Internet2 Infrastructure and Services to Support GENI Projects

Matt Zekauskas
matt@internet2.edu

GEC5
21-July-2009
Seattle, WA

INTERNET®

Internet2 101

- It's a floor wax and a desert topping
- Membership organization, started by universities; universities, regional networks, companies are members
- A community
- Partnership working on advanced networking
- And it runs a national backbone
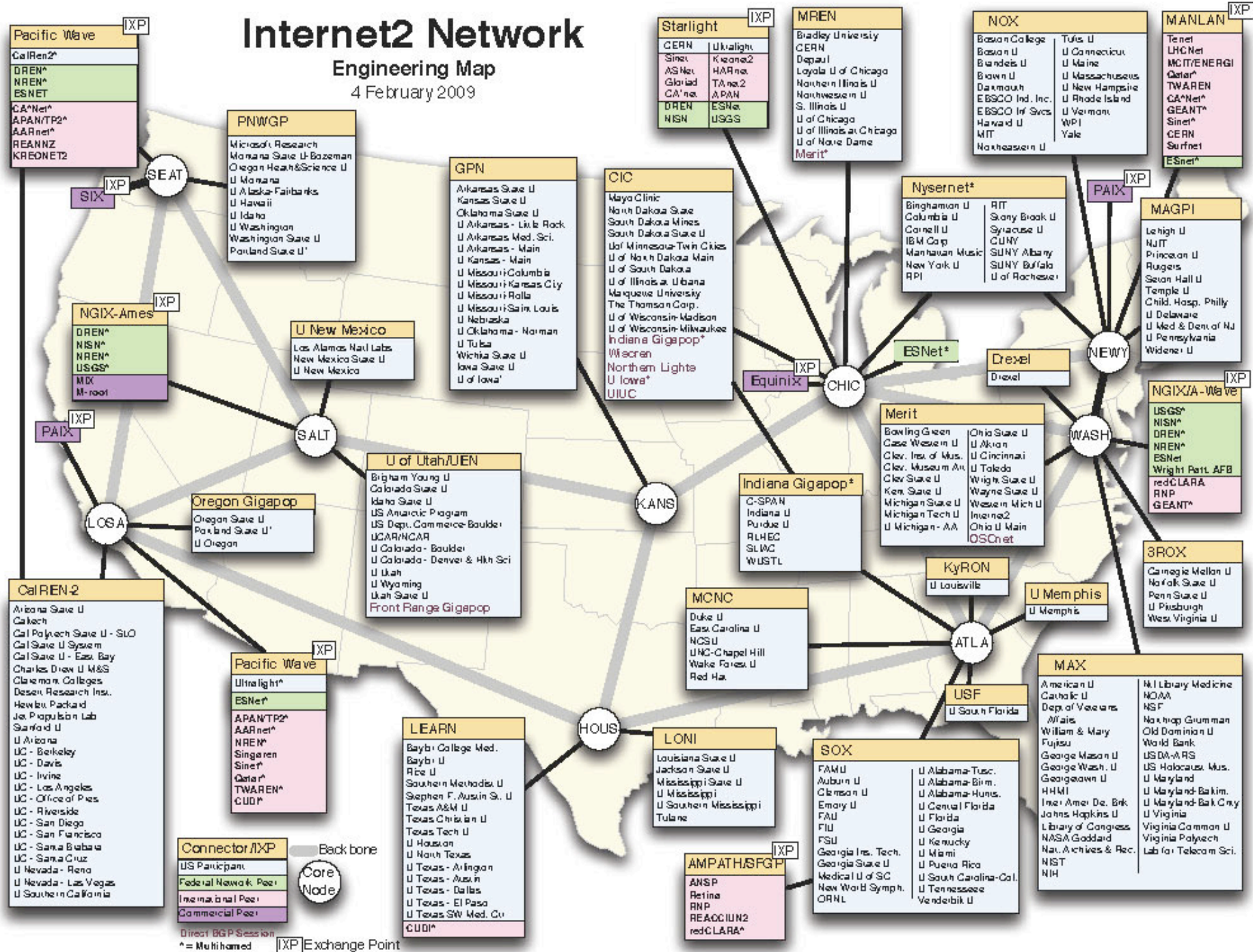
INTERNET®

