

High Speed Fiber Networks

***Required Infrastructure for Teaching, Research and
Economic Growth***

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WWW.CENIC.ORG

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R&E Networking in USA

- ◆ 1969-90--**ARPANET** (Milnet split off in '83)
- ◆ 1981-96--**BITNET/CREN**
- ◆ 1981-91ish--**CSNET** (CSnet merged with BITNET into CREN)
- ◆ 1986-95ish—**NSFNet**
- ◆ Mid 90's-**Commercial Internet**
- ◆ 1995-2001ish--**vBNS**
- ◆ 1996-97---**Internet2/Abilene**
- ◆ 1997-**CENIC/CalREN (California)**
- ◆ 2002-03-**CENIC** deploys statewide fiber backbone
- ◆ 2003-**NLR** (www.nlr.net) created for deploy national fiber backbone

CENIC-the Company

- ◆ Originally formed to bring high speed networking to all higher education research institutions in CA
- ◆ Have since started to serve all educational segments (Pre college, 2 year colleges, 4 year non-research colleges) of the State
- ◆ Advocate for broadband deployment in California

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.

CENIC's CalREN Network

- ◆ Fiber backbone throughout California from San Diego, to LA, SF Bay area, Sacramento, down central valley to Riverside, to San Diego (see attached)
- ◆ Fiber used because it
 - ◆ Enables very high speed/capacity connections
 - ◆ Enables bandwidth increases at small, marginal costs
 - ◆ Is cost effective in the longer term
 - ◆ Enables multiple networks to be operated over a single pair of fiber, using Dense Wave Division Multiplexing (DWDM)

Who We Serve

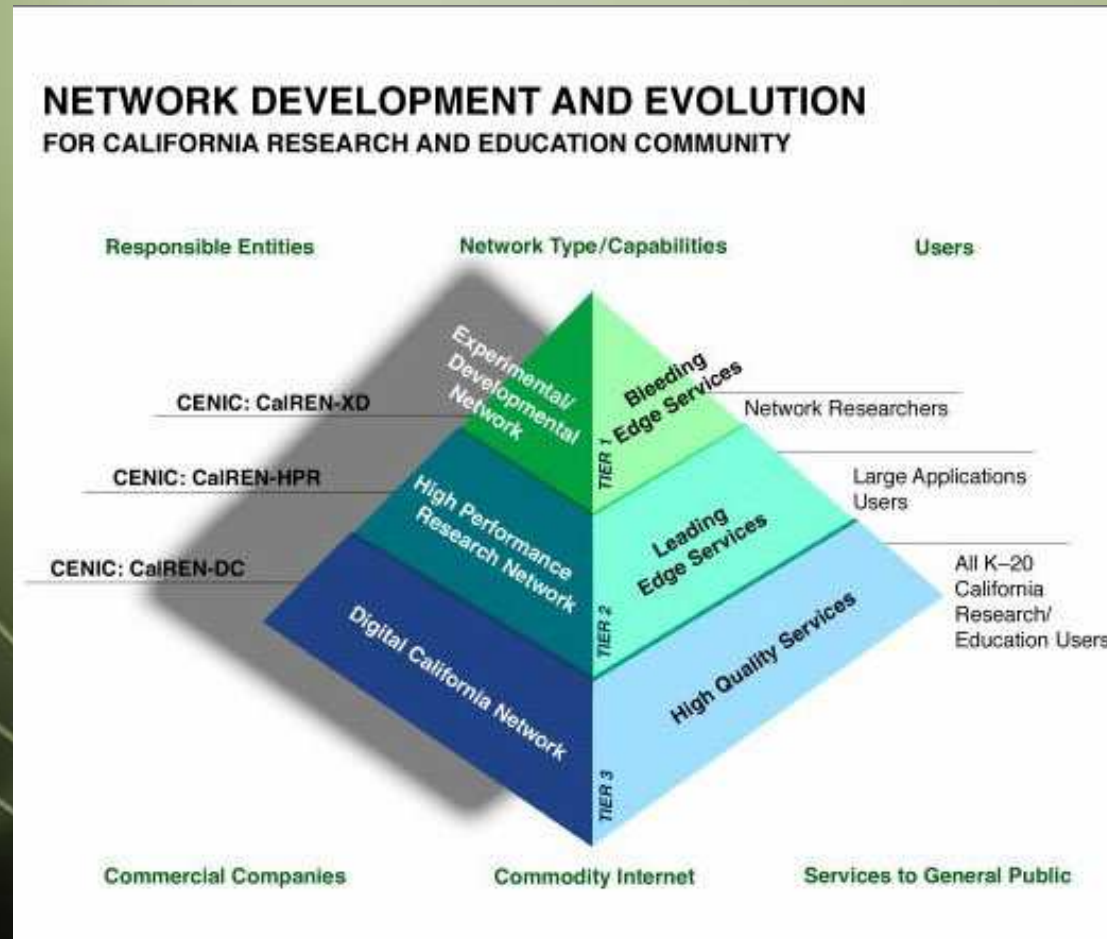
- ◆ 7,039 K-12 schools and 887 school districts with 4.7M students
- ◆ 887 K-12 school districts
- ◆ 109 CCC's with over 2.5M students
- ◆ 24 CSU campuses with over 400K students
- ◆ 10 UC campuses with over 170K students
- ◆ CalTech, Stanford, USC with over 44K students
- ◆ Nevada Educational System, Arizona State and University of Arizona

