Control of Multiple Packet Schedulers for Improving QoS on OpenFlow/SDN Networking

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Outline

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QoS in OpenFlow

Versions

- OpenFlow (OF) has improved since it was released
- Queues have come up in OF 1.0
  - OF can forward packets to queues through enqueue action
  - Queues are configured from `dpctl` and `tc` tools
  - To enable traffic shaping
- Latest version 1.3
  - It has brought rate limiting feature through meter tables
  - QoS configuration of entire network from control plane

QoS in OpenFlow

Related Work

- Kim [Kim et al., 2010] proposes a framework to provide automated traffic shaping on OpenFlow networks
- Sonkoly [Sonkoly et al., 2012] describes the importance to have bandwidth slicing mechanism on Ofelia testbed
- Cinvalar [Cinvalar et al., 2010] and Egilmez [Egilmez et al., 2012] work introduced routing mechanism by considering packet delay and loss criteria

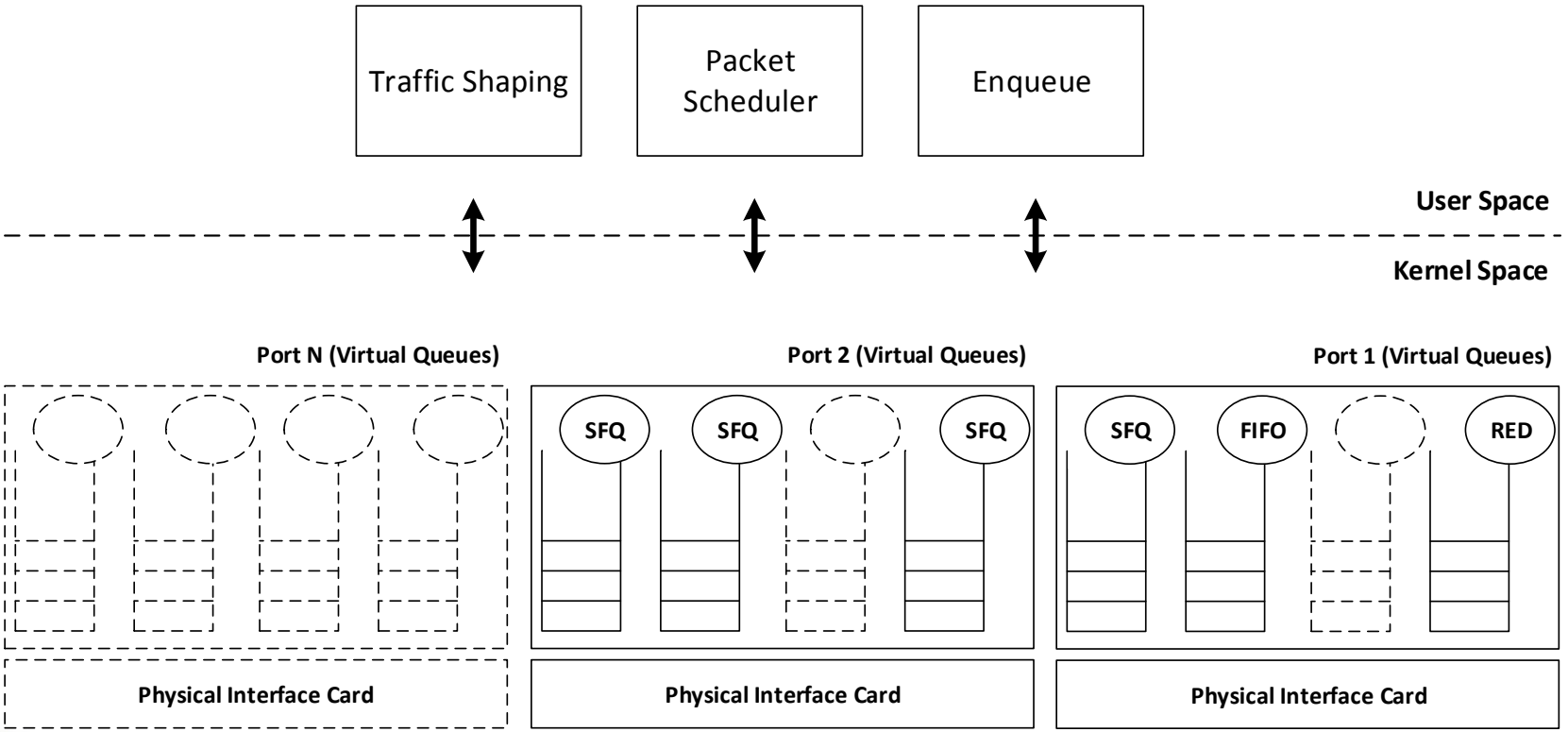
QoSFlow Proposal

Goal

- QoSFlow is a proposal to enable control of multiple packet schedulers available in the Linux kernel
- Currently, QoSFlow provides control of such packet schedulers:
  - HTB (Hierarchical Token Bucket)
  - SFQ (Stochastic Fairness Queueing)
  - RED (Randonly Early Detection)
  - FIFO - default scheduler
