

# 2011-2013 Bi-Annual Report



The Corporation for Education  
Network Initiatives in California



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## Letter From the President

Dear friends,

Around the country and the world, new possibilities in research and education are moving at the pace of technology. As that pace accelerates, it's critical that California's research



*Louis Fox, President/CEO*

and education communities have the advanced networking they need to meet their most pressing needs and promising opportunities. This need is CENIC's reason for being—and for the strides we've made in the last two years.

At CENIC, we are always seeking new and better ways to help our members achieve their missions. This means working closely with California's education and research communities and tailoring one of the world's most advanced networks to their needs. Knowing that those needs are evolving at the pace of technology, so are we.

In 2011-2013, we developed new technical capabilities, relationships and services—all dedicated to answering our members' most pressing challenges and promising opportunities.

We embarked on new infrastructure projects that extend and strengthen the California Research & Education Network (CalREN) within California and beyond. This biennial report takes a look at the implementation of 100-Gigabit networking in California and around the world—what it enables and what lies ahead. It also

explores the network's evolution through software-defined networking with the creation of COTN, the California OpenFlow Testbed Network.

As the network's capabilities and reach continue to expand, so do our relationships with a diverse group of vital public-serving organizations. We have renewed our alliance with the California Telehealth Network, the state's leading agency focused on increasing access to healthcare through the innovative use of technology. We are actively investigating our ability to expand the institutions we serve to include libraries and cultural institutions—kindred communities that are stewards of precious knowledge and gateways to new ideas.

Every innovation that comes from advanced networking pushes the boundaries and increases demand for even greater network performance. As ultra-high-performance speeds become the new standard, CENIC's mission endures: to ensure that our members continue to enjoy the cost-effective, high-bandwidth networking essential to achieving their missions and answering the needs of their faculty, staff, students and patrons. Our strides in advanced networking are strategic—dedicated to keeping our members at the leading edge of research and education.

For all of us at CENIC, it's an honor and inspiration to join forces with our members to support the ideas and innovation that are shaping a bright future for California. As much as we've achieved together in the last two years, we look forward to possibilities that lie ahead.

## CENIC Mission & Goals

California's education and research communities leverage their networking resources under CENIC, the Corporation for Education Network Initiatives in California, in order to obtain cost-effective, high-bandwidth networking to support their missions and answer the needs of their faculty, staff, and students.

CENIC designs, implements, and operates CalREN, the California Research & Education Network. CalREN is a high-bandwidth, high-capacity Internet network specially designed to meet the unique requirements of these communities, and to which the vast majority of the state's K-20 educa-

### 2012-13 CENIC Board of Directors

Chair:

**David Ernst**

(through 12/31/2012)  
Associate Vice President and  
Chief Information Officer  
Information Resources and  
Communications  
University of California Office  
of the President

**Bill Clebsch**

(as of 1/1/2013)  
Associate Vice President  
Information Technology  
Services  
Stanford University

Vice Chair:

**Patrick Perry**

Vice Chancellor  
California Community  
Colleges

Treasurer:

**Anne Mallory**

County Superintendent  
Imperial County Office of  
Education

Secretary:

**Bruce Briggs**

Chief Information Officer and  
Assistant Vice Chancellor  
Information Technology  
Services  
CSU Office of the Chancellor

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Sonoma State University

**Keric Ashley**

Director, Data Management  
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Education

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Technology Officer  
San Diego Unified School  
District

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District Director  
Information Services  
North Orange County  
Community College District

**Peter M. Siegel**

Chief Information Officer and  
Vice Provost  
Information and Educational  
Technology  
UC Davis

**Larry Smarr**

Director  
California Institute of  
Telecommunications and  
Information Technology  
UC San Diego

**Richard N. Katz**

President, Richard N. Katz &  
Associates

tional institutions are connected. In order to facilitate collaboration in education and research, CENIC also provides connectivity to CalREN for non-California institutions and industry research organizations with which CENIC's Associate researchers and educators are engaged.

CENIC is governed by its member institutions. Representatives from these institutions also donate expertise through their participation in various committees designed to ensure that CENIC is managed effectively and efficiently, and to support the continued evolution of the network as technology advances.

### CENIC is committed to the following goals:

- Continuously improving a robust, cost-effective, state-of-the-art communications network, accessible to participating education and research institutions,
- Working with member institutions to define a value chain of services, and developing innovative ways to deliver scalable solutions to members,
- Leading efforts of participating institutions to provide end-to-end service quality and interoperability among member institutions, and promoting adoption across network boundaries,
- Advancing the collective interests of the institutions by leveraging their diversity and relationships to accrue benefits to individual members,
- Providing a competitive advantage in the global marketplace to the education and research communities,
- Communicating the value of CENIC as California's recognized provider of network services for education and research,
- Providing opportunities for innovation in teaching, learning, and research through use of the network, and
- Strengthening participation in the state, national, and international education and research networking communities.

## CENIC Values & Principles

The CENIC Core Values describe the standards by which CENIC and its employees should operate. These values do not change with time or circumstance and should not be compromised. They are the underpinnings of our corporate culture and should be reflected in everything we do.

- **Integrity:** We conduct ourselves according to high ethical standards.
- **Stewardship:** We respect the resources our Associates have entrusted to us – time, money, effort, and intellectual capital – and pledge to act as responsible stewards of all of these.
- **Accountability:** We take responsibility for our conduct in dealings with each other and our Associates.
- **Respect:** We act with consideration, tolerance, and dignity towards others.

The CENIC Guiding Principles describe in broad terms the factors that inform and help determine CENIC's actions and decisions. In most cases, the actions and decisions reflect the application of CENIC Core Values to specific situations through striking a balance between or among extremes suggested by applying these principles in isolation.

- **Excellence:** We conscientiously strive for quality and distinction in our work.
- **Initiative:** We proactively identify and take the appropriate actions needed to provide solutions.
- **Collaboration:** We work cooperatively with each other and with our Associates in support of shared goals and common interests.
- **Service:** We recognize our role in helping our Associates achieve their missions.
- **Innovation:** We value creativity in the pursuit of new technologies and solutions when appropriate.
- **Reliability:** We recognize the importance of the services provided to our Associates and their dependence upon those services.



2011-13

## CENIC Committees & Councils

### Advisory Council Chairs

#### Business Advisory Council:

##### **Doug Hartline**

Director, Core Technologies  
UC Santa Cruz

#### HPR Network Advisory Council:

##### **Rodger Hess**

(through 12/31/2011)  
Network Architect  
UC Davis

##### **Tad Reynales**

(as of 1/1/2012)  
Chief Infrastructure Officer  
Calit2@UCSD

##### **Erik McCroskey**

(as of 1/1/2013)  
Principal Network Engineer, Infrastructure  
Services  
UC Berkeley

#### DC Network Advisory Council:

##### **Jeremy Powell**

(through 12/31/2011)  
Director of Technology  
Tustin Unified School District

##### **Russ Selken**

(as of 1/1/2012)  
Director, K12HSN  
Butte County Office of Education

##### **Susan Reese**

(as of 1/1/2013)  
Director, Instructional and Information  
Technology Projects and Services  
Cal Poly Pomona

### Committee Membership

#### Audit Committee

Ruben Armiñana, Chair  
Doug Hartline  
Mark Crase, California State University  
Peter Siegel  
Deborah Ludford

#### Finance Committee

Anne Mallory, Chair  
Doug Hartline  
Keric Ashley  
Peter Siegel  
Patrick Perry  
Trevor Stewart, Butte College  
Sam Steinhardt, Stanford  
Louis Fox, President and Chief Executive Officer,  
CENIC\*  
Bill Paik, Chief Financial Officer, CENIC\*

#### XD/HPR Committee

John Dundas, Chair  
John Silvester, University of Southern California  
Larry Smarr  
Jim Davis, UCLA  
Ron Johnson  
Rodger Hess (through 12/31/2011)  
Greg Hidley, UC San Diego  
Tom DeFanti, UC San Diego  
Erik McCroskey  
Tad Reynales, UC San Diego (as of 1/1/2012)  
Peter Siegel  
Russ Hobby, UC Davis  
Christine Haska, Naval Postgraduate School  
David Reese, Vice President and Chief  
Technology Officer, CENIC\*  
Louis Fox, President and Chief Executive Officer,  
CENIC\*  
Brian Court, Director of Network Engineering and  
Design, CENIC\*

\* Non-voting

## CENIC Networking Relationships

### America's Lightpaths (AmLight)

[www.amlight.net](http://www.amlight.net)

Americas Lightpaths (AmLight) enables research and education amongst the people of the Americas through the operation of production infrastructure for communication and collaboration between the U.S. and Western Hemisphere science and engineering research and education communities.

The effort is fundamentally collaborative, encompassing the NSF's AmLight support (Award #OCI-0963053) and committed financial resources of AURA, ANSP, and RNP, the resources of FIU and CENIC, AtlanticWave and PacificWave, and the networks of ANSP, CUDI, RedCLARA, REUNA, and RNP. Through AtlanticWave and PacificWave, there is production connectivity and peering to North American backbone networks Internet2, ESnet, and CANARIE. Through RedCLARA there is production connectivity to thirteen national research and education networks (NRENs) with plans to expand to eighteen NRENs during the life of the project.

### California Telehealth Network

[www.caltelehealth.org](http://www.caltelehealth.org)

California Telehealth Network's mission is to promote advanced information technologies and services to improve access to high quality healthcare focusing on medically underserved and rural Californians. An independent non-profit 501(c)3, CTN was initially funded through the FCC's Rural Health Care Pilot Program which provided CTN with \$22.1 million, the largest single state award of its kind. Additional funding has been provided by

the California Emerging Technology Fund, the California HealthCare Foundation, the California Teleconnect Fund, the National Coalition for Health Integration, United HealthCare and the University of California.

