GENI Architecture

Global Environment for Network Innovations

The GENI Project Office (GPO)

www.geni.net

Clearing house for all GENI news and documents

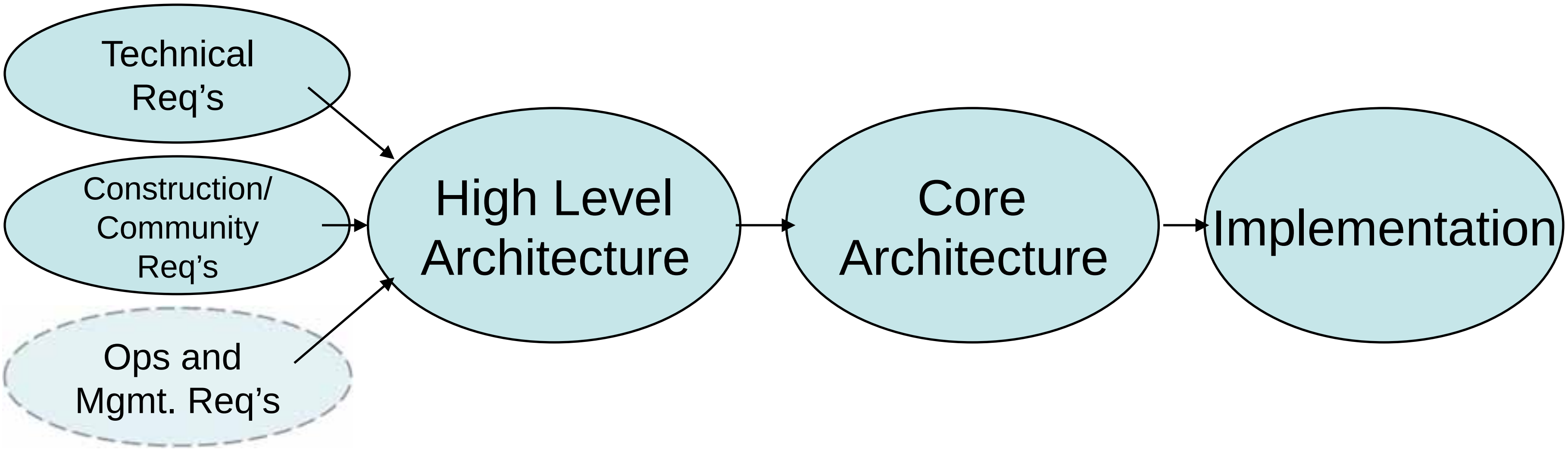
Acknowledgement

- These slides have evolved over time as the architecture has. Larry Peterson, John Wroclawski, and the Planning Group Architecture WG deserve thanks for producing much of the material.

Outline of this Talk

- High-level requirements
  - Design goals for the GENI facility
- Facility substrate
  - A hardware-oriented view of what GENI might look like
- Core architectural elements
  - Key concepts that form the basis for the architecture
- Discussion of maturity levels
  - Fixed vs. squishy vs. undefined

Design flow



Requirements

Overall Design: modularity and structure

Narrow Waist: abstractions and Interfaces

Narrow Waist: algorithms and implementation choices

Top-Level Requirements

1. Generality
    A. Minimal Constraints
        - allow new data formats, new functionality, new paradigms,…
        - allow freedom to experiment across the range of architectural issues (e.g., security, management,...)
    B. Breadth of Representative Technology
        - include a diverse and representative collection of networking technologies, since any future Internet must work across each of them, and the challenges/opportunities they bring
2. Sliceability
    - support many experiments in parallel
    - isolate experiments from each other, yet allow experiments to compose their experiments to build more complex systems

Top-Level Req (cont)

3. Fidelity
   A. Device Level
      - expose useful level(s) of abstraction, giving the experimenter the freedom to reinvent above that level, while not forcing him or her to start from scratch (i.e., reinvent everything below that level)
      - these abstractions must faithfully emulate their real world equivalent (e.g., expose queues, not mask failures)
   B. Network Level
      - arrange the nodes into representative topologies and/or distribute the nodes across physical space in a realistic way
      - scale to a representative size
      - expose the right network-wide abstractions (e.g., circuits, lightpaths)
   C. GENI-Wide
      - end-to-end topology and relative performance
      - economic factors (e.g., relative costs, peering)

Top-Level Req (cont)

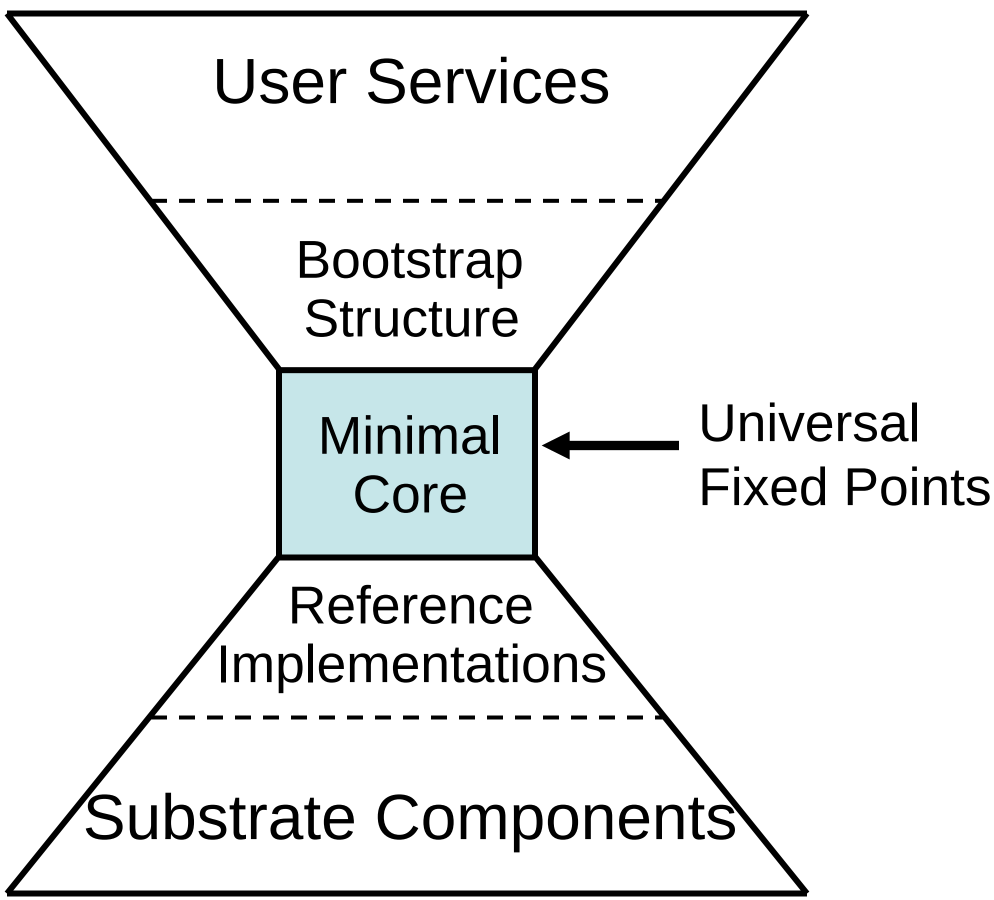
4. Real Users
   - allow real users to access real content using real applications
   - provide incentives and mechanisms to encourage this
   - Support *long-lived* experiments and services
5. Research Support
   A. Ease-of-Use
      - provide tools and services that make the barrier-to-entry for using GENI as low as possible (e.g., a single PI and one grad student ought to be able to use GENI)
      - Key point: this community builds its own tools.