Network Description

- ◆ 2400 miles of fiber
- ◆ Cisco optical (DWDM) equipment, switches and routers
- ◆ Digital CA network backbone-2.5gbps
- ◆ High Performance Research backbone-10 gbps
- ◆ XD-specialized for custom research needs

A Tiered Network . . .

The Pyramid



CalREN

- ◆ Fiber network supports needs of high end research-it is a critical component of University research
- ◆ High speed network facilitates collaboration-faculty and researchers do not work alone. The network enables the barriers of geography to be removed
- ◆ Provides for long term cost effective network services

CalREN: Benefits to California's Economy

- ◆ Research partnerships drive innovation-
\$90 billion CA future market according to CA
Public Utilities Commission for broadband
deployment
- ◆ Magnet for corporate investment of national
broadband infrastructure and job creation from
countries such as India and China

CENIC helps UC prepare high school students for college.

U.C. College Prep Online

The screenshot shows the UCCCP website with a blue header containing the University of California logo and the text 'UCCCP COLLEGE PREP ONLINE'. A navigation bar includes 'Contact Us' and 'F.A.Q.'. The main content area features a central message: 'PREPARING STUDENTS FOR COLLEGE SINCE 1999'. Below this are sections for 'EVENTS:', 'STUDENTS:', 'SCHOOLS:', and 'NO CHILD LEFT BEHIND:', each with a list of services. A left sidebar contains icons for 'STUDENTS', 'EDUCATORS', 'SERVICES', and 'RESEARCH', along with a 'Login' button. A right sidebar lists 'AP Biology', 'AP Calculus', and 'AP Environmental Science' with corresponding images.

UNIVERSITY OF CALIFORNIA
UCCCP
COLLEGE PREP ONLINE

Preview Our Multimedia Content

Contact Us F.A.Q.

STUDENTS

EDUCATORS

SERVICES

RESEARCH

Login

PREPARING STUDENTS FOR COLLEGE SINCE 1999

EVENTS:

- UCCP Online Teaching & Learning Institute 2005

STUDENTS:

- Enroll in Spring courses now!
- Online tutoring and AP Exam prep available

SCHOOLS:

- Offer online courses to your students with UCCP
- UCCP multimedia content available through Classroom Learning Kits

NO CHILD LEFT BEHIND:

- UCCP is an official services provider
- Online tutoring available

AP Biology

AP Calculus

AP Environmental Science

It is not possible to provide a teacher of advanced mathematics within every high school in California. There are not enough teachers in enough places to meet the need. UCCP delivers Advanced Placement (AP), honors, and pre-AP courses throughout the state.

CENIC enables interactive learning.