University R&E Networking

- "The Internet2 Architecture"
- Three tiered
    - Universities
    - Aggregated by Regional Networks nee "gigaPoPs", also Regional Optical Networks
    - Connected by national backbone(s) [one of which is operated by Internet2, the Internet2 Network.]
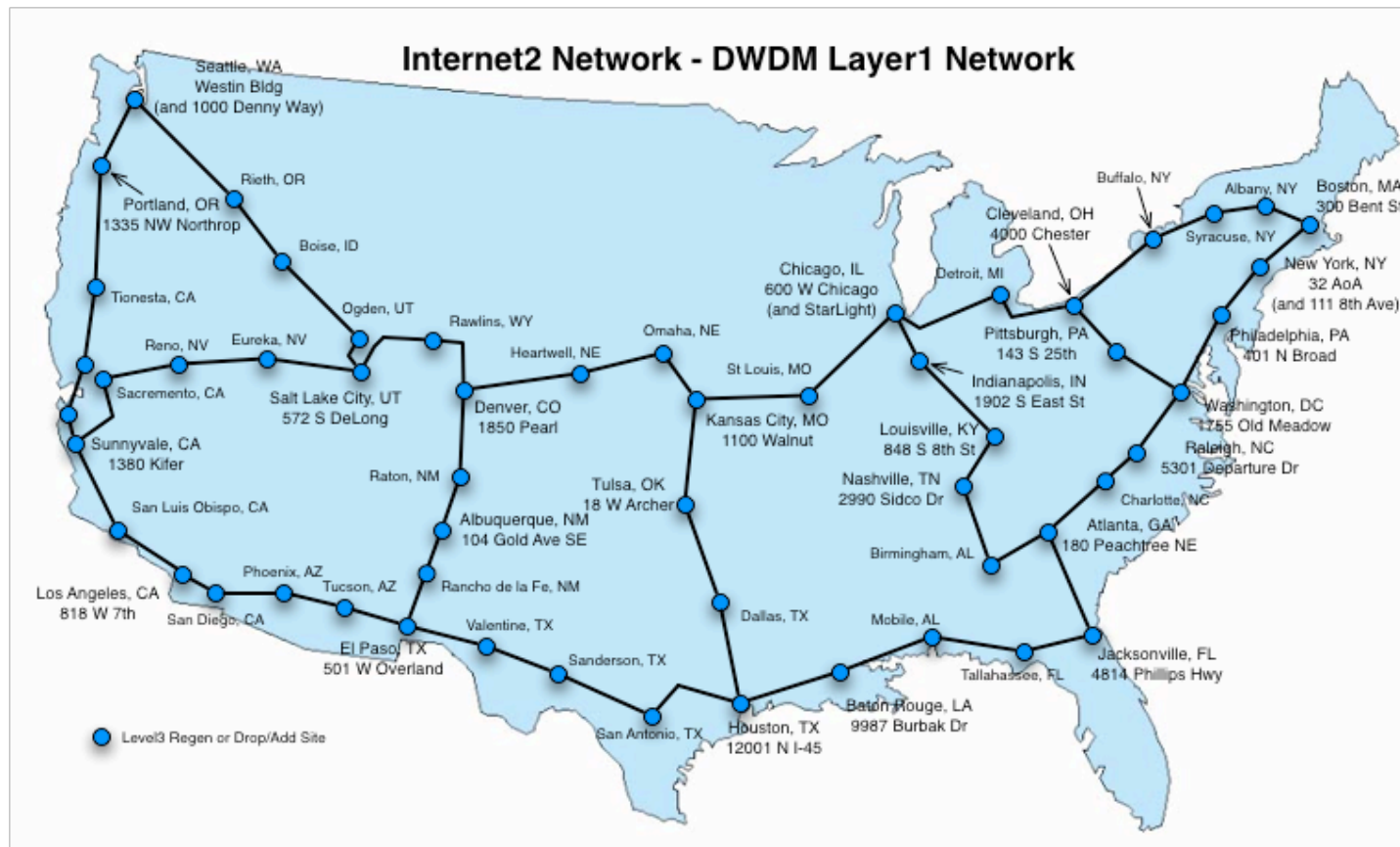- Peering at R&E Exchange Points
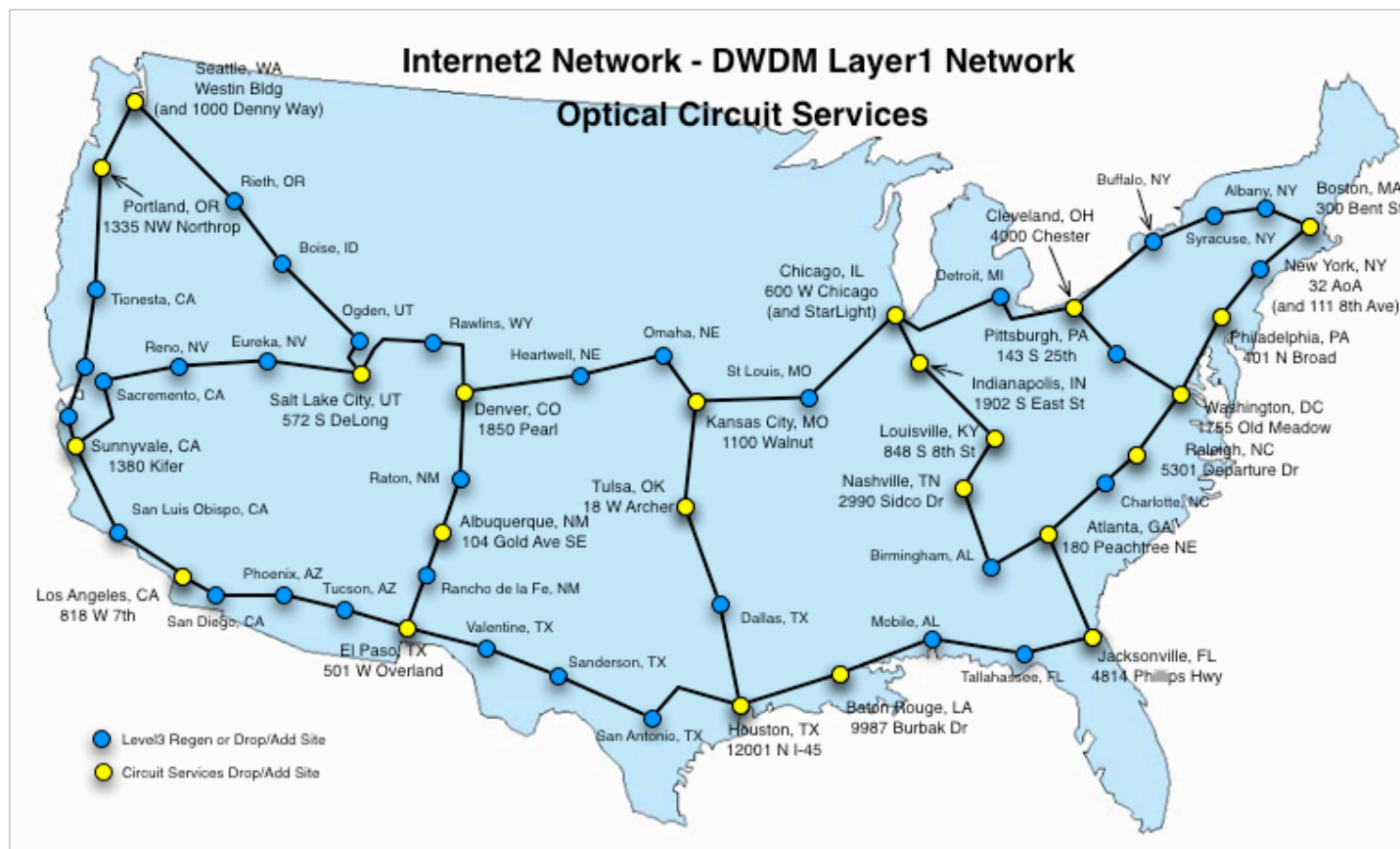
Internet2 Network
Engineering Map
4 February 2009

