Building GENI

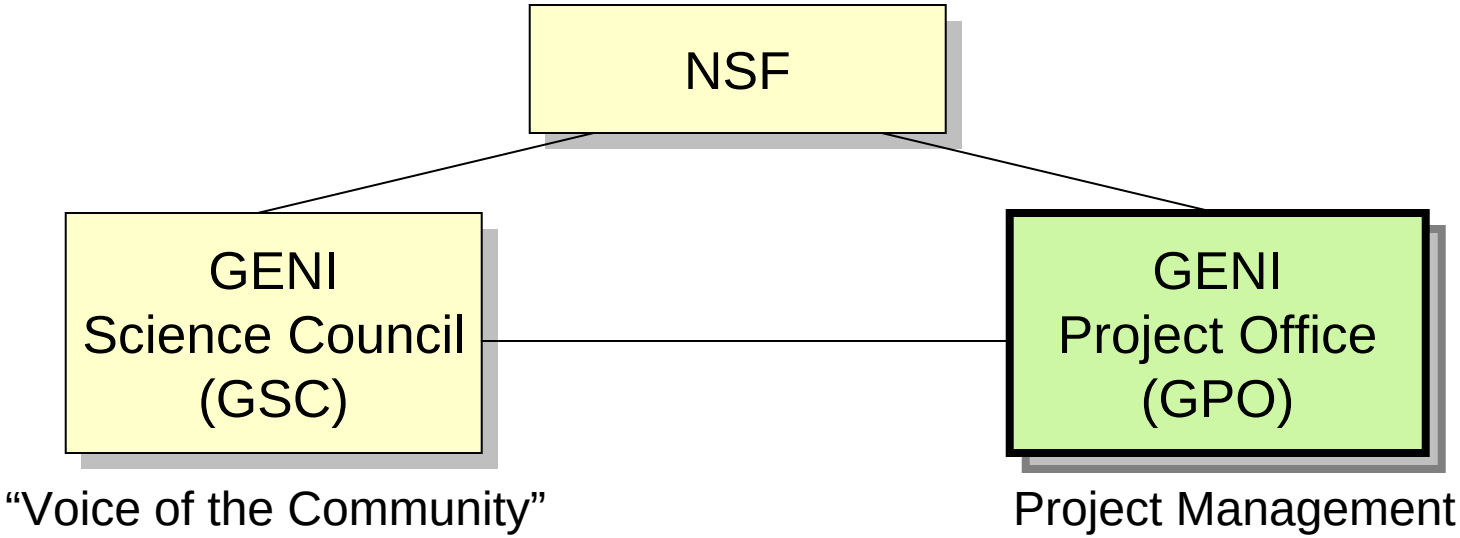
It's Time to Start

Chip Elliott
GENI Project Director

www.geni.net

Clearing house for all GENI news and documents

GENI Roles & Responsibilities



Key Roles and Responsibilities

GSC

- Definitive source of “what we need in GENI”
- Authors of GENI Research & Education Plan
- Technical advisory & oversight to GPO

GPO

- Project management and execution
- GENI architecture and system engineering
- Cost & schedule estimates for construction
- Authors of GENI facility construction plan
- Home for Working Groups

GPO Leadership

Chip Elliott
Project Director

Aaron Falk
(Community Nominee)
Engineering Architect

Kristin Rauschenbach
Substrate Architect

Henry Yeh
Project Manager

Heidi Picher Dempsey
Operations &
Integration Director

Craig Partridge
Outreach Director

“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

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

GENI is a Huge Opportunity

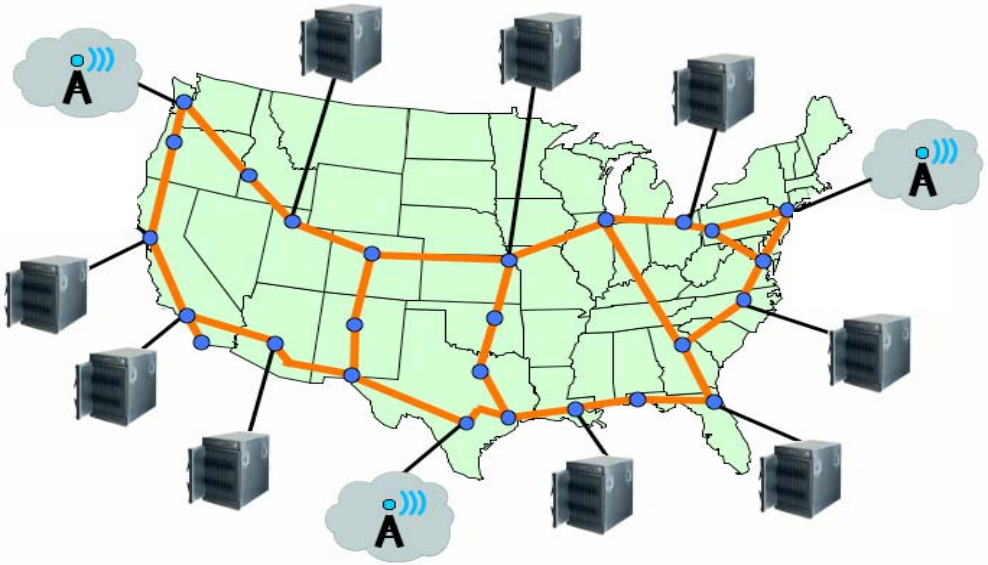
- **GENI is an unbelievably exciting project for the community**
  - Our research community has changed the world profoundly. GENI opens up a space to do it again.
- **We believe the whole community will pitch in and build GENI together**
  - Our vision is for a very lean, fast-moving GPO, with substantially all design and construction work performed by academic and industry research teams
- **We'd like the community to start building prototypes immediately**
  - within a GENI project framework that is open, transparent, and broadly inclusive

Outline

- What is GENI?
- GENI Planning and Construction
- GENI will be Designed & Built by the Community
- Prototyping GENI – It's Time to Start

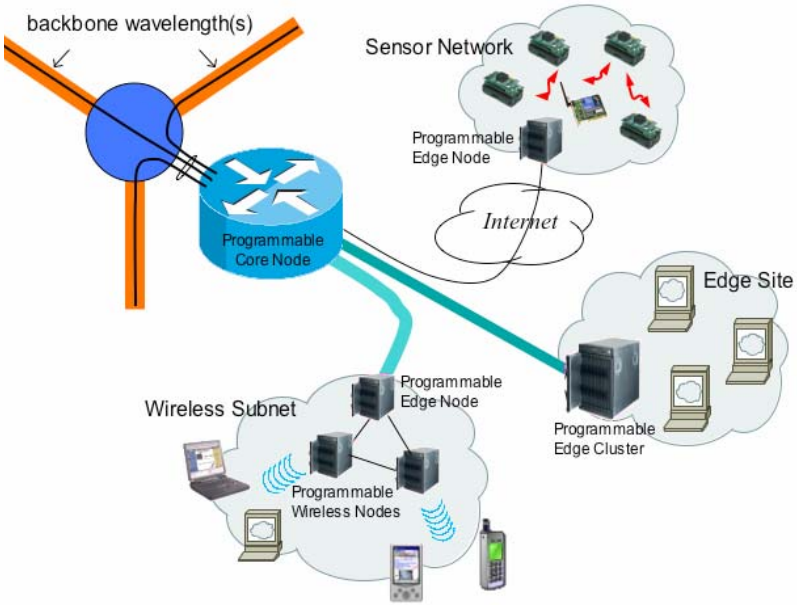
The GENI Vision

A national facility to explore radical designs for a future global networking infrastructure