### Corporación Universitaria para el Desarrollo de Internet (CUDI)

[www.cudi.edu.mx](http://www.cudi.edu.mx)

The Corporación Universitaria para el Desarrollo de Internet (CUDI) is a Mexican nonprofit corporation composed of members from the public and private sectors. CUDI funds an advanced, high-speed network in Mexico and has agreements with a number of carriers that provide high-performance applications to higher education and research institutions.

### Energy Science Network

[www.es.net](http://www.es.net)

ESnet provides the high-bandwidth, reliable connections that link scientists at national laboratories, universities and other research institutions, enabling them to collaborate on some of the world's most important scientific challenges including energy, climate science, and the origins of the universe. Funded by the U.S. Department of Energy's (DOE) Office of Science and located within the Scientific Networking Division at Lawrence Berkeley National Laboratory, ESnet provides scientists with access to unique DOE research facilities and computing resources. CENIC's CalREN connects to ESnet via a 100G connection in Sunnyvale.



## Internet2

[www.internet2.edu](http://www.internet2.edu)

Internet2 is a not-for-profit advanced networking consortium comprising more than 200 US universities in cooperation with 70 leading corporations, 45 government agencies, laboratories, and other institutions of higher learning as well as over 50 international partner organizations.

Internet2 members leverage the organization's high-performance network infrastructure and extensive worldwide partnerships to support and enhance their educational and research missions. Beyond just providing network capacity, Internet2 actively engages its community in the development of important new technology including middleware, security, network research, and performance measurement capabilities which are critical to the progress of the Internet.

## Western Regional Network

[www.westernregional.net](http://www.westernregional.net)

In 2010, Pacific Northwest GigaPoP, Front Range GigaPoP, the University of New Mexico, and CENIC announced the formation of the Western Regional Network, a multi-state partnership to ensure robust, advanced, high-speed networking availability for research, education, and related uses through the sharing of network services. These RONS provide networking services to the following states: Alaska, California, Colorado, Idaho, Montana, Nevada, New Mexico, Washington, Hawaii, Oregon, and Wyoming.

WRN will provide access to shared NLR, Internet2, Pacific Wave, and other regional fiber- and IP-based services for instruction, research, medical education and clinical care, and economic development purposes.

## CENIC Professional Relationships

### EDUCAUSE

[www.educause.edu](http://www.educause.edu)

EDUCAUSE is a nonprofit association whose mission is to advance higher education by promoting the intelligent use of information technology. EDUCAUSE programs include professional development activities, applied research, strategic policy advocacy, teaching and learning initiatives, online information services, print and electronic publications, special interest collaborative communities, and awards for leadership and innovation.

### Global Lambda Integrated Facility

[www.glif.is](http://www.glif.is)

GLIF, the Global Lambda Integrated Facility, is an international virtual organization that promotes the paradigm of lambda networking. The GLIF participants are National Research and Education Networks (NRENs), consortia, and institutions working with lambdas.

GLIF members provide lambdas internationally as an integrated facility to support data-intensive scientific research, and support middleware development for lambda networking.

### Internet Educational Equal Access Foundation

[www.ieeaf.org](http://www.ieeaf.org)

The Internet Educational Equal Access Foundation (IEEAF) is a non-profit corporation created by its member institutions to accept assets donated to the global education community by a broadly defined telecommunication industry and corporate community. Founding member institutions

include the Corporation for Education Network Initiatives in California (CENIC), the Pacific Northwest GigaPoP, the Pacific Internet2 Coalition, the University of Maryland, and GEO.

### StateNets

[www.statenets.org](http://www.statenets.org)

State Research and Education Networks (StateNets) provide increasingly vital infrastructure services that extend beyond networking into enterprise applications, middleware, broadband policy, and state-wide procurement in support of education, research and development, health care, state and local government, and university outreach and public service. The mission of StateNets is to provide a national forum for collaboration among individual state networks; to develop and support a community of practice; to build consensus with colleagues across the country and to provide a leadership role in articulating a unified vision in the research and education networking community.

### The Quilt

[www.thequilt.net](http://www.thequilt.net)

The Quilt, a coalition of advanced regional network organizations, is a dynamic forum where leaders from throughout the advanced research and education network community build on the intellectual capital and best practices of network service providers worldwide. Based on the participants' combined experiences in operations and development of leading edge technologies, the Quilt aims to influence the national agenda on information technology infrastructure, with particular emphasis on networking.

## CENIC Associates

### California K-12 System

Alameda COE  
Alpine COE  
Amador COE  
Bishop Elementary School  
Butte COE  
Calaveras COE  
CA Department of Education  
Chaffey Joint UHSD  
Chowchilla School District  
Colusa COE  
Contra Costa COE  
Del Norte COE  
Dos Palos High School  
El Dorado COE  
Fresno COE  
Glenn COE  
Humboldt COE  
Imperial COE  
Kern COE  
Kings COE  
Lake COE  
Lake Tahoe USD  
Lassen COE  
Los Angeles COE  
Los Angeles USD  
Loyalton High School  
Madera COE  
Mono COE  
Marin COE  
Mariposa COE  
Mendocino COE  
Merced COE

Modoc COE  
Monterey COE  
Napa Valley USD  
Napa COE  
Nevada Joint UHSD  
Northern Humboldt UHSD  
Orange County DoE  
Placer COE  
Plumas COE  
Red Bluff High School  
Riverside COE and RCOE Indio Office  
Sacramento COE  
San Benito COE  
San Bernardino CSS  
San Diego COE  
San Francisco COE  
San Joaquin COE  
San Luis Obispo COE  
San Mateo COE  
Santa Barbara CEO  
Santa Clara COE  
Santa Cruz COE  
Santa Maria UHSD  
Shasta COE  
Sierra COE  
Siskiyou COE  
Solano COE  
Sonoma COE  
Stanislaus COE  
Sutter County Schools  
Tehama COE  
Trinity COE  
Truckee High School  
Tulare COE  
Tulelake Basin Joint USD

Tuolumne COE  
Ventura COE  
Victor Valley CC  
Yolo COE  
Yuba COE

### California Community Colleges

Chancellor's Office  
Alameda  
Allan Hancock  
American River  
Antelope Valley  
Bakersfield  
Barstow  
Berkeley City  
Butte  
Cabrillo  
Cañada  
College of the Canyons  
Cerritos  
Cerro Coso  
Chabot  
Chaffey  
Citrus  
Coastline  
Columbia  
Contra Costa  
Copper Mountain  
Cosumnes River  
Crafton Hills  
Cuesta  
Cuyamaca  
Cypress  
De Anza  
College of the Desert

Diablo Valley  
East Los Angeles  
El Camino  
Evergreen Valley  
Feather River  
Folsom Lake  
Foothill  
Fresno City  
Fullerton  
Gavilan  
Glendale  
Golden West  
Grossmont  
Hartnell  
Imperial Valley  
Irvine Valley  
Lake Tahoe  
Laney  
Las Positas  
Lassen  
Long Beach City  
Los Angeles City  
Los Angeles Harbor  
Los Angeles Mission  
Los Angeles Pierce  
Los Angeles Southwest  
Los Angeles Trade Tech  
Los Angeles Valley  
Los Medanos  
Marin  
Mendocino  
Merced  
Merritt  
MiraCosta  
Mission  
Modesto Junior

Monterey Peninsula  
 Moorpark  
 Mt. San Antonio  
 Mt. San Jacinto  
 Napa Valley  
 North Orange County  
 CCD Office  
 Ohlone  
 Orange Coast  
 Oxnard  
 Palomar  
 Palo Verde  
 Pasadena City  
 Porterville  
 College of the  
 Redwoods  
 Reedley  
 Rio Hondo  
 Riverside  
 Sacramento City  
 Saddleback  
 San Bernardino Valley  
 San Diego Centers  
 for Education and  
 Technology  
 San Diego City  
 San Diego Mesa  
 San Diego Miramar  
 San Francisco City  
 San Joaquin Delta  
 San Jose City  
 San Mateo  
 Santa Ana City  
 Santa Barbara City  
 Santa Monica  
 Santa Rosa  
 Santiago Canyon  
 College of the  
 Sequoias

Shasta  
 Sierra  
 College of the  
 Siskiyous  
 Skyline  
 Solano  
 Southwestern  
 Taft  
 Ventura  
 Victor Valley  
 West Hills Coalinga  
 West Hills Lemoore  
 West Los Angeles  
 West Valley  
 Woodland  
 Yuba  
**California State  
 University**  
 Office of the  
 Chancellor  
 California Maritime  
 Academy  
 California State  
 Polytechnic University  
 San Luis Obispo  
 California State  
 Polytechnic University  
 Pomona  
 CSU Bakersfield  
 CSU Channel Islands  
 CSU Chico  
 CSU Dominguez Hills  
 CSU East Bay  
 CSU Fresno  
 CSU Fullerton  
 Humboldt State  
 University  
 CSU Long Beach  
 CSU Los Angeles

CSU Monterey Bay  
 CSU Northridge  
 Sacramento State  
 University  
 CSU San Bernardino  
 CSU San Marcos  
 CSU Stanislaus  
 San Diego State  
 University  
 San Francisco State  
 University  
 San Jose State  
 University  
 Sonoma State  
 University

## University of California

UC Office of the  
 President  
 Office of State  
 Governmental  
 Relations  
 UC Berkeley  
 Lawrence Berkeley  
 National Laboratory  
 UC Davis  
 UC Davis Medical  
 Center  
 UC Irvine  
 UC Los Angeles  
 UC Merced  
 UC Riverside  
 UC San Diego  
 UC San Francisco  
 UC Santa Barbara  
 UC Santa Cruz

