Tag-based Model for Knowledge Sharing in Agent Society (Extended Abstract)

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ABSTRACT
In this paper we discuss a tag-based model that facilitates knowledge sharing. Sharing the knowledge incurs a cost for the sharing agent, and thus non-sharing is the preferred option for selfish agents. Through agent-based simulations we show that knowledge sharing is possible even in the presence of non-sharing agents in the population. We also show that the performance of an agent society can be better when some agents bear the cost of sharing instead of the whole group.

Categories and Subject Descriptors
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence| Multiagent systems

General Terms
Algorithms, Design, Experimentation, and Human Factors.

Keywords
Cooperation, Altruism, Tags, Simulation and Artificial Society.

1. INTRODUCTION
Both human and animal societies have an innate ability to operate in groups. Our concern in this paper is to experiment with tag-based mechanisms, where groups are formed using tags. Members that belong to a particular group share their skills with other members of the group. To start with, not all members in the society might be skilled in performing a task, and also not all members that possess the skill might want to share. We investigate how to make knowledge sharing possible even in the presence of non-sharing selfish agents in the population. In equitable societies, it is always best to share the cost of communal services. But, in some cases, it is best for an individual to bear costs rather than dividing the cost to the entire society. In this work we demonstrate one such example where the whole society is better off when some individuals bear the sharing cost.

2. EXPERIMENTAL MODEL
Our model presented here is a social interaction model, where agents play a game called the knowledge-sharing game. Having 'a piece of precious information' is considered to be knowledge in this work. For example, the information about the food source or possessing a skill can be considered to be the knowledge which directly relates to the fitness of an agent. Non-sharing is the selfish option which benefits the individual but not the society. Sharing benefits the society by spreading the knowledge, which improves the overall wealth of the society. Sharing does cost the donor who shares but not the receiver who receives the benefit. As the donating agent spends some time and effort in the process of donating, it incurs this cost. The agent could have decided to be selfish and hence conserve that cost. Donation costs the donor, and the donor does not get anything in return. Donations reduce the wealth of the donor, which reduces its survival and reproduction chances. The parameters of the experiment are Knowledge (K), Sharing (S), Wealth (W) and Tag (T). Knowledge (K bit) could be 0 or 1. If K=1, the agent possesses the knowledge, otherwise it does not. Sharing (S bit) could be 0 or 1. If S=1, the agent is willing to share, otherwise it does not. Wealth (W) could be 1 or below. When the agent initially possesses the knowledge, its Wealth is set to 1. But each time it shares the knowledge, it losses 0.1 from its Wealth. Tag (T) is a string of binary bits. Agents with same tag belong to same group.

Cite as: Tag-based Model for Knowledge Sharing in Agent Society, (Extended Abstract), Sharmila Savarimuthu, Maryam Purvis, Martin Purvis, *Proc. of 8th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2009),* Decker, Sichman, Sierra and Castelfranchi (eds.), May, 10–15, 2009, Budapest, Hungary, pp. 1299–1300

2.1 Experiment and Result
Among 100 individuals at the outset, half are sharers (S=1), and half are not (S=0). Every player is randomly assigned a tag which is a 3-bit string (000, 001…). The population has 8 (2^3) tag groups. Out of 100 individuals initially 20 have knowledge (K=1) to start with, hence they have the wealth score of 1 for possessing knowledge. The agents in the experimental setup are of 4 different types. **Type K+S+:** agents with knowledge, do share (K=1, S=1). **Type K-S+:** agents without knowledge, do share (K=0, S=1). **Type K+S-:** agents with knowledge, do not share (K=1, S=0). **Type K-S-:** agents without knowledge, do not share (K=0, S=0). All the 8 groups get random distributions of these 4 types of players. In this game, players are randomly paired and are made to interact. Sharing happens only if their tags match (they only share with their fellow group members) and when one player (player1) has the knowledge and the tendency to share (K=1, S=1) and the paired player (player2) is without knowledge (K=0). The player who acquires the knowledge gains the wealth score 1. 1 is the maximum value of wealth that a player can have at any time in this game. Thus, if a player received the knowledge once, its wealth value can never surpass 1. Sharing the knowledge does cost the donor (0.1) in terms of wealth. Each time it shares, it loses 0.1 from its wealth. The receiver gets the wealth benefit of 1 without incurring cost. From the individual agent's perspective, it is better not to share, so that it can keep its score high and increase its survival chances. But for the overall society's welfare, it is good to share. The game is played with 100 players over duration of 1000 iterations. In each iteration, every player gets to play the game once as a donor (player1) and once as a receiver (player2). The conversion process at the end of each iteration works in the following way. 10% of the population is picked randomly, paired and compared by wealth score. With every pair the high scorer in wealth gets the chance to convert the low scorer to its tag group. If both players are of same wealth, one of them gets to convert by random selection. Up to this part it is the same mechanism as explained in the work [1]. The current work differs in the following steps where conversion takes place. The winning agent converts the losing agent by adding the agent to its group. The converted agent does not have the knowledge (K=0) when joining the new group and it retains its original behavior (S bit). Since it

