Report from the September GENI Optical Workshop

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www.geni.net
Clearing house for all GENI news and documents

Workshop description

- Objective: further refine role/opportunity for GENI optical substrate.
  - How can optics radically alter the future global network architecture?
  - Slicing and federation
  - Enhance services for the CS and networking community
  - Cost realism
- Diverse participation, 45 attendees
  - Industry (15)
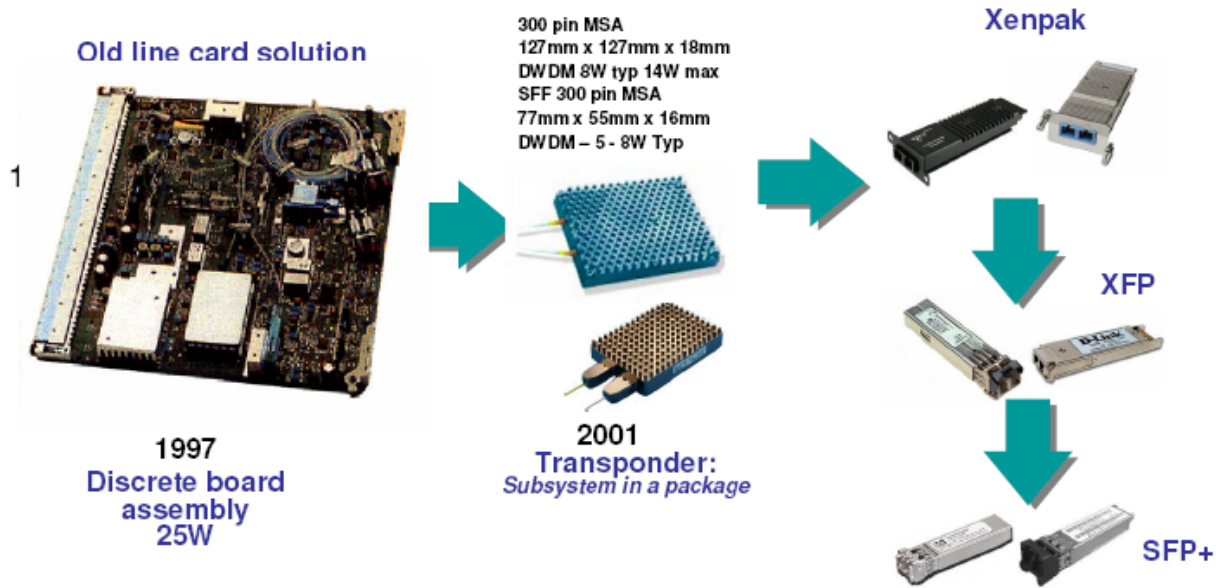 - Academia (21)
  - Government agencies (9)

Workshop organization

- Experts in five topic areas
  - Integrated photonics; Tom Koch
  - Network topologies; Ruth Ann Mullen
  - Commercial development roadmap; Franko Kueppers
  - Cross layer research opportunities; Keren Bergman
  - Access and RF/optical systems; Stojan Radic

- Active audience participation

- Senior panel summary: Biswanath Mukherjee, Alan Willner, Curtis Menyuk

Call for a researcher-accessible, flexible, heterogeneous optical substrate that encourages and accommodates rapidly changing technology.

Five future design influences: PICS

Old line card solution

1

1997
Discrete board assembly 25W

300 pin MSA
127mm x 127mm x 18mm
DWDM 8W typ 14W max
SFF 300 pin MSA
77mm x 55mm x 16mm
DWDM – 5 - 8W Typ

