

# SWITCH

The Swiss Education & Research Network

## **GENI – A new breed of testbed for network innovation**

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GENI: Global Environment for Network Innovations.

- Initiative planned by the NSF CISE (Directorate for Computer and Information Science and Engineering). First workshops in early 2005, first “Project Execution Plan” (PEP) from January 10 2006.
- Large-scale experimental facility to help developing the “future Internet”. Includes
  - Research program
  - Global experimental facility
- Funded by NSF through grants for US research community
- Long-term project

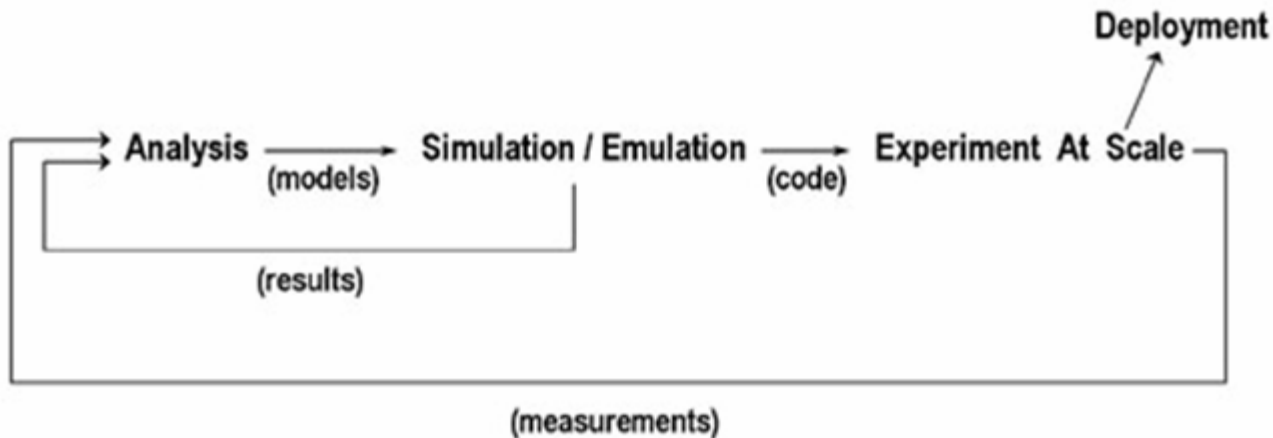
The PEP identifies a number of fundamental deficiencies of the current Internet

- Inadequate security in the face of eroding trust
- Cannot tap the full potential of emerging technologies (wireless communication, sensor networks etc.)
- Inadequate level of availability (should be “at least as available as the telephone system”), must work in times of crisis etc.
- Hard to configure and manage

Incremental changes may not be able to fix it all. Research

- New core functionality (naming, addressing, ...)
- Enhanced capabilities (security, availability, ...)
- New architecture (wireless, ad-hoc, pervasive devices, ...)
- New services/applications (large-scale distributed apps., ...)

