

Expanding US/Brazil FIDC Testbed Federation

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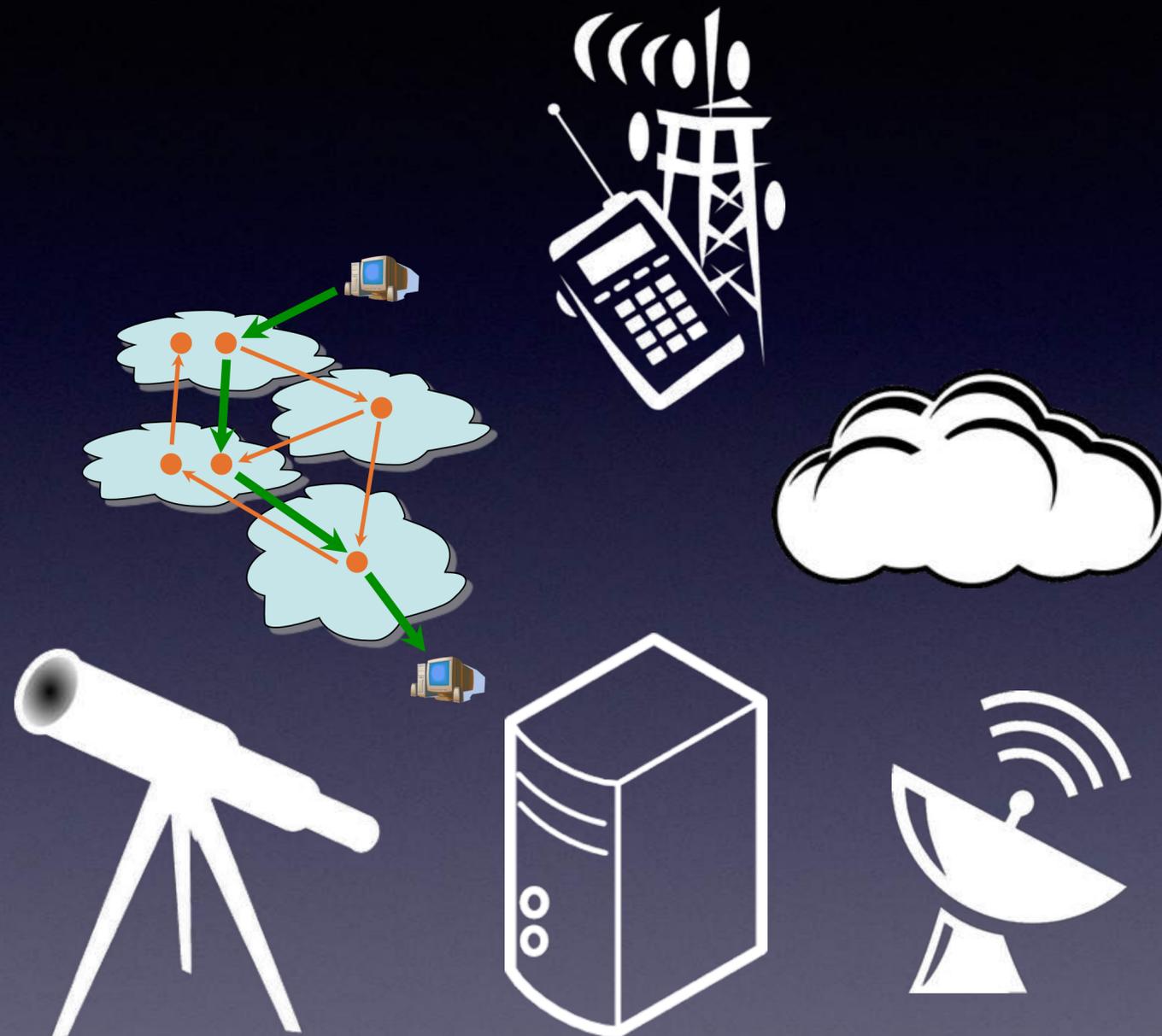


Cyberinfrastructure Lives to Serve

All applications and services rely on cyberinfrastructure.

High performance applications and services need precision cyberinfrastructure

- The right resources
- In the right place
- Running the right software



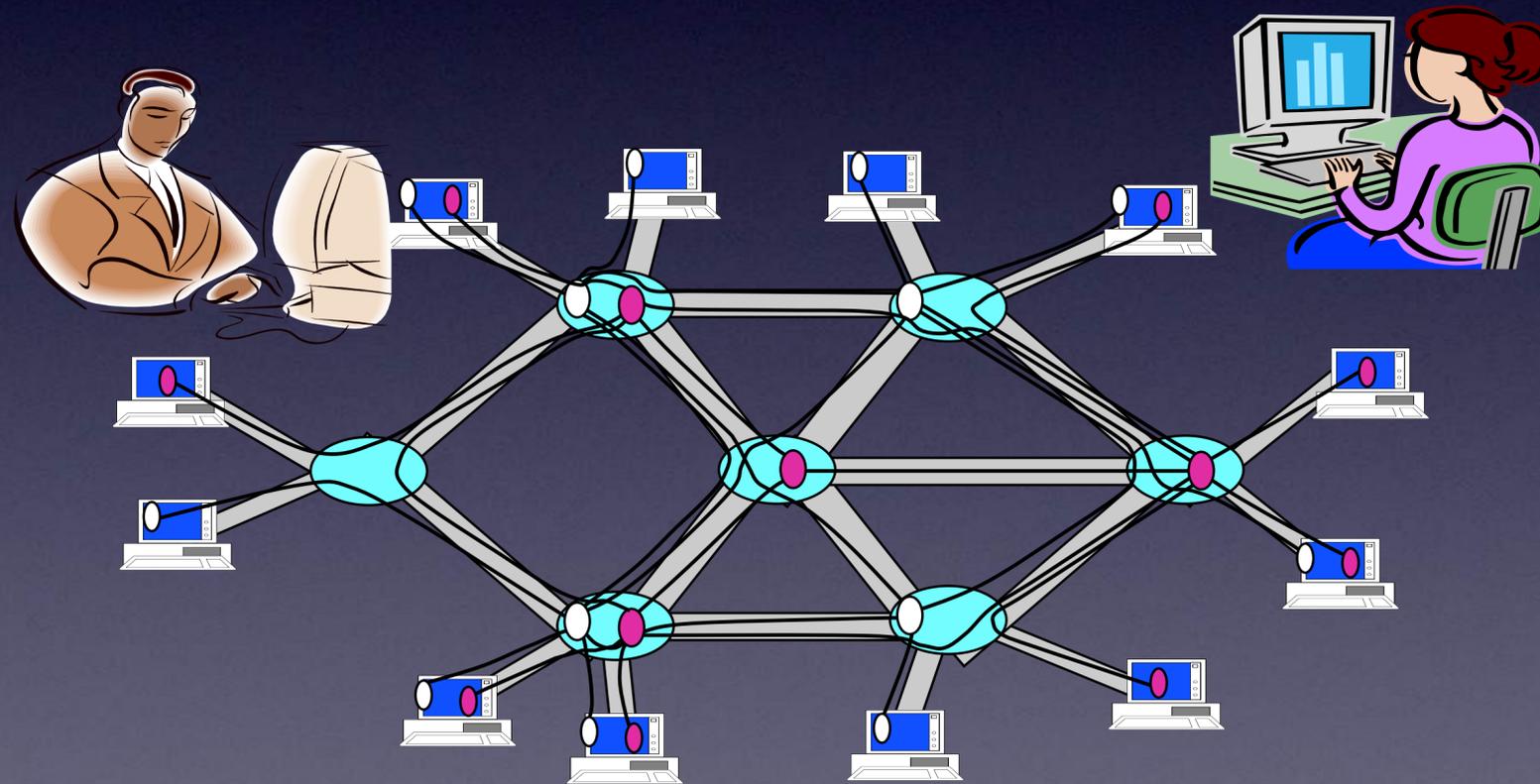
Two Key FIDC Concepts

Install the software I want throughout my network slice
(into firewalls, routers, clouds. ...)

And keep my slice isolated from your slice, so we don't
interfere with each other

Deep
Programmability

Slicing



We can run many different “future
Internets” in parallel.

