Lecture 9: SDN Applications

CS 234 / NetSys 210: Advanced Computer Networks

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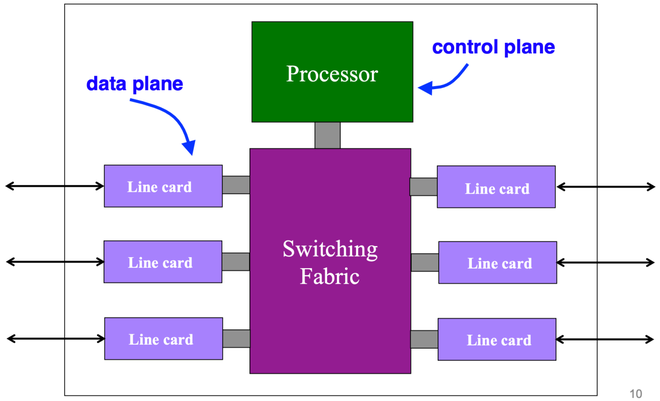
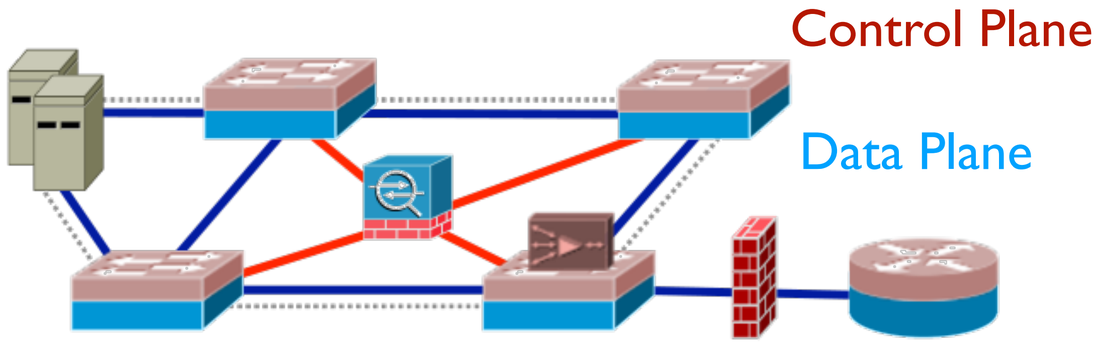
This lecture uses material from Google B4 and Arpit Gupta

Two Planes of Networking

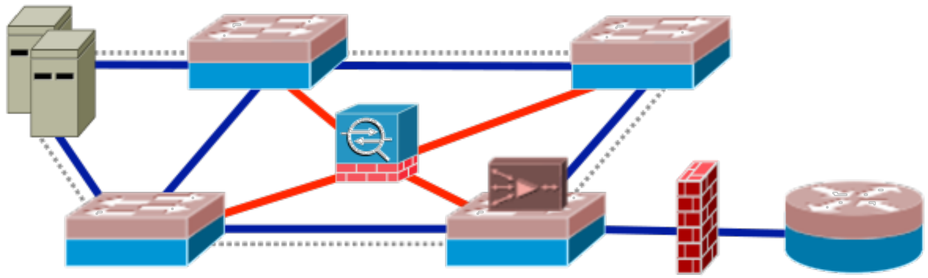
- Data plane: forwarding packets
  - Based on local forwarding state
- Control plane: computing that forwarding state
  - Involves coordination with rest of system

