GENI

Global Environment for Network Innovations

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www.geni.net
Clearinghouse for all GENI news and documents

Our goals for this meeting

- The GPO seeks concrete plans for collaboration between FIRE and GENI development efforts in the next 6-12 months.
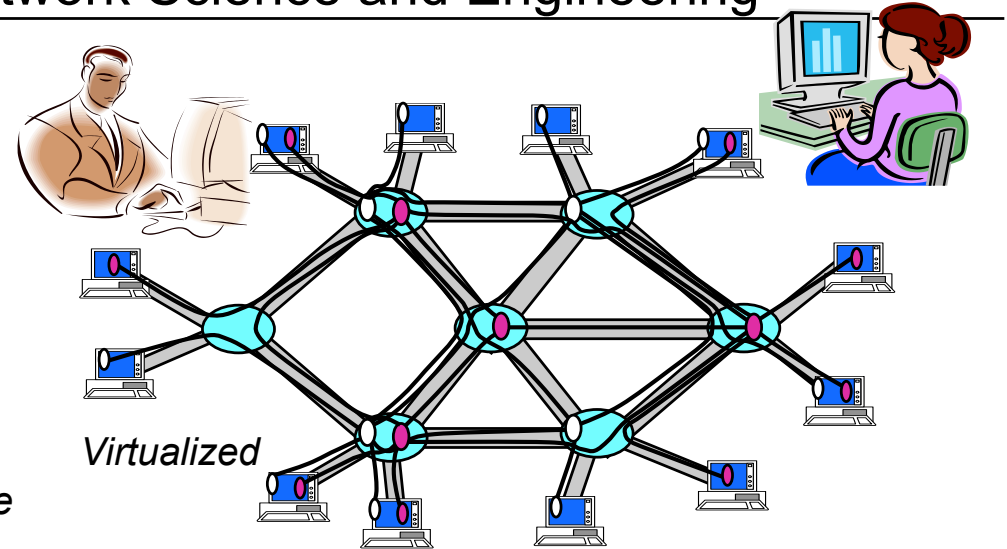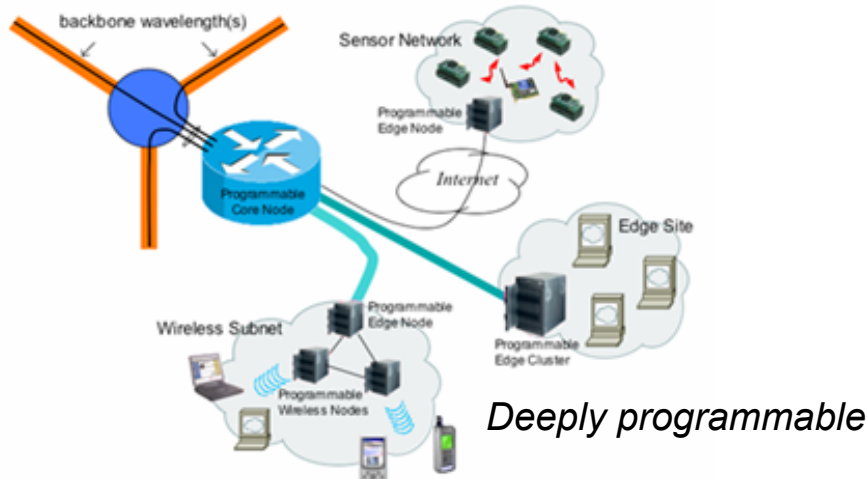
Outline

- **What is GENI?**

- How we'll use it, how we'll build it

- The GENI system concept

- GENI Spiral 1

- How can you participate?

The GENI Vision

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

Deeply programmable

Virtualized

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

Sensor Network

Federated International Infrastructure

Heterogeneous, and evolving over time via spiral development

www.geni.net

Mobile Wireless Network

Edge Site

4

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 <u>not</u> an experiment !
    - GENI is a suite of infrastructure on which experiments run

GENI creates a huge opportunity for ambitious research!

Outline

- What is GENI?

- How we'll use it, how we'll build it

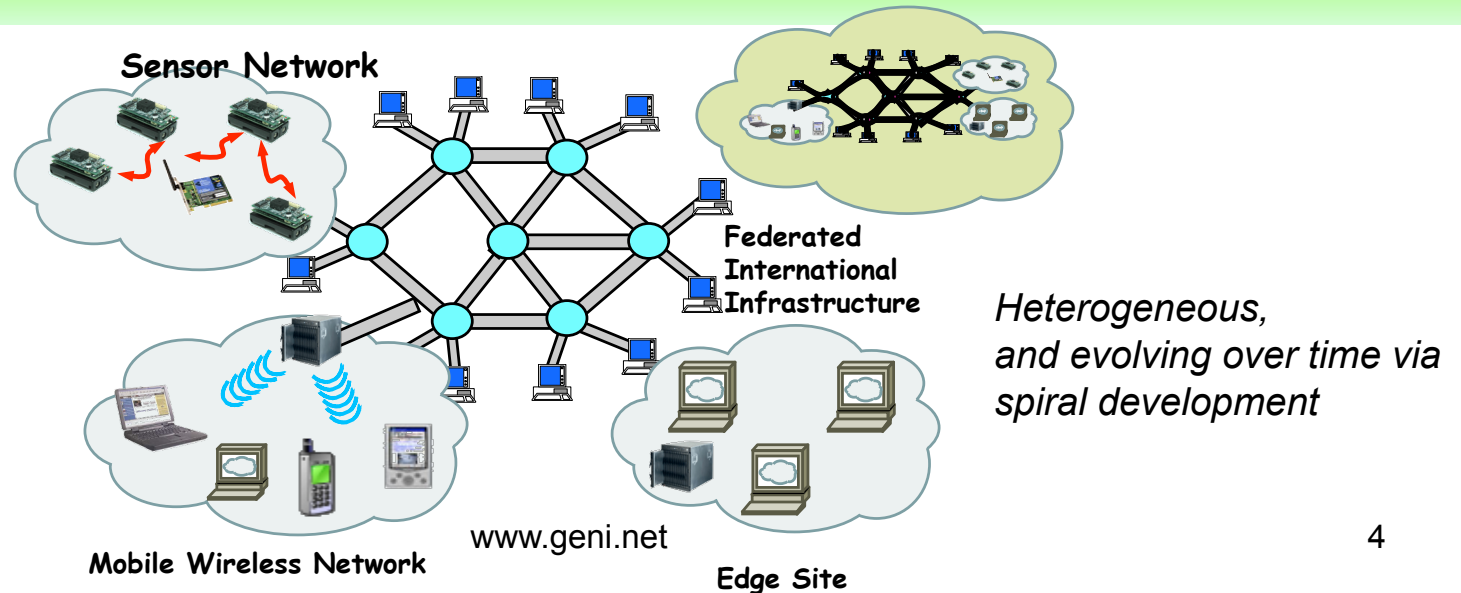- The GENI system concept

- GENI Spiral 1

- How can you participate?

How We'll Use GENI

Note that this is the "classics illustrated" version – a comic book!
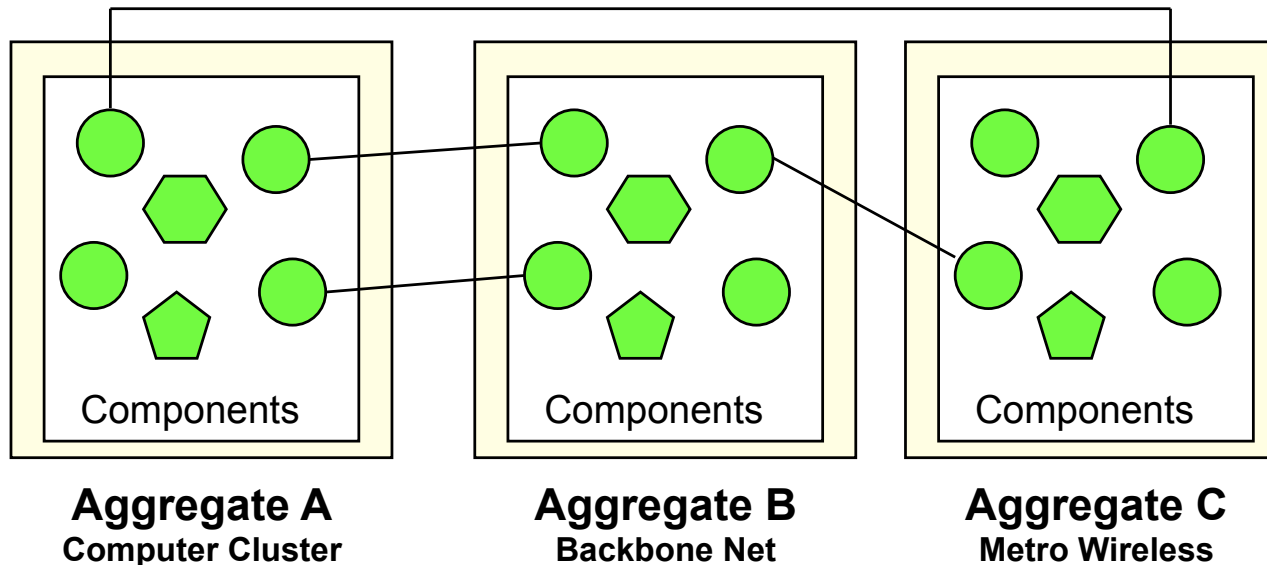
Please read the Network Science and Engineering Research Agenda to learn all about the community's vision for the research it will enable. Your suggestions are very much appreciated!

Resource discovery
Aggregates publish resources, schedules, etc., via clearinghouses

What resources can I use?

