

Simulating Social Network Formation: A Case-Based Decision Theoretic Model

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ABSTRACT

Social networks depict complex systems as graph theoretic models. The study of the formation of such systems (or networks) and the subsequent analysis of the network structures are of great interest. For information systems research and its impact on business practice, the ability to model and simulate a system of individuals interacting to achieve a certain socio-economic goal holds much promise for proper design and use of cyber networks. We use case-based decision theory to formulate a customizable model of information gathering in a social network. In this model, the agents in the network have limited awareness of the social network in which they operate and of the fixed, underlying payoff structure. Agents collect payoff information from neighbors within the prevailing social network, and they base their networking decisions on this information. Along with the introduction of the decision theoretic model, we developed software to simulate the formation of such networks in a customizable context to examine how the network structure can be influenced by the parameters that define social relationships. We present computational experiments that illustrate the growth and stability of the simulated social networks ensuing from the proposed model. The model and simulation illustrates how network structure influences agent behavior in a social network and how network structures, agent behavior, and agent decisions influence each other.

Keywords: *Case-Based Decision Theory, Information Technology, Mathematical Simulation, Social Networks*

INTRODUCTION

A social network consists of a set of agents, which represent individuals or organizations, and a set of arcs which connect the network

agents. Social network theory suggests that these connections provide each agent with social capital and that the attributes of individuals are less important than their relationships and ties with other agents within the network. Modeling the formation of such networks allows us to study between- and within-organizational phenomena from a new perspective by not only

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focusing on the value of each agent but also on the value of the agent's connections.

In the current study, we introduce a case-based decision theoretic model of social network formation, which allows us to simulate the interactions between agents and their social environment, resulting in their networking decisions. In our approach, the network structure captures the dynamics of decision situations. In addition, sensitivity analysis and proper adjustment of network parameters provide results that can lead to insights about the structure of many real-world networks. Each agent observes its neighbors in the network and derives an evaluation of the value of the various links that the agent can engage in. Thus, the agent's network environment acts as its knowledge base for making networking decisions.

Complementary approaches to developing plausible models of social network formation, such as the p^* models suggested in the social science literature, offer valuable contributions; however, these methods estimate model parameters using an *observed network* as a static framework on which one can then use statistical procedures to determine how well the model represents the data (for a tutorial see Robins, Pattison, Kalish, & Lusher, 2006). We propose in this article, using an illustrative example, that we can analytically develop models of endogenously forming and adapting social networks where the agents are prescribed to behave in a certain way given their incentives and payoffs. Then, computationally, we can adjust model parameters to model the expected behavior of agents in specific social structures.

Social network structures can be designed using the particular setting of various parameters. Different parameters, such as the benefit of forming links and the costs associated with link formation and maintenance, result in different structures. For example, a network structure may be scale-free where any sample of nodes has properties that describe the whole network. On the other hand, a network structure may have some nodes with many links (high status flow) and some others with very few links (low status flow). The status flow describes, for instance,

why a start-up company involved with a strategic alliance with a well-recognized company instantly gains legitimacy. The structure of the network and the properties of the participating agents may describe policy formulations resulting in desired network interactions and agent behavior. For example, agents with weaker alternatives in a social network (i.e., low status flow) would benefit from a more constrained structure, especially if they can be the conduit of communication (e.g., department secretary), while those endowed with stronger alternatives (e.g., company CEO) would do well to work within a more public communication structure that promotes bidding (Bolton, Chatterjee, & McGinn, 2003). Recently, a laboratory experiment showed that varying the communication links causes sharp shifts in both the coalitions that form and the profits earned by individual bargainers in a social network (Bolton et al., 2003). We develop a theoretical framework to illustrate a network formation process and show how adjusting network connections and incentives to connect can result in networks with different sensitivities to a set of underlying network parameters.

In addition to viewing a social network from a status flow perspective, a social network can be viewed as a network where each node has some information that others do not possess (i.e., information asymmetry). From this perspective, the dissemination of information across a network of agents and the analysis of the impact of perceived costs and benefits of this distribution is the key focus. This information flow perspective proposes that key factors that influence the seeking of knowledge in a network are knowing what the other agent knows (i.e., peripheral knowledge), valuing what that agent knows, the ability to gain timely access to that agent's thinking, and perceiving that seeking information from that agent would not be too costly (Borgatti & Cross, 2003).

An individual's decision choices often depend on the forces which operate within the social network that connects him to others. Each agent is then, in this regard, not viewed as an isolated decision maker but as a node within

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