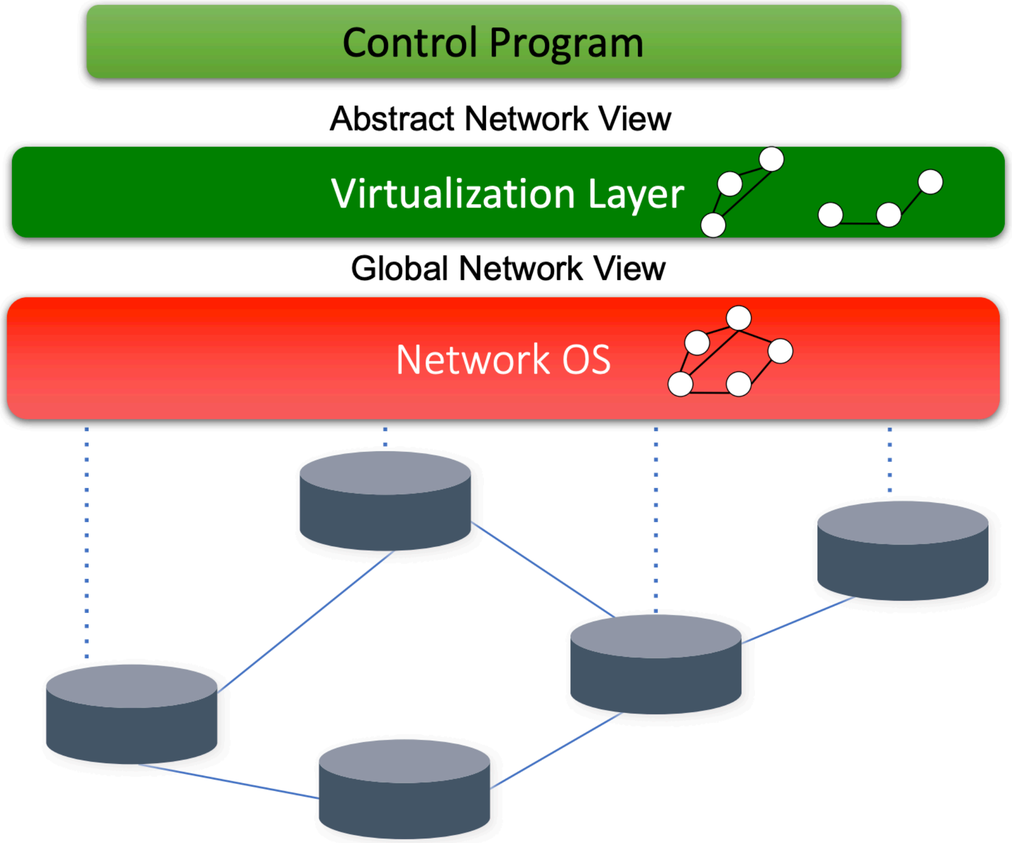




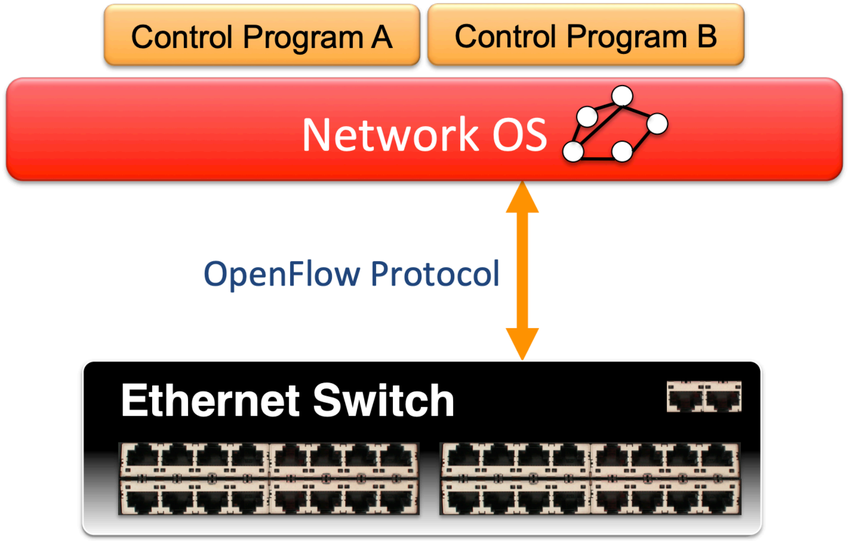
Traditional Networks

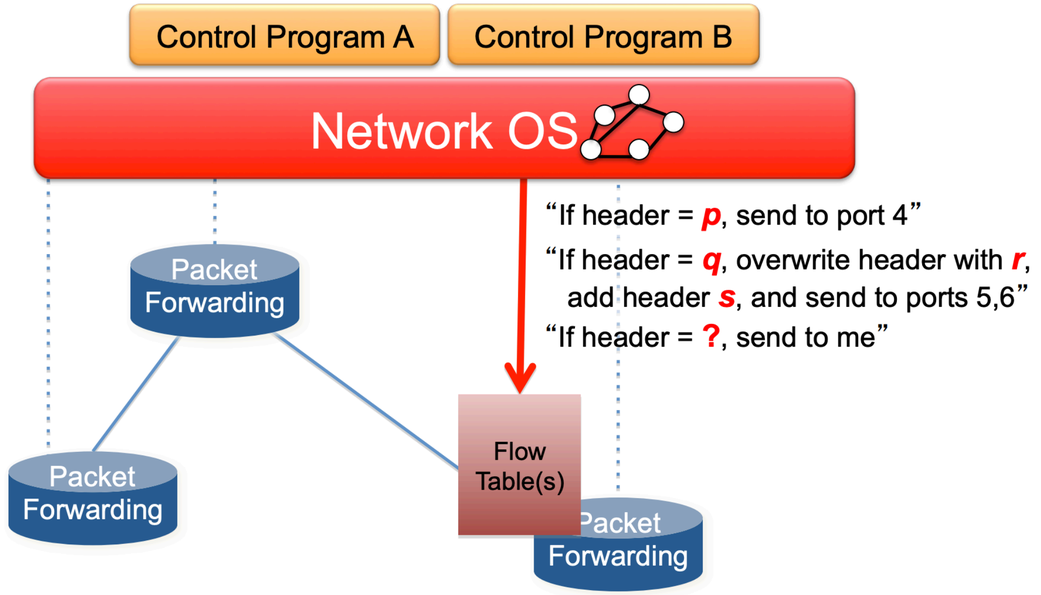
Traditional vs. Software Defined Networks





