CENIC
CONNECTING CALIFORNIA

# C2TAG - Introduction to CENIC Ops, PMO, and Services

06/03/25

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**CENIC** is a 501(c)(3) **with the mission to advance education and research statewide by providing the world-class network essential for innovation, collaboration, and economic growth.**

California State University System

University of California System

California Community Colleges

Stanford University

University of Southern California System

California K-12 System

Naval Postgraduate School

California Public Libraries

California Institute of Technology

# CENIC Benefits to California Institutions

CENIC's California Research and Education Network (CalREN) is a multi-tiered, high-performance network serving the majority of research and education institutions in the state. Each year, 20 million Californians use CalREN at 12,000 member institutions.

**By using CalREN broadband, CENIC member institutions enjoy supremely reliable, efficient, and cost-effective access as well as these benefits:**

- Unlimited broadband use
- Access to a state-of-the-art network
- Entry into a participatory, membership organization
- Network design expertise
- Cloud connectivity and content services
- 24/7 Network Operation Center
- Scaling services to the need
- Federal and state subsidy assistance
- Lower costs on circuits & equipment
- A global community of tens of thousands of Research & Education institutions


CENIC
California Research and Education Network (CalREN)
CANARIE
Canada
100 Gbps
PNWGP
ESnet
DREN
Internet2
Denver
UltraLight
(CalTech)
Vancouver
Seattle
Albuquerque
NREN
(NASA Ames)
ESnet
Palo Cedro
Chico
Corning
Colusa
Sacramento
Merced
Fresno
Bakersfield
Emeryville
Sunnyvale
San Francisco
Palo Alto
Soledad
San Luis Obispo
Palm Desert
Riverside
Yuma
El Centro
Los Angeles
Tustin
San Diego
Tijuana
UH Oahu
UH Hawaii
CalREN Nodes
Optical add/drop
Optical add/drop & DC
Optical add/drop, DC, & HPR

# PACIFIC WAVE

## NATIONAL & INTERNATIONAL PEERING EXCHANGE

Pacific Wave is a project of CENIC & PNWGP


**Western Regional Network**

States served by WRN members:

- **ABQG**: New Mexico
- **CENIC**: California
- **FRGP**: Colorado, & Wyoming
- **PNWGP**: Washington, Montana, Alaska, Oregon, & Idaho
- **UH**: Hawaii

With Support from the National Science Foundation Award #2029306

# Western Regional Network

## Hosted Compute Resources by Site

The following institutions host listed compute resources for the use of all CENIC AIR participants.

| | CPU | GPU | | CPU | GPU |
|---|---|---|---|---|---|
| Cal Poly Humboldt | 88 | 8 | Sacramento State | 28 | 8 |
| Sunnyvale (CENIC) | 191 | 0 | UC Merced | 84 | 14 |
| Sunnyvale (Internet 2) | 72 | 1 | UC Riverside | 216 | 20 |
| UC Santa Cruz | 433 | 27 | CSU San Bernardino | 196 | 16 |
| Stanford U | 28 | 0 | LAX (CENIC) | 48 | 0 |
| CSU Monterey Bay | 28 | 0 | CSU Fullerton | 572 | 70 |
| UC Santa Barbara | 60 | 17 | U Southern California | 12 | 0 |
| UC Los Angeles | 72 | 0 | San Diego CCD | 24 | 8 |
| Caltech | 72 | 0 | San Diego State U | 1944 | 172 |
| UC Irvine | 96 | 14 | UC San Diego | 7656 | 547 |
| CSU Chico | 28 | 15 | | | |


# CENIC AIR

**CENIC** ARTIFICIAL INTELLIGENCE RESOURCE

| | |
|---|---|
| California State Universities | 23 |
| The University of California | 10 |
| California Community Colleges | 116 |
| Independent Universities | 4 |
| CENIC AIR Network Path | |
| Hosted Capacity and Capabilities | |
| • CPU Cores | 11,948 |
| • GPUs | 937 |
| • TB Storage & growing! | 4561 |

The Majority of *Nautilus* GPUs Reside in the CENIC AI Resource (CENIC AIR): Hosted by and Available to CENIC Associates

NRP Nautilus

# Network Operations Team


*December 2024*

- 26 Full-Time Staff
- 20 Network Engineers
- 3 Network Administrators
- 3 Lead Engineers
- 3 Part-Time Interns

Available 24x7x365

**NOC Number: 714-220-3494 | NOC Email: noc@cenic.org**

# Supporting the Community

## Traditional NOC Functions

- Monitor The Network
- Open and Resolve Tickets
- Answer Phone Calls
- Triage Alarms
- Send Announcements to Community


Our engineers are expected to handle all issues and unresolved tickets.

**NOC Number: 714-220-3494**

**NOC Email: noc@cenic.org**

# One Stop Shop for Our CENIC community


- Monitor the Networks
- Respond to Associates' Queries
- Resolve Circuit Outages
- Mitigate DDoS Attacks
- Process Vendor Maintenances
- Change Control Requests
- Schedule Remote Hands for Maintenance
- Collaborate with Hardware Vendors (TAC)
- Resolve Complex Routing Issues
- Provision New Services for Associates
- Deploy and Upgrade New Hardware
- Operational Readiness of Devices and Circuits
- Maintain Contacts and CLR Database
- Ensure the Safety and Security of the Network
- Conduct Service Impacting Maintenance

# Maintenance

**Types of Maintenances**

- CENIC Maintenance
- Partners / Providers
- Member / Campus

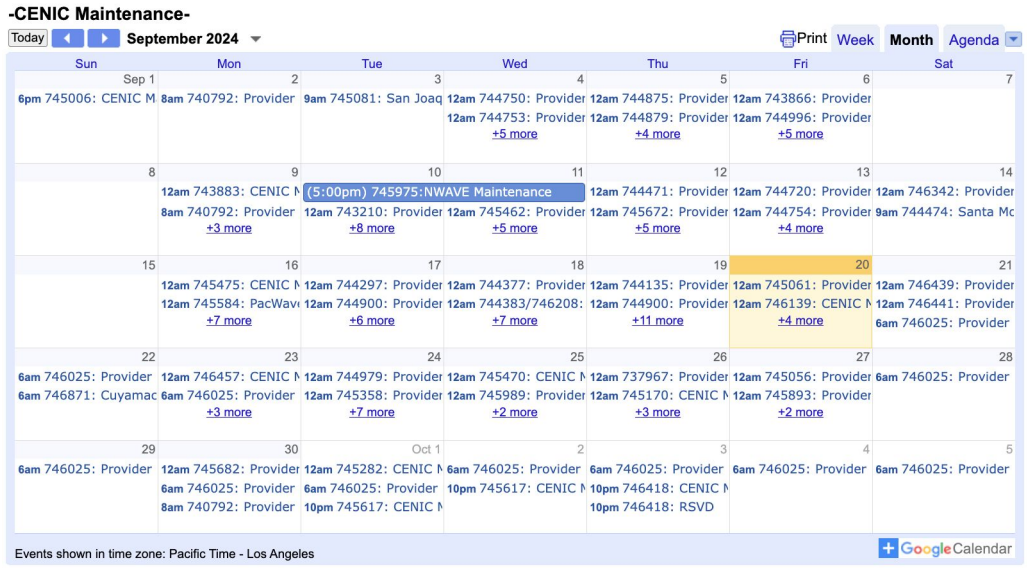


# CENIC Maintenance Lead Times

- **Standard Maintenances (10:00 PM - 5:00 AM)**
  - Announced 4 business days ahead
- **Non-Impact Maintenance (After 5:00 PM)**
  - 24 hours
- **Emergency Maintenance**
  - Announced same day
  - Very rare
- **Member or Campus Maintenances**
  - Please the Notify NOC

# https://cenic.org/network/operations

## Maintenance Calendar




## NOC Escalation List

Providing continued and uninterrupted service to our members while maintaining the safety and well-being of our employees is our top priority. CENIC has enhanced its escalation procedures to ensure that any issue is resolved in the shortest possible time and with the mobilization of the appropriate resources. CENIC's Network Operations Center (NOC) is the first point of contact for all services provided over the California Research and Education Network (CalREN), which is monitored 24 hours a day, 7 days a week, 365 days a year.

### Network Support:

**Level 1:** CENIC Network Operations Center | Office: 714-220-3494 | Email: noc@cenic.org

**Level 2:** Michael Gong - Manager Network Operations | Office: 714-220-3432 | Cell: 714-390-1648 mgong@cenic.org

## Targeted Network Announcements

In response to community demand, CENIC has developed a new database with the capability of sending targeted notifications to our community, which we will begin using on April 7th, 2022. This new database together with valuable feedback from various CENIC Associates and RENs has contributed to the development of an improved outage and maintenance announcement profile that includes the following changes:

**https://cenic.org/network/operations/targeted-network-announcements-faq**

**NOC Number: 714-220-3494 | NOC Email: noc@cenic.org**

# Announcement Notification Example

Summary of ONGOING outage:

START: 14:12 PST, Thu 01/16/2025
END: ONGOING

SCOPE: Circuits Down in The NorCal Region

STATUS: Pending Telco Action

COMMENTS:
The NorCal circuits remain down. Comcast states that there is a fiber cut in Sacramento. Repair crews are on site. There is no ETR at this time.

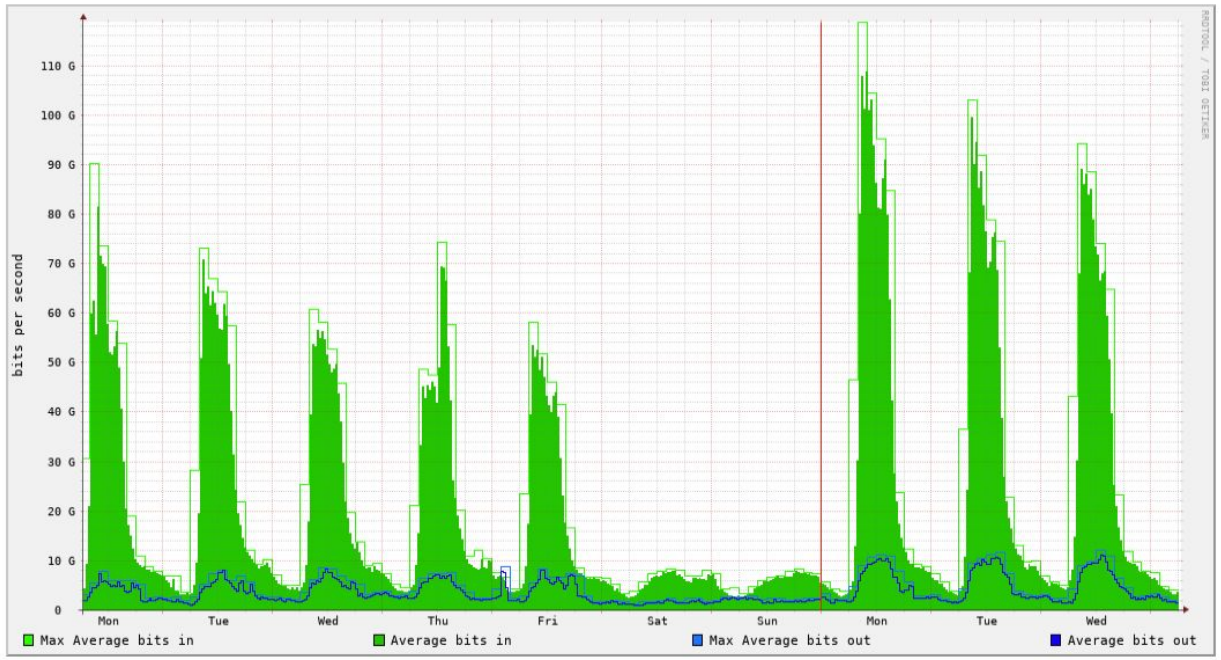
LOSS OF DIVERSITY FOR:
- CSU Chico

LOSS OF CONNECTIVITY FOR:
- CSU Chico - HPR
- Los Rios CCD - Elk Grove Center
- Roseville Public Library

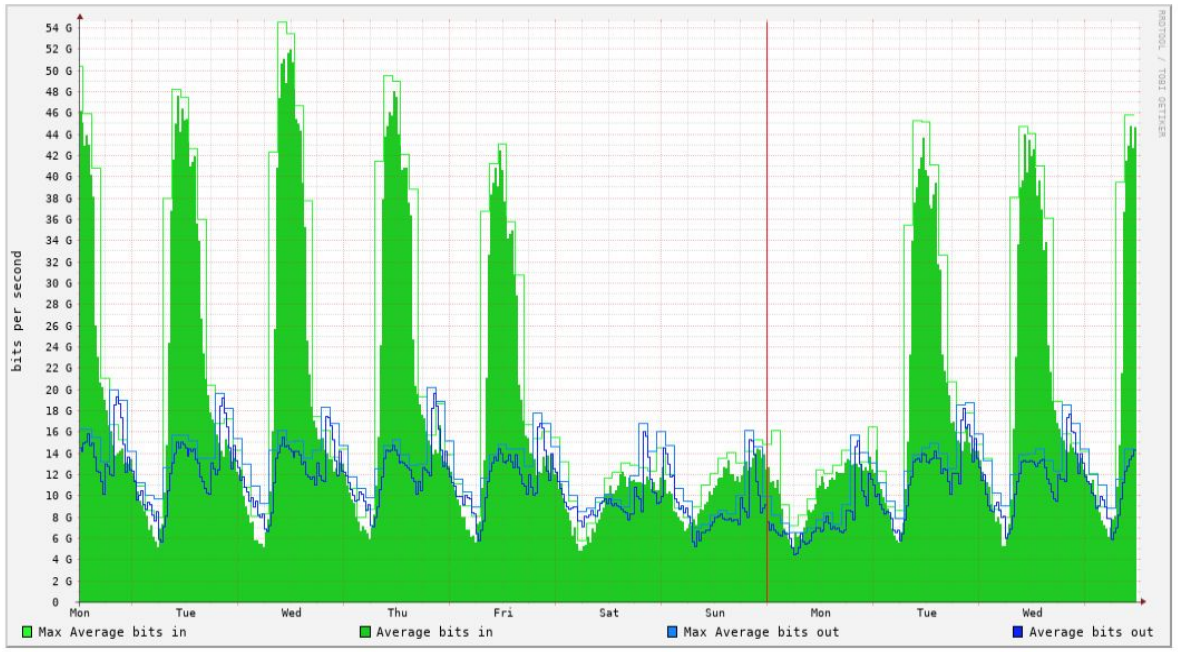
IMPACTED L3 SERVICES (PROVIDED FOR REFERENCE ONLY):
- DC-L3-CSUCH1-SACR2-20G-28791
- DC-L3-LRCCEGC-SACR2-1G-7201
- DC-L3-ROSELIB-SACR2-1G-28924
- HPR-L3-CSUCH1-SACR2-20G-28792

# Cricket (Bandwidth Usage)

https://cenic.org/network/real-time-mngmt-tools




Google Peering




Lumen 200G Peering in Los Angeles

# CENIC Network Operations

## Contact Information

Phone: 714-220-3494 | Email: noc@cenic.org

# CENIC Service Catalog

# CENIC Service Catalog – 2025

CENIC provides cost-effective, high-bandwidth networking to support our community members, respond to the needs of their faculties, staff, students, and associated research groups, and to facilitate excellence in scientific, education, government, and private sector collaboration and innovation.

CENIC provides a full suite of network services over the California Research and Education Network (CalREN), a high-capacity network with more than 8,000 miles of optical fiber.

