EMERGING AND ENABLING
GLOBAL, NATIONAL, AND REGIONAL
NETWORK INFRASTRUCTURE

TO SUPPORT
RESEARCH & EDUCATION

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Today’s Presentation

- **GLOBAL NETWORK REACH**
  - INTERNATIONAL
  - NATIONAL
  - REGIONAL OPTICAL NETWORKS (RONs)

- What are the “Drivers” for the new emerging networks

- FLR – What is it, How it provides for your Research Needs

- Internet2: What is the Innovation Platform and what makes an innovation campus?
Europe – India Map
Asia Pacific Map
North American Map
visit: [http://www.glif.is/publications/maps/](http://www.glif.is/publications/maps/) for even more maps!
“The Quilt” as of 2010
Florida LambdaRail  Florida’s Research and Education Network

Internet 2 Network Infrastructure Topology

Internet2 Network Infrastructure Topology
July 2013

Internet2 Network by the numbers:
77 Juniper M6100 routers in support ofexLayer 3 IP and service networks
21 Juniper and Alcatel-Lucent 8560 routers in support ofAdvanced Layer 2 service networks
69 western extradition links
25 PE links
13.172 iBGP links (all nearly complete dark fiber)
85 PTPs of upstream capacity
128 PTPs of Layer 2 and Layer 3 capacity
300+ Cisco DA-105 and 5000+ network elements
2,400+ links/muxed capacity with Espresso Communications

In support of the Florida Turnpike
National LambdaRail

www.nlr.net

Your vision. Your network.
“Drivers” for these new networks...

- The main drivers for these new 'application-empowered' networks are:
  - high-performance e-science projects that consists of very large-scale applications - such as high-energy physics, astronomy, earth science, bio-informatics and the environmental sciences.
  - Emerging next generation technologies.
  - **Key driver:** The research community should have “Friction Free” access to these new advanced networks in order to get their work done.
What is FLR?

Member owned facilities based regional optical network

- FLR is owned and operated on behalf of 12 Florida research institutions:
  - Florida Atlantic University
  - Florida Gulf Coast University
  - Florida Institute of Technology
  - Florida International University
  - Florida State University
  - Nova Southeastern University
  - University of Central Florida
  - University of Florida
  - University of Miami
  - University of North Florida
  - University of South Florida
  - and the University of West Florida.

- **42 FLR Affiliates** (includes Sanford-Burnham Medical Research Institute)
- FLR responds to participants’ needs and enables an evolving terrain of education and research infrastructure. Affiliates gain access to the network either through a FLR Equity partner’s network or a direct connection to the FLR infrastructure.
"To provide a cost effective, ultra-high speed, interconnected, broadband service delivery network that enables Florida’s higher education institutions and partners to collaborate, connect, utilize and develop new innovative broadband applications and services in support of their scientific research, education, and 21st century economy initiatives"
FLRWave Optical Topology
FLRNet Services

- R&E Networking
  - Internet2 (both Layer2 & Layer3 services)
    - Interne2 Innovation Platform
  - National LambdaRail
- Layer 3 VPN service (“Virtual Backbone”)
  - UF Statewide Backbone VRF
  - Research Backbones (ability to extend XSEDE and other mission spec networks. For example, support for SSERCA projects)
- Content Peering
- Internet Services
  - Access to Internet2 Net+ services
  - Based on Cisco ASR 9010 routers
    - 10G, 40G, 100G edge capability.

All services available via IPv4 and IPv6
FLRNet - Services continued

- 150G of Research Peering Capacity
  - 10G Primary, 10G Secondary to NLR L3 ***
  - 100G to Internet2 Innovation Platform / AL2S
  - 10G to Internet2 direct to Atlanta (now via AL2S)
  - 10G AL2S Baton Rouge to FLR Pensacola PoP
  - 10G to Starlight (used for Esnet peering and other research) ***
  - Peering with Cwave at 10G. ***
- >52G+ of Commodity Peering Capacity.
  - 10G at the NOTA
  - 10G at TIE
  - 20G to Google
  - 1G with Transitrail ***, 2.5Gbps+ with Internet2 TR/CPS.
  - 10G to Akamai AANP
- 55G of Internet Capacity (Cogent, Level3 & Hurricane Electric)
- 65% of FLR commodity traffic enters or leaves via Peering paths rather than commodity providers. (Unmetered and free to FLR members)

*** L3 To be decommissioned February 17th. Services to be moved over to Internet2 AL2S
FLR - The Network Designed for Research
FY 2012-2020

- Planning ahead for a new 100 Gigabit FLRNet backbone – 2015
- Capability to increase FLRWave to ~8 terabits/sec
- Dedicated waves and VPNs available since April 2005
- Low latency, high network bandwidth with “headroom”
- 100 Gigabit connection to Internet2 Advanced Layer2 Services Network (AL2S) SDN/OpenFlow (Installed January 2013)
- Support access to GENI, GLIF, AMPath, Atlantic Wave, ESnet, LHCNet, US Ignite + many other resources worldwide
- AL2S extended to AMPath via 100G FLRWave – 2Q2014
What size network aperture do you require?
Typical FLR PoP Site
Typical Optical Node
ASR 9000 100G Linecard – Jacksonville PoP
What makes up an Innovation Platform?