OpenFlow

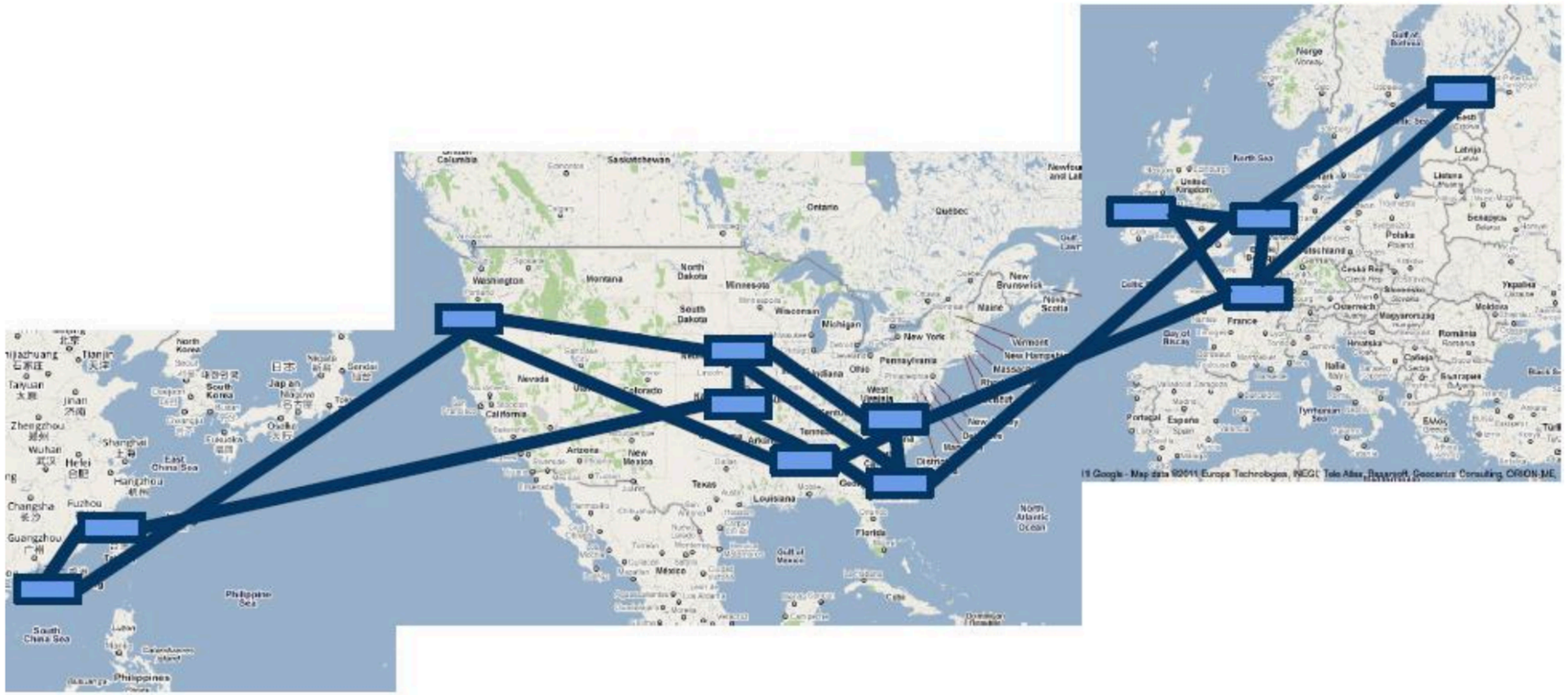

Control Program A
Control Program B
Network OS
OpenFlow Protocol
Ethernet Switch


Control Program A
Control Program B
Network OS
"If header = p, send to port 4"
"If header = q, overwrite header with r,
add header s, and send to ports 5,6"
"If header = ?, send to me"
Packet Forwarding
Packet Forwarding
Flow Table(s)
Packet Forwarding

B4: Experience with a Globally-Deployed Software Defined WAN

[SIGCOMM'13]

Google’s WAN


Washington
Montana
North Dakota
Minnesota
South Dakota
Wisconsin
Michigan
New York
Pennsylvania
Ohio
Nevada
California
Arizona
New Mexico
Texas
Louisiana
Florida
Mexico
Gulf of Mexico
North Atlantic Ocean
Ontario
Quebec
Sasketchewan
Columbia
Maine
Vermont
Japan
South Korea
North Korea
Philippine Sea
South China Sea
Philippines
Norge
Polska
Deutschland
France
España
Portugal
Italia
Österreich
Magyarország
România
Česká Rep.
Беларусь
Україна
Latvija
Lietuva
North Sea
Tyrrhenian Sea
Ελλάς
Türkiye
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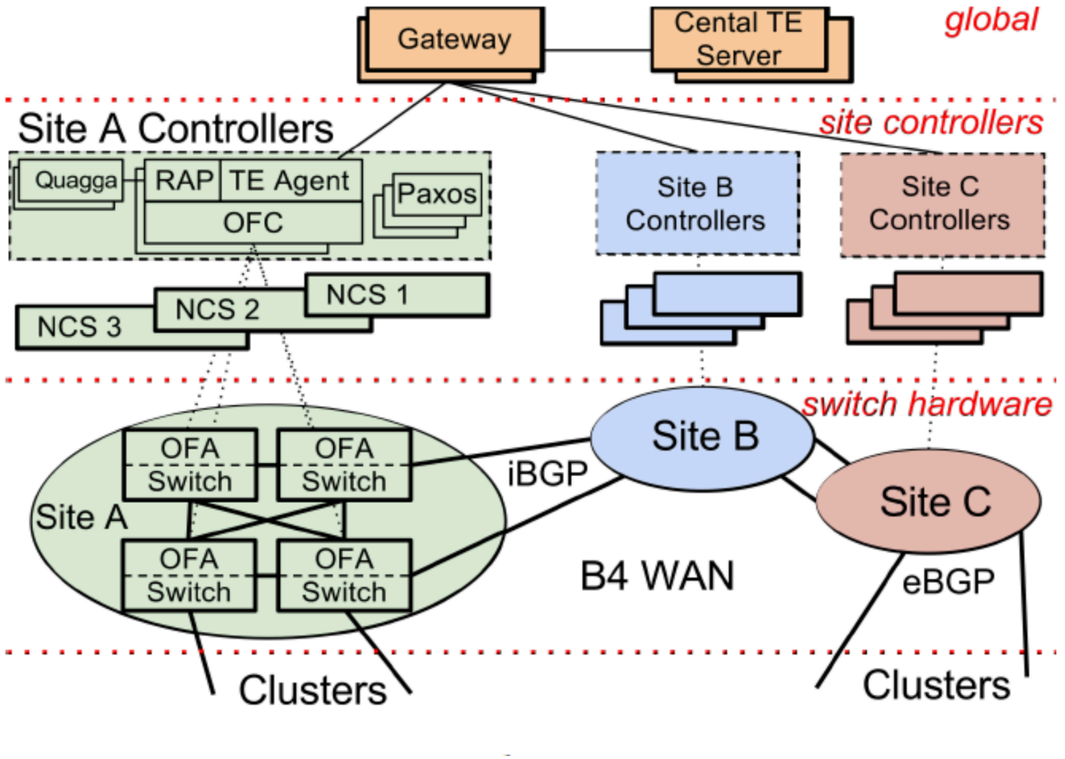
Traditional WAN vs. Google WAN

