Embedding Real-Time Substrate Measurements for Cross-Layer Communications

ERM: Embedded Real-Time Measurements

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Major Challenges

• Address the GENI challenge of architectural experimentations across diverse heterogeneous technologies by supporting **embedded real-time measurements** and enabling **cross-layer communications**

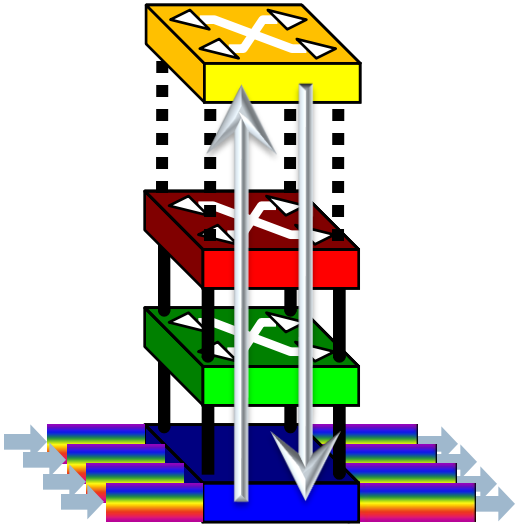
• Assess and develop GENI requirements for real-time measurements capabilities

• Evaluate performance impact under several scenarios of bidirectional cross layer information exchange

• Software integration into identified control plane framework(s) within the GENI prototyping efforts

Motivation: Cross-layer Signaling

- **Limitations of layered architecture: Additional functionalities of lower layers can not be communicated to higher layers**
- **Need for transparency to substrate (physical performance, topology, etc.) to enable GENI experimentation**
- ***Cross-layer communications* provides bi-directional information exchange between layers.**



Application (Video, Voice, Data)

Network layer (IP)

"Circuit" layer (SONET/SDH, OTN)

Physical layer (WDM)

Project Infrastructure and Requirements

Project cluster: all clusters

- Contribute to **all** control plane and framework groups
- Collaborate with other measurement groups
    - Measurement System (Univ. of Wisconsin)
    - Data Plane Measurements (Univ. Houston)

Possible Measurement Parameters:

- Bit-error rates (BERs)
- Burst errors
- Latency performance
- Physical topology structure
- … [to be determined by other clusters]

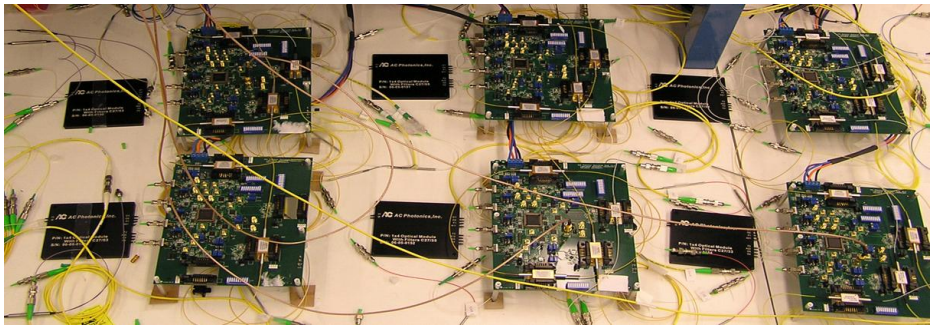
Require:

- Access to GENI cluster control planes for software development, testing, and release
- Open programmable control plane and router interfaces
- Embedded monitoring devices installed in the physical layer with ability to extract optical layer performance monitoring metrics, e.g. FEC modules within IP routers

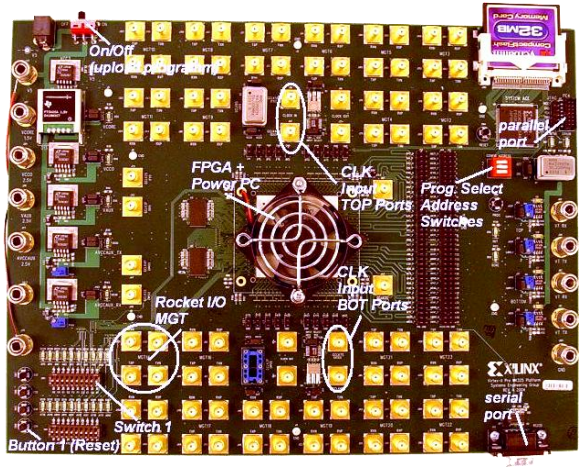
Project Plans: Task 1 (year 1)