   B. Observability
      - make it possible to observe and measure relevant activity

Top-Level Req (cont)

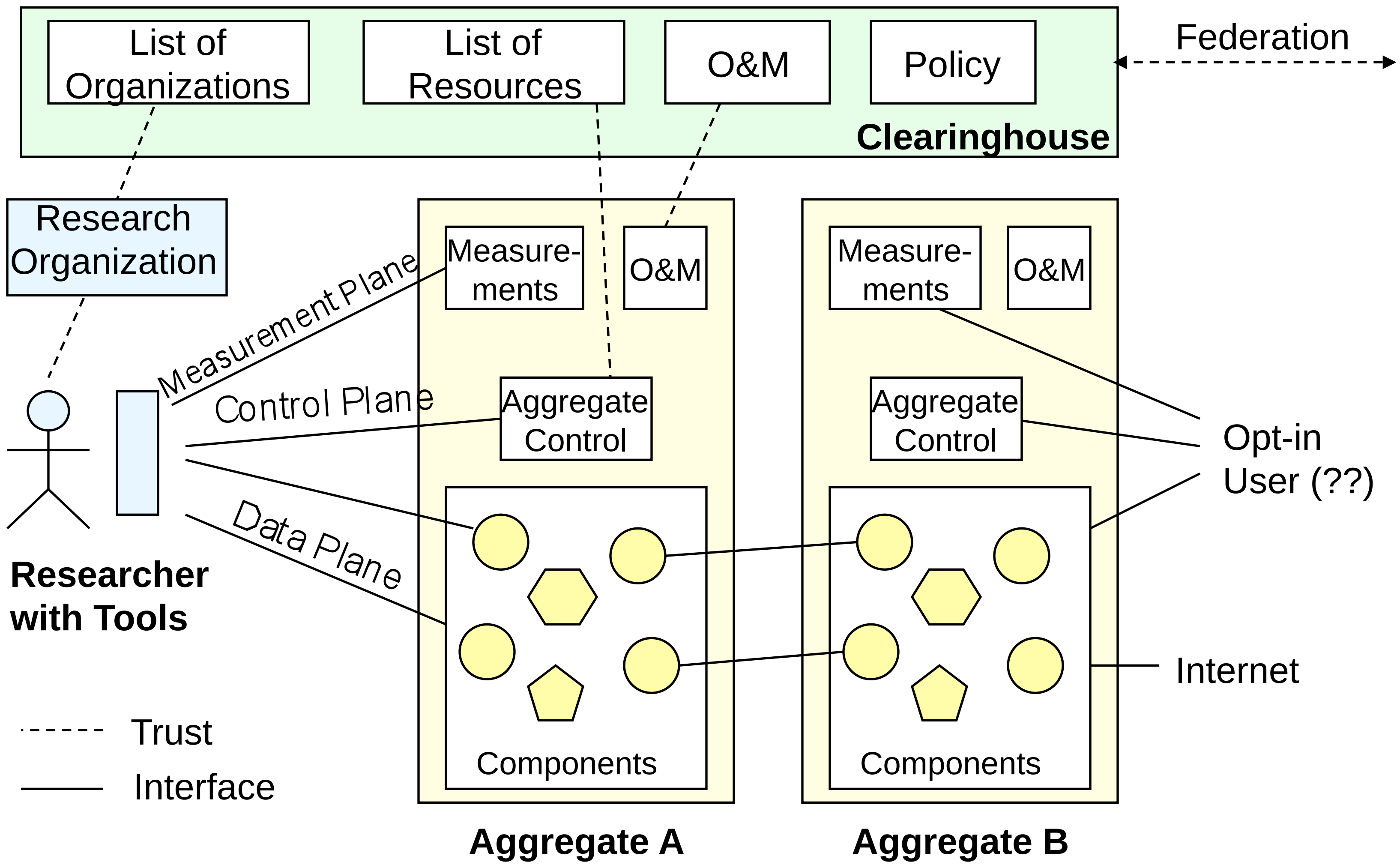
6. Sustainability
   A. Extensible and evolvable
      - accommodate network technologies contributed by various partners
      - accommodate new technologies that are likely to emerge in next several years
      - support technology roll-over without disruption
   C. Operational Costs
      - the community should be able to continue to use and support the facility long after construction is complete
      - Trade off increased capital cost for decreased operational cost when appropriate

Facility Architecture (View 1)



- name spaces, registries, etc
    - for key system elements (users, slices, & components
- set of interfaces
    - ("plug in" new substrate components)
- support for federation
    - ("plug in" new partners)

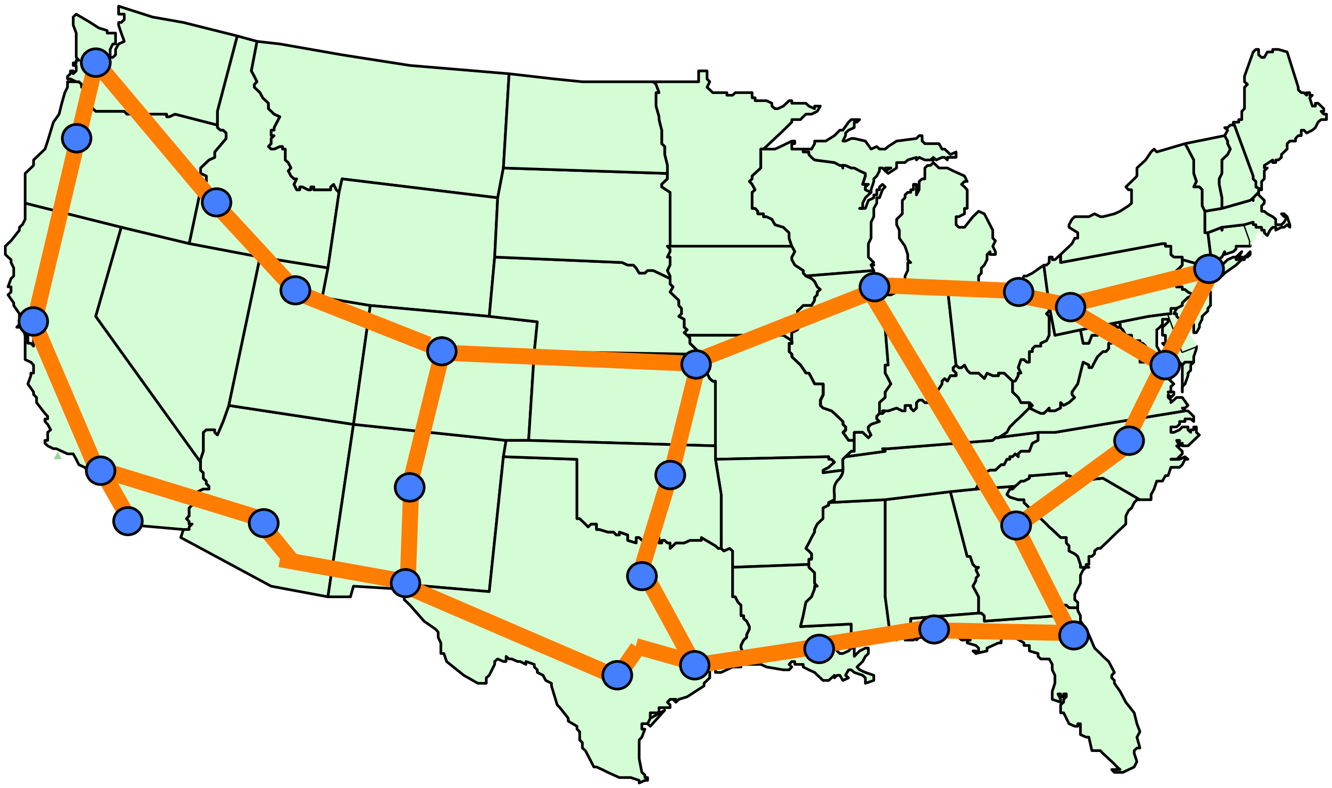
Facility Architecture (View 2)



