Gulf Wave
A distributed NREN Exchange for the Gulf

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Global NREN TelePresence Community

CTS-1300

Global NREN TelePresence Community

California State University System
CENIC (California State R&E Network) NOC
O'Bryant High School (Boston)
Cambridge Rindge & Latin School (Boston)
Cisco Center for Excellence
Cornell University
Duke University
Florida International University
Fresno, CA Unified School District
Fryberg Academy (Maine)
Garden Grove, CA Unified School District
George Mason University
Georgia Tech University
Harvard University
Inver hills Community College (Minnesota)
Indiana University
Johns Hopkins University
Lawrence Livermore National Laboratory
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
Otrero Junior College
Paradise Valley Unified School District
Pennsylvania State University
Pittsburgh Supercomputing Center
Purdue University
RENCI (North Carolina)
Rice University
Smithsonian Institution
Stanford University
Towson University
Texas A&M University
University of California, Berkeley
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of Chicago
University Of Colorado
University of Denver
University of Illinois Chicago
University of North Carolina Chapel Hill
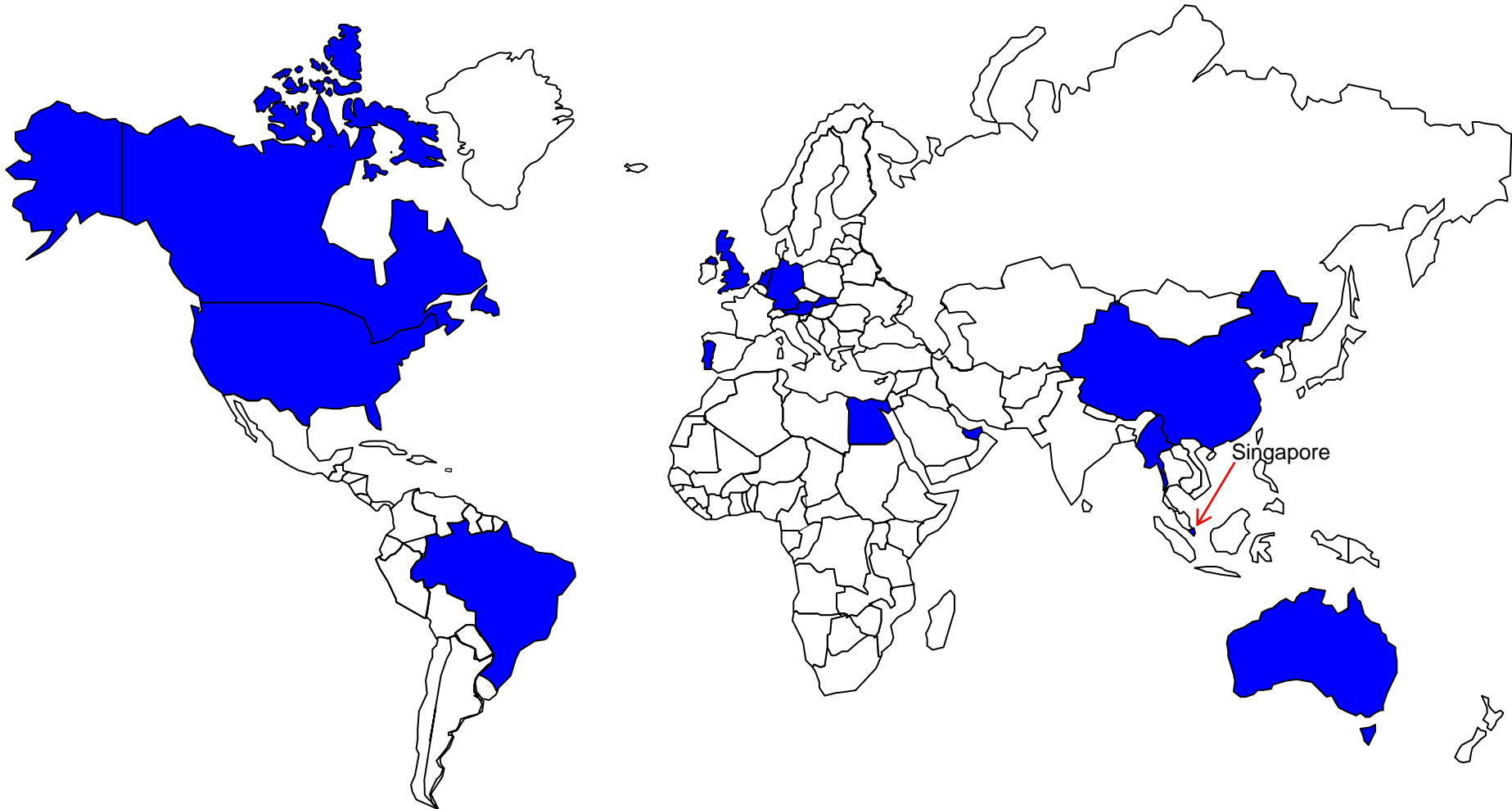University of Michigan

