Hybrid Circuit/Packet Networks with Dynamic Capacity Partitioning

Chaitanya S. K. Vadrevu

University of California, Davis

svadrevu@ucdavis.edu

Pune, India, 13 – 15 December 2010

IP over WDM Networks

Logical Topology
IP Topology

IP Layer

IP Services

IP Router

Optical Layer

Physical Topology

Wavelength Services

OXC

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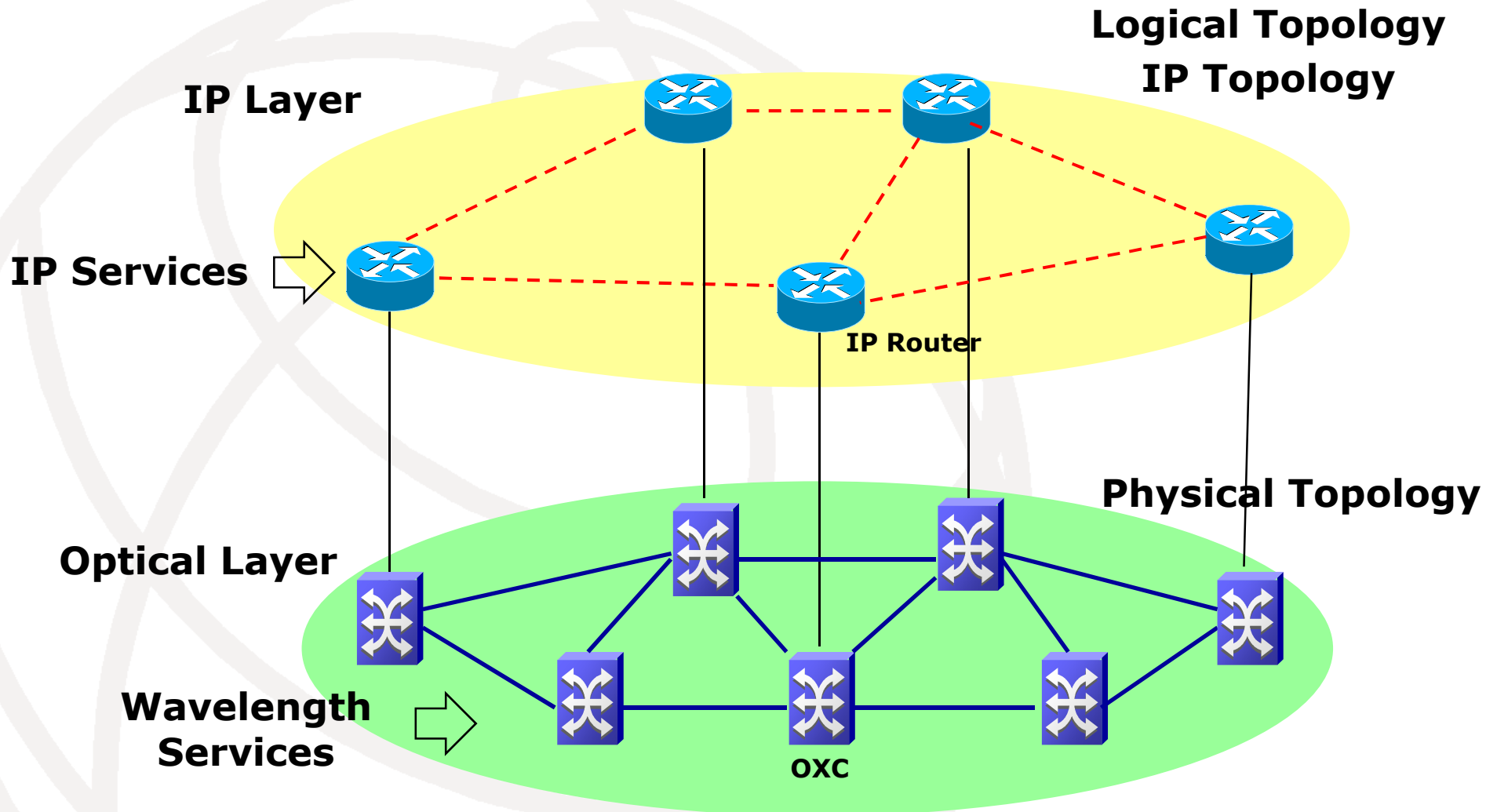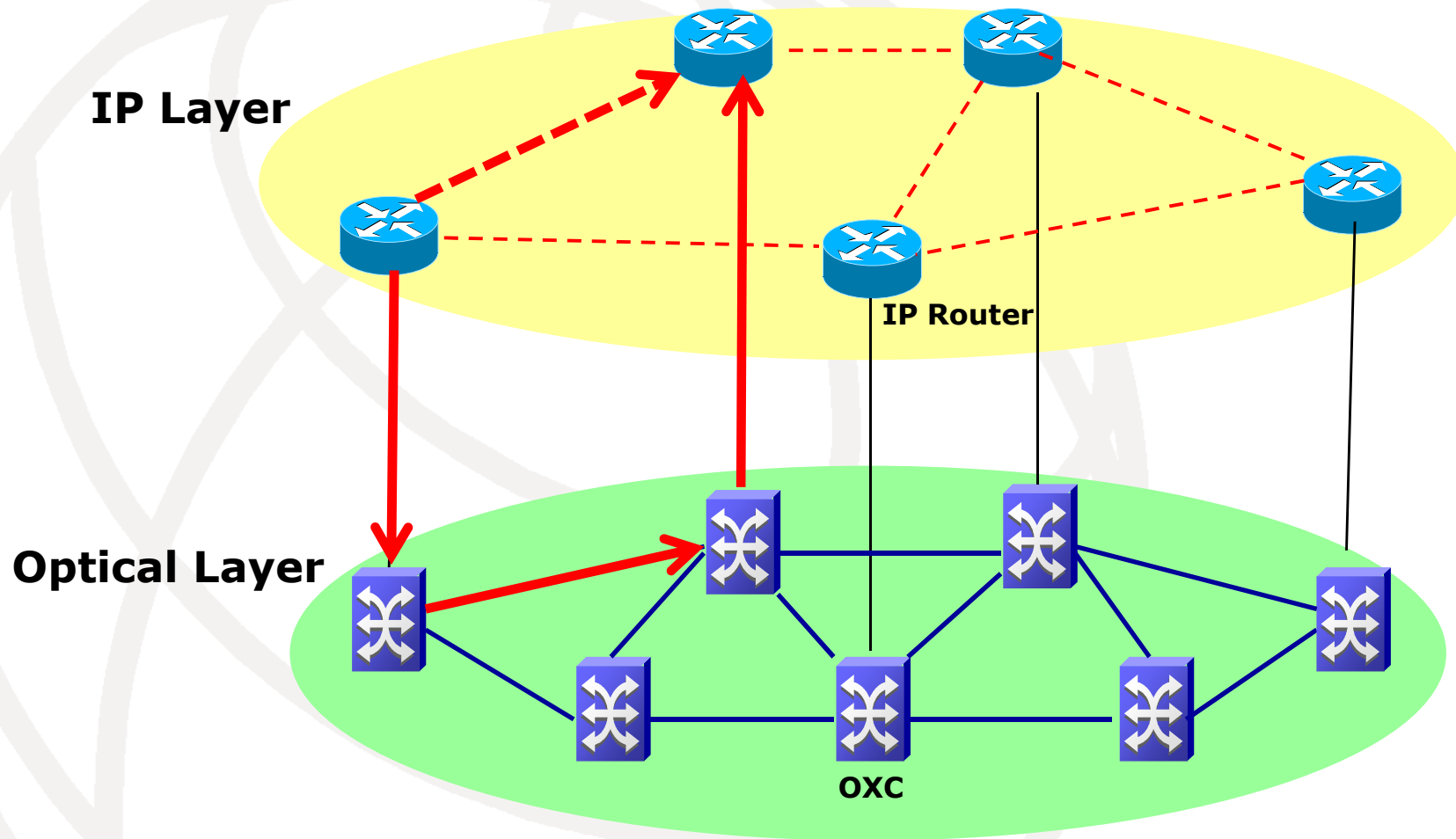ITU-T Kaleidoscope 2010 – Beyond the Internet? Innovations for future networks and services

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Mapping IP Connections over Optical Layer

IP Layer

IP Router

Optical Layer

OXC

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Provisioning Wavelength Connections

