Hierarchical Adaptive Cooperation for Emergency Response

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Problem

In emergencies, such as earthquakes, terrorist attacks, fire, biochemical spills, a rapid and organized response is vital.

A number of agent-based (robots) technologies have been used for emergency response. However, an efficient level of teamwork is critical in such situations, where these is uncertainty about the environment as well as the connections and teamwork with other agents.

Motivation

The ultimate goal is to achieve optimal performance within a limited time. Thus, we design an adaptive algorithm which allows an agent to choose individual initiatives, versus multiagent team initiatives.

Contribution

We first analyze the factors which affect teamwork performance. Through this analysis, we provide a new concept of a super agent which provide team level granularities, in order to avoid certain constraints arising in the dynamic topologies, yet decrease the computation complexities among the agents. Here, we design an hierarchical adaptive cooperation algorithm (*HACA*) to automatically form a topology to achieve optimal performance.

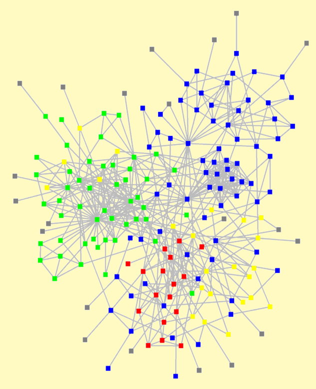
Open Questions

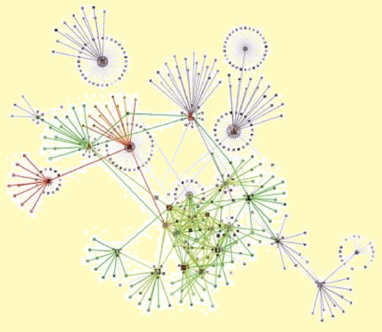
Initial experimental results of our HACA give promise to this new concept of super agent adaptive learning. This adaptive learning can provide the knowledge needed to various levels of agents in this hierarchical organization. Wisely choosing teamwork will give multiagent learning an important component to achieve an optimal performance within reasonable time in a dynamic environment.

Factors that affect team work

What are the factors in a teamwork situation to determine the overall performance?
Our research focuses on investigation of the following:

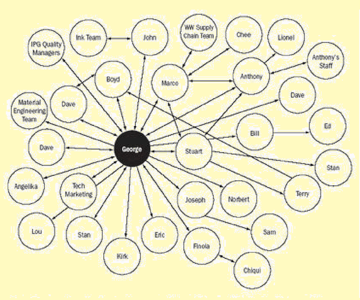
1. density ratio of each agent's connections with its neighbors;
2. choice of connection topology: random, chain, or cycle.

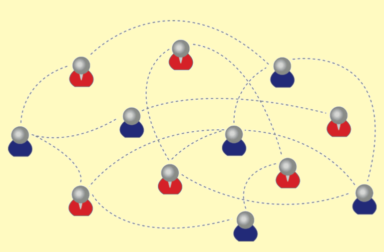




We propose to analyze how topology can affect team performance in a cooperative environment, and to what extent this topology affects team rewards, and why, and how can we free the rewards constraints from the dynamic topologies.

In DCEE (Taylor et al. 2010), an ad-hoc network example shows that "teamwork can be harmful". However, team group performance on social networks is not affected by network topology, such as cliques, pair-cliques, ring, and random graph (Mason and Suri 2010). In DCEE, certain solo moves appear in team work, which decrease the overall reward.

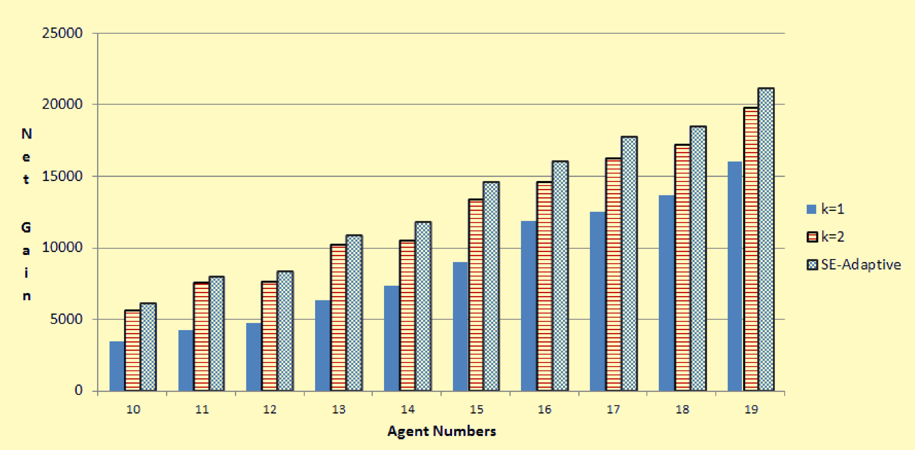




In social networks, there are more contributions from each individual, more engagement in a group, and is thus better for everyone. However, the connection among the group members brings in another issue: why contribute, when one can get a free lunch? Social networks are driven by individual rewards; how to use this motivation to improve team rewards is our next research topic.