Development of Real-Time Measurement Capabilities

- Identify real-time measurement resources within the GENI prototyping framework
- Evaluate user access to ERM to enable deeper exposure of optical substrate
- Evaluate measurement equipment and methods, possibly with experimental verification



Programmable optical substrate switching fabric

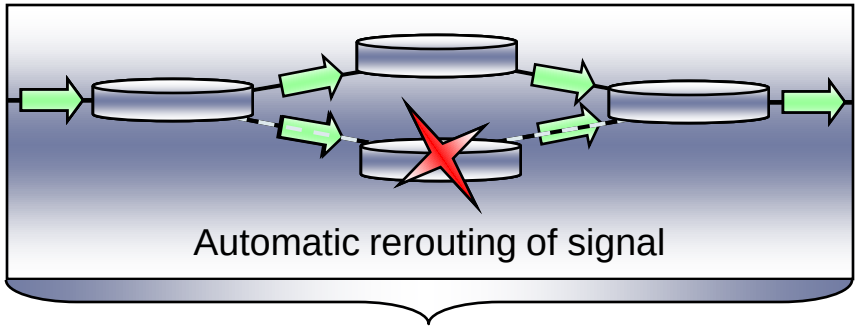


FPGA board

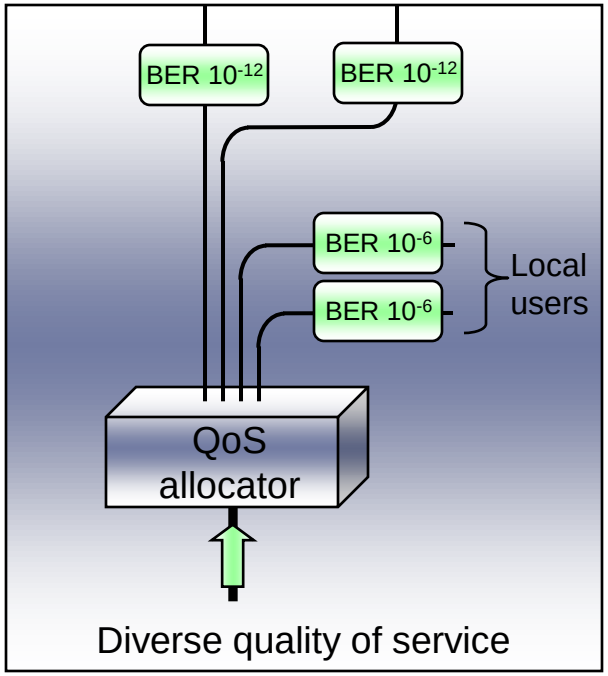
Dynamic optical data introspection for delivering diverse QoS, self management, and resilience

Network Resilience
- ubiquitous link monitoring
- failure diagnosis and repair
- traffic restored/rerouted

Quality of Service
- dynamic allocation
- tailored to users' needs
- efficient use of resources



