NRENs as Economic Development Engines

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What is an NREN?

An NREN (National Research & Education Network) is a specialized ISP (Internet Service Provider) dedicated to supporting the needs of the research and education communities within a nation or global region

NRENs	ISPs
Not for Profit	For Profit
Peer only with other NRENs exchanging only academic routes	Peer promiscuously and exchange full Internet routes
Hundreds of large flows (single flow can be > network capacity)	Millions of small flows (mostly web page traffic)
Few customers (< 500 Universities & Labs)	10Ks – 100Ks+ Customers
Strong Relationship between NRENs & their Customers	No Relationship between ISPs & their Customers
Community of Users	No Community of users

87 Networks reachable via Internet2 Network

Europe-Middle East

Europe (GEANT2)	Malta (Univ. Malta)
Austria (ACOnet)	Netherlands (SURFnet)
Belgium (BELNET)	Norway (UNINETT)
Croatia (CARNet)	Palestinian Territories
Czech Rep. (CESNET)	(Gov't Computing Center)
Cyprus (CYNET)	Poland (PIONIER)
Denmark	Portugal (RCTS2)
(Forskningsnettet)	Qatar (Qatar FN)
Estonia (EENet)	Romania (RoEduNet)
Finland (Funet)	Russia (RBnet, RUNNET)
France (Renater)	Slovakia (SANET)
Germany (G-WIN)	Slovenia (ARNES)
Greece (GRNET)	Spain (RedIRIS)
Hungary	Sweden (SUNET)
(HUNGARNET)	Switzerland (SWITCH)
Iceland (RHnet)	Syria (HIAST)
Ireland (HEAnet)	United Kingdom
Israel (IUCC)	(JANET)
Italy (GARR)	Turkey (ULAKBYM)
Jordan (JUNET)	*CERN
Latvia (LATNET)	
Lithuania (LITNET)	
Luxembourg (RESTENA)	

Asia-Pacific

Australia (AARNET)
China
  (CERNET, CSTNET, NSFCNET)
Fiji (USP-SUVA)
Hong Kong (HARNET)
India (ERNET)
Indonesia (ITB)
Japan (SINET, WIDE, JGN2)
Korea (KOREN, KREONET2)
Malaysia (MYREN)
New Zealand (KAREN)
Philippines (PREGINET)
Singapore (SingAREN)
Taiwan (TANet2, ASNet)
Thailand (UNINET, ThaiSARN)
Vietnam (VINAREN)

Africa

Algeria (CERIST)
Egypt (EUN/ENSTINET)
Morocco (CNRST)
Tunisia (RFR)
South Africa (TENET)