loses to another agent, it joins the winner's group. The new agents acquire knowledge when they interact with other agents in the population that have knowledge and also have the tendency to share their knowledge. By this process, after each iteration 5% of the population get converted and thus the total population has a steady state with a value fixed at 100. In our results, when we say 'knowledge is sustained' it refers to the agent population where more than 85% of the agents have the knowledge and also the knowledge is passed on to the newcomers which are being converted in every iteration. Our current results show that the knowledge could be sustained in the population even with the presence of selfish agents. It is an interesting result since the society sustained knowledge all the time (100% as opposed to 16% in previous work [1]). Results from a sample run are presented in figure 1. It is shown that the number of sharers is always 50 (S line) and the knowledge is sustained (K line) in the society. It was observed in [1], that the knowledge sharing is achievable only with the absence of non-sharers. A sample result is shown in figure 2 where the number of sharers increased and the whole population is full of sharers, hence the knowledge is sustained. The change in the algorithm is made in the conversion phase where the new member agents retained their behavior and inherited the tag, instead of inheriting the behavior of the high scorer with tag as presented in the previous work [1]. In the current work, the newcomer retains its own behavior and inherits the tag, but not knowledge. If the newcomer is a non-sharer it comes to the new group as a non-sharer. If it is a sharer, it comes as a sharer. Both these cases are advantages in the current mechanism. If a sharer comes to the group and receives knowledge from an existing sharer in this group, it starts sharing within the group as well. If a non-sharer comes to the group and receives knowledge from an existing sharer in this group, its wealth becomes 1. As it never shares, its wealth is high, and it converts other players and brings new members to this group. That is the reason that the number of sharers and non-sharers remained the same, but still the knowledge sharing was made possible and was sustained and passed on for future generations.

3. EXPERIMENT ON COST SHARING

We have also experimented on individual vs. group cost bearing. In the setup explained in 2.1, the sharer who shares always pays the cost for donation which reduces its wealth. So we have used a different mechanism where the cost should not be incurred individually by the sharer alone but by everyone in the group. Everyone's wealth is reduced by *cost/n* where *n* is the number of members. We experimented with both of these cost bearing mechanisms to find which is better. We tested 2 types of cost bearing with 2 sets. Each set has 4 groups. They play the knowledge sharing game within their group. Out of 8 groups, 4 play with individual cost sharing (set 1) and 4 play with group cost sharing (set 2). We wanted to know which one is better. Except for having 2 sets having different cost bearing mechanisms, everything else is the same as explained in 2.1. Our results showed that groups from set 1 become the winner every time. It is because when the cost is shared just by a sharer during a game, only one person's wealth is reduced; hence its survival chance is low. It could be converted to another group if it gets picked against a wealthier player. In the other case where the cost is shared by everyone in the group, everyone loses a little of their wealth when every time there is a sharing in the group. It makes the whole group weaker and the members are prone to be converted when playing against the wealthier player. In this experiment we have noticed that the individual cost bearing is effective. This is because only few people lose their wealth by bearing the cost and others who are not sharing the cost are stronger and they convert weaker players from other groups. So always the winner is a group from the set 1 which ended up with all the players getting converted to its group and sustained the knowledge. In summary, it was good for the society to have some people who could sacrifice for the well being of the group instead of everyone in the society contributing to cost sharing.

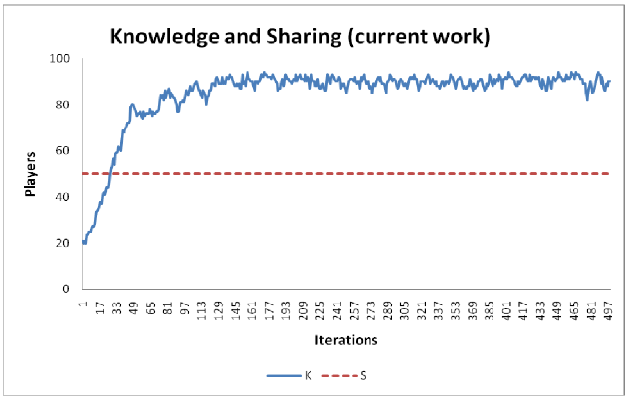

Figure 1: The K line shows the knowledge and the S line shows the sharing.

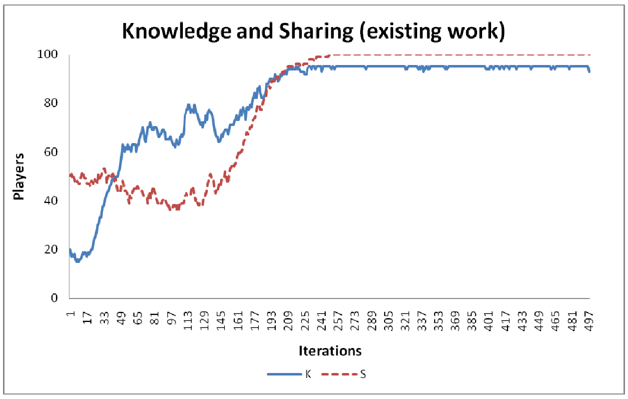

Figure 2: The K line shows the knowledge and the S line shows the sharing.

4. CONCLUSION

In this paper we have presented our results about how a society could share and sustain knowledge even in the presence of selfish agents that are present in equal proportions. We have also showed that bearing the cost individually is a better option than bearing it across the whole group. For future work we consider having multiple knowledge within the society. For more details see [2].

5. REFERENCE

[1] Savarimuthu, S., Purvis, M. A., Purvis, M. K., "Emergence of Sharing Behavior in a Multi-agent Society using Tags", Proceedings of IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2008). (in press).

[2] Savarimuthu, S., Purvis, M. A., Purvis, M. K., "Tag-based Model for Knowledge Sharing in Agent Society", Discussion Paper 2009/01. Department of Information Science, University of Otago, Dunedin, New Zealand. (Unpublished)