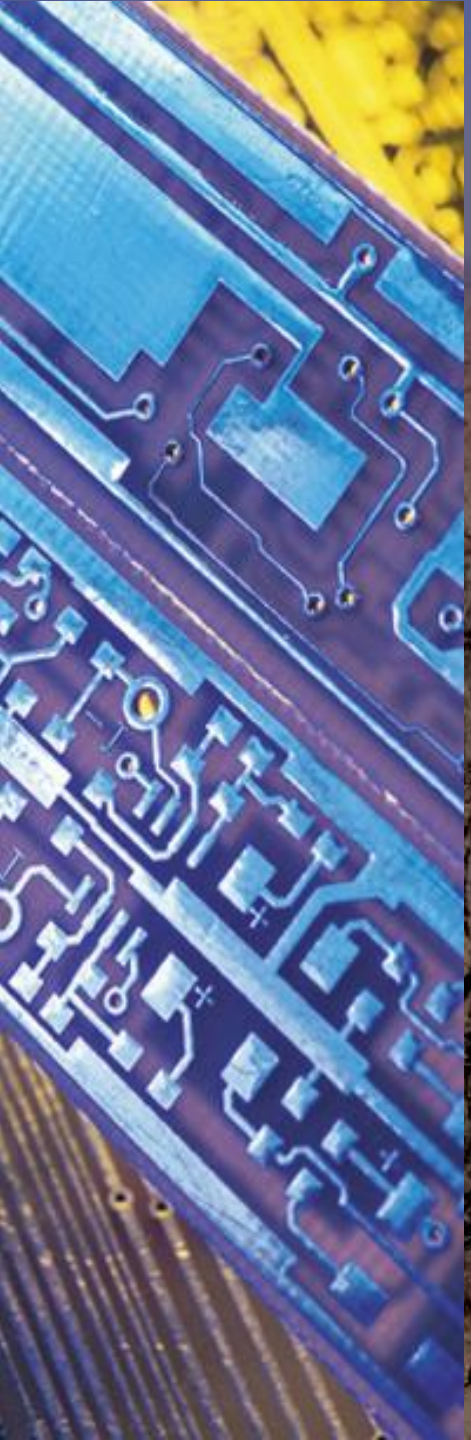


# *The Evolution of CALREN - California's Research and Education Network*

John Silvester

*Chair of the CENIC Board*
*Vice-Provost for Scholarly Technology, University of Southern California*

*CUDI*
*Veracruz, Mexico*
*April 29th, 2005*

# Education in California – Overview

- University of California – 9 (10) campuses
- 3 Private Research Universities – Caltech, Stanford, University of Southern California
- California State University – 23 campuses
- Community Colleges – over 100
- Other independent institutions of higher education – over 100
- K-12 schools – over 9000
- Various government labs and university affiliated research institutes

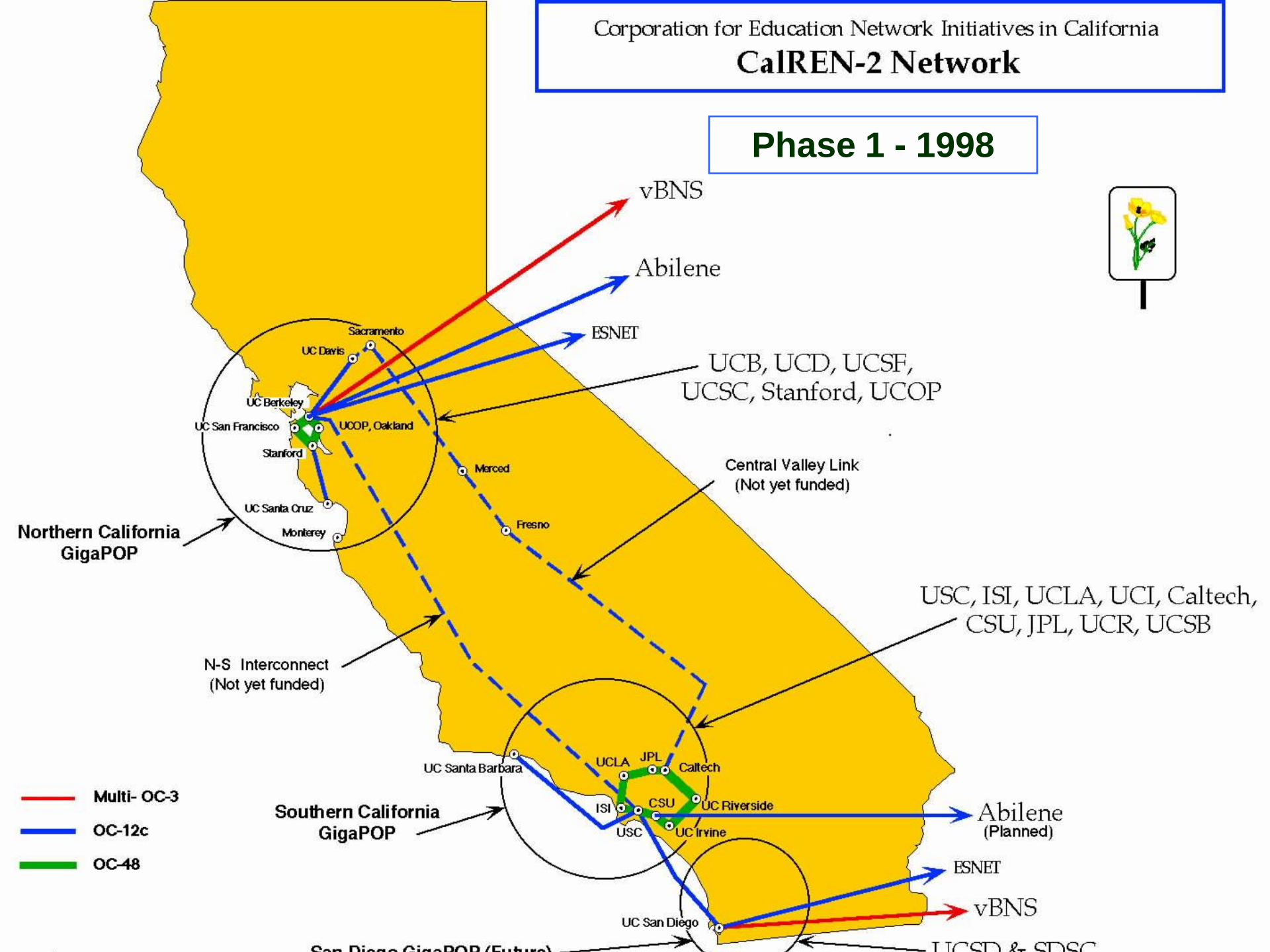
# State of Networking in 1996

- 4-CNET connected the CSU system with extension out to community colleges
- Most institutions had their own commodity internet connections
- UC operated some private leased lines
- No statewide K-12 network
- Some individual county and school district networks

