SDN WAN Applications

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CS 538 February 26, 2018

Initial "Killer apps"

Cloud virtualization

- Create separate virtual networks for tenants
- Allow flexible placement and movement of VMs

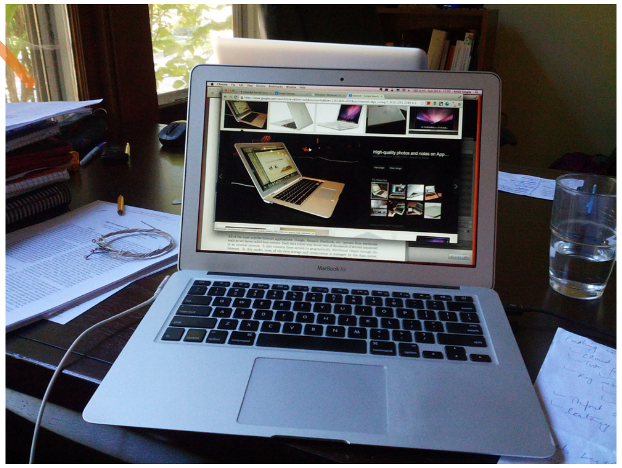
WAN traffic engineering

- Drive utilization to near 100% when possible
- Protect critical traffic from congestion

Key characteristics of the above

- Special-purpose deployments with less diverse hardware
- Existing solutions aren't just annoying, they don't work!

How large online services work



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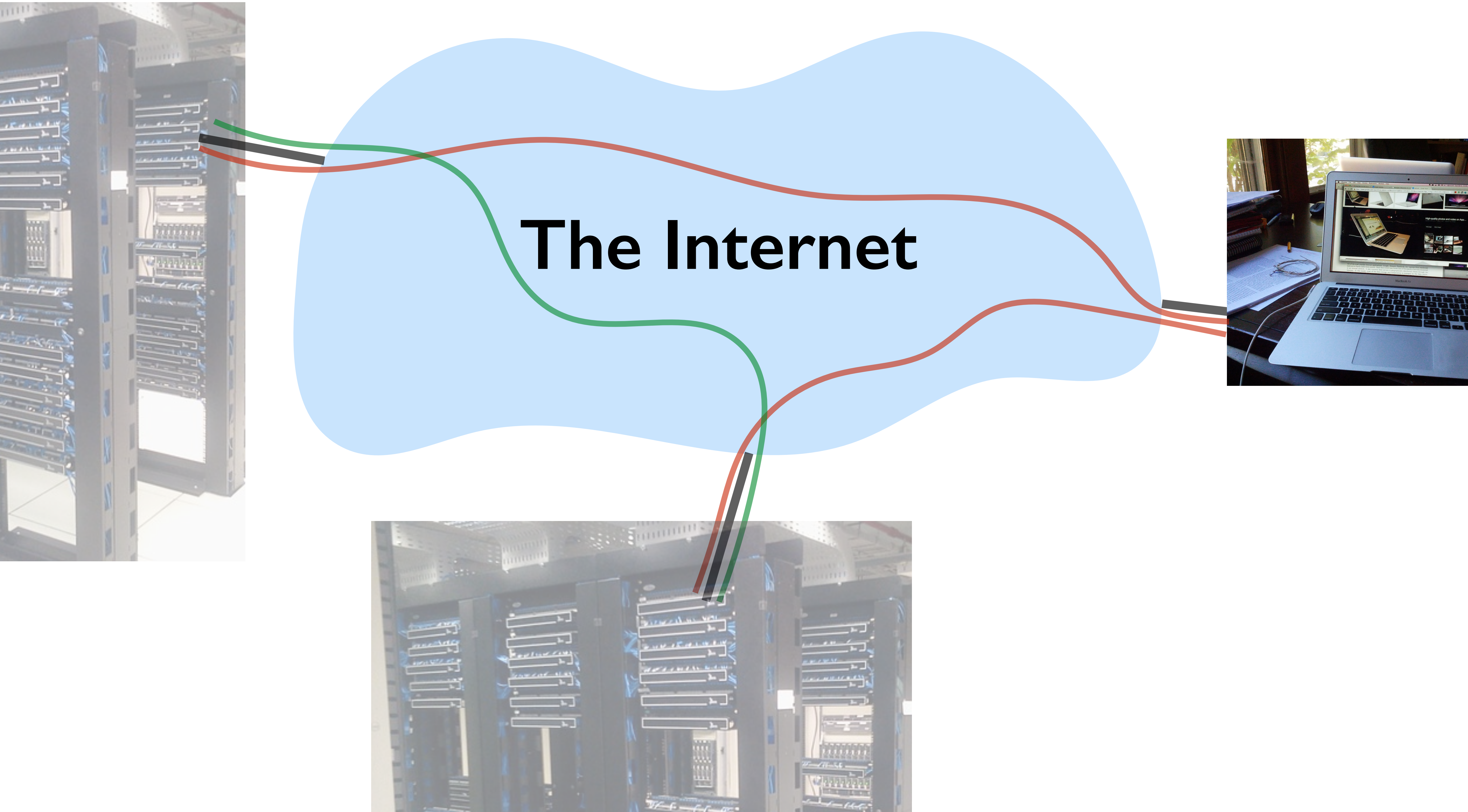

Why multiple data centers?

Data availability

Load balancing

Latency

Local data laws

Hybrid public-private operation

Inter-data center traffic is significant

IEEE INFOCOM, 2011

A First Look at Inter-Data Center Traffic Characteristics via Yahoo! Datasets

Yingying Chen[1], Sourabh Jain[1], Vijay Kumar Adhikari[1], Zhi-Li Zhang[1], and Kuai Xu[2]

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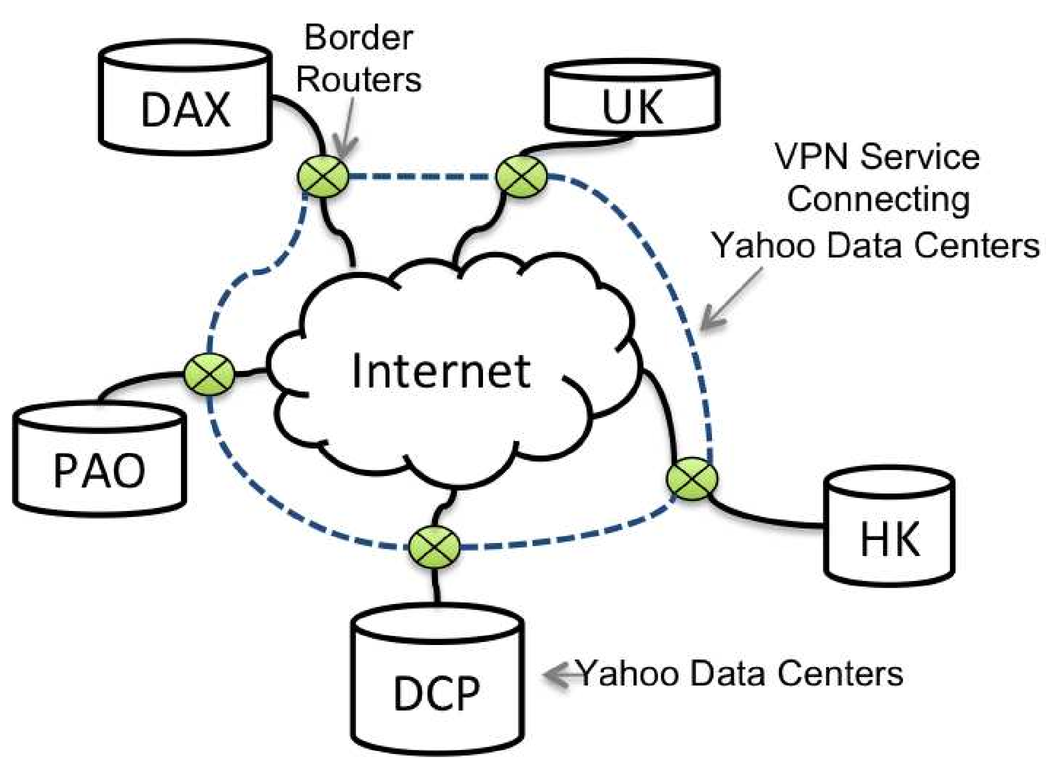

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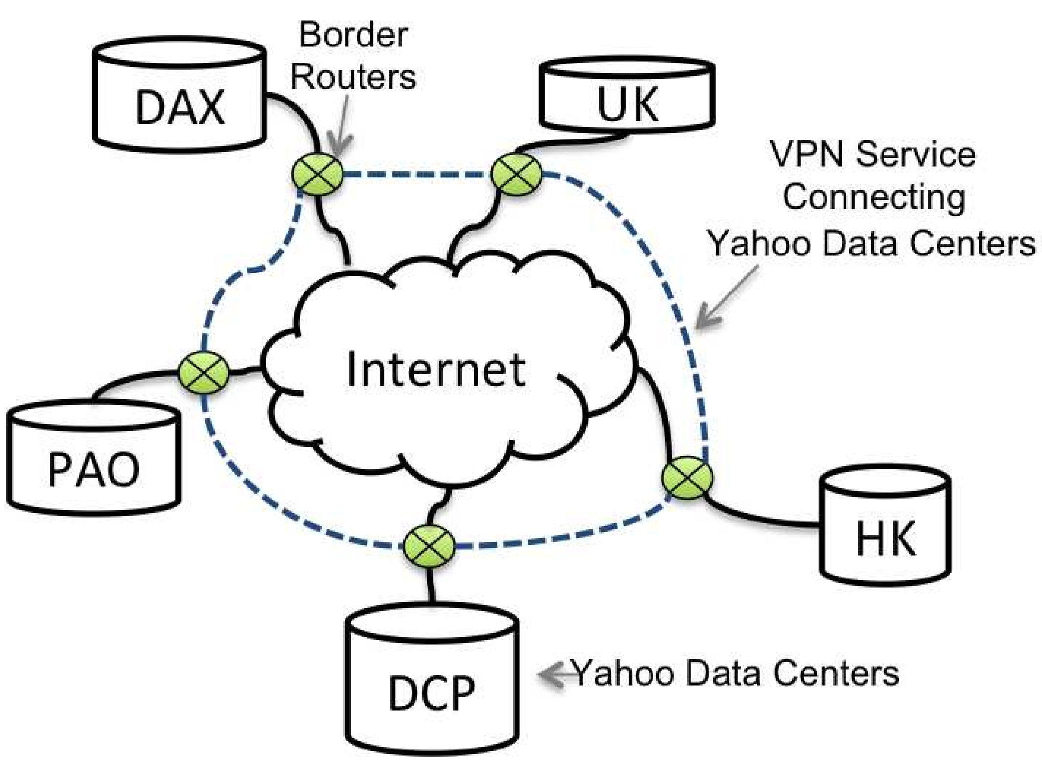