## Private Universities

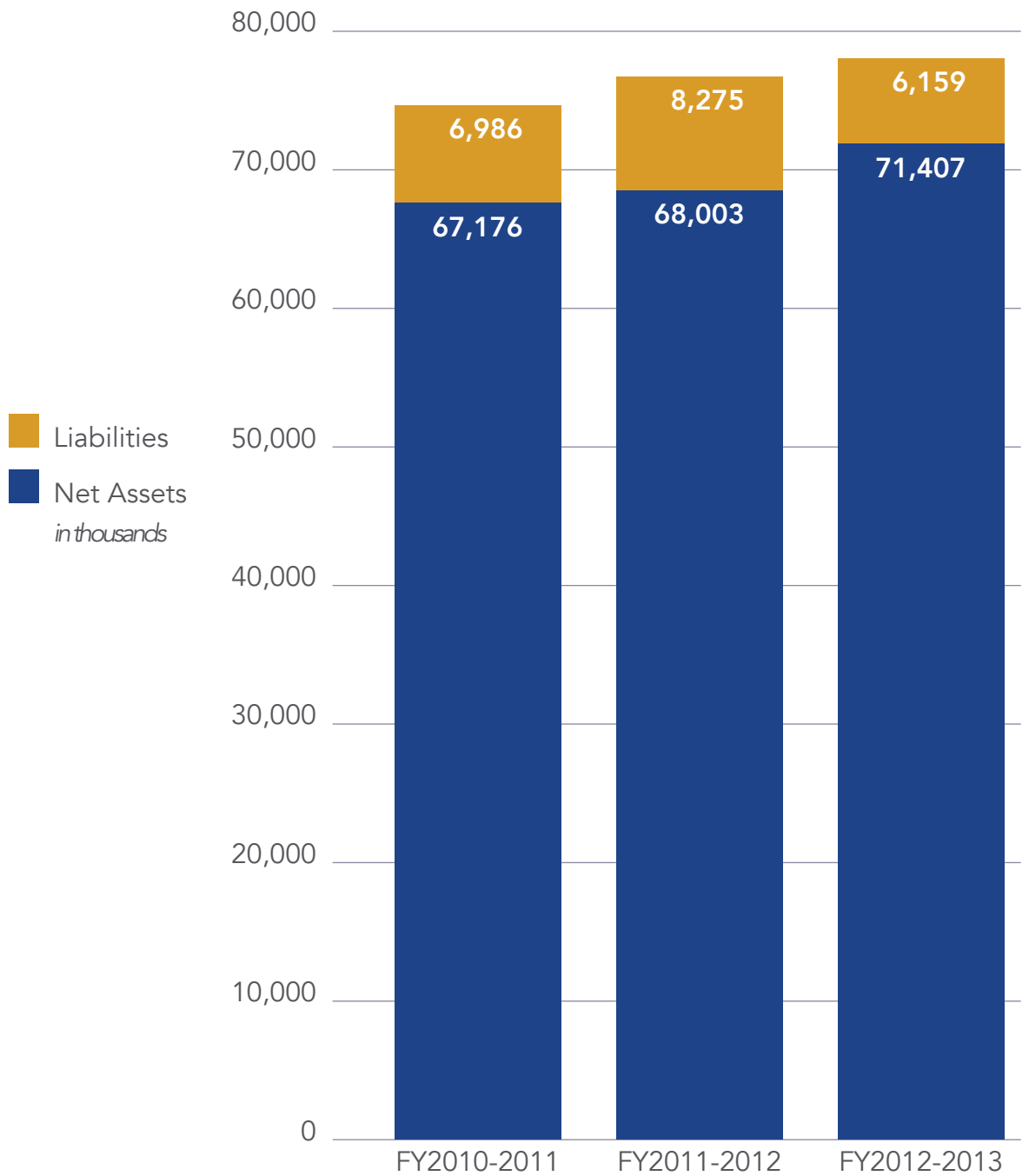
California Institute of  
 Technology  
 Jet Propulsion  
 Laboratory  
 Stanford University  
 Stanford Linear  
 Accelerator Center  
 Stanford Medical  
 Center  
 Stanford Hopkins  
 Marine Station  
 University of  
 Southern California  
 USC Health Sciences  
 Campus  
 USC Information  
 Sciences Institute  
 USC University Park  
 Campus

## CalREN Associates

Carnegie-Mellon  
 University West  
 Chapman University  
 NASA Ames Research  
 Center  
 Naval Postgraduate  
 School  
 Nevada System of  
 Higher Education  
 Pepperdine University  
 University of  
 Pennsylvania,  
 Wharton West  
 University of San  
 Diego  
 University of San  
 Francisco

## 2011-2013 CENIC Financial Statement

	FY2010-2011	FY2011-2012	FY2012-2013
Liabilities	6,986	8,275	6,159
Net Assets	67,176	68,003	71,407
Total Assets	74,162	76,278	77,566



# The California Research & Education Network

One of California's most powerful tools in maintaining its economic and innovative leadership position is the California Research & Education Network (CalREN). Among the world's most advanced such networks, CalREN makes possible both big science and big classrooms, enabling both to reach around the globe and bring people and resources together at the speed of light. With the power that CalREN enables for nearly 10 million Californians every day, the pace of scientific and educational innovation in the Golden State has accelerated, even during times of austerity. In fact, in March of 2013, CENIC announced a record-breaking year for traffic growth. The traffic flowing through CalREN to external networks

topped out at 18 Petabytes in February 2013, with a 99.1% growth rate over February 2012. The growth rate from January 2012 to January 2013 was similarly impressive at 93%.

The backbone capacity from the Los Angeles (LAX) backbone node to the Riverside (RIV), Tustin (TUS), and Sunnyvale (SVL) nodes has been increased as follows:

- Two 10 Gbps trunk upgrades between LAX and RIV
- Two 10 Gbps trunk upgrades between LAX and SVL
- Increased capacity from 10 Gbps to 20 Gbps between LA and TUS

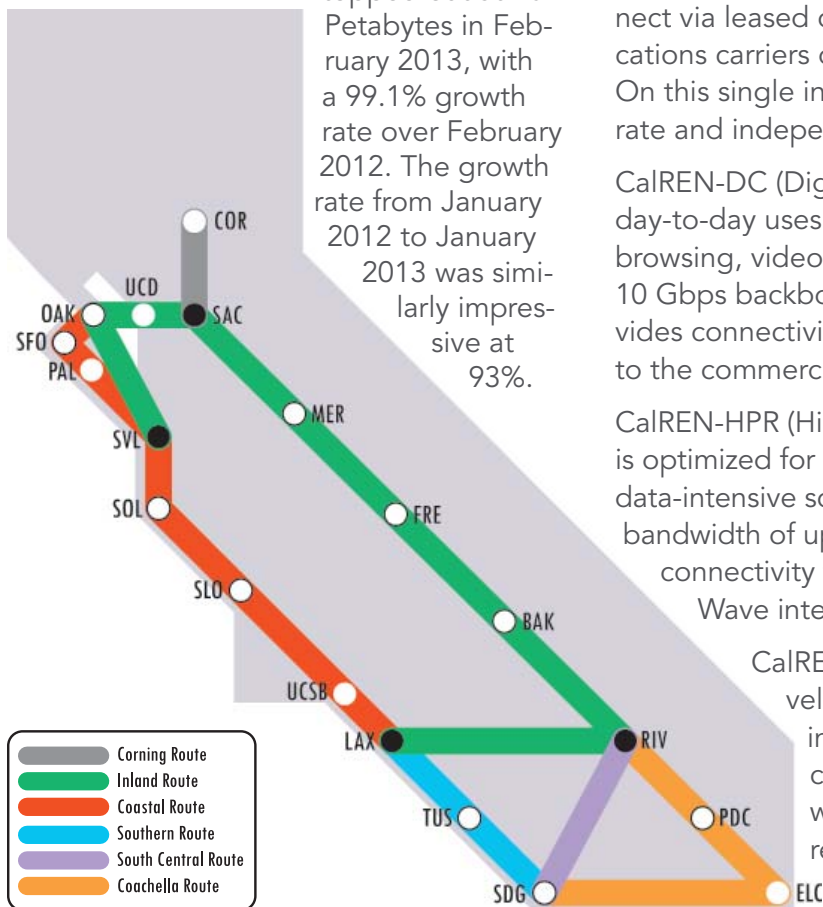
## CalREN: Three Independent Networks in One

CalREN consists of a 3,800-mile fiber-optic backbone to which nearly 10,000 research and education sites in all 58 counties connect via leased circuits from telecommunications carriers or CENIC-managed fiber. On this single infrastructure, three separate and independent networks operate.

CalREN-DC (Digital California) supports day-to-day uses such as e-mail, web browsing, videoconferencing, features a 10 Gbps backbone bandwidth, and provides connectivity for all CENIC Associates to the commercial Internet.

CalREN-HPR (High-Performance Research) is optimized for "power users" in the data-intensive sciences, with a backbone bandwidth of up to 40 Gbps, and provides connectivity to Internet2 and the Pacific Wave international peering facility.

CalREN-XD (eXperimental/Developmental) is the "bleeding-edge" tier of CalREN, composed of a set of network resources devoted to research on the network.