View the entire CENIC service catalog here on the CENIC website:
https://cenic.org/network/network-service-catalog

# CENIC Service Overview – 2025

**Primary Network Services:**

- CalREN Digital California (**DC**)
- CalREN High Performance Research (**HPR**)

**MPLS VPN Services:**

- L2 VPN Network Service – **E-LINE**
- L2 VPN Network Service – **E-LAN**
- L3 VPN Network Service – **IP-VPN**

**Layer 1 Services:**

- Optical Service
- Optical Spectrum as a Service

**Other Network Services:**

- CENIC Rapid Private Interconnect (RPI)
- CENIC DDoS Mitigation Service (DMS)
- CENIC AIR ScienceDMZ (**New!**)

**Internet2 Services available via CENIC:**

- Internet2 AL2S
- Internet2 Cloud Connect
- Internet2 RPI
- Internet2 InCommon & Net+ Services

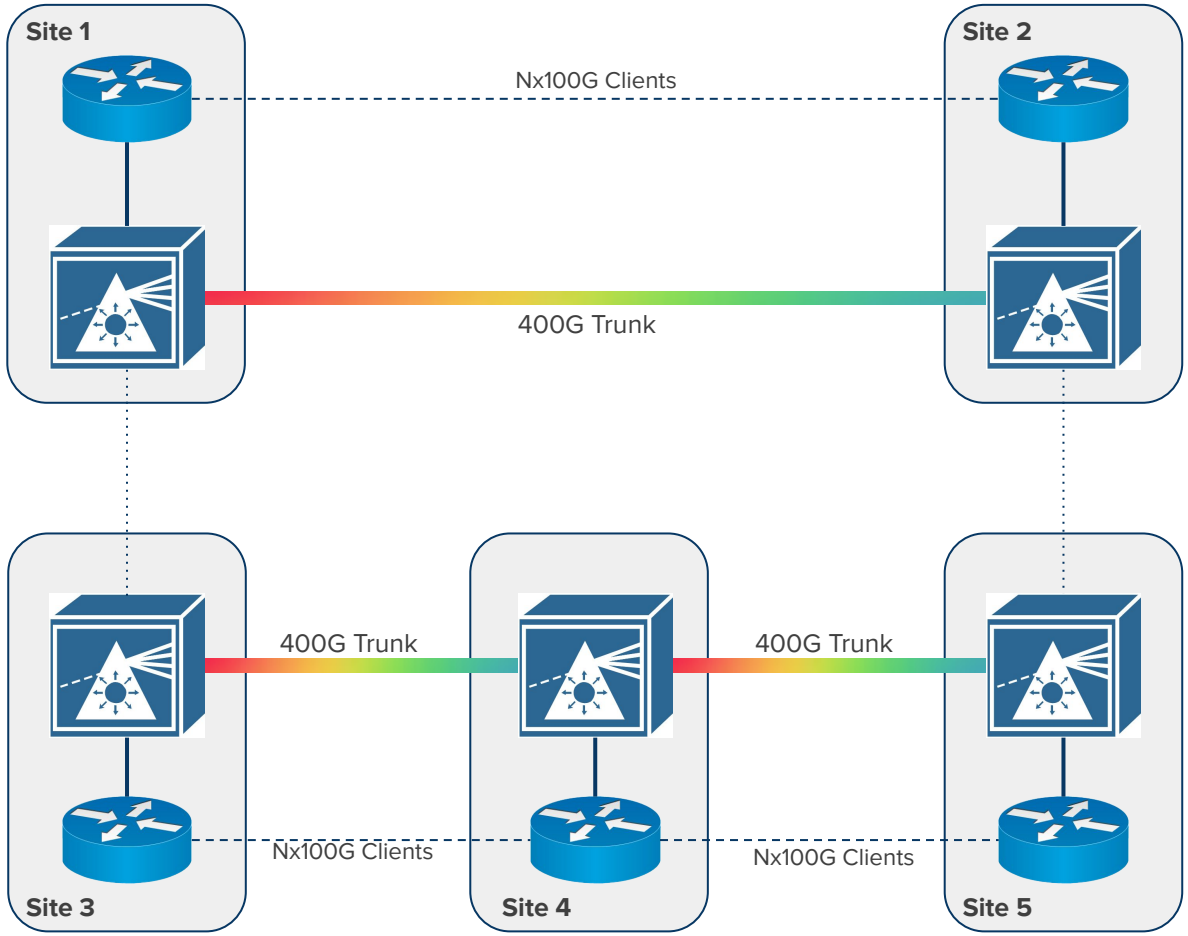
# Metro Optical Services

# Metro Optical Solutions

- CENIC currently manages 33 WAN optical circuits connecting associates to CalREN over dark fiber
- While optical networking is a critical component of CalREN, it is typically a lower priority for CENIC Associates
- Many associates do not have engineers with optical experience on-staff
- CENIC is now able to offer a metro optical solution, in which CENIC manages an associate's non-CalREN connecting optical network
- This design is an optional addition to WAN optical solutions
- At this time, CENIC is only able to offer metro optical services using CENIC approved hardware and software

# Metro Optical Example

- Three 400G trunk circuits over dark fiber (ranging from 15-85km)
- CENIC manages the optical hardware, while the Associate manages the directly connected switches
- 2x100G client handoffs provisioned initially
- Ability to grow up to 3x400G per span (12x100G clients per optical device)
- Currently in-use by one associate



# Metro Optical - General Scope of Work

1. CENIC works with Associate to gather requirements
2. CENIC selects appropriate hardware and software, using standardized CENIC platforms
3. Bill of Materials shared with Associate for review and approval
4. CENIC procures hardware and software
5. CENIC deploys and turns up the equipment
6. CENIC provides handoffs to Associate
7. CENIC operates the optical network and dark fiber 24x7x365
8. Moves, Adds, Changes, Deletes (MACD) are handled separately as needed

# WAN Optical Updates

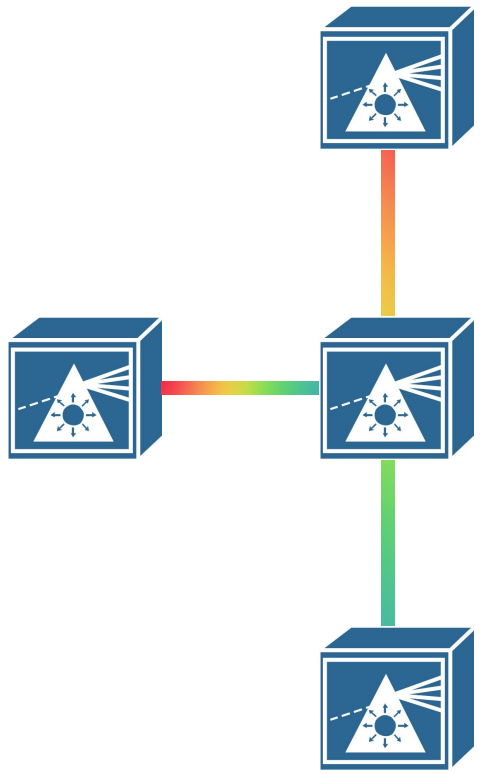
# WAN Optical Updates

- CENIC has traditionally provided Layer 1 services to connect Associates over dark fiber to CalREN, typically using a complete optical line system
- We can now provide more flexible service offerings based on the fiber and associate requirements
- **Optical Line System** categories:
  - OLS Full
  - OLS Lite
  - OLS Free
- **Transponder** categories:
  - IPoDWDM
  - Discrete TXPs

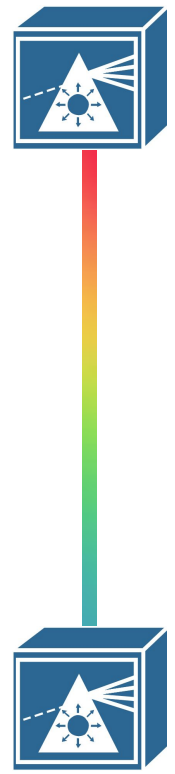
# Optical Line System

- Three solutions:
  - OLS Full
  - OLS Lite
  - OLS Free
- OLS Full provides the most flexibility, with support for very long spans, rings, and more than two degree nodes
- OLS Lite provides simpler fiber management, typically only applicable for point-point designs
- OLS Free is for short spans that only require a transponder solution

OLS Full



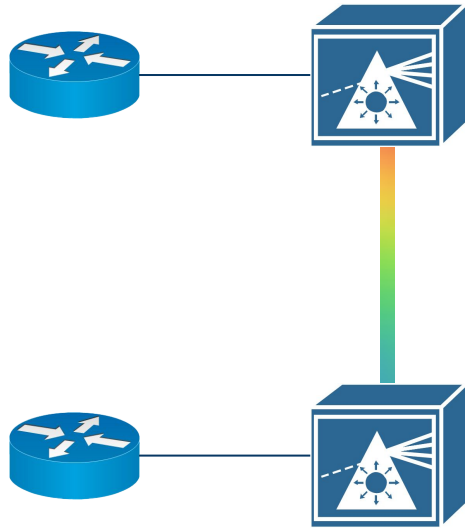
OLS Lite



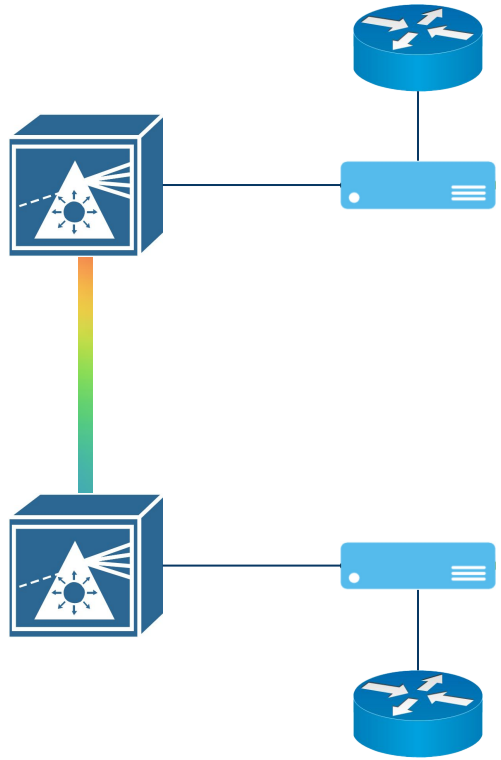
# Transponders

- Two solutions:
  - IPoDWDM
  - Discrete TXPs
- Each solution would be combined with an OLS solution in the previous slide
- IPoDWDM uses a ZR or similar optic in a CENIC or Associate managed router/switch
- Discrete TXPs use independently managed transponders, such as Ciena Waveservers or Cisco NCS1014s

IPoDWDM



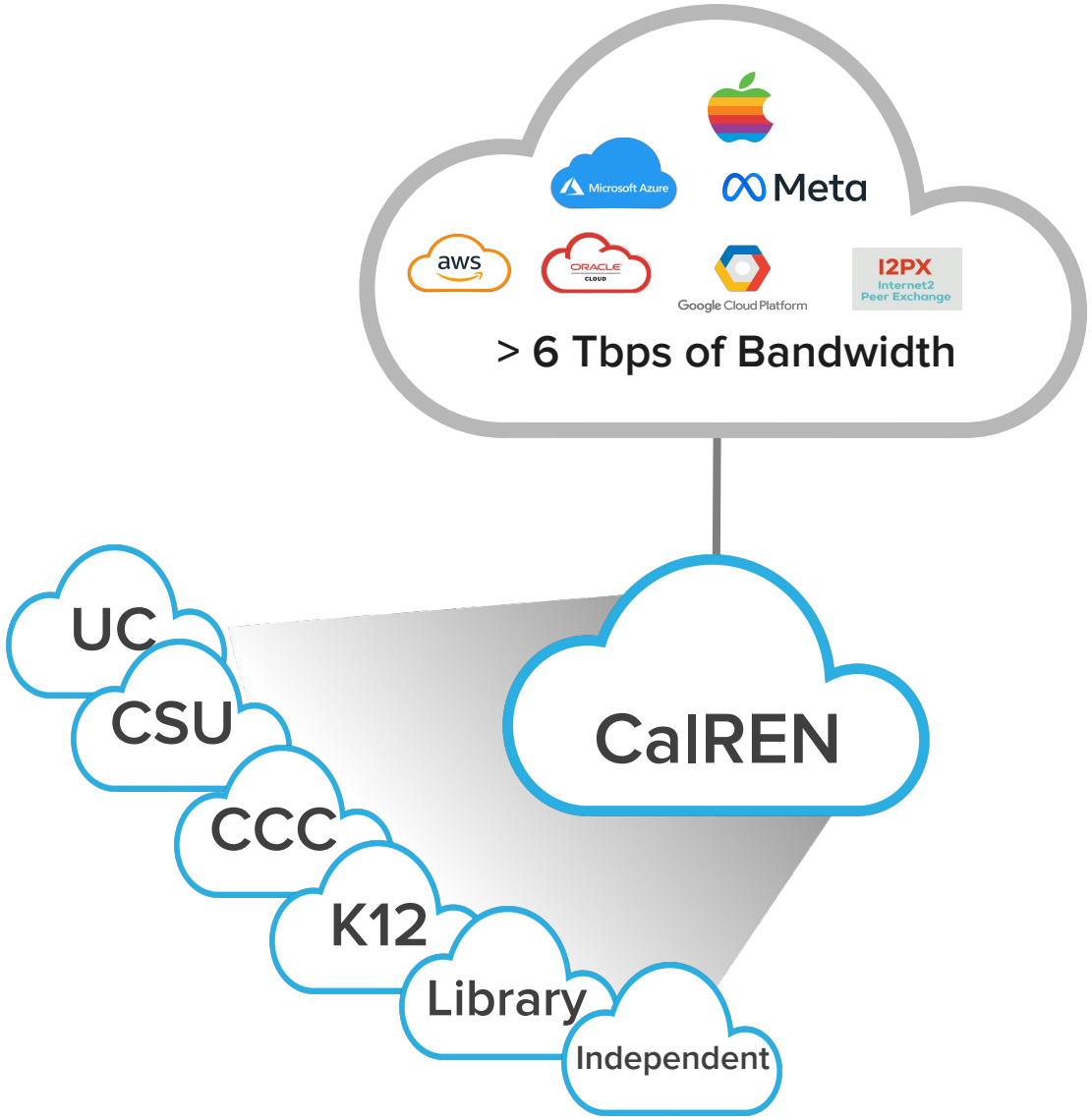
Discrete TXPs



# CaIREN Digital California Service (DC)

# Digital California (DC)

- Used by majority of CENIC members
- Connectivity to general Internet
- Direct connectivity to other CENIC members
- Transit, peering and cloud services built in

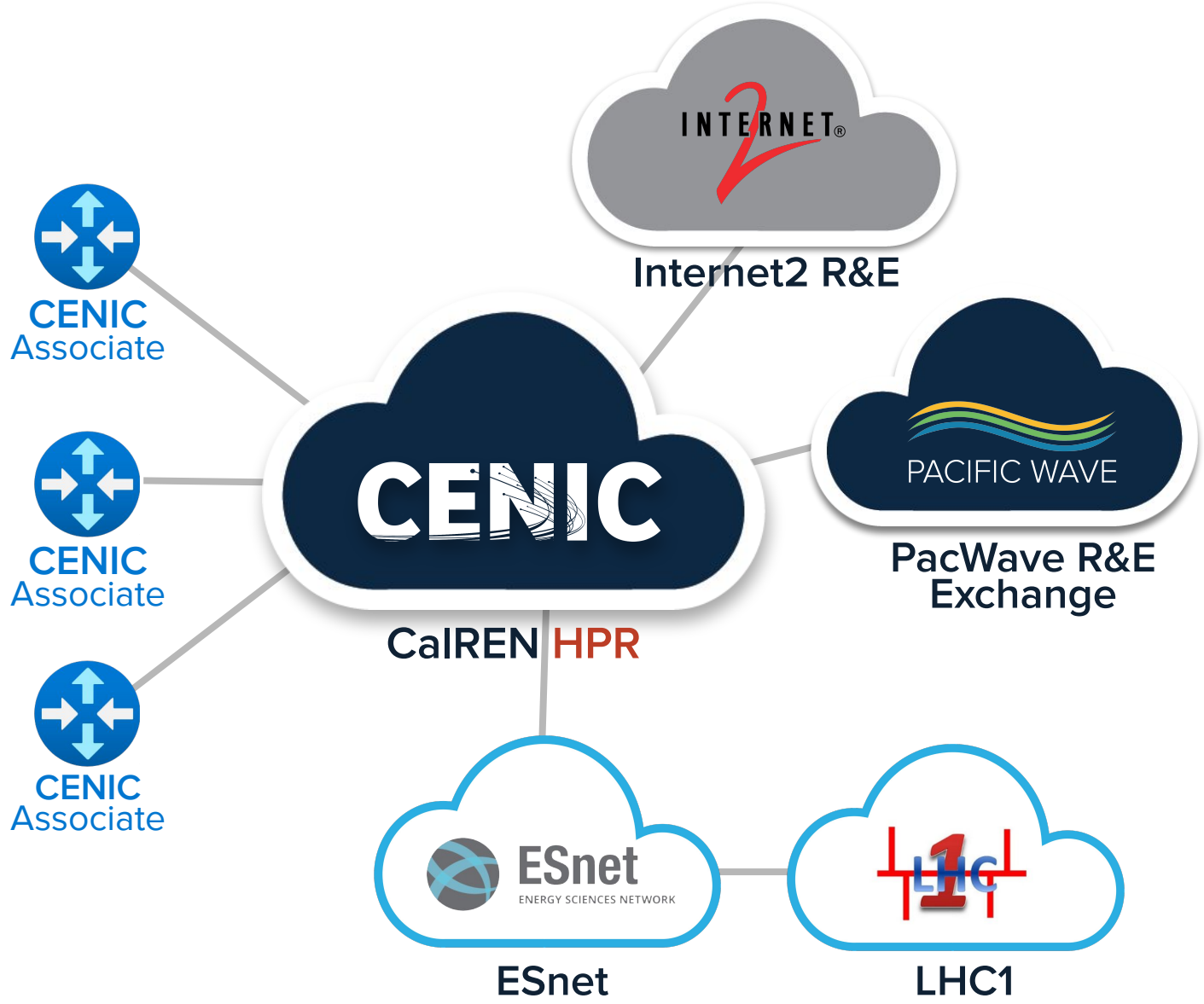


# CalREN Digital California (DC) Service

# CaIREN
# High Performance Research Network Service
# (HPR)

# High Performance Research (HPR)

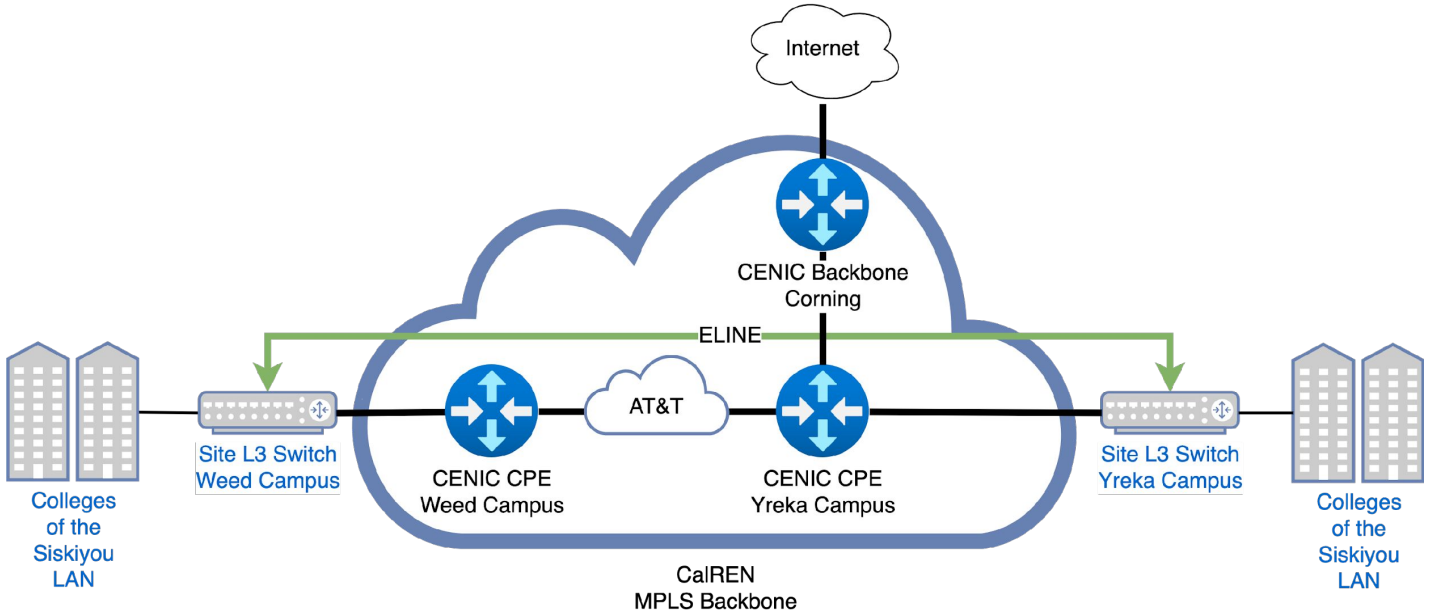
- R&E Only
- Leading edge network for large-application users
- Connectivity to:
  - Internet2 R&E
  - ESnet/LHCONE
  - Pacific Wave Exchange
  - NA-REX
  - And more…
- VRF inside CalREN Backbone