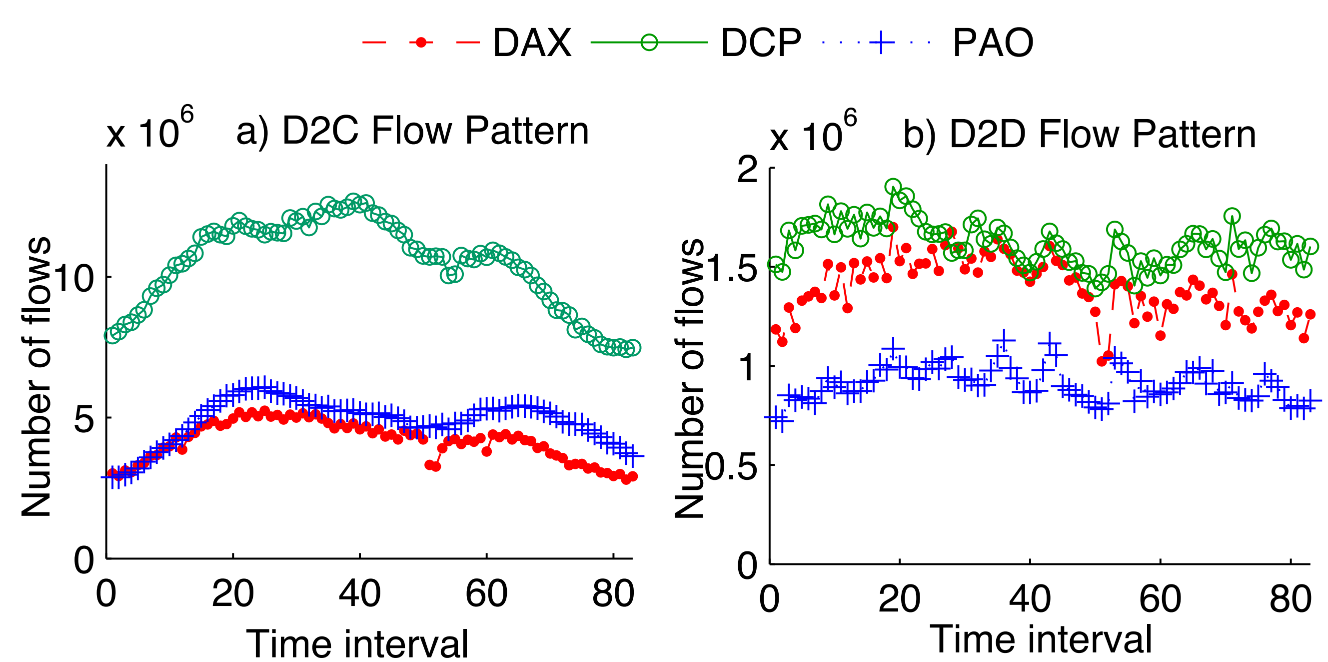

Inter-data center traffic is significant


Back-Office Web Traffic on The Internet

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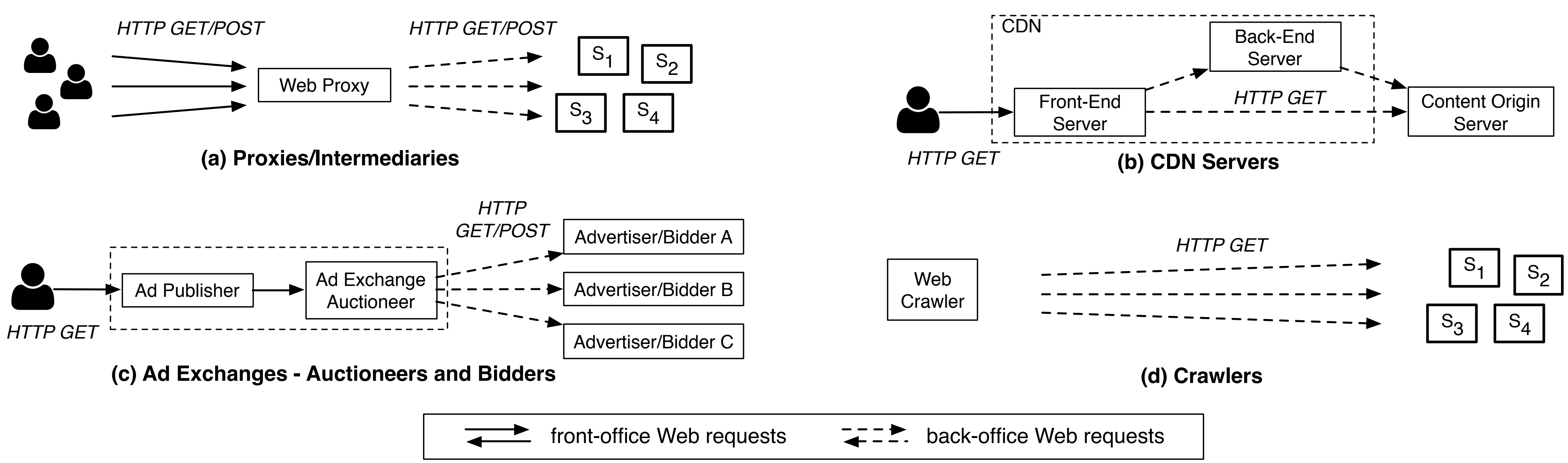
[IMC 2014]



"Back office" web traffic:
server-to-server rather than
directly communicating with user

Inter-data center traffic is significant

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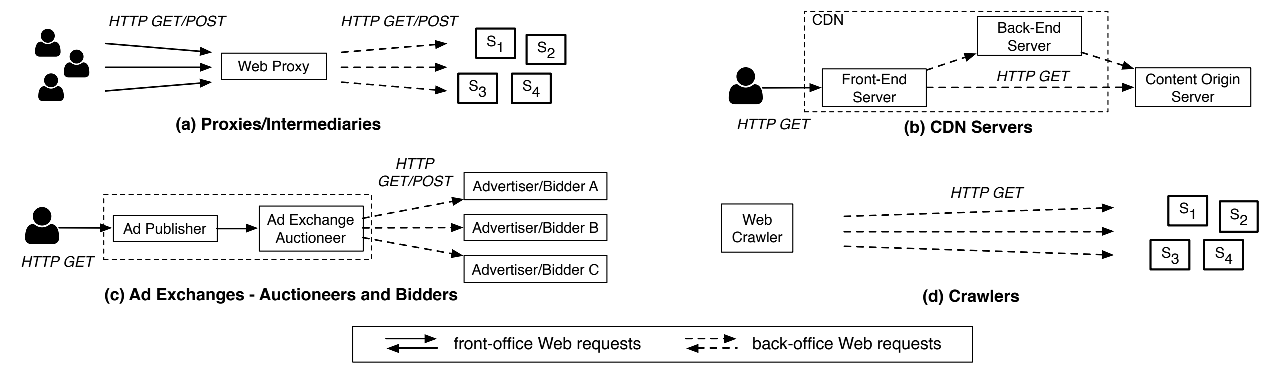
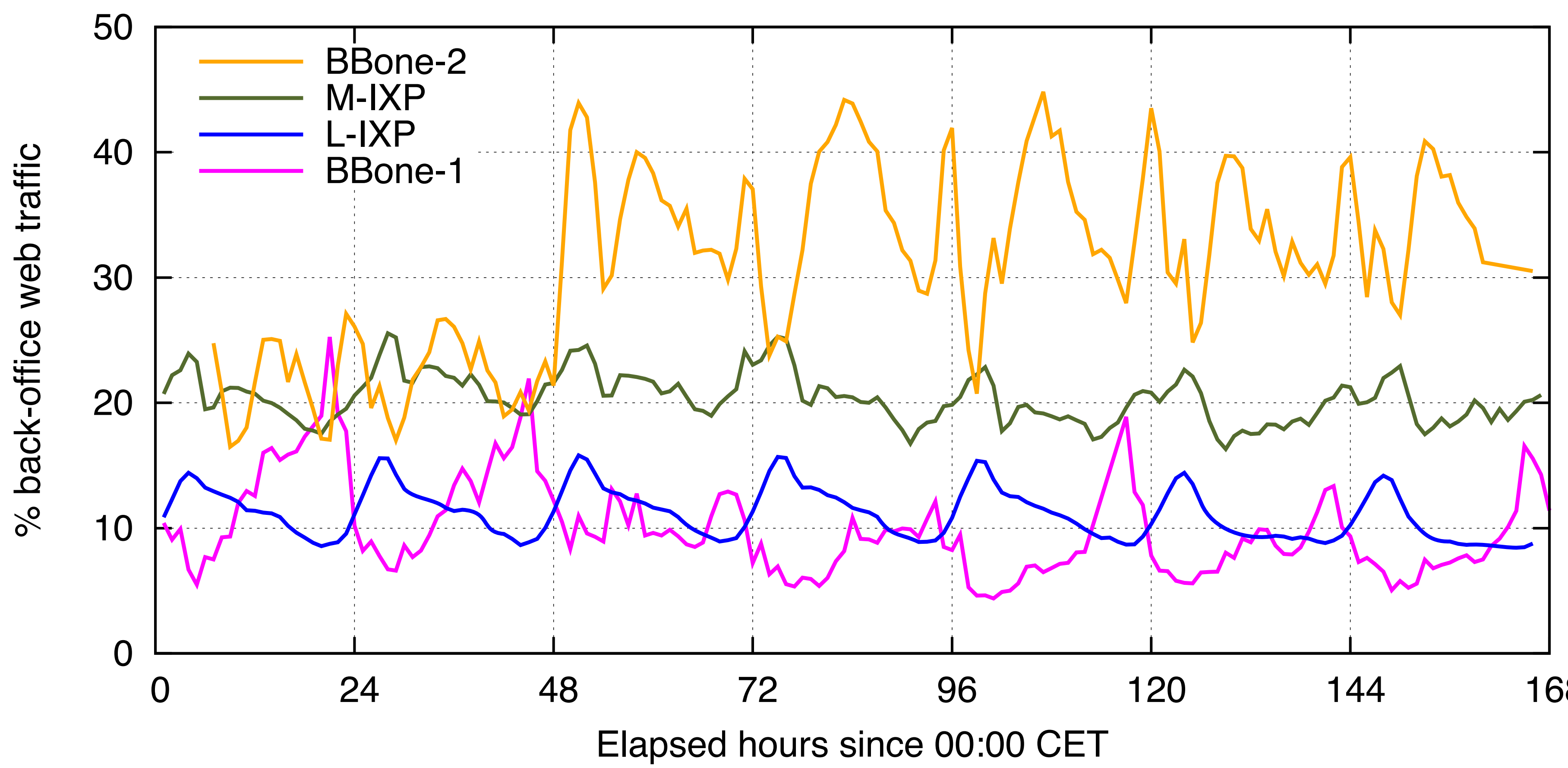




