

GENI

Exploring Networks of the Future

Aaron Falk
July 20, 2009
www.geni.net



- Introduction to GENI
- Introduction to the Working Groups

- What is GENI?
- How we'll build it, how we'll use it
(Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

Global networks are rapidly transforming societies and economies

Increasing social and economic reliance on the Internet

- Social networking
- Banking and finance
- Online stores and commerce
- Shared virtual worlds

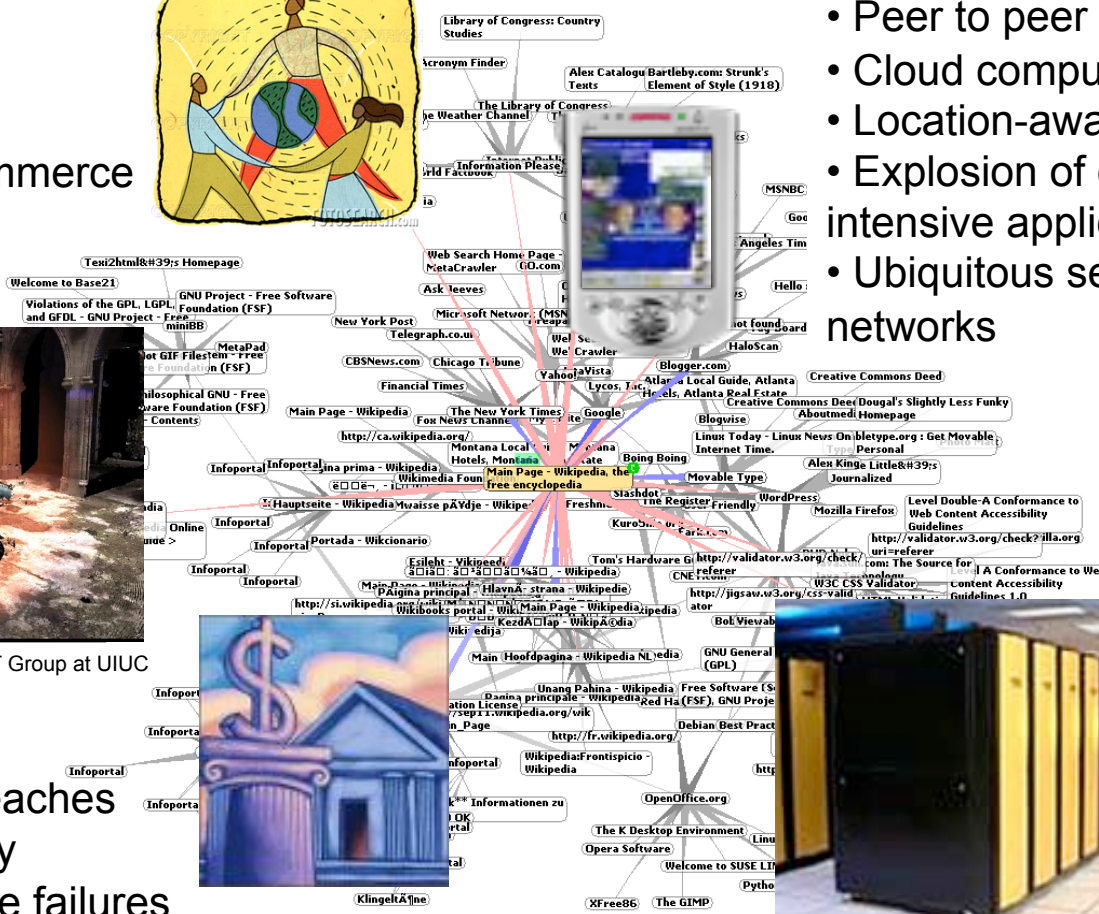


Society-changing innovations

- Peer to peer
- Cloud computing
- Location-aware services
- Explosion of data-intensive applications
- Ubiquitous sensor networks



Credit: MONET Group at UIUC



Worrying trends

- Increasing security breaches
- Rapidly eroding privacy
- Potential for large-scale failures





National Science Foundation Network Science & Engineering (NetSE)

Science

Understand the complexity of large-scale networks

- Understand emergent behaviors, local-global interactions, system failures and/or degradations
- Develop models that accurately predict and control network behaviors

Network science and engineering researchers

Technology

Develop new architectures, exploiting new substrates

- Develop architectures for self-evolving, robust, manageable future networks
- Develop design principles for seamless mobility support
- Leverage optical and wireless substrates for reliability and performance
- Understand the fundamental potential and limitations of technology

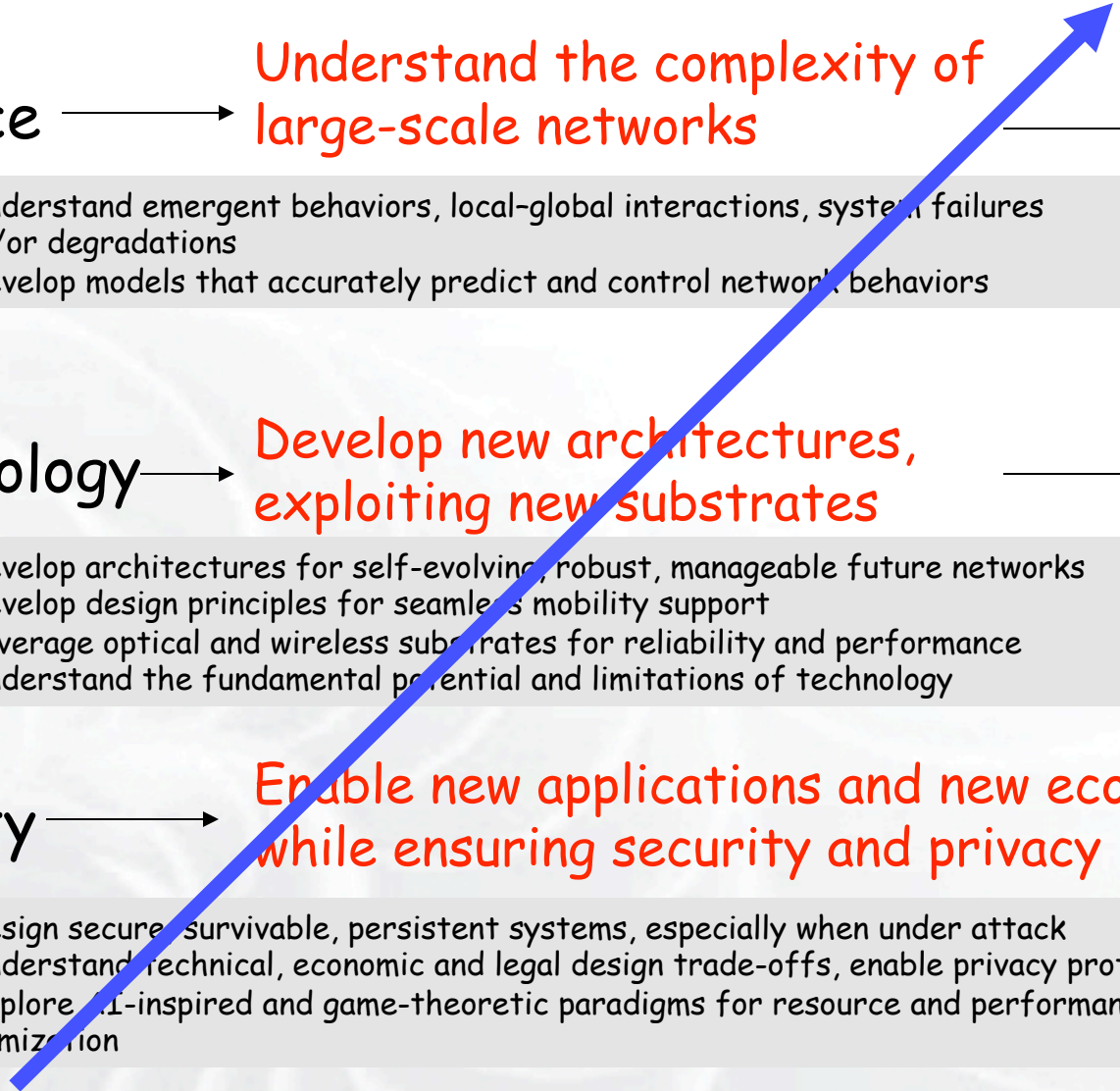
Distributed systems and substrate researchers

Society

Enable new applications and new economies, while ensuring security and privacy

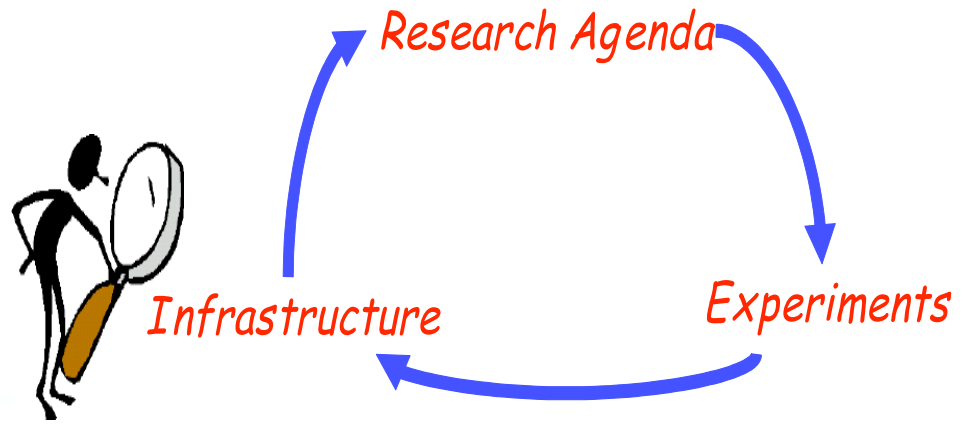
- Design secure, survivable, persistent systems, especially when under attack
- Understand technical, economic and legal design trade-offs, enable privacy protection
- Explore AI-inspired and game-theoretic paradigms for resource and performance optimization

Security, privacy, economics, AI, social science researchers



Research Agenda / Experiments / Infrastructure

- Research agenda
 - Identifies fundamental questions
 - Drives a set of experiments to validate theories and models
- Experiments & requirements
 - Drives what infrastructure and facilities are needed
- Infrastructure could range from
 - Existing Internet, existing testbeds, federation of testbeds, something brand new (from small to large), federation of all of the above, to federation with international efforts
 - No pre-ordained outcome



Existing Input

- | | |
|--|---|
| <ul style="list-style-type: none"> • Clark et al. planning document for Global Environment for Network Innovations • Shenker et al. "I Dream of GENI" document • Kearns and Forrest ISAT study • Feigenbaum, Mitzenmacher, and others on Theory of Networked Computation | <ul style="list-style-type: none"> • Hendler and others in Web Science • Ruzena Bajcsy, Fran Berman, and others on CS-plus-Social Sciences • NSF/OECD Workshop "Social and Economic Factors Shaping the Future of the Internet" • NSF "networking" programs <ul style="list-style-type: none"> – FIND, SING, NGNI |
|--|---|



GENI creates major opportunities
for academia and industry to . . .

Understand global networks
and their evolving interactions with society

Innovate at the frontiers of network
science and engineering

Transform the science of network research
and the larger world of communications



The GENI Planning Group and Many, Many Working Group Volunteers

Larry Peterson, Princeton (Chair)
Tom Anderson, Washington
Dan Blumenthal, UCSB
Dean Casey, NGENET Research
David Clark, MIT
Deborah Estrin, UCLA
Joe Evans, Kansas
Terry Benzel, USC/ISI

Nick McKeown, Stanford
Dipankar Raychaudhuri, Rutgers
Mike Reiter, CMU
Jennifer Rexford, Princeton
Scott Shenker, Berkeley
Amin Vahdat, UCSD
John Wroclawski, USC/ISI
CK Ong, Princeton

And Within NSF

Peter Freeman
Debbie Crawford
Larry Landweber
Suzi Iacono

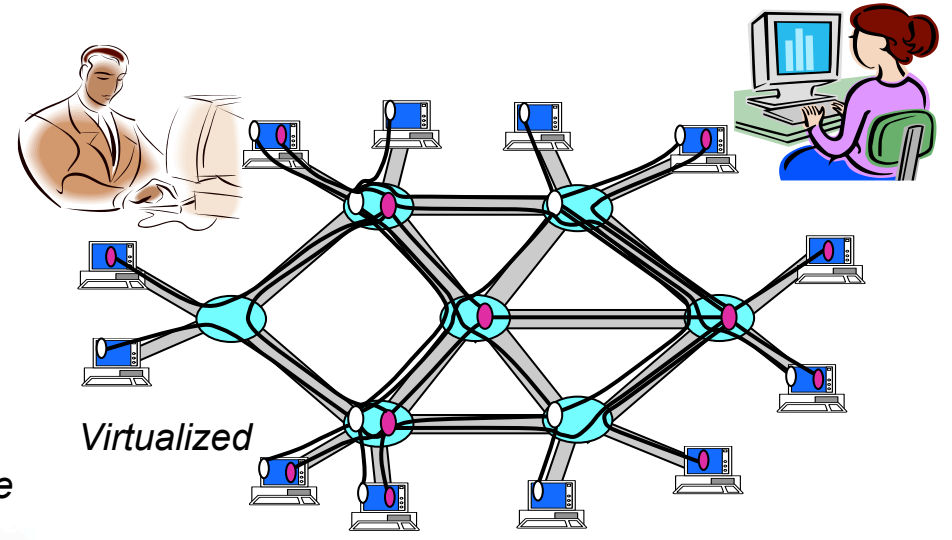
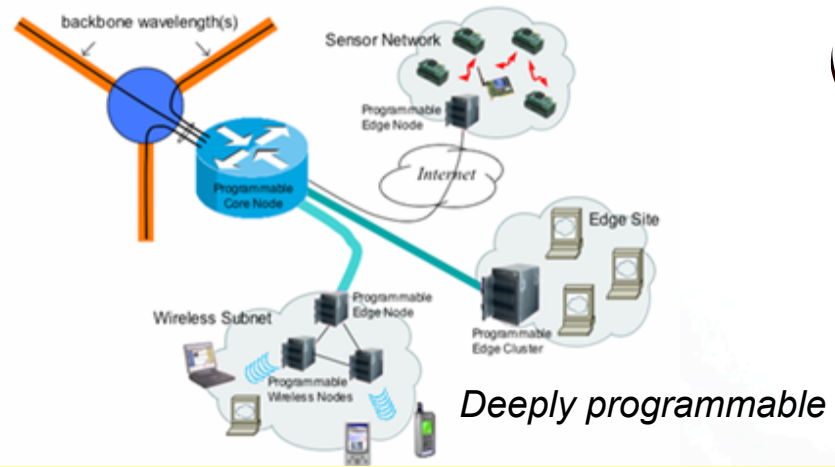
Guru Parulkar
Darleen Fisher
Cheryl Albus
Allison Mankin

Ty Znati
Gracie Narcho
Paul Morton

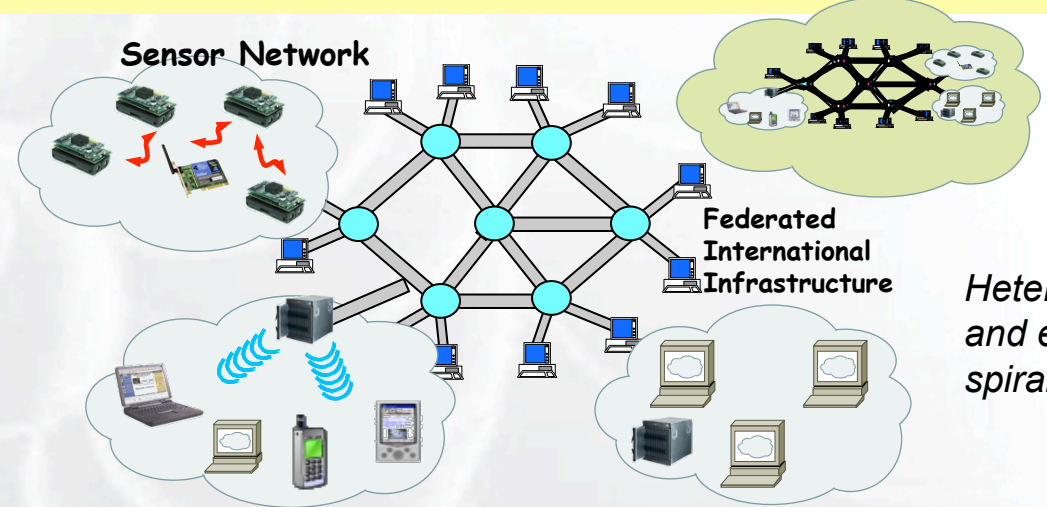
Their hard work has created GENI's Conceptual Design,
the starting point for all our work going forward.

GENI Conceptual Design

Infrastructure to support at-scale experimentation



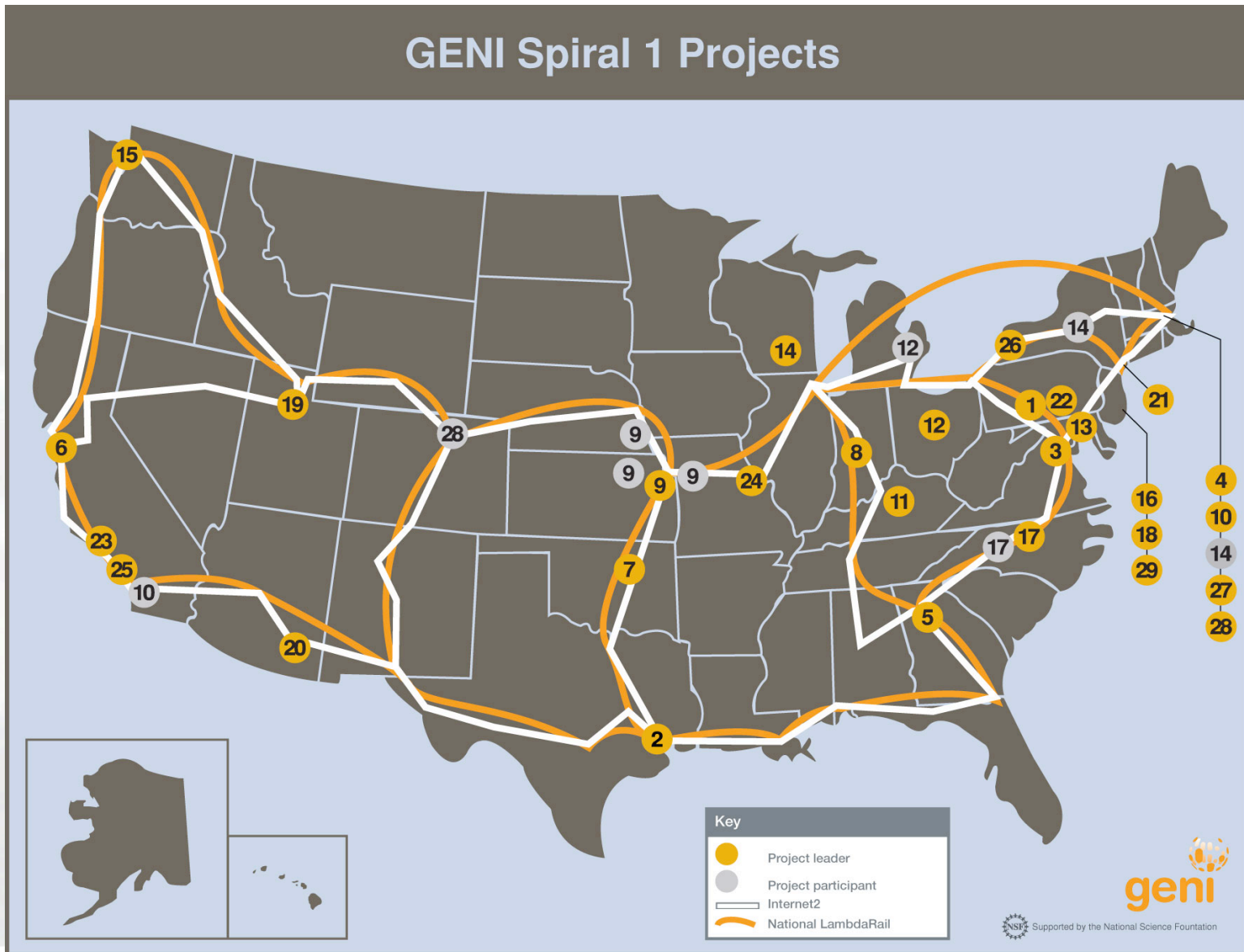
Programmable & federated, with end-to-end virtualized "slices"



Heterogeneous, and evolving over time via spiral development

Current status - GENI Spiral 1

Rapid prototyping, integration, and early experiments



Supported by the National Science Foundation

Spiral 1 Academic-Industrial Teams

Project Name	● Project Lead	● Project Participants
1. CMUlab	● Carnegie Mellon University	
2. D Meas	● University of Houston	
3. Digital Object Registry	● Corporation for National Research Initiatives (CNRI)	
4. DOME	● University of Massachusetts Amherst	
5. DTunnels	● The Georgia Institute of Technology	
6. EnterpriseGENI	● Stanford University	
7. GENI4YR	● Langston University	
8. GMOC	● Indiana University	
9. GpENI	● University of Kansas	● Kansas State University, ● University of Nebraska-Lincoln ● The University of Missouri-Kansas City (UMKC)
10. GushProto	● Williams College	● UC San Diego
11. INSTOOLS	● University of Kentucky	
12. KANSEI	● Ohio State University	● Wayne State University
13. MAX	● University of Maryland	
14. MeasurementSys	● University of Wisconsin-Madison	● Boston University ● Colgate University
15. MillionNodeGENI	● University of Washington (Seattle)	
16. ORBIT	● Rutgers University	
17. ORCA/BEN	● The Renaissance Computing Institute (RENCI)	● Duke University
18. PlanetLab	● Princeton University	
19. ProtoGENI	● University of Utah	
20. PROVSERV	● University of Arizona	
21. ERM	● Columbia	
22. REGOPT	● Pittsburgh Supercomputing Center (PSC)	
23. SECARCH	● SPARTA, Inc.	
24. SPP	● Washington University	
25. TIED	● USC Information Sciences Institute	● University of California, Berkeley
26. UB_OANets	● SUNY Buffalo	
27. UMLPEN	● University of Massachusetts Lowell	
28. ViSE	● University of Massachusetts Amherst	
29. WIMAX	● Rutgers University	



- What is GENI?
- How we'll build it, how we'll use it
(Two Comic Books)
- The GENI system concept
- GENI Spiral 1
- How can you participate?

