# CalREN: Advanced Network(s) for Education in California

John Silvester, USC and CENIC

# CENIC Mission and Goals

- **Mission:**

  "…to develop, deploy and operate leading edge network-based services and to facilitate and coordinate their use for the RESEARCH and EDUCATION community to advance learning and innovation"

- **Goals:**

  - Provide competitive advantage in global marketplace to EDUCATION and RESEARCH communities
  - Provide opportunities for innovation in TEACHING, LEARNING, and RESEARCH through use of the network.

# Historical Timeline for R&E Networking in USA

- 1969-90 **ARPANET** (Milnet split off in ‘83)
- 1981-96 **BITNET/CREN**
- 1981-91 (c) **CSNET** (CSnet merged with BITNET into CREN)
- 1986-95 (c) **NSFnet**
- 1995-2001 (c) **vBNS**
- 1996-97 **Internet2/Abilene founded Abilene deployed**
- 1997 **CENIC founded (California), CalREN in operation**
- 2002-03 **CENIC deploys statewide fiber backbone**
- 2003 **NLR created to deploy national fiber backbone**

# Education in California – Overview

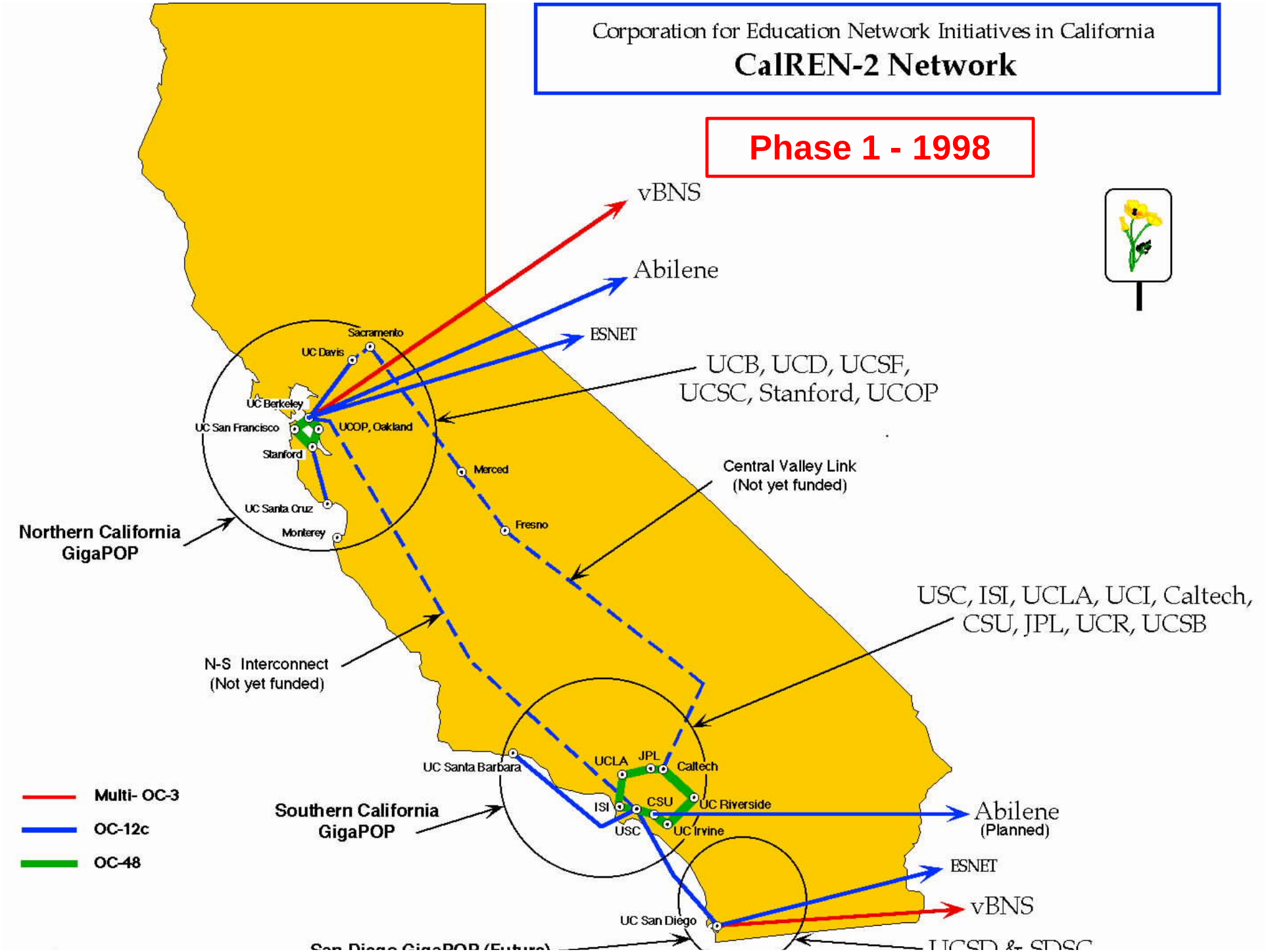
- University of California – 9 (10) campuses
- 3 Private Research Universities – Caltech, Stanford, University of Southern California
- California State University – 23 campuses
- Community Colleges – over 100
- Other independent institutions of higher education – over 100
- K-12 schools – over 9000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

# State of Networking in 1996

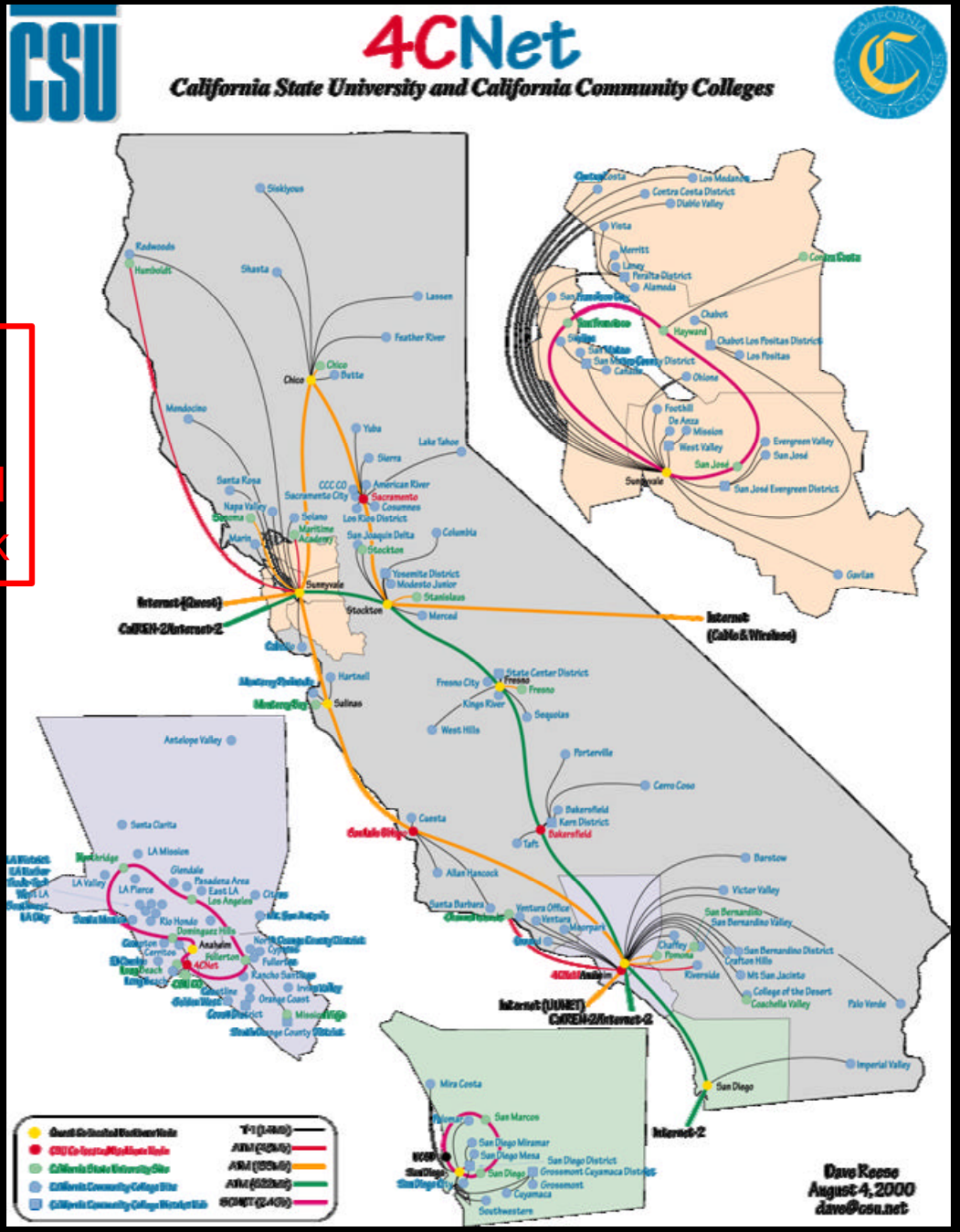
- 4-CNET connected the CSU system with extension out to community colleges
- Most institutions had their own commodity internet connections
- UC operated some private leased lines
- No statewide K-12 network
- Some individual county and school district networks