# MPLS VPN Services
# Layer 2 Virtual Private Networks
# E-LINE

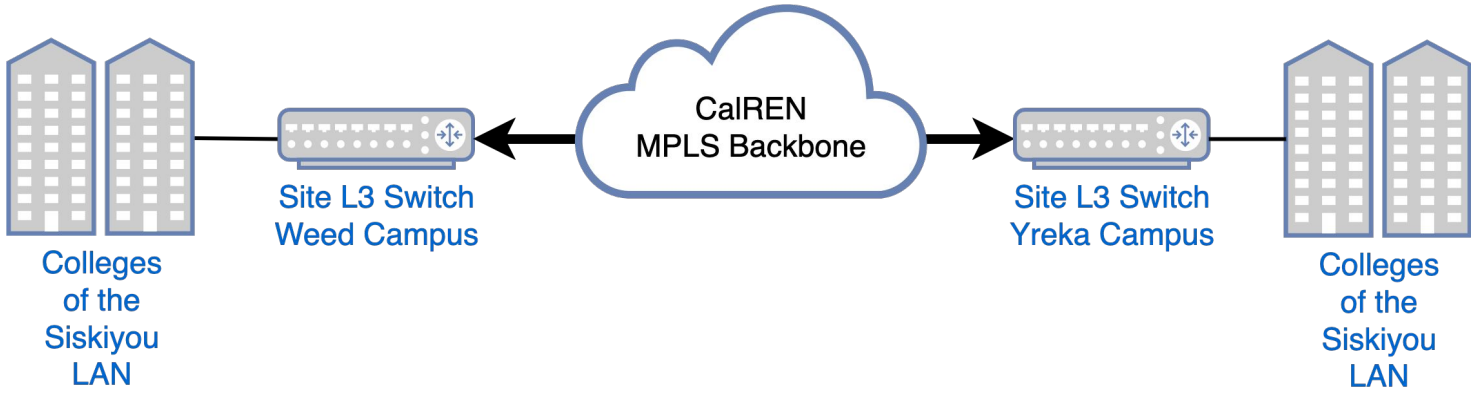
# L2VPN – E-LINE

- Use to extend layer 2 networks between 2 remote locations
- Use case: Transparently connect two locations
- Fiber-like connection between locations – with less cost than dark fiber

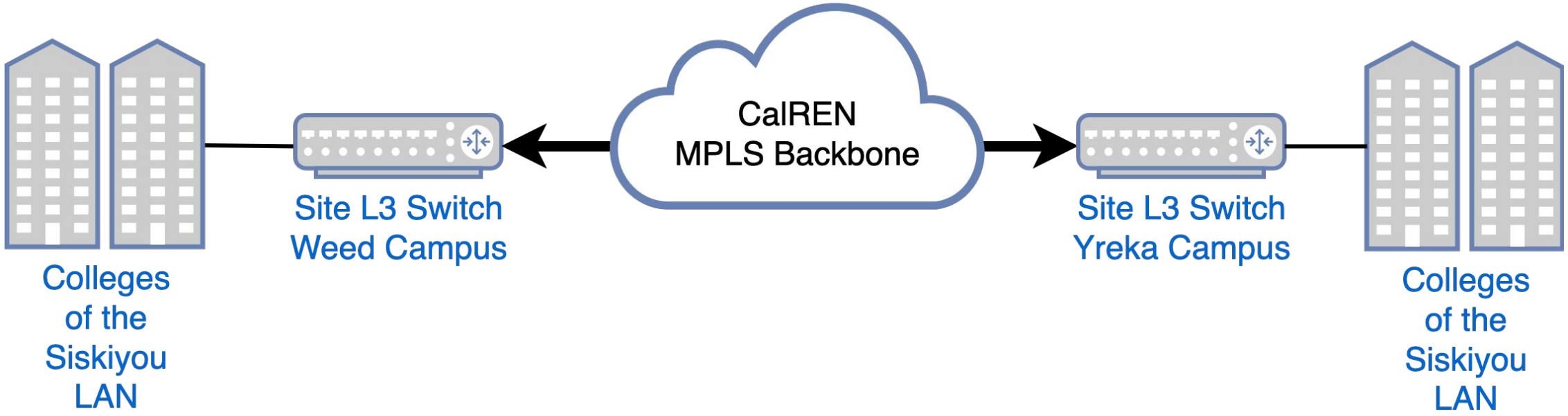


# L2VPN – E-LINE Case Study

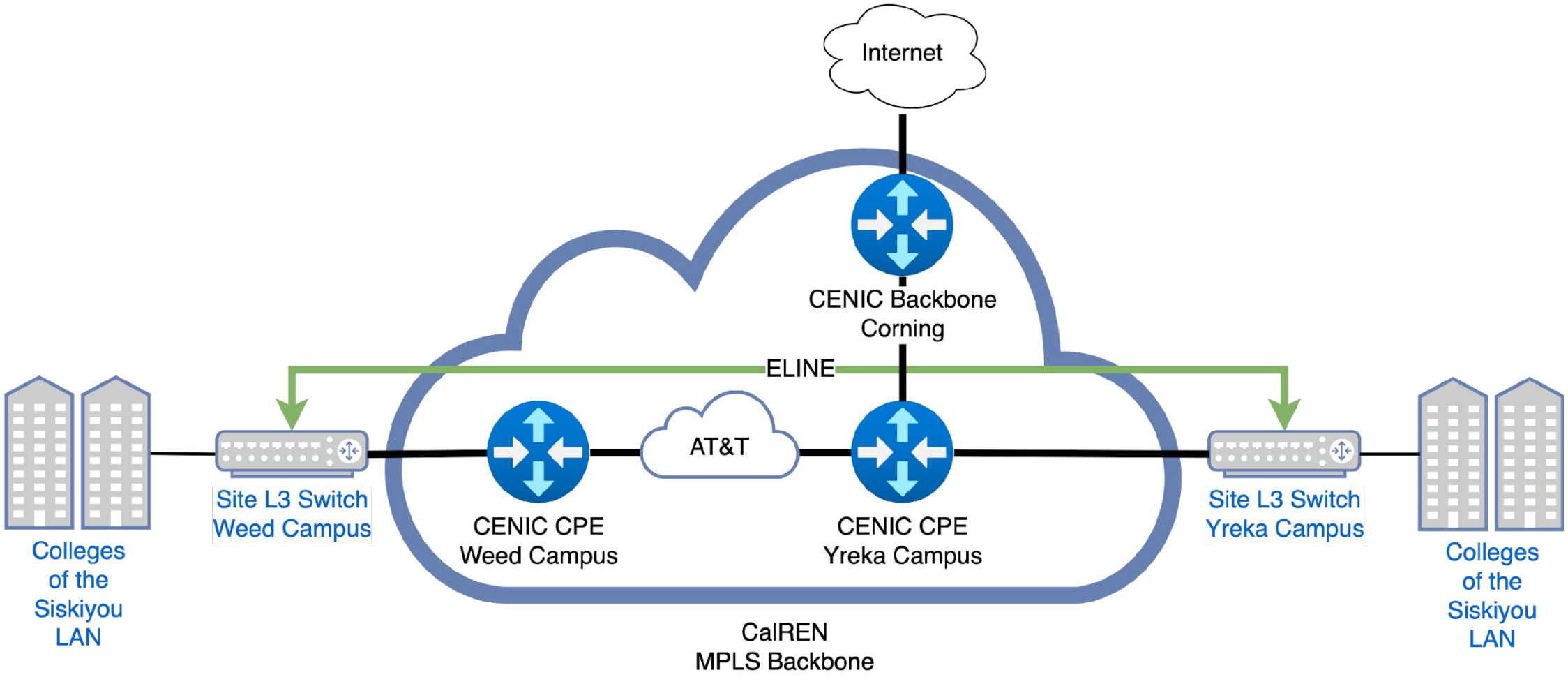
- Connect remote campuses without routing or extra hardware
- Recently provisioned Weed Campus and Yreka Campus E-LINE for Colleges of the Siskiyou