Pacific Wave IXP
- CalRen2^
- DREN^
- NREN^
- ESNET
- CA^Net^
- APAN/TP2^
- AARnet^
- REANNZ
- KREONET2

PNWGP
- Microsoft Research
- Montana State U-Bozeman
- Oregon Health&Science U
- U Montana
- U Alaska-Fairbanks
- U Hawaii
- U Idaho
- U Washington
- Washington State U
- Portland State U'

GPN
- Arkansas State U
- Kansas State U
- Oklahoma State U
- U Arkansas - Little Rock
- U Arkansas Med. Sci.
- U Arkansas - Main
- U Kansas - Main
- U Missouri-Columbia
- U Missouri Kansas City
- U Missouri Rolla
- U Missouri Saint Louis
- U Nebraska
- U Oklahoma - Norman
- U Tulsa
- Wichita State U
- Iowa State U
- U of Iowa'

CIC
- Mayo Clinic
- North Dakota State
- South Dakota Mines
- South Dakota State U
- U of Minnesota-Twin Cities
- U of North Dakota Main
- U of South Dakota
- U of Illinois a. Urbana
- Marquette University
- The Thomson Corp.
- U of Wisconsin-Madison
- U of Wisconsin-Milwaukee
- Indiana Gigapop*
- Wiscren
- Northern Lights
- U Iowa*
- UIUC

Starlight IXP
- CERN
- Sinet
- ASNet
- Gloriad
- CA^net
- DREN
- NISN
- Ultralight
- Kreonet2
- HARnet
- TANet2
- APAN
- ESNet
- USGS

MREN
- Bradley University
- CERN
- Depaul
- Loyola U of Chicago
- Northern Illinois U
- Northwestern U
- S. Illinois U
- U of Chicago
- U of Illinois at Chicago
- U of Notre Dame
- Merit*

