All-Optical Buffer

Tomas A. Tinoco
Electrical Engineering and Computer Science
Diablo Valley College
University of California, Berkeley

Optical Communications and Photonic Networks Group

Mentor: John Mack
University of California, Santa Barbara

Project funded by: DARPA
Current Communication Networks

- Information broken into packets (e.g. Internet).
- Packets transmitted optically.
- Packets routed electronically $\rightarrow$ O/E & E/O conversions.
- Electronic switching speed $<<<$ Optical transmission capacity.

Long Distance Optical Communication Network

Electronic Cisco Routers
Future Communication Networks

- Optical Routers.
- Keep data in optical domain → No O/E & E/O conversions.
- Routing capacity x100.
- Lower power consumption and cost.
Key Component

- All-Optical Buffer.
- Necessary for avoiding packet collisions inside optical routers.
- Exploit time domain → Store light for a variable time period.
- Use a fiber delay loop to make packet circulate.

Buffers to store packets

Feedback Loop

All-Optical Buffer

All-Optical Router

Packet
Optical Input Port

Optical Output Port
Project Goals

- Build a large scale buffer prototype.
- Help design & implement buffer switching control.
- Simulate routing control signals & test buffer behavior.

Optical Signal
Electronic Signal

Optical Transmitter → All-Optical Buffer → Optical Receiver

Feedback Loop

Switching Control

Routing Signals

Computer
Making the Optical Buffer

- Semiconductor Optical Amplifiers (SOA).
- Isolators.
- Attenuators.
- Couplers and Splitters.
- Band Pass Filter.
- Optical Fiber.

![Image of optical buffer setup in OCPN Lab](OCPN Lab)
Controlling the Optical Buffer

- Turn SOAs ON/OFF using a Field Programmable Gate Array (FPGA).
- Specify path and loop duration in FPGA clock cycles.
- Simulate Electronic Random Access Memory (RAM) → Read/Write.

00 – Let packet through
10 – Store packet (Write)
01 – Release packet (Read)
11 – Do nothing
Circulating Packets

- Buffer parameters: Path = 120ns & Loop = 60ns.
- One circulation → Packet relative delay = 180ns.

Power vs. Time

0 Circulations 1 Circulation 2 Circulations 3 Circulations
All-Optical Buffer

Measuring Bit-Error-Rate

- Send packets using an Optical Transmitter (6.4GHz).
- Measure Bit-Error-Rate = Errors/Total Number of Bits Received.
- Find power penalty for different # of circulation.
Power Penalty Analysis

Receiver Power (dBm)

Bit Error Rate

-0 Circulations
-1 Circulations
-2 Circulations
-3 Circulations
-4 Circulations
-5 Circulations
-6 Circulations
-7 Circulations
-8 Circulations
Summary

- Optical Routers require a way of storing packets.
- Solution: Feed-back optical buffer.
- Implementation: 2x2 switch using SOAs.
- Limitation: More circulations → Signal quality decreases.

Kamelian Semiconductor Optical Amplifier (SOA)
Future Work

- Improve buffer to achieve more # of circulation.
- Build and test an optical router that uses optical buffers.
- Integrate optical buffers on microchips.

Acknowledgements

CNSI, INSET, John Mack and all the members of the OCPN group.