a. title of the submission:
Mobile Agent Strategies for the Provision of Public Goods: An Experimental Study

b. topic area of the submission:
Economics

c. two or three keywords that describe the submission:
Economic Games, E-Commerce, Mobile Software Agents.

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Abstract

This paper experimentally examines the behaviour of mobile software agents (MAs) as they use various contribution strategies towards the provision of a threshold public good. By combining the e-commerce and economics elements of the contribution game together with MA technology we present an effective tool for analysis of these elements. Through use of this tool we have produced a large set of threshold contribution game experimental results.

From analysis of the results observations are made that highlight the effectiveness of using MAs to represent players in an economic game. These observations consist of player strategy analysis, player strategy evaluation, and system equilibrium analysis.

Keywords: Economic Games, E-Commerce, Mobile Software Agents.

1. INTRODUCTION

This paper experimentally examines the behaviour of mobile software agents (MAs) as they use various contribution strategies towards the provision of a threshold public good. We begin by introducing the threshold public good contribution game and the motivation for developing an application that uses MAs to play a contribution game.

1.1 Threshold Contribution Game

A threshold public good contribution game [1, 2] consists of players who make private contributions towards the production of a public good. The public good will be provided if the net contributions meet or exceed a predetermined (but not necessarily public) threshold value. Players lose their contribution when there is not enough contributed to meet the threshold value. In order for behaviour evolution to be observed a threshold game is usually repeated over time with the players being able to keep some knowledge of the previous rounds but not accumulate profits for re-contribution (players always have a fresh start at the beginning of each round).

A quick examination of the game reveals that the player who contributes nothing, while other players contribute enough to attain the provision of the public good, is the player that benefits the most. This observation presents a force encouraging players to attempt to take a free ride on the contributions of others. In contrast to this there is always the competing force established by the fact that if everyone takes free rides then even the very attainable public goods will never be provided.

People in society often have a more complex situation where among other things they may be able to claim some of their contribution back and are likely choosing from and spreading their contributions across multiple public goods. The game results examined in this paper are generated by MAs playing the basic threshold public good contribution game with the one additional complexity of having the choice to make a contribution towards one of three goods.

1.2 Motivation for a Mobile Agent Application

The ability to use MA technology as a replacement for human players in a public good threshold contribution game is the obvious and main reason for developing a MA based application. The difficulty and cost of assembling human participants for the purpose of performing any experiment
is often significant incentive for examining computer based simulation and modelling. MA technology offers an environment that is well suited for the examination of autonomous, mobile, decision making entities which are perceivably similar to human players. This has been shown in related work done on agent pricing strategy analysis [3]. 

In our previous work [4] we introduced an application called MATCH (Mobile Agent based Threshold Contribution game Host) which was an application that enabled MAs to play a threshold contribution game. By running MATCH we were able to show that MAs could play using various strategies and that these strategies could be ranked in terms of their ability to attain the payoff of a public good. We concluded that the utilisation of MAs to play economic games provided meaningful insight into the behaviour of MAs and that the area of strategy development as well as behaviour characterisation needed further development.

Related work [5, 6] in the development of an economic model for medical data retrieval lead to a simple load balancing “game” being played with MAs. This load balancing game highlighted the value of strategies for MA decision making and provided incentive from the MA technology side to further study the strategy related behaviour of MAs through using an economic game (which initially lead us to the development of MATCH).

2. METHOD

As mentioned in the introduction we use MAs to play a basic threshold contribution game with the additional complexity of having to select one of three public goods to contribute towards. The game is played with 15 player MAs that each have up to 100 credits at the beginning of each round to contribute from. The threshold for the game is set at 450 credits and the payoff for reaching the threshold is 89 credits to each of the players who contribute (contribution of 0 credits is acceptable and allows a player to receive a payoff if net player contributions meet the threshold).

For each round played the MAs go through the process of choosing a public good, contributing towards the good, and waiting for provision of the public good. The two decisions of which good to contribute towards and how much to contribute are controlled by the individual MA’s strategy. All of the strategies except for the Random and Range strategies are based on knowledge of previous contribution rounds.

A re-engineered version of MATCH has been developed that enables the generation of significant amounts of trial results. Both the development of the first version of MATCH and the re-engineered version were done using a Java based agent platform [7]. The trial results are stored in extensible markup language (XML) format to facilitate ease of transformation and analysis. From analysing these results we make numerous observations about the strategy based behaviour of MAs playing a threshold public good contribution game and the effects of their behaviour on the system as a whole.

3. RESULTS

Over 100 game play results for each strategy have been collected and evaluated.

![Figure 1: Mean Difference of Contribution and Payoff (net profit).](image)

Figure 1 illustrates the ranking of strategies in terms of achieving profit. The Majority, Percent, and Growth strategies clearly out perform the other strategies considered. The Satisfaction strategy appears to linearly increase with the number of rounds played. The Random and Range strategies appear to not be a function of the number of rounds played and will likely never be profitable.

4. DISCUSSION

Some general observations about the system as a whole can be made. In viewing the big picture of the system we are mainly interested in how it approaches equilibrium. One such equilibrium position is where all 15 MA players are contributing 30 credits towards one good. Clearly this is the position that the Growth, Majority, and Percent strategies quickly reach with the Satisfaction strategy appearing also
to be approaching this equilibrium point. Another equilibrium could be located at a point where maximum profit is not as valued as the regular and relatively efficient provision of all three goods. It is likely that the Random and Range strategies are getting payoff of all three goods in a normal distribution however the consistency of this payoff is not evaluated in the present work.

Figure 1 shows three strategy groups. The first group consists of the Majority, Percent, and Growth strategies. This group is distinguished by an asymptotic approach to the maximum mean difference of 885 credits (15 players * 30 credit contribution - 15 players * 89 credit payoff). These strategies performed very well due to the quality of information that they received from the referee and how well they used this information.

The Satisfaction strategy is in a group of its own and it appears to linearly approach the maximum. This is very interesting and since the strategy is dependent on weighting factors it should be possible to adjust the factors and examine the relationship between the factors and the results. Another interesting feature of this strategy is that the only information from the referee that is used in the strategy is the mean difference between contribution and payoff amounts for all players in the game (significantly less information than received by the Majority, Percent, and Growth players).

The third group consists of the Random and Range strategies. This group is distinguished by a flat line with little variation. It is obvious from the graph that these strategies are not learning anything from previous rounds. This is exactly the type of results we would expect since we know that their strategies are random and not based on previous round results. Since the Range strategy weights specific contribution values it should be possible to adjust the weight in order to increase or decrease the effectiveness of the strategy.

5. FUTURE WORK

Future work is planned in the area of strategy development and game play results analysis.

In the area of strategy development there is a need to determine additional equilibrium positions and to develop strategies that seek these positions. Some immediate work stemming from the results will be the verification of convergence for the Satisfaction strategy and an analysis of the effect of adjusting the mobility and responsiveness factors.

6. CONCLUSION

This paper has introduced experimental results from using MAAs to play a threshold public good contribution game with the complexity of having to contribute towards one of three goods. The results have been analysed allowing us to observe strategy rankings and effectiveness. We have also been able to categorise strategies into groups related to how the strategies behave and noting how this affects system equilibrium. This work leads to an indication that the MA paradigm is a powerful approach for development of an e-commerce simulation environment. Future work to strengthen our findings is planned in the area of strategy development and game play results analysis.

Acknowledgements

The authors thank TRLabs and NSERC for their generous support of this project.

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