% of web traffic that is “back office” in 4 ISP, IXP data sets

Google's WAN (2011)

"B4: Experience with a Globally-Deployed Software Defined WAN"
Jain et al., ACM SIGCOMM 2013

"B4 has been in deployment for three years, now carries more traffic than Google's public facing WAN, and has a higher growth rate."

Recall: Classic TE solutions

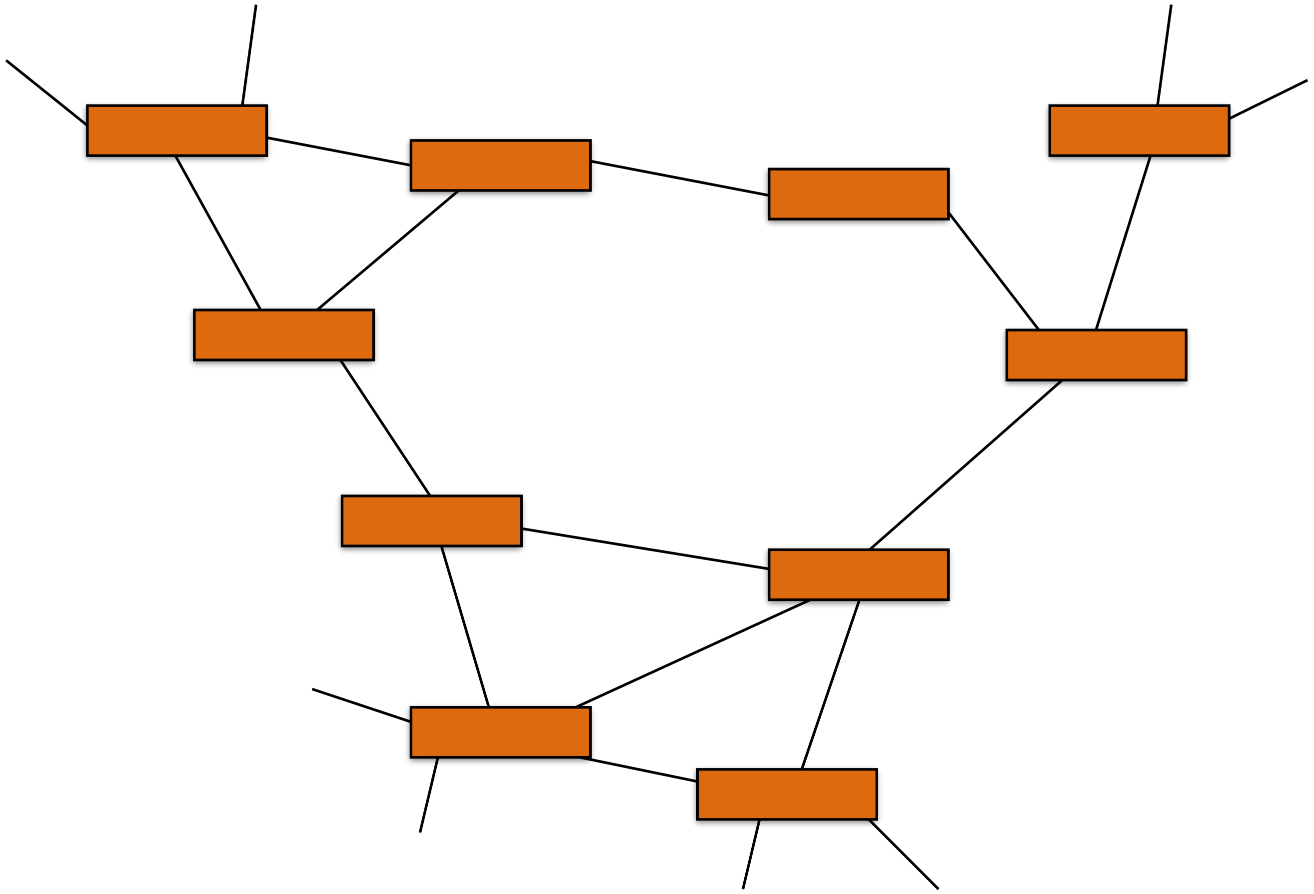
Approach 1: Optimize OSPF weights

- e.g. OSPF-TE
- Need to propagate everywhere: can't change often
- Artificial constraints make it difficult to optimize
  - Same weights apply to all traffic
  - So all traffic at one ingress follows same paths

Approach 2: Allocate traffic to explicit MPLS paths

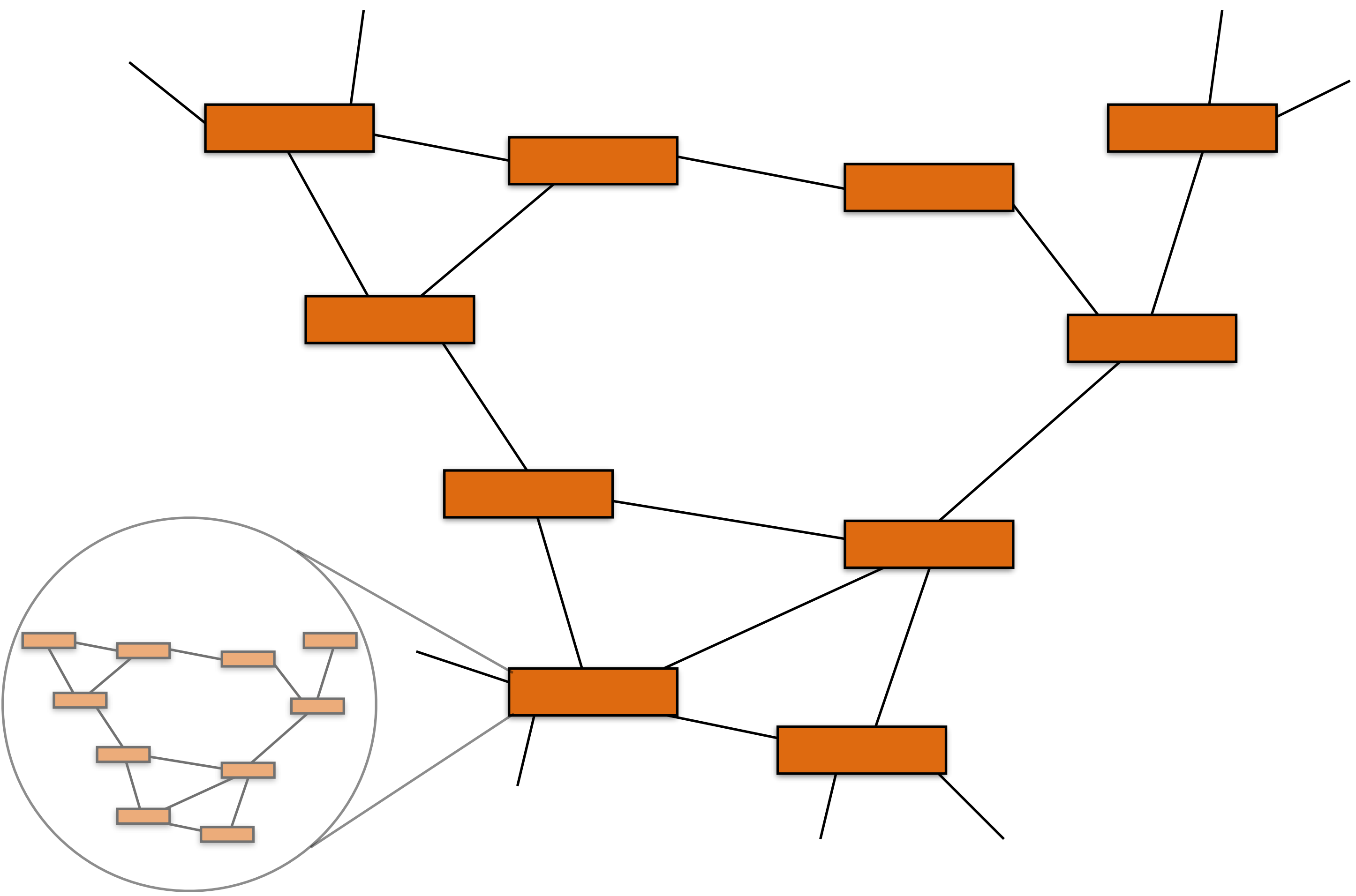
- Control protocol like RSVP-TE reserves capacity and constructs MPLS tunnels at each router along path
- Tradeoff: improves path choice but also state in routers
  - Not all possible paths will be available

Recall: MPLS with RSVP-TE



[Slide Credit: Ankit Singla]

Recall: MPLS with RSVP-TE



1 Link-state protocol (OSPF / IS-IS)

[Slide Credit: Ankit Singla]

