I. MOTIVATION

• GpENI
  The Great Plains Environment for Network Innovation – GpENI is an international programmable network testbed centered on a regional network. GpENI has been funded in part by National Science Foundation GENI (Global Environment for Network Innovation) program and the EU FIRE (Future Internet Research and Experimentation) programme. International topology is anchored on Lancaster University in the UK, ETH Zürich and Uni-Bern in Switzerland, C-Lab at Kaiserslautern in Germany, and NorNet at Simula in Norway. Each university has a GpENI node cluster interconnected to one-another and the rest of GENI by Ethernet VLAN, and within KanREN by OpenFlow.

• KanREN OpenFlow
  The KanREN GENI project extends GpENI by adding OpenFlow capabilities within KanREN (Kansas Research and Education Network). KanREN is a logical ring throughout the state of Kansas interconnecting institutions of higher education. Brocade OpenFlow switches have been deployed with production KanREN switches at most of these institutions, as well as in the Ku GpENI cluster with interconnection to the Ku InstaGENI rack from HP. A full mesh OpenFlow overlay is provided over KanREN. The KanREN OpenFlow ring is connected to the GENI cloud through a root switch in Kansas City with the GpENI switch in the KanREN rack in the Internet 2 suite in the Level 3 PoP in Kansas City. This provides OpenFlow capabilities to users of KanREN and the GENI community.

• US Ignite
  US Ignite is a national initiative to prototype and demonstrate new applications that benefit from high-performance and programmable network infrastructure, including that developed as part of Future Internet programs including GENI. We have deployed a telemedicine application as a cooperative effort between KanREN and the KU Medical Center. It assists home care-givers for patients with dementia, and uses GpENI network infrastructure and the KU InstaGENI rack as a private cloud.

II. PROJECT GOALS

• Build a collaborative research infrastructure in Kansas, the Great Plains region, and internationally
• Provide programmable network infrastructure enabling GpENI member institutions to conduct experiments in Future Internet architecture
• Provide a flexible infrastructure to support the GENI program, mesoscale OpenFlow deployment, and GENI rack access
• Provide an open environment on which the networking research community can run experiments
• Develop and conduct network resilience experiments
• Support transport layer protocol experiments and video streaming

III. GpENI and KanREN-GENI TESTBED and EXPERIMENTS

• GpENI Node Clusters
  There are a number of node clusters as shown in Figure 1. Each GpENI node cluster consists of several components, physically interconnected by a Gigabit Ethernet switch to allow arbitrary and flexible experiments. Each cluster consists of the following components: GpENI management and control processor, PlanetLab programmable nodes managed by MyPLC with GENIwrapper SFA sub-aggregate manager, VINT based programmable routers, a managed Gigabit Ethernet switch, and site specific experimental nodes.

• KanREN OpenFlow Deployment
  Universities on KanREN have OpenFlow-enabled switches as shown in Figure 2. A full mesh OpenFlow topology is available as an OpenFlow overlay. Ring topology is used in the OpenFlow switch experiment. As shown in Figure 3, the blue dots represent the Brocade OpenFlow switches and green lines the links. The red polygon represents the challenge region.

• KanREN OpenFlow Experiment
  Eight OpenFlow switches deployed in the KanREN network are used in the challenge emulations. The network links and nodes that have been challenged are shown in red. The traffic originates from Lawrence, KS and Wichita, KS to Pittsburg, KS. When the challenge takes down Wichita – Pittsburg and Lawrence – KC link each time in our two challenge scenarios, the traffic reroutes around the failure regions and we present the average delay to reroute. Floodlight OpenFlow controller is used and installed at Lawrence, KS.

• Sprint Physical Network Experiment
  The experiment begins with reading adjacency matrix for different physical topologies and create Mininet experiments automatically with realistic delay and bandwidth configurations. OpenFlow switches are used to represent network node in the physical topologies (topology data from KU-TopView). Sprint physical topology is used in this experiment with nodes shown in red and links in green. The traffic originates from Seattle, WA to New York City, NY and Los Angeles, CA to Miami, FL. When the regional challenge occurs at Chicago and later at Dallas, the traffic is rerouted around the challenge and the new path is calculated by the controller. Floodlight OpenFlow controller is used in this experiment. We plot the delay it takes to reroute the traffic.

IV. TCP VARIANTS EXPERIMENTS

• TCP Variants Comparison
  The topology includes two servers with one switch connecting them. The link from the source to the switch is 1 Gbps while the link for the destination is 100 Mbps with the total round-trip time of 100 ms. Traffic is sent using iPerf from the source to the destination via the OpenFlow switch and TCP result is recorded using TCP probe module. We present the throughput comparison among Illinois, Cubic, and YeAH.

• MPTCP Experiments
  Four coupled congestion control algorithms LIA, OLIA, BALIA, and WVegas are compared in case of link failure for MPTCP. Two paths are used with round-trip time 32.4 ms and 50.4 ms and the total run time is 100 s. Path 1 is mostly used while little traffic is on path 2. Challenge occurs to path 1 at 30 s and the traffic is pushed to path 2. The challenge stopped at 60 s and it lasts 10 s for the traffic to shift back to path 1.

V. REFERENCES