- The current implementation is based on OF 1.0 and extends the datapath based on it

QoSFlow Proposal

Design of Datapath Extension: Addition of QoS modules



QoSFlow Proposal

How Does the Control Plane Attach Schedulers?

- OpenFlow protocol is extended
- New messages are added to OF protocol in order to enable control plane to attach packet schedulers
  - Header (OF Type): `OFPT_QUEUEING_DISCIPLINE`
  - Subtypes for: HTB, SFQ, RED and FIFO
  - Body: where specific parameters of each scheduler are carried
- The datapath handles such messages properly by converting them into Netlink message (low-level message)
- Then, the datapath opens a channel with the Linux kernel for configuration

Performance Evaluation

Methodology

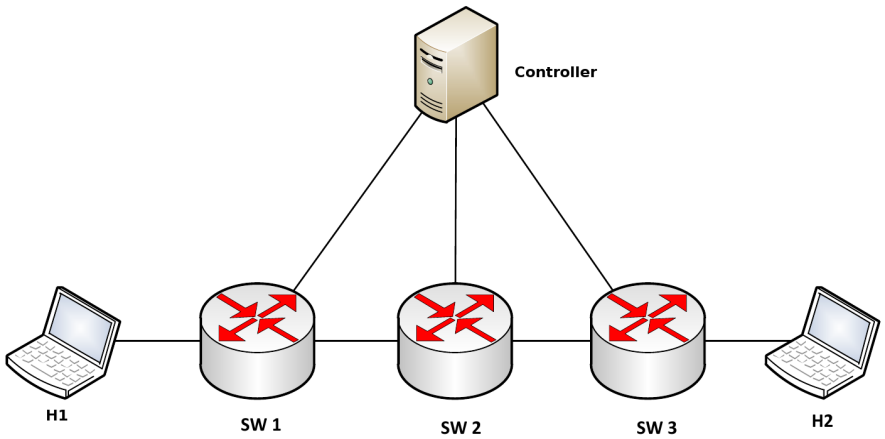
- The assessments consist of:
  - Response time of a switch to configure packet schedulers
  - Maximum throughput achieved by switch
  - CPU and RAM overhead (use of *top* tool)
  - Bandwidth isolation feature
  - QoE (use of *Evalvid* framework)
- The testbed is done over TP-Link 1043ND switch model with OpenWrt Backfire (embedded Linux)
- QoSFlow datapath executes on top of OpenWrt as a deamon

Performance Evaluation

Methodology

- Maximum throughput
  - TCP flow
  - Iperf tool
- Bandwidth isolation
  - TCP and UDP flows
  - Iperf tool
- QoE
  - Two identical videos
  - Evalvid framework

