Agent-mediated Electronic Commerce: An MIT Media Laboratory Perspective

Alexandros Moukas

Software Agents Group,
MIT Media Laboratory,
Cambridge, MA 02139, USA

moux@media.mit.edu

Robert Guttman

Software Agents Group,
MIT Media Laboratory,
Cambridge, MA 02139, USA

guttman@media.mit.edu

Pattie Maes

Software Agents Group,
MIT Media Laboratory,
Cambridge, MA 02139, USA

pattie@media.mit.edu

http://ecommerce.media.mit.edu

Abstract

Software agents, semi-intelligent autonomous tools, will play an increasing role in electronic commerce applications. In this paper we give an overview of the work conducted at MIT's Media Laboratory on different types of agents for electronic commerce: from consumer to consumer "smart" classified ads systems, to merchant agents that provide integrative negotiation capabilities; from agents that facilitate expertise brokering to distributed reputation facilities. Furthermore, we discuss a full-day ecommerce experiment with 170 participants and present our results along with lessons learned.

1 Introduction

Over the past two years, a new kind of software application has appeared based on a synthesis of ideas from artificial intelligence, human-computer interaction and electronic transactions: agents that help mediate electronic commerce activities. Agents differ from "traditional" software in that they are personalized, autonomous, proactive, and adaptive. These qualities make agents particularly useful for the information-rich and process-rich environment of electronic commerce.

Shopping activities require a large effort from a consumer and include searching for parties interested in selling or buying what the consumer wants to buy or sell (e.g., by sifting through catalogs, advertisements in newspapers and television, shelves in stores, etc.), comparing prices and

other features of the good or service to help make an optimal purchase decision, and exchanging currency for a product through some agreed upon, and ideally secure, channels. Traditional Consumer Buying Behavior (CBB) models often need to be redefined to adapt to the electronic world [13], [14]. Agent technology can apply to one or more stages of the CBB models, like Problem Recognition (using agent-based collaborative filtering tools, e.g. [15], [16]), Information Search and Evaluation of Alternatives (using constraint satisfaction technology, e.g. [17]), Negotiation and Purchase Decision (using negotiation distributed and integrative negotiation, e.g. [18], [19], [20] and [21]) and post-purchase evaluation (using reputation mechanisms, feedback, e.g. [22]).

Electronic commerce - in particular, the buying and selling of goods, financial vehicles, and services on the Internet - has so far fallen short of its potential of redefining the marketplace. Reasons for this include consumer buying habits, security and trust concerns, and uncertain market models. In addition to streamlining traditional transactions, agents enable new types of transactions. For example, the elusive one-to-one marketing becomes more of a reality when consumer agents capture and share (or sell) consumer demographics. Prices and other transaction dimensions need no longer to be fixed; selling agents can dynamically tailor merchant offerings to each consumer. Economies of scale become feasible in new markets when agents negotiate on special arbitration contracts. Dynamic business relationships will give rise to more competitively agile organizations. It is these new opportunities combined with substantial reduction in transaction costs that will revolutionize electronic commerce.

This paper is organized as follows: section two discusses background and motivation issues and how they relate to our work. Section three introduces our first generation of agent marketplaces and discusses the results from a real world experiment we conducted. Section four outlines our current work in different aspects of agent-mediated electronic commerce. Finally, section five contains our summary and concluding remarks.

2 Background and Motivation

One of the first domains that web-based electronic commerce focused on was **consumer to consumer** applications that resembled classified ads. Some of the first sites allowed users to perform

keyword searches on the ads [1], some had their ads nicely categorized, making it easier to find ones of interest [2], while other sites had more advanced searching capabilities. For example, Stanford's Infomaster [3] allowed consumers to fill out a form that precisely describes the kind of apartment they are looking for. Infomaster searches the ad databases of several local newspapers and returns those which describe apartments that match the user's specification. These "classified ad" sites provide tools to help the consumer find ads of interest. Certainly, such tools are useful. Yet they only assist with one step in the multi-step process of buying and selling, that of finding ads which match what one is looking for. The idea behind our first system, **Kasbah** was to help users with the other major step in the process, the negotiations between buyer and seller, by providing agents which can autonomously negotiate and make the ``best possible deal'' on the consumer behalf. In Kasbah we try to address issues of **trust and distributed reputation mechanisms** in electronic commerce both from a buyer's and from a seller's perspective.

