We can combine multiple queueing disciplines (‘link features’) and activate them at the same time

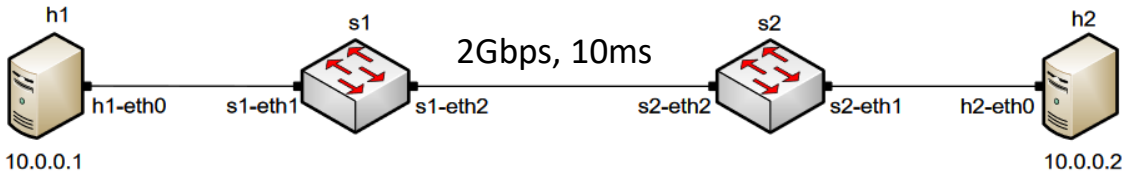


Combining NETEM and TBF

- The command below activates NETEM on interface s1-eth2 to emulate delay
- The new keyword in this command is *handle* and its value reflects the number shown above each qdisc in the figure on the right
- This means that our NETEM qdisc is attached to the root with the handle1







Combining NETEM and TBF

- Now this command adds the second rule which applies rate limiting using tbf
- The new keyword in this command is *parent* and its value reflects the number of the parent qdisc
- The tbf qdisc is attached to the NETEM qdisc (configured in the previous slide)
- TBF has a handle 2: if we decide to attach further qdiscs