- Traditional WAN routing
  - Treat all bits the same
  - 30-40% average utilization
  - High-end routing gear
- Google WAN
  - More control over applications and routers
  - Some bandwidth intensive applications with deadline flexibility
  - Limited number of sites

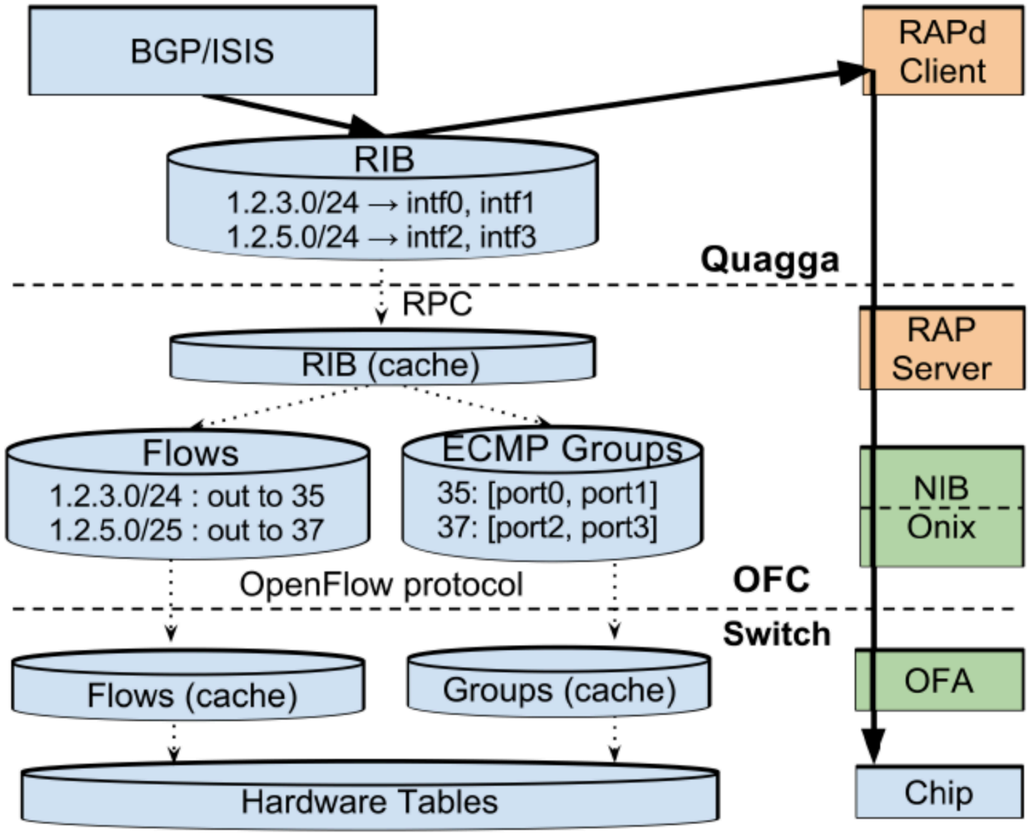
B4 Goals

- Increase WAN utilization close to 100%
- Decrease cost of bandwidth-provisioning while also providing reliability
- Cost-efficiency