Americas

Latin America (redCLARA)
Argentina (RETINA)
Brazil (RNP2/ANSP)
Canada (CA*net)
Chile (REUNA)
Colombia (RENATA)
Costa Rica (CR2Net)
Guatemala (RAGIE)
Mexico (Red-CUDI)
Nicaragua (RENIA)
Panama (RedCyT)
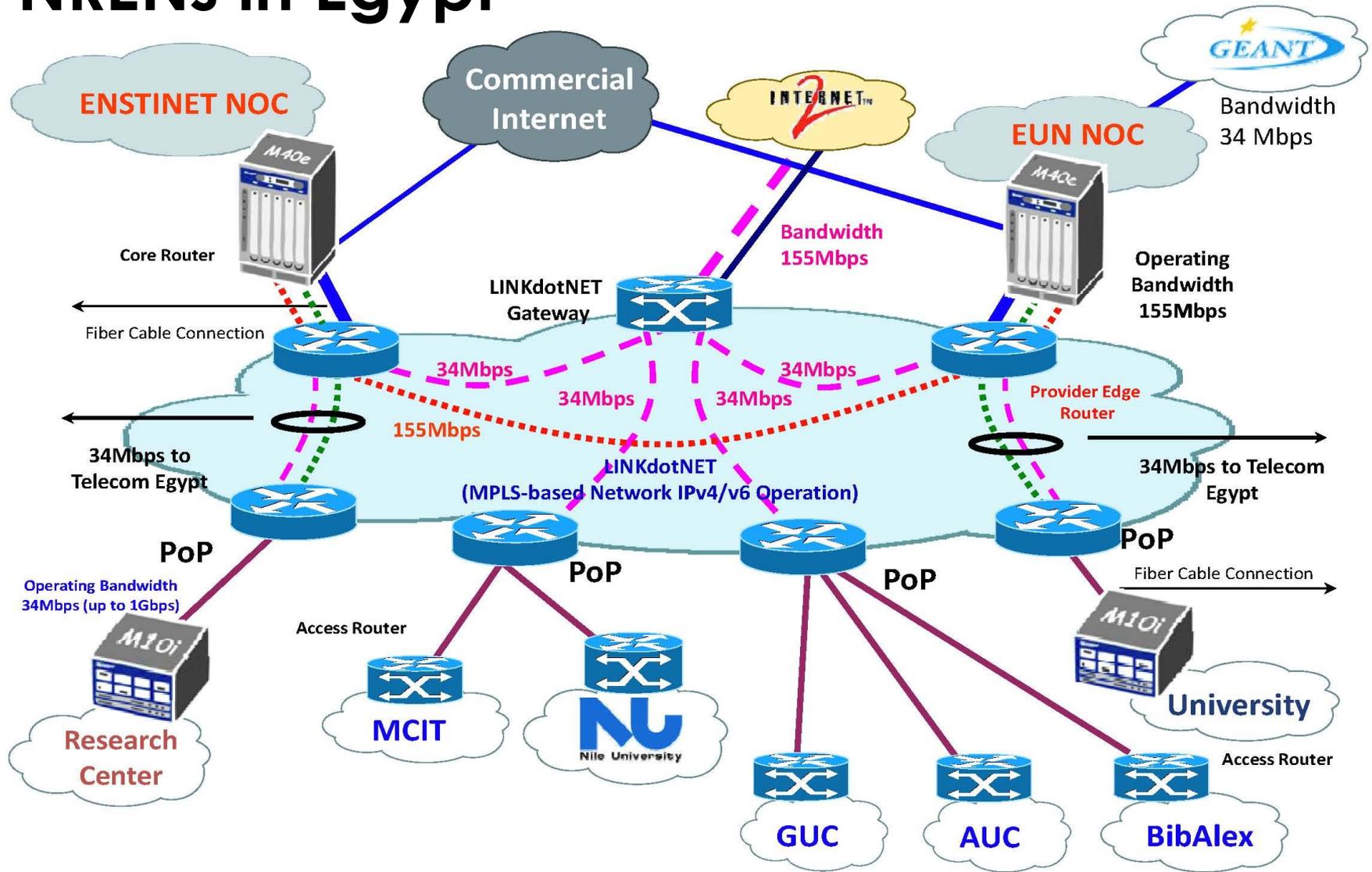Peru (RAAP)
Uruguay (RAU2)
Venezuela (REACCIUN2)

Central Asia

Armenia (ARENA)
Georgia (GRENA)
Kazakhstan (KAZRENA)
Tajikistan (TARENA)
Uzbekistan (UZSCI)

INTERNET 2

This is a representative list of the first tier of globally interconnected NRENs.
There are another 50 or so NRENs not on this list.

**GLIF: Global Integrated Lambda Facility
Does not show links < 10 Gbps**

NRENs in Egypt

IPv6 Deployment In Research Universities; Case Study
Nezar Nabil Sami

3/9/2010

GLORIAD-Taj Expansion

USA-RUSSIA-CHINA-KOREA-NETHERLANDS-CANADA-DENMARK-FINLAND-ICELAND-NORWAY-SWEDEN

INDIA-EGYPT-SINGAPORE

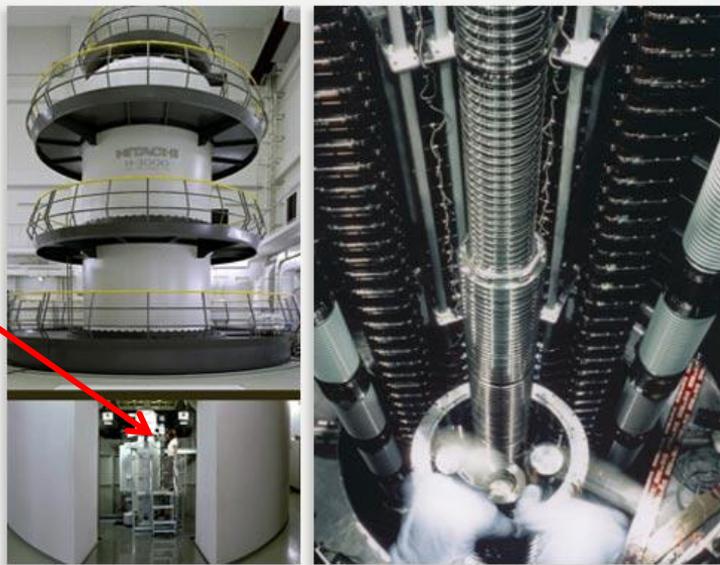The new Taj expansion is highlighted in orange on this map

