# Games at Work-Agent-Mediated E-Commerce Simulation

Martin Griss, Reed Letsinger
Software Technology Laboratory
HP Laboratories Palo Alto
HPL-2000-52
April, 2000

E-mail:martin_griss@hp.com
reed_letsinger@hp.com

E-commerce, agents, games, simulation, Zeus

In this paper, we describe our research into flexible, agent-based e-commerce systems. During the summer, we are building an experimental multi-player shopping game, in which agents will represent buyers, sellers, brokers and services of various kinds. The choice of a game format has intrinsic appeal for demonstration and educational value, and also serves as a controlled vehicle for experimenting with alternative individual and group economic strategies, and for evaluating the effectiveness of agent-based systems for this e-commerce.

# Games at Work - Agent-Mediated E-Commerce Simulation


Martin Griss
Hewlett-Packard Labs
1501 Page Mill Road
Palo Alto, CA 94304 USA
(650) 857-8715
martin_griss@hp.com

Reed Letsinger
Hewlett-Packard Labs
1501 Page Mill Road
Palo Alto, CA 94304 US
(650) 857-5974
reed_letsinger@hp.com


*(To be presented at Autonomous Agents 2000, Barcelona, Spain, June 2000)*


## ABSTRACT

In this paper, we describe our research into flexible, agent-based e-commerce systems. During the summer, we are building an experimental multi-player shopping game, in which agents will represent buyers, sellers, brokers and services of various kinds. The choice of a game format has intrinsic appeal for demonstration and educational value, and also serves as a controlled vehicle for experimenting with alternative individual and group economic strategies, and for evaluating the effectiveness of agent-based systems for e-commerce.



## Keywords

E-commerce, agents, games, simulation, Zeus.


## 1 INTRODUCTION

The shift from traditional store and catalogue sales to internet-enabled electronic commerce promises to change the way businesses interact with each other and with their customers [Sharma 1999; Glushko 1999]. Companies will have instant access to unbounded, world-wide markets; prices and product packaging can be determined dynamically through negotiation on a per transaction or per customer basis; many short-lived, task-specific collaborations between companies will replace the more expensive, long-lasting partnerships and contracts common today. It is sometimes claimed that electronic commerce has the potential to create "an environment where companies will be at their most agile and marketplaces will approach perfect efficiency" [Maes 1999; Guttman 1998, 1998a]. This optimistic outcome is clearly not inevitable. Throwing a myriad of untried, novel business models out into the marketplace could just as easily result in expensive failures and risk losing consumer confidence in the entire e-commerce enterprise.

Business planners and e-commerce product designers need inexpensive, safe ways to evaluate the potential consequences of novel combinations of market models, business strategies, and new e-services. HP is building an E-Commerce Ecology Lab that combines theoretical and experimental techniques to help evaluate different business scenarios before they are imposed on the marketplace [Charness 2000]. Groups of 10-20 students are given real money, and asked to play "to win" against each other in a simplified electronic market to test selected predications of game theory and human behavior. Recently, work has started developing a new tool for this Lab – a framework for e-commerce simulation games. The framework is being constructed on top of a community of interacting software agents. This report describes what we are attempting to accomplish with these games, why we have decided to use agent technology to build them, and what we have done to date.

## 2 E-COMMERCE GAMES

We hypothesize that properly constructed games can offer important insights into proposed e-commerce business strategies, and that these insights will nicely complement the understanding achievable using formal analysis and simulation techniques. Playing e-commerce games can have a similar value to business planners that war games have to military planners, or management training simulation games have for business managers. They help assess where strategic and tactical thinking is vulnerable, suggest new strategies for competing in the imagined situations, and stress-test the tools in something like field conditions. If sufficiently enticing, games can tap into the best strategic imagination of business planners. Once strategies have been discovered by playing the games, they can be coded up into simulators in order to evaluate how they work on larger scales than can reasonably to run in a game format, or they can be formally analyzed using techniques drawn from game theory, stochastic process modeling, market microstructure theory, or other disciplines.

