



GENI

Global Environment for Network Innovations

Chip Elliott
GENI Project Director
celliott@bbn.com

www.geni.net

Clearing house for all GENI news and documents

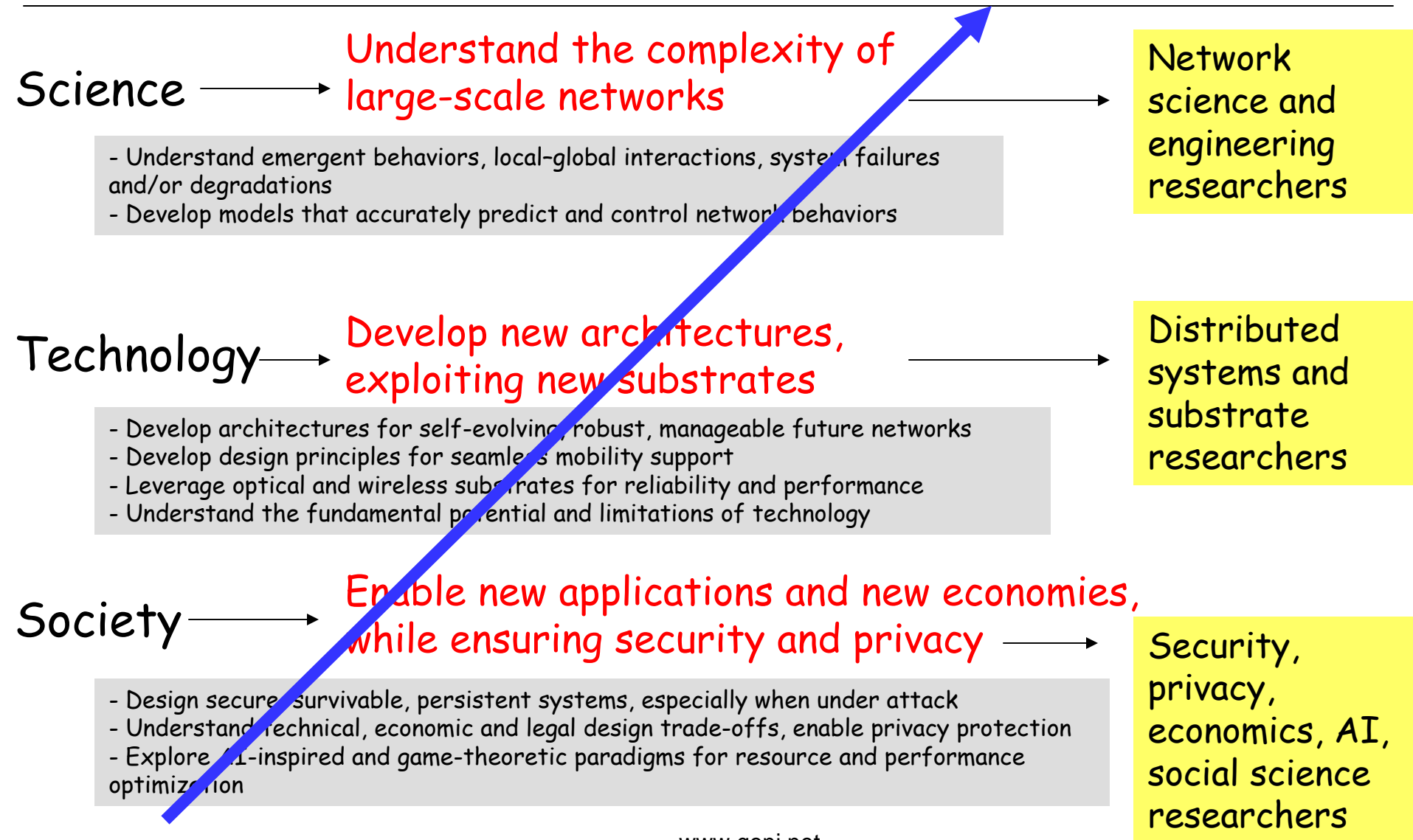


Outline

- 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?



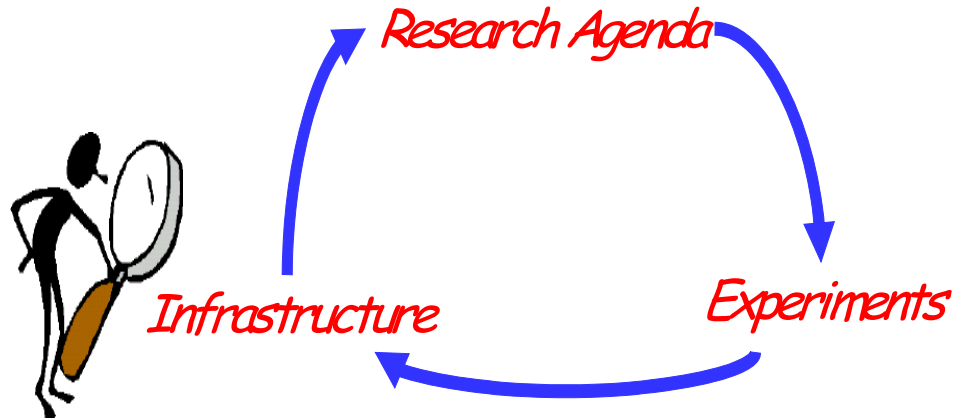
GENI supports Fundamental Challenges Network Science & Engineering (NetSE)





Research Agenda to Experiments to 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

- 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
- 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
 - FIND, SING, NGNI



“Our founders”

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

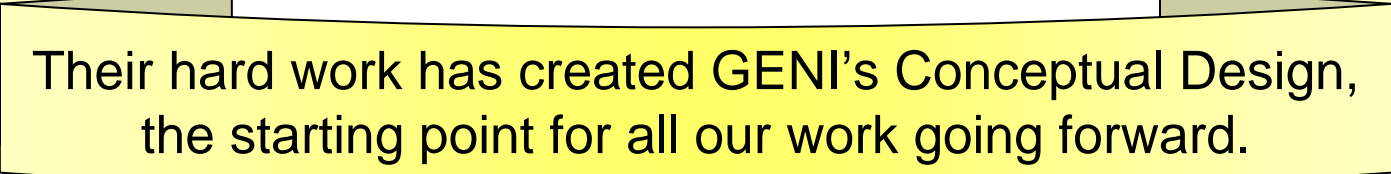
Nick McKeown, Stanford
Dipankar Raychaudhuri, Rutgers
Mike Reiter, CMU
Jennifer Rexford, Princeton
Scott Shenker, Berkeley
Amin Vahdat, UCSD
John Wroclawski, USC/ISI
CK Ong, Princeton

And Within NSF

Peter Freeman
Debbie Crawford
Larry Landweber
Suzi Iacono

Guru Parulkar
Darlene Fisher
Cheryl Albus
Allison Mankin

Ty Znati
Gracie Narcho
Paul Morton

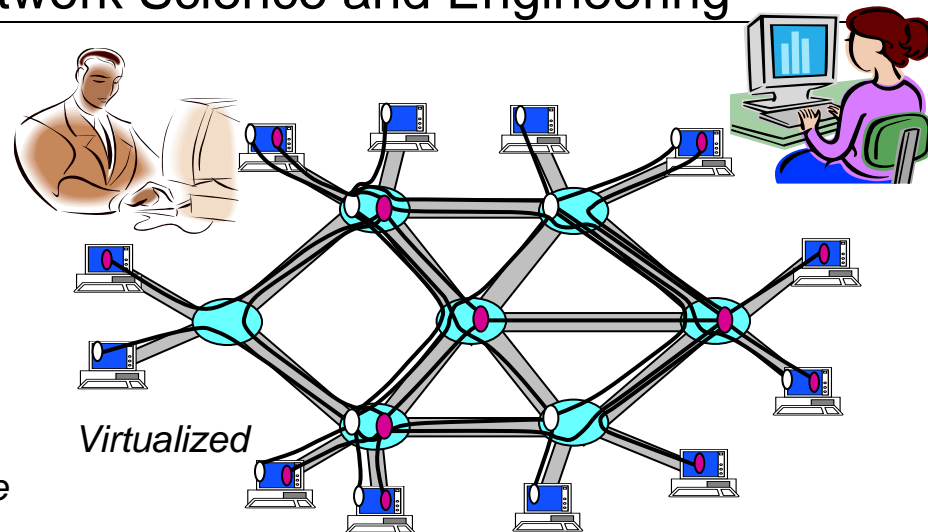
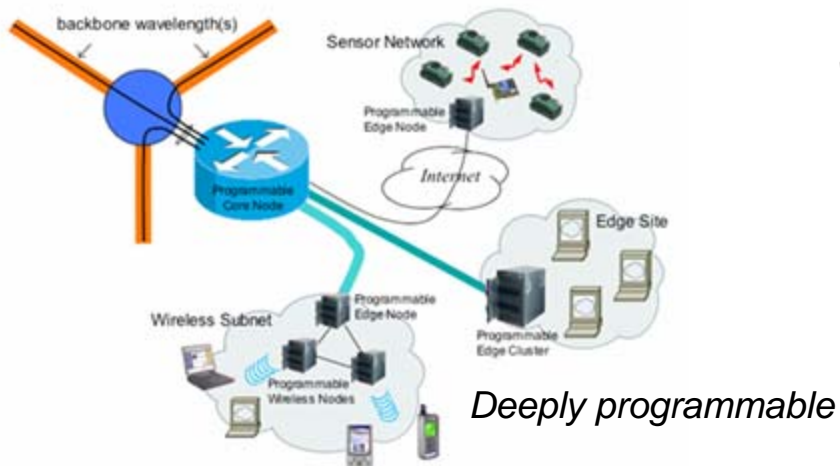
A yellow ribbon graphic with a black outline, containing text. The ribbon has pointed ends on the left and right sides.