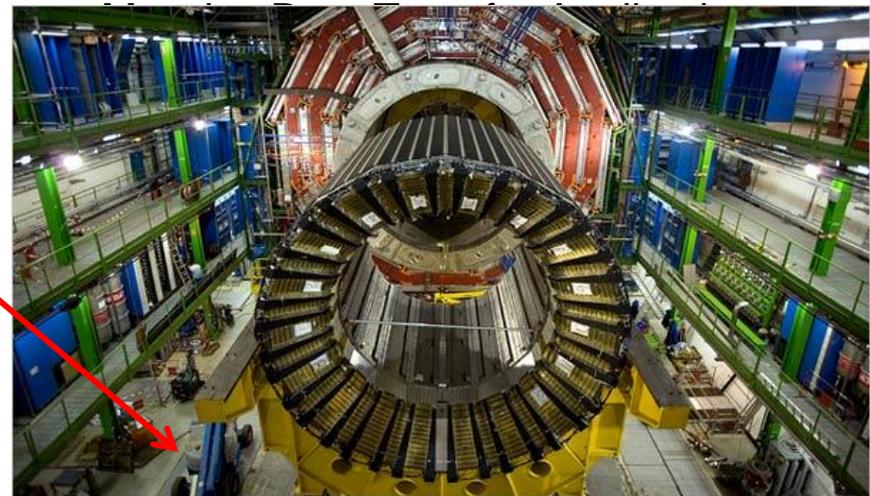Global Ring Network for Advanced Applications Development

Based on Illustration (2007) by Natasha Bulashova, GLORIAD Russia

What are NRENs Used for?

- Academic Community NREN Applications
  - Eduroam: World-Wide Roaming Access Service
  - E-Content Portals: Egyptian Science and Technology Portal
  - Global NREN TelePresence Community
  - Commodity Internet Service (sometimes)

