Introduction to the Special Issue on Agent Technologies for Electronic Commerce

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1 Introduction

An individual's survival and comfort depends on the goods he or she possesses and the skills with which he can adapt the environment to his needs. His surrounding community may volunteer to add to his store of possessions or offer services. Beyond that, the individual can meet his needs only through trade with others. To negotiate a trade, the individual and a trading partner must agree upon a real-numbered value assigned to goods and services. Then monetary tokens that represent this value are exchanged for the goods or services.

Through electronic commerce, i.e. the use of a computer network to enhance trade, physical distance is no longer a barrier to the search for a trading partner. A widely-held view of the future is that computer networks will increase an individual's chances of finding trading partners with goods or services that meet his need. Besides information about needed and offered goods and services, the network can transmit electronic monetary tokens that cannot be falsely generated, so they truly represent a value in lieu of goods. In some cases the goods and services themselves can be transmitted across the network, such as digital multimedia products, or organizational or reasoning services. Thus electronic commerce is a natural tool for procuring goods and services that improve our survival and comfort.

This simplified description of e-commerce provides just enough background for us to point out the opportunities and problems inherent in e-commerce, to which the papers in this issue are addressed:

- Negotiation of the value of a good or service can be done electronically, through auctions [9, 10, 3, 8, 7].
- When the items to be traded cannot be described in simple terms, or the trade is not a simple transfer of ownership, then negotiation of the terms

of a contract is required. This negotiation too can be done electronically [8, 3].

- In a marketplace where both trading partners are physically present, verification of the value of traded goods is possible before the exchange takes place. But an electronic marketplace may not allow verification until after the exchange; moreover the verification will not be done in the presence of the other partner so disputes cannot be settled *vis à vis*. Electronic trading is more likely to succeed if trust among the participants can be established beforehand [8, 6, 10].
- Much information about the history of the market and its participants will be available in electronic trading, and by reacting to that information, i.e. learning about the market and its participants, a trading partner will be able to minimize the risk of having unsuccessful trades and to maximize outcomes [2, 11].
- If an individual does not meet the expectation of his trading partner, the community may wish to punish this individual by sharing that fact, so that his reputation will suffer, diminishing his chance of participating in further trade [5, 1, 11]
- The ease of use and efficiency (speed) of transactions in an electronic market place determines how successful the trading partners can be. Effective markets of the future must be able to handle very large numbers of transactions among large numbers of traders [9, 8, 7, 6, 4].

The premise of this special issue is that the computer agent technology is applicable to these problems. Computer agents can act as the actual participants in the trade, on behalf of humans. These agents may have some autonomony to make decisions affecting the trade. This raises a natural concern: is it dangerous to give an autonomous computer program access to personal information and the ability to make decisions about money? Before non-expert human users will accept and be able to use agent technologies, the capabilities of the technology need to be increased, and in many cases existing AI techniques are already applicable. When that happens, the advantages of using computers for communication, calculation, memory and reasoning will accrue to electronic commerce. Several papers also consider the electronic marketplace where these agents will act. These markets are being designed to remove the advantages of misrepresenting an agent's intention. In this issue we see designers taking advantage of the large body of scienctific and economic theory, including game theory, optimization techniques, utility theory, statistics, probability theory, and theories of evidence.

2 A Guided Tour

The accepted papers have been placed in the issue in an order that reflects a progression of ideas. It starts at negotiation [3] which depends upon trust [10],

which depends upon reputation [5, 1] and upon learning about the market [11] and finding alliances [6]. Then we explore detailed designs of the market [7, 9] and of agents within it [9, 4]. The issue closes with a proposal that unifies many of the ideas [8]. The following paragraphs place the papers into this organization.

While negotiation of price by auctions occurs in many of the papers, the first paper [3] can deal with negotiation of more detailed contracts. This paper exploits the logic programmer's ideal of executable specification, in this case using Grosof's Courteous Logic Programming. General knowledge about auctions and specific knowledge about the user's preferences, are collected and mapped to a given auction protocol for execution.

In [10], negotiating when an agent does not fully trust another agent is shown to lead to as efficient a marketplace as one in which agents fully trust each other, as long as the degree of trust is accurate.

