Evaluation of an Agent-Mediated Social Network

Taneem Ibrahim, Aaron Arthurs, and Henry Hexmoor
: Dept. of Computer Science and Computer Engineering,
Engineering Hall, Room 340A,
University of Arkansas,
Fayetteville, AR 72701
{tibrahi, ajarthu, hexmoor}@uark.edu

Abstract

The goal of this work is to design and implement an agent-based system that facilitates interaction among a group of individuals who are part of an organization, observe types and frequencies of interaction from which we can draw some conclusions about nature of social interactions among individuals and the group, and automate interaction via agents who represent their human counterparts. The resulting system is a test-bed to model a variety of knowledge aware environments but is independent of any domain. Our test bed model is a 50x50 grid, where we randomly place a large number of eggs. Agents collaborate with each other or work independently to capture all the eggs. We show that when agents work in a team they achieve the maximum output as a whole. These findings may also suggest a prevailing model of trust among agents.

1. Introduction

Collaboration is commonplace in human activity and increasingly in agent-only and human-agent teams. Collaborative technologies are typically considered to fall into three areas: facilitating communication, enhancing information sharing, and improving coordination. These technologies range from real time as in the case of shared visualization tools to asynchronous as in the case of shared databases. Generally, to date, these tools are passive and the initiative for collaboration remains with the human users. Fields such as Computer Supported Cooperative Work (CSCW) and Knowledge Management (KM) explore human motivations for collaboration and produce methods that lead to development of collaboration tools. Furthermore, it is not always known why and how computer systems can act effectively as collaborators. Current computer systems lack capabilities required for working successfully as useful and time ly collaborators.

The larger goal of this work is to design and implement an agent-based system that (a) facilitates interaction among a group of individuals who are part of an organization, (b) observe types and frequencies of interaction from which we can draw some conclusions about nature of social interactions among individuals and the group, (c) automate interaction via agents who represent their human counterparts. We have implemented domain independent system and used it as a test-bed to model a variety of knowledge aware environments. For experimentation, we devised a possible domain where a group of individuals, each with a unique identity, to work on their own to capture Easter eggs scattered on a 2-dimensional grid, say a 50 by 50 grid. Individuals can move one square at a time and if they are next to an Easter egg, they can grab it. Individuals cannot occupy the same square. Easter eggs are numbered and each person sees the entire grid with locations of all available eggs. As eggs are gathered by individuals, they disappear from the grid. Individuals do not know location or target egg of other individuals. They may attempt to communicate with specific individuals or broadcast a message to others if they wish. They may announce their own location, suggest teaming (sharing an egg and working together to capture it), break a teaming arrangement, a new egg to be pursued, etc. Messages may contain false information.

In this paper, we describe the design architecture of the agent mediated system, and draw conclusions form the experimental results of the strength of the agents' social network.

2. Background

Steve Marsh contributed the earliest works on trust in multiagency [4]. More recent theories of trust in multiagency are found in [2]. A model of trust based on opinions of other agents, their reputation and experience is found in [7]. Michael J. Prietula [6] has recently developed a trust model to study the emergence of multi-agent "trusted information structures" in a group setting. that incorporates emotion in the trust model [6]. Our trust model is similar [1]. Prietula and Carley [6] performed experiments to determine the effects of trust and rumor on rational cooperative agents. In our project, each agent's task was to collect easter eggs from a 50x50 grid board. In this process, we first experimented with a single agent trying to collect all eggs on the board and then we experimented with multiple agents of upto five. The target was to prove that when multiple agents are working together, they form a strong trust network and at the end also collect eggs faster than they would individually.

3. Design of the Agent Mediated System

The system is an agent oriented software package that allows users to interactively search a 10x10 grid for Easter eggs. As the eggs are picked up, points are awarded, Figure 1. As the user searches diligently for an Easter egg, he/she will be competing against other users using the same server. The user will be able to locate his exact location on the grid and the location of all the eggs. However, the user will not be informed of the other players' locations. Although the user will not be able to visually see where the other players are, the user will be able to communicate with the other players via peer-to-peer instant messaging. These instant messages will then appear on a group-facilitated whiteboard. All messages from all users will appear on the whiteboard. The game board will be constructed with a real time graphical user interface. As the game continues, an application exists that allows the user to keep a record of all the transactions that take place within the system. The heart of this application is the server. The server keeps track of the game state and authorizes moves requested by clients. While the user is on the game interface, he/she will have the freedom to move all around the board. However, the user will not be allowed to pick and place the desired location. The user may only move one square at a time. Also, the user may send one direct message to another player or to all players. If the user wishes to have communication with multiple players, the user must use the whiteboard. The game ends when all the eggs have been collected. At the end of the game, the points will be tallied and the winner will be named.