GENI
Clearinghouse

These

Researcher

Components

Components

Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless
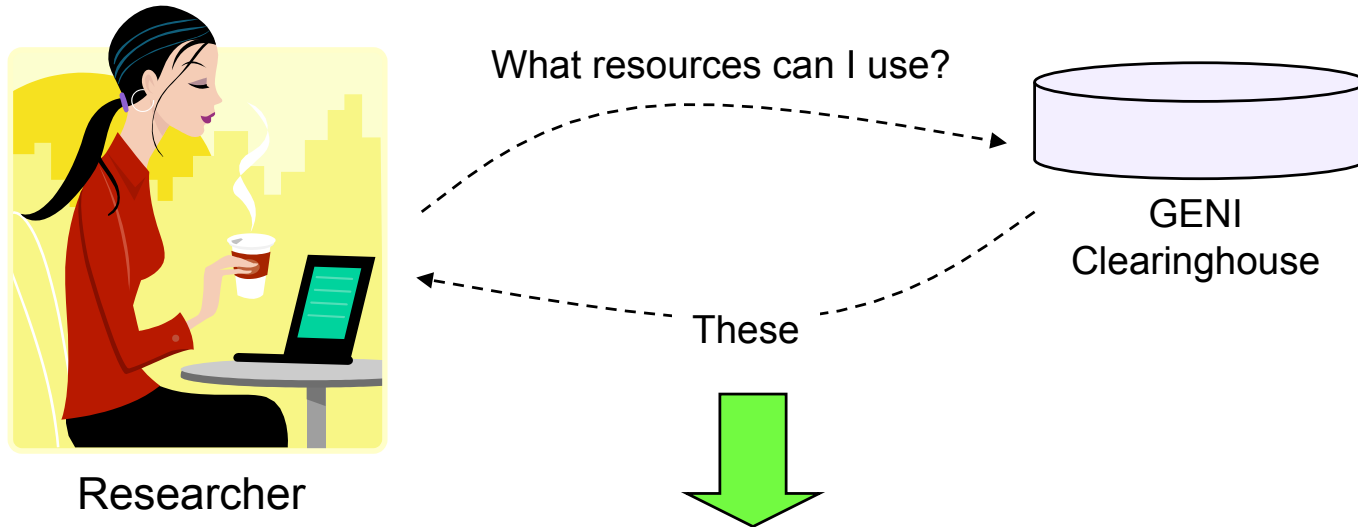
Slice creation
Clearinghouse checks credentials & enforces policy
Aggregates allocate resources & create topologies

Create my slice

GENI
Clearinghouse

Components

Components

Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless
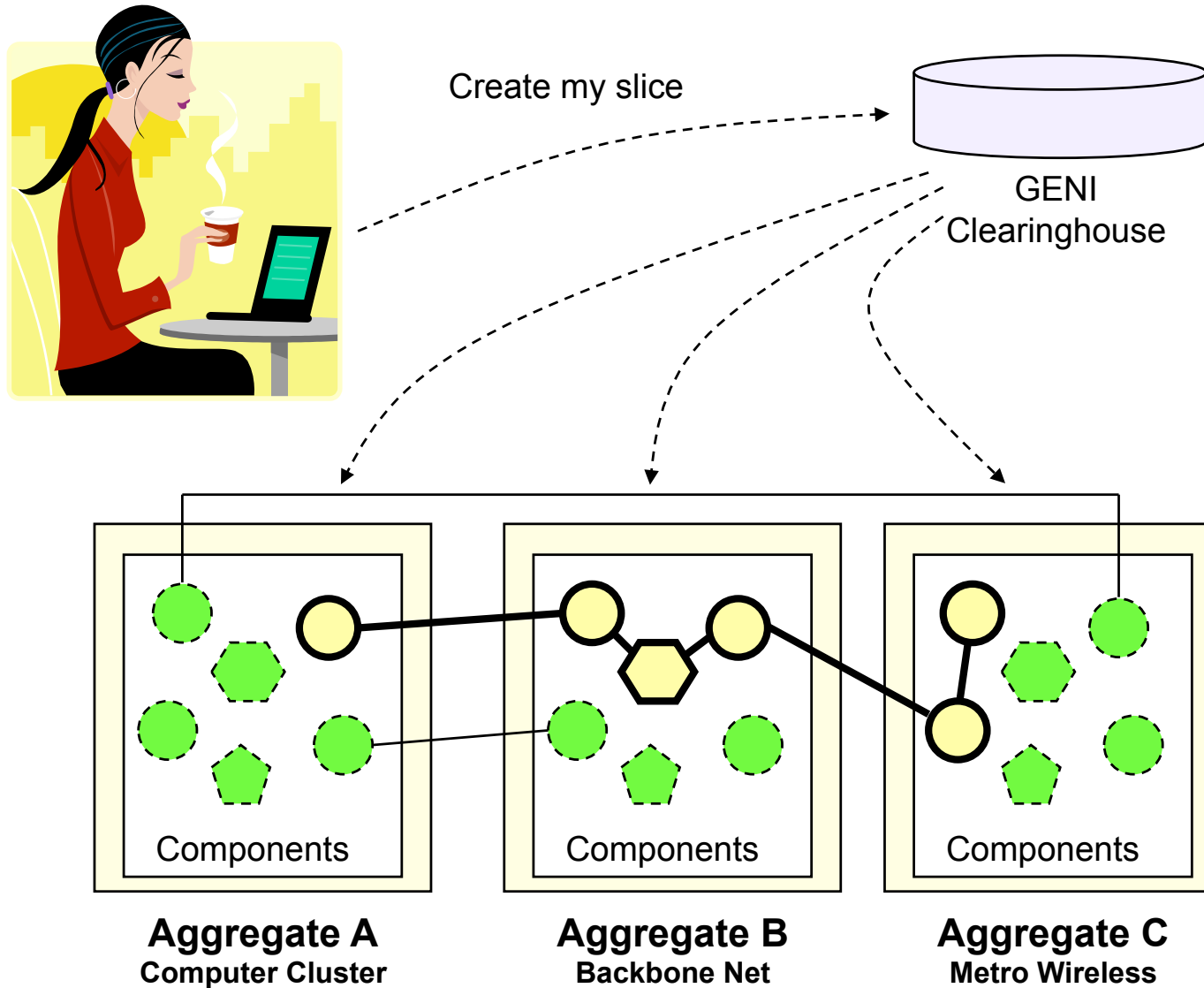
Researcher loads software, debugs, collects measurements
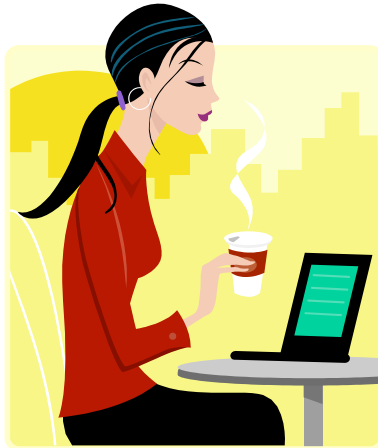
Experiment – Install my software, debug, collect data, retry, etc.

GENI Clearinghouse

Components

Components

Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless
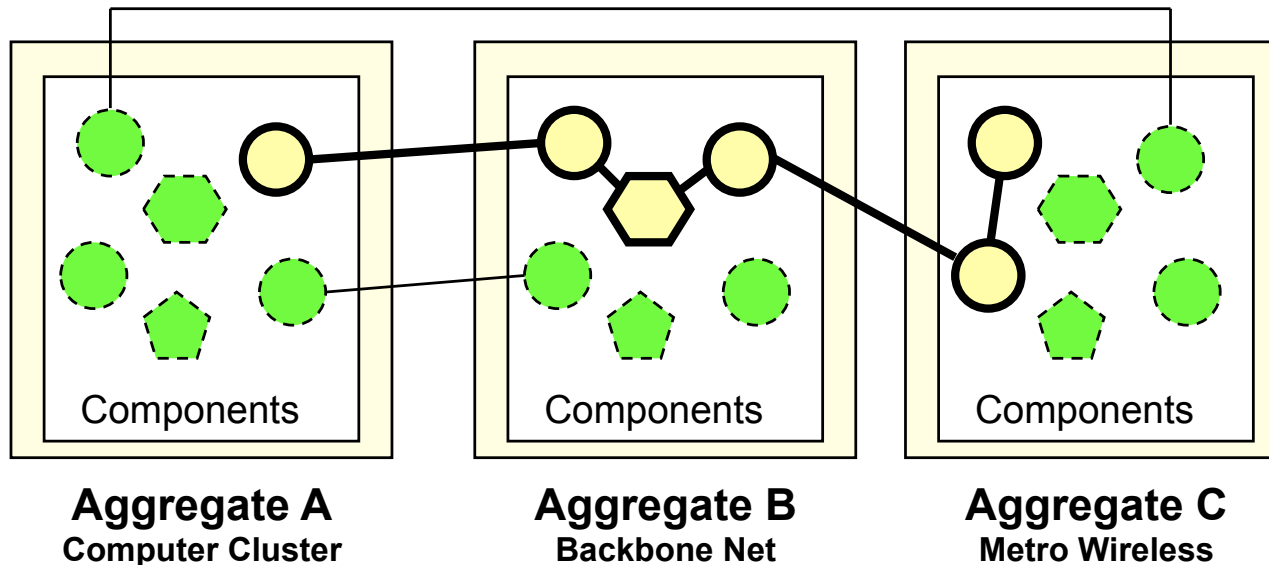
Slice growth & revision

Allows successful, long-running experiments to grow larger

Make my slice bigger !

GENI
Clearinghouse

Components

Aggregate A
Computer Cluster

Components

Aggregate B
Backbone Net

Components

Aggregate C
Metro Wireless
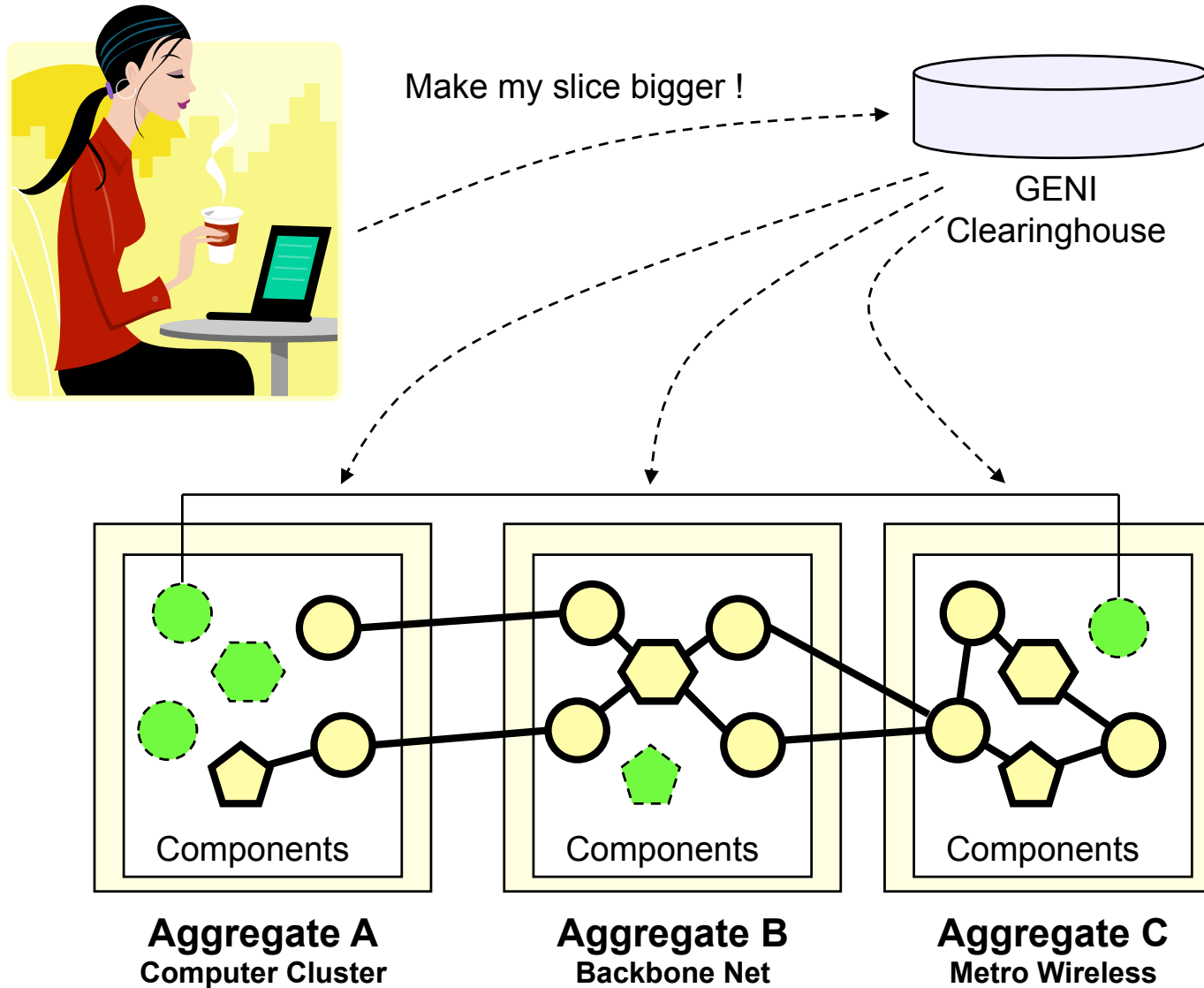
Federation of Clearinghouses
Growth path to international, semi-private, and commercial GENIs

Make my slice even bigger !