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

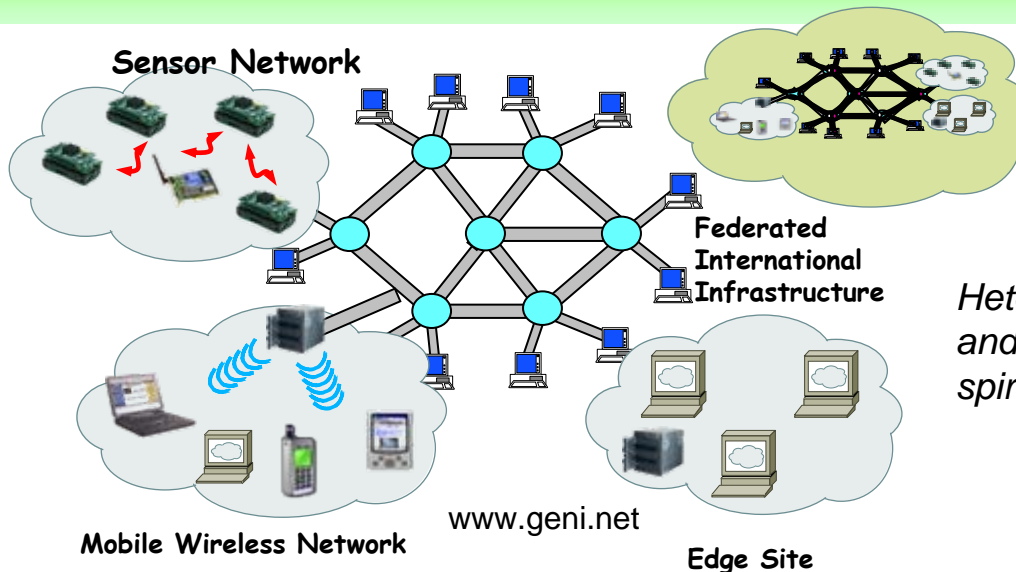


The GENI Vision

A national-scale suite of infrastructure for long-running, realistic experiments in Network Science and Engineering



Programmable & federated, with end-to-end virtualized “slices”



Heterogeneous, and evolving over time via spiral development



Outline

- 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!*



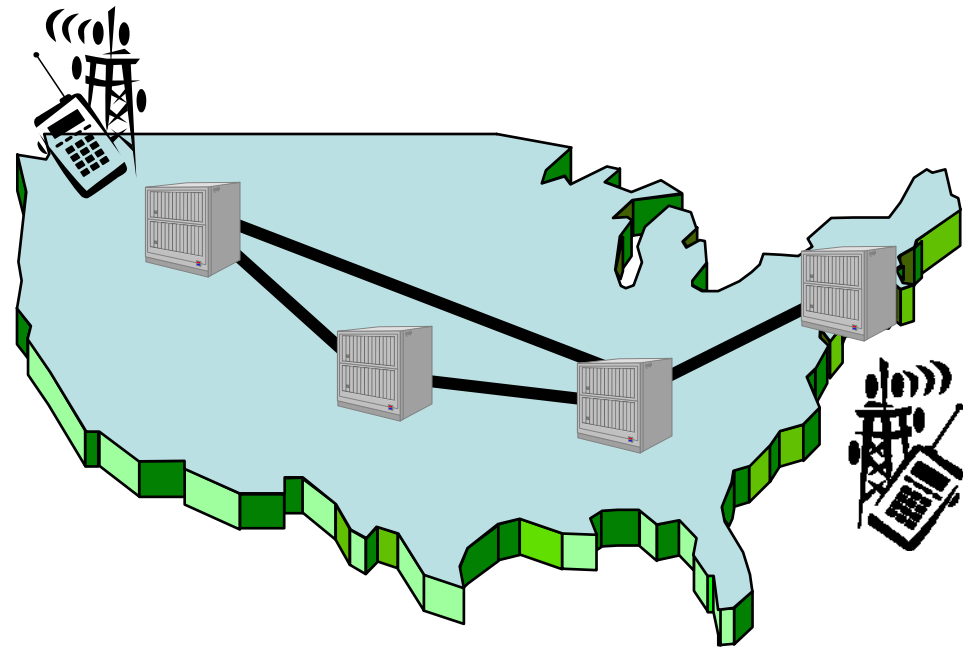


Trying it out

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



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.



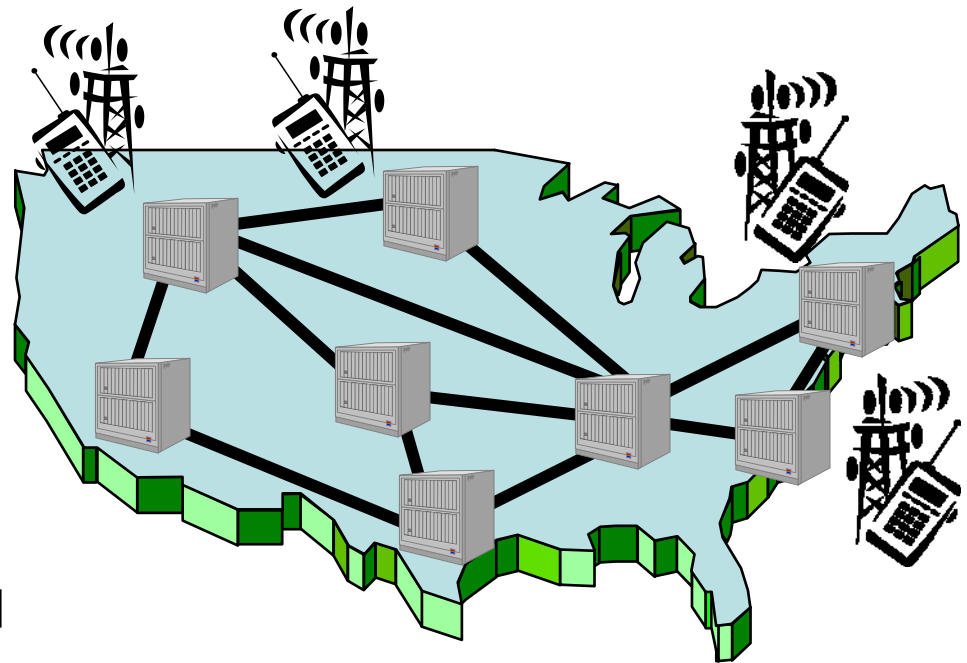
It turns into a really good idea

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.

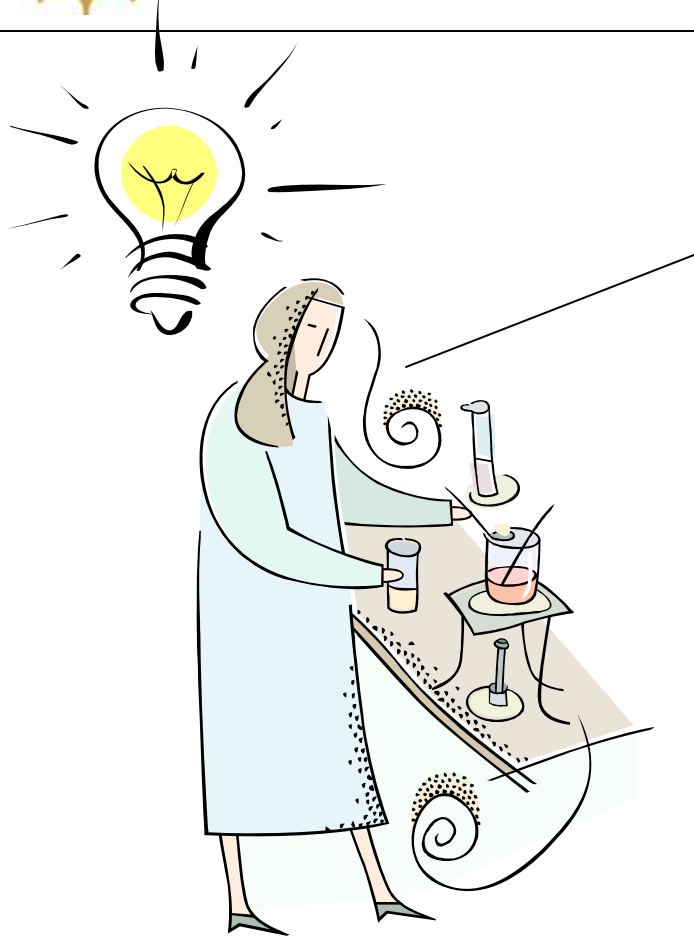


I always said it was a good idea, but way too conservative.





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.



