GENI Technical Priorities from the Experimenter's and Educator's perspective

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This document presents a prioritized list of technical priorities for GENI based on feedback that the GPO has received from experimenters and educators. This list was gathered by current GENI users so the list might be biased toward immediate needs.
The technical priorities listed are divided into four categories:

- **Existing Capabilities.** Capabilities that are currently available and widely used that are important to be maintained.
- **Improvements to existing capabilities.** Existing capabilities that might not be as robust or as reliable as desired.
- **Enhancements.** Modest improvements to current functionality that will greatly improve the user experience and broaden the research supported by the testbed.
- **New Frontiers/Capabilities.** Functionality that might not be currently present but is essential in order to expand the research capabilities and be prepared for the next generation of cyberinfrastructure.

This document only provides a list of priorities but does not address any budgeting or organization needs in order to address them. We look to the community to provide feedback on these areas. Also the items are prioritized only within each category but not overall.

Existing Capabilities

1. **Deployed Hardware Support.** Keep the currently deployed GENI Hardware operational (replace faulty parts, ensure that is it powered on, connected to the network, etc). This includes any operational actions that are needed for the resources to be up, e.g. AM software reboot.
2. **Software Services.** Ensure that the currently deployed GENI software is maintained (bug fixes, regular updates, compliance to the latest APIs, etc). This includes maintenance of necessary artifacts like supported disk images for VMs (e.g. latest Ubuntu, latest OVS), or standard RSpecs.
3. **User Support and Helpdesk.** When users are asked to provide feedback to the community about their experience with GENI, this is a very typical comment:

‘‘The greatest thing is the technical support from the community, help in debugging, and bug fixing to enable the experiments“

4. **Programmable Networking** Maintain the ability to deploy highly programmable topologies e.g. through OpenFlow support or other standards that might be adopted in the future.

5. **Multi site topologies.** This is a two-fold functionality that includes both the required physical connectivity between sites and the necessary software (e.g. SCS) to be able to bring up multi-site topologies over the GENI dataplane.

6. **Expand the GENI footprint,** both the size of each site and by adding new sites. *“As GENI gains more users and scaling capabilities, it is becoming more difficult to get large number of resources“*. This request also comes up from instructors that teach larger classes.

Improvements to existing capabilities

1. **Reliability, stability.** One of the biggest problems and concerns from the user community has been the stability of the testbed and the confidence that something that worked one day will also work the next. *“I would say the hardest part of the testbed is to actually load all the VMs successfully. Once everything is up, it works really well.“*
GENI is a large distributed system and guaranteeing that all the resources are up all the time is not feasible. However, we should take steps to increase the probabilities that reasonable requests are successful.

2. **Better support for programmable networking** Enhance the GENI testbed to better support these topologies, e.g. alleviate interference from non-programmable switches including the Virtual Switch at the VM servers.

3. **Multi-site topologies, not over the internet** One of the most used features of GENI is its geographic diversity and its ability to allow the user to really control the location of the resources and connect them dynamically in different configurations. Most users are interested in using the GENI backbone but end up using the control plane (natively or over GRE tunnels) because of technical difficulties with the data plane (lack of available bw, lack of stitching at a site, lack of available VLANs, instability of the stitching service).

4. **Documentation.** Currently there are some intro materials in the form of tutorials and “recipes“ on how to do some common things on GENI. Documentation needs to be maintained and up to date. Also users could benefit from better documentation on: *available resources, capabilities of different aggregates, tool documentation, capabilities of the deployed hardware.*

5. **More bandwidth in the GENI core.** Currently most of the sites are connected with 1Gbps, which is sliced very thinly among multi-site slices. Many times it is hard to get more than 10Mbps between sites.

6. **Federation with new testbeds.** As new tesbeds are being deployed ensure that there are the processes, the mechanisms and the right APIs to allow quick federation both in terms of Authorization/Authentication and in terms of resources (i.e. be able to create hybrid topologies that span multiple testbeds). A good example is the federation work that is

happening with the NSFCloud teams (Chameleon and Cloudlab). Currently several GENI users (both researchers and educators) have successfully used the Cloudlab deployments.