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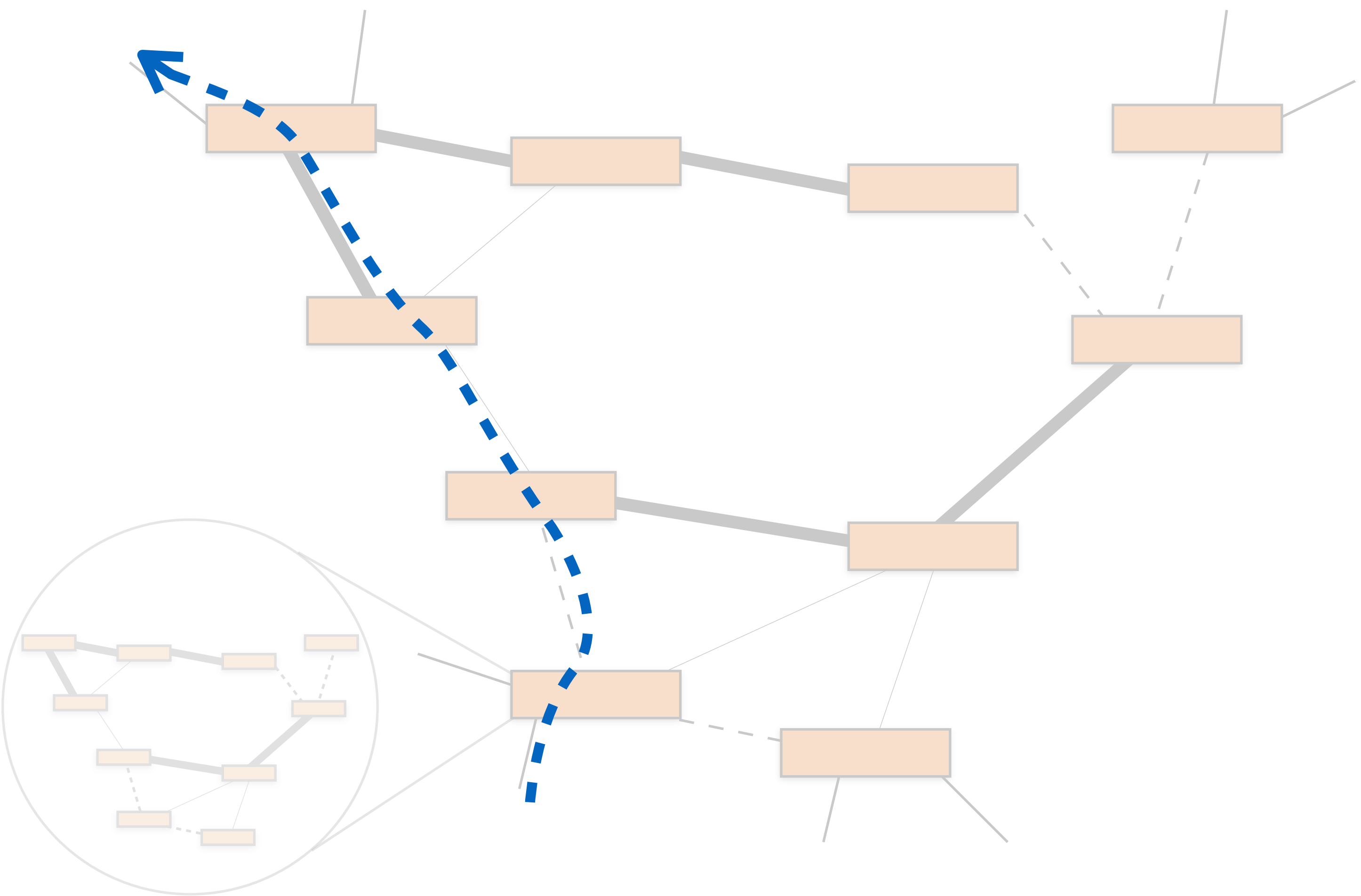

1. Link-state protocol (OSPF / IS-IS)
2. Also flood available bandwidth info
3. Fulfill tunnel provisioning requests

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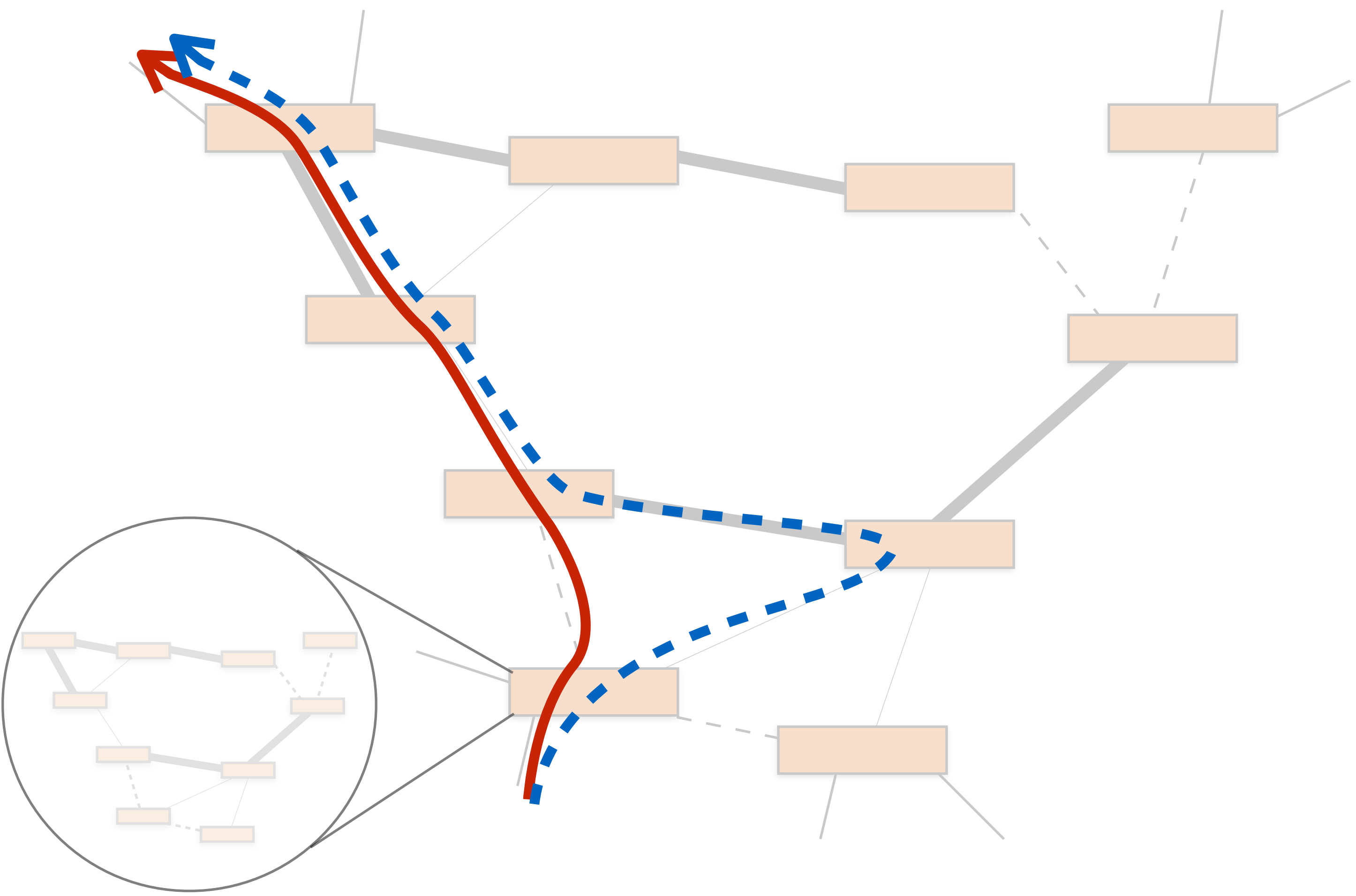

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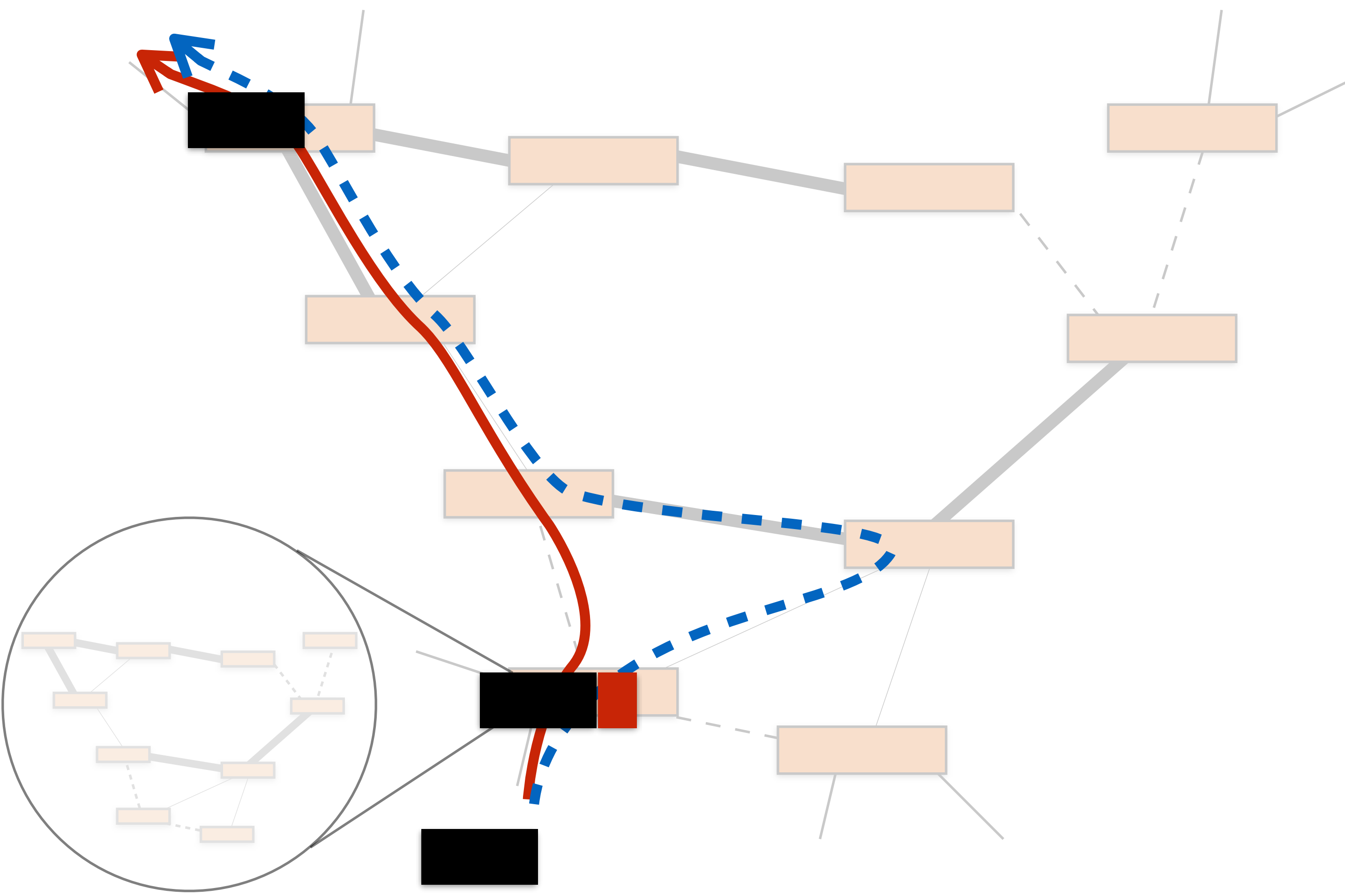