Moral of this story

- 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

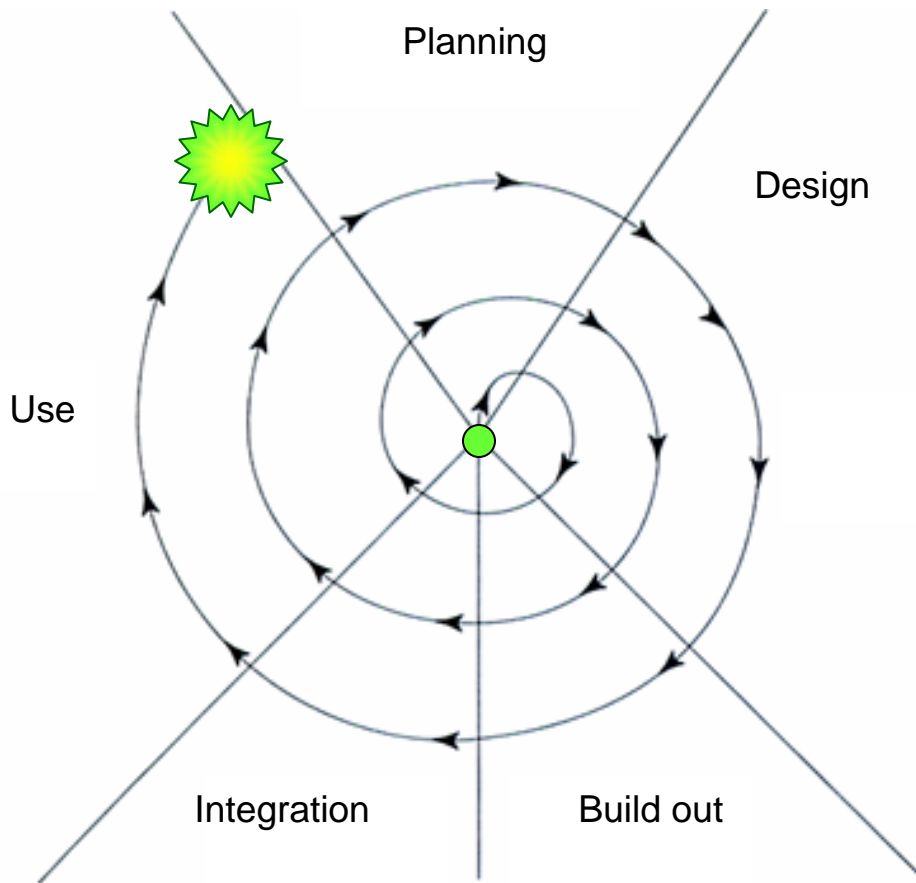
Note that this is the “classics illustrated” version – a comic book!

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



GENI Prototyping Plan

- 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.

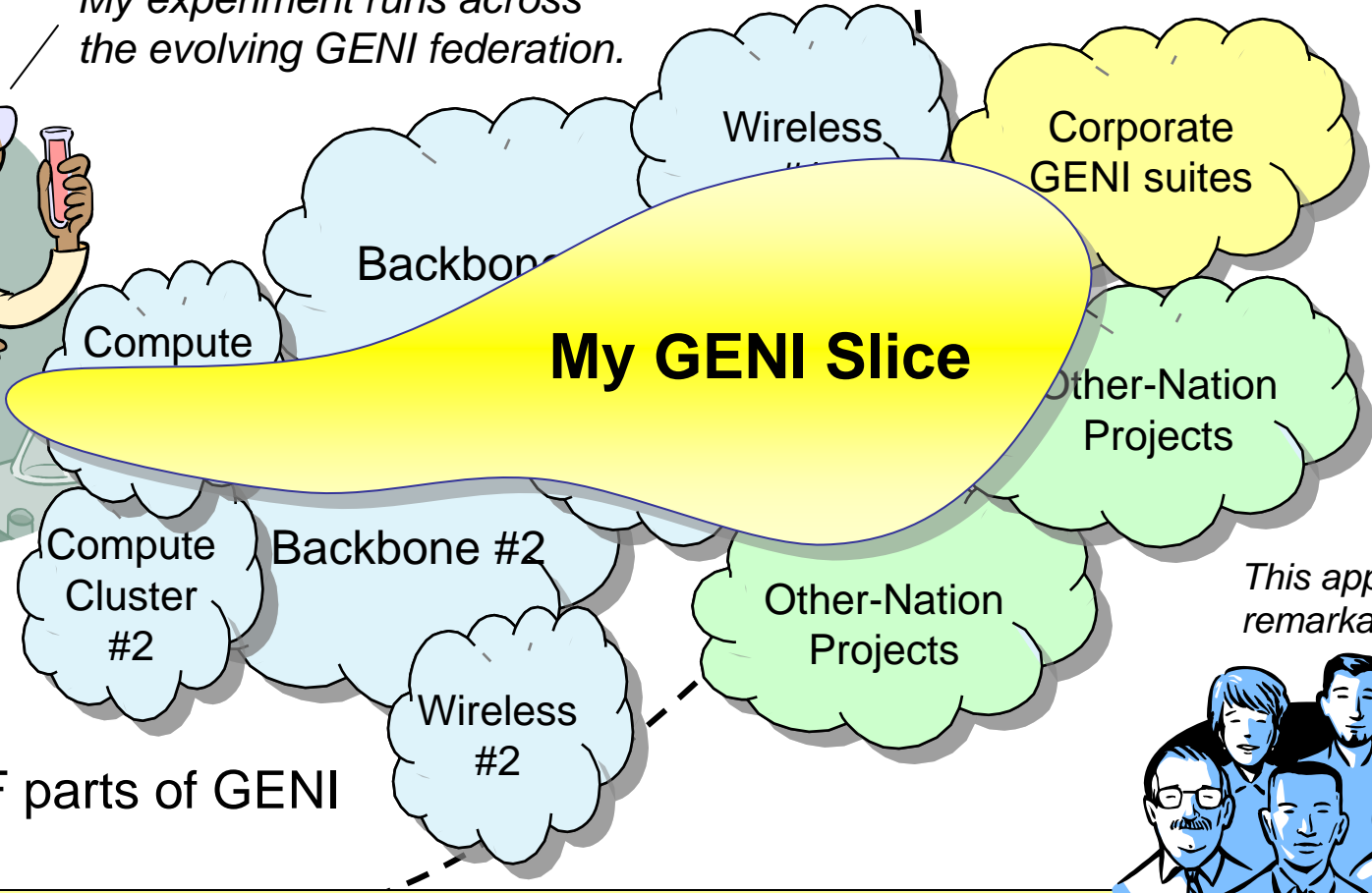
- **Spiral Development Process**
Re-evaluate goals and technologies yearly by a systematic process, decide what to prototype and build next.



Federation

GENI grows by “gluing together” heterogeneous infrastructure

My experiment runs across the evolving GENI federation.



This approach looks remarkably familiar . . .



NSF parts of GENI

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

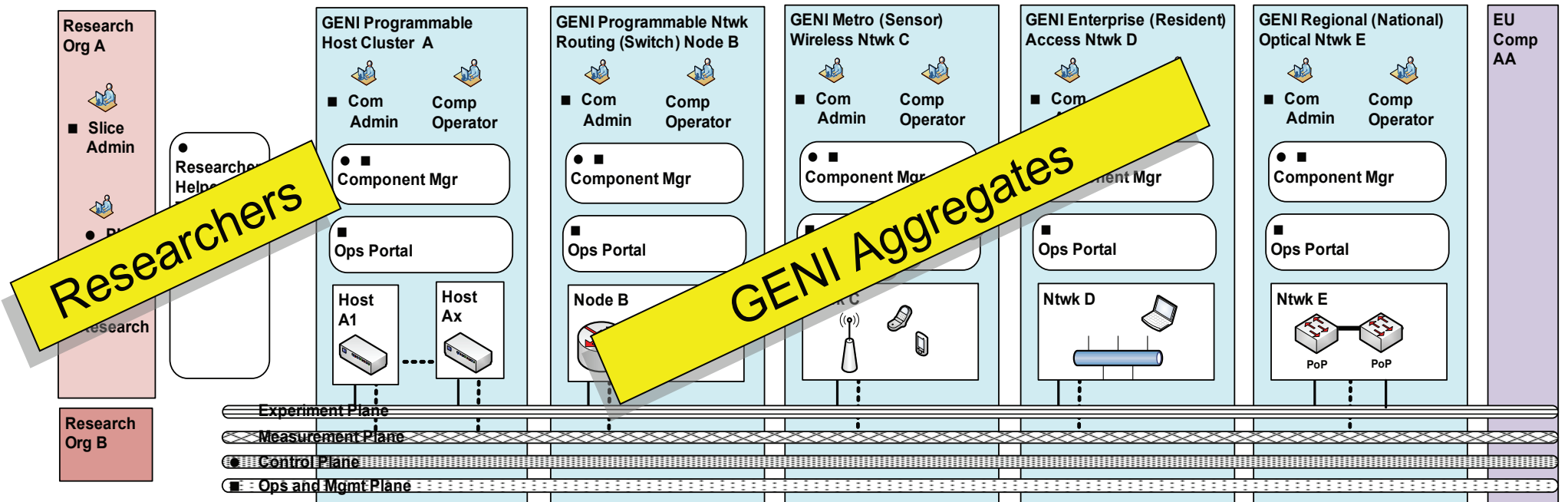
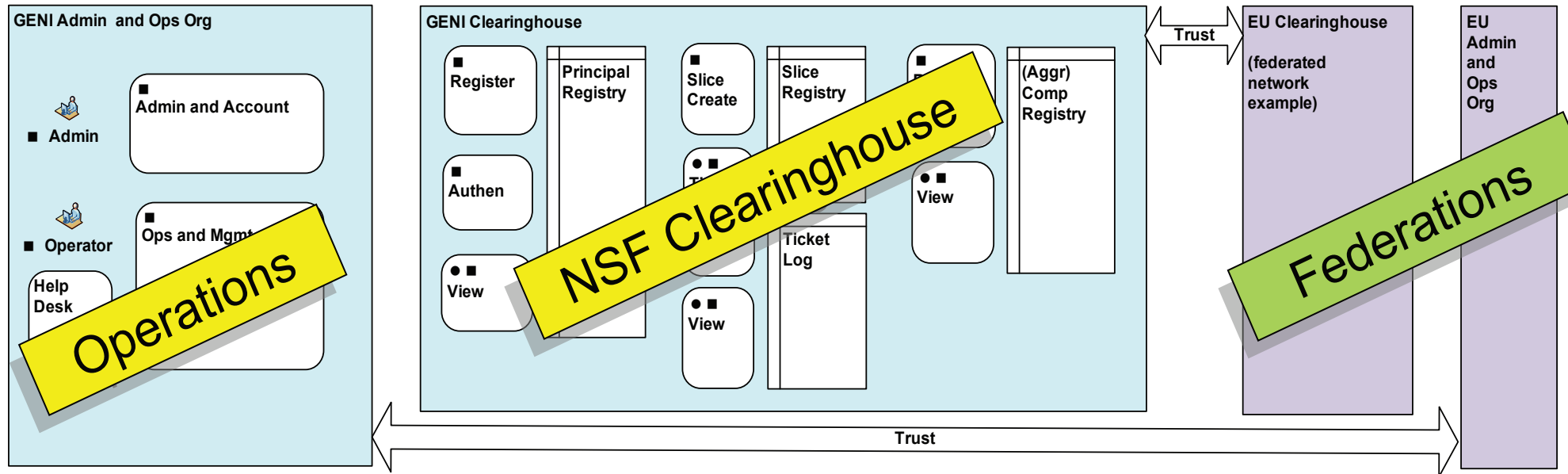