Program Everything



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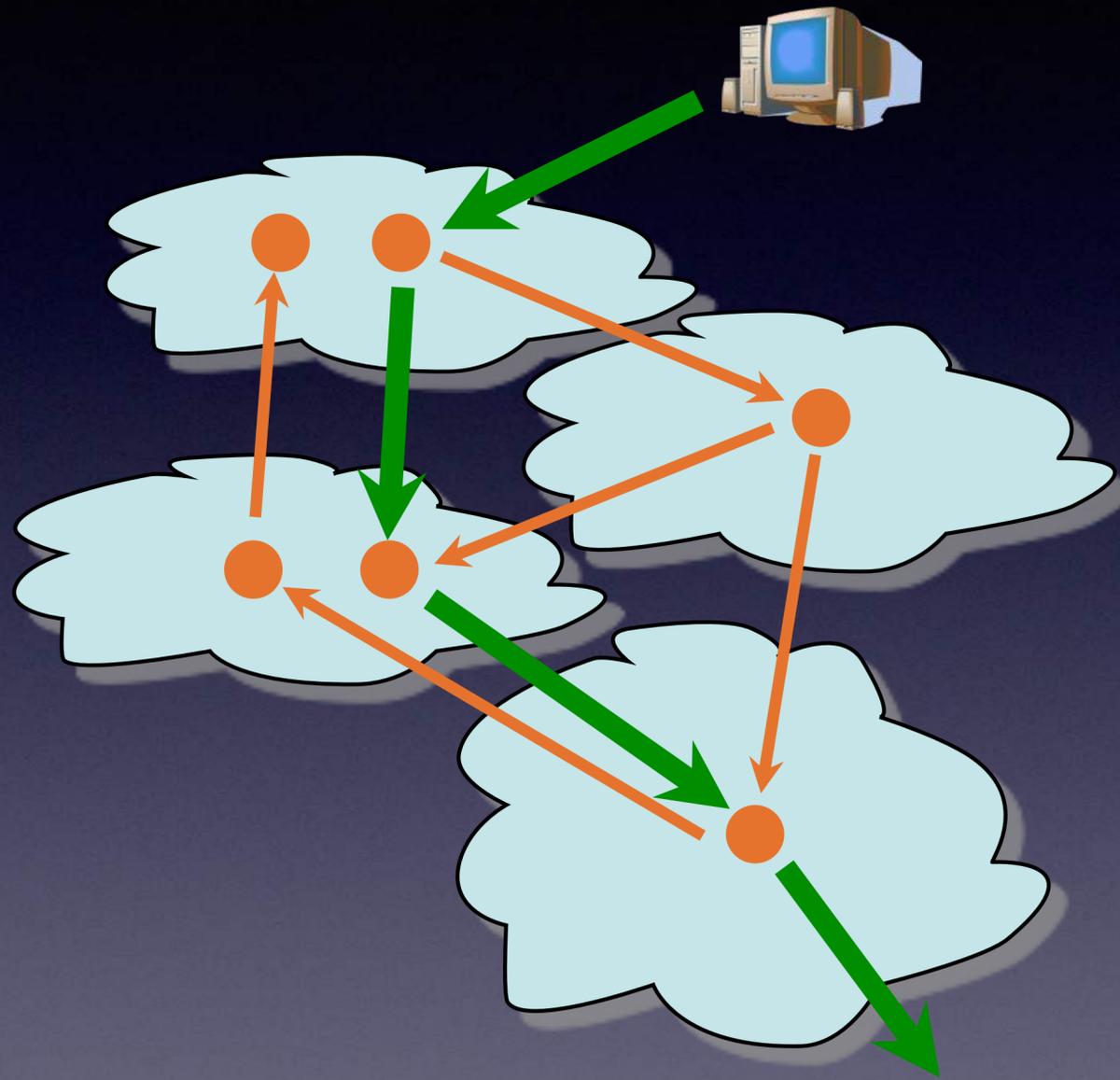
Program Everything



Computers

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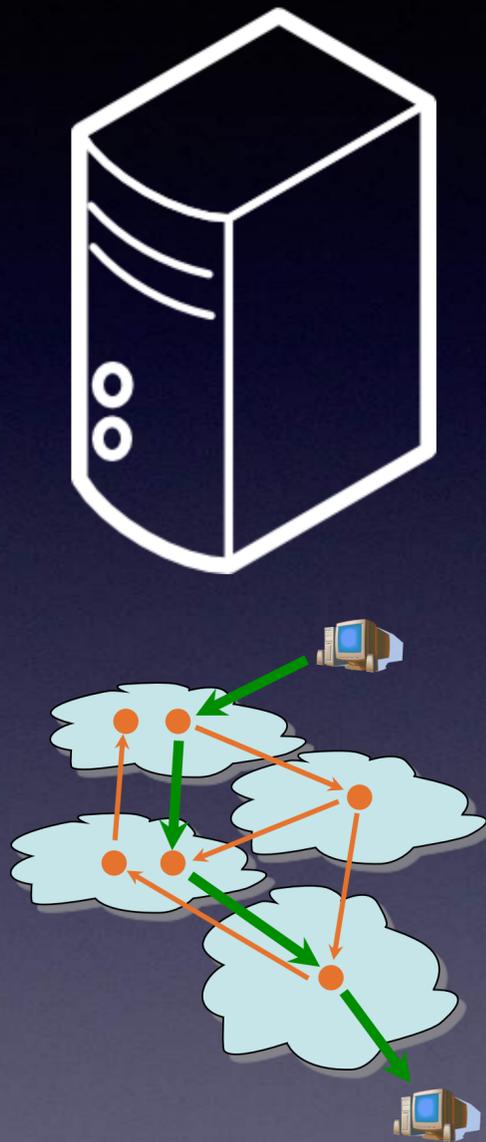
Program Everything



