Distributed Network Computation

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Distributed computation studies a distributed network of computers interconnected via communication links. My research focuses on various fundamental theoretical questions in distributed computation: (1) How fast can we compute in a distributed network? (2) Can we design networks that can “heal” themselves? (3) How to compute efficiently in highly dynamic networks?

We have developed new techniques for showing powerful lower bounds on fundamental distributed computing problems using the theory of communication complexity. For the first time, these techniques give a uniform approach to derive non-trivial lower bounds for a wide range of important network optimization problems such as minimum spanning tree, shortest paths, minimum cut, etc. It improves upon and subsumes previous seminal results in distributed computing lower bounds. Another key contribution is lower bounds for distributed verification: we show tight lower bounds for many verification problems including spanning tree, connected spanning subgraph, Hamiltonian cycle, shortest path tree etc. We have significantly extended and generalized our techniques to quantum distributed computing as well.

My research has resulted in efficient distributed algorithms for a variety of fundamental distributed computing problems. We designed the first algorithms for performing random walks efficiently in a distributed network. Our algorithms have applications in various distributed computing tasks which use random walks as a subroutine. In particular, we demonstrate applications to computing a random spanning tree and to decentralized computation of spectral properties. We have also developed fast distributed random walk algorithms in dynamic networks, resulting in fast algorithms for information dissemination in dynamic networks. Other main contributions are almost-optimal algorithms for gossip-based aggregate computation, efficient gossip-based discovery algorithms for distributed and social networks, and efficient distributed algorithms for computing distance sketches.

We have developed the first localized algorithms for designing self-healing networks that preserves the spectral properties of the underlying network. Such an algorithm can be a building block for designing large-scale networks that can withstand failures.

We have developed a rigorous framework for distributed computation in highly dynamic networks (such as peer-to-peer networks). For the first time, we have provably efficient algorithms for fundamental problems such as agreement, search, storage, and random walks in dynamic networks.

Selected Publications:


Prof. Gopal Pandurangan is affiliated with the Division of Mathematical Sciences, Nanyang Technological University, Singapore. He is also a visiting faculty at the Department of Computer Science, Brown University, USA. Earlier he has held positions at Purdue University, USA, and Rutgers University, USA. He has a Ph.D. from Brown University, Masters from SUNY Albany, and B.Tech. from IIT Madras. He is a senior member of the ACM and IEEE.