Outline

- 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?

GENI System Decomposition (simplified)

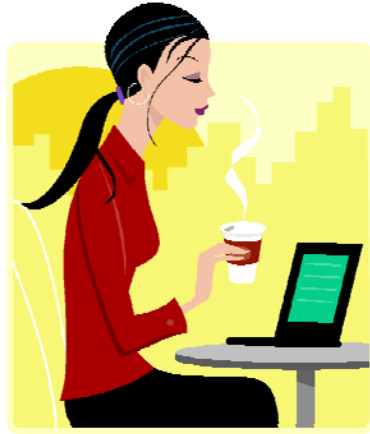
Engineering analysis drives Spiral 1 integration





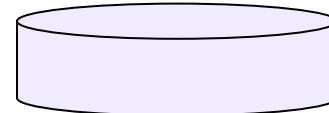
Resource discovery

Aggregates publish resources, schedules, etc., via clearinghouses



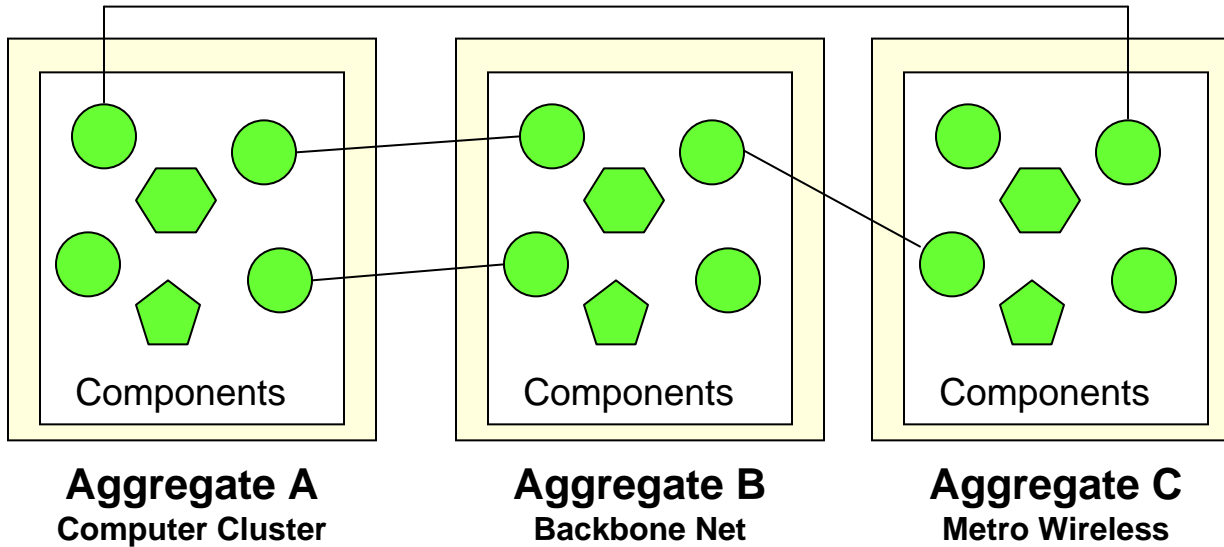
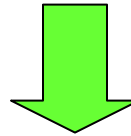
Researcher

What resources can I use?



GENI
Clearinghouse

These

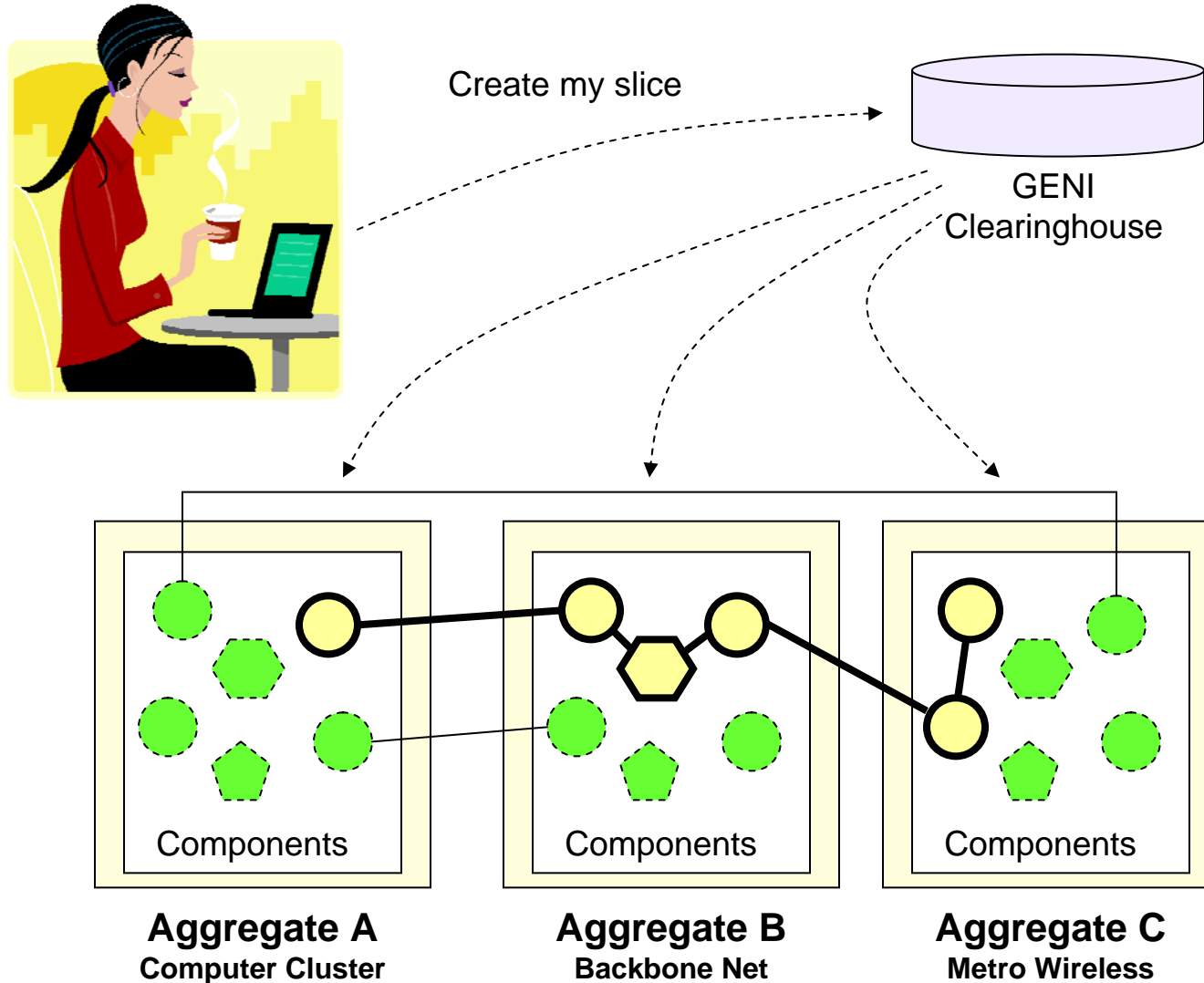




Slice creation

Clearinghouse checks credentials & enforces policy

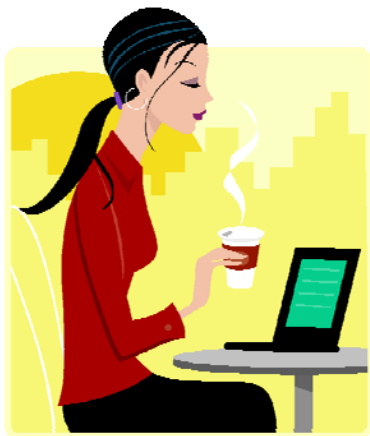
Aggregates allocate resources & create topologies