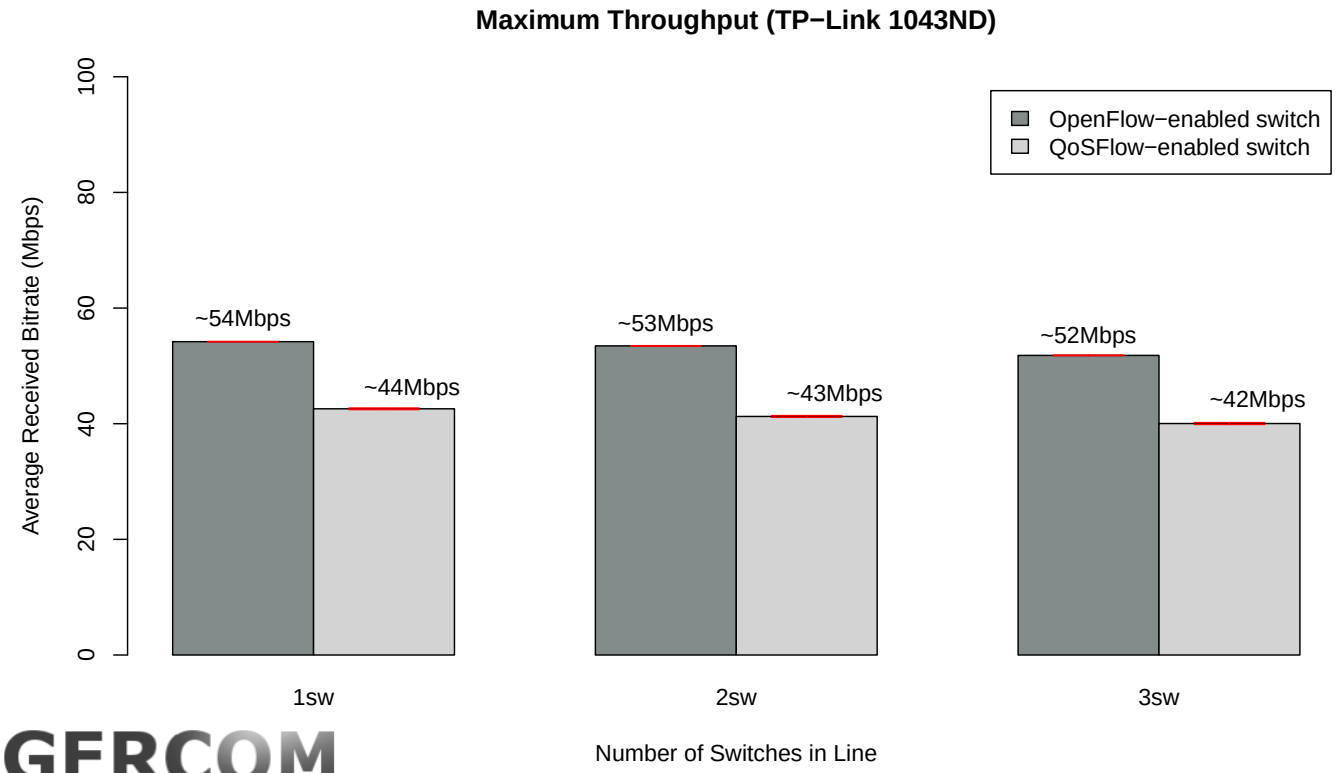
- Network Topology



Performance Evaluation

Switch Capacity