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Problem 1: inefficiency

ACM SIGCOMM, 2013

Achieving High Utilization with Software-Driven WAN

Chi-Yao Hong (UIUC) Srikanth Kandula Ratul Mahajan Ming Zhang
Vijay Gill Mohan Nanduri Roger Wattenhofer (ETH)
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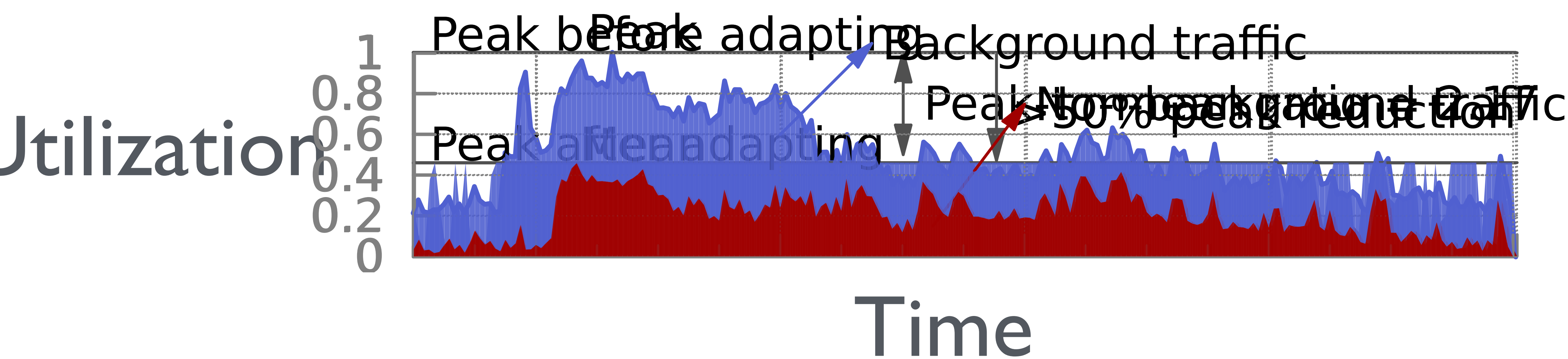
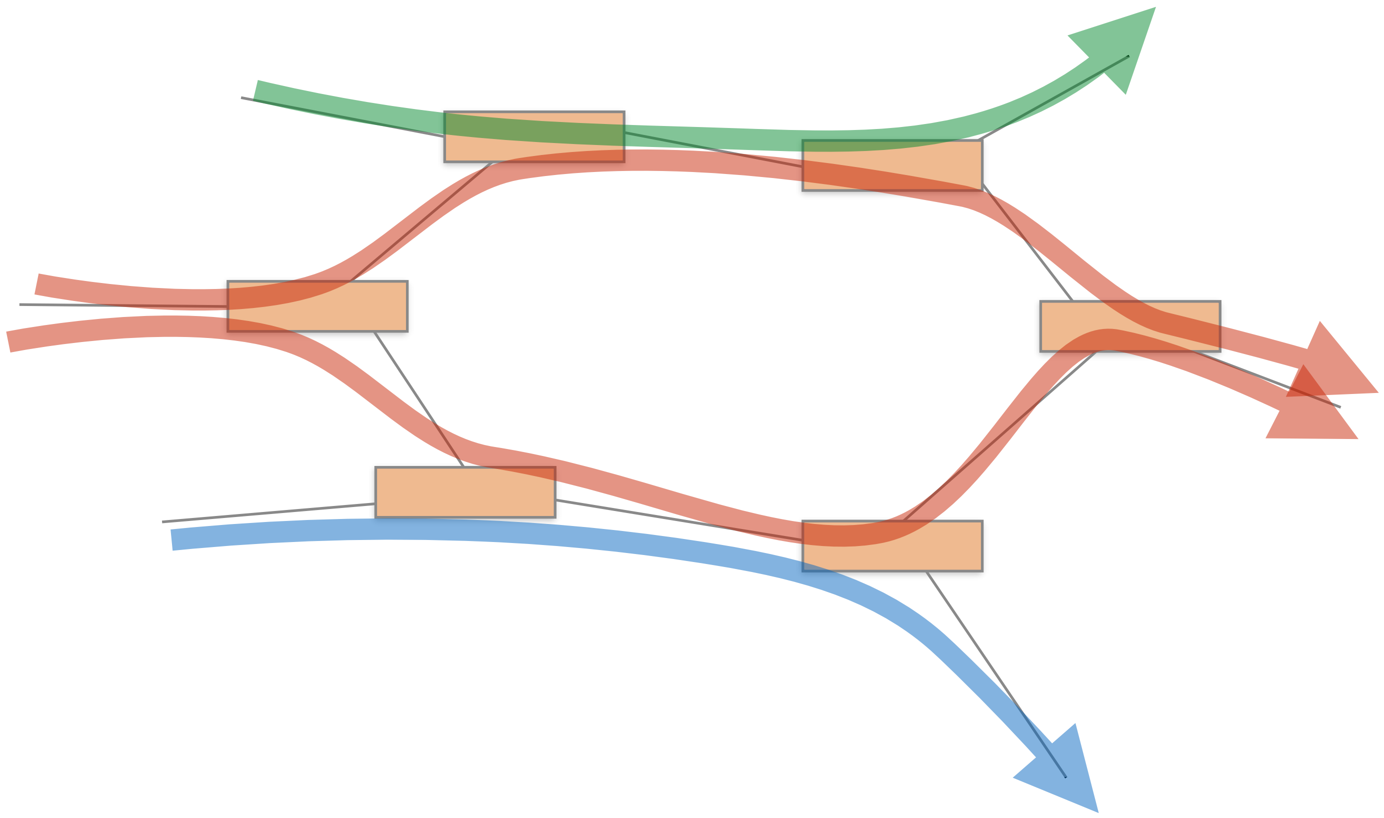


Problem 2: inflexible sharing



2x the bandwidth!

B4 key design decisions

[Jain et al., SIGCOMM 2013]

Separate hardware from software

B4 routers custom-built from merchant silicon

Drive links to 100% utilization

Centralized traffic engineering

Google's B4

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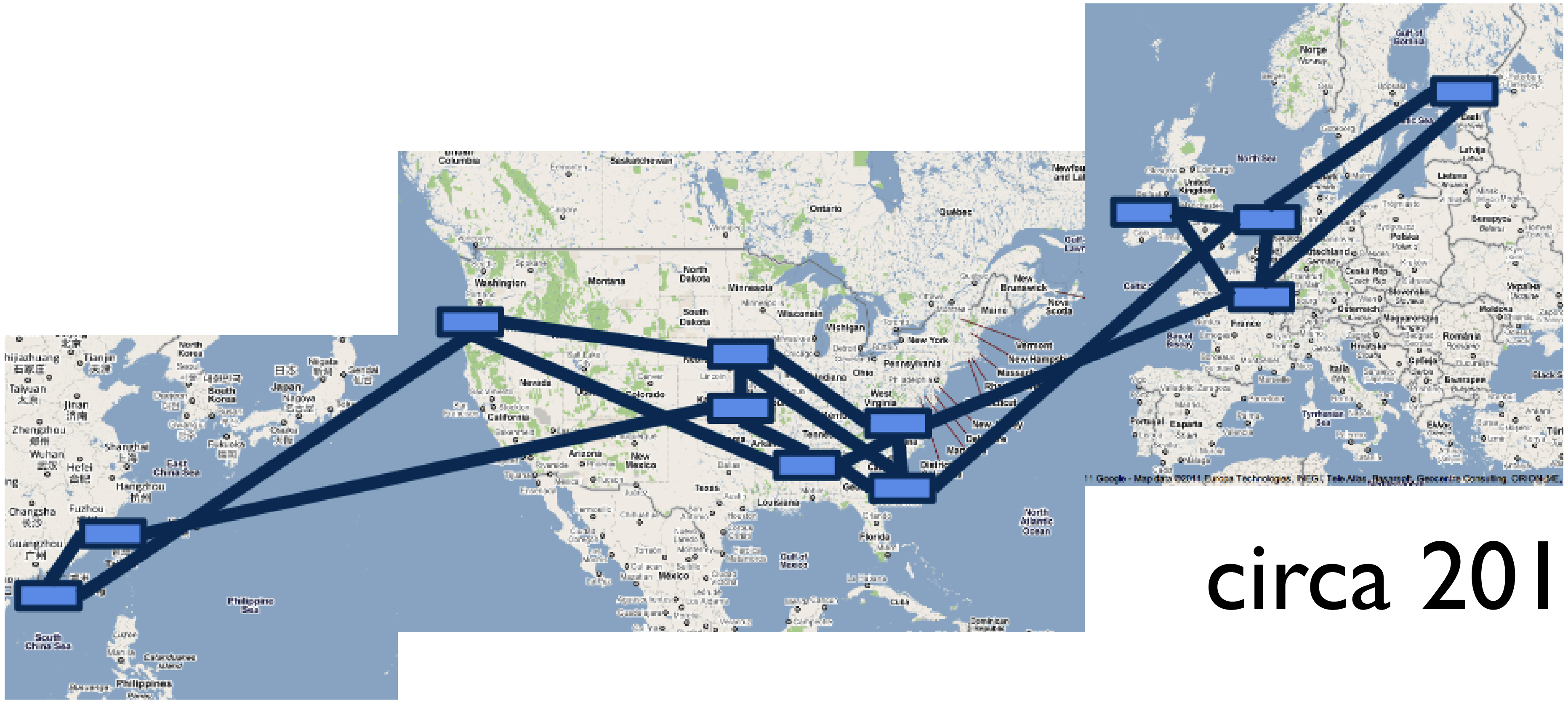