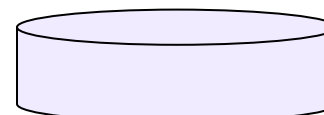


Experimentation

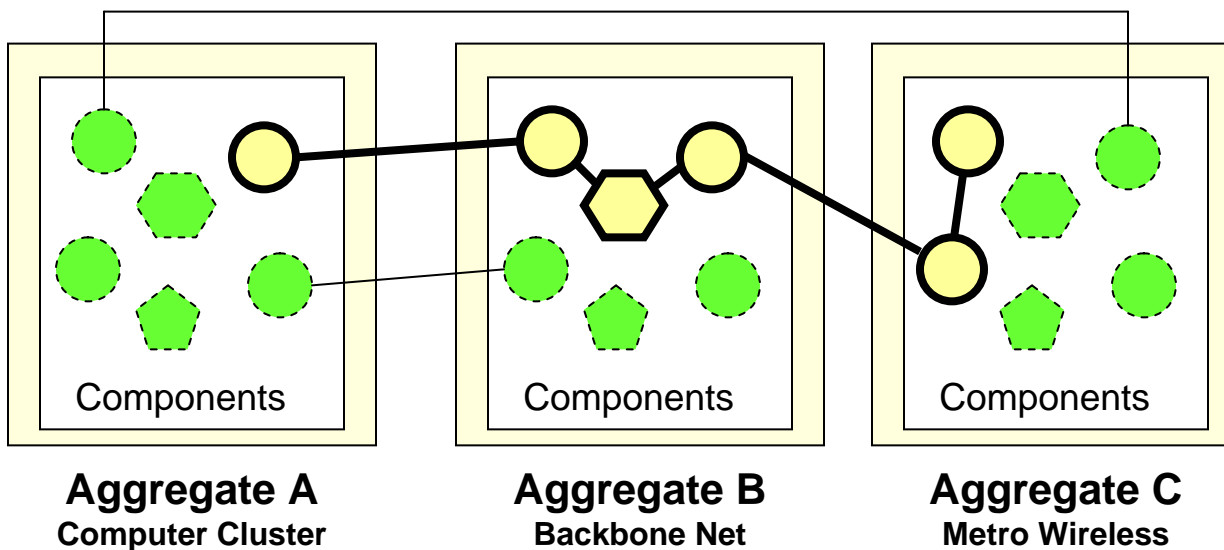
Researcher loads software, debugs, collects measurements



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



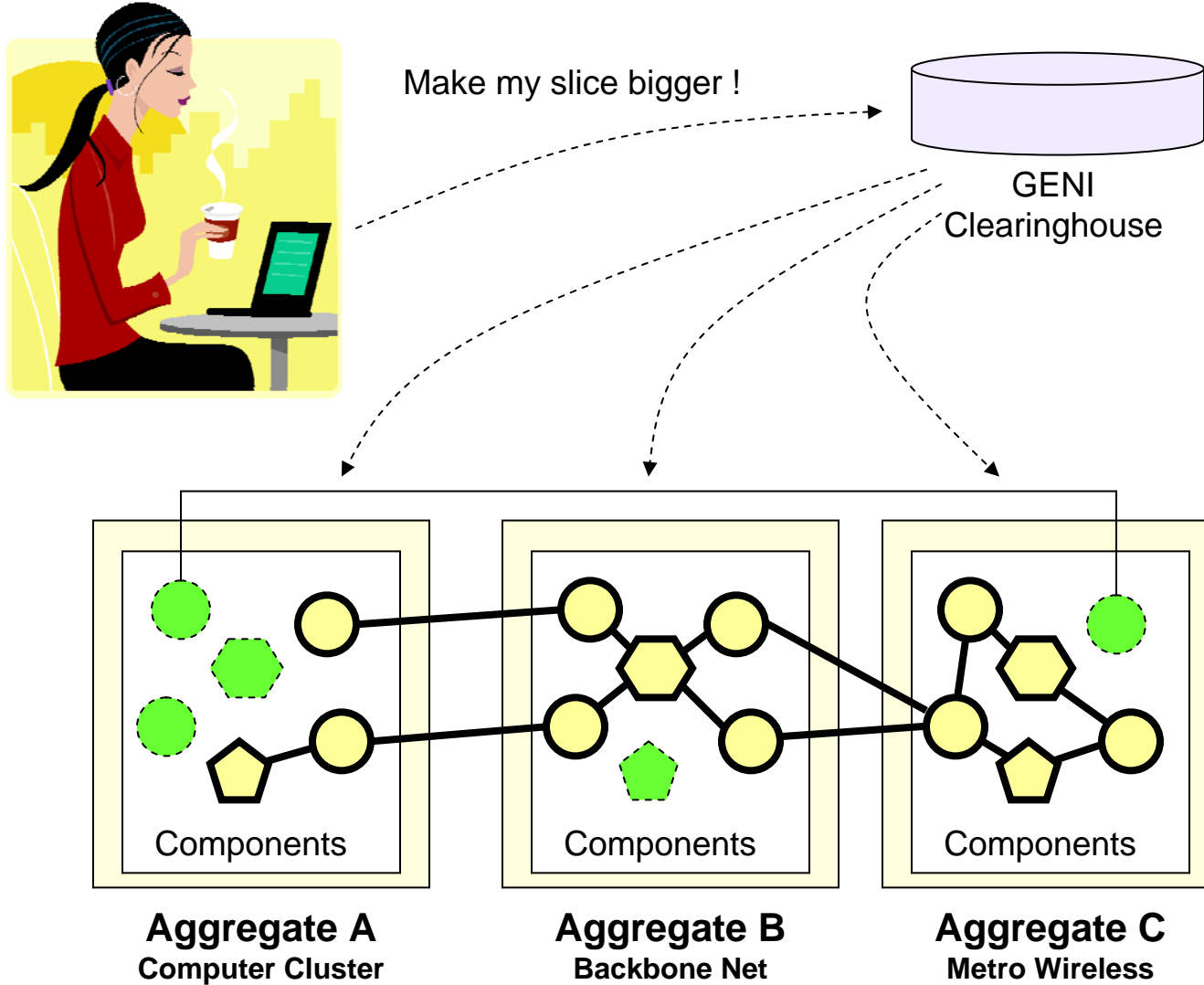
GENI
Clearinghouse





Slice growth & revision

Allows successful, long-running experiments to grow larger



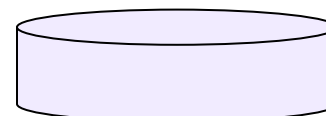


Federation of Clearinghouses

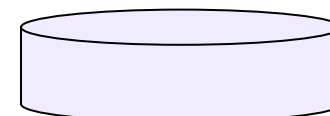
Growth path to international, semi-private, and commercial GENIs



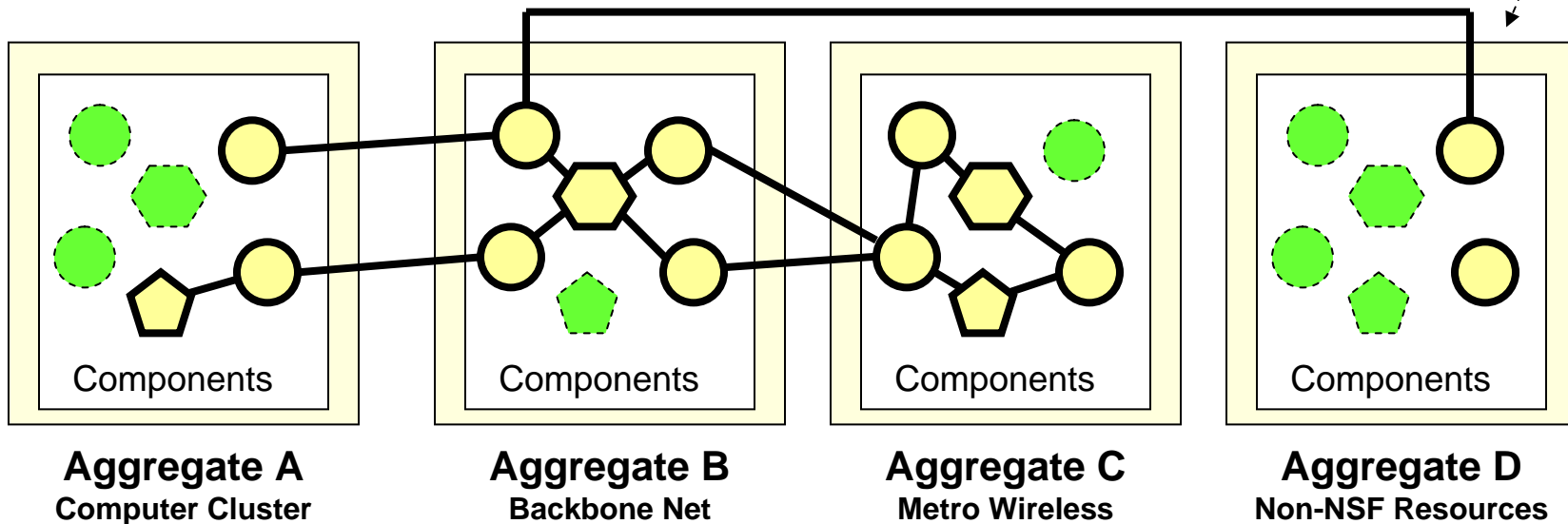
Make my slice even bigger !