IP Layer

IP Router

Optical Layer

OXC

B

B

P

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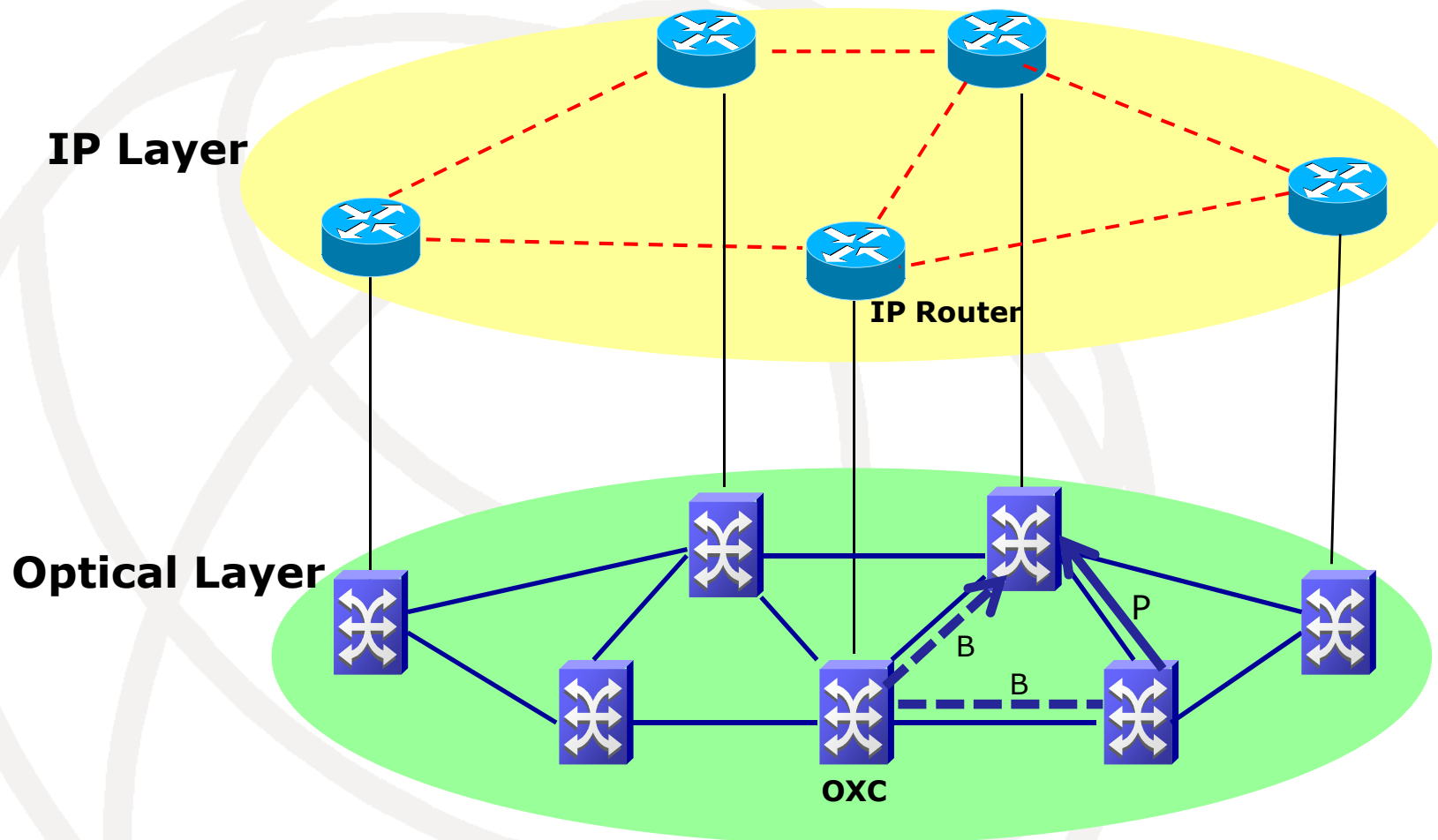
ESnet

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About ESnet

- Two core networks: (1) IP (packet network) and (2) Science Data Network (SDN) (circuit network)

Legend:
- IP router
- SDN router
- Optical node
- Lab
- IP
- SDN
- 20G SDN
- NLR 10G
- MAN
- Lab Link
- Peering Link

Map labels: PNNL, BNL, Ames, StarLight, MAN LAN (32 A of A), LB, PPPL, SLAC, FNL, ANL, JLAB, ORNL

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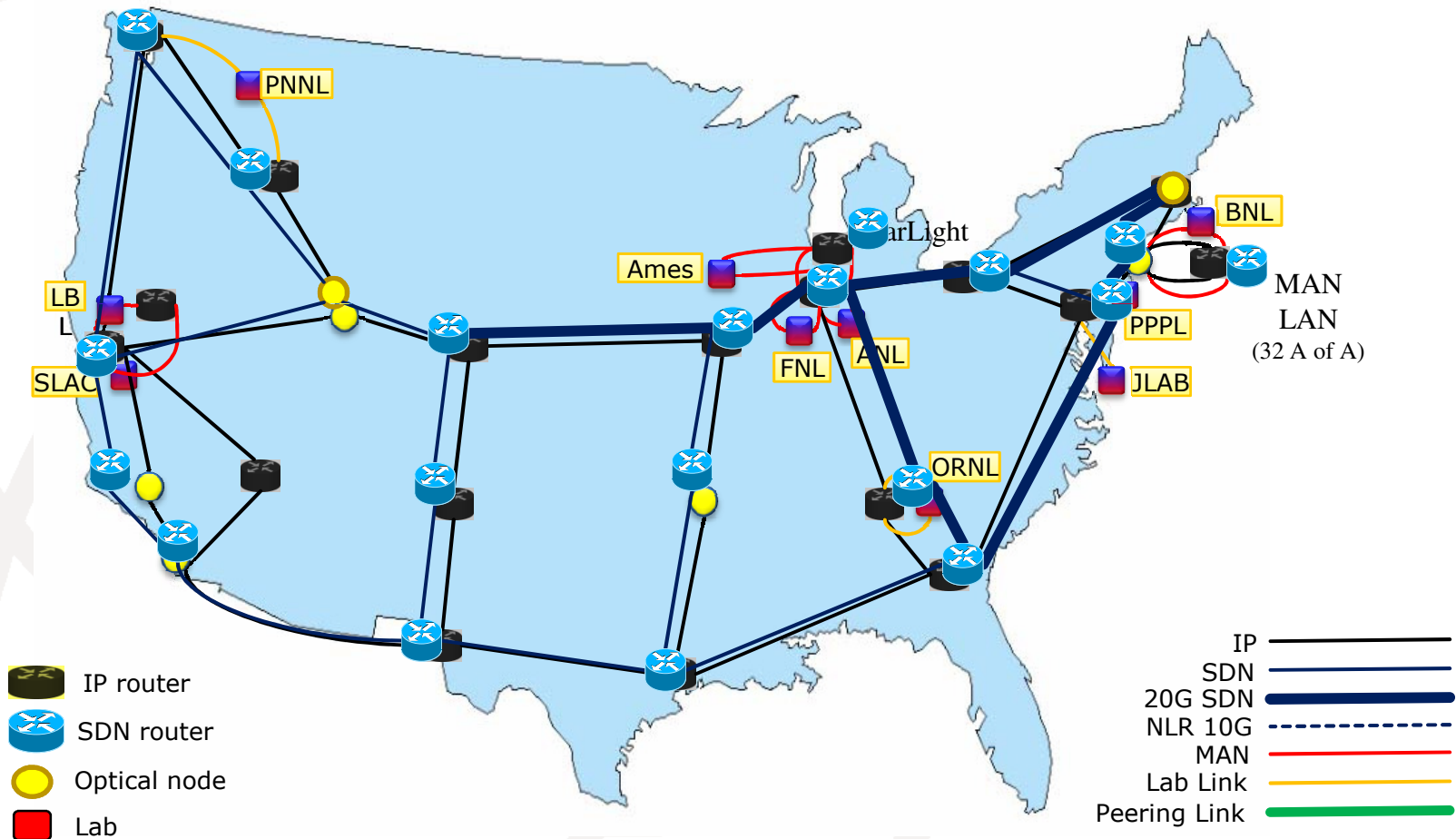
Motivation

