GENI Project Update

IETF-78 MOBOPTS Research Group

Maastricht, Netherlands

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www.geni.net

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Outline

- GENI – Exploring future internets at scale
- GENI's status and plans
  - GENI Spiral 2
  - Meso-scale buildout
  - Starting experimentation
- Looking ahead

Global networks are creating extremely important new challenges

Science Issues

We cannot currently understand or predict the behavior of complex, large-scale networks

Innovation Issues

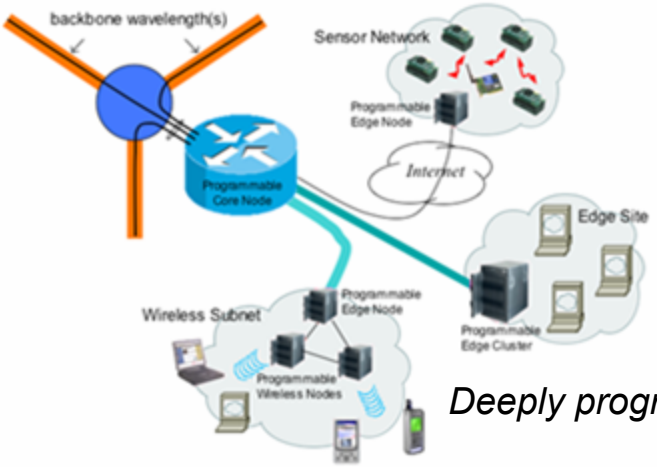
Substantial barriers to at-scale experimentation with new architectures, services, and technologies

Society Issues

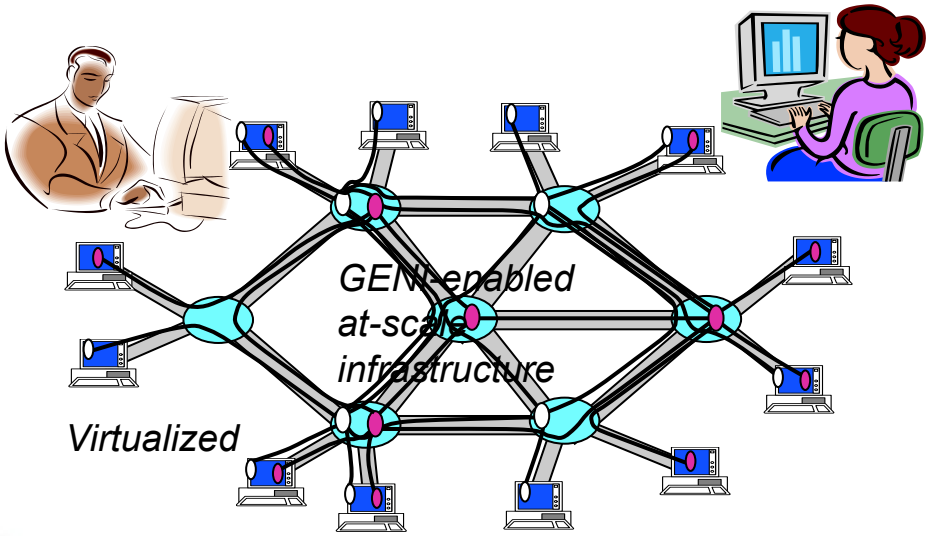
We increasingly rely on the Internet but are unsure we can trust its security, privacy or resilience

GENI Conceptual Design

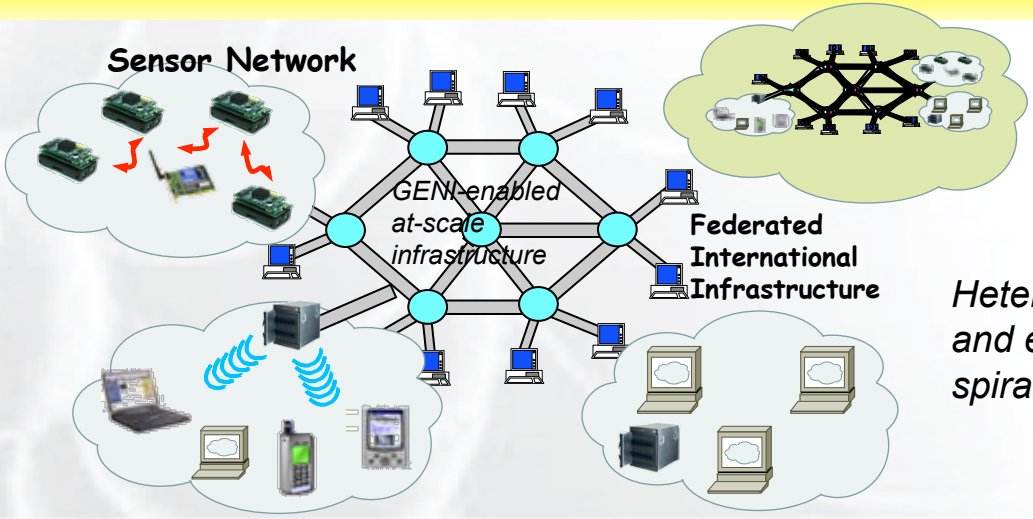
Infrastructure to support at-scale experimentation



Deeply programmable



Programmable & federated, with end-to-end virtualized "slices"



Heterogeneous, and evolving over time via spiral development

How We'll Use GENI

Note that this is the "classics illustrated" version – a comic book!

Please read the Network Science and Engineering Research Agenda to learn all about the community's vision for the research it will enable. Your suggestions are very much appreciated!

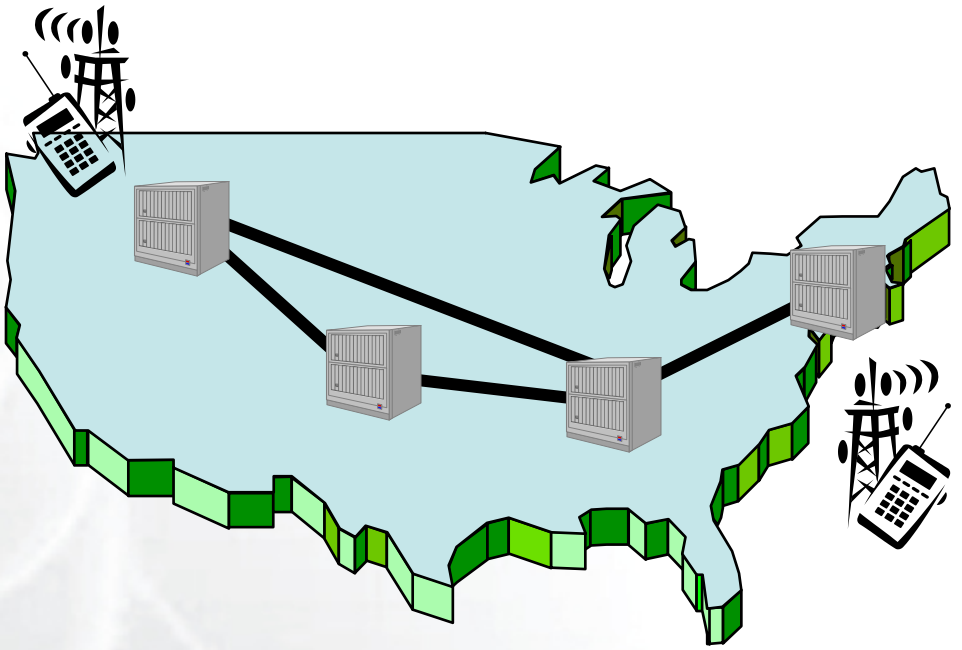
A bright idea

I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

That will never work! It won't scale! What about security? It's impossible to implement or operate! Show me!

