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Multilayer Network Resilience Analysis and Experimentation on GENI

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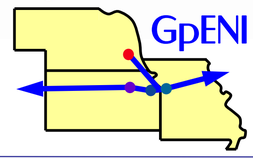


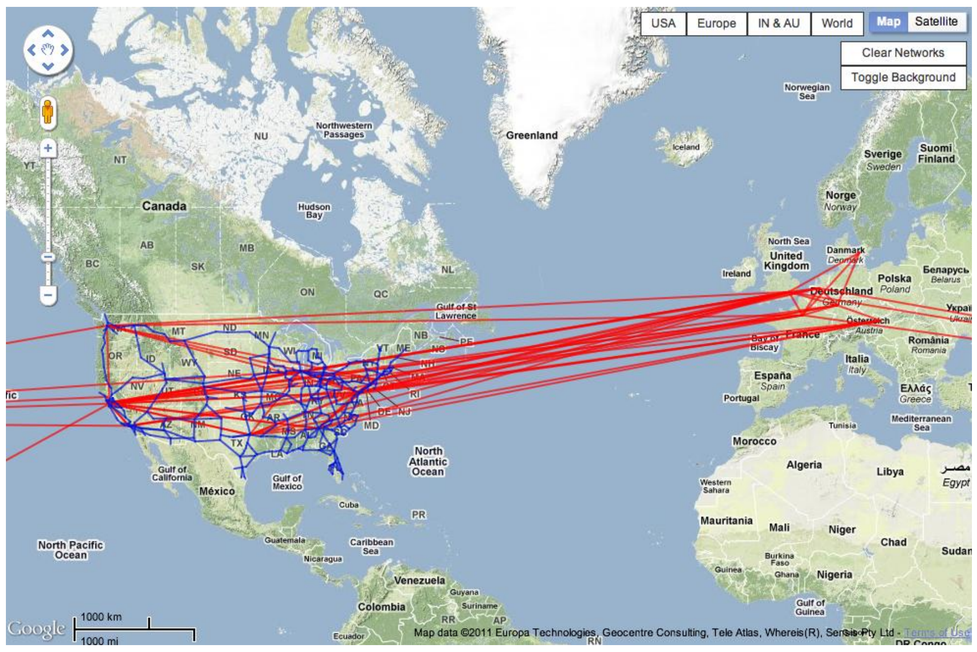
Abstract

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 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.

Research Objectives

Cross-verifying thee components experimentally:

1. Realistic Topology Generation
2. Challenge Simulations
3. End-to-End Multipath algorithms



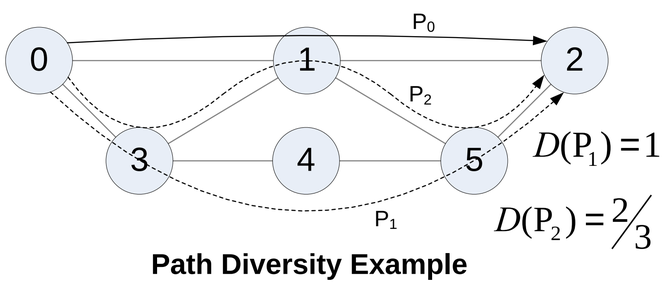
Topology viewer and combiner developed as part of this project using the Google Maps API http://www.ittc.ku.edu/resilinets/maps/

Path Diversity Theory

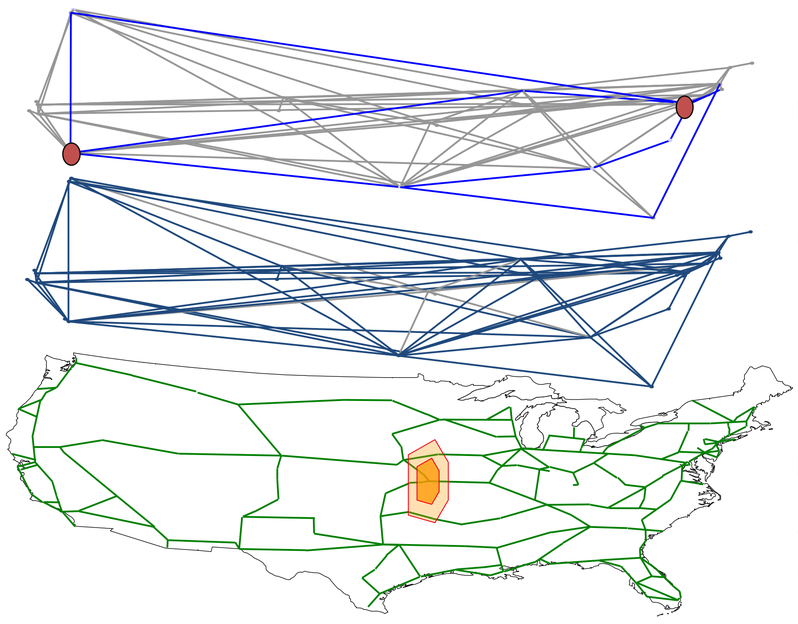
Given a path: $P = L \cup N$

Diversity is defined as:

$$D(P_k) = 1 - \frac{|P_k \cap P_0|}{|P_0|}$$



Path Diversity Example

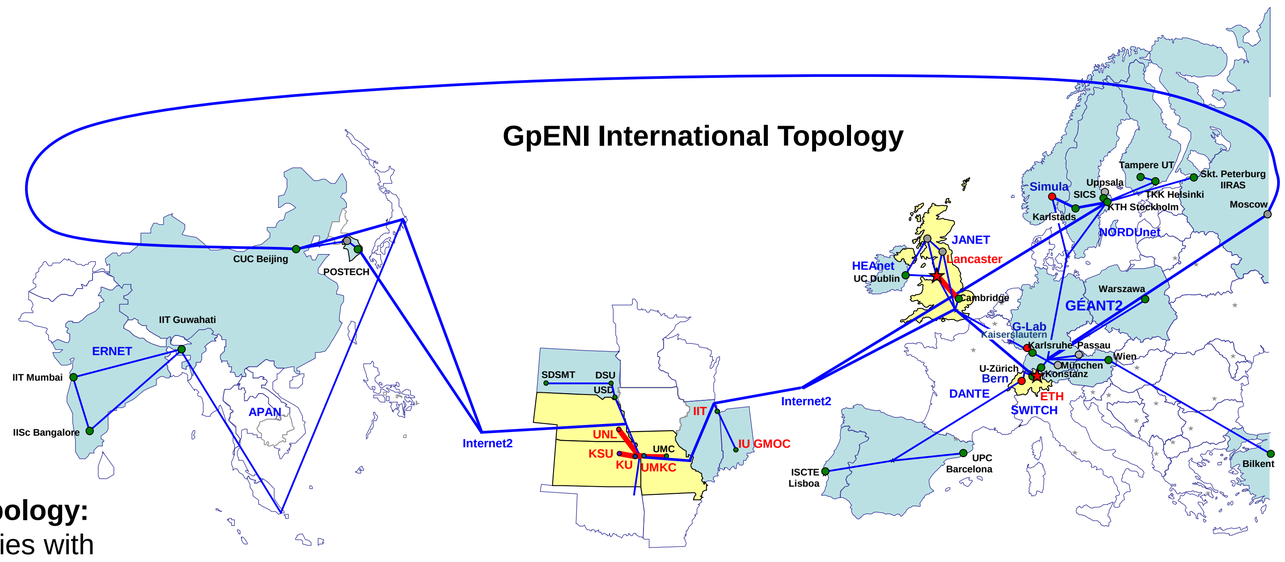


Multi-layer Experimentation

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



Work in Progress and Future

Develop cross-platform diversity routing agent.
Develop topology server and challenge manager.
Implement ResTP in Python.
Implement traffic generators for large transfer, 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 VINI 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.

Publications

James P.G. Sterbenz, Egemen K. Çetinkaya, Mahmood A. Hameed, Abdul Jabbar, and Justin P. Rohrer, “Modelling and Analysis of Network Resilience”, *The Third IEEE International Conference on Communication Systems and Networks (COMSNETS)*, Bangalore, India, January 2011, pp. 1–10.

James P.G. Sterbenz, Justin P. Rohrer, and Egemen K. Çetinkaya, “Multilayer Network Resilience Analysis and Experimentation on GENI”, ITTC Technical Report ITTC-FY2011-TR-61349-01, The University of Kansas, July 2010.

James P.G. Sterbenz, David Hutchison, Egemen K. Çetinkaya, Abdul Jabbar, Justin P. Rohrer, Marcus Schöller, Paul Smith, “Resilience and Survivability in Communication Networks: Strategies, Principles, and Survey of Disciplines”, *Computer Networks: Special Issue on Resilient and Survivable Networks (COMNET)*, vol.54 iss.8, June 2010, pp. 1245–1265.

Justin P. Rohrer, Abdul Jabbar and James P.G. Sterbenz, “Path Diversification: A Multipath Resilience Mechanism”, *The 7th IEEE International Workshop on the Design of Reliable Communication Networks (DRCN)*, Washington, DC October 2009, pp. 343–351.

Ph.D. Dissertation: Justin P. Rohrer, “End-to-End Resilience Mechanisms for Network Transport Protocols”, in progress.

Ph.D. Dissertation: Egemen K. Çetinkaya, “Performance Evaluation of Communication Networks under Challenges”, in progress.

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NSF National Science Foundation WHERE DISCOVERIES BEGIN