Corporation for Education Network Initiatives in California

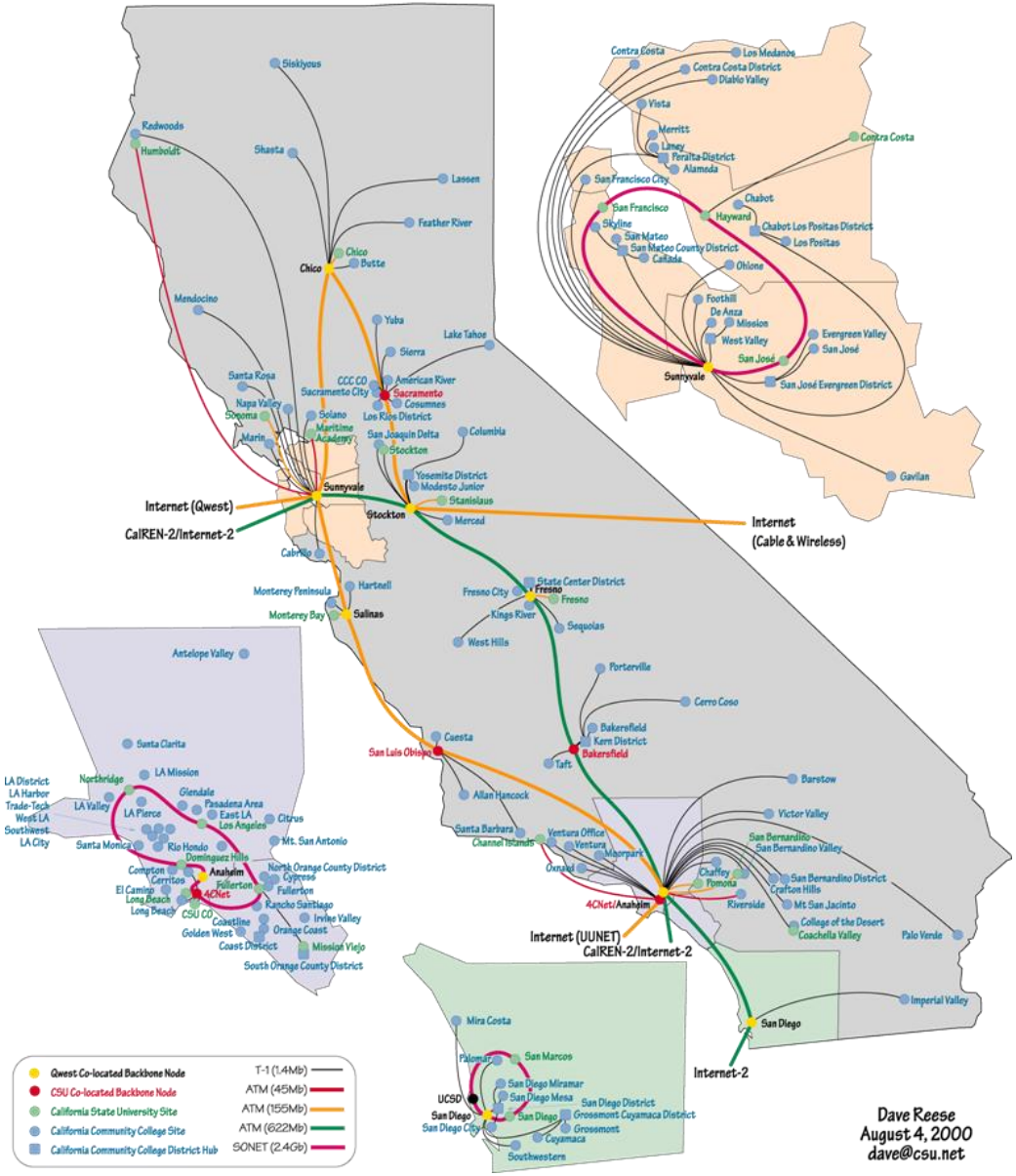
# CalREN-2 Network

## Phase 1 - 1998



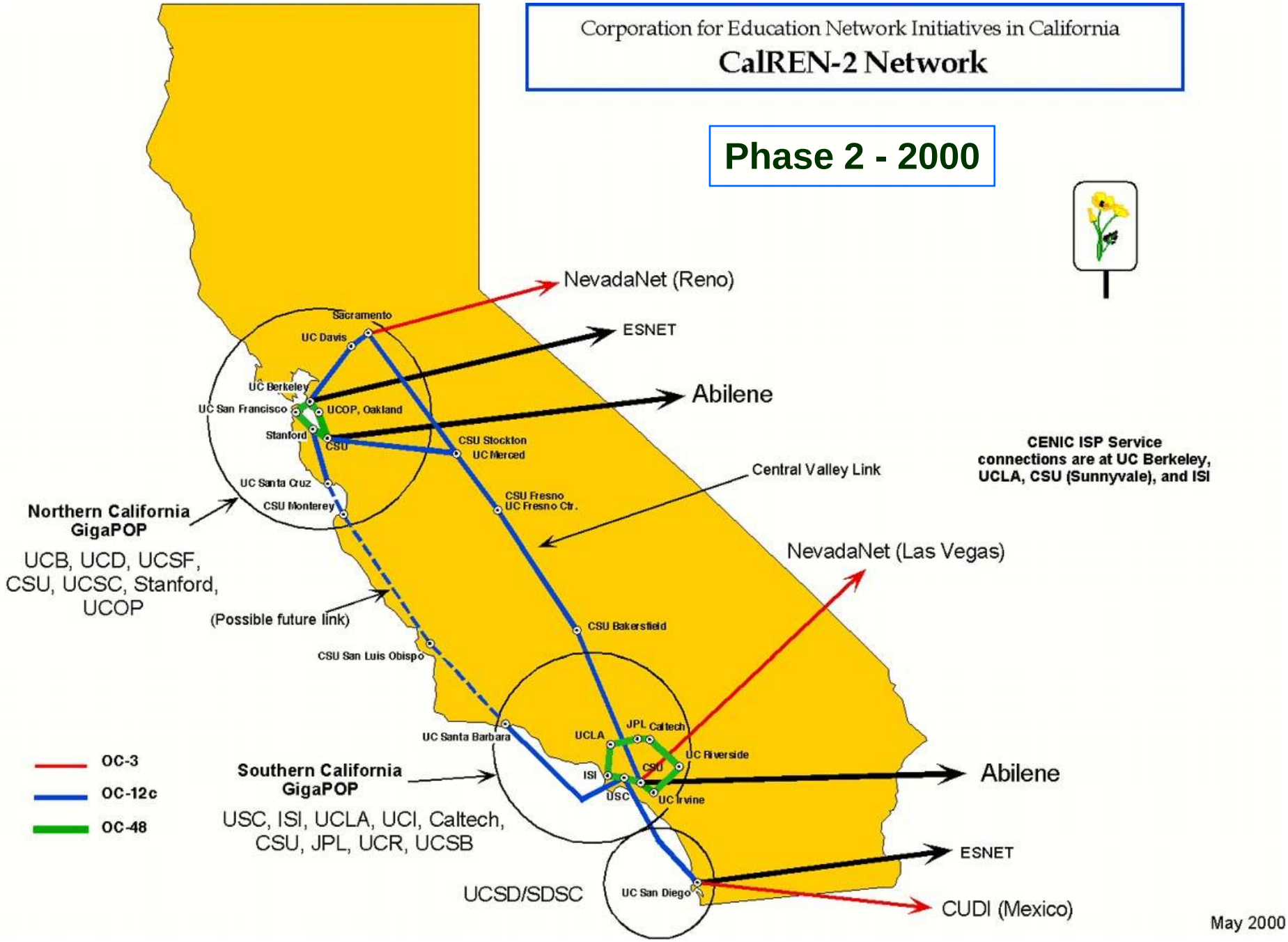
# 4CNet

**California State University and California Community Colleges**





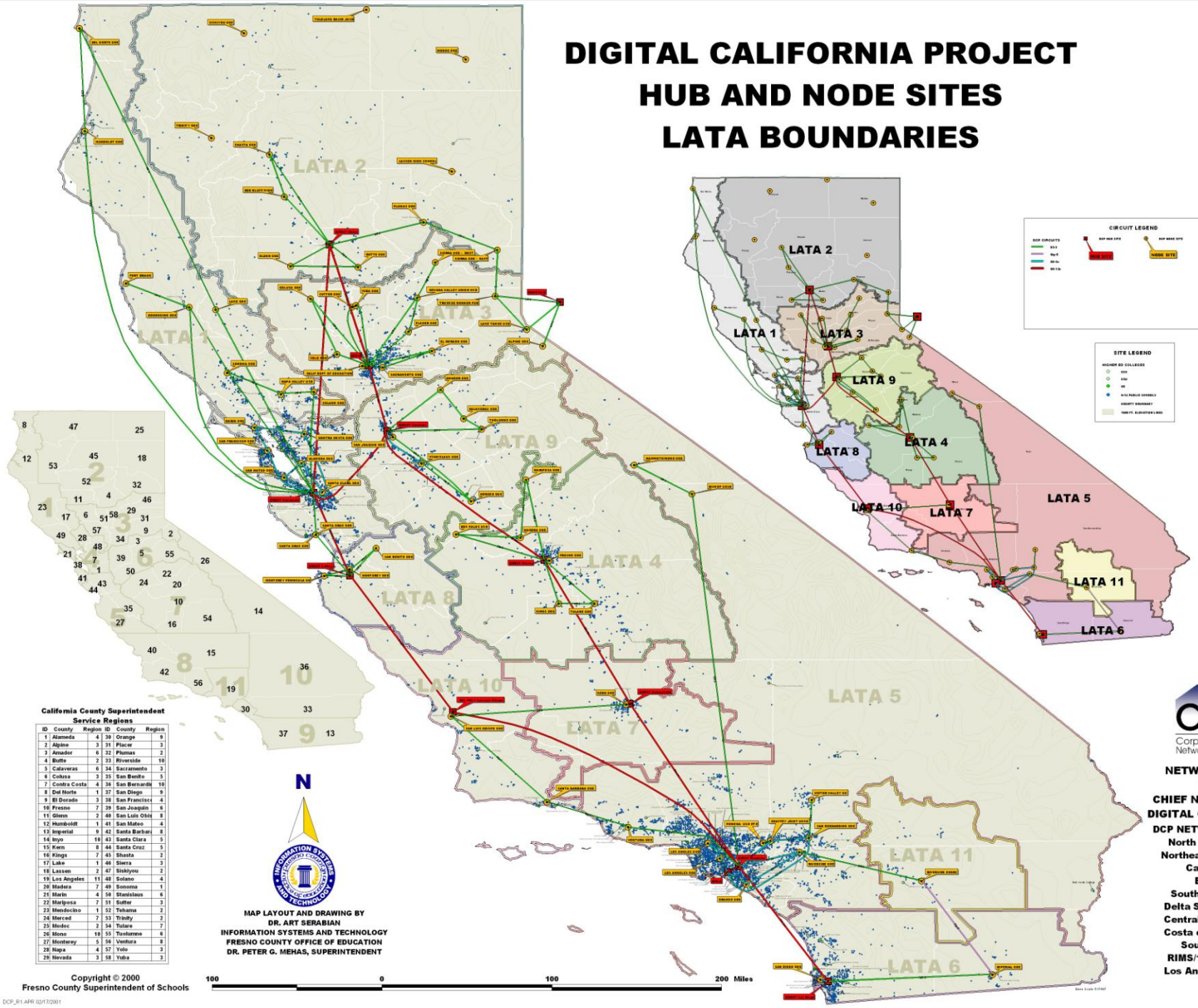
Dave Reese
August 4, 2000
dave@csu.net


Corporation for Education Network Initiatives in California
CalREN-2 Network
Phase 2 - 2000
NevadaNet (Reno)
ESNET
Abilene
Sacramento
UC Davis
UC Berkeley
UC San Francisco
UCOP, Oakland
Stanford
CSU
CSU Stockton
UC Merced
UC Santa Cruz
CSU Monterey
CSU Fresno
UC Fresno Ctr.
Central Valley Link
CENIC ISP Service connections are at UC Berkeley, UCLA, CSU (Sunnyvale), and ISI
Northern California GigaPOP
UCB, UCD, UCSF, CSU, UCSC, Stanford, UCOP
(Possible future link)
NevadaNet (Las Vegas)
CSU Bakersfield
CSU San Luis Obispo
UC Santa Barbara
UCLA
JPL Caltech
UC Riverside
CSU
ISI
USC
UC Irvine
Abilene
Southern California GigaPOP
USC, ISI, UCLA, UCI, Caltech, CSU, JPL, UCR, UCSB
ESNET
UCSD/SDSC
UC San Diego
CUDI (Mexico)
OC-3
OC-12c
OC-48
May 2000

# Digital California Project

- DCP – Digital California Project – extend connectivity to (public) K-12 schools
- Funded from California State in FY 2000/01
- $32M through University of California Implementation through CENIC
- Program Steering Committee - Advisory board of involved constituents from K-20
- Subsequent budget reductions -- $26M -$21M - $14M – eliminated as direct funding for 2004-05 – now what?

# DIGITAL CALIFORNIA PROJECT
# HUB AND NODE SITES
# LATA BOUNDARIES




**California County Superintendent Service Regions**

| ID | County | Region | ID | County | Region |
|---|---|---|---|---|---|
| 1 | Alameda | 4 | 30 | Orange | 9 |
| 2 | Alpine | 3 | 31 | Placer | 3 |
| 3 | Amador | 6 | 32 | Plumas | 2 |