Networks

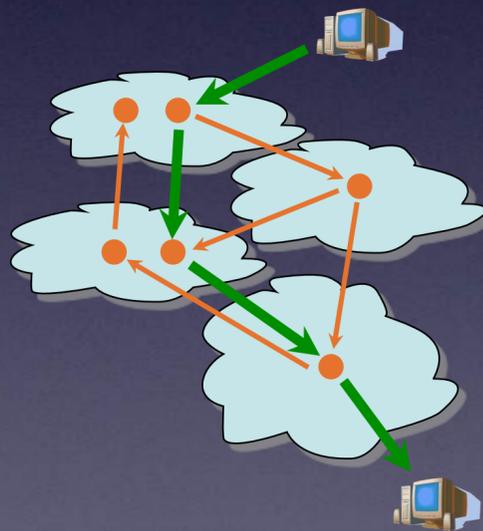


Program Everything



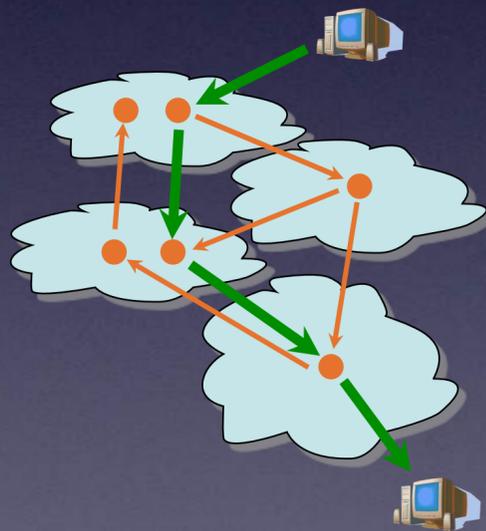
4G Cellular

Program Everything

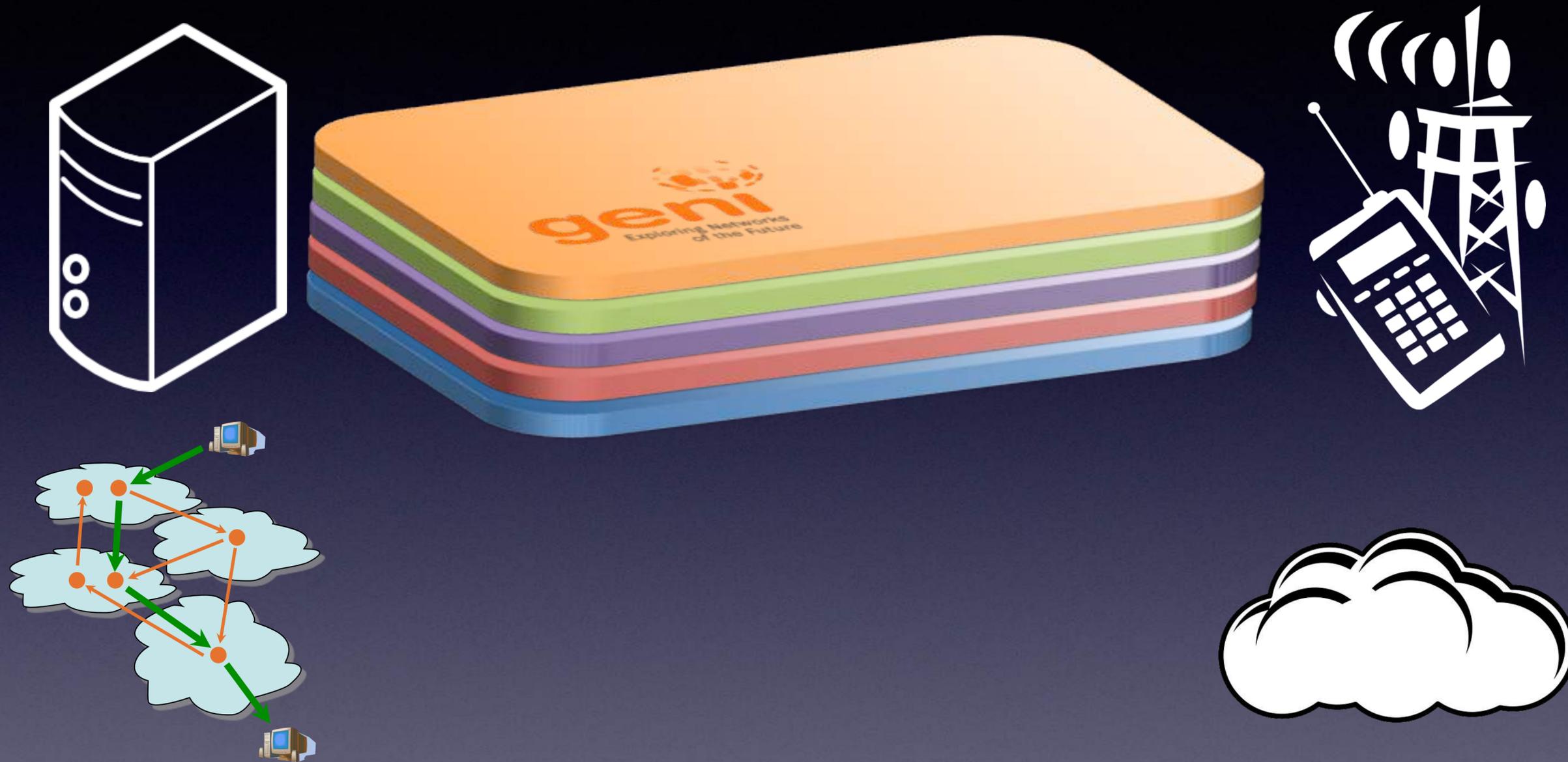


Clouds

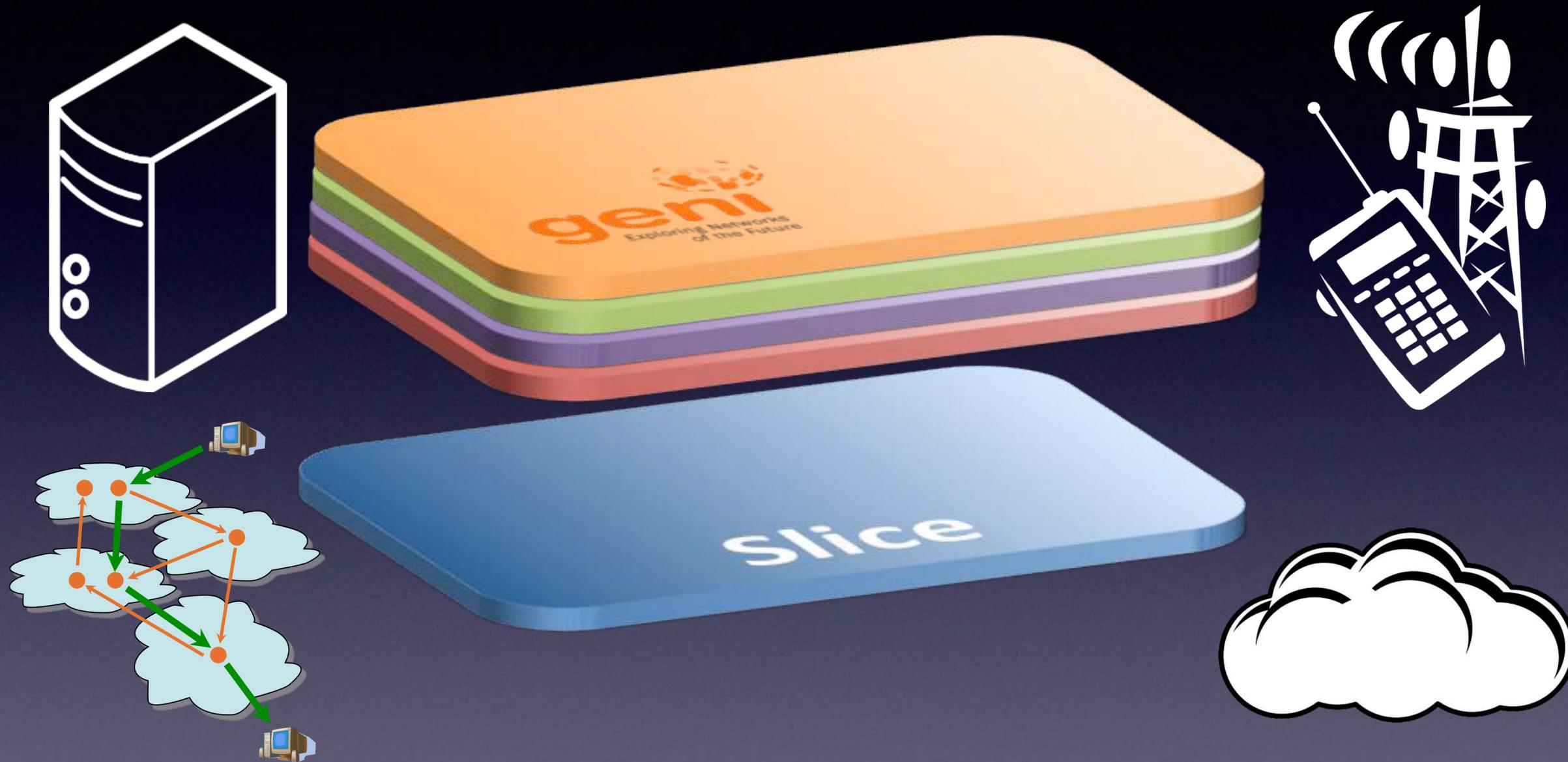
Program Everything



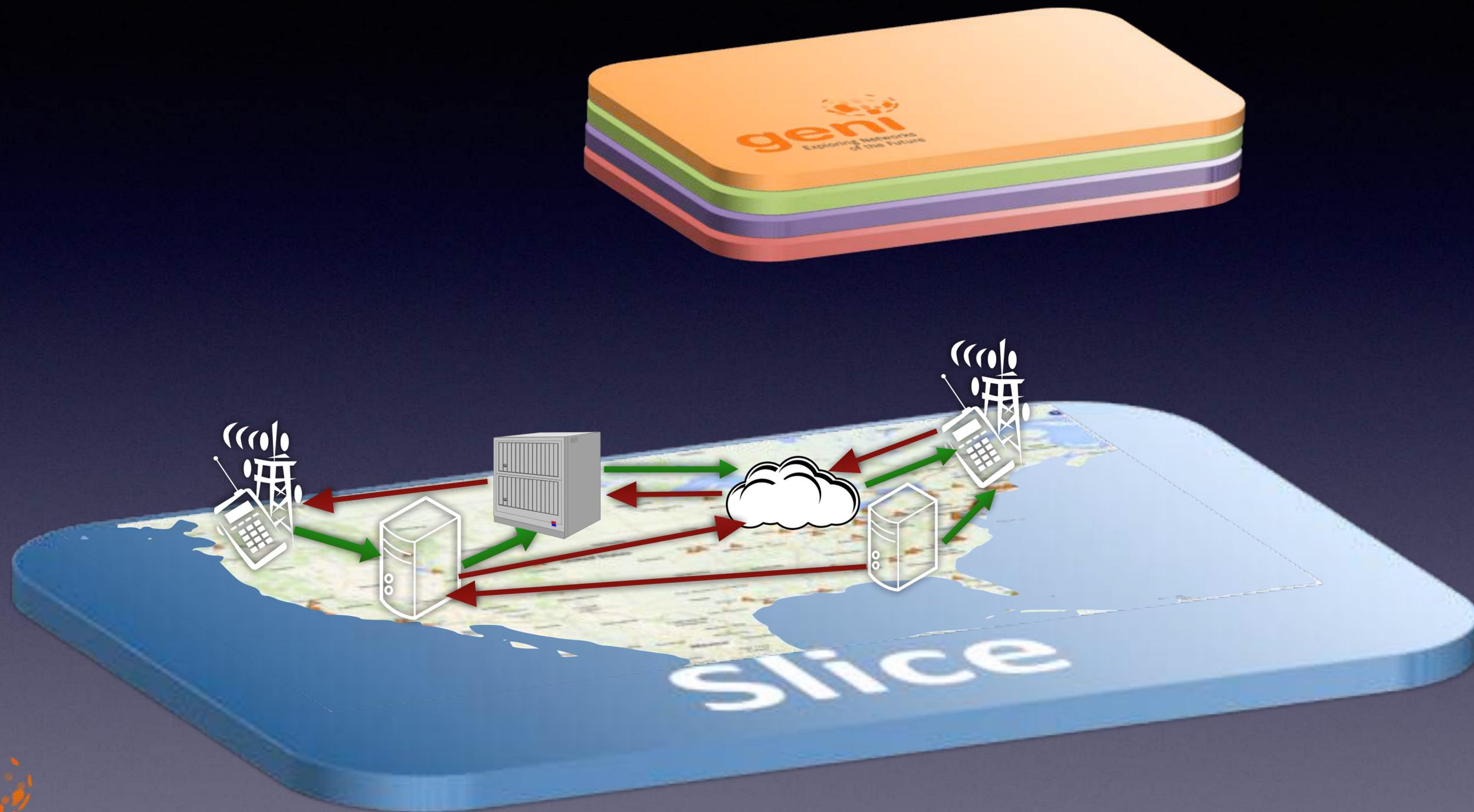
End-to-end Integrated Slices



End-to-end Integrated Slices



Precision Cyberinfrastructure



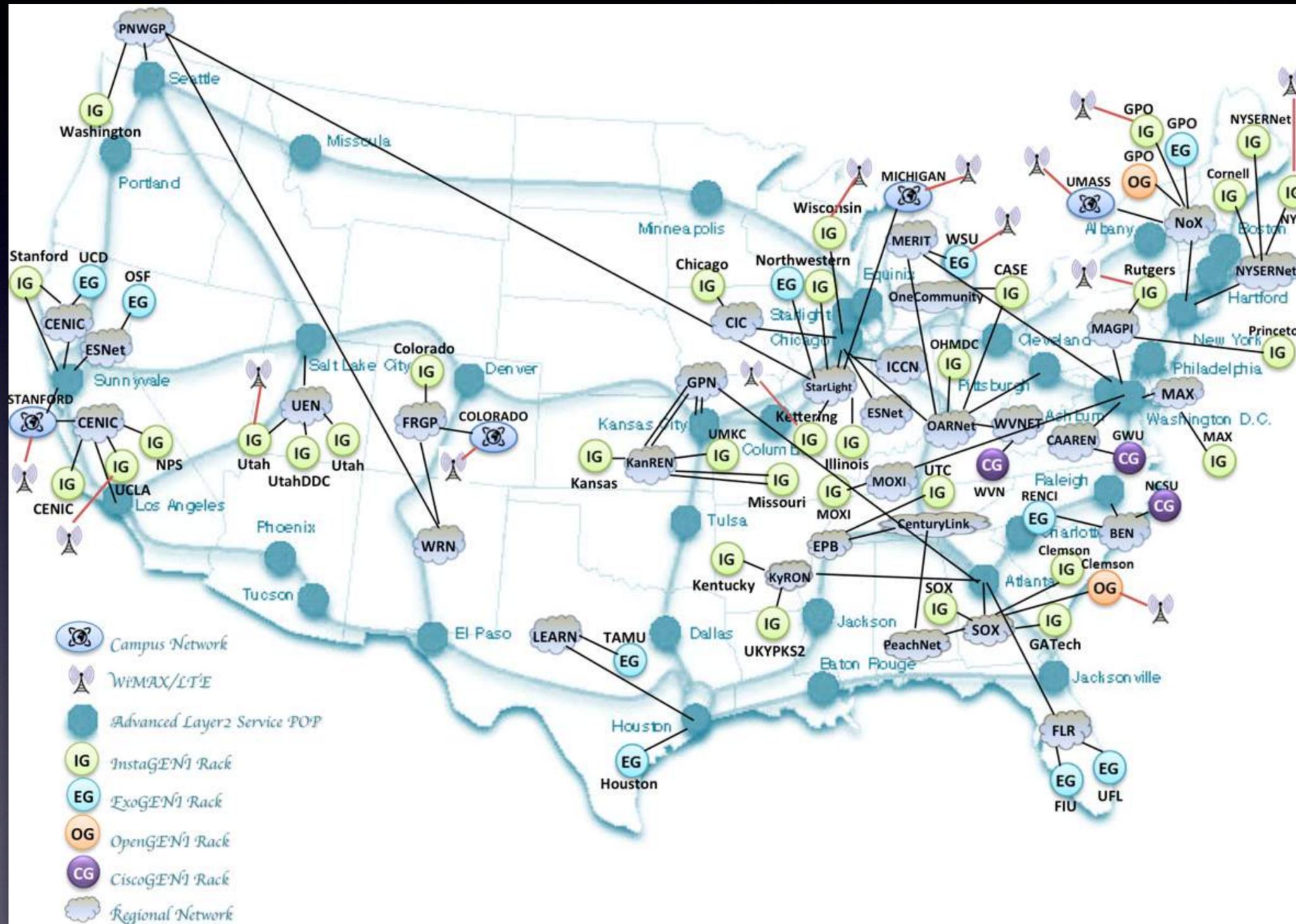
GENI's Sliced Infrastructure



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GENI's Sliced Infrastructure



Nationwide Precision Cyberinfrastructure

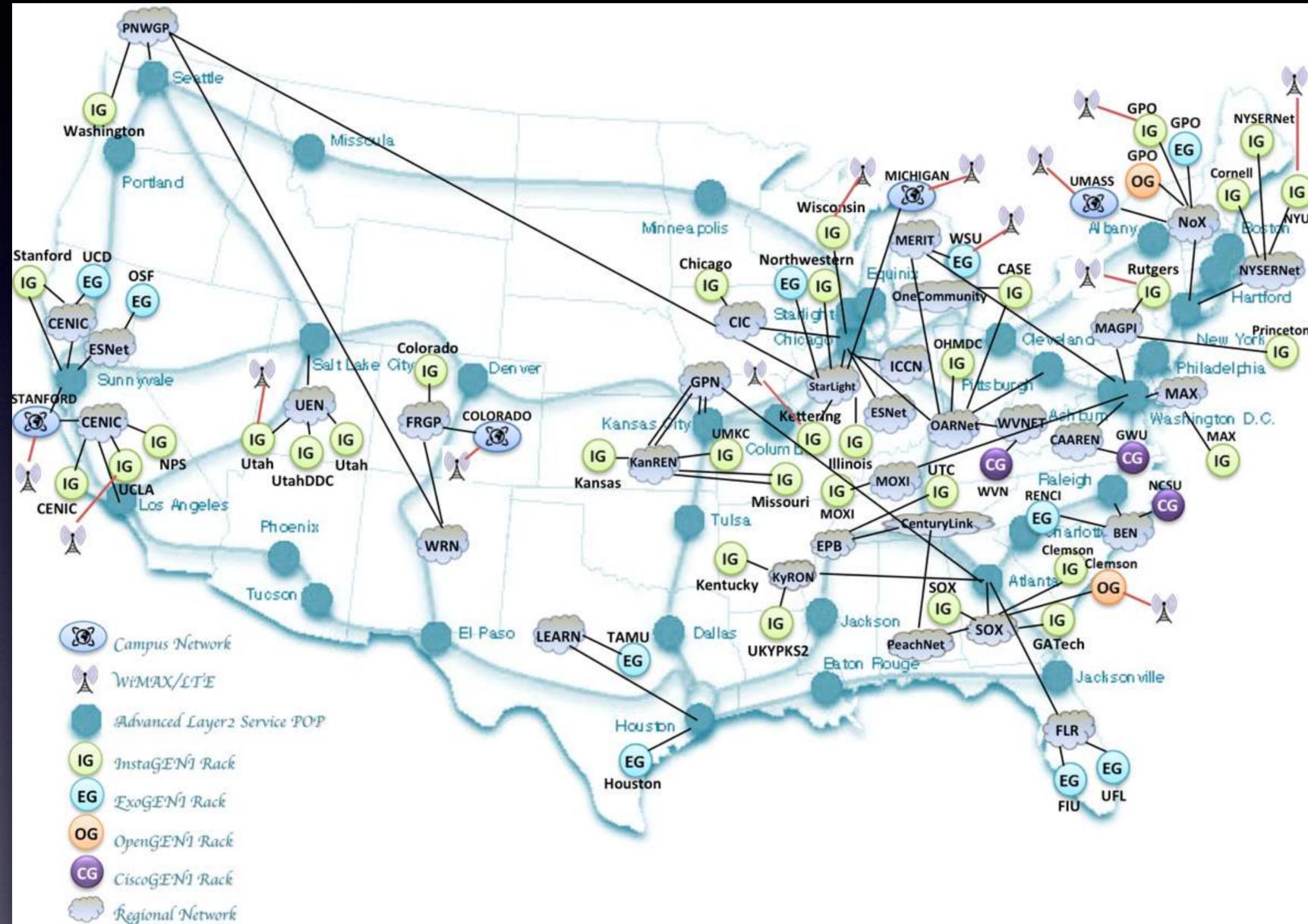
GENI-installed cyberinfrastructure

- GENI Racks - 58 racks in current deployment
- GENI Wireless - 26 base stations at 13 sites

All are sliced and deeply programmable

Interoperable US cyberinfrastructure includes

- NSF Cloud
