An Agent-Based Model of Insurance and Protection Decisions on IT Systems

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ABSTRACT

This paper discusses the key role of incentives in information systems security. Vulnerabilities can be reduced, and even removed, if individual motivations are taken into account in the process of protection and insurance design. The article first discusses the importance of externalities, free-riding behavior, uncertainty and the incentives mismatch between individuals and organizations involved in information systems security. Previous works perform this study using a game theoretical approach but the paper shows that an agent-based model is capable of including the heterogeneity and interrelations among individuals, not focusing on the reached equilibrium but on the dynamics prior to its emergence.

Keywords: Agent-Based Social Simulation, Agent Based Model, Artificial Social System, Economics of Security, Incentives, Insurance, Inter-Agent Interaction, Protection

1. INTRODUCTION

Over the last few years, research about economics of security has built interdisciplinary links and produced valuable common viewpoints from unexpected sectors. Security is becoming a multidisciplinary research topic that crosses academic borders (Anderson and Moore, 2009). The role of incentives is becoming as important as the correct design of computing systems in order to be trusted by potential clients. Agent-based models is one of the tools that allows simulating and predicting the behavior of agents and the system as a whole. It is possible to introduce the appropriate decision-making process and incentives scheme to produce a result and to explore the process dynamics.

To improve the security level of systems, engineers use many different mathematical techniques, including concepts extracted from game theory and microeconomic theory. Agent-based models have not yet been applied to this research area. However, most of the conclusions in previous works highlight the importance of agents’ behavior. For example, the level of security of a system depends on the effort of designers and users to keep the system safe. In the same

DOI: 10.4018/IJATS.2015070101
way, testing results depend on the effort of all the testers to provide valuable results. Therefore, the vulnerabilities of systems are closely-tied to activities conducted by the less-caring developer of the system (Anderson and Moore, 2006). Nonetheless, the authors suggest that under some circumstances, the vulnerabilities can also depend on activities performed by the individuals who usually perform relatively well during development of a system. In their opinion, the role of incentives on human behaviors should be studied from an economic perspective. However, effects of decisions on the rest of the users should also be taken into account, as it is assumed in a game theoretic approach (Grossklags et al., 2008a).

When a user invests in protection, other users also benefit from this action as it reduces their possibility of being attacked. Then, investments have a positive externality on the rest of the members of the system. At the same time, a selfish user does not have to have taken into account this externality when she chooses her security investment level. The security result of the network as a whole is suboptimal most of the cases (Jiang, 2009; Kunreuther & Heal, 2003). According to Anderson (2001), in addition to the technical part, information security involves power relations, trade barriers and market segmentation with product differentiation. Asymmetric information and moral hazard are the two main concepts in this regard. As soon as regulators eliminate bad incentives, other organizations will be prone to create new ones. The model presented in this work deals with information transmission and management, and how agents decide to invest in their protection.

The next part focuses on the interdependency of users in systems and the effects of externalities and, then, adequate incentive schemes to mitigate free-riding behavior are discussed, which incentives are convenient to promote the exchange of information about security and, finally, the role of uncertainty in security decisions is studied. With these findings, the third section claims that a game theory approach might not be sufficient to cover these aspects and propose an agent-based modeling as a novel approach to information systems security. Finally, it is concluded that an agent-based model is capable of including in its design the most important aspects related with security and offers a framework to simulate the behavior of users under different scenarios.

2. ROLE OF INCENTIVES IN INFORMATION SYSTEMS

In this section the main findings of economics of security applied works are reviewed and it is discussed how these issues may be included within a game theory framework and how they can be incorporated into an agent-based model.

2.1. Users Interdependency

Clearly, security investments by one user might reduce the dissemination of virus and other malware. One of the characteristics of network systems is the positive externality of security investments. Network security depends not only on the sum of individual security investments of the members but also on the interdependencies among them. Indeed, when a user does not care about the protection of her system the dissemination of malware becomes easier. On the contrary, when a user invests in her protection, then other users are positively affected as their infection risk is reduced. Consequently, any investment undertaken by the users has a positive externality for other users (Jiang et al., 2011). Users do not take into account this externality when they choose their investment level and, therefore, security of the whole system will be suboptimal. In a non-cooperative environment, each user tends to choose her investment level in order to minimize both the risk and the cost of security (Jiang et al., 2008). This behavior often
Norm Emergence with Biased Agents

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