Trying it out

My new architecture worked great in the lab, so now I'm going to try a larger experiment for a few months.



He uses a modest slice of GENI, sharing its infrastructure with many other concurrent experiments.

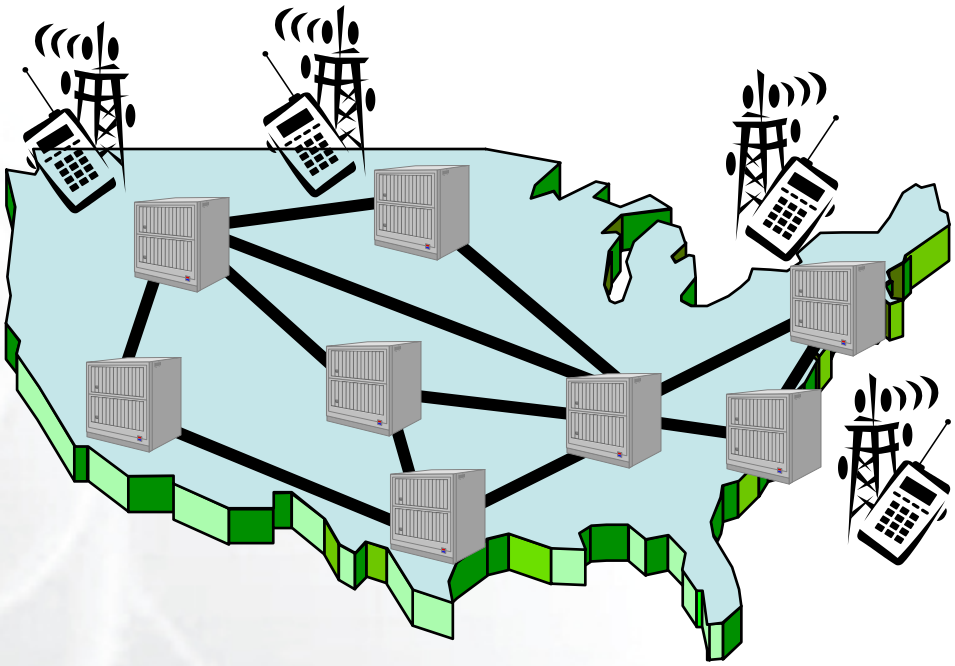
And so he poured his experimental software into clusters of CPUs and disks, bulk data transfer devices ('routers'), and wireless access devices throughout the GENI suite, and started taking measurements . . .

It turns into a really good idea

Boy did I learn a lot! I've published papers, the architecture has evolved in major ways, and I'm even attracting real users!

Location-based social networks are really cool!

His experiment grew larger and continued to evolve as more and more real users opted in . . .



His slice of GENI keeps growing, but GENI is still running many other concurrent experiments.

Experiment turns into reality

My experiment was a real success, and my architecture turned out to be mostly compatible with today's Internet after all – so I'm taking it off GENI and spinning it out as a real company.

I always said it was a good idea, but way too conservative.

Meanwhile . . .

I have a great idea! If the Internet were augmented with a scalable control plane and realtime measurement tools, it could be 100x as reliable as it is today . . . !

And I have a great concept for incorporating live sensor feeds into our daily lives !

If **you** have a great idea, check out the **NSF CISE Network Science and Engineering** program.

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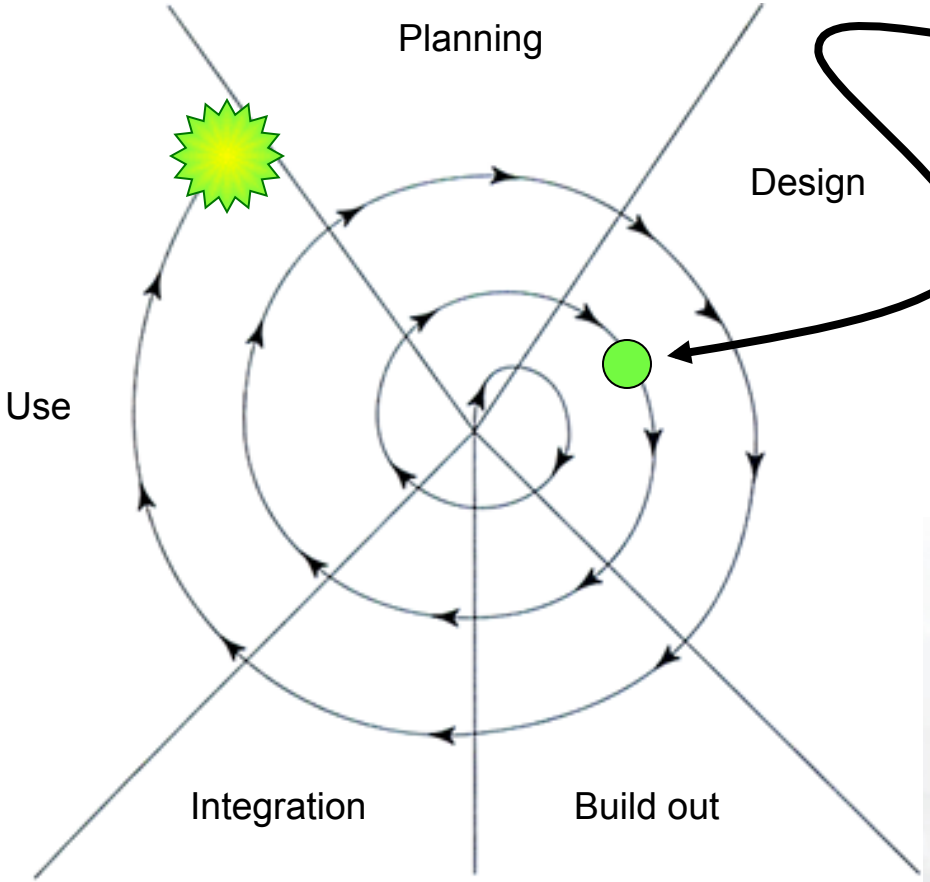
Spiral Development

GENI grows through a well-structured, adaptive process



GENI Prototyping Plan

GENI Spiral 2

Early experiments, meso-scale build, interoperable control frameworks, ongoing integration, system designs for security and instrumentation, definition of identity management plans.

Envisioned **ultimate goal**

Example: Planning Group's desired GENI suite, probably trimmed some ways and expanded others. Incorporates large-scale distributed computing resources, high-speed backbone nodes, nationwide optical networks, wireless & sensor nets, etc.

- ## Spiral Development Process

  Re-evaluate goals and technologies yearly by a systematic process, decide what to prototype and build next.

