KINBER PennREN Network

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Enabling the Innovation Economy
Why Not Pennsylvania?

- Geography – Costly to Install Facilities
- ILEC’s and State Legislature Lobbyists
- Cooperation/Collaboration Between State Agencies, Public and Private Concerns
- Ownership/Control/Operation
Opportunity

• **American Recovery and Reinvestment Act**
  
  • $7.2B for “…complete Broadband and Wireless Internet Access”
  
  − Department of Commerce
    National Telecommunications and Information Agency
    $4.7B Broadband Technology Opportunity Program
  
  − Department of Agriculture
    Rural Utility Services
    $2.5B Broadband Initiatives Program
Idea for the PA-HPN...
2/17/10 – KINBER Awarded BTOP Grant to Build PennREN

Mission: To serve Pennsylvania through the establishment and sustainment of a high-speed research and education network that connects our institutions of higher learning with K-12 programs to advance the education, health care, work force development and training programs across the Commonwealth.

“Once completed, PennREN will not only form interconnections among the vast majority of our institutions of higher learning, but will also provide new opportunities to partner with K-12 schools, increase access to national and federal research centers and enhance the availability of telemedicine and the use of electronic medical records. The quality of life and economic development implications of this network cannot be overstated.”

Jeff Reel, KINBER Executive Director
Network Details

- Capital Budget - $128,958,031
  - Federal Stimulus Funds - $99,660,678
  - Matching Funds - $29,297,353
- 48 Strands Constructed for PennREN
  - Over 1700 Route Miles
  - Outsourced Fiber Maintenance
- 13 Optical Regeneration Service Nodes
- 56 Service Distribution Access Nodes
Award for Construction

Contracts for the design and implementation of the PennREN project were awarded to Quanta Services, Inc., and its LLC subsidiaries of Sunesys and Blair Park Services, both of which are based in Warrington. Local and regional workers employed by Sunesys and Blair Park Services will install the fiber optic network. Quanta also will provide $24 million in matching funds to supplement the federal award.

Sunesys is a premier provider of metro-based fiber optic infrastructure services. Sunesys is unmatched in its legacy of scope, speed and stability to build, manage and expand its pervasive network of next generation fiber and fiber-based transport services. Our networks service 4 of the 5 largest Metropolitan Areas of the United States.

Quanta Services, Inc. (NYSE: PWR) is a $3.3B specialized contracting services company, delivering infrastructure network solutions for the electric power, natural gas, telecommunications and cable television industries, with over 15,000 employees and operations in all 50 states and Canada.
Pennsylvania’s REN!
Middle Mile Network

Science and Research

Content and Collaboration

Interconnection And Access

Consolidation, storage, cloud, virtualization

Private, Shared Services

Health Centers

Universities, Science And Research Centers

Community Colleges, IUs

Economic Development Partnerships

PennREN
Services and Opportunities for Researchers and Educators

• Dark Fiber (dedicated)
• Dedicated point to point (multipoint) Ethernet
• Connectivity to shared statewide R&E backbone
• Access to National R&E backbones
• Access to commercial Internet

Research Partnerships

Collaboration Opportunities

Grants, Funding Opportunities

New “customers” and “participants” for programs

Cost effective ways to “connect” using PennREN
**PennREN Logical Design**

- **Service Nodes**
  - 13 Service Node locations for backbone connectivity (optical, L2, L3) services
  - Service nodes hosted at member institutions
  - Provides services to access nodes and optical regeneration where necessary

- **Access Nodes**
  - 56 Access Node locations
  - Access nodes hosted at member institutions
  - On ramps and off ramps for access to fiber and services
Deployment Strategy

Backbone Core Network

- Members can “join” the network at 13 service node locations
- Last mile connections from service providers
- Other RENs will be connected to PennREN at Services Routing Nodes
Growth Strategy

Using this strategy for “connecting” members, PennREN will grow and reach further and deeper into all corners of the state. Members can benefit from the “network effect”.

Access Network
- More members can “join” the network at 56 access node locations
- Last mile connections from other service providers to bring members onto the network
Who is Building PennREN?

- Blair Park/Sunesys: Statewide fiber optic network
- Blair Park/Sunesys: Fiber from right-of-ways into buildings
- Member IT, FM Teams: Rooms to host PennREN nodes
- Blair Park/Sunesys: Cabinets, fiber terminations in Service and Access Nodes
- TORREYPOINT: Network electronics (optical gear), Layer 2,3
KINBER’s Optics: OFS TrueWave® REACH Fiber

- **Challenges:**
  - A limited number of fibers (48)
  - An open access network
  - High bandwidth needs
  - Significant un-regenerated transmission distances
  - Possibly many technologies and platforms operating over the same optical fiber
  - A need to avoid multiple fiber types under the same cable sheath

- **Solution:**
  - A medium-dispersion NZDF (non-zero dispersion shifted fiber) as defined under ITU G.656
  - Supports the most possible wavelengths using conventional DWDM
  - Can support CWDM
  - Minimal dispersion compensation costs
  - Viable for next-gen 40G and 100G technologies
PennREN Network

• Engineered in partnership with TorreyPoint, ADVA Optical, and Juniper Networks
• 15 segment network
  – 48 strands of fiber optic cable across 1600 route miles within PA
  – 69 Sites
  – Layer 1 through Layer 3
  – GMPLS Design
Layer 1

- **ADVA FSP3000**
  - Both 2-degree and 8-degree ROADMs, depending on topology
  - Raman amps where needed
  - 40 channel system
  - 1 100Gb/s lambda (but presented to routers at multiple 10Gb/s using a 10x10 transponder card)
West Ring, DWDM System Design