- High capacity backbone and programmable core nodes
- Large clusters of CPUs and storage

- Large, wide-area footprint
- Edge / access technologies (e.g. sensor networks)
- Shared among researchers by virtualization & slices

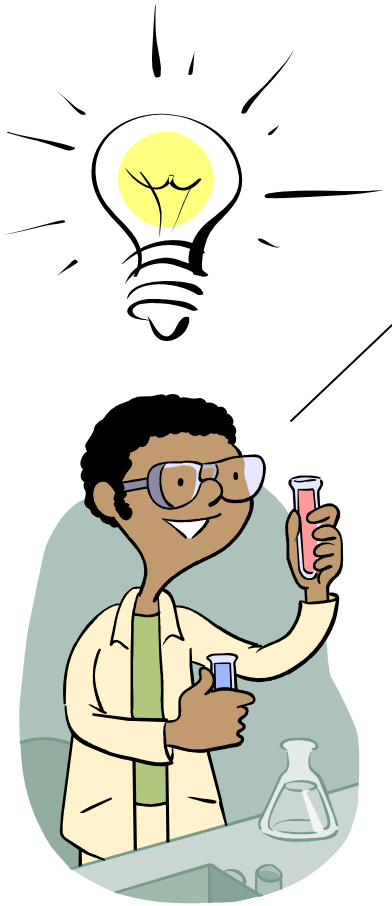


How We'll Use GENI

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

Please read the GENI Research and Education Plan to learn all about the community's vision for GENI and the research it will enable. Your suggestions are very much appreciated!

A bright idea

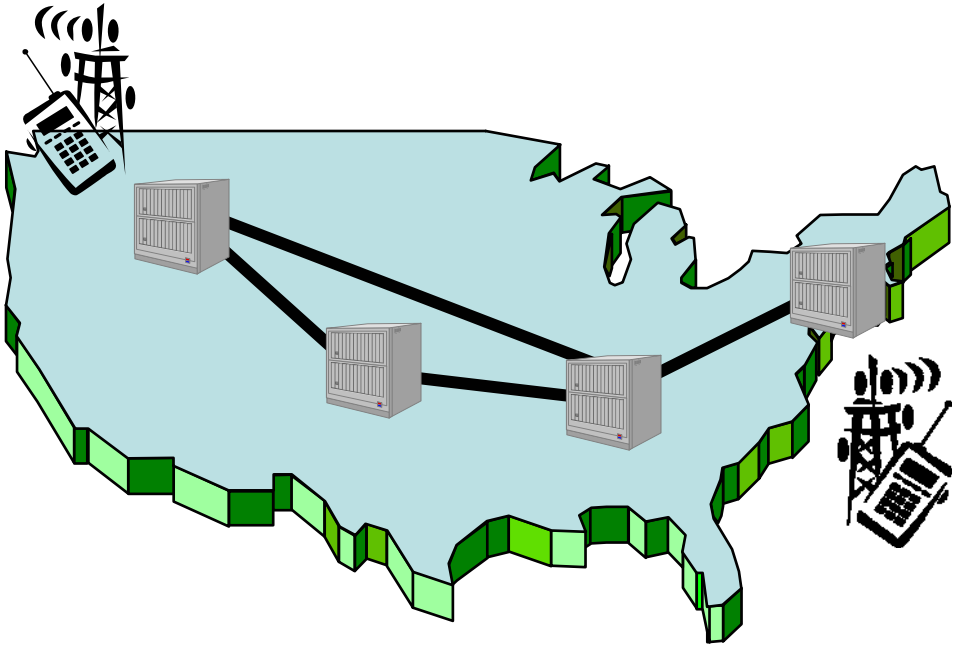


I have a great idea! The original Internet architecture was designed to connect one computer to another – but a better architecture would be fundamentally based on PEOPLE and CONTENT!

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 facility, and started taking measurements . . .

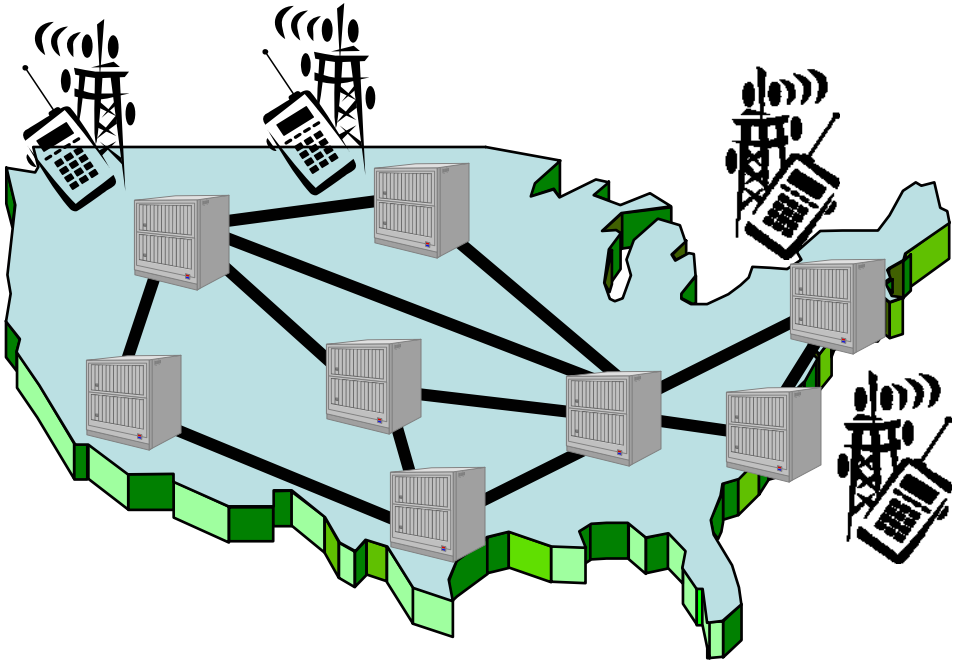
He uses a modest slice of GENI, sharing the facility with many other concurrent experiments.

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!

