International Exchanges Current and Future

Jim Dolgonas

President and Chief Operating Officer

CENIC

April 4, 2006

CENIC

- Originally formed in 1997 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

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 using Dense Wave Division Multiplexing (DWDM). CENIC uses Cisco optical equipment-15808 and 15454's

CalREN Network Description

- 2400 miles of fiber
- 200+ circuits, from DS/3 to 1G/bs
- Cisco optical equipment, switches and routers
- Digital CA network backbone-2.5gbps
- High Performance Research backbone-10 gbps
- XD-specialized for custom research needs

CalREN Fiber Backbone

What is CENIC Today

- 35 staff members
- 24 hour staffing of NOC
- HPR Net, DC Net and Business Advisory Councils
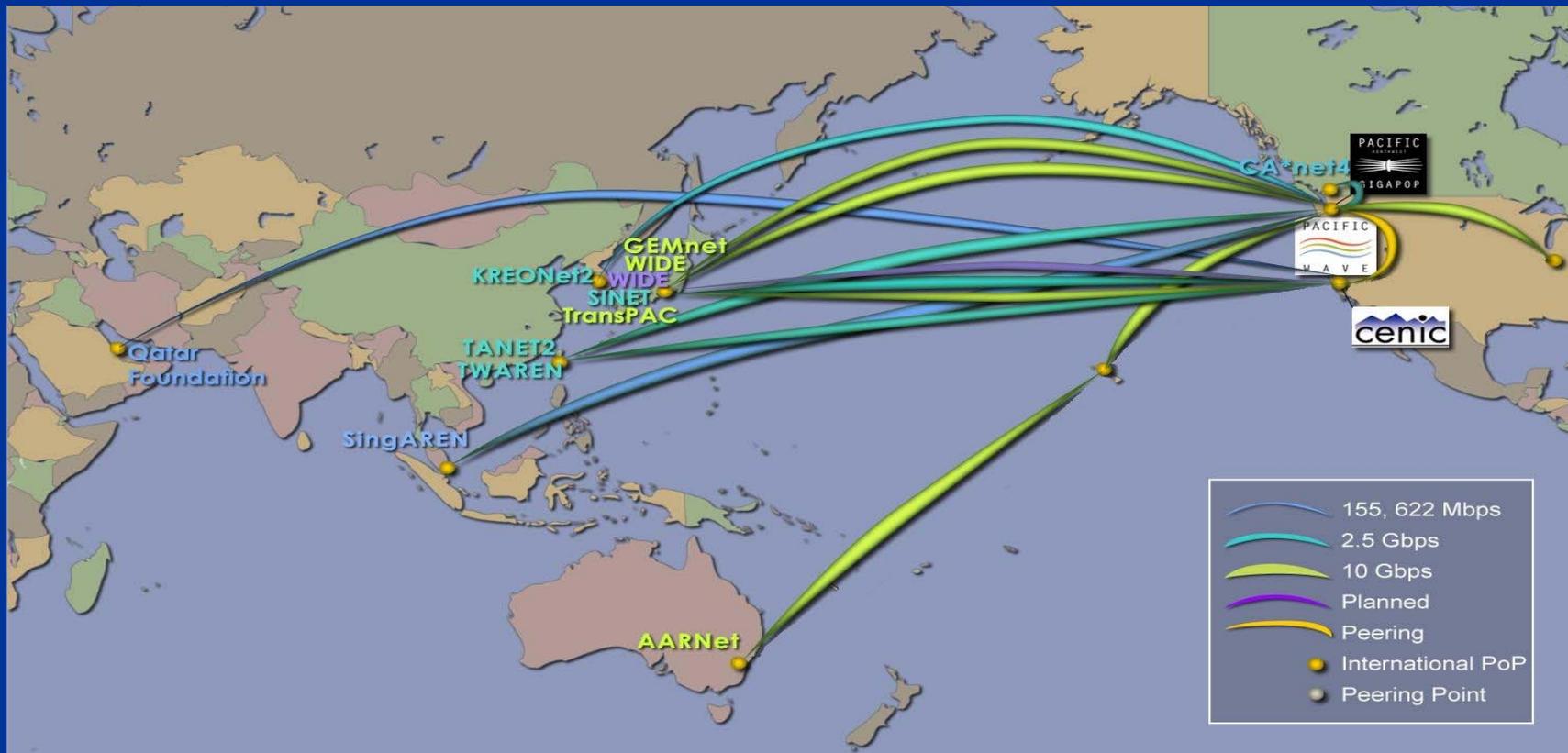- $48M annual revenues

Why International Exchanges

- Improved network performance to meet needs of science and education
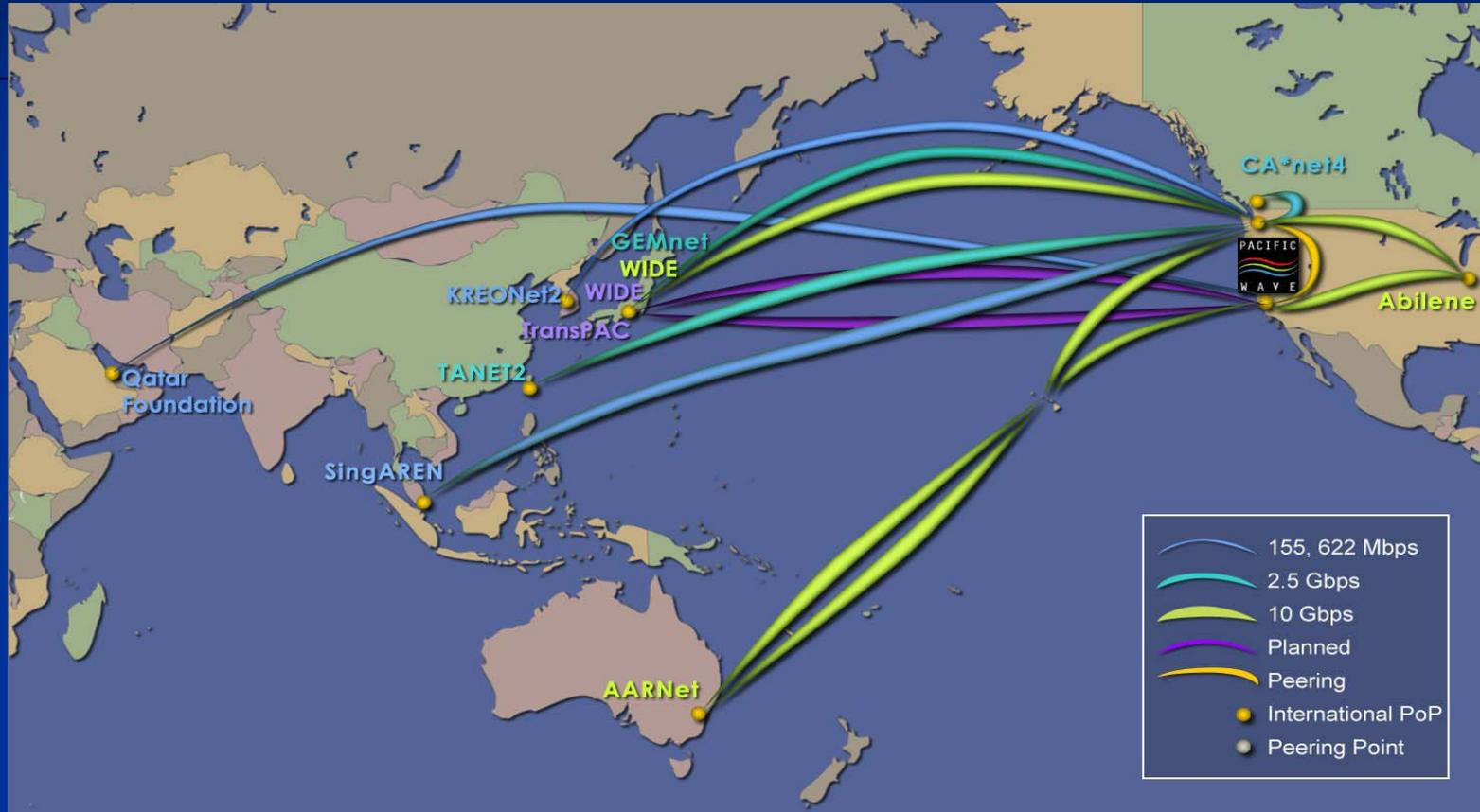- Cost savings