How to accurately determine trust is explored in the next three papers. Trust estimates can be gleaned from an agent's reputation, which in [5] is determined by role fulfillment. A theory of how reputation varies over time in response to other agents' recommendations is presented and supported by experimental evidence.

Given the importance of reputation in establishing trust, and that much information about transactions can be gathered by electronic markets, in [1] a reputation management system is proposed that gathers information from a variety of sources. It uses Dempster-Schaefer theory to combine evidence and to arrive at an expected trustworthiness. Rather than depending on a centralized reputation authority which may not be available, here reputation is propagated among small referral networks of trusted agents that may vary in membership. This helps to ensure accurate ratings that track changes in trustworthiness; robustness of this tracking is experimentally verified.

Focused on the same problem, [11] uses reinforcement learning to train buyers to choose the most trustworthy sellers. At the same time sellers are trained to adjust the price and quality of their goods to better match the buying capacity and expectation of the buyers. Experimental validation of the theory for buyers is a recent extension of this work.

Continuing with the seller's point of view, [2] looks at learning about the consumer population, where information is gained by experimenting with different pricing schedules. A price schedule sets the incremental costs of additional items, such as whether and how much cheaper it is to buy in bulk. The time taken to decide which price schedule gives highest profitability may be so long that in the meantime the consumer population has changed. So choosing a price schedule quickly is balanced against choosing the best one, as in any online learning situation.

[6] looks at several ways an agent may choose to join a coalition, or allied group of buyers, with the aim of increasing individual benefit. A side effect is that the market becomes more predictable and stable, and that communication is reduced allowing the number of particpants to increase.

The next paper continues this concern with the design of the market, for effi-

ciency as the number of trading partners increases, and for its overall behaviour. [7] provides a prototype multi-unit double auction market ruled so that participants gain no advantage by inaccurately reporting their reservation price or their supply. Thus reputation and trust, which has been a focus of papers so far, is less of a concern for this paper since the market's rules encourage honest trading practices. This paper also experimentally and theoretically verifies this double auction market's efficiency (how much of the market's value is actually obtained).

The next two papers are concerned with the design of agents within the context of a market or society. [9] considers how changes in the market should change the agent's negotiation strategy, uniquely taking into account such factors as eagerness, and remaining trading time, as well as usual factors based on competition. [4] proposes two distributed archictectures for agents in search of information; one is generic and the other is focused on information that often moves from site to site and cannot be depended upon to stay at one site. These systems seem applicable for finding trading partners in dynamically changing market with no central directory of sellers or buyers.

Finally [8] describes three systems: a configurable auction server for combinatorial auctions, a leveled commitment contract optimizer for determining optimal contract price, and an exchange planner for anonymous safe exchanges between buyer and seller. This suite offers solutions to many of the problems listed above.

3 About this issue

Some of the authors submitting papers to this issue of Computational Intelligence presented papers and/or attend the workshop on Novel E-Commerce Applications of Agents (NECAA) at AI 2001, the Canadian Artificial Intelligence Conference held in Ottawa on June 8, 2001. The closing date for submissions of papers to this issue was the beginning of February 2002. As the date for publication of this issue is November 15, 2002, this material represents the current state of the art.

In total twenty papers were submitted to this issue, and eleven papers were deemed of sufficiently high quality by at least two reviewers to be included, in some cases with a very quick second review. Several of the remaining papers are being considered for subsequent issues of Computational Intelligence.

Seventeen research institutions are represented by the authors of this issue: the Chinese University of Hong Kong, three Carnegie Mellon groups (Graduate School of Industrial Administration, The Robotics Institute, and the Center for Advanced Learning and Discovery), IBM Research's Institutue for Advanced Commerce, MIT Sloan School of Management, National Research Council Canada's Institute for Information Technology in Ottawa and its Institute for Information Technology – e-Business in Fredericton, North Carolina State University, State University of New York Buffalo, three University of Michigan groups (Artificial Intelligence Lab, Department of Economics and School of In-

formation), the University of New Brunswick, the University of Saskatchewan, and the University of Waterloo. A further nine institutions are represented by other submitted papers.

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