Unlike consumer to consumer electronic commerce, the early stages of **business to consumer** (retail) electronic commerce were not problem-free. The majority of the merchants established an on-line presence very similar to their static mail-order catalogs. The product information was static, there was no connection to their back-office and legacy systems and their on-line store and the transaction had to be finalized and the payment be made through a human operator.

That initial state of affairs had reached a more or less steady state, with consumers "browsing" through the merchants sites (in a way similar to traditional "window shopping"), and the merchants themselves competing with each other in terms of pricing, service, warranty, web site presentation and design, etc. However, the introduction of the first consumer shopping agents changed drastically this fragile modus operandi. Consumer Shopping Agents were able to collect prices from a large number of merchants with no effort from the part of the consumer in almost zero time; moreover, they were programmed to look just for the best price. They didn't take into consideration any of the additional merchant offerings mentioned above. BargainFinder [4], one of the first agents for price comparison offered valuable insights into the issues involved in price comparison in the on-line world. For example, a third of the on-line CD merchants accessed by BargainFinder blocked all of its price requests because merchants inherently did not wanted to compete on price alone. Value added services that merchants offered on their

web site were being bypassed by BargainFinder and therefore not considered in the consumer's buying decision. This was one of the first lessons learned in the electronic commerce arena: *merchants don't want to be compared just in product price terms.*

A while later, a new type of consumer agents, like Jango [5] and [23] hit the market which managed to "solve" the merchant blocking issue by having the product requests originate from each consumer's web browser instead of from a central site as in BargainFinder. This way, requests to merchants from a Jango-augmented web browser appeared as requests from real consumers. This was another lesson learned: *The merchants with a web presence will be forced to interoperate with agents.* This kind of "aggressive interoperability" makes it convenient for consumers to shop for commodity products but does not leave merchants with many options. If merchants provide on-line catalogs, they will be accessed by agents whether merchants want them to or not.

In order for merchants to survive in the on-line commerce environment they need to be able to differentiate themselves from other merchants. Our **Tete-a-Tete** system addresses the merchant differentiation issue and tries to give merchants a competitive edge by providing them with agents that will on-the-fly negotiate with consumer agents on a customized feature space that will include many more attributes than just price. However, this is not as easy as it sounds given the existing state of merchant on-line stores, which are designed and optimized to be accessed by humans. The vast majority of web pages are currently written in HTML (hypertext markup language) which is a data format language. In contrast, XML (extensible markup language) is a data content meta-language allowing for the semantic tagging of data [6], [7] and [8]. Microsoft and Netscape have each promised support for XML with style sheets in their respective web browsers to help augment HTML with XML tags to create the next generation of WWW on-line stores what are readable both by humans and agents.

Finally, an aspect of electronic commerce where agent technology application are very promising is that of **services**. One of our systems focuses on agents that can act as brokers that facilitate knowledge transfer and just-in-time consulting types of transactions.

3 Kasbah: The First-Generation of Agent Marketplaces

Since 1994 we have embarked upon a research program to create electronic agent marketplaces. Our first system, Kasbah, is an electronic marketplace where agents buy and sell to one another on behalf of consumers [9]. Kasbah is a consumer to consumer electronic commerce system and is based on continuous double auction mechanisms.

In a Kasbah environment we think of a selling agent as being analogous to a classified ad. When a consumer creates a new selling agent, it gives a description of the item they want it to sell. Unlike the traditional classified ad, though, which sits passively in its medium and waits for someone to notice it, Kasbah's selling agents are pro-active. Basically, they try to sell themselves, by going into the marketplace, contacting interested parties (namely, buying agents) and negotiating with them to find the best deal.