Current GENI Status

GENI-enabling testbeds, campuses, and backbones

BEN
Breakable Experimental Network
of the Future
ORBIT
PLANETLAB
An open platform for developing, deploying, and accessing planetary-scale services
ProtoGENI
UIC
UMASS LOWELL
THE QUILT
UPMC
PARIS UNIVERSITAS
at&t
ARISTA
Battelle
ca
ciena
CISCO
FUJITSU
CNRI
hp
invent
IBM
infinera
JEFFREY HUNKER ASSOCIATES LLC
Technology • Government • Global business • Insight with impact
JUNIPER
NETWORKS
nicira
NETRONOME
Microsoft
NEC
Qwest
Radio Technology Systems
SPARTA

Infrastructure examples

DRAGON core nodes
Mid-Atlantic Crossroads

WAIL, U. Wisconsin-Madison

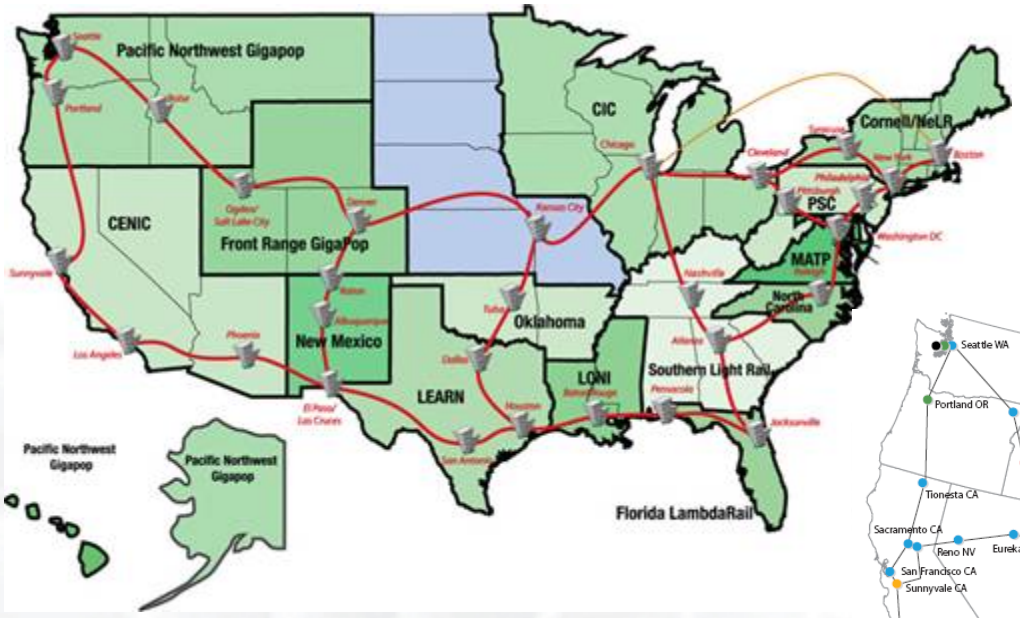
DieselNet, U. Mass Amherst

ViSE,
U. Mass Amherst

SPPs, Wash U.

ORBIT, Rutgers WINLAB

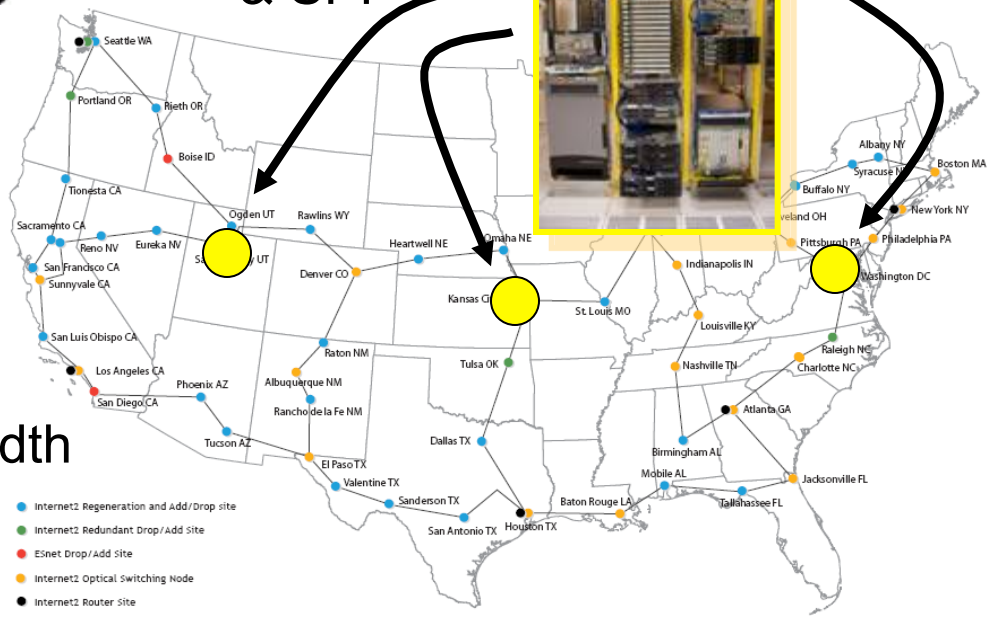
Internet2 and National LambdaRail



Internet2

10 Gbps dedicated bandwidth

ProtoGENI & SPP



National LambdaRail

Up to 30 Gbps nondedicated bandwidth

40 Gbps capacity for GENI prototyping on two national footprints to provide Layer 2 Ethernet VLANs as slices (IP or non-IP)