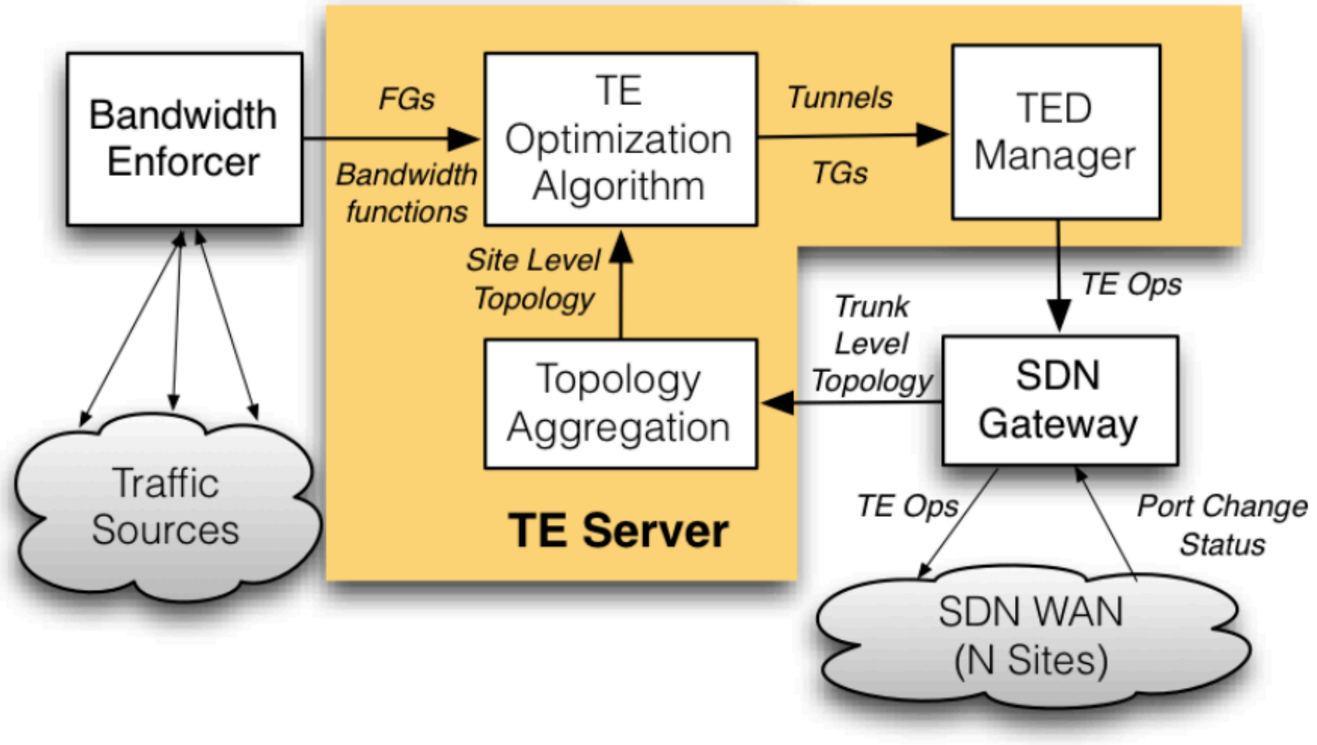
B4 Architecture Overview



Integrating Routing with OpenFlow Control in B4



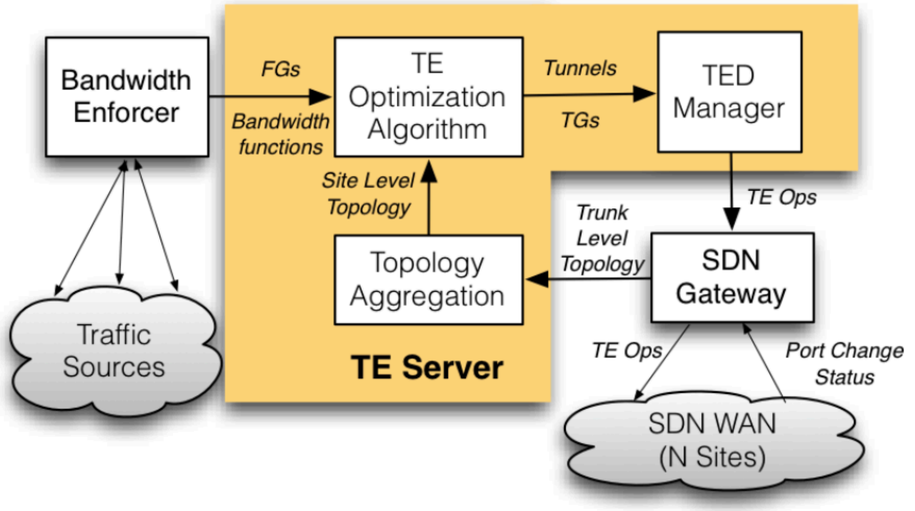
B4 Traffic Engineering Overview



Applications are aggregated to Flow Group: {source site, dest site, QoS}

TE Optimization Algorithm

- **Tunnel Selection** selects the tunnels to be considered for each FG.
- **Tunnel Group Generation** allocates bandwidth to FGs using bandwidth functions to prioritize at bottleneck links.
    - Max-min fairness
- **Tunnel Group Quantization** changes split ratios in each FG to match the granularity supported by switch hardware tables.



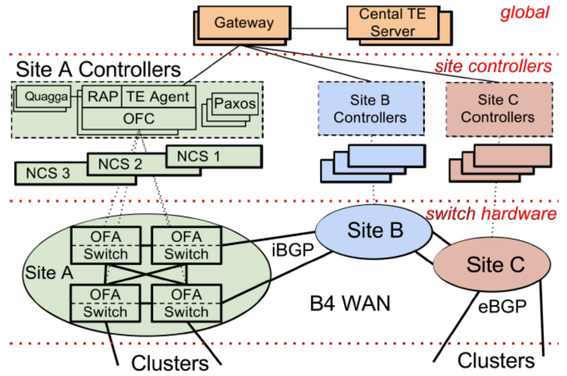
TE as Overlay

~~Integrated, centralized service combining routing and traffic engineering?~~

Traffic Engineering (central)

Standard Routing (ISIS) (per switch)