CCC Confer

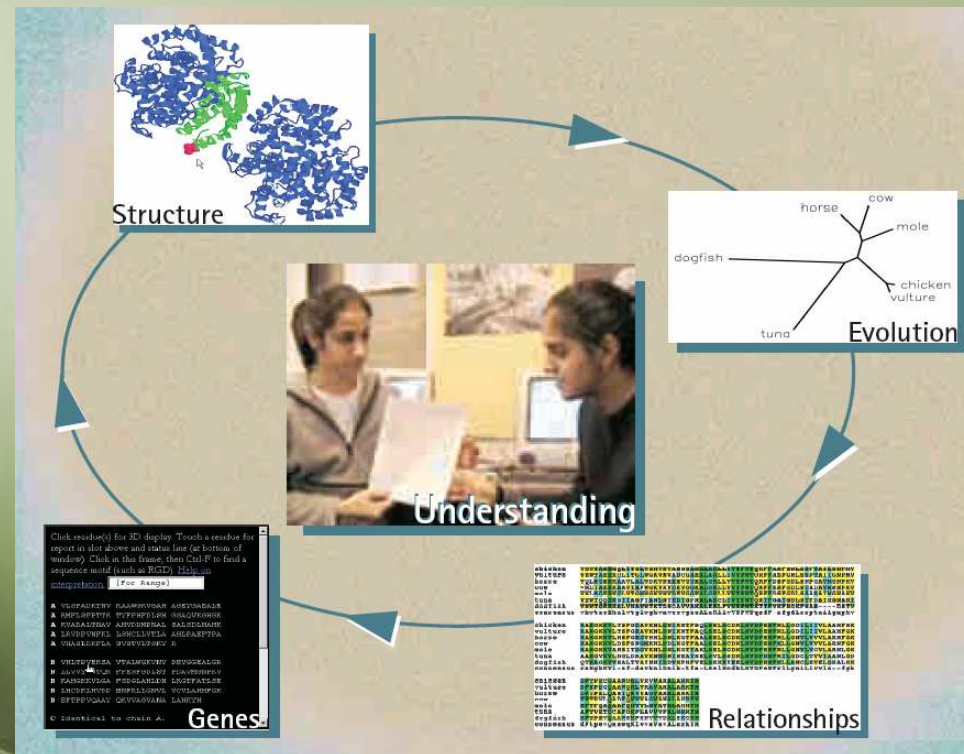
CCC Confer leverages CalREN's high speed to offer students and faculty the opportunity to combine phone calls with online chat and simultaneous application sharing.

The screenshot shows the CCC Confer website. At the top, there is a navigation bar with links for HOME, ABOUT US, MEETING CENTER, TRAINING CENTER, SERVICES/PRODUCTS, HELP, and CONTACT US. Below the navigation bar, there is a banner for "Meet & Confer", "Call Confer", and "Office Hours", stating "Used in 109 California Community Colleges System Wide." A button below the banner says "Click Here To Test Drive The New CCC Confer 2005 Model". The main content area is divided into three columns. The left column has a "LOG IN" section with links for "Meet & Confer", "Office Hours", and "Live Online Training". Below that is a "SCHEDULE" section with links for "Meet & Confer Request", "Office Hours Request", and "Call Confer Request". The middle column has a "TRAINING" section and a "RESOURCES" section. The right column has an "ARCHIVES" section with a link for "Meet & Confer". The middle and right columns also feature promotional text for "Anytime, Anywhere", "Just the Phone", and "Virtual Office Space" services, each with a "Learn More" link. At the bottom, there is a section titled "Experience the Power of CCC Confer" with a paragraph describing the service.

CENIC enables interactive learning.

The Biology Workbench

The Biology Workbench supports remote identification and manipulation of protein sequences. It has been used by university faculty nationwide in biology courses.



CENIC takes the distance out of learning.

Virtual Education in Orange County



Instead of reading about space history in textbooks, students from Brea Junior High School toured the Smithsonian National Air and Space Museum guided by LeRoy London, director of educational outreach.

Educators in Orange County enjoy direct access to nationally renowned researchers and practitioners and to their colleagues both in the county and beyond.

CaIREN-DC Videoconferencing Services

CENIC does digital media.

ACME Animation

Twice weekly ACME links classrooms high schools, occupational centers, community colleges and California State Universities to studio professionals at Disney, DreamWorks, and Warner Brothers. The college matriculation rate of ACME high school participants has reached 91%.



We ***know*** our network has to be there when you are.