Beyond their role as a source of insight into how different market mechanisms and business models might play out in the real marketplace, e-commerce games have several other potential values. They provide a flexible playground for suggesting new business models, and for training business managers in how to operate with novel strategies. They can act as a vivid showcase to communicate what a new business model might look like in practice. Games can also be used as a preliminary step to constructing fully automated simulation environments, by replacing the human players with agents that pursue similar strategies. We also expect that constructing these games will help us better understand how to design agents that play a direct role in e-commerce.

A typical player in an e-commerce game will act as a high-level decision maker (e.g. a CEO) of a company that buys, sells, and possibly manufactures a variety of goods and services. Others might play the roles of customers, auditors, or regulators of these companies. This is in the style of well-known PC Games, such as

SimCity, EverQuest or Ultima Online, in which one or more players take on some roles to create and interact with the system, set fiscal policy, etc., and the system provides other roles, such as advisors of various kinds. The games can vary the market mechanisms used to buy and sell – one-to-one negotiations, auctions, fixed prices, customized packaged deals, advertising, etc. Also, the rules for evaluating the worth of a player's position can be varied to represent different business strategies. For one player, growing large market share might be more valuable than accumulating assets, while another player might be more profit-driven. A third dimension that can be varied is the nature of dependencies among different types of goods and services. Supply-chains among different players may need to be set up, as well as other forms of collaborations. Our goal is to develop a framework that makes it easy to construct any of these types of games.

## 2.1 Questions to be Explored

By observing how players behave in different game situations, we expect to be able to evaluate different hypothetical market mechanisms and business models in terms of several different issues:

- Efficiency: Under different market mechanisms, how much time and cost does it take to transact a single purchase or sale?
- Fairness: Does everyone have an equal opportunity to participate in a negotiation? Do prices favor buyers over sellers, or vice versa? Can one player or a small set of players manipulate prices to their advantage?
- Stability: Do prices, or other metrics, fluctuate wildly, or stay within reasonable bounds?
- Trust: Do players trust their collaborators, or is some form of guarantee or insurance needed to permit collaborations to form and remain stable?
- Effectiveness of strategies and business models: Which strategies work best in a given market configuration?
- How do product bundling and advertising strategies interact with buyer and seller strategies?

## 2.2 Some Game Scenarios

### *2.2.1 Primitive Markets*

In the simplest form of an e-commerce game, all that players can do is buy and sell goods from each other. Each player starts with an inventory of different types of goods, and a supply of money. The players buy and sell their goods directly from each other, exchanging goods for money. Each player has a scoring function that assigns an overall value to his current combination of possessions – both goods and cash. The only decisions a player can make is what to buy or sell when, and what negotiation strategies to use. The objective for each player is to increase the value of his possessions, as measured by his scoring function. These games represent simple marketplaces, without middlemen and without interference from outside regulators or uncontrolled economic factors.

Despite their simplicity, many variations of these primitive market games are worth exploring. By allowing players to choose their negotiation strategies, it should be possible to gain some insight into which strategies are most effective in different circumstances. The rules that define legal negotiations can be varied. The number of offers and counter-offers can be limited, or a cost can be assigned to each step. Rules can be added regulating how much information about the progress of a negotiation can be held privately between the parties, and how much must be shared with potential competitors. Observing how players adjust their negotiation strategies to get the best leverage from different rules can help predict how real companies might behave if restricted in similar ways. See [Priest 1999; Cliff 1998] for other HP Labs work on agent-based negotiation and trading.

Another choice in designing these primitive games is deciding how similar the players' roles are. At one extreme, every player starts with identical inventories and cash reserves, and the same scoring function is used to determine the worth of the players' positions. More interesting and realistic games can be defined simply by setting up different player roles which start with their unique distribution of possessions, and possibly their own scoring function.

Appropriately chosen scoring functions can shift the balance between purely competitive games and games that encourage more or less cooperation. Players may need to establish contracts, or larger consortia, to achieve their goals. Questions of trust become important in these cases.