| 4 | Butte | 2 | 33 | Riverside | 10 |
| 5 | Calaveras | 6 | 34 | Sacramento | 3 |
| 6 | Colusa | 3 | 35 | San Benito | 5 |
| 7 | Contra Costa | 4 | 36 | San Bernardi | 10 |
| 8 | Del Norte | 1 | 37 | San Diego | 9 |
| 9 | El Dorado | 3 | 38 | San Francisc | 4 |
| 10 | Fresno | 7 | 39 | San Joaquin | 6 |
| 11 | Glenn | 2 | 40 | San Luis Obi | 8 |
| 12 | Humboldt | 1 | 41 | San Mateo | 4 |
| 13 | Imperial | 9 | 42 | Santa Barbar | 8 |
| 14 | Inyo | 10 | 43 | Santa Clara | 5 |
| 15 | Kern | 8 | 44 | Santa Cruz | 5 |
| 16 | Kings | 7 | 45 | Shasta | 2 |
| 17 | Lake | 1 | 46 | Sierra | 3 |
| 18 | Lassen | 2 | 47 | Siskiyou | 2 |
| 19 | Los Angeles | 11 | 48 | Solano | 4 |
| 20 | Madera | 7 | 49 | Sonoma | 1 |
| 21 | Marin | 4 | 50 | Stanislaus | 6 |
| 22 | Mariposa | 7 | 51 | Sutter | 3 |
| 23 | Mendocino | 1 | 52 | Tehama | 2 |
| 24 | Merced | 7 | 53 | Trinity | 2 |
| 25 | Modoc | 2 | 54 | Tulare | 7 |
| 26 | Mono | 10 | 55 | Tuolumne | 6 |
| 27 | Monterey | 5 | 56 | Ventura | 8 |
| 28 | Napa | 4 | 57 | Yolo | 3 |
| 29 | Nevada | 3 | 58 | Yuba | 3 |

MAP LAYOUT AND DRAWING BY
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INFORMATION SYSTEMS AND TECHNOLOGY
FRESNO COUNTY OFFICE OF EDUCATION
DR. PETER G. MEHAS, SUPERINTENDENT



DCP_R1.APR 02/17/2001

cenic
Corporation for Education Network Initiatives in California

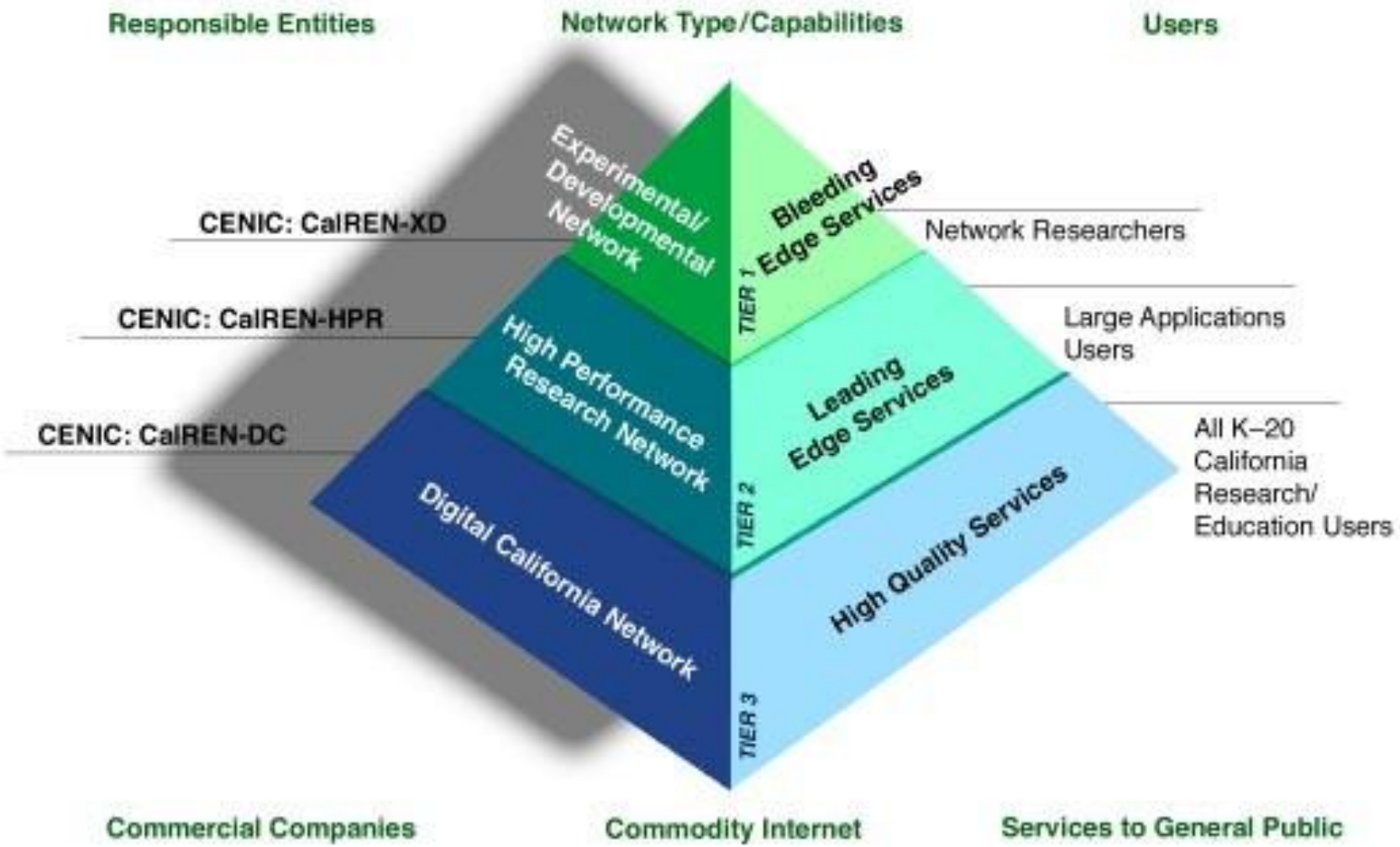
**NETWORK DESIGN TEAM**
**DAVE REESE**
**CHIEF NETWORK ARCHITECT**
**DIGITAL CALIFORNIA PROJECT**
**DCP NETWORK DESIGN LIAISONS**
North Coast/1, Paul Tichinin
Northeastern/2, Russell Selken
Capital/3, Bob Carter
Bay/4, Mac Carey
South Bay/5, David Barnett
Delta Sierra/6, Bill Engelhardt
Central Valley/7, Art Serabian
Costa del Sur/8, John Lindsay
Southern/9, Skip Sharp
RIMS/10, Douglas Slonkosky
Los Angeles/11, James Magill