at night



on the weekend

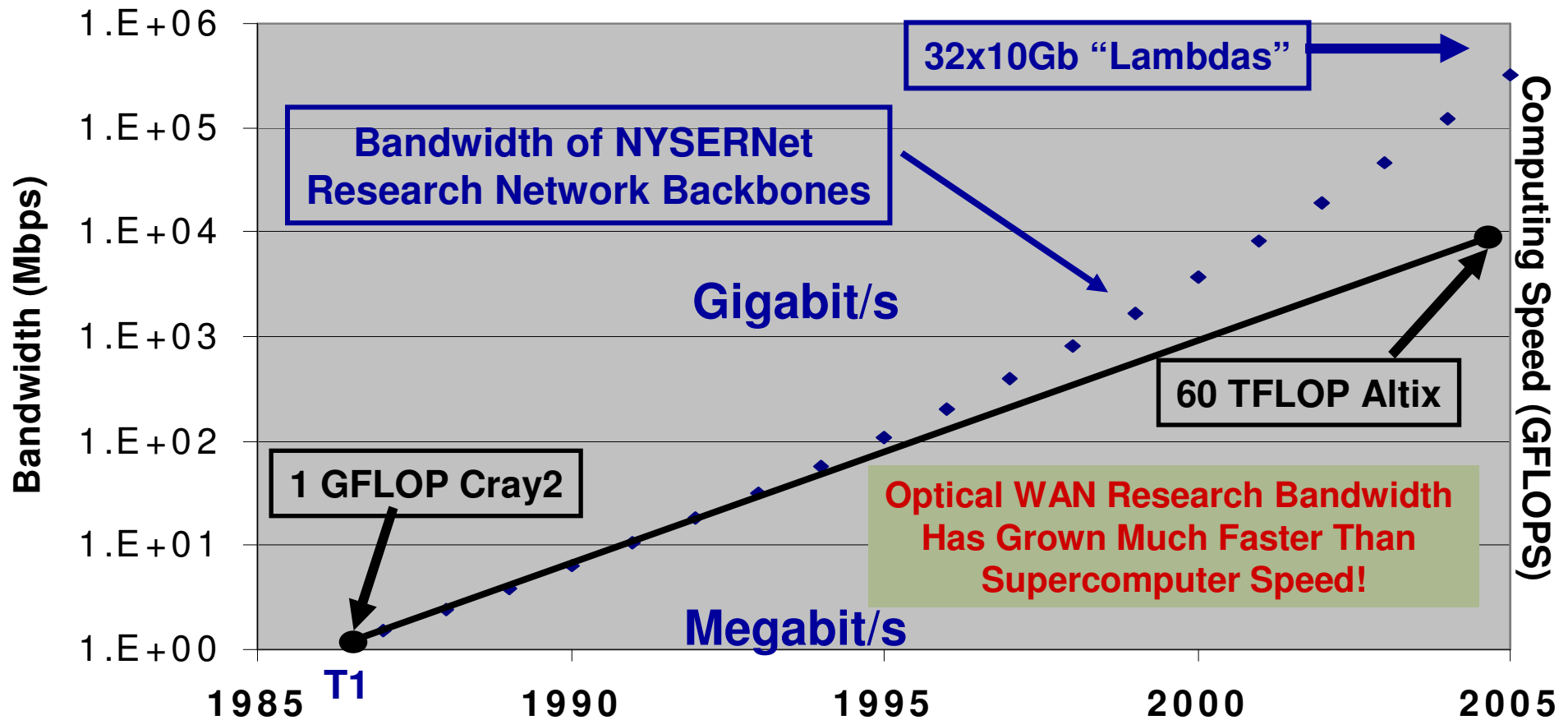


or whenever

**We're ready to respond to network trouble reports
24 hours a day, 7 days a week, 365 days a year.
(and leap year)**

From "Supercomputer-Centric" to "Supernetwork-Centric" Cyberinfrastructure

Terabit/s



Multiple HD Streams Over Lambdas Will Radically Transform Network Collaboration

University of Washington



Prof. Smarr



Prof. Aoyama

JGN II Workshop
Osaka, Japan
Jan 2005

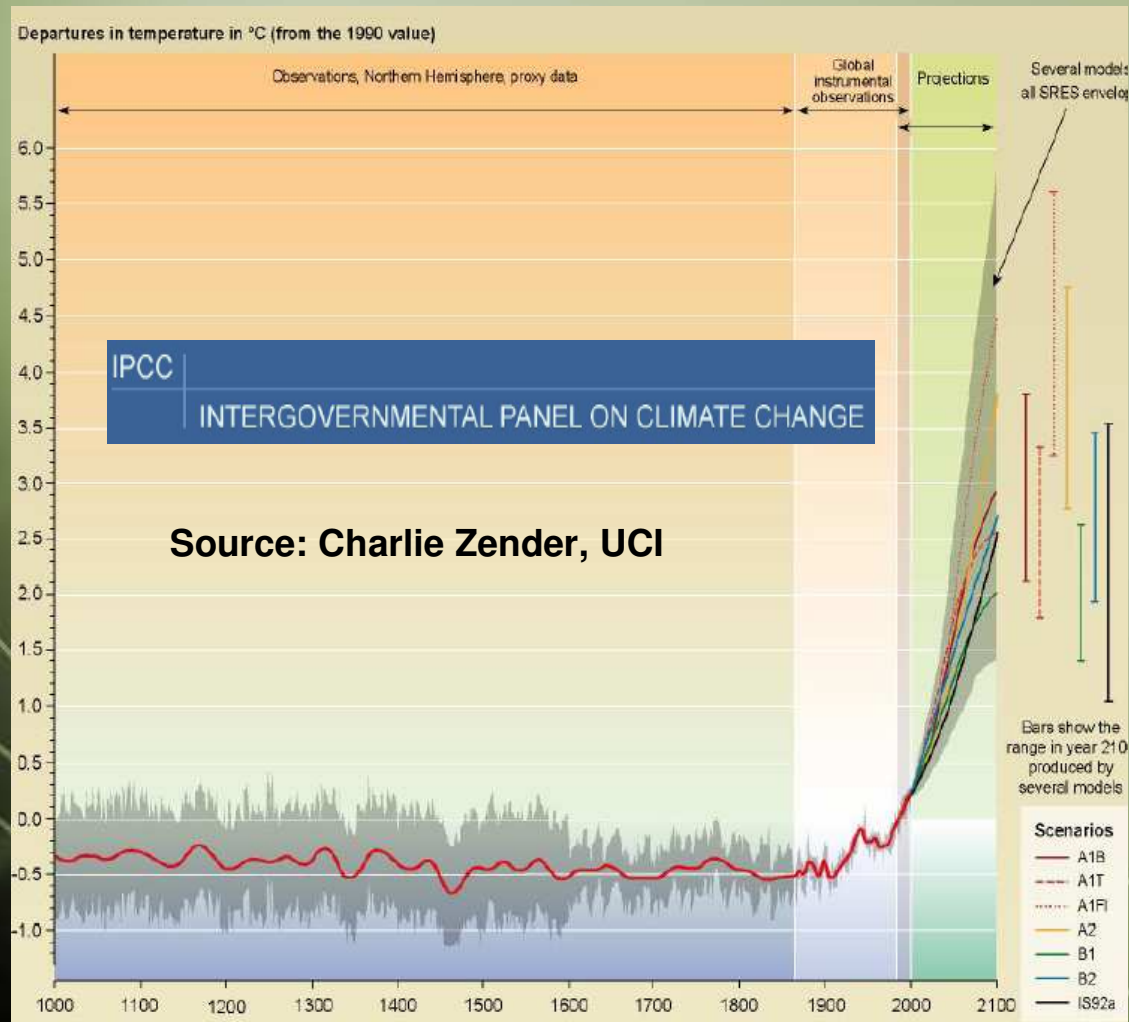
Telepresence Using
Uncompressed 1.5 Gbps HDTV
Streaming Over IP on Fiber Optics



Source: U Washington Research Channel

Establishing TelePresence
Between AIST (Japan) and KISTI (Korea) and PRAGMA in Calit2@UCSD Building in 2006

Variations of the Earth Surface Temperature Over One Thousand Years



Adding Web and Grid Services to Lambdas to Provide Real Time Control of Ocean Observatories



LOOKING: <http://lookingtosea.ucsd.edu/>
(Laboratory for the Ocean Observatory Knowledge Integration Grid)

- ◆ Goal: Prototype Cyberinfrastructure for NSF's Ocean Research Interactive Observatory Networks (ORION) Building on OptIPuter
- ◆ Collaborators at: MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie



Use of Networking in Support of Medical Sciences

- ◆ Blood Flow Model: Even the extraordinarily accurate model of blood flow in the human arterial system is so large that it depends on the resources at four TeraGrid sites simultaneously: TACC, the Pittsburgh Supercomputing Center, the National Center for Supercomputing Applications in Illinois, and the San Diego Supercomputer Center. Using software technology from the Globus Alliance, with specialized tools developed at Northern Illinois University to manage the communication between computers, Karniadakis is able to spread his application across multiple computers. The total capacity of all the computers used is nearly 35 teraflops.

"We take advantage of all of that," said Karniadakis, "and the fast network connections make it possible to synchronize and re-synchronize the calculations as necessary. Now we can investigate what happens when arterial flow is blocked at any point, as may happen in various disease processes, and we can design strategies to prevent or overcome the effects."

How fast do you want to go?