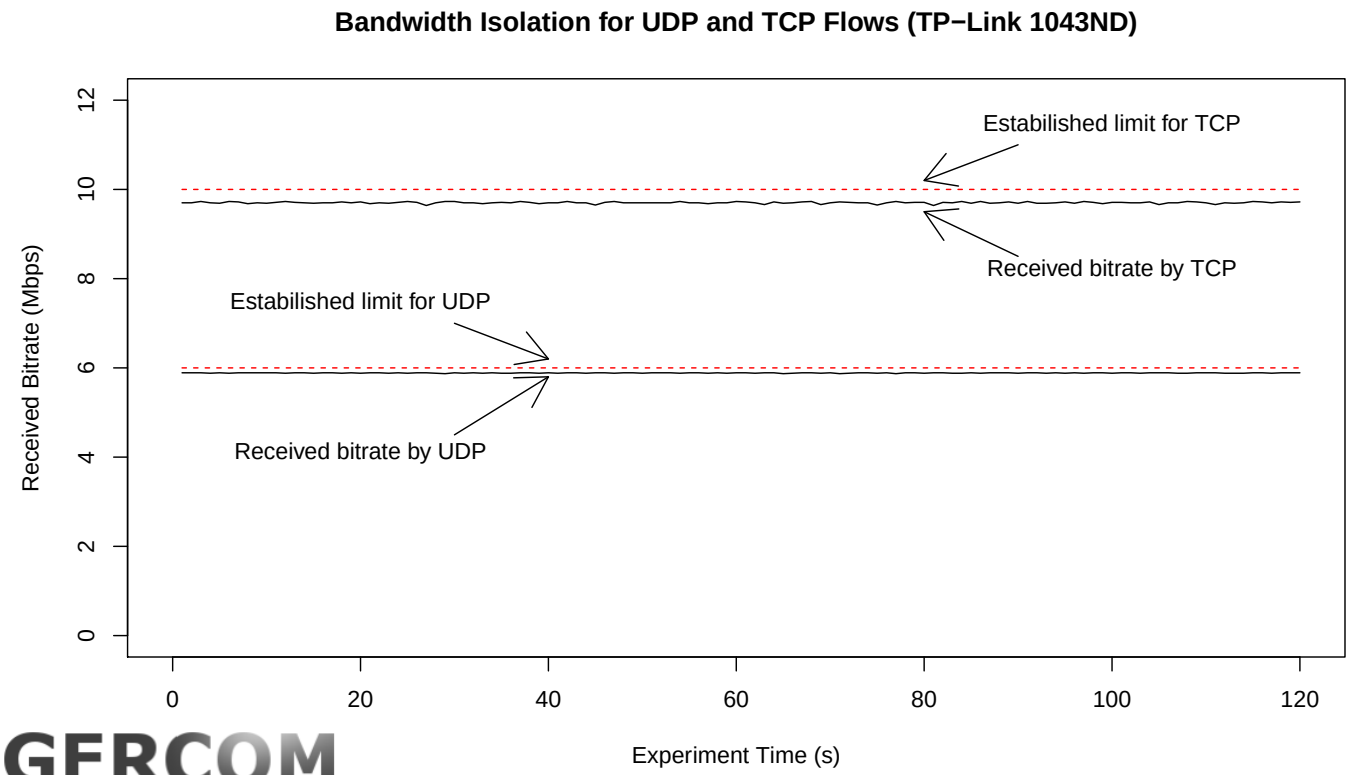
- Maximum throughput achieved by OF and QoSFlow switches