A selling agent is autonomous in that, once released into the marketplace, it negotiates and makes decisions on its own, without requiring consumer intervention. The consumer does have high-level control of its behavior. When the consumer creates a new selling agent, they set several parameters to guide it as it tries to sell the specified item. These parameters are:

- *Desired date to sell the item by.* People usually have a deadline by which they want to sell something. For example, a graduating student might want to sell their bicycle before they leave school, because they cannot take it with them.
- *Desired price.* This is the price the consumer would *like* to sell their good for.
- *Lowest acceptable price.* This is the lowest price the consumer *will* sell their good for. If the consumer has junk in their basement that they want to get rid of, they may set the desired price rather high, hoping someone might be willing to pay it, and also set the lowest acceptable price to a more realistic level. On the other hand, a person willing to accept nothing less than their asking price would set the lowest acceptable price to be the desired price.

These parameters define the agent's goal: to sell the item in question for the highest possible price --- ideally, the desired price, but as low as the lowest acceptable price, if that is what it takes

to attract buyer interest in the time frame given. Exactly how to achieve this goal is left to the agent.The appropriate metaphor here is that of a personal assistant [11]. You tell your personal assistant what you would like to be done (“sell this for the best possible price"), and trust it to figure out how to accomplish this task, freeing your time and energy for more interesting pursuits. In addition, we hope that agents might be able to sell (and buy) goods better (e.g. at a higher price) than the consumer would be able to, by taking advantage of their edge in processing speed and communication bandwidth. The different strategies are depicted in Figure 1

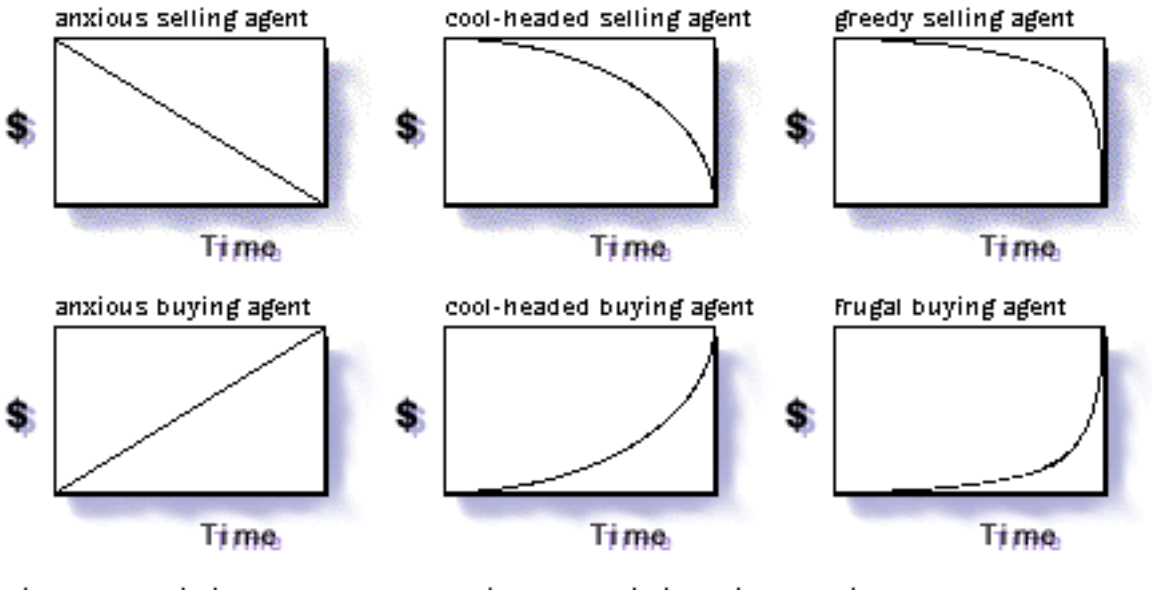

Figure 1 Agents Strategies

While an agent is “free” in terms of how to achieve its objective, the parameters described above suggest how it works. The crude heuristic used by the agents in the current version is: begin by offering the item at the desired price. If there are willing buyers, great. If not, as time goes along, lower the asking price to entice more interest. When the desired date to sell the good by rolls around, the asking price should be about the lowest acceptable price. Of course, all the interesting action is in the subtleties and nuances of how the selling agent goes about lowering the price. It is possible that there will be no buyers (perhaps the lowest acceptable price is too high, or no one interested in what the agent is selling). In this case, the agent fails to achieve its goal.