Highest Bandwidth Awarded at SC05

On November 17, 2005, CalTech, Stanford Linear Accelerator Center and the Fermi National Accelerator Center was awarded for their entry: "Distributed TeraByte Particle Physics Data Sample Analysis" measuring 131.57 Gbps of IP traffic.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

CalREN-XD eXperimental/Developmental

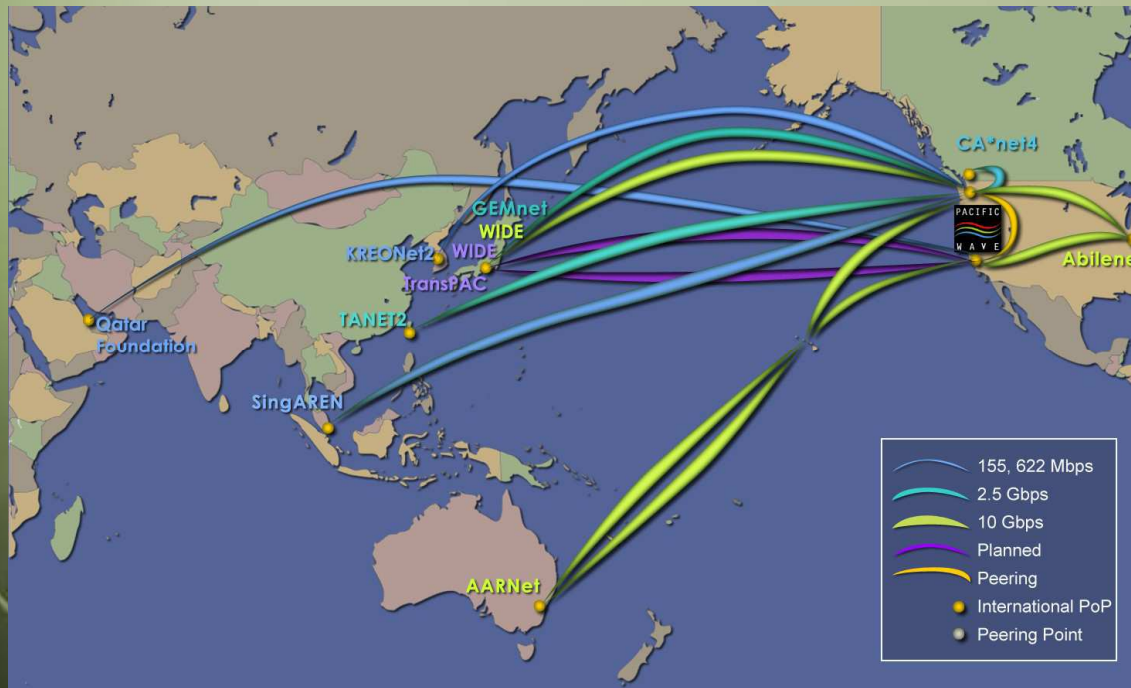
Shaking up quake research.

NEESgrid



One of the beauties of the NEESgrid will be its power as a teleobservation and teleoperation tool. In other words, researchers will be able to control experimental tools – such as a seismograph, a camera, or even a robot – at remote sites from their desktop workstation.

Pacific Wave . . .



The fruit of a collaboration between CENIC, Pacific Northwest Gigapop and USC, Pacific Wave is designed to enhance efficiency of IP traffic among participants.