# L2VPN Private Network Service E-LINE: User View

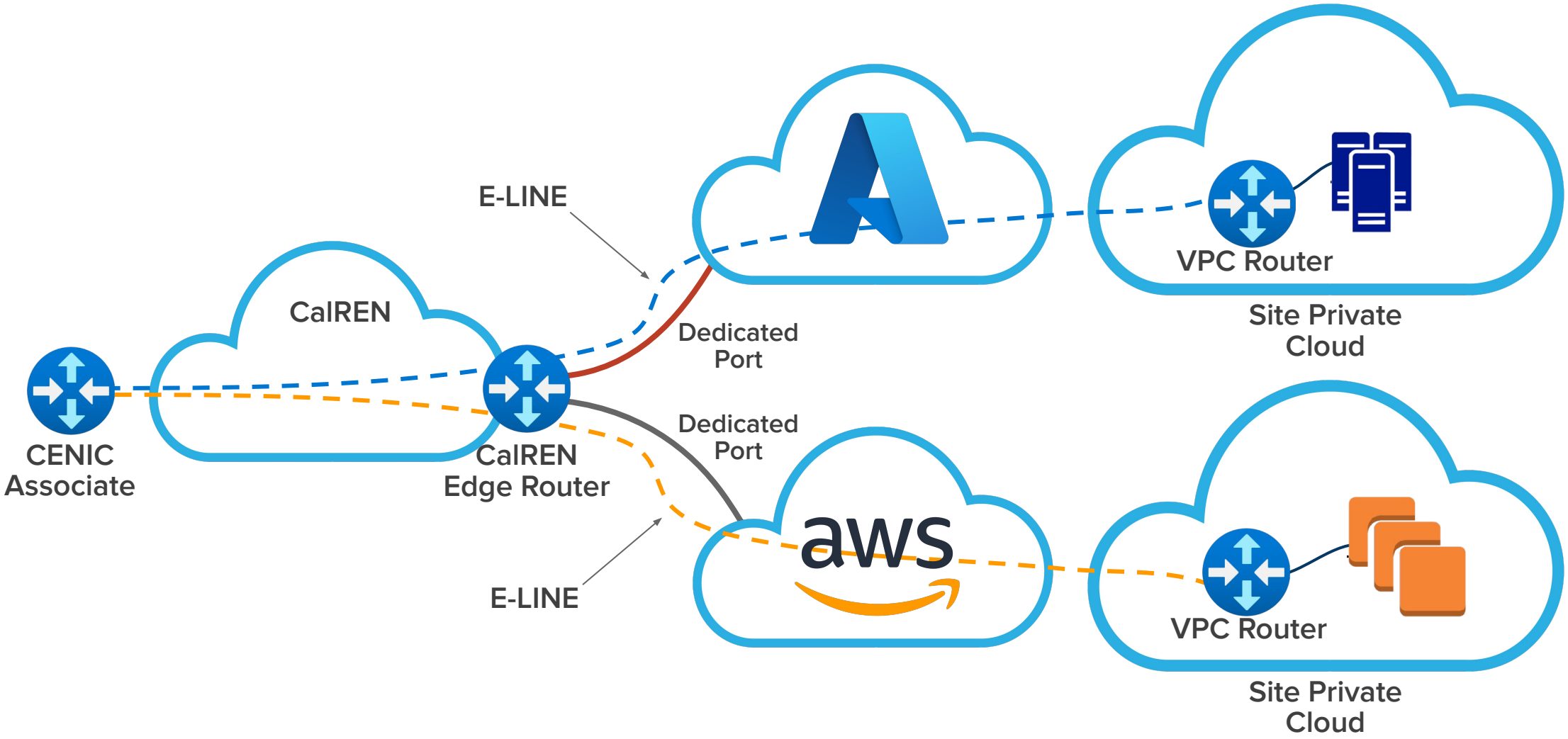


# L2VPN Private Network Service E-LINE: CENIC View



# MPLS VPN Services
# CENIC RPI over E-LINE

# CENIC Rapid Private Interconnect (RPI) over E-LINE

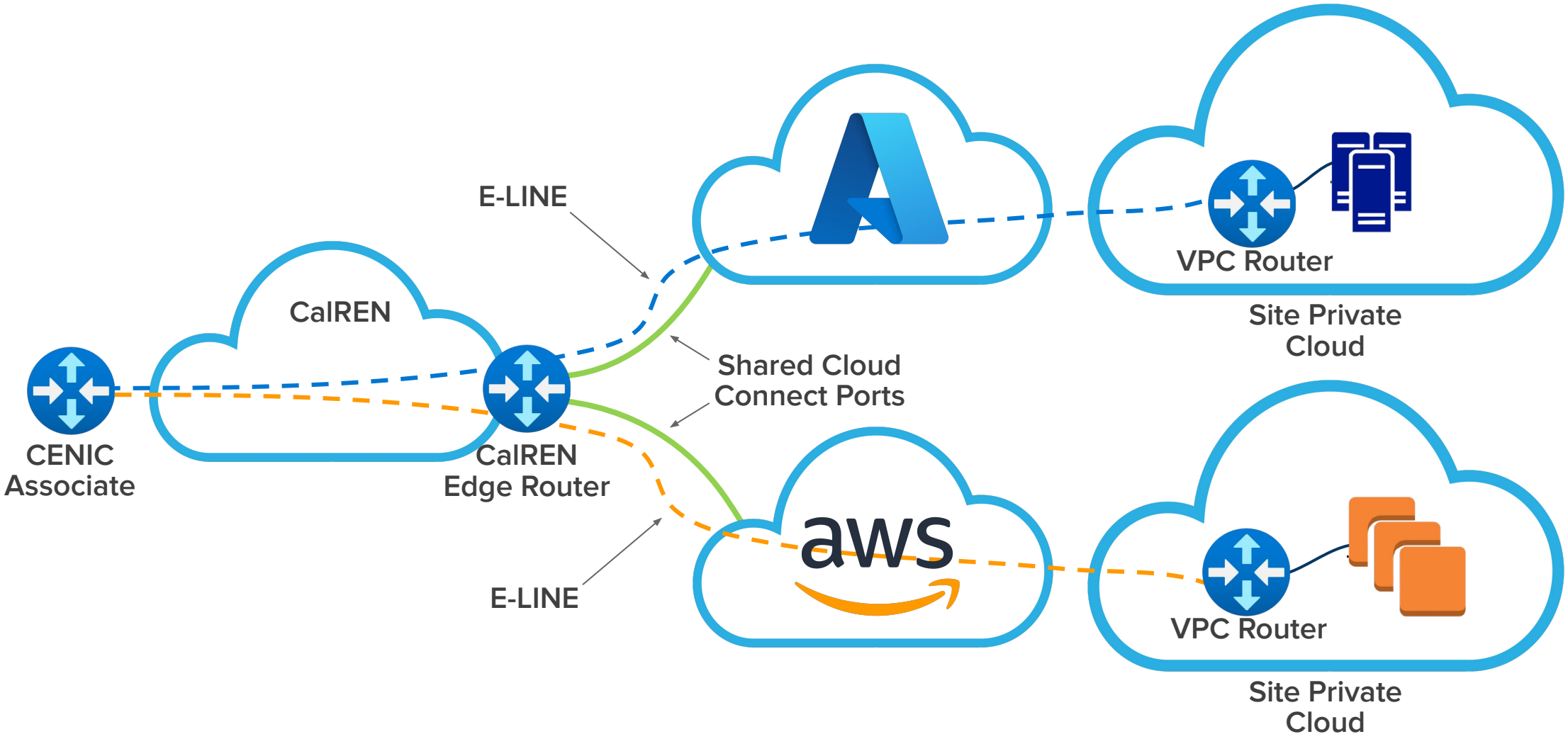


# MPLS VPN Services
# Cloud Connect Services

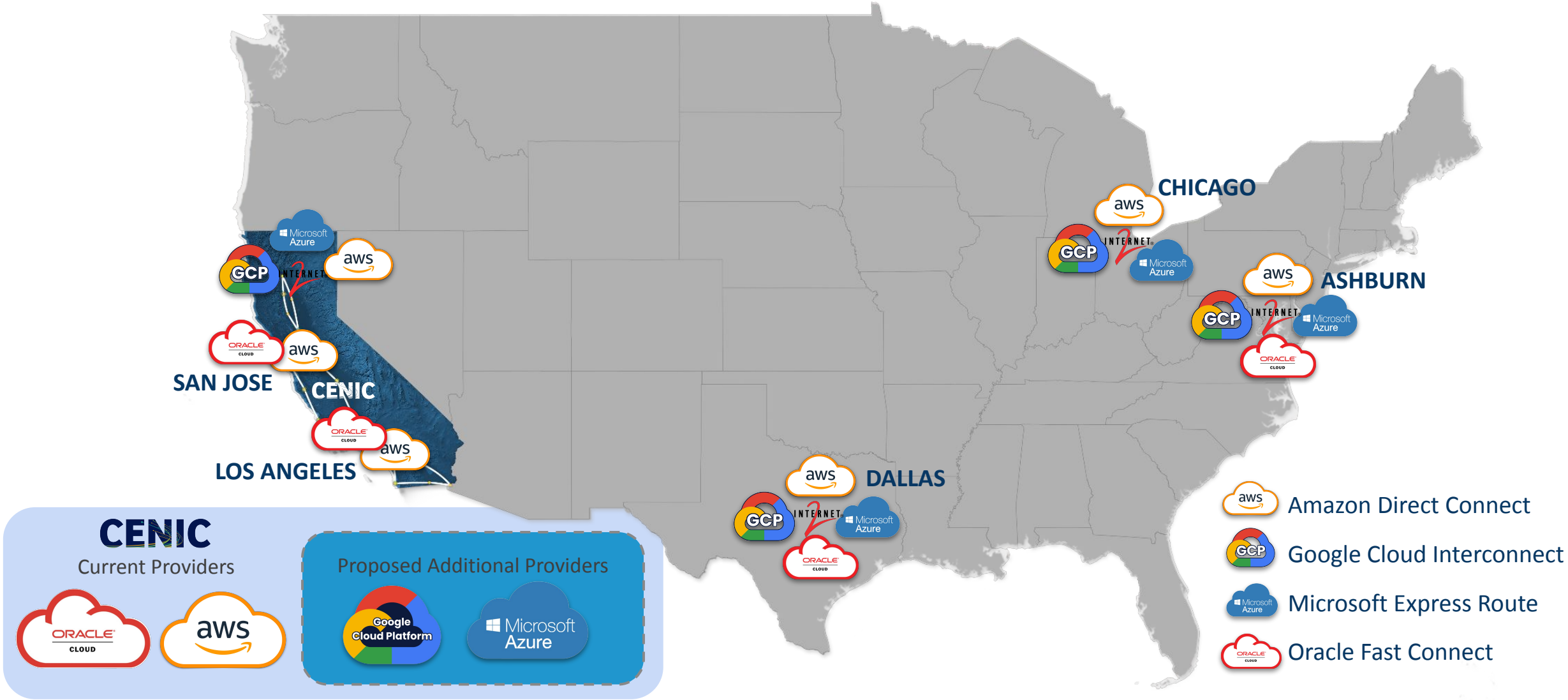
# Cloud Considerations

- Cost
- Bandwidth
- Latency
- Performance
- Resiliency

# CENIC Rapid Private Interconnect (RPI) over E-LINE



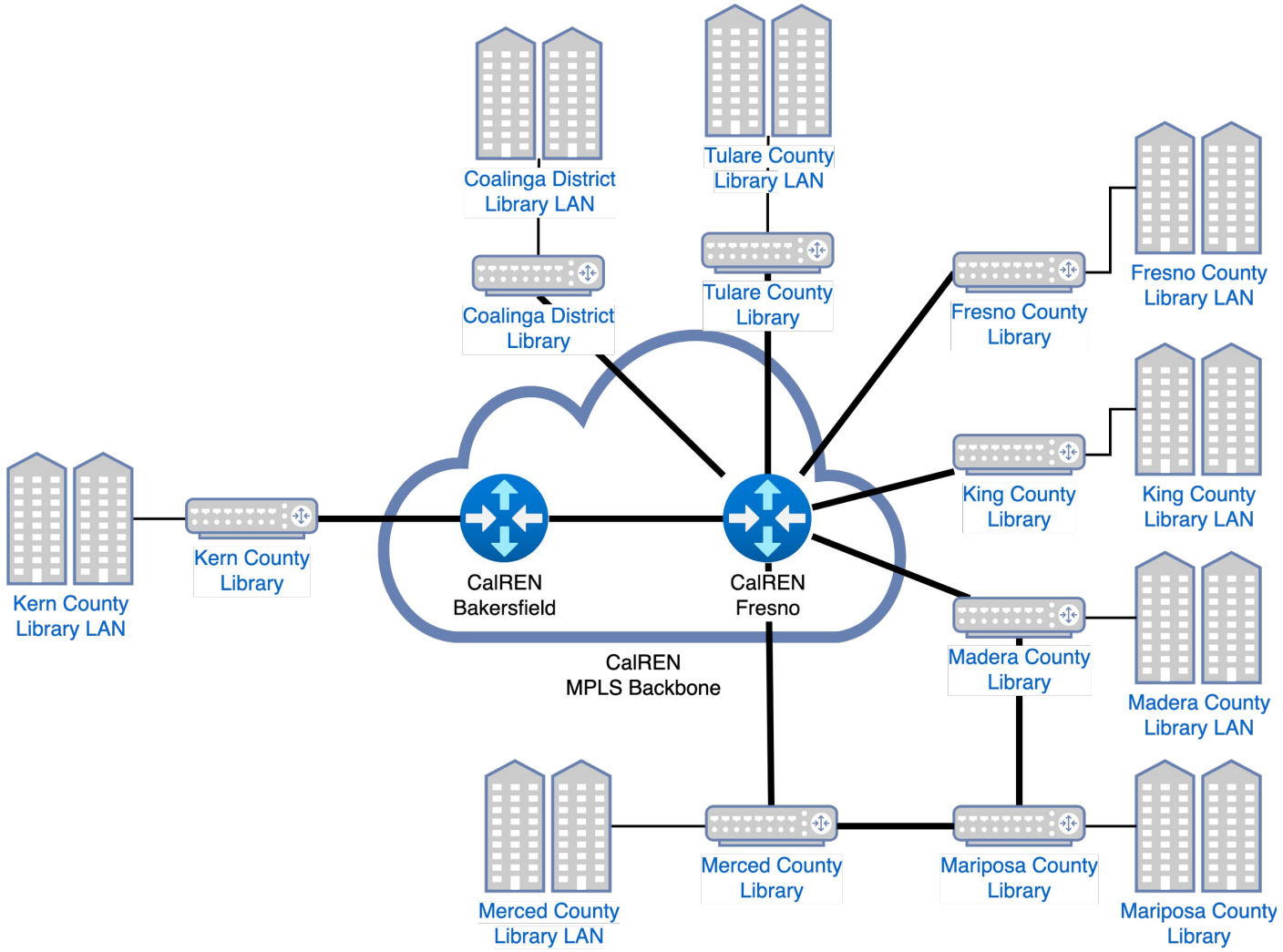
# Cloud Connect



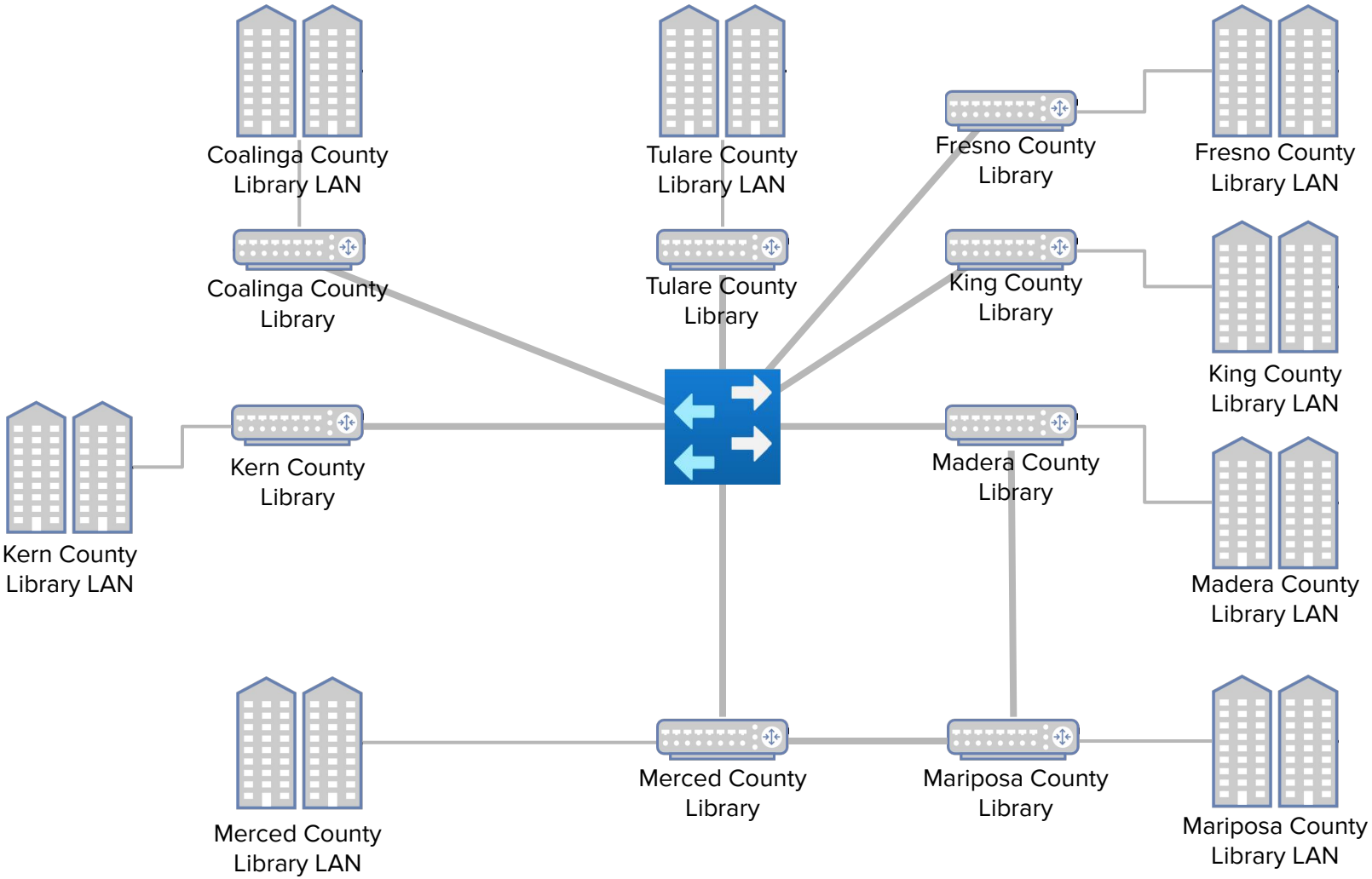
# MPLS VPN Services
# Layer 2 Virtual Private Networks
# E-LAN

# L2VPN – E-LAN

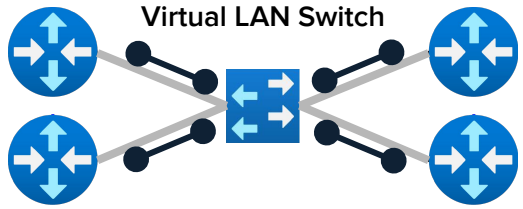
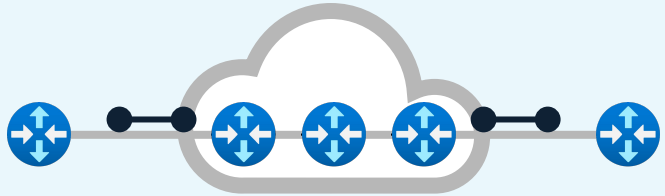
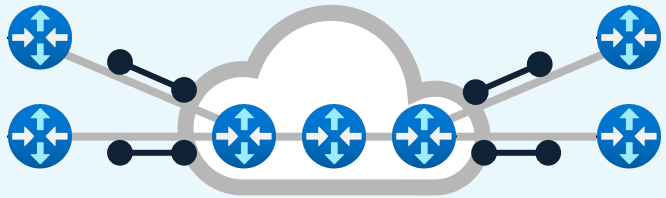
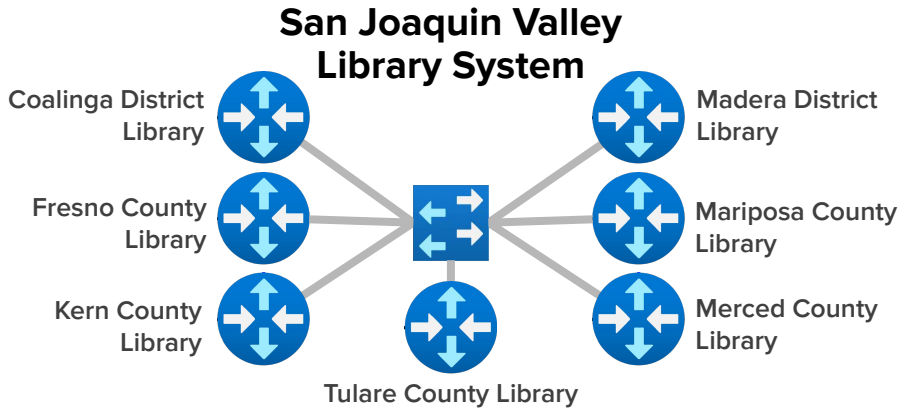
- Use to extend layer 2 networks between 2 or more remote locations
- Use case: Transparently connect three or more campuses
- Let us do the switching for you



# L2VPN Private Network Service – E-LAN User View



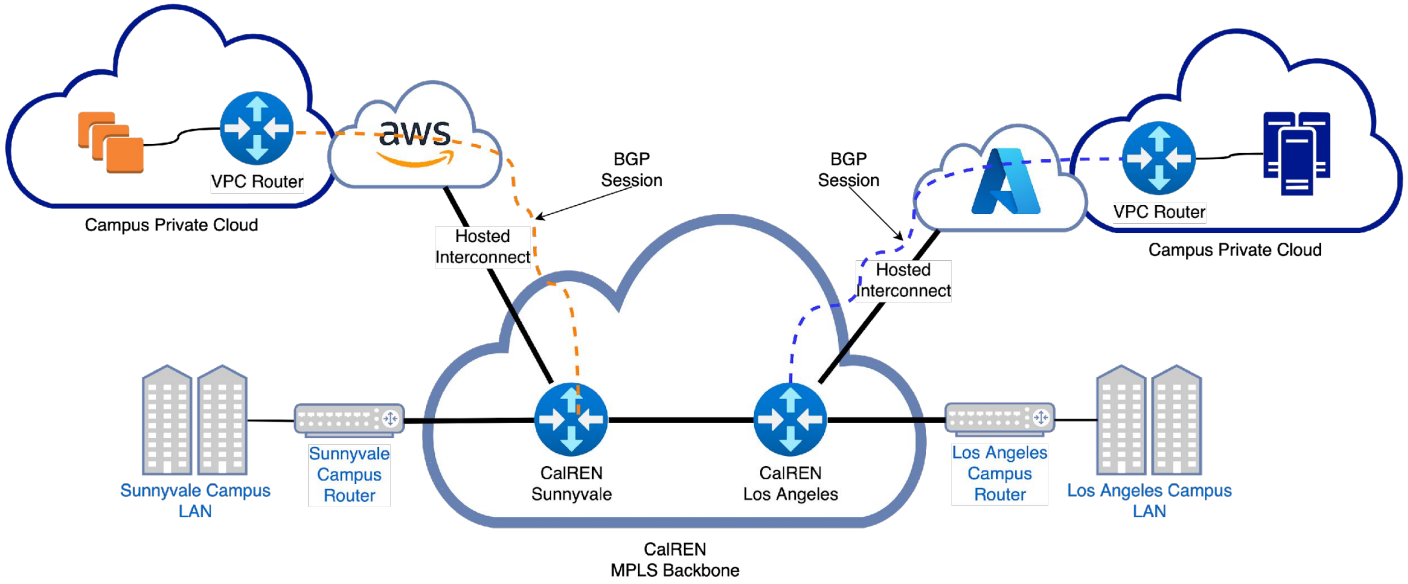
# E-LAN and E-LINE Comparison

| SERVICE TYPE | E-LINE | E-LAN |
|---|---|---|
| CONNECTION | Point-to-Point | Multipoint-to-Multipoint |
| ASSOCIATE VIEW |   |   |
| CENIC VIEW |  |  |
| EXAMPLES |   |   |