University of Missouri
University of South Carolina
University of South Florida
University of Southern California (USC)
University of Texas
University of Oklahoma
University of West Virginia
University of Wisconsin
US National Science Foundation
Virginia Tech (Riverstone Energy)
Wake Forest University
Washington University - Saint Louis
Central Queensland University (Australia)
Monash University (Australia)
Parkes Observatory (Australia)
Swinburne University (Australia)
University of Melbourne (Australia)
Victoria University (Australia)
Vienna University of Economics (Austria)
Universidade Candido Mendes (Brazil)
Brandon University (Canada)
University College of the North (Canada)
University of Winnipeg (Canada)
Peking University (China)
People's University (China)
Zhongshan University (China)
Bibliotheca Alexandrina (Egypt)
Fraunhofer Institute (Germany)
Waag Society (Netherlands)
NATO C3 Agency (Netherlands)
Stenden University (Netherlands)
Museu do Design e da Moda (Portugal)
National University Singapore (Singapore)
Technical University of Kosice (Slovakia)
Slovak University of Technology (Slovakia)
Thailand-Uninet (Thai NREN)
American University of Dubai (UAE)
University of Warwick (United Kingdom)

> 200 TelePresence Systems at Universities in 16 Countries

Connectivity to 1000+ TelePresence rooms at Cisco
via TATA and AT&T
+ TATA TelePresence Customers & Public Rooms
+ some connectivity to AT&T Customers & Public Rooms

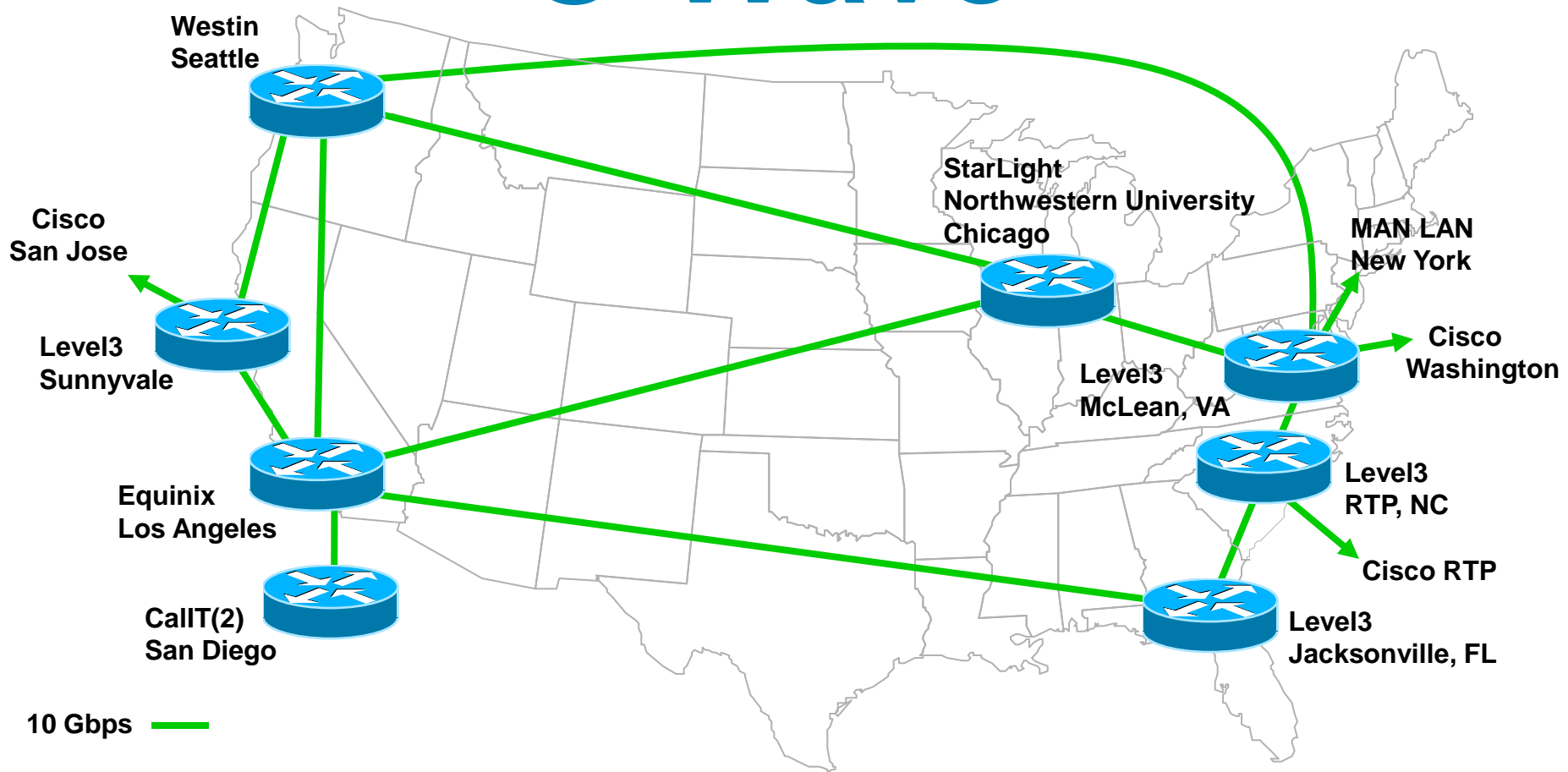Most universities and university systems listed above have multiple TelePresence units