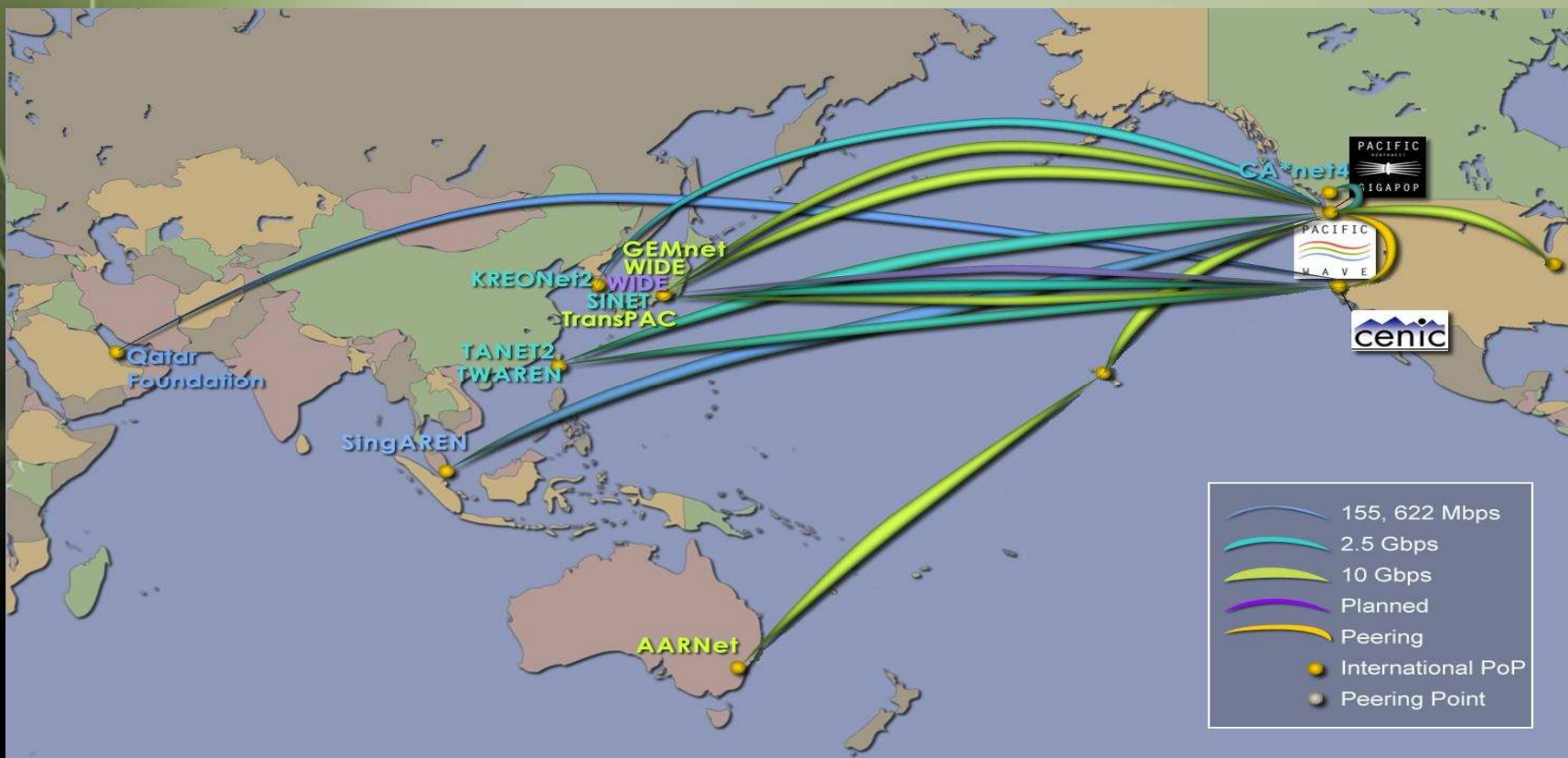
International Exchanges to Support Interconnection of R&E Networks

- ◆ Avoid passing traffic over commercial internet to:
 - ◆ Obtain better performance
 - ◆ Avoid unnecessary costs

PACIFIC WAVE

an International Connection & Exchange partnership of PNWGP (Washington State R&E) & CENIC,

done in collaborations with StarLight, and our international network partners, and partially funded by NSF



Pacific Wave Participants . . .

- ◆ Internet2
- ◆ AT & T Broadband/Comcast
- ◆ CA*net4
- ◆ CENIC/CaIREN
- ◆ Defense Research and Education Network (DREN)
- ◆ Energy Sciences Network (ESnet)
- ◆ GEMnet
- ◆ KREONet2
- ◆ Los Nettos
- ◆ Microsoft
- ◆ Pacific Northwest Gigapop (PNWGP)
- ◆ Peer1.net
- ◆ Pointshare
- ◆ Qatar Foundation
- ◆ Singapore Advanced Research and Education Network (SingAREN)
- ◆ Taiwan Research Network (TANET2)



A Use of International Collaboration

- ◆ The Southern California Coastal Ocean Observing System, provides a rich set of integrated instruments in coastal waters spanning the U.S./Mexico border.
- ◆ Access to high speed networking is essential for the technology to be adopted globally

CalRen Enables International Collaborative Experiments

Grid Computing and High-Bandwidth Networking: Telescience Project UC San Diego

- ◆ Tele-operation of remote bio-imaging instruments permits researchers to acquire and share data free of the constraints of geographical barriers