Signal rerouted when failure encountered

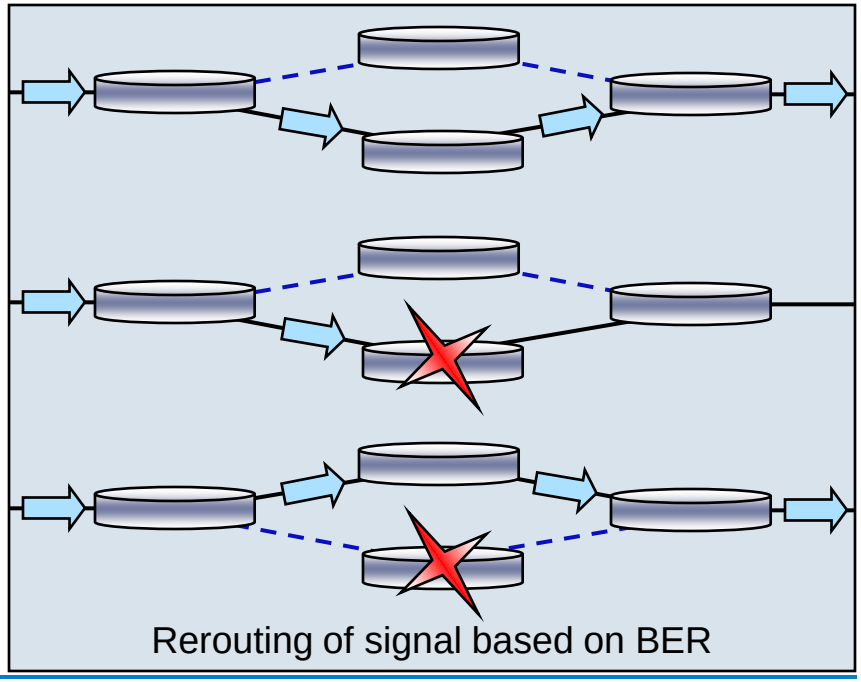


Broadband programmable multicasting via cross-layer communications

Demonstrate broadband multicasting in the optical physical layer

- Leverage cross-layer communication to reconfigure the packet routing based on performance monitoring measurements
- Provide varying QoS classes based on network topology and performance monitoring

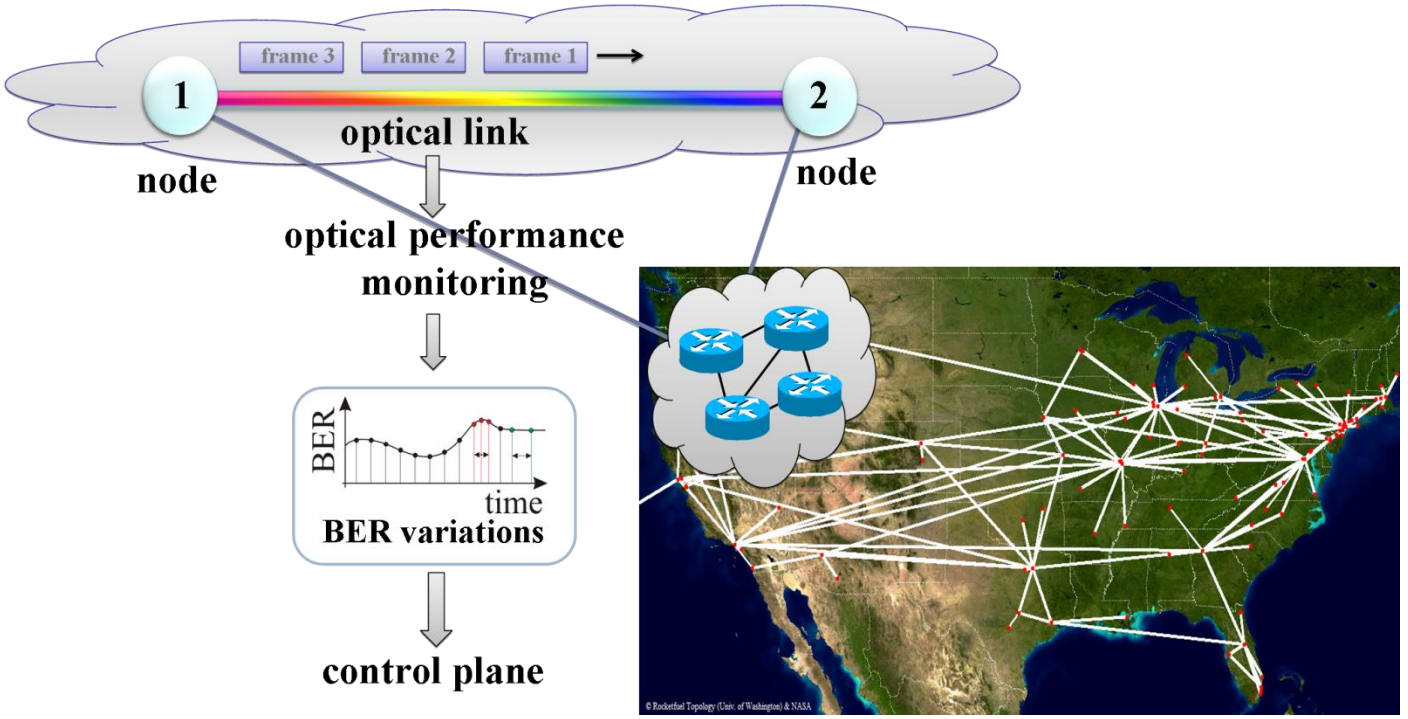
Signal is automatically rerouted through the network whenever it encounters a problem