IP Network
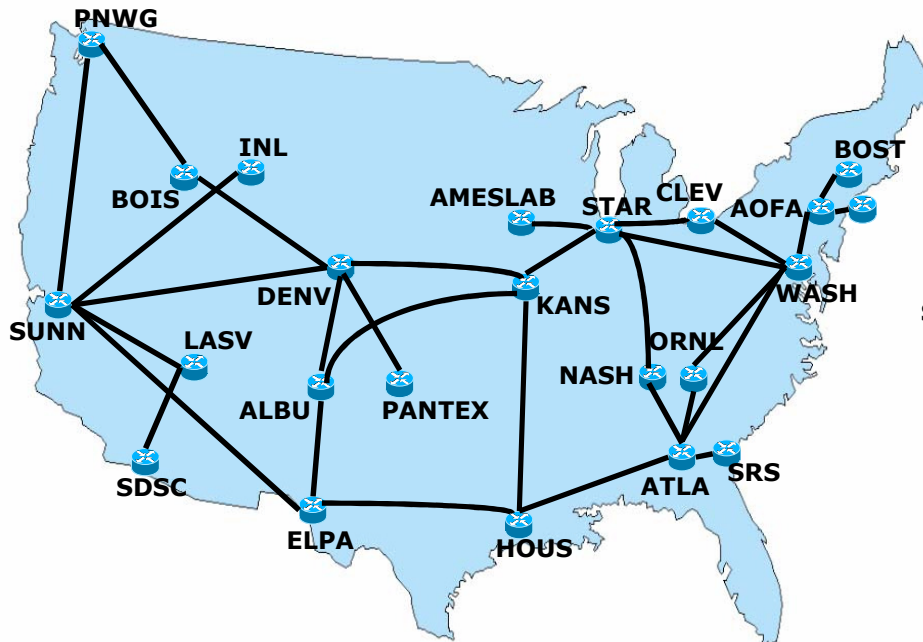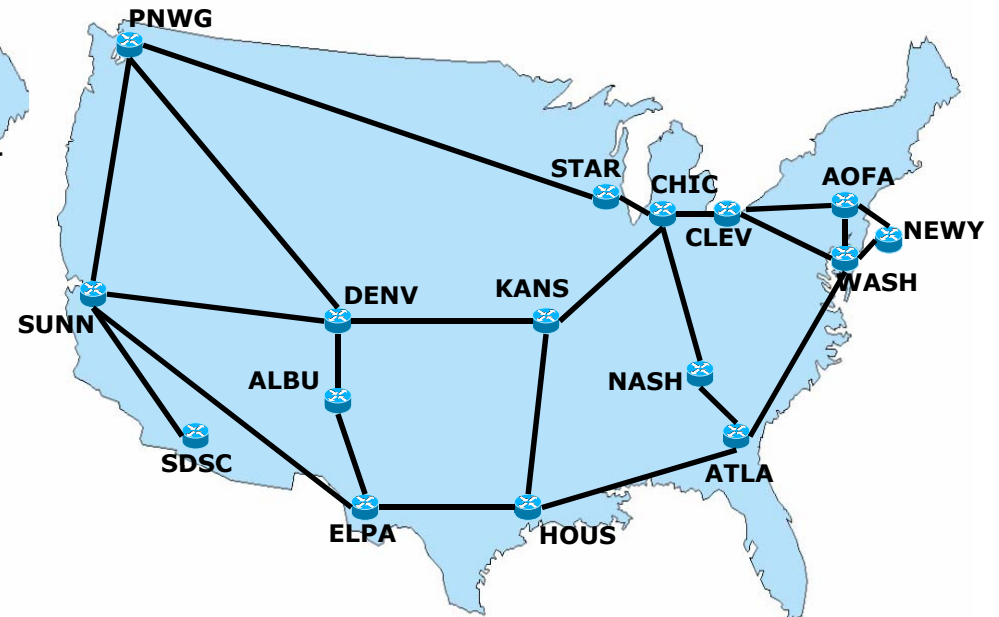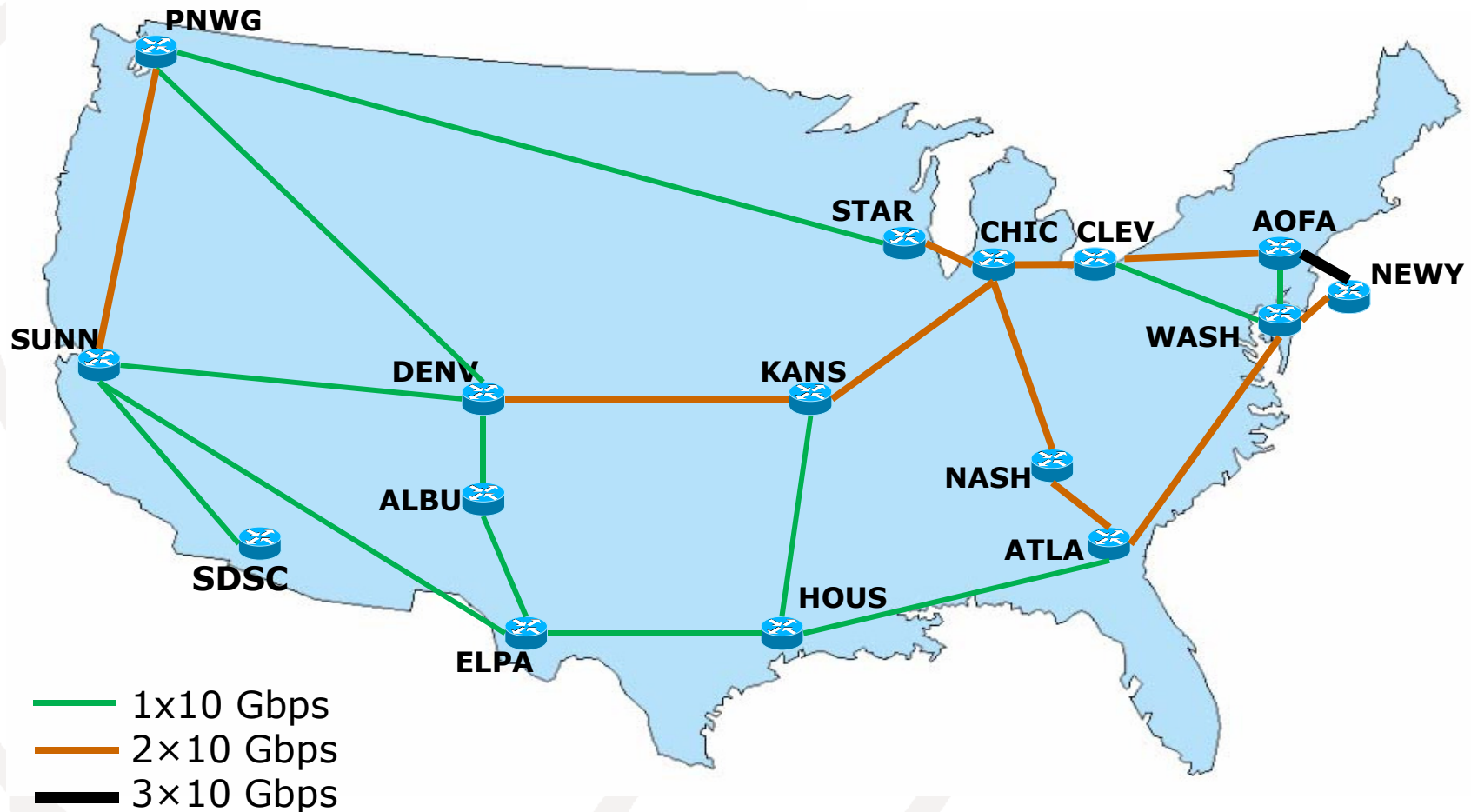
SDN Network

SDN circuits are traffic-engineered circuits similar to dynamic wavelength circuits in terms of flow handling end to end

■ **Present Mode of Operation (PMO):**

◆ Fixed partition between SDN and packet networks

■ **Future Mode of Operation (FMO) (?)**

◆ Flexible partition between SDN and packet networks

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Extracting Topology Information from http://weathermap.es.net