- Bandwidth Intensive NREN Applications

Electron Microscope @ Osaka University

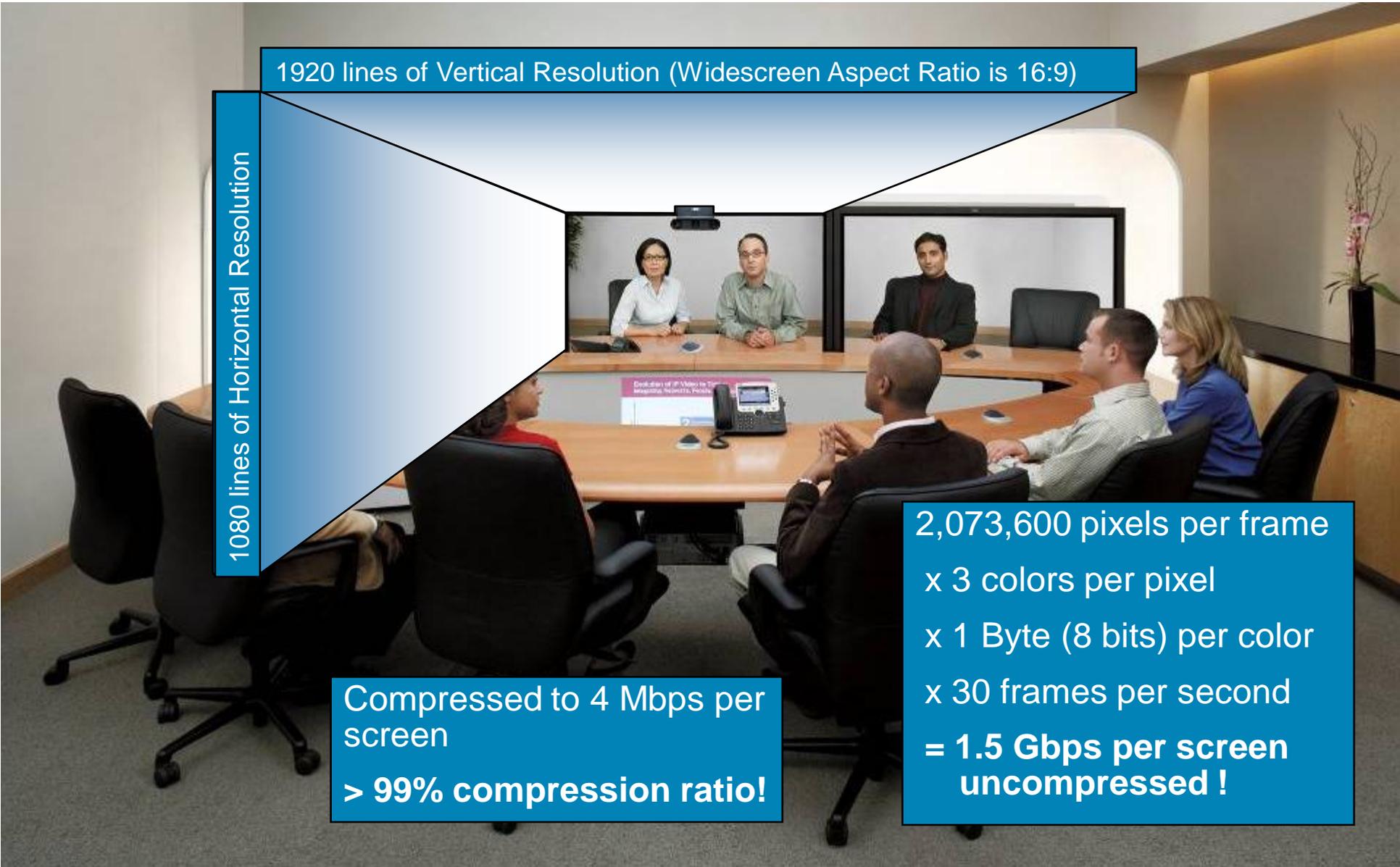**Large Hadron Collider @ CERN**

Cisco TelePresence Resolution & Traffic Characteristics

1920 lines of Vertical Resolution (Widescreen Aspect Ratio is 16:9)

1080 lines of Horizontal Resolution

2,073,600 pixels per frame

x 3 colors per pixel

x 1 Byte (8 bits) per color

x 30 frames per second

= 1.5 Gbps per screen uncompressed !

Compressed to 4 Mbps per screen
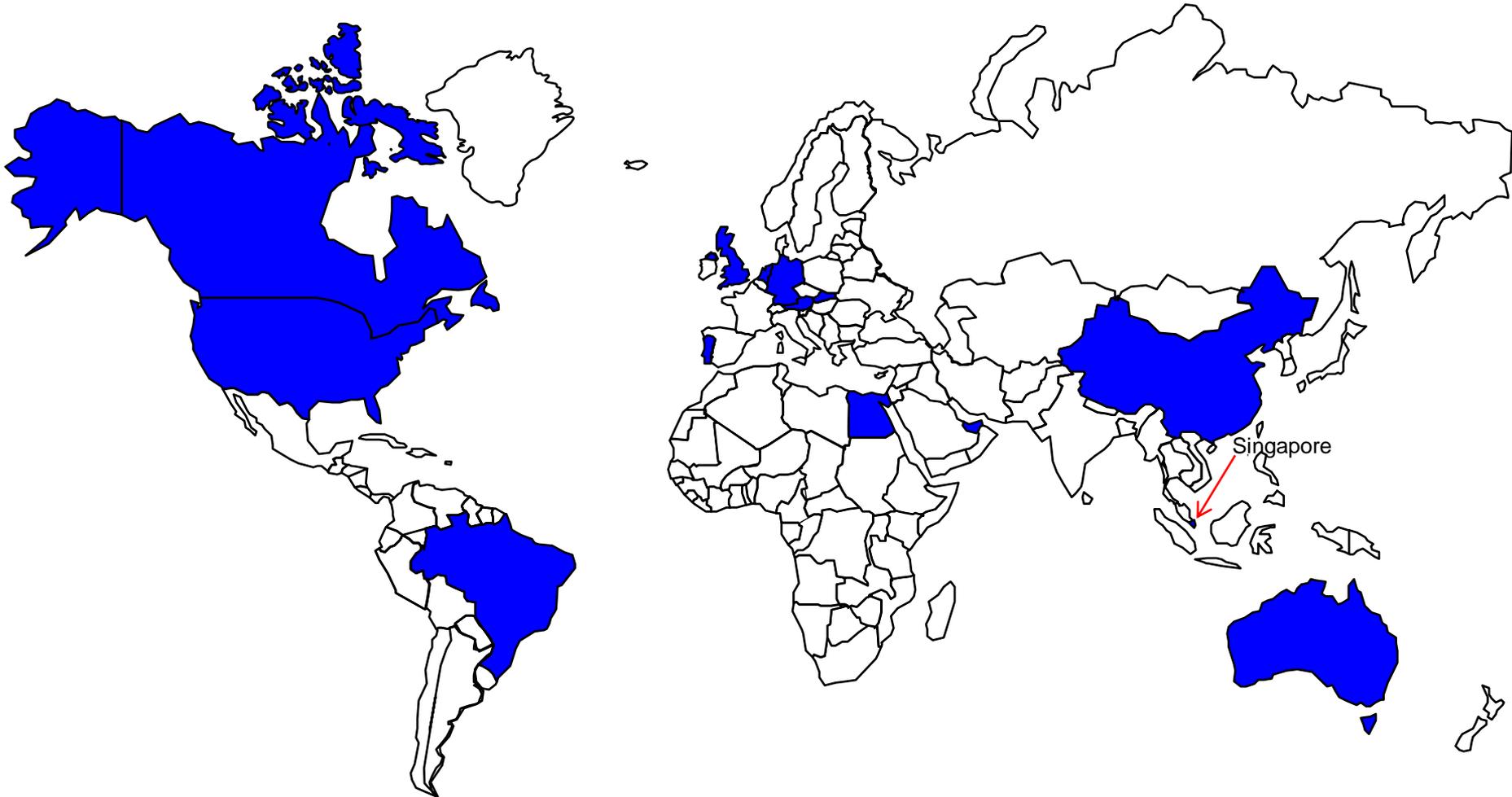
> 99% compression ratio!