circa 2011

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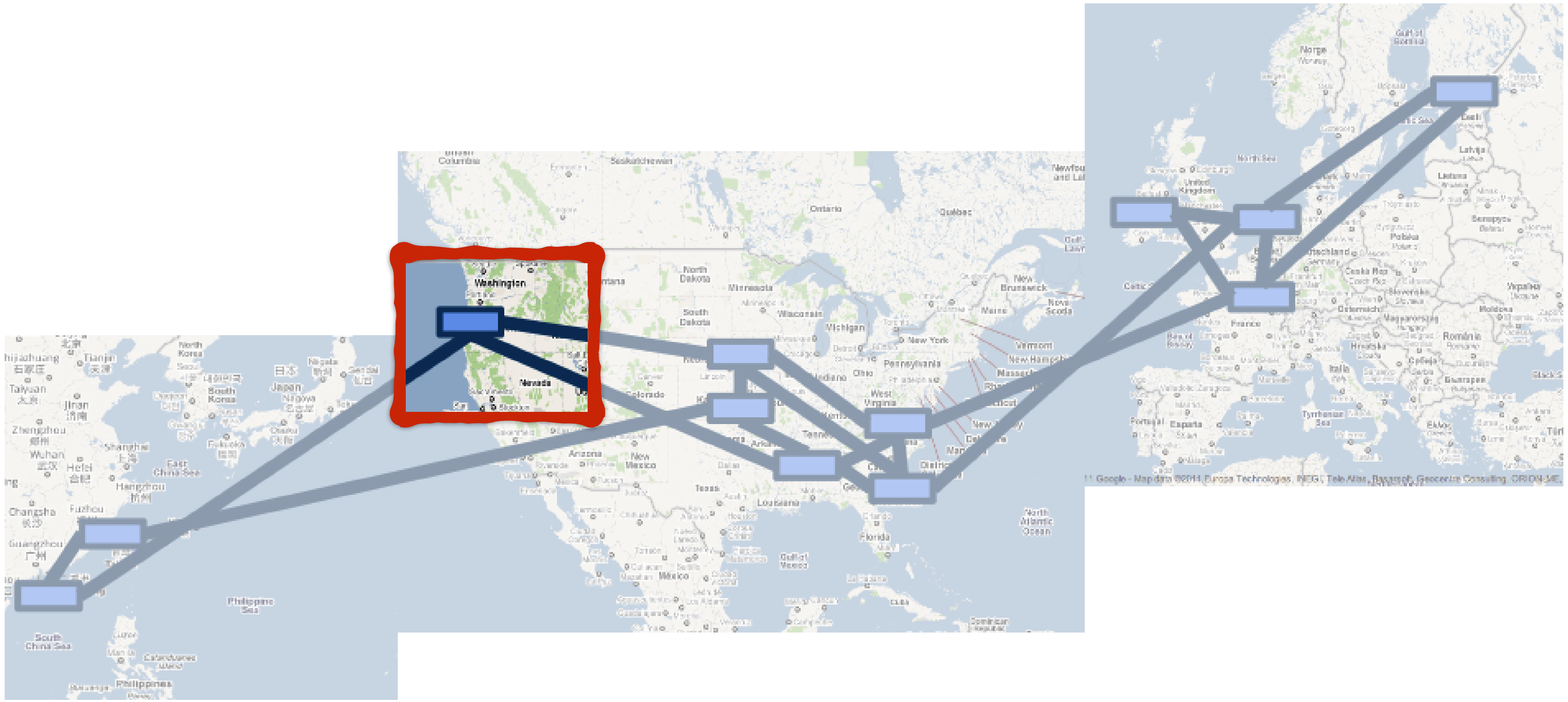
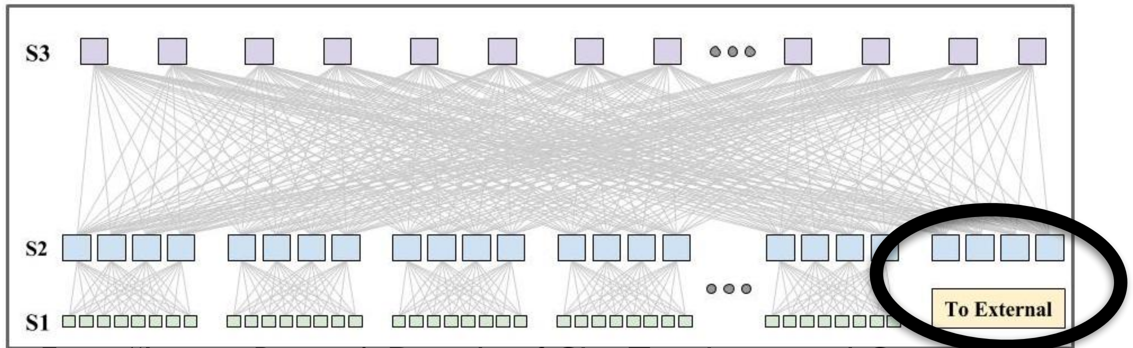
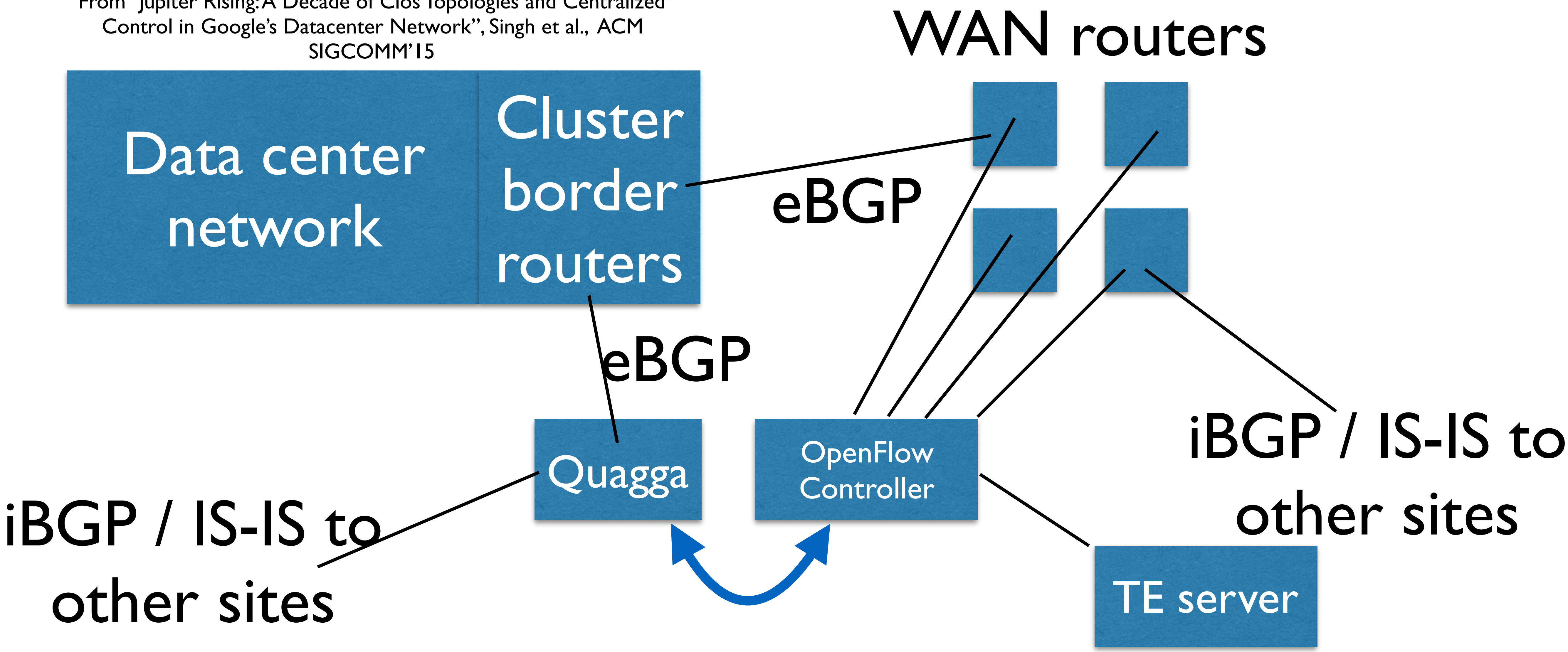