■ SDN Topology

16 SDN nodes
35 bidirectional 10G waves

PNWG, STAR, CHIC, CLEV, AOFA, NEWY, SUNN, WASH, DENV, KANS, NASH, ALBU, SDSC, ATLA, HOUS, ELPA

— 1×10 Gbps
— 2×10 Gbps
— 3×10 Gbps

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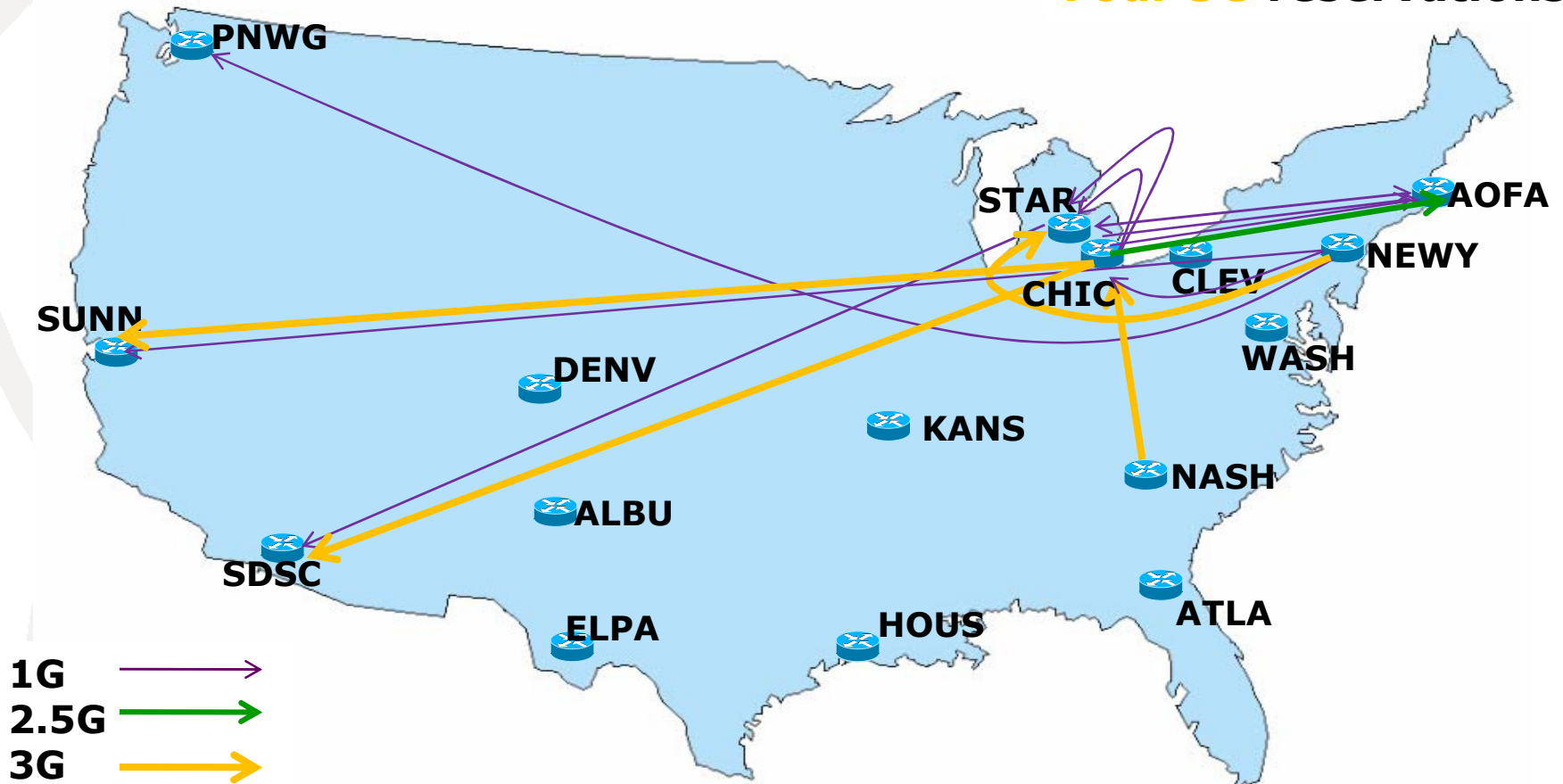
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SDN Reservation Information from Database (1)

- 15 active reservations from database (14.1 MB, 09/29/09)
  - Start time, end time, created time
    - An example: 1234484100, 1550016900, 1234484100
  - Bandwidth (of the circuit)
  - Routing (of the circuit)

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SDN Reservation Information from Database (2)

■ 15 active reservations

Ten 1G reservations
One 2.5G reservation
Four 3G reservations

PNWG

STAR
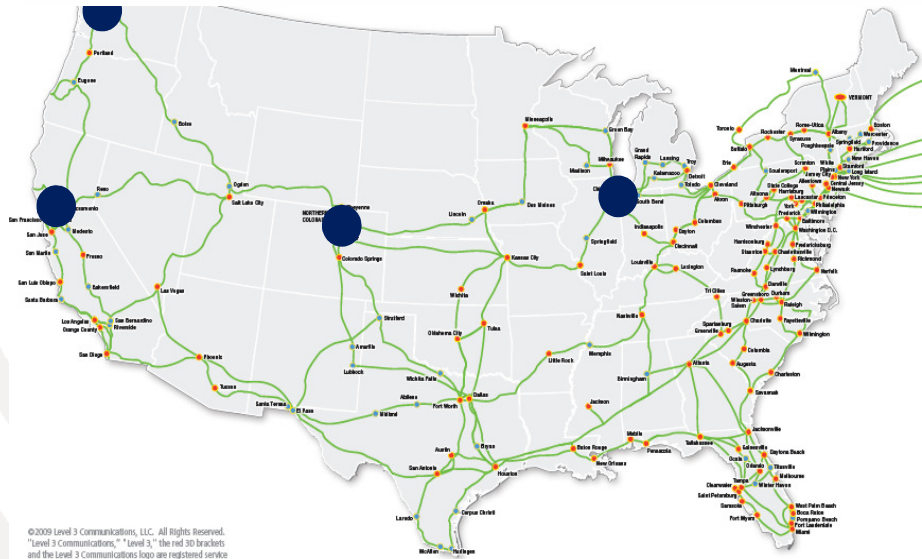
AOFA

CHIC

CLEV

NEWY

SUNN

WASH

DENV

KANS

NASH

ALBU

SDSC

ATLA

ELPA

HOUS

1G →
2.5G →
3G →

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Routing SDN Reservations

- Routing of one reservation (CHIC-SUNN)

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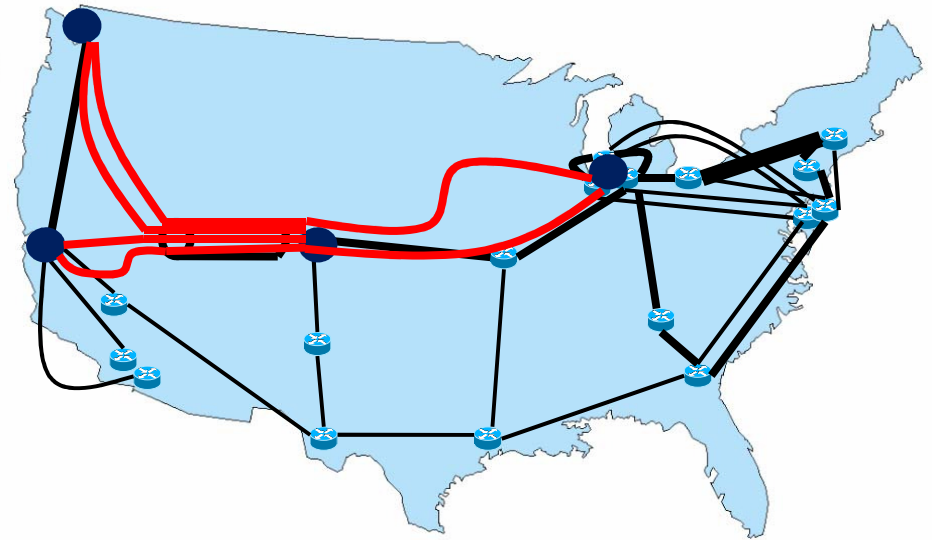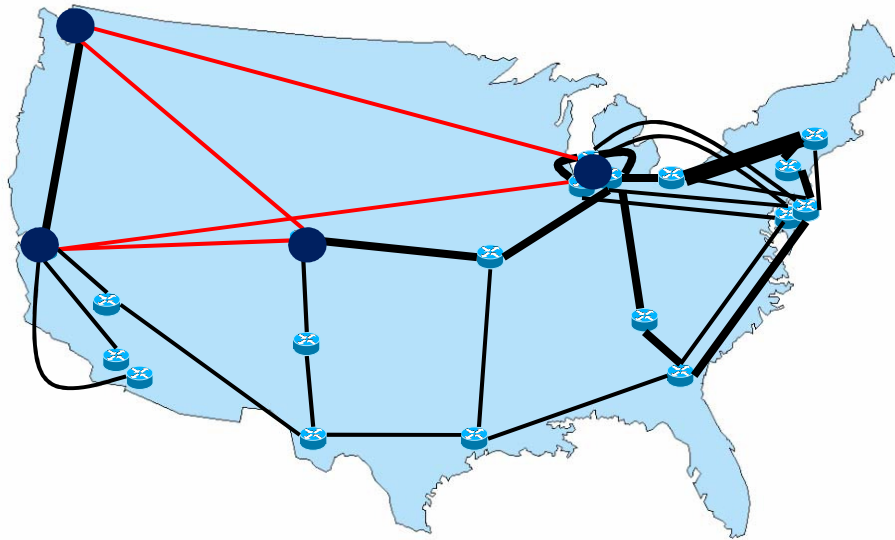**ITU-T Kaleidoscope 2010 – Beyond the Internet? Innovations for future networks and services**