## Segmental Updates

### K-12 Updates:

#### 100 Mbps:

Del Norte County Office of Education

#### DS-3:

Bishop USD

Bishop USD — Mono County Office of Education

Alpine County Office of Education

#### Gigabit:

Alameda County Office of Education (x2)

Colusa County Office of Education (x2)

Humboldt County Office of Education — Northern Humboldt USD

Kern HSD

Lassen County Office of Education

Lassen County Office of Education — Modoc County Office of Education

Montebello USD

San Mateo County Office of Education — Santa Clara County Office of Education

Colusa County Office of Education

Burbank Unified School District

### 10-Gigabit:

Contra Costa County Office of Education

Fresno County Office of Education

Orange County Department of Education

Orange County Department of Education — Garden Grove USD

San Bernardino County Superintendent of Schools

San Francisco Unified School District

Chaffee Joint Union High School District

Alameda County Office of Education

San Mateo County Office of Education

Santa Clara County Office of Education

### Ring Redesigns and Other:

Humboldt County Office of Education — Del Norte County Office of Education

Santa Clara County Office of Education — San Mateo County Office of Education

Replacing and deploying new terminal servers to K12 node sites throughout the network

### CCC Updates:

#### 100 Mbps:

College of the Canyons

College of the Canyons Canyon Country Campus

#### DS-3:

Yuba Community College District Clear Lake Campus

#### Gigabit:

Los Rios Community College District Center at UC Davis

Ohlone College Newark Center for Health Sciences and Technology

Coast Community College District

Cuyamaca College

Grossmont College

Copper Mountain College

Mt. San Jacinto College

Sierra College

#### 10-Gigabit:

San Bernardino Valley College

#### Ring Redesigns:

North Orange County Community College District

## CSU Updates:

### DS-3:

CSU East Bay Concord Campus

### Gigabit:

CSU Chico

CSU San Bernardino

CSU Dominguez Hills (x2)

### 10-Gigabit:

San Diego State University (x2)

San Francisco State University (x2)

Sacramento State University

Cal Poly Pomona

Cal Poly SLO

CSU Northridge

CSU Fullerton

San Jose State University

CSU Chico to CalREN-DC and HPR

Humboldt State University

San Diego State University (x2)

## UC Updates:

### Gigabit:

UC Hastings College of Law

UC San Francisco (completed 2nd phase of metro area network)

### 10-Gigabit:

UC Davis Medical Center (CalREN-DC)

UC Davis Medical Center (CalREN-HPR)

UC San Francisco — UCSF Data Center

UC Santa Cruz (x2)

UC Davis

UC Riverside

## Non-charter Updates:

### 100 Mbps:

University of Pennsylvania Wharton West Campus

### 300 Mbps:

Pepperdine University Malibu Campus

### 500 Mbps:

University of San Diego  
Pepperdine University

### Gigabit:

University of San Francisco  
Chapman University

## Other Network Updates:

Installation of needed equipment throughout Central Valley in preparation for optical equipment in support of Central Valley Next Generation Broadband Infrastructure Project

100 Gbps connection to ESnet at Sunnyvale

## The CENIC Network Operations Center

CENIC's Network Operations Center (NOC) functions as the 24x7x365 point of contact for all services provided over CalREN, which are monitored and managed around the clock by CENIC's network engineers.

The technical functions performed by the CENIC NOC include the administration of the optical (Layer 1), Ethernet (Layer 2), and routing (Layer 3) components of the three tiers of CalREN. The network engineers also diagnose and resolve equipment failures, coordinate the decommissioning of retired equipment across the entire CalREN network, and perform tasks in support of circuit installations and backbone upgrades.

CENIC's network engineers also continuously develop and refine operational aspects of the NOC itself, including documentation, processes, and actively promoting the development of technical knowledge and expertise within the team. Keeping the NOC team current with the latest technologies implemented over CalREN is an exciting and necessary activity

for supporting the evolving needs of the K-20 research and education community that CENIC was created to serve.

Of course, the CENIC NOC and network engineers also function as the main customer interface between CENIC and the community. This function includes responding to abuse complaints, coordinating service upgrades to sites, and planning and communicating maintenance events.

### Continued Excellence in Customer Service

Beginning in 2005, the CENIC community has provided vital feedback on the performance of the CENIC NOC through an online survey. Upon resolution of each request for assistance and problem ticket, the requestor is asked to complete the survey. Since its creation, 672 responses have been collected. For the 2011-13 fiscal years, respondents indicated a high level of satisfaction with NOC services as expressed by agreement with the following statements:

#### "The NOC representative I primarily worked with ... "

- 99%** Understood my problem.
- 97%** Handled my problem with an appropriate level of urgency.
- 93%** Was able to resolve my problem in the initial contact.
- 96%** Followed through with requested information.
- 98%** Confirmed that I was satisfied with the resolution.
- 99%** Was helpful.
- 99%** Courteous.
- 97%** Knowledgeable.
- 99%** Patient.
- 98%** Thorough.
- 98%** Articulate.

## Enabling Research & Education Within California

### COTN: The California OpenFlow Testbed Network

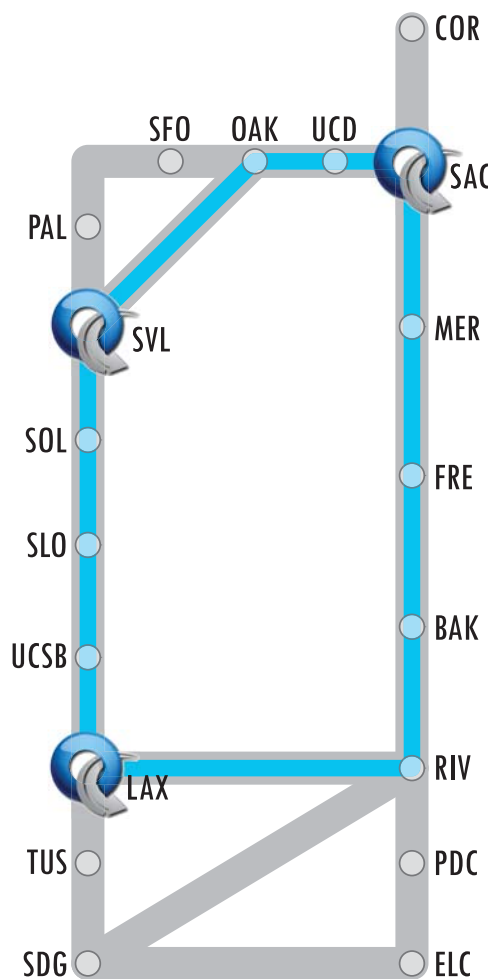
Through OpenFlow, a network switch software which gives researchers the power to modify the behavior of active network devices, innovative routing and switching protocols can be developed and then tested in working networks. Thus, the OpenFlow-enabled California OpenFlow Testbed Network (COTN) will aid California network specialists in the development of tomorrow's Internet, using today's networks as a testbed for innovation.

COTN is a high-bandwidth (10-Gigabit Ethernet) dedicated, breakable research network spanning California deploying OpenFlow-enabled switches into the backbone of CENIC's CalREN network at Los Angeles, Sunnyvale, and Sacramento. It connects with emerging OpenFlow testbeds within the national research networks. Because COTN is collocated with major network Points of Presence (POPs) in California, it can be readily expanded to include connectivity to other such testbeds throughout the nation.

COTN was developed in response to a solicitation from the Global Environment for Network Innovation (GENI), an NSF-sponsored virtual laboratory at the frontiers of network science and engineering for exploring future internets at scale. (GENI is supported by NSF award #CNS-0714770.)

The High-Performance Research (HPR) tier of CENIC's CalREN network already links California's research universities where a great deal of GENI-related research and collaboration is taking place. University of California campuses connected by CalREN-HPR have already designated faculty

researchers in setting up an OpenFlow testbed, including Berkeley, Davis, Merced, Santa Cruz, and San Diego. These researchers operating under the aegis of the Center for Information Technology Research in the Interest of Society (CITRIS) are also collaborating with others at the California Institute for Telecommunications and Information Technology (Calit2) at UC San Diego and UC Irvine, and the Lawrence Berkeley National Laboratories. Other GENI-related research is also being carried out at Caltech, Stanford University, UCLA, and the University of Southern California.



*\*Supported by NSF award #0944089 for GENI Development and Prototyping (D&P) Infrastructure.*

## The Central Valley Next Generation Broadband Infrastructure Project

The Central Valley Next Generation Broadband Infrastructure Project is designed to improve the availability of broadband networking infrastructure for 18 counties within the California Central Valley area: Amador, Calaveras, Colusa, El Dorado, Fresno, Kings, Kern, Mariposa, Merced, Madera, Nevada, Placer, Tuolumne, Tulare, San Joaquin, Stanislaus, Sutter, and Yuba.

The \$66 million Project, funded by the American Recovery and Reinvestment Act

as well as the California Public Utilities Commission (CPUC)'s California Advanced Services Fund, and CVIN member affiliates, involves building, operating, and maintaining a fiber-optic network infrastructure that will traverse 1,371 miles of California's Central Valley in addition to last-mile wireless capability over parts of four counties (Fresno, Kern, Kings, and Tulare). Initially, the CVNGBIP will focus on connecting community anchor institutions via fiber, including 19 county office of education sites, 14 community college sites, 3 California State University campuses, and 20 county/main libraries. The full





list of these anchor institutions is available on the Project website at [www.cvnngbip.org](http://www.cvnngbip.org). Educational institutions, libraries, and public safety sites will be served by CENIC as CVIN's subcontractor, with business and residential customers being served by CVIN LLC.

The Project's routes and construction plans were developed during an extensive series of meetings held with county and city leaders, institution representatives, and experts throughout the 18 counties, and in July 2011, the environmental reports required by the National Environment Policy Act (NEPA) and the California Environmental Quality Act (CEQA) were completed for review by the National Telecommunications and Information Administration (NTIA) and the CPUC. With their approval and the engineering of routes and entrances to anchor tenant sites, construction was launched in November 2011.

## California Telehealth Network and CENIC Renew Alliance

In April of 2013, the California Telehealth Network (CTN), the state's partnership for telehealth, and CENIC renewed their agreement to provide CTN member sites with Internet access through CENIC's secure gateway connection.

As a result of this partnership, CTN member sites also enjoy secure connectivity with CENIC member sites, which include nearly 10,000 research and education institutions both public and private throughout California. Through CENIC, CTN member sites also receive secure connectivity to national medical and educational research platforms such as Internet2.

CTN is California's leading agency focusing on increasing access to healthcare through the innovative use of broadband and health information technology which includes the use of telehealth and telemedicine with a focus on rural and medically underserved Californians.

"CTN's partnership with CENIC has been critical to our success in establishing a secure, reliable, high performance broadband infrastructure for our healthcare providers," said CTN President and CEO, Eric Brown. "As CTN continues to expand our use of additional broadband providers and technologies here in California, the core CENIC backbone and networking expertise will continue to be one of our most valuable assets."



