Simulating Tolerance in Dynamic Social Networks

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ABSTRACT

This paper studies the concept of tolerance in dynamic social networks where agents are able to make and break connections with neighbors to improve their payoffs. This problem was initially introduced to the authors by observing resistance (or tolerance) in experiments run in dynamic networks under the two rules that they have developed: the Highest Rewarding Neighborhood rule and the Highest Weighted Reward rule. These rules help agents evaluate their neighbors and decide whether to break a connection or not. They introduce the idea of tolerance in dynamic networks by allowing an agent to maintain a relationship with a bad neighbor for some time. In this research, the authors investigate and define the phenomenon of tolerance in dynamic social networks, particularly with the two rules. The paper defines a mathematical model to predict an agent’s tolerance of a bad neighbor and determine the factors that affect it. After defining a general version of tolerance, the idea of optimal tolerance is explored, providing situations in which tolerance can be used as a tool to affect network efficiency and network structure.

Keywords: Dynamic Networks, Neighbor, Rule, Social Networks, Tolerance

INTRODUCTION

In multi-agent systems, different agents aim to achieve different goals, yet must develop some system of cooperation within the system (Axelrod, 1997; Davidsson, 2002). In this research, the systems of social networks (Epstein, 1999; Watts, 1999; Newman, 2003) are of particular interest to us. In such systems, all agents are self-interested and try to maximize their own utility. This can be done by adjusting their strategy or by adjusting their environment and disconnecting from agents while making connections with others. These systems can be governed by pre-determined rules to control individual decision making and social interactions. The existence of a basic network model, such as random network, small-world network (Watts, 1999), and scale-free network (Newman, 2003), couple with some economic game, provides a network of self-interested agents with specific goals, and the application of individual decision making rules and social interaction rules make the network dynamic, resulting in questions about the final network structure, such as stability, efficiency, and tolerance.

The current research in this direction occurs on two different levels: a low-level decision that an agent must make to determine its game

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strategy, and a higher-level decision to change the links in the network, and, ultimately, the overall network structure. Most of the current research uses the static network so only the low-level decision is achieved, i.e. the agents can only change their own actions but not other agents that they are connected to. Here a network will be called static if edges are never created or removed after the generation of the graph. Static networks may well model social behaviors in a relative stable environment such as a community where people barely move around and always keep the same relationships to others.

Our research focuses on dynamic networks that the edges are created and removed as the network evolves. Therefore in our system, both the low-level decision on agent’s individual actions and higher-level decision on agent’s social interactions are considered to help agents maximize their utility. The dynamic network approach can model many dynamic systems such as behaviors in social network service (SNS) where agents frequently change their relationships to others. Examples include the friendship networks of high school students (Fararo & Sunshine, 1964), the network of citations between scientific papers (Redner, 1998), links between web pages on the World Wide Web (Albert & Barbasi, 2002) and network of human sexual contact (Liljeros, Edling, Amaral, Stanely, & Aberg, 2001).

In dynamic social networks, several social interaction rules have been developed to improve agents’ decision-making processes so that they break off connections with agents that are not beneficial. One of these social interaction rules is called the Highest Weighted Reward (HWR) in order to give agents the ability to update their neighborhood in a social network (Wu & Zhang, 2009). The HWR rule weighted recent rewards from a relation more than that of the long-time-ago rewards. Agents’ decision about whether to keep a relationship or not is based on if the weighted rewards is greater than the weighted average reward earned from every relationship. Adopting the HWR rule, one can easily transform a classic static network into a dynamic network with few restrictions on how agents observe their neighbors and how agents make the decision about when to keep an existing connection or disconnect it so they can connect to a new neighbor. A special case of the HWR rule is when the weight is 1 so all previous interactions are weighted as the same in agent’s current decision. We call this special case another rule – the HRN rule (Highest Rewarding Neighborhood) (Zhang & Leezer, 2009).

In the HWR rule, some degree of tolerance between agents has been noticed. That is, an agent may not break off a connection with a harmful neighbor. We call this phenomenon tolerance. The primary goal of this study is to develop a full understanding of tolerance in social networks and its effects. We will first provide models to predict tolerance in the social networks that use the HWR rule. Once these have been established and confirmed, our goal will be to develop further conclusions about tolerance in social networks: we will compare the developed models and study the effects of tolerance in social networks to develop an understanding of how control of tolerance in a dynamic network can be used.

Tolerance is one of the newest problems being discussed in dynamic social networks. By studying the causes and effects of tolerance in social network models, it can be consciously used in the development of new social interaction rules, rather than simply being a side effect of many rules with no determined cause. This paper studies tolerance in networks in two main areas:

1. Identification of the cause of tolerance in the social network model.
2. The development of a mathematical model to describe tolerance and apply results to a network simulation.

The paper is structured as the following. We first give a literature review of tolerance in fields of social psychology and provide other backgrounds of dynamic networks, individual decision rules, and social interaction rules. Then we introduce both the HRN rule and the HWR rule that lead to the phenomenon of tolerance...
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