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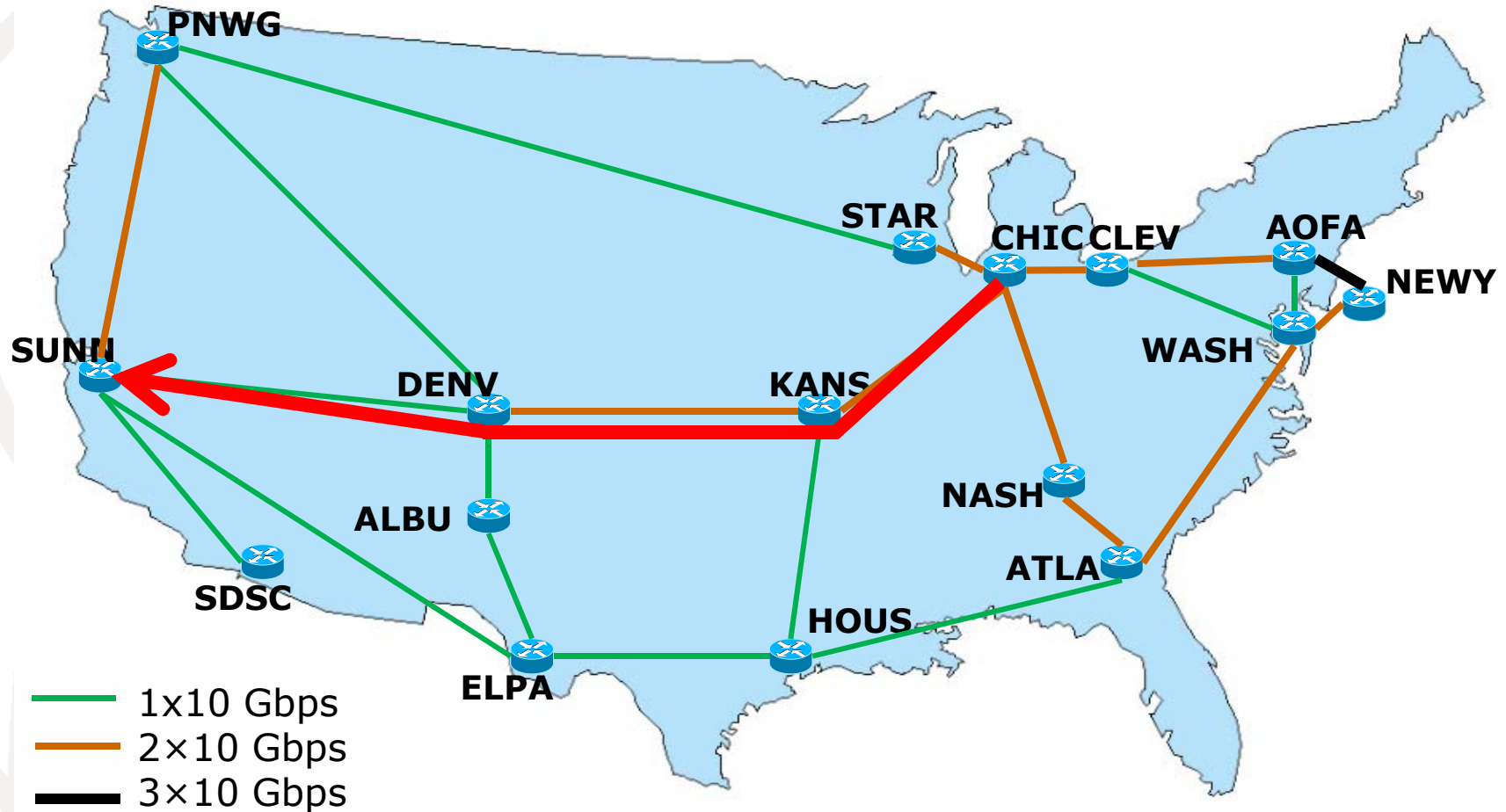
Mapping Logical Links to Physical Links

- Assumption: disjoint logical links are also physically disjoint

- Implication: different waves leased are assumed to be physically disjoint
  - May not be true in reality
  - Need to consider Shared Risk Link Group (SRLG)

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Logical Links with SRLG

- SDN Physical Topology?
- Level3?
- SRLG: need to consider
- Ongoing work: consider SRLG

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Protected Services in ESnet

- Objective: protect as many reservations possible *using current SDN resources*

- ESnet has a significant amount of idle capacity in its present mode of operation (615 Gbps)
  - Can we enhance the network's operation?
    - e.g., *provide protection to SDN reservations*?
  - Which protection mechanism is more suitable?

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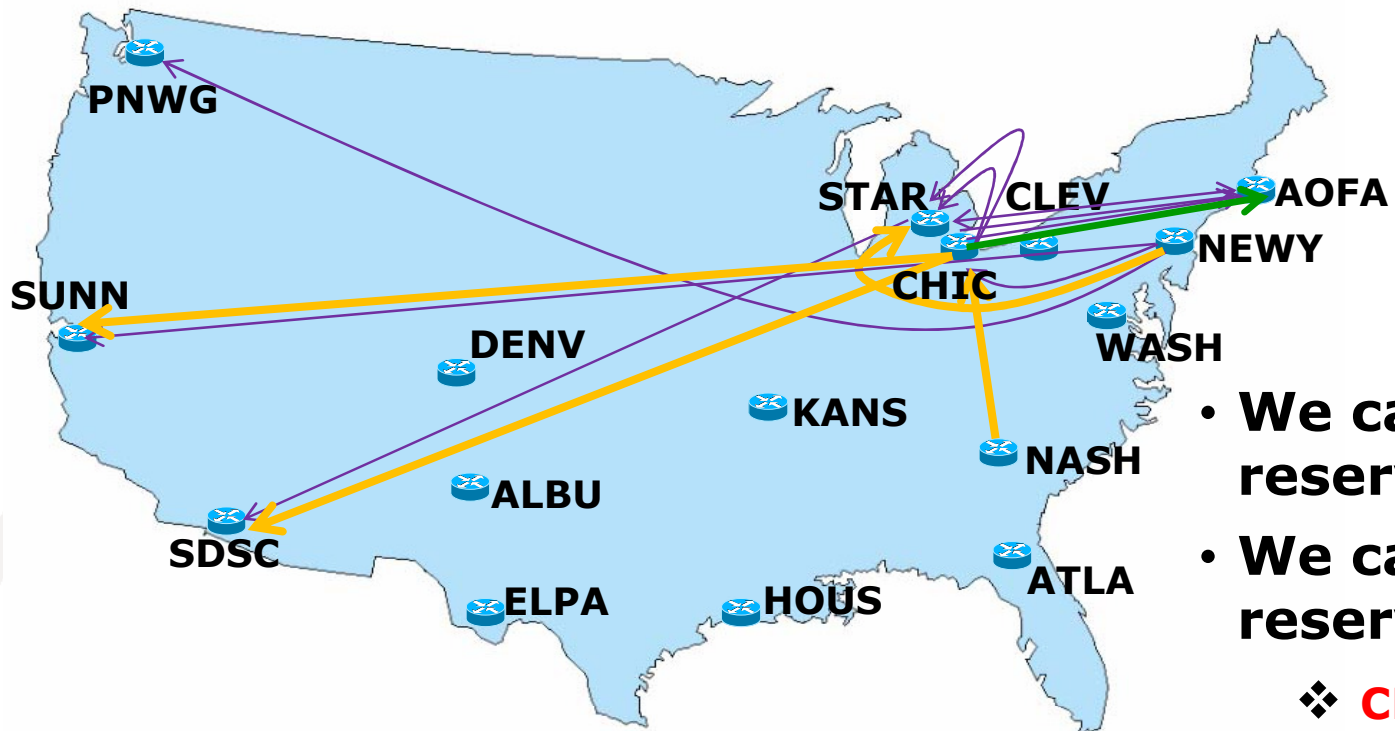
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Protecting SDN Services in ESnet