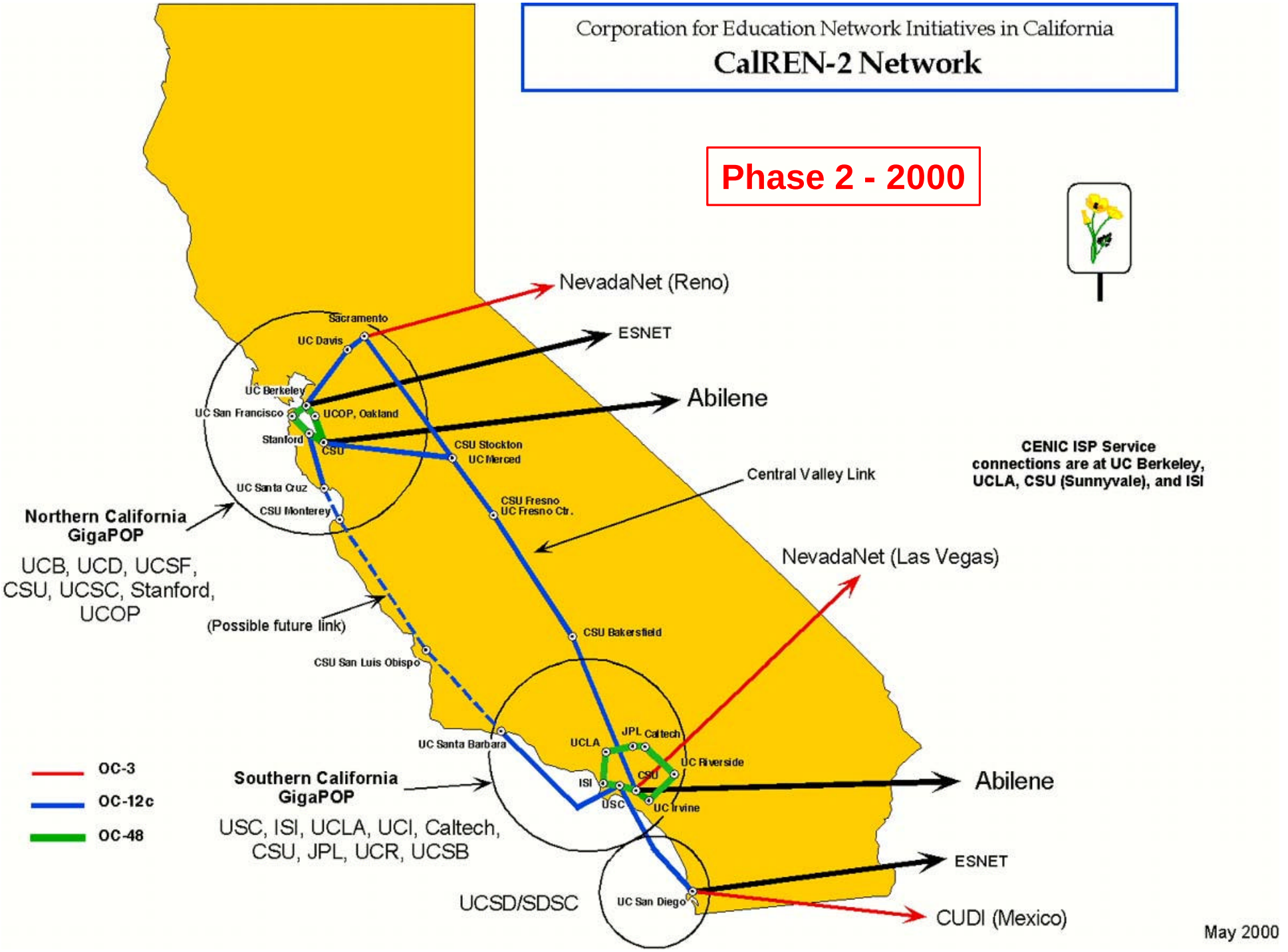
# Evolution of CalREN

- Phase I – Focussed on serving research campuses and providing access to national networks: vBNS ✍ Abilene (Internet2)
- Phase II – Integrate California State Universities and Community colleges
- Phase III – Extend service to public K-12 schools
- Phase IV – Redesign for efficiency recognizing the need for multiple networks on a shared infrastructure: the fiber based network


Corporation for Education Network Initiatives in California
CalREN-2 Network
Phase 1 - 1998
vBNS
Abilene
ESNET
UCB, UCD, UCSF,
UCSC, Stanford, UCOP
Central Valley Link
(Not yet funded)
USC, ISI, UCLA, UCI, Caltech,
CSU, JPL, UCR, UCSB
Sacramento
UC Davis
UC Berkeley
UC San Francisco
UCOP, Oakland
Stanford
Merced
Fresno
UC Santa Cruz
Monterey
Northern California
GigaPOP
N-S Interconnect
(Not yet funded)
UC Santa Barbara
UCLA
JPL
Caltech
ISI
CSU
UC Riverside
USC
UC Irvine
Southern California
GigaPOP
Abilene
(Planned)
ESNET
vBNS
UC San Diego
Multi- OC-3
OC-12c
OC-48

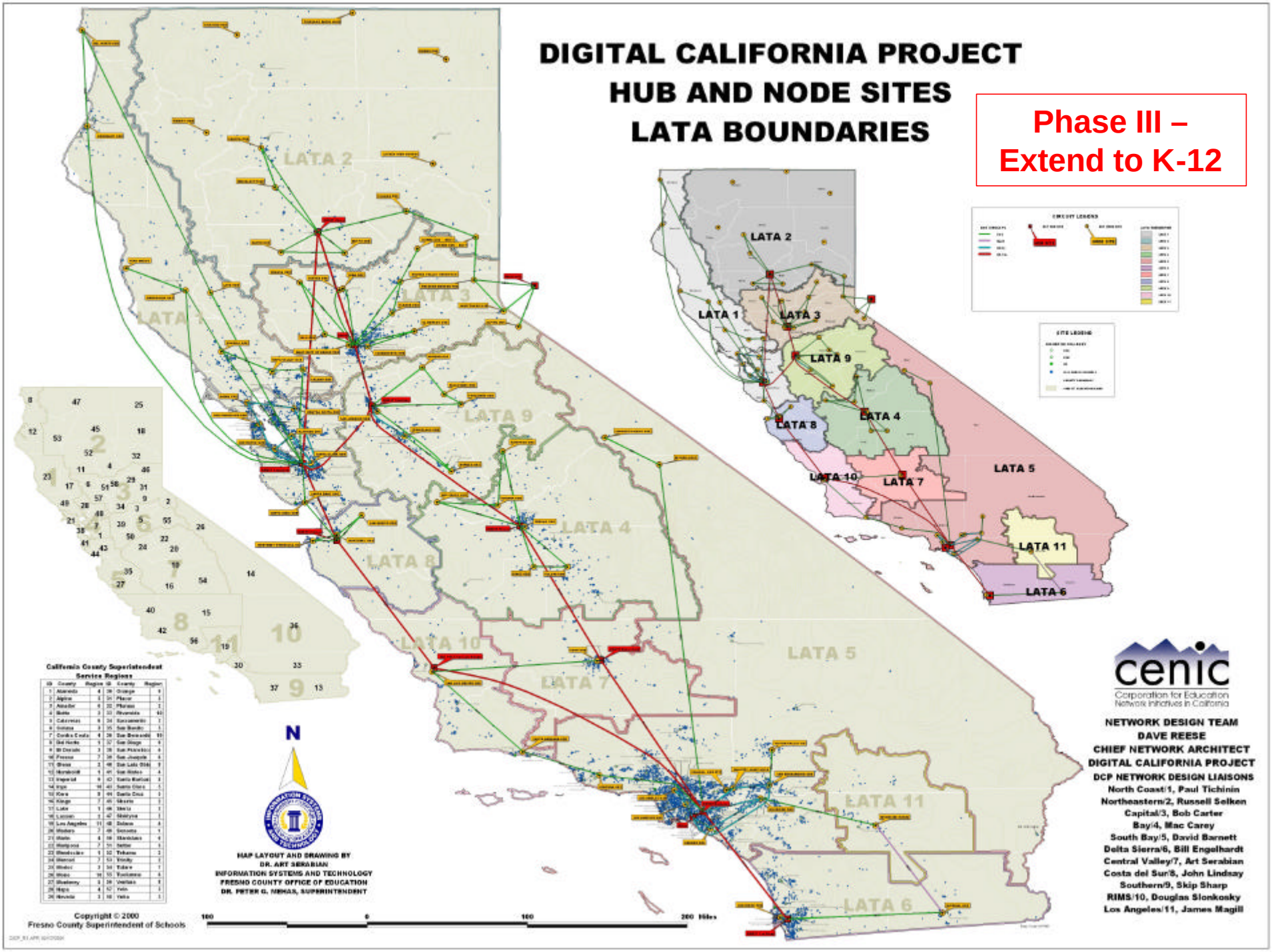
Phase II: Interconnect with CSU and CCC Network