# Redesigning CalREN

- In late 1999, with the approaching end of current SONET contracts (late 2002), CENIC began thinking about the next generation CalREN
- User demand:
  - Reliable ‘commodity’ network
  - High bandwidth (IP) network in support of research (Abilene)
  - Some demand for dedicated resources
  - Significant demand for experimental and research networks at level 3, level 2 and even level 1
- This formed the thinking for an integrated infrastructure built on dark fiber

# NETWORK DEVELOPMENT AND EVOLUTION

## FOR CALIFORNIA RESEARCH AND EDUCATION COMMUNITY



# CALREN-DC
# Digital California

- IP based network.  2.5-10 GB
- Serves-140 H.E institutions; 8000+ elementary and high schools
- 8.0 million+ student, faculty and staff users
- I2 connectivity and commodity ISP services.

# CALREN-HPR

## High Performance Research Network

- IP network: 10Gb, potentially several wavelengths
- 50+ Research institutions, National Laboratories and San Diego Super-computing Center in California
- California component of Internet2 with 10G and OC-12 connections
- Serves hundreds of researchers, demanding applications

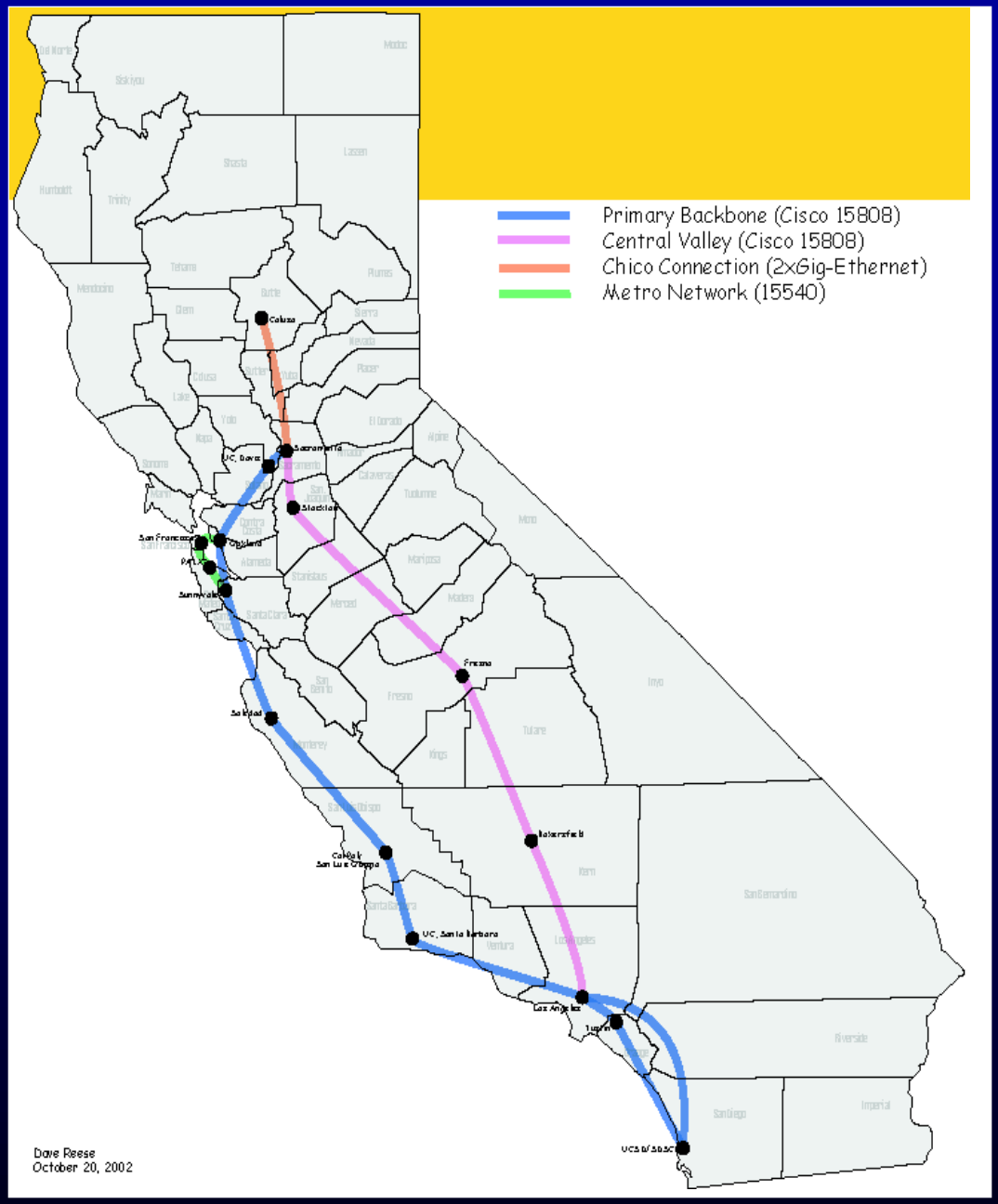
# CALREN-XD

## Experimental/Development Network

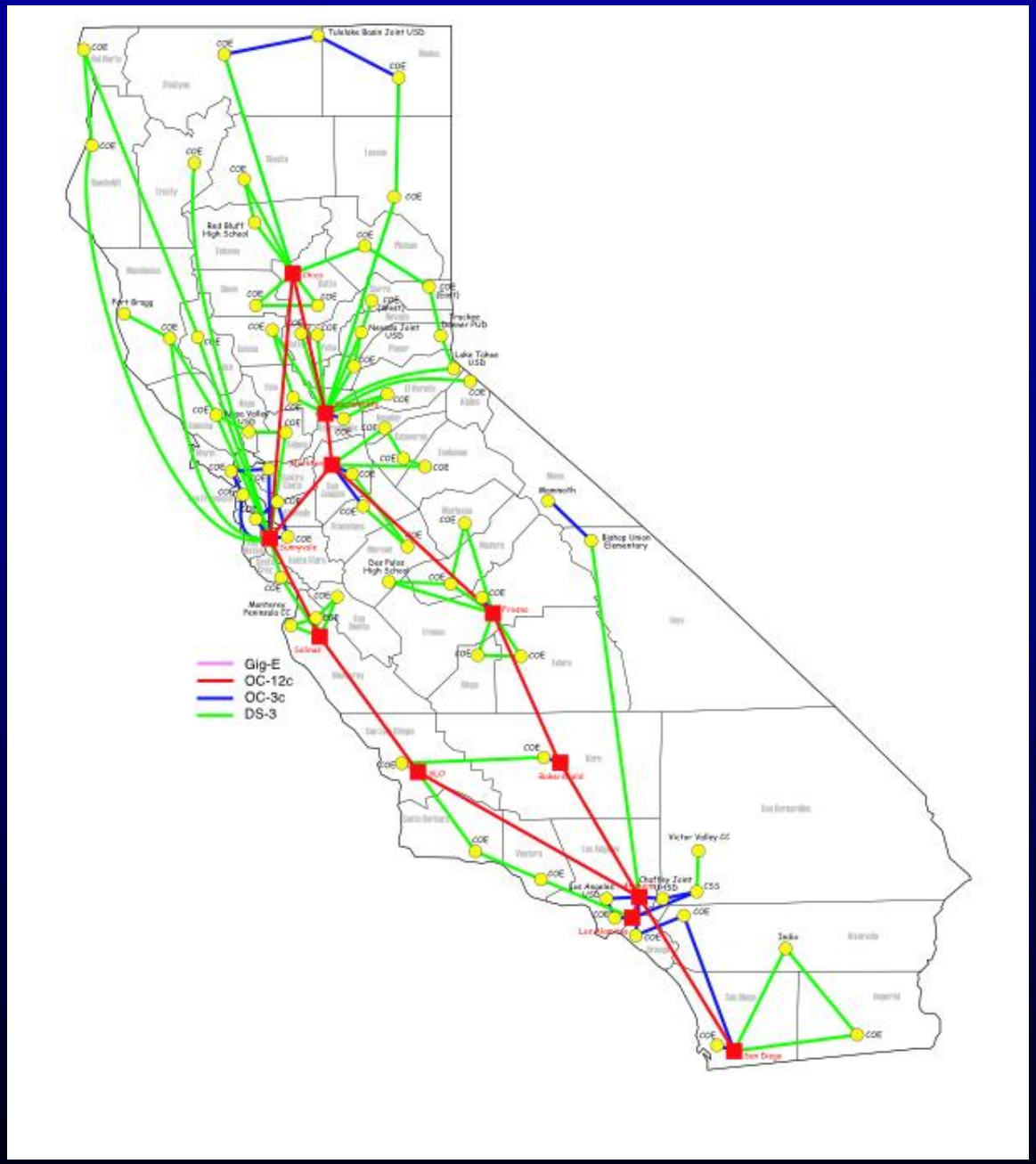
- 10.0 Gb Wavelengths and Dark Fiber
- Potential for Wavelength Switching and Special Network Configurations
- California Component of NLR
- Special applications, e.g. Teragrid
- Serves Network Researchers in California Research Institutions – primarily four UC Institutes; USC's ISI; Stanford; and Caltech

# CALREN - today

- 3 backbones – one commodity, one production, one research oriented, sharing physical resources where applicable
- Integrated at the physical and operations level, separable at the link and network levels
- Separate local solution from long-haul solution (due to different possibilities, players)
- Combination of dark fiber and wavelengths