GENI
Clearinghouse

Federated
Clearinghouse

Components

Components

Components

Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Aggregate D
Non-NSF Resources
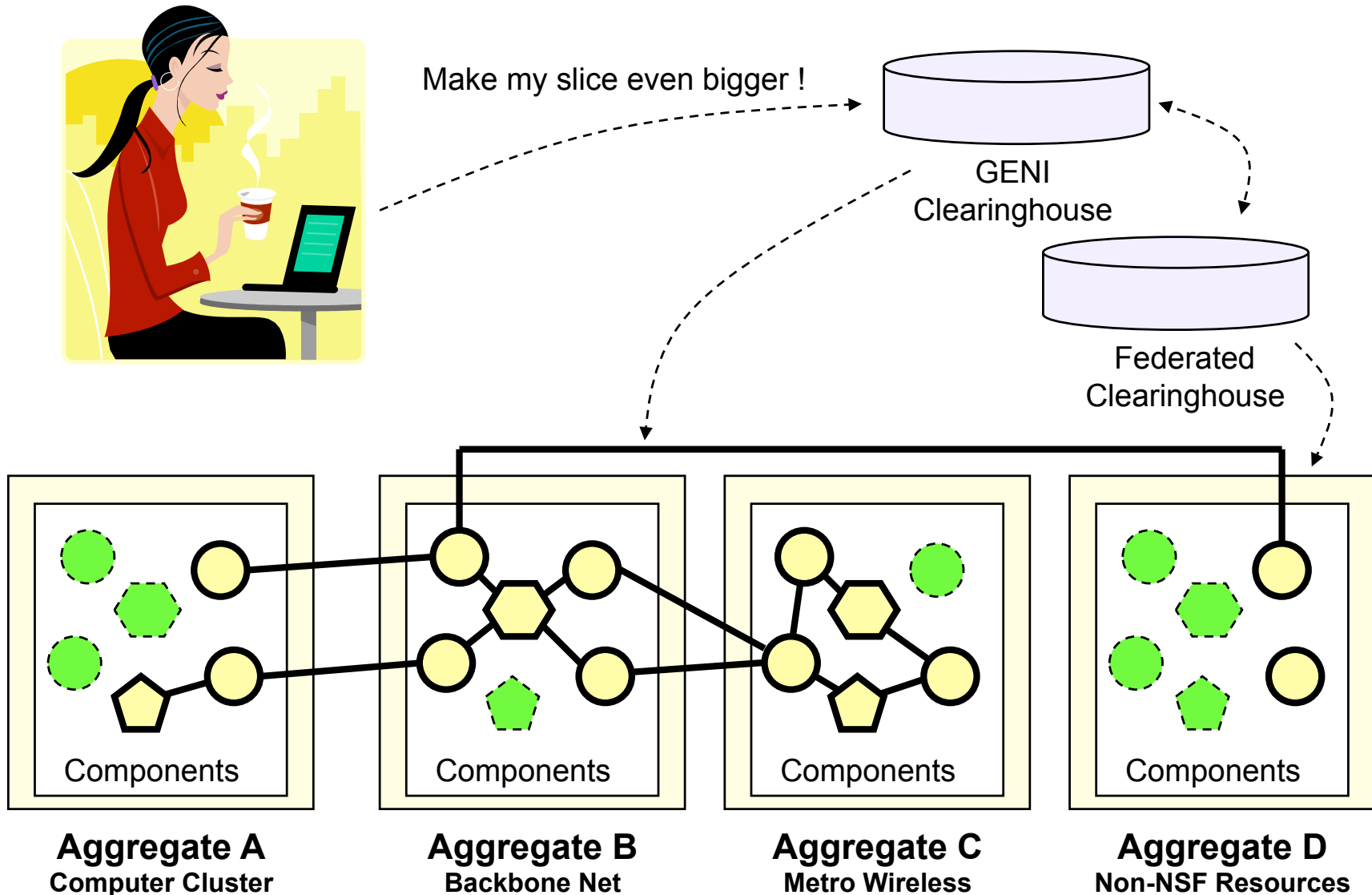
Operations & Management
Always present in background for usual reasons
Will need an 'emergency shutdown' mechanism

Stop the experiment immediately !

Oops

GENI Clearinghouse

Federated Clearinghouse

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Aggregate D
Non-NSF Resources

Components

Components

Components

Components
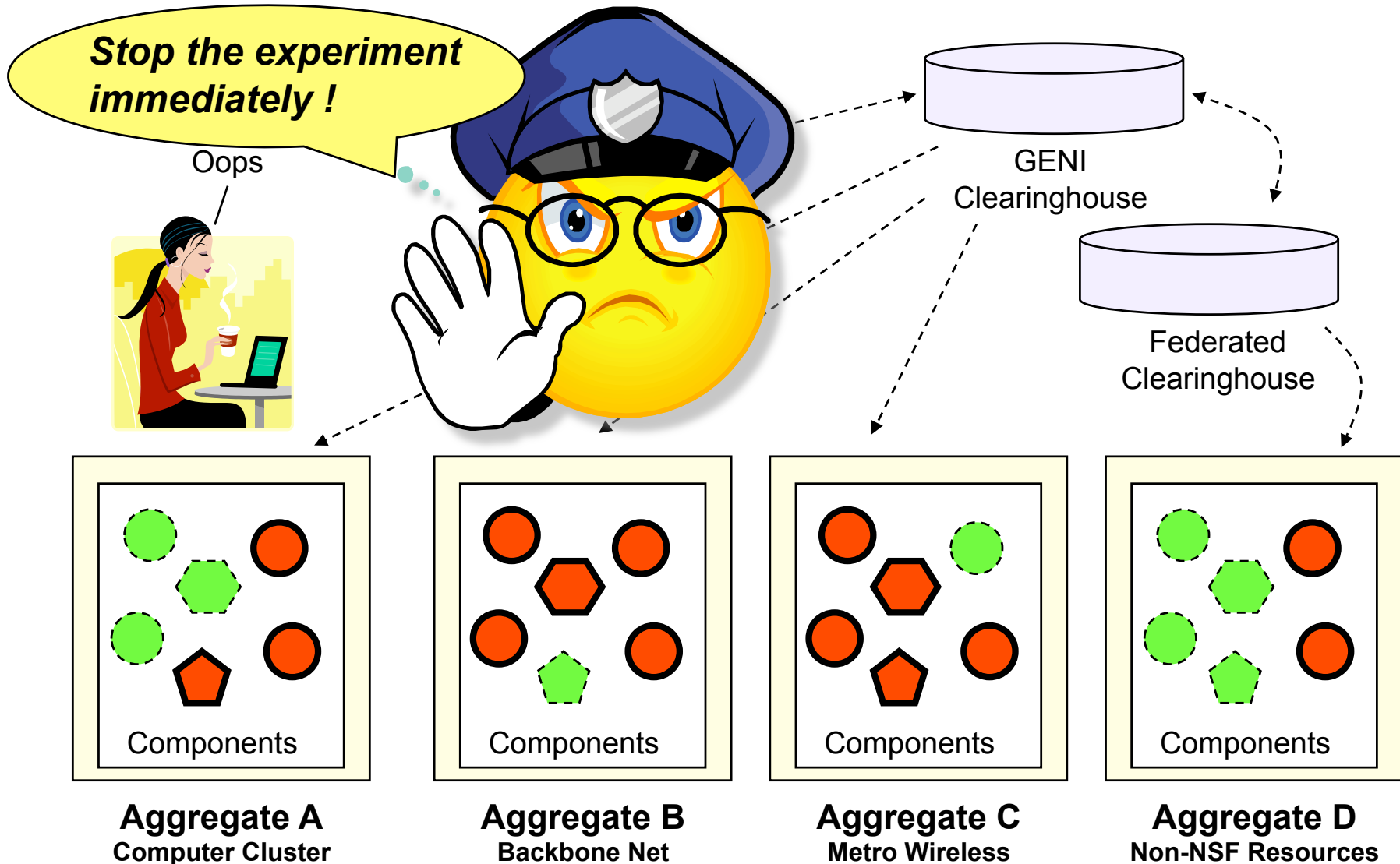
How We'll Build GENI

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

Planning

Design

Use

Integration

Build out

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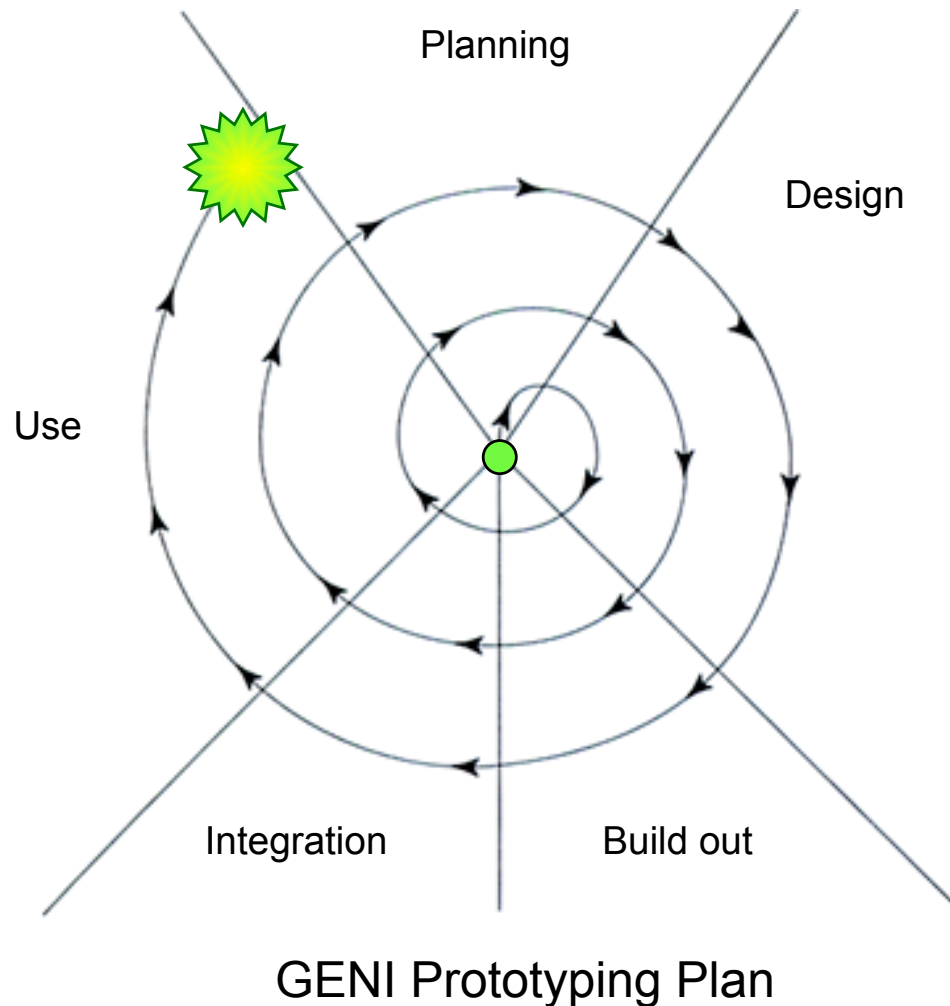
- **Envisioned ultimate goal**
  Example: Planning Group's desired GENI suite, probably trimmed some ways and expanded others. Incorporates large-scale distributed computing resources, high-speed backbone nodes, nationwide optical networks, wireless & sensor nets, etc.