The consumer can check on his/her selling agents, see which other agents they have talked to, and what prices they have been offered. This information might prompt the consumer to do something like lower an agent's price parameters, if they see that offers are coming in much lower than expected. The consumer always has final control over their agents. When a selling agent reaches an agreement with a buying agent, their consumers may want to give the ok, so to speak, before the agents ''shake hands" on the deal. To investigate the validity of our design we conducted an day-long experiment with people using the system to buy and sell real products. The next section describes this effort and discusses a few lessons learned.

3.1 Kasbah Agent Marketplace Experiment

On October 30th 1996, the Media Laboratory organized a symposium on "Digital Life" for 171 attendees from industry [10]. Many of these people were not technically inclined and none had been introduced to the Kasbah concept beforehand. The attendees were given a total of three objects as well as some money (50 "bits", as we called our unit of currency). We invited the attendees to participate in the experiment and to create "selling" agents to sell some of the objects they owned but did not want and to create "buying" agents to buy some of the objects they wanted to own. When a participant created an agent, he/she would determine its characteristics such as: is it a buying or a selling agent, what does the agent buy or sell (chosen from a limited list of goods), what is the initial asking (or offer) price, what is the final lowest asking (or final highest offer) price and what is the "strategy" the agent will use to lower (or raise) its price over time.

Attendees were able to create agents all day long. At the end of the day, they could exchange their money for wine (70 bits for one bottle). Hence, wine could be said to correspond to the "gold standard" of the economy created; people would decide how many bits objects were worth to them based on the fact that a bottle of wine was worth 70 bits.

Participants in the agent marketplace experiment were immersed in an environment involving interactive kiosks, a transaction center, and several large-scale displays. participants created and interacted with their agents via 20 keyboardless kiosks which consisted of a computer worksta-

tion, monitor, mouse, and bar-code reader. Participants initiated a personalized session by scanning their name tag badge with the bar-code reader. Once automatically logged in, participants were provided with a list of their active agents, a list of completed transactions, and options for creating new agents and changing old ones. The interface was entirely mouse driven æ participants navigated a simple point-and-click interface to create, modify, and monitor their agents. No keyboard input was required. The interface was designed to facilitate short interactions, so that all participants could use the 20 kiosks during the 30 to 60 minute breaks. A typical participant session lasted about five minutes.