- *Using Current SDN Resources (Fixed Partition, PMO)*

    - Objective: Protect as many SDN reservations as possible using existing idle capacity

- *Using Current SDN and IP Resources (Flexible Partition, FMO)*

    - Objective: Protect all SDN reservations by dynamic partitioning of capacity between SDN and IP networks

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Using Current SDN Resources
(Fixed Partition, PMO)

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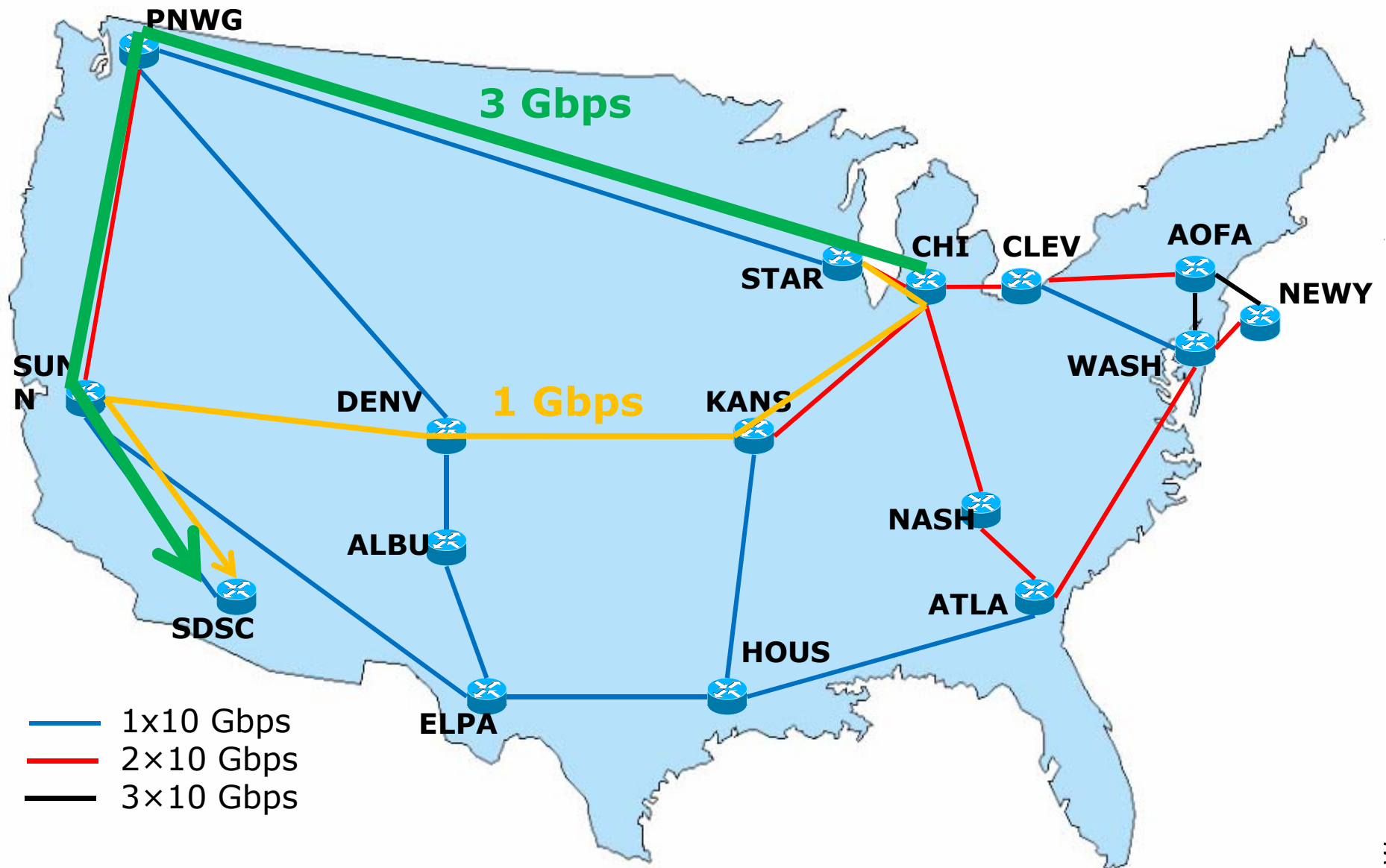
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- **We can protect 13/15 reservations**
- **We cannot protect the reservations**
  - ❖ **CHIC-SDSC** (3 Gbps)
  - ❖ **STAR-SDSC** (1 Gbps)
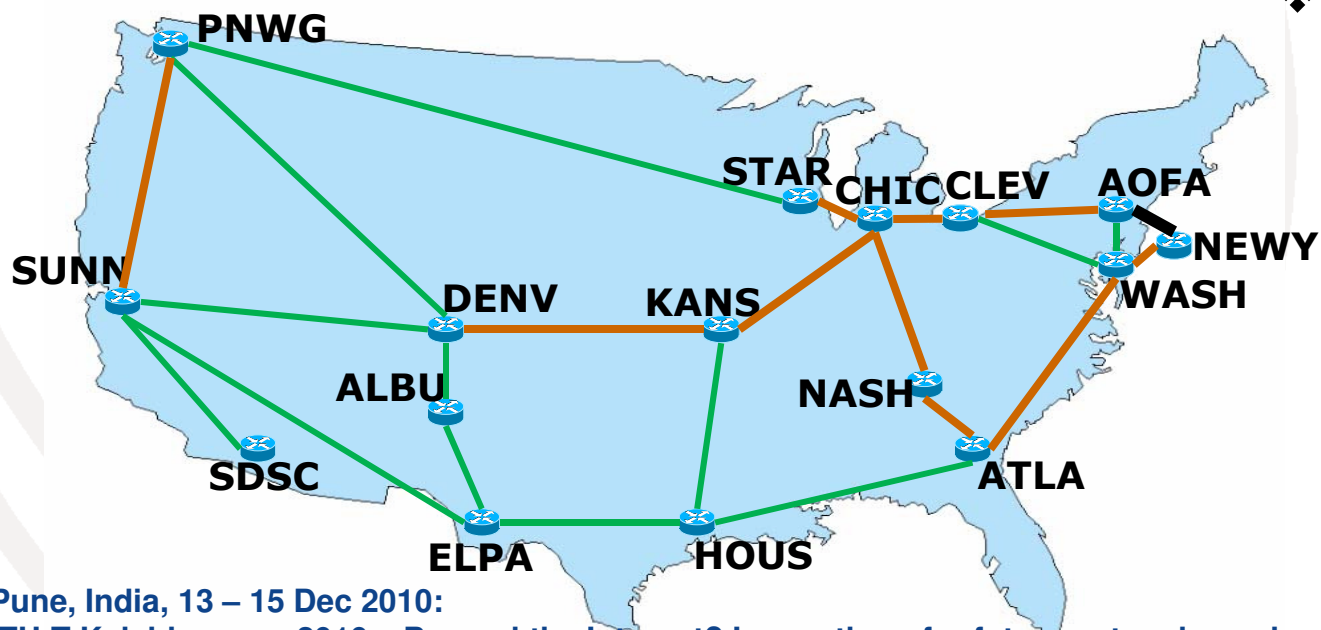
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Two Unprotected Reservations

3 Gbps

1 Gbps

PNWG

STAR
CHI
CLEV
AOFA
NEWY
WASH
SUN
N
DENV
KANS
NASH
ALBU
ATLA
HOUS
SDSC
ELPA

1x10 Gbps
2×10 Gbps
3×10 Gbps

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Protection Using Current SDN Resources