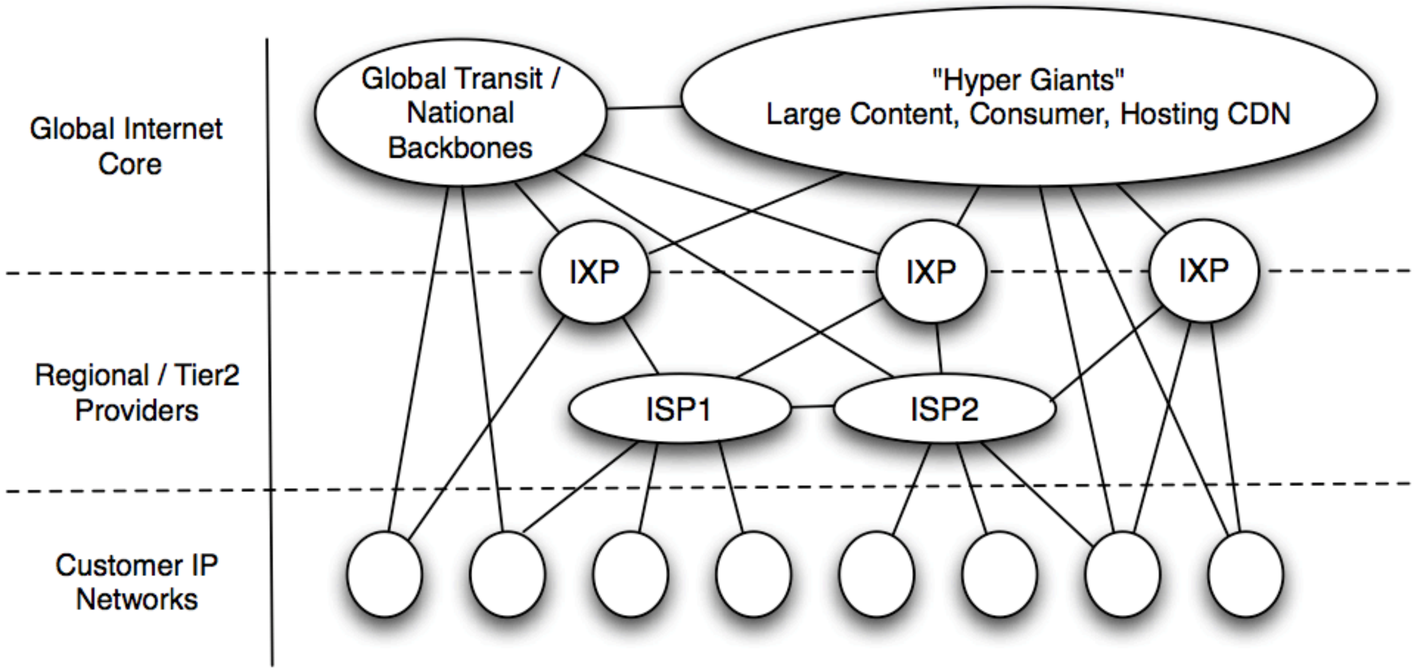
"**Big red button**": disable TE service and fall back to shortest-path forwarding at any time



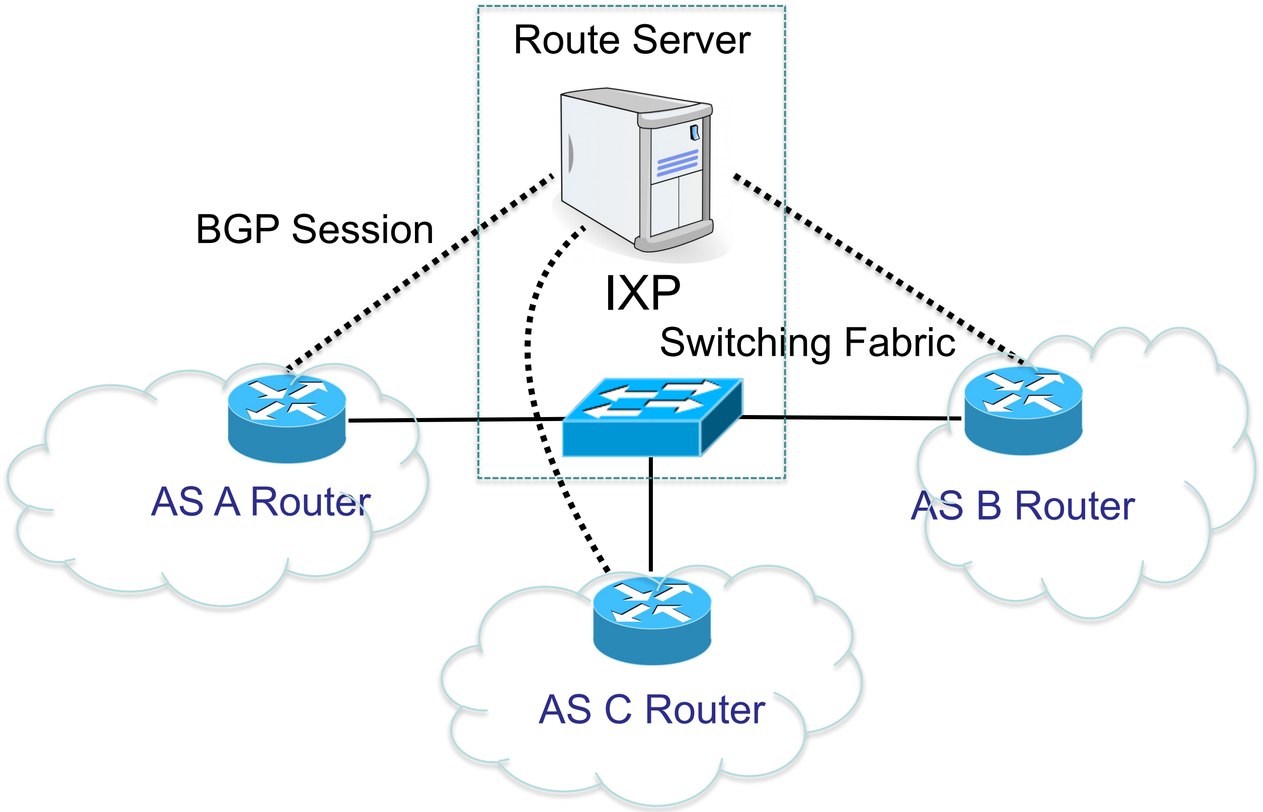
SDX: A Software-Defined Internet Exchange