NOX
- Boston College
- Boston U
- Brandeis U
- Brown U
- Dartmouth
- EBSCO Ind. Inc.
- EBSCO Inf Svcs
- Harvard U
- MIT
- Northeastern U
- Tufts U
- U Connecticut
- U Maine
- U Massachusetts
- U New Hampshire
- U Rhode Island
- U Vermont
- WPI
- Yale

MANLAN IXP
- Tenet
- LHCNet
- MCIT/ENERGI
- Qatar^
- TWAREN
- CA^Net^
- GEANT^
- Sinet^
- CERN
- Surfnet
- ESnet^

Nysernet*
- Binghamton U
- Columbia U
- Cornell U
- IBM Corp
- Manhattan Music
- New York U
- RPI
- RIT
- Stony Brook U
- Syracuse U
- CUNY
- SUNY Albany
- SUNY Buffalo
- U of Rochester

MAGPI
- Lehigh U
- NJIT
- Princeton U
- Rutgers
- Seton Hall U
- Temple U
- Child. Hosp. Philly
- U Delaware
- U Med & Dent of NJ
- U Pennsylvania
- Widener U

ESNet*

Drexel
- Drexel

NGIX/A-Wave
- USGS^
- NISN^
- DREN^
- NREN^
- ESNet
- Wright Patt. AFB
- redCLARA
- RNP
- GEANT^

U New Mexico
- Los Alamos Natl Labs
- New Mexico State U
- U New Mexico

NGIX-Ames IXP
- DREN^
- NISN^
- NREN^
- USGS^
- MIX
- M-root

Merit
- Bowling Green
- Case Western U
- Clev. Inst of Mus.
- Clev. Museum Art
- Clev State U
- Kent State U
- Michigan State U
- Michigan Tech U
- U Michigan - AA
- Ohio State U
- U Akron
- U Cincinnati
- U Toledo
- Wright State U
- Wayne State U
- Western Mich U
- Internet2
- Ohio U Main
- OSCnet

Indiana Gigapop*
- C-SPAN
- Indiana U
- Purdue U
- RLHEC
- SLLAC
- WUSTL

KyRON
- U Louisville

U Memphis
- U Memphis

3ROX
- Carnegie Mellon U
- Norfolk State U
- Penn State U
- U Pittsburgh
- West Virginia U

U of Utah/UEN
- Brigham Young U
- Colorado State U
- Idaho State U
- US Antarctic Program
- US Dept. Commerce-Boulder
- UCAR/NCAR
- U Colorado - Boulder
- U Colorado - Denver & Hlth Sci
- U Utah
- U Wyoming
- Utah State U
- Front Range Gigapop

Oregon Gigapop
- Oregon State U
- Portland State U'
- U Oregon

MCNC
- Duke U
- East Carolina U
- NCSU
- UNC-Chapel Hill
- Wake Forest U
- Red Hat

USF
- U South Florida

MAX
- American U
- Catholic U
- Dept of Veterans Affairs
- William & Mary
- Fujitsu
- George Mason U
- George Wash. U
- Georgetown U
- HHMI
- Inter Amer De. Bnk
- Johns Hopkins U
- Library of Congress
- NASA Goddard
- Nat. Archives & Rec.
- NIST
- NIH
- Natl Library Medicine
- NOAA
- NSF
- Northrop Grumman
- Old Dominion U
- World Bank
- USDA-ARS
- US Holocaust. Mus.
- U Maryland
- U Maryland-Baltim.
- U Maryland-Balt City
- U Virginia
- Virginia Common U
- Virginia Polytech
- Lab for Telecom Sci.

CalREN-2
- Arizona State U
- Caltech
- Cal Polytech State U - SLO
- Cal State U System
- Cal State U - East Bay
- Charles Drew U M&S
- Claremont Colleges
- Desert Research Inst.
- Hewlett-Packard
- Jet Propulsion Lab
- Stanford U
- U Arizona
- UC - Berkeley
- UC - Davis
- UC - Irvine
- UC - Los Angeles
- UC - Office of Pres
- UC - Riverside
- UC - San Diego
- UC - San Francisco
- UC - Santa Barbara
- UC - Santa Cruz
- U Nevada - Reno
- U Nevada - Las Vegas
- U Southern California

Pacific Wave XP
- Ultralight^
- ESNet^
- APAN/TP2^
- AARnet^
- NREN^
- Singaren
- Sinet^
- Qatar^
- TWAREN^
- CUDI

LEARN
- Baylor College Med.
- Baylor U
- Rice U
- Southern Methodist U
- Stephen F. Austin St. U
- Texas A&M U
- Texas Christian U
- Texas Tech U
- U Houston
- U North Texas
- U Texas - Arlington
- U Texas - Austin
- U Texas - Dallas
- U Texas - El Paso
- U Texas SW Med. Ctr
- CUDI^