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



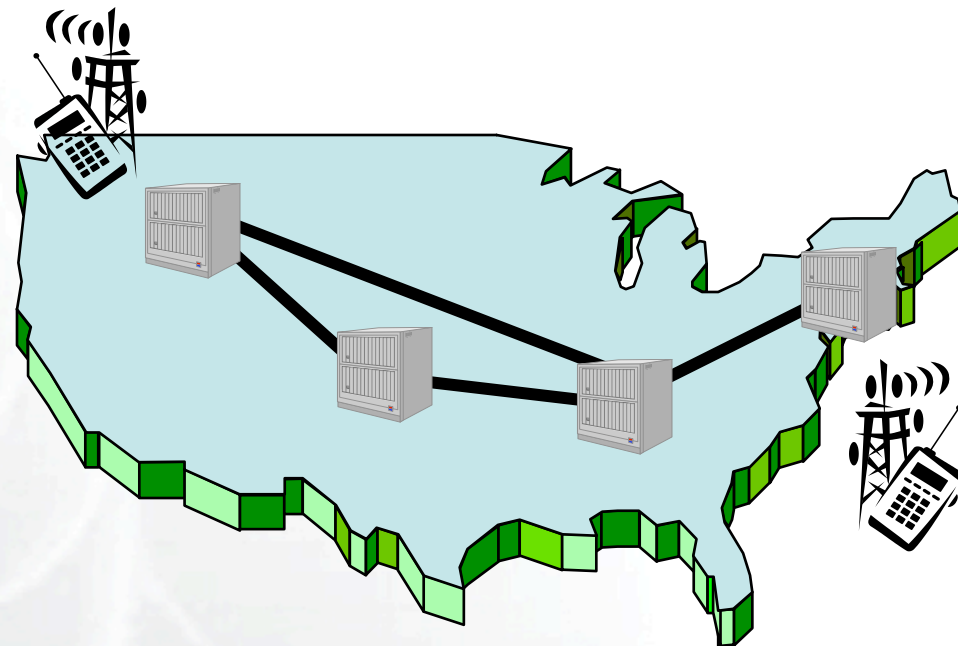
I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

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





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



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 . . .

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

It turns into a really good idea

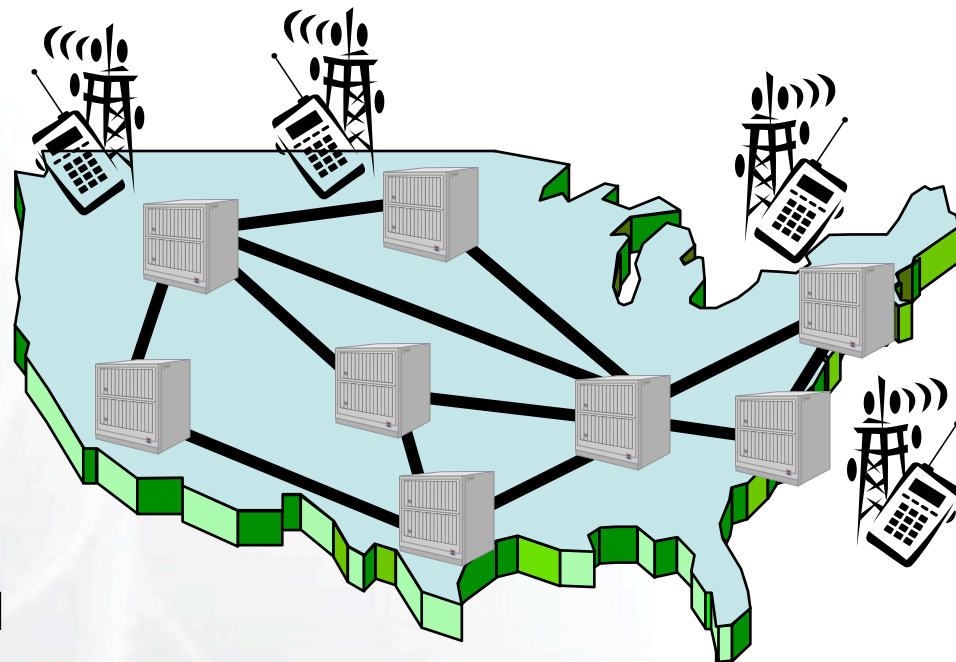
Boy did I learn a lot! I've published papers, the architecture has evolved in major ways, and I'm even attracting real users!



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

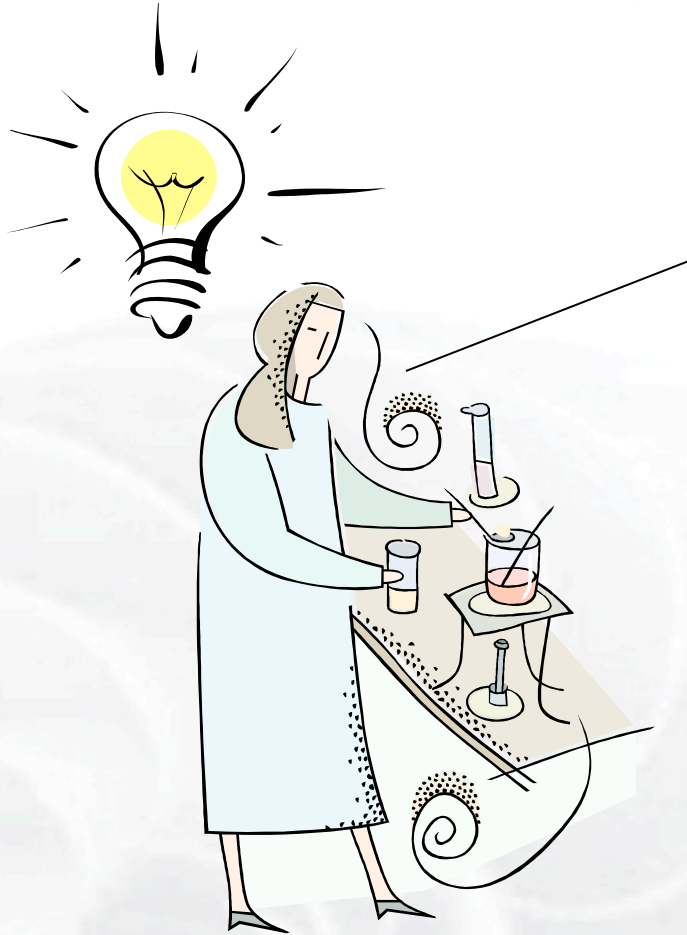


My experiment was a real success, and my architecture turned out to be mostly compatible with today's Internet after all – so I'm taking it off GENI and spinning it out as a real company.

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.

- GENI is meant to enable . . .
 - Trials of new architectures, which may or may not be compatible with today's Internet
 - Long-running, realistic experiments with enough instrumentation to provide real insights and data
 - 'Opt in' for real users into long-running experiments
 - Large-scale growth for successful experiments, so good ideas can be shaken down at scale
- A reminder . . .
 - GENI itself is not an experiment !
 - GENI is a suite of infrastructure on which experiments run

GENI creates a huge opportunity for ambitious research!

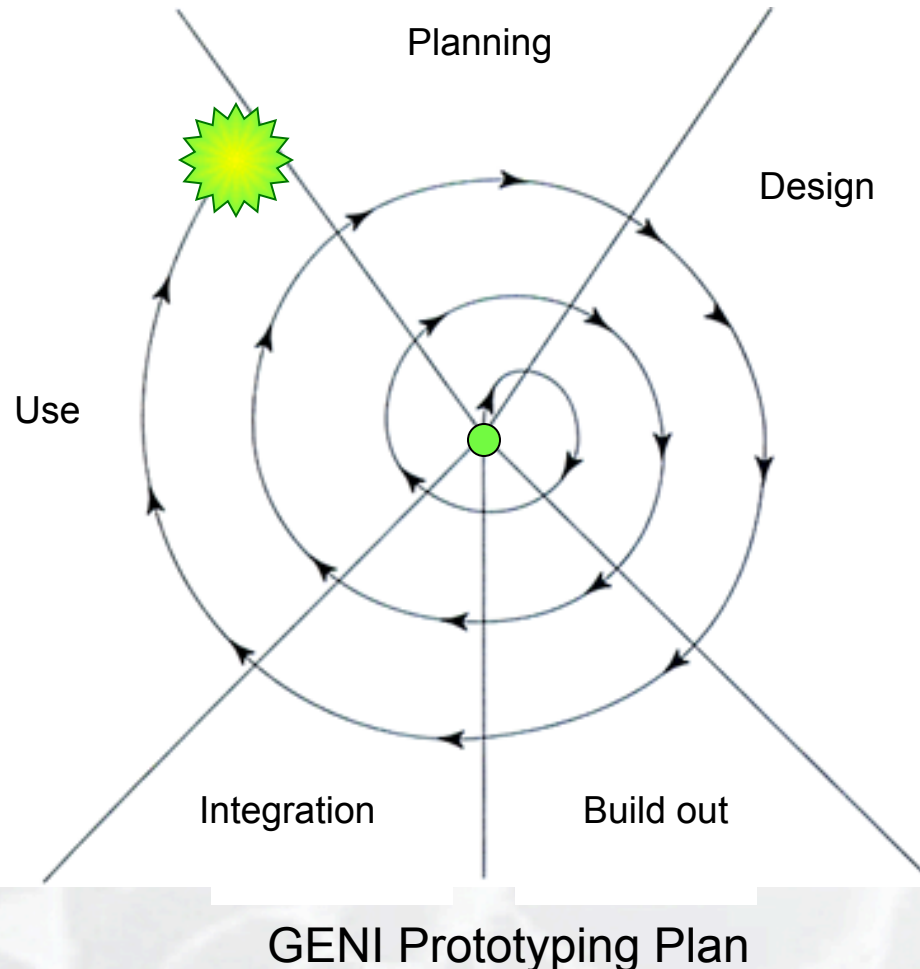
How We'll Build GENI

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

Please read the GENI System Overview and GENI Spiral 1 Overview for detailed planning information.

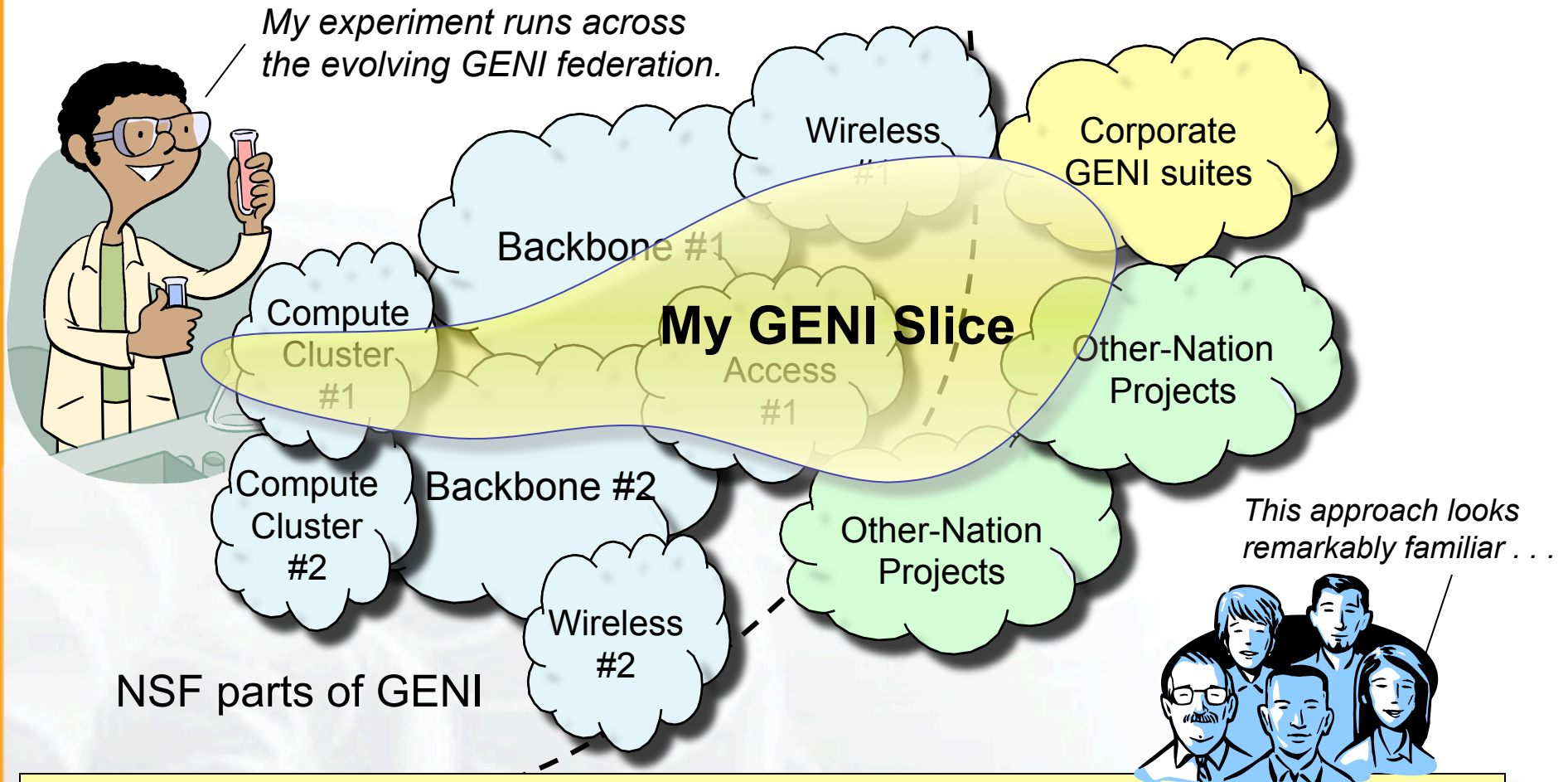
Spiral Development

GENI grows through a well-structured, adaptive process



- An achievable **Spiral 1**
Rev 1 control frameworks, federation of multiple substrates (clusters, wireless, regional / national optical net with early GENI 'routers', some existing testbeds), Rev 1 user interface and instrumentation.
- ★ 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.

GENI grows by “gluing together” heterogeneous infrastructure

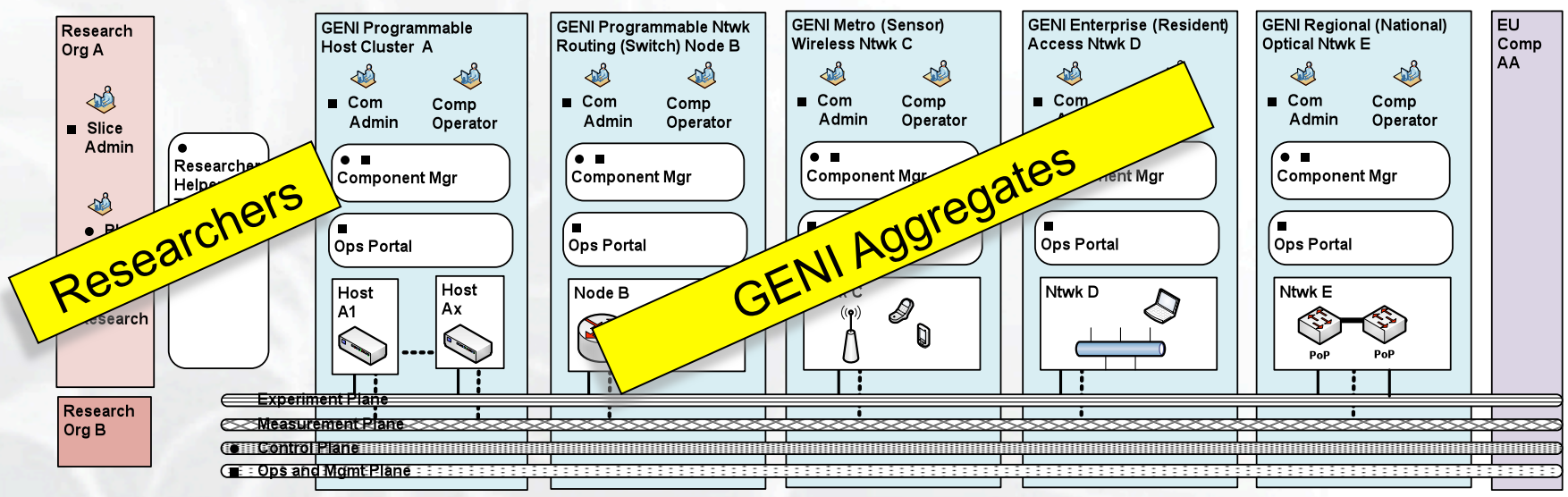
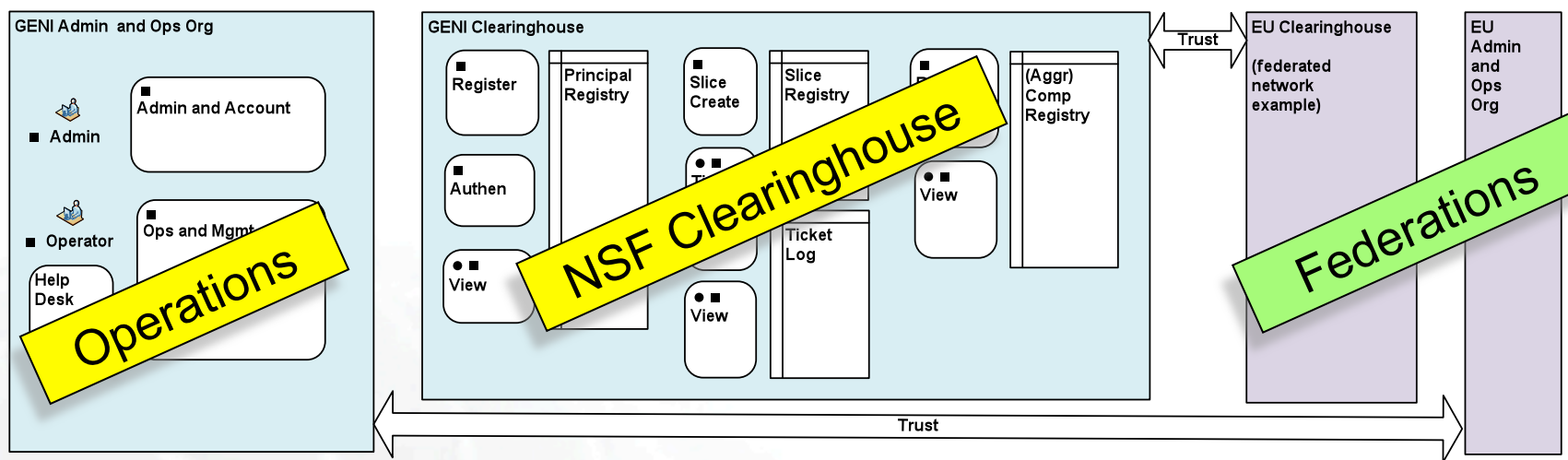


