Towards Collective Learning for MAS

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1. INTRODUCTION

Learning issues in Multi-Agent Systems (MAS) is essential to allow agents to adapt to the environment and environment's changes. Several researches on this field have proposed a set of different learning mechanisms for agents. For instance, neural networks, reinforcement learning and some modifications of them allow agents to learn individually. In other words, agents learn by themselves by interacting with the environment with no influence of other agents. In this case, the search space is higher as the number of agents and the complexity of the model is increased. As a consequence, even though several possibilities can be evaluated, the time required for accurate evaluation is highly increased. This mechanism is used when considering heterogeneous agents. More sophisticated implementations provide knowledge exchange capabilities. In this case all agents are homogeneous and they exchange the strongest rules they have learned. Under this circumstance, it may speed the learning time due to the fact that the search space is reduced. However, this reduction of the search space may cause the elimination of some important characteristics of the environment.

These two types of mechanisms are useful, but they fail in problems, such as rescue of lives in disasters, where the environment is highly dynamic, information is limited, immediately response is required, number of agents is considerable and agent's specialization is necessary. In this kind of situation, a sort of organizational learning is required.

For this reason, in this paper, a collective learning mechanism for MAS is proposed. It consists on grouping agents in communities in each of which all agents share knowledge (rules), increasing the learning speed of agents in the community. Also, the creation of groups provides the capability of keeping diversity. Finally, in a certain time, common behaviors between communities are analyzed in order to obtain general behavior required for every agent. This mechanism is implemented in XCS [1].

2. COMMUNITY OF PRACTICE BY XCS

2.1 Concept

The community of Practice by XCS (COPXCS)[4] was inspired by the concept of community of practice [2] in organizational theory. Community of practice consists of grouping people who share similar goals and interests. In pursuit of these goals and interests, they employ common practices, work with the same tools and express themselves in a common language. Through such common activity, they come to hold similar beliefs and value systems. In other words, they learn collectively. Members of an organization may participate in several communities according to their interests and responsibilities, improving the organizational knowledge and therefore, the performance of the organization.

Agents are grouped in communities, according to the similarity of tasks they should perform, improving learning accuracy and speed. The learning is performed in three levels as showed in Figure 1.

1. *Individual level* (Individual Learning): Agents learn independently by using XCS as learning mechanism
2. *Group level* (Knowledge Exchange within communities): In each community, agents exchange their most valuable knowledge (rules with higher strengths). These rules are inserted in all community members with neutral strength initialization due to the fact that good rules for one agent may not be good for another.
3. *Collective level* (Knowledge Exchange between communities): Useful knowledge

obtained in every community is exchanged between communities, generalizing some global knowledge that is required for every agent in the system. The reason is that necessary experience for every agent may not be learnt in some communities due to lack of learning opportunities.

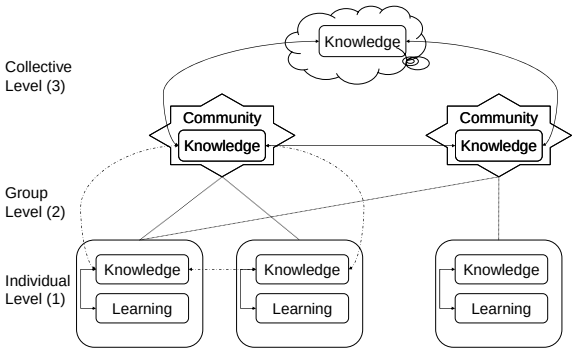

Figure 1. Learning mechanism based on community of practice. Learning takes place in three levels: individual level, group level and collective level.

A variation of the maze problem was employed to evaluate the performance of the proposed method. For details, see [4].

3. CONCLUSIONS

This paper presents the COPXCS as an organizational learning algorithm for MAS based on the concept of community of practice in organizational theory. The learning takes place in three levels: (1) individual level, (2) group level, and (3) collective level. Experimental results showed a good performance of the proposed algorithm. Further research based on more sophisticated problems will be considered. Additionally, adequate criteria for grouping agents will be analyzed. Finally, the concept will be applied with other learning mechanisms.

4. REFERENCES

[1] Butz, M. V., Kovacs, T., Lanzi, P. L., and Wilson, S. W., "Toward a theory of generalization and learning in XCS," *IEEE Transactions on Evolutionary Computation*, 8, 1 (Feb. 2004), 28- 46.

[2] Wenger, E. C., Snyder, W., Pfeffer, J., Sutton , R., and Brown, J., *Harvard Business Review on Organizational Learning*, Harvard Business School Press, 2001

[3] Sutton, R. and Barto, A., *Reinforcement Learning: An Introduction*, MIT Press, 1998

[4] Leon, Y., Takadama, K., Shimohara, K. and Katai, O., "Community of Practice under Learning Classifier Systems," in Ninth International Workshop on Learning Classifier Systems (IWLCS), 2006 (to appear)