Project Plans: Task 2 (year 1)

Cross-Layer Simulations

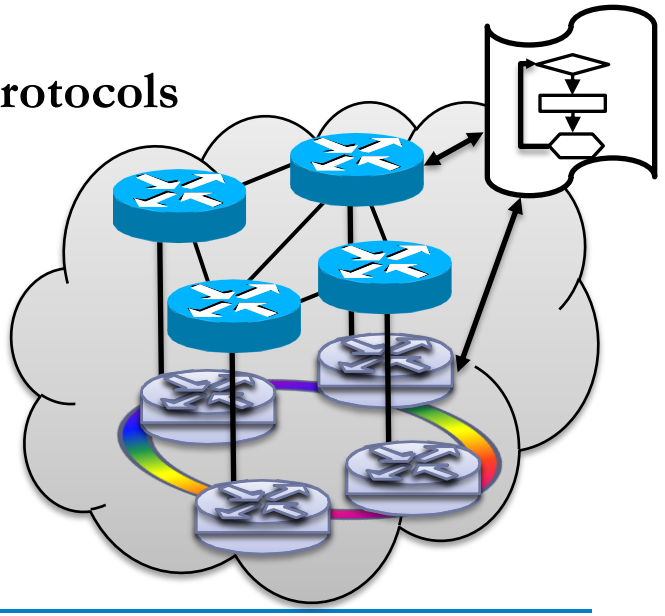
- Develop ERM-driven cross-layer experiments
- Evaluate performance impact in discrete event network simulation environment



Studying Cross-Layer Signaling with Network Simulators

Requires implementation of:

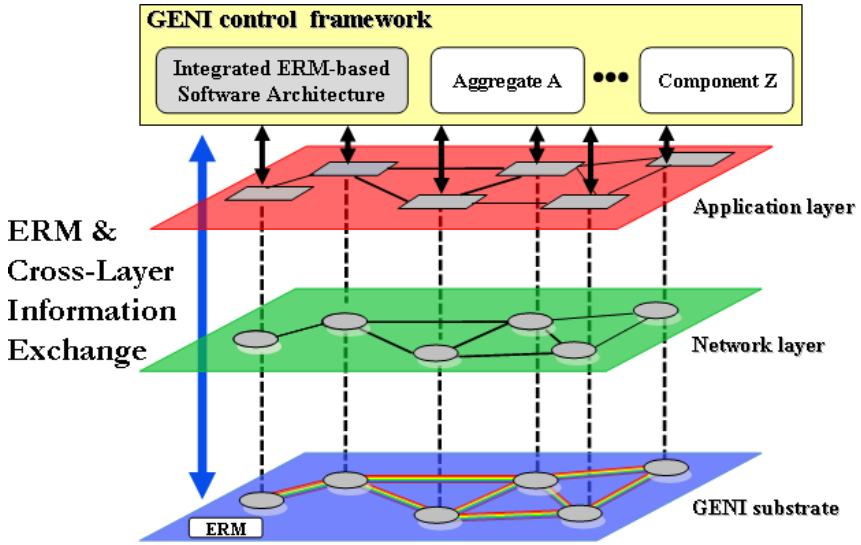
- **"physical layer" into network simulation software ⇨ WDM channels, models for physical impairments, mapping onto BER variations, ...**
- **QoS-aware wavelength assignment and routing protocols**
- **Modules for inter-layer communication**
- **Modified tools for analyzing simulation results**



Project Plans: Task 3 (year 2)

Software Integration

- Determine control plane requirements to enable ERM
- Investigate possible software integration techniques
- Develop software architecture based on ERM requirements
- Work with the GENI Project Office to identify a candidate control framework for integration within GENI infrastructure
- Collaborate with control group to integrate software



Conclusions

- Develop real-time embedded measurements capabilities within the GENI infrastructure
- Enable deeper exposure, transparency to substrate, for cross-layer information exchange and user access
- Integration with a GENI control plane:
  - software will dynamically monitor the performance of the optical substrate and allow for control and management decisions (e.g. rerouting) in a cross layer fashion based on the optical layer configuration and performance.