LONI
- Louisiana State U
- Jackson State U
- U Mississippi
- U Southern Mississippi
- Tulane

SOX
- FAMU
- Auburn U
- Clemson U
- Emory U
- FAU
- FIU
- FSU
- Georgia Ins. Tech.
- Georgia State U
- Medical U of SC
- New World Symph.
- ORNL
- U Alabama-Tusc.
- U Alabama-Birm.
- U Alabama-Hunts.
- U Central Florida
- U Florida
- U Georgia
- U Kentucky
- U Miami
- U Puerto Rico
- U South Carolina-Col.
- U Tennessee
- Vanderbilt U

AMPATH/SFGP IXP
- ANSP
- Retina
- RNP
- REACCIUN2
- redCLARA^

Connector/IXP
- US Participant
- Federal Network Peer
- International Peer
- Commercial Peer
- Backbone
- Core Node
- Direct BGP Session
- ^ = Multihomed
- IXP Exchange Point

Nodes: SEAT, SIX, PAIX, SALT, LOSA, KANS, CHIC, Equinix, ESNet*, Drexel, NEWY, WASH, ATLA, HOUS, NGIX-Ames, PAIX

Internet2 Backbone Contribution

- A Dedicated 10 Gbps Wave on the Internet2 DWDM System
  - Participated with University of Utah in Spiral 1
  - Potential use by other projects whenever possible
- Access is through regional and campus networks
  - IP Network
  - Dynamic Circuit Network (DCN)
  - Direct connectivity
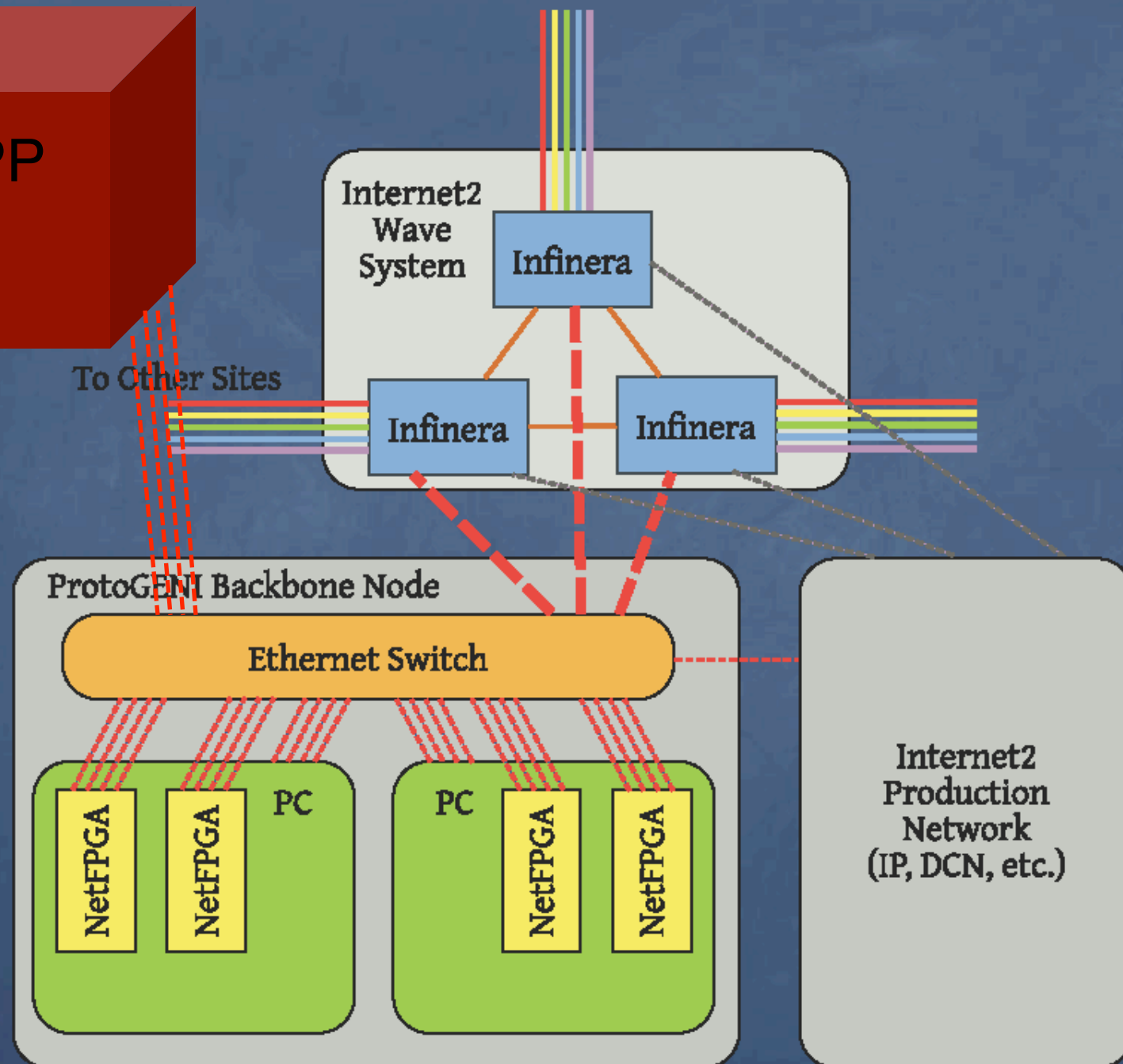- Have an MoU with the GPO for use of the wave