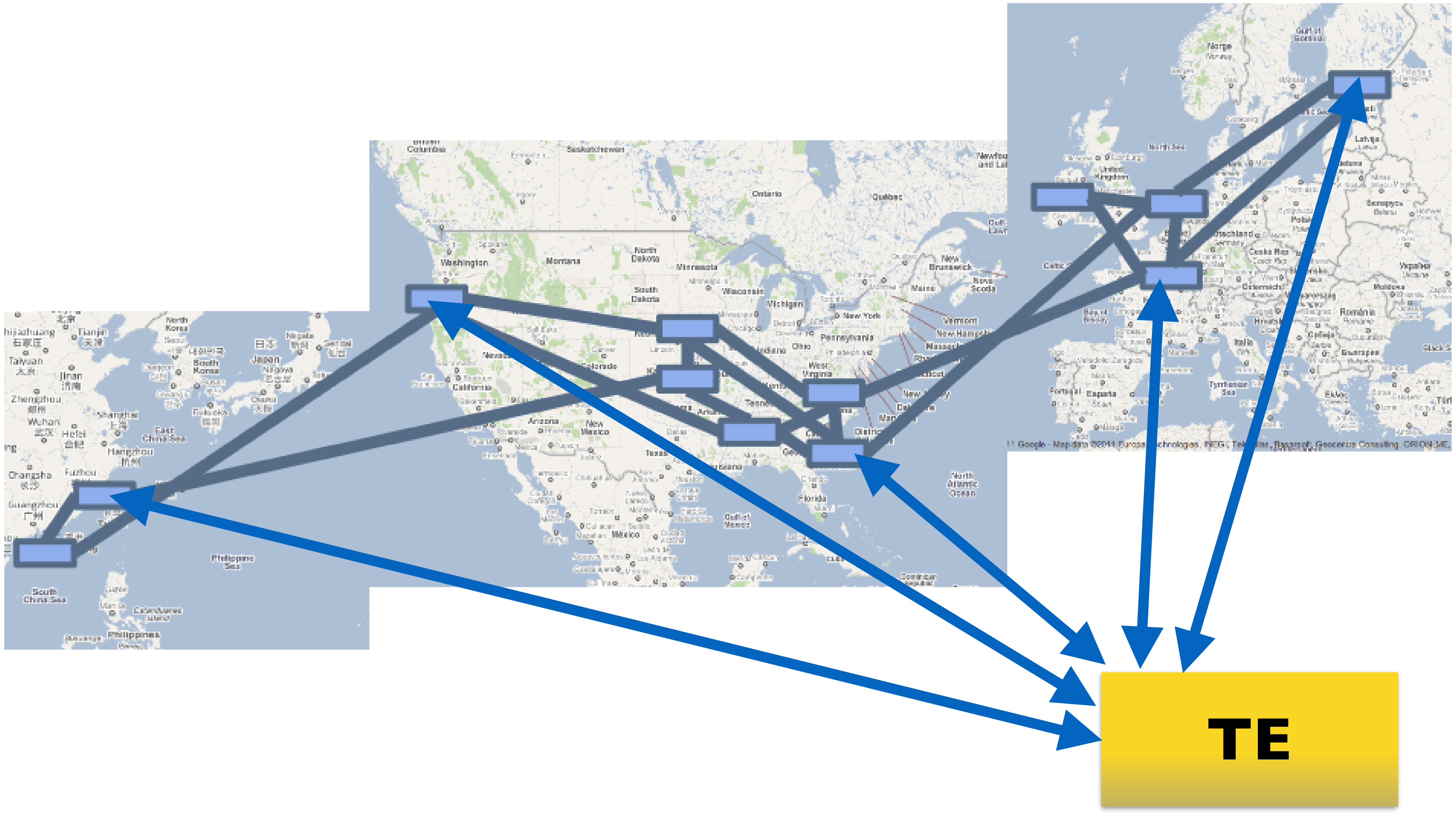
Google's B4: view at one site



From "Jupiter Rising: A Decade of Clos Topologies and Centralized Control in Google's Datacenter Network", Singh et al., ACM SIGCOMM'15



Google's B4: Traffic engineering



Vs. Semi-Distributed TE

What aspects of B4 would have been difficult with MPLS-based TE such as TeXCP?

What aspects of B4 are similar to TeXCP?

Small group discussion

1 How does B4 scale?

- Subsecond centralized scheduling of more traffic than Google's public WAN serves!

2 What does B4 assume about network's traffic?

- In what environments would these assumptions be violated?
- In what other environments would they be valid?

How does B4 scale?

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Hierarchy

- Not a simple controller-to-switch design!

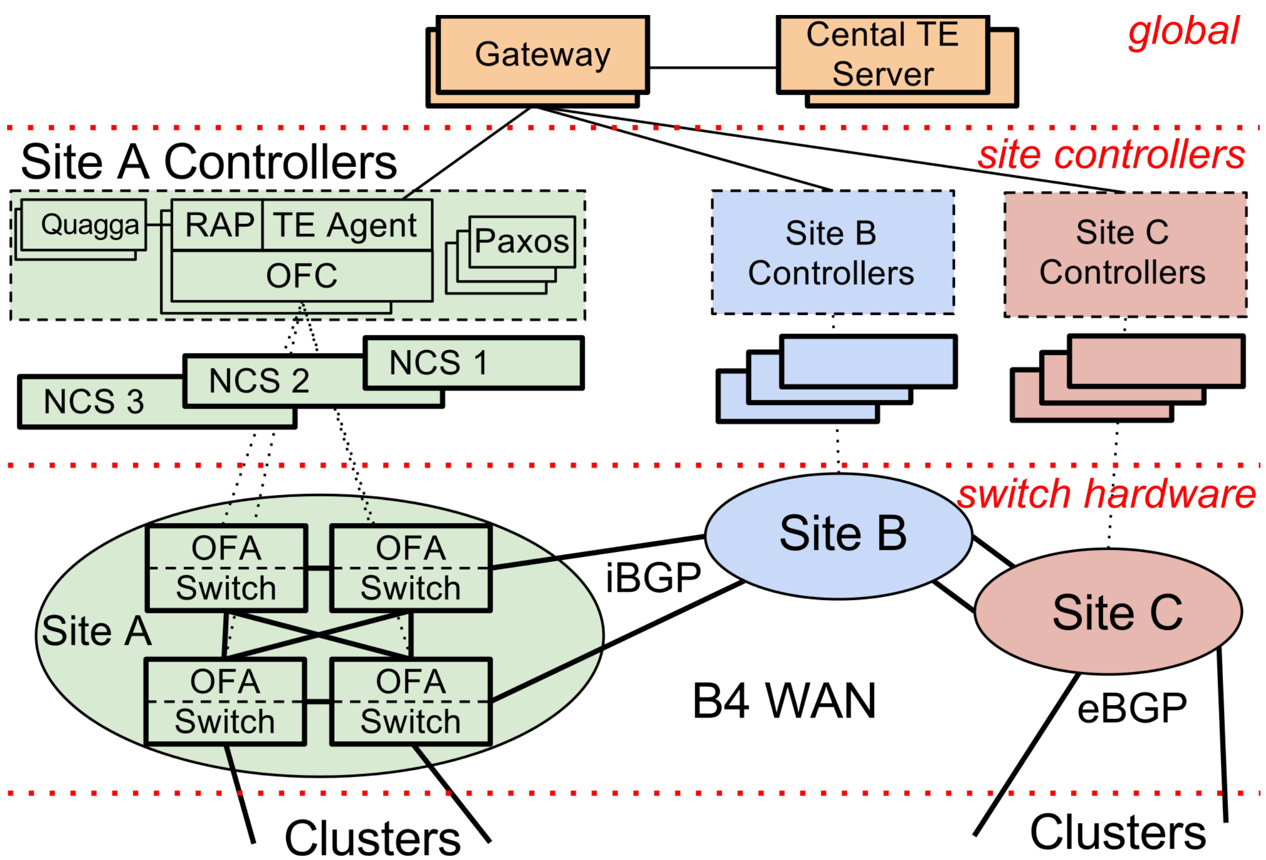

Figure 2: B4 architecture overview.

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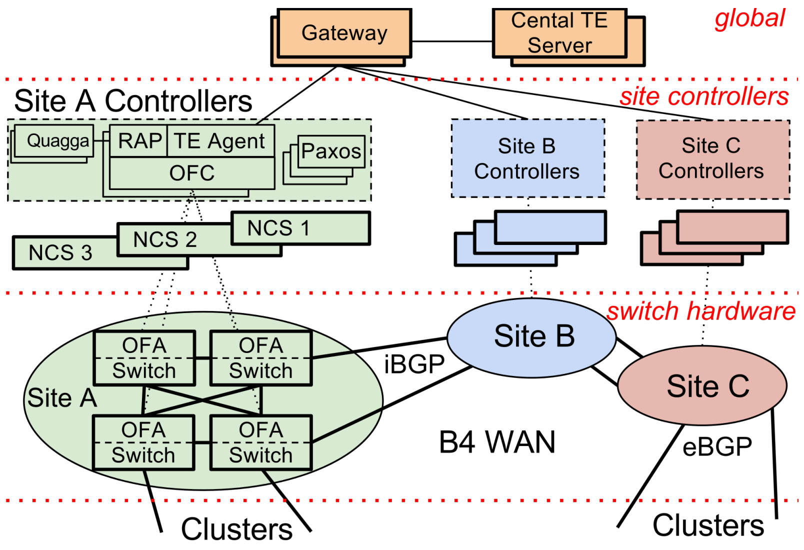

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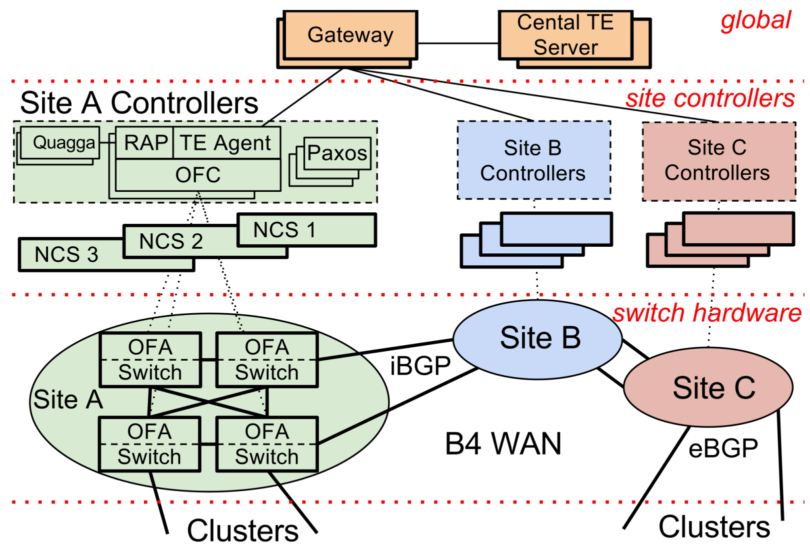
Aggregation

- Node = site (data center)
- Link = 100s of links
- Flow group = {src, dst, QoS} tuple