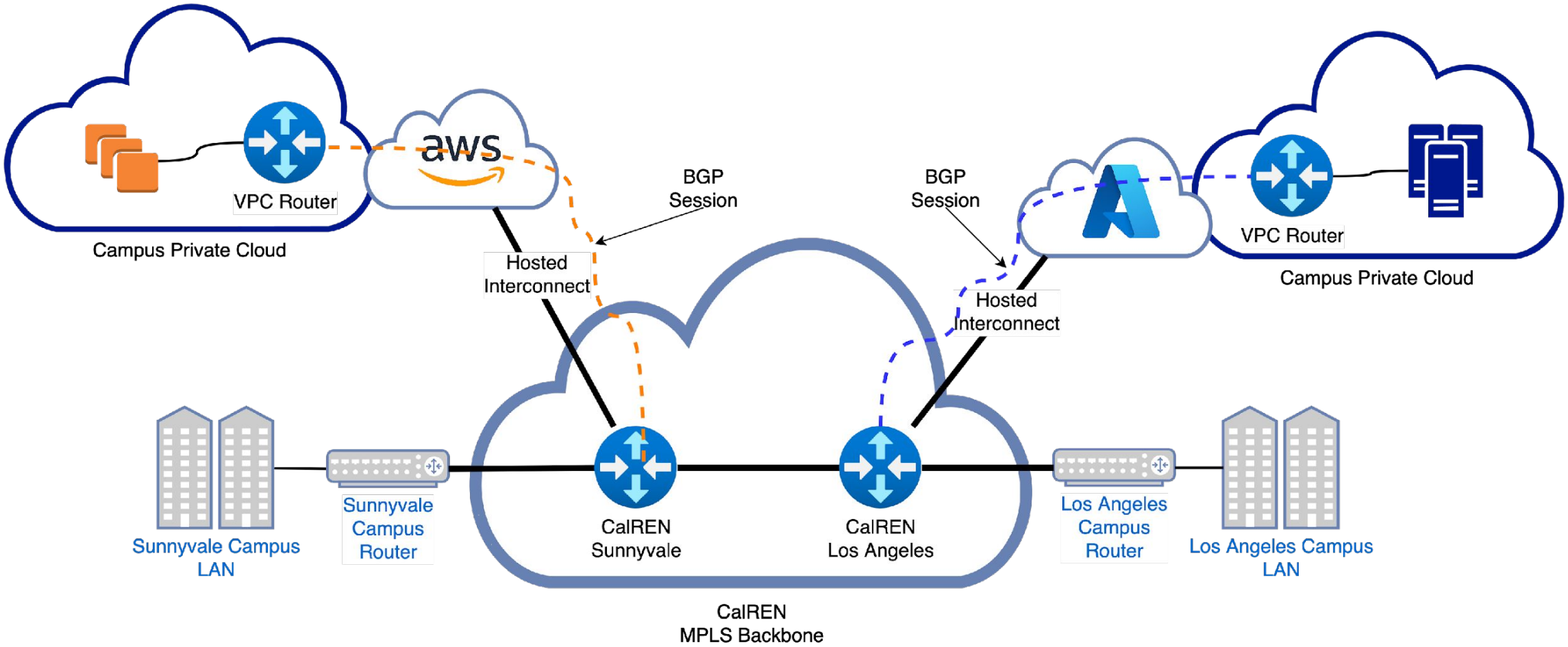
# MPLS VPN Services
# Layer 3 Virtual Private Networks
# IP-VPN

# L3VPN – IPVPN

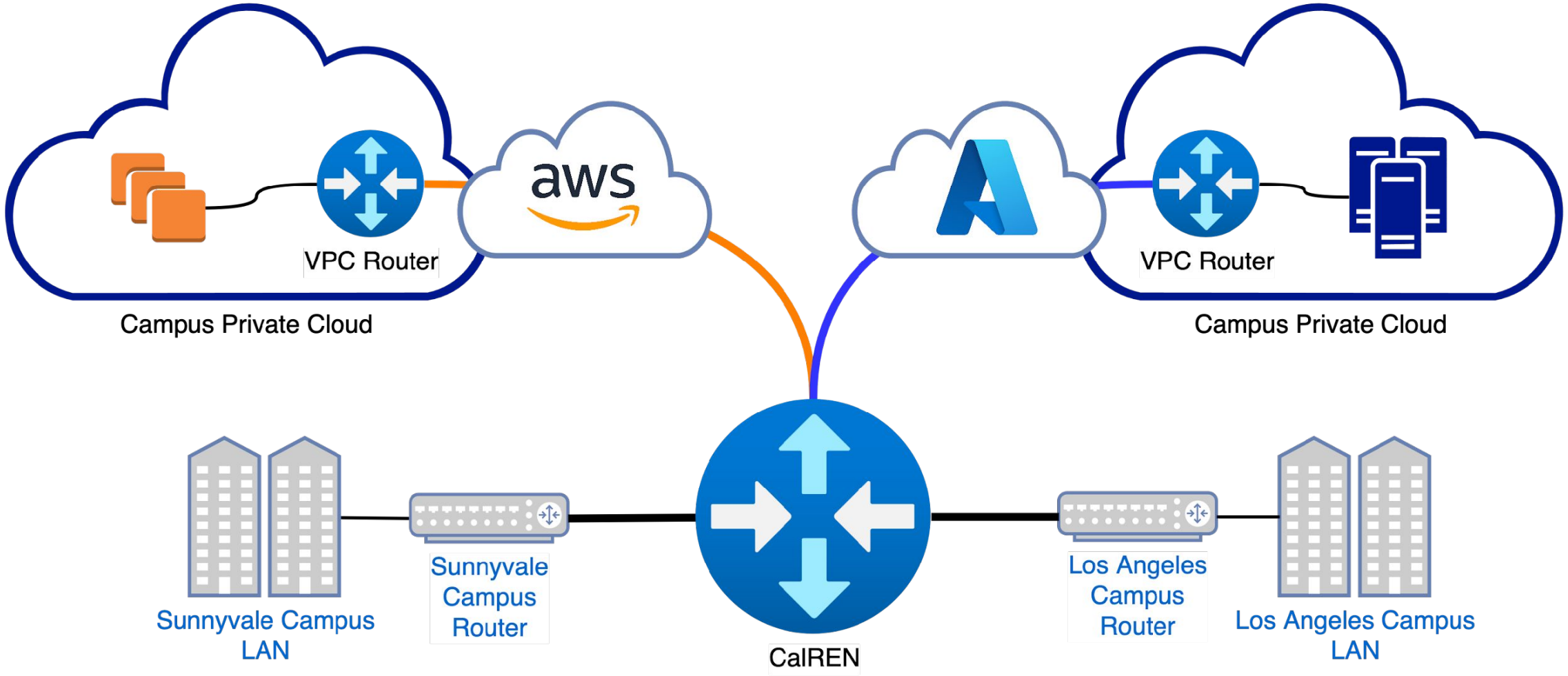
- Dedicated Routing Instance (VRF)
- Allows the use of private IP addresses across geographically diverse sites
- Use case:
  You already run BGP with us and want to extend your LAN to multiple locations or connect to private multi-cloud



# L3VPN Private Network Service – IPVPN CENIC View

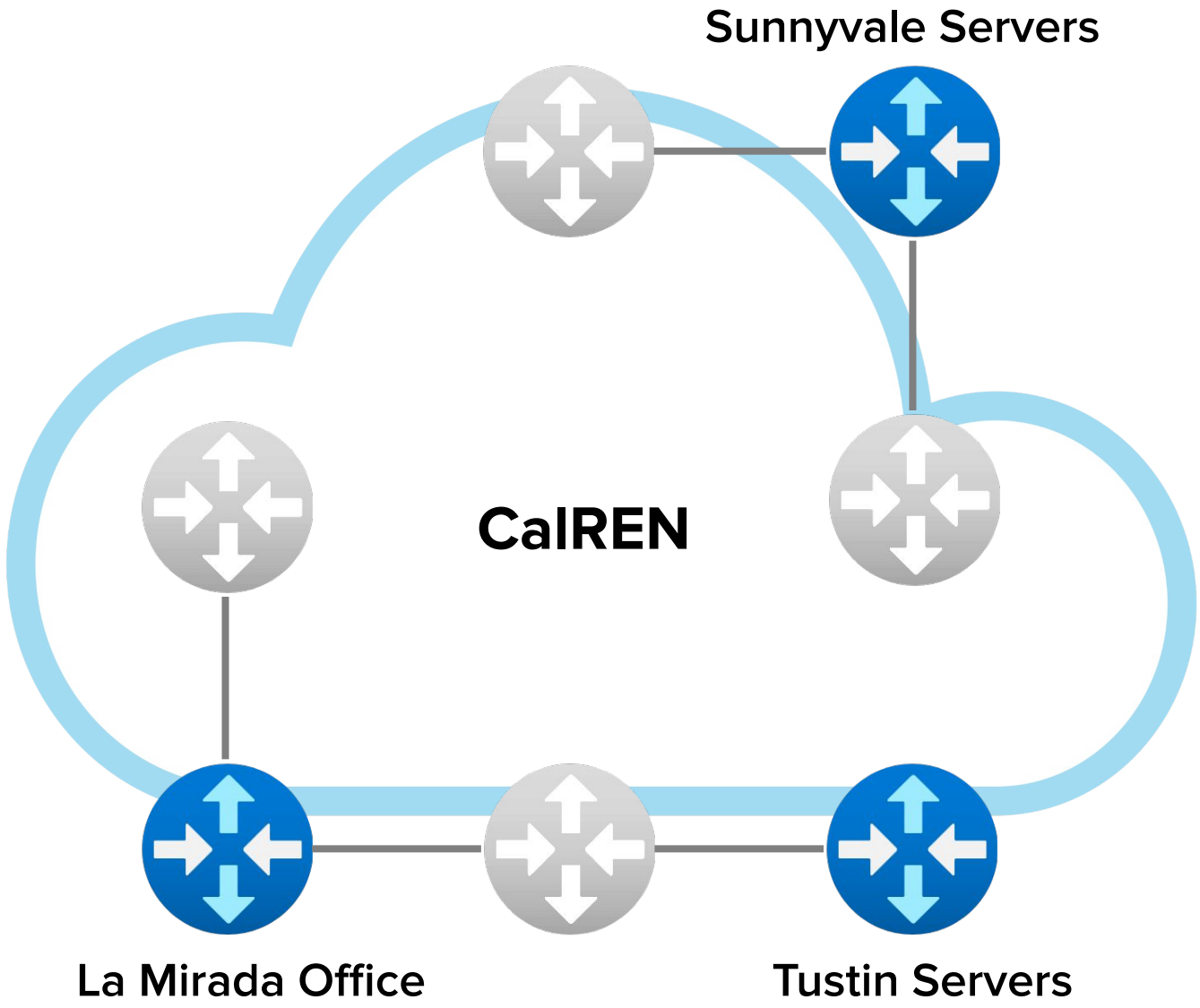


# L3VPN Private Network Service – IPVPN User View



# L3VPN – IPVPN Case Study - CENIC

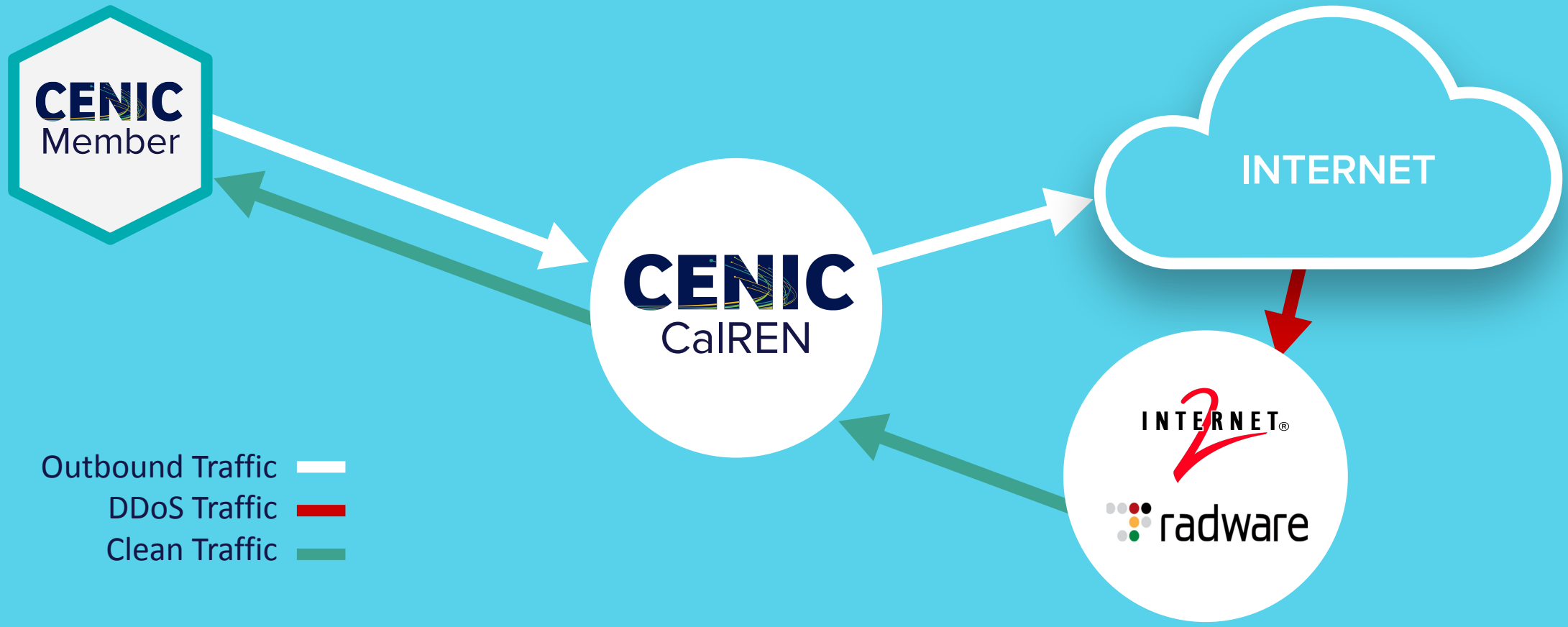
- Server deployments across 3 locations can use private IP addresses across CalREN with no impact to other users of the CalREN



# CENIC DDoS Mitigation Service (DMS)

# DDoS Mitigation Service (DMS)

**DDoS Mitigation Service:** A managed solution that works to clean CENIC's traffic by Internet2's Radware DDoS scrubbing infrastructure. Scrubbing centers are located in the US.



# DDoS Mitigation Service (DMS)

## Protects Against

- Radware's DMS Product Mitigates Volumetric Attacks that Operate at the Network and Transport Layer of the Open Systems Interconnection (OSI) Model.
- Protection is Offered Against DDoS Attacks that Target Network Infrastructure and Equipment in an Effort to Overwhelm Bandwidth and Session Handling Capacity.

