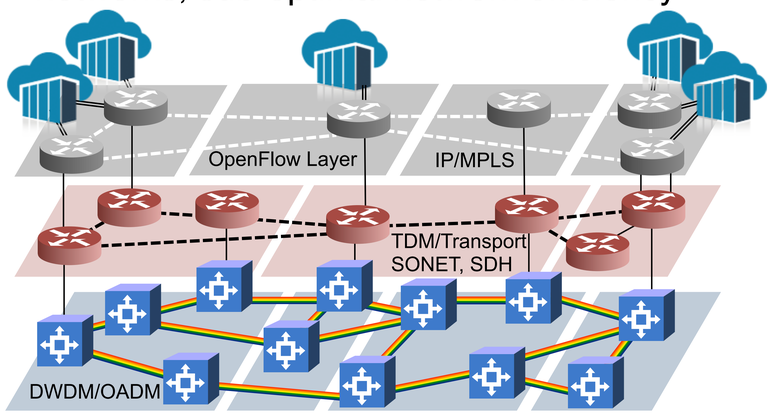
Traffic Optimization in Multi-Layered WANs using SDN

Henrique Rodrigues[1], Inder Monga[2], Abhinava Sadasivarao[3], Sharfuddin Syed[3], Chin Guok[2], Eric Pouyoul[2], Chris Liou[3], Tajana Rosing[1]

[1]*University of California, San Diego* [2]*Energy Science Networks* [3]*Infinera Corporation*

Motivation

- Wide Area Networks (WANs) typically support multiple services with varying demands
- Networks are organized into various segments with equipment from different vendors
- Control planes usually have proprietary extensions making them non-interoperable
- Consequences: increased OPEX, inflexible networks, sub-optimal network efficiency



Software Defined Networking for WANs

- Unified control plane can solve the problems
- Previous work propose distinct management interfaces or segregated management using SDN (Google B4 and Microsoft SWAN)

In Port	VLAN ID	Ethernet			IP			TCP	
		SA	DA	Type	SA	DA	Proto	Src	Dst

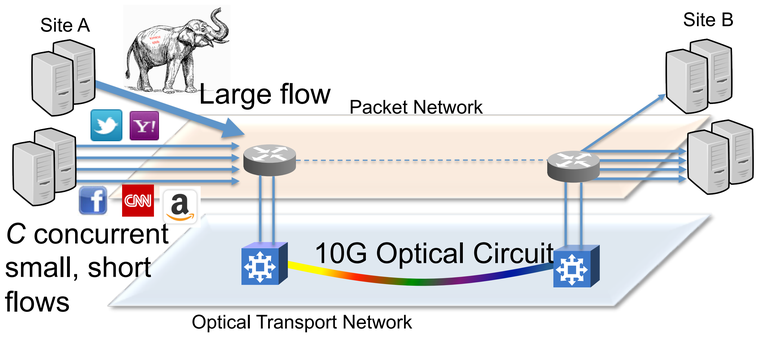
In/Out Port	In/ Out Lambda	VCG	Starting Time-Slot	Signal Type

Design goals

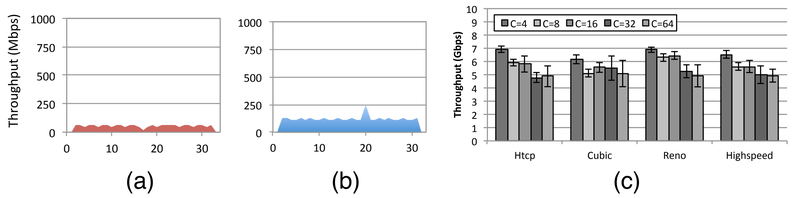
- **Unified Control Plane** for packet/optical data planes - optimal cross-layer traffic engineering
- **Topology Service** to minimize manual intervention in topology discovery
- **Multi-layer Flow Visibility** for improved TE
- **Traffic Offloading** between layers for mixed

Unified Control Plane for WAN Traffic

- Enables cross-layer traffic visibility and application-aware traffic optimization
- Example: interaction of multiple small flows and intermittent big inter-data center flows
- Managing all traffic with the same policies impacts performance, making the case for *multi-layer traffic optimization & offloading*