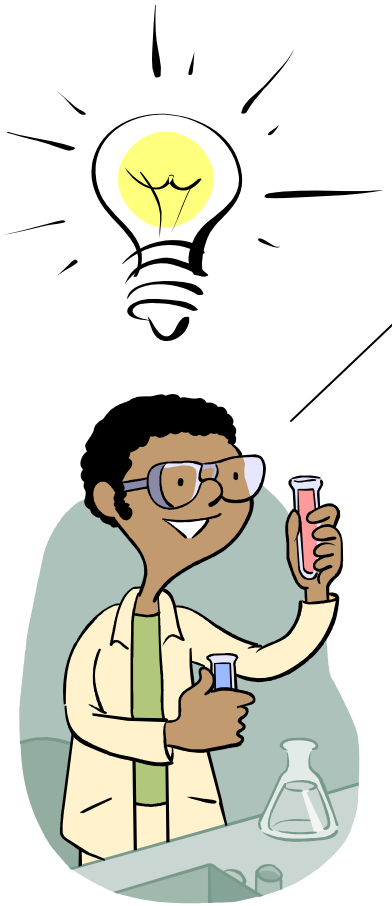
Location-based social networks are really cool!

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 FIND, SING, or NGNI** programs which are funding new architectural work. www.nets-find.net

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 stable facility on which experiments run

GENI creates a huge opportunity for ambitious research!

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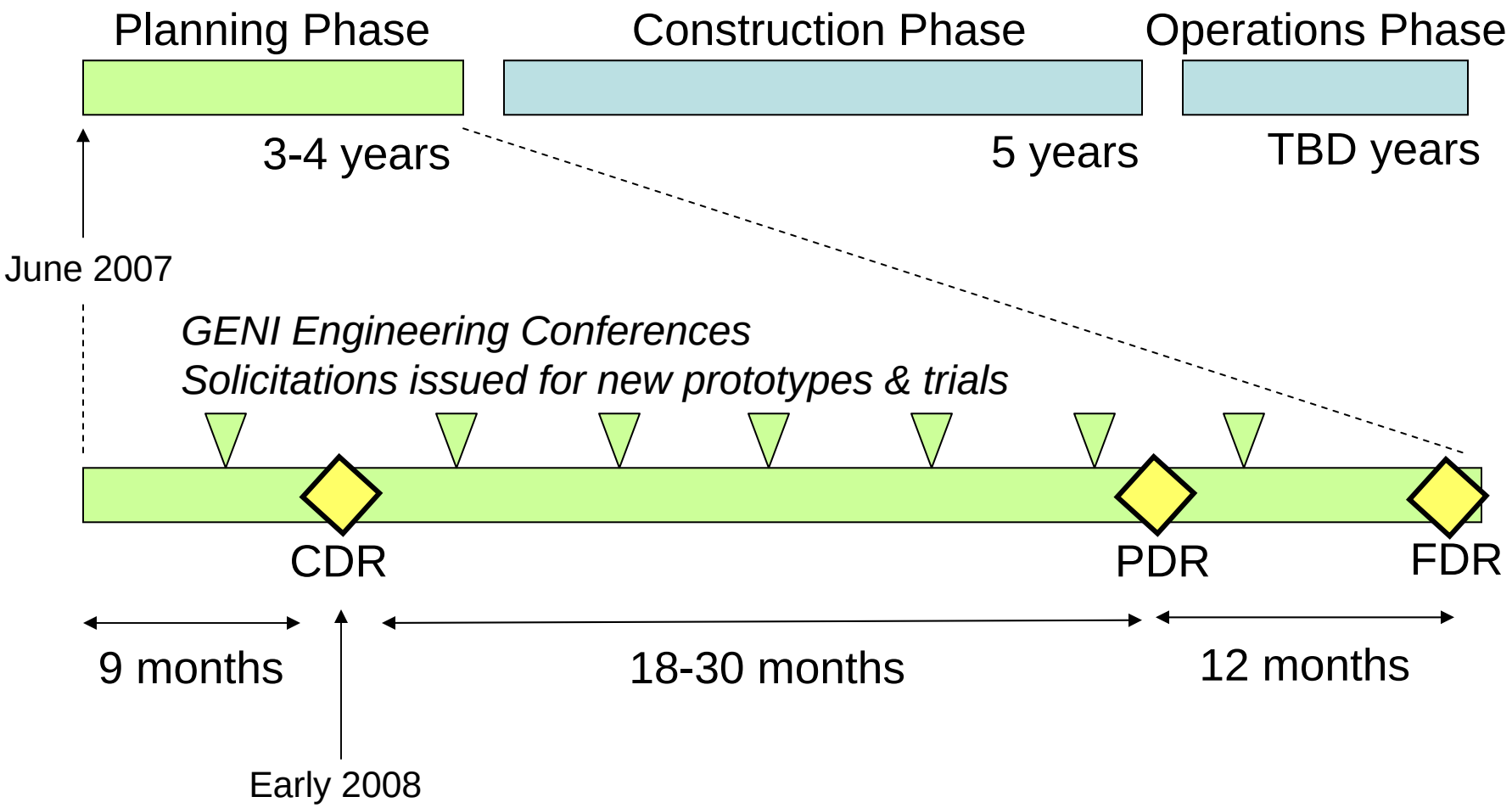
Current Timeline for GENI Planning and Construction



Our plan for building GENI

- Start with a clear, achievable starting point and an envisioned “ultimate goal”
- Begin prototyping and trials immediately
  - Gain **practical experience** with prototypes, and adjust “wishlists” and requirements as we go
  - Make **realistic estimates** of cost and operational complexity based on early experience with prototype systems, rather than guess-work
  - Add features, complexity, and new technologies incrementally, based on experience to date
- Repeatedly assess GENI’s current risk and usefulness as planning and construction unfold, and adjust plans accordingly