Nationwide Meso-scale Prototype

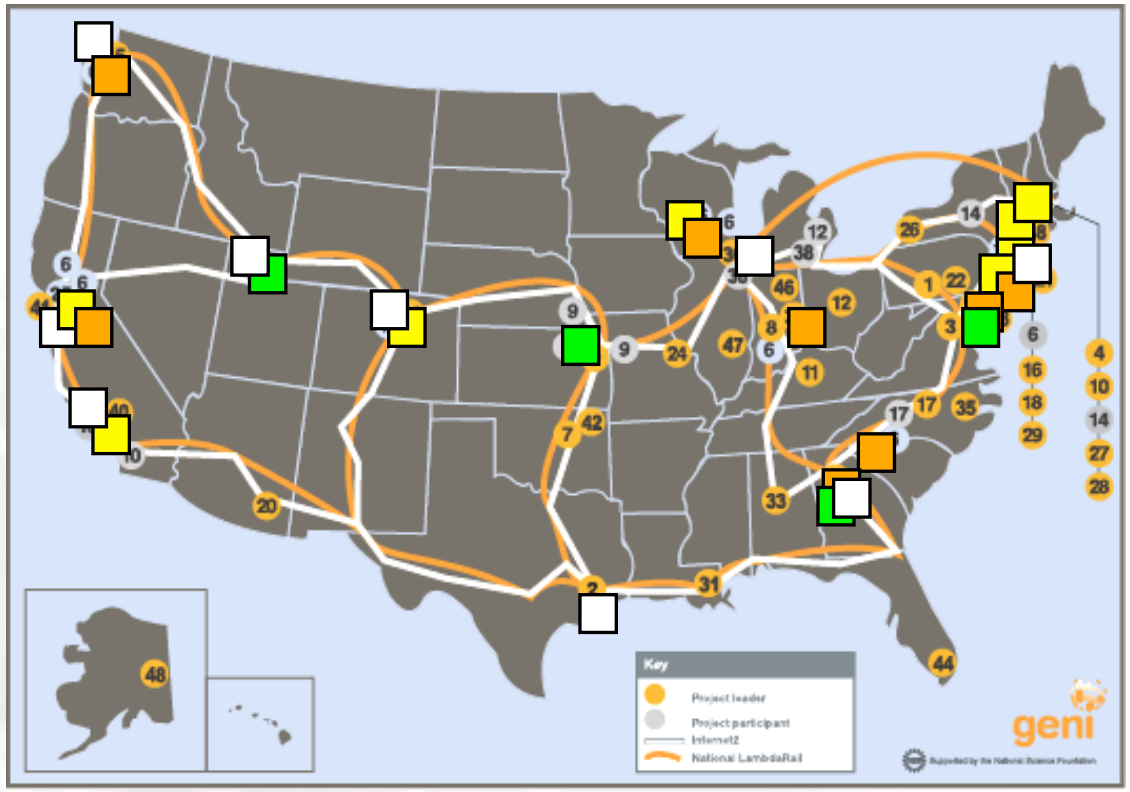
Current plans for locations & equipment

OpenFlow

Stanford
U Washington
Wisconsin U
Indiana U
Rutgers
Princeton
Clemson
Georgia Tech

ShadowNet

Salt Lake City
Kansas City
Washington, DC
Atlanta



WiMAX

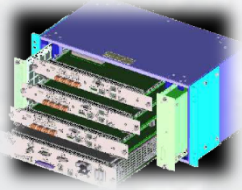
Stanford
UCLA
UC Boulder
Wisconsin
Rutgers
NYU Polytech
UMass
Columbia

OpenFlow Backbones

Seattle
Salt Lake City
Sunnyvale
Denver
New York City
Houston
Chicago
Los Angeles
Atlanta