Goals: avoid technology “lock in,” add new technologies as they mature, and potentially grow quickly by incorporating existing infrastructure into the overall “GENI ecosystem”

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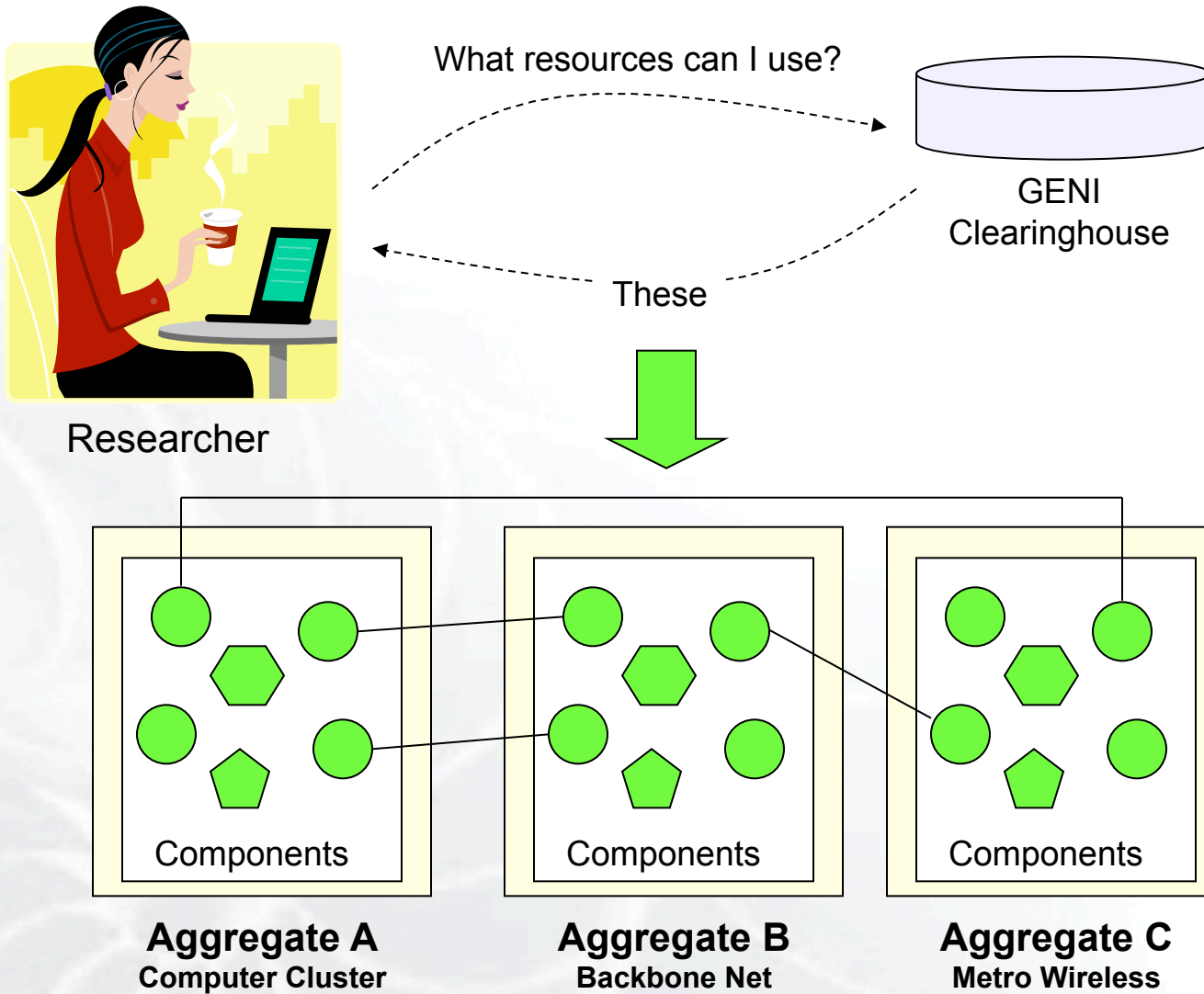
GENI System Decomposition (simplified)

Engineering analysis drives Spiral 1 integration



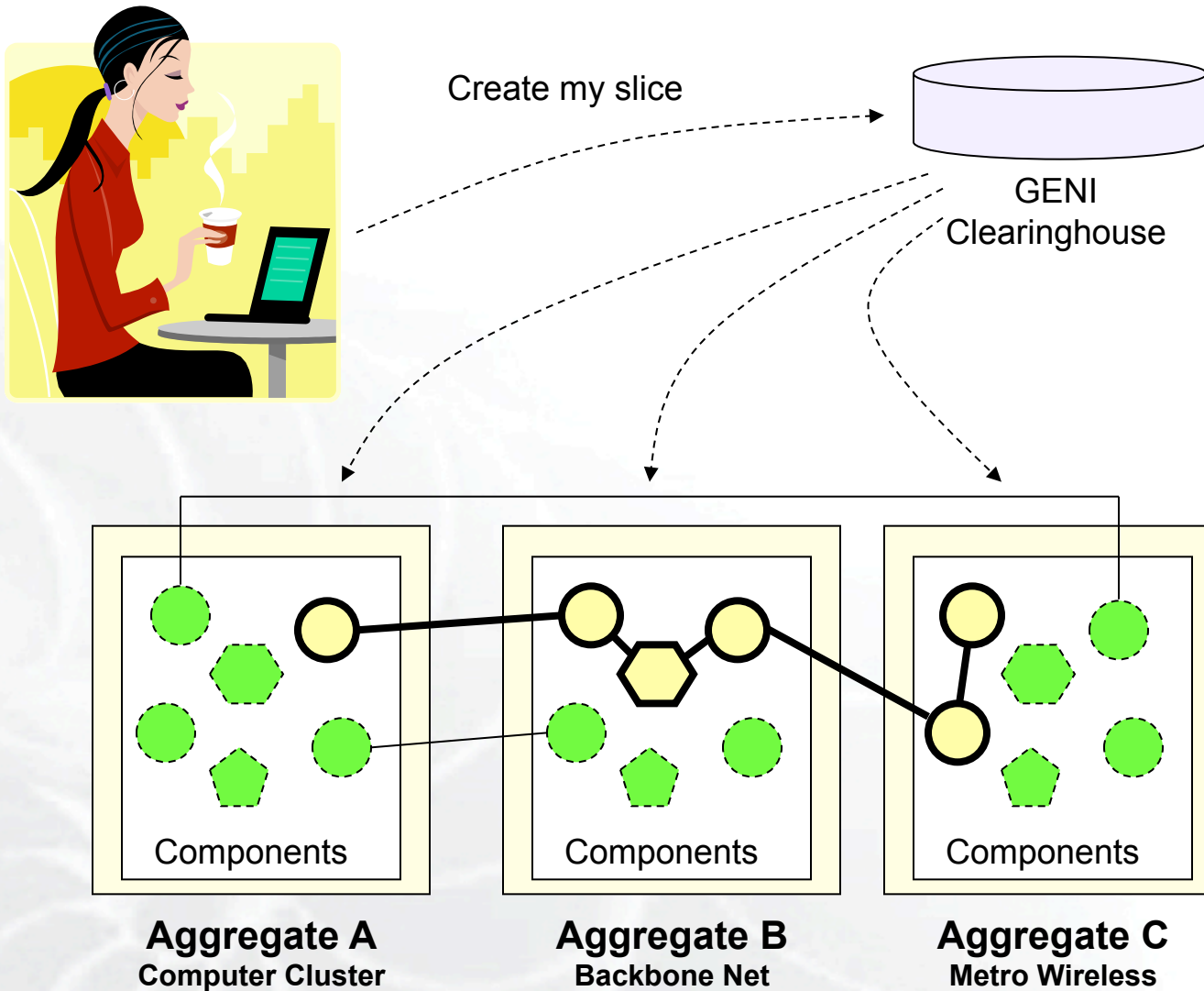
Resource discovery

Aggregates publish resources, schedules, etc., via clearinghouses



Slice creation

Clearinghouse checks credentials & enforces policy
Aggregates allocate resources & create topologies

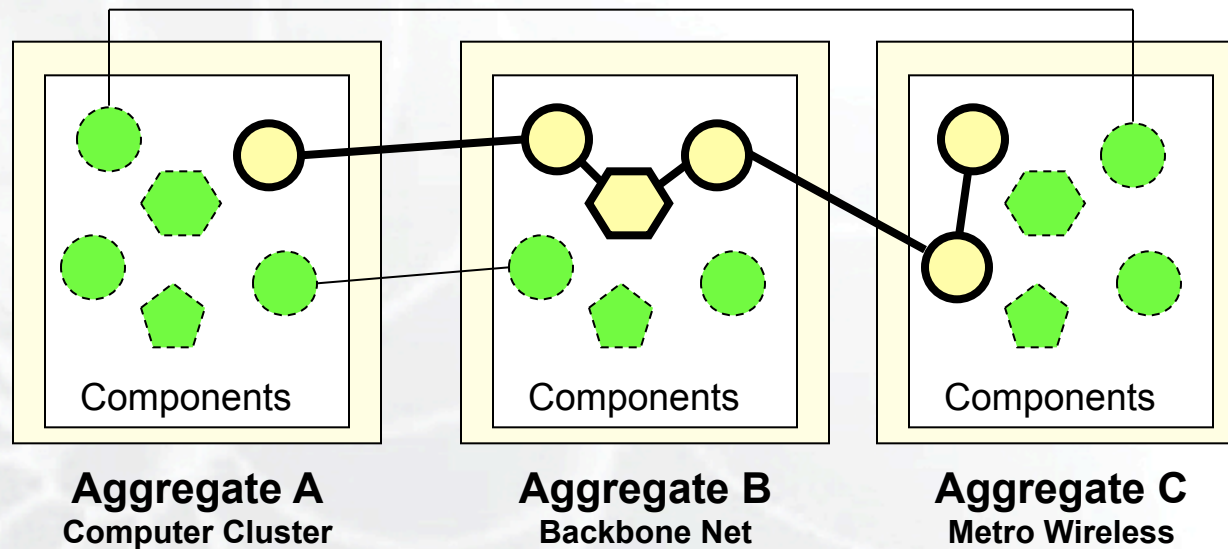
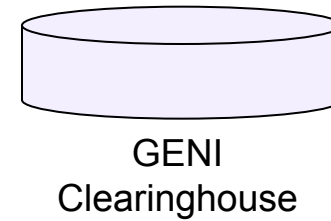


Experimentation

Researcher loads software, debugs, collects measurements

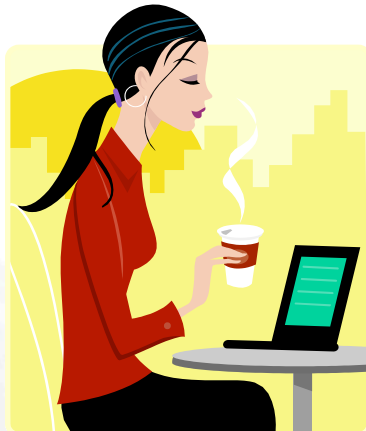


Experiment – Install my software, debug, collect data, retry, etc.



Slice growth & revision

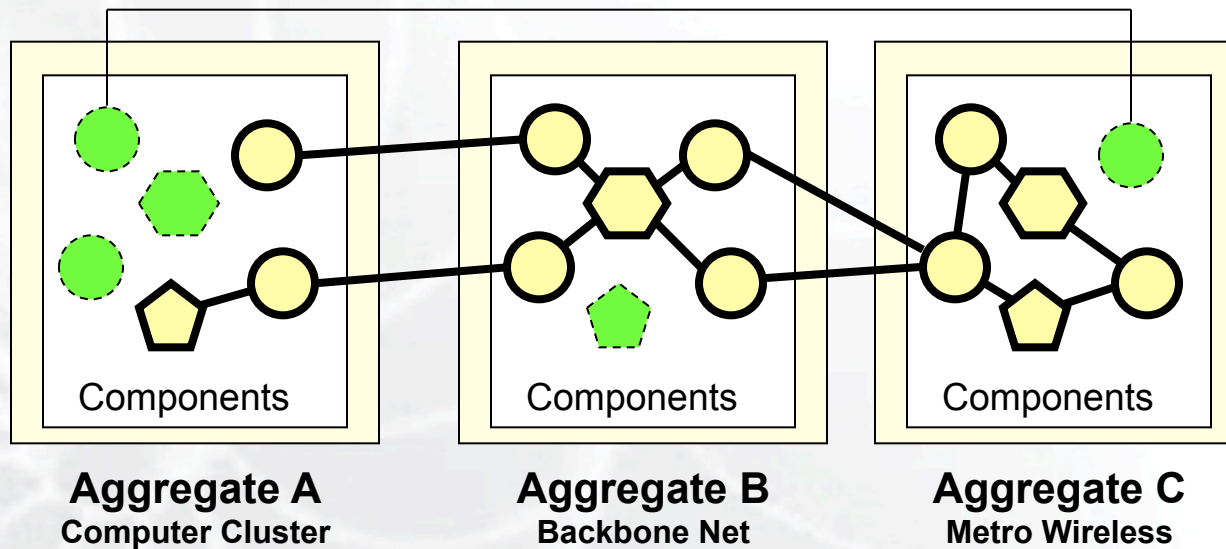
Allows successful, long-running experiments to grow larger



Make my slice bigger !

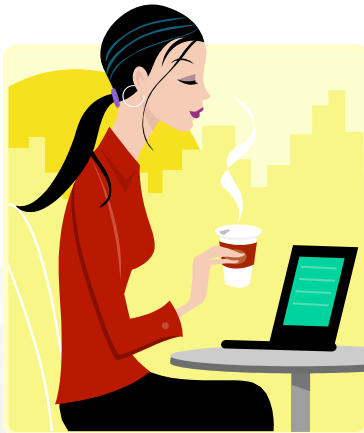


GENI
Clearinghouse

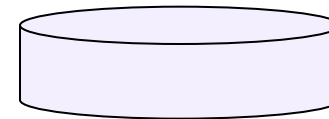


Federation of Clearinghouses

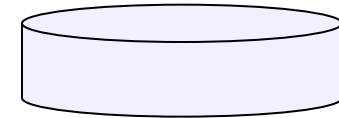
Growth path to international, semi-private, and commercial GENIs



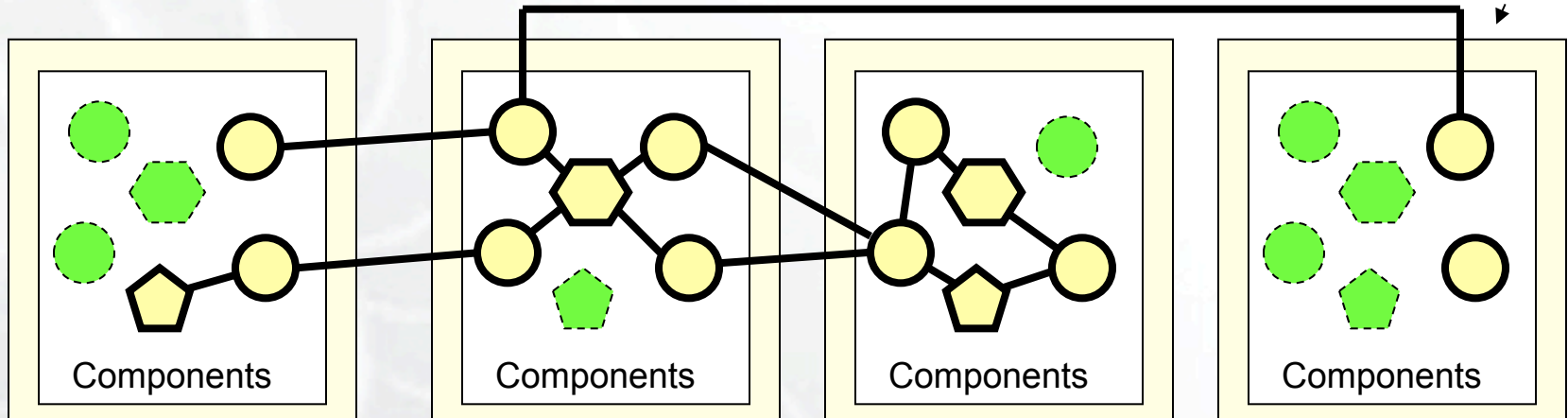
Make my slice even bigger !



GENI
Clearinghouse



Federated
Clearinghouse



Aggregate A
Computer Cluster

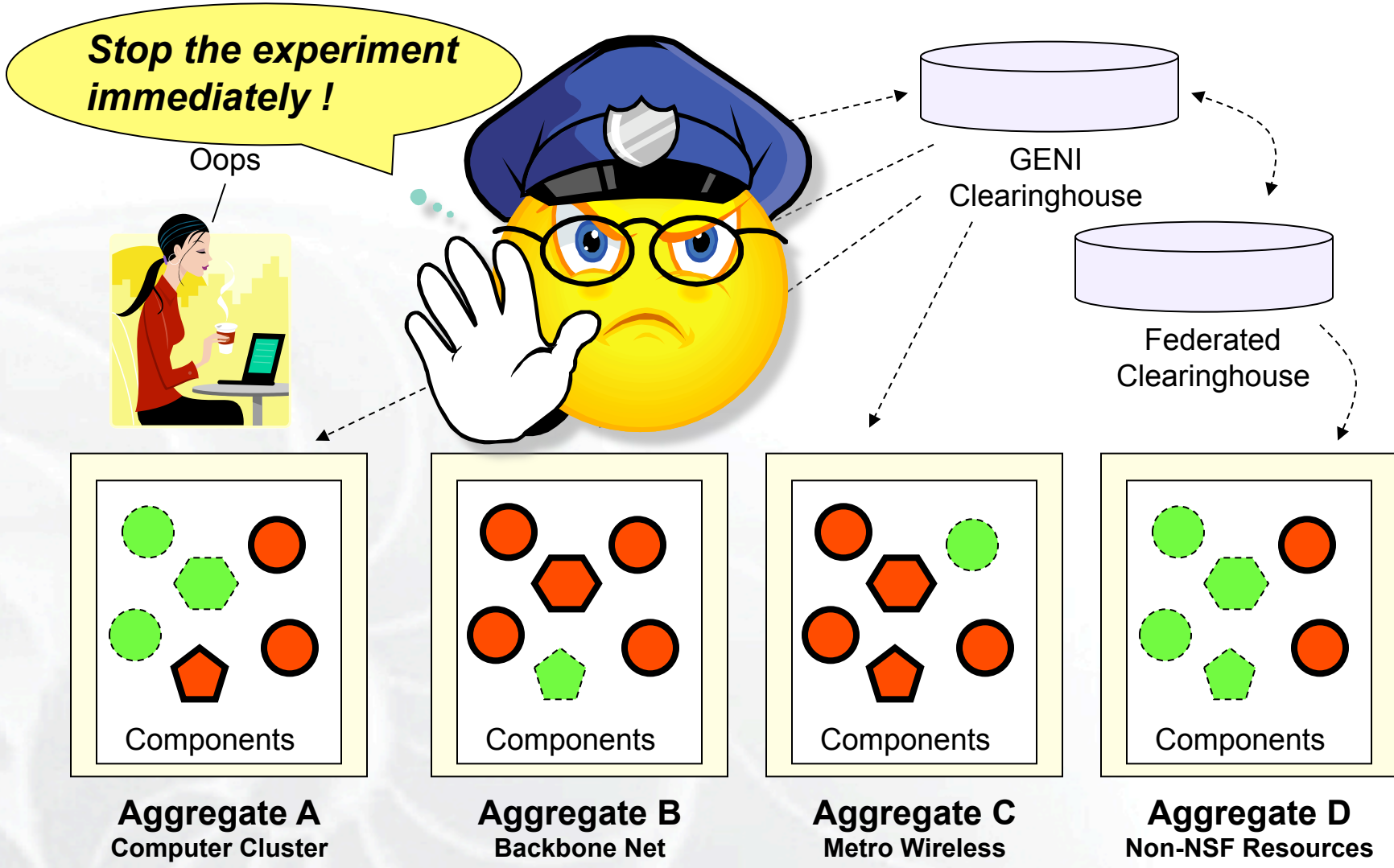
Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Aggregate D
Non-NSF Resources

Operations & Management

Always present in background for usual reasons
Will need an 'emergency shutdown' mechanism



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GENI Project Office Announces \$12M for Community-Based GENI Prototype Development

July 22, 2008

The GENI Project Office, operated by BBN Technologies, an advanced technologies solutions firm, announced today that it has been awarded a **three year grant worth approximately \$4M a year** from the US National Science Foundation to perform GENI design and risk-reduction prototyping.