Global NREN TelePresence Community

Baylor University
California State University System
CENIC (California State R&E Network)
City of Boston
City of Cambridge
Cisco Center for Excellence
Cornell University
Duke University
Florida International University
Fresno, CA Unified School District
Fryeburg Academy
Garden Grove, CA Unified School District
George Mason University
Georgia Tech University
Harvard University
Indiana University
Johns Hopkins University
Long Beach, CA Unified School District
Madison Area Technical College
Massachusetts Institute of Technology (MIT)
National Lambda Rail
New York University (NYU)
North Carolina State University
Oakland, CA Unified School District
Paradise Valley Unified School District
Pennsylvania State University
Pittsburgh Supercomputing Center
Purdue University
Rice University
Riverstone Energy
Smithsonian Institution
Stanford University
Towson University
University of California, Berkeley
University of California, Irvine
University of California, Los Angeles
University of California, San Diego

University Of Colorado
University of Denver
University of Illinois Chicago
University of North Carolina Chapel Hill
University of Maine
University of Michigan
University of Missouri
University of South Carolina
University of Southern California
University of Texas
University of West Virginia
University of Wisconsin
US National Science Foundation
Virginia Tech
Wake Forest University
University of Melbourne (Australia)
University New South Wales (Australia)
University of Southern Queensland (Australia)
University of Queensland (Australia)
Vienna University of Economics (Austria)
Universidade Candido Mendes (Brazil)
University of Manitoba (Canada)
Peking University (China)
People's University (China)
Zhongshan University (China)
Bibliotheca Alexandrina (Egypt)
Fraunhofer Institute (Germany)
NATO C3 Agency (Netherlands)
Stenden University (Netherlands)
Museu do Design e da Moda (Portugal)
Technical University of Kosice (Slovakia)
Slovak University of Technology (Slovakia)
University of the Arts (United Kingdom)
University of Warwick (United Kingdom)
National University Singapore (Singapore)
American University of Dubai (UAE)
+ TATA TelePresence Customers & Public Rooms
+ some connectivity to AT&T Customers & Public Rooms

Most universities and university systems listed above have multiple TelePresence units.

TelePresence in Education

Singapore

NLR & ANKABUT demonstrate the first international TelePresence call between universities over NRENs

Dr. Arif al-Hammadi (centre) presenting via WebEx (left) with Steve Cunningham and JJ Jamison joining via TelePresence (right)

NLR

Pittsburgh Supercomputing Center
Pittsburgh, PA USA

Khalifa University of Science, Technology and Research (KUSTAR) Abu Dhabi, UAE

ANKABUT

HH Sheikh Nahyan Bin Mubarak Al Nahyan, Minister of Higher Education and Scientific Research (centre) in a lively debate with the "virtual" TelePresence conference participants.

NRENs as Economic Development Engines?

- Universities have a mandate to contribute to their nation's economic development and NRENs are one of the tools they use to do this

- Corporate Research Laboratories use NRENs to reach Universities and Research Labs
  - Microsoft Labs connects to Internet2
  - Cisco Systems' Center of Excellence connects to National Lambda Rail

- Corporations communicate and collaborate with Universities using TelePresence over NRENs
  - Cisco; General Electric; American Express

- **National, Regional, and Global Research & Development Communities are built around NRENS!**