## Connections Beyond California

### 100 Gbps Connectivity to Energy Sciences Network

Between them, CENIC and the Energy Sciences Network (ESnet) serve some of the most advanced and innovative research institutions in the world, including universities, national laboratories, super-computing centers and large-scale scientific facilities. Now, all of those facilities can enjoy ultra-high-performance connectivity between the networks that serve them since the establishment in April of 2013 of a 100 Gbps connection between CENIC's CalREN and ESnet in Sunnyvale.

This new ultra-high-bandwidth connection will enable more effective collaboration on pressing, data-intensive scientific challenges. The potential for harnessing the combined capabilities of systems like the

Edison and Hopper supercomputers at the National Energy Research Scientific Computing Center (NERSC), and the Gordon system at the San Diego Supercomputer Center (SDSC) — served by ESnet and CENIC's CalREN respectively — to study challenges such as climate change or cleaner energy is only one such example. Many other laboratories and facilities on both networks can be linked with one another over the new high-speed connection and accessed by researchers around the and across the nation. High-speed peering between networks like CalREN and ESnet are helping to create a new landscape for data-intensive science, where advanced networks truly become instruments for discovery.

*Hopper is NERSC's first petaflop system, a Cray XE6 that placed number 5 on the November 2010 Top500 Supercomputer list.*



In late 2012, ESnet put into production a transcontinental 100 Gbps network, making it the world's fastest network dedicated to scientific research. Established in 1986, ESnet connects more than 40 Department of Energy research sites and provides critical links between DOE-supported researchers at national labs and universities with unique experimental facilities in the U.S. and around the world.

## 100 Gbps Networking Along the US West Coast

In February 2012, CENIC, the Pacific Northwest Gigapop (PNWGP), and Internet2 announced plans for a major, long-term collaboration to deploy 100 Gigabit per second (Gbps) networking capabilities across the entire West Coast of the United States, to share a common optical networking infrastructure, and to work on many network based initiatives.

This shared infrastructure, using PNWGP and CENIC fiber-optic cable and Internet2's new Ciena optical system, will initially support the West Coast portion of Internet2's new nationwide backbone network and the advanced Research & Education (R&E) peering and exchange services provided by CENIC and PNWGP. This long-term collaboration includes the Pacific Wave international distributed exchange, whose major exchange and access points in Seattle and Los Angeles are being interconnected with 100 Gbps capacity to support interconnections and transport at 100 Gbps speeds. Twenty-seven networks representing more than 40 countries throughout the Pacific Rim, the Americas, and the Middle East connect to one another via Pacific Wave.

"These 100 Gbps network interconnection and transit capabilities will enable our U.S. and international research partners to achieve the performance and service capabilities required by next generation research initiatives," noted Louis Fox, President and CEO of CENIC.

"This is an extraordinary step forward in cooperation and mutual commitment between Internet2 and two R&E technology leaders, PNWGP and CENIC," said Dave Lambert, CEO of Internet2. "We will work together to best and most cost-effectively serve our overall R&E community with next generation capabilities and services."

"By partnering on this infrastructure, we are able to share our resources and expertise and further leverage our long-term reliance upon Internet2 and also the proven Internet2 network operations center to achieve reliable, ultra-high-performance networking which is affordable for our members and partners," said Amy Philipson, Executive Director of PNWGP.

Internet2, CENIC, and PNWGP also will provide advanced broadband network capabilities, services, content, and applications to expand the U.S. Unified Community Anchor Network's (U.S. UCAN) western community and to existing participants in all three organizations' collective R&E networks.

Ron Johnson, chair, Pacific Northwest Gigapop, and Stephen Wolff, chief technology officer, Internet2, both of whose involvements in the Internet date back to the early days of ARPAnet and NSFnet, praised this new partnership and network fabric. Johnson noted that this "establishes the evolved relationship between

*High-bandwidth network link enables seamless data-intensive collaboration between Mexico's Ensenada Center for Scientific Research and Higher Education (CICESE) and Calit2 at UC San Diego.*



our organizations as well as the directly shared technical platform that we have all been seeking. This will enable the R&E communities we serve both to pursue the next generation of innovations enabled by our networks, apps, and content, and to extend them for even broader impact to other key constituencies." Wolff echoed these views, saying "thanks to this partnership, there will be many new opportunities for collaboration in the service of our communities and in the advancement of technology."

### Enhancing Mexican-American Research Collaborations

Given their proximity and the breadth of research taking place at UC San Diego and Mexico's Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) in Baja California, network-dependent collaboration between these institutions holds great promise. Highly bandwidth-reliant and data-intensive disciplines ranging from oceanography to disaster response, distributed learning and

sharing of rich-media resources among students on both sides of the border, and the development of software tools that support network-based collaboration, are only a few of their specialties. Yet until recently, the lack of high-speed networking between UCSD and CICESE was a serious and demonstrable impediment to Mexico-U.S. collaboration in these and other fields.

To address this obstacle to joint research, the UC San Diego division of the California Institute for Telecommunications and Information Technology (Calit2) and CICESE worked with CENIC and its counterpart in Mexico, the Corporación Universitaria para el Desarrollo de Internet (CUDI), to expand available bandwidth linking researchers between the two research hubs. CUDI is responsible for research and education networking in Mexico, and the partnership is supported there by the Consejo Nacional de Ciencia y Tecnología (CONACYT), Mexico's equivalent to the US National Science Foundation (NSF).



CONACYT and partners funded a 10 Gbps link between Tijuana and Ensenada (where CICESE is located), as well as last-mile improvements serving not just CICESE but the National Autonomous University of Mexico (UNAM) as well.

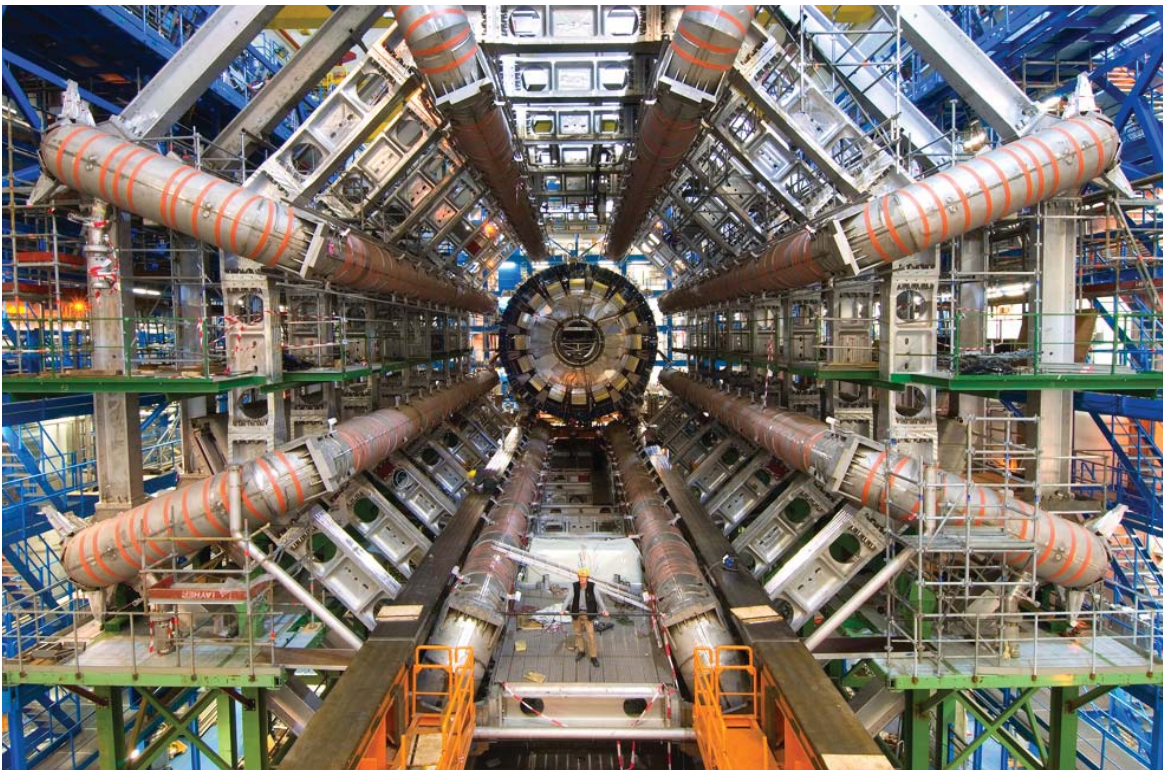
Improved network bandwidth from UCSD to Tijuana is enabled by NSF funding for 10 Gbps upgrades to CENIC networking equipment in the Tijuana Bestel POP. As a result during the 2011-12 fiscal year, CENIC and CUDI improved cross-border bandwidth to 10 Gbps from the previous 1 Gbps, and implemented a new 10 Gbps connection between Tijuana and Ensenada. Ultimately, these improvements will enable new research collaborations between Calit2, UCSD and CICESE, and among other Mexican and US institutions served by CENIC and CUDI.

Furthermore, this collaboration was chosen by CENIC as winner of the 2012 Innovations in Networking Award for High-Performance Applications.

### Connecting to LHCONE and the Large Hadron Collider

During the past fiscal year, CENIC established 10 Gbps connectivity with the LHC Open Network Environment (LHCONE) overlay network in Los Angeles to support large LHC-related flows between Tier-1/2/3 sites separate from the general purpose R&E infrastructures.

LHCONE is designed as an access environment and shared private network for the Tier-1/2/3 sites. It builds on the familiar idea of exchange points — locations and switch fabrics where many networks meet to exchange traffic.



*Installation of ATLAS calorimeter at Large Hadron Collider.  
Photo by M. Brice  
©CERN*

With this connection — created at no additional cost to Associates — researchers at Caltech, the California State University, the University of California, Lawrence Berkeley National Laboratories, and the Stanford Linear Accelerator Center can participate in LHCONE.