- **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.

Wireless #1

Corporate GENI suites

Backbone #1

Compute Cluster #1

My GENI Slice

Access #1

Other-Nation Projects

Compute Cluster #2

Backbone #2

Other-Nation Projects

Wireless #2

This approach looks remarkably familiar . . .

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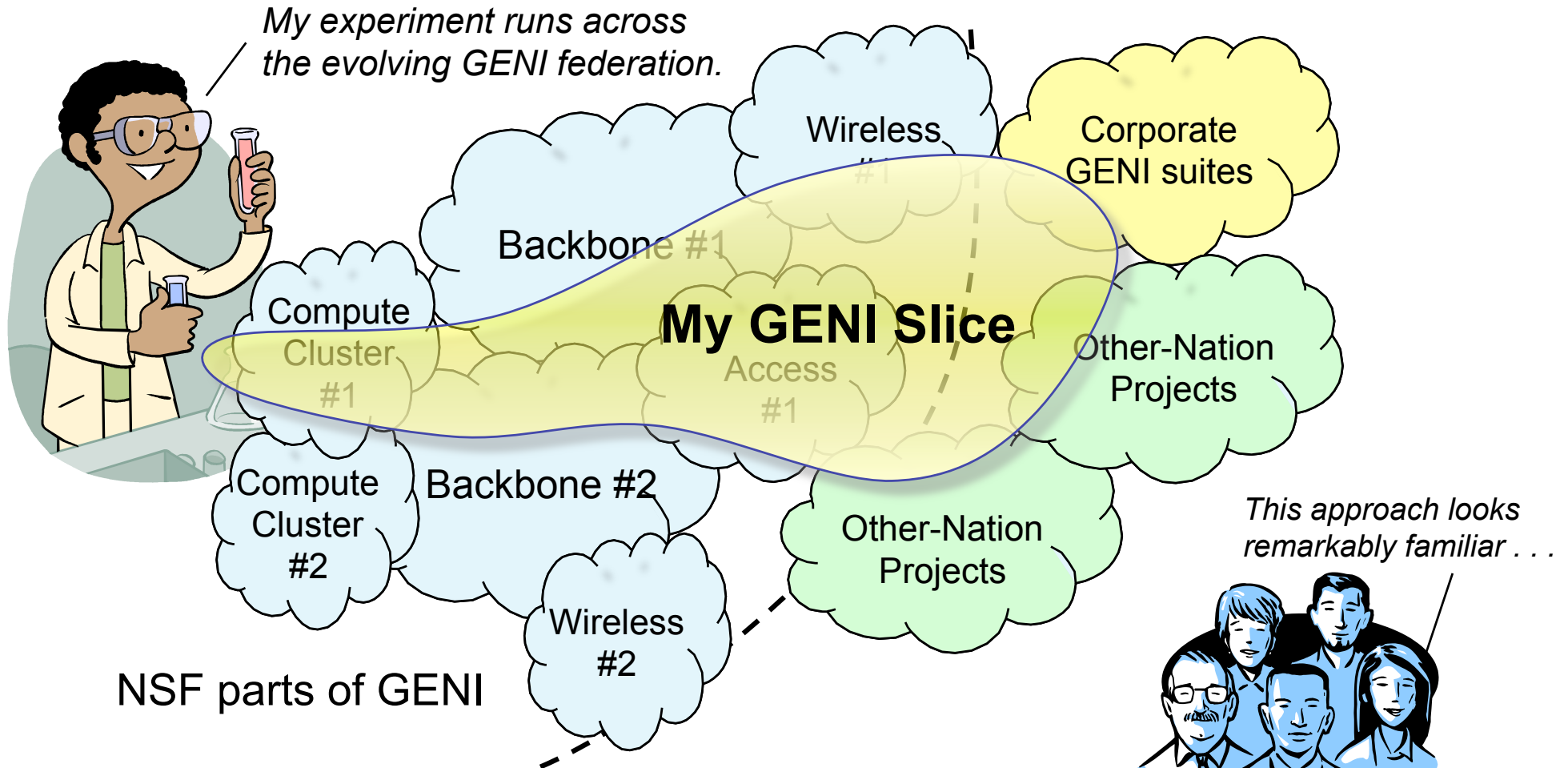
Goals: avoid technology "lock in," add new technologies as they mature, and potentially grow quickly by incorporating existing infrastructure into the overall "GENI ecosystem"

Outline

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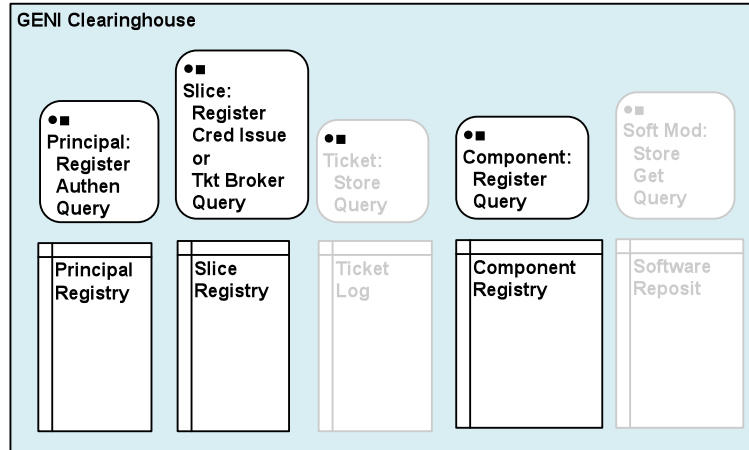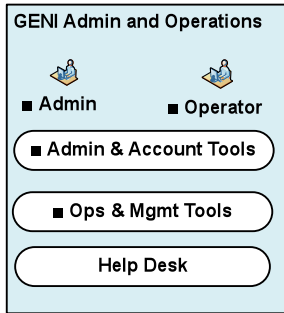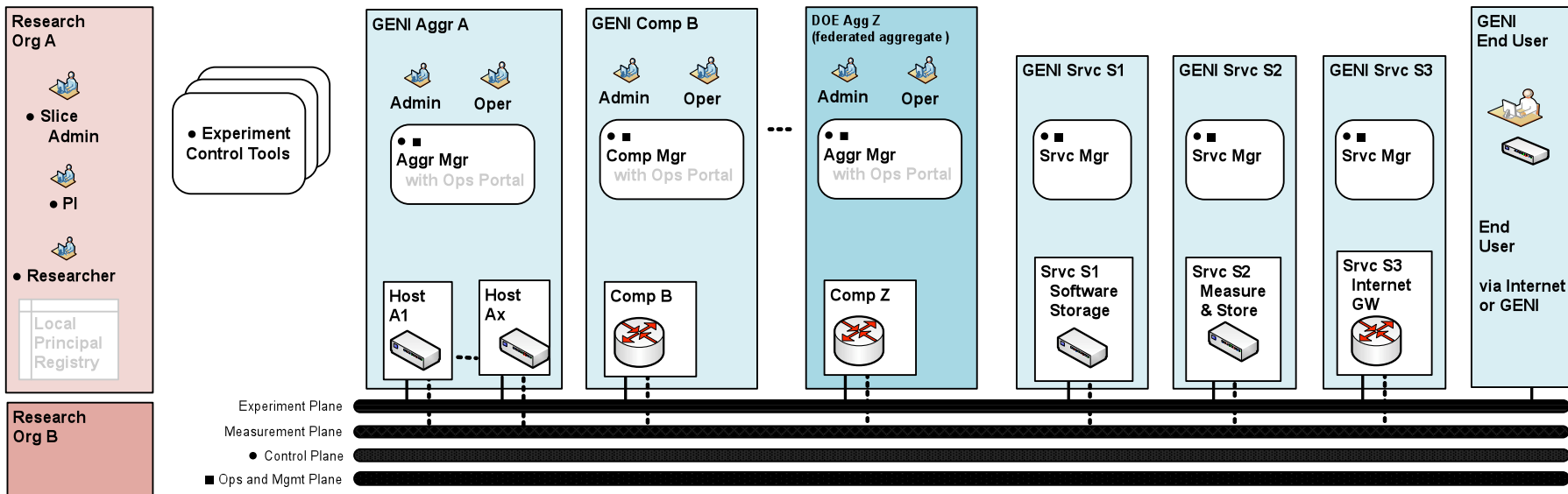- How we'll use it, how we'll build it
- The GENI system concept
- GENI Spiral 1
- How can you participate?

GENI System Decomposition

GENI Admin and Operations
- Admin
- Operator
- Admin & Account Tools
- Ops & Mgmt Tools
- Help Desk

GENI Clearinghouse

Principal: Register Authen Query	Slice: Register Cred Issue or Tkt Broker Query	Ticket: Store Query	Component: Register Query	Soft Mod: Store Get Query
Principal Registry	Slice Registry	Ticket Log	Component Registry	Software Reposit

Keep in mind: this is a snapshot of a work-in-progress. Expect it to change. Tell us what's wrong with it.