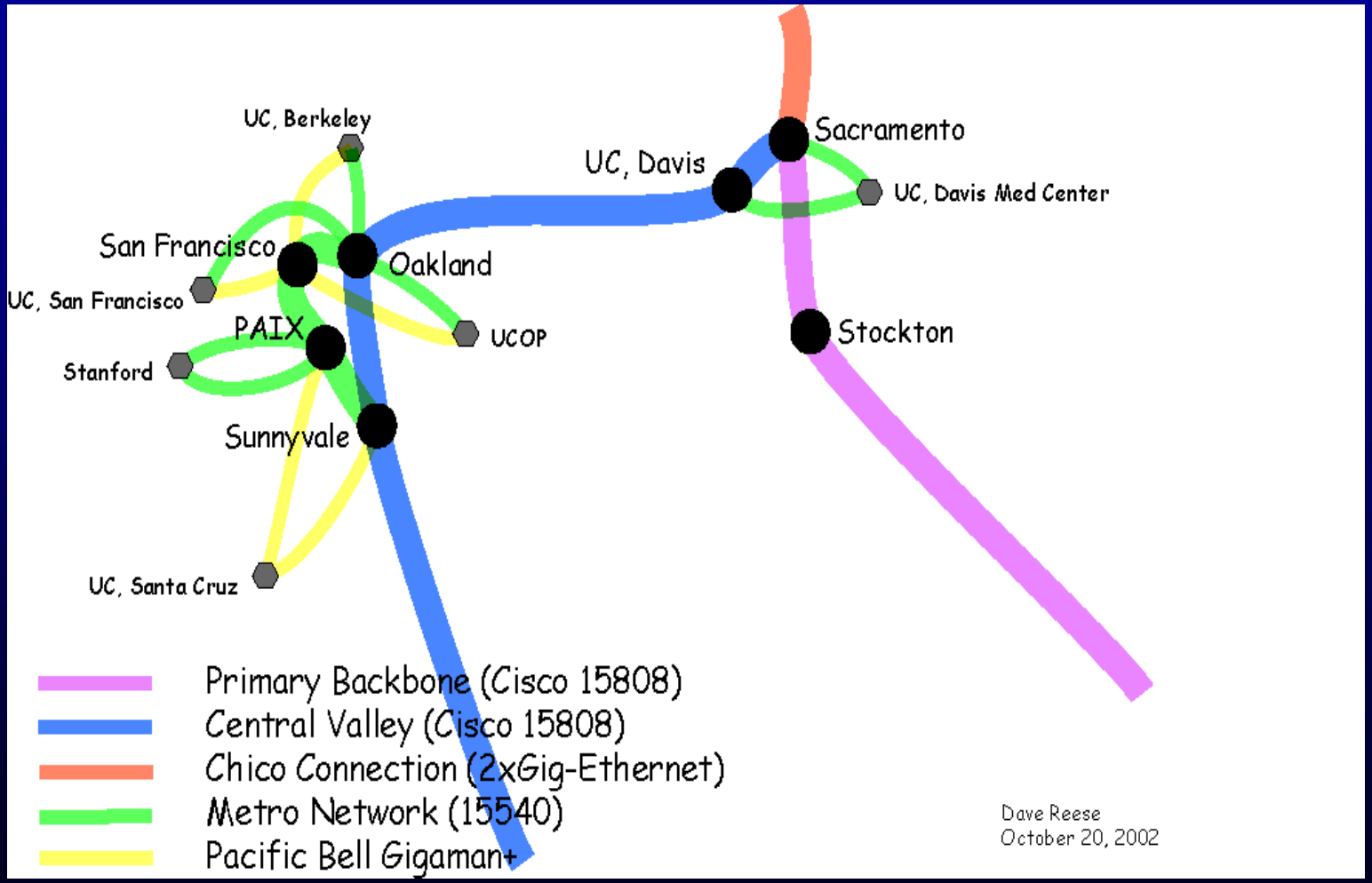



# CalREN Backbone Network 2003

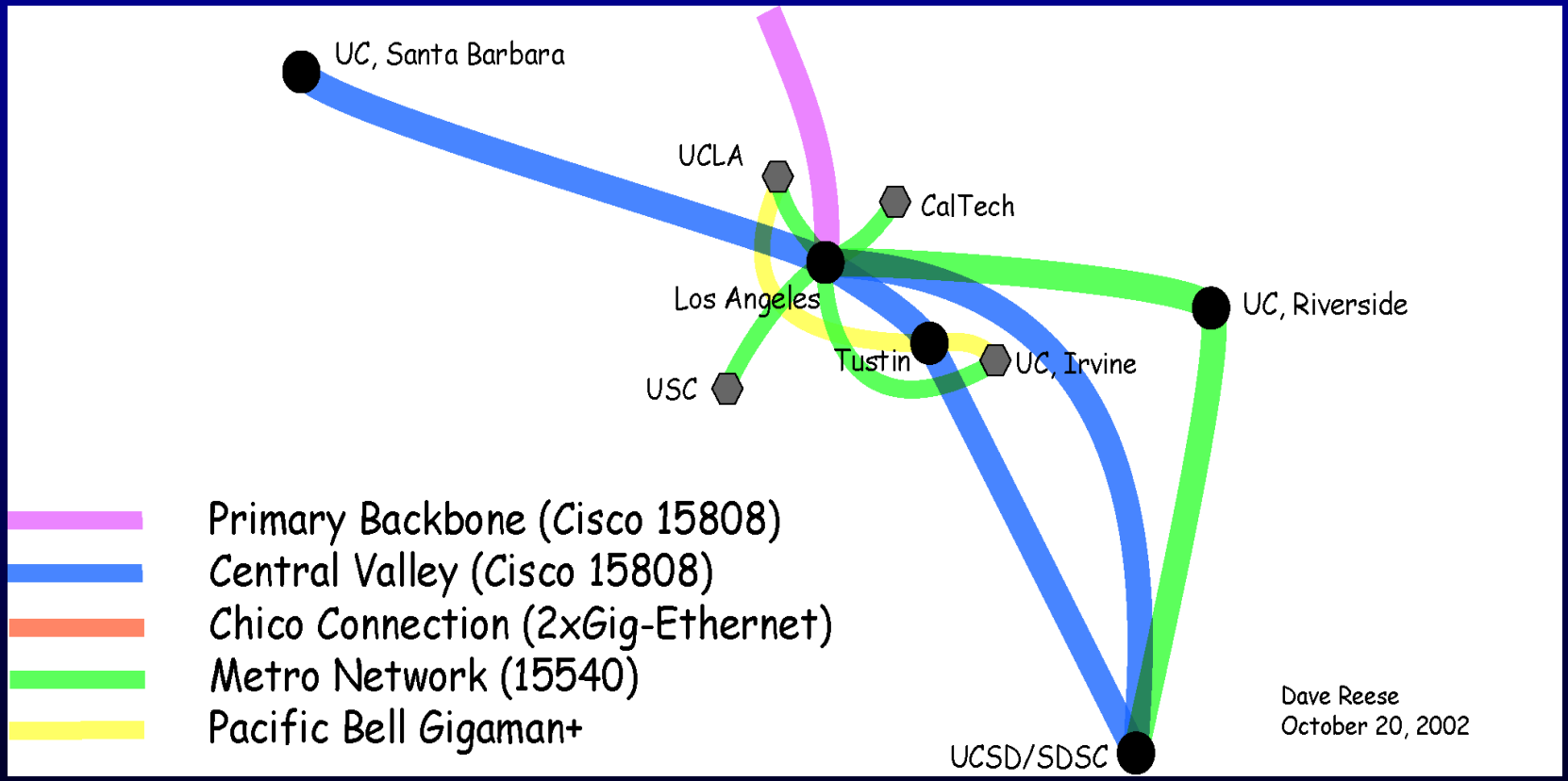



# Digital California Overlay

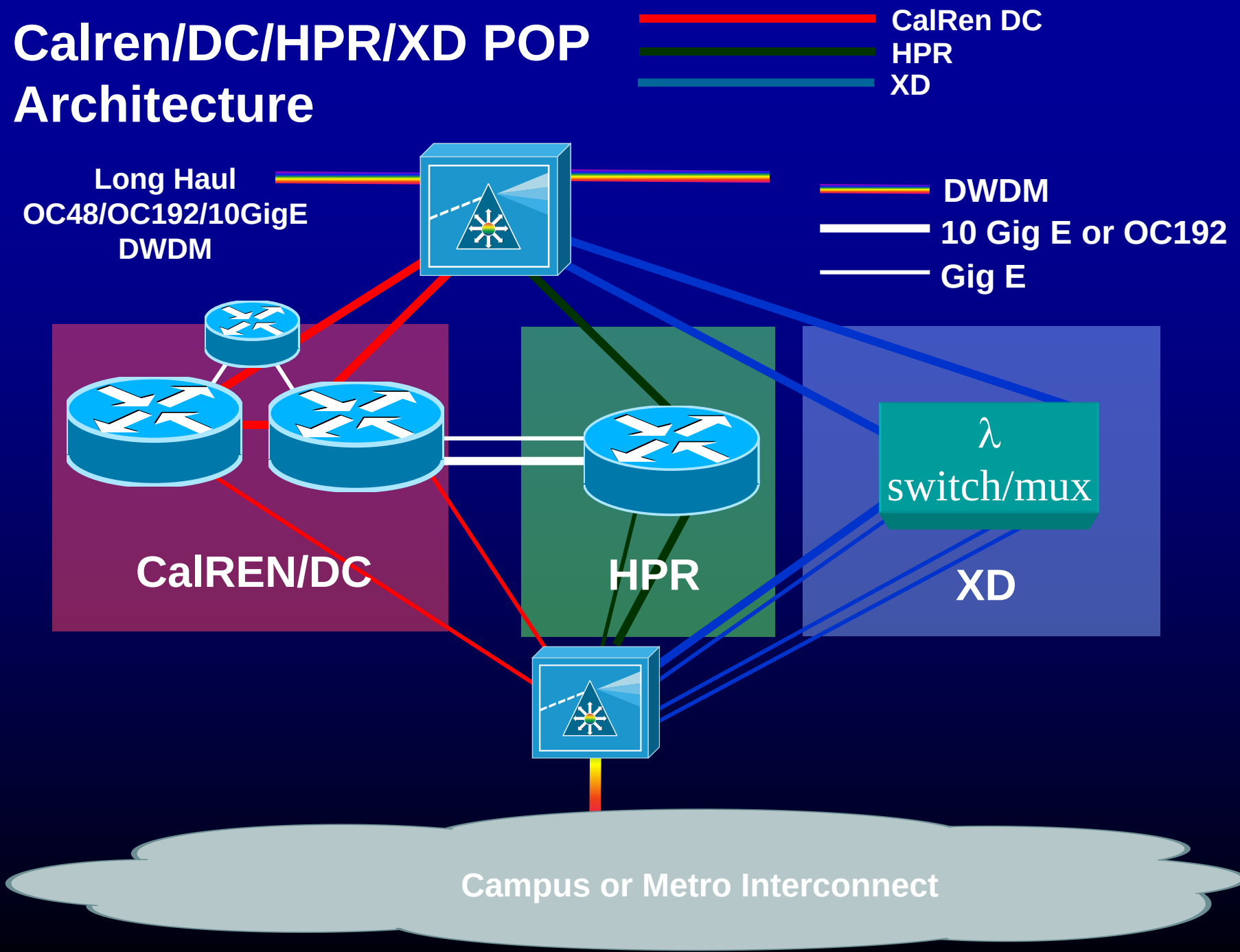