GENI Needs Rapid Prototypes

Work should begin immediately by multiple teams

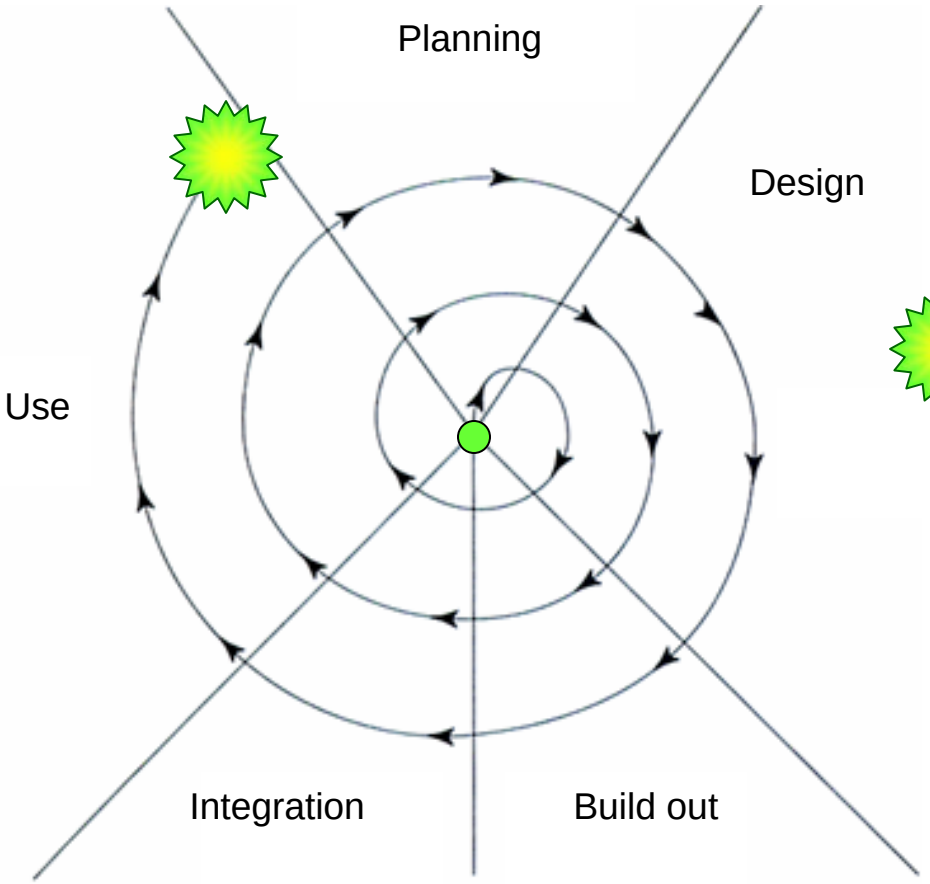
GENI's envisioned technology *TODAY*

TRL	NASA Definition, adapted to GENI Context
1	Basic principles observed and reported.
2	Technology concept and/or application formulated.
3	Analytical and experimental critical function and/or characteristic proof-of-concept achieved in a laboratory environment.
4	Component and/or breadboard validated in a laboratory environment.
5	Component and/or breadboard validated in a relevant environment.
6	System/subsystem model or prototype demonstration in a relevant lab environment.
7	System prototype demonstrated in an end-to-end "GENI-like" environment.
8	Actual system completed and demonstrated in the end-to-end GENI environment.
9	Actual system "flight proven" through successful end-to-end GENI experiments.

GENI needs to be *here* before Construction Phase decision

Spiral Development

GENI grows through a well-structured, adaptive process

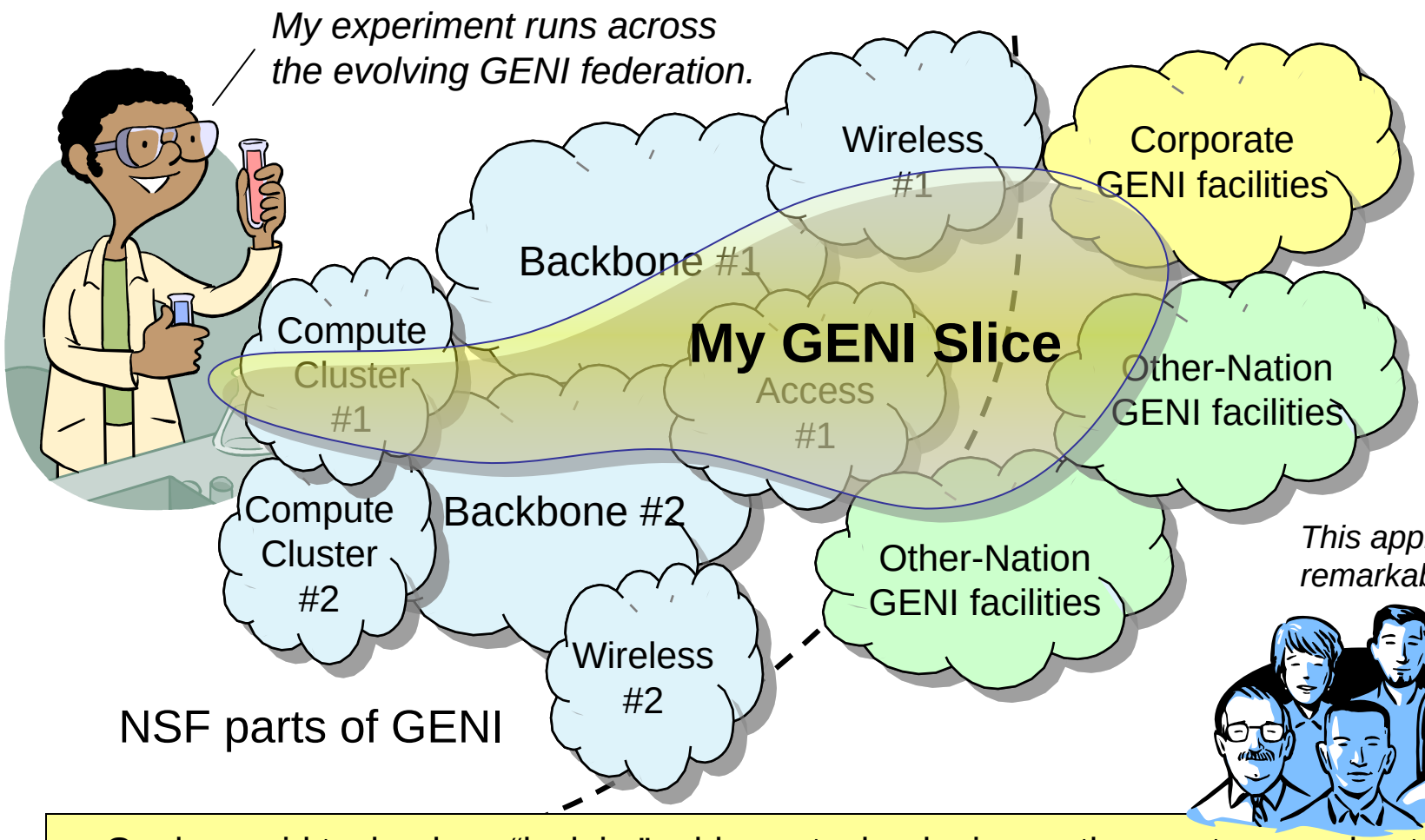


Strawman GENI Construction Plan

- An achievable **starting point**
  Example: Rev 1 “narrow waist”, federation of multiple substrates (clusters, wireless, regional / national optical net with early GENI ‘routers’, perhaps some existing testbeds), Rev 1 user interface and instrumentation.
- Envisioned **ultimate goal**
  Example: Planning Group’s desired GENI facility, 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