Research Org A
- Slice Admin
- PI
- Researcher
- Local Principal Registry

Research Org B

- Experiment Control Tools

GENI Aggr A
- Admin
- Oper
- Aggr Mgr with Ops Portal
- Host A1
- Host Ax

GENI Comp B
- Admin
- Oper
- Comp Mgr with Ops Portal
- Comp B

DOE Agg Z (federated aggregate)
- Admin
- Oper
- Aggr Mgr with Ops Portal
- Comp Z

GENI Srvc S1
- Srvc Mgr
- Srvc S1 Software Storage

GENI Srvc S2
- Srvc Mgr
- Srvc S2 Measure & Store

GENI Srvc S3
- Srvc Mgr
- Srvc S3 Internet GW

GENI End User
- End User via Internet or GENI

- Experiment Plane
- Measurement Plane
- Control Plane
- Ops and Mgmt Plane

Slices

GENI Operations & Management

- Admin
- Operator
- Admin & Account Tools
- Ops & Mgmt Tools
- Help Desk & Tools

GENI Clearinghouse

Principal:
Register
Authen
Query

Principal
Registry

Slice:
Register
Cred Issue
or
Tkt Broker
Query

Slice
Registry
- Slice A Record
- Slice B Record

Ticket:
Store
Query

Ticket
Log

Comp:
Register
Query

Comp
Registry

Soft Mod:
Store
Get
Query

Software
Reposit

Research Org A

- Experiment Control Tools
- Researcher

Research Org B

- Researcher

GENI Aggr A
- Aggr Mgr
- Host A1
- Host Ax

GENI Aggr B
- Aggr Mgr
- Comp B

DOE Aggr Z (federated aggr)
- Aggr Mgr
- Aggr Z

GENI Srvc S1
- Software Storage

GENI Srvc S2
- Measure & Store

GENI Srvc S3
- Visualization Service

GENI End User
- End User
- via Internet or GENI

Slice A — Sliver / Sliver / Sliver / "Sliver" / "Sliver"

Slice B — Sliver / Sliver / Sliver / "Sliver" / "Sliver" / "Sliver" / "Sliver"

Experiment Plane
Measurement Plane
- Control Plane
- Ops and Mgmt Plane

Clearinghouse Federation

Outline

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

GENI Spiral 1 has now begun!
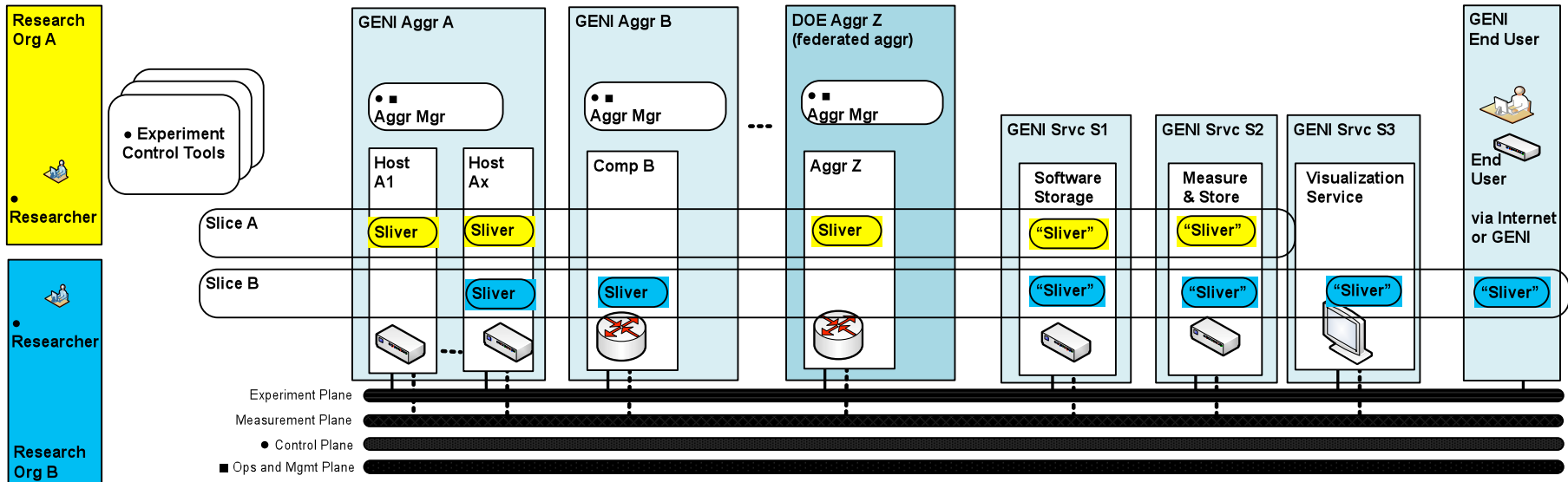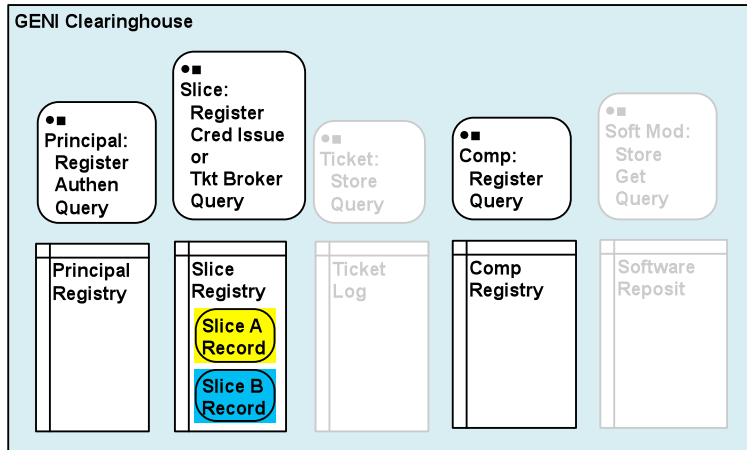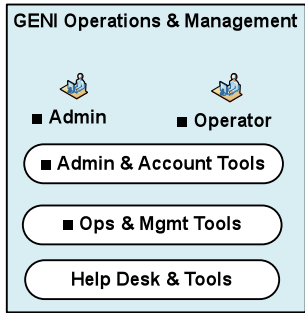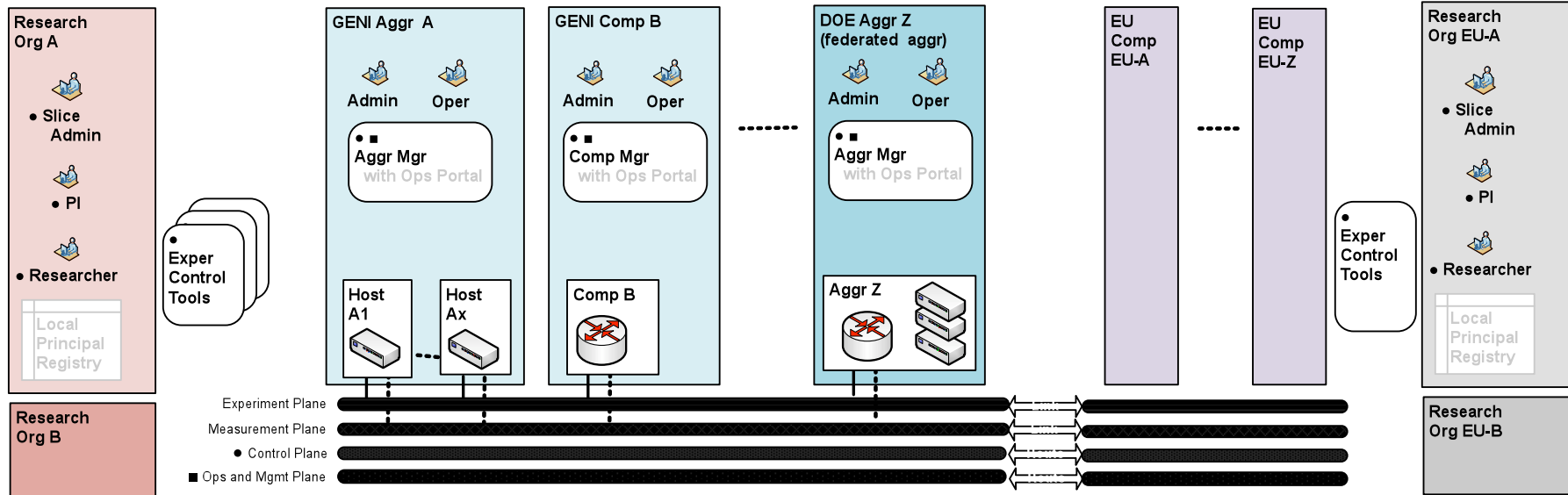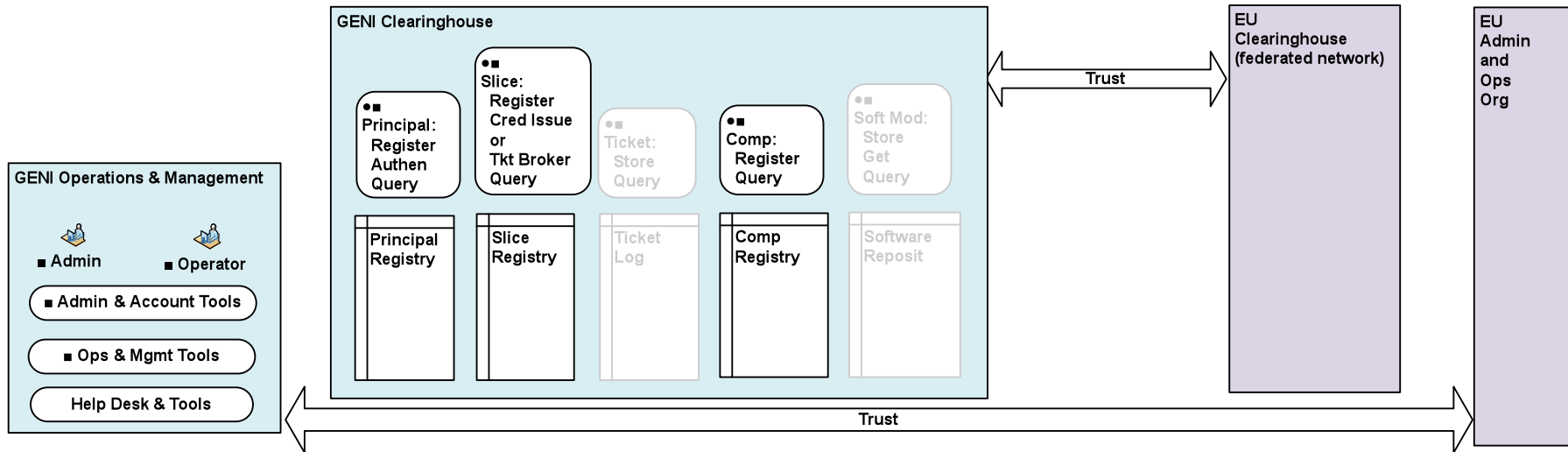## First results expected in 6-12 months