## Research cycle

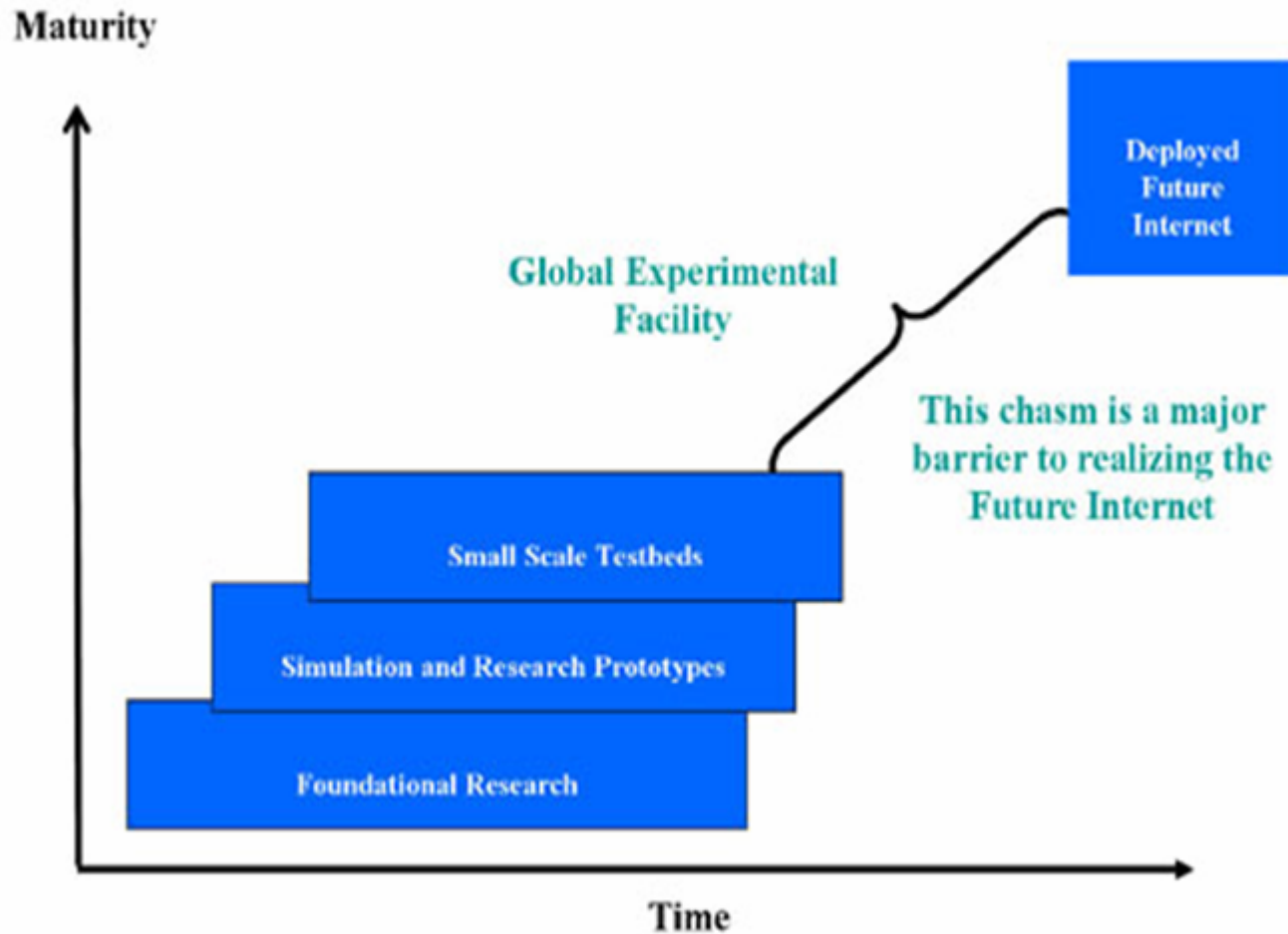


- Simulation/Emulation
  - Backed by conjecture rather than empirical data
  - Overly simplistic modelling (topology, workload, device failure etc.)
- Theoretical Analysis
  - Mostly even more detached from reality

Extensive experimentation is required to understand complex new protocols. **Need real users, real traffic, real implementations, real measurements.** However, ...

## Two types of testbeds

- Production-oriented
  - Only incremental changes to existing technologies
  - Stable implementations
  - Real traffic from real users
  - Conservative
- Research-oriented
  - Radical new designs (“clean-slate”)
  - Bleeding edge implementations
  - No real users/small group of dedicated testers
  - Synthetic traffic



- Collection of globally distributed hosts (700+ hosts, 300+ sites, 30+ countries)
- Run common software for management
- Key concepts:
  - *Distributed virtualization*
    - *Each physical node hosts any number of virtual nodes*
    - *A collection of virtual nodes forms a slice*
    - *Nodes within a slice form an overlay network on top of the Internet*
  - *Programmability: virtual nodes are freely programmable*
  - *Opt-in per-user/per-application*
    - *Attracts real users*
    - *Demand drives deployment*
- *New paradigm*
  - *Support real users and clean-slate design simultaneously*
  - *Provide plausible deployment path*

## Limitations

- Commodity PC hardware, no way to incorporate other node or link technologies
- Artifacts from underlying network may affect experiments
- Notoriously underprovisioned (node hardware, network capacity at hosting organizations)
- Steep learning curve
- Largely designed and supported by graduate students