[SIGCOMM'14]

Interdomain Ecosystem



Conventional IXPs



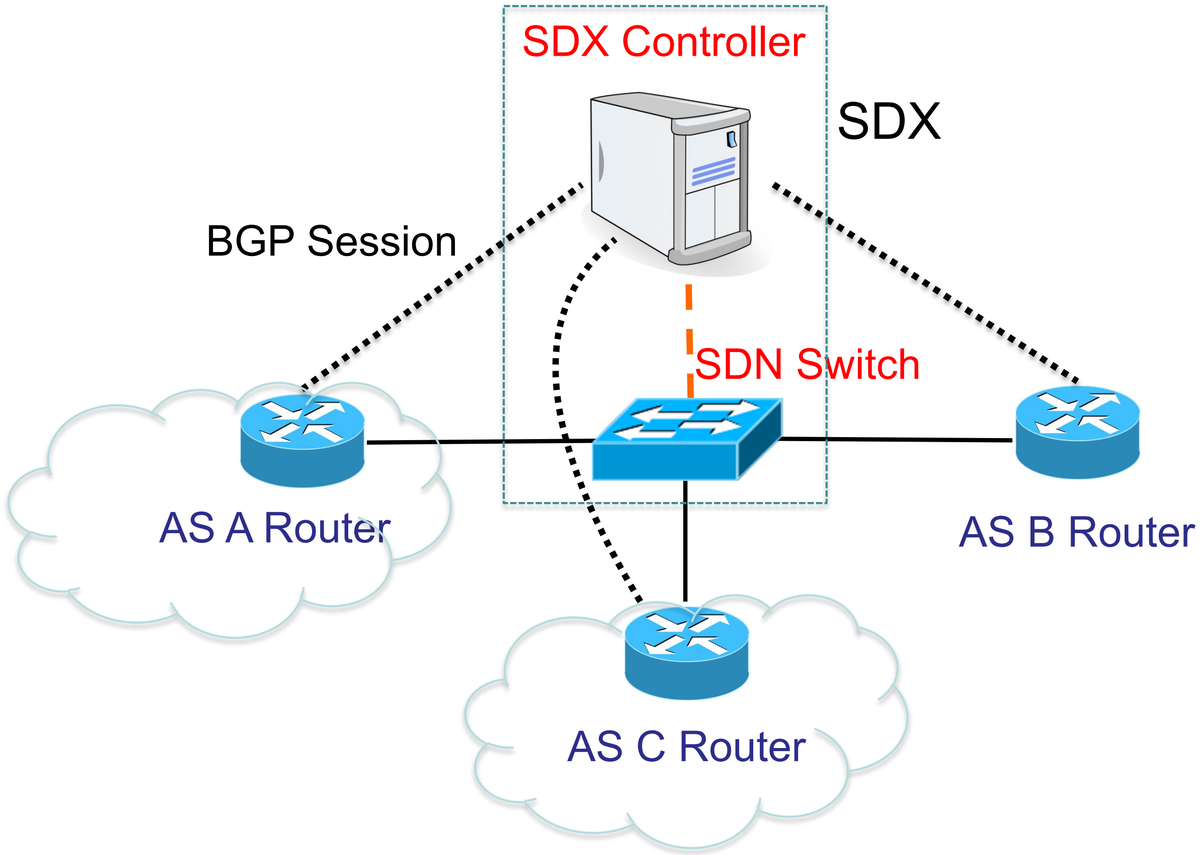
Conventional IXP Shortcomings

- Routing only on destination IP prefixes
  (No customization of routes by application, sender)

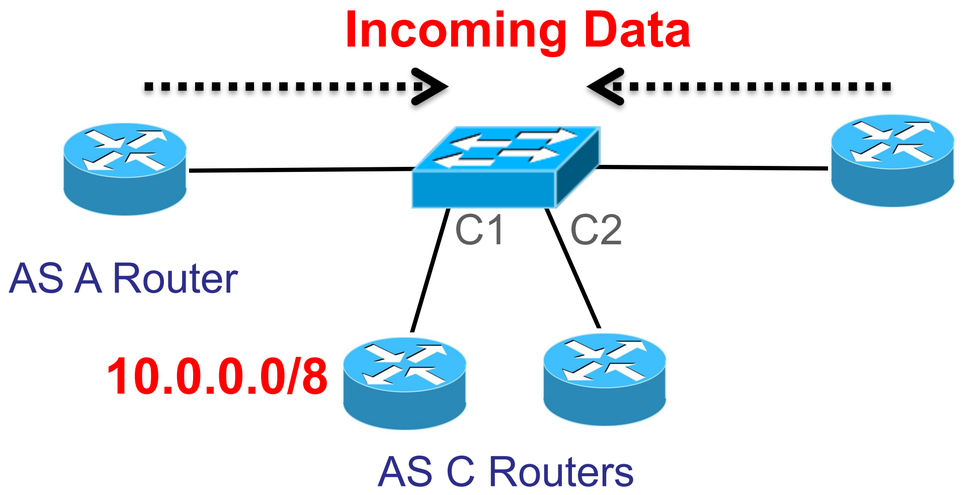
- Can only influence immediate neighbors
  (No ability to affect path selection remotely)