GENI
Clearinghouse



Federated
Clearinghouse

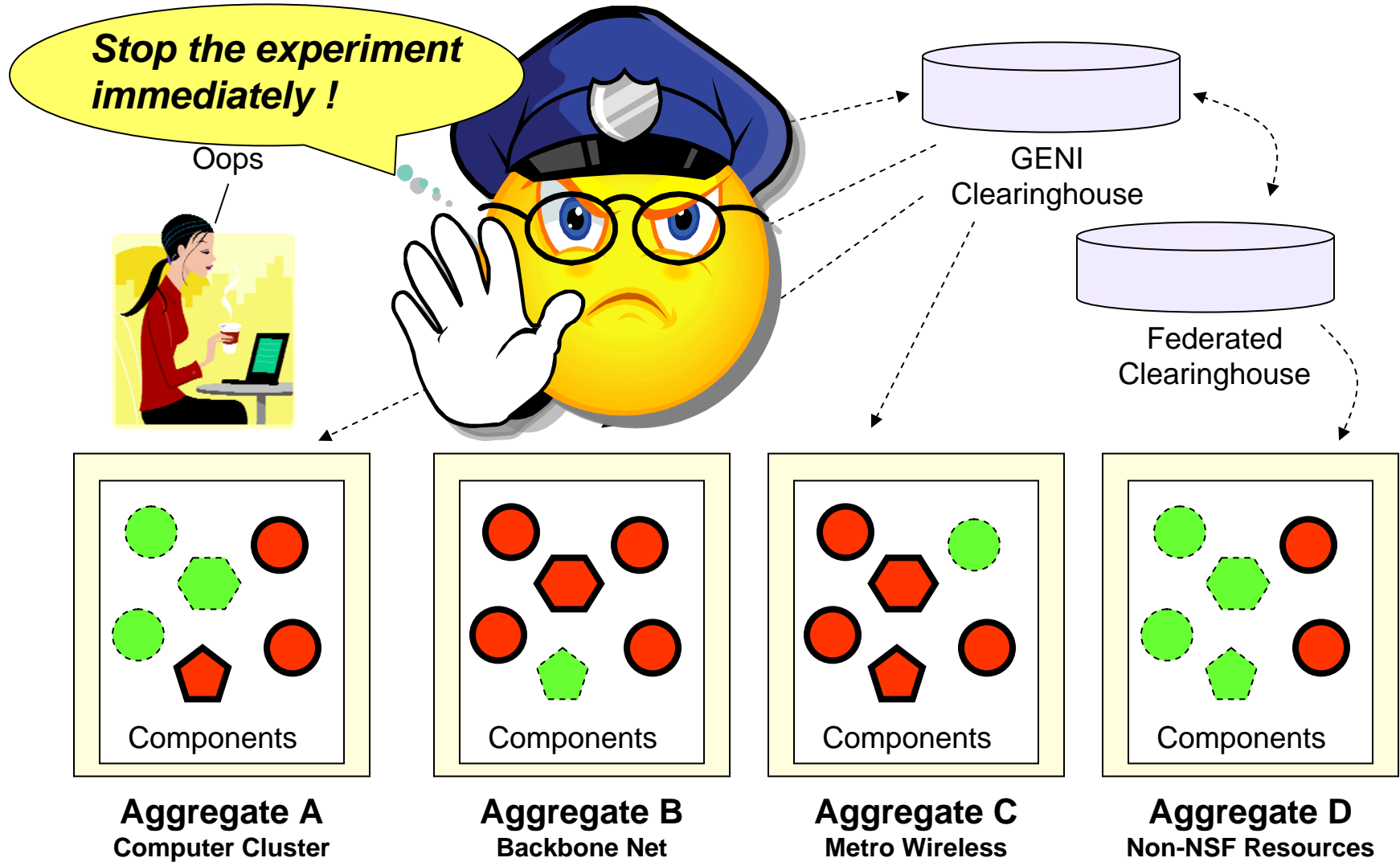




Operations & Management

Always present in background for usual reasons

Will need an 'emergency shutdown' mechanism





Outline

- 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?



GENI Spiral 1 has now begun!

First results expected in 6-12 months

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

July 22, 2008

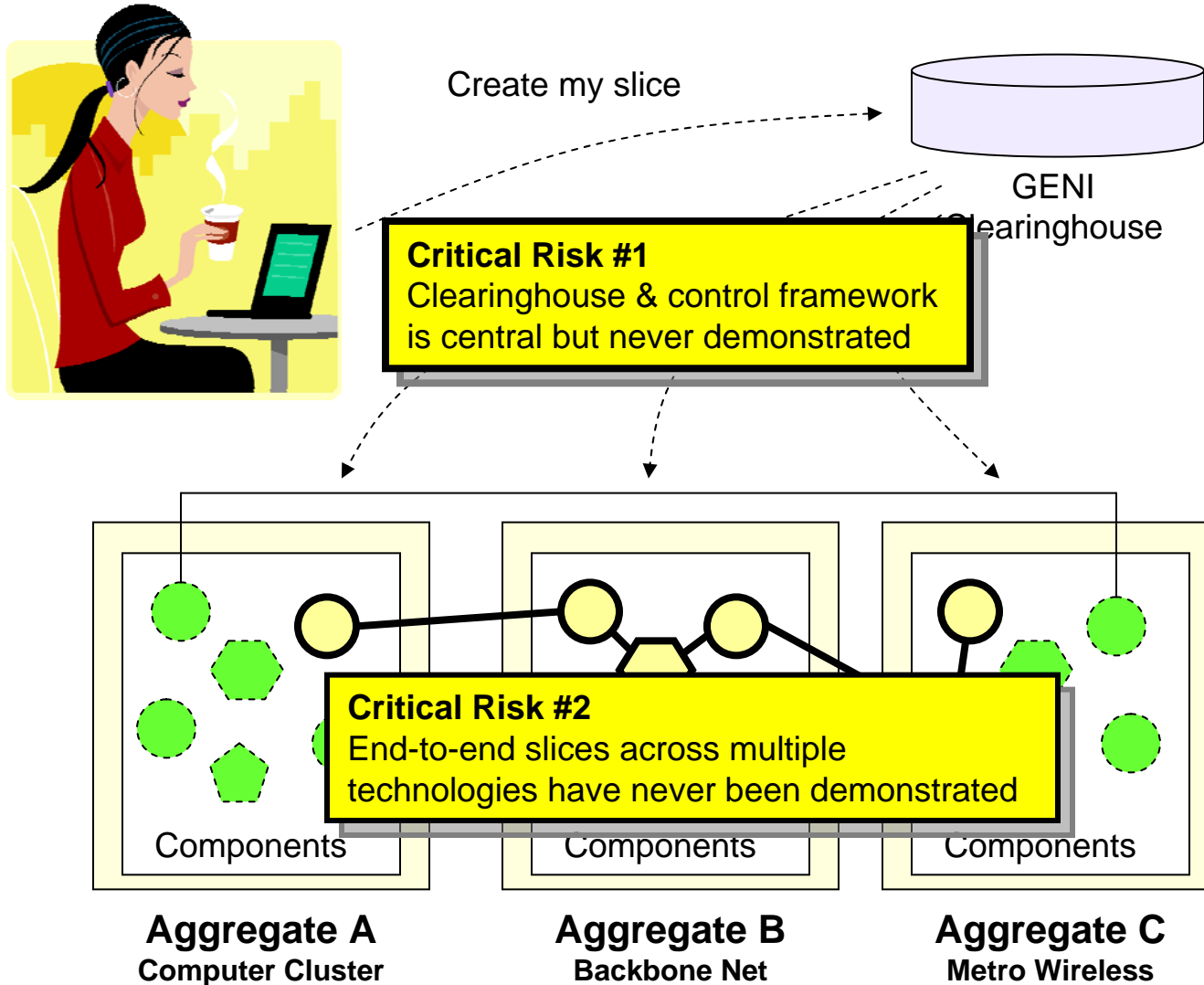
The GENI Project Office, operated by BBN Technologies, an advanced technologies solutions firm, announced today that it has been awarded a **three year grant worth approximately \$4M a year** from the US National Science Foundation to perform GENI design and risk-reduction prototyping.

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's Critical Technical Risks

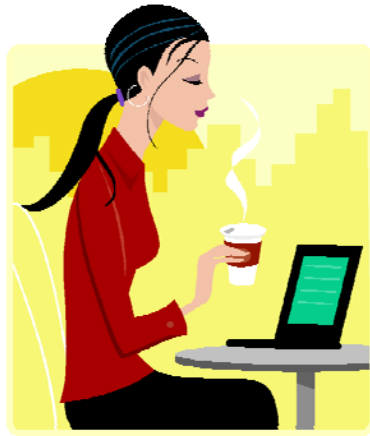
These risks drive the Prototyping Goals for GENI Spiral 1