Experiment: multiple flows with different demands compete for a single 10G optical circuit. C small flows transfer HTTP data from web pages, large flow of several GBs shares same circuit



Network throughput over time (in seconds) for small flows when C=4 (a) and C=8 (b). Throughput in Mbps for (a) and (b). Combined throughput of all flows (c)

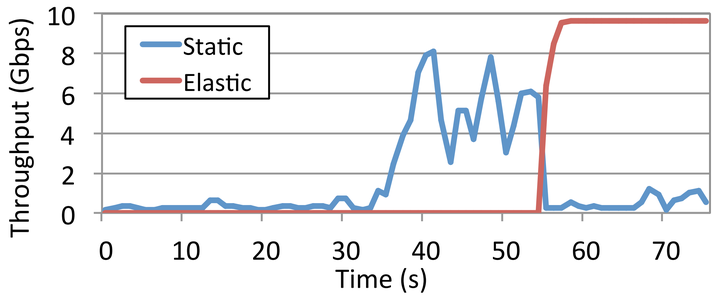
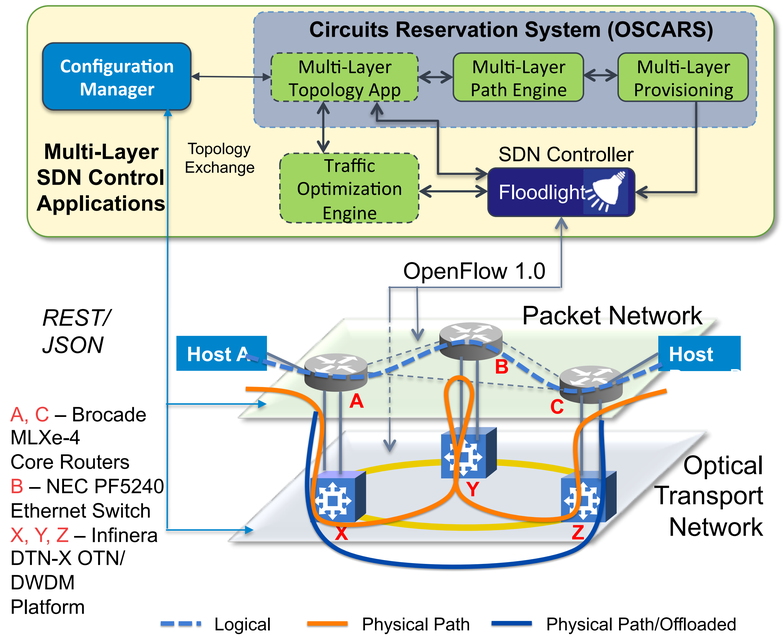


Figure: Elastic bandwidth allocation for large transfers at t=55. Large flow starts at t=35. Throughput is limited by contention, and extra resources improve network utilization & performance.

System Architecture



- Floodlight (or any traditional SDN controller) used to control packet and optical devices using standard OF
- Optical Transport Switch (OTS):
  - Maps physical connections to virtual ports on optical transport switches
  - Multiple virtual ports per physical port
- Path Computation Engine (PCE) builds annotated graph of physical network and determines best route/circuit across packet and optical networks
  - Traffic grooming and splitting based on required bandwidth specifications given to OSCARS
- Intermediary packet nodes used to build network wide monitoring by packet sampling
- Traffic Optimization Engine reorganizes the network dynamically to improve application performance

Main References

[1] Doverspike, Robert D., and Jennifer Yates. "Optical network management and control." Proceedings of the IEEE 100.5 (2012): 1092-1104.
[2] "Packet and circuit convergence" http://archive.openflow.org/wk/index.php/PAC.C
[3] Jain, Sushant, et al. "B4: Experience with a globally-deployed software defined WAN." Proceedings of the ACM SIGCOMM 2013 conference on SIGCOMM. ACM, 2013.
[4] Hong, Chi-Yao, et al. "Achieving high utilization with software-driven WAN." Proceedings of the ACM SIGCOMM 2013 conference on SIGCOMM. ACM, 2013.
[5] ESnet's Fasterdata Knowledge Base - http://fasterdata.es.net/performance-testing/perfsonar/troubleshooting/packet-loss/