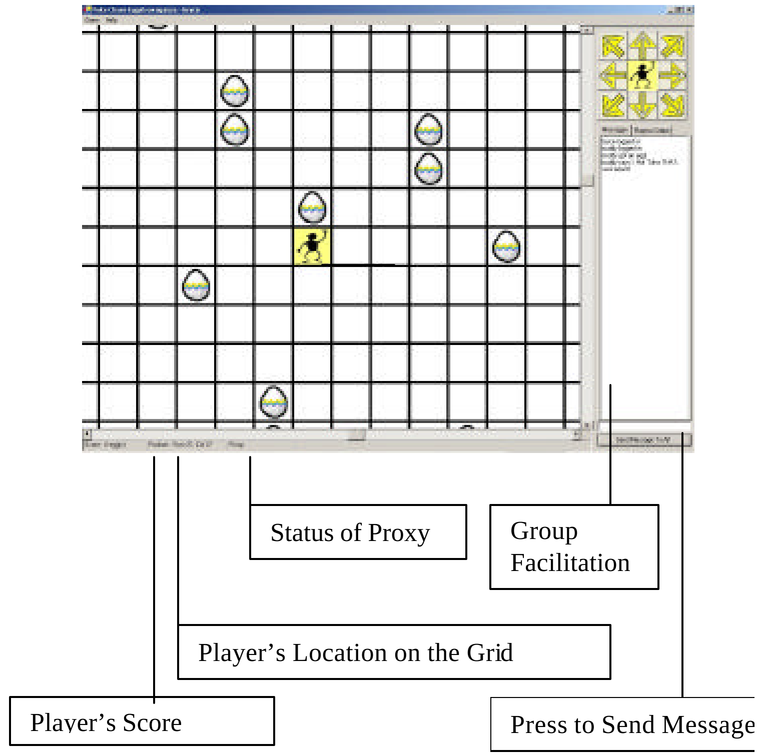

Figure 1: Snapshot of the Game Application

4. Proxy Agents

The proxy agent represent users to continue play of the game without being physically present. The proxy agent acts as an "autopilot" for game play. It makes decisions on how to go about capturing eggs, and it communicates with other users or agents in the game.

Each proxy is setup by each user to determine how it will make decisions and communicate with others. The user opens the "proxy agent settings" window and chooses which mode the agent will operate under. The available modes are the following:

Passive – The agent targets "stray" eggs, eggs that not close to other eggs. The agent accepts all requests made from other players.

Aggressive – The agent targets the closest egg to its current position. It does not communicate with other players and will not accept any request from other players.

Greedy – The agent targets groups of eggs. This agent communicates with others and makes and accepts or rejects requests to and from other players based on information given to it by the Matchmaker agent.

Once a mode has been selected for the agent to operate under, it considers data which it collects from different parts of the game, which we will call its "senses". The agent has physical or local senses and speech or remote senses. The physical senses include things that can be detected without using information from other players (egg positions, current position on the board, score, etc.) The speech senses are picked up from communication with other players through use of the chat and whiteboard. For instance a player may post to the whiteboard that it is targeting a specific egg, and the proxy agent will be able to parse the message and determine that a specific egg is being targeted by another player. The following are some examples of the types of senses that will be implemented.

Physical Senses

- Egg positions
- Current position
- Score

Speech Senses

- Eggs targeted by other players
- Other player's stats (score, position, etc.)
- Identify a request from another player

The agent gathers information from its senses and, depending on which mode it is in, completes an action which corresponds to the information. The following are some of the actions that could possibly be performed by the agent.