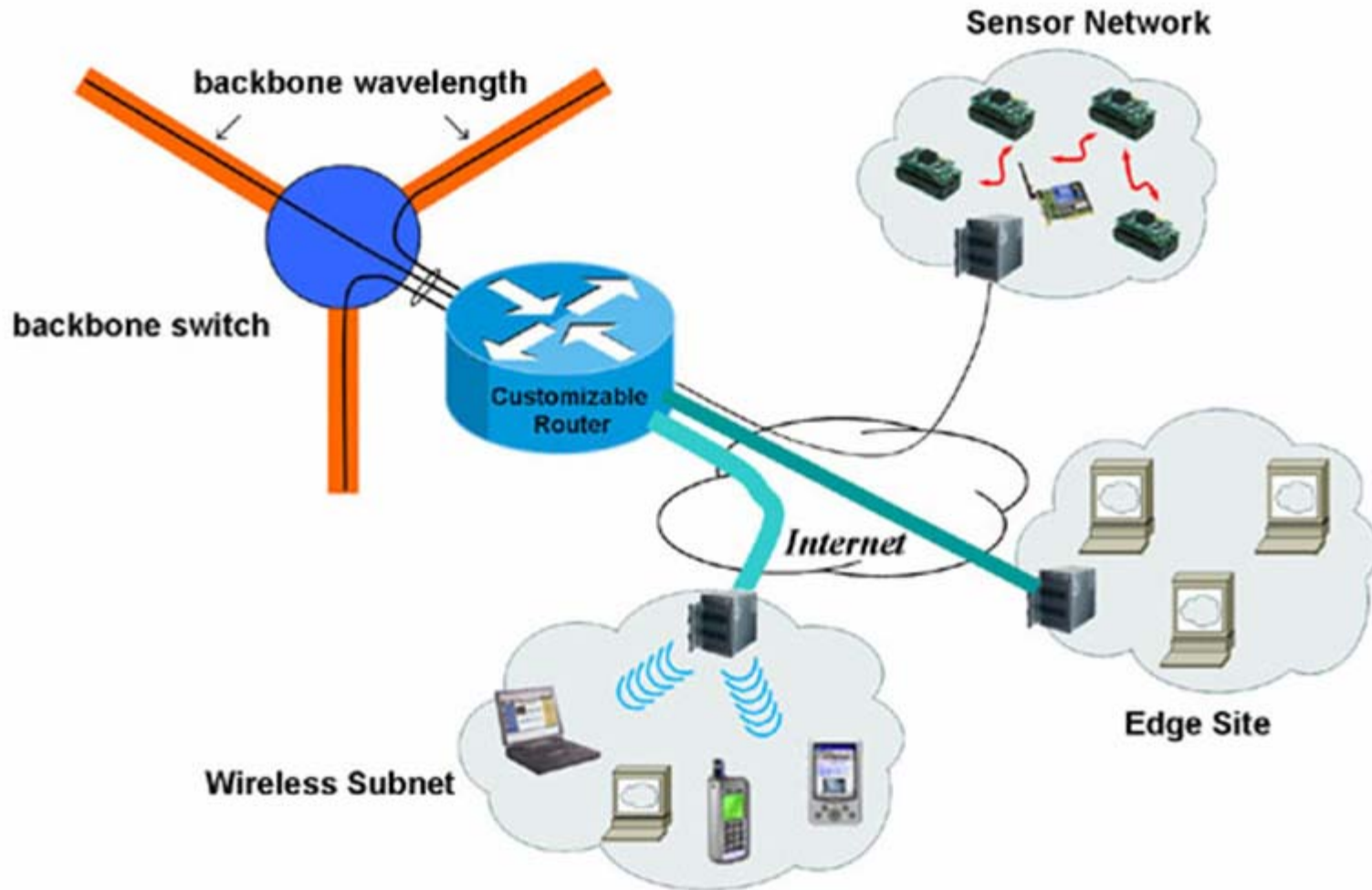
GENI builds heavily on ideas from PlanetLab and takes them to the next level. Two components

