Analysis of Robustness for a Japanese Business Relation Network by Percolation Simulation

Hirokazu KAWAMOTO[1], Hideki TAKAYASU[2,3], and Misako TAKAYASU[1]

[1]Department of Computational Intelligence and Systems Science, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology, 4259-G3-52, Nagatsuta-cho, Midori-ku, Yokohama 226-8503, Japan.
[2]Sony Computer Science Laboratories, 3-14-13, Higashigotanda, Shinagawa-ku, Tokyo 141-0022, Japan
[3]Meiji Institute for Advanced Study of Mathematical Sciences, Meiji University, 4-21-1 Nakano, Nakano-ku, Tokyo 164-8525, Japan

[1]kawamoto@smp.dis.titech.ac.jp

Abstract

We apply percolation theory to a business relation network in Japan, which is composed of about 3 million links among 300,000 firms. First, we explain the indicator which can measure robustness of each node by estimating the probability to be included in the critical cluster at the percolation threshold. Next, we show the basic properties of this quantity and discuss its applicability.

Keyword: Complex Network, Percolation Transition, Robustness, BtoB, Big Data

Intensive studies are now on progress about the complex network of business firms consisted of millions of links, which is characterized by a power law distribution of link numbers as shown in Fig.1. A network evolution model is proposed considering elementary processes such as new entry, mergers and bankruptcy [1]. Money flow on the network is also an attractive target of scientific study [2,3]. Also, network robustness under random removal of nodes or links are discussed [4].
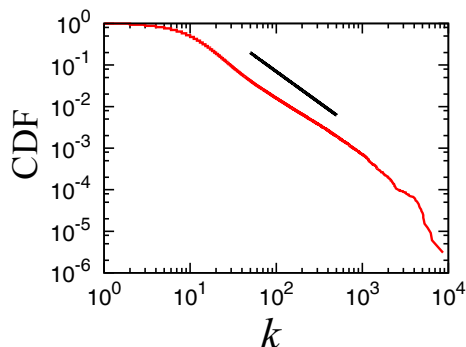

Figure. 1. Cumulative distribution of the number of links per node k.

Percolation theory is the standard base for study on robustness of networks such as electrical power networks and neural networks [5,6]. In this study, we investigate robustness of the business relation network by using percolation theory.

First, we introduce the indicator which can measure robustness of each node by estimating the probability to be included in the critical cluster at the percolation threshold. Next, we analyze statistical properties of this indicator to show that this quantity is quite independent of already known quantities which have been introduced for characterization of complex networks. Finally, we extract characteristic structure and discuss robustness in Japanese business relation network.

References

[1] W. Miura, H. Takayasu, and M. Takayasu, Physical Review Letters, vol. 108, p. 4, 2012.

[2] H. Watanabe, H. Takayasu, and M. Takayasu, New Journal of Physics, vol. 14, p. 16, 2012.

[3] K. Tamura, W. Miura, and M. Takayasu, International Journal of Modern Physics: Conference Series, vol. 16 (2012) 93-104.

[4] E. Viegas, M. Takayasu, W. Miura, K. Tamura, T. Ohnishi, H. Takayasu and H.J. Jensen, Complexity vol.18, 34 (2013).

[5] S. V. Buldyrev, R. Parshani, G. Paul, H. E. Stanley, and S. Havlin, Nature, vol. 464, pp. 1025-1028, Apr 2010.

[6] I. Breskin, J. Soriano, E. Moses, and T. Tlusty, Physical Review Letters, vol. 97, p. 4, Nov 2006.