Actions

- Directional moves (up, down, left, right, etc.)
- Target an egg
- Post message to whiteboard (e.g. "I'm targeting this particular egg…")
- Make/Accept/Reject a request

Requests are made from player to player and each request has three actions associated with it: a player can make a request to another player, a player can accept a request made by another, or a player can reject a request made by another player. There are no "conditional" requests meaning that each request, when accepted, can be fulfilled in only one way. Some examples of requests that could me made are as follows.

Requests

- request a player move to a particular space on the board
- request a player move in a particular direction
- request to know a players stats (score, position, etc.)
- request to know which egg the player is targeting

5. Experimental Results

In order to conduct the research, we set up the agents to play against each other across a network of five computer stations. First, we experiment with a single agent playing the game. Then consecutively we experiment with two, three, four, and five agents. The time it takes to capture all the eggs in the grid is directly proportional to the number of agents. Therefore, when the agents are working in a team they tend to outperform the agents who are working alone. For instance, while trying to capture 100 eggs on the grid, it took 180 seconds for a single agent to capture all 100 eggs, whereas a team of five agents captured all 100 eggs in 70 seconds Figures 2 and 3. There is a huge performance difference in these runs. This suggests a prevailing model of trust among agents. The human user can also benefit from a meta-communication control mechanism as in the case of U.S. Air Force's Rotorcraft Pilot's Associate (RPA) [3]. While the pilot is interacting with the associate, the associate can be instructed to alter its perceptions and intentions.