- Campus Cyberinfrastructure (CC-*)
- US Ignite cities
- ACI-REF



Sliced R&E networks



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Why Federate?



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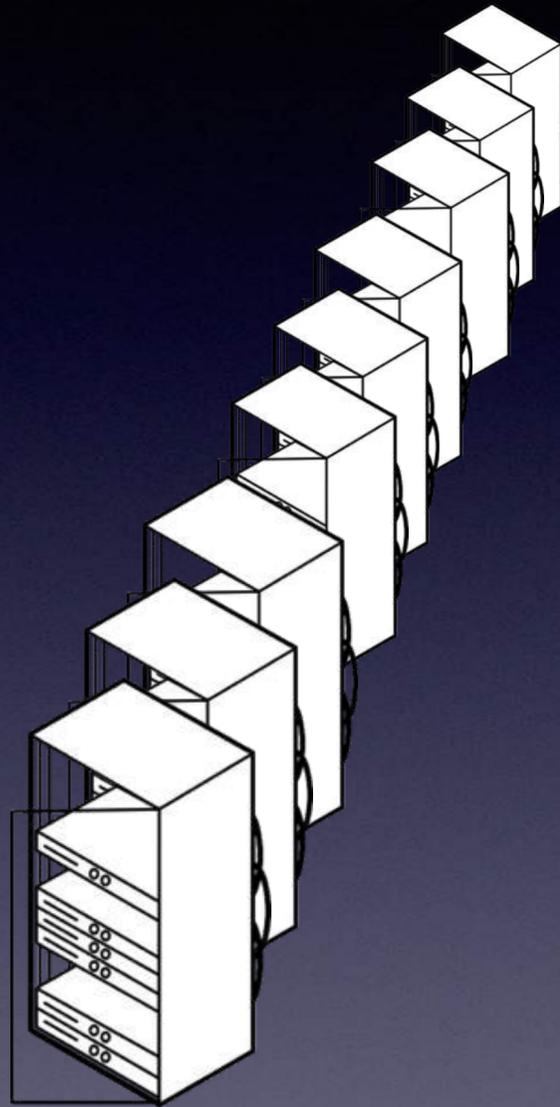
Why Federate Internationally?

A Few Observations Motivating Federation

There are clear potential benefits to all FIDC constituencies: end users, owners / managers, and developers.

- Researchers want access to more resources, different resources, and resources around the world.
- Extend the reach of research users of each participating federate.
- Introduce participating testbeds to new user groups.
- Preserve the unique capabilities of participating testbeds (including geography).
- Enable participating testbeds to enter into multiple arrangements for specific purposes. (“Federation is not monogamous.”)