Initial Results

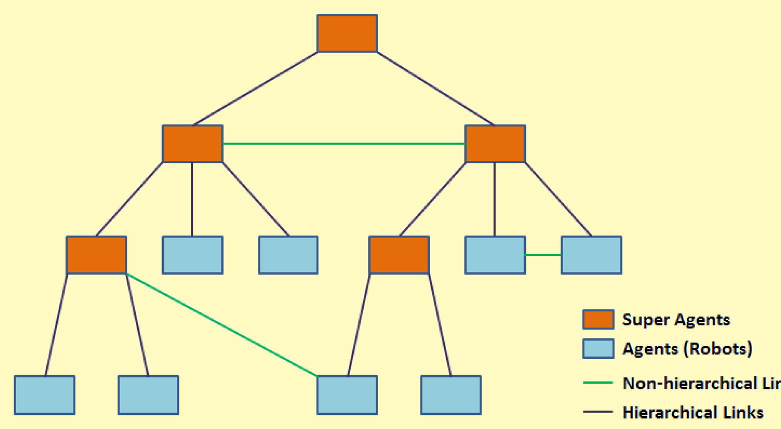
Figure combines a maximum dense topology and a minimum connection topology in one graph, where the HACA algorithm can choose a level of teamwork based on the neighbor connections and gives the best performance among the three. In a group of agents, $size$: 10-19, the result shows that the average of net gain obtained by HACA algorithm is higher than the average net gain of using either k=1 or k=2 only one at time alone, but with much less time consumption.



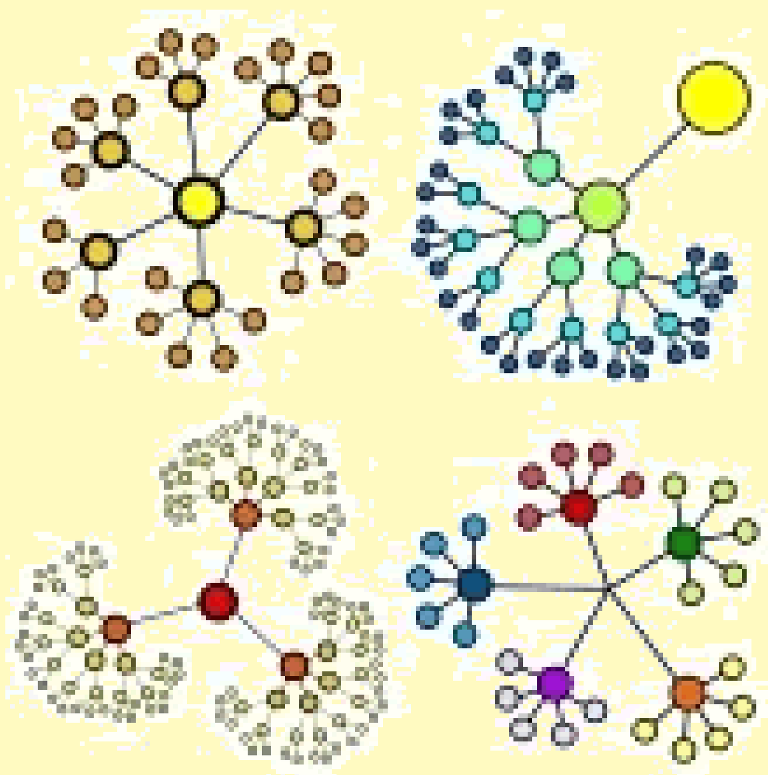
Super Agents

To answer the question 'what level of teamwork is needed' and 'what type of role is required', we will develop super agents in this multiagent environment.

- First, address the time issue along with teamwork computation. In teamwork, multiple agents tend to work together and achieve an optimal, equilibrium gain; however, the combinatory computation grows exponentially along with agent numbers.
- Second, a super agent organizes and shares knowledge among its group of related agents.



We create this virtual super agent to represent a dense group of agents (as a higher hierarchical level team leader). Within this group, each agent performs alone; while among super agents, negotiation is performed to achieve the best rewards for its group.



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Acknowledgements

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