- Internet2
- Campus
- You?
Three Key Components required at the Campus:

- 100Gbps Layer2 Connection
- Software Defined Networking
- Science DMZ (OpenFlow, DYNEs)

Providing:

- Unconstrained bandwidth availability, enabling widespread applications development and delivery

- A deeply programmable environment where compute, storage, visualization and transport capabilities can all be driven by applications

- Solutions that overcome traditional bottlenecks, passing high-bandwidth traffic and allowing performance monitoring

Source: Internet2 “Enabling Innovation on the Campus”
What is an Innovation Campus?

- Creates an environment of open and unconstrained bandwidth throughout the campus, regional and national networks
- Re-architects the campus network to support large scientific data flows (by building a “Science DMZ,” for example)
- Deploys software-defined networking (SDN) and OpenFlow capabilities to allow SDN-enabled application deployment
- Upgrades network connections to the nationwide R&E networking fabric with SDN and 100GE support
- Integrates network-awareness into adaptive applications
- Develops and deploys tools and best common practices to solve end-to-end network performance issues (PerfSonar)
As Innovation Platform partners, Innovation Campuses need to provide an upgrade path, based on the needs and requirements of their constituencies, to support end-to-end 100GE connectivity between their campuses and the Internet2 Network. Where a campus connects to the Innovation Platform via 100GE from an advanced regional network, the advanced regional network must participate in the Innovation Platform as well.

In addition, the Innovation Campus needs to provide a reliable Layer 2 transport network within the campus networking environment. This Layer 2 network will become both increasingly interconnected with higher-layer services, and increasingly programmable, to integrate with advanced applications—allowing the capabilities and suite of services to evolve quickly.
Innovation Campuses can support community and application innovations by making a long-term commitment to implement SDN technologies and supporting advanced applications for research groups that request it.

Innovation Campuses can also foster an environment for innovation by providing access to programmable network capabilities, affording researchers the ability to build and manage end-to-end VLANs—from within the campus, through the regional network, and across the Internet2 backbone to other regional networks, campus networkers and researchers. Often this capability will be provided using OpenFlow standards, but other SDN standards are suitable as well. This is likely to include support for a GENI Rack, as part of the larger GENI project.

As SDN capabilities expand to include production-grade virtualization and “slicing,” researchers should be able to load their SDN applications directly onto the network platform at the local, regional, national and global level.
The Science DMZ model, developed by the Department of Energy’s ESnet, is a dedicated portion of an Innovation Campus’s network, located as close to the network perimeter as possible, that serves only high-performance science applications and is directly connected at 100GE to the larger Innovation Platform. The equipment, configuration and security policies of the Science DMZ are optimized for science applications—not for general-purpose or “enterprise” computing. A Science DMZ must include support for end-to-end performance diagnosis and verification.

More info on Science DMZ can be found at ESnet’s website: fasterdata.es.net.
Science DMZ

Prototype Science DMZ

Source: Eli Dart – ESNet
Internet2 Innovation Platform – Acting with common purpose

- Innovation Campuses are crucial partners in the effort to build an Innovation Platform that provides the advanced architecture the research and education community needs to deliver fundamentally transformational solutions.

- The Internet2 community believes that a new Innovation Platform will produce a new breed of solutions for some of research and education’s most pressing challenges—from the rising cost of education to the increasing globalization of research—as well as a new breed of possibilities. Possibilities that will move beyond the research and education community to provide positive outcomes for our society. We believe our community can once again help to define a global path forward, together.
Innovation Platform Pilot Sites as of January 2014
The objective of this proposal is to bring the Internet2 Innovation Platform to researchers in two key buildings on the University of Central Florida (UCF) campus by extending a dedicated research network. UCF has already committed funds to establish the core of the research network in the Partnership III building in the Central Florida Research Park (CFRP) by the end of June 2013. The proposed plan will give on-campus researchers access to a Science DMZ, software-defined networking (including OpenFlow), and 10 Gb/s ports at their desktops. Our team represents collaboration between faculty and staff at the STOKES Advanced Research Computing Center (STOKES ARCC) and UCF’s Office of Information Technologies & Resources, which is precisely the necessary collaboration to implement this proposed phase of our long-term cyberinfrastructure (CI) plan.

PI’s: Wiegand & Finch
Questions?

Thanks!
Network Exponentials: From 56Kbps to 100Gbps in 25 years!