700 Gbps
Total capacity in SDN

Capacity utilization in SDN with no protection

85 Gbps

Protection Using Current SDN Resources

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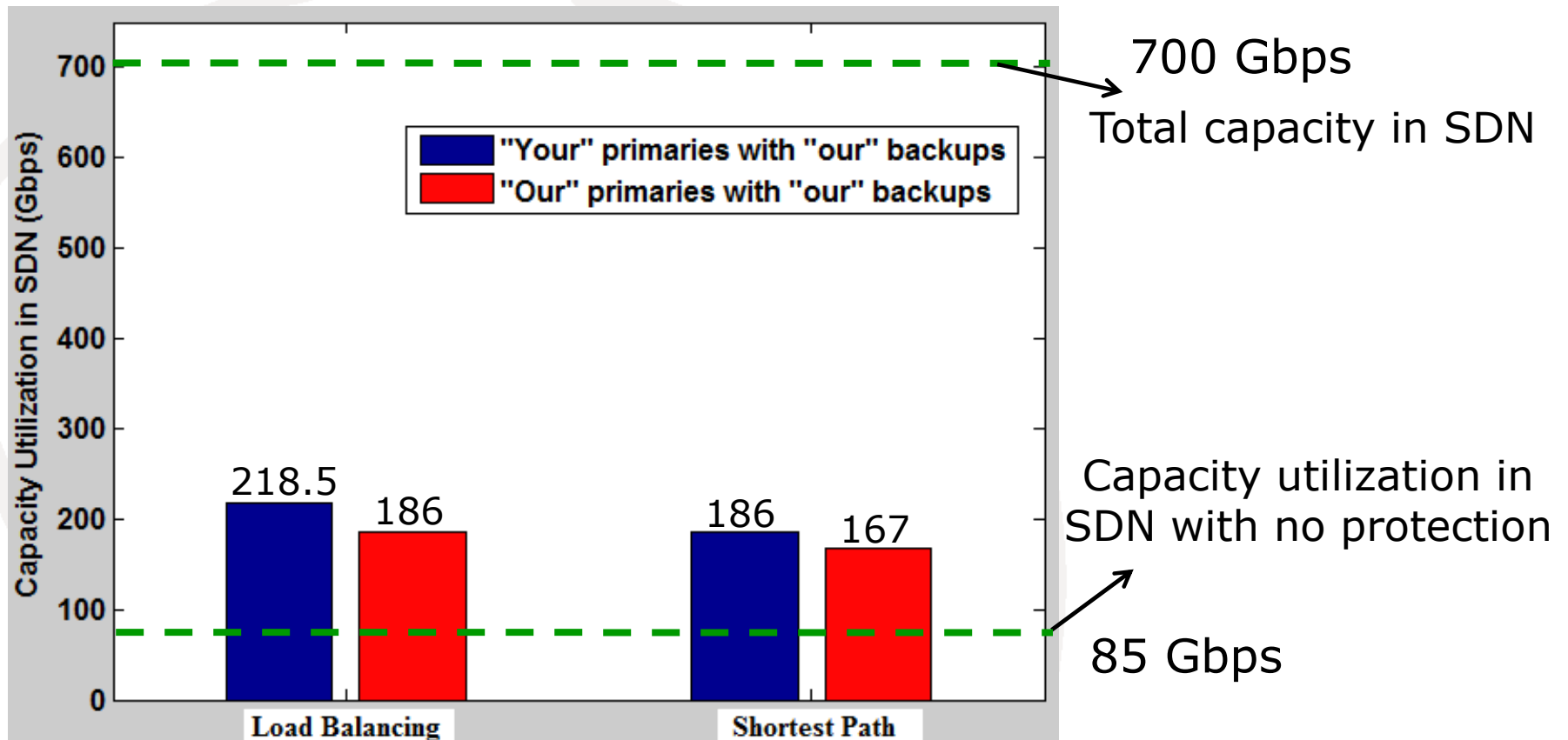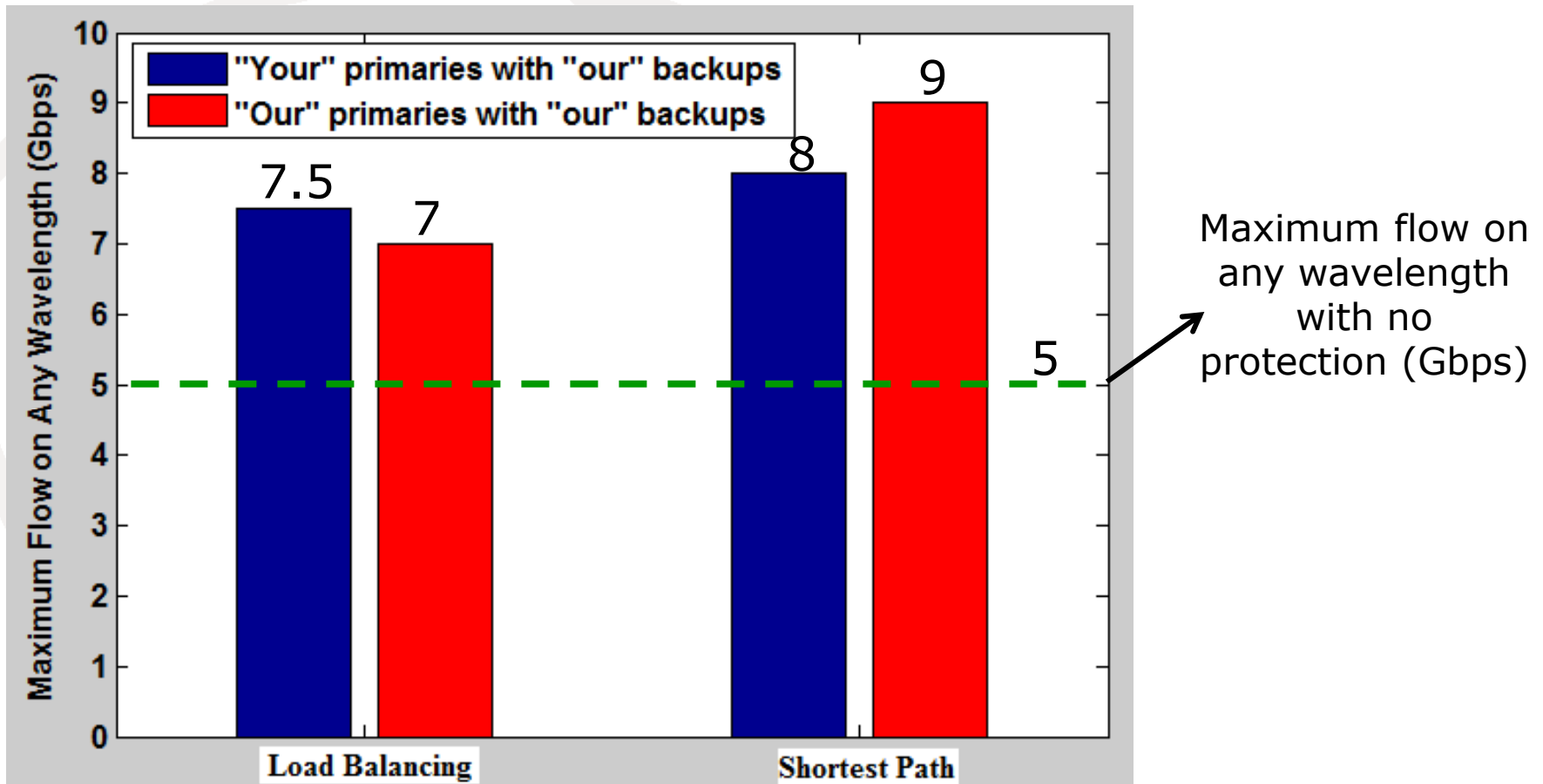
Using Current SDN and IP Resources to Protect All SDN Connections

(Flexible Partition, FMO)