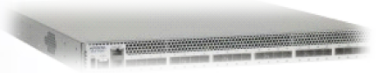
HP ProCurve 5400 Switch

Juniper MX240 Ethernet Services Router



NEC WiMAX Base Station

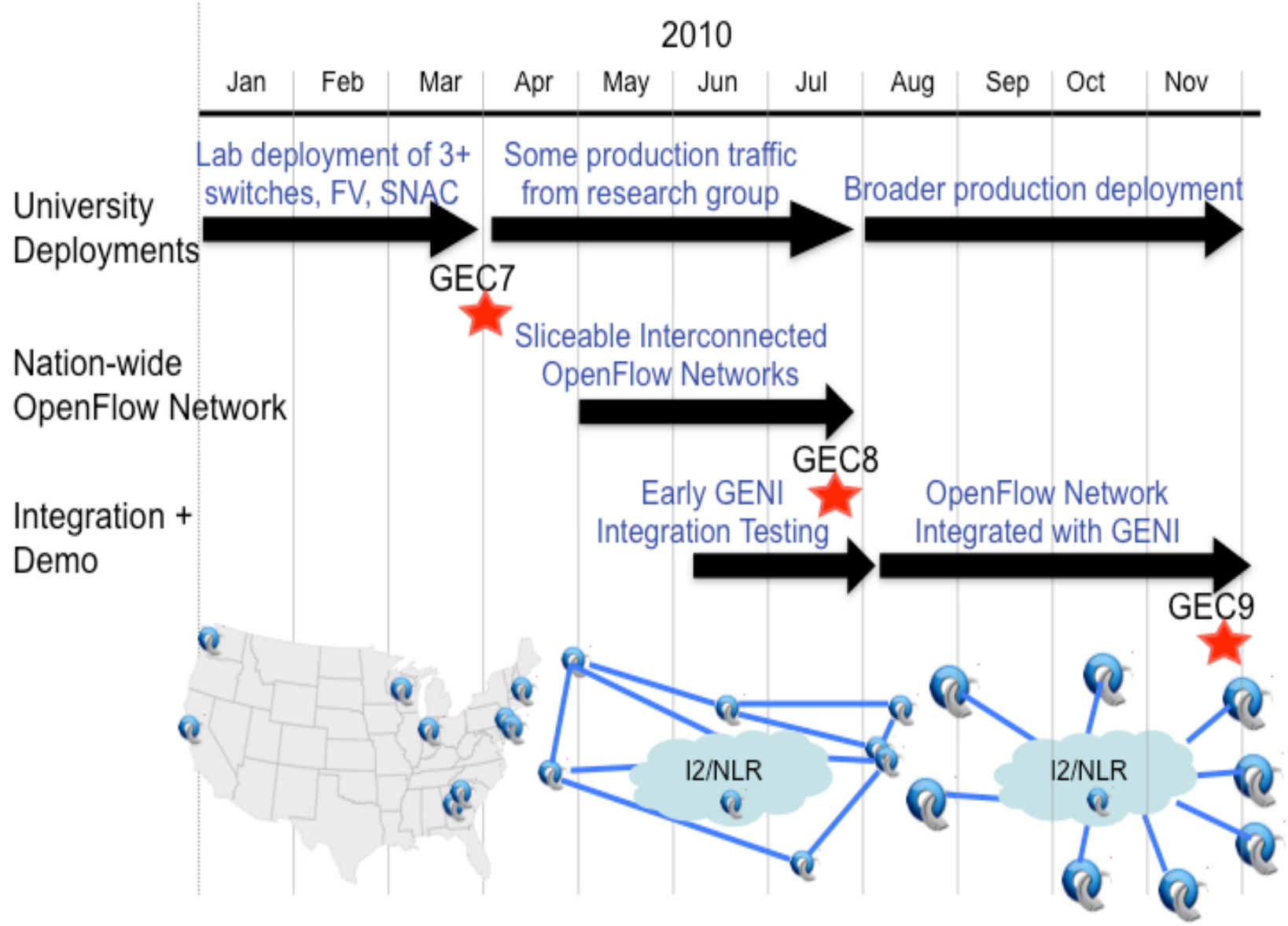
Toroki LightSwitch 4810



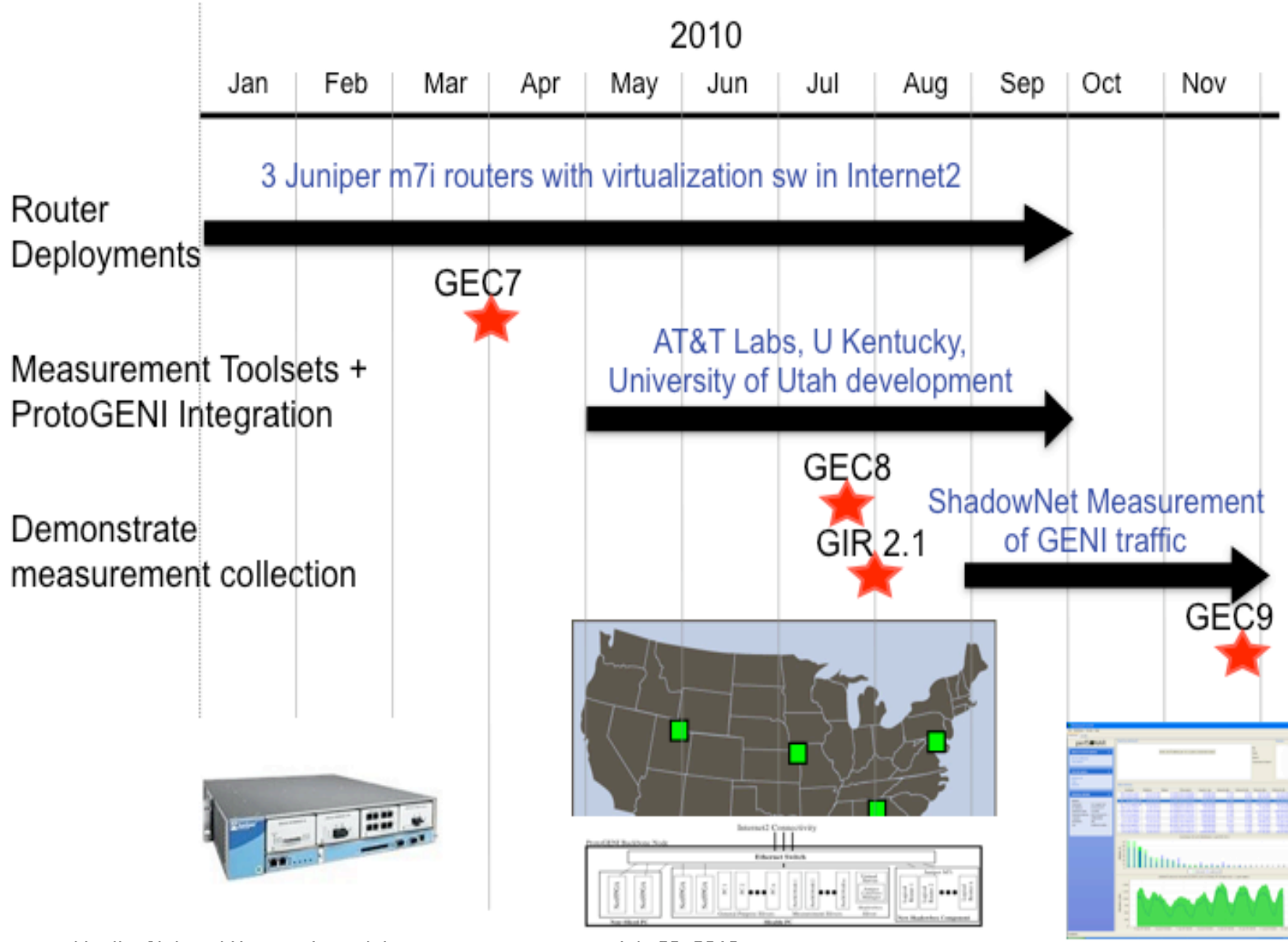
Arista 7124S Switch

NEC IP8800 Ethernet Switch

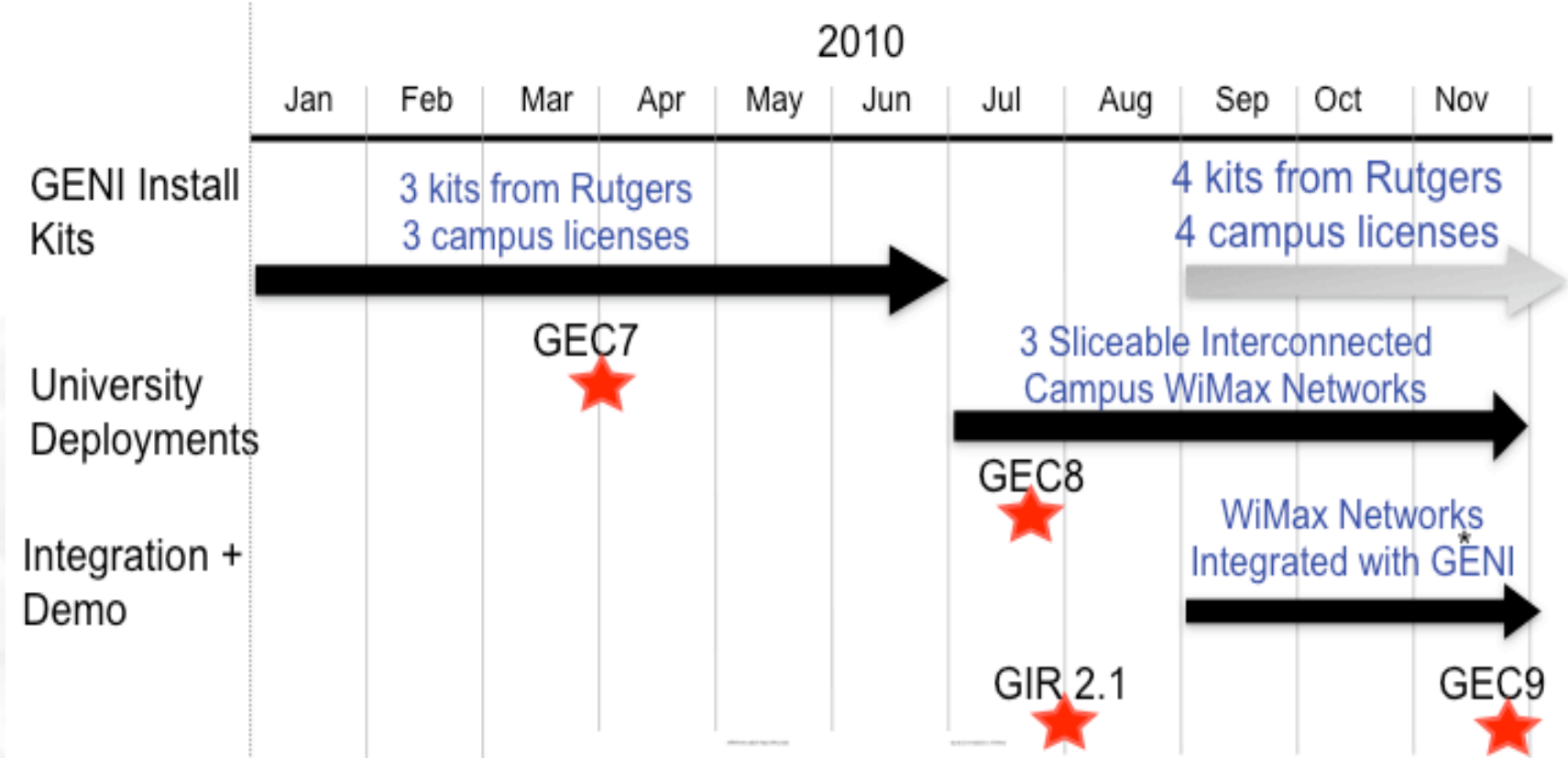
OpenFlow Deployment Roadmap

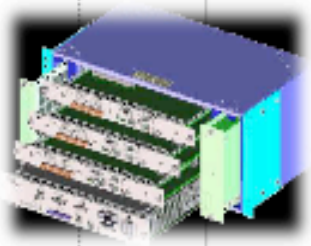


ShadowNet Deployment Roadmap



WiMAX Deployment Roadmap





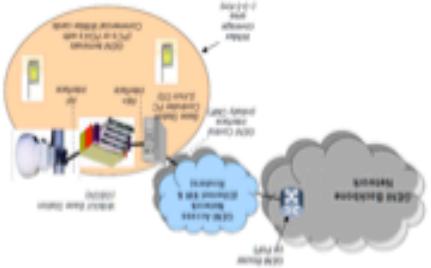


Figure 1. WiMAX campus buildout.