### *2.2.2 Facilitated Markets*

Most real markets include a number of middlemen – human or organizational agents that provide different sorts of services aimed at helping the primary trading agents be more effective. Trade brokers can centralize the one-on-one negotiations of primitive markets into many kinds of auctions [Guttman 1998b; Preist 1999a, 1999b]. They can also consolidate many requests into a smaller number that are easier to handle in the market. Banks can be introduced to give traders more options in borrowing or investing money. Other agents can specialize in addressing trust issues, acting as Chambers of Commerce, the SEC or Moodys, to provide ratings of companies, or insurance against default or fraud. Information brokers can collect and sell information about competitors or potential customers. Agents might play the role of malls which provide common services to a number of sellers. Players could then be "mall owners", deciding what kinds of mall style, services and fees would make one mall attractive to suppliers.

Adding such facilitation agents to the e-commerce games will create more realistic-feeling virtual worlds, and it will enable investigation into potential business models that belong to this second tier of market support services.

### *2.2.3 Regulated and Embedded Markets*

The games discussed so far operate in closed worlds. The only changes that occur are the direct result of some allowed move by one of the players. Each player is concerned with maximizing his or her own scoring function, and is less concerned with global properties of the market. These two simplifying characteristics, the lack of global regulatory oversight, and the insensitivity to outside influences, can be addressed by introducing agents that either strive to maintain certain metrics within bounds, or that randomly perturb some variables that can impact the players choices. An example of the first kind of agent might be called "Alan Greenspan," playing a role similar to that of the Federal Reserve Board. To simulate the fact that markets are impacted by external factors, an agent might be built that occasionally changes the supply of some resource, or imposes taxes on certain types of transactions. This introduces different types of risk that players will need to take into account in developing their strategies.

## 3 AGENTS FOR E-COMMERCE GAMES

We have chosen to use agent-based technology for construction of multi-player e-commerce games for two primary reasons. First, we wanted to develop a test-bed for exploring the capabilities of agent-mediated e-commerce environments in a realistic but controlled environment to advance our research in agents and service systems [Kuno 2000; Durante 2000]. Second, we wanted an extremely flexible environment in which new services and roles could be quickly prototyped.

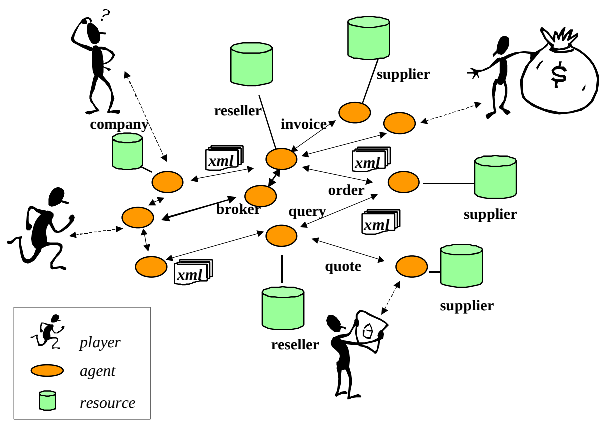


***Figure 1 - Agent-mediated e-commerce game***

Since we want to quickly experiment with many different game scenarios, varying strategies and roles frequently, we need a flexible, component technology. Instead of using a commercially available game engine, we felt using a multi-agent system would allow us to explore fairly realistic, small scale e-commerce systems.

As Sharma describes in his article on building e-commerce applications with components [Sharma 1999] the next generation of e-commerce applications, including simulation environments such as our games, requires much more flexibility, larger and more complex applications and many more applications, integrating processes across enterprises. Many of these application components will be written at different times and by different developers. As developers, we need more powerful ways of quickly building these flexible distributed systems and new services that will provide a more compelling and entertaining user experience.

Software agent technology is believed to have great potential for this [Maes 1999]. Agents will dynamically discover and compose e-services and mediate interactions; XML will become the lingua-franca of agent-based e-commerce interaction [Glushko99, Meltzer 1998]. As illustrated in Figure 1, agents can serve as representatives or delegates to handle routine affairs, monitor activities, set up contracts, execute business processes, and find the best services [Chen 2000, Griss 2000].