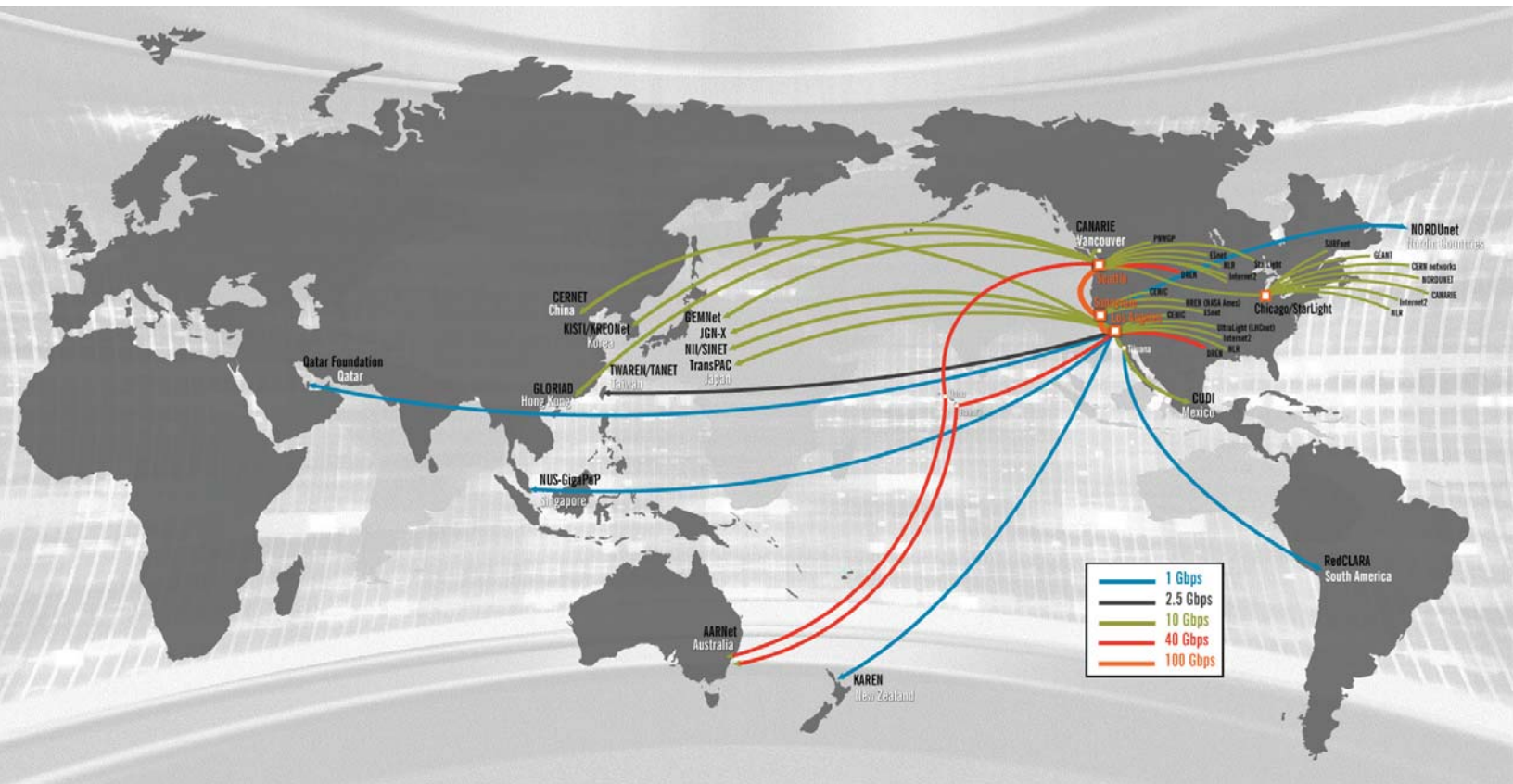
As with many big-science projects, particle and high-energy physics research facilities generate vast amounts of data, and access to the data plus the computing resources and storage needed to make the most of it, presents a constant challenge to global researchers. The LHC team has addressed this via the creation of a tiered structure of networked data and compute resources. At the root is the Tier-0 site — located at

CERN itself, this site contains all raw data gathered by the facility. Eleven Tier-1 sites are globally located and carry out data storage and analysis. 164 Tier-2 and over 300 Tier-3 sites are more remotely placed still, and can be comprised of anything from university lab networks to a single PC.

### Pacific Wave: Advanced Connectivity Throughout the Pacific Rim and Beyond

Pacific Wave is a state-of-the-art international peering exchange through which regional and national research and education networks throughout the Pacific Rim and the world meet and exchange traffic at one of five locations in three cities along the US West Coast (Seattle, WA;

*Pacific Wave's worldwide high-performance connectivity.*



Sunnyvale and Los Angeles, CA) connected via a 100 Gbps backbone. Pacific Wave is a joint project between CENIC, the Corporation for Education Network Initiatives in California, and the Pacific Northwest Gigapop, and is operated in collaboration with the University of Southern California and the University of Washington.

Through Pacific Wave, there are very few R&E networks that CENIC cannot reach through direct peering relationships. Almost all international R&E connectivity in the United States is provided by Pacific Wave, Starlight, and AMPATH — all regional efforts.

In addition to providing connectivity to international networks, Pacific Wave also connects multiple national networks including the federal networks such as the Energy Sciences Network (ESnet), the NASA Research and Education Network (NREN), Defense Research and Engineering Network (DREN) and soon the NOAA Research Network (N-Wave). Through its connection to Starlight, Pacific Wave also provides the possibility of peering with National Institutes of Health (NIH), NASA Integrated Services Network (NISN), Large Hadron Collider (LHCONE), and United States Geological Survey (USGS). Direct connections to these networks facilitate the transfer of large quantities of data needed for collaborative research in areas such as high energy physics, genomics, climate science and astronomy.

The past two fiscal years have seen significant activity in Pacific Wave, as the 100

Gbps West Coast Long-Term Agreement mentioned previously has interconnected the major access points in Seattle and Los Angeles at 100 Gbps. New participants were added in China (CERNET), and in the Nordic countries (NORDUNET and GLORIAD). In addition, a 10 Gbps connection to StarLight in Chicago has been implemented via the Northern Wave infrastructure, creating improved connectivity between Asia, North America, and Europe, including the Northern Wave participants (Northern Wave is an NSF-funded project of North Dakota State University and PNWGP). Pacific Wave subsequently announced a peering agreement with Northern Wave that will allow their participants to peer with each other. Thus researchers and educators at any connecting institution along the Northern Wave path in Illinois, Wisconsin, Minnesota, North Dakota, Montana, and Washington have access to participants on the Pacific Wave exchange, and vice versa.

In addition to these activities, Pacific Wave also announced dynamic circuit provisioning using the On-demand Secure Circuits and Advance Reservation System (OS-CARS) developed by ESnet. This capacity of Pacific Wave allows researchers (via their regional network provider) to reserve, and have dynamically allocated during the reservation period, a point-to-point network facility across one or more networks.

The following table lists the international networks that participate in Pacific Wave, the countries they support, and the Internet exchanges they use to connect with US networks.



CONNECTS AT	NETWORK	LOCATION(S)
STL • LA	AARNet	Australia
STL	CANARIE	Canada
SVL • LA	CENIC/CalREN	California
LA	CERNET	China
LA	redCLARA	Latin America*
LA	CUDI	Mexico
STL • LA	Defense Research & Engineering Network II & III	USA
STL • SVL	Energy Science Network	USA
STL	GEMnet	Japan
STL	GLORIAD	Northern Hemisphere**
STL • SVL • LA	Google	USA
STL • LA	Internet2	USA
LA	JGN-X	Japan
LA	KAREN	New Zealand
STL	KISTI/KREONet	South Korea
LA	Los Nettos	California
STL	Microsoft Corporation	USA
LA	NII/SINET	Japan
SVL	NASA Research & Education Network	USA
SVL	NORDUNET	Scandinavia****
LA	NUS-Gigapop	Singapore
STL	Pacific Northwest Gigapop	USA
LA	Qatar Foundation	Qatar
SVL • LA	Softbank Telecom	Japan
LA	TransPAC2	Asia***
LA	TWAREN	Taiwan
LA	UltraLight	USA

\* Members nations include Argentina, Bolivia, Brazil, Colombia, Costa Rica, Chile, Ecuador, El Salvador, Guatemala, Mexico, Panamwa, Paraguay, Peru, Uruguay, and Venezuela.

\*\* Member nations include China, South Korea, Russia, the United States, Canada, the Netherlands.

\*\*\* Member nations include Japan, South Korea, China, Philippines, Hong Kong, South Vietnam, Thailand, Malaysia, Singapore, Indonesia, and Pakistan.

\*\*\*\* Member nations include Denmark, Finland, Iceland, Norway, and Sweden.

## CENIC 2012 Annual Conference

Facilitating connections is what advanced networks are all about, and CENIC's annual conference seeks to further that mission by bringing California's K-20 research and education community together with colleagues across all boundaries. In 2012, Palo Alto was the place where educators, researchers, and network specialists came together to showcase their achievements, share information, and create new opportunities for innovation during Beyond the Network, the 2012 CENIC annual conference. And thanks to Gold Sponsor NCast, Beyond the Network can continue to benefit interested parties in California and beyond, as the archived webcast of the conference proceedings is available online at the conference program in both high- and low-resolution

formats suitable for any connection speed.

Among the highlights of the conference were the two excellent Keynote Addresses by Google and UC San Diego's Amin Vahdat and Gig.U's Blair Levin. Vahdat examined the current state of today's mega-datacenters, where they will be heading in the future, and how this will invariably alter the shape of the networks that link them with one another and their users lest the datacenters of tomorrow become massive islands of computational power that are nearly impossible to manage or harness well. Blair Levin, former Executive Director of the FCC's National Broadband Planning effort and currently serving the same role for Gig.U, treated the role of higher



*CENIC Conference attendees in Palo Alto, CA.*

education in the US in the development of a strategic bandwidth advantage, defined by him as ensuring that each citizen has the capacity they need to collaborate with others in ways that will benefit the country. Levin provided historical context using other disruptive technologies of the past, and examined the strategies used in other countries and why higher education plays a vital role in a country like the US, where so much infrastructure deployment is governed by market economics.