7. **Resource Monitoring.** A user facing service that allows users to get a snapshot of the current status of the testbed (what resources are up or down, what resources are loaded or exhausted, etc).

8. **Consistency across federation.** Basic capabilities of similar resources should be the same (or very similar) across the federation. A good example is the AM API version supported by similar aggregates.

9. **Better control over network characteristics**. Bandwidth limit enforcement, bandwidth provisioning, prioritized traffic, delay, loss.

Enhancements

1. **Dynamic Resource Reservation.** This is brought up by users both for allowing to modify their experiment after reservation and to support large complicated topologies. *"It is still difficult to get large slices to come up completely. This would be less of a problem if it were possible to fix a slice after it has come up", "Adding/removing links, nodes, storage to existing slices when needed"*

2. **Modern Hardware.** In order to be able to support cutting-edge research, the ecosystem needs to constantly be enhanced with modern and/or unique hardware (e.g LTE base station, infiniband, OpenFlow 1.3). This can be achieved a few ways:

   - Hardware refresh of existing infrastructure.
   - Federation with new testbeds.

3. **Stitching to non-GENI resources.** Many time experimenters want to programmatically bring in their experiment unique resources. The support for dynamic cyber infrastructure deployments is essential. Some examples from the past include:

   - Resources deployed within the Internet 2 network.
   - Unique instruments, e.g. a microscope
   - Connectivity to new facilities, e.g. Argonne Labs

4. **Better integration of wired and wireless resources**. Although the current deployments have been designed to tightly integrate the wireless resources with the local GENI Racks there is still a disconnect from the user's perspective when trying to use both type of resources in one experiment and the process is fairly manual. Currently there is some support for account integration through the GENI portal, we still need to develop better tools to make it easy for users to include wireless resources in their wired experiments and vice versa.

5. **Better tooling.** Users have expressed the desire to have better tools available to help them with experimentation. Some areas that are often mentioned are (in order of popularity):

(a) Tools to manage large and complex deployments with the ability to script and orchestrate experiment. Current solutions like LabWiki have been hard to use and most users come up with custom one-time solutions.

(b) Tools to import experiments from other platforms to GENI (mininet, NS3, Amazon AWS, etc).

6. **Support for long running services on GENI.** Some of the issues that are currently faced by users trying to run prototype services on GENI are in order of importance:

   (a) **Lack of dynamic reservations**, ability to change/grow/shrink based on the status of the testbed and the needs of the service.

   (b) **Public routable IPs** on the dataplane, since this is a service it needs to have a way to interface with end users. Most commonly used method today is the use of the control plane.

   (c) **Short and varying expiration times**, which causes inadvertently to loose parts of the deployment.

7. **Advanced reservations** for large experiments or unique resources.

New Frontiers/Capabilities

It is important both to researchers using GENI and to the testbed and systems community engaged in GENI development that GENI continue to support and drive cutting edge networking research and cyberinfrastructure. Acknowledging that there is wide diversity of opinion on which future directions are most promising, the following list identifies some areas where users have indicated strong interest.

- Expand heterogeneity in resources. Include unique hardware like microscopes, radar, sensors, etc. This goal could be achieved by including these items in GENI proper, through federation, or a combination of both.
- Additional focus on enabling low-latency, interactive applications.
- Expand interoperation with new and future testbeds and other cyberinfrastructure systems to expose users to new capabilities and resources. The desired end state here is an agile dynamic fabric (perhaps SDX/SDI-based) that expands the capabilities of each individual system. Some possible focus areas include:
  - Interoperation with HPC facilities.
  - Interoperation with emerging wireless testbeds, including potential city-scale wireless testbeds and IoT-focused wireless testbeds
  - Expanded interoperation with commercial cloud services, such as Amazon Web Services. *"... we would like to include large computational clusters and/or large private data stores within slices owned by [...] users who have [access] to such private resources."*
  - Expanded interoperation with collaborating international testbeds.