Statistical Models and Algorithms for Assessing Robustness and Reliability of Networks with Applications in Cybersecurity Insurance

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Abstract

Modern cyber systems and computer infrastructure for commerce and communications, such as cyberspace, the Internet, electronic payment systems, and file-sharing systems, can be represented as complex networks. Cybersecurity insurance is one of the possible ways to manage risk exposure for these complex cyber networks. For the pricing of cybersecurity insurance, comprehending the loss of availability of a cyber or physical network subject to attacks or failures and assessing the risks of a complex network is of great interest. To understand the risk of complex networks, we propose a modified Wiener process model for the degeneration of the network functionality upon removing nodes due to attacks or malfunctions. We also propose three statistical testing procedures based on the Wiener process model to compare the risk and resilience of two different networks, which can be used to compare risks in the cybersecurity insurance domain. The proposed methodologies can be applied to any topological measures of network robustness or risk. Practical data analysis for the peer-to-peer file-sharing networks and the Enron email network are presented to illustrate the proposed model and methods. Monte Carlo simulations are used to evaluate the performance of the proposed methodologies, and practical recommendations are provided.