INTERNET®
2

Internet2 Network - DWDM Layer1 Network

Internet2 Network - DWDM Layer1 Network
Optical Circuit Services

Internet2 Network - Optical Circuit Services
IP Services
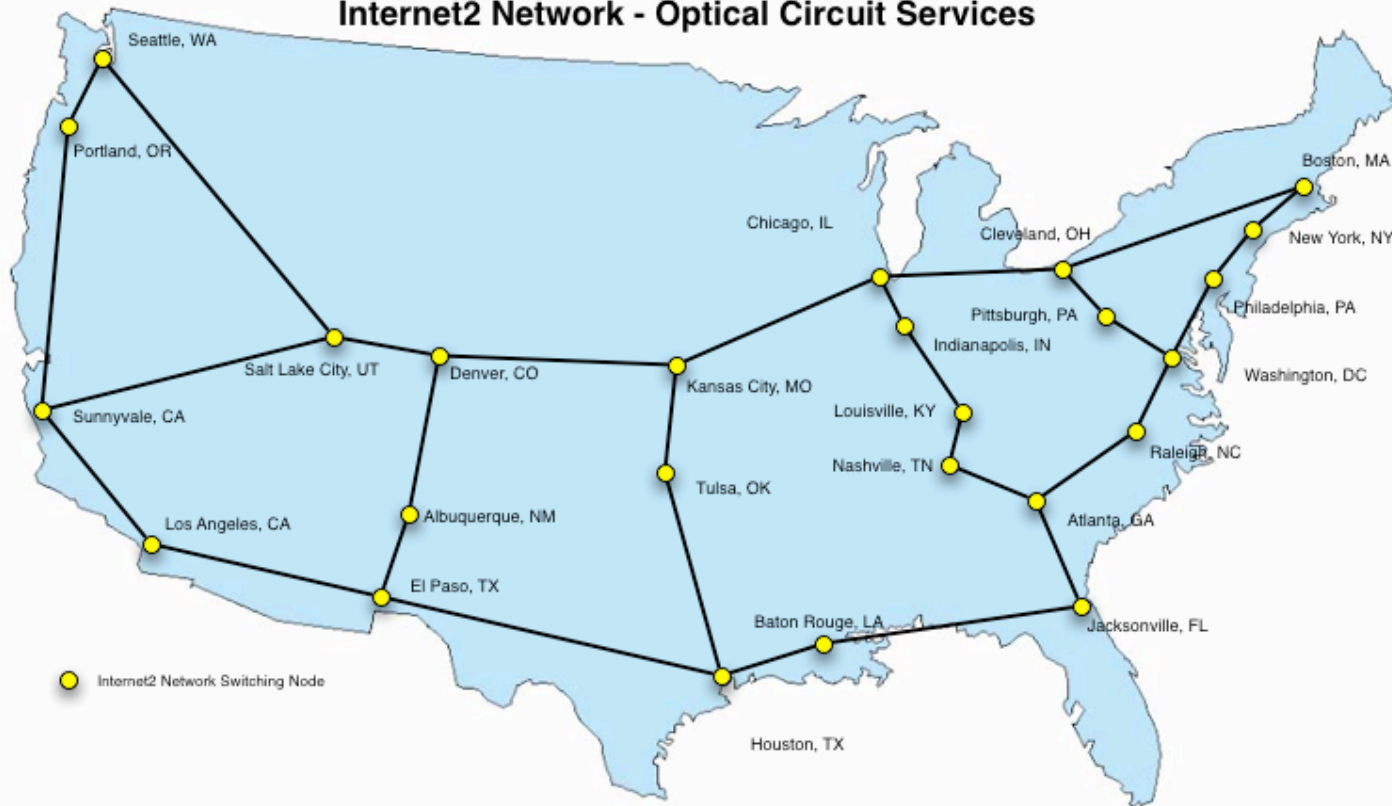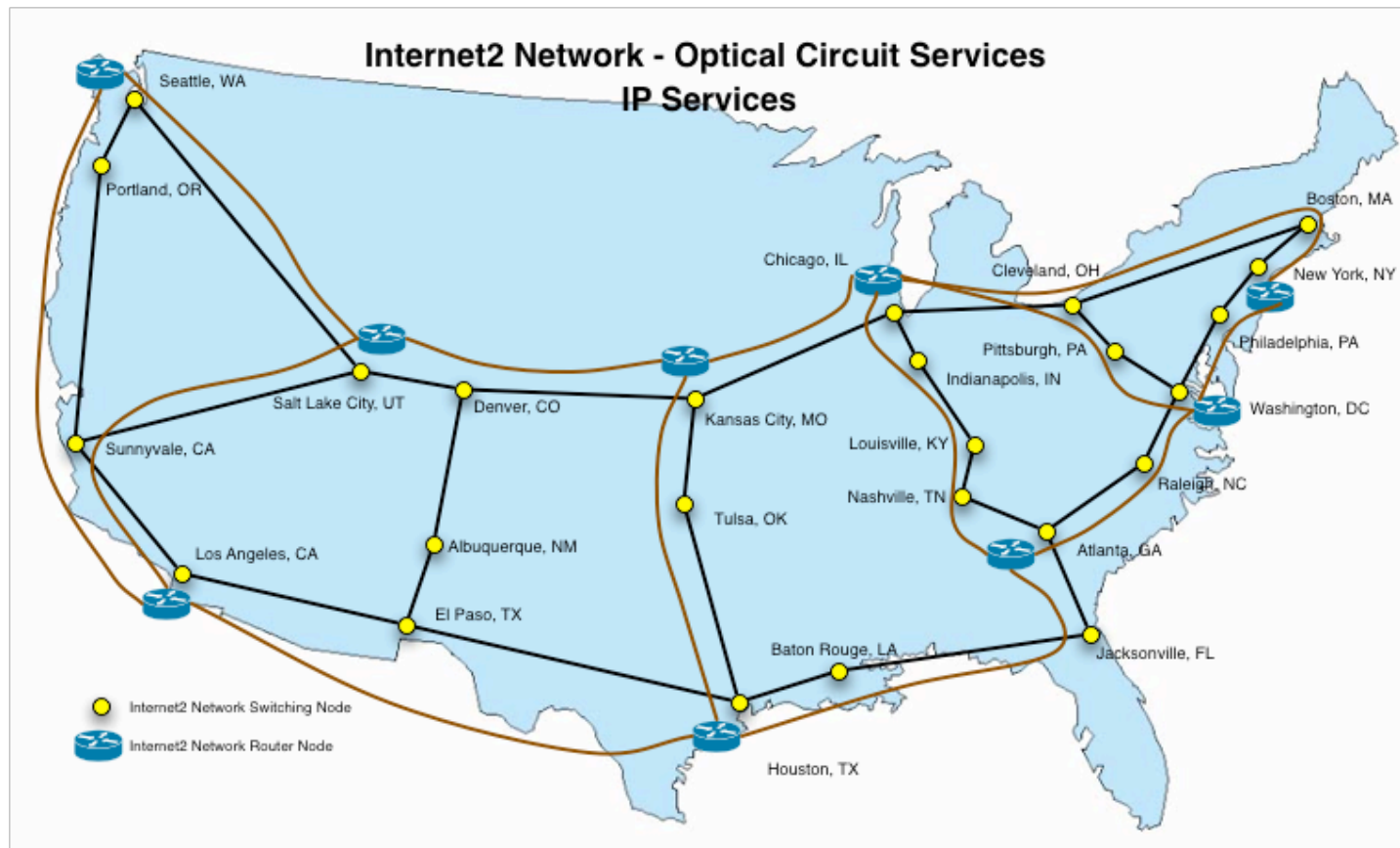
GENI using Internet2

- So far, we've been asked to
  - Host ProtoGENI in some PoPs
  - Host "Internet-scale Overlay Hosting" nodes in the same PoPs (aka "SPP")
  - Help provide Rutgers-NICTA "layer 2" connectivity

•SPP

Internet2 Wave System

Infinera

To Other Sites

Infinera

Infinera

ProtoGENI Backbone Node

Ethernet Switch

PC

NetFPGA

NetFPGA

PC

NetFPGA

NetFPGA

Internet2 Production Network (IP, DCN, etc.)

Access possibilities

- IP. Standard layer 3, v4 or v6
- Dynamic circuit network. We (intend to) have the ability for a connector attached to DCN to be able to signal a circuit to (one or more) ProtoGENI nodes. [local and/or regional parts *do not* have to be dynamic!] (layer 2)
- Direct connection. If you can cost-effectively reach a node, plug in.

