Enhancement of Network Resilience with Optimizing Topologies

By

Prof. Akira Namatame
Dept. of Computer Science, National Defense Academy, Japan

www.nda.ac.jp/~nama

Date: 11 April 2013, Thursday
Time: 3.00pm to 4.00pm
Venue: MAS Executive Classroom 1 (MAS-03-06)
Host: Asst. Prof. Cheong Siew Ann

Abstract

The increasing scale and complexity of networked systems has necessitated an approach for network resilience and robustness. Since the network topology has a direct impact on performance such as resilience and robustness, a mechanism of self-control is also an important and immediate requirement. The network topology is the most fundamental network property on which self-control is deployed, and the control over the topology has a direct impact on network performances. The network topology impacts on failure spread in networks. The issue of enhancing network resilience could be analyzed with optimizing the underlying network topology.

Network science has attracted considerable attention over the last decade. Two principal approaches have contributed to understanding complex networks so far. The first is an assembly mechanism that derives the structure of large-scale networks from processes that describe the piecewise addition of nodes and links according to simple heuristic rules such as preferential attachment. The second approach is via an optimization principle that aims at optimizing network performance through its evolution. Traditionally, optimization has a strict mathematical definition, which refers to obtaining the solutions that strictly specialize a well-defined function. Here we adopt a looser definition by extending it to include a tendency of the network to improve its performance as a result of evolution. We define metrics on network robustness and resilience and formulate multi-criteria network optimization problems. We use generic algorithm (GA) to solve these optimization problems and obtain optimal network topologies. Many real-world problems are complex with a very large parameter space. Accordingly, most attempts for finding the best solution are not realistic. In stead, finding a good enough solution or a better solution in an iterative manner becomes alternative.

Both the most susceptible network and the least susceptible networks to cascading failure are obtained using generic optimization and their network topologies are characterized and these networks are characterized. The least susceptible network to minimize cascade failure or systemic risk in financial networks is characterized as a core-periphery network. Such a core-periphery network consists of a partial complete graph of core nodes and stub nodes connected only to the core nodes.

We also obtain the most susceptible network to cascade failure. The most susceptible network is characterized as an onion-like network, in which nodes with similar degrees are more likely connected. However the most susceptible network to cascade failure has the highest robustness to random and intentional node attack.

Short Biography

Dr. Akira Namatame is Professor of Computer Science Department at National Defense Academy of Japan. His research interests include multi-agent systems, complex networks, evolutionary computation, and game theory. In the past ten years he has given over 30 invited talks, and over 10 tutorial lectures in international conferences and workshops, and academic institutions. He has organized more than 20 international conferences and workshops, and special sessions. He is the editor-in-chief of Springer’s Journal of Economic Interaction and Coordination (JEIC), editor in Modeling and Simulation Society Letter. He has published more than 250 refereed scientific papers, together with eight books on multi-agent systems, collective systems and game theory. More detail information can be obtained through www.nda.ac.jp/~nama.

College of Science
Nanyang Technological University
SPMS-04-01, 21 Nanyang link, Singapore 637371
Fax: +65 6515 8229 Tel: +65 6513 8459