* up to 10 locations

Starting Experimentation

- To succeed as a virtual laboratory, GENI must support a wide variety of experiments.
- Early GENI goals include support for
  - Repeatable and/or “in the wild” behavior
  - Large-scale infrastructure
  - Novel network architecture
  - Deep programmability
  - Programmable switches and routers
  - Opt-in users
- These capabilities are rapidly taking shape
  - GENI will continue to increase in capability, scale, and interoperability

Evolution

- Today:
  - GENI backbones connect ProtoGENI, SPP, BEN
  - Other resources connect via IP using tunnels as needed
  - Four control frameworks
  - GPO-assisted, manual stitching of VLANs
  - Limited tools for discovery, management, measurement
- By Fall 2010
  - OpenFlow & WiMax campuses
  - Interoperability between PlanetLab and ProtoGENI control frameworks
  - Improved tools
- In 2011
  - Prototype I&M system
  - Common control framework API
  - End-users

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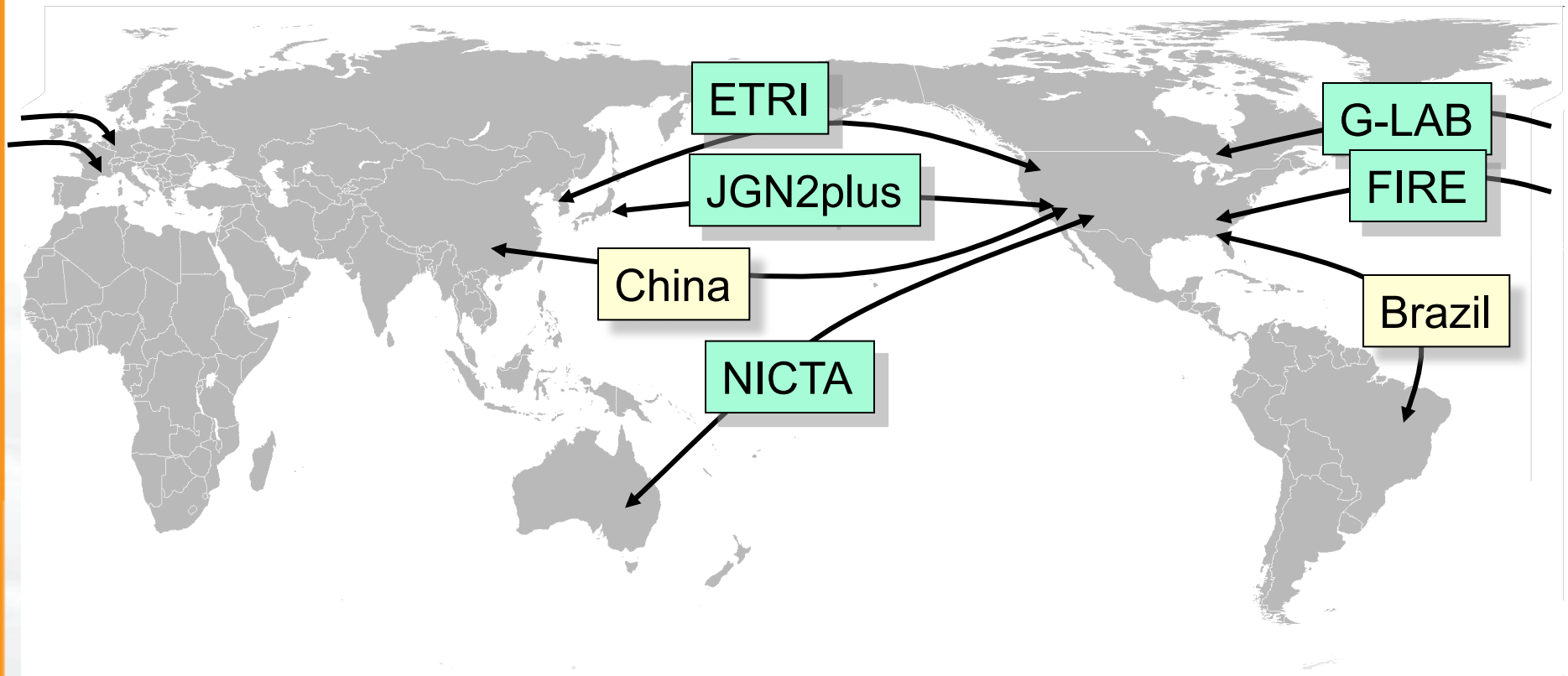
GENI Solicitation 3

- Solicitation areas
  1. **Aggressively grow meso-scale build** (next slide)
     1. Enhanced regional & backbone buildouts
     2. More WiMAX sites
     3. New “GENI Racks” (eg rack of PCs with OpenFlow switch)
  2. **GENI Instrumentation system** (build & deploy)
  3. **Experiment support / training / education & curriculum development**

- Solicitation document: see www.geni.net
- Proposal deadline: August 20, 2010

These are exciting times all around the world!



The GENI project is actively collaborating with peer efforts outside the US, based on equality and arising from direct, "researcher to researcher" collaborations.

GENI Engineering Conferences

Meet every 4 months to review progress together

- **9th meeting, open to all: November 2-4, 2010, Washington, DC**
  - Team meetings, integrated demos, Working Group meetings
  - Also discuss GPO solicitation, how to submit a proposal, evaluation process & criteria, how much money, etc.
  - **Travel grants** to US academics for participant diversity
- Subsequent Meetings, open to all who fit in the room
  - Held at regular 4-month periods
  - Held on / near university campuses (volunteers?)
  - All GPO-funded teams required to participate
  - Systematic, open review of each Working Group status (all documents and prototypes / trials / etc.)
  - Also time for Working Groups to meet face-to-face
  - Discussion will provide input to subsequent spiral goals

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Thanks!