Key Goals for GENI Spiral 1

Drive down the critical technical risks in GENI's concept



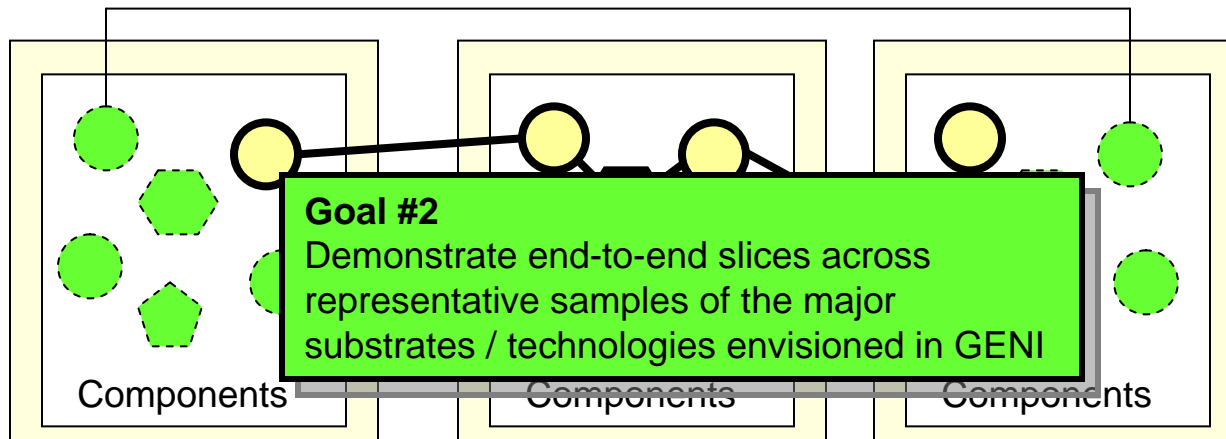
Create my slice



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

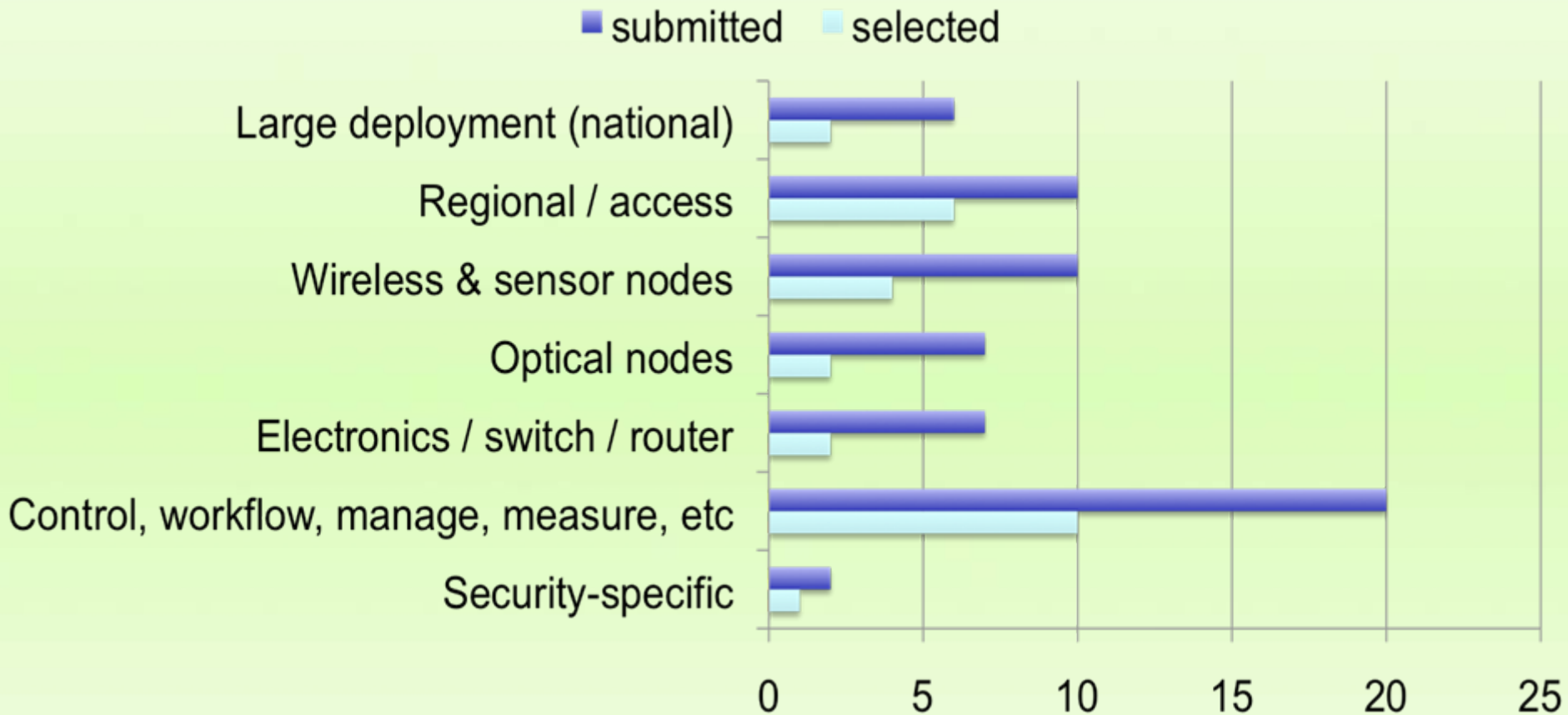
Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