- Physical network substrate
- Global management framework

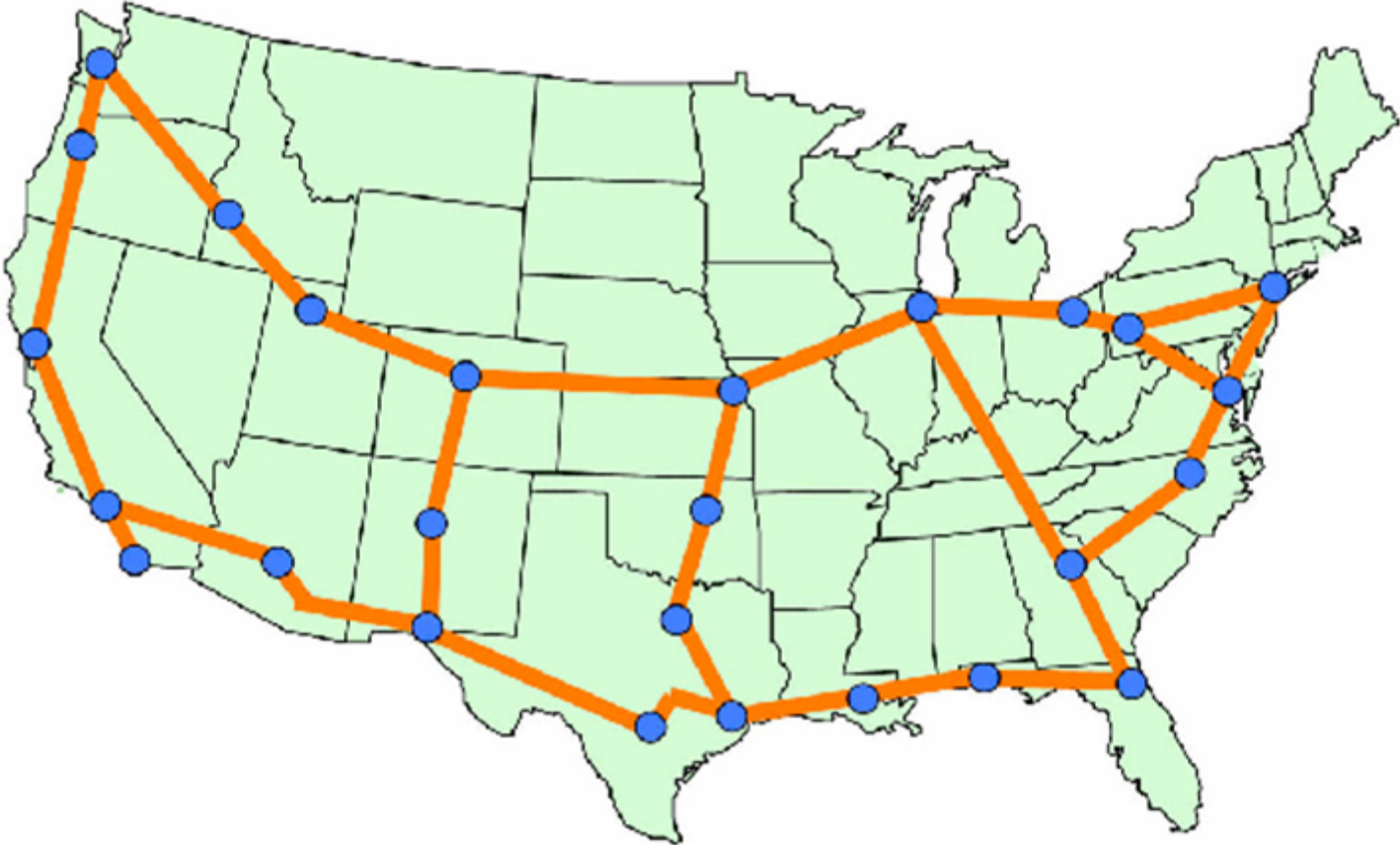
Slice as central concept: the management framework virtualizes the physical substrate and makes it available to experiments as slices.

