Artificial Markets and Adaptive Agents

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The Problem: The project aims to understand the problem-solving power, efficiency, and accuracy of double-auction markets with real human agents. Armed with this knowledge, we hope to gain a greater understanding of markets as a generalized problem-solving mechanism (for both financial and non-financial domains) as well as a better concept of how humans interact via a market, in order to make more realistic artificial trading agents.

Motivation: When the Dow Jones Industrial Average hit 10,000, magazines, economists, and regular people all over touted the amazing strength of the American economy. Implicitly, everyone understood the Dow Jones–a single number–to be a proxy for the strength of the entire American economy. Simply put, markets seem to have the ability to convert complex, distributed information into a single number which represents that information. We wish to understand this process and apply it to new domains.

Previous Work: In 1990 the Santa Fe Institute organized the Double Auction Market Tournament whose goal was to analyze the game played by computerized trading strategies and compare the performance of different strategies [2]. In 1996, other Santa Fe Institute members developed an entirely artificial stock market, using agents which evolved trading strategies [4]. The behaviors of individual agents and the overall market were observed and analyzed. Interestingly, stock market bubbles and bursts could occur without any external stochastic process. On the other hand, in the University of Iowa's political stock market [1], speculators bet on the outcome of some future political events, such as the U.S. presidential elections. The market provides an experimental study for investigation of human trading behaviors. There are also various projects on market based-mechanisms aiming to tackle the problem of resource allocation in distributed system with multiple intelligent agents [3]. More recently, a group from MIT tried to integrate the empirical and artificial appropaches [5].

Note: the previous section was borrowed, with some modifications, from Nicholas Chan's research abstract.

Approach: Our proposed research consists of two complementary parts:

In **Web-Based Trading Programs**, we have implemented a java client and server. The server and client come in two flavors: either the traditional buy/sell stock market, or a future's market for other types of trading games. Our server is responsible for keeping accurate data on all accounts, crosses trades, maintains synchronicity and file-locking, and utilizes an oracle database for persistance and data lookup. It also takes care of several special cases, for example dividend payouts, special informational bulletins, and timekeeping. The client operates through java-enabled web clients, and allows the same functionality as commercial web-based trading programs, such as limit and market orders, real-time updates and graphing of stock pricing, and order cancellation. A screen shot of a recent version can be found on the next page.

With a stable trading interface, we invent and run **real-world experiments** with groups of students. Each game has a particular economic significance to it. For example, in the CRL trading game (http://market.mit.edu/crl), we seek to understand market efficiency and the ability for a market to transfer information among its traders. Traders are provided with different (but true) information about a stock. In order to correctly price the stock (and hence 'win' the game), they must transfer information from one to another via the market. In the bike pump game (http://market.mit.edu/bike), we seek to use the market to compute a non-financial question–the popularity of 10 different recently invented bike pumps. Finally, in the CPI and Unemployment futures markets (http://market.mit.edu/unemployment), we test the ability of traders to create a better prediction of important economic numbers than mainstream economists. In effect, the last two are about using markets to 'compute' very difficult and challenging numbers.

Difficulty: For markets to work, generally three properties are helpful. In our environment, one or more of these may be in practice hard to achieve due to a limitation of various resources. 1) A large number of traders; 2) Informed traders

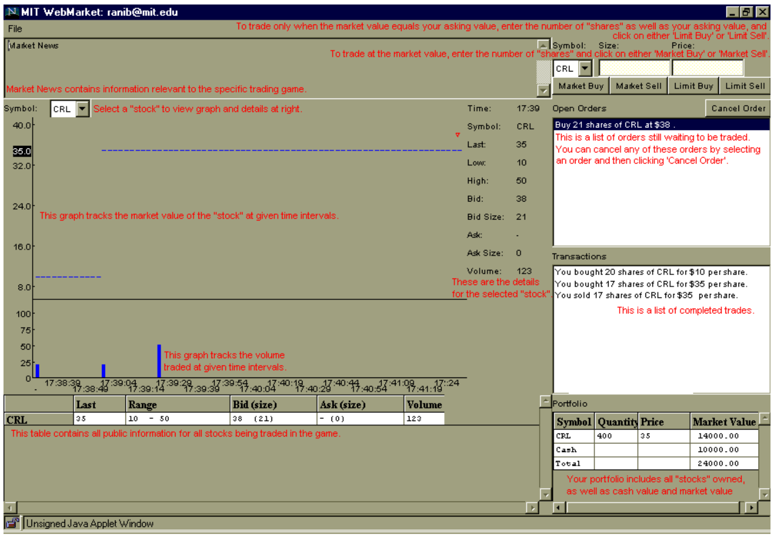

Figure 1: Annotated screen shot of our trading interface

(particularly in CPI and Unemployment prediction); 3) the self-interest that comes with 'betting' with real money. In addition, writing scalable and stable web client/server software is difficult.

Impact: This research can make strides into understanding real economic agents, as well as the power of markets. Because our research is highly empirical, we can actually determine the efficacy of markets in new domains. We can also analyze and observe actual trading behavior, over the course of controlled games. Both of these results are potentially important to the world of economics, distributed computer science, and artificial intelligence.

Future Work: In the next phase of the project, we will improve the GUI for the web client, increase the scalability of the web server, create more trading games, and find more groups of students to participate in them. We expect our trading games to become increasingly focused on new domains for prediction that are conventionally not market-focused.

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