2001
Transponder:
Subsystem in a package
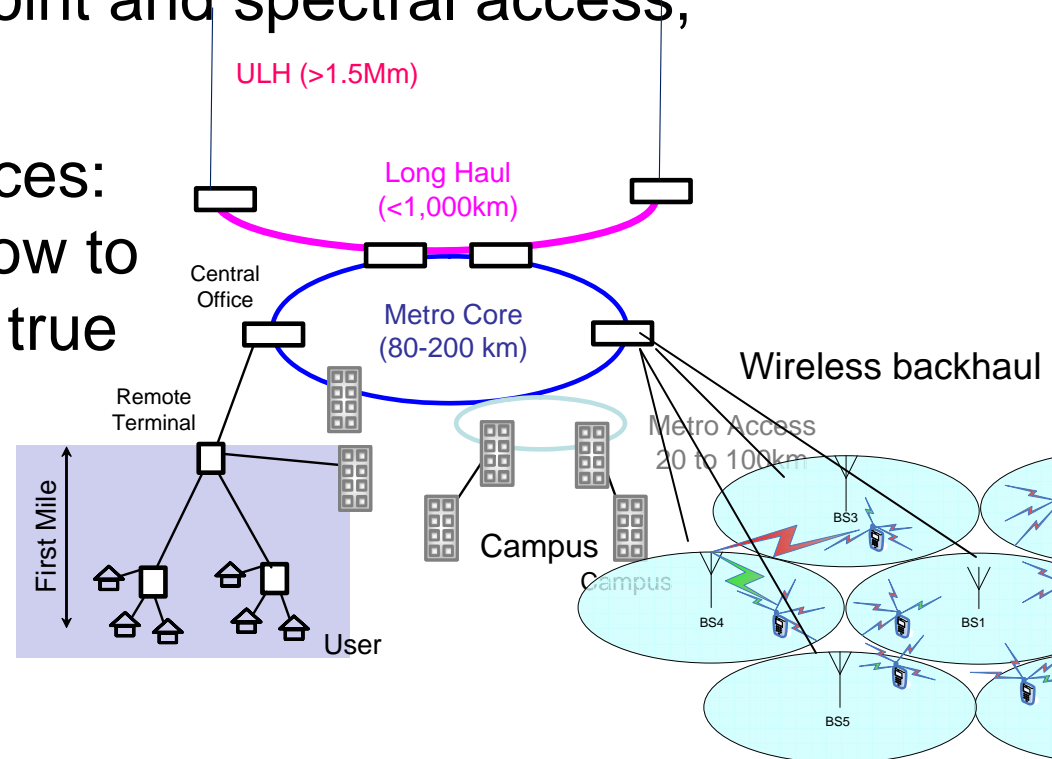
Xenpak

XFP

SFP+

- Dramatic reduction in cost and power and increased functionality via photonic integration will change architectures
  - Links and nodes, bandwidths, granularity, remote functions, intelligence, integrated capabilities

- Brand new topologies, services, and bandwidth from the edge

  - Giant PONs (passive optical network), wireless optimization, multipoint and spectral access, bandwidth driver

  –Heterogeneous services: where to aggregate, how to protect, how to realize true end-to-end?

  –Where is the edge?

ULH (>1.5Mm)

Long Haul (<1,000km)

Central Office

Metro Core (80-200 km)

Wireless backhaul

Remote Terminal

Metro Access 20 to 100km

First Mile

Campus

Campus

BS3

BS4

BS1

BS5

User

Five future design influences: crossing layers

- GENI has the potential to support a vibrant cross-layer research agenda
  - Optics dual role: part of the service, part of the experiment
  - Agile, on-demand optical circuits
  - Self-configuring, intelligent, adaptable interfaces
  - Multipoint, broadcast and select architectures
  - Dynamic-automatically-provisioned architectures
  - RF/optical interfaces and access—end-to-end
  - Network operations: automation, simplified management, power-efficient nodes
  - Optics is not just bandwidth: programmable, intelligent, application-aware are all possible

App

Trans

Net

Link

Phys
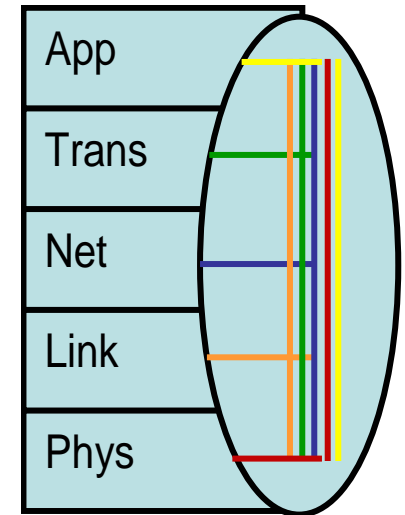
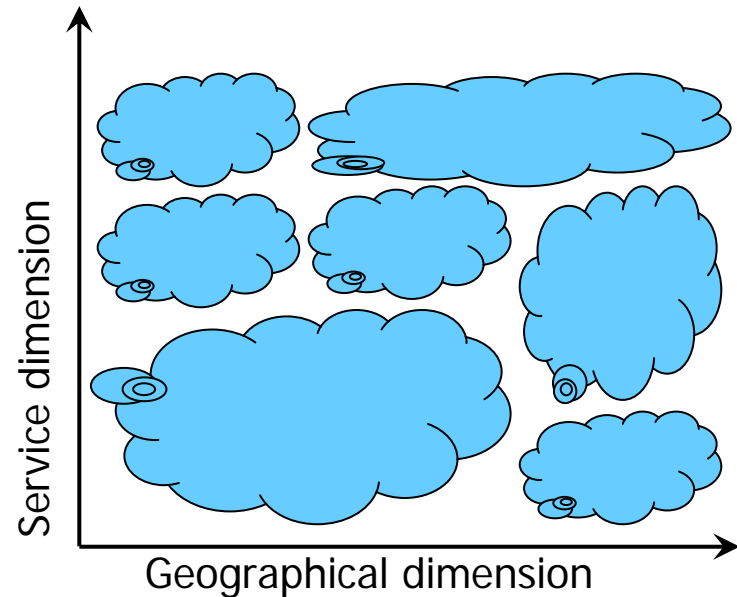# Five future design influences: topology, operations