Notes and Assumptions:
- Each power level shown represents the power level per channel (in dBm) at the amplifier output port. Assumed gain values (in dB) are shown for modules with provisionable gain.
- Fiber is assumed to be new OFS TrueWave Reach with an average loss of 0.23 dB/km at 1550 nm and an additional connector margin of 1 dB per span.
Optical layer - ROADM

- WDM engineering rules and scalability can be quite complex, especially in a metro environment (rings, mesh, every node an OADM)

- SDH/Sonet networks much simpler to plan:
  - Access to entire bandwidth at every ADM
  - Simple engineering rules (single hop only)
  - Easy addition of new network elements

- Optical layer reconfigurability addresses many, but not all of those issues:
  - Single wavelength granularity
  - Power budget and dispersion (but not OSNR) reset at every node
  - Reduced module variety (compared to filters dedicated to part of the spectrum)

ROADM simplifies engineering rules; WDM network scales more like an SDH/Sonet ring
Connection to Routers

- In some places, the routers will have grey 10Gbps Ethernet optics, fed into a transponder card.
- Transponder card does OEO and grooms the lambda to the appropriate channel.
- Will be done in places where the distances are too far to drive, directly from colored optics on the routers.
Connection to Routers

• In places where distances are within limits, the routers will have tunable optics

• Lambdas from the routers will be carried as alien waves across the DWDM infrastructure
Service Node Layer 2/3

1 G Client Access 20 Ports

10 G Client Access Ports

10 G Network Ports

10 G Client Access Ports

10 G Network Ports

20 1 G SFP Ports

4 10G XFP+ Ports

MX480

MX 480 min config with MPC-2’s

13 Service Nodes
Routing Nodes

- 2 of them
  - 401 N Broad, Philly
  - Alleghany Center Mall

- Also Juniper MX480
  - But with “-R” (full BGP routing table) cards

- IPv6 from day 1
GMPLS – Layer 1

• Alien Wavelength Support - ADVA ROADM network provides full support for DWDM alien wavelengths from Juniper route ports

• Standards compliant control planes provide automated GMPLS-based cross-platform provisioning and resource management

• Single network management solution for Layer 2/Layer 3 provisioning

• 100G Integration
GMPLS – Layer 2/3

• MPLS brings the benefits of Circuits to IP
  - Supporting network segmentation and privacy
  - Enhancing the end user application experience with traffic engineering that enables fine-tuning of the network to deliver appropriate level of QoS
  - Improving network resiliency with features like MPLS fast reroute, enabling sub 50 millisecond reroute to maintain real-time traffic during a node or link failure
GMPLS – Layer 2/3 (Cont.)

- MPLS brings the benefits of Circuits to IP
  - Boosting network scalability and performance
  - Allowing optimal utilization of network bandwidth
Dynamic Recovery in IP/Optical Benefits

1. Protection against Data Center / POP Isolation
2. <50ms protection against Fiber cut with FRR
3. Only 2 Wavelengths needed between Data Center and POP locations
4. Zero additional network cost:
   a. Router Interfaces fully utilized: no need for standby provisioning
   b. Number of Wavelength used is less or equal to provisioned Wavelengths
   c. Optical Network status before and after failure scenario is identical
Dynamic Recovery in IP/Optical Scenario

• **Scenario:**
  - Protect a Data Center with dual homed connection from a network isolation

• **Starting condition:**
  - The two core routers are equipped with GMPLS, supporting packet/optical on-demand provisioning
  - The Optical network is capable to react according to routing demand

• **Failure scenario:**
  1. First fiber cut is recovered by routing devices in <50ms by FRR → no consequent action in the optical network required
  2. Node isolation in case of second fiber cut recovered by activating backup path
Dynamic Recovery in IP/Optical Network Build-Out
Failure Scenario 1): 1st Cut
Failure Scenario 3): 2nd Cut
Repair Scenario
Normalization Scenario

- Normalization Procedure (packet traffic running on backup)
  1. 1st fiber cut repaired
  2. Optical LSP can’t be used, as end-points are busy
  3. Wait
  4. 2nd fiber cut gets repaired
  5. Packet traffic moved to O-LSP-2 in a make-before-break manner
  6. Optical Backup LSP is torn down
  7. Original O-LSP-2 can be recovered
  8. Packet traffic balanced among available optical LSPs
Normalization Scenario: Repair 1st Cut
Normalization Scenario: Repair 2nd Cut

- Data Center
- Server
- Core Router A
- Core Router B
- DWDM Switch S
- DWDM Switch T
- DWDM Switch U
- DWDM Switch V
- DWDM Switch W
- Router Y
- Router Z
- POP

Network Elements:
- MPLS LSP
- GMPLS O-LSP
- Failed O-LSP
Dynamic Recovery in IP/Optical Summary

1. IP/Optical Networking enables superior Data Center protection *without* installing additional Interfaces

2. Total Cost of Ownership can be tuned to *lowest cost* per bit without compromising availability

3. Operating an IP/Optical network combines the *reliability* of network planning with the benefits of agile networking
Service Nodes

- Each service node is capable of providing policy-based MPLS connection
Expected Deployment

- **Packet Optical Release 1**
  - DWDM XFPs directly on router interfacing ADVA ROADM node
  - Peer-to-Peer CP interoperability
  - Network management visibility of DWDM interface on select routers
- **Packet Optical Release 2**
  - Tunable DWDM pluggable optics interfacing ADVA optical transport network
  - Policy demarcation point for applying protection and restoration in the transport network
  - Network management visibility across entire DWDM domain
Summary

- GMPLS
  - Simplified manageability
  - Improved performance and scalability
  - Reduced cost
Questions?

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