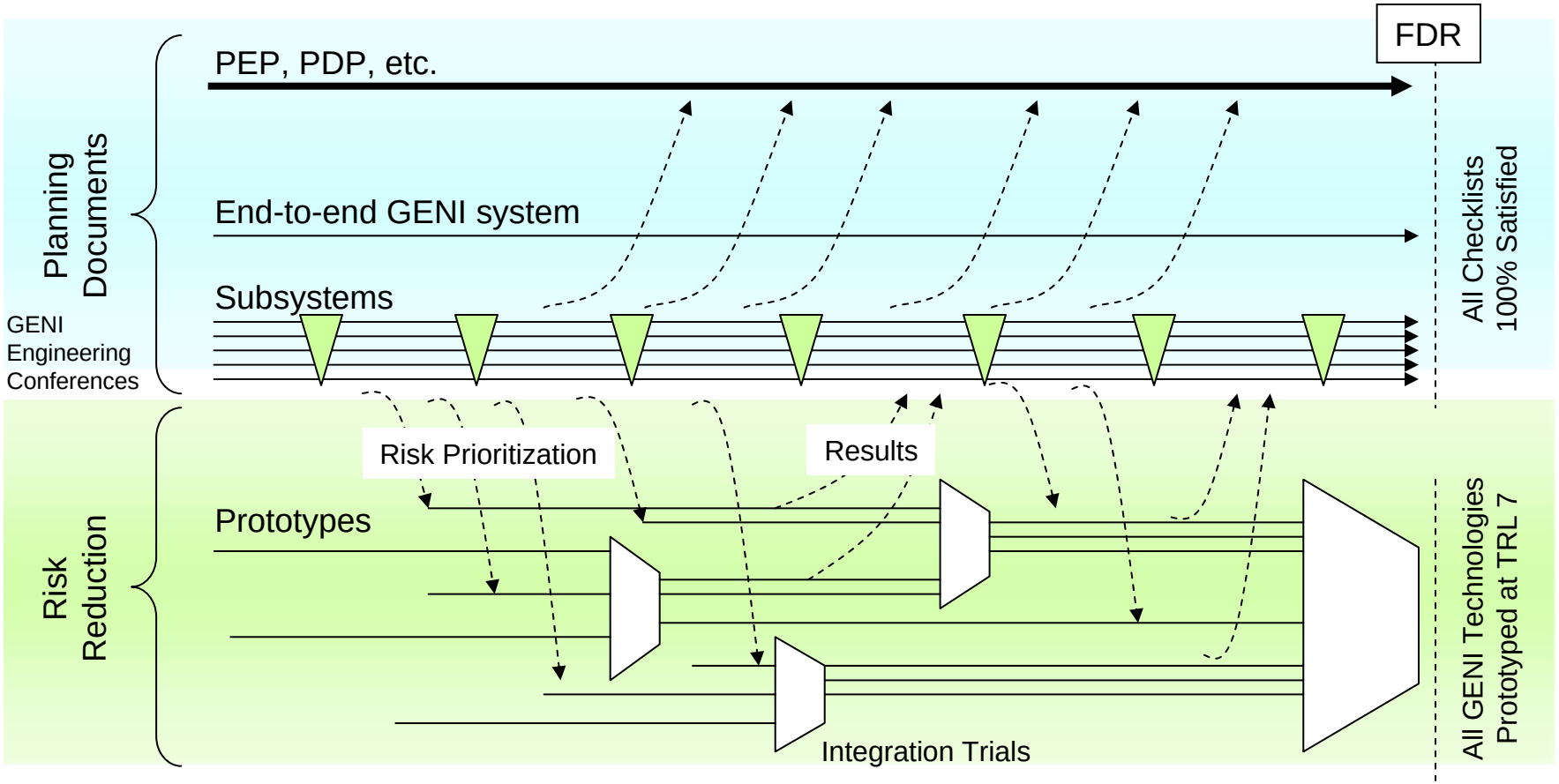
GENI grows by "gluing together" hetrogeneous facilities over time



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

GENI's Planning Phase
Prototyping while refining design & budget

"Paper" Design Documents, Schedule, Budget, etc.



Academic / Industrial Prototyping, Integration, Experiments

Outline

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GENI will be 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 will be emphasized
  - Design process will be open, transparent, and broadly inclusive
  - Open-source solutions will be 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 will 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 GSC and GPO)

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How the GPO will Fund Rapid Prototyping and Experiments

- Needs are driven by “long poles” in GENI construction – the high risk design and technology areas
  - High risks are identified at 4-month intervals by GSC / GPO review panel
  - GPO issues solicitations once or twice per year
  - Proposals are merit-reviewed by NSF-style panels
  - GPO continuously monitors contracts for performance
  - Quick decisions and quick funding are essential
- Goal is to have multiple development teams up to speed in each area before construction begins, who can then bid on the big construction contracts

Main Goals for this Solicitation

(Which Risks are We Reducing?)

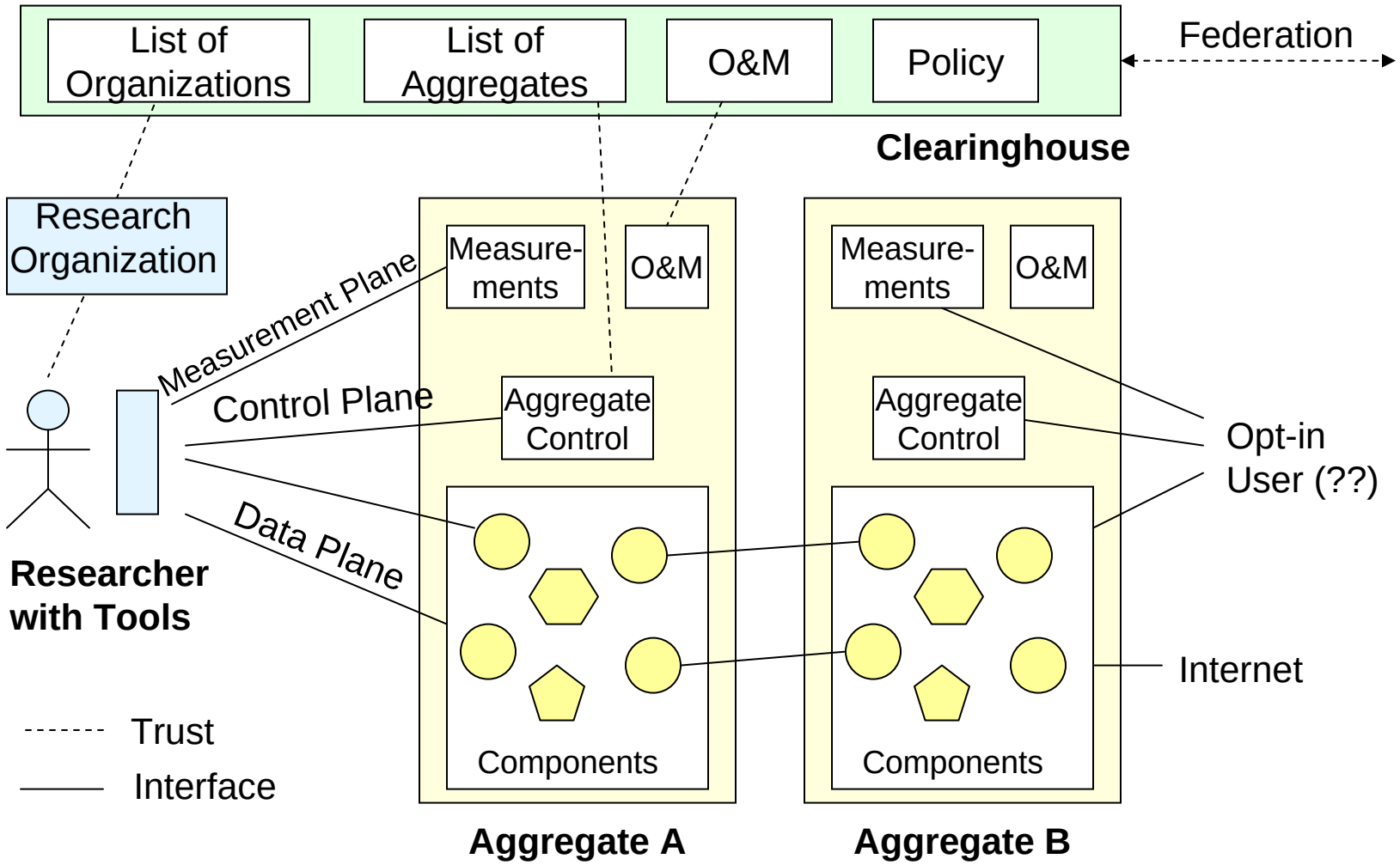
- **Architecture & requirements development**. Create/improve designs for areas including instrumentation, security (identity, authentication, and authorization mappings to existing technologies), resource description and discovery, federation, and user opt-in. Analyses and some prototyping in these areas will be useful.