- GENI may dramatically alter topology-fashion
  - Baseline mesh: but where is the edge?
  - Can programmable topologies replace pt-pt circuits?
  - Will GENI change traffic patterns?
  - Optically-driven dislocations: power, PICs, applications, wireless, dynamic protection
- Commercial folks are focused on operations (services)
  - Power!, simpler operations, resilience, video
  - OOO vs OEO, automation, restoration, bandwidth

Future design influences: business

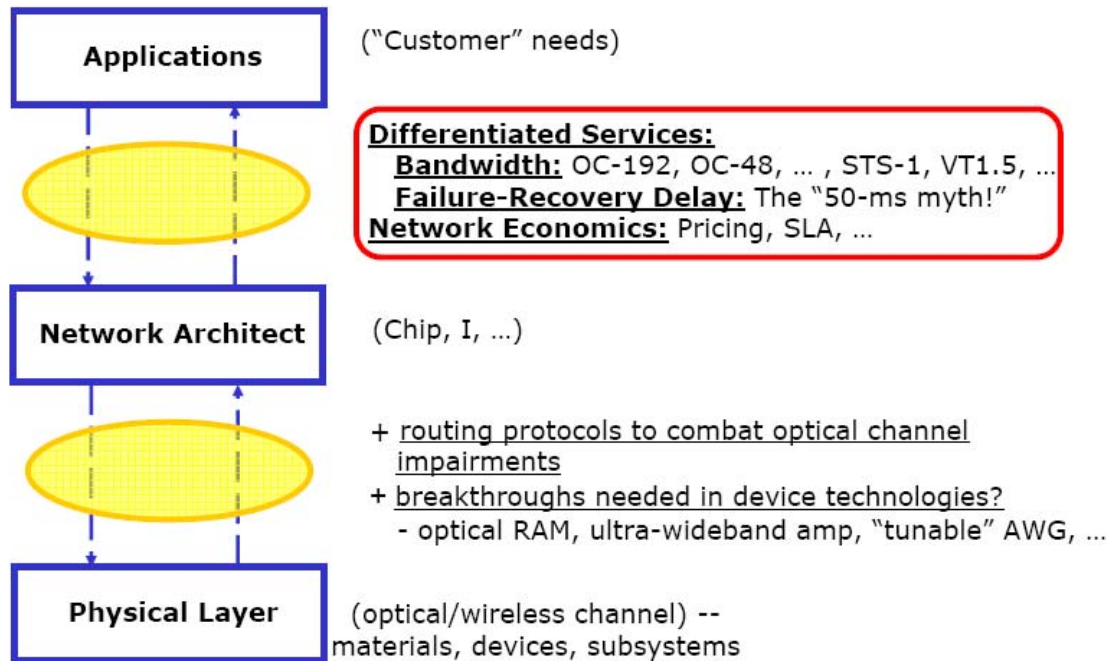**Deregulation of almost all global markets leads to a broader variety of players:**

- Content, service, access, transport providers
- Local, regional, national, global players

☞ **Not 'the' single master-planned network**

Senior panel summary

Optical Networking:
Holistic Approach

| Applications | ("Customer" needs) |

Differentiated Services:
  Bandwidth: OC-192, OC-48, ... , STS-1, VT1.5, ...
  Failure-Recovery Delay: The "50-ms myth!"
Network Economics: Pricing, SLA, ...

| Network Architect | (Chip, I, ...) |

+ routing protocols to combat optical channel impairments
+ breakthroughs needed in device technologies?
  - optical RAM, ultra-wideband amp, "tunable" AWG, ...

| Physical Layer | (optical/wireless channel) -- materials, devices, subsystems |

Sept. 25, 2007   © B. Mukherjee, UC Davis: "GENI Optical Workshop"   5

- Push/pull technology relationship
- Cooperative research
  – economics,
  – services,
  – protocols,
  – architecture,
  – modeling,
  – channels,
  – components

NSF GENI Workshop

Q: How Can GENI "Fail" From the Optics Perspective?
A: If it is Black & White ("It's Analog!")