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

# Phase III: Digital California Project

- DCP – Digital California Project – extend connectivity to (public) K-12 schools and provided for commodity Internet connectivity
- Funded from State of California (somewhat problematic due to unpredictability and political pressures)
- Program Steering Committee - Advisory board of involved constituents from K-20


DIGITAL CALIFORNIA PROJECT
HUB AND NODE SITES
LATA BOUNDARIES
Phase III – Extend to K-12
LATA 1
LATA 2
LATA 3
LATA 4
LATA 5
LATA 6
LATA 7
LATA 8
LATA 9
LATA 10
LATA 11
California County Superintendent Service Regions
N
MAP LAYOUT AND DRAWING BY
DR. ART SERABIAN
INFORMATION SYSTEMS AND TECHNOLOGY
FRESNO COUNTY OFFICE OF EDUCATION
DR. PETER G. MEHAS, SUPERINTENDENT
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Fresno County Superintendent of Schools
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

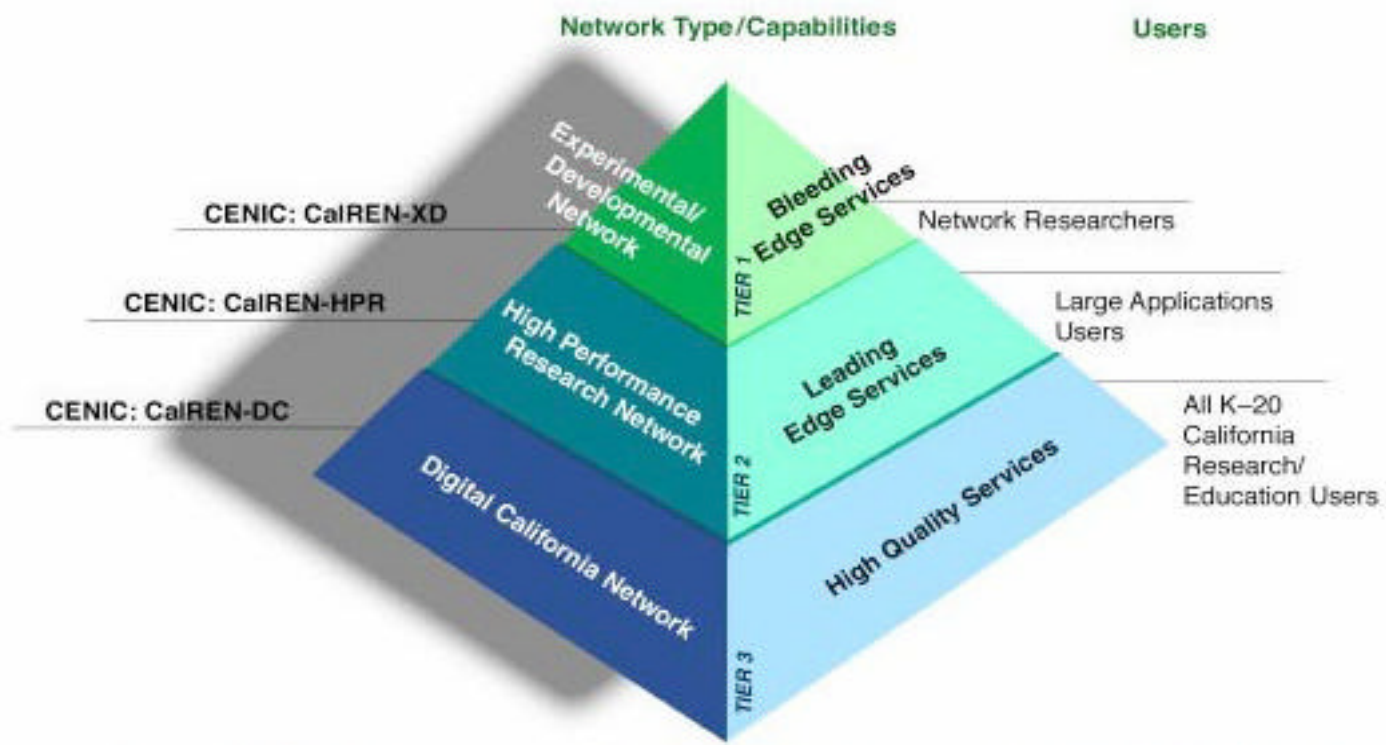
# Phase IV: A Fiber Infrastructure

- Cost effective
- Ability to provide multiple networks on single infrastructure
- Customize services to meet variety of needs instead of one size fits all
- Ability to provision services quickly to meet specialized needs - i.e., research projects, iGRID

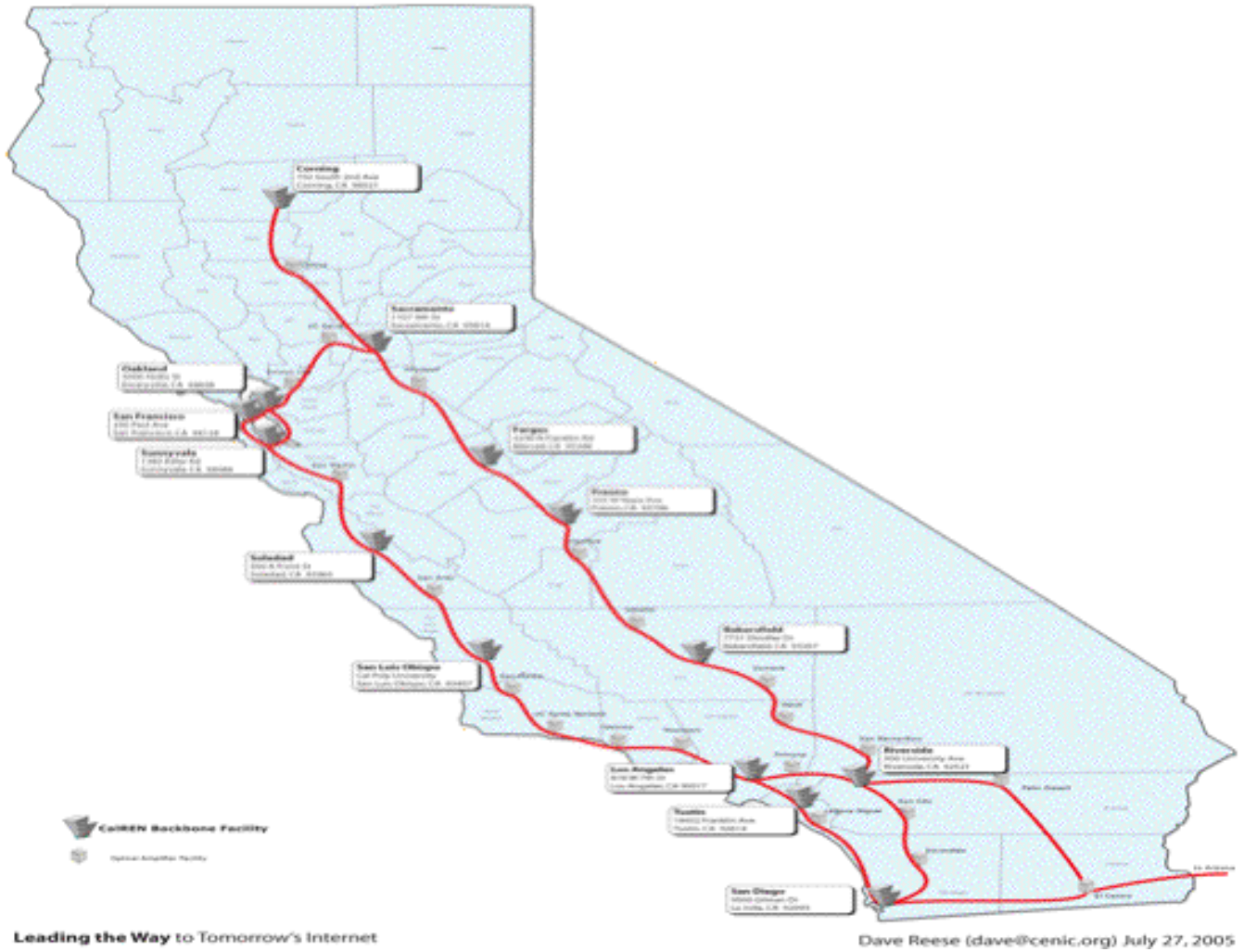
# CENIC/CalREN Tiers of Service

## Network Development and Evolution

For California Research and Education Community



# CalREN Optical Backbone
## Serving California's Research and Education Community



# CALREN - today

- 3 backbones on one physical infrastructure – 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

http://www.cenic.org/calren/maps.htm

# 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
- Also serves Network Researchers in California Research Institutions – primarily four UC Institutes; USC's ISI; Stanford; and Caltech