The funds will be used to contract with **29 university-industrial teams** selected through an open, peer-reviewed process. The first year funding will be used to **construct GENI Spiral 1, a set of early, functional prototypes** of key elements of the GENI system.

GENI Spiral 1 Projects

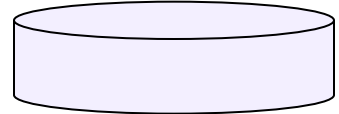


GENI's Critical Technical Risks

These risks drive the Prototyping Goals for GENI Spiral 1

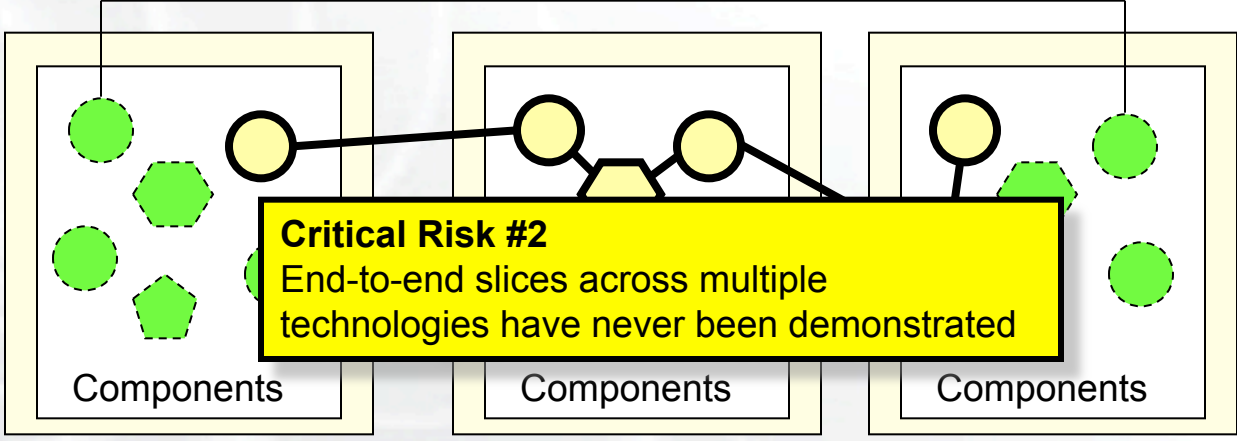


Create my slice



GENI Clearinghouse

Critical Risk #1
Clearinghouse & control framework is central but never demonstrated



Critical Risk #2
End-to-end slices across multiple technologies have never been demonstrated

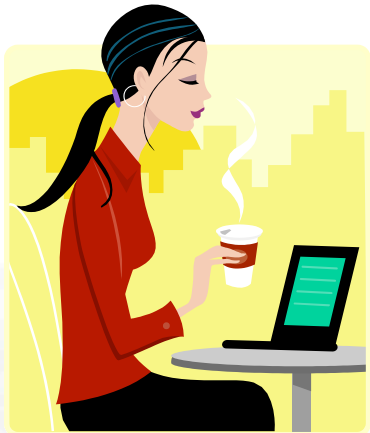
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

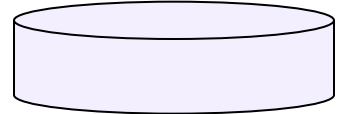
Aggregate C
Metro Wireless

Key Goals for GENI Spiral 1

Drive down critical technical risks in GENI's concept

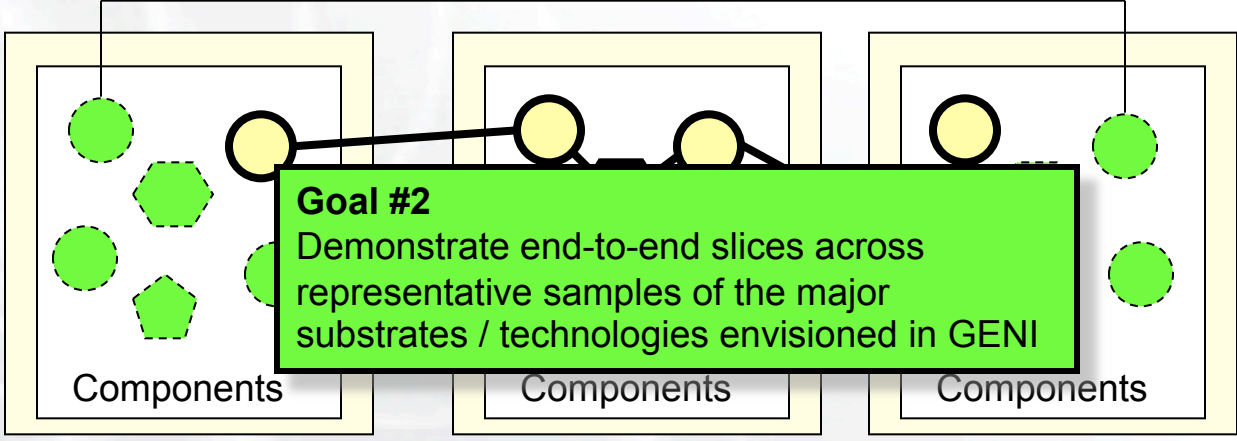


Create my slice



GENI
Clearinghouse

Goal #1
Fund multiple, competing teams to develop GENI Clearinghouse technology, encourage strong competition within the first few spirals



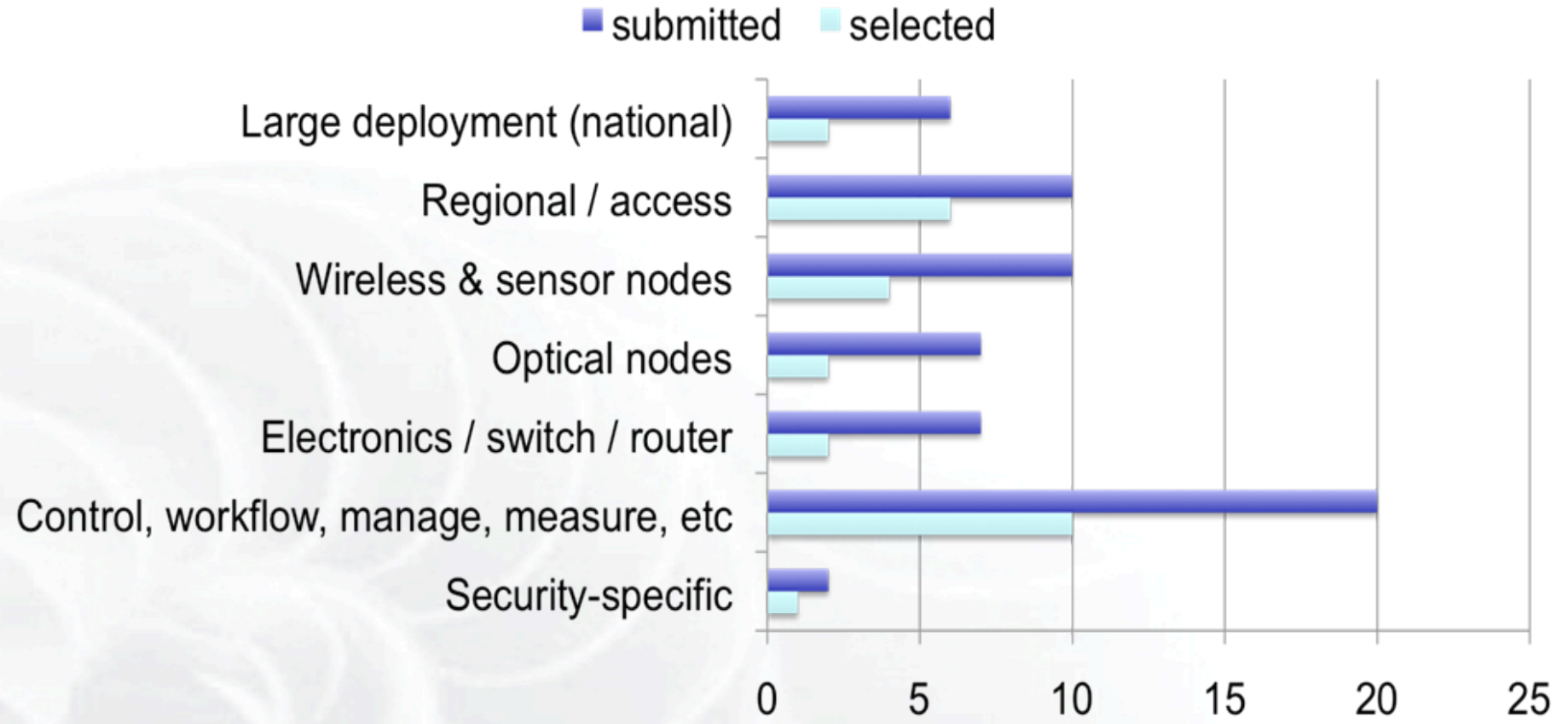
Goal #2
Demonstrate end-to-end slices across representative samples of the major substrates / technologies envisioned in GENI

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

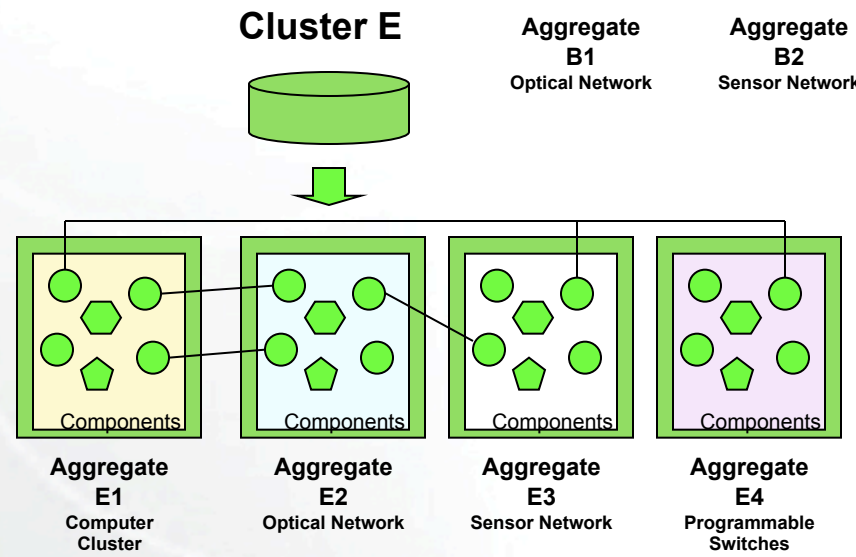
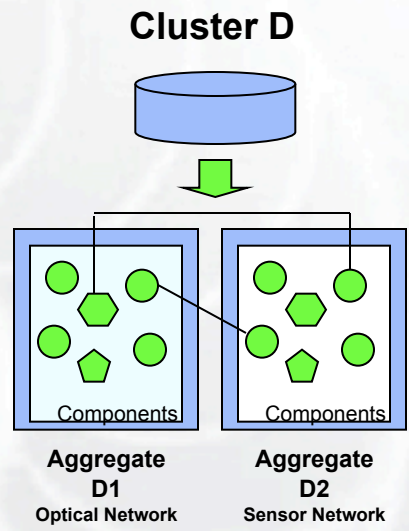
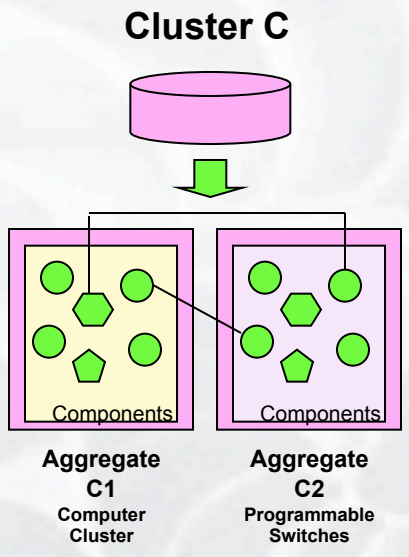
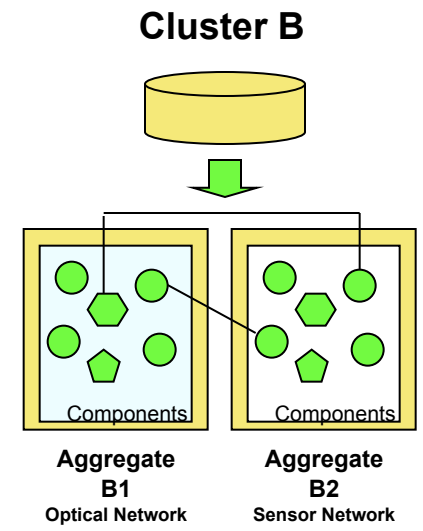
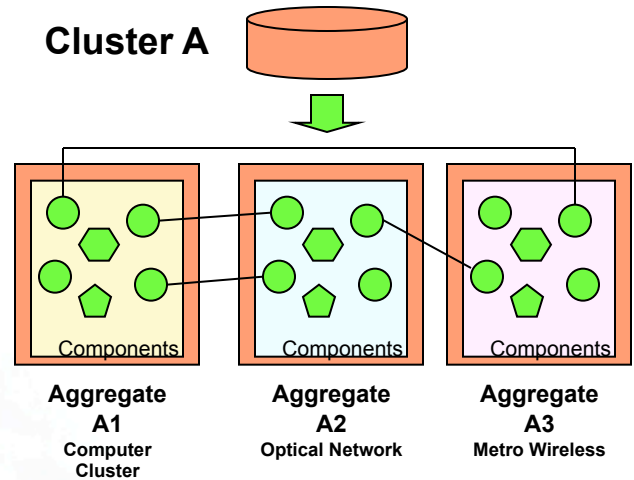
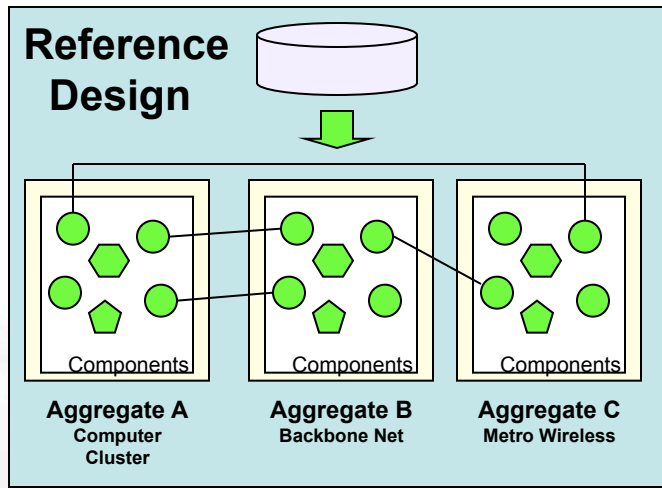
Aggregate C
Metro Wireless

1st GENI Solicitation – proposal areas

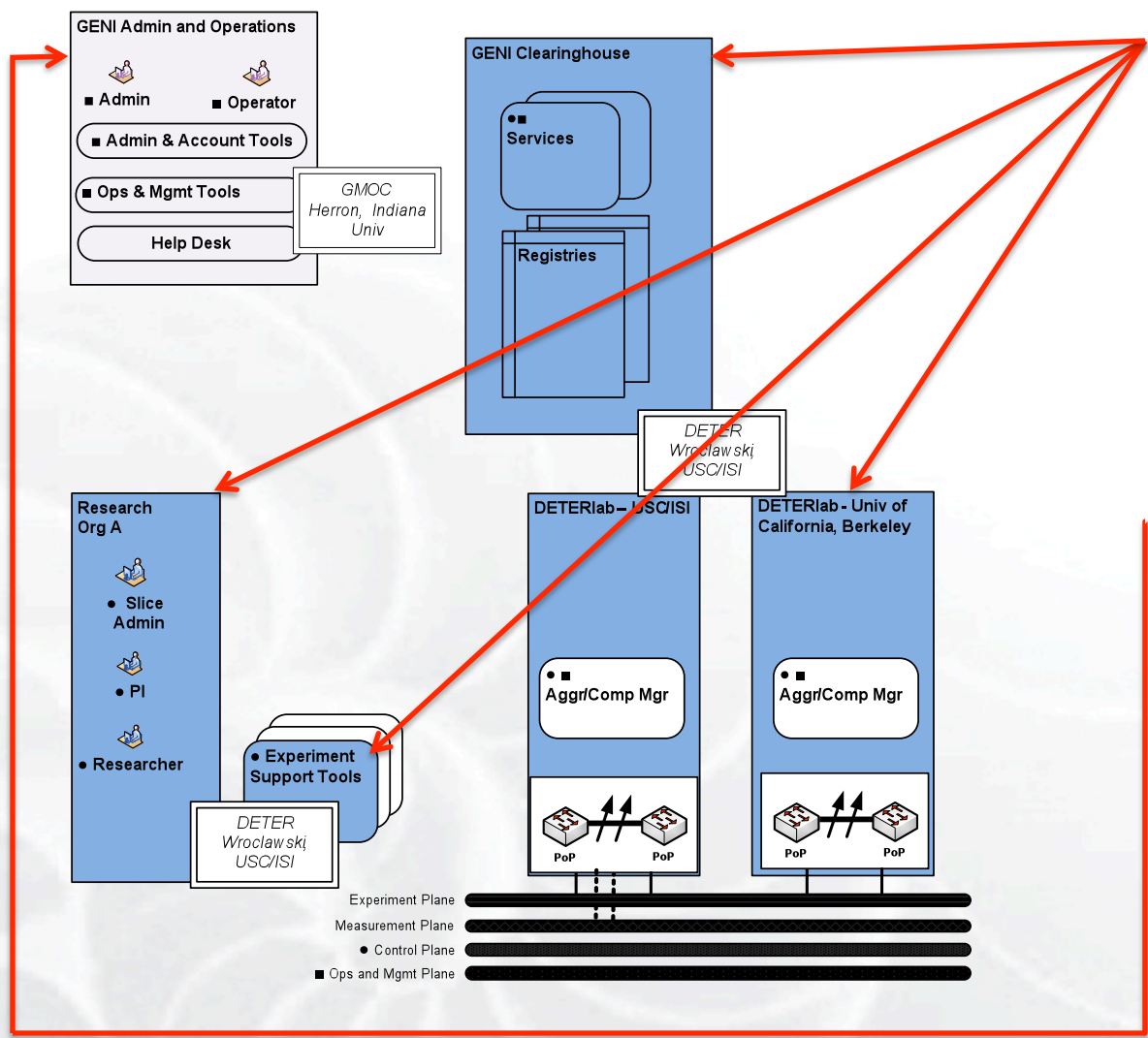


Spiral 1 integration and trial operations

Five competing control frameworks, wide variety of substrates

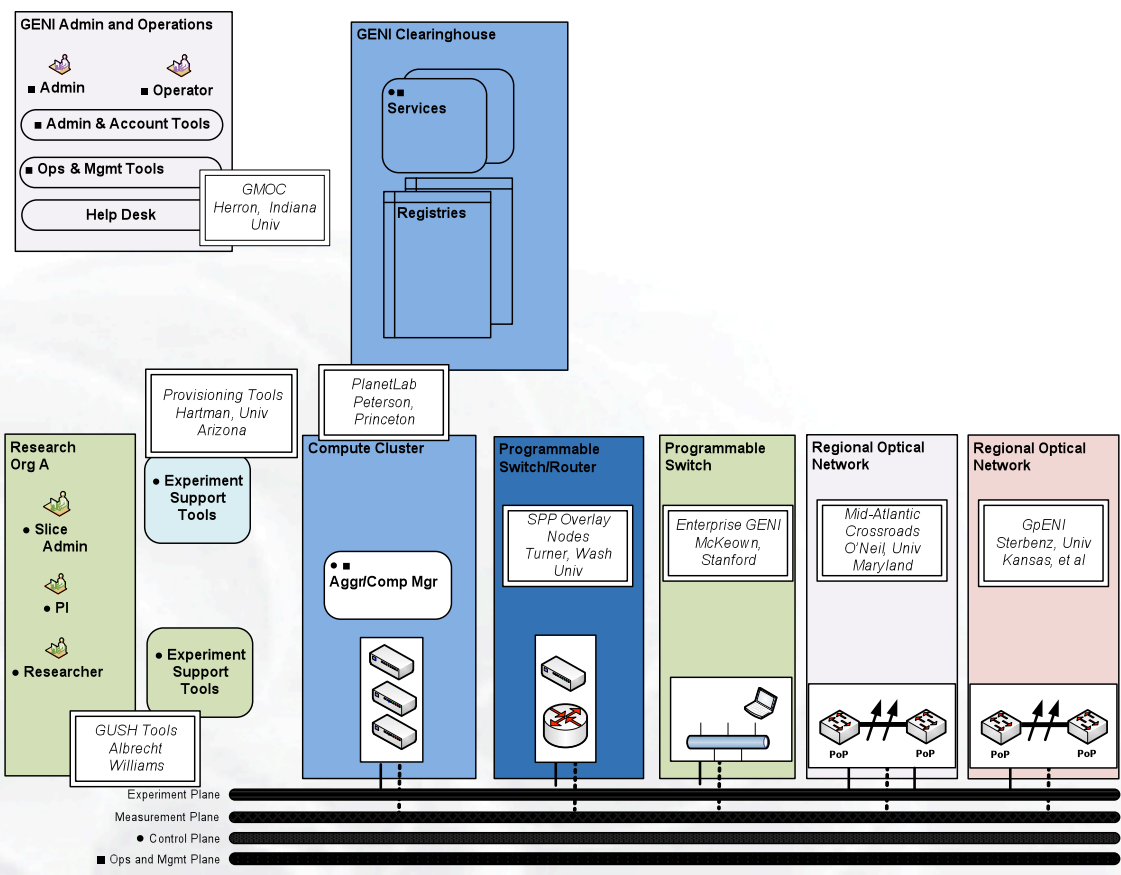


Cluster A Integration (uses TIED/DETER control framework)