TelePresence in Education

Singapore

> 200 TelePresence Systems at Universities in 16 Countries

Cisco's NREN

C-Wave

Westin Seattle

Cisco San Jose

Level3 Sunnyvale

Equinix Los Angeles

CalIT(2) San Diego

StarLight Northwestern University Chicago

Level3 McLean, VA

MAN LAN New York

Cisco Washington

Level3 RTP, NC

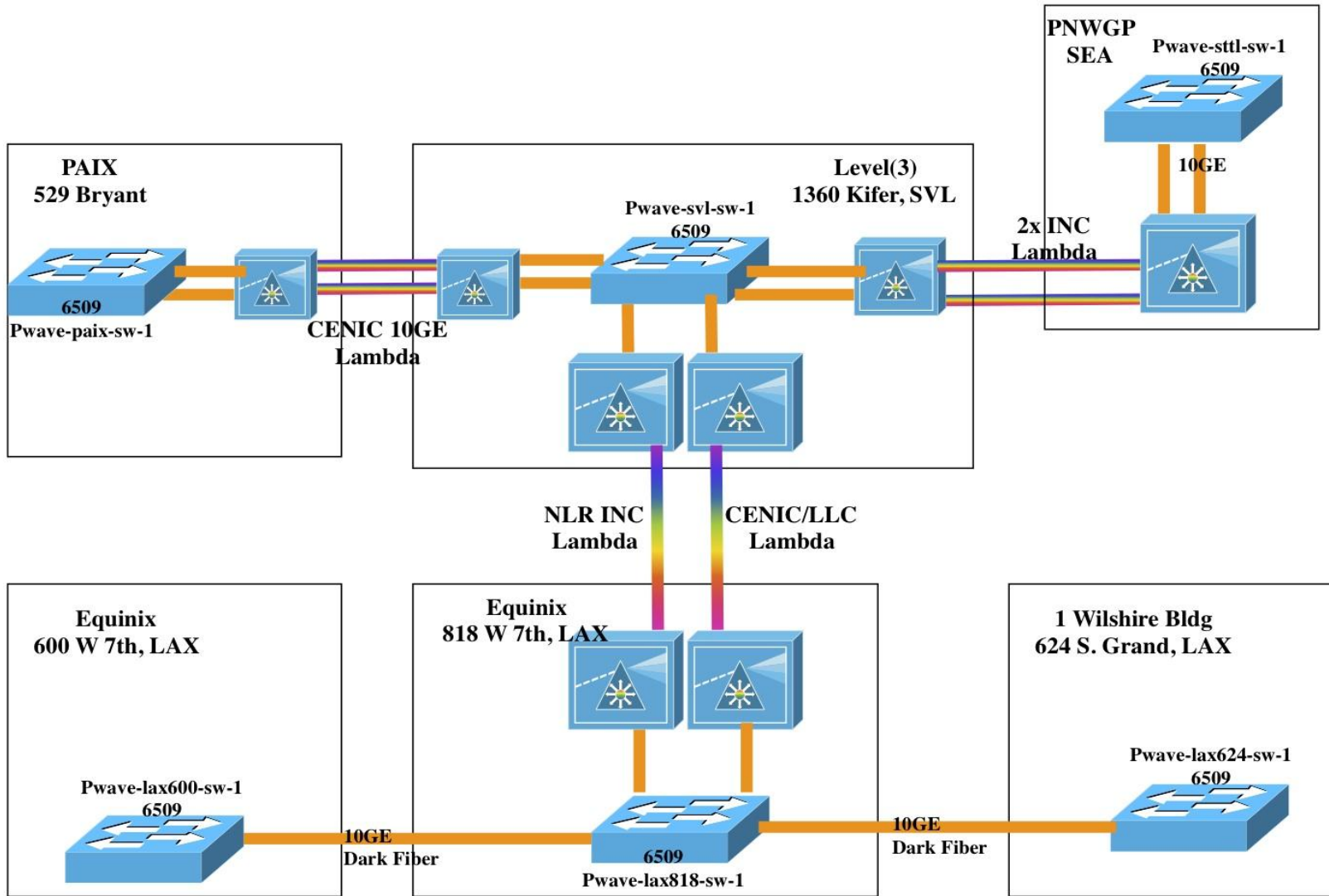**Cisco RTP**

Level3 Jacksonville, FL

10 Gbps ———

Cisco has its own Research Network!