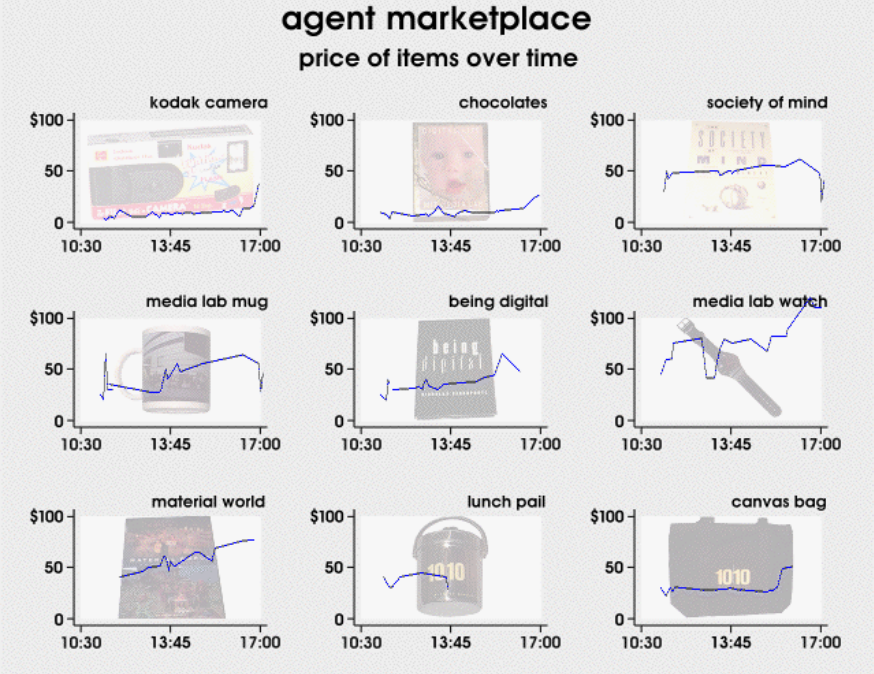

Figure 2 Price of items over time

In addition to the kiosks, several other devices and displays were used to disseminate information. Each participant received a personal alphanumeric pager which would notify them whenever one of their agents had made a deal. For example, if Andy had created an agent named James Bond to sell a lunch pail, and this agent then made a deal with one of Pattie's agents, Andy was paged with the message: “Andy, I sold your Media Lab lunch pail to Pattie Maes for $53. --

James Bond". Pattie was paged with a similar message from her agent. At one point, about half-way through the day, buying and selling agents sent suggestions to participants' pagers when it seemed unlikely that they would make a deal by the end of the day with the price parameters given by the participant. For example, if a participant created an agent to buy a box of chocolates and the maximum price the agent would offer was 20 percent lower than the average selling price of chocolates throughout the day, that agent would page the participant with the message: "Tip: you may want to raise my maximum offer if you want to buy those chocolates - *James Bond*."

An 8 foot high projection display and two large monitors provided visualizations of marketplace statistics including histograms of buying and selling prices for each of the nine good types and a time-series projection illustrating the trend in actual transaction prices for each good over time. Figure 2 shows one of the time-series displays. A scrolling LED 'ticker-tape' displayed up-to-the-minute market information about each of the goods being traded, such as the highest bid, lowest asking price, and last transaction amount.

Upon being notified of a transaction (either via the pager or the participant interface), participants were told to report to the transaction center to exchange the good for the price agreed upon. We anticipated situations where one party would arrive several minutes after the other party (or fail to show up altogether) and wanted to avoid making the participants wait around since they had very busy schedules. Thus, when two participants arrived asynchronously, the transaction center, which had a supply of extra money and surplus goods, completed the one-sided deals. If the two participants arrived at the same time, they carried out the transaction privately between themselves. The transaction center was also used to provide general information and assistance, to make change, and to sell the wine at the end of the day. Two other incidents happened which can be identified in Figure 2. Around 12:30pm, one of the participants spread a rumor saying that at the end of the day, every person present would receive a free Media Lab watch. As a result the price of watches plummeted because people hurried to change the prices of their watch-buying agents. When it was pointed out later that this news was false, the price of watches picked up again.

Another phenomenon that took place is that the prices of items generally rose towards the end of the day. This is the case because at the end of the day, people could only buy wine if they had more than $50. Anyone owning less than $50 was happy to spend all their money on whatever good they could buy, because the money became useless at the end of the experiment.

