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## BACKGROUND

### Experience in GENI

#### Infrastructure Building Phase

We have participated in building of the GENI infrastructure: first through small scale GENI rack placeholders with a server set and associated network nodes on Texas university campuses, UT-Austin, TAMU, Rice, and UH. Consecutively, we were awarded to host a GENI rack on UH campus. The connectivity through the metro regional network (SouthEast Texas Gigapop - SETG), the state regional R&E network (Lonestar Education and Research Network - LEARN), and their Internet2 connections were established with the help of UH IT and CIO. Finally, with the NSF CC-NIE award, we had established more resource allocation and connectivity options with Virtual Topology Services on UH campus.

#### Collaboration with Industry and Advanced Experiments on Network Research

Industry collaboration helped make advanced networking experiments serve towards a commercial goal while investigating the underlying science and attempting at creating a baseline in performance expectations. Every industry has its own tools and testbeds to achieve such metrics and understanding of performance. Resources on a testbed such as GENI serves both parties in a complementary fashion with great benefits: industry can utilize resources while participating in skill development of their future workforce, academia can gain deeper insight into what may be the pressing problems in real-life cases. We have collaborated at different levels with a number of small and big companies such as Dell, Intel, Cavium Networks, vArmour, Infoblox, and YumaWorks. Deploying virtual appliances to test and verify, product development initiatives, and demonstration of new features were underlying motivations.

## FUTURE OF GENI INPUT

**What are the key activities that should be continued, initiated, or wound down to meet the community's goals for GENI?**

- 1 **Tutorials on advanced tools** that provide transferable skills, community support larger than just the tool developers
- 2 **Development activities** to create common abstractions for future development and advancement of user tools in addition to an **advanced infrastructure and architecture team** to help continue on advancing GENI resources and offerings in networking field above and beyond what is available in public and private clouds
- 3 *Terminate tool and framework development* that has requirements for specialized skill sets that will not transfer to employment opportunities for students or cannot be part of the curriculum for computer networking (since it is very specialized and unique to one lab/institution/entity)
- 4 Initiate an infrastructure governance model for future administration and maintenance of the existing investments in both software and hardware

**What approaches to governance, administration, and finance should be employed?**

### **What is being governed, administered, financed?**

Software - should be managed, maintained through existing open source models

Hardware (racks, other resources to be deployed, etc.) - training on what hardware may need what level of services should be provided

Circuit services from regionals and Internet2 - service level agreements should be created with a working relationship setup between regionals, campuses, and the federated GENI entity

### **Governance:**

CIO

Regional networks and Internet2

Campuses

A shared governance procedure should be clearly defined that includes the parties above and their associated authority levels. For example, a list of resources, location, designated administrator, and a responsible party for maintenance should be created for each GENI resource. On a micro level, this constructs a research infrastructure that is used by the community while supported by IT organizations [1].

### **Administration:**

Administration's main role is the control and checks on resource setup/maintenance on GENI federation through maintenance and verification of GENI AM-API implementations. Any existing resource should maintain compatibility with the existing AM-API software in order to provide its resources to the GENI federation. The administration's sole purpose is then to be the neutral entity checking against the promised SLAs by resource provider, implementation of GENI AM API for resources, and providing resource integration with the GENI federation (at the level that the resource provider may have in their SLA).

### **Finance:**

Various funding sources and structures may be possible for the GENI testbed. Each line of funding may sponsor a different aspect of the testbed. For example, experimenter demands on the resources may be funded with research funds of the experimenter. Some credits may be assigned to entities that provide equipment and other support on the testbed (operational, testing, and other - to be defined in an administration and finance process doc/model). These credits may pay for experimenter costs. The funding for experimentation research may have part of its IDC allocated for the expense of testbed since this is part of the infrastructure (just like electricity, office space, etc. are) that enables university labs to conduct research.

Closer ties with industry may pay for different aspects of operations and more resource setup on the federation. For example, evaluation of enterprise software and hardware offerings is a need in most campus IT organizations and this is ripe with research projects for students, and research labs for investigations while serving industry goals and university IT organizations. Partnerships with amazon AWS should be explored for extending resources and building coordinated and paid resources for data, compute and network.

### **What contributions and lessons can the GENI experience and community offer to future research cyberinfrastructure projects?**

The main contribution we see transferring to the community is the distributed system design cycle and experience that the community has gone through. The GENI federation is a perfect example of how decentralized yet integrated set of resources can be made available in a programmable fashion to the testbed users. Enabling how opt-in usage can be instantiated is something GENI experience could not deliver but the lessons learned may help future research CI projects.

GENI federation is a living proof of the challenges in how security may be built into the design from day one on all aspects of building cyberinfrastructure. The experience on how federated interaction may work among the various aggregates is a model for other such resource integration models to follow. The experiences on user access, experiment setup, and continued cognizant behaviour is a work in progress and such access methods with their learning experiences on the users is a big consideration in the future testbed-based research activities.

[1] <http://internet2-wgsgdn.readthedocs.org/en/latest/>