2000

Software Agents for Automated Transaction Negotiations: Implementation and Evaluation

Kaushal Chari
University of South Florida, kchari@coba.usf.edu

Paul J. Hu
University of South Florida, paulhu@coba.usf.edu

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Kaushal Chari, Department of ISDS, University of South Florida, kchari@coba.usf.edu
Paul J. Hu, Department of ISDS, University of South Florida, paulhu@coba.usf.edu

Abstract

Software agents have the potential to serve as effective surrogates of humans in conducting business transactions in an electronic commerce environment. The reported proceeding research aims to evaluate the performance of software agents in automated transaction negotiations. As part of this research, agents are being built using IBM aglets, and their performance evaluation within various experimental settings is currently underway.

Research Overview and Motivation

The proliferation of newly emerging Internet and WWW technologies has created innovative and exciting multidisciplinary research opportunities in information systems/technology. Software agent is one research area that has received fast-growing interests and attention from researchers and practitioners alike. In an era characterized by new business models established and prevalent in electronic marketspace, examination of software agents for automated transaction negotiations is essential and timely.

Software agents are software entities that function continuously and autonomously in a particular environment, often inhabited by other agents and processes (Shoham 1997). In spite of conceivable differences in role and sophistication, software agents by and large share several common characteristics, including reactivity, autonomy, collaborative behavior, embedded knowledge and inferential capability, mobility, and adaptability (Etzioni and Weld 1995, Franklin and Graesser 1996). Software agents can be programmed to incorporate task domain-specific knowledge, problem-solving capabilities, and human preferences and reasoning (Shoham 1997). When properly designed and deployed, these agents may alleviate or even remove such common human processing constraints as information overload, search-space limitation and bounded rationality (Maes 1994). Because of the discussed and other desired characteristics, software agents exhibit promising potentials in serving as effective surrogates of their human principals in automated transaction negotiations within common business contexts (Maes P., R. H. Guttman, and A. G. Moukas, 1999).

Negotiation is an essential aspect of business activities. In many business transactions, negotiation proceeds in an iterative manner and usually is a tedious and a time-consuming process through which market participants may or may not reach an agreement necessary for completing a transaction. Automating such negotiations in an EC environment is highly desirable. A system called INSPIRE is a non-agent based system that supports negotiations on the world wide web (Kersten G. E., and S. J. Noronha, 1999). Investigations of agent-based negotiations by previous research are limited. Kraus (1996) has presented a theoretical model for negotiations requiring multiple encounters, each of which takes place with incomplete information. Each agent maximizes his or her utility at each phase of the negotiation process, leading to equilibrium reached at each phase. Sandholm and Lesser have modeled different coalition formations among bounded rational agents (Sandholm and Lesser 1995).

Chavez and Maes (1996) have taken a simplistic approach to develop a system (Kasbah) for automated selling and buying by software agents over the Internet. In their system, software agents deterministically exchange offer parameter (i.e., price) without learning from or adapting to the negotiation process, based on some embedded programmed price function defined over a finite time window. In the Bazaar project, Zeng and Sycara consider negotiations as a sequential decision process (Zeng and Sycara 1996). Software agents in Bazaar use Bayesian probability updates to learn from negotiations. Oliver (1996) has proposed a genetic algorithms (GA) approach where market participants play strategies against each other, thereby resulting in improved strategies in subsequent generations. Expanding the work by Oliver, Dworman, Kimbrough and Liang developed appropriate GAs to discover high-quality negotiation strategies in situations where multiple coalitions are formed (Dworman, Kimbrough and Liang 1996).

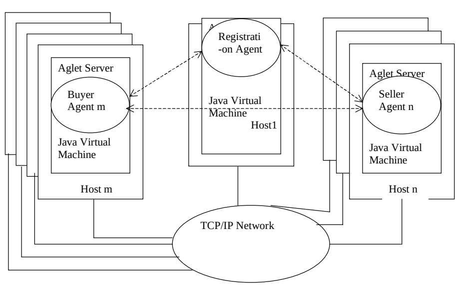
Collectively, the literature suggests that acceptance of software agents by human principals, at a minimum, requires their encompassing the preference and reasoning capabilities of human users and demonstrating desired utilities for achieving a performance level comparable or superior to that commonly accomplished by human users. In response to the limited previous research on agent-based automated transaction negotiation support and evaluation, we have designed and developed a multi-agent system, whose performance evaluation is currently underway. Specifically, we use controlled experiments to evaluate the system in such areas as market efficiency and comparative performance of individual agents (with various negotiation strategies) under different market structures.