Nodes
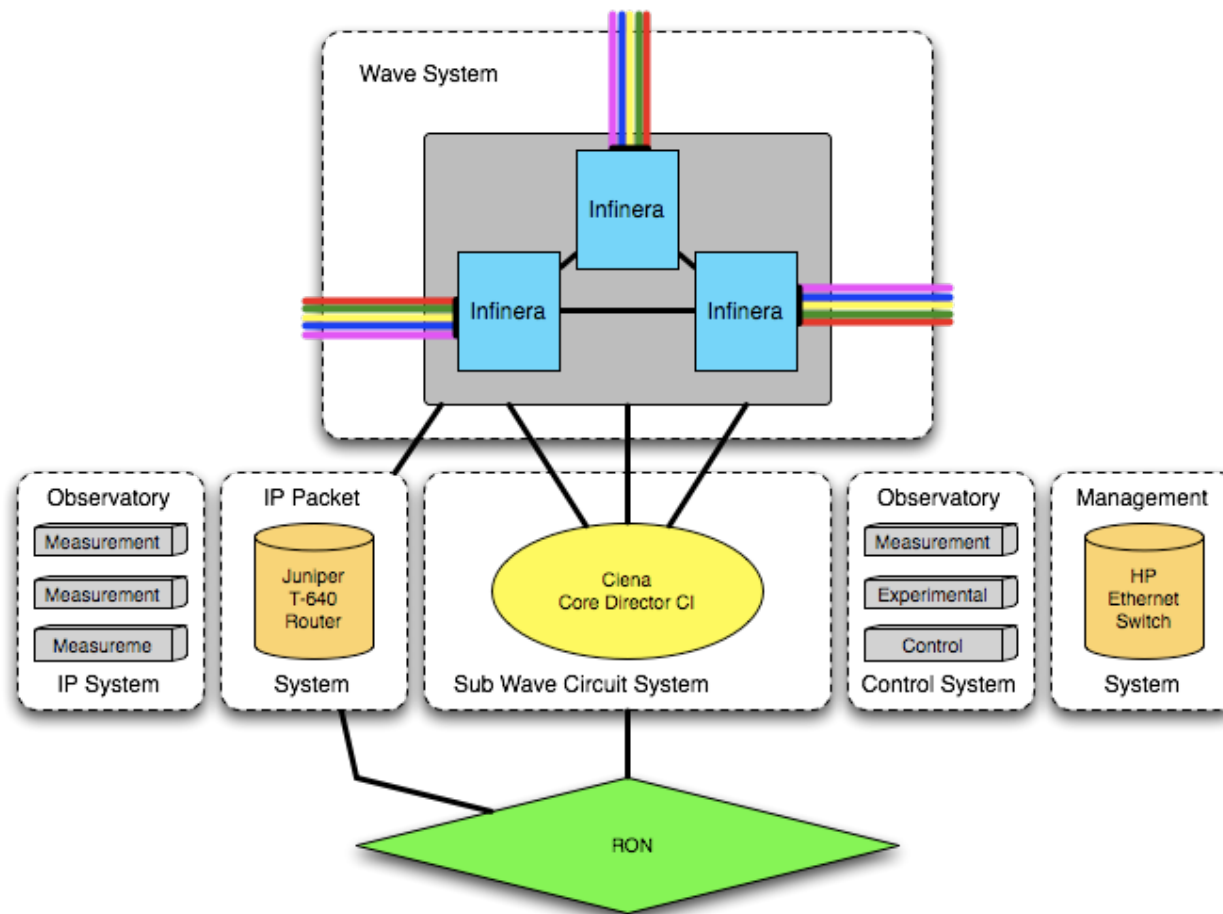
Other Services

- Collocation Services
  - Internet2 backbone nodes
  - Depends on availability of power and space
  - Geographically diverse set of nodes
- Access to Internet2 Observatory
  - Data collection mechanisms
  - Test points
- Support in connecting to backbone
  - Working with RON and campuses to facilitate connectivity

INTERNET2®

Internet2 Observatory

- Collocation for network research projects
  - PlanetLab / VINI nodes at Router Nodes
  - 100x100 nodes (NetFPGA) nodes
- Data collections
  - Routing, Netflow, Latency, Bandwidth, Usage, Router, Logging

INTERNET®

www.internet2.edu

Questions?

matt@internet2.edu

INTERNET®

Current DCN Connectors

- CENIC
- CIC-Omnipop
- GPN
- LEARN
- LONI
- MAX

- MERIT
- NOX
- NYSERnet
- PNWGP
- UEN

INTERNET2®

DCN and "ION"

- Part of DCN is being "product-ized" and branded as "ION" (doesn't stand for anything).
- The ability for connectors to easily create VLANs among each other using a web interface
- Mainly FYI

INTERNET2®