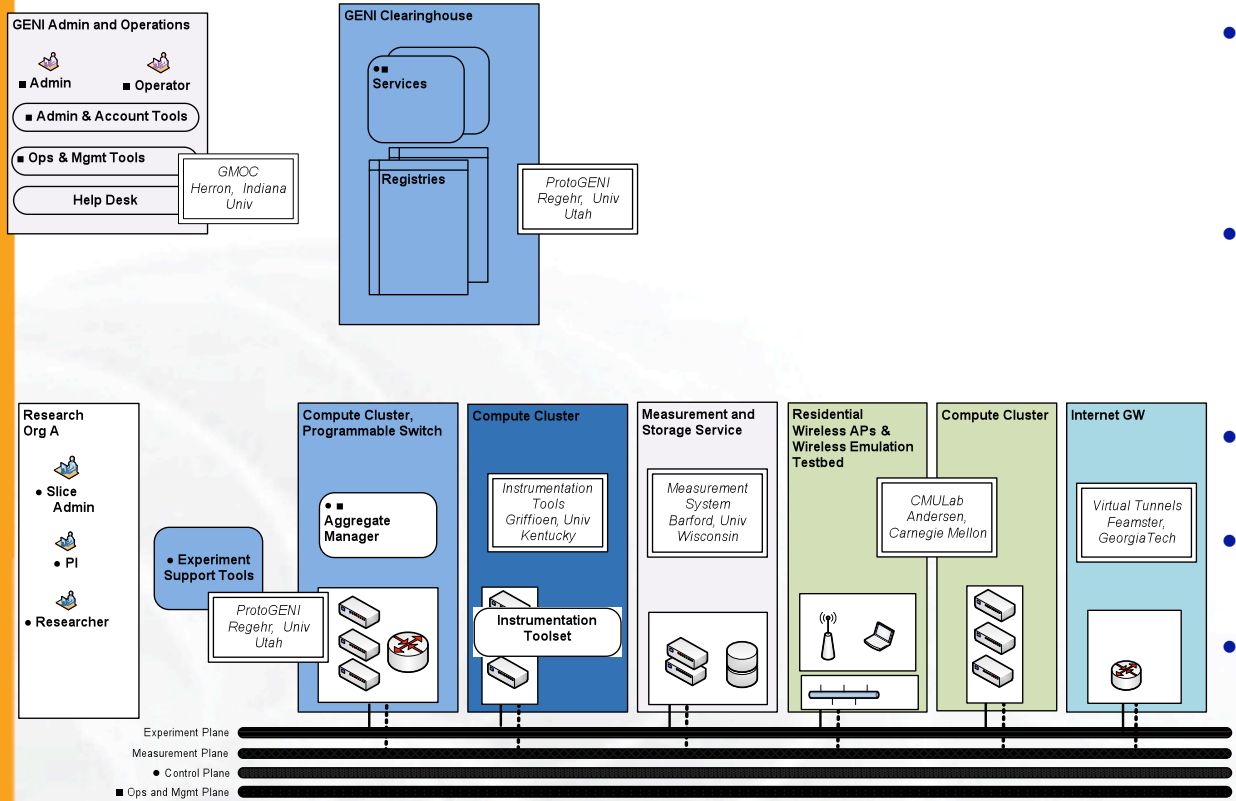
- **DETER Trial Integration**
 - DETER security testbed
 - Emphasis on federation
 - Clearinghouse, CM
 - 100+ nodes at ISI, UC Berkley
- **GMOC**
 - Global Research NOC (Indiana)

Cluster B Integration (uses PlanetLab control framework)



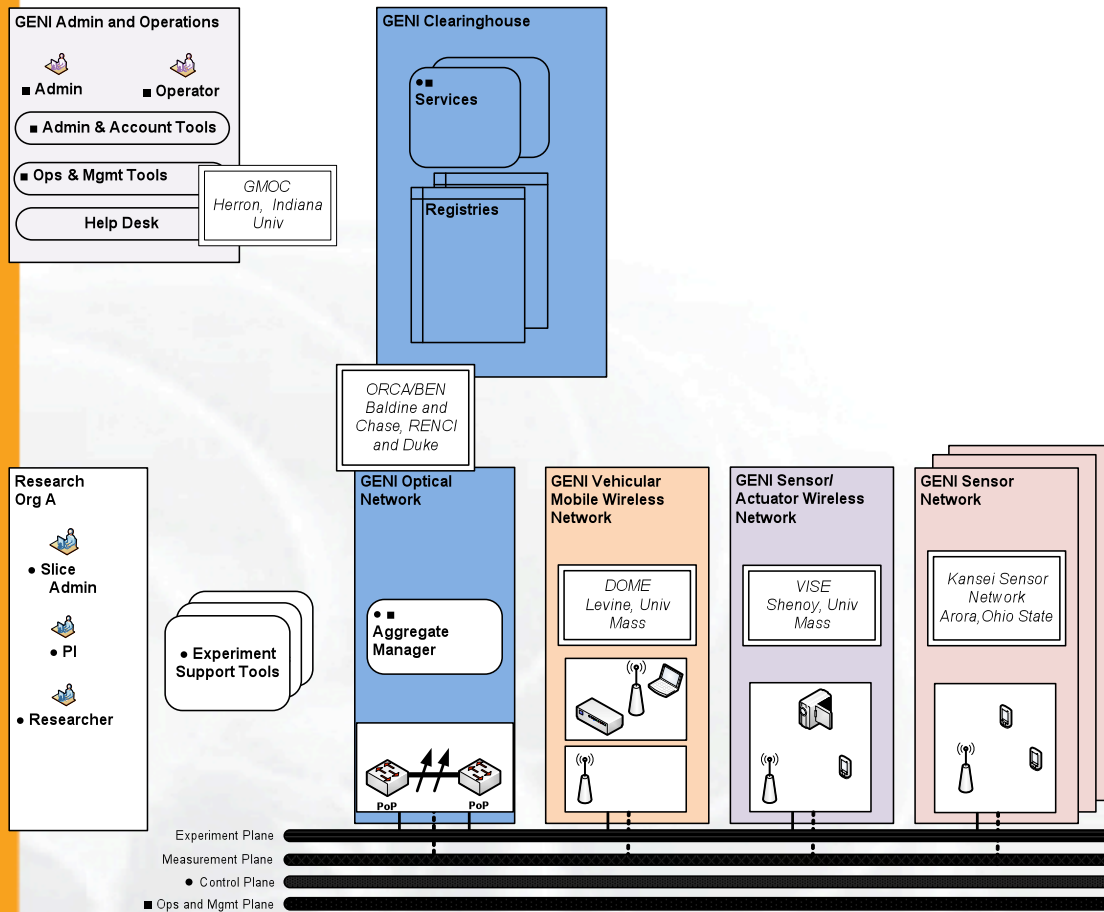
- PlanetLab
 - Clearinghouse, CM
 - 800+ nodes
 - VINI (virtual topologies)
- Enterprise GENI
 - GENI VLANs on enterprise nets
- SPP Overlay Nodes
 - Programmable routers
- GUSH Tools
 - Experiment design tools
- Provisioning Service
 - Slice & experiment management tools
- Mid-Atlantic Crossroads
 - Regional network with VLAN control plane
- GpENI
 - Regional network with sliceable optics & routers
- GMOC

Cluster C Integration (uses ProtoGENI/Emulab Control Framework)



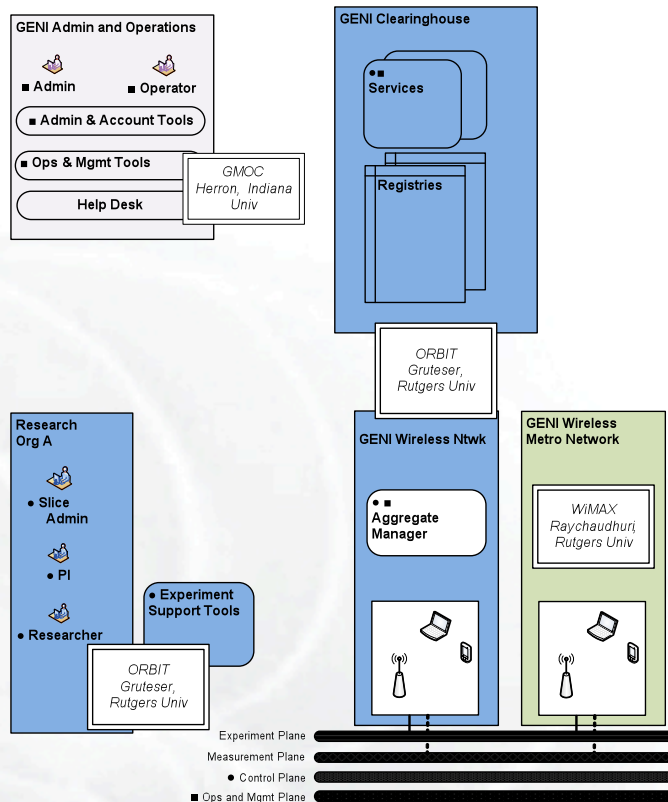
- ProtoGENI
 - Clearinghouse, CM
 - Emulab resources
 - (370+ nodes)
- CMULab
 - Home Wireless APs
 - Emulab cluster
 - Wireless emulation testbed
- Instrumentation Tools
 - UK Edulab (compute/store)
- Measurement System
 - GIMS prototype
- Virtual Tunnels
 - Dynamic tunnel tools
 - BGP distribution tools
- GMOC

Cluster D Integration (uses ORCA Control Framework)



- ORCA/BEN
 - ORCA resource leasing software
 - Metro-Scale Optical Testbed (BEN)
- VISE
 - CASA (radar, video, weather sensors)
- Kansei Sensor Network
 - Wireless sensor network arrays
 - 3 federated sites each w/~100 sensor nodes
- Diverse Outdoor Mobile Environment (DOME)
 - Programmable nodes with radios on city busses
- GMOC

Cluster E Integration (uses ORBIT control framework)

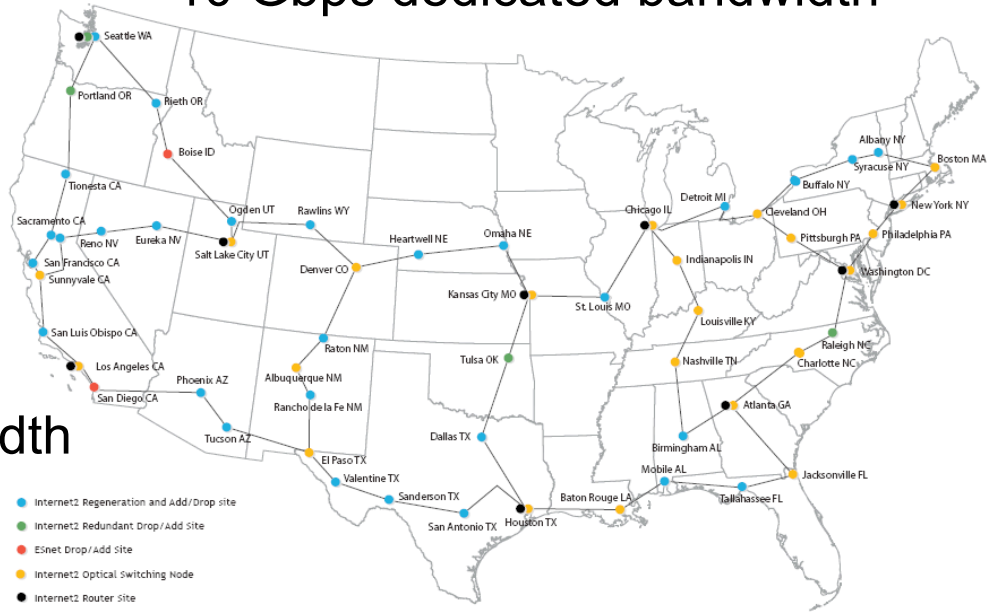


- ORBIT
 - Heterogeneous testbed control, management, & measurement software
 - WINLAB wireless testbeds resources (400+ sensor nodes)
 - NICTA (Australia) wireless outdoor traffic testbed
- WiMAX
 - Open, programmable WiMAX base station
- GMOC



National Lambda Rail
 Up to 30 Gbps nondedicated bandwidth

Internet2
 10 Gbps dedicated bandwidth



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

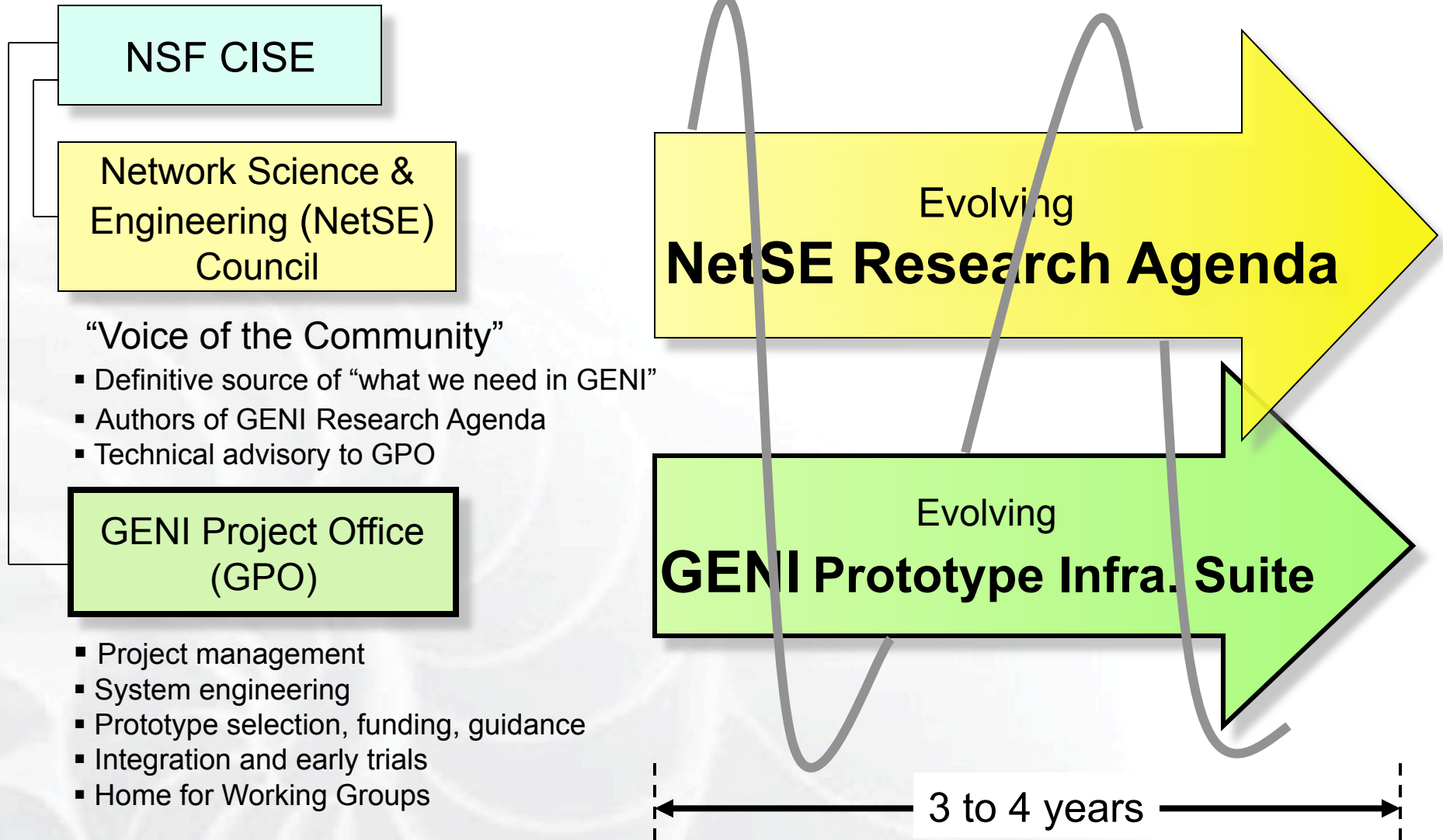
Prototyping GENI through campuses

- August Meeting at O'Hare
 - Thanks to EduCause (Mark Luker, Garret Sern)
 - Stimulated by Larry Landweber
- CIOs from 11 major research universities
 - Berkeley, Clemson, GA Tech, Indiana, MIT, Penn State, Rice, U. Alaska, UIUC, UT Austin, U. Wisconsin
- Discussions of representative GENI prototypes
 - Nick McKeown, Stanford (OpenFlow)
 - Arvind Krishnamurthy, UW (Million Node GENI)
 - GPO Staff
- Near-term GENI / CIO activities
 - How to “GENI-enable” campus IT infrastructure
 - Coordinated policy for handling side-effects of network research (Larry Peterson, Helen Nissenbaum)

- Provides the very first, national-scale prototype of an interoperable infrastructure suite for Network Science and Engineering experiments
- Creates an end-to-end GENI prototype in 6-12 months with broad academic and industrial participation, while encouraging strong competition in the design and implementation of GENI's control framework and clearinghouse
- Includes multiple national backbones and regional optical networks, campuses, compute and storage clusters, metropolitan wireless and sensor networks, instrumentation and measurement, and user opt-in
- Because the GENI control framework software presents very high technical and programmatic risk, the GPO has funded multiple, competing teams to integrate and demonstrate competing versions of the control software in Spiral 1

Nothing like GENI has ever existed; the integrated, end-to-end, virtualized, and sliceable infrastructure suite created in Spiral 1 will be entirely novel.

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NetSE Council



Ellen Zegura (Chair)



Tom Anderson (UW)



Joe Berthold (Ciena)



Charlie Catlett (Argonne)



Mike Dahlin (UT Austin)



Chip Elliott (GPO)



Joan Feigenbarum (Yale)



Stephanie Forrest (UNM)



Jim Hendler (RPI)



Michael Kearns (U.Penn)



Ed Lazowska (UW)



Peter Lee (CMU)



Larry Peterson (Princeton)



Jennifer Rexford (Princeton)



Alfred Spector (Google)

And not shown . . .

