

Project Summary.

The emergence of the Internet has not only changed many aspects of our day-to-day life, but also rearranged research priorities in many disciplines, in particular computer science. New paradigms of computation lead to viewing the network itself as a computer and require an understanding of computation distributed across a large-scale and unstructured networks, whose many nodes are capable of performing computations independently.

In this proposal, we focus on problems related to networks that are highly dynamic, changing over time as nodes or the objects they hold (e.g., files, services) join, leave or move within the network. For example, a distributed hash table maintains information about a dynamic set of objects in a network and requires a decentralized protocol that uses little memory per node, but that keeps track of the copies of the objects that may be created, moved or destroyed at any time. An even more basic problem in dynamic scenarios is *routing*, where all that is sought is a way to efficiently send packets from any source node to any destination node. In both location and routing problems, tradeoffs arise among the different cost measures. A further complication is presented by the possibility of node or link failure, be it simple “crash” failure, or an adversarial one.

Major goal of the proposed research: *We propose to design locality-sensitive distributed protocols for maintaining location services and routing schemes in dynamic networks and in the presence of node failures, including Byzantine failures.*

Intellectual Merit. The proposed work builds upon the PIs’ existing work in distributed location services and compact routing, and leads to locality-sensitive location and routing schemes in highly dynamic networks and in scenarios where fault-tolerance is important. Despite a lot of effort, location service and routing problems are still wide open in the highly dynamic settings proposed here, and the increase in difficulty from static to dynamic scenarios is such that the dynamic scenario is really a completely new problem. Similarly, the step towards tolerating Byzantine failures is likely to involve completely new techniques. Several new problems are proposed, motivated by questions on fundamental properties of computation and communication in distributed networks.

Broader Impact. The PIs’ earlier work on distributed object location has been integrated in real-world system. Since the proposed research focuses on more realistic scenarios but problems just as important, in all likelihood it will lead to implementations and systems of wide applicability. The research will be integrated into classroom teaching by introducing new concepts in undergraduate and graduate algorithms courses. The development of new courses will contribute to the better training of students at ASU. Besides supporting graduate student research, the PIs will involve undergraduate students in research through the supervision of independent studies and honor-college theses. The PIs expect that through this project, they will be able to continue their successful mentoring and retention of minority and female students, especially women undergraduate and graduate majors in computer science and in particular in the area of network algorithms. The proposed work will advance our understanding of the structure of networks that we rely on in everyday life, and improve efficiency and reduce the vulnerability of computer networks and applications, thus contributing towards the development and deployment of secure network applications and infrastructure. Hence, this proposal will impact not only the CS Algorithms, Networking and Systems communities at large (and that includes the NSF SING and GENI initiatives), but also all the diverse communities (from banking to social networks, for example) which increasingly rely on secure and robust communication network infrastructures for their most basic tasks.