# How is the Network used?

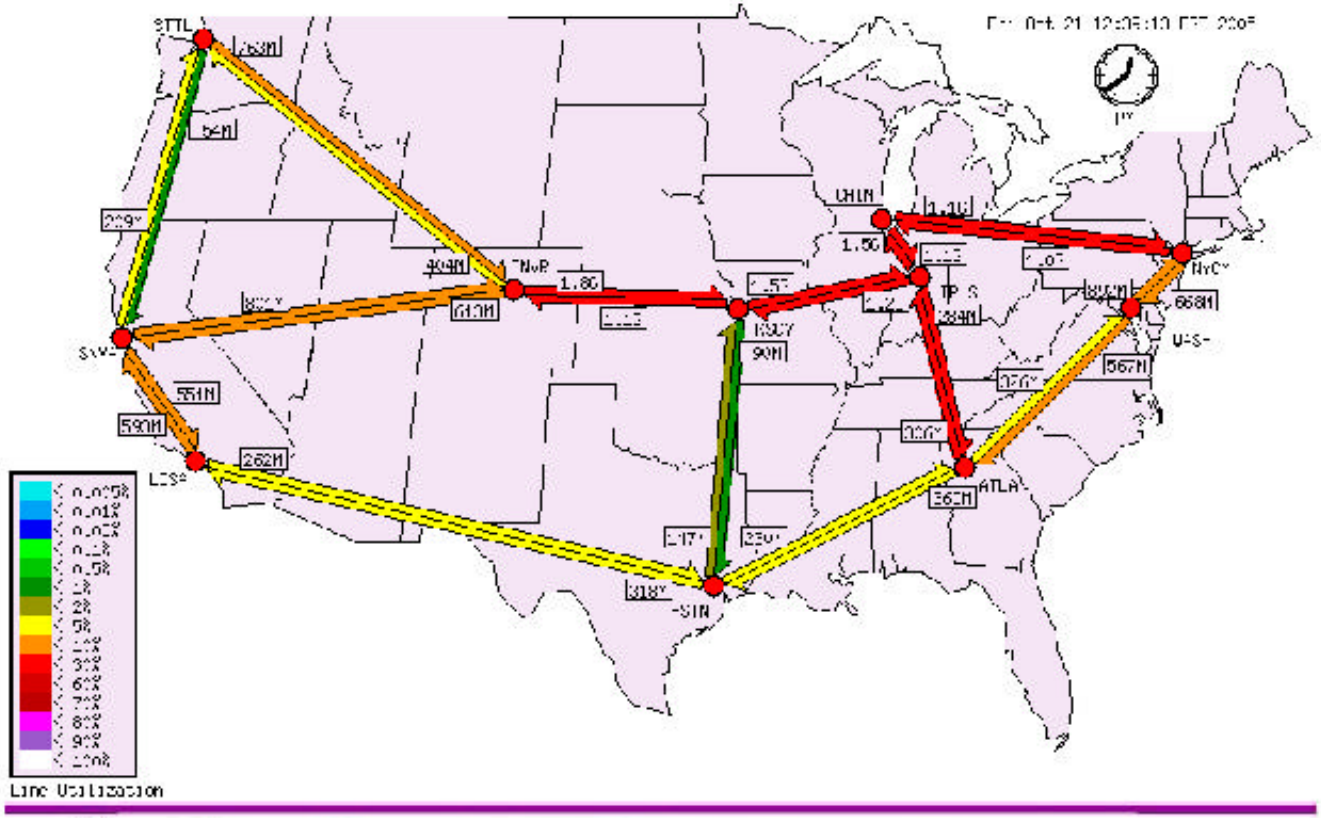
- Education---Teaching and Learning Applications
  - Shared resources, digital libraries, learning materials
  - Webcasts
  - Distance learning programs
  - Video-conferencing
  - Professional development (in situ)
- Research
  - Digital Libraries and content access
  - Multi-institution collaborations (video-conference, shared resources, collaborator ion)
  - High resolution content
  - “Big Science”
  - Large-scale applications (traffic flows and data sets.)
  - Investigating the next generation internet (NGI), network observatories

# Network Traffic Measurements

- Abilene
  http://loadrunner.uits.iu.edu/weathermaps/abilene/

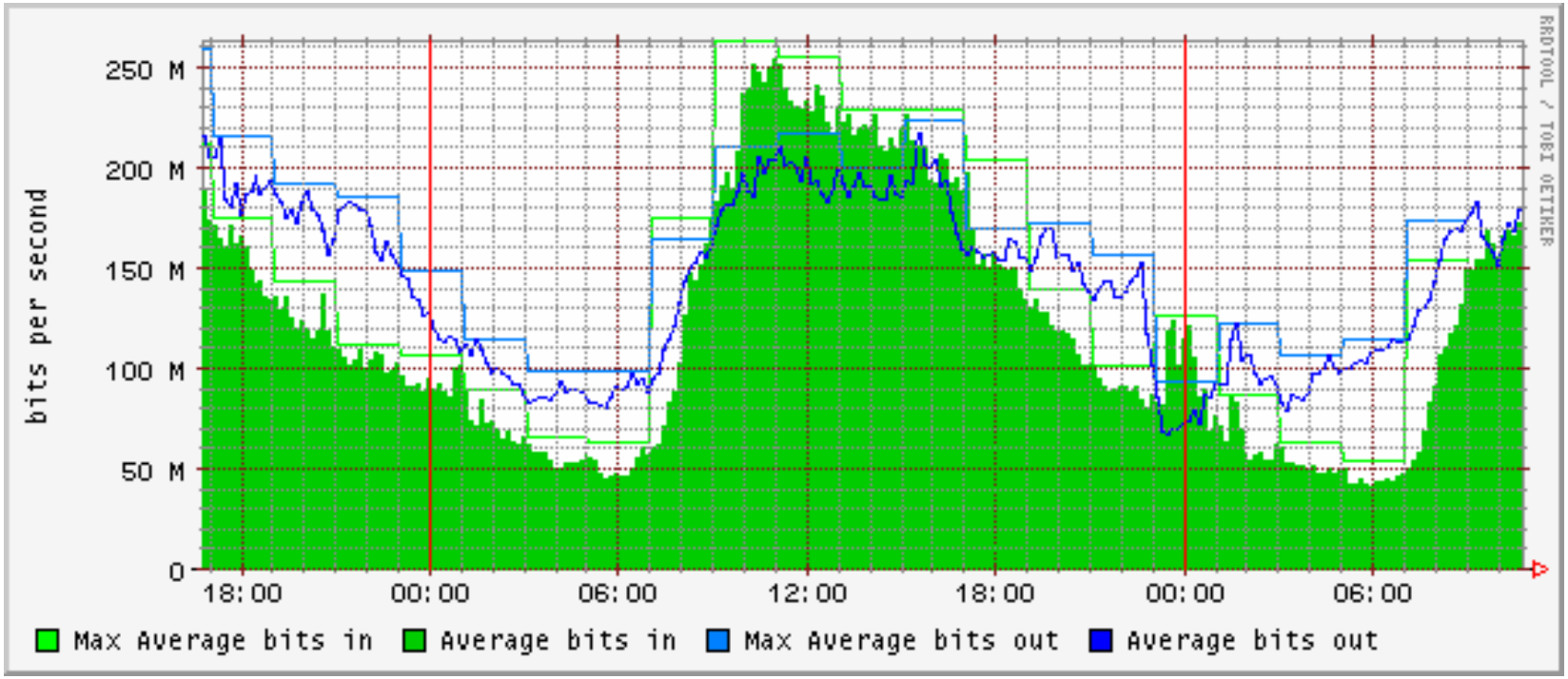
- CalREN
  http://www.cenic.org/calren/noc.htm

