Simulation of TCP performance with optical buffers

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Optical switching in backbone networks

- Wavelength switching
  - granularity: wavelength
  - commercial
  - research: control level

- Packet switching
  - granularity: packet
  - still being researched
  - research: hardware, protocols and control
Optical wavelength switches

- Lambda router of Lucent (1999)
- Other companies (such as Nortel) offer similar switches.
- Switching is slow.
- MEMS Technology
Optical packet switches

• KEOPS (1998)
• STOLAS (2003)
• DAVID (2003)
• University of California, Davis
Generic optical packet switch
Optical packet switch architectures

- They employ different switching fabric technology.
- They use optical buffers of different architectures and at different places.
Basic architectures of optical buffers

- Optical buffers are just bundles of optical fiber.
- Differ in complexity, cost.
- Usual performance metrics: cost, packet loss, signal distortion.
Advanced architectures of optical buffers

- More expensive
- More flexible: can work as FIFO queues.
- Distort signal because of SOA.
- PROBLEM: buffer size cannot be large.

a single recirculating buffer

an array of recirculating buffers
Multi-exit recirculating buffer

- The delay is variable.
- The delay is more finely-grained in comparison with regular recirculating buffer.
TCP and optical packet switching

• In the evaluation of OPS hardware (KEOPS, DAVID, STOLAS, Davis), TCP is ignored.
• TCP is mentioned occasionally for edge routers.
• There is no work on how TCP is influenced by optical buffer architectures.
QUESTIONS

- Which optical buffer architecture serves TCP best?
- Because optical buffers cannot be large, what is the minimal buffer size acceptable by TCP?
- Which of the two below is better for TCP?
Why is it worth studying?

• Because we believe that no large optical buffers are required for backbone networks with TCP. This would be great, because large optical buffers are impossible now.

• Work of McKeown et al., Raina & Wischik suggest that TCP should work fine with small buffers in backbone networks.
Simulation setup

- There are thousands of TCP flows.
- We change the optical buffer architecture and the buffer size.
Simulation setup - continued

• Software simulation
  - A custom simulator written in C++
  - It can simulate a large number of flows with a high bitrate link.
  - It's an idealized system, which might perform different from a real system.

• Hardware simulator
  - Two computers running Linux connected with an Ethernet link
  - Should simulate a real TCP implementation.
  - Should simulate a 10Gb/s link with 10k flows.
Linux simulation

• To simulate a 10Gb/s link with a 1Gb/s Ethernet, we need to slow down the system clock 10 times.

• We need 10k flows, and so 10k tasks sending data. Linux is able to switch 1000 tasks/s, and achieving more might be difficult.

• Tools are already there: token bucket for regulating a link rate, and “netem” for introducing backbone network latency (50ms).
Conclusion

• Optical packet switching is promising to deliver packet-level granularity in the backbone networks.
• Very little is known about TCP performance with optical buffers.
• We plan to find out what optical buffer architecture best serves TCP and what buffer sizes are optimal.