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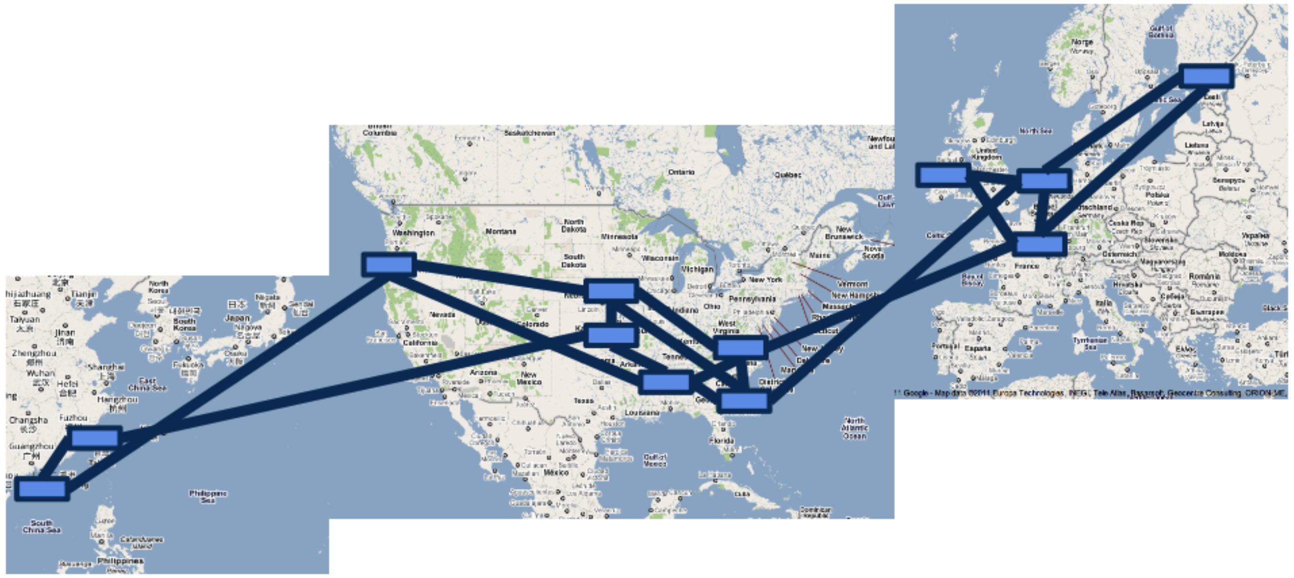

Figure 1: B4 worldwide deployment (2011).

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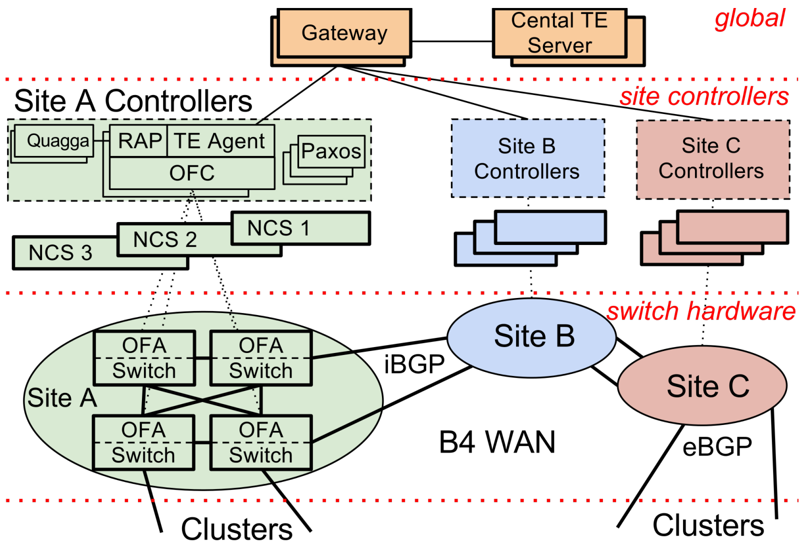
Algorithms

- Greedy heuristic approximation algorithm



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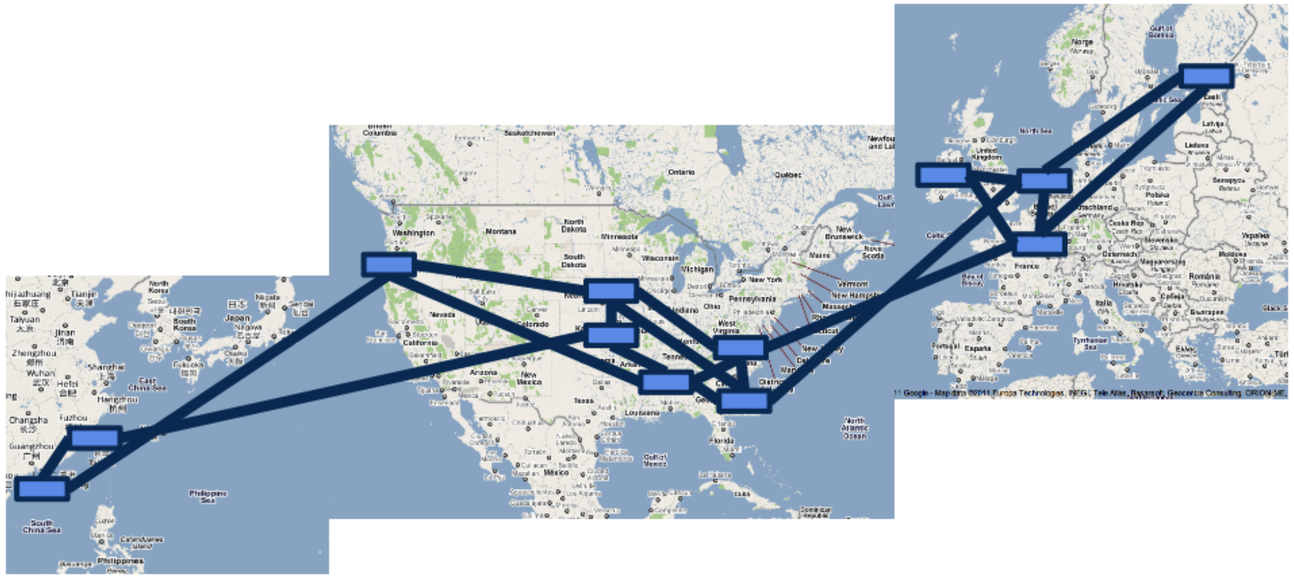

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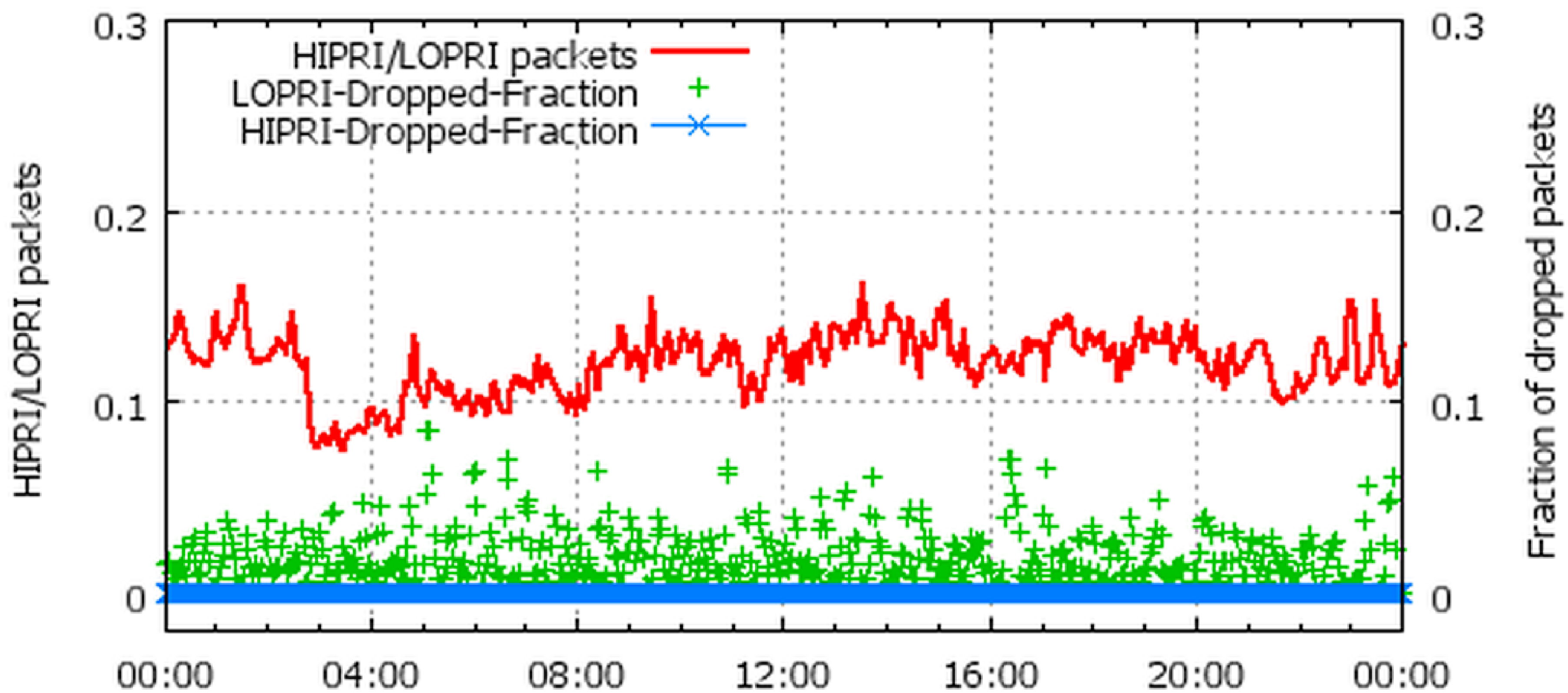
What assumptions about traffic?

Design makes what assumption about traffic to approach 100% utilization on some links?

- High priority traffic is in the minority
- Elastic traffic is the majority (backups, offline data analytics, ...)



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When would that assumption be violated?

- Google's user-facing wide area network

Microsoft's SWAN

ACM SIGCOMM, 2013

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