## Does Not Protect Against

- Other Types Of Cyber Attacks → Generally Targeting the Application Layer
  - Ransomware/Malware
  - SQL Injection
  - Cross-Site Scripting

# DDoS Mitigation Service (DMS) – Options

- **Operationally & Technically Identical**
- **Differing Responsibilities for Monitoring & Response Activity**

## CENIC Managed Solution

- Subscriber of CENIC's DDoS Mitigation Service
- CENIC will perform the following:
  - All Technical Setup to Support Mitigation Routing
  - DDoS Detection of Volumetric Attacks
  - Activation of Mitigation Scrubbing Services - Upon Customer Approval
  - Provide Quarterly Reports of Mitigation Activity

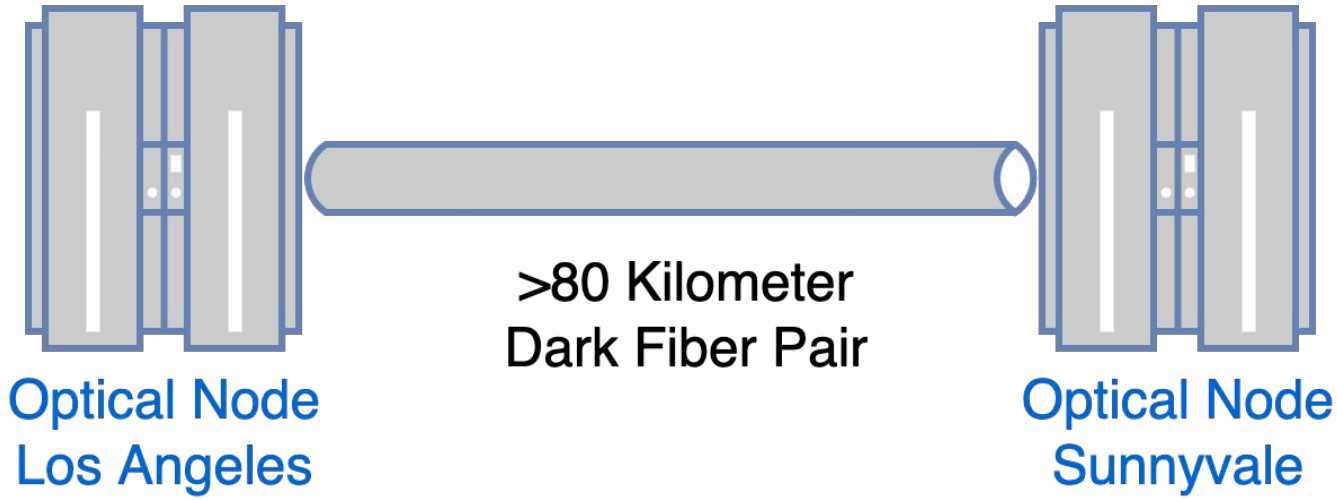
## Self-Service Solution

- Downstream Tenant of Internet2/Radware
  - Direct Access to the Service Provider Security Operations Center (SOC):
    - *Initiate Scrubbing*
    - *Portal Access to Review Mitigation Efforts and Reporting*
    - *Direct VRF*
- Responsible for Own DDoS Detection and Activation of Mitigation Scrubbing Services

# Layer 1 Services
# Optical Service

# What is an Optical Line System (OLS)?

- Deployed optical components to transmit signal from one location to another over fiber
- Can be between any 2 locations
- Backbone to Edge
- Backbone to Backbone
- Edge to Edge

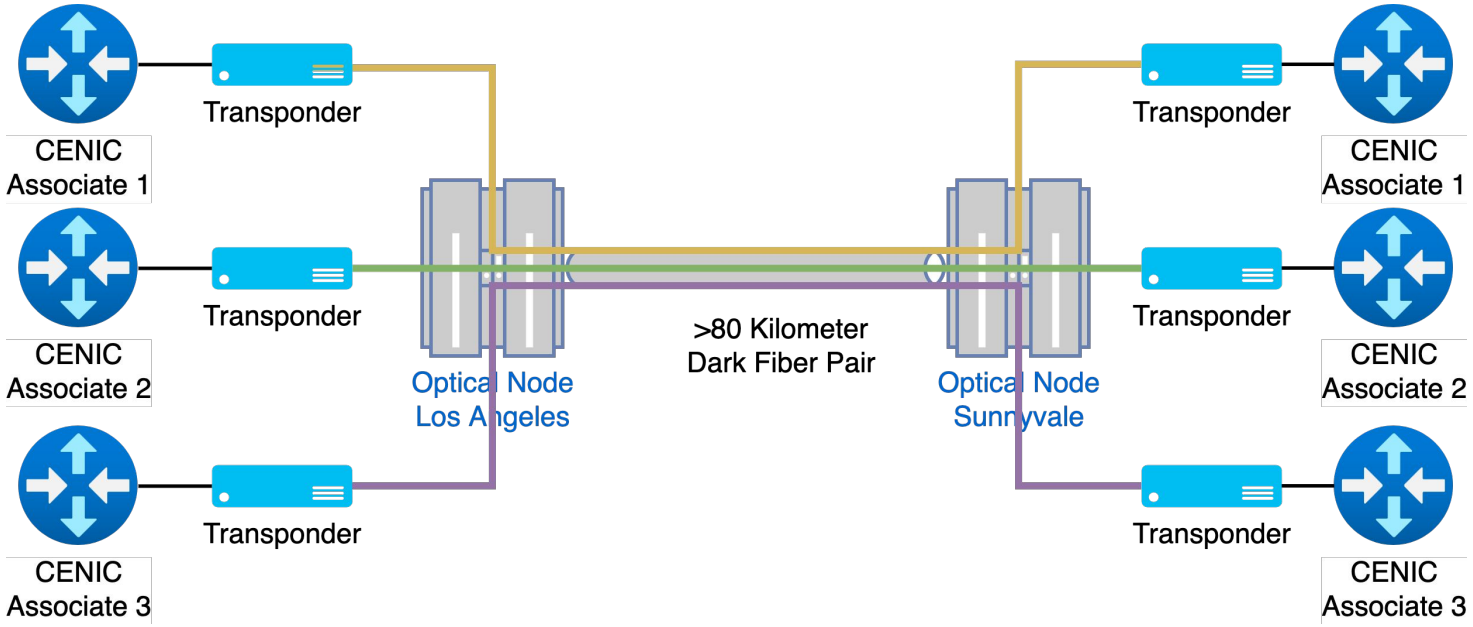


# Service over an OLS

- Transponder takes regular signal and converts to a frequency
- Frequency is carried from A to Z
- Frequency converted back to regular signal
- 400G/200G/100G Ethernet

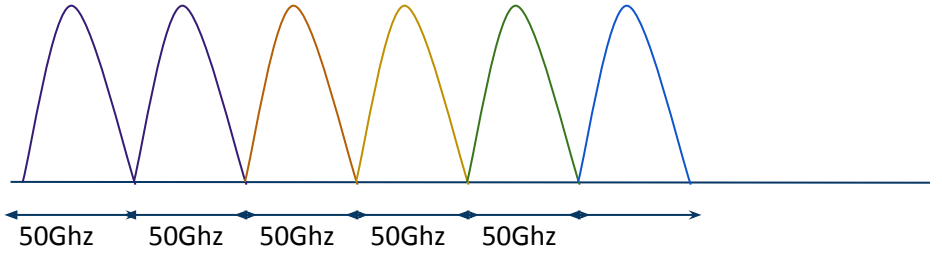
# Multiple services over an OLS

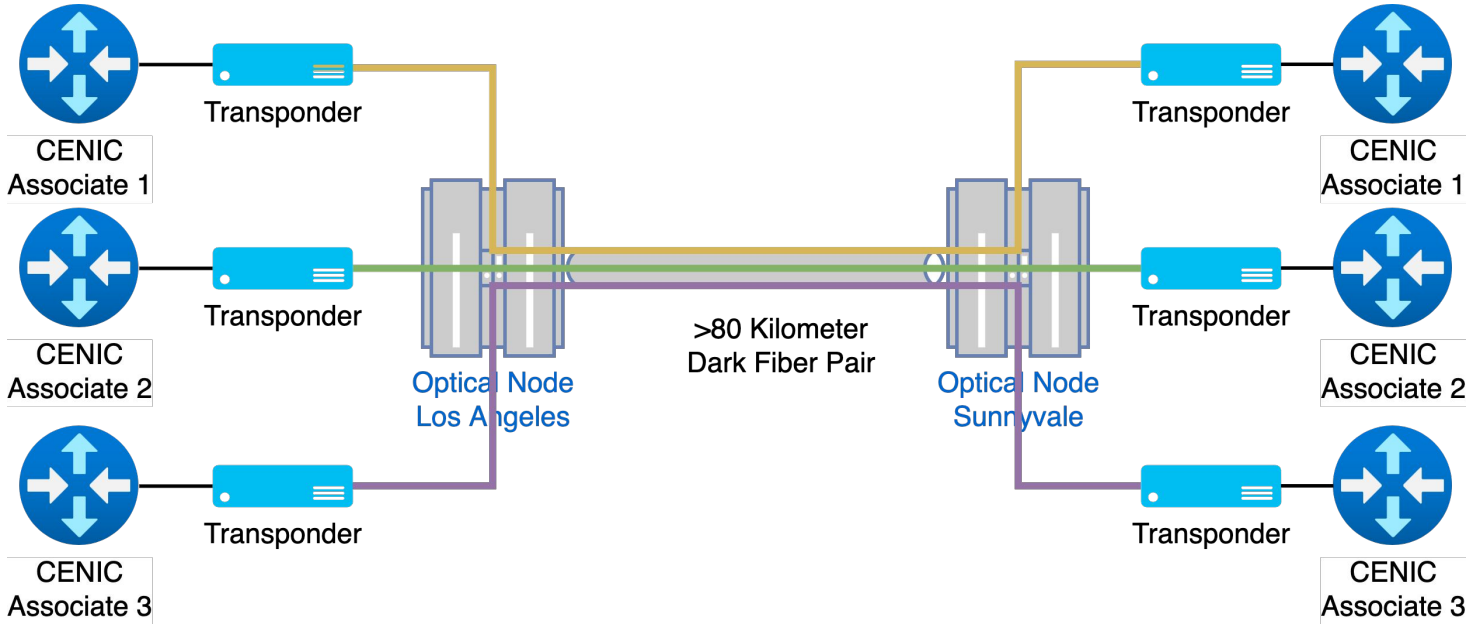
- Transponder takes regular signal and converts to a frequency
- Frequency is carried from A to Z
- Frequency converted back to regular signal
- 400G/200G/100G Ethernet



# Legacy OLS
# 2009 - 2018

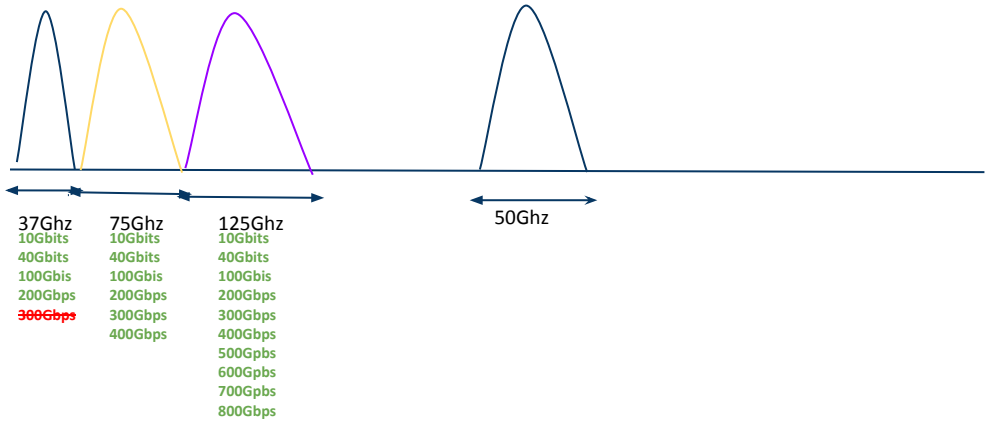
- Fixed Grid – 50Ghz
- 4800Ghz capacity
- 96 Channel Maximum
- All channels, no matter the service, takes 50Ghz
- 200Gb/s maximum capacity per service

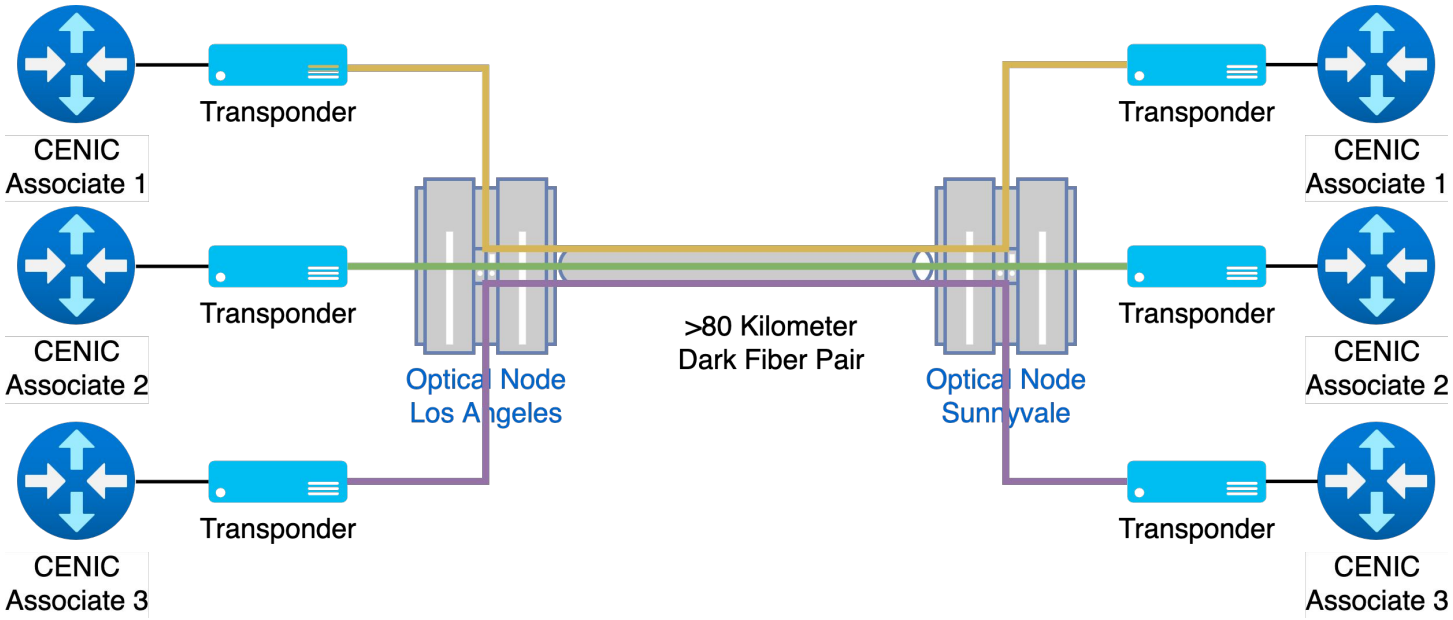


# Current Gen OLS 2019 – Present

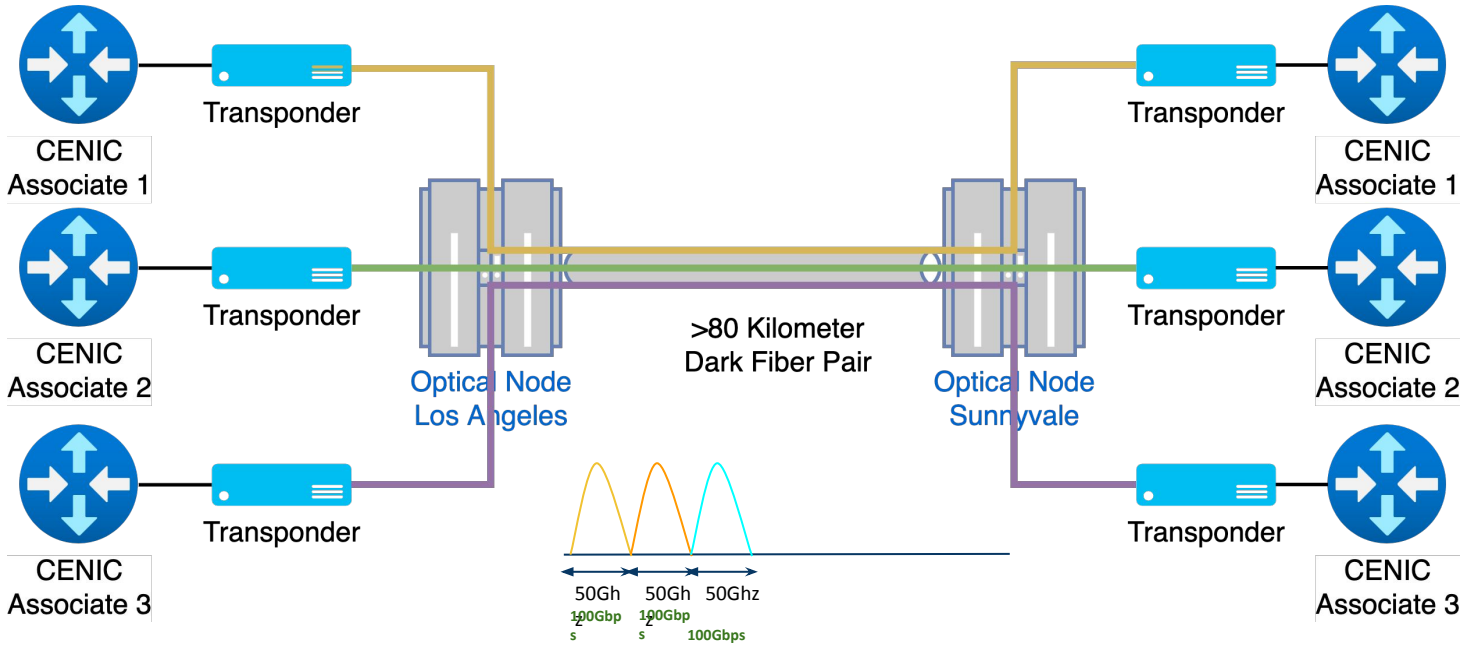
- Flexible grid
- 4800Ghz capacity
- Each service only uses the required amount of spectrum
- Compatible with fixed 50Ghz
- Support for 400Gb/s+ services

