

Network Science and Complex Social Systems: Analysis and Applications

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Many real-world systems can be modeled as networks, a group of vertices linked together in pairs by edges. Here the vertices represent individuals and the edges represent the interactions between the individuals. Studies have shown that the connection pattern, in other words the topological feature of the network, is crucial to the statistical properties of the system.

The study of network science can be divided into two main subjects: how the rules of individual behavior change the connection pattern, and how the connection pattern affects the system behavior. This thesis mainly focuses on how the networks evolves under certain rules and further resolves two specific problems.

The first and most important contribution of this thesis is that we provide an analytical result which describes the size and structure of any intermediate state of the network in the pruning process of the K-core decomposition. K-core decomposition is a well-known algorithm that has been used in thousands of papers by scientists from a broad range of research fields. It also exhibits interesting critical behaviors of interest to physicists. Our theoretical results are both practically meaningful to the application of the algorithm and also valuable to the theoretical study of critical phenomena.

The second contribution of this thesis is the study of the evolution of stationary networks that have relatively stable size and density. We develop a simple preferential attachment model and later find its application in a real-world email network. Analysis proves that such a network will follow an exponential distribution which is in agreement with the real-world data.

The rest of the thesis present two works studying social problems from the perspective of complex systems. We analyze the stable marriage problem and study a few variations of the Gale-Shapley model. We also use quantitative methods to study the citing patterns of scientists, the results can help to identify high quality papers.

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