Diversion: the physical substrate

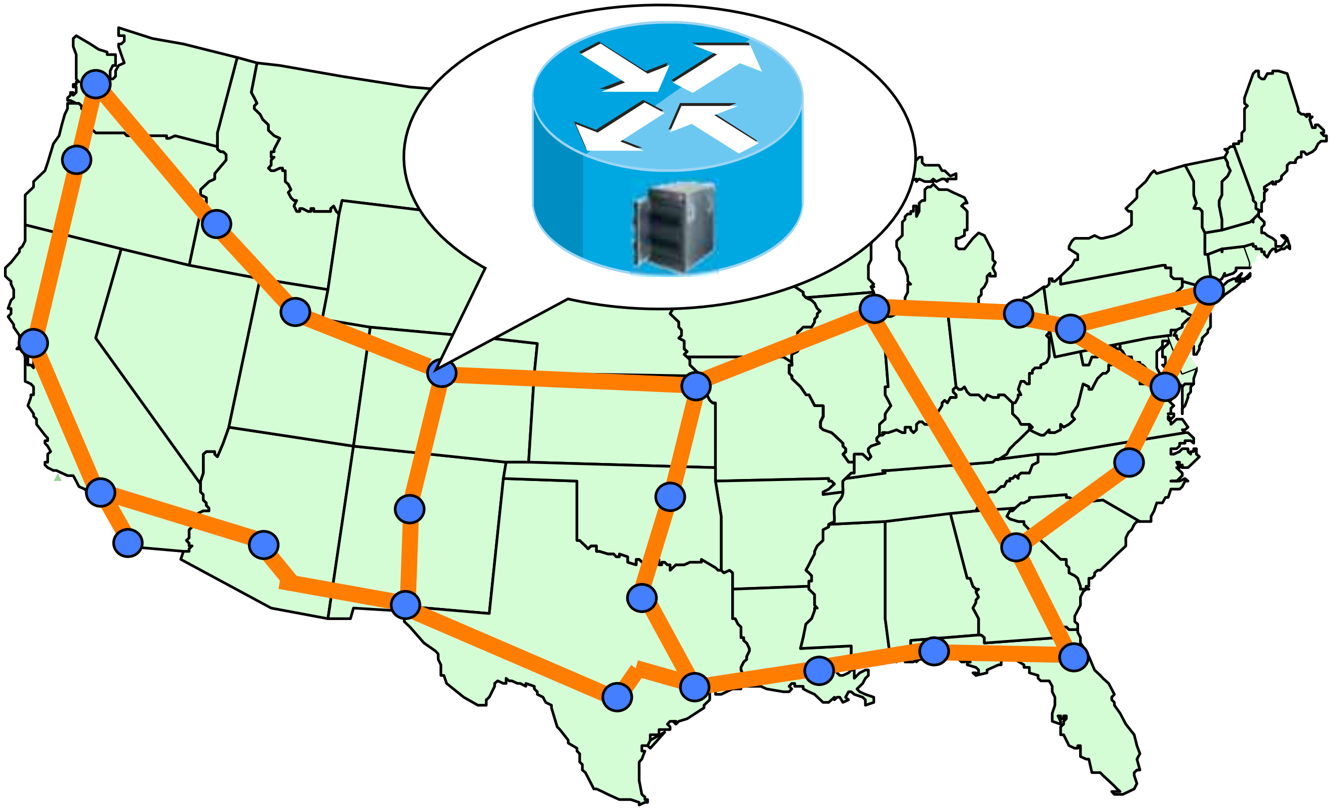
- The key function of the GENI system is to support flexible, useful embedding of *experiments* within a shared *physical substrate.*
- To understand the system architecture, it is helpful to first understand the sorts of physical resources the architecture is designed to control.

National Fiber Facility

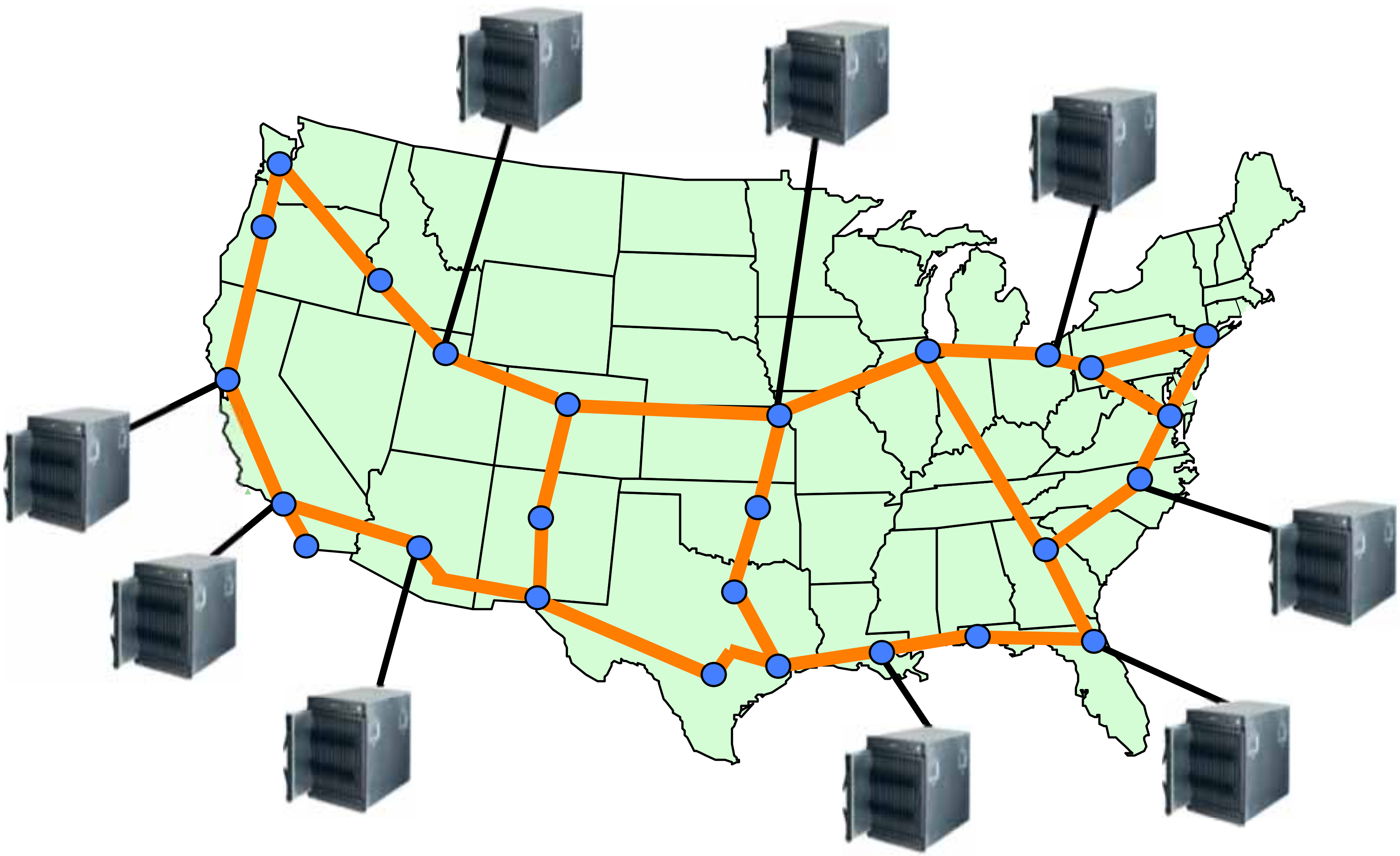


We expect there to be multiple backbone providers.