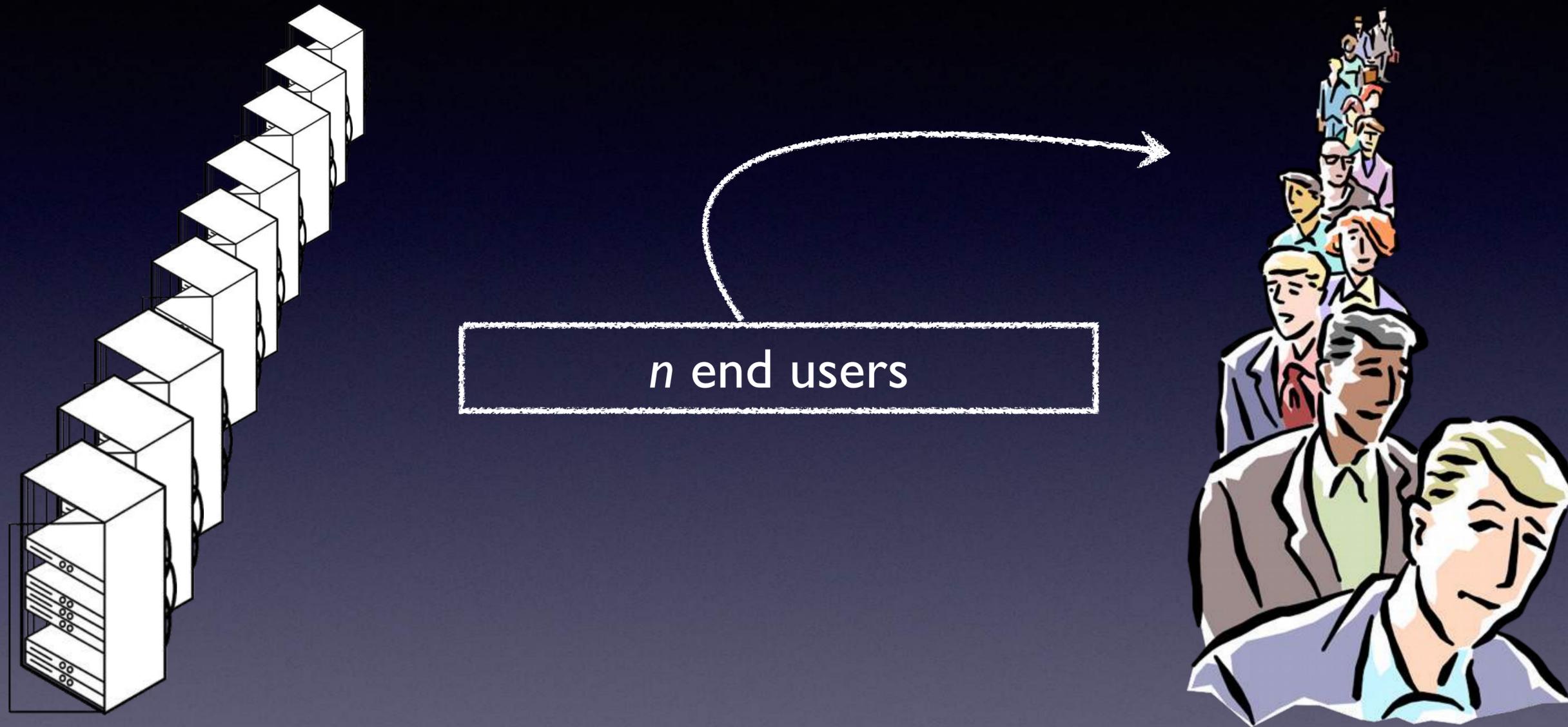
Federation Creates Trust Leverage



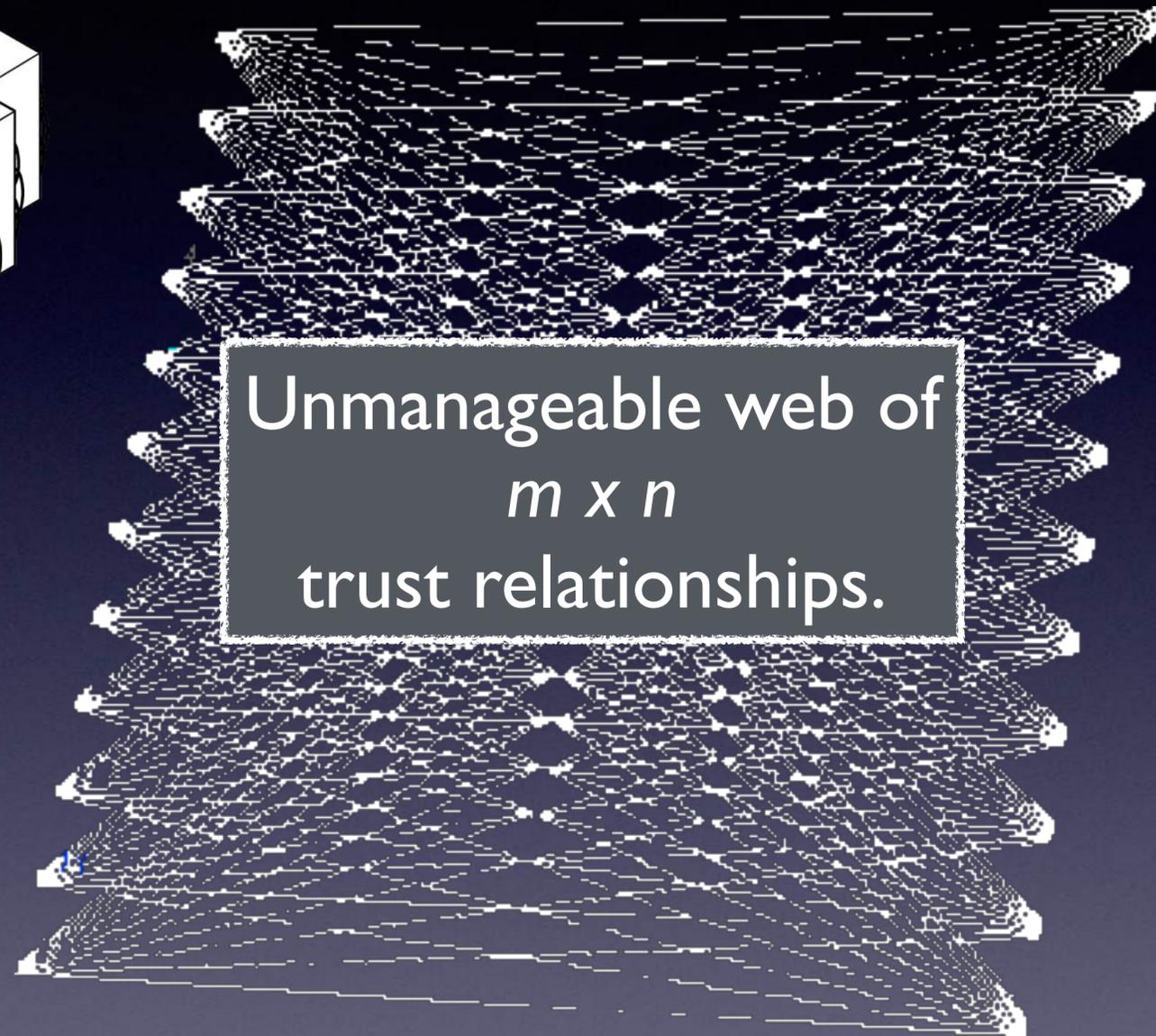
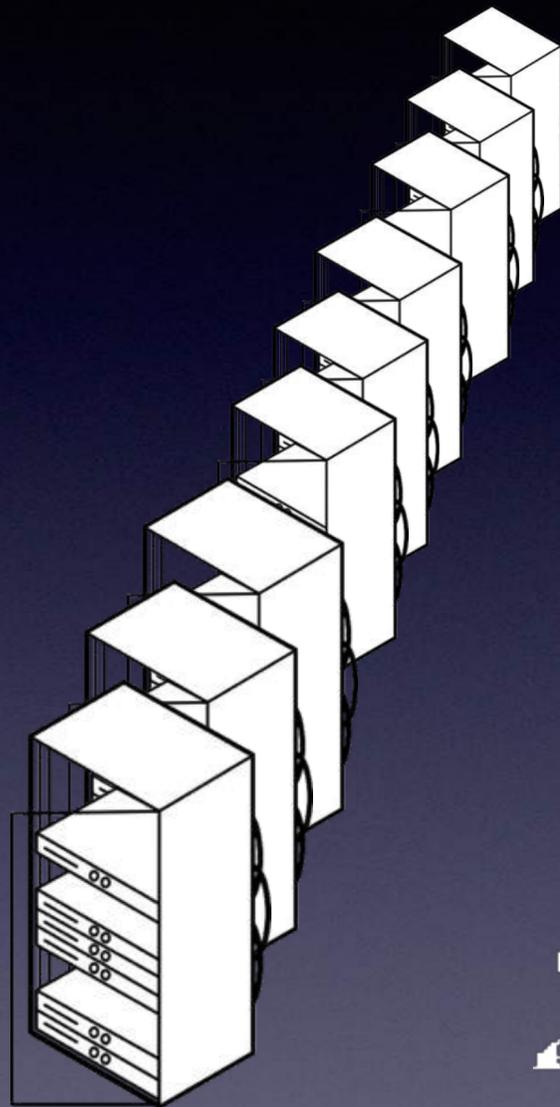
m resource providers