# INDIANA UNIVERSITY ABILENE NOC WEATHERMAP

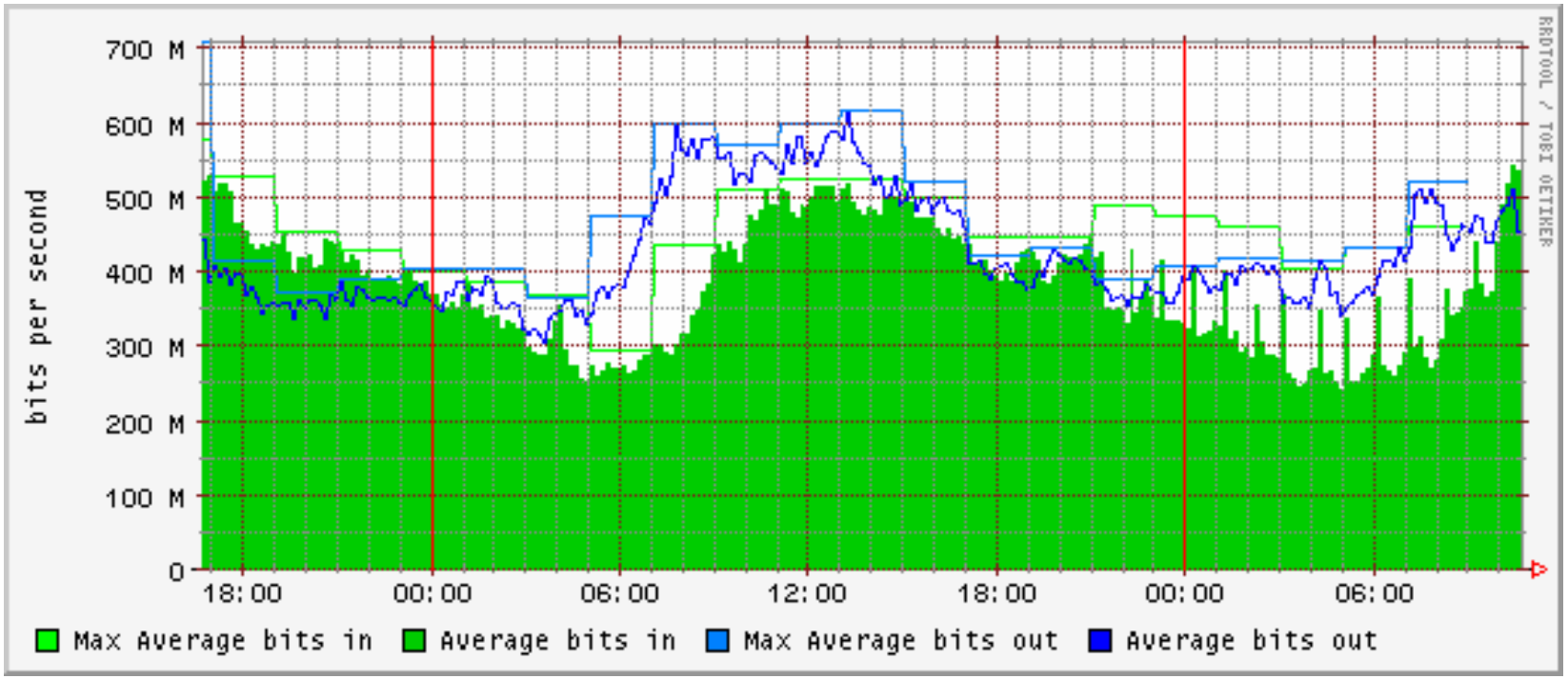



Documentation

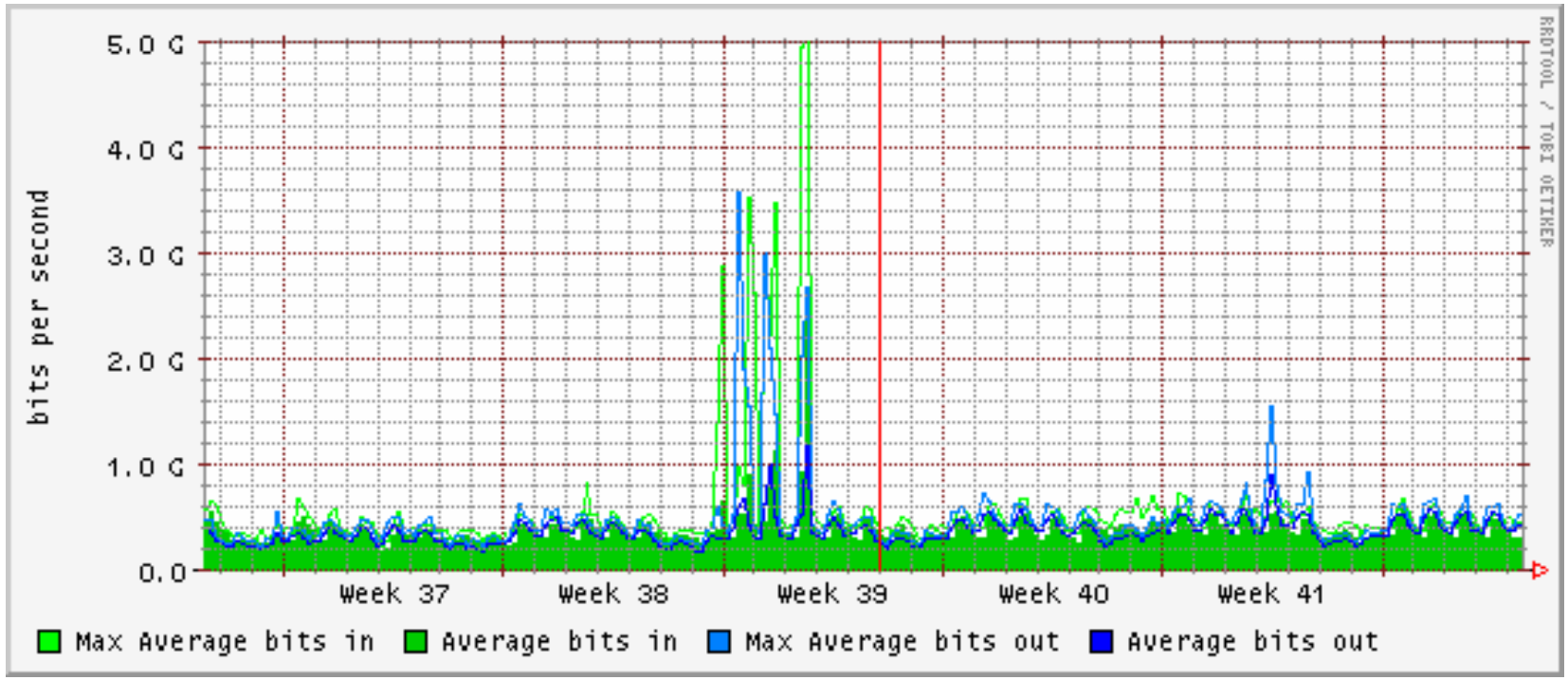
# CalREN-DC (10/21/05)



# CENIC HPR Backbone today (10/21/05)



# Monthly Stats



# Example 1: Video-conferencing

- Routine on-demand video-conferencing for classroom use, improved collaborations, reduced travel, etc.
- Internet2 has Internet2 commons

  commons.internet2.edu
- CENIC offers a video-conference service http://www.cenic.org/services/cvs/

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Corporation for Education Network Initiatives in California

**LEADING THE WAY TO TOMORROW'S INTERNET**

Google Search

About CENIC | Network | Services | Projects | Associates | Publications | Events

QUICK LINKS

- CalREN Video Services
- About CVS
- Schedule a Videoconference
- A-Z index
- Equipment
- Tutorials, Papers, Guides
- Events & Publications
- Contact Us
- CENIC Home

# CalREN VIDEO SERVICES

CVS Schedule Online Listing of all scheduled videoconferences

You may use the menu on the left side of the page to find information on this web site sorted by topic, or the links below to find information sorted by target audience.

**Information for different types of users:**

- Video Conference Schedulers
- Network Administrators
- Participants
- Presenters

The Corporation for Education Network Initiatives in California (CENIC) provides Video over IP services over CalREN. Its charge is to support the current technological environment for existing rooms and technology involved in videoconferencing while integrating Video over IP into the environment.

This web site is intended to support teachers, students, network administrators, videoconference schedulers, researchers, and videoconference participants. Your comments are welcome.

Website questions: webmaster@cenic.org
Last Update: October 13, 2005

 Privacy Statement Sitemap Opentracker.net: Website Statistics

| | |
|---|---|
| *Wednesday, Oct 5, 2005* | |
| **09:00 AM** | Reservation Name - Keystone Conference Strand B_ 2<br>Event starts at Wednesday, Oct 5, 2005 09:00 AM<br>Duration - 08:00:00<br>Participants - Keystone Strand 2 and Keystone Conf Brea Jr HS and Keystone Conf Grant Joint Union HSD and Keystone Conference Konocti USD and CENIC Kelly IP Dial-In and Keystone Conf OCDE - Unit 1 and Keystone Conf OCDE - Unit 2 and Keystone Conf Oregon Dept of Human Svcs and Keystone Conference Fulton Middle School<br>Conference Bandwidth or Line Rate - 384 kbps<br>Recurrence: Yes |
| *Thursday, Oct 20, 2005* | |
| **05:00 PM** | Reservation Name - Sociology 341 (Terry Roberts)_ 9<br>Event starts at Thursday, Oct 20, 2005 05:00 PM<br>Duration - 01:49:00<br>Participants - CSU Fullerton El Toro and CSU Fullerton HE-6<br>Conference Bandwidth or Line Rate - 384 kbps<br>Recurrence: Yes |
| **05:25 PM** | Reservation Name - NURS 171 Pathophysiology (Andrei Alexandru)_ 2<br>Event starts at Thursday, Oct 20, 2005 05:25 PM<br>Duration - 04:50:00<br>Participants - Allan Hancock CC W-22 and SVL ISDN 1: 408-522-9600<br>Conference Bandwidth or Line Rate - 384 kbps<br>Recurrence: Yes |
| **05:55 PM** | Reservation Name - ME 224 (Curt Frazier)_ 9<br>Event starts at Thursday, Oct 20, 2005 05:55 PM<br>Duration - 02:25:00<br>Participants - CSU Fresno Engineering 188 and CSU Bakersfield Lancaster Room 201<br>Conference Bandwidth or Line Rate - 384 kbps<br>Recurrence: Yes |
| **06:25 PM** | Reservation Name - Archeology 101<br>Event starts at Thursday, Oct 20, 2005 06:25 PM<br>Duration - 01:35:00<br>Participants - College of the Sequoias IM 110 and Porterville RN<br>Conference Bandwidth or Line Rate - 384 kbps<br>Recurrence: Yes |