Agents System Implementation

Implementation of a prototype multi-agent system is underway, using IBM Java aglets. IBM's aglet software development kit can be downloaded for free and is the sole reason for choosing the aglet environment. Currently, the system supports negotiations between or among multiple buyer and seller agents, based on their respected embedded intelligence. Figure 1 illustrates the system's architecture design. As shown, buyer and seller agents are initiated and executed within aglet server processes running on distributed host machines interconnected via a TCP/IP network. The aglet server process interfaces with the Java virtual machine.

All seller agents advertise their products through registration with a registration agent. Buyer agents also register with the registration agent from which they obtain information about existing seller agents. Subsequently, buyer agents select and engage in direct negotiations with promising seller agents via message passing. Negotiation takes place in the following ways: (1) Sellers post price and other parameter values that are public knowledge, buyers then enter into secret negotiations sequentially, one at a time, (2) Sellers post price and other parameter values that are public knowledge, buyers enter into secret negotiations concurrently, and (3) Sellers post prices and other parameter values that are public knowledge, buyers enter into negotiations concurrently, the details of offers and counter offers is public knowledge. Message passing among buyers and sellers is done to support the above three negotiation mechanisms. There are plans to use secure socket layers (SSL) to encrypt private information of agents. The security model of aglets is robust enough to handle a variety of security threats.

Figure 1. Multi-Agent Architecture



Evaluation Designs and Expected Contributions

Evaluation of individual agents with various embedded negotiation strategies (including pre-defined decay function, weighted average strategy that incorporates market information, and interpolation strategy with market information) is currently underway. Specifically, we anchor all evaluative investigations using a utility-based approach, with which competing offers characterized by multiple factors central to the buyer (or seller) is evaluated using a utility function. The utility function of the human principal is determined by eliciting his or her preferences in an experimental setting and then generating a utility function based on regression. We envisage a software module to do the task of eliciting user preferences, generating utility functions and then transferring utility functions to agents. Agents can then evaluate competing offers solely based on utility values without human intervention. In our experimental study, we have an agent for every human subject. The agent acts as the surrogate of its human principal by incorporating human principal's utility function. Thereby creating a heterogeneous multi-agent environment.

Utility functions are specific to products and are multi-dimensional. For instance, competing offers from different vacation-package seller agents may vary in such parameters as price, dates, package-quality and payment methods. The seller determines the various parameters associated with a product. Each parameter may have multiple options. To continue with our example, a seller may make several payment methods available to buyers, based on different credit or debit arrangements. Jointly, the exact choice of the respective parameters comprises a unique package (or bundle) which will be evaluated by the buyer, using his or her internal utility function. From a buyer's perspective, valuation of individual (competing) packages (bundles) may be a function of time. That is, the buyer probably is willing to accept packages of decreased utility (from his or her perspective) as the time-remains-to-buy dwindles.

The exact manner by which products and services are traded in the marketspace may vary with the underlying market structure considerably. For transaction negotiations, market structure can be largely characterized by such attributes as offer information availability, negotiation process exclusiveness (multiple-concurrent versus single-preemptive process), negotiation secrecy and post-negotiation information availability. The relative performance of different agents, which is anticipated to be dependent on the market structure, will be evaluated accordingly.

Results obtained from this research are expected to contribute to an increased understanding of agent-based negotiation support and advance the design and development of effective software agent systems for automated transaction negotiation support. Evaluation results of the study may provide valuable insights into the feasibility of large-scale deployments of software agents in the marketspace, fostering software agent technologies in EC applications. Furthermore, the findings will generate important implications to the education of agent technology and its real-world practices.

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