PACIFIC WAVE

an International Connection & Exchange partnership of PNWGP & CENIC,

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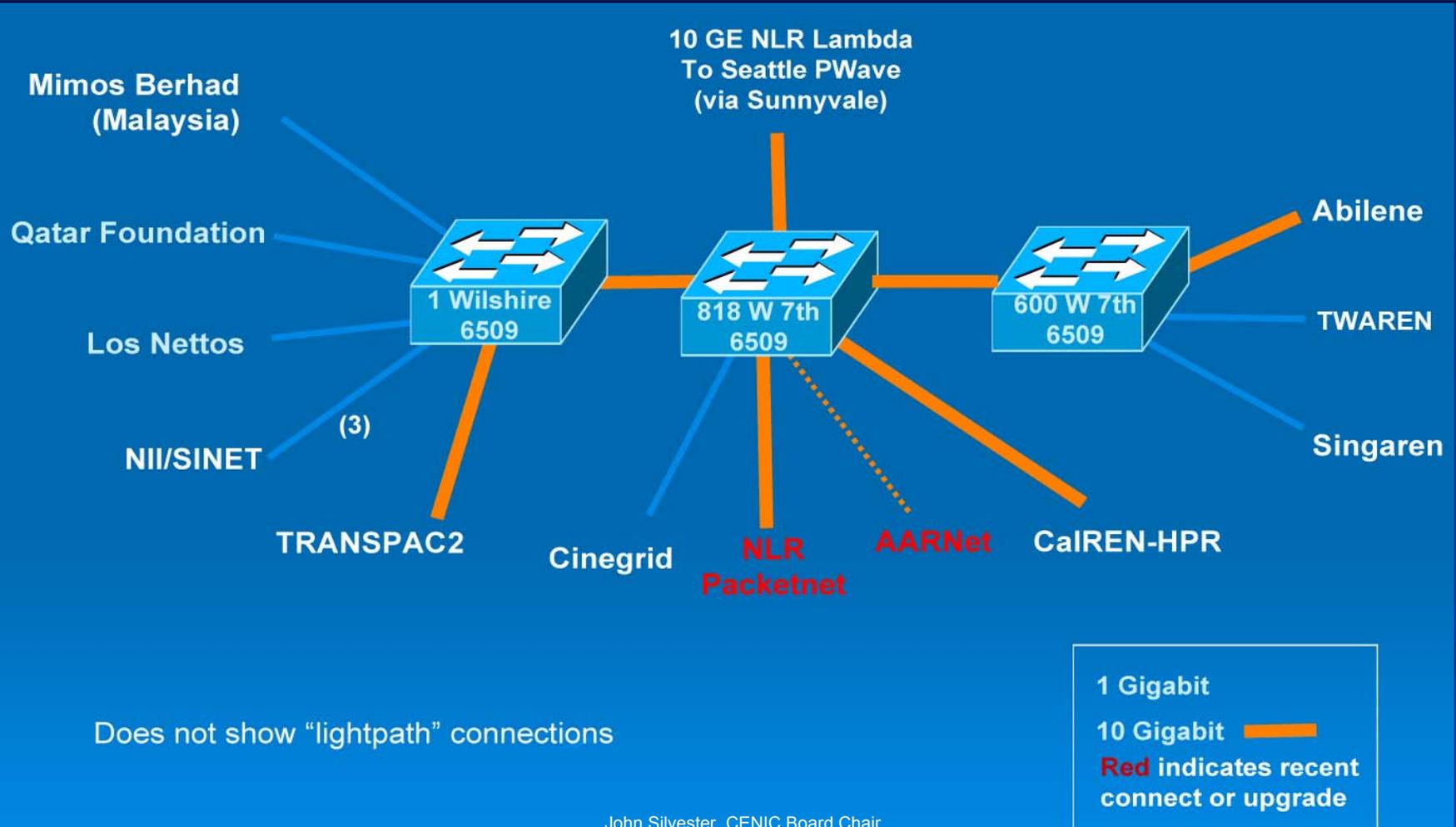
Pacific Wave…

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

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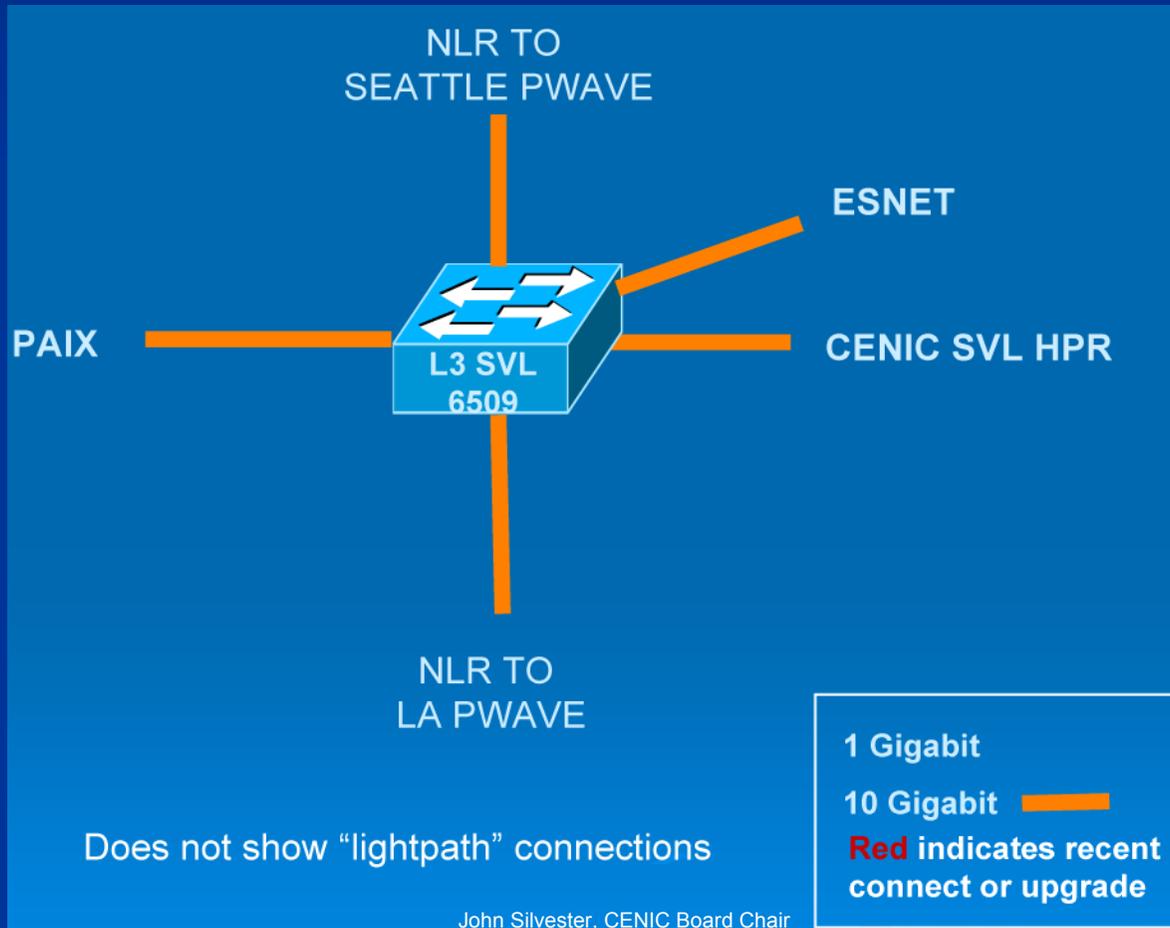
- Internet2
- AT & T Broadband/Comcast
- CA*net4
- CENIC/CalREN
- Defense Research and Education Network (DREN)
- Energy Sciences Network (ESnet)
- GEMnet
- KREONet2
- Los Nettos
- Microsoft
- Pacific Northwest Gigapop (PNWGP)
- Peer1.net
- Pointshare
- Qatar Foundation
- Singapore Advanced Research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