# Example 2: Distance Learning

- USC converted its traditional ITV based Engineering DL program to IP delivery a few years ago. This allowed worldwide access rather than to a limited distribution of participating companies/sites.
- Application for many Universities and K-12, e.g. the University of California's College Preparation (UCCP) program

# USC Viterbi School of Engineering
# Distance Education Network [DEN] Overview

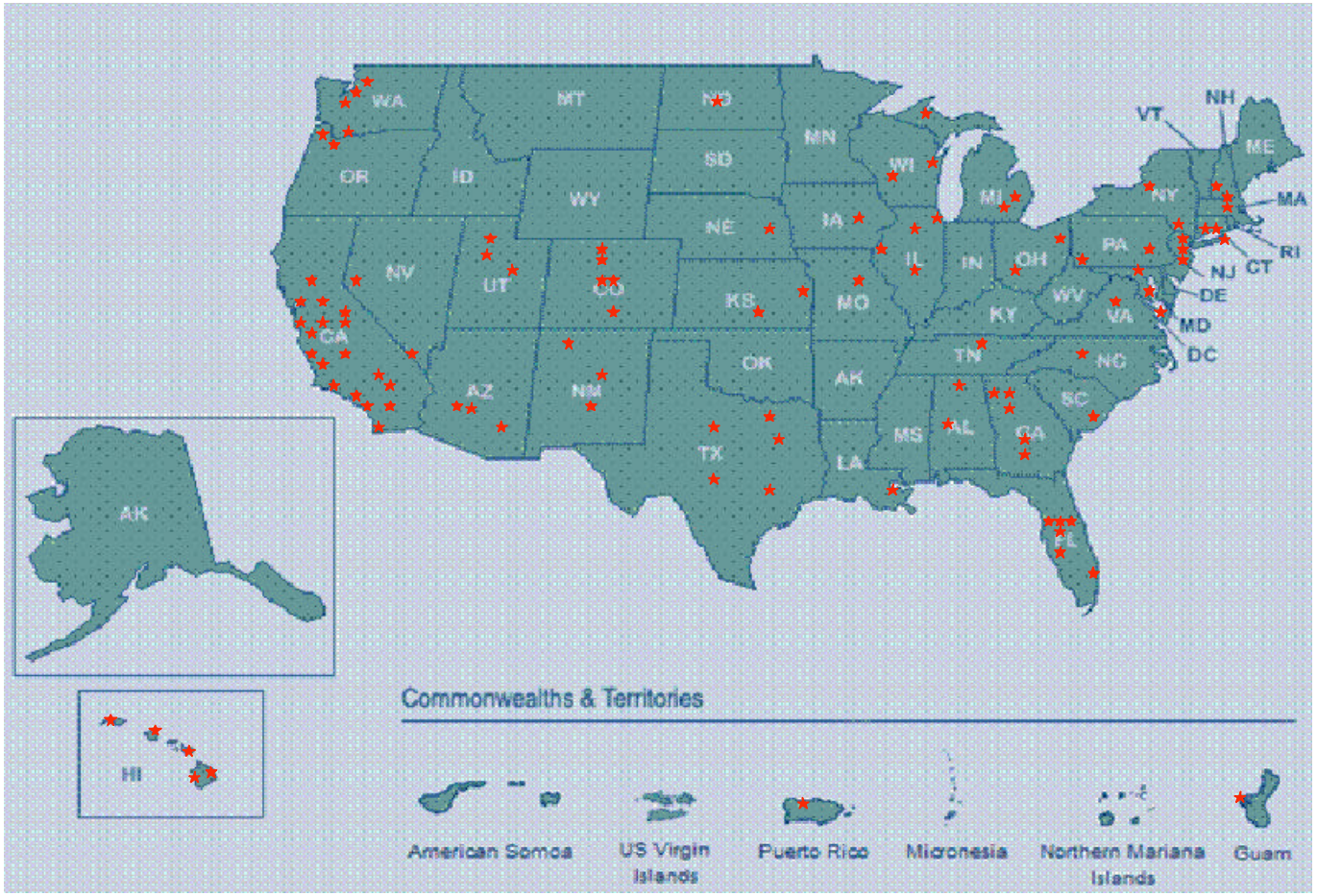
USC Viterbi School of Engineering

- Pioneer in Distance Learning
  - 1972 Microwave
  - 1997 Satellite
  - 1999 E-Learning
- Designed for the professional engineer
- Named “one of the top e-learning graduate engineering programs” by *U.S. News & World Report*
- USC DEN offers the widest number of graduate degrees ONLINE, among the top 25 engineering schools
  - 28 Master’s degrees, 5 Graduate Certificate programs, SAP academic certification, and 1 Engineer degree

# USC Viterbi School of Engineering
# Distance Education Network [DEN] Overview

USC Viterbi
School of Engineering

DEN's student base spans 38 states, 2 territory within the U.S, and 2 locations abroad



# Distance Education Network [DEN]
# Global Initiatives

USC Viterbi School of Engineering

USC Viterbi School of Engineering's global initiatives include:

- DEN has also supported individual students in Canada, the Marshall Islands, Japan, Kuwait, and Germany.
- Partnership with Chevron Corporation to offer petroleum engineering degrees to its non-U.S. based employees. Special tuition scholarships to Chevron employees are available to qualified candidates (January 2005).
- MoU with Indian Institute of Technology (IIT) to develop collaborative programs in joint research, distance learning, and student and faculty exchanges. Initial focus on programs in information technology/communication, biomedical technology and, especially, engineering management (June 2004).
- Letter of intent with Tsinghua University (Beijing, China) to collaborate in continuing education, distance education, and mutually explore areas of interest (April 2005).
- MoU with Qualcomm to open DEN's programs to non-U.S. based employees (March 2005).

# USC Online Graduate Engineering Degrees Via DEN

USC Viterbi School of Engineering

- M.S. in Aerospace Engineering (General)
- M.S. in Aerospace Engineering (Astronautics)
- M.S. in Aerospace & Mechanical Engineering (Computational Fluid & Solid Mechanics)
- M.S. in Aerospace & Mechanical Engineering (Dynamics & Control)
- M.S. in Biomedical Engineering (Medical Imaging & Imaging Informatics)
- M.S. in Civil Engineering (Construction Engineering)
- M.S. in Civil Engineering (Structural Engineering)
- M.E. in Computer-Aided Engineering
- M.S. in Computer Engineering
- M.S. in Computer Science (General)
- M.S. in Computer (Computer Networks)
- M.S. in Computer Science (Computer Security)
- M.S. in Computer Science (Multimedia & Creative Technologies)
- M.S. in Computer Science (Software Engineering)

# USC Online Graduate Engineering Degrees Via DEN

USC Viterbi School of Engineering

- M.S. in Electrical Engineering (General)
- M.S. in Electrical Engineering (Computer Networks)
- M.S. in Electrical Engineering (Multimedia & Creative Technologies)
- M.S. in Electrical Engineering (VLSI Design)
- M.S. in Engineering Management
- M.S. in Industrial & Systems Engineering
- M.S. in Integrated Media Systems
- M.S. in Mechanical Engineering (General)
- M.S. in Medical Device & Diagnostic Engineering
- M.S. in Petroleum Engineering (General)
- M.S. in Petroleum Engineering (Smart Oilfield Technologies)
- M.S. in Product Development Engineering
- M.S. in System Safety & Security
- M.S. in Systems Architecture & Engineering