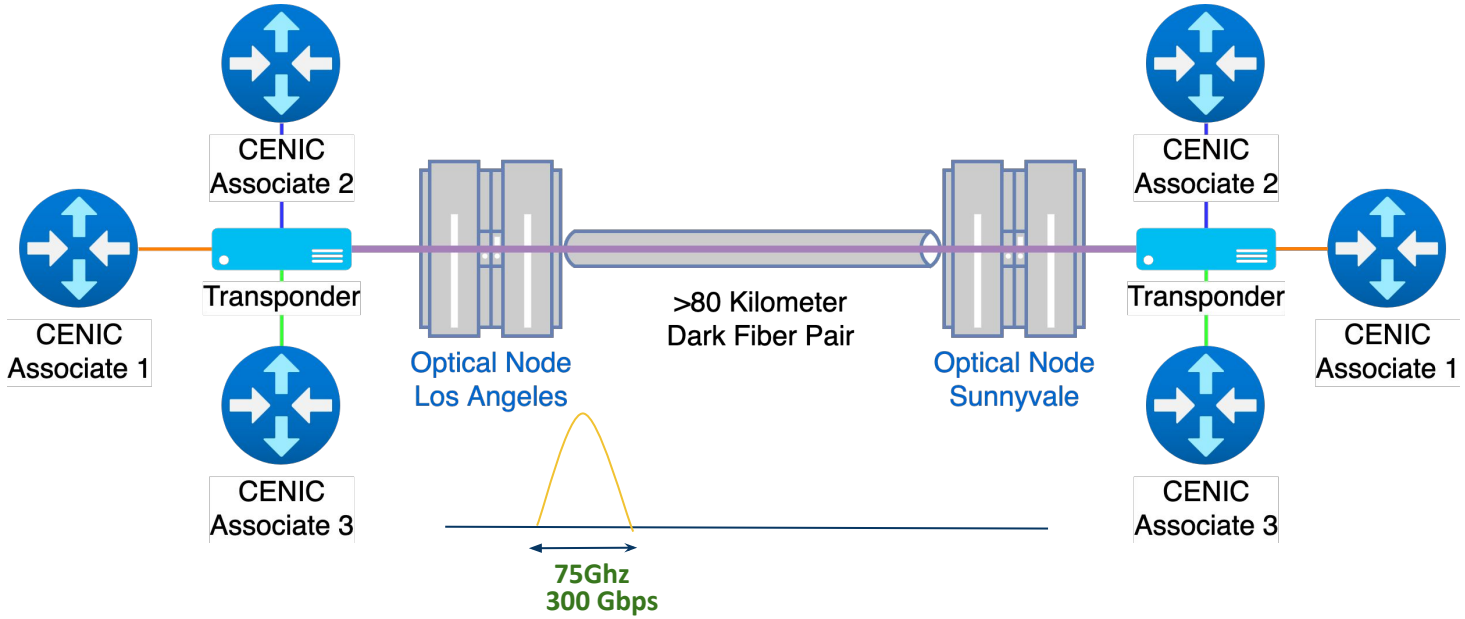


# Legacy vs Current

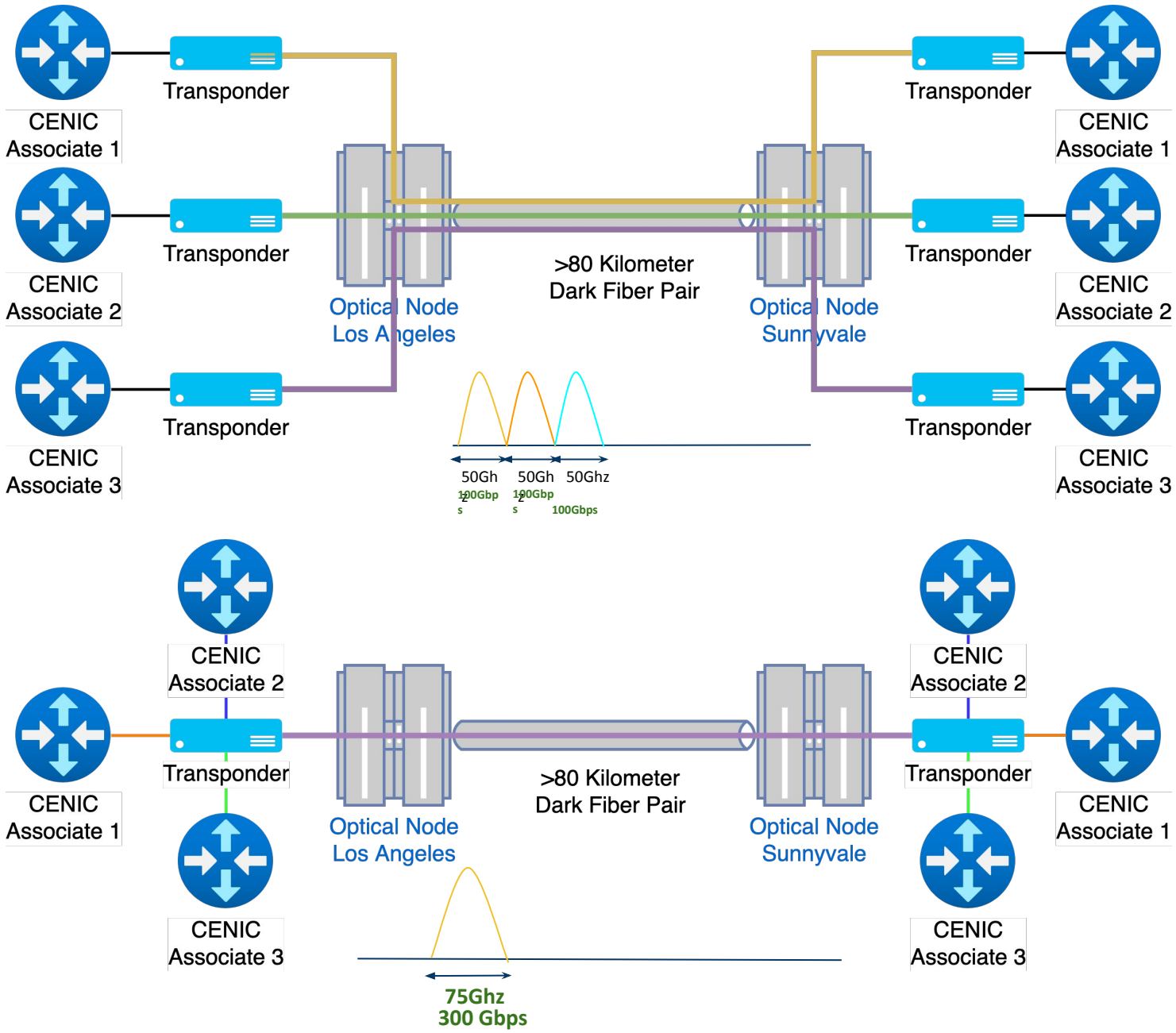
- 300Gb/s service
- 3X Equipment + 3X Spectrum required
- $210K vs $70K
- Space and power higher



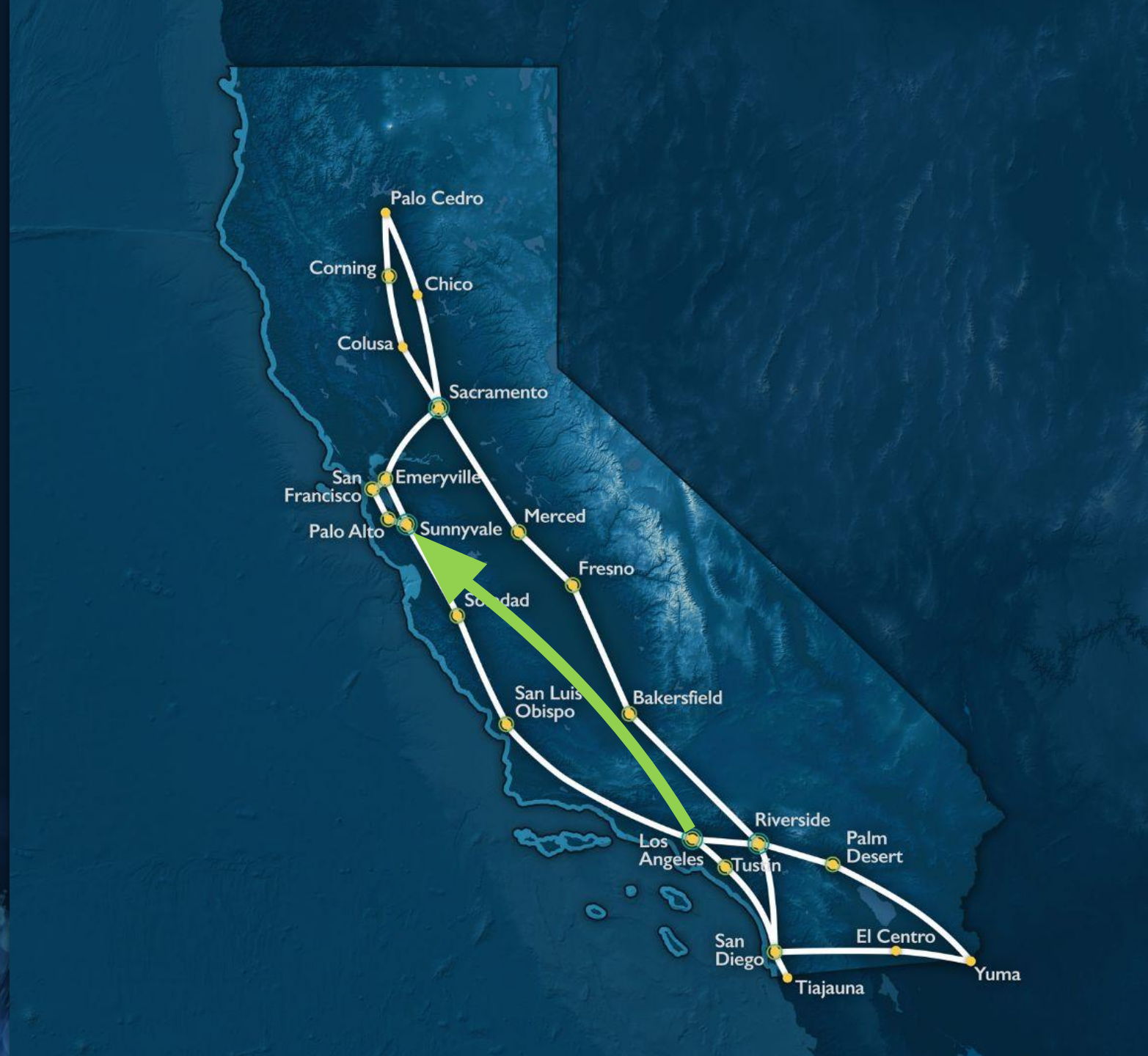
# Extra spectrum: Spectrum as a Service

- As we upgrade to newer equipment, space, spectrum, and power is freed for use
- Spectrum is available for CENIC Associate use



# Optical Service

- Gets you from here to there and back on top of dark fiber, with no layer 2 or layer 3 equipment in between
- Any network can be run over the top of an optical service
- Example: 400 Gigabits per second of capacity between Los Angeles and Sunnyvale

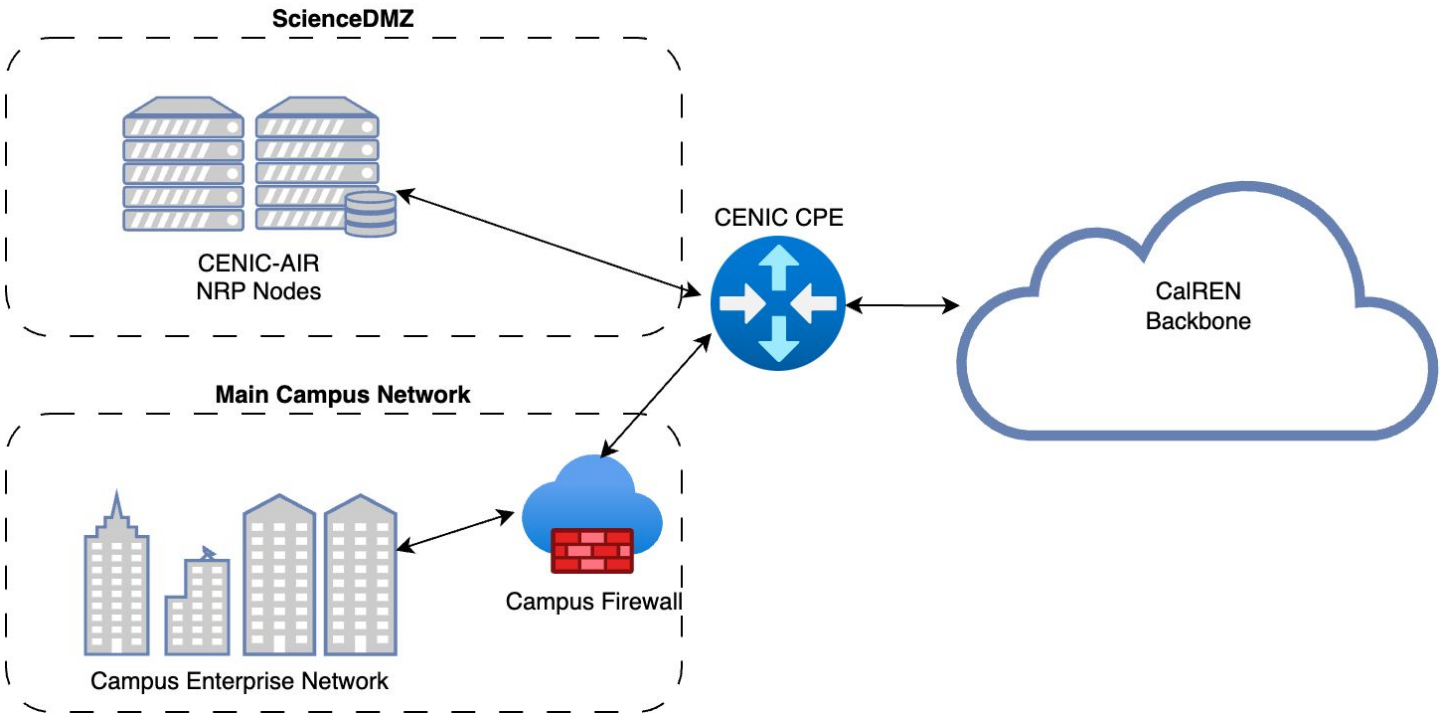


# CENIC AIR ScienceDMZ

NRP NATIONAL RESEARCH PLATFORM

# ScienceDMZ Concept

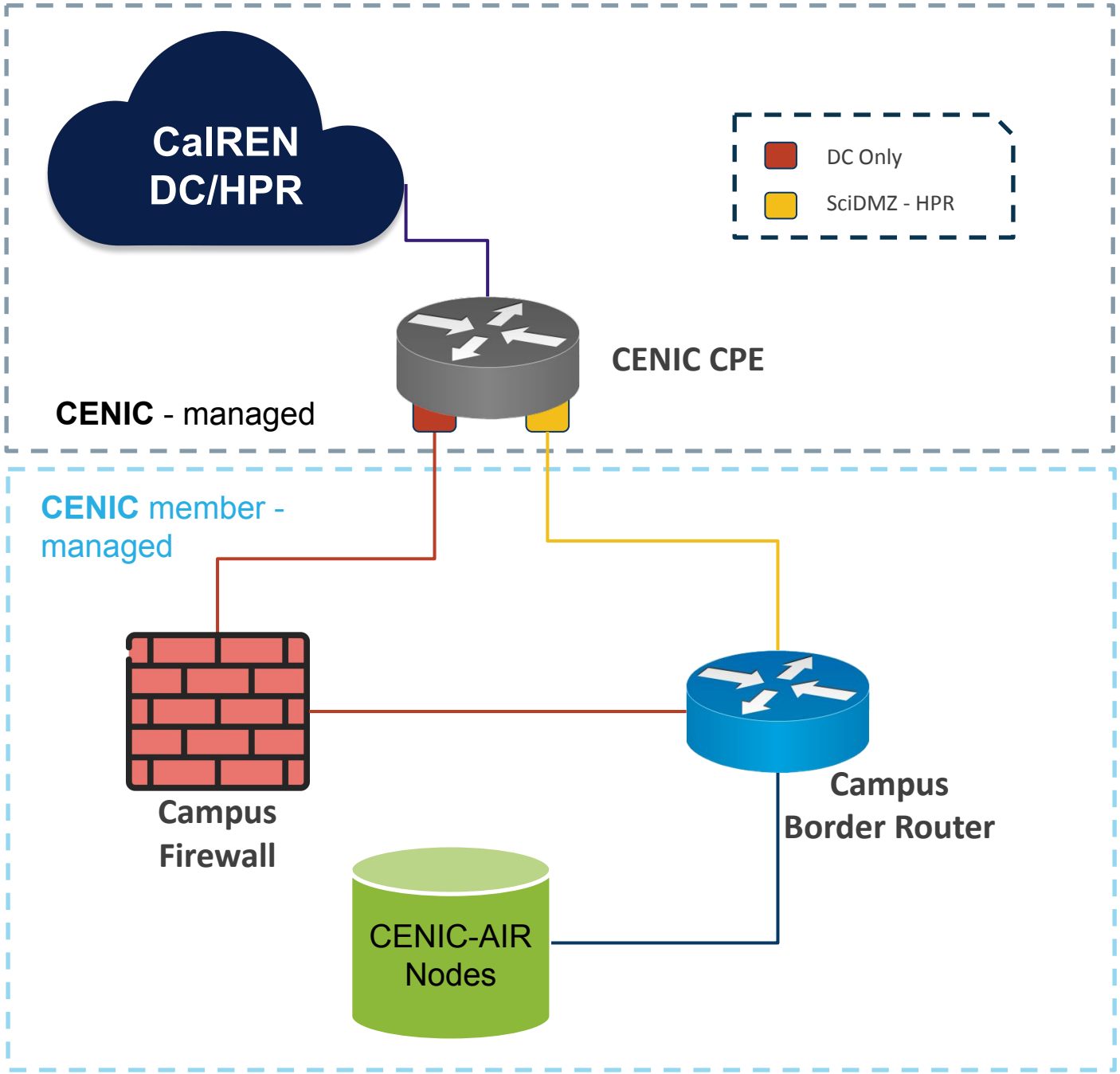
- Direct access to CalREN
- Optimized for high-performance computing