Roscoe Giles
Helen Nissenbaum



GENI is being Designed & Built by the Community Via an Open, Transparent, & Fair GPO Process

- All design, prototyping, & construction will be performed by the research community (academia & industry)
- Openness is emphasized
 - Design process is open, transparent, and broadly inclusive
 - Open-source solutions are strongly preferred
 - Intellectual property is OK, under no-fee license for GENI use
- GPO will be fair and even-handed
 - BBN brings no technology to the table
 - BBN does not intend to write any GENI software, nor does it envision bidding on any prototyping or construction activities (but “never say never”)
 - If BBN does create any GENI technology, it will be made public at no cost



Working Groups drive GENI's Technical Design Meet every 4 Months to Review Progress Together

- **Working Groups**, open to all
 - The locus for all GENI technical design
 - Patterned on the early IETF
 - Discuss by email, create documents, meet 3x per year in person
 - Each led by Chair(s), plus a professional System Engineer
- **GENI Engineering Conferences**, 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
 - Results in prioritized list for next round of prototype funding areas (priorities decided by NetSE and GPO)



GENI Working Groups (WGs)

Open to all, participate via **geni.net** email and wiki

- **Substrates**

All hardware, real-estate, facilities, etc., required for the GENI infrastructure suite (including optical networks, wireless, computers, etc.)

- **Control Framework with Federation**

Written definitions of the core GENI mechanisms for providing experimental control of a node or collection of nodes. The very earliest version must incorporate federation.

- **Experiment Workflow**

Tools and mechanisms by which a researcher designs and performs experiments using GENI. Includes all user interfaces for researchers, as well as data collection, archiving, etc.

- **User Opt-In**

How do “real users” (not researchers) participate in GENI experiments. Includes both mechanisms and considerations such as privacy, etc.

- **Operations, Management, Integration, and Security**

How do operators provision, operate, manage, and trouble-shoot GENI? Includes all mechanisms for integrating and securely operating the GENI infrastructure suite.



GENI Engineering Conferences

Meet every 4 months to review progress together

- **4th meeting March 31-April 2, 2009, Miami, open to all**
 - 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

- **Second solicitation closed on Feb. 20, 2009**
- What kinds of proposals do we solicit?
 - Analyses & idea papers
 - Prototypes of high-risk GENI technology
 - Integrations and trials of prototypes
- How are proposals judged?
 - Merit review
 - Joint academic / industrial teams are favored but not required
 - Open source will be favored but not required
(IP licenses on www.geni.net)

GENI Solicitation 2 – Proposals due Feb. 20

- Overview
 - Solicitation issued December 2008
 - Proposals due February 20, 2009
 - Total funds ~ \$3.5 M / yr for 3 years, as always subject to availability of funds
 - Existing / new GENI participants both welcome
- Strong preference given to . . .
 - Joint Academic / Industrial teams
 - Active participation of campus / regional infrastructure providers (e.g., letter from campus CIO)
- Main solicitation interests
 - Security design and analysis for GENI
 - Experimental workflow prototypes
 - Instrumentation and measurement prototypes
 - Early tries at international federation
 - Other good ideas

www.geni.net

Solicitation and background information

GENI is a Huge Opportunity

- **GENI is an unbelievably exciting project for the community**
 - Our research community has changed the world profoundly. GENI opens up a space to do it again.
- **We believe the whole community will build GENI together**
 - Our vision is for a very lean, fast-moving GPO, with substantially all design and prototyping performed by academic and industry research teams.
- **GENI Spiral 1 is now underway !**
 - within a GENI project framework that is open, transparent, and broadly inclusive.

www.geni.net

Clearing house for all GENI news and documents

Introduction to GENI Working Groups

Control Framework WG

GENI Experiment Workflow and Services WG

Operations, Management, Integration and Security WG

Substrate WG

End-User Opt-In WG

Introduction to Control Framework Working Group

**GENI Engineering Conference 5
Newcomer's Meeting
Seattle, WA**

**Christopher Small
July 20, 2009
www.geni.net**



- Introductions
- Definition of the GENI Control Framework
- Scope of Control Framework Working Group
- Activities in the GENI Control Framework WG
- How can you understand the CFs?
- How can you participate in the WG?

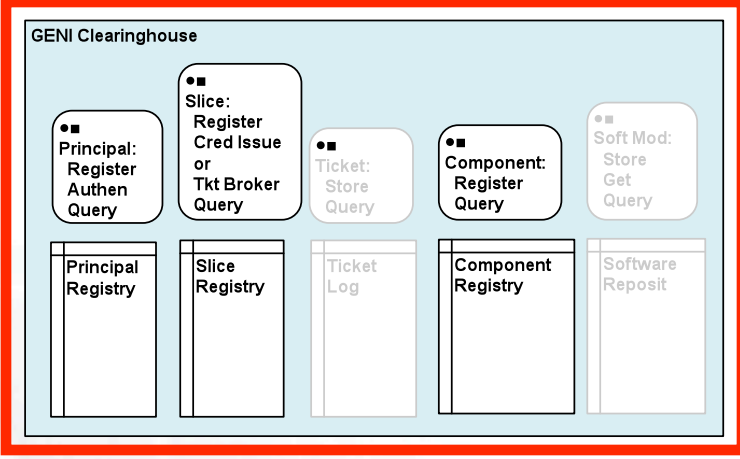
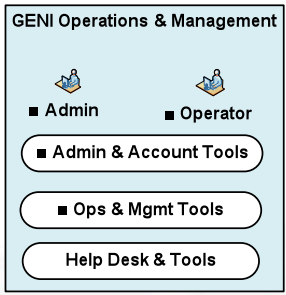
- Christopher Small
 - Current: System Engineer in the GPO at BBN
 - Previous: Systems researcher (Bell Labs, Sun Labs, BBN), software developer (mostly startups)
 - Boston University undergrad, Harvard graduate school (safe dynamically extensible operating systems)
 - csmall@bbn.com
- GENI roles:
 - Control Framework WG System Engineer
 - Currently GPO system engineer for three Spiral 1 projects

- Current
 - Larry Peterson, Princeton, PlanetLab
 - John Wroclawski, USC/ISI, TIED (DETER)
- Incoming (after GEC5)
 - Rob Ricci, University of Utah, ProtoGENI/Emulab
 - TBD

- What is universal across GENI aggregates?
- What is needed to set up and manage cross-aggregate experiments?
- How will GENI accommodate evolution, and will be with or without a full transition of all GENI nodes at once?

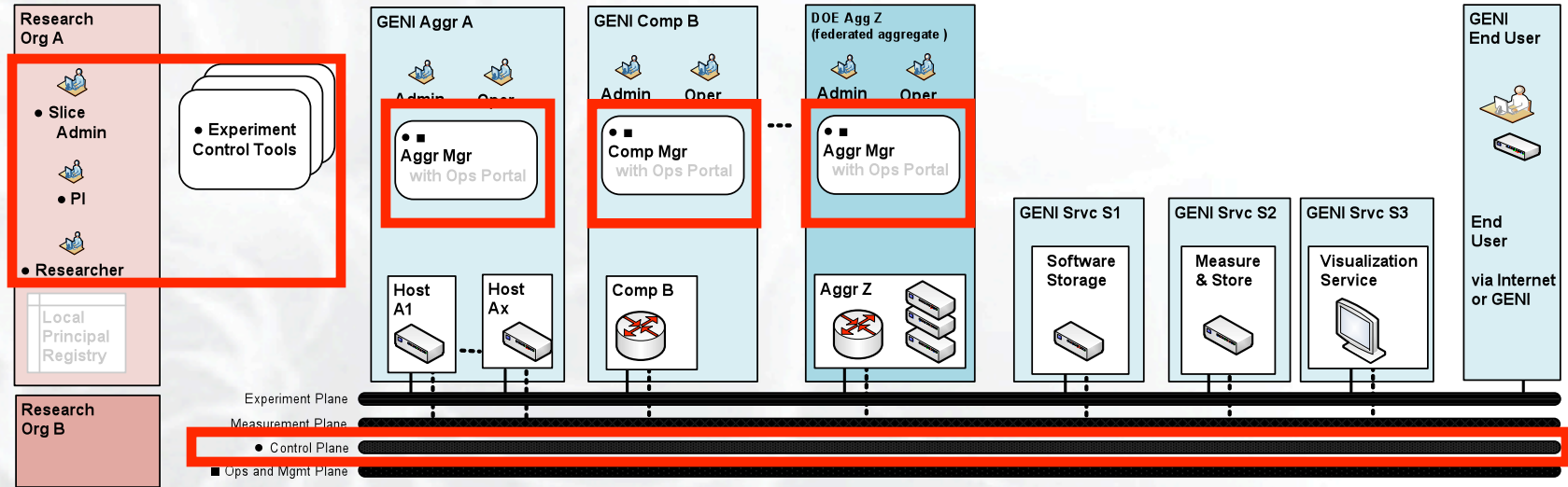
- **Aggregate control**
 - discovering, obtaining and managing resources
- **Slice control**
 - interfaces and mechanisms for establishing and controlling slices
- **Access control within GENI**
 - usage policy representation and administration mechanisms
- **Interactions external to GENI**
 - facility federation
- **Key enabling services**
 - identity, authentication

Control Framework: Schematic View



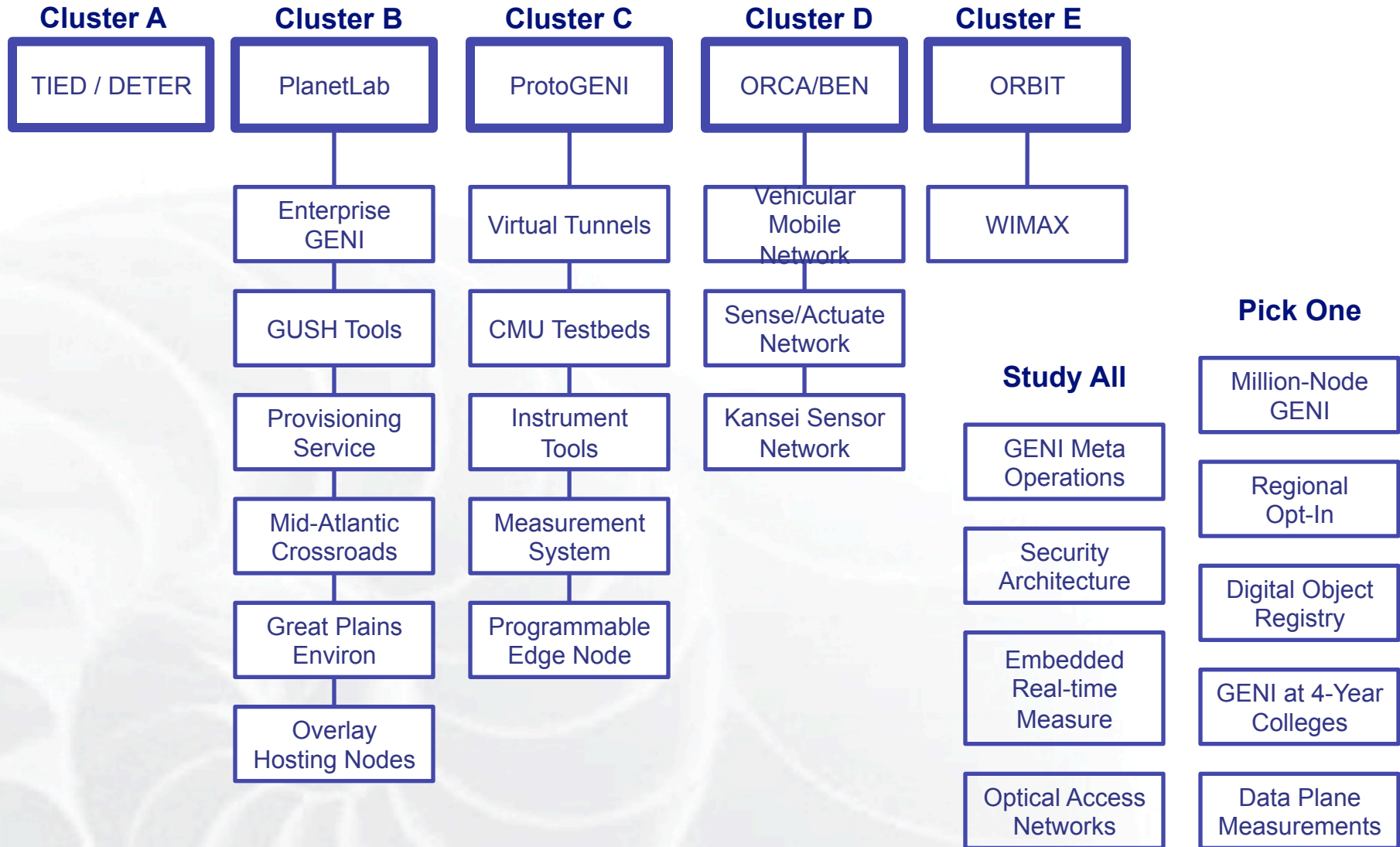
Registries, aggregate managers, and researcher tools to discover, reserve, and manage resources

<http://groups.geni.net/geni/wiki/GeniControlFrameworkRequirements>



Cluster	Control Framework	PI/PoC
A	TIED (DETER)	John Wroclawski
B	PlanetLab	Larry Peterson
C	ProtoGENI (Emulab)	Rob Ricci
D	ORCA/BEN	Ilia Baldine
E	ORBIT	Marco Gruteser

- Define and document requirements
- Forum for discussion of resource specifications (RSpecs), security, other shared control framework issues
- Integration underway
 - See <http://groups.geni.net/geni/wiki/SpiralOne>



- Control Framework requirements document is currently being revised
 - Requirements will be used to evaluate CF designs
 - Revision 1.3 published in January 2009
 - <http://groups.geni.net/geni/wiki/GeniControlFrameworkRequirements>
- Next
 - Work towards a rough consensus between control framework projects and GPO
 - Revise document and review again

How can you understand the CFs?

- Read GENI system overview for a “roadmap”
- See <http://groups.geni.net/geni/wiki/GeniControl>
- Read GENI CF requirements document draft
- Read GENI CF overview document drafts:
 - PlanetLab (Cluster B)
 - ProtoGENI (Cluster C)
 - ORCA (Cluster D)
- Check status of each CF project on GENI wiki
- Talk with PIs

How can you participate in the CFWG?

- Check wiki for activities:
 - <http://groups.geni.net/geni/wiki/GeniControl>
 - See meeting announcements, notes, presentations.
 - Check work in progress, DRAFT documents, etc.
- Join the mailing list!
 - Listen, and then participate in a discussion.
 - Participate in document reviews.
 - Once you are on (any) list, you can contribute to the wiki.
- Attend meetings

- Introduction of new workgroup chair(s)
- News from the GPO (Christopher Small, GPO)
 - Update on CF Requirements document
 - Identity management
- Network stitching
 - Intro (Christopher Small, GPO)
 - Network stitching in MAX, Chris Tracy (MAX)
 - Network stitching in ProtoGENI/Emulab, Rob Ricci (ProtoGENI)
 - Network stitching in ORCA/BEN, Yufeng Xin (BEN)
 - Planned network stitching in cluster B, Larry Peterson (PlanetLab)

Experiment Workflow and Services Working Group

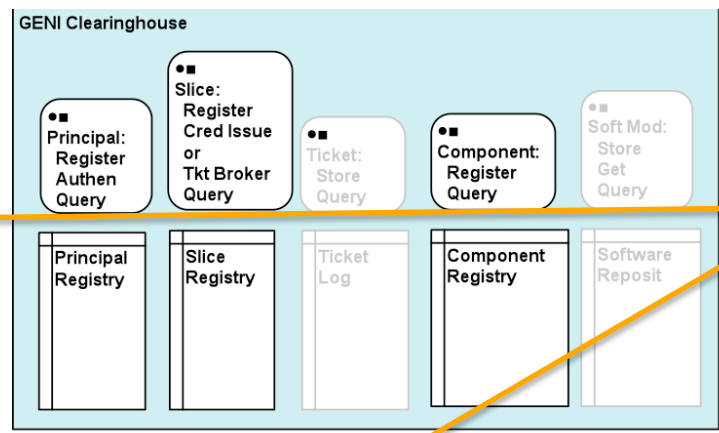
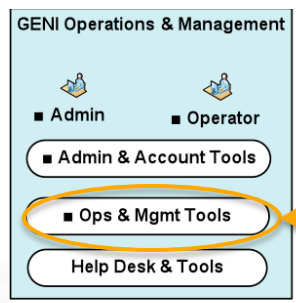
**GENI Engineering Conference 5
Seattle, WA**

**Vicraj Thomas
July 20, 2009
www.geni.net**

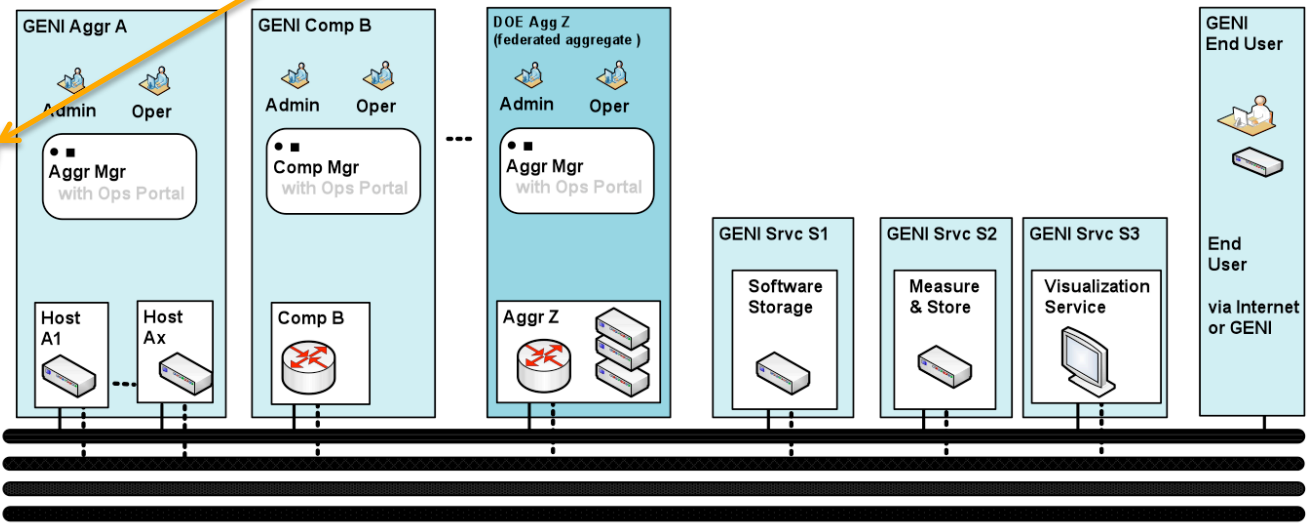


- Identify and specify tools and services needed to run experiments on GENI
 - Planning, scheduling, deploying, running, debugging, analyzing, growing/shrinking experiments
 - Collaboration
 - Multiple researchers on an experiment
 - Building on other experiments
- <http://www.geni.net/wg/services-wg.html>

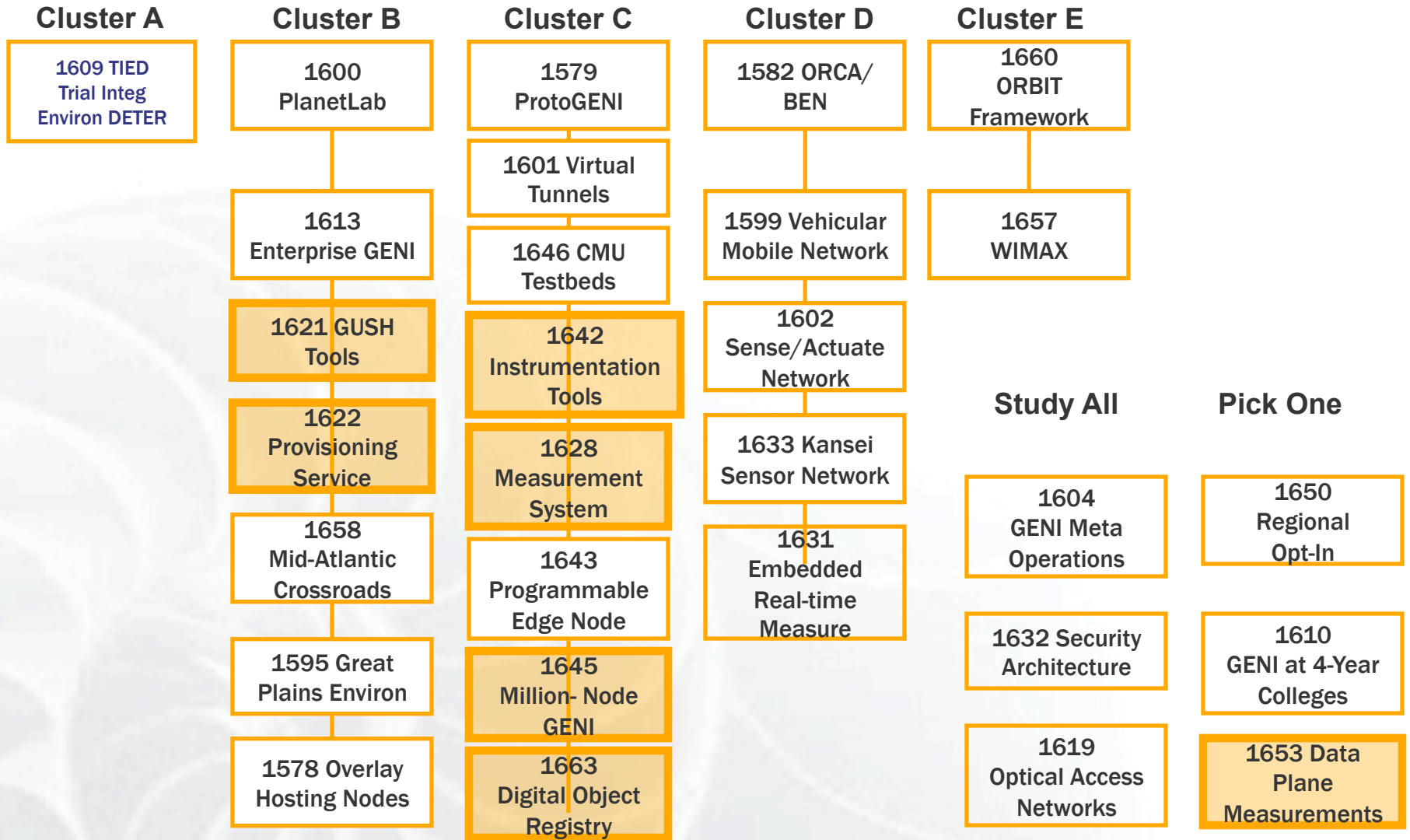
Relationship to GENI Architecture



The Experiment Services and Workflow WG focuses on experimenter-users needs for planning, scheduling, running, debugging, analyzing and archiving experiments.