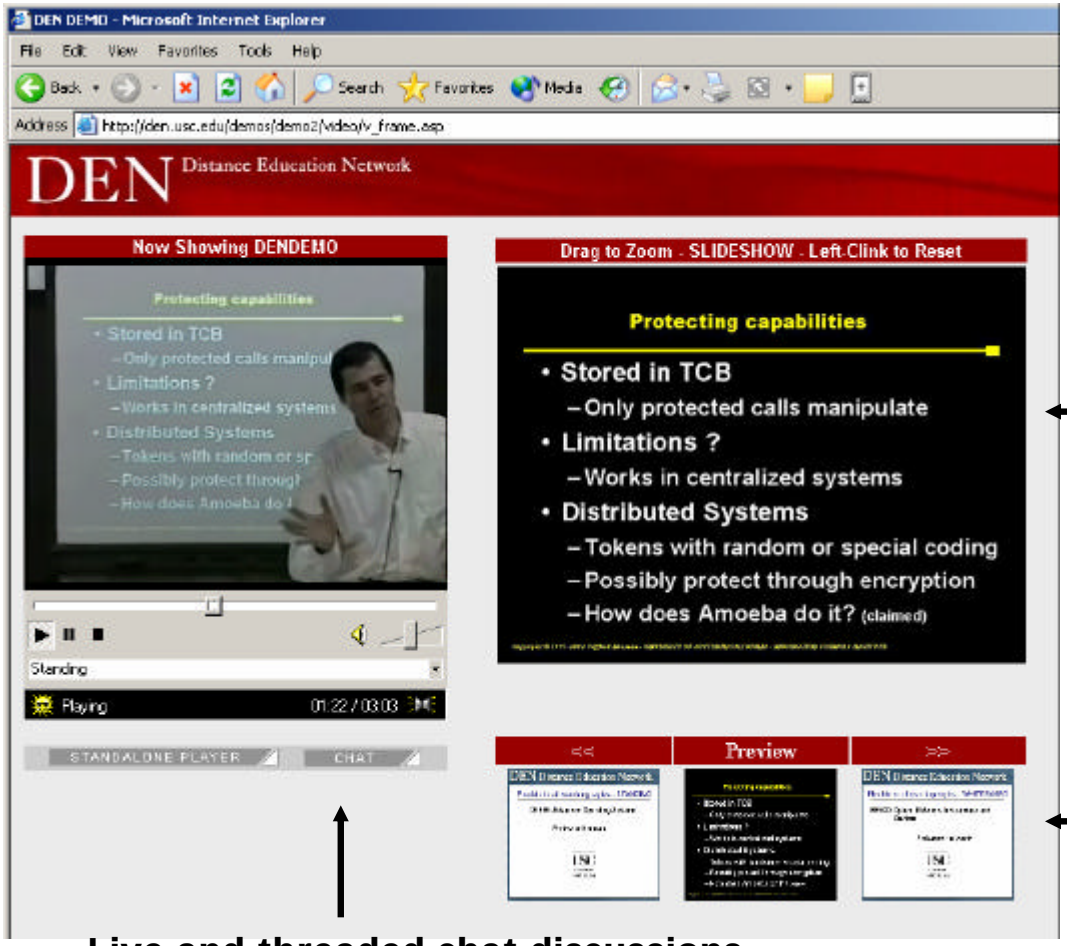
# USC Graduate Certificate Programs Via DEN

USC Viterbi School of Engineering

- Graduate Certificates offered via DEN:
  - Aerospace Engineering (Astronautics) – 4 courses
  - Engineering Technology Commercialization – 4 courses
  - Petroleum Engineering (Smart Oilfield Technologies) – 4 courses
  - Systems Architecture & Engineering – 5 courses
  - System Safety and Security – 5 courses

# DEN's E-Learning System

USC Viterbi School of Engineering




**Courses can be viewed live. All lectures are archived and accessible for the entire semester.**

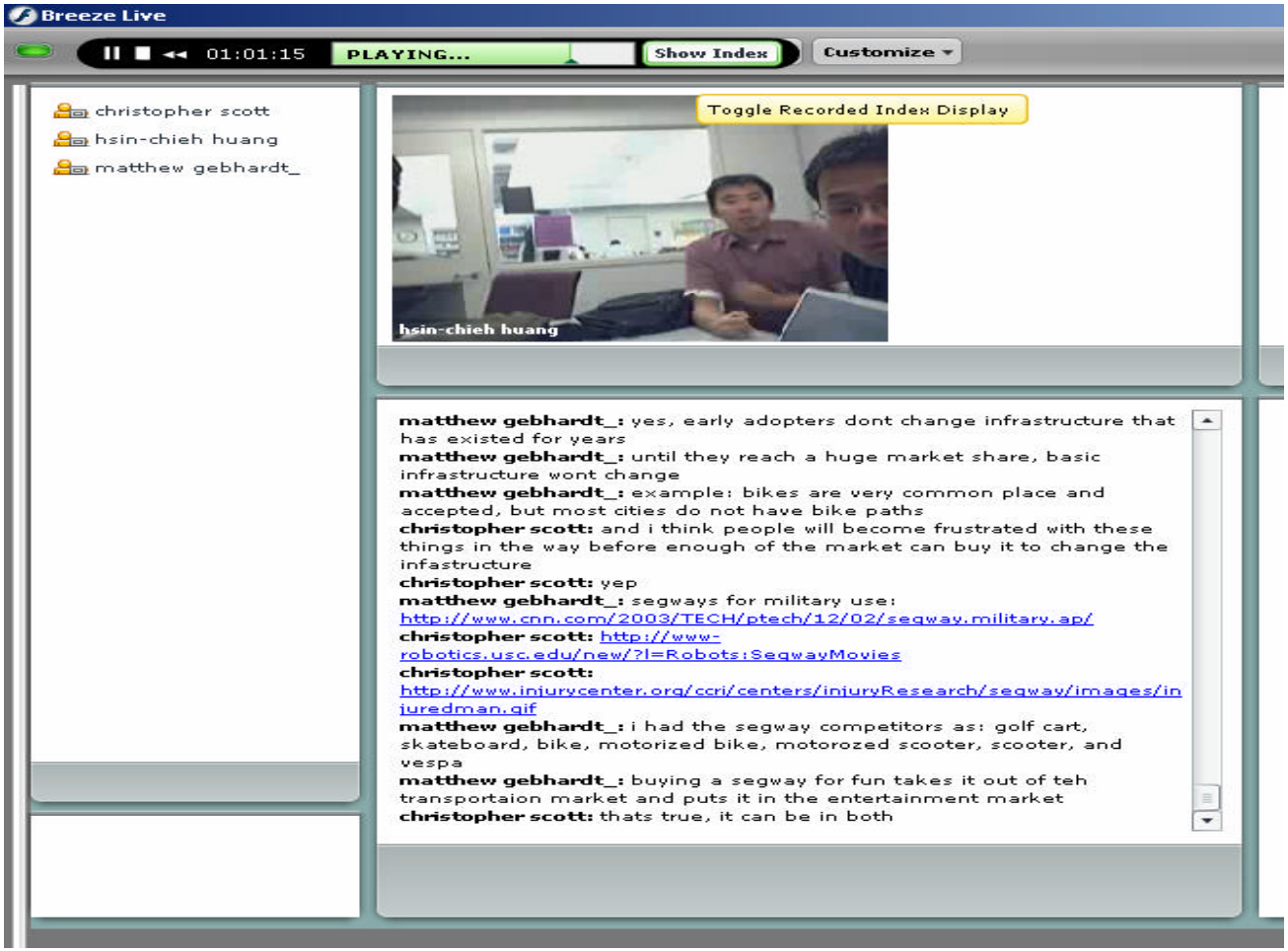
**Presentations and class notes are enlarged for better viewing; can be downloaded and printed!**

**Previews of upcoming and previous slides for quick navigation**

**Live and threaded chat discussions available to encourage interactivity**

# DEN's E-Learning System

USC Viterbi
School of Engineering

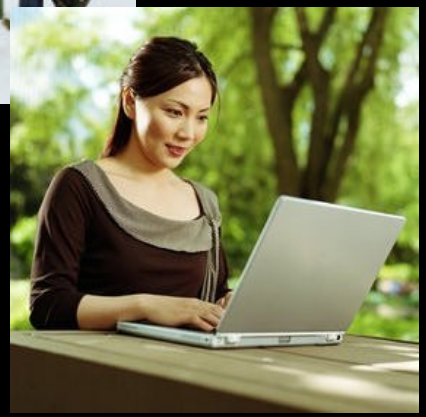



**Virtual meetings and presentations**

Since 1972, DEN has enabled thousands of full-time working engineers
to advance their education and careers...





