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Intelligent agents for supporting construction procurement negotiation

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Abstract

Negotiation is commonly required to reach a final contractual agreement in construction material procurement. However, even simple negotiations often result in suboptimal agreements, thus 'leaving money on the table.' An automated system that could evaluate bids, negotiate to finalize the bid, and value the individual characteristics of negotiating parties would be useful to both contractors and suppliers. This study examines common negotiable issues and options for construction material procurement, and presents an agent-based system, named C-Negotiators, that helps a contractor and suppliers to negotiate via the Internet. Genetic algorithm is used to find the most beneficial agreement for all parties, and web-based development is used to improve negotiation efficiency. Experiments also were conducted and demonstrated that C-Negotiators improved negotiation efficiency by saving negotiation time and cost, and improved negotiation effectiveness by suggesting a better agreement with higher joint payoff. Although the increase in payoff was smaller than expected, the improvement should increase for more complex negotiation problems involving more issues and options, or complicated preferences and for inexperienced negotiators. The application of the system is mainly limited by its symmetric optimization, while procurement negotiations in the construction industry are biased towards the contractor, and also by user comfort with their preferences and negotiations being monitored by the system.

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1. Introduction

Most construction business processes rely heavily on traditional means of communication such as face-to-face meetings and the exchange of paper documents such as technical drawings, specifications, and site instructions. The construction industry has long recognized the need to increase the efficiency of these processes by exchanging large volumes of information quickly and cheaply (Deng, Li, Tam, Shen, & Love, 2001). As international competition continues to intensify, significant numbers of construction organizations are strategically investing heavily in information technology to gain competitive advantage (Betts, 1999). Various web-based collaboration platforms for project management and procurement have also been developed. One example is the PrimeContract developed by Primavera System Inc (Primavera System, 2003), which attempts to streamline intra-company and inter-company business processes, and supports project team communication, procurement, bid/auction, bid analysis, and contracting.

Construction material procurement is a key business where negotiation is commonly required to reach final contractual agreement. However, even simple negotiations often result in suboptimal agreements, thus 'leaving money on the table' (Raiffa, 1982). Based on Oliver (1996), while many factors lead negotiators to miss out on gains, falsely assuming fixed pies and the framing of the situation often cause parties to fail to reach mutually beneficial agreements. The challenge of negotiation arises partly from the fact that each side has private information about their own payoff function but is ignorant of the values and strategies of the other side. Exacerbating this situation is the negotiators' incentive to misrepresent their preferences.

For illustration, consider the following scenario: a general contractor has solicited several bid proposals from suppliers registered on a web-based construction procurement platform. Besides preferring a cheaper price, the contractor also prefers payment by usance check instead of cash to maintain cash flow level, and prefers delivery of materials in small consignments as required to avoid

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overloading site storage space. Suppliers with no previous business with a contractor are likely to attempt to show their competitiveness by offering the contractor considerable flexibility during negotiations. For example, one supplier, as a new comer, may be willing to offer large price discounts if procurement can be extended to include other related materials, as well as one-week notice for delivery, and 60-day usance check if future procurement is possible. Currently, such routine business transactions often involve some form of negotiation between the parties. Usually neither side knows the preferences of the other: the prospective contractor does not know the costs of the supplier, and the supplier does not know how much the buyer values each negotiable issue.

The cost and time involved in negotiation mean that contractors must limit the number of prospective suppliers they negotiate with, and also the number of options included in negotiations. A cheap and efficient negotiation method would allow the exploration of more prospective suppliers and options. Clearly, an automated system that could evaluate bids, negotiate to finalize the bid, and value the characteristics of the negotiating parties would be useful to both contractors and suppliers.

Bazerman (1994) classified negotiations into two categories based on negotiator attitudes: distribution (claiming a share of the pie) and integration (enlarging the available pie). The distribution type of negotiation is a zero-sum game, i.e. a gain for one party is a loss for another. Such negotiations involve each party using the strategy of predicting the bottom line of the other and presenting an offer that maximizes their own benefit. Such negotiations generally result in low satisfaction level. On the other hand, the integration type of negotiations promotes cooperation among negotiators. Because each negotiator has different preferences regarding each negotiable issue and option, the strategy is not to attempt to win on all issues, but to identify those issues that the negotiators care about most and make tradeoffs accordingly. Such negotiations usually achieve a higher satisfaction level.

Decision support research has focused on the design and development of tools for aiding negotiators in various domains, such as Genie (Harris, Kraus, Wilkenfield, & Blake, 1991) that stresses model visualization capabilities, NEGOPLAN (Krovi, Graesser, & Pracht, 1999) that generates if-then production rules, and GBML (Matwin et al., 1991) that identifies rules for improving negotiations. Software agents are also applied to facilitate negotiation. Software agents are computer programs with a certain degree of autonomy, which are continuously active and interact with other systems on behalf of users (Bradshaw, 1997). Snadholm and Lesser (1995) found that cooperative agents often exist and perform enterprise tasks such as production planning and meeting scheduling. Competitive agents do not give in during negotiations except in exchange for compensation because they only care about their benefit and do not consider mutual benefit. However, this competitive style prevents the disclosure of individual preferences and often compromises individual benefit. Several electronic commerce web sites, such as Auction Bot (2001), eBay's Auction Web (2003), Kasbah, 2003, and OnSale (2003), also offer agents that help in on-line price negotiations. For example, Kasbah adopts distribution type of negotiations and allows users to define their own agents with buying strategies (i.e. anxious, cool-head, and frugal), selling strategies (i.e., anxious, cool-head, greedy, and initialization parameters (e.g. asking price, acceptable price, and deadline). T@T (2003), additionally to price, allows both buyer and sellers to customize their agents and negotiate on the issues of warranty, delivery time and method, service plan, return policy, and free bonus. No agents have been developed specifically for negotiating construction procurement between contractor and suppliers.

This study examines common negotiable issues and options for construction material procurement, and develops an agent-based system that helps a contractor and suppliers to negotiate via the Internet. Genetic algorithm is used to find the most beneficial agreement for both parties, and web-based development helps improve the negotiation efficiency. Experiments were also conducted to assess the effectiveness and efficiency of the system compared with human negotiation.

2. Practice of negotiation on construction procurement

The general contractor for a project needs to procure materials and equipment from suppliers to execute the project. The contractor also may need to subcontract part of the work to specialty traders because of considerations of technological specialties, resource availability, profit margin, and risk diversification. After identifying procurement items, tenders from suppliers are invited and evaluated. The evaluation may lead directly to a final decision awarding the contract to the supplier offering the best deal without further negotiation. This situation frequently occurs when space in negotiable issues is limited because negation takes time and man-hours. However, especially for a valuable or complex contract, the procurement of some items still requires further negotiation with several prospective suppliers. Negotiation on issues such as price, terms of payment, and delivery may give the contractor business leverage.

In practice, issues to be negotiated are determined at the beginning of negotiations, but new issues sometimes may arise during negotiations. The contractor proposes desired options for the negotiable issues, and the supplier proposes a price based on these options. The proposed price may be continuously lowered during the negotiations. The supplier may also request that terms be modified or include new issues to offset price decreases. The negotiation ends when both parties agree on the options and price.

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