Alan E. Willner

**University of Southern California
Los Angeles, CA 90089-2565**

Heterogeneity is in, we need much more heterogeneity in the optical layer!

Multiple "optical" granularities. Analog and digital. Multiple topologies.

Optics can be adaptable and flexible, not just rigid (big) pipes—this takes cross-layer research/thinking.

Find the right balance: too rigid, or too wild and wooly, and GENI will fail.

How to design the optical substrate?

- Think in terms of functions, not just new devices
  - Automation: self-managed "adaptive" resources (impairments, wavelengths, bandwidth, routes)
  - Efficient routing: ooo vs eoe, granularity, # of nodes
  - Monitoring network: routing based on physical state of network
  - Multi-variable routing tables: determine variables, interpret cost functions
  - Reliability: dynamic levels of protection
  - Security: new optical layer vulnerabilities and opportunities
  - Brand new services and topologies: intelligent, adaptable interfaces
  - Flexible topologies: what time scale?
  - Cheap optical access: if/how to support direct end-users
  - Greater access bandwidths: wireless and wireline, is core ready?
- Support key substrate functions, parallel technology paths

Senior panel summary

- Building (and using) GENI is a cross-disciplinary exercise.

- We must encourage teams that include Social, Behavioral, Economic, CS, Networking, Engineering, and Physics collaborating.

- We [academic research] also must ally with industry and government agenicies.

Key consensus points

- Optics can help GENI, and GENI can optical research
  - Flexibility, brand new architectures
  - Cross-flow of ideas with dual-, multi-financial support
- Ensure vibrant cross-layer research agenda
  - Give researchers access to the optical layer
- "Power as an independent variable"
  - Power will drive future network and equipment designs
  - GENI must go "green" and optics will play an essential role
- Don't drive to a single, static topology, experiment with topology
- GENI must avoid technology lock-in, obsolescence
  - Embrace uncertainty and controversy, enable research and provide flexibility
  - Parallel path: burned-in and high-risk technologies
- Commercial research roadmap consistent with GENI, but highly directed objectives and incremental process
- Future-looking and non-competitive: GENI must be the "change agent" for global scale networks

UCSB

Layered Research Representation

Provides programmable framing and transport protocols.
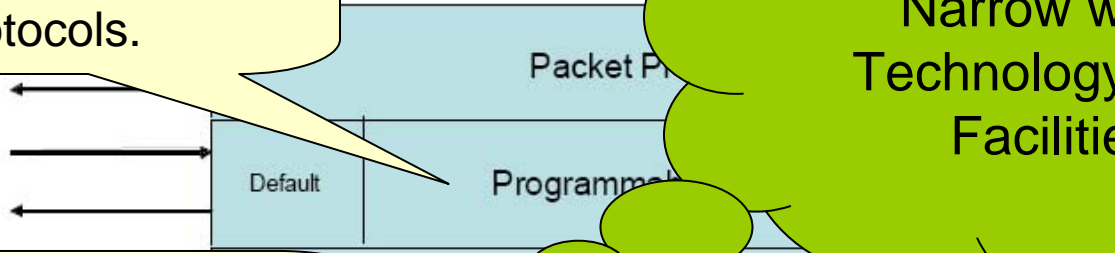
Services?
Operations?
Narrow waist?
Technology suite?
Facilities?

Packet Pr...

Default | Programma...

Provides direct optical access to any wavelength or spectrum.

Fast Circuit Switch

Wavelength Selective Switch

Provides electrical access to any wavelength on the network and also supports fast-circuit cut-through.

Fiber Switch

Provides direct access to multiple fibers.

Next steps

- Identify and design around "fixed" and "flexible" technology points
  - Spiral development, federation, slices, narrow waist
- Develop strawman for heterogeneous optical substrates
  - include lessons learned from past testbeds
- Encourage "cross-layer" thinking/interactions
  - Educate, collaborate, create interdisciplinary teams
  - Implementers and funding agents
- Solicit additional commercial feedback: parallel implementation path
- Identify (near term) risk areas for prototyping activity