Distributed NREN Exchanges

- NREN Exchanges follow two models:
    - Exchanges at a Point: MAN LAN (New York); STAR LIGHT (Chicago); NetherLight (Amsterdam); AMPATH (Miami)
    - Distributed Exchanges: Pacific Wave (US West Coast); Atlantic Wave (US East Coast)

- Historically the motivations behind exchange model choices have come down critical mass, which is heavily influenced by submarine cable landing points, and politics.

- Distributed Exchanges are a good fit in some situations because they allow NRENs which may not have a critical mass of either Research & Education (R&E) Institutions or submarine cable landing points to band together to create that mass.

- The motivation/business case behind building Pacific Wave was to create enough critical mass to make it a "Destination" NREN Exchange.

- NRENs throughout Asia Pacific know that landing in either Los Angeles; San Francisco; or Seattle gets them free VLAN transit to any other point and to US and other International NRENs.

- More direct connectivity among US West Coast R&E Institutions are a benefit of Pacific Wave but were not a motivation for creating the exchange.

- Pacific Wave has been a great success. It is now a destination landing point for Asian NRENs and has been a catalyst in enabling/driving collaboration between US and Asian R&E Institutions.

Pacific Wave

**PNWGP
SEA**
Pwave-sttl-sw-1
6509

10GE

**PAIX
529 Bryant**

**Level(3)
1360 Kifer, SVL**

Pwave-svl-sw-1
6509

**2x INC
Lambda**

6509
Pwave-paix-sw-1

**CENIC 10GE
Lambda**

**NLR INC
Lambda**

**CENIC/LLC
Lambda**

**Equinix
600 W 7th, LAX**

**Equinix
818 W 7th, LAX**

**1 Wilshire Bldg
624 S. Grand, LAX**

Pwave-lax624-sw-1
6509

Pwave-lax600-sw-1
6509

**10GE
Dark Fiber**

**10GE
Dark Fiber**

6509
Pwave-lax818-sw-1

New Universities Persian Gulf

- Persian Gulf Countries are aggressively trying to diversify their economies and are building many new universities as part of that effort

- UAE: NYU Abu Dhabi

- Qatar: University Branch Campuses from: USA (6 Universities), Canada, United Kingdom; France

- Saudi Arabia: 23 New Universities being built

including KAUST

NRENs and Higher Education in Persian Gulf

- There are NRENs up and running in the United Arab Emirates and Qatar

- NRENs are being build in Saudi Arabia and Oman

- NRENs are being considered in Bahrain and Kuwait

- But there are no NREN Exchanges in the region!

NRENs and NREN Exchanges are as much about building collaborative research and education communities, which share resources, as they are about providing bandwidth and connectivity.
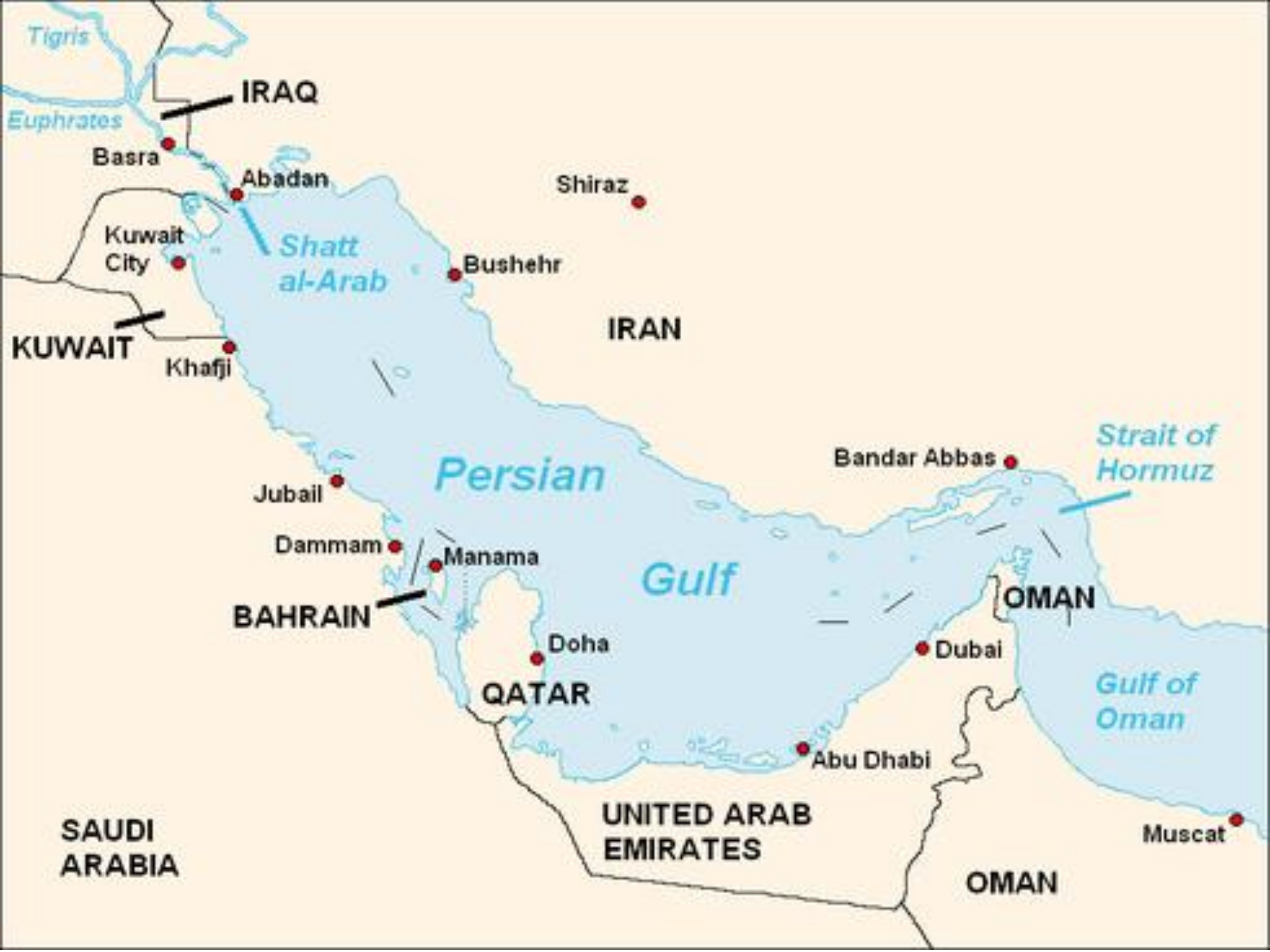
A Distributed Exchange for the Gulf