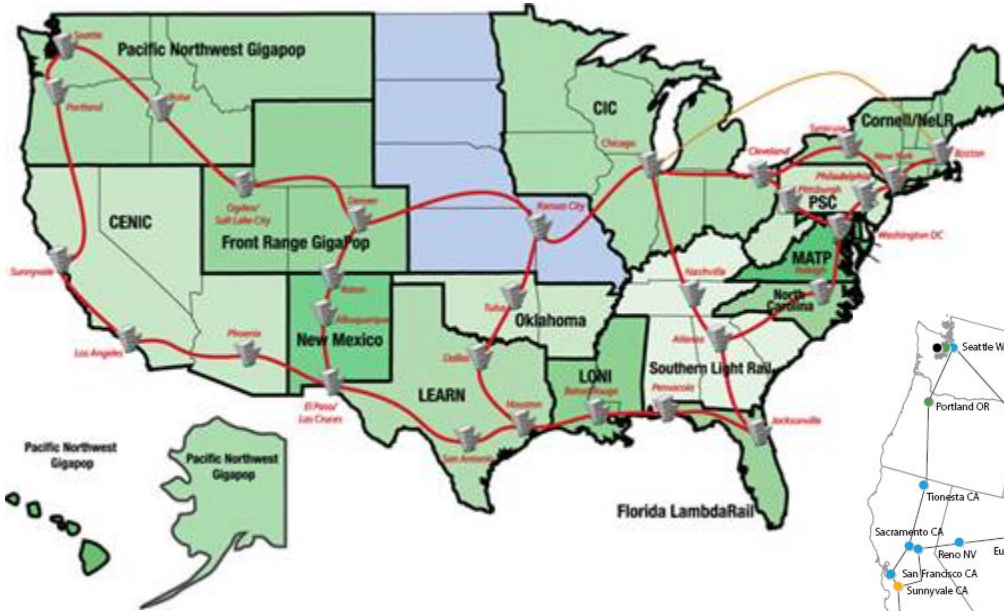


1st GENI Solicitation – proposal areas





Generous Donations to GENI Prototyping Internet2 and National Lambda Rail

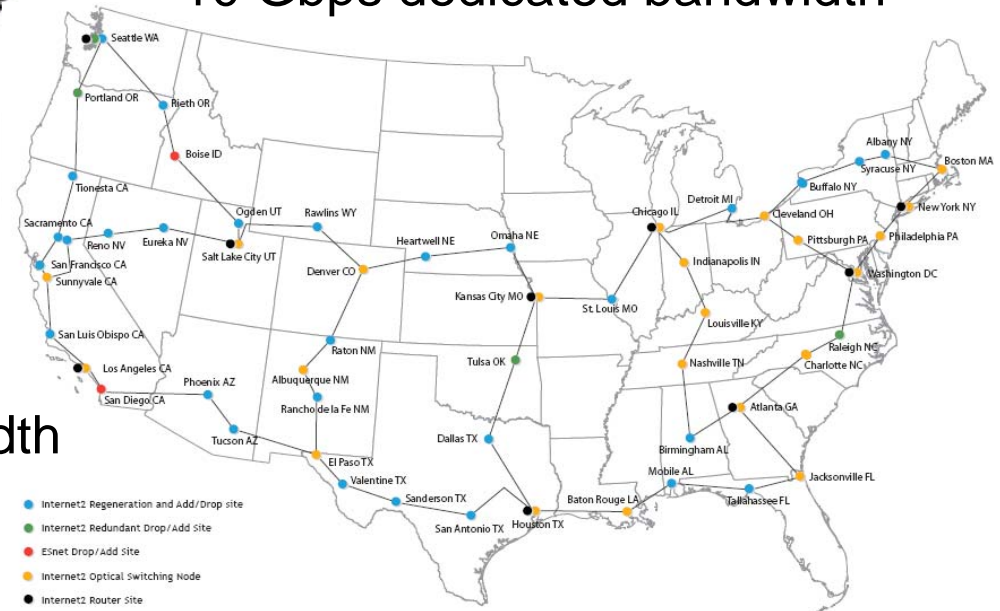


National Lambda Rail

Up to 30 Gbps nondedicated bandwidth

Internet2

10 Gbps dedicated bandwidth

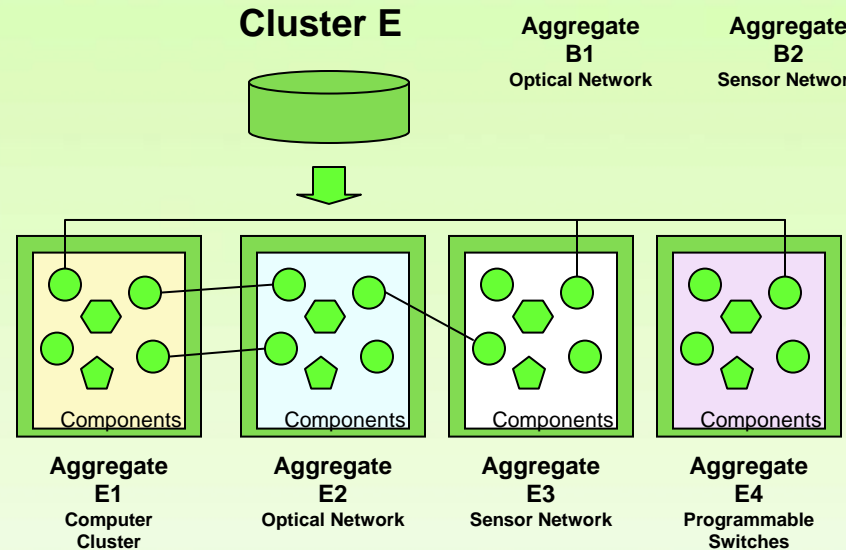
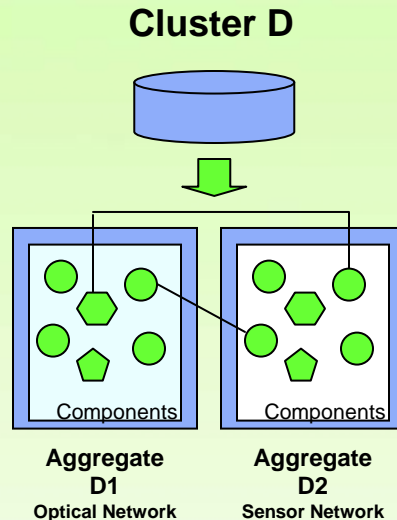
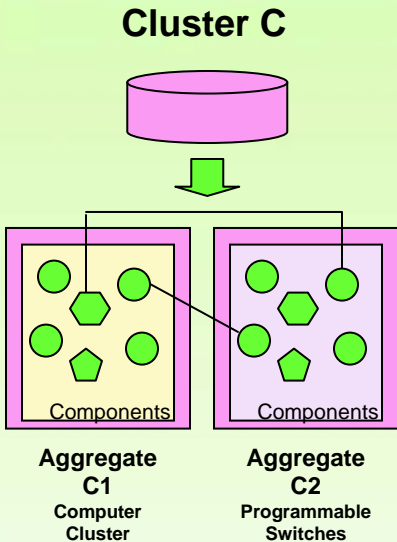
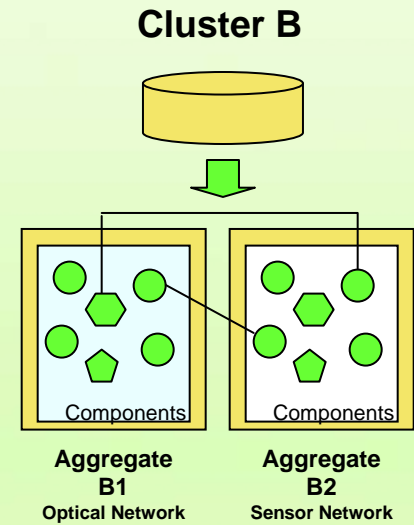
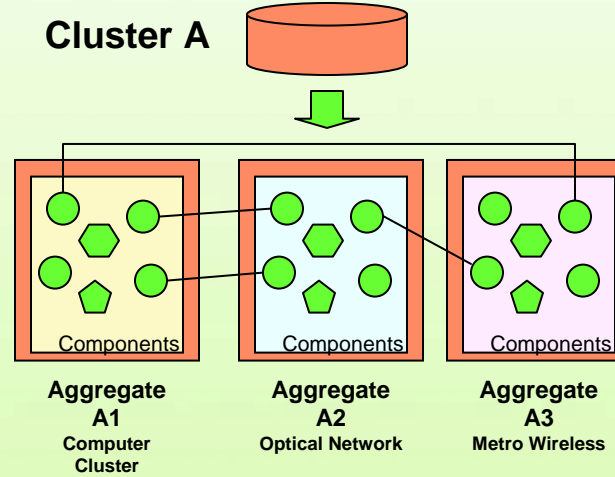
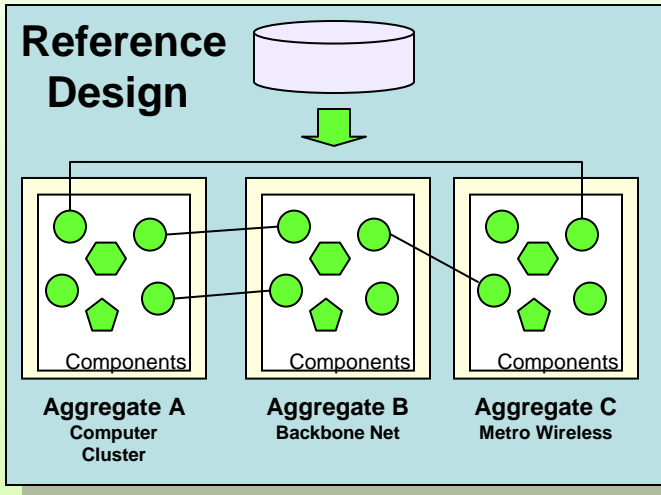


**40 Gbps capacity for GENI prototyping on two national footprints
to provide Layer 2 Ethernet VLANs as slices (IP or non-IP)**



Spiral 1 integration and trial operations

Five competing control frameworks, wide variety of substrates





GENI Spiral 1

- 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.



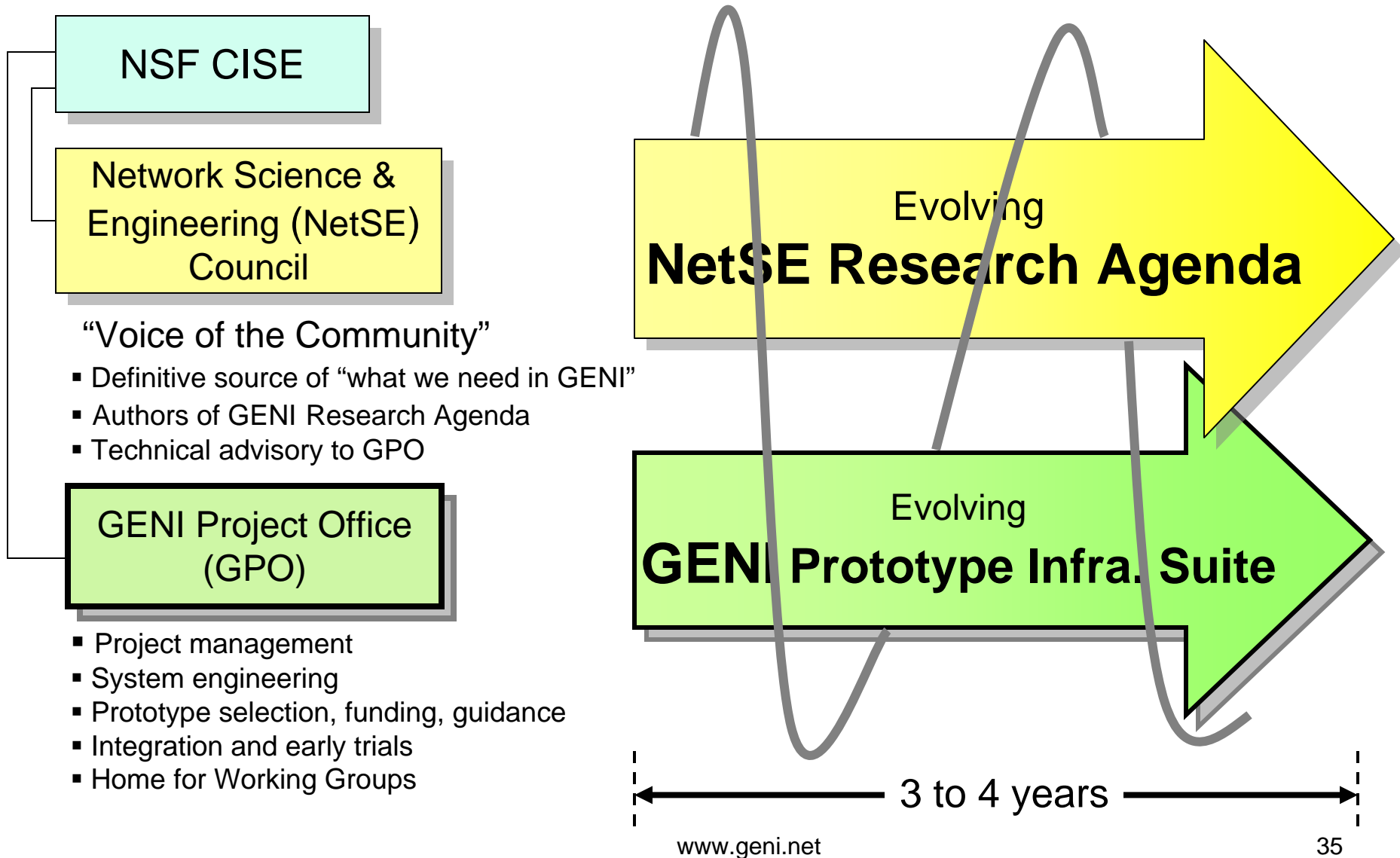
Outline

- 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?



GENI in Context

Supports the Evolving NetSE Research Agenda





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 lists

- **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

- **3rd meeting Oct. 28-30, 2008 in Palo Alto, open to all**
 - Reviews current GENI status, 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



GPO Solicitations

Academic-industrial teams favored but not required

- **Second solicitation coming soon**

- 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 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