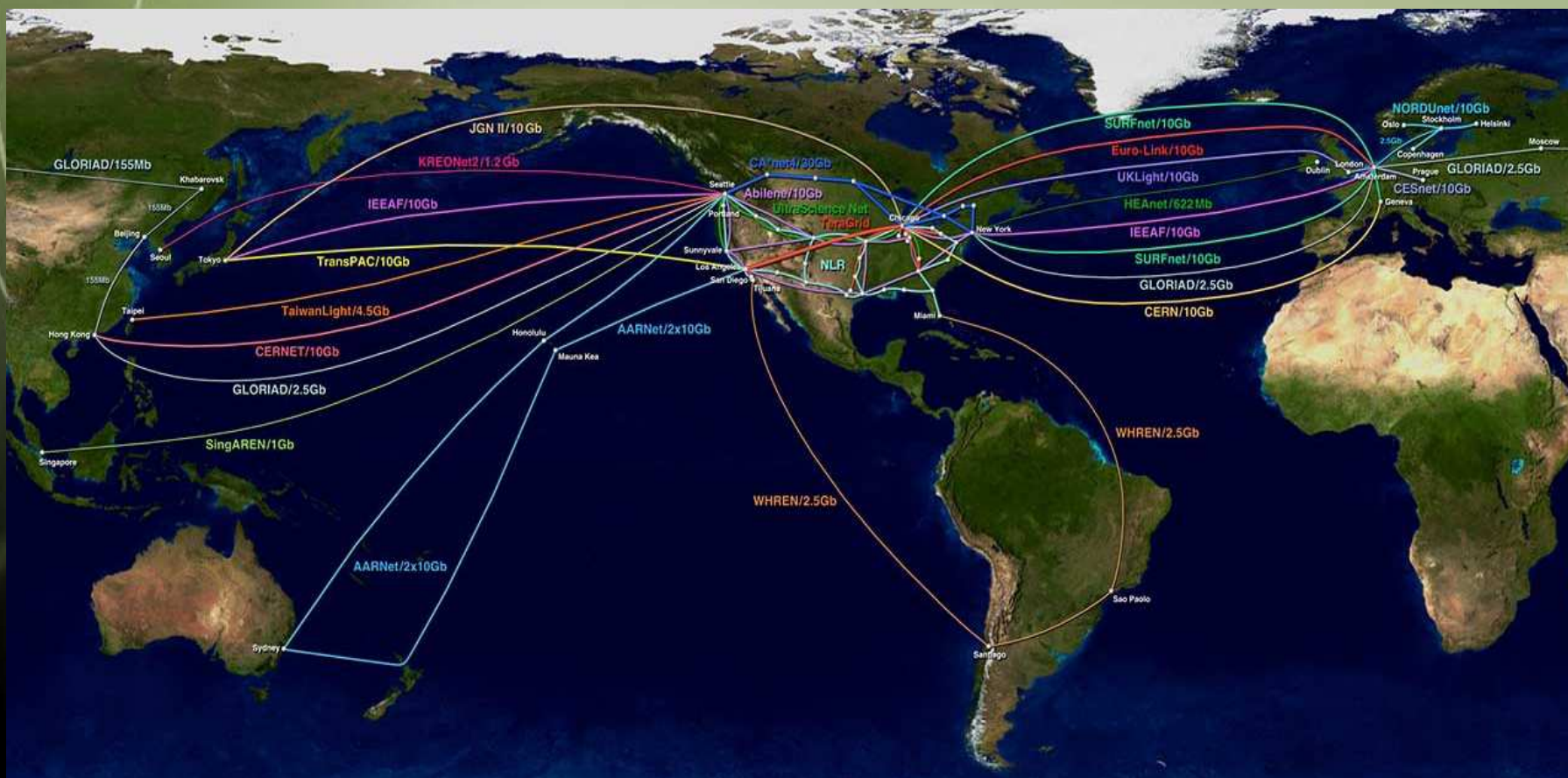
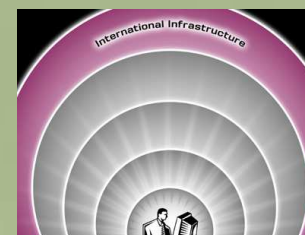


CalRen Enables International Collaborative Experiments

- ◆ Real-time nature of remote instrument control involves QoS considerations, requires very large bandwidth
- ◆ Collaborative instrument control free of geographical constraints: virtual laboratories. A distributed team of researchers anywhere in the world can perform a complete experiment (the Multipurpose Virtual Laboratory at the ELETTRA high-energy facility in Italy).



Global Lambda Integrated Facility



Visualization courtesy of Bob Patterson, NCSA. www.glif.is

Changes in R&E Impacting Networking Needs

- ◆ **Growing urgency for new network technologies**
- ◆ **Increased collaboration worldwide on “Big” Science projects**
- ◆ **Exponential growth in size of data sets being accessed**
- ◆ **Need for multiple dedicated/private research networks**
- ◆ **iGRID conference in Nov. demonstrated many examples of high-end and lightpath network applications**

Potential List of Future CENIC Net Services

- ◆ End to end optical lambda/wave services
 - ✓ Ends are labs/desktops at campuses
 - ✓ Cross national and international network boundaries
 - ✓ Ability to obtain these for short periods of times on short notice (user switched??)
- ◆ End-to-end switched ethernet services (same as above)
- ◆ New-experimental routed services (layer 3, to complement experimental routed services of NLR)

Questions?

<http://www.cenic.org>

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