# Northern California



# Southern California



# Calren/DC/HPR/XD POP Architecture



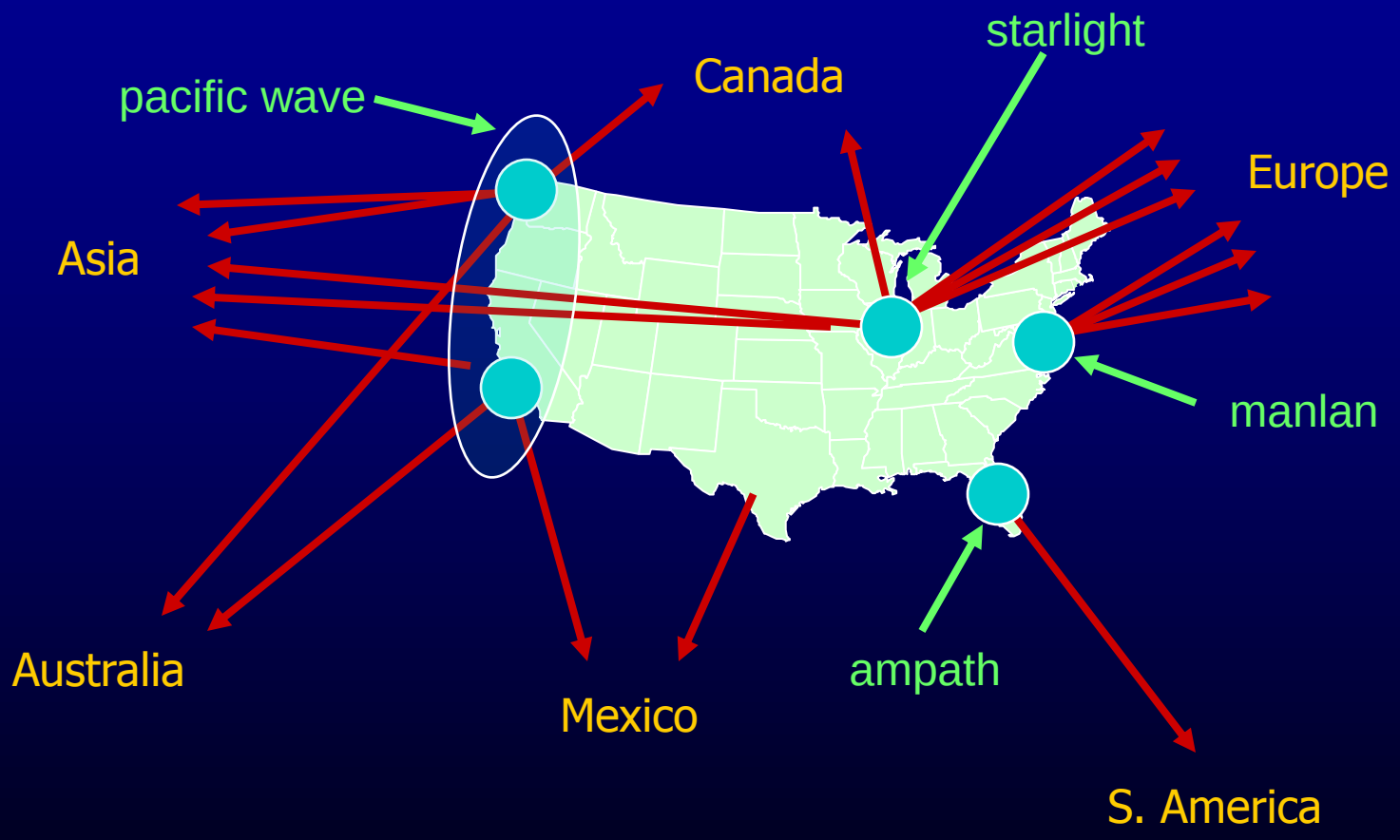
# Relation to National and International Nets