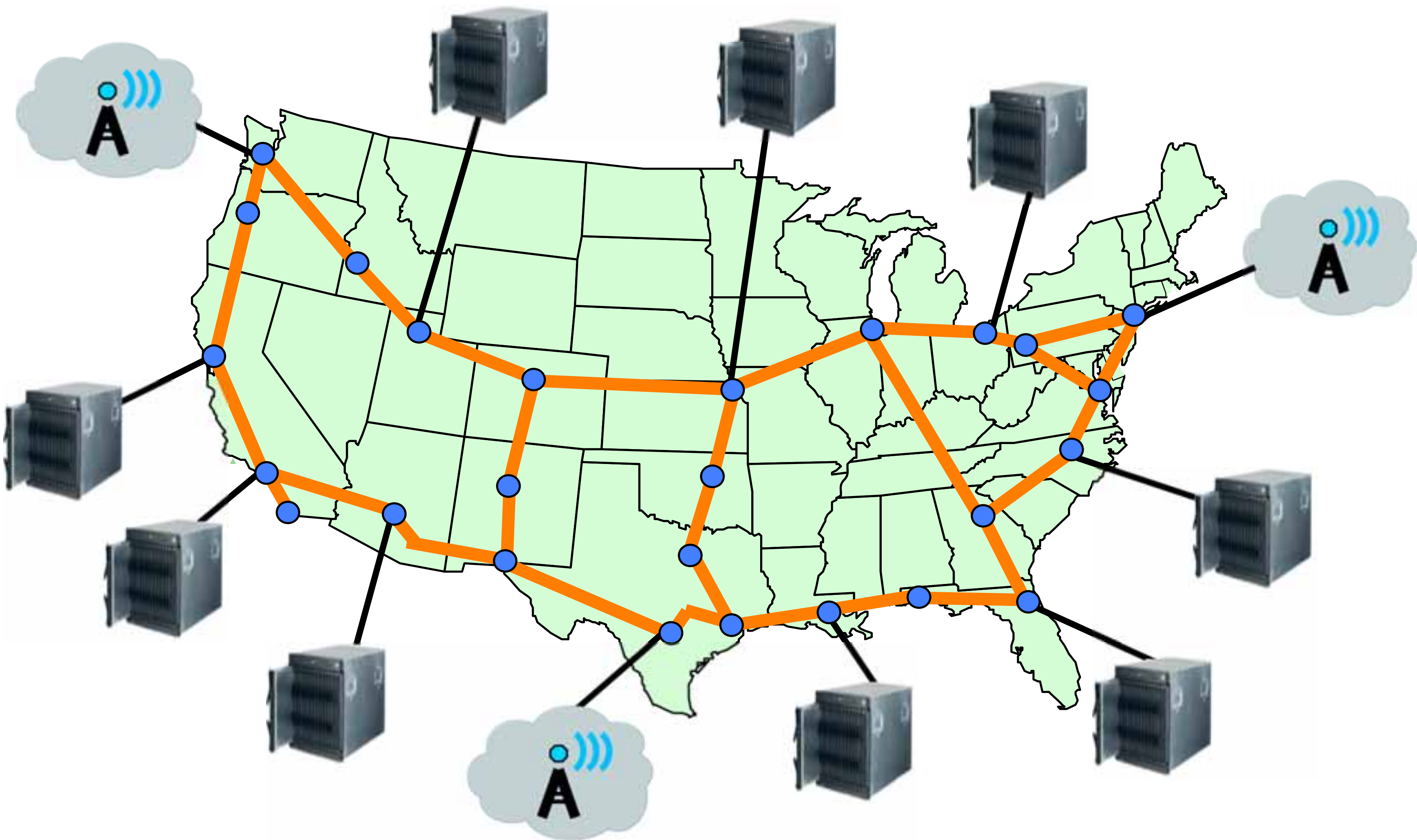
+ Programmable Switch/Routers



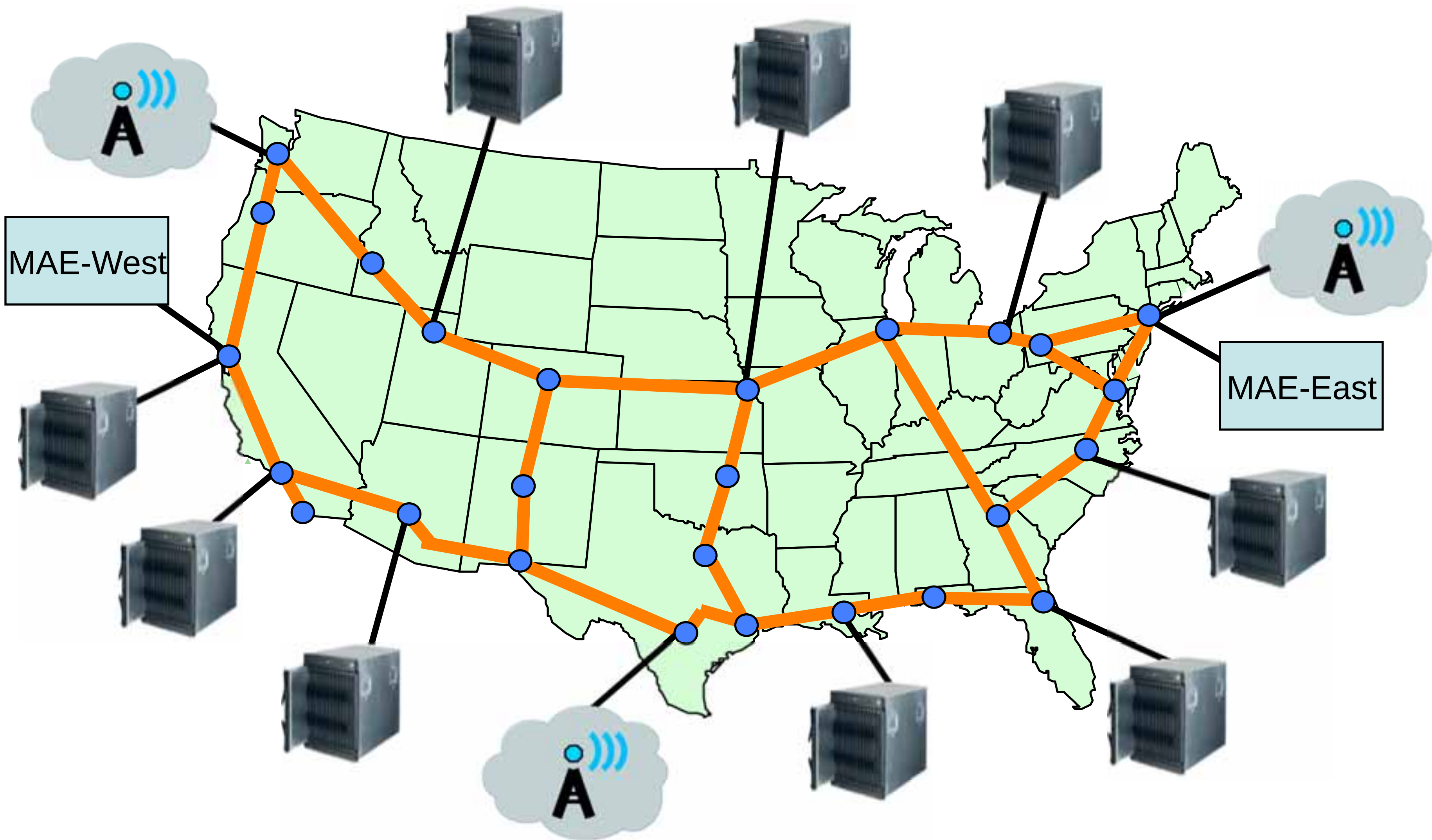
+ Clusters at Edge Sites



+ Wireless Subnets



+ ISP Peers



GENI-izing the Substrate

- Previous slides described a strawman physical substrate

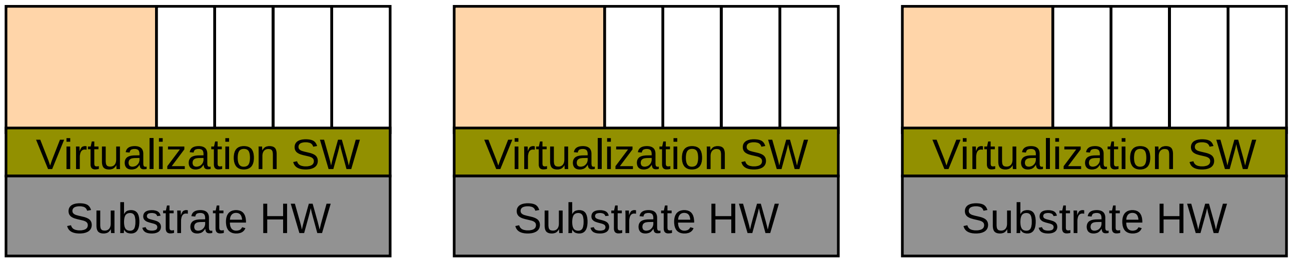
- Next slides describe GENI's system architecture - the software abstractions, objects, and functions that make this physical substrate available to GENI's researchers as experiments.

Substrate Hardware

Substrate HW Substrate HW Substrate HW

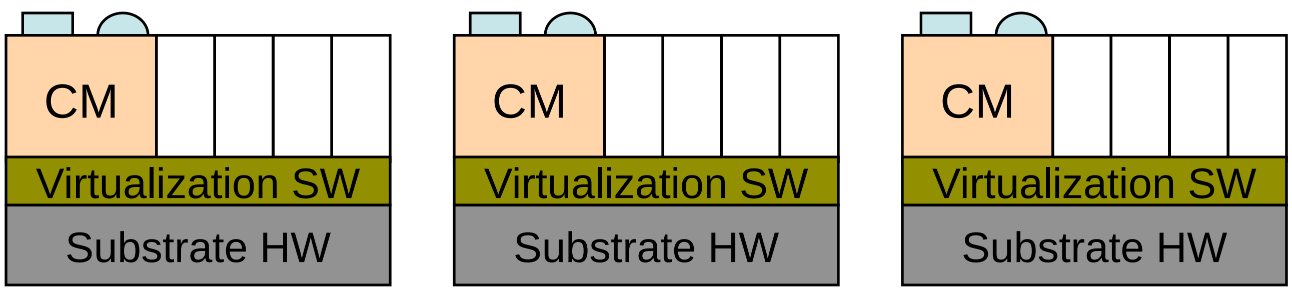
Slicing Model and Software

- (often, “virtualization”)