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IP Network

From http://weathermap.es.net/ June 24, 2010
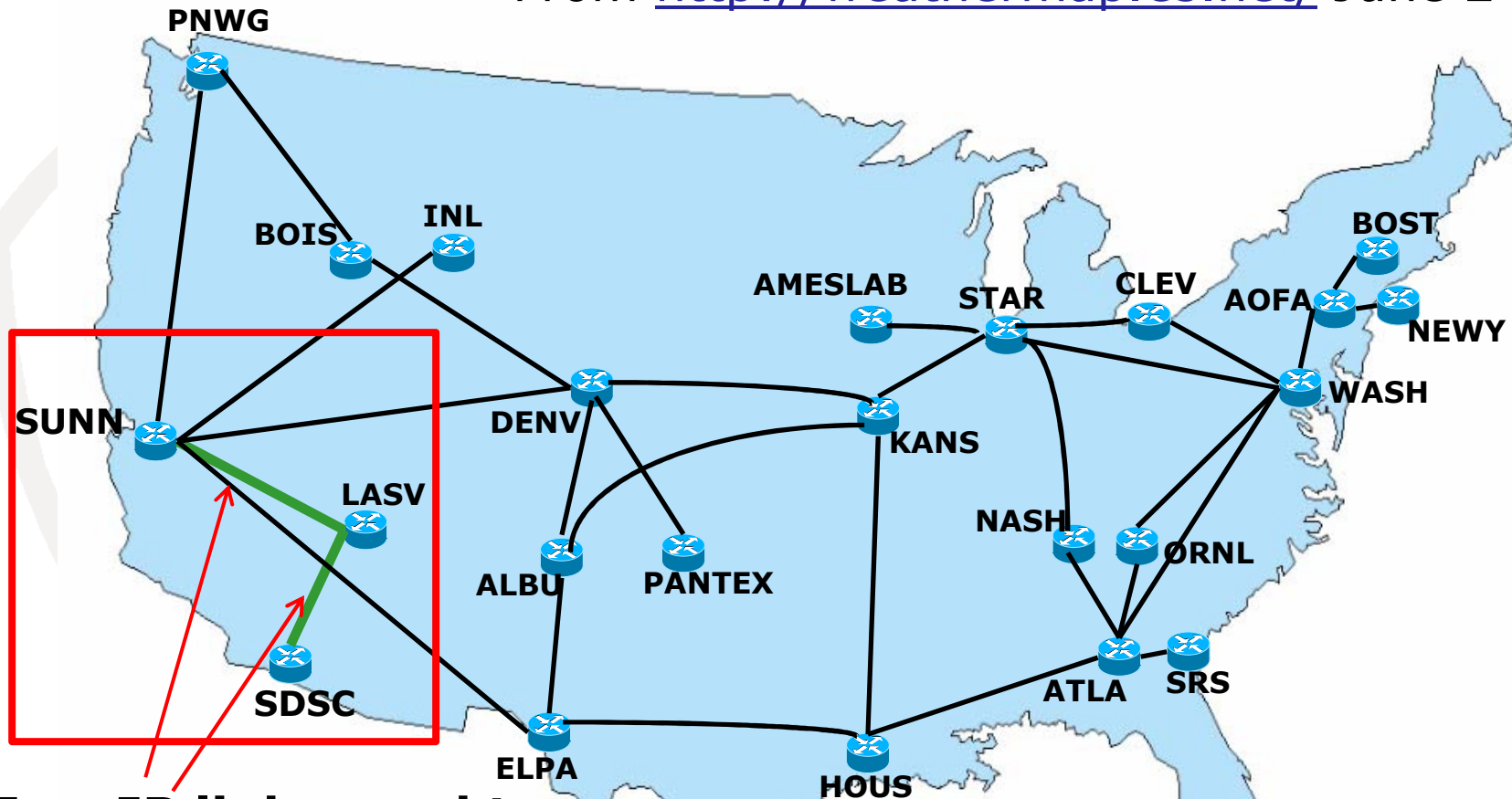
Two IP links used to protect SDN reservations to SDSC

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Flexible Partition
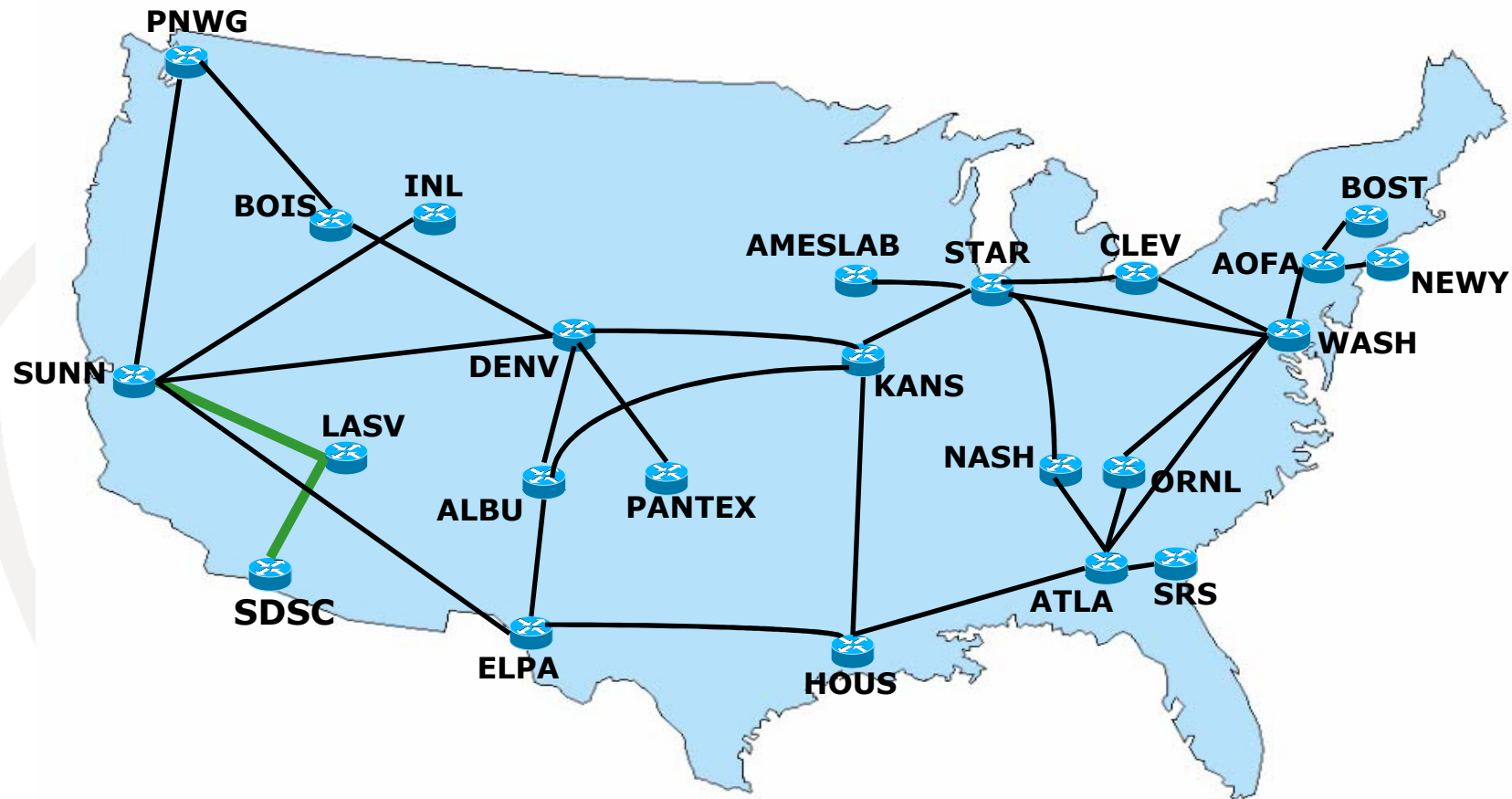
- Capacities of these two IP links are both 622 Mbps
- Two unprotected reservations are (1) 1 Gbps; (2) 3 Gbps
- Two reservations can be partially protected by borrowing capacity from IP links

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Summary of Results (1)

- **ESnet has lot of capacity deployed, and a lot of it is unused**
  - Total SDN capacity in the network is 700 Gbps
  - Only 85 Gbps is active, 88% of capacity idle
- **13 SDN reservations can be protected using 218.5 Gbps of capacity**
  - Still 70% of total capacity is idle
- **2 SDN reservations cannot be protected**

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Summary of Results (2)

- Two unprotected SDN reservation requests are
  - CHIC-SDSC (3 Gbps)
  - STAR-SDSC (1 Gbps)

- Two reservations can be protected by borrowing capacity over SDSC-LASV and SDSC-SUNN IP links
  - Up to 622 Mbps of SDN traffic to SDSC can be protected (*partial protection*)

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Thank you for your attention!

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