*Blair Levin, Executive Director, Gig.U*



*Amin Vahdat, Director, Center for Networked Systems*

Trips to Associate sites continue to be conference highlights as they have been in past years, and 2012 was no different. Wednesday morning saw attendees gather on the campus of Stanford University for a half-day of programming on topics ranging from astronomy and cosmology to particle physics, an interactive HD lecture viewing system, and the means by which data-mining techniques are being used to map the Internet-less network of intellectuals that spurred the European Enlightenment centuries ago.

Yet another highlight of the conference this year was, as always, the presentations given by the winners of the 2012 Innovations in Networking Awards, which further showcased the ways in which advanced networking can empower collaboration across boundaries of all kinds, as well as the vital role played by legislators like California's Alex Padilla in overcoming the boundaries that define the digital divide. The 2012 Outstanding Individual Contribution Award went to former Director of the Technology Unit for the California Community Colleges Catherine McKenzie. In this position, McKenzie oversaw the Telecommunications and Technology Infrastructure Program, which distributes technology related funds to the California Community Colleges and oversees major system-wide projects. In addition to her work at the CCCCCO, Catherine has been dedicated to supporting CENIC in multiple ways and consistently sought opportunities to engage in joint efforts between CENIC and the CCCCCO. Further information on this year's award winners can also be found at [cenic2012.cenic.org](http://cenic2012.cenic.org).

## A Showcase of Innovation at Stanford University

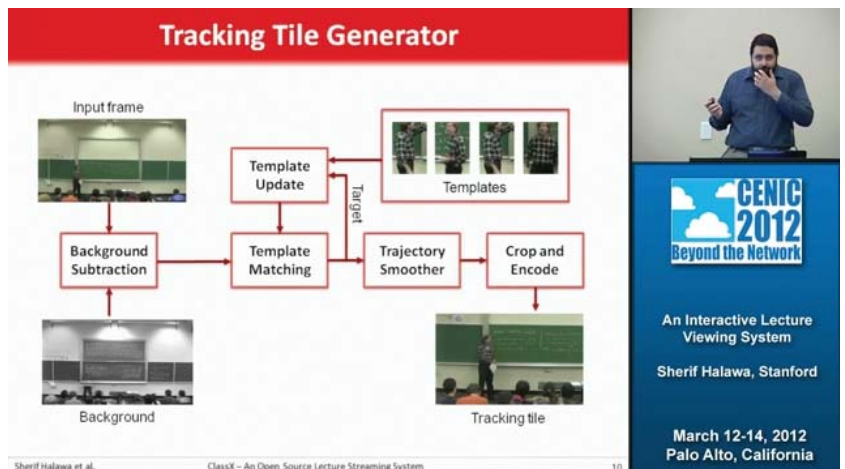
Stanford University is known worldwide as a hotbed of advanced research and education, and attendees to the 2012 CENIC annual conference were able to see why firsthand with presentations spanning the teaching and learning as well as research in the sciences and humanities, all demonstrating the clear benefits of advanced networks as catalysts for 21st century innovation.

Data-intensive sciences were the focus of the first part of the day's programming, with Stanford researchers in astronomy and experimental particle physics illustrating the many ways in which discoveries in these disciplines have become utterly dependent on modern networks. Particle physics experiments of course generate notoriously vast amounts of data, all of which must be stored, reduced, simulated, and analyzed before it can begin producing fruit, straining at the seams of even terabyte- and petabyte-level storage in short order, as Stanford's Richard Mount illustrated in engaging fashion with a tour of the discipline's past history with advanced networks. Astronomy researchers Ralf Kaehler and Rick Bogart demonstrated a similar dependency in their own areas of research, together with stunning visual simulations of the universe's evolution and actual video of the activity of the Sun.



*Click to watch Richard Mount.*

After the morning break, Sherif Halawa gave attendees a tour of the ClassX interactive lecture viewing system by which lectures at the University are captured in extremely high-definition and made accessible to students in an interactive fashion, allowing them to pan and zoom in on areas of individual interest to them at will, and view synchronized slides and other supplemental lecture information simultaneously.



*Click to watch Sherif Halawa.*



*Click to watch Sarah Murray.*

Finally, Stanford's Sarah Murray introduced attendees to the concept of a data and communications network without a network — the intellectual "network" of letters and other knowledge passed among participants in the European Enlightenment of the 17th and 18th centuries. Through some methods similar to those used to map network activity, the activity of individual thinkers in the Enlightenment can be plotted out in a way that shows the spreading of ideas and vitality throughout the continent and beyond in ways that have never before been appreciated.

Again, these and other presentations at Stanford and the Sheraton Palo Alto can be found at [cenic2012.cenic.org](http://cenic2012.cenic.org).



## Educational Applications:

# NPS/DLI Academic Network Partnership

CENIC Associate the Naval Postgraduate School (NPS), together with the US Army's Defense Language Institute Foreign Language Center (DLIFLC), developed an academic network partnership to enable DLIFLC to access the NPS's CENIC capabilities and thus enhance their students' language training with real-time news feeds, social networking, and mobile access to course materials, while still remaining subject to the increasingly firm security policies of the Department of Defense (DoD).

Responsible for training over 20,000 professional and squad designated linguists in the military in addition to general purpose forces, US Army's Defense Language Institute's Foreign Language Center (DLIFLC) opted to reach across service branch boundaries to the NPS about leveraging the campus's CENIC capabilities to enhance their language instruction and help

them meet the military's need for qualified linguists, currently at an all-time high.

Through the pilot phase of the planned DLIFLC migration to the NPS academic network, performed of course according to stringent DoD security standards, students were given mobile learning devices and access to Internet based systems that they previously did not have access to. Through these capabilities, which most of today's college students take for granted, the DLIFLC students were able to access class materials from home or a mobile device, use Skype to confer with peers and faculty members, and remain connected to the school and their coursework after graduation. Thanks to this project, students reported recapturing between 15 and 30 minutes of their seven-hour class day, translating over a 64-week course to an additional 9 days of valuable training.

*Doug Hartline (UCSC), Doug Weisman, Jonathan Russell, Joe LoPiccolo, Christine Haska (NPS), Louis Fox (CENIC), Col. Daniel Pick (DLIFLC).*





## Gigabit/Broadband Applications: CA State Senator Alex Padilla

Alex Padilla represents the 20th Senate District which includes most of the San Fernando Valley in Los Angeles. Chair of the Senate Energy, Utilities and Communications Committee and Vice Chair of the California Broadband Council, Padilla has authored several bills to promote universal broadband access in California to bridge the digital divide.

- Senate Bill 1193 (2008), which established the California Advanced Services Fund (CASF) to help fund broadband infrastructure in areas of California without high-speed Internet access;
- Senate Bill 1040 (2010), which expanded the CASF to add a revolving loan program for broadband infrastructure and grants for urban and rural broadband consortia;
- Senate Bill 1462 (2010), which established the California Broadband Council to increase state agency coordination of broadband deployment and adoption;
- Senate Bill 493 (2011), which provided public computer centers access to surplus state computers; and
- Senate Bill 3 (2011), which reauthorized California's universal service programs.

*Doug Hartline  
(UCSC), Louis Fox  
(CENIC), CA State  
Senator Alex Padilla  
(Dist. 20)*



## High-Performance Research Applications: Enhancing Mexican-American Research Collaborations

Until recently, the lack of high-speed networking between California and Mexico was a serious and demonstrable impediment to collaborations in many data-intensive fields. To address this obstacle to joint research, the UC San Diego division of the California Institute for Telecommunications and Information Technology (Calit2) and CICESE worked with CENIC and its counterpart in Mexico, the Corporación Universitaria para el Desarrollo de Internet (CUDI), to expand available bandwidth linking researchers between the two research hubs. CUDI is responsible for research and education networking in Mexico, and the partnership is supported there by the Consejo Nacional de Ciencia y Tecnología (CONACYT), Mexico's equivalent to the U.S. National

Science Foundation (NSF). CONACYT and partners have funded a 10 Gbps link between Tijuana and Ensenada (where CICESE is located), in addition to last-mile improvements serving not just CICESE but the National Autonomous University of Mexico (UNAM) as well.

The improved bandwidth from UCSD to Tijuana was enabled by the AmLight project's NSF International Research Network Connections (IRNC) award for 10 Gbps upgrades to CENIC networking equipment in the Tijuana Bestel POP. As a result, CENIC and CUDI have improved cross-border bandwidth to 10 Gbps from the current 1 Gbps, and implement a new 10 Gbps connection between Tijuana and Ensenada.

*Doug Hartline (UCSC), Federico Graef Ziehl (CICESE), Larry Smarr (Calit2), Carlos Casassus (CUDI), Louis Fox (CENIC), Greg Hidley (Calit2), Raul Rivera (CICESE), Tad Reynales (Calit2), Jose Lozano (CICESE), Hans Reyes (CUDI)*





## Experimental/Developmental Applications: Trans-Pacific Digital Cinema Microscopy

During the Tokyo International Film Festival's CineGrid session in October of 2011, live streaming digital cinema and the sharing of high-resolution scientific imaging were combined with microscopy at 4k/60P for the first time, as 4k microscopic images of living microorganisms at 60 frames per second were captured and streamed live from the University of Southern California (USC)'s School of Cinematic Arts across the Pacific Ocean to an audience in Tokyo. Network connectivity provided by USC, CENIC, AboveNet, CineGrid, CISCO Cwave, Pacific Wave and Japan's JGN-X formed the 10 Gigabit

trans-Pacific path that enabled this event. USC Cinematic Arts' Richard Weinberg, project leader, and international digital media research consortium CineGrid had previously demonstrated simultaneous 4k microscopic image capture and live HD streaming along the US West Coast and across the Pacific in 2009. With the addition of Nippon Telegraph and Telephone (NTT) Network Innovation Laboratory members, the 2011 demonstration increased the resolution from HD to 4k/60fps, achieving a fourfold increase in number of pixels and a doubling of the frame rate.