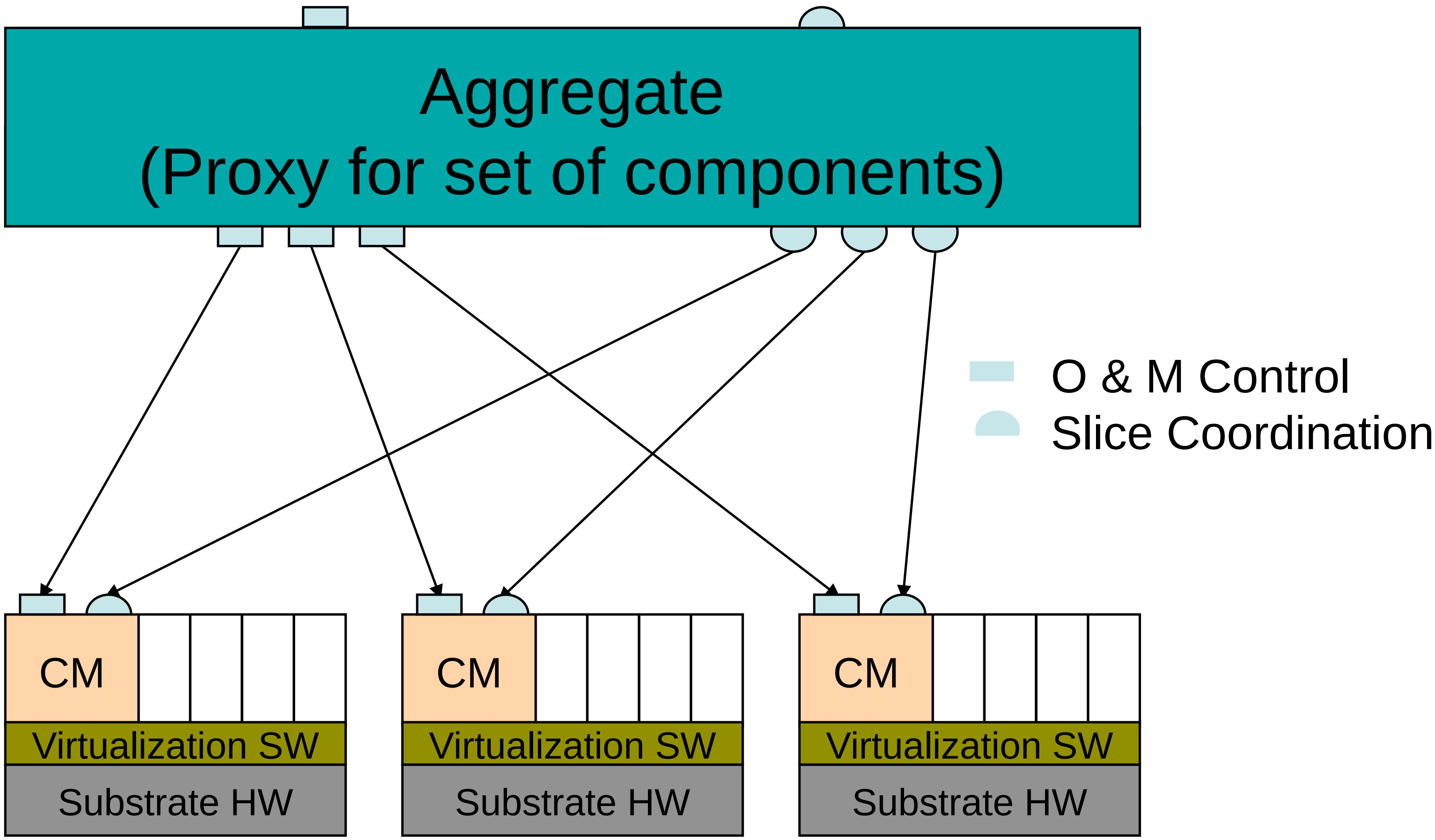


Components

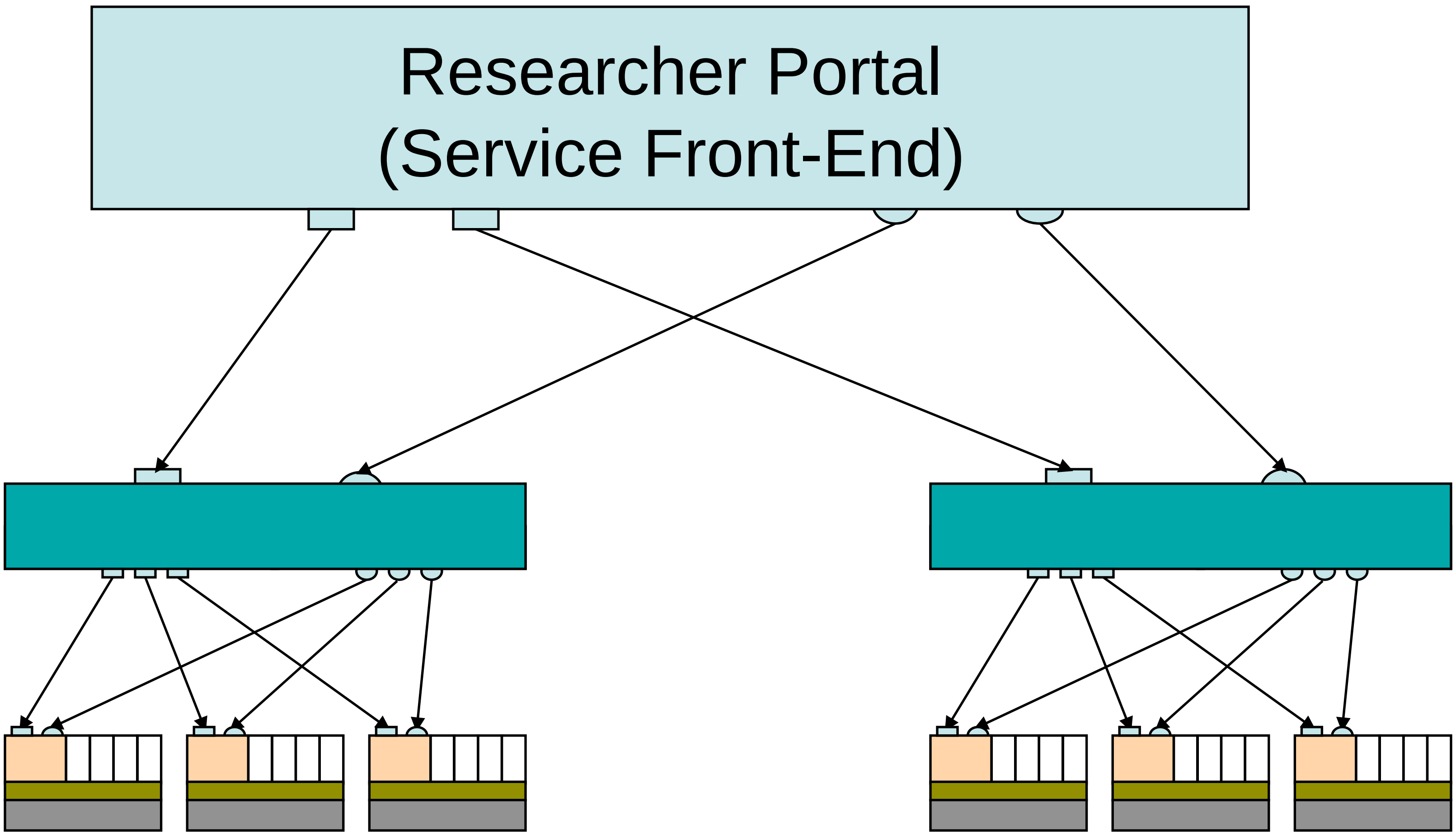
- Export a standard component manager interface
  - Resource allocation (to slices) and control
  - Minimal management



Aggregates


Aggregate
(Proxy for set of components)
O & M Control
Slice Coordination
CM
Virtualization SW
Substrate HW
CM
Virtualization SW
Substrate HW
CM
Virtualization SW
Substrate HW

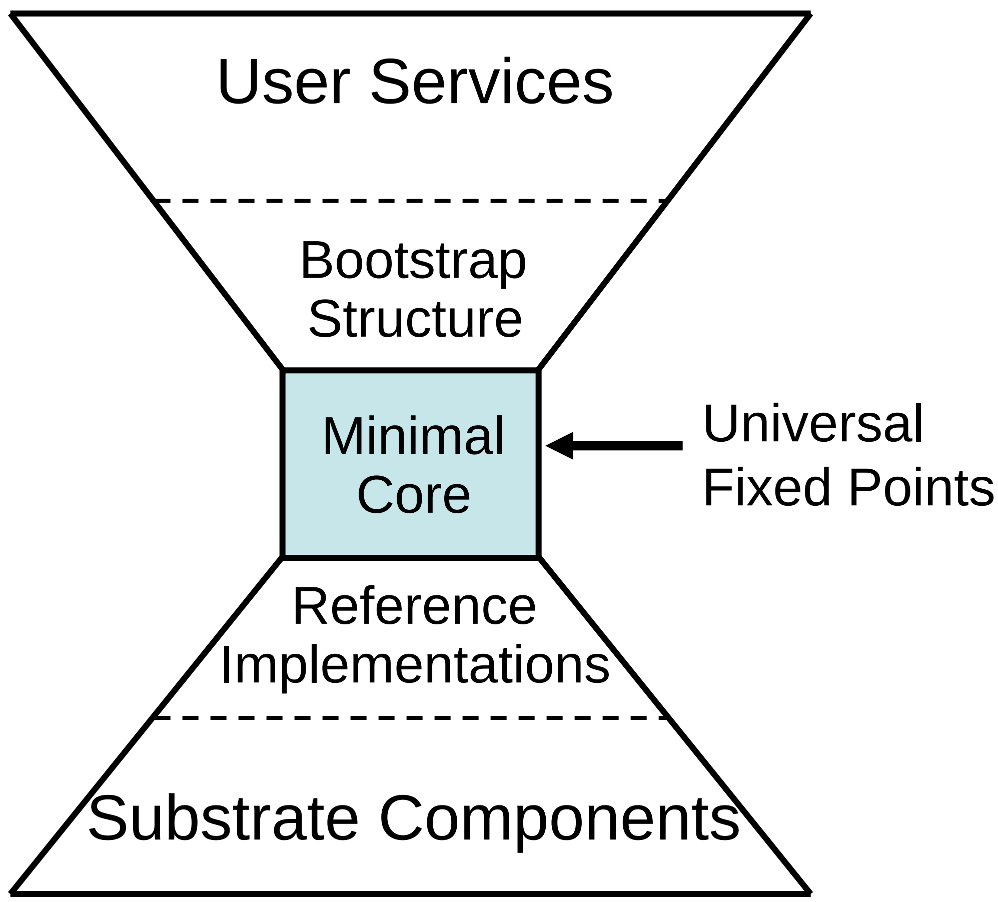
User Portals



The Core Architectural Elements

- Previous slides have described the physical substrate, and some aspects of the overall software architecture that supports it
- Next slides describe the minimal set of core abstractions that serve as “fixed points” for the GENI architecture
  - This allows other system elements to evolve flexibly and independently
    - New components, services, partners, …
    - Particularly relevant during this early development / prototyping phase.

