Project Summary

A wide range of applications in the nascent field of cloud computing and in other fields require stable, low-delay wide-area connectivity together with capabilities of co-scheduling network and server resources. As a result, both research-and-education network providers (e.g., Internet2 and ESnet4) and commercial providers (e.g., AT&T and Verizon) have recently started to deploy scheduled dynamic circuit services (SDCS) as a complement to their IP-routed and leased-line service offerings. Under such services, corporations, universities, research laboratories and other enterprises connect to their SDCS provider networks via SDCS-access links, and then, on an as-needed basis, place scheduling requests for a fixed-rate circuit lasting for a fixed duration, for either earliest possible usage or scheduled usage at some point in the future.

While carrying significant potential impact, SDCS are currently limited by the centralized nature of their architectures. As a result, they provide little support for dynamic routing and scheduling of circuits across administratively heterogeneous domains. This lack of adequate support for inter-domain routing represents a major hurdle to the full-scale deployment of SDCS. The main objective of this project is to tackle this challenge by devising distributed solutions supporting scheduled dynamic circuit services across domains. The proposed work entails pursuing fundamental research both at the theoretical level and at the protocol design level, consistent with the complementary expertise of the PIs in this area.

Intellectual Merit. The proposed research consists of two inter-related thrusts: (i) algorithms and theoretical analysis; and (ii) protocol design and implementation. The first thrust focuses on the problem of designing distributed routing algorithms for SDCS that provably converge and provide performance guarantees on user-performance metrics (e.g., delay and blocking probability). It entails investigations of fundamental associated challenges, such as loop prevention, support for path switching and multi-path routing, and resiliency to failures. It also aims at developing theoretical benchmarks against which the performance of a practical routing protocol can be compared. The second thrust focuses on the design, development, and prototyping of such a protocol, referred to as the scheduled circuit routing protocol (SCRP). Key challenges in the design of SCRP include: (i) how to efficiently aggregate and disseminate information pertaining to future availability of network resources (e.g., link and path bandwidth) over a long time horizon;; (ii) how to minimize control-plane message overhead while maximizing data-plane performance. Extensive simulations and Emulab experiments will be used to validate SCRP operations.

Broader impact. The development of an inter-domain routing infrastructure for scheduled dynamic circuit services promises to impact a wide range of high-throughput and real-time applications belonging to various fields, ranging from medical to scientific to commercial. Industry outreach will be achieved through a collaboration with Juniper Networks. In particular, Juniper will make a large collection of virtual machines running the JunOS operating system available for the project’s teaching and research activities. Under an international collaboration with Dr. Amir Karniel, a Faculty member at Ben Gurion University of the Negev, Israel, the PIs plan to demonstrate the ability of SCDS to support innovative remote haptics applications enabling users to transparently manipulate remote objects as if they were placed in their own hands. Undergraduate students will be engaged in real testbed experiments of these technologies.

Key Words: High-Speed Networking; Resource Allocation and Management; Graph Theory and Algorithms; Joint Routing and Scheduling; Testbed and Implementation.