NATIONAL RESEARCH PLATFORM

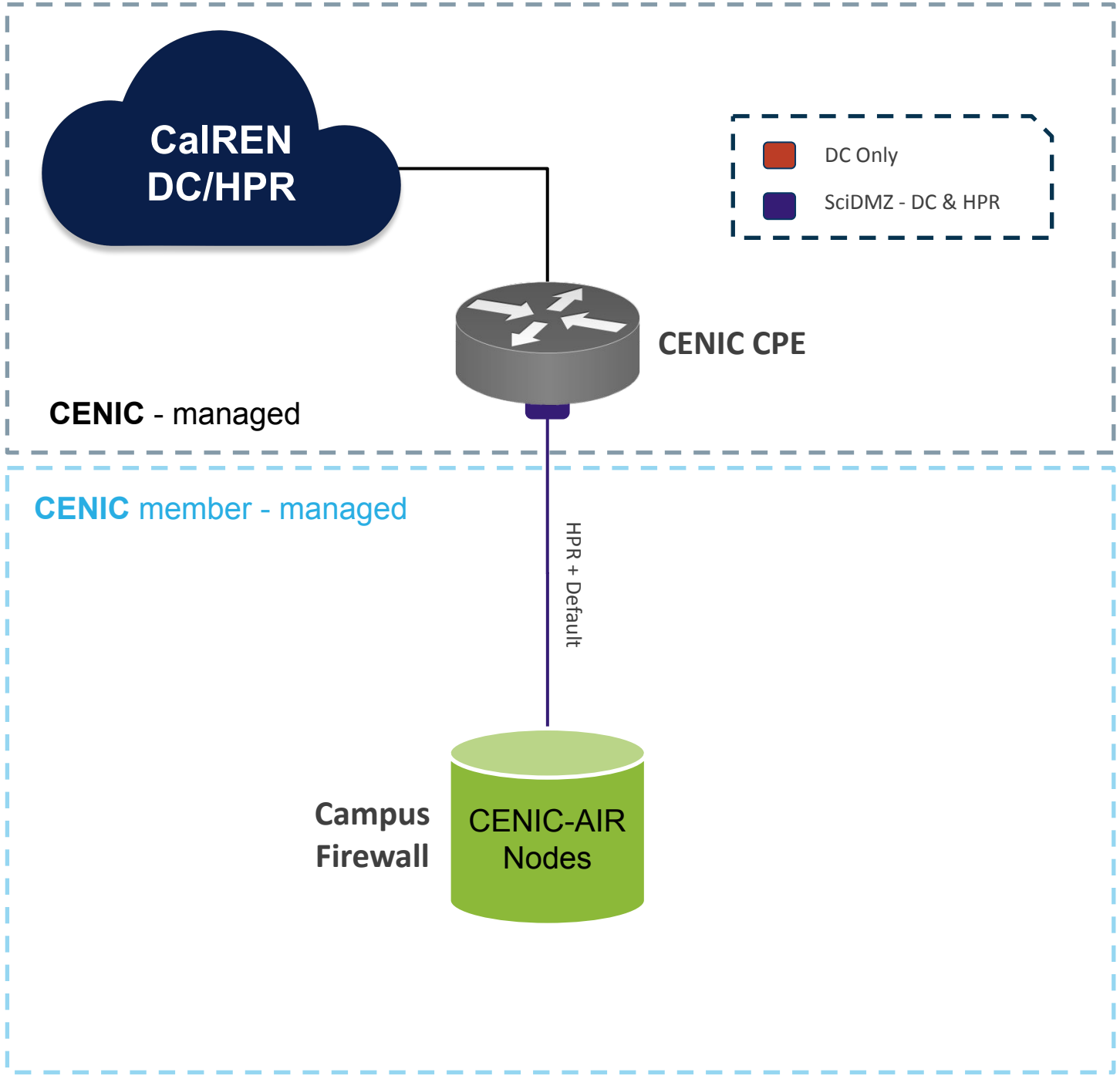
# ScienceDMZ routing: Campus Border Router

- Internet Routing through Firewall
- CENIC-AIR HPR routing through SciDMZ link



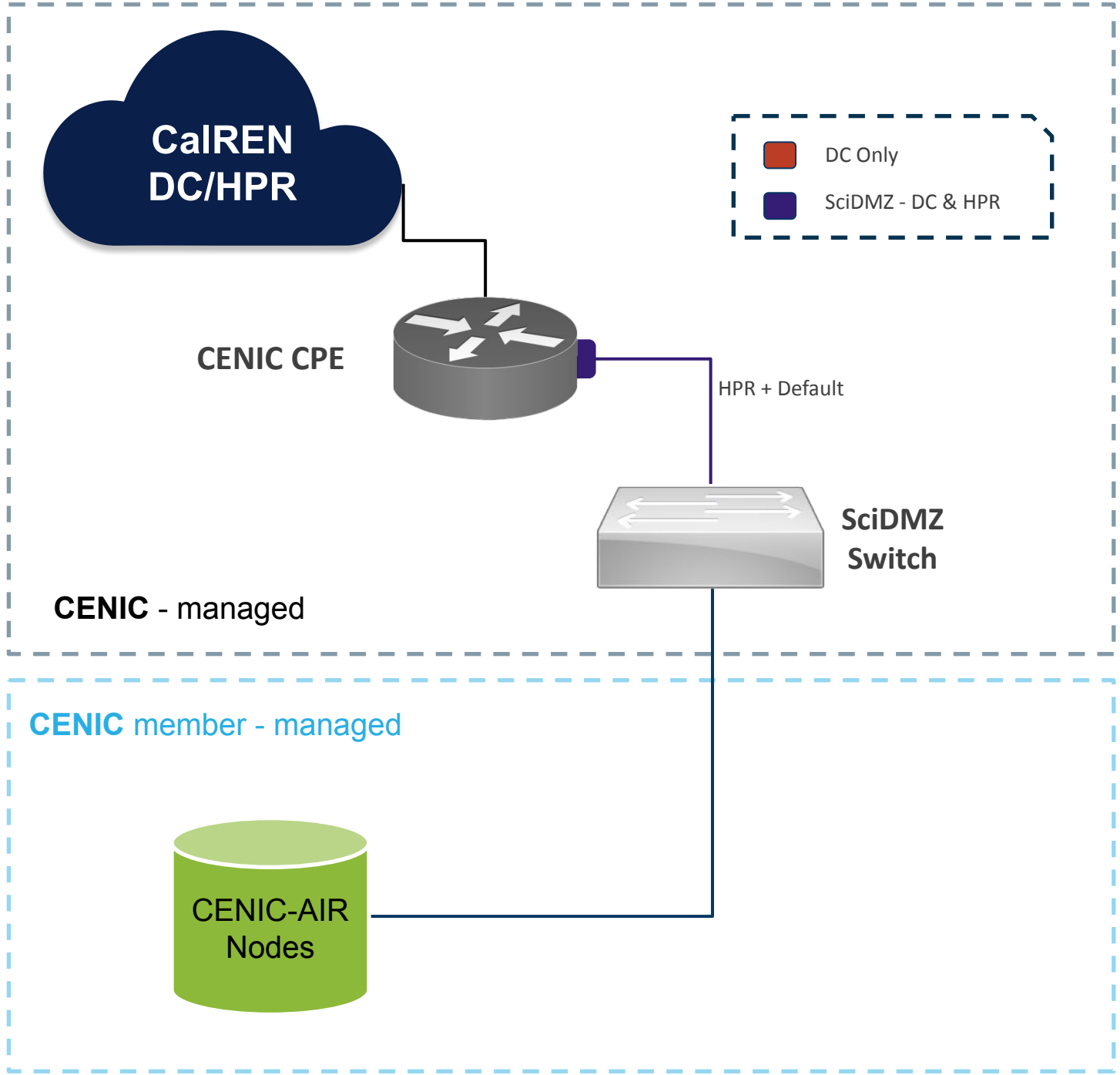
# ScienceDMZ routing: Fully Routed SciDMZ

- Internet Routing and CENIC-AIR HPR routing through SciDMZ link



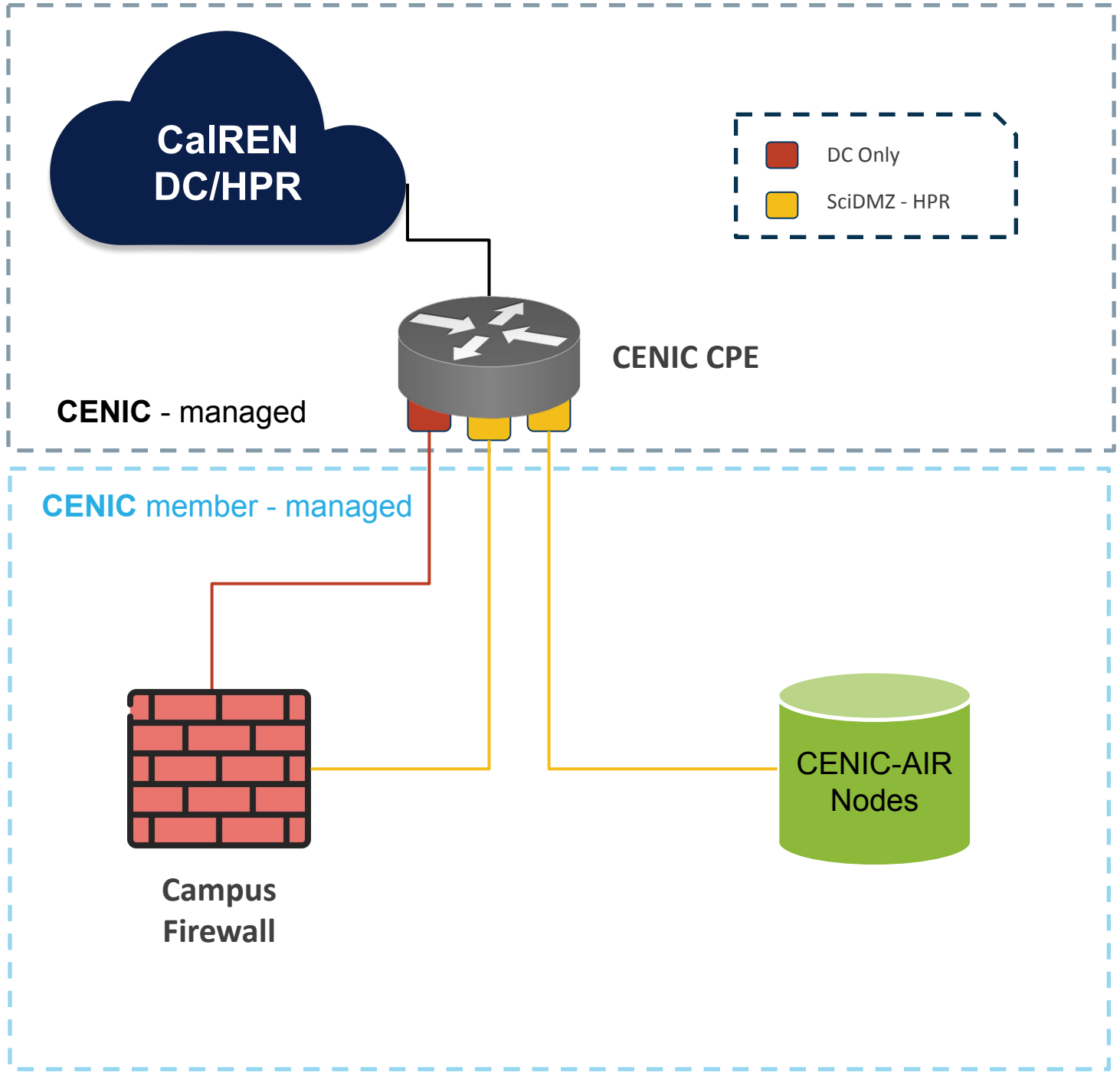
# ScienceDMZ routing: Managed SciDMZ

- SciDMZ switch managed by CENIC
- CENIC-AIR HPR routing through SciDMZ link



# ScienceDMZ routing: Local FW

- Internet Routing passed from CENIC-CPE through Firewall
- CENIC-AIR HPR routing through SciDMZ link

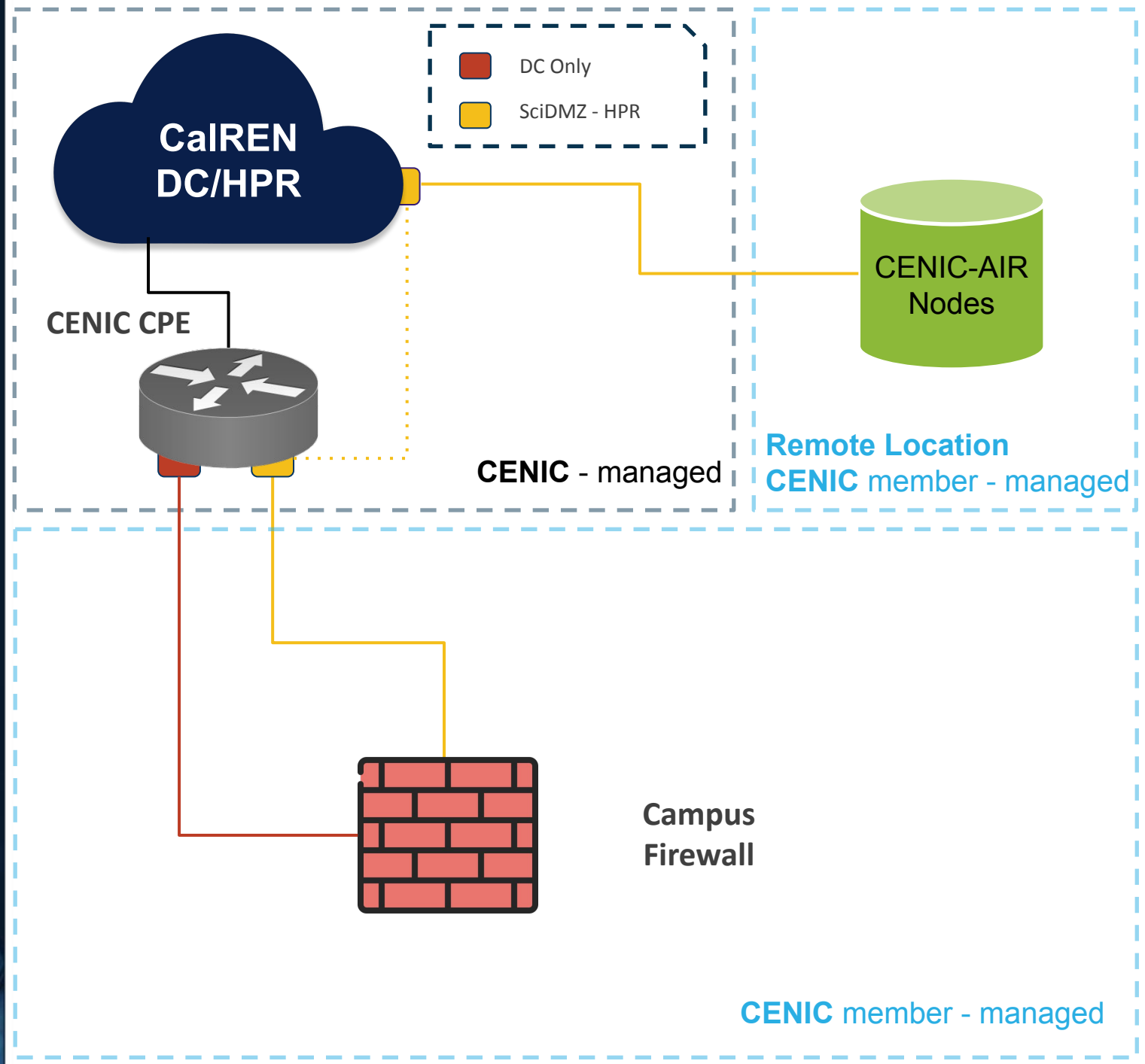



NATIONAL RESEARCH PLATFORM

# ScienceDMZ routing: Remote FW

For members with CENIC-AIR nodes at remote locations:

- Internet Routing passed from CENIC-CPE through Firewall
- CENIC AIR HPR routing through SciDMZ link




NATIONAL RESEARCH PLATFORM

# Program Management Office

- CENIC's Program Management Office is here to serve you, our member
- Our focus is service deployment and helping to manage internal CENIC projects
- We manage E-Rate activities for K12 and Libraries each year
- While service impacts or issues should always be sent directly to the CENIC NOC, all other inquiries can be routed through the PMO

K12/BIG - Son Nguyen/Joe Chavez
Libraries - Stella Kwon/Rebecca Ou
CCC - Ken Roberts
CSU - Tim Chia (temp)
UC - Tristan Gaspas
Privates/Independents - Tristan Gaspas

pm@lists.cenic.org

# Thank you!