Modelling Business Negotiations for Electronic Commerce

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Abstract

E-commerce "localizes global markets" by opening remote markets to retail and to small companies. Newly developed E-commerce tools allow individual and organizational buyers to search for suppliers anywhere and make deals electronically. We propose a software agent that interacts with a buyer and elicits information about the criteria, preferences, and limitations, and that conducts business negotiation on behalf of the buyer. The agent has been implemented and tested in Negoplan, a software system that supports the simulation of decision processes. Results of several negotiation simulations are presented.

1. Introduction

Internet connectivity and the steadily increasing bandwidth open up exciting possibilities, in particular content-rich interactions ranging from electronic commerce to video-conferencing, and distance education. Electronic commerce (E-commerce) is a common name for a variety of software tools and systems that offer such services as search for information, transaction management, authentication and