Related Spiral 1 Projects



- Chair: Prof. Jeff Chase, Duke University
- Email list to discuss topics of interest
 - Open to all
 - Subscribe at URL on previous slide
- Working Group Wiki page
 - <http://groups.geni.net/geni/wiki/GeniServices>
 - Any email list subscriber can contribute to wiki
- Face-to-face meetings at GECs

- Vicraj Thomas
 - Background in highly dependable distributed systems and networks, network security
 - Ph.D. University of Arizona, MS University of Rhode Island, B. Tech. IIT Mumbai
- GENI roles
 - Experimenter Workflow and Service WG SE
 - Security SE (with Heidi Picher Dempsey)
 - GPO coordinator for five Spiral 1 projects

- **Lifecycle of a GENI Experiment**
 - Community review held on Fri April 17
 - <http://groups.geni.net/geni/attachment/wiki/ExperimentLifecycleDocument/ExperimentLifeCycle-v01.2.pdf>
- **Experiment Workflow Services: Spiral 1 Capabilities**
 - Draft in review by clusters
- **Workflow Services: Technical Requirements**
 - Not started
- **GENI Measurement System Architecture**
 - Measurement workshop held on 26 June 2009

- Purpose: Identify tools and services to support experimentation with GENI
 - Steps in the lifecycle of an experiment
 - From experiment planning to experiment sunsetting
 - Taxonomy of tools and services needed to support these steps
- Illustrated using a “usage narrative”
 - Fictional story of an experiment that starts at a university, grows to include a industrial collaborator and opt-in users, and eventual transitions to product

- Purpose:
 - Understand different approaches to experimenter tools and services
 - Inform Spiral 1 clusters about tools they may be able to leverage from other clusters
 - Identify areas where additional tools are needed
- Catalog of tools organized according to taxonomy in the lifecycle document
- Community review to be scheduled after comments from clusters

- Tomorrow at 3.30pm
- Agenda:
 - 3.30pm - 3.40pm WG goals and deliverables; Documents status
Vic Thomas
 - 3.40pm - 3.45pm Report on the GENI Measurement Workshop
Joel Sommers
 - 3.45pm - 4.05pm ORBIT experimenter tools
Max Ott
 - 4.05pm - 4.25pm ORCA experimenter tools
Yufeng Xin and
David Irwin
 - 4.25pm - 4.45pm ProtoGENI experimenter tools
Rob Ricci
 - 4.45pm - 5.05pm PlanetLab experimenter tools
Jeannie Albrecht
 - 5.05pm - 5.25pm TIED experimenter tools
Ted Faber
 - 5.25pm - 5.30pm Wrap-up

- How are experiments specified in each of the Spiral 1 clusters? What are the declarative and procedural aspects of this specification?
- How is this specification used by the tool chain available to experimenters?
- What are the experimenter tools in one cluster that might be ported to other control frameworks?
- What assumptions do tools make about the control framework? What assumptions might be specific to their control framework?



Introduction to GENI Integration and the Operations, Management, Integration and Security (OMIS) Working Group

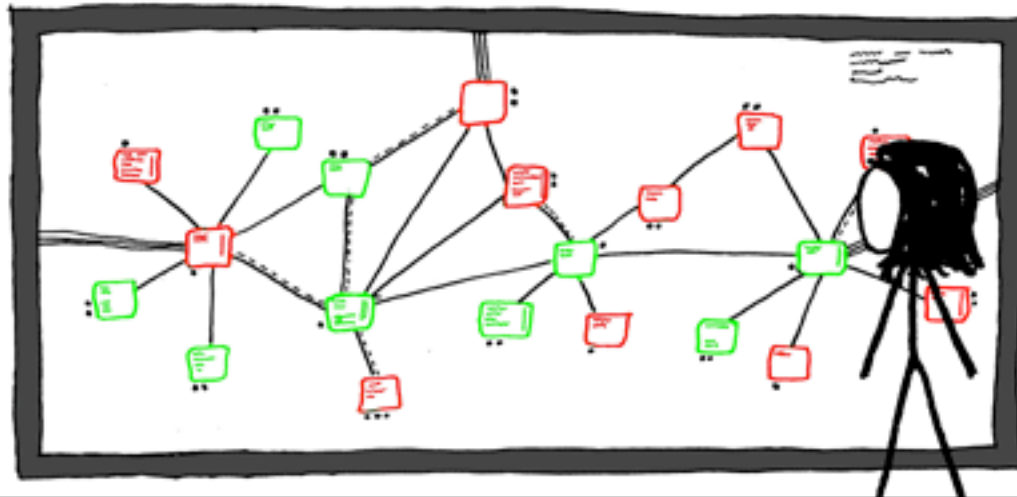
**GENI Engineering Conference 5
Newcomer's Meeting
Seattle, WA**

Heidi Picher Dempsey

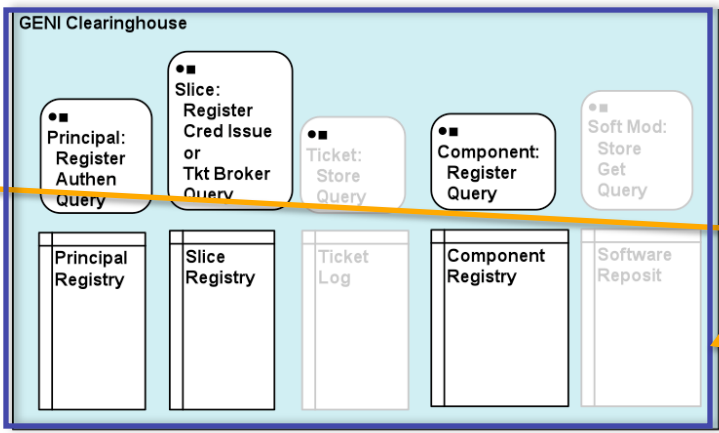
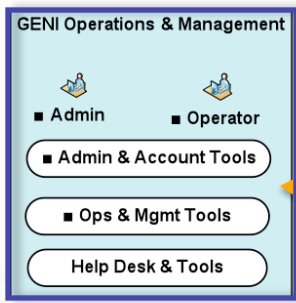
**July 20, 2009
www.geni.net**

- **hdempsey@geni.net**
 - Operations Director for GENI (e.g. mailing lists, wiki, web site, demos, eventual GENI operations as it evolves)
 - **geni-ops@geni.net** (don't worry if your first message to this list is "held for approval"—we're trying to limit SPAM)
 - Coordinator for project leads and GPO system engineers on GENI integration milestones for each spiral (<http://groups.geni.net/geni/roadmap> lists all current and past-due milestones by target date for Spiral 1)
 - System Engineer for several Spiral 1 projects
 - (with Mike Patton and projects) engineer GENI network connections (e.g. Internet2, NLR, regional networks, campus networks)

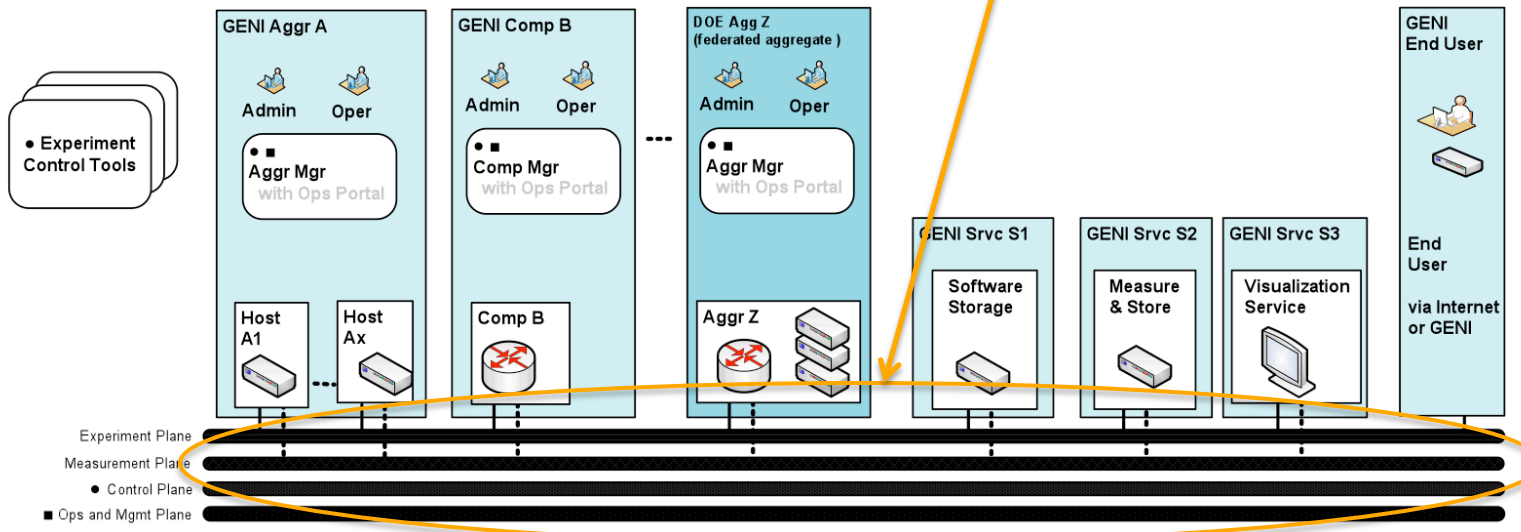
- hpd@bbn.com
 - Chair of the OMIS working group (Mike Patton is the system engineer for OMIS). <http://groups.geni.net/geni/wiki/GeniOmis> has lots of OMIS information.
 - Advisor for several GENI interns (send resumes!)
 - GPO visitor (should we come to *your* campus or office?)



OMIS relationship to GENI Architecture

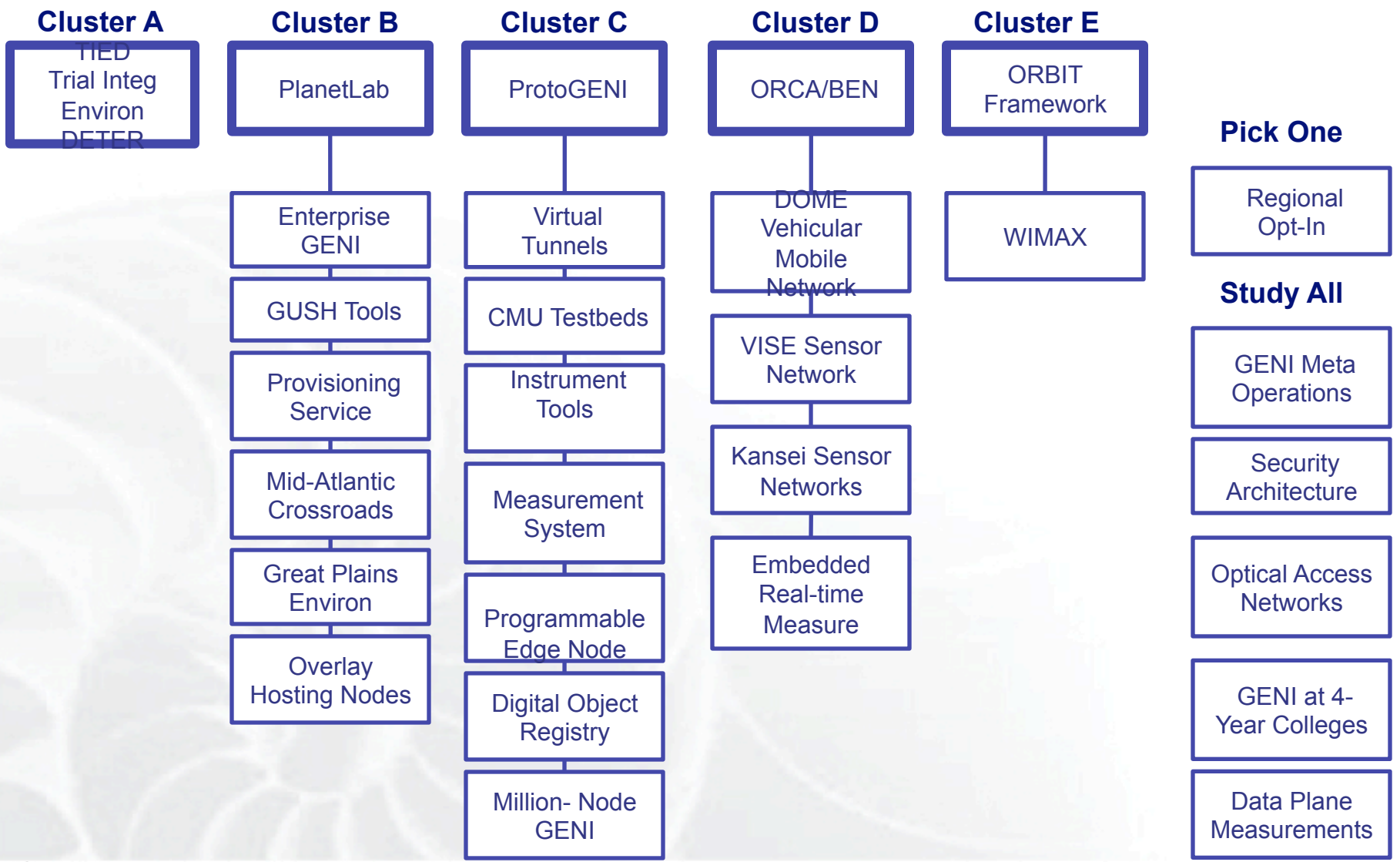


How do we integrate and operate GENI and manage its services? How will this differ as spirals evolve? What are GENI's operational security requirements for researchers, users, and operators?



- **O**perations Framework: define and engineer high-level functions required for coordinating operations in the near-term research and prototype environment. We like use cases (<http://groups.geni.net/geni/wiki/GeniOmisUseIntro>) and discussions.
- **M**anagement: Data Sharing for GENI Meta Operations (http://groups.geni.net/geni/attachment/wiki/GENIMetaOps/operational_dataset_v31.pdf). We like interfaces, APIs, and data structures.
- **S**ecurity: Draft Recommended Use Policy (<http://groups.geni.net/geni/wiki/RUP>) and Spiral 1 Draft Security Architecture (<http://groups.geni.net/geni/attachment/wiki/GENISecurity/GENI-SEC-ARCH-0.4.pdf>). Pay special attention to Spiral 1 action items in security draft!

But wait, you forgot the "3" in OMIS!



No we didn't , it's a group effort!

- Spiral 1 GENI project pages explain how integration milestones relate (<http://groups.geni.net/geni/wiki/SpiralOne>). (If they don't, they should—complain!)*
- Funded projects' contacts, schedules, links to other sites, and quarterly reports all available on wiki
- GENI tickets show progress, allow projects to request actions from each other and GPO, escalate issues (Tickets by milestone report <http://groups.geni.net/geni/report/3>).
- All working group mailing list participants get wiki (and ticket) write access. (Sign up at <http://lists.geni.net/mailman/listinfo>)
- GPO tracks this as part of evaluating, funding, and continuing GENI projects.

* they provide better info than slide⁹⁶

Isn't that a lot of overlap?

- That's why OMIS is a nosey group. ;-)
- Lots of projects started Spiral 1 doing similar but related things in different places (clusters). Most plan to show integrated prototypes by September 2009.
- "Horizontal" cuts (e.g. substrates, routing, data planes) overlap by nature.
- "Vertical" cuts, e.g. control interactions between clearinghouses and aggregates may differ greatly in implementation, but carry out many of the same high-level functions.
- GENI "Meta Operations" is in early definition stage, but is likely to create windows into this kind of GENI data where there is overlap and interest (well, maybe skylights for the vertical windows).



GENI wiki examples (look for yourself)

GENIMetaOps - GENI: geni - Trac

http://groups.geni.net/geni/wiki/GENIMetaOps

Most Visited - Electronic Time Rec... BBN Internal Web GENI.net Global Envi... rjgrey j - Google Sea... Google Calendar

{3} Active Tickets by Milestone ... lists.geni.net Mailing Lists GENIMetaOps - GENI: geni - Trac

Wiki | Spiral One | GPO Docs | Timeline | Roadmap | View Tickets | Search

Start Page | Index by Title | Index by Date | Last Change

GENI META-OPERATIONS CENTER

Project Number
1604

Project Title GENI Meta Operations
a.k.a. GMOC

Technical Contacts
Principal Investigator Jon-Paul Herron jph@grnoc.iu.edu Co-Principal Investigator Luke Fowler luke@grnoc.iu.edu

Participating Organizations
[Indiana University Bloomington, IN](#)
[Global Research Network Operations Center Indianapolis, IN](#)

Scope
The scope of work on this project is to facilitate the sharing of operational and experimental information among GENI experimental components.

This effort has both technical development and operation; Center (GMOC) would require a well-defined protocol to h and for the providers of prototypes to send those details I suggest a modular approach, with a generalized protocol

Project

Roadmap - GENI: geni - Trac

http://groups.geni.net/geni/roadmap

Most Visited - Electronic Time Rec... BBN Internal Web GENI.net Global Envi... rjgrey j - Google Sea... Google Calendar

{3} Active Tickets by Milestone ... lists.geni.net Mailing Lists Roadmap - GENI: geni - Trac

Milestone: ENTGENI: Draft API/protocol between ENTGENI AM and Clearinghouse
Due in 2 days (04/01/09)

Start work with other parties to agree on the API/protocol between the GENI Clearinghouse and Aggregate Component Manager. This work is ongoing. The milestone "ENTGENI: Start integrating interfaces from ENTGENI AM to Clearinghouse" depends on significant progress on the ongoing work.

Milestone: ENTGENI: Version 0 Aggregate Component Manager
Due in 2 days (04/01/09)

Implement Version 0 Aggregate Component manager for an OpenFlow network.

Milestone: GMOC: Define Common Operational Dataset
Due in 2 days (04/01/09)

67%

Closed tickets: 2 Active tickets: 1

Coordinate with GENI projects and define a Common Operational Dataset. This is a minimum set of operational-related data that should be common among all components that would be monitorable by the GMOC. Ongoing work in months 1-6.

