



GENI Breakout Session: From Core to Edge – Optical Networks, Measurements, and Real-Time Issues

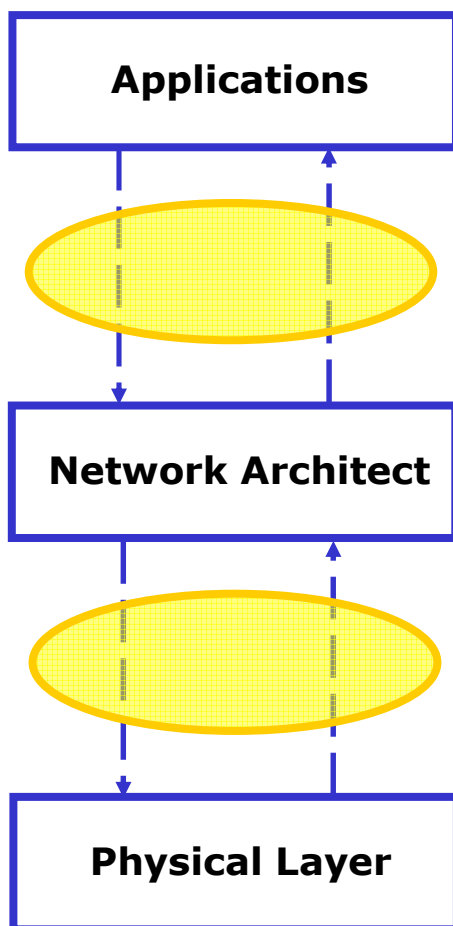
Co-Chairs:

Darleen Fisher (NSF), Lui Sha (UIUC), Biswanath Mukherjee (UC Davis)
dfisher@nsf.gov, lrs@cs.uiuc.edu, mukherje@cs.ucdavis.edu

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Optical Networking: The Inter-Disciplinary “Layers”



(“Customer” needs)

Traditional Networks: “one size fits all!”

In GENI, we need support for diversity in:
Bandwidth, Failure-Recovery Delay, Reliability,
Real-Time Support, Experiments + Measurements, ...
Network Economics Studies: Pricing, SLA, ...

(many of us)

In GENI,
+ can we experiment with routing protocols to combat optical channel impairments?
+ support breakthroughs in device technologies?
- optical RAM, ultra-wideband amp, “tunable” AWG, ...

(optical comm. channel) --
materials, devices, subsystems



GENI: Application-Driven Architectures

- Can end hosts (not just routers) “dial for bandwidth” on demand?
- Efficiently “groom” flows of diverse bandwidth on high-capacity channels
 - What is “inverse multiplexing”?
- GENI should support “Lambda Grids”
 - Collection of “lightpaths” (high-capacity bandwidth pipes)
 - Optimally mapped to application needs
 - Reconfigure connectivity as necessary
 - “Routed-edge, switched-core architecture”
 - **Concept of “virtualization”**
- Can GENI support “Light Trees”?
 - Multicasting in the optical domain
 - One to many; Many to one; Many to many
- Example Applications
 - Real-time collaborative visualization; Genomes-to-Life (GTL); etc.
- Can GENI allow users to set up a “separated” control plane?



GENI: Bridging Edge to Core

- Can GENI support emerging access network architectures?
 - Passive Optical Networks (PONs), WDM-PONs, Free-space optics, ...
 - Requirements
 - scalable (to support 1 Gbps (and beyond) per user)
 - flexible (in terms of instantaneous bandwidth allocations)
 - fair (to users and SPs over same access network infrastructure)
 - cost-effective
 - allow the development of **new unanticipated services/applications**
- Can GENI support hierarchical / hybrid nets seamlessly?
 - Core + metro + edge networks
 - Optical/wireless access networks



GENI: Robust Network Design

Today's Internet: reactive

- Dynamically discover alternate routes when failure occurs

GENI must support:

- “Proactive” methods
 - Plan efficient recovery strategies in advance
- Notion of “*degraded service*”
 - vs. “binary” (no service at all when failure occurs)
- Methods to deal with large-scale network disasters
 - correlated failures/attacks

Food for thought (what's the difference?)

- Survivable network architectures vs. network security
- Overloads vs. faults vs. attacks

GENI: (Optical) Hardware Acceleration



Can GENI support:

- OOO switching and all-optical networking
 - e.g., impairment-aware routing, quantum computing, code routing, ...
- Development of 3R regeneration, all-optical wavelength conversion, multicast-capable optical switching, optical memory, ...
- Denser integration of functionality and reduction of optical hardware footprint, power consumption, and cost
 - e.g., photonic integrated circuits, optical backplanes, ...



GENI Real-Time Issues: Overview

- Under the sponsorship of NSF, 2 RT GENI workshops have recently completed.
- Goals:
 - Identify the high impact real time applications that can take advantage of the potential of GENI.
 - Abstract their requirements and understand their impacts to slicing/isolation, virtualization, control of interactions at the [experimental facility in realistic scale](#)
 - Create a research agenda to create the infrastructure that will usher the convergences of communication, computing and the intelligent sensing and control.

RT Applications and Implications



- Remote robot assisted surgery so that the few expert surgeons may carryout the critical step (e.g. 15- 30 min)
- Coordinated reactions to prevent cascade failures in electric network.
- ...
 - Delay and jitter controls down to 1 msec or better
 - Distributed views and coordinated actions in RT
 - Control of redundant paths and routers for reliability
 - Certifiable isolation, protection, and interaction control mechanisms (ensuring well-formed dependency) for safety
 - Security: + tampering of remote, unattended sensors
- What are the implications to mechanisms for slicing and virtualization at each layer of abstraction from middleware to programmable routers, and slicing at physical layer?

Questions/Requirements for GENI



- Ability to inject controlled amount of “wild” traffic into a slice
- Ability to inject fault for testing dependability, isolation, and calibration across the stack
- Role of programmable switches/routers
- Measure link-level properties and diagnose problems (incl. access to switches/routers)
- Build repository of measured data (network/link properties)
- Access to (anonymized) payload traffic, not just control
- Ability to replay traffic
- Interactions between “slices”
- GPS granularity global time reference

Questions/Requirements for GENI--2



- Can GENI provide transparent connectivity (fiber termination) bet. two end points for research?
- Set of rules using which one can plug in his own equipment such as all-optical switch?
- Multilayer multicast capability
- Use bottom layer to build dispatch mechanism only, and leave policy making to users
- Need good management and monitoring system