There are over 100 published agent systems, each providing and emphasizing different combinations of features and implementations [Huhns 1998; Jennings 1998]. Different systems have differing models of security, communication, conversation control, persistence and mobility. An agent platform manages the creation, deletion, and monitoring of agents. We wanted to have an agent system built using Java, XML and HTTP, with an appropriate level of autonomy and intelligence, and a FIPA standard multi-agent communication language and conversation management.

The major categories of agents include: **personal agents,** which interact directly with the user and are highly personalized; **mobile agents,** which are sent out to collect information or perform actions at one or more remote sites and then return with results; and, **collaborative agents,** which communicate and interact within a multi-agent system.

For our e-commerce game simulator, we wanted personal and collaborative agents that could display high degrees of autonomy and intelligence, using rules, knowledge-bases and planning capabilities to determine with whom to communicate and what to do and say next. By an "autonomous" agent, we mean an agent that has its own threads of control, pursues its own goals, and communicates with other agents and its environment as it determines is appropriate for achieving its goals. While mobility is interesting for some e-commerce systems, we did not feel it essential for our e-commerce game environment.

An important goal was to allow web-based interfaces, and future XML-based communication with other e-service projects in our laboratory using the XML/Java based HP e-speak technology as a core [ESPEAK; Kuno 2000; Durante 2000].

After looking at several available agent frameworks (such as Zeus, Grasshopper, Aglets, OAA and Jackal), as well as two home grown mobile agent systems (CWave [Mueller-Planitz 2000] and Dynamic Agents [Chen 1998, 2000]), we selected Zeus as a basis for our game framework. We felt Zeus had the best mix of intelligent, multi-agent capabilities, and that it would be relatively easy to modify to add the additional features we need.

Zeus was developed at the British Telecom Labs [Nwana 1999]. It adopts a layered approach to agents. Basic Agents are able to follow the agent communication protocol with other agents in the community. This protocol is based on the FIPA Agent Communication Language[O'Brien 1998], which has the advantages of being quite rich, well documented, and standard. Simple trading agents add the capabilities to maintain an inventory of goods (called "resources" in Zeus), and to buy and sell goods following simple negotiation protocols and strategies. These simple agents are almost a perfect match to the requirements of our primitive market games. A third layer of Zeus agents adds the ability to plan sequences of steps needed to accomplish a goal, to monitor the execution of plans, and backtrack when necessary. Also, these agents can be supplied with forward-chaining rules that respond to perceived changes in the environment. These two additional features – goal directed, planned behavior, and reactive behavior determined by simple rules – will greatly simplify the job of writing more complex agents that are capable of acting as players in the game, or as middlemen.

Zeus is open-source, and written in Java. Its code is well organized. It has been carefully designed to be highly flexible. For instance, its core goal processing algorithm is implemented as a state machine that can be easily modified. These are all additional reasons Zeus appealed to us as a basis for our work.

On the other hand, Zeus suffers from a few limitations from our point of view. It does not fit well with web technology. It does not base its communication on HTTP or XML standards. A second issue is that, although Zeus does a good job at providing easy to understand specifications of goals, tasks and rules, writing new protocols is not well supported. We have not yet done thorough scalability assessments of Zeus, but our early experience suggests that, a small game, with perhaps 10-20 players/roles, and several agents per role, will be feasible. Finally, although the code is well-written and organized, there is very little documentation that helps guide the developer through the details.

For future connection to e-services built on HP's e-speak [ESPEAK] and HP Labs e-services technology [Kuno 2000; Durante 2000], we need both XML-based communication and flexible multi-agent conversation control [Finin 1997; Moore 1998]. Modes of control that we would like to use include: loose control, which assigns to each agent a set of rules that control conversations; tighter control, which expects compatible agents to use a common protocol (e.g. nested state machine representation and engine); or workflow control, in which a single collaboration workflow model and engine is associated with a group of agents.