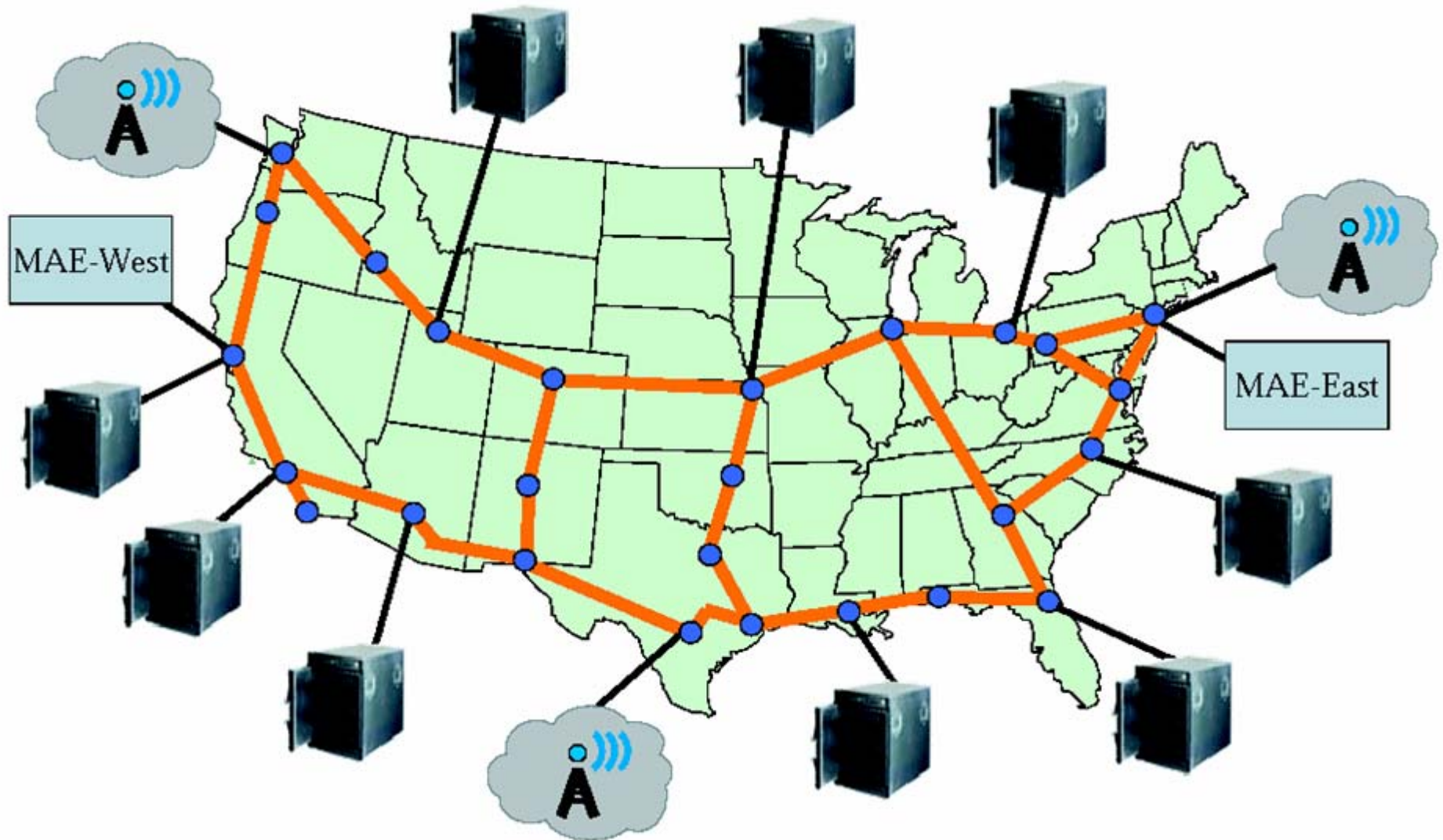
Expandable collection of building blocks.

- Node technologies
  - PC clusters supporting virtual machines, very similar to PlanetLab
  - Customizable High-Speed Router
  - Optical switching
- Links
  - US fiber facility (National Lambda Rail)
  - Tail Circuits
    - Lambdas, Tunnels, MPLS etc.
    - Provide “ingress points” for edge sites into GENI
- Wireless subnets
  - Five technologies (802.11, 3G/WiMax, Cognitive Radio Subnet, Sensor Subnets)