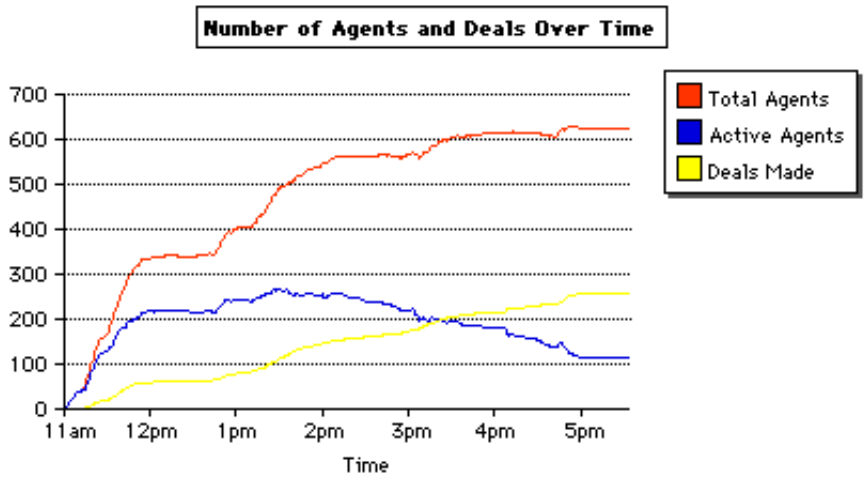

Figure 3 Number of Agents and Deals over Time

Figure 3 shows the total number of agents, the number of active agents (those agents that have not yet made deals), and the cumulative number of completed deals made over the course of the day. The kiosks were accessed heavily during program intermissions and more moderately during lunch. This coincides with the number of agents spikes at the start of the experiment and at particular times - roughly between 11am and 12pm, 1pm and 2pm, and again at 3pm. The noticeable agents spike just before the 5:00pm market close was due to the transaction center infusing agents into the marketplace to distribute the remaining goods. By 1:30pm, the number of active agents in the marketplace began to decrease due to agents making deals faster than they were being created. This corresponds with the substantial rise in deals made around that 1:30pm time frame. The flat-line of agents and deals at 5:00pm is due to kiosks being switched off and the convergence of each agent's negotiation price to its termination price at the 5:00pm hard-coded deadline.

Finally, interviews with participants have revealed that the level of intelligence or sophistication which a buying/selling agent could ultimately demonstrate is limited more by user-agent "trust" issues than by limitations of AI technology. In particular, in order for these agents to be widely accepted, it is crucial that the agent's behavior can easily be understood and controlled by the user.

3.2 PDA@Shop

So far electronic markets and physical markets have been totally separated. One of our other Kasbah-related projects, PDA@shop incorporates a layer of functionality that merges the virtual and the physical marketplaces for the benefit of the shopper. The consumer can use the Personal Digital Assistant (PDA) comparative shopping system to obtain alternative prices, as well as reputation ratings of the potential on-line seller. When the consumer finds himself in a physical vendor's store he can use his PDA to communicate with Kasbah and create a *buying* agent. When the consumer creates a new broker-agent, he/she must set several parameters that the agent will use when it negotiates with the different selling agents. PDAs have several limitations that are relevant to resources required for comparison shopping, namely -- bandwidth, processing speed, and sustainable network connectivity. The goal of PDA@shop is to provide consumers with robust point-of-sale comparison shopping capabilities. Our prototype uses a commercial PDA with an intermittent network connection and the ability to spawn agents. These semi-intelligent shopping programs visit on-line marketplaces and acquire price offers for a set of consumer-requested items.

The aim of the PDA@shop project is to build a domain-independent system, which uses minimum domain-specific knowledge. The system uses a Personal Digital Assistant (PDA) -- in our system we are using US Robotics Pilot Pro [12] -- as an interface communicating with a Kasbah Server for the back-end computational work in order to facilitate search for product types, their names and prices, as well as company names and related reputation quotes.

The consumer can use his/her PDA while looking on a particular product in a shop, or a product advertisement, or even while browsing the web, in order to retrieve relevant information about

the specific model and the producing company, as well as alternative brands available in the market and their respective prices and specifications. Thus the consumer increases his/her options, and can choose between the price offered in the physical market place or the alternative one on the electronic marketplace.

4 Current Efforts

Our current efforts try to address issues like distributed component-based marketplaces, open and extensible languages and protocols for locating and defining goods and services, merchant differentiation, value-based product comparisons, buying decision aids, visualization of marketplace data and activities, as well as issues of trust and reputation of the second generation agent-mediated electronic commerce systems.

In this section we will briefly outline merchant selling agents, methods for a merchant to differentiate on-line, electronic commerce for services and finally a distributed way of establishing reputation mechanisms for electronic transaction partners.

4.1 Tete-a-Tete: Merchant Differentiation

Tete-a-Tete provides a unique negotiation approach to retail sales. It tries to provide to merchants a way of effectively dealing with consumer agents by providing a way for merchants to differentiate themselves in product and service attributes other than price, like delivery time, service, warranty, etc. Unlike most other negotiation systems which negotiate only over price, Tete-a-Tete negotiates across multiple terms of a transaction - e.g., warranty length and options, shipping time and cost, service contract, return policy, quantity, accessories/bundles, credit/loan options, payment options, and other merchant value add. Like Kasbah, this negotiation takes the form of bargaining but not using simple raise or decay functions as in Kasbah. Instead, Tete-a-Tete's shopping agents use the evaluation constraints captured during the Product Brokering and Merchant Brokering stages as dimensions of an overall utility function. This utility function is used by a shopping agent to negotiate an optimal deal with a complementary sales agent.