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Backup Slides

Useful GENI Links & Documents

- GENI wiki: http://groups.geni.net
- GENI System Overview (describes conceptual design): http://groups.geni.net/geni/attachment/wiki/GeniSysOvrvw/GENISysOvrvw092908.pdf
- GENI Spiral Two Overview (summarizes current goals and projects): http://groups.geni.net/geni/attachment/wiki/SpiralTwo/GENIS2Ovrvw060310.pdf
- Spiral Two Project Pages: http://groups.geni.net/geni/wiki/SpiralTwo
- Experimenter Page (summarizes available resources): http://groups.geni.net/geni/wiki/GeniExperiments

GENI Concepts & Terminology

- Researcher
  - someone who wishes to run an experiment or service on GENI.
- Clearinghouse
  - A collection of trust anchors, identifying researchers and resources
  - A collection of operational services that facilitate the GENI control framework
    - Researcher account and resource utilization recordkeeping
    - Resource discovery services
    - Federation-wide policy implementation
    - Operations and management services
  - GENI currently includes multiple clearinghouses which are beginning to federate with each other.
- Aggregate
  - a collection of resources available for GENI researchers under common ownership and administration
- Aggregate Manger
  - The entity responsible for resource discovery, experimenter authorization, resource allocation, and coarse control at an aggregate
  - Exports a standard interface, *the GENI Aggregate API*
- End-User
  - A principal participating in GENI who is not a GENI researcher
  - End-users may generate traffic that passes through GENI resources or be measured by GENI experiments
  - End-users may also contribute computational or networking resources for GENI researchers to use, e.g., Million-node GENI

GENI Concepts & Terminology (2)

- Sliver
  - The resources in an aggregate allocated to an experiment
  - May be allocated virtually or physically
- Slice
  - A collection of slivers
  - The primary abstraction for accounting and accountability
  - The basis for resource revocation (i.e., shutdown).
  - Slice = slivers + authorized researchers
- RSpec
  - Resource specification
  - Represents all GENI resources that can be bound to a sliver within an aggregate.
  - Describes both the resources available, advertised or allocated at a component and the relationships between those resources, and perhaps other resources.
- Credentials
  - Authenticated documents which describe privileges held by a principal and are cryptographically signed
  - Currently, the format is an XML structure containing X.509 certificates issued by a Clearinghouse
- Clusters
  - An organizational construct used for rapid integration of GENI resources with a control framework
  - GENI currently has 4 clusters around the PlanetLab, ProtoGENI, ORCA, and ORBIT control frameworks
  - The importance of clusters for interoperability will decline as common APIs and tools are sActiveported

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Programmable WiMax Base Stations

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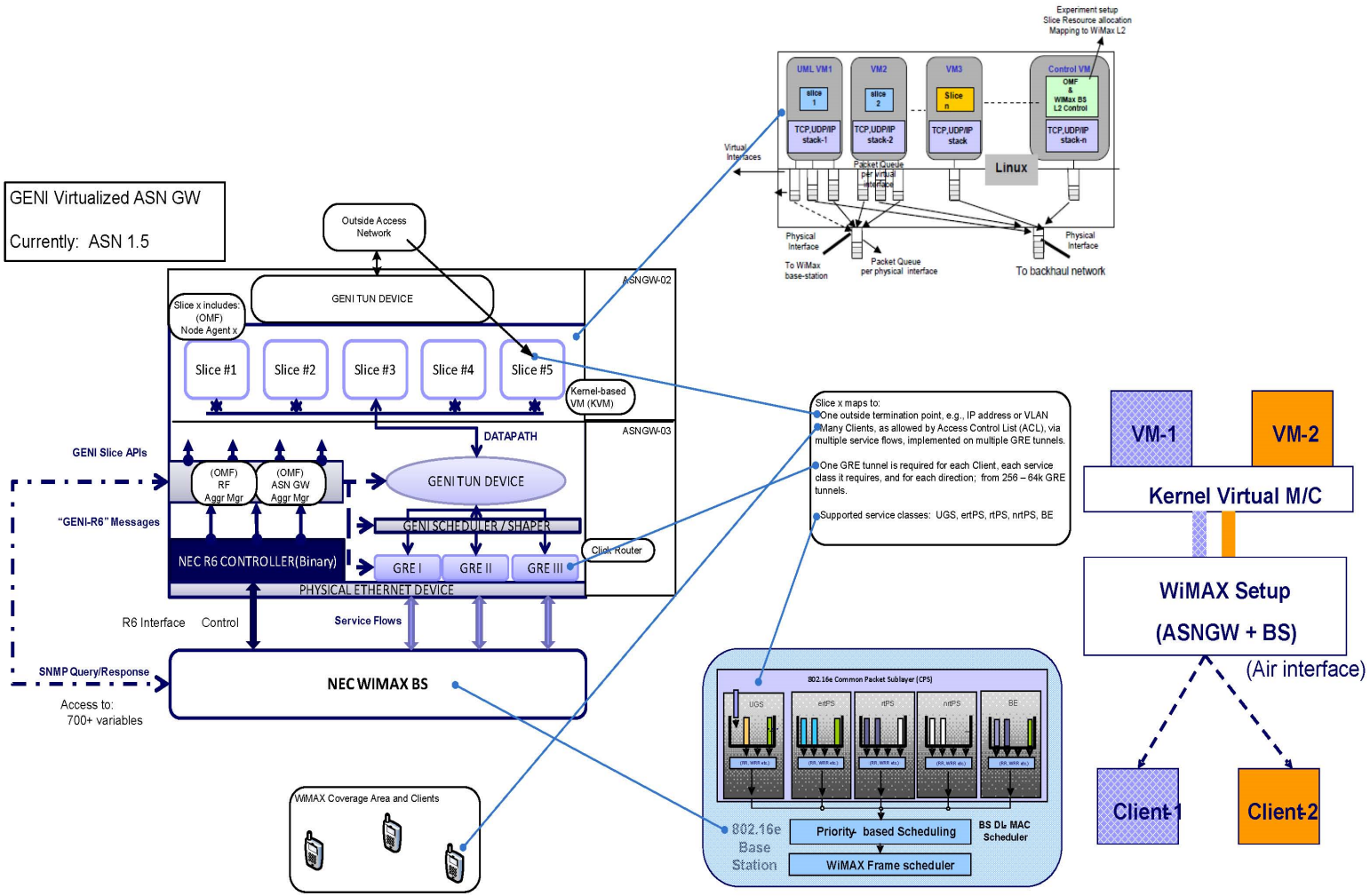
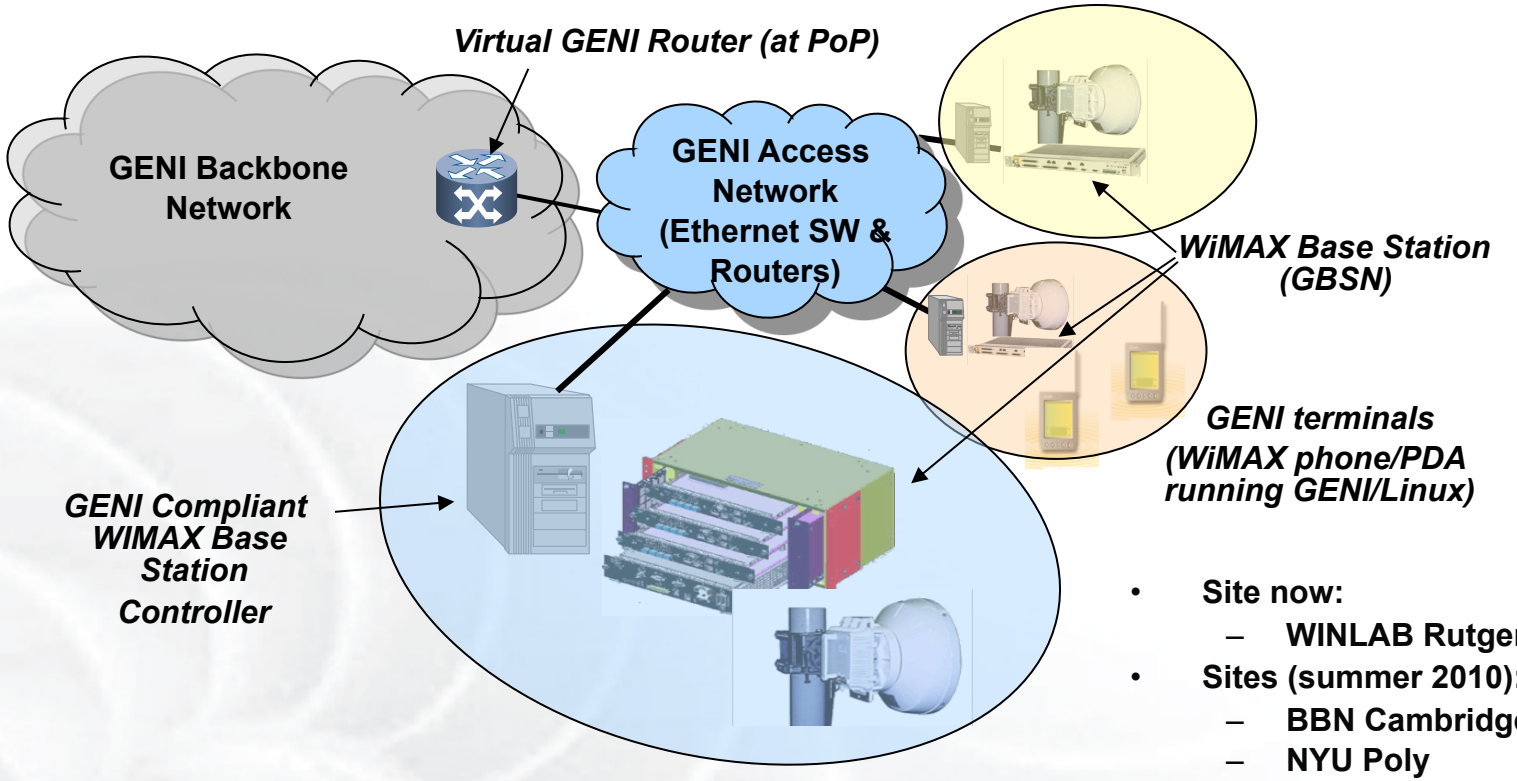
WiMAX kit (software)