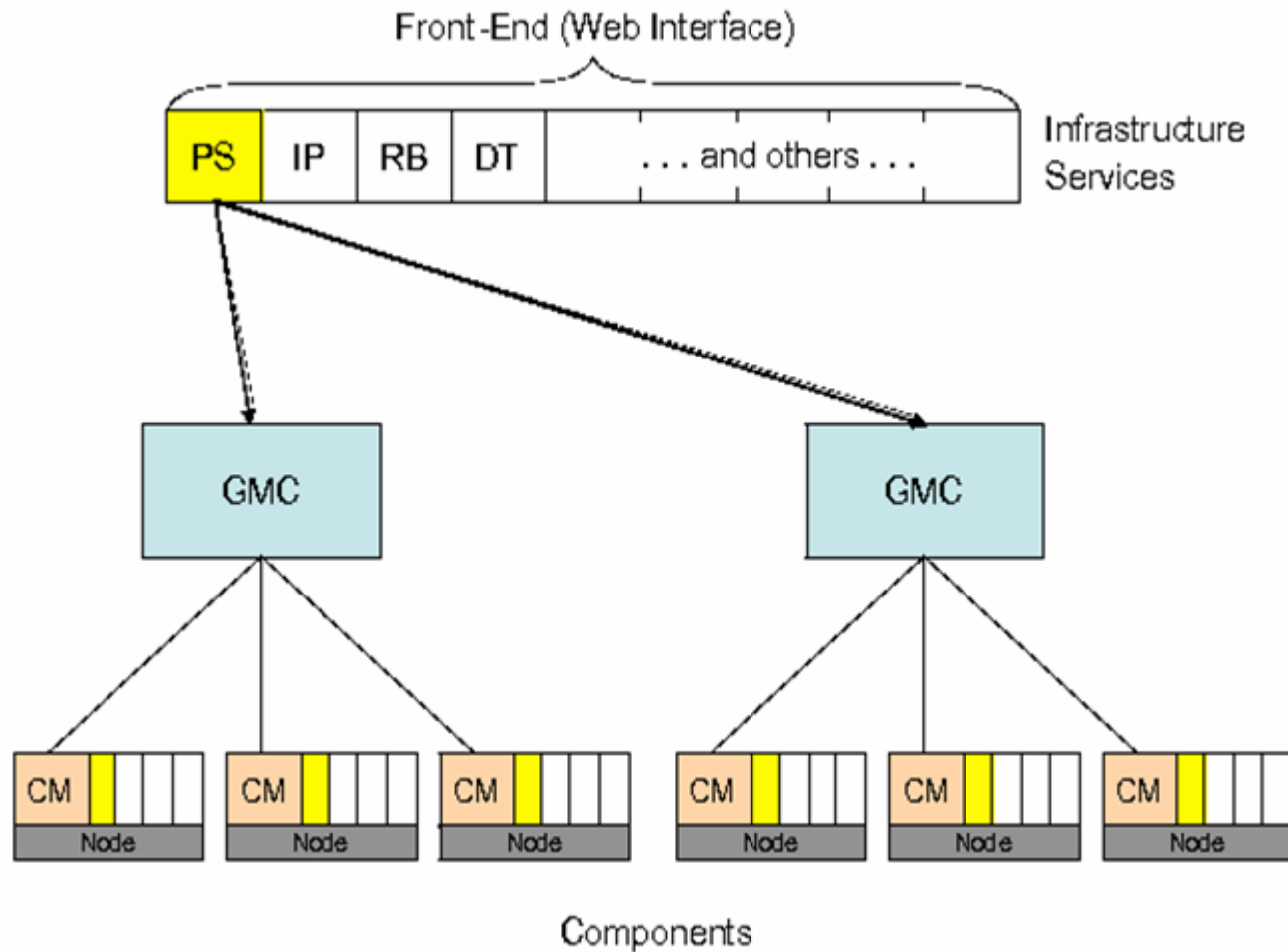
- Initiative of US universities, regional networks, private sector technology companies
- Not-for-profit, 20 members
- Planned merger with Internet2 (founding member)
- “By researchers, for researchers”
- Nationwide dark fiber infrastructure, IRU from Level(3), Wiltel, AT&T
- DWDM, up to 32-40 lambdas per fiber, 10Gbps each
- Sole purpose is to provide network resources to the research community (“User-empowered networking resources and capacity”)





Embeds slices into the GENI substrate and controls them on behalf of experiments. Layered design

- Component manager
  - Controls a building block
  - Provides interface to virtualized capabilities the building block offers
- GENI Management Core (GMC)
  - Instantiate slices across collections of building blocks
  - Remotely manage slices
  - Needs to be small, simple, well-defined.
  - Expected to remain stable during GENI lifetime
- Infrastructure services
  - Provides user/administrator interface to GENI
  - Manage/monitor slices, allocate resources, provide development tools
  - Expected to change during GENI lifetime as technology progresses



## Experimental Next Generation Internet in Europe

- Project proposal by Cisco, started in April 2005, looking for NRENs as partners
- Originally focused on building research infrastructure like NLR in Europe
- New focus after announcement of GENI in August 2005
- Leverage GEANT2 capabilities (lightpaths) to build a GENI counterpart in Europe
- Cisco's CRS-1 with IOS-XR fulfills GENI virtualization requirements
- Partial mesh between CRS-1's at participating NRENs using 10GE lightpaths
- Project still in very early stage

- GENI
  - <http://www.nsf.gov/cise/geni/>
  - <http://www.geni.net/>
- NLR
  - <http://www.nlr.net/>



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