Hour-Glass Revisited



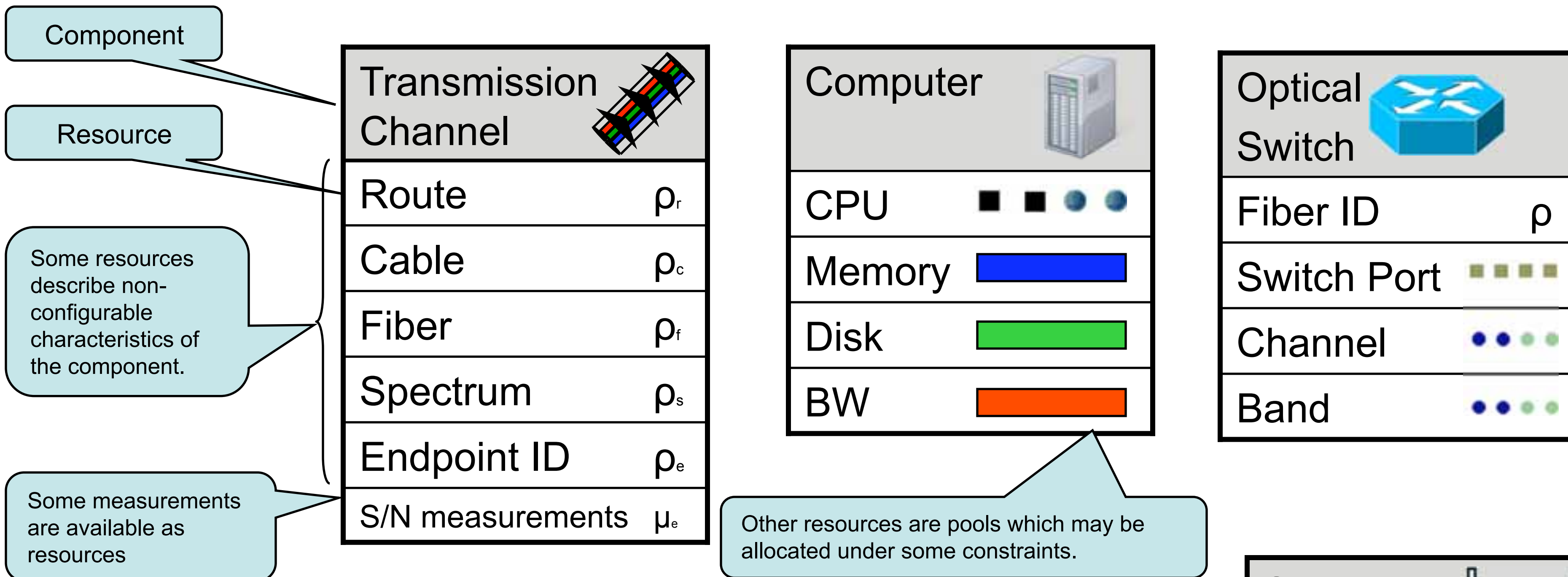
Principals

Researcher: A user that wishes to run an experiment or service in a slice, or a developer that provides a service used by other researchers.

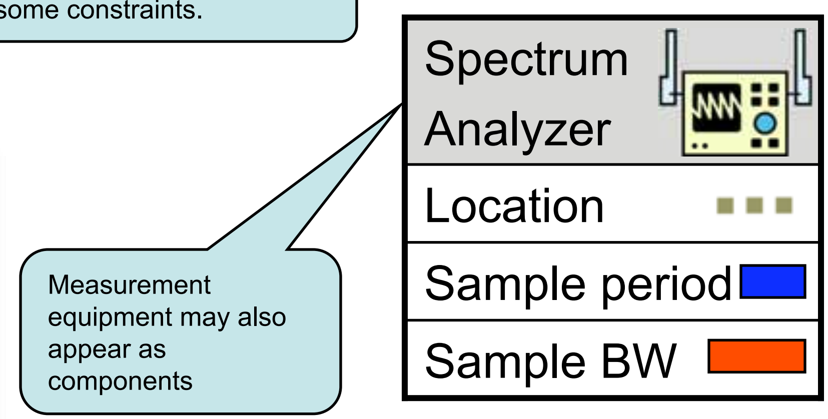
A **slice authority (SA)** is responsible for the behavior of a set of slices, vouching for the users running experiments in each slice and taking appropriate action should the slice misbehave.

A **management authority (MA)** is responsible for some subset of substrate components: providing operational stability for those components, ensuring the components behave according to acceptable use policies, and executing the resource allocation wishes of the component owner.