- CALREN connects to Abilene at LA and SNY
- CALREN is an integral part of NLR (LA-SNY)
- CALREN connects to Federal Networks (SNY)
- International Connections through PACIFICWAVE – a joint project of CENIC and PNWG (Seattle)

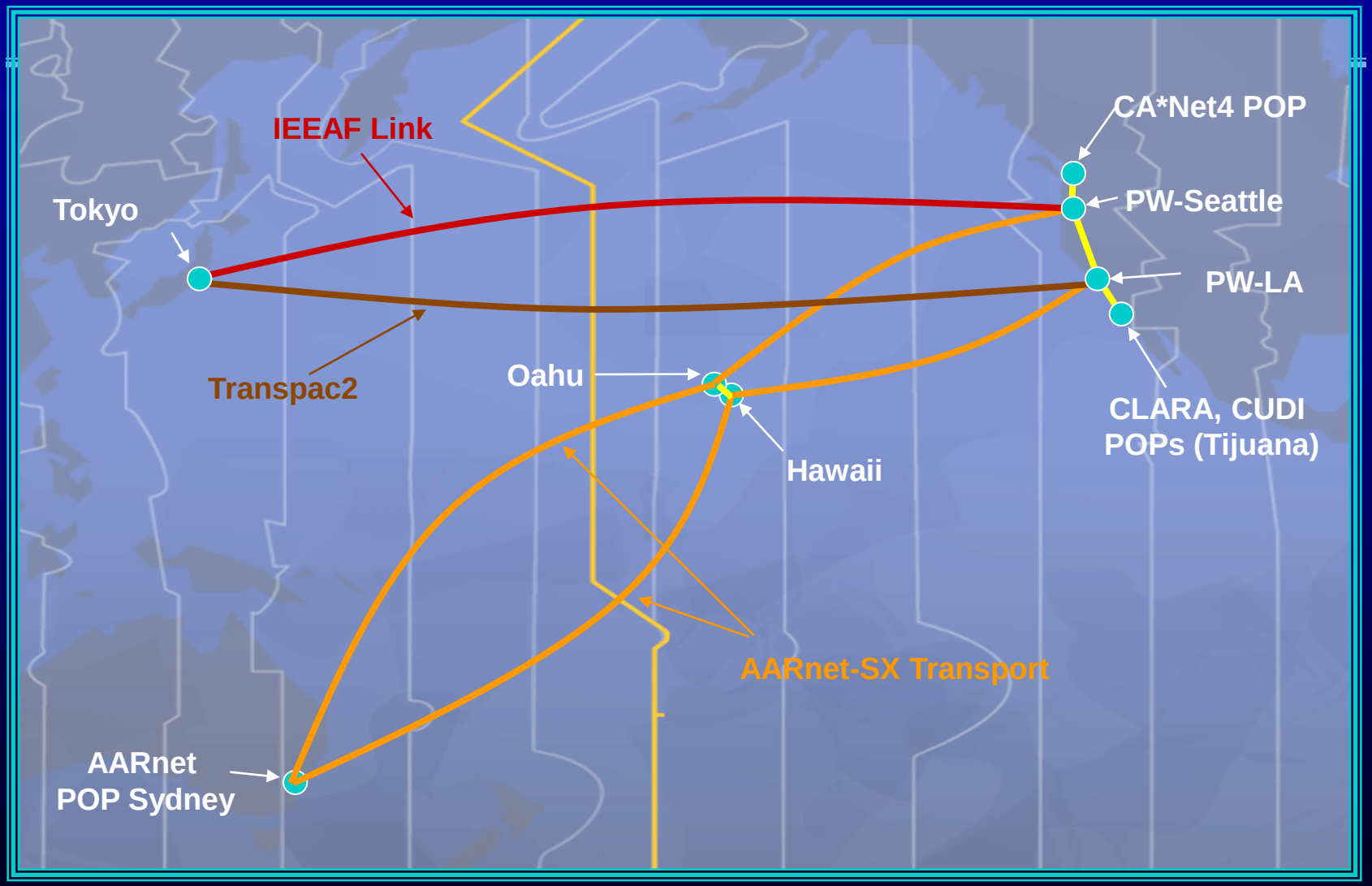
# Abilene (Internet2) backbone 2004

# National Connections - NLR

# International R&E Networks connecting to US



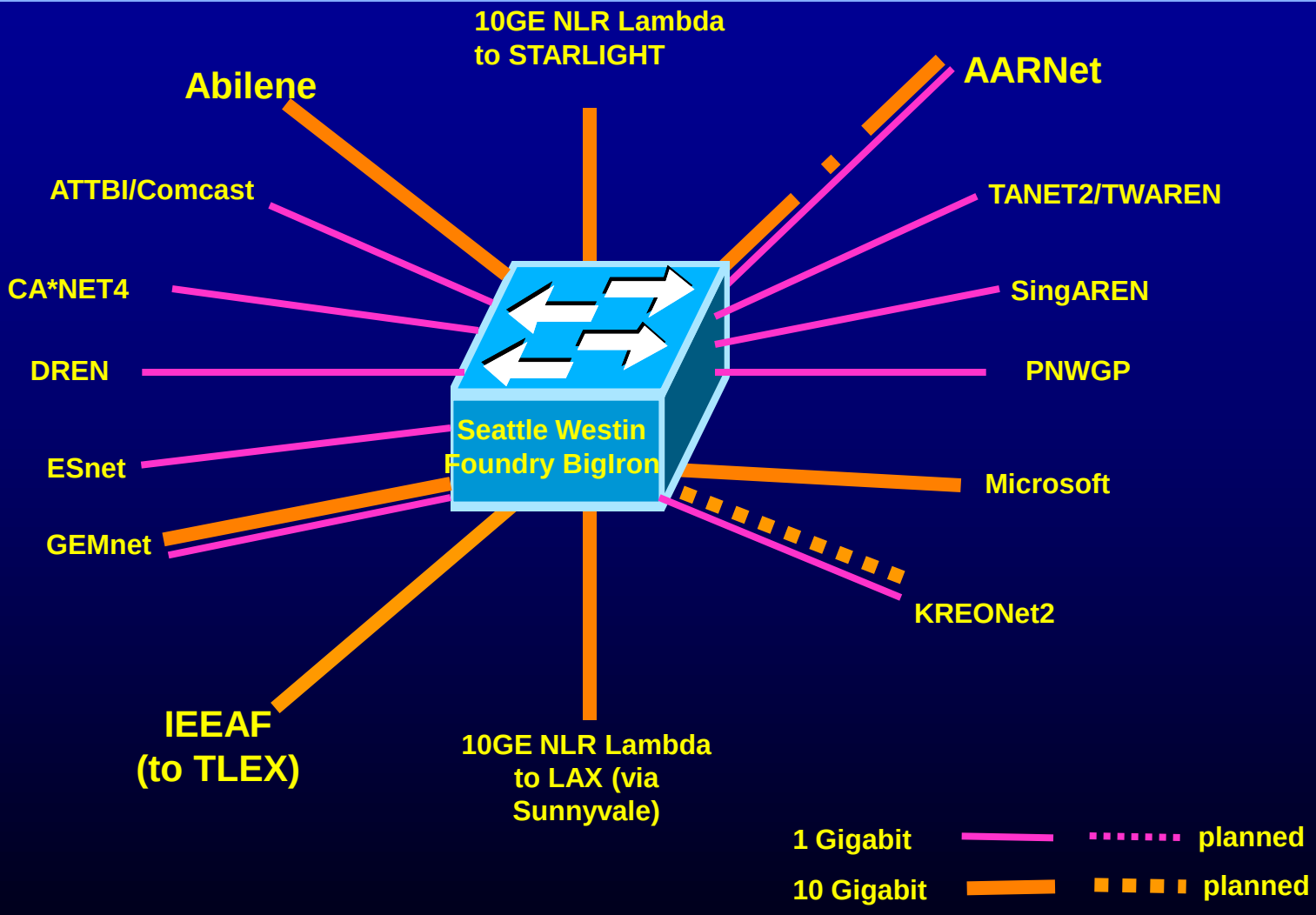
# 2005 NSF-IRNC related Pacific Connections (10G)



