Rethinking Cross-Layer (IP-over-Optical) Demand-Responsive Networking

Zhizhen Zhong
Tsinghua University & UC Davis
zhongzz14@mails.tsinghua.edu.cn, zzzhong@ucdavis.edu
27 Apr. 2018
Networks Lab Group Meeting
Cross-layer networking is an old topic

How old it is?
Cross-layer networking is an old topic

How old it is?

- Energy-minimized design for IP over WDM networks
- Integrated dynamic IP and wavelength routing in IP over WDM networks
- Traffic grooming in an optical WDM mesh network
- IP over optical networks: A framework
- Saving energy in IP-over-WDM networks by switching off line cards in low-demand scenarios

Did you mean: optical multi-layer survivable

Intelligent optical networking for multi-layer survivability
- Resilience in multilayer networks
- Differentiated multi-layer survivability in IP/WDM networks
- Survivability in optical networks
- Data-centric optical networks and their survivability
Internet on OSI 7 layer model

OSI 7 layer model in networks

Where I have been working on

7 layer model protocol stack

• **Network: transmission and switching**

• For **information transmission** (L0/L1), user data (L7) from clients needs to go through 7 layer protocol stack to be encapsulated.

• For **information switching** (L3), information go through 3 layer protocol stack to perform routing based on packet IP address.
Research paradigms in cross-layer networking

- Basic problem: resource mapping, optical bypass
Research paradigms in cross-layer networking

- Solid paradigms, well received.
- Static one-shot optimization.
  - Can be solved by operation-research methods (ILP), fine!
  - If ILP is too complex, we have heuristics.
  - Already adopted in industry.
- Dynamic event-driven simulation
  - Dynamically setup or tear down lightpaths
  - Question: how to define “dynamic”?
Dynamic cross-layer networking: demand responsive?

- Basic assumption for dynamic traffic grooming: “when a new traffic arrives, we should decide whether to groom it onto existing lightpaths, or setup a new lightpath.”

  Setting a new lightpath requires some time, does the arriving traffic has to wait? The problem is more severe if we want to achieve agile cross-layer networking.
Dynamic cross-layer networking

- When a traffic arrives:
  - IP layer packet: immediate serve
  - Optical layer circuit: 100 ms setup for a lightpath
  - For a 10Gb/s traffic flow, waiting 100 ms means 1Gbit!
  - We cannot wait for lightpath to setup.
Real equipment data

- Three vendor equipments from: Huawei, ZTE, fiberhome
- lightpath setup/teardown/recover time measurement

Basic idea: We have some pre-established lightpaths. When a new request comes, it will be immediately served by these lightpaths, at the same time, we setup new dedicated lightpath. When new lightpath is done, we switch the traffic to the new lightpath.

Problems to answer

- How do we design the resource buffer layer under dynamic traffic?
- Do we need to setup resource buffer lightpath for all node pairs?
  - Topology, capacity for resource buffer layer
- Tradeoff: how much we buffer, better access delay, worse throughput.
Thank you for attention!

Zhizhen Zhong
Tsinghua University & UC Davis
zhongzz14@mails.tsinghua.edu.cn, zzzhong@ucdavis.edu
27 Apr. 2018
Networks Lab Group Meeting