PACIFIC

W A V E

Pacific Wave - Los Angeles

John Silvester, CENIC Board Chair

Pacific Wave - Sunnyvale

NLR TO
SEATTLE PWAVE

ESNET

PAIX

L3 SVL
6509

CENIC SVL HPR

NLR TO
LA PWAVE

Does not show "lightpath" connections

1 Gigabit

10 Gigabit

Red indicates recent connect or upgrade

John Silvester, CENIC Board Chair

13

Pacific Wave - Seattle

NLR-Packetnet
Abilene
ATTBI/Comcast
CA*NET4
DREN
ESnet
GEMnet
WIDE/TLEX (IEEAF)

NLR Lambda to STARLIGHT

AARNet
TANET2/TWAREN
SingAREN
PNWGP
Microsoft
KREONet2

Seattle Westin CISCO 6509

NLR Lambda to LAX (via Sunnyvale)

John Silvester, CENIC Board Chair

Does not show "lightpath" connections

1 Gigabit
10 Gigabit
Red indicates pending

14

International Networking Connections

NSF-OCI-IRNC-Program

- GLORIAD - Global Ring Network for Advanced Applications Development
- Transpac2 - operates link from US (PW-LA) to Japan
- TransLight/PacificWave - Buildout of PW and landing of AARnet layer3 link into Seattle, and lightpath link into LA via Hawaii
- TransLight/StarLight - operates links from US to Latin America, Miami to Sao Paulo (to CLARA, ANSP, and RNP), and (with CENIC) San Diego to Tijuana (to CLARA and CUDI)

International Networks

- APAN
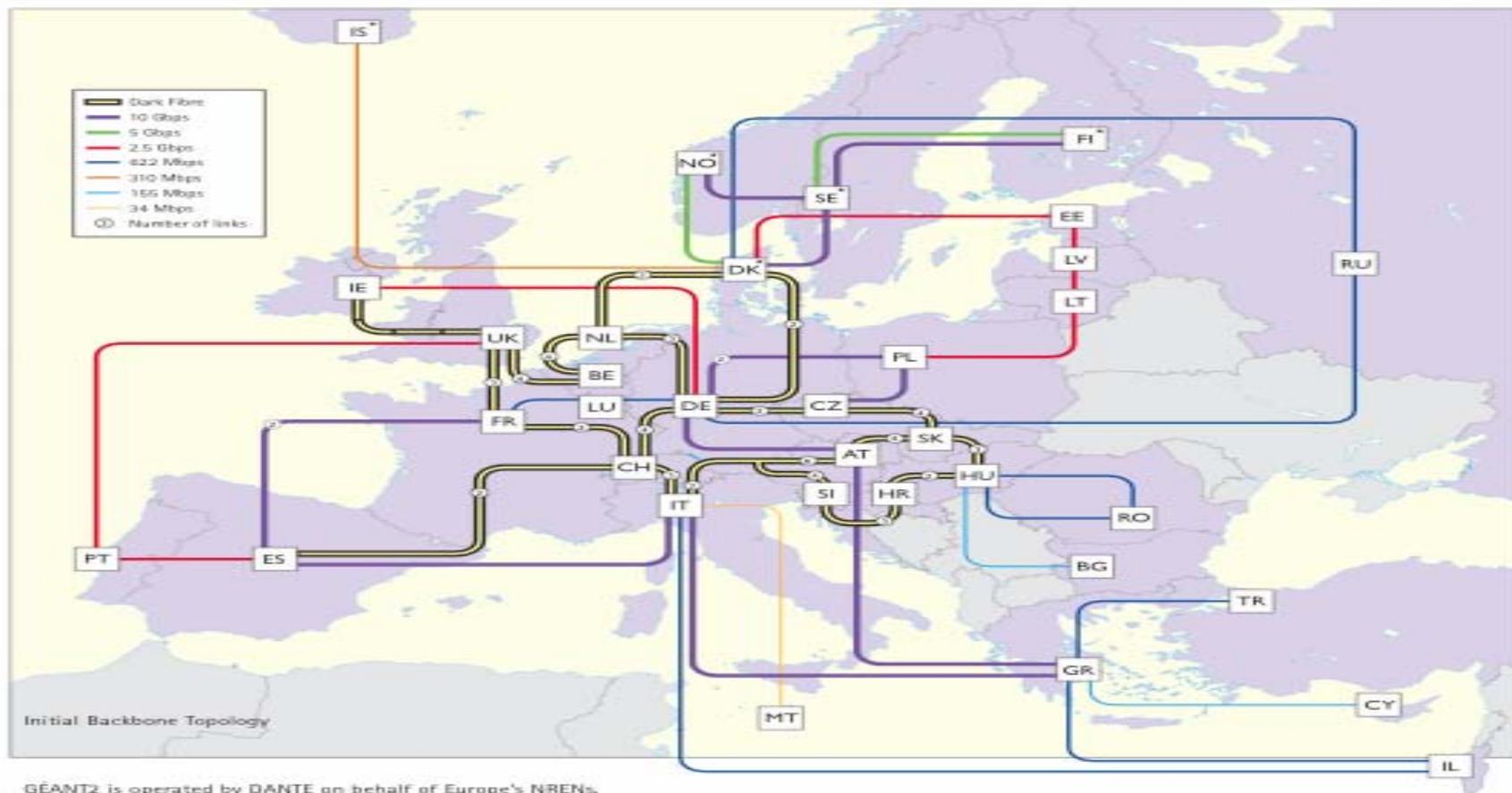- CLARA
- EUMEDCONNECT
- GEANT2
- GLORIAD
- TEIN2