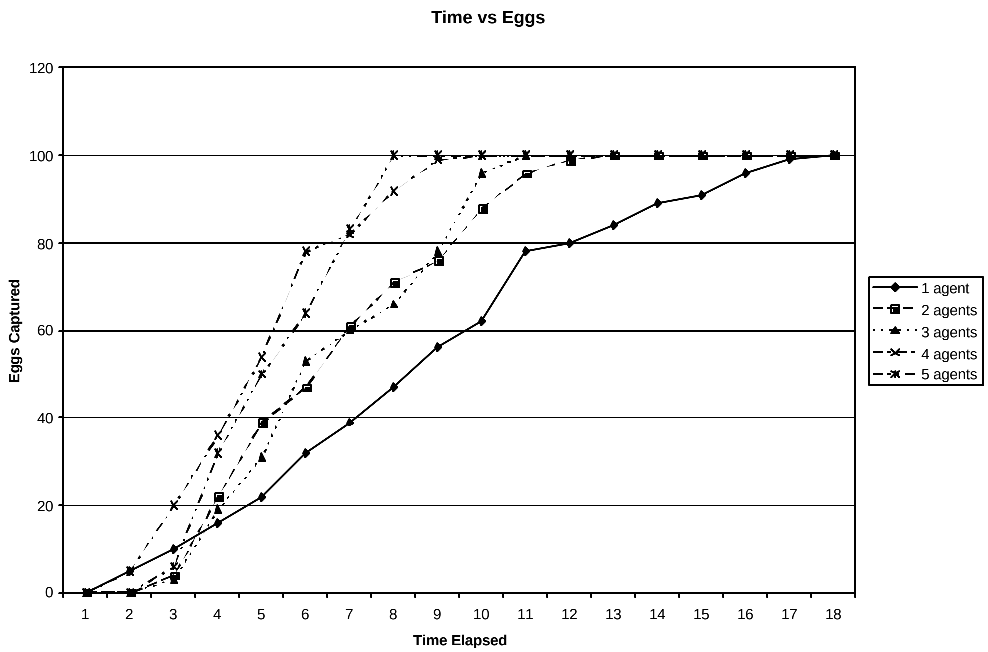

Figure 2: Performance of Agents with 100 Eggs on the Grid

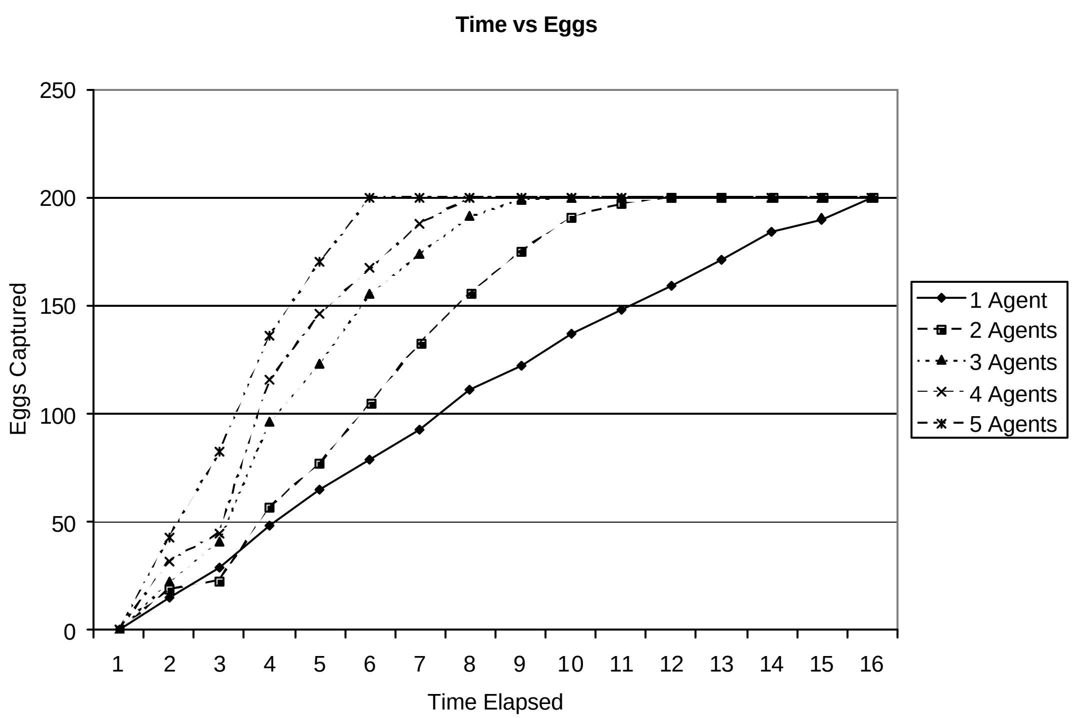

Figure 3: Performance of Agents with 200 Eggs on the Grid

4. Conclusion

In this paper we have shown that a team of agents perform a lot better than they perform individually. Agents can communicate with each other and create teams based on their level of trust network. Agents can also broadcast messages to everyone via the white board. These kinds of communications foster the trust among agents and eventually lead them to excel at their tasks. Agents can have three different roles-aggressive, passive, and greedy. They can create teams of different combinations such as a team of aggressive and greedy agents or a team of greedy and passive agents. Agents can also team up with human users. Future research can be done in the area of trust network evaluation between humans and agents.

References

[1] G. Beavers and H. Hexmoor, 2003b. Understanding Agent Trust, In *Proceedings of The International Conference on Artificial Intelligence (IC-AI 2003*), Las Vegas, Nevada.

[2] C. Castelfranchi and R. Falcone 2002. Tuning the Agent Autonomy: the Relationships between Trust and Control, In Autonomy, Control, and Delegation Workshop in AAAI 2002, Edmonton.

[3] H. Funk, C. Miller, C. Johnson, and J. Richardson, 2000. Applying Intent-Sensitive Policy to Automated Resource Allocation: Command, Communication and Most Importantly, Control. In *Proceedings of the Conference on Human Interaction with Complex Systems*. Urbana-Champaign, Ill.

[4] S. Marsh 1992. Trust and Reliance in Multi-Agent Systems: A Preliminary Report. In: 4th European Workshop on Modeling Autonomous Agents in a Multi-Agent World (MAAMAW), Rome.

[5] S. Marsh 1994. Formalizing Trust as a Computational Concept, Ph.D Thesis, University of Stirling, April 1994.

[6] M. Prietula, K. Carley, K., 2000. Boundedly Rational and Emotional Agents Cooperation, Trust and Rumor, In: *Trust and Deception in Virtual Societies*. Cristiano Castelfranchi and Yao-Hua Tan (eds).

[7] B. Yu and M.P. Singh, 2002. An Evidential Model of Distributed Reputation Management, *Proceedings of First International Joint Conference on Autonomous Agents and Multi-Agent Systems*, pages 294-301.