GENI Project Office Announces $12M for Community-Based GENI Prototype Development
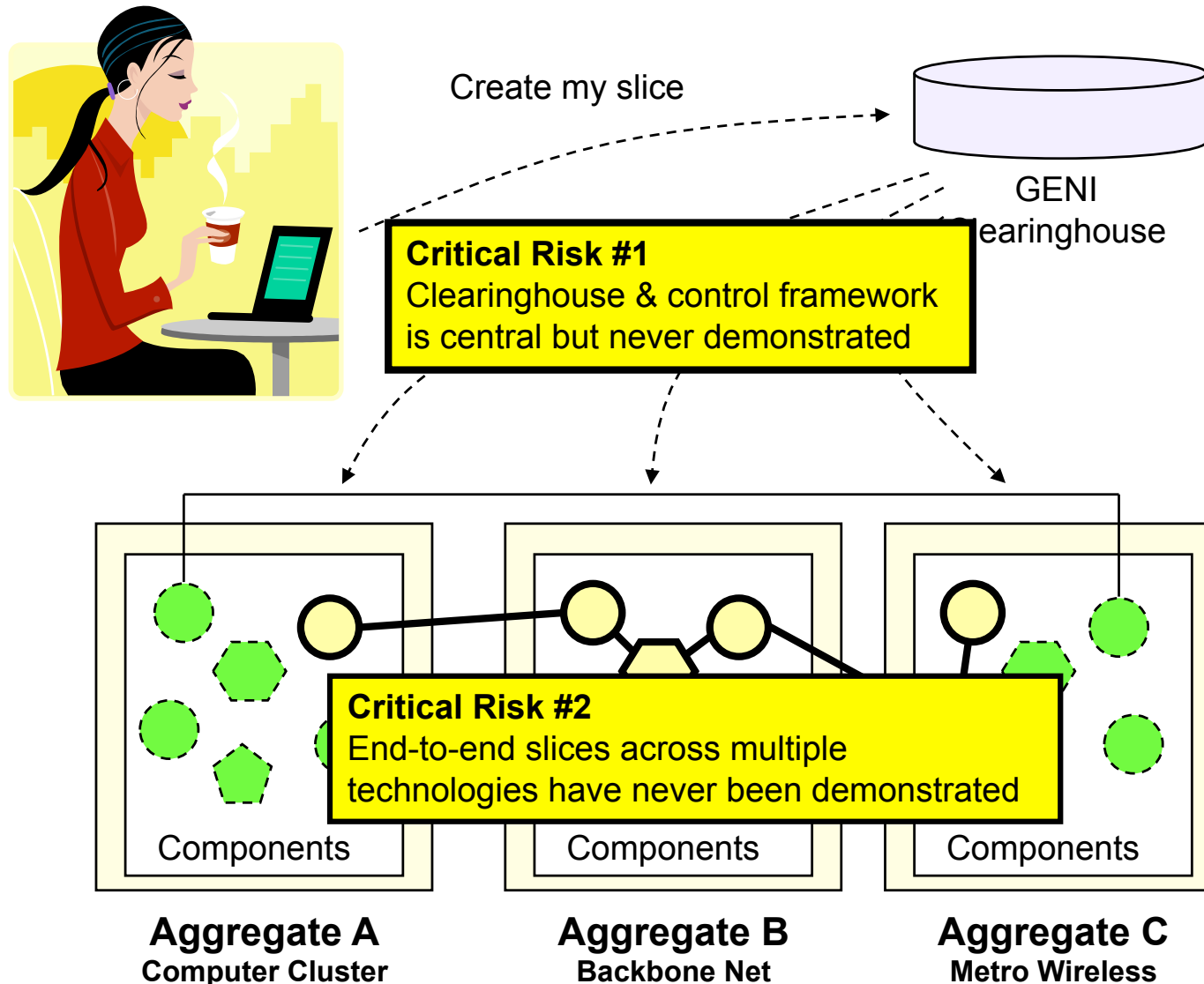
July 22, 2008

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

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

Components

Components

Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless

Key Goals for GENI Spiral 1
Drive down the critical technical risks in GENI's concept

Create my slice

GENI
...nghouse

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

Components

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Components

Aggregate A
Computer Cluster

Aggregate B
Backbone Net

Aggregate C
Metro Wireless
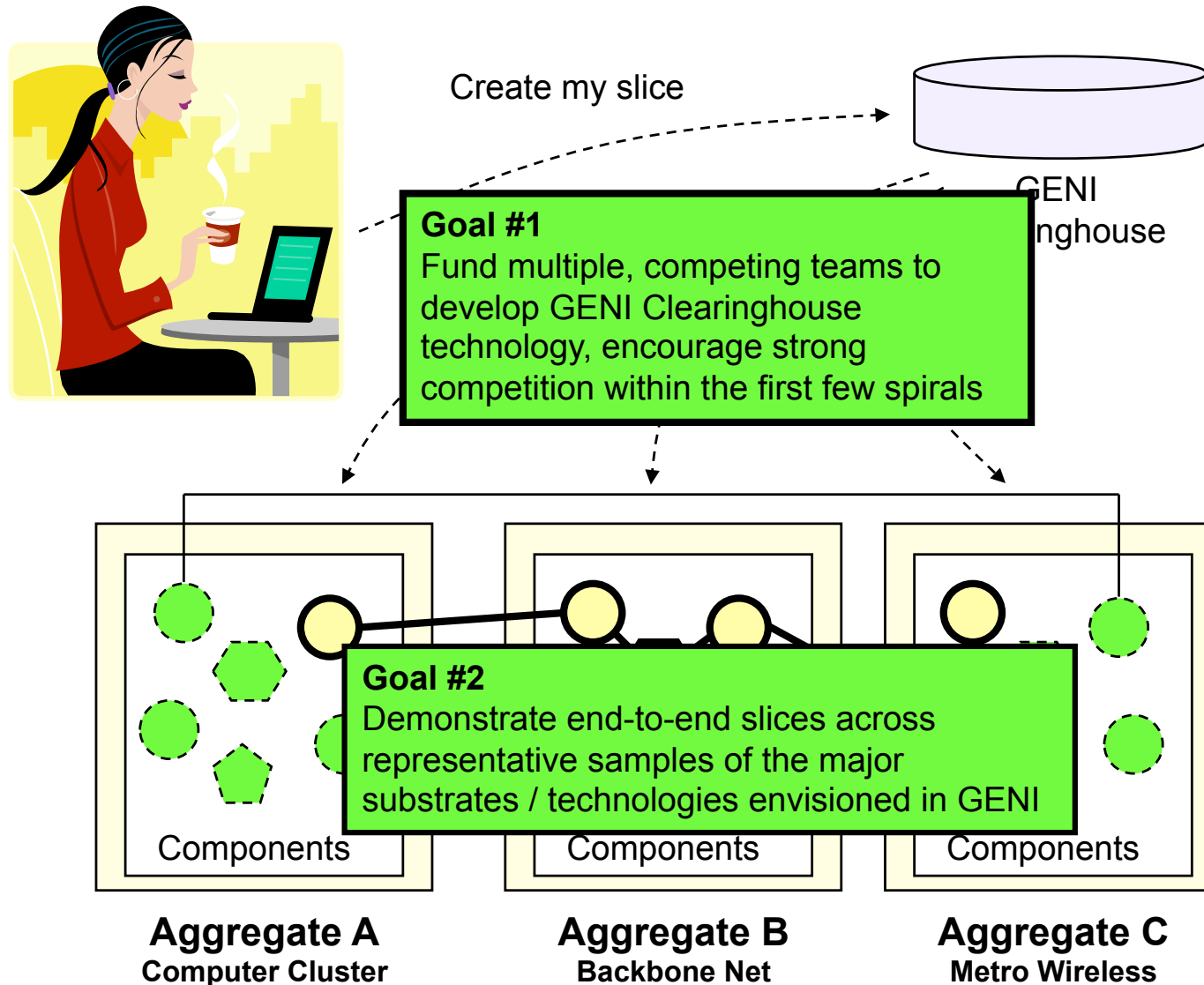
Internet2 and National Lambda Rail

Internet2
10 Gbps dedicated bandwidth

National Lambda Rail
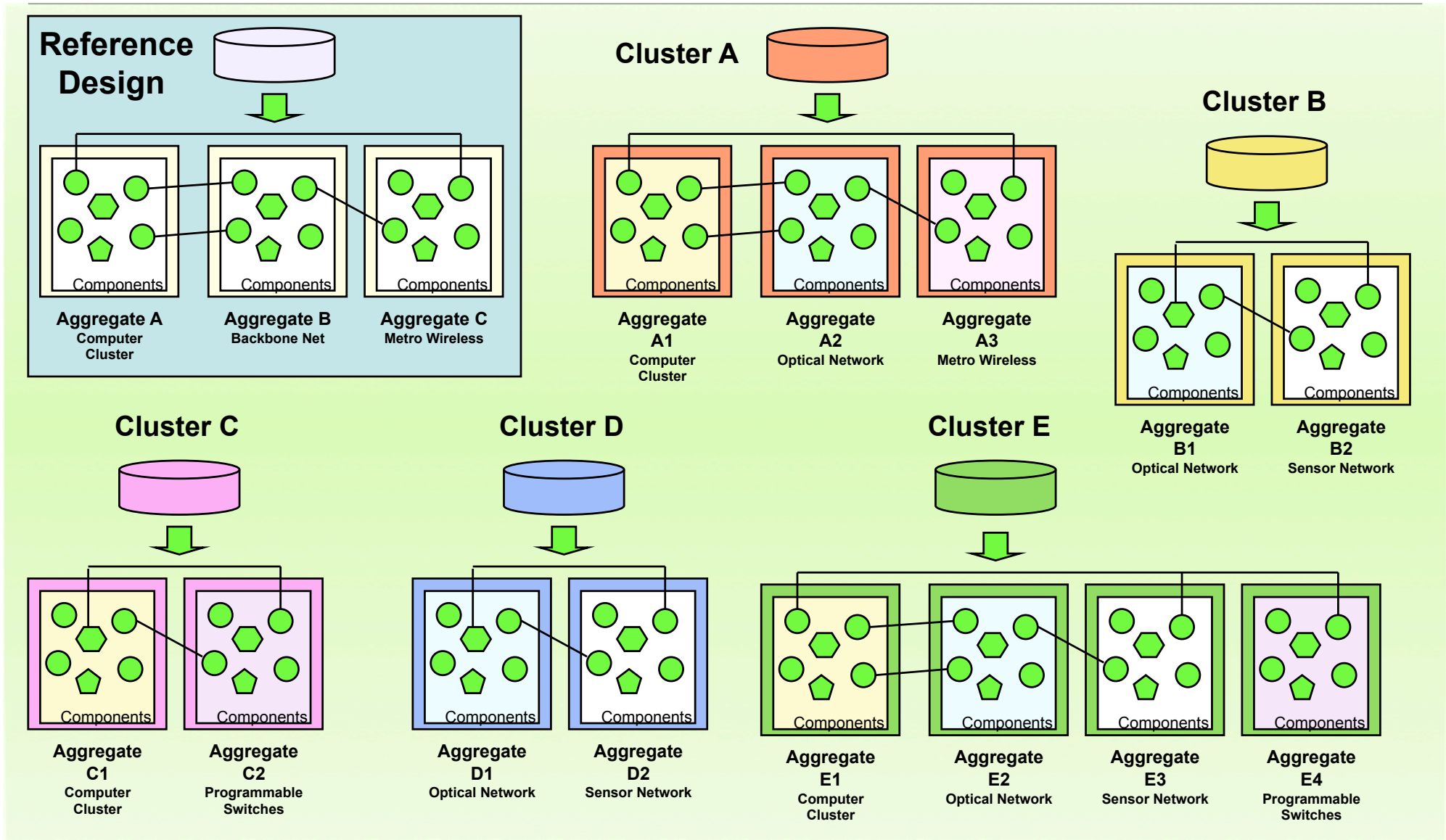Up to 30 Gbps nondedicated bandwidth