APAN Network
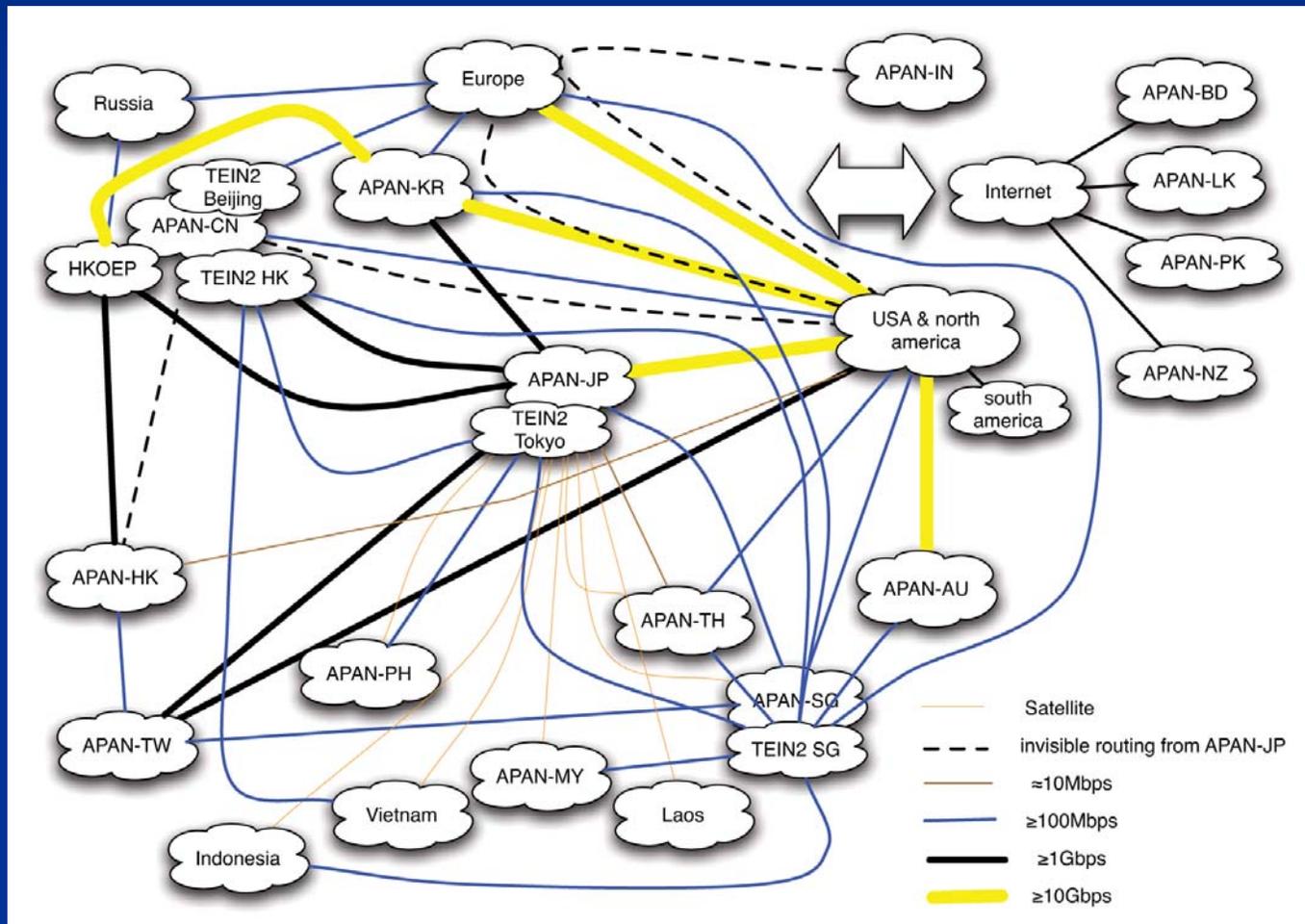
GÉANT2
The world–leading research and education network for Europe.
★ Connect ★ Communicate ★ Collaborate

Initial Backbone Topology

GÉANT2 is operated by DANTE on behalf of Europe's NRENs.

GÉANT2 is co-funded by the European Commission within its 6th R&D Framework Programme.

CLARA

Cooperación Latino Americana de Redes Avanzadas

Português | English

Sobre CLARA | Proyecto ALICE | RedCLARA | Proyectos | Eventos | Centro de Documentación | Sala de Prensa | Enlaces de Interés
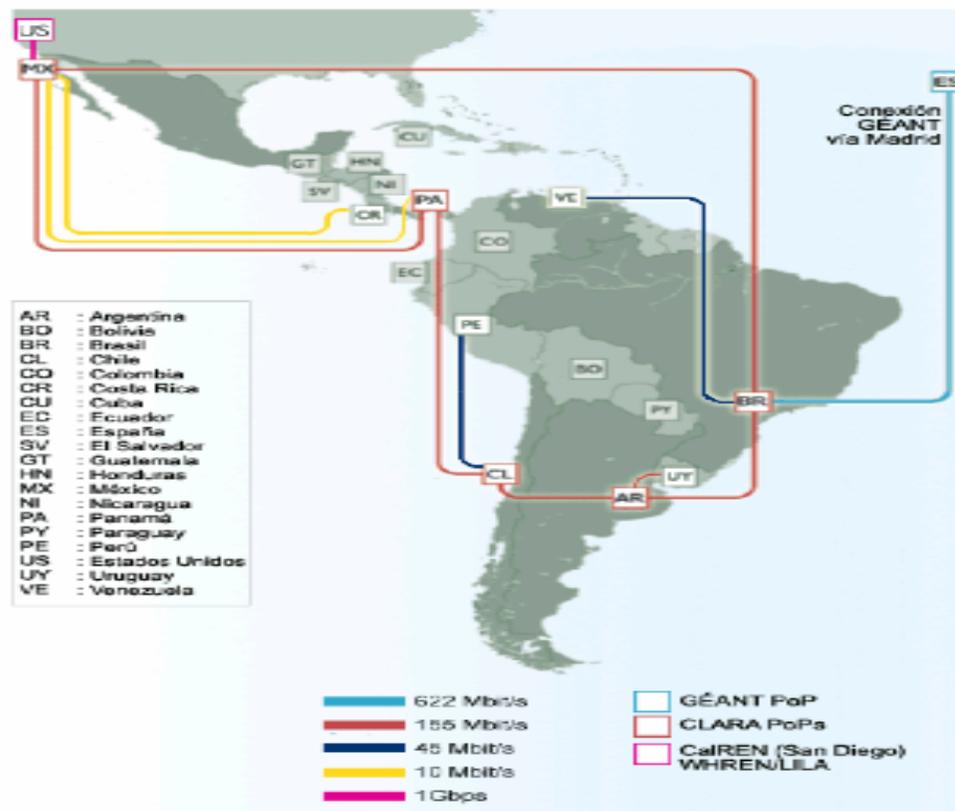
Descripción Técnica
Operación de RedCLARA
Comisión Técnica
Grupos de Trabajo
Ingeniería de la Red
NOC Operación de la Red
Mapa de la Topología
Cronología RedCLARA

RedCLARA
Mapa de la Topología de RedCLARA

>> Descargue el mapa generado por el Proyecto ALICE en Octubre de 2005.