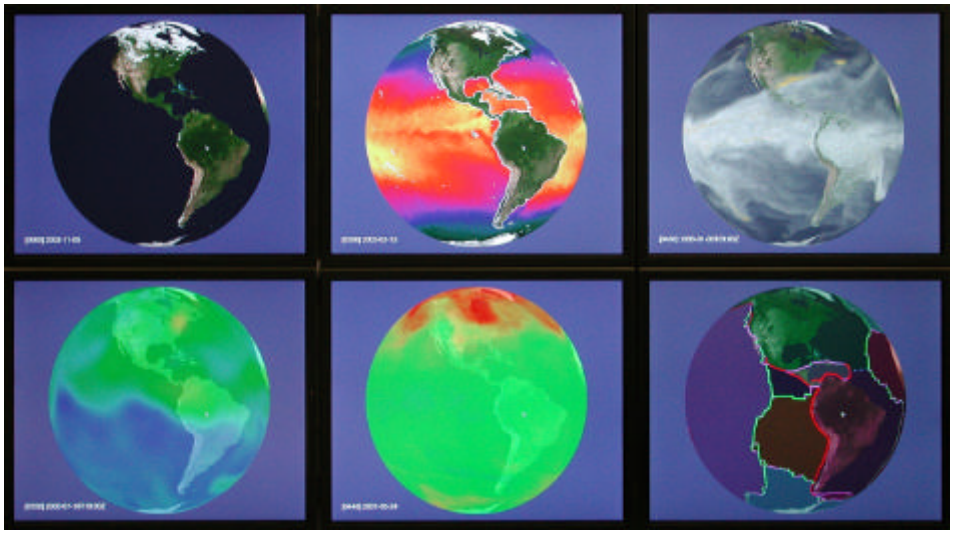
By allowing them to earn their Master's degree from USC
from the comfort of their home, office, or great outdoors...

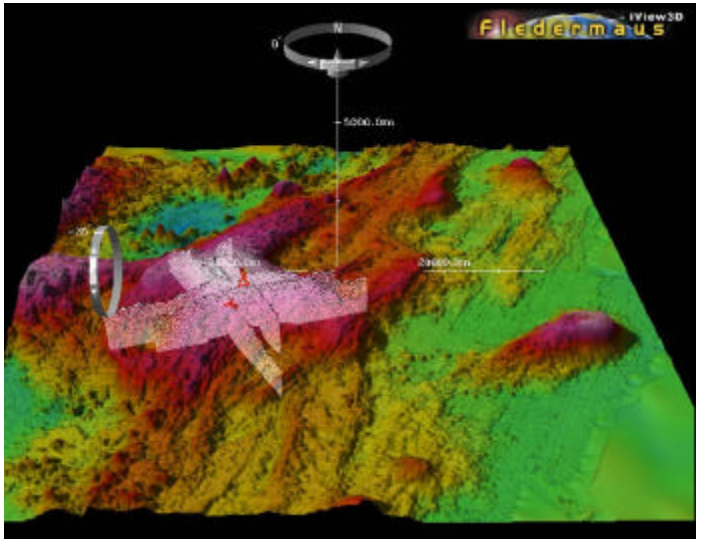
# Example 3: Big Science

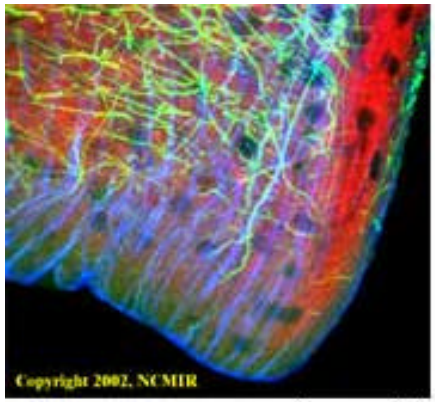
- Increased collaboration worldwide on“Big” Science projects
- Exponential growth in size of data sets being accessed
- Need for multiple dedicated/private research networks (CalREN-XD, NLR)
- iGRID last month demonstrated many examples of high-end and lightpath network applications

  http://www.igrid2005.org/program/demos_list.html

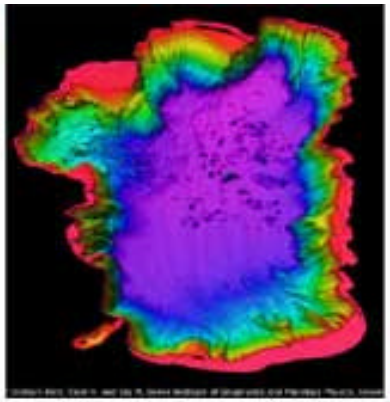
# Current Projects Served by Fiber Nets : OptIPuter





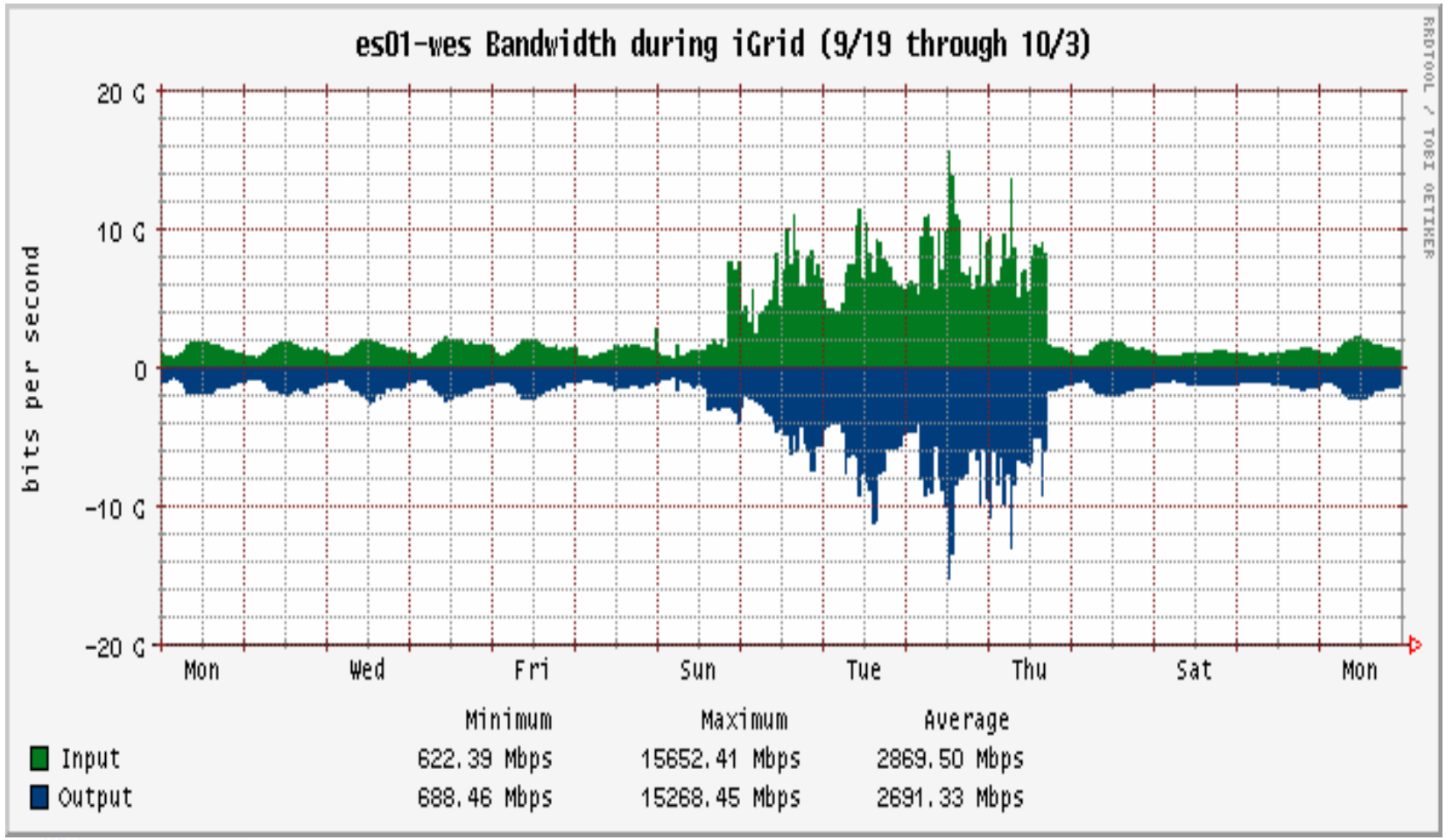

Marketta Bobik



Graham Kent


Francisco Capani & Eric Bushong

# Sample Traffic Measurement from iGRID



# Example 4: Network Research:
## Virtualized Testbed for Network Research

- Provide multiple heterogeneous virtual networks on a common substrate.
- Engage broad networking research community.
- Bridge gap between cutting-edge research and production usage.
- Proposed by:
  - ~ Tom Anderson, University of Washington
  - ~ Larry Peterson, Princeton University
  - ~ Scott Shenker, UC Berkeley
  - ~ Jon Turner, Washington University in St. Louis

# Conclusions

- Advanced networks are now so ubiquitous that we use them in everyday work (teaching, research, administration) without thinking about them.
- There is a next generation of research users that are demanding higher bandwidth and dedicated resources
- Today it is mostly science driving the high end (e.g. HEP, astronomy, ..) but we are starting to see the humanities and other disciplines taking advantage of the capabilities
- As Broadband networks get to more and more homes – the students will put greater demands on campus networks.
- K-12 is just now starting to take advantage of advanced networks – there is a longer learning curve here.