4.2 Services Electronic Commerce

This project investigates how software agent technology can be used to facilitate knowledge transfer and “just-in-time-consulting”. Imagine a person trying to acquire expertise about a particular problem being able to get assistance in real time. We propose an infrastructure which allows that person to - without much effort - locate an expert who is available to help the expertise-seeker remotely at that moment in time. Specifically, we are building an “electronic market for expertise”, and having agents that can match up expertise-seekers and experts and make deals for an on-the-fly consulting relationship. To participate in this knowledge marketplace, a person can create selling agents that know what expertise that person has and when that person is available to help someone else (and possibly how much s/he charges). Someone in need for consulting can create a buying agent that knows what kind of expertise that person needs and by when (in the next 3 minutes, in the next 3 days, etc.). The buying agent may also have information on how to compare different people offering the expertise (criteria such as: price charged, reputation of the expert, level of expertise, availability, etc.). The market automatically matches up these different buying and selling agents. Once a match has been made, other media are used to implement the tutoring relationship (email, phone, as well as richer communication media). In a similar scenario, a doctor while examining a patient with a rare disease might want an additional expert's opinion for that disease in the next ten minutes (while the patient is still there). The doctor's agents would search for other doctors that can be of assistance in that case and based on a series of parameters (doctor reputation, availability, cost, expertise etc.) decide with which ones to begin negotiations with, conduct the negotiations along a set of different attributes (for instance, if the consultant doctor is in the middle of a meeting, the consulting fee would be higher), conclude them in real time and place a phone call to the consulting doctor.

4.3 Agent-based Distributed Reputation Mechanisms

The core of this project has to do with the current expansion of the usage of the Internet in various aspects of our everyday life and the birth it brought to several kinds of digital communities. The members of these communities (which can be both end consumers and merchants) are often

unrelated to each other, and have no information on each other's reputation or reliability history. This kind of information is vital in Agent mediated Electronic Commerce interactions, where the potential counterpart's reputation can be a significant factor of the price level negotiation strategy, or even the deciding factor of whether to interact with the particular consumer or not. Therefore Kasbah, and our second generation of agent systems will allow for reputation differentiation that can make the on-line shopping experience more efficient and realistic. Our mechanisms rely on collaborative rating among the consumers of the system, after every agent mediated interaction and a personalized evaluation of the various ratings assigned to each consumer or merchant.

5 Concluding Remarks

Our first-generation agent-mediated electronic commerce systems are already creating new markets (e.g., low-cost consumer-to-consumer) and beginning to reduce transaction costs in a variety of business models. However, we still have a long way to go before software agents transform how businesses conduct business. This change will occur as Software Agent technology matures to better manage ambiguous content, personalized preferences, complex goals, changing environments, and disconnected parties, but more importantly, as standards are adopted to succinctly and universally define goods and services, consumer and merchant profiles, value added services, secure payment mechanisms, inter-business electronic forms, etc.

During this next-generation of agent-mediated electronic commerce, agents will streamline business-to-business transactions beyond recognition, reducing transaction costs at every stage of the supply chain. Finally, at some critical threshold, new types of transactions will emerge in the form of dynamic relationships among previously unknown parties. At the speed of bits, agents will strategically form and reform coalitions to bid on contracts and leverage economies of scale -- in essence, creating dynamic business partnerships that exist only as long as necessary. It is in this third-generation of agent-mediated electronic commerce where virtual and non-virtual companies will be at their most agile and marketplaces will approach perfect efficiency.[1]

1. Note to reviewers: We would appreciate any comments on the content, and the targeted audience of this paper. Should the paper be more technical? More focused? More general? Should it be discussing more related work?

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