Federation Creates Trust Leverage



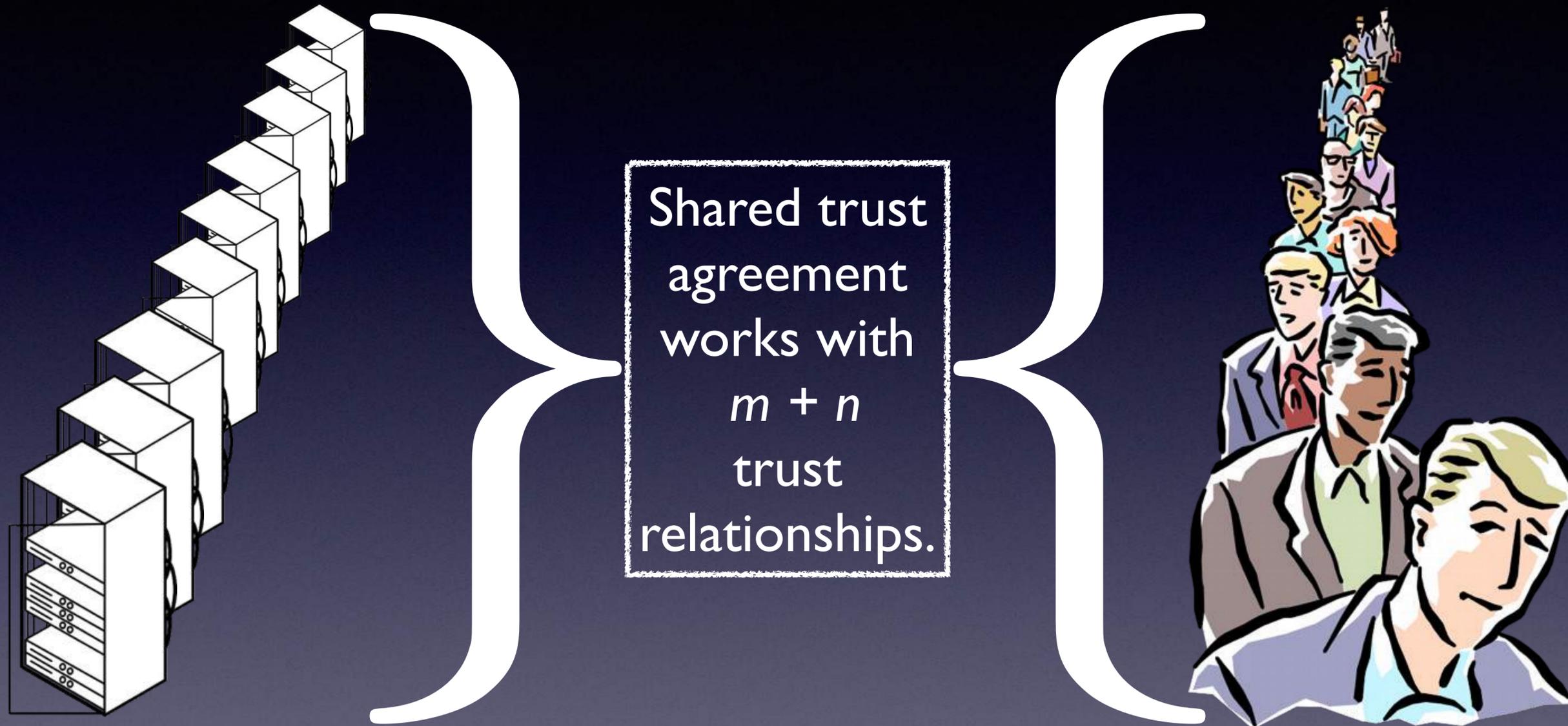
Federation Creates Trust Leverage



Unmanageable web of
 $m \times n$
trust relationships.



Federation Creates Trust Leverage



New opportunities and risks arise when nesting federation relationships.

Federation Implementation Mechanisms



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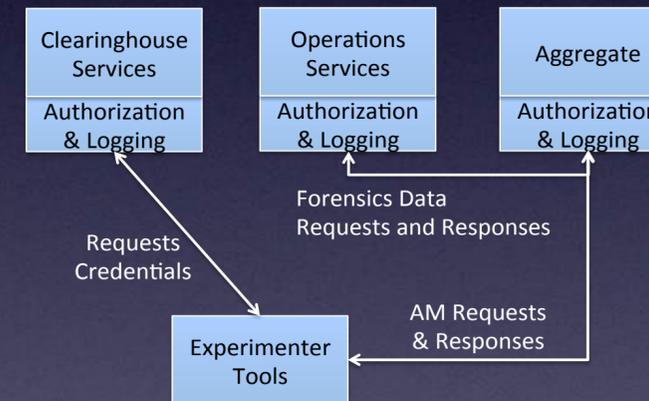


FIDC Testbed Federation In Three (Hopefully Easy) Steps

Choose to federate and
establish policies



Control plane federation



Data plane federation



FIDC Testbed Federation

Administrative and Policy Prerequisites

Establishing a federation of testbeds is a human endeavor first. Successful federation relies on:

- Clear understanding of shared benefits
- Mutual trust, with boundaries
- Shared terminology



FIDC Testbed Federation

Example Policy Considerations



Reconcile membership / access policies.

- Federates may have divergent policies.
- Often addressed via simple policies, so long as key data is collected (e.g., “Is this user an academic?”).

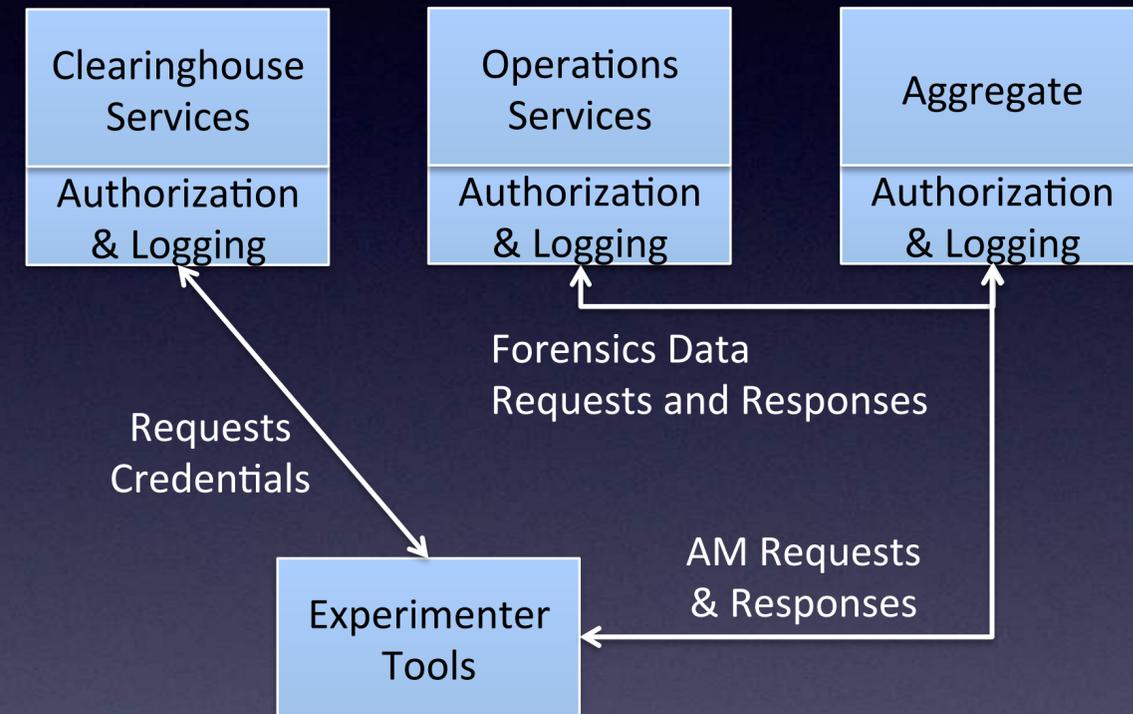
Enforce policy locally, so each participant can monitor its own needs and obligations. Examples:

- “Only Administrators may shut down resources.”
- “Researchers from testbed X may collectively consume no more than Y% of resources from testbed Z.”

FIDC Testbed Federation Architecture Components for AAA

Essential control plane services to support federated trust

- Authentication: validate requester's identity
- Authorization: verify permission to perform action
- Accounting: keep records for audit, billing, incident response



All API specifications used in emerging international federation are under development by an international consortium. Open source implementations of API and components are available.

FIDC Testbed Federation

Implementation Mechanisms for AAA

Current international federation efforts are benefiting from existing AAA capabilities at participating federates and from adoption of open standards.

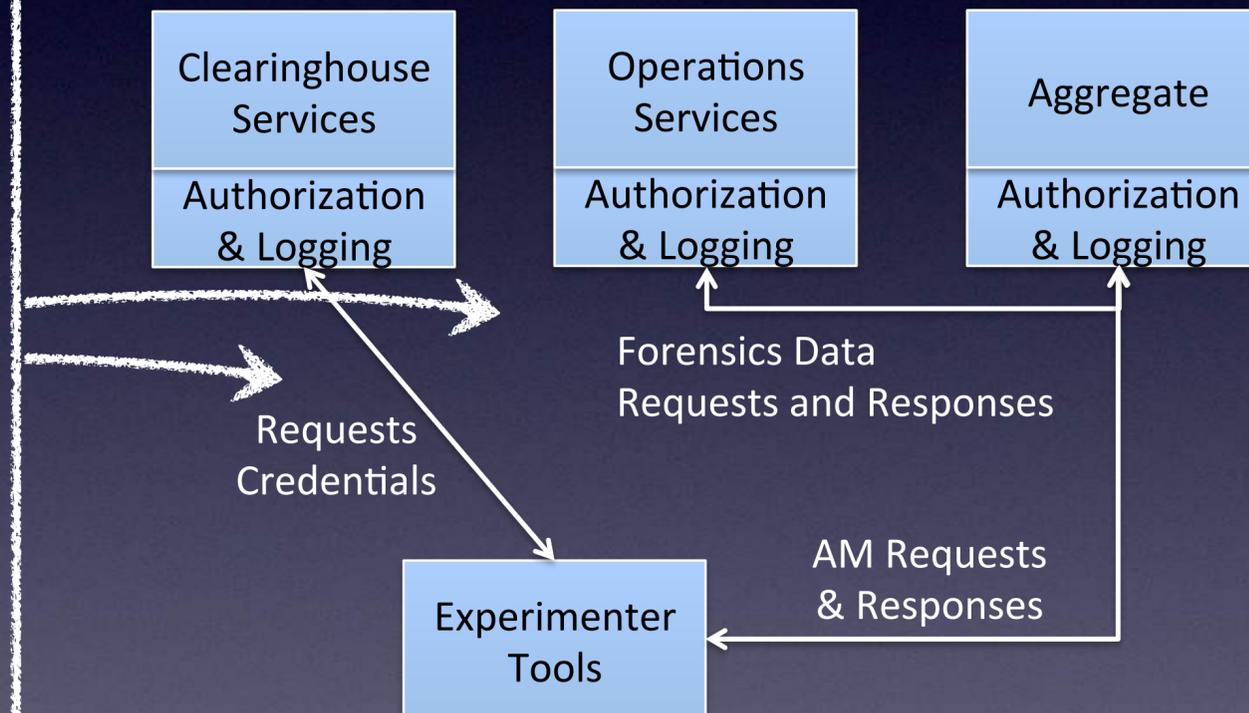
- Authentication
 - ▶ X.509 certificates and secure socket layer (SSL)
- Authorization: verify permission to perform action
 - ▶ Early implementation via slice federation architecture (SFA) and role-based access control (RBAC)
 - ▶ Increasingly adopting attribute-based access control (ABAC) for expressiveness and accountability benefits
- Accounting
 - ▶ Transaction and status records in standard database

