Group and Reputation Modeling in Multi-Agent Systems

Ari Halberstadt [1], Lik Mui [2]

[1] 9 Whittemore Road, Newton, MA 02458, USA
ari@magiccookie.com
http://www.magiccookie.com/
[2] MIT Laboratory for Computer Science, 200 Technology Square, Cambridge, MA 02139
lmui@lcs.mit.edu
http://www.lcs.mit.edu/

1 Introduction

In our formal framework [1] the reputation for agent *b* in agent *a*'s mind is *a*'s estimate of the probability that *a* will approve of *b* in the next encounter between them.* Reputation can be used within distributed systems as a representation for reliability measures in multi-agent systems [3,4,5].

2 Model

Boyd and Richerson (1988) and Tirole (1996) have considered groups in the context of game theory. Their group models are simple aggregations of agents with no obvious relationships among groups. We introduce a hierarchical tree model for groups in which agents can belong to multiple groups. Groups possess parameters that affect the behavior of member agents. These parameters include: member group size, interaction probability for members within the group, and probability for a non-participant agent to observe an encounter between agents. Observers are agents who do not participate in an encounter but instead record the participants' actions and outcomes of an encounter[5]. Each agent has its own perception of individual agent and group member actions. Agents maintain interaction histories of other individual agents, and use these histories to ascribe reputations to individual agents and to groups of agents for varying contexts. Agents use strategies in combination with observations for decision making. For encounters between agents in different groups, we introduce the concept of shared group environment. This shared environment is the least common ancestral node for the involved agents in the group hierarchy.

3 Simulations

The prisoner's dilemma is a well known framework for the study of cooperation[9]. In our simulations, we apply repeated prisoner's dilemma encounters over multiple generations to randomly selected pairs of agents. In each generation, a new population of agents is created based on the fitness of agents in the preceding generation.

---

* Definitions of reputation and related quantities can be found in Ostrom, 1998.

Tit-for-tat (TFT) can be an evolutionarily stable strategy (ESS) against always defecting agents when the probability of interaction among TFT agents is sufficiently high[9,10]. We explored the effect of group reputation — measured as the proportion of cooperations over the total number of encounters for a given group as observed by an agent — on TFT population size. In absence of group reputation, TFT population size decreases when each generation consists of 10,000 encounters. By introducing group reputation, TFT population size can increase, as shown in figure 1, even with a much smaller number of interactions per generation.

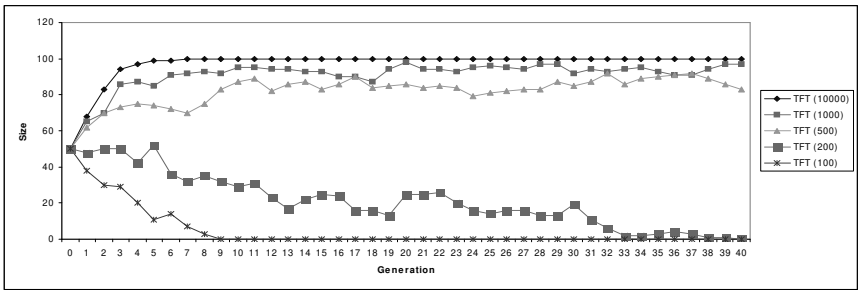

Figure 1. Effect of group reputation on evolution of TFT population size in simulations with two types of agents: TFT and all-defecting agents. In each encounter, agents were paired randomly from the total population. The number of encounters per generation (shown in the legend) was varied in each experiment while the total population size was fixed at 100 agents. Above certain number of encounters per generation, the use of group reputation by TFT agents makes them resistant to attacks by all-defecting ones [8,9,10].

We have also studied the effect of the following parameters on population size of TFT agents and that of defecting agents: individual reputation, probability of interaction, number of observers per encounter, and the probability of observation by an agent.

References

1. Mui, L., Mohtashemi, M., Ang, C., Szolovits, P.: Collaborative Sanctioning for Distributed Systems. MIT LCS Memorandum, 2001
2. Ostrom, E.: A Bahavioral Approach to the Rational-Choice Theory of Collective Action. American Political Science Review, 92(1), 1998, pp. 1-22
3. Glass, A., Grosz, B.: Socially Conscious Decision-Making. Autonomous Agents, 2001
4. Yu, B., Singh, M. P.: A Social Mechanism of Reputation Management in Electronic Communities. Cooperative Information Agents' 2000
5. Zacharia, G., Maes, P.: Collaborative Reputation Mechanism in Electronic Marketplaces. Proc 32nd Hawaii International Conference on System Sciences, 1999
6. Boyd, R., Richerson, P. J.: The Evolution of Reciprocity in Sizable Group. Journal of Theoretical Biology, 132, 1988, pp. 337-356
7. Tirole, J.: A Theory of Collective Reputations (with Applications to the Persistence of Corruption and to Firm Quality. The Review of Economic Studies, 63(1), 1996, pp. 1-22
8. Nowak, M. A. and Sigmund, K.: Evolution of Indirect Reciprocity by Image Scoring. Nature, 393, 1998, pp. 573-577
9. Axelrod, R.: The Evolution of Cooperation. Basic Books, New York, 1984
10. Maynard Smith, J: Evolution and the Theory of Games, Cambridge University Press, Cambridge, 1982