Topología de la Troncal Septiembre de 2005

AR	: Argentina
BO	: Bolivia
BR	: Brasil
CL	: Chile
CO	: Colombia
CR	: Costa Rica
CU	: Cuba
EC	: Ecuador
ES	: España
SV	: El Salvador
GT	: Guatemala
HN	: Honduras
MX	: México
NI	: Nicaragua
PA	: Panamá
PY	: Paraguay
PE	: Perú
US	: Estados Unidos
UY	: Uruguay
VE	: Venezuela

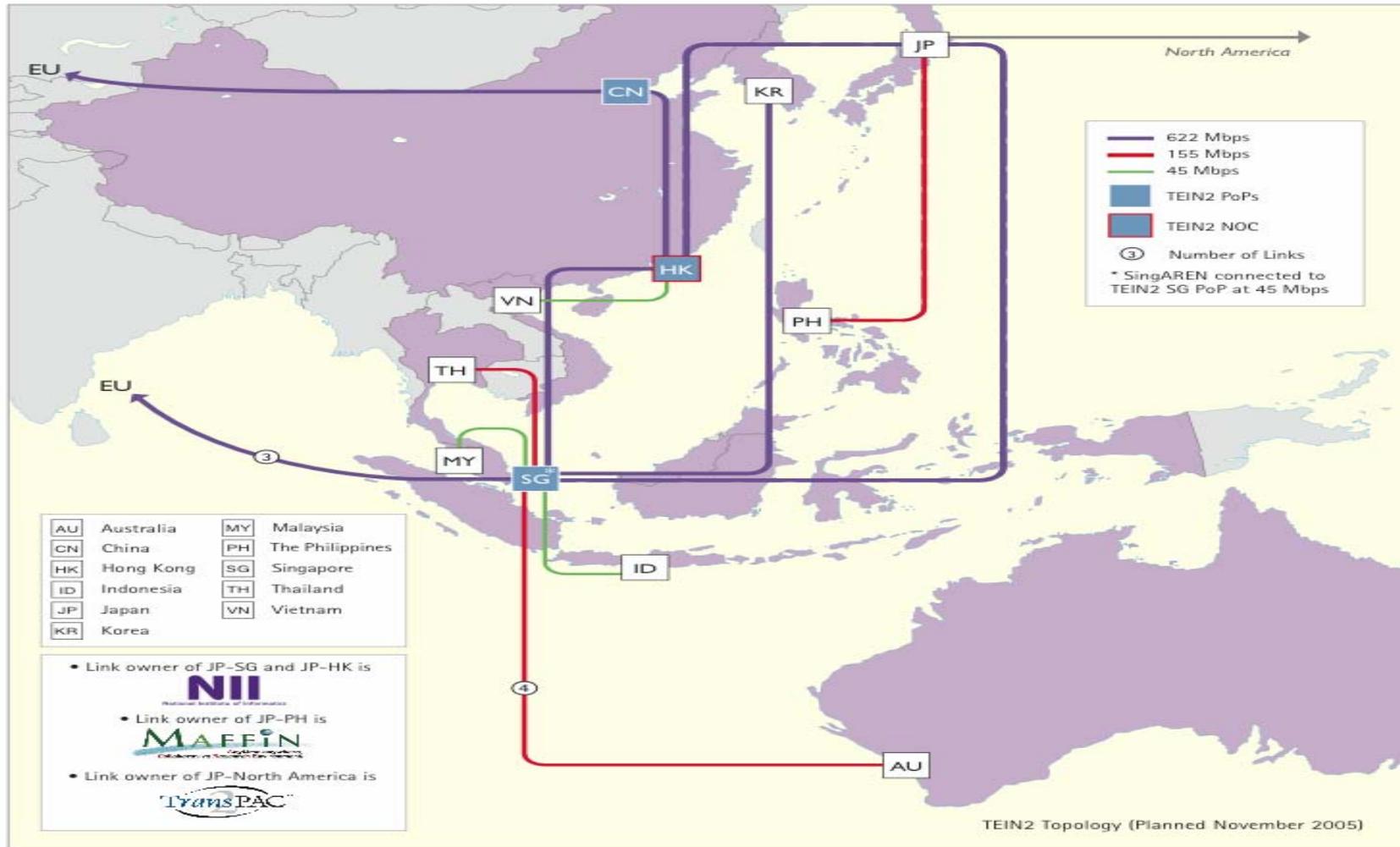|			
622 Mbit/s		GÉANT PoP	
155 Mbit/s		CLARA PoPs	
45 Mbit/s		CalREN (San Diego) WHREN/LILA	
10 Mbit/s			
1 Gbps			

>> Descargue el mapa anterior, generado por el Proyecto ALICE en Octubre de 2004.

CLARA: Fono (56-2) 337 0360 – Fono/Fax (56-2) 2733732 | Sitio Internet optimizado para una resolución de pantalla de 800x600 pixeles y navegadores en versión 5.5 o posterior | Diseño y Desarrollo: Gerencia de Relaciones Públicas y Comunicaciones CLARA.
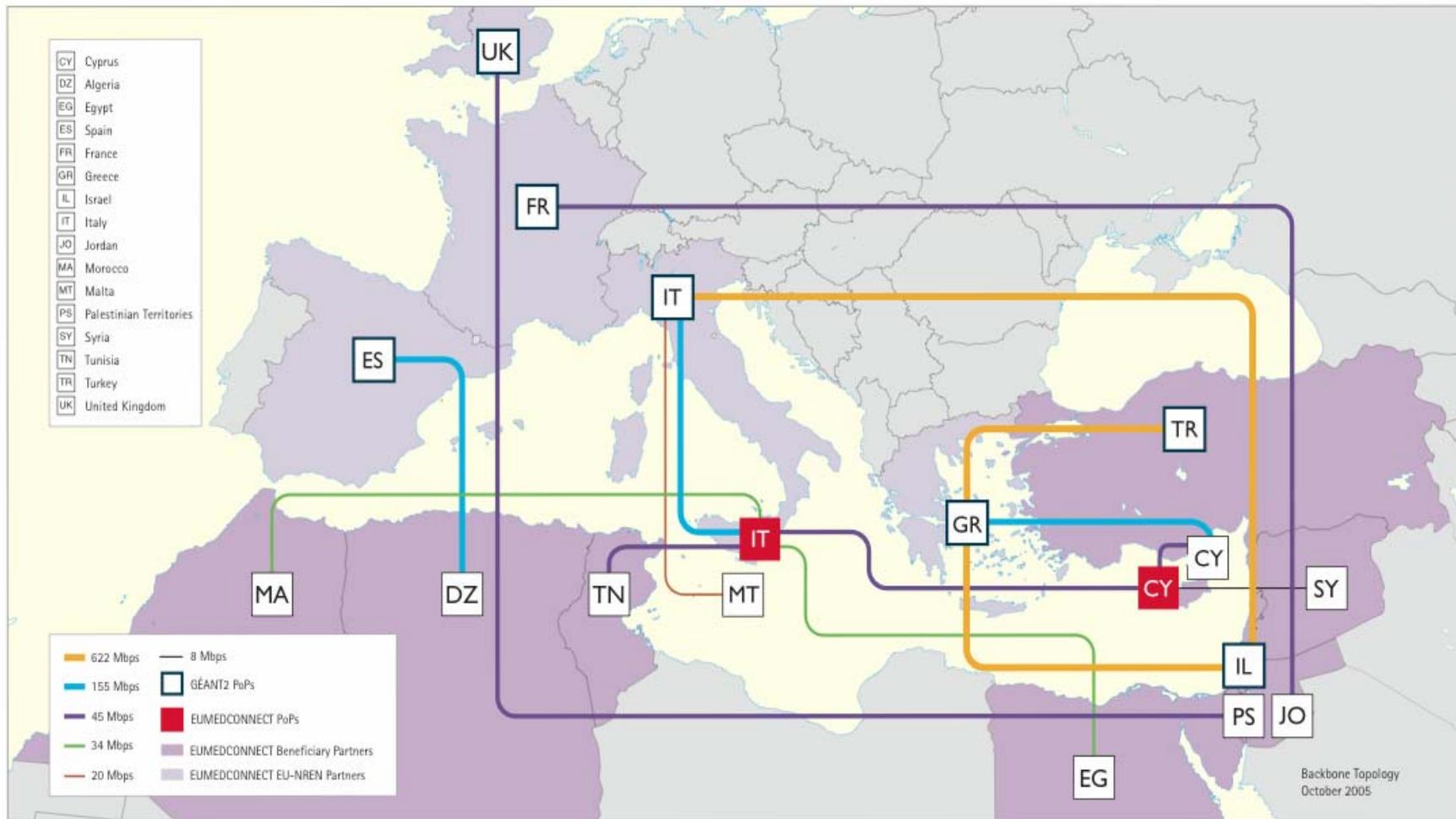
TEIN2
Regional Connectivity for Asia–Pacific Research and Education
Linking Asia–Pacific to Europe and beyond