# 4 CURRENT STATUS AND NEXT STEPS

This work is in a very early stage. So far, we have built a team, including collaborators from the University of Utah and UC Santa Cruz; we have built a simple game using Zeus; and we have started work modifying Zeus to meet some of our requirements.

## 4.1 Initial Game

We have designed and implemented a simple game based on a simulated primitive market. The game was suggested by the Kasbah experiment developed by the MIT Media Lab [Chavez 1996, 1997]. Each player starts with an initial inventory of goods, and a supply of cash. Players then buy and sell goods directly from each other, trying to maximize their score, as determined by a scoring function. When a player logs on via a web interface, he gives the system a name that identifies him to the other players, and specifies how many goods he wants in his starting inventory. The more goods he starts with, the less money he is given, and vice versa. The player can choose to start the game in the position of a buyer – with lots of cash but few goods – or as a seller – with a well supplied inventory, but little cash, or somewhere in between. In order to keep the domain of the game as familiar as possible, we decided to use cards drawn from an ordinary bridge deck as the goods that players buy and sell. After the player has told the system how many cards he wants to start with, he is dealt a random hand of that size form a complete deck. (Hence, there can be several two of clubs in the game, although any one player can only have one in their initial inventory.) When a player chooses to sell a card, he specifies which card, the starting and limit price, and the rules for dropping the price he wants to use in the negotiation. At this point, he passes control to an agent that interacts with agents of other players to try to complete the sale. Buying is similar, except that the player has the flexibility to describe the card he wants in terms of its properties – e.g. a club, or a king.

The Zeus agents are typically more heavy-weight than the agents used in Kasbah. In the original Kasbah experiment, one agent was created for each transaction, and destroyed on completion. The GUI enabled players to monitor the state of all of their agents. In our Zeus environment, a single agent is associated with each player/role, handling all of his transactions, perhaps using several delegated agents and services, based on a selected strategy. Different choices and configurations of personal agents, and supporting agents, will allow different allocations of decision making responsibility between the player and his agent.

The scoring function is the experimental variable in the game. A simple scoring function would be a weighted sum of the goods in the inventory, considered one at a time. For instance, each Ace might count fourteen points, king thirteen, queen twelve, jack eleven, and all other cards, ten. More interesting scoring functions will take combinations of cards into account, like the evaluation of poker hands: straights and flushes of different lengths could be counted in computing the overall score.

## 4.2 Zeus Modifications

Work on adding web-based GUIs is underway. We are using two approaches in tandem: a light-weight Java-coded HTTP server that can be embedded in any Zeus agent, and a slightly heavier, but more flexible Java-coded publish/subscribe bus (JBUS), that makes inter-applet communication and event-based notification easier [Longson 2000].

We anticipate providing an agent-wrapper to allow XML-based communication with the e-speak-based e-service environment; perhaps this could go as far as replacing the lisp style FIPA ACL encoding used by Zeus.

## 4.3 Extensions to the game

Once our simple multi-card based e-commerce game (Agora 1) is operational, we will add new facilitating agents, modifying strategies, and changing the resources that the players buy and sell. We are designing the system so it will be easy to replace cards by other more realistic choices of goods, include a richer set of multi-resource scoring functions, and experiment with different assigned goals per role. The games should evolve to become both more interesting and realistic. We are particularly interested in developing games for regulated marketplaces, in which community-wide scoring functions are combined with the scoring functions of individual players.

Additionally, we plan to provide personal agent interfaces to several mobile devices and web-based support services [Zacharia 1998], provided by the HP Labs CoolTown environment [Caswell 2000; Kindberg 2000; Krishnan 2000].

We will have several college interns working with us this summer, to help make the games enticing, to evaluate player strategies and to develop and integrate new capabilities.

## ACKNOWLEDGMENTS

Our thanks to the team members, Dick Cowan, Steve Fonseca, Bob Kessler, Joe Longson and Farrell Wymore.

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