- **Slicing as a basic construct, employed end-to-end across a range of technologies.** Here near-term, working demonstrations of the relevant GENI subsystems and trial integrations will be particularly useful, as will early demonstrations of instrumentation in a sliced environment.

- **Developing a practical approach for administrative and operational control** that addresses the needs of cooperative facility hosts (e.g., universities); federated, interconnected facilities (e.g., non-NSF GENI facilities); subcontracted facilities (e.g., optical networks or co-location facilities); and a GENI Network Operations Center.

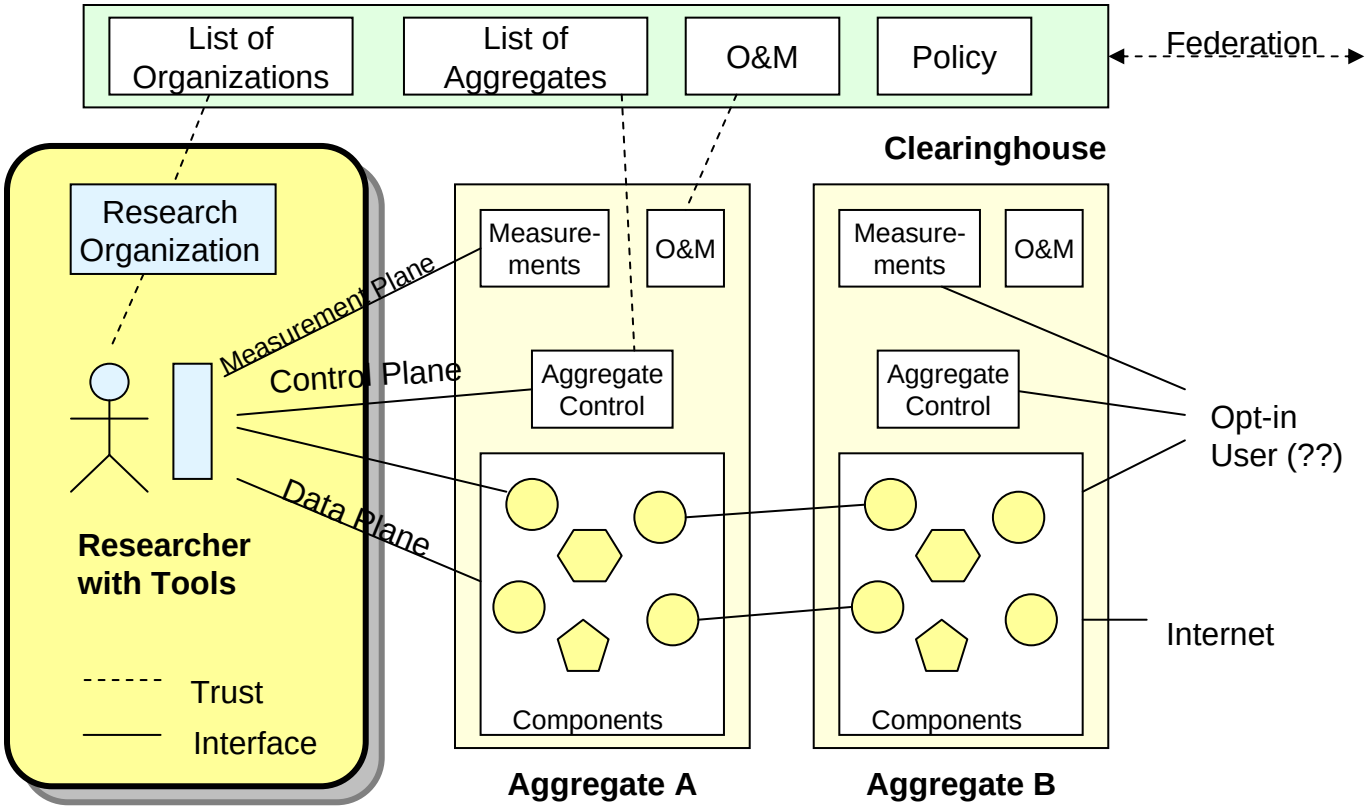
Strawman GENI Block Diagram

The full architecture is more general than this diagram;
this concrete example is for clarity and as a general introduction.