- Currently NRENs and individual universities in the Gulf are running their own circuits to Amsterdam, New York and Los Angeles with no cost sharing from the US or Europe and no savings from multi-customer bulk bandwidth pricing.

- A Distributed NREN Exchange in the Gulf would create a "Destination" Exchange that NRENs in the US and Europe might be willing to cost share to get to.

- Gulf NRENs could form purchasing alliances to get group pricing for circuits they could still purchase separately.

- ISPs connecting to an exchange in the Gulf might offer discounted rates and a distributed exchange has the potential to create a regional ISP market that would be more competitive than existing national markets.

- If Gulf Wave grows large enough it might attract transit connectivity from NRENs in countries further East like India and Pakistan and may be able to provide an NREN path directly to NRENs in China and Japan for its members.

Gulf Wave (in 3 baby steps*)

Eventually a Distributed Exchange requires dedicated bandwidth and equipment but it is possible to start taking baby steps toward building the Exchange and its collaborative research community

Today: QFREN and ANKABUT both connect to NYC but do not peer

MAN LAN

QFREN

ANKABUT
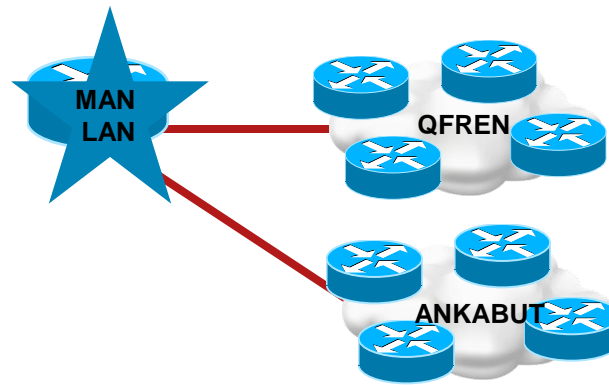
* Politics are some of the biggest challenge is building NREN Exchanges. One of the benefits of baby steps is that if you accidently step on someone toes it does not hurt that much and you can apologize and work on a course correction.
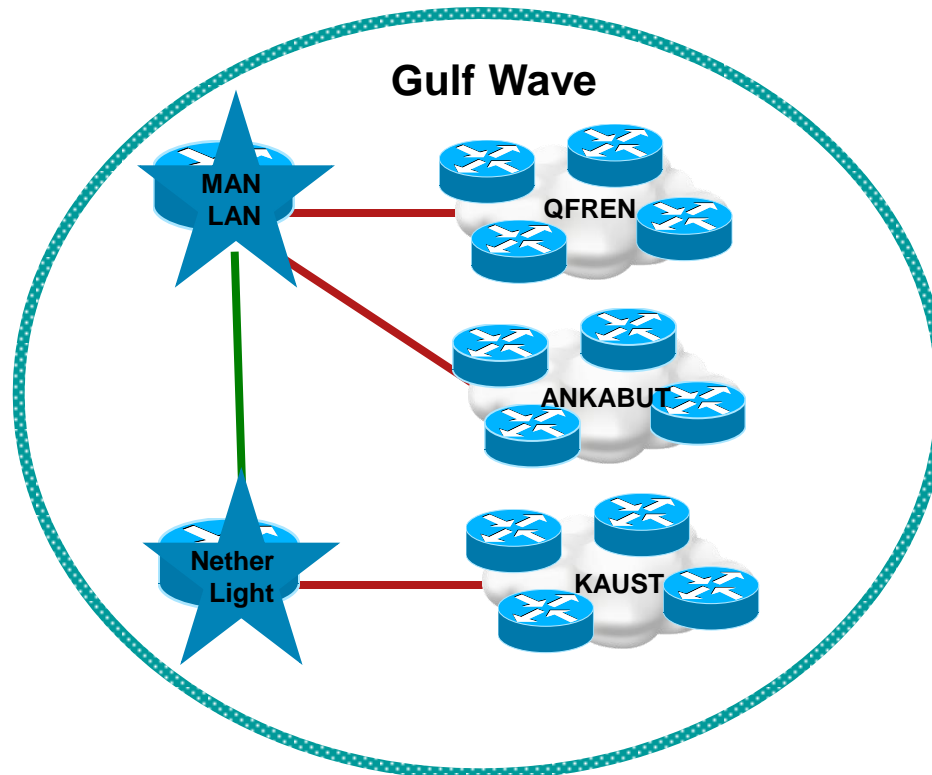
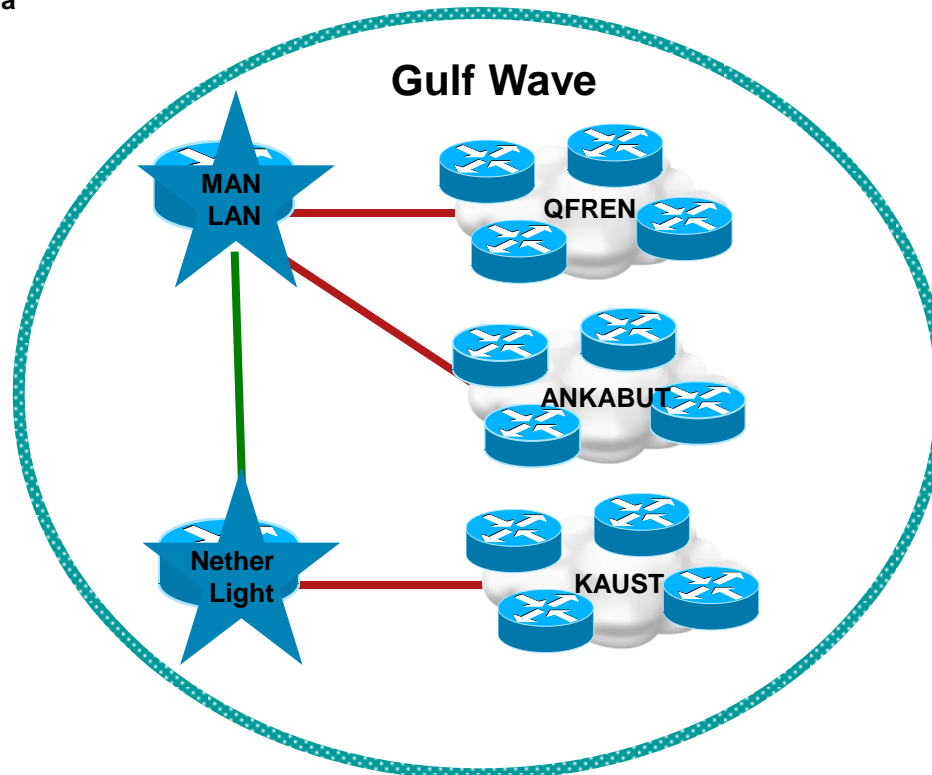# Gulf Wave (in 3 baby steps)