Performance Evaluation

Bandwidth Isolation

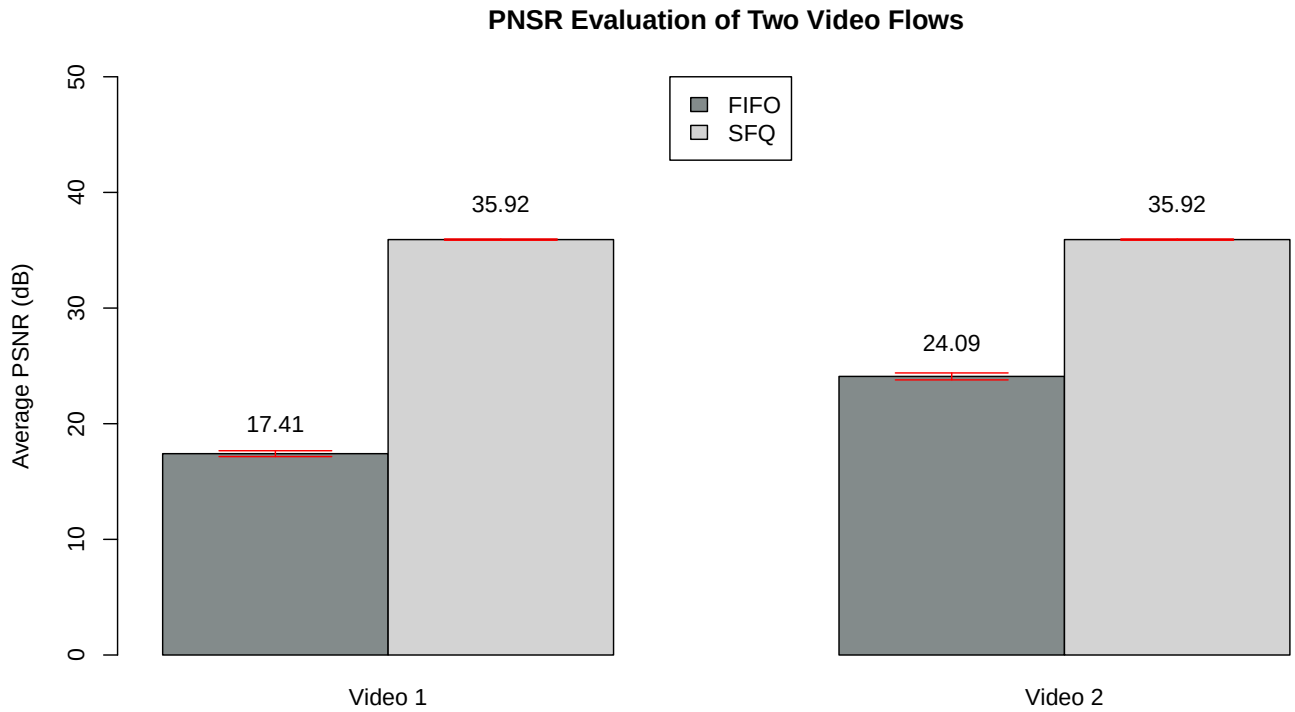
- Ability of bandwidth slicing



Performance Evaluation

QoE

- FIFO vs SFQ performance

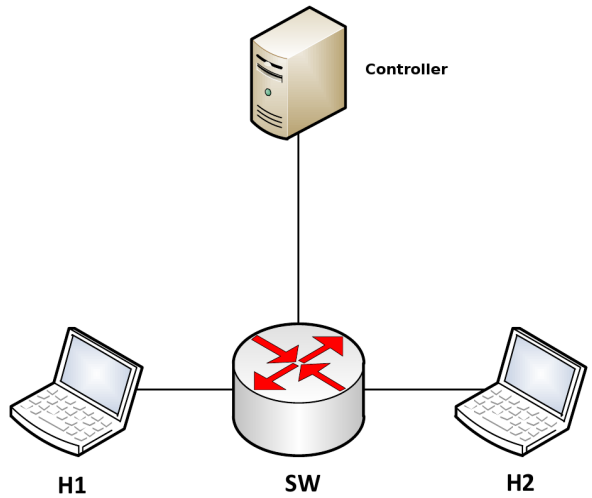


Performance Evaluation

Methodology

- Response time
  - Diference time before and after a QoS operation
- CPU and RAM overhead
  - `$ top -p <pid>`
  - Display Linux processes