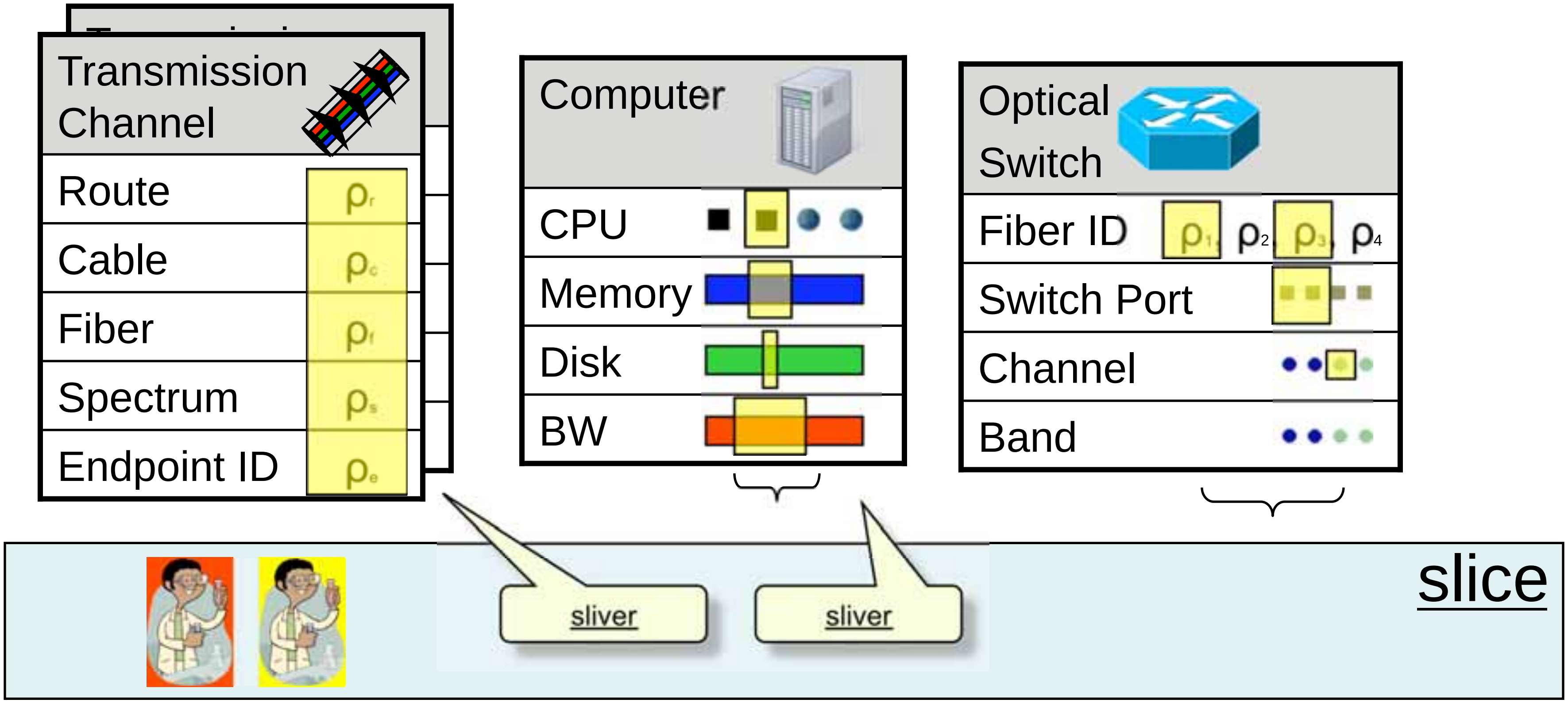
Components & Resources



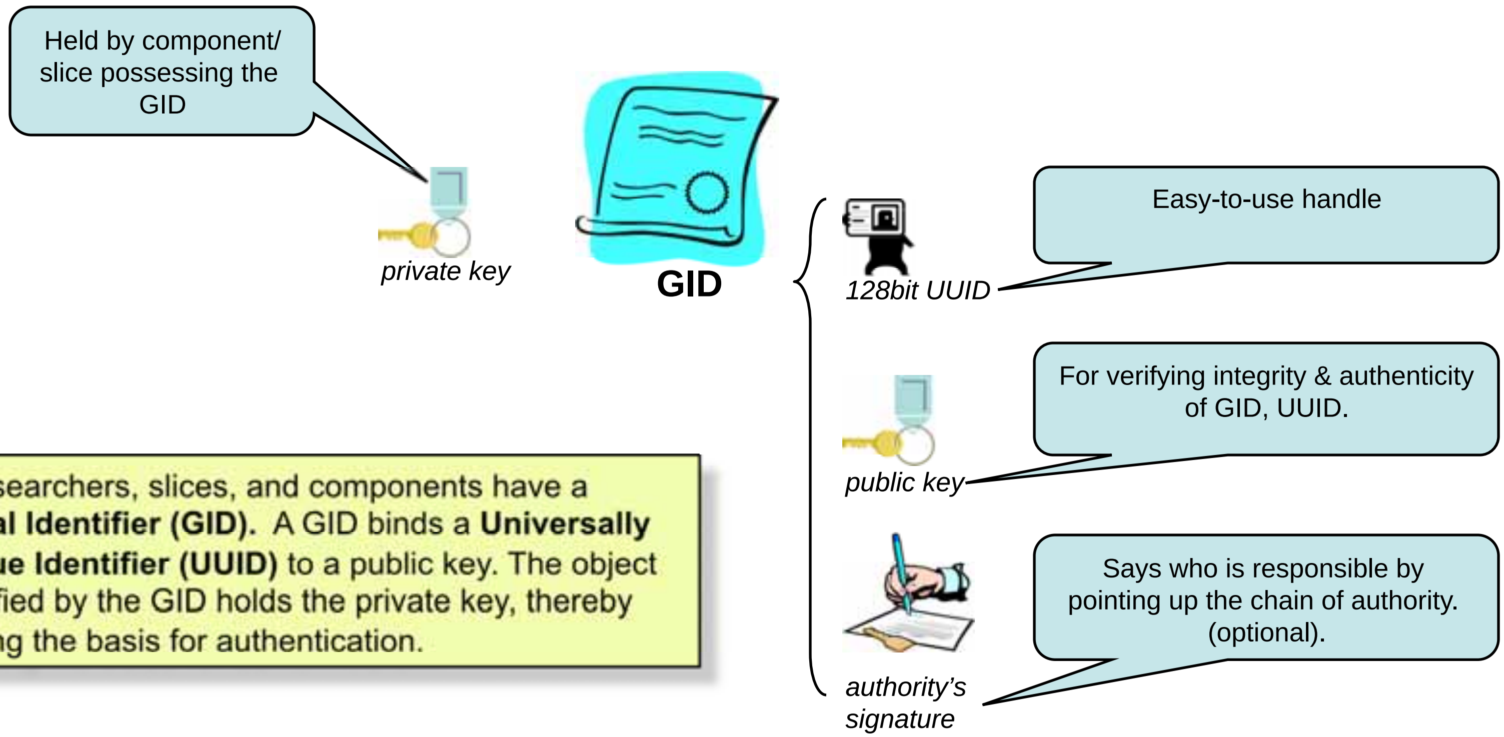
Component: An object representing a physical device in the GENI substrate. A component consists of collection of **resources**. Such physical resources belong to precisely one component. Each component runs a **component manager** that implements a well-defined interface for the component. In addition to describing physical devices, components may be defined that represent logical devices as well.



Slivers & Slices



Identifiers



All researchers, slices, and components have a **Global Identifier (GID).** A GID binds a **Universally Unique Identifier (UUID)** to a public key. The object identified by the GID holds the private key, thereby forming the basis for authentication.

Minimal Core

- Principals
  - Slice Authorities (SA)
  - Component Management Authorities (MA)
  - User (researcher/experimenter, not "end user")
- Objects
  - Slices - containers for experiments
    - Registered, Embedded, Accessed
  - Components - providers of resources
- Data Types
  - Global Identifiers (GID)
  - RSpec: resource specification
  - Tickets (credentials issued by component MA)
  - Slice Credentials (express live-ness, issued by SA)

Core (cont)

- Default Name Registries
  - Slice Registry (e.g., geni.us.princeton.codeen)
  - Component Registry (e.g., geni.us.backbone.nyc)
- Component Interface
  - Get/Split/Redeem Tickets
  - Create and Control Slices (“Slivers”)
  - Query Status

Core (cont)

- Control Interfaces
  (Minimal common elements)
  - Return to known state
  - Start/stop
  - Become more intelligent (boot load)
- Federation Interfaces
  - Cross-domain accountability
  - Policy expression and management

Maturity levels

- General statement
  - The strawman design builds on significant community experience.
    - PlanetLab, Emulab, DETER, others.
  - The strawman design is *work in progress*.
    - It is not implemented.
    - Some parts are incomplete.
    - Some are in great flux.
  - … but the initial version is *incremental and “simple”*
  - Component and service prototypers will work *in parallel* with the control plane development.

Relatively Mature

- Core system objects - users, components, ..
- Concept & function of components
- Concept & function of universal identifiers
- Concept of resource specifications
- Simple model for slice and component registries
- …

Less Mature

- Configuration management
  - How are components at a site related?
- Federation model and interfaces
  - How do we build experiments across different administrative regions?
- Operations and management interfaces
  - Ensure sufficient reliability, accessibility
  - Track usage to plan for future needed
- …