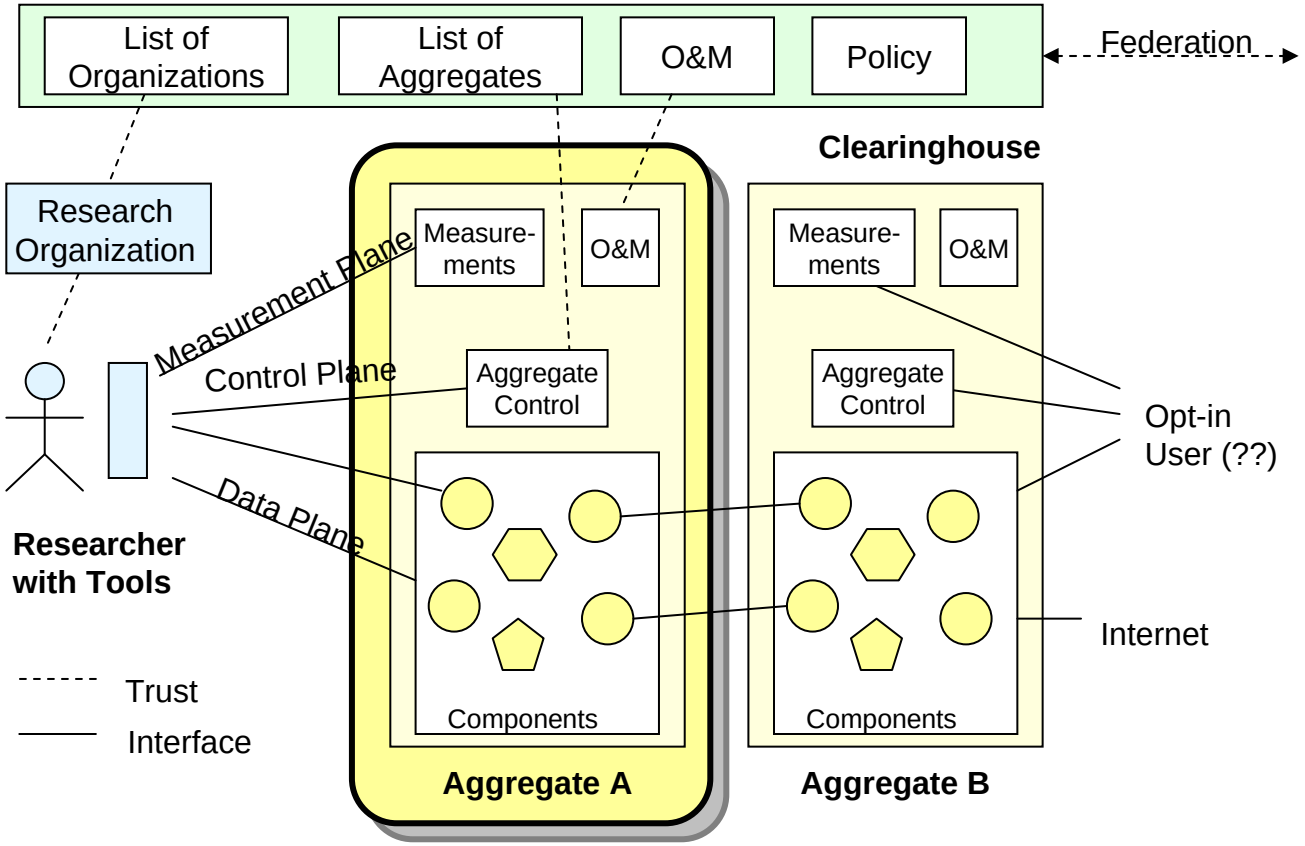
Strawman GENI Block Diagram

Researchers and Research Organizations



A researcher belongs to one or more research organizations, who will vouch for him/her. A researcher has tools (user interfaces) to interact with Aggregates. A research organization may belong to one or more clearinghouses.

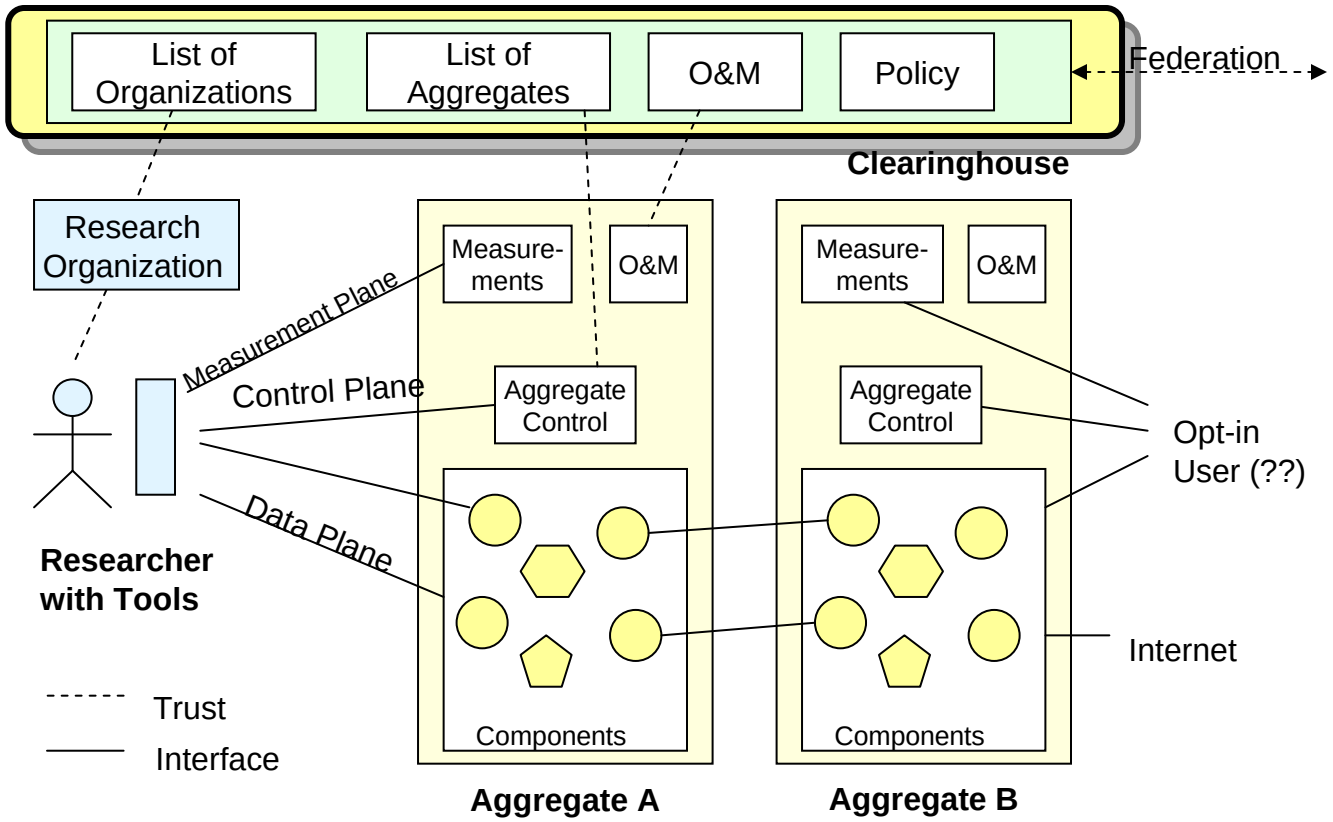
Strawman GENI Block Diagram
Managed Aggregates



An Aggregate is a coherent set of components which is controlled as a whole; it may belong to multiple clearinghouses. Components may include CPUs, disks, switches, optical or wireless nodes, (virtual) links, etc. Aggregates also include (controllable) instrumentation and make measurements available. Aggregates may use any O&M systems they find useful. Researchers interact with Aggregate Control to set up slices, download code, debug, etc.