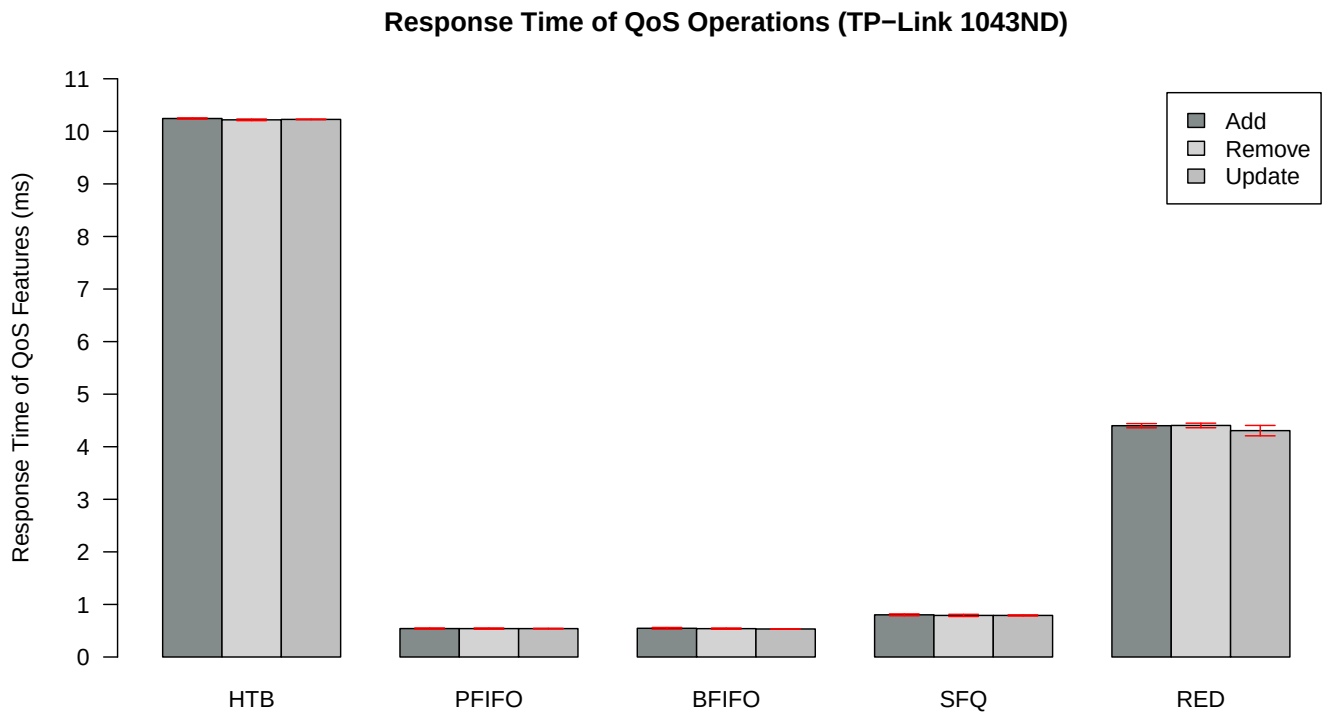
- Network Topology



Performance Evaluation

Response Time

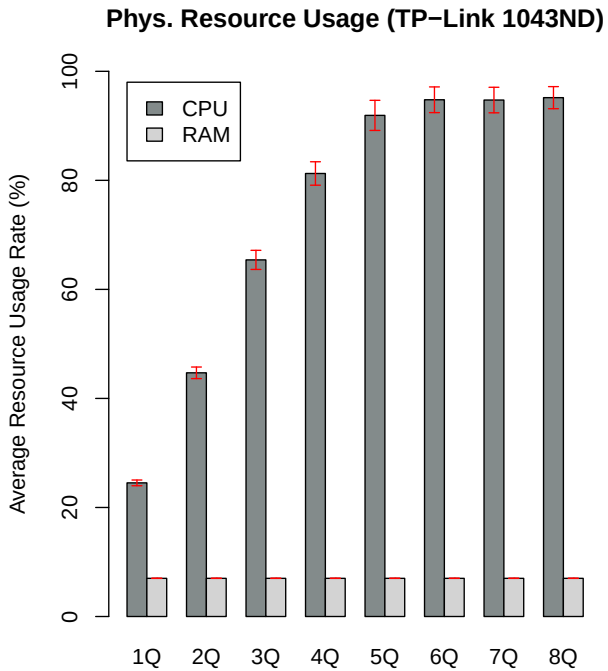
- Communication delay from user-space to kernel-space



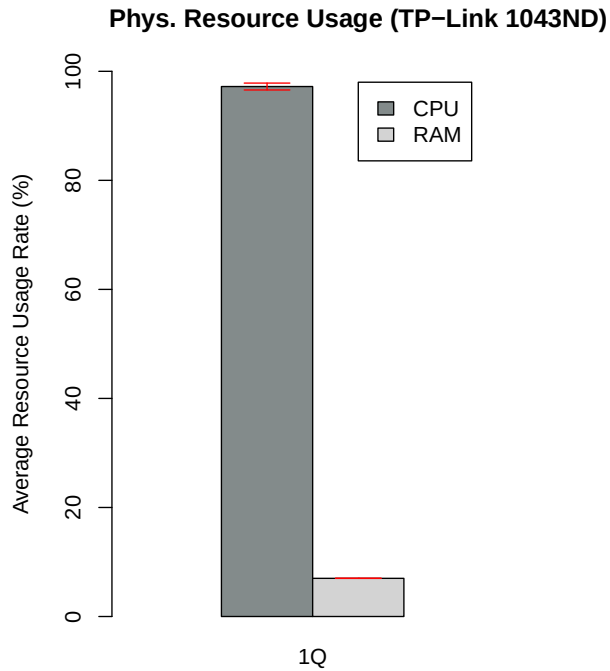
Performance Evaluation

Number of Queues Impact: CPU and RAM usage

- Output port: 8 queues x 5 Mbps vs 1 queue x 40 Mbps



Queues with 5 Mbps



A Queue with 40 Mbps

Conclusion and Future Work

- QoSFlow brings Linux packet schedulers into OF networks by extending standard datapath and the OF protocol
- We believe that QoSFlow can be used on backbone networks for QoS and QoE improvement
- The focus of this work is the datapath performance
- As work ahead..
  - Investigation of other packet schedulers
  - Assessments on more sophisticated OF switches
  - Analysis on impact of schedulers over other QoE metrics
  - Policy-based management framework
- We've been implementing the current features into OF 1.3

Acknowledgments

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Thank You!

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