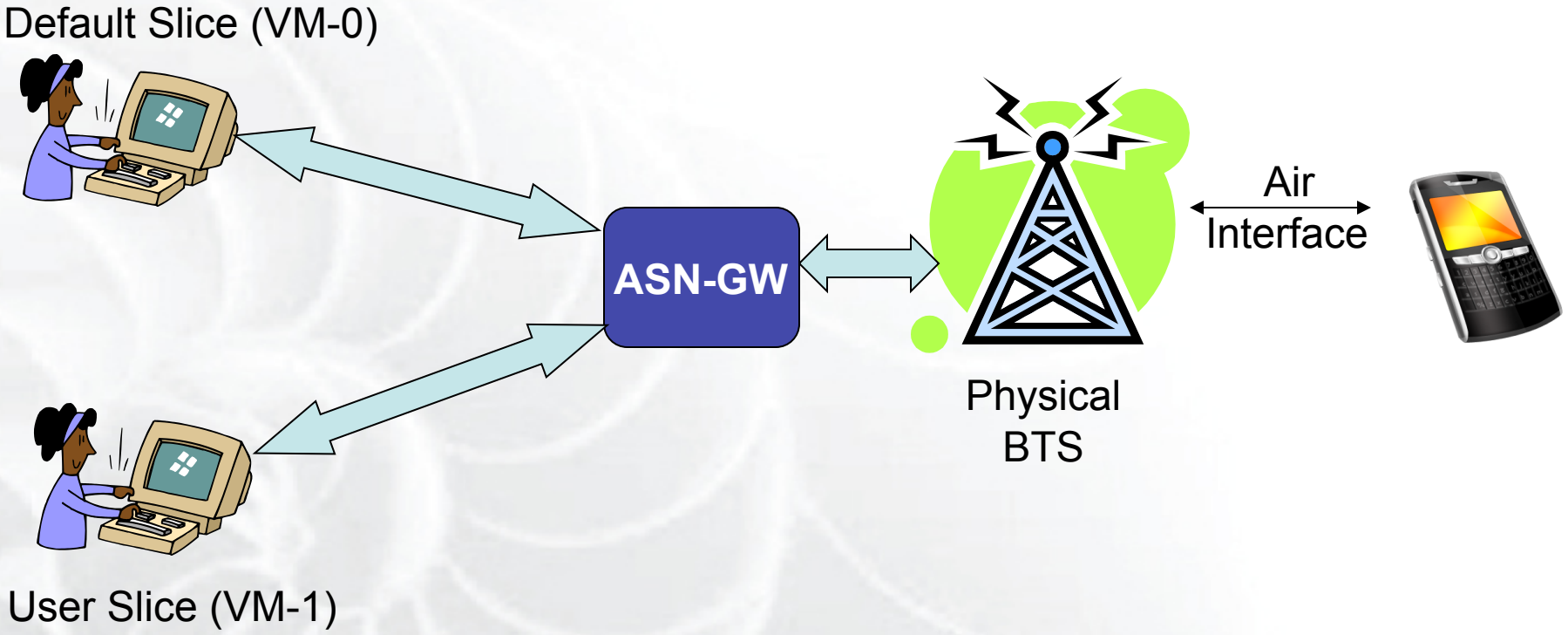
Programmable WiMax Base Stations



- Site now:
  - WINLAB Rutgers
- Sites (summer 2010):
  - BBN Cambridge
  - NYU Poly
- Sites (late 2010):
  - Columbia
  - UMass Amherst
  - Univ Wisconsin
  - Univ Colorado Boulder
  - UCLA

WiMax Experiment Setup Steps

- Use OMF instance (GENI AM) at a site:
  - (1) Get account from site Admin
  - (2) Login to site
  - (3) Access other sites, as desired (later)
- Do basic OMF admin functions:
  - (1) Initialize grid services
  - (2) List all running slices
  - (3) Create your slice
- Use your slice:
  - (1) Configure and program slice
    - Add data path to GENI backbone network
  - (2) Start/Stop Slice
  - (3) Add Client
    - Registers a client with the slice
    - Currently adds default service flow settings for the client
    - Adds mapping to the datapath controller on ASN-GW
  - (4) Configure measurements with OML
  - (5) Conduct experiment

Mock WiMax Experiment Sequence

- Mobile associates, gets added to default slice, starts UL traffic
- Slice user starts a new slice, adds the mobile to its slice
- Datapath switch from (Mobile – VM0) ➔ (Mobile – VM1)