40 Gbps capacity for GENI prototyping on two national footprints to provide Layer 2 Ethernet VLANs as slices (IP or non-IP)
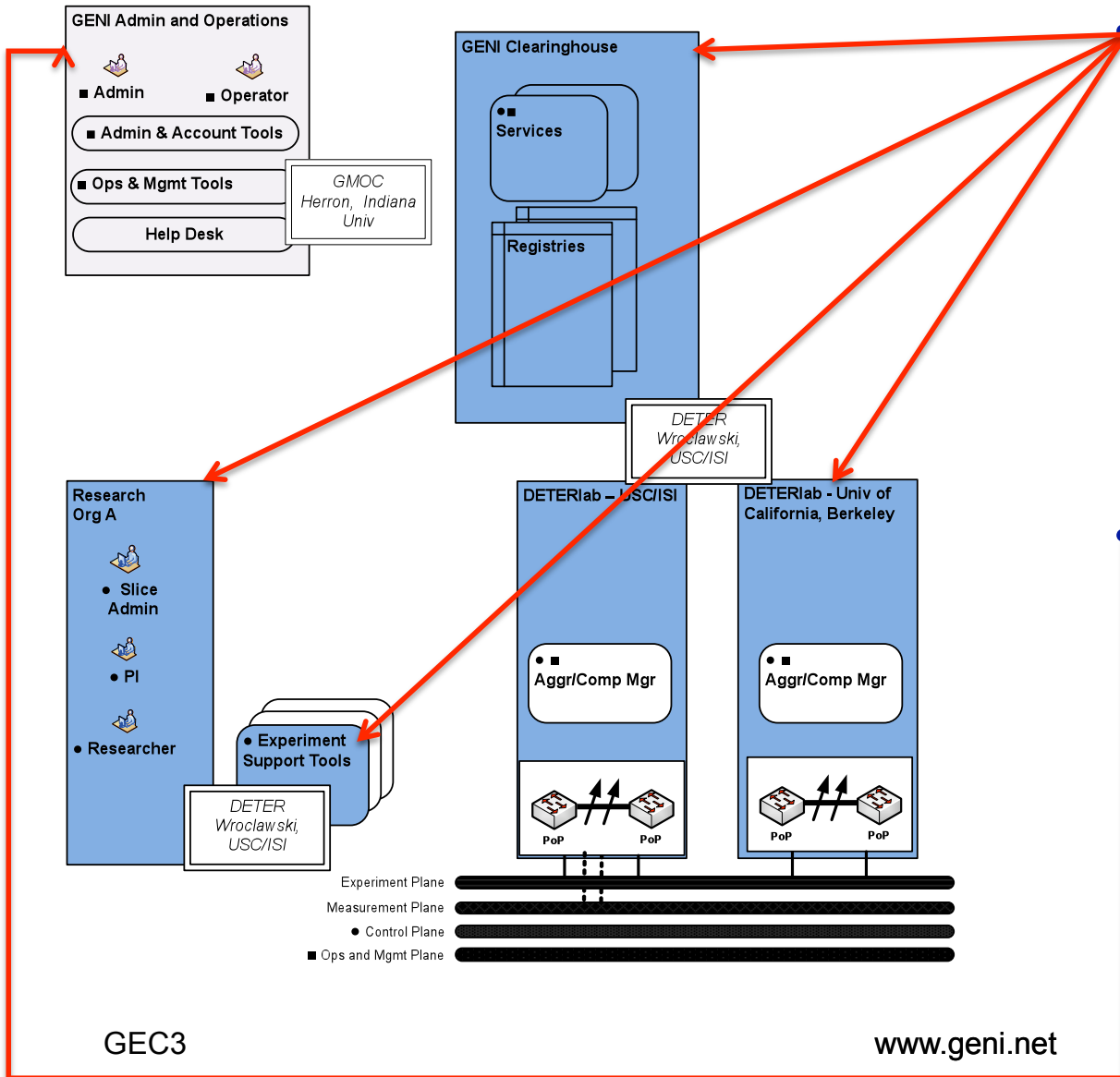
Spiral 1 integration and trial operations
Five competing control frameworks, wide variety of substrates

Reference Design

Aggregate A — Computer Cluster
Aggregate B — Backbone Net
Aggregate C — Metro Wireless

Cluster A

Aggregate A1 — Computer Cluster
Aggregate A2 — Optical Network
Aggregate A3 — Metro Wireless

Cluster B

Aggregate B1 — Optical Network
Aggregate B2 — Sensor Network

Cluster C

Aggregate C1 — Computer Cluster
Aggregate C2 — Programmable Switches

Cluster D

Aggregate D1 — Optical Network
Aggregate D2 — Sensor Network

Cluster E

Aggregate E1 — Computer Cluster
Aggregate E2 — Optical Network
Aggregate E3 — Sensor Network
Aggregate E4 — Programmable Switches

Cluster A Integration
(uses DETER control framework)
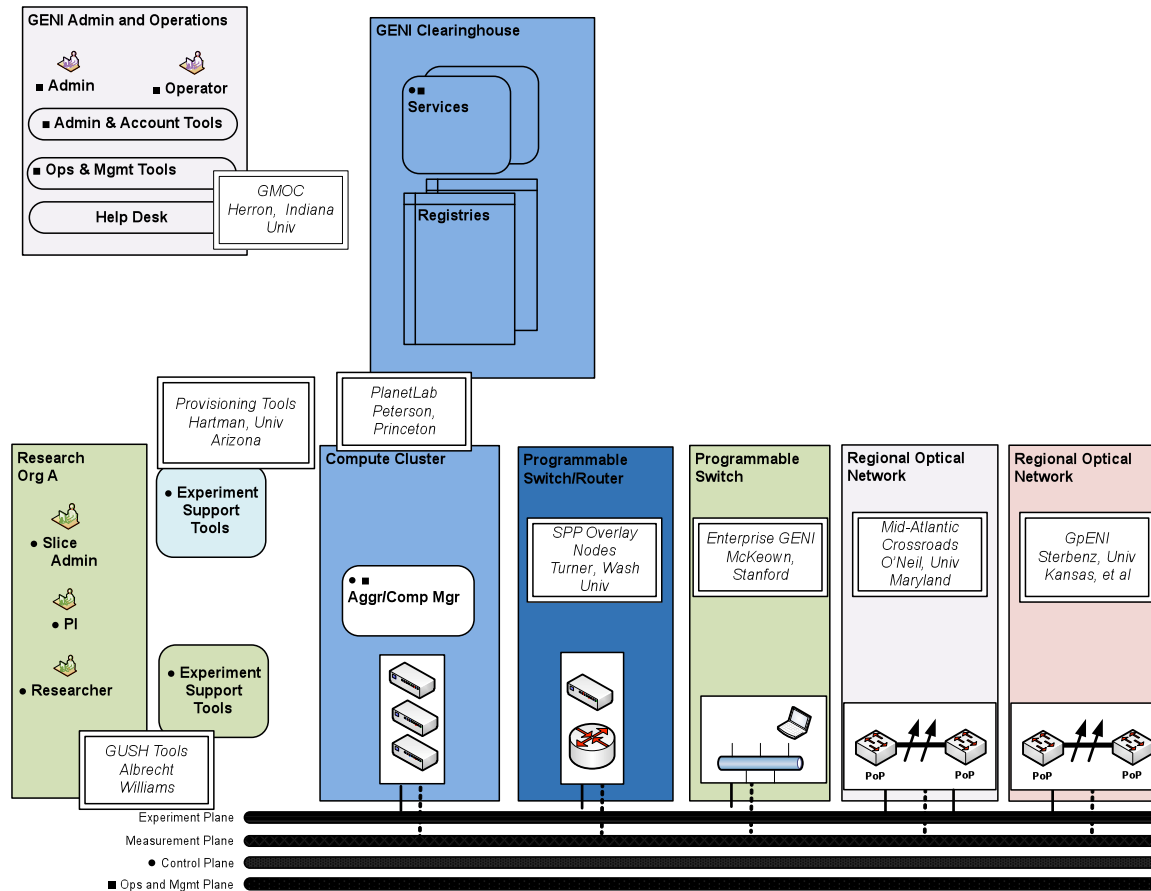

DETER Trial Integration

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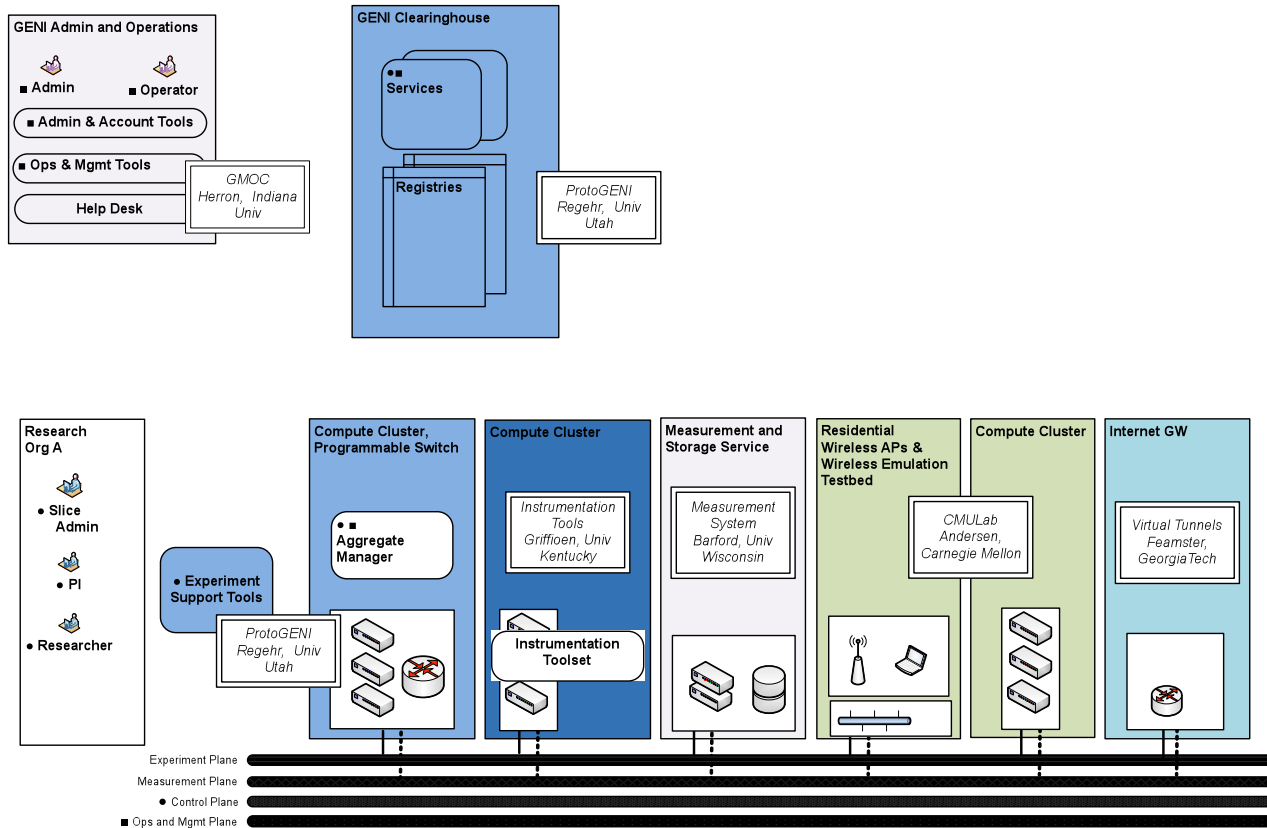
- **ProtoGENI**
  - Clearinghouse, CM
  - Emulab resources
  - (370+ nodes)
- **CMULab**
  - Home Wireless APs
  - Emulab cluster
  - Wireless emulation testbed
- **Instrumentation Tools**
  - UK Edulab (compute/store)
- **Measurement System**
  - GIMS prototype
- **Virtual Tunnels**
  - Dynamic tunnel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