FIDC Testbed Federation

Common APIs for Control Plane Federation

The federation API for “clearinghouse” services provides conceptually centralized federation management services, including

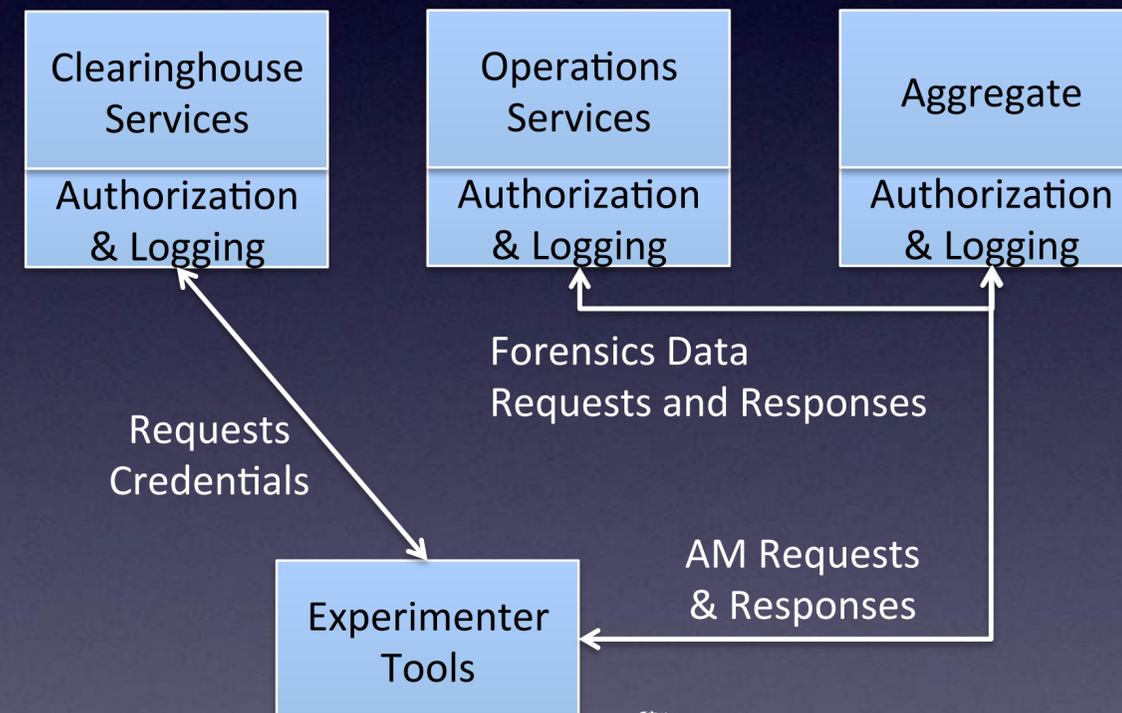
- Member authority
- Slice authority
- Monitoring



FIDC Testbed Federation

Common APIs for Control Plane Federation

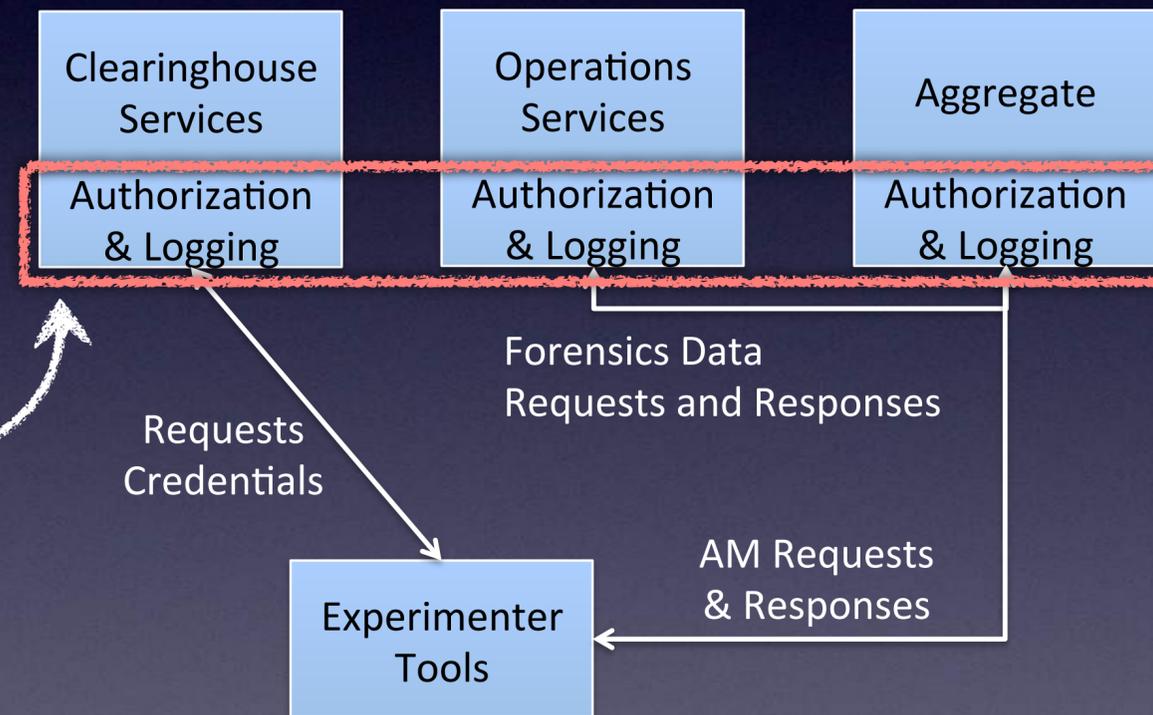
The aggregate manager (AM) API connects user tools to the individual aggregate managers for resource allocation, configuration, and management.



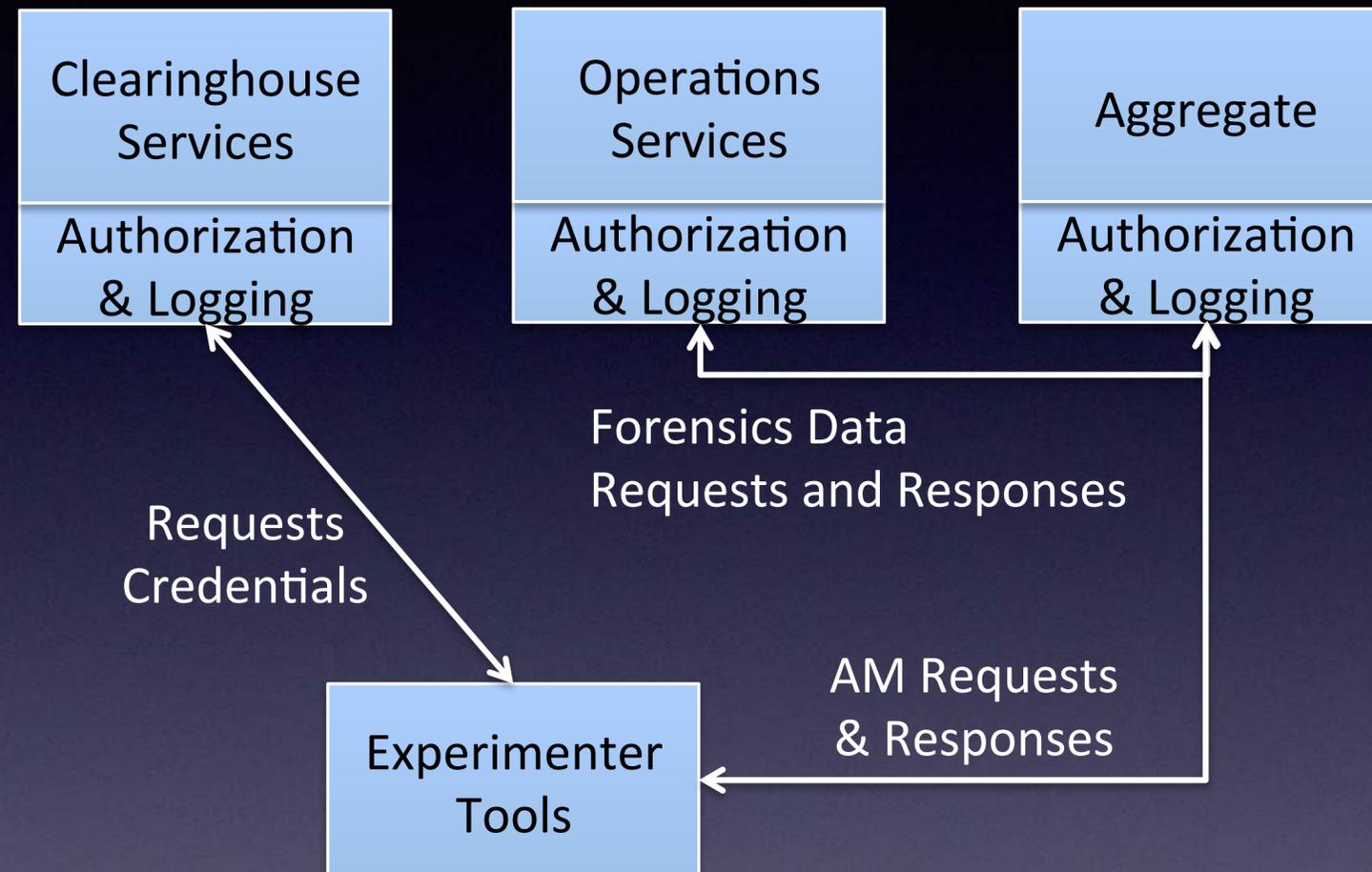
FIDC Testbed Federation

Common APIs for Control Plane Federation

Policy management is enforced locally – each component in the federation acts as a policy enforcement point.



