

# Ramping Up Experiments in GENI

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## I. INTRODUCTION

The Global Environment for Network Innovations – GENI – is a suite of research infrastructure rapidly taking shape in prototype form across the United States. It is sponsored by the US National Science Foundation,<sup>1</sup> with the goal of becoming the world’s first laboratory environment for exploring future internets at scale, thereby promoting innovations in network science, security, technologies, services and applications.

GENI’s current development phase, Spiral 3, marks a time of transition from *building GENI* to *using GENI*. A hallmark of this phase is an emphasis of the role of experimentation in defining GENI’s capabilities and guiding the project’s future development.

Initial explorations by and reports from GENI experimenters provide strong evidence that the key GENI concepts of *sliceability* and *deep programmability* are working in a prototype nationwide deployment and that these capabilities support a wide variety of experiments. These reports also identify objectives for future GENI development, which are being incorporated into project plans.

## II. RESULTS ON THE GENI MESO-SCALE PROTOTYPE

Much of the GENI development community’s effort during GENI Spiral 2, a one-year period beginning in October 2009, was devoted to the development of a “meso-scale Prototype,” deploying key GENI technologies across the United States. By November 2010, the meso-scale Prototype was sufficiently stable to support significant experimentation. This prototype configuration is of significant scale, spanning fifteen campuses, two national backbone networks, and eleven regional networks (Fig. 1).

Simultaneously with the development of the meso-scale prototype, the GENI development community and the NSF encouraged active experimentation via several forms of outreach to the networking, distributed computing, and network science research community.

- GENI “brave pioneer” shakedown experiments
- NSF-sponsored GENI Experimenters workshop<sup>2</sup>

<sup>1</sup> GENI is funded by the National Science Foundation. Any opinions, findings, conclusions or recommendations expressed in this material are the author’s and do not necessarily reflect the views of the National Science Foundation.

<sup>2</sup> <http://www.cs.princeton.edu/~jrex/gew.html>



Figure 1: GENI Meso-Scale Prototype, November 2010

- GENI experimenter demonstrations at the 9<sup>th</sup> GENI Engineering Conference (GEC9)<sup>3</sup>
- GENI support for NSF’s Future Internet Architecture (FIA) program<sup>4</sup>
- Joint DFG / NSF doctoral consortium<sup>5</sup>

In addition to these explicit forms of outreach, GENI resources are generally available on an ongoing basis to interested researchers.

Experimenter results and feedback are continuously gathered via formal and informal communication mechanisms.

- Telephone and e-mail communication
- Experimenter feedback sessions at GECs
- Journal and conference publications

Experimenter reports indicate a high level of success in using the following key GENI capabilities.

- **GENI Slices** – identify the resources needed for an experiment and isolate them from other simultaneous experiments.
- **Deep Programmability** – permits experimenters to affect the behavior of components at all points in the network.
- **Distributed, virtualized GENI components.**
- **Interoperable, federated, and heterogeneous resources.**

<sup>3</sup> <http://groups.geni.net/geni/wiki/Gec9PlenaryDemoAbstracts>

<sup>4</sup> <http://www.nets-fia.net/>

<sup>5</sup> <http://groups.geni.net/geni/wiki/FirstDfgGeniDoctoralConsortium>

### III. NEXT STEPS FOR GENI CAPABILITIES

The GENI meso-scale prototype provides real and immediate capability for network research. However, experimenters have also identified important areas where continued GENI development and expanded deployment will substantially enhance GENI's ability to realize its key goals. Notably, experimenters have expressed a desire to deploy GENI slices requiring larger network topologies than are available in the current meso-scale prototype. Similarly, they often seek additional in-network computational resources. Finally, the GENI experimenter community would benefit from additional support tools to facilitate experiment design, deployment, and maintenance.

The GENI development community is preparing to address several of these needs in the next stage of development. Goals for this upcoming stage include:

- Development and deployment of "GENI racks," which will place substantial computation and storage capabilities, along with programmable network components, at more key locations in the network.
- Deployment of GENI-enabled network switches in regional and national research networks.
- Experimenter education, tools, and support.