Multilayer Network Resilience Analysis and Experimentation on GENI

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Abstract

GENI is evolving to provide a promising environment in which to do experimental research in the resilience and survivability of future networks, by allowing programmable control over topology and mechanism, while providing the scale and global reach needed to conduct network experiments far beyond the capabilities of a conventional testbed. We will use GENI in general, and the GpENI infrastructure (expanding to 40 clusters with 200 nodes worldwide), federated with the larger GENI PlanetLab control framework and interconnected to several ProtoGENI facilities to perform resilience and survivability experiments at scale, both in terms of node count and with the geographic scope needed to emulate area-based challenges such as large-scale disasters. Furthermore, we will use these experiments to cross-verify with analytical and simulation-based resilience research currently underway at The University of Kansas leveraging topology and challenge generation tools (KU-LoCGen and KU-CSM) developed for this purpose, with emphasis on resilience metrics and multi-path multi-realm diverse transport developed as part of our NSF FIND research.

Path Diversity Theory

Given a path: \( P = L \cup N \)

Diversity is defined as:

\[
D(P_i) = 1 - \frac{P_i \cap P_j}{|P_i|}
\]

Path Diversity Example

ResTP
End-to-End Multipath Transport

GENI Testbed:
Including GpENI, ProtoGENI, and PlanetLab aggregates

Diverse Physical Topology:
Multi-ISP fiber topologies with simulated infrastructure attacks

Research Objectives

Cross-verifying the components experimentally:
1. Realistic Topology Generation
2. Challenge Simulations
3. End-to-End Multipath algorithms

Publications


Work in Progress and Future


Implement traffic generators for large transport, CBR, and transactional data using ResTP. Select a set of topologies, both from real ISPs and synthetically generated.

Run a range of experiment cases using traffic generators, emulating random faults, correlated failures, and intelligent attacks.

Cross-verify results with previous simulation studies.

Run long-term experiments using real data over ResTP to analyze its performance given real-world outages in the GENI testbed.

Use of G-Lab/GENI Infrastructure

To perform these experiments, several major parts of GENI are required: the PlanetLab and ProtoGENI control frameworks, along with the GpENI and federated substrate infrastructures. GpENI is an international programmable testbed centered on a regional optical network in the Midwest US funded in part by the NSF GENI program and the EU FP7 FIRE programme, expanding to approximately 40 institutions in Europe (including G-Lab), Asia, and Canada. GpENI is programmable from layers 1 to 7 with DCN (dynamic circuit network) and VINN integrated with the PlanetLab control framework in GENI Cluster B. Additionally, we may be able to exploit OpenFlow capabilities being deployed in GENI. Finally, we will depend on monitoring tools under development by the community to enhance our own experiment instrumentation.

Multi-layer Experimentation

Implement GpENI international Topology

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