FIDC Testbed Federation Control Plane Federation

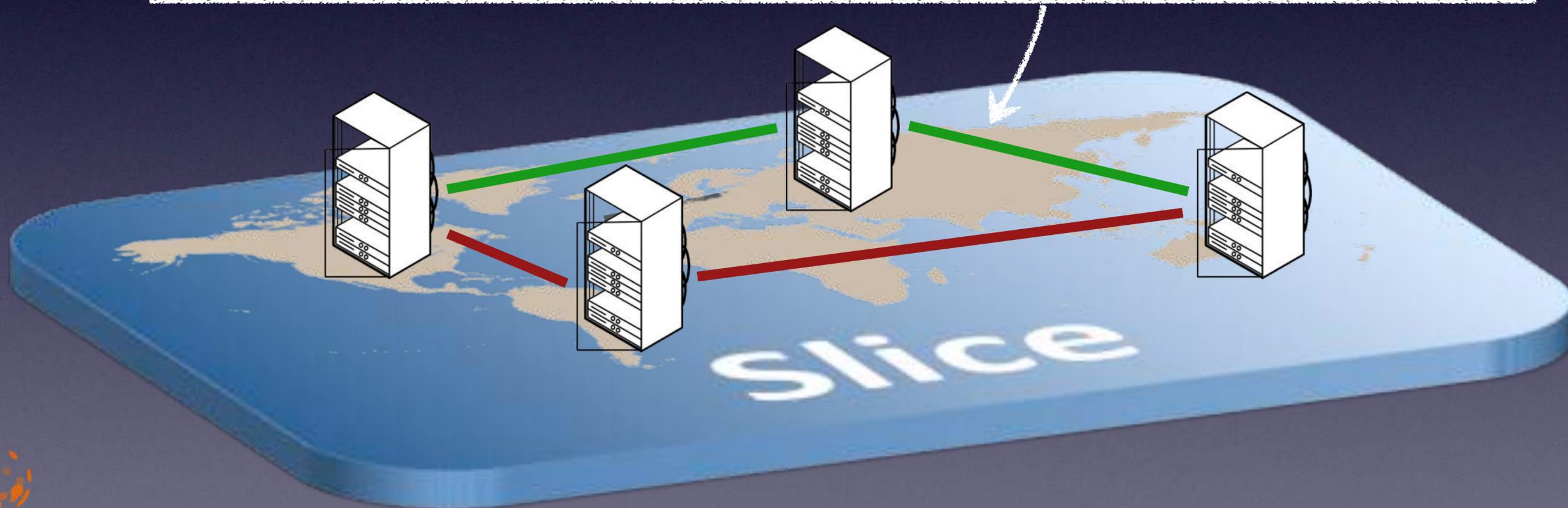


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FIDC Testbed Federation Data Plane Federation

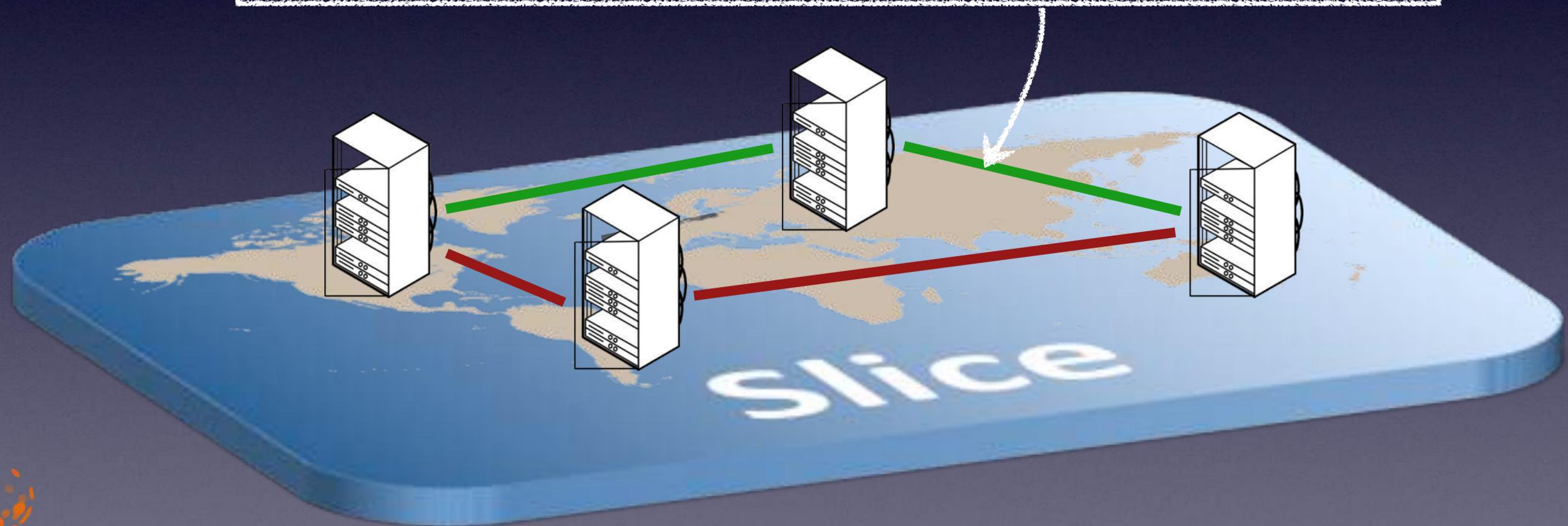
International FIDC data plane at layer two is possible via

- On-the-fly VLAN allocation from a reserved “bundle”
- SDN-controlled network virtualization
- Dynamic circuit provisioning (e.g. NSI)



FIDC Testbed Federation Data Plane Federation

Current research and prototyping of SDX and SDI capabilities holds great promise for extending deep programmability uniformly into federated data plane.



How are we doing?



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Current International Federation Activities

An Emerging FIDC Testbed Federation



Early federation
participants

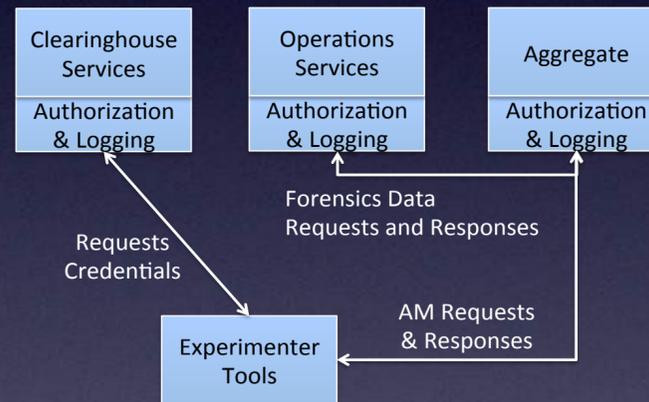
Discussions began summer 2013 to define control and data plane federation approach and stand up multi-lateral federation infrastructure.

US / Brazil Federation Progress

Choose to federate and establish policies



Control plane federation



Data plane federation



Automation and Routinization are Key

Automation,
Familiarity

<i>Domains involved in the path</i>	<i>Average time to provision a new circuit</i>	<i>Average number of e-mails exchanged</i>
RNP, ANSP, RedCLARA[18], AmLight, Internet2 and/or ESnet	< 2 minutes	0
With other domains using OSCARS or NSI support	< 2 minutes	0
With domains not using OSCARS or NSI support, with up to three networks in the path	5 days	10
With domains not using OSCARS or NSI support, with more than three networks in the path	12 days	65
With domains in other continents not using OSCARS or NSI support	45 days	100

Pain

Ref: Ibarra, J.; Bezerra, J.; Morgan, H.; Fernandez Lopez, L.; Stanton, M.; Machado, I.; Grizendi, E.; Cox, D.A., "Benefits brought by the use of OpenFlow/SDN on the AmLight intercontinental research and education network," in Integrated Network Management (INM), 2015 IFIP/IEEE International Symposium on , vol., no., pp.942-947, 11-15 May 2015. doi: 10.1109/INM.2015.7140415

Worldwide Growth in FIDC Testbeds



National/regional FIDC testbed activity.

Building a multi-national group of FIDC testbeds, seeking new partners, working from a basis of equality to expand opportunities for researchers worldwide.

FIDC Testbed Federation

Key Research Challenges

Federation of FIDC testbeds remains a relatively new phenomenon, with key technology still being defined

- Control plane policies are often simple to trivial.
- Need better resource description and discovery for tight, heterogenous federations.
- A menagerie of dynamic circuit provisioning protocols complicates data plane federation.

Next Steps

- Continue and expand research collaborations (which will drive testbed innovation).
- Pursue and institutionalize testbed federations, building on data plane progress.

We have made an excellent start in international federation of FIDC testbeds, but there is still a long way to go.

References

Final Report, NSF Workshop on the Development of a Next-Generation Cyberinfrastructure, December 2014.

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Berman, M. and Brinn, M., "Progress and challenges in worldwide federation of future internet and distributed cloud testbeds." Science and Technology Conference (Modern Networking Technologies) (MoNeTeC), 2014 First International, IEEE, 2014. doi:10.1109/monetec.2014.6995579.

OpenMultinet: <http://www.open-multinet.info/>, <https://github.com/open-multinet/federation-am-api>.



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Exploring Networks
of the Future



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