Road map

Tickets

Done

#	Summary	Component	Version	Type	Owner	Created
#34	Initial CMN/GAB code merged with PROTOGENI	CMN/GAB	2.1.1	Task	qde@ca.cmu.edu	03/10/09
CMN GAB: Merge patches into PROTOGENI distribution Release						
#35	Investigate VLAN connectivity to CMN	CMN/GAB	2.1.1	Task	jdembree@ppri.com	12/03/08
CMN GAB: Get CMN PROTOGENI node on IS VLAN Release						
#35	Complete phinging 2 homelayer nodes up	GPO	2.1.1	Task	qde@ca.cmu.edu	03/11/09
CMN GAB: Deploy and commence operations of 2 residential Homelayer nodes Release						
#43	Million node GENI demo of SEC 4	PROTOGENI	2.1.1	Task	jdembree@ppri.com	03/10/09
#20	PROTOGENI demo of SEC 4	PROTOGENI	2.1.1	Task	lccc@ca.cmu.edu	03/11/09
#19	redevelopment of aggregate block for use in the aggregate component	DMEAS	2.1.1	Task	awolcott	12/11/08
#12	add obj-in (not just nml obj-in) to GENI aggregator	GPO	2.1.1	Task	lccc@ca.cmu.edu	12/11/08
#04	operational release discussion from GMOC	GPO	2.1.1	Task	lccc@ca.cmu.edu	03/11/09
#03	CMN demo of SEC 4	CMN/GAB	2.1.1	Task	bdnuss@ca.cmu.edu	03/11/09

Done

- **Integration status**
 - Network (Mike Patton)
 - Operations and Management (Jon-Paul Herron)
 - Security (Stephen Schwab)
 - Recommended Use Policy (Heidi Picher Dempsey)
- **Interactive Design Discussions**
 - Emergency Shutdown
 - Distributed data sharing
 - Distributed authorization
- **Lightning Talks (open to all—no slides required)**
 - Quilt Regional Networks status update (Jen Leasure)
 - Yours??

Introduction to the Substrate Working Group

GENI Engineering Conference 5 Newcomer's Meeting Seattle, WA

**Harry Mussman
July 20, 2009
www.geni.net**



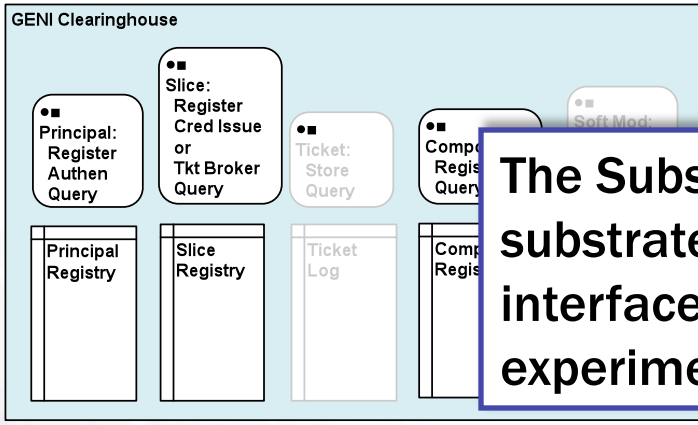
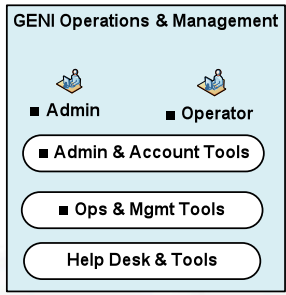
Substrate WG Co-Chairs

- Patrick Crowley – Washington University, St. Louis
- Joseph Evans – University of Kansas
- Peter O’Neil – Mid Atlantic Crossroads

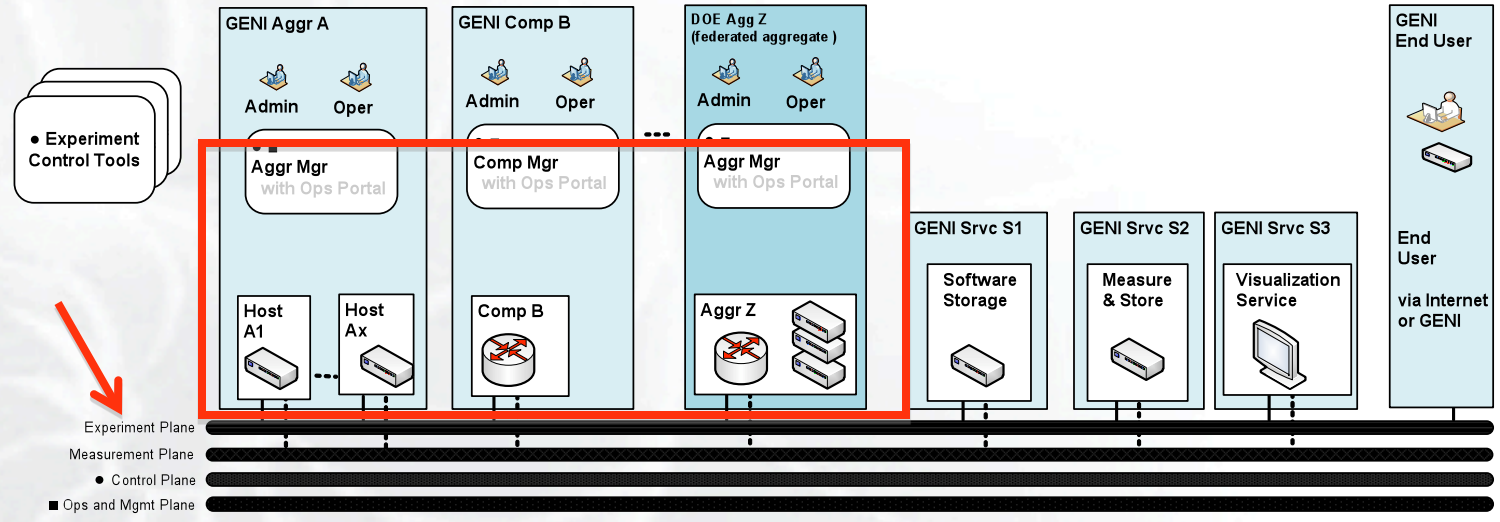
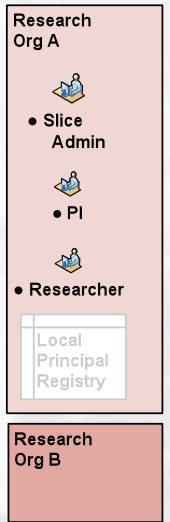
- New Co-Chairs to be announced, effective GEC 6

- Harry Mussman
 - Current: Senior Systems Engineer in the GPO at BBN
 - Last: Voice-over-IP architect at BridgePort Networks (a startup) and GTE Internetworking/Genuity
 - BSEE Univ Michigan, MSEE Northwestern Univ, PhD Stanford Univ
 - hmussman@bbn.com
- GENI roles:
 - Substrate WG SE
 - Opt-in WG SE
 - GPO coordinator for seven Spiral 1 projects

- Frame technical issues from top-down
 - Collect issues from WG, organize and revise
 - Use to identify and structure WG documents
- Synthesize input from bottom-up
 - Collect input from WG, compile and distribute
 - Look for and summarize consensus (or lack of it)
- Draft WG documents...
 - Manage process to completion
- Assist WG communications
 - Take and distribute notes
 - Maintain wiki



The Substrate WG focuses on substrates (aggregates) and their interfaces, with emphasis on the experiment plane



Spiral 1 Substrate Projects

National Backbones

NLR
Internet2

Campus Networks

Enterprise
GENI

Regional Optical Networks

GpENI
Mid-Atlantic
Crossroads
ORCA/BEN

GIMS

Measurement
System

Wireless and Sensor Networks

CMU Testbeds
Vehicular Mobile
Network
Sensor/Actuator
Network
Kansei Sensor
Network
Orbit
Framework
WiMAX

CPU Clusters

ProtoGENI
PlanetLab
TIED

Programmable Nodes

SPP Overlay
Hosting Nodes
ProtoGENI
Programmable
Edge Node

Accomplishments during Spiral 1

- Spiral 1 goal: “vertical integration”
 - Between Control Framework (CF) and Substrate
 - Via Aggregate Manager (AM)
 - Allows Researcher to discover resources; authorize and reserve resources; and use resources in a Substrate
 - Well underway for most substrates
 - Each CF has a different approach and implementation for AM
- Spiral 1 goal: “horizontal integration”
 - Setup connections for data plane between Components in a Substrate, and between Substrates
 - First goal: End-to-end VLAN connections, utilizing NLR or Internet2 backbone network
 - Starting now for some substrates
- Spiral 1 goal: catalog all GENI substrates and resources
 - First Substrate Catalog compiled with input from substrate projects

Agenda for WG Meeting on Tuesday

- Welcome and introduction of new co-chair(s), effective GEC6
 - Patrick Crowley, Joe Evans and Peter O'Neil, WG co-chairs

Review of recent Spiral 1 vertical and horizontal integration examples:

- ORCA integration with BEN (20 min)
 - Yufeng Xin – RENC1
- ORBIT (OMF) integration with a WiMAX base station (20 min)
 - Ray Raychaudhuri - WINLAB/Rutgers
- PlanetLab GENI integration with DRAGON resources in MAX (20 min)
 - Chris Tracy - MAX, incoming co-chair
- Introduction to UltraScience Net (15 min)
 - Nagi Rao - Oak Ridge National Laboratory
- WG Goals for Spiral 2 (10 min)
 - Joe Evans and Peter O'Neil, WG co-chairs
- Wrap up, review of action items and issues for plenary
 - Christopher Small – GPO (standing in for Harry Mussman, WG SE)

WG Goals for Spiral 2

- Improve ease of “vertical integration”
- Extend “horizontal integration”
- Extend and improve catalog of all GENI substrates and resources

How can you participate in the WG?

- Check wiki for activities:
 - <http://groups.geni.net/geni/wiki/GeniSubstrate>
 - See meeting announcements, notes, presentations
 - Check work in progress, DRAFT documents, etc.
- Join the mailing list!
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Introduction to the End-User Opt-In Working Group

GENI Engineering Conference 5 Newcomer's Meeting Seattle, WA

**Harry Mussman
July 20, 2009
www.geni.net**



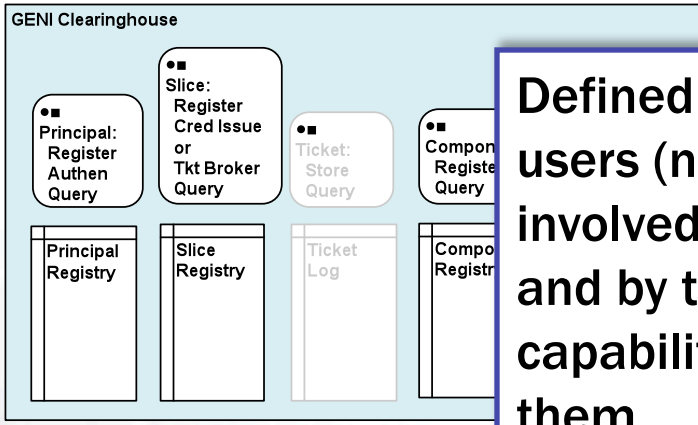
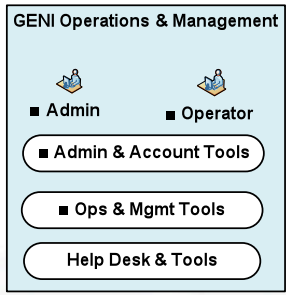
End-User Opt-In WG Chairs

- Helen Nissenbaum – NYU
- Henning Schulzrinne – Columbia Univ
- New Co-Chairs to be announced, effective GEC 6

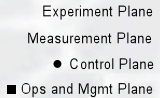
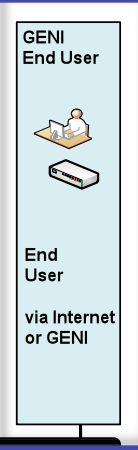
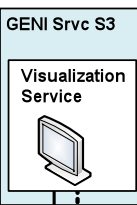
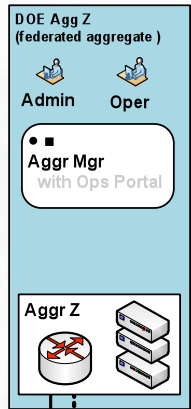
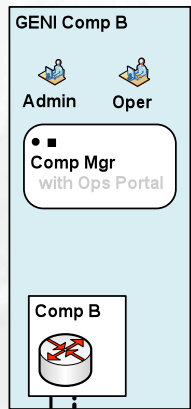
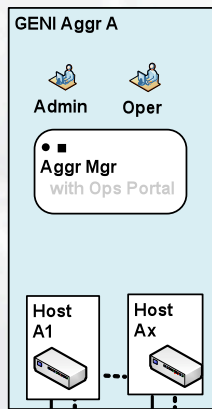
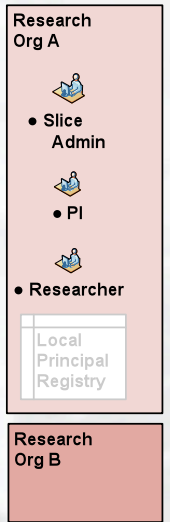
- Harry Mussman
 - Current: Senior Systems Engineer in the GPO at BBN
 - Last: Voice-over-IP architect at BridgePort Networks (a startup) and GTE Internetworking/Genuity
 - BSEE Univ Michigan, MSEE Northwestern Univ, PhD Stanford Univ
 - hmussman@bbn.com
- GENI roles:
 - Opt-in WG SE
 - Substrate WG SE
 - GPO coordinator for seven Spiral 1 projects

- Frame technical issues from top-down
 - Collect issues from WG, organize and revise
 - Use to identify and structure WG documents
- Synthesize input from bottom-up
 - Collect input from WG, compile and distribute
 - Look for and summarize consensus (or lack of it)
- Draft WG documents...
 - Manage process to completion
- Assist WG communications
 - Take and distribute notes
 - Maintain wiki

What is GENI End-User Opt-In?



Defined by: Use cases where end users (not researchers) become involved with GENI experiments; and by the services and capabilities necessary to support them.

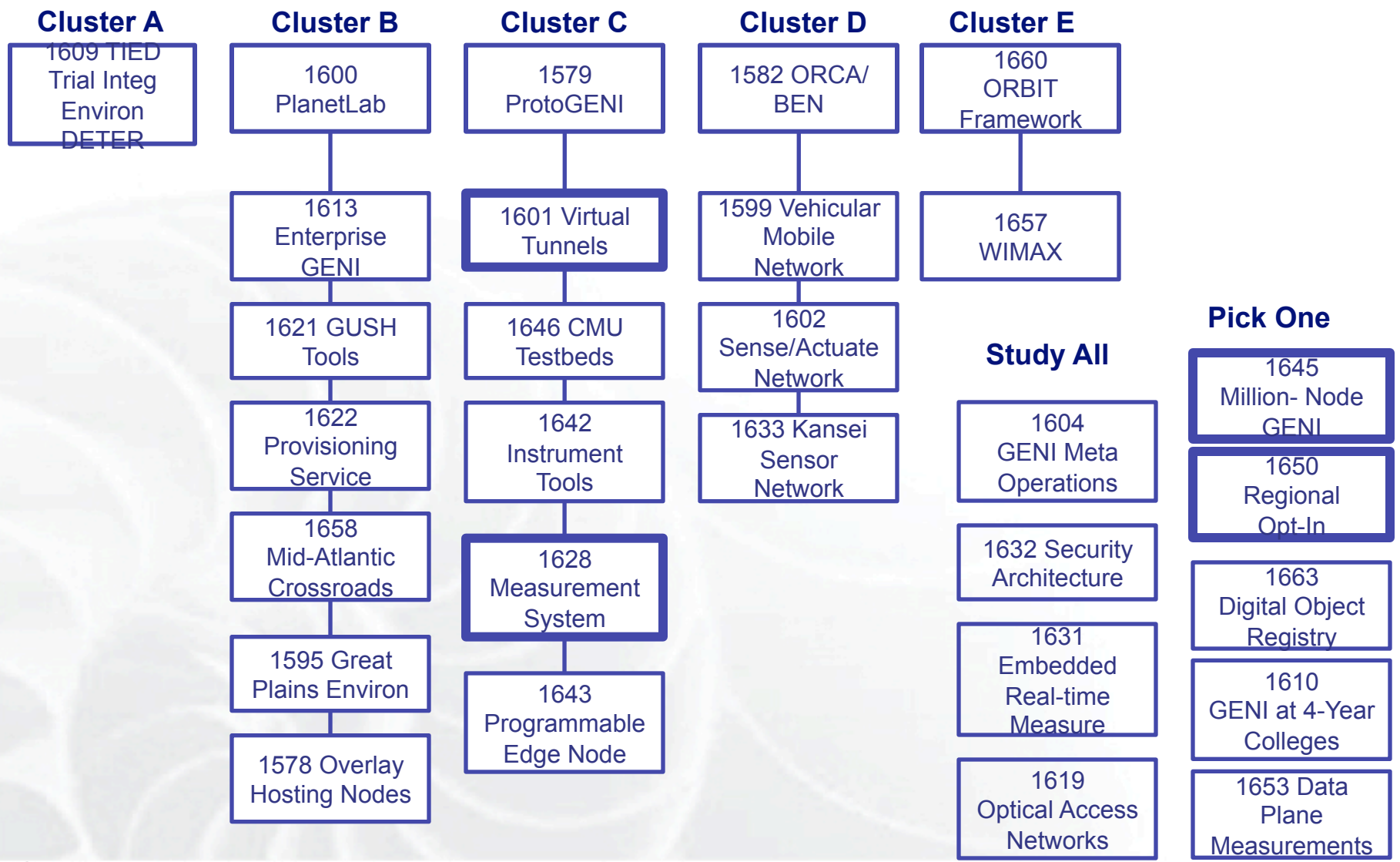


Scope of the End-User Opt-In WG

- How do end-users (including Internet users) participate in GENI experiments?
- What are the various aspects including user interfaces, scheduling, debugging, measurement, archiving data, sandboxes, etc?
- What are the privacy and legal issues involved in user opt-in?

- Use Case 1: A user chooses to participate in a GENI experiment to receive a service
 - See Opt-in Workshop report by Craig Partridge.
- Use Case 2: : A user chooses to participate in a GENI experiment to contribute resources for others
 - Studied in 1645 Million Node GENI project (Justin Cappos – U Washington).
- Use Case 3: A group of users are pulled into a GENI experiment
 - See DRAFT requirements from 1650 Regional Opt-In project (Matt Mathis – PSC).
- Use Case 4: A 3rd party use is undesirably affected by a disruptive GENI experiment
 - Consider experience from PlanetLab by Larry Peterson - Princeton.

Spiral 1 Projects with End-User Opt-In Capabilities



- WG “writing meeting” in NYC on April 14
 - See <http://groups.geni.net/geni/wiki/041409NYCOptInWGAgenda>
 - Several attendees, many references, several contributions
- Objectives were met, including:
 - Baseline view of GENI opt-in
 - Based on contributions and notes from meeting, wrote DRAFT document: “GENI End-User Opt-In Overview”
 - To expand one key topic, wrote separate DRAFT document: “GENI Structure Overview”, including entities, actors and agreements.
 - Expected range of GENI structures must be supported by GENI architecture, particularly control framework
 - Mitigating opt-in risks and solving opt-in issues will drive need for particular agreements

Agenda for WG Meeting on Tuesday

- Welcome and introduction of new co-chair(s), effective GEC6
 - Henning Schulzrinne – Columbia Univ, WG co-chair
- System Engineering Report (15min)
 - Harry Mussman – GPO, WG SE
- Opt-In Plans and Issues with OpenFlow (15min)
 - Guido Appenzeller – Stanford Univ
- Update on Opt-In Plans and Issues with Seattle (Million Node GENI) (15min)
 - Justin Cappos – Univ Washington
- GENI Structure of Entities, Actors and Agreements (15min)
 - Harry Mussman – GPO, WG SE
- GENI Best Practices to Minimize Opt-In Risks (30min)
 - Henning Schulzrinne – Columbia Univ, WG co-chair
- WG Goals for Spiral 2 (5min)
 - Henning Schulzrinne – Columbia Univ, WG co-chair
 - Justin Cappos – Univ Washington, incoming WG co-chair
- Wrap up, review of action items and issues for plenary
 - Harry Mussman – GPO, WG SE

- Review “GENI End-User Opt-In Overview” document
 - Reach rough consensus
 - Extend...?
- Review “GENI Structure Overview” document
 - Reach rough consensus
 - Need to involve other WGs.....how?
 - Moving towards overall GENI structure and policies....?
 - Extend.....?

How can you participate in the WG?

- Check wiki for activities:
 - <http://groups.geni.net/geni/wiki/GeniOptIn>
 - See meeting announcements, notes, presentations
 - Check work in progress, DRAFT documents, etc.
- Join the mailing list!
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