- **GMOC**

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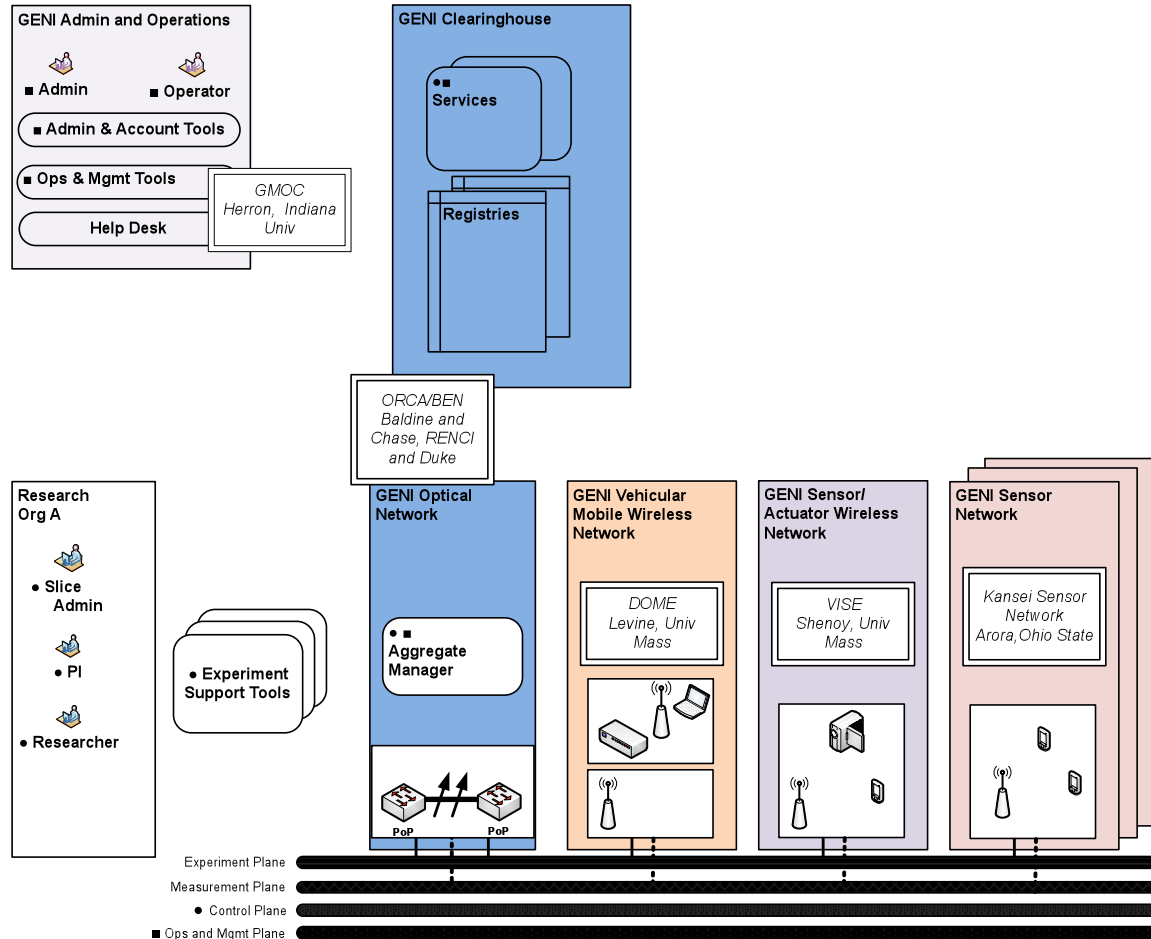
- **ORCA/BEN**
  - ORCA resource leasing software
  - Metro-Scale Optical Testbed (BEN)
- **VISE**
  - CASA (radar, video, weather sensors)
- **Kansei Sensor Network**
  - Wireless sensor network arrays
  - 3 federated sites each w/~100 sensor nodes
- **Diverse Outdoor Mobile Environment (DOME)**
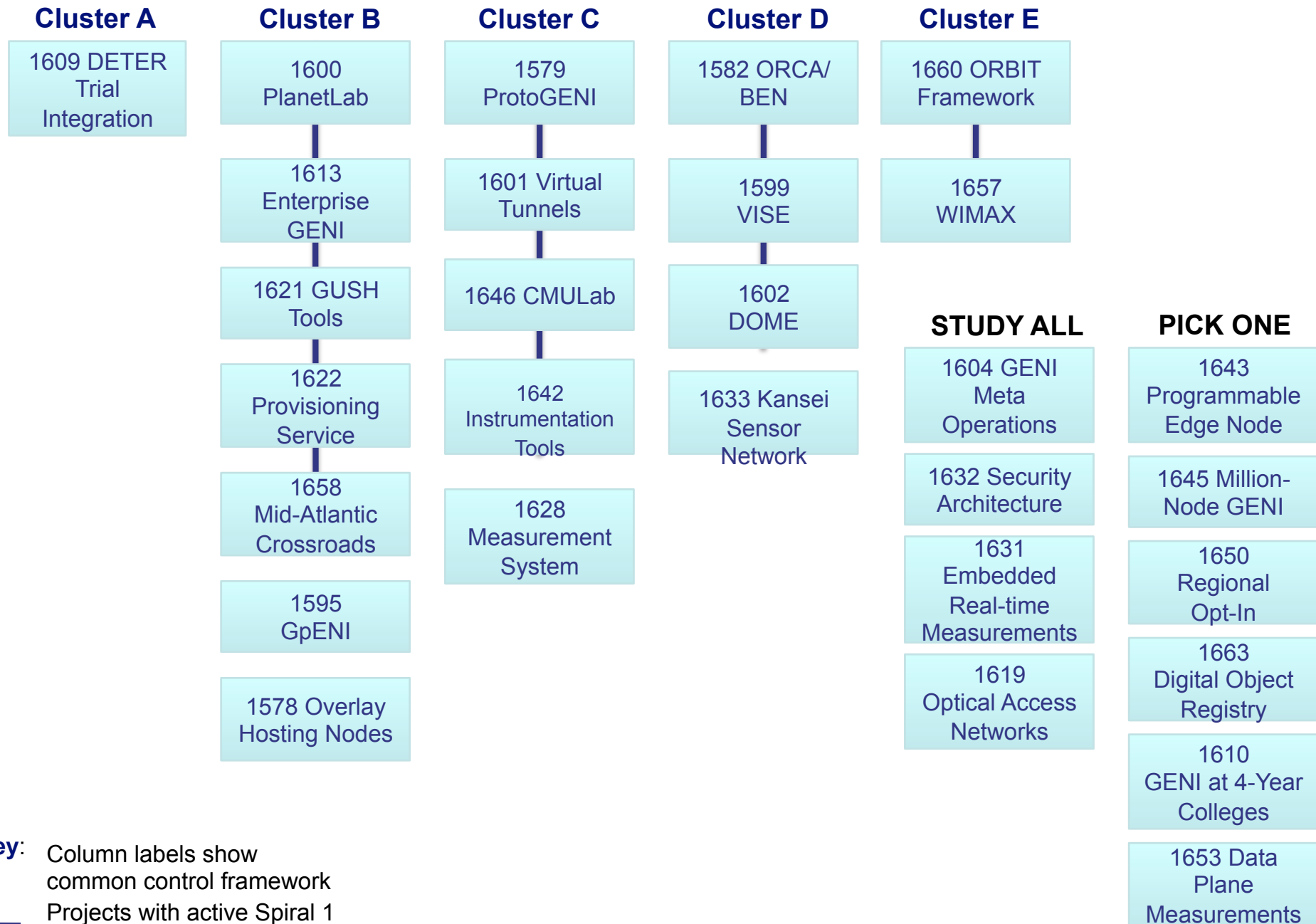 - Programmable nodes with radios on city busses
- **GMOC**

Cluster E Integration
(uses ORBIT control framework)
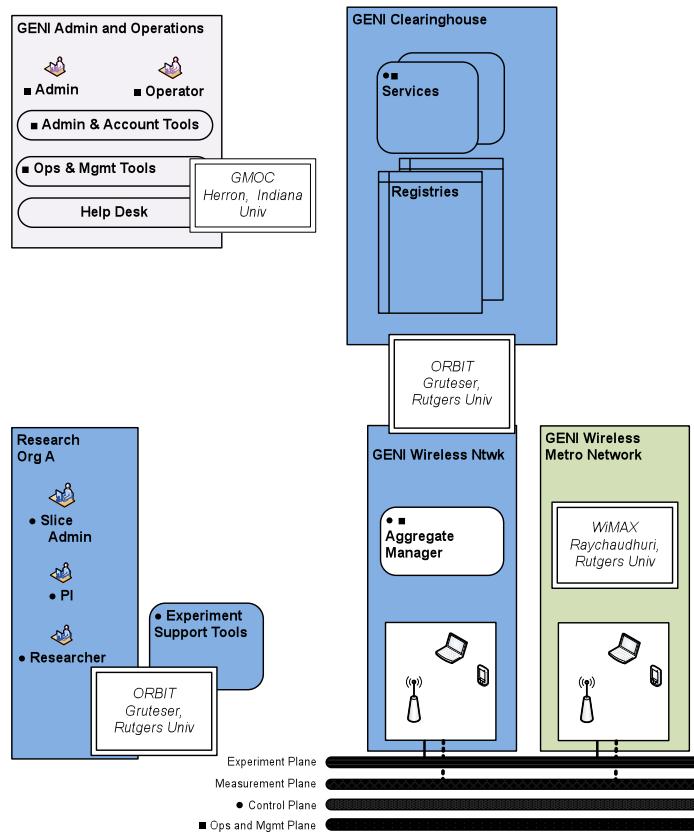
- **ORBIT**
  - Heterogeneous testbed control, management, & measurement software
  - WINLAB wireless testbeds resources (400+ sensor nodes)
  - NICTA (Australia) wireless outdoor traffic testbed

- **WiMAX**
  - Open, programmable WiMAX base station

- **GMOC**

GENI Spiral 1 Integration: 5 Control Framework Clusters

Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
1609 DETER Trial Integration	1600 PlanetLab	1579 ProtoGENI	1582 ORCA/ BEN	1660 ORBIT Framework
	1613 Enterprise GENI	1601 Virtual Tunnels	1599 VISE	1657 WIMAX
	1621 GUSH Tools	1646 CMULab	1602 DOME	
	1622 Provisioning Service	1642 Instrumentation Tools	1633 Kansei Sensor Network	
	1658 Mid-Atlantic Crossroads	1628 Measurement System		
	1595 GpENI			
	1578 Overlay Hosting Nodes			

STUDY ALL

- 1604 GENI Meta Operations
- 1632 Security Architecture
- 1631 Embedded Real-time Measurements
- 1619 Optical Access Networks

PICK ONE

- 1643 Programmable Edge Node
- 1645 Million-Node GENI
- 1650 Regional Opt-In
- 1663 Digital Object Registry
- 1610 GENI at 4-Year Colleges
- 1653 Data Plane Measurements

Key: Column labels show common control framework
Projects with active Spiral 1 clearinghouse interfaces

Our goals for this meeting

- The GPO seeks concrete plans for collaboration between FIRE and GENI development efforts in the next 6-12 months

  - At least 1 Experiment Plane integration
    - Layer 2 connectivity, i.e., end-to-end Ethernet VLANs, between some GENI aggregates and FIRE components

  - At least 3 Control Framework federations
    - The ability to for GENI researchers to include FIRE resources in their slice, and vice-versa, via the GENI control framework
    - Choose from one of the five GENI control frameworks

  - Solicitation 2 expects to fund the US portion…