*Doug Hartline (UCSC), Natalie van Osdol (Pacific Interface), Louis Fox (CENIC), Richard Weinberg (USC), Laurin Herr (Pacific Interface).*



## Ultra High-Performance Networking for California

The 100G and Beyond Workshop, sponsored by the California Institute of Telecommunications and Information Technology (Calit2), the Energy Sciences Network (ESnet), and CENIC, was held in Calit2's Atkinson Hall on the campus of UC San Diego on February 26, 2013 to examine 100 Gbps networking and the ways in which it will impact areas as diverse as data-intensive science, health care, media arts applications, smart manufacturing, and more.

Workshop panels and presentations focused on a myriad of ways in which 100 Gbps networks promise great innovation

in the decades to come. Also treated were the campus and lab strategies that could enable researchers and the facilities in which they operate to take full advantage of the next standard for research and education networking, innovation on the network itself, and regional, national, and international testbeds.

"100 Gbps networking is the new standard for data-intensive research and education, and workshops like these are necessary to understand the way ahead, not only in terms of network design, but also to make sure that applications, facilities, and re-

*Attendees at  
100G and Beyond  
Workshop at UC San  
Diego*





searchers themselves are prepared to take as much advantage of ultra-high-performance networks as possible,” said CENIC President and CEO Louis Fox.

Calit2 Director Larry Smarr concurred, citing PRISM@UCSD, an innovative campus network project, enabled by a recent National Science Foundation grant to UCSD’s Phil Papadopoulos. PRISM will create optical “Big Data Freeways”, with speeds between 10 and 120 Gbps, between data-intensive users, scientific instruments, clusters, and Calit2 and the San Diego Supercomputer Center, where it will interconnect to a CENIC 100 Gbps connection. PRISM creates an “easy-to-replicate” prototype of what can and must be done to ensure that the benefits of wide area 100 Gbps networking reach all the way into individual users and their labs. “We’ve brought together a wide range of data intensive application users with network specialists to create a unique user-driven high-bandwidth campus cyberinfrastructure,” Smarr stated. “This “last-mile” outreach to the application end-users must be done worldwide if the global research community is to see all the possible benefits of 100 Gbps networking.”

ESnet Director Greg Bell also spoke of the necessity for community-building when observing the growth of traffic on the Energy Science Network, which provides the high-bandwidth connections that link scientists at national laboratories, universities, and other research institutions. “Traffic on our network has historically grown by ten times every four years, and doubles every 18 months, and 80% of the traffic on ESnet goes beyond it to other networks. There is an extremely tight coupling between ESnet and other national and regional networks, and the communities they serve.”

The workshop program, slides, and more information can be found at [cenic.org](http://cenic.org).

## CENIC 2013 Annual Conference

From March 11-13, 2013, members of the CENIC community and colleagues came together for three days of presentations, demonstrations, and human networking at the San Diego home of the California Institute for Telecommunications and Information Technology (Calit2@UCSD). In the Calit2 Auditorium and Theater in Atkinson Hall, attendees learned of the latest advances in network-enabled teaching and learning, as well as the innovations in network research and technology supporting some of the most demanding big-science applications.

Conference highlights include Keynote Addresses by Calit2 Executive Director Larry Smarr, University of San Diego law professor David McGowan, and ESnet's

Greg Bell, as well as fascinating presentations on the latest network-enabled teaching and learning innovations, and frontier research in advanced networks themselves.

Dr. Smarr's Monday March 11 Keynote Address revolved around the ways in which a research university would need to plan,



*Calit2 Director Larry Smarr*



design, and implement its own networking in order to take advantage of ultra-high-performance connectivity at 100G or more, using UC San Diego's PRISM infrastructure as an example. The Keynote Address was given in Calit2's Atkinson Auditorium, a room capable of delivering a Gigabit to each individual seat, meaning, as Smarr informed the audience, that the entire Auditorium was capable of 200 Gbps in full use.

With two Keynote Addresses focusing on the technical aspects of advanced networks, University of San Diego Professor of Law David McGowan provided a fresh and fascinating perspective on networks from a legal, policy, and cultural point of view, all of which have become increasingly important now that, as he stated to conference attendees, "the world decided to run itself on your back." McGowan treated

University of San Diego's David McGowan.



three topics: net neutrality, security and privacy, and the traditional cultural influence exerted by universities over the network itself and where this culture is headed.



ESnet's Greg Bell

The Wednesday March 13 Keynote Address was delivered by Greg Bell, Division Director of the Energy Sciences Network (ESnet), the advanced network serving more than 40 Department of Energy research sites, including all national laboratories. Bell gave attendees a meaty overview of ESnet itself, a new way to view advanced networks as instruments for discovery, and the relevance of these new outlooks to California.

UC Berkeley's Ken Lindahl was honored with the 2013 Outstanding Individual Contribution Award. From the earliest days of CalREN, Ken has been instrumental in its design, development, and deployment. Ken was a vital force in the creation of the original CalREN infrastructure, constructed of leased circuit-based rings between the Bay Area, Los Angeles, and San Diego, and contributed untold hours to network design and implementation and provided invaluable assistance on CENIC's Optical Network Infrastructure Initiative.

Thanks to the team at Calit2, the entire CENIC 2013 conference was webcast and is available on the Calit2 YouTube channel, where you'll find the highlighted video below and much more. A full conference program and links to all available presentation slides can be found online at [cenic2013.cenic.org](http://cenic2013.cenic.org).



## Educational Applications: iLabs Remote Online Lab Network

Northwestern University's iLabs enables a paradigm shift in the delivery of science lab experiences for students and teachers. By remotely placing expensive laboratory equipment virtually in the hands of students using Web browsers, iLabs allows students early exposure to real scientific laboratory environments. Unlike conventional facilities, iLabs can be shared and accessed widely by audiences across the world who might not otherwise have the resources to purchase and operate costly or delicate lab equipment. And because iLabs are available outside regular school hours, students can carry out their assignments from any location with Internet access, providing significantly more lab time with greater flexibility of access, and potentially improved learning outcomes. These labs enrich science and engineering education by personalizing the laboratory



Northwestern University's Kemi Jona describes the iLabs system.

learning experience, permitting instructors to use class time more productively, and increasing the scope of experiments to which students have access in the course of their academic careers.

To date, over 5,800 students and teachers have used the iLab Network, running over 8000 experiments. A number of these participants are located at institutions receiving network connectivity from CENIC.

## Gigabit/Broadband Applications: The California Emerging Technology Fund

CETF is a statewide non-profit organization whose mission is to close the digital divide by accelerating the deployment and adoption of broadband to unserved and underserved communities and populations, and to ensure that California is a global leader in the availability and use of broadband technology. CETF accomplishes this mission by making investments in broadband programs and projects to improve access, affordability, applications, accessibility and assistance—the “5As” of the Digital Divide.

Sunne Wright McPeak was named President and CEO of CETF in December, 2006. Her focused leadership and drive for results over the past six years has positioned California as a national leader in closing the



CA Emerging Technology Fund's Sunne McPeak addressing attendees remotely.

digital divide, with groundbreaking projects and programs that include Get Connected! (to drive adoption), California Telehealth Network, Digital Literacy programs, Smart Housing Policy, School2Home (to improve education), and serving as manager of two U.S. Department of Commerce grants focused on connecting Californians to broadband and digital careers.

## High-Performance Applications: UC Santa Cruz Cancer Genomics Hub (CGHub)

As a 5-petabyte database which stores tumor genomes sequenced through National Cancer Institute projects, the CGHub's mission is to facilitate the work of scientific researchers. It is designed to be a fully automated resource, appearing to the user as an extension of the user's home institute computing system. Of course, making such vast amounts of data accessible to collaborating researchers nationally and internationally requires advanced networking such as that provided by CENIC to allow the research to be carried out as seamlessly as possible.

CGHub is designed to support all three major NCI cancer genome sequencing



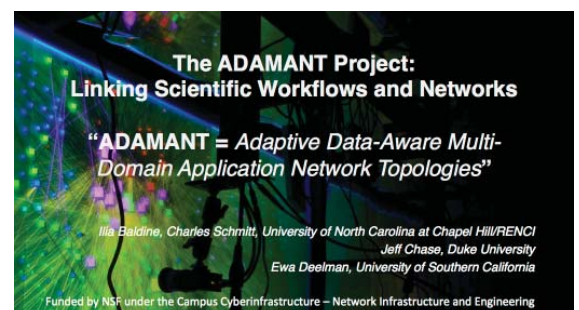
UC Santa Cruz's Linda Rosewood describes the Cancer Genomic Hub.

programs: the Cancer Genome Atlas (TCGA), Therapeutically Applicable Research to Generate Effective Treatments (TARGET), and the Cancer Genome Characterization Initiative (CGCI).

## Experimental/Developmental Applications: Project ADAMANT

Workflows, especially data-driven workflows and workflow ensembles, are becoming a centerpiece of modern computational science. However, scientists lack the tools that integrate the operation of workflow-driven science applications on top of dynamic infrastructures that link campus, institutional and national resources into connected arrangements targeted at solving a specific problem.

Project ADAMANT (Adaptive Data-Aware Multi-domain Application Network Topologies) brings together researchers from RENC/UNC Chapel Hill, Duke University and USC/ISI and two successful software tools to solve these problems. The project leverages ExoGENI, an NSF-funded GENI testbed, as well as national research and



XD winner Project ADAMANT workflow tool.

education network providers of on-demand bandwidth services, specifically, National LambdaRail (NLR), Internet2 (I2), and the Energy Sciences Network (ESnet), and existing OSG computational resources to create elastic, isolated environments to execute complex distributed tasks.



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