GENI

The Global Environment for Network Innovations (GENI) is a suite of network research infrastructure now in its design and prototyping phase. It is sponsored by the National Science Foundation to support experimental research in Network Science and Engineering (NetSE).

NetSE research challenges us to understand networks broadly and at multiple layers of abstraction from the physical substrates through the architecture and protocols to networks of people, organizations, and societies. The intellectual space surrounding this challenge is highly interdisciplinary, ranging from new research in network and distributed system design to the theoretical underpinnings of network science, network policy and economics, societal values, and the dynamic interactions of the physical and social spheres with communications networks. Such research holds great promise for new knowledge about the structure, behavior, and dynamics of our most complex systems – networks of networks – with potentially huge social and economic impact.

As a concurrent activity, community planning for the suite of infrastructure that will support NetSE experiments has been underway since 2005. This suite is termed the Global Environment for Network Innovations (GENI). Although its specific requirements will evolve in response to the evolving NetSE research agenda, the facility's conceptual design is now clear enough to support a first spiral of planning and prototyping. The core concepts for the suite of GENI infrastructure are as follows.

- **Programmability** – researchers may download software into GENI-compatible nodes to control how those nodes behave;
- **Virtualization and Other Forms of Resource Sharing** – whenever feasible, nodes implement virtual machines, which allow multiple researchers to simultaneously share the infrastructure; and each experiment runs within its own, isolated slice created end-to-end across the experiment's GENI resources;
- **Federation** – different parts of the GENI suite are owned and/or operated by different organizations, and the NSF portion of the GENI suite forms only a part of the overall "ecosystem"; and
- **Slice-based Experimentation** – GENI experiments will be an interconnected set of reserved resources on platforms in diverse locations. Researchers will remotely discover, reserve, configure, program, debug, operate, manage, and teardown distributed systems established across parts of the GENI suite.

As envisioned in these community plans, the GENI suite will support a wide range of experimental protocols, and data dissemination techniques running over facilities such as fiber optics with next-generation optical switches, novel high-speed routers, city-wide experimental urban radio networks, high-end computational clusters, and sensor grids. The GENI suite will be shared among a large number of individual, simultaneous experiments with extensive instrumentation that makes it easy to collect, analyze, and share real measurements.

GENI's Design Goals

As the system design for GENI evolves it is guided by the following design goals. These goals have been derived to ensure the resulting infrastructure suite will be useful to the research community by encouraging wide-spread deployment, diverse and extensible technologies, and support for real-user traffic.

Goal	Explanation
Generality	GENI should give each experimenter the flexibility needed to perform the desired experiment. This means that each component should be programmable, so that researchers are not limited to experimenting with small changes to pre-existing functionality.
Diversity & Extensibility	GENI must include a wide class of networking technologies, spanning the spectrum of wired and wireless technologies available today. GENI must also be extensible—with explicitly defined procedures and system interfaces—making it easy to incorporate additional technologies, including those that do not exist today.
Fidelity	GENI should permit experiments that correlate to what one might expect in a real network.
Observability	GENI must offer strong support for measurement-based quantitative research.
Ease of Use	GENI must remove as many practical barriers as possible to researchers being able to make full use of its federated infrastructure.
Sliceability	To be cost-effective, GENI must be a shared infrastructure suite that can be used to support multiple experiments running on behalf of many independent research groups.
Controlled Isolation	GENI must support strong isolation between slices so that experiments do not interfere with each other.
Opt-in	To support meaningful deployment studies, GENI must make it easy for a broad mix of users to "opt in'' to experimental services.
Security	GENI must be secure, so that its resources cannot accidently or maliciously be used to attack today's Internet.
Federation & Sustainability	GENI must be designed for a 15-20 year lifetime.

Many of these goals are in tension with each other. Where possible GENI's design will permit researchers to affect the balance, for example where sliceability is in tension with fidelity, the infrastructure suite should permit some experiments on dedicated hardware to enable high-fidelity measurements in addition to supporting platforms that may be shared.

To achieve these goals, the GENI project uses an engineering approach informed by the success of the Internet and the open source software movement:

- Start with a well crafted system architecture
- Build only what you know how to build
- Build incrementally
- Design open protocols and software
- Leverage existing technology