North America

EU

CN

KR

JP

HK

VN

PH

TH

MY

SG

ID

AU

Legend:
- 622 Mbps
- 155 Mbps
- 45 Mbps
- TEIN2 PoPs
- TEIN2 NOC
- ③ Number of Links
- * SingAREN connected to TEIN2 SG PoP at 45 Mbps

AU	Australia	MY	Malaysia
CN	China	PH	The Philippines
HK	Hong Kong	SG	Singapore
ID	Indonesia	TH	Thailand
JP	Japan	VN	Vietnam
KR	Korea		

- Link owner of JP-SG and JP-HK is **NII** National Institute of Informatics
- Link owner of JP-PH is **MAFFIN**
- Link owner of JP-North America is **TransPAC**

TEIN2 Topology (Planned November 2005)

Linking Mediterranean research and educational communities to Europe

EUMED connect
www.eumedconnect.net

Legend (countries):
- CY Cyprus
- DZ Algeria
- EG Egypt
- ES Spain
- FR France
- GR Greece
- IL Israel
- IT Italy
- JO Jordan
- MA Morocco
- MT Malta
- PS Palestinian Territories
- SY Syria
- TN Tunisia
- TR Turkey
- UK United Kingdom

Legend (connections):
- 622 Mbps
- 155 Mbps
- 45 Mbps
- 34 Mbps
- 20 Mbps
- 8 Mbps
- GÉANT2 PoPs
- EUMEDCONNECT PoPs
- EUMEDCONNECT Beneficiary Partners
- EUMEDCONNECT EU-NREN Partners

Backbone Topology
October 2005

DANTE
www.dante.net

Consortium GARR

GRNET ΕΔΕΤ

IRIS

Renater

GEANT2
www.geant2.net

Creating a research and education network for the Mediterranean

EUMEDCONNECT is co-funded by the European Commission through the EUMEDIS programme

EuropeAid

How Are We Using International Exchange Connections

CUDI-CENIC Fiber Dedication at
Border Governor's Conference, July 14, 2005

US   Mexico

Torreon Conference---Fiber Dedication Linking Mexico and US, crossing at San Diego-Tijuana

- **Shared Security**

- **Energy**

- **Trans-National Crime**

- **Education and Research**

- **Business Development**

http://www.cudi.edu.mx/

Culmination of Three Years of Work Between Calit2, CICESE, CENIC, and CUDI

SDSU Visualization Center

cenic
Corporation for Education Network Initiatives in California

LEADING THE WAY
TO TOMORROW'S INTERNET

cudi

Larry Smarr, Calit2

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

Multiple HD Streams Over Lambdas Will Radically Transform Network Collaboration
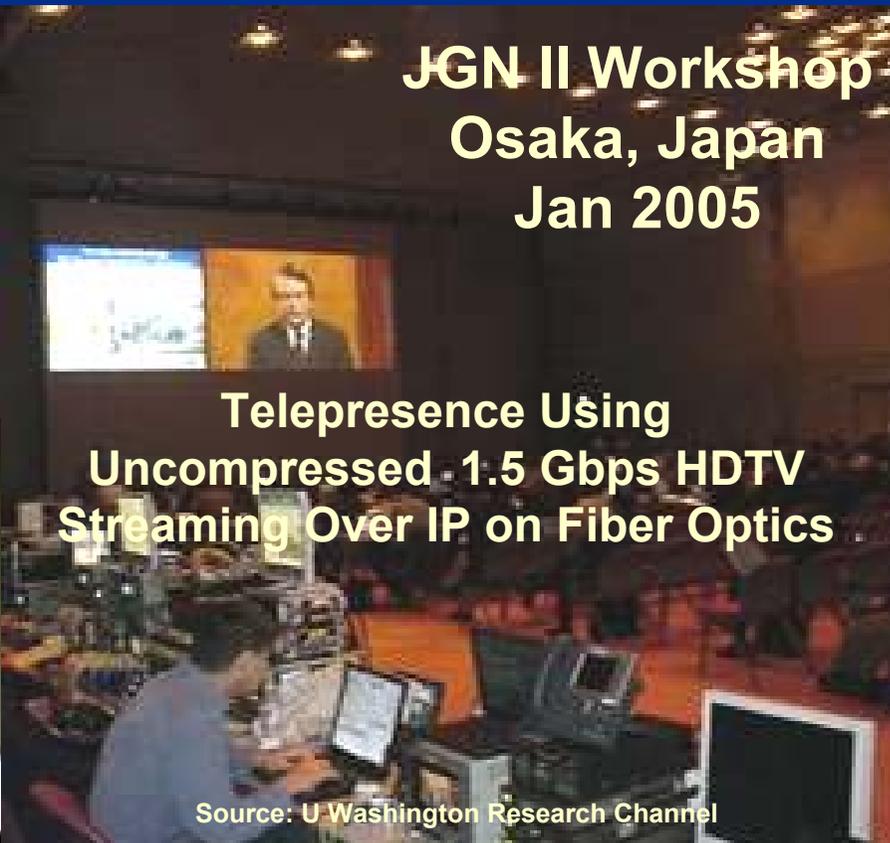