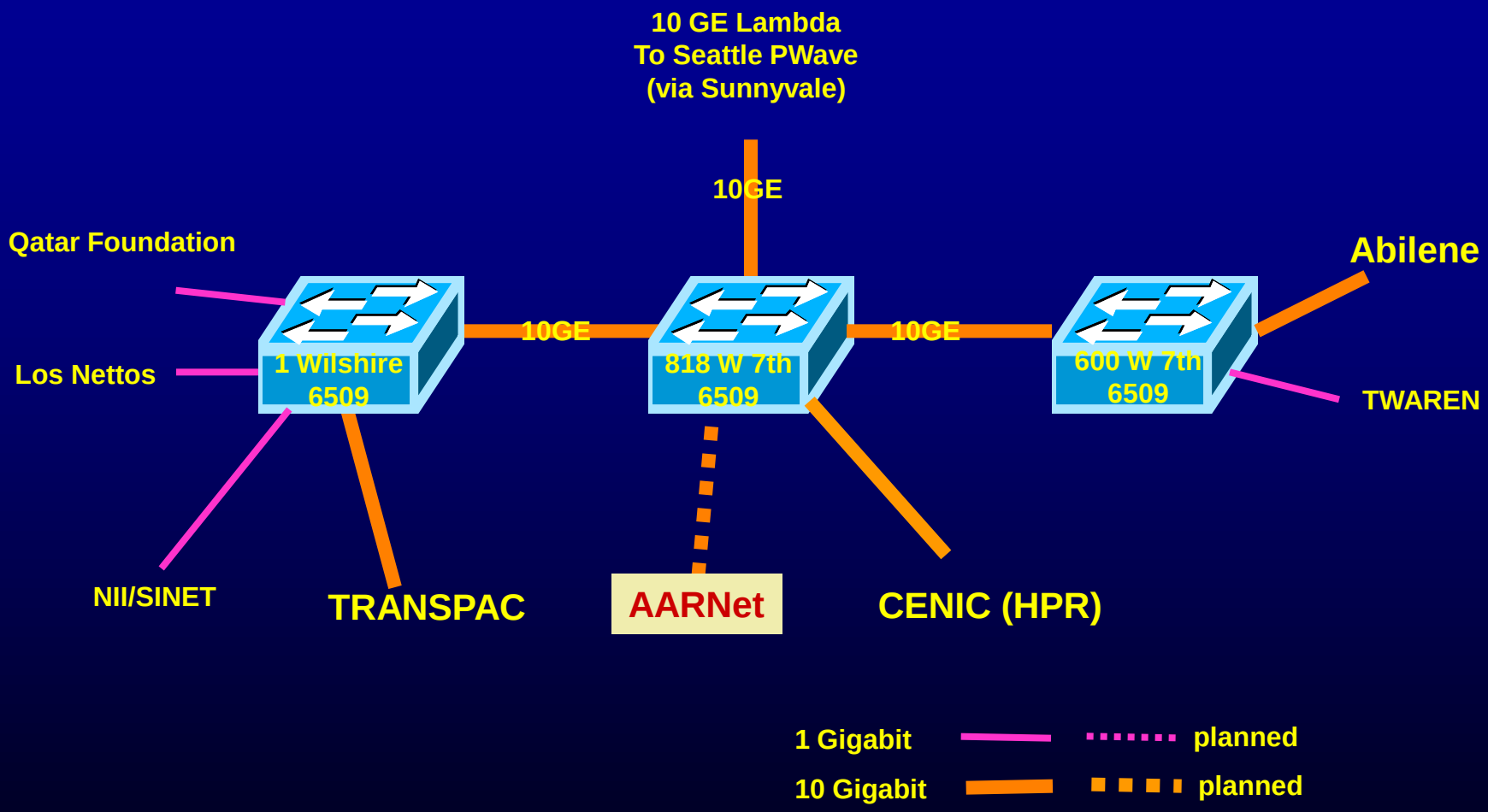
# PacificWave

- Partnership between CENIC and PNWGP (Pacific Northwest Gigapop - Seattle)
- Concept: an extensible, geographically dispersed peering fabric so that you can connect at any one location on the fabric and have the option to peer with any other participant, regardless of where they are connected
- Uses 10G wave to connect the physical exchange points and build VLANS to interconnect peers
- Recently received funding from NSF-IRNC program to extend capabilities and provide support for international connections through PacificWave

# PacificWave Seattle

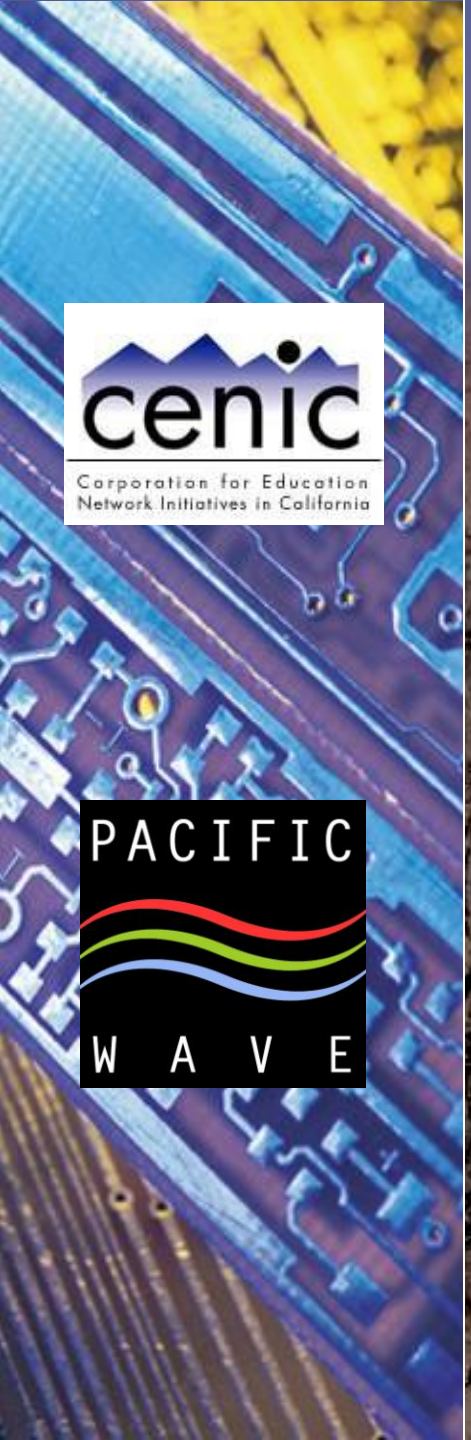


# Pacific Wave - Los Angeles



# What's next? – development of CalRen-XD

- Some waves are in use – Teragrid (LA to San Deigo), Optiputer (San Diego to LA to Chicago), CaveWave (San Diego to Chicago)
- More to come. Many (5+?) will be brought up in support of IGRID'05 (San Diego) and SC'05 (Seattle).
- Layer 1 switching for CALREN-XD, NLR, HOPI and GLIF through PacificWave




# For More Information

silvester@usc.edu

CENIC: www.cenic.org

Pacific Wave: www.pacificwave.net