Step 1: QFREN and ANKABUT peer in NYC

Gulf Wave

MAN LAN
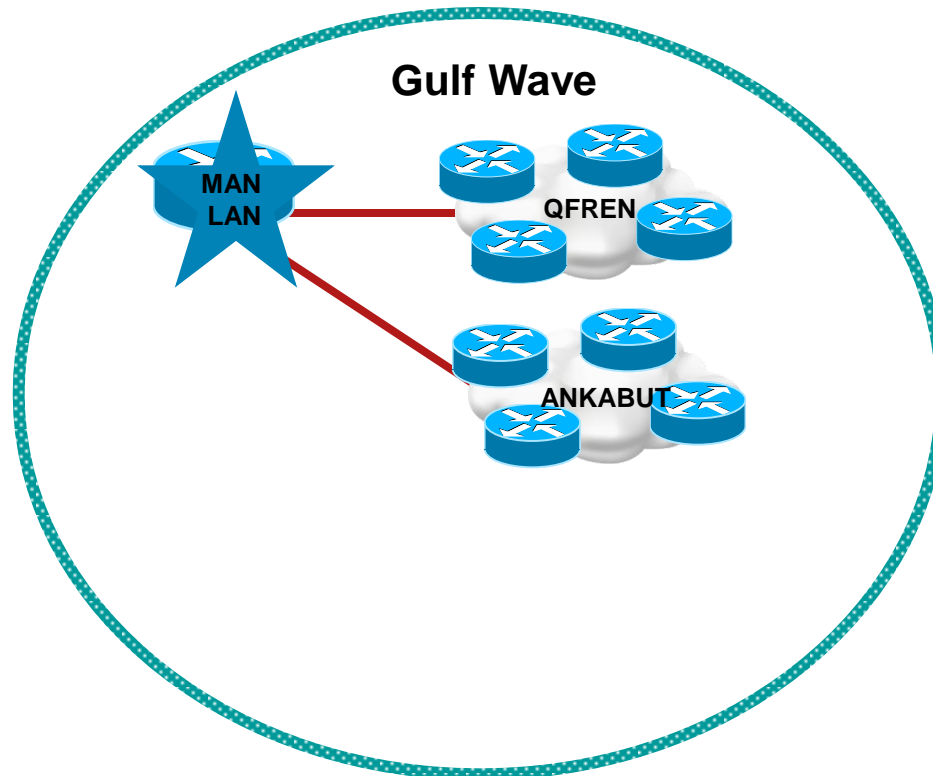
QFREN

ANKABUT

Gulf Wave (in 3 baby steps)

Step 2: QFREN and ANKABUT both peer with KAUST via GLORIAD

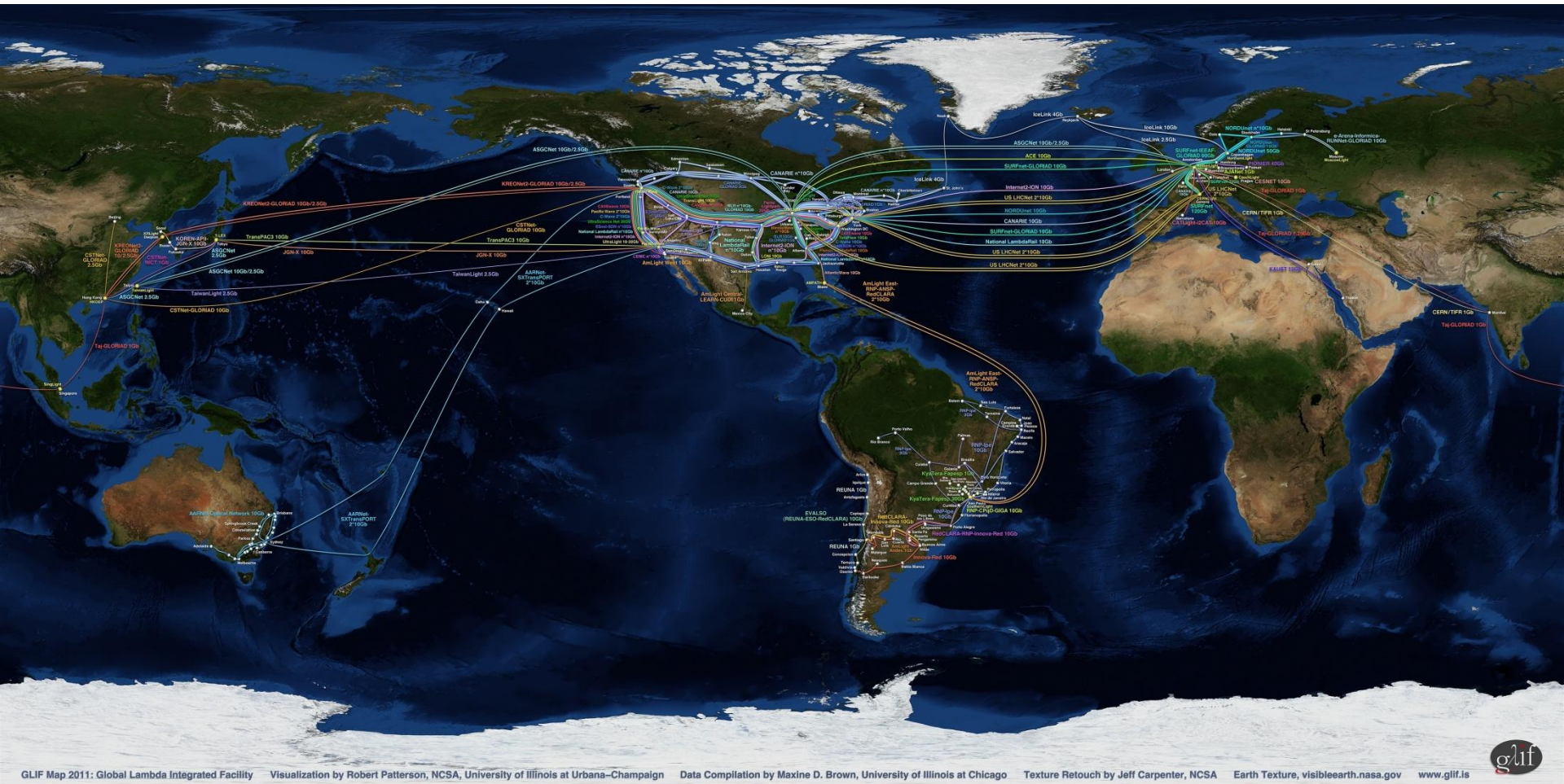**Gulf Wave**

MAN LAN

QFREN

ANKABUT

Nether Light

KAUST

Gulf Wave (in 3 baby steps)