University of Washington

Prof. Smarr

Prof. Aoyama

青山

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**

26

Adding Web and Grid Services to Lambdas to Provide Real Time Control of Ocean Observatories
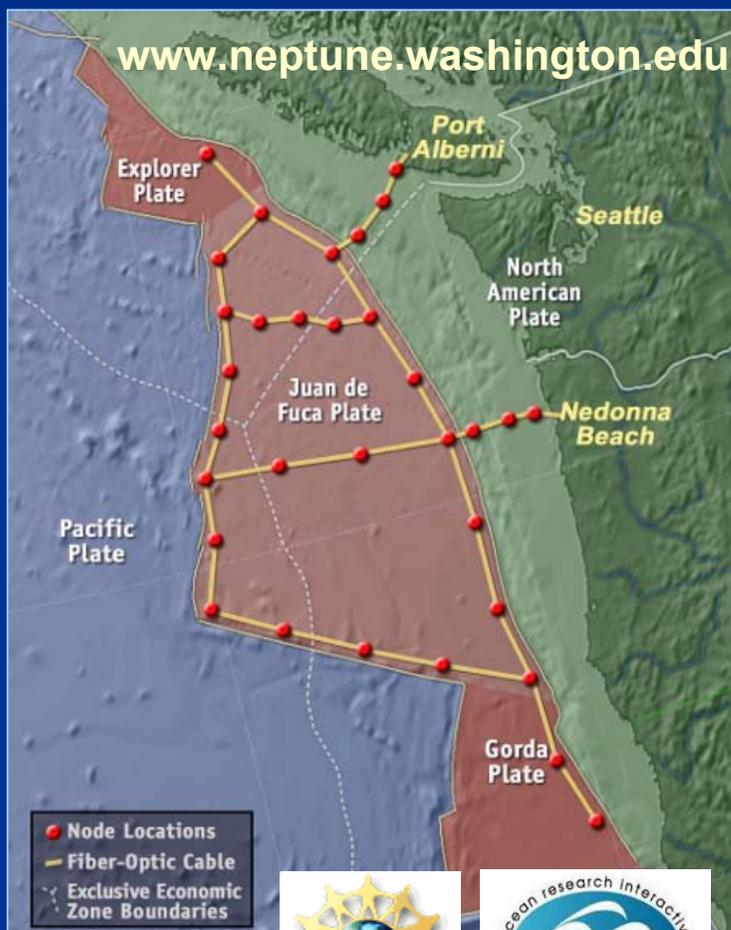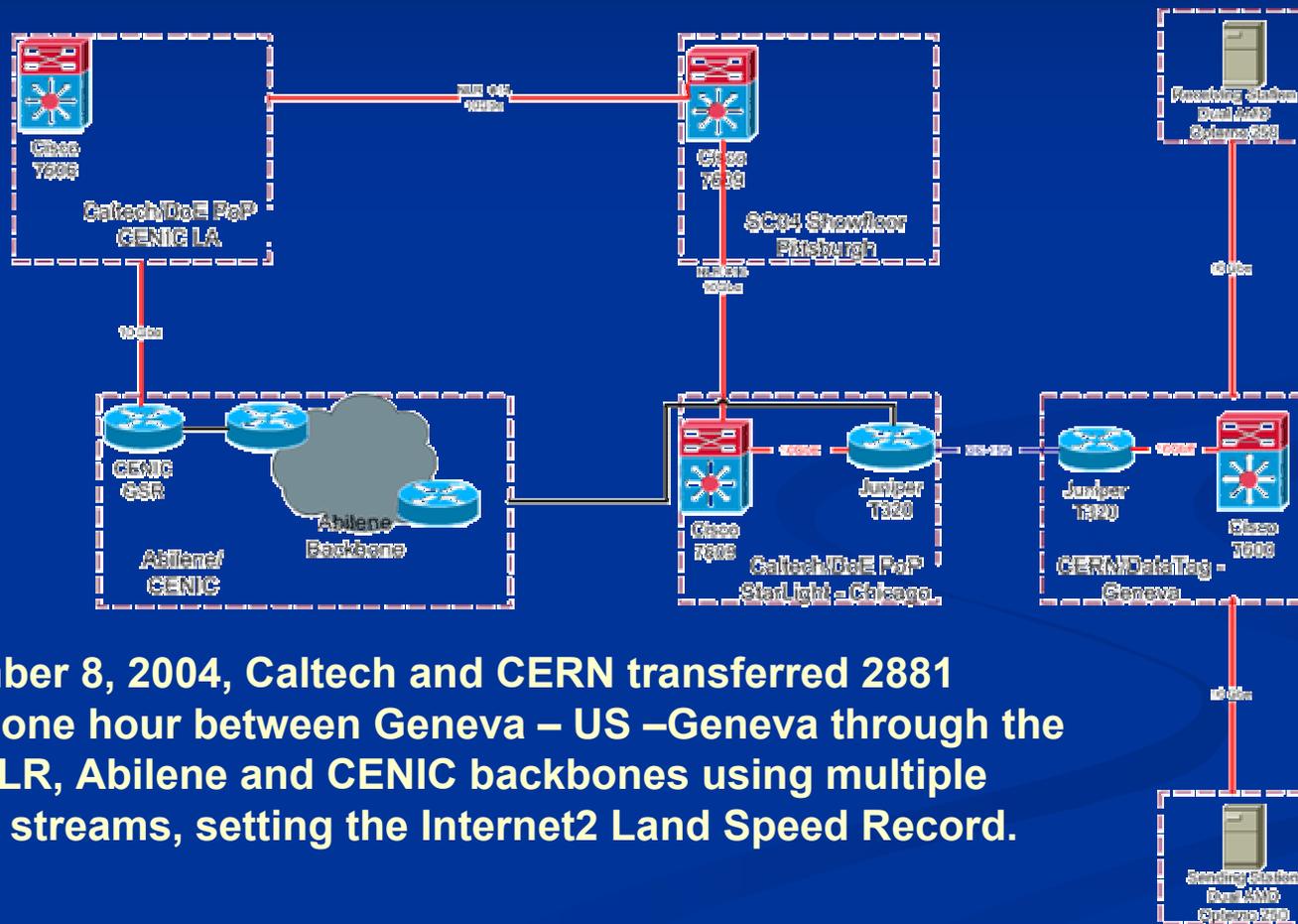
www.neptune.washington.edu

- 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

How fast do you want to go?
Internet2 Land Speed Record

On November 8, 2004, Caltech and CERN transferred 2881 GBytes in one hour between Geneva – US –Geneva through the LHCnet, NLR, Abilene and CENIC backbones using multiple FAST TCP streams, setting the Internet2 Land Speed Record.