- Indirect control over data-plane forwarding
  (Indirect mechanisms to influence path selection)

SDX = SDN + IXP

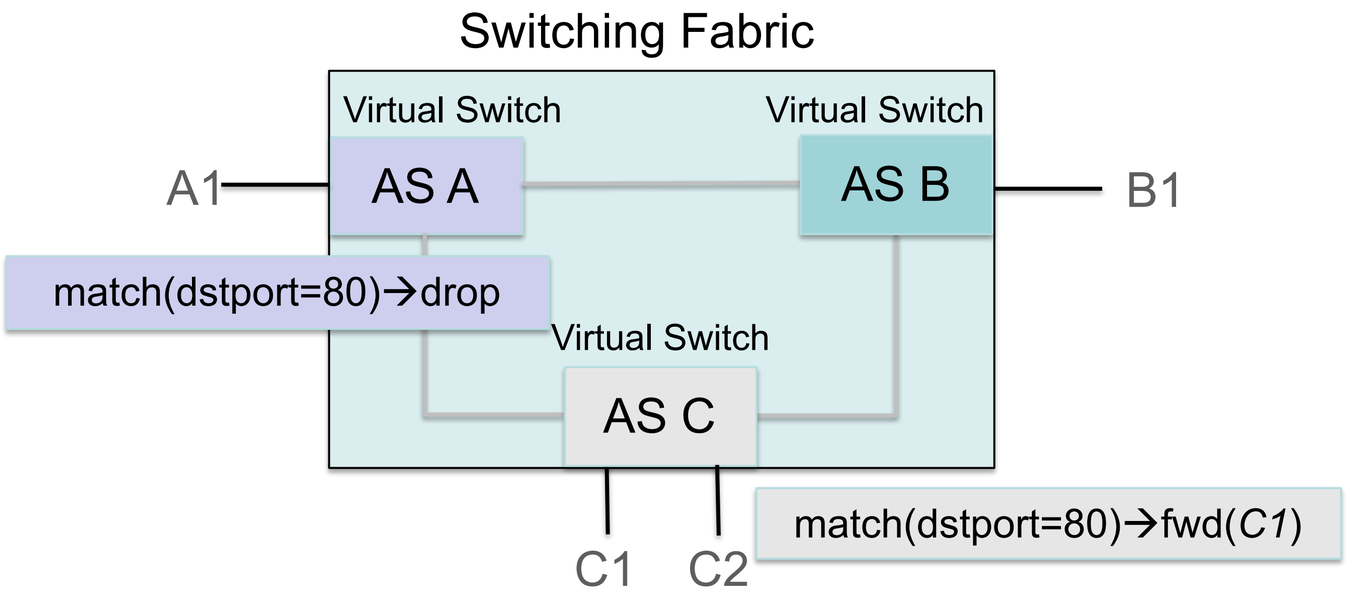

SDX Controller
SDX
BGP Session
SDN Switch
AS A Router
AS B Router
AS C Router

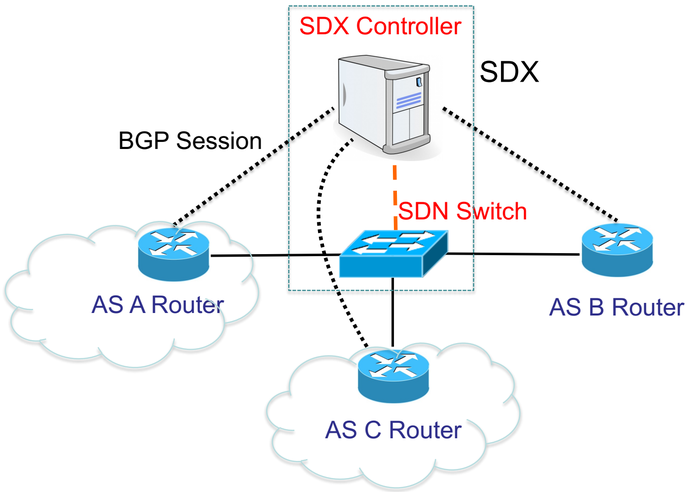
Use Case: Inbound Traffic Engineering



Incoming Traffic	Out Port	Using BGP	Using SDX
dstport = 80	C1	?	match(dstport =80)→ fwd(C1)

Virtual Switch Abstraction





SDN for Interdomain Routing

- Forwarding on multiple header fields
  (not just destination IP prefixes)

- Ability to control entire networks with a single software program
  (not just immediate neighbors)

- Direct control over data-plane forwarding
  (not indirect control via control-plane)

Other Applications

SDN Applications

- Cellular Edge (Central Office) Fine-grained Control (easier traffic monitoring, reduced latency, etc.)
- SDN control of Radio Access Network
- Improving QoS (WAN, cloud)
- Security applications

Thanks!