Step 3: Gulf Wave participants expand beyond peering to running jointly managed infrastructure to enable a VLAN service
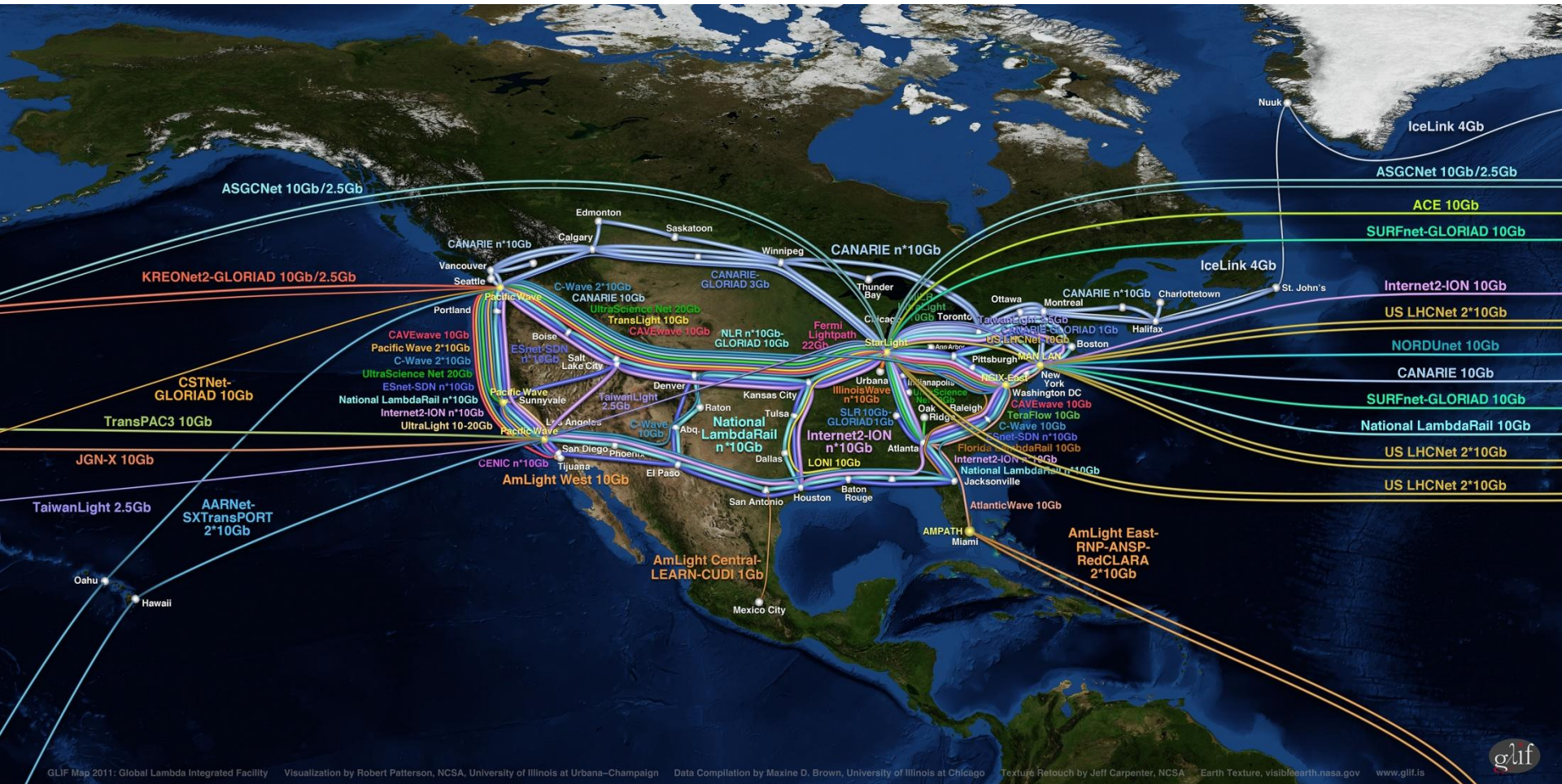
GLIF

GLIF Map 2011: Global Lambda Integrated Facility   Visualization by Robert Patterson, NCSA, University of Illinois at Urbana–Champaign   Data Compilation by Maxine D. Brown, University of Illinois at Chicago   Texture Retouch by Jeff Carpenter, NCSA   Earth Texture, visibleearth.nasa.gov   www.glif.is

Global Lambda Integrated Facility

GLIF

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