CalREN-XD eXperimental/Developmental

28

Variations of the Earth Surface Temperature Over One Thousand Years


29
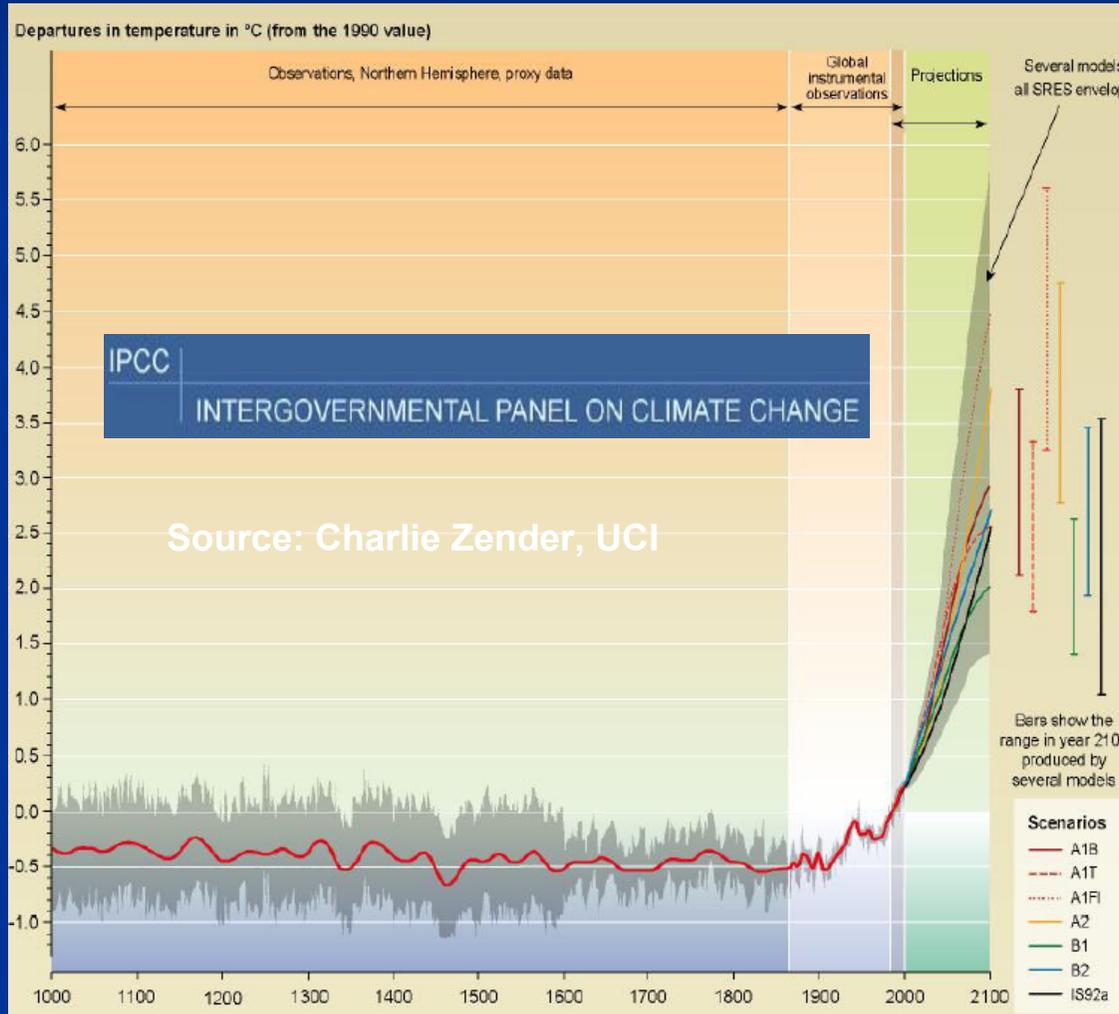
Future Exchange Directions

Exchanges

- Becoming more important as places to interconnect layer 3 networks (both national and international)
- Need to migrate to offer broader range of services, to become Global Optical Lightpath Exchanges (GOLES)

John Silvester, CENIC Board Chair

Layer 1 and 2 "Lightpath" Networking

- CANARIE has been a leader in development of Lightpath networks
- GLIF is the key international development in this area
- NLR, now fully deployed, allows networks at the link or Ethernet layer and Lambda or Lightpath layer. NLR National Layer 2 Network
- Several project specific networks like Optiputer are deployed on NLR
- Internet 2's HOPI also utilizes NLR

Global Lambda Integrated Facility
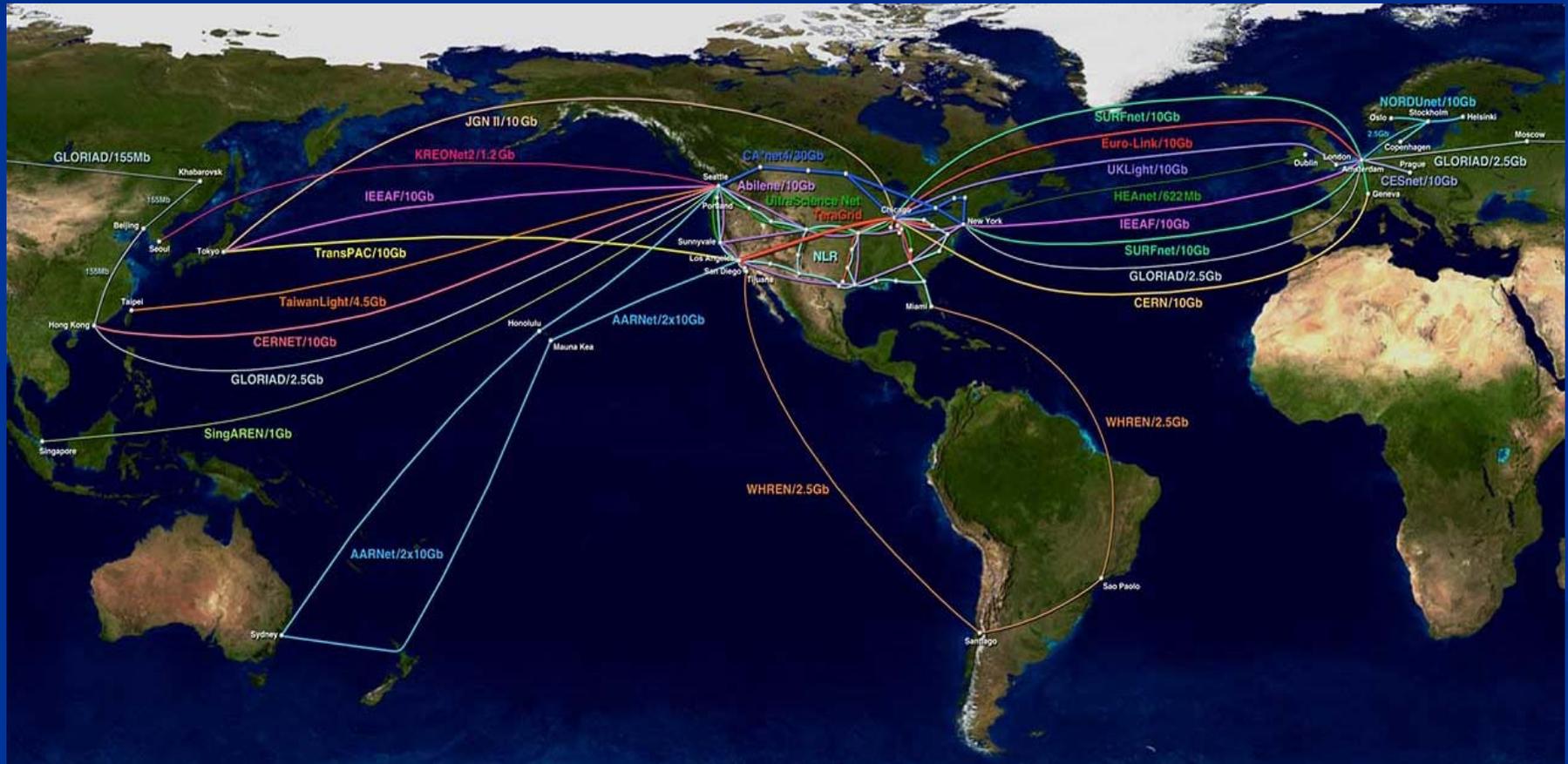
Visualization courtesy of Bob Patterson, NCSA. www.glif.is

33

Changing Requirements for Exchanges

- Exchange points need to provide a wider array of services:
  - Layer 3 Interconnect (routed)
  - Layer 3 Interconnect (over layer 2 switch)
  - Layer 2 Interconnect (Ethernet switching)
  - Layer 1 Interconnect (wave switching)
  - Layer 0 Interconnect (fiber interconnect)
  - PacificWave is moving in this direction to allow us to continue to participate in the world of Global R&E networking.

John Silvester, USC

Questions?

http://www.cenic.org

Jim Dolgonas

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