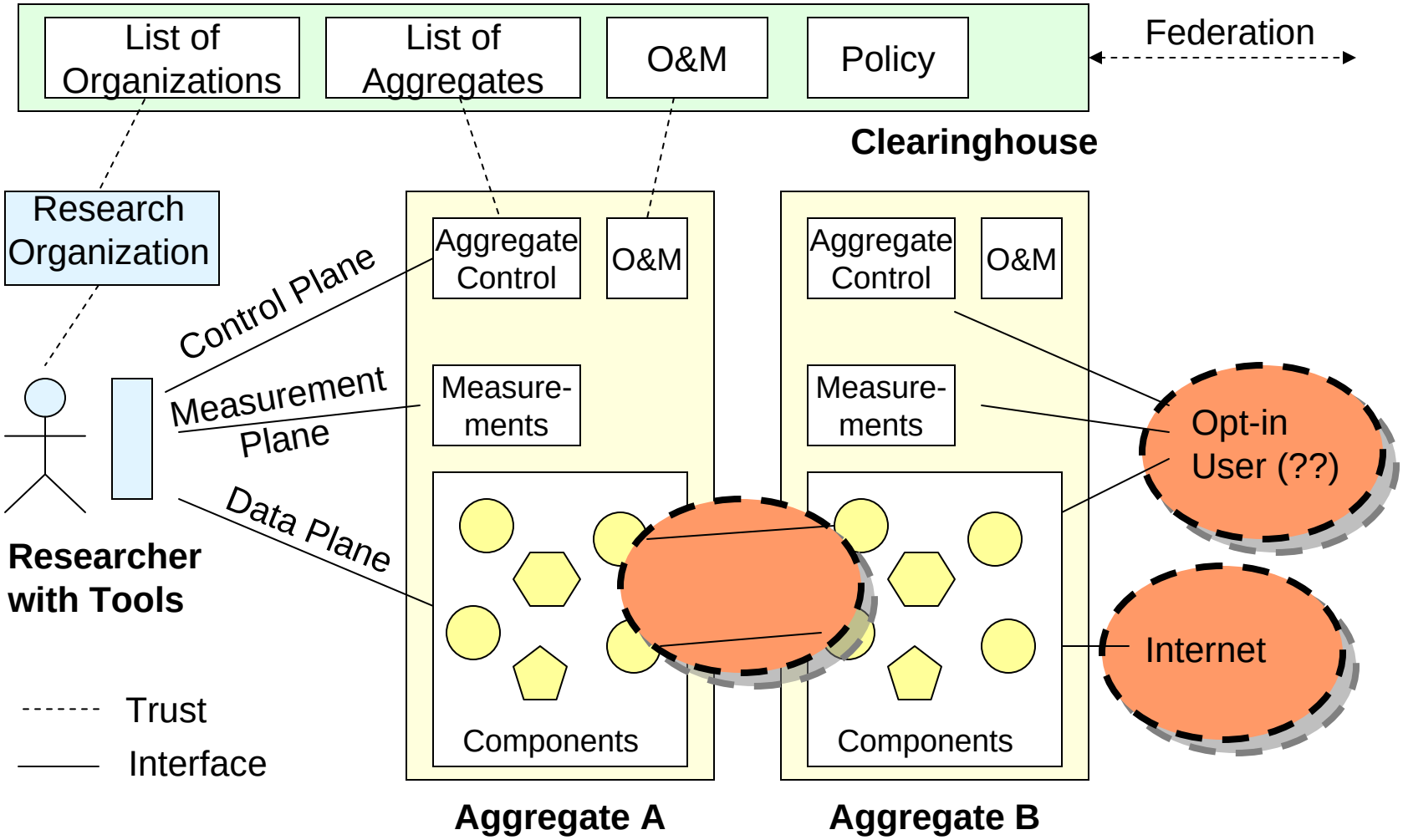
Strawman GENI Block Diagram

Clearinghouses and Federation



A clearinghouse organizes trust relationships and policies; it also provides the basic means by which Aggregates may be discovered and their status, planned schedules, etc, can be obtained. There will be multiple clearinghouses which will federate. The GENI project will operate the NSF clearinghouse. 'Federation' is the interface between clearinghouses.

This is an *early strawman*; it will need work.
Particularly Problematic Aspects of this Block Diagram



Possible Proposals for this Solicitation
(What kinds of things might you bid?)

- **For: Architecture & requirements development**.
  - You might bid: '**Analysis**' proposals for writing papers on architecture or requirements, buying time to participate in working groups, etc.

- **For: Slicing as a basic construct, employed end-to-end across a range of technologies.**
  - You might bid: '**Prototyping**' and '**integration**' proposals for demonstrating GENI-compatible subsystems in the 12-month timeframe. It would be extremely helpful if these could include integration of multiple kinds of subsystems, and/or very early field demonstrations.

- **For: Developing a practical approach for administrative and operational control.**
  - You might bid: '**Analysis**' proposals to suggest approaches and perhaps buy time to participate in the relevant working group, and '**integration**' proposals that operate very early GENI prototypes to discover issues & report results into working group.

In this strawman context . . .

What does ‘build a prototype’ mean ?

Examples only – all good ideas welcome!

1. **Make an Aggregate Controller** that is compatible with the Narrow Waist, which is the central part of the control plane (being designed in parallel). As a concrete idea, this might be a Linux machine running a reference implementation of Narrow Waist software.
2. **Make one or more components** that can be controlled, so that the Aggregate as a whole can have researchers allocate slices, download software into components, debug, etc.
3. Or – **design and build a clearinghouse**.
4. Note that many existing systems can be ‘GENI-ized’ by steps 1 and 2, although it may also be helpful to create new prototypes from scratch.

For the first solicitation, we are particularly interested in:

1. Prototypes of reference software for an Aggregate Controller and/or Components (implement the Narrow Waist plus download, debug, etc.)
2. The following types of prototype Aggregates: clusters of CPUs and storage; regional and national optical nets; wireless and sensor nets.

In this strawman context . . .

What does ‘trial integration’ mean ?

Examples only – all good ideas welcome!

1. **Making a working Aggregate** that incorporates components supplied by prototype builders, commercial vendors, etc.

2. Or – **link two Aggregates** together through their data planes.

3. Or – **link one ore more Aggregates to a clearinghouse** prototype.

Be bold! Be creative!

Drive the design forward!

All beginnings are difficult . . .

but we think you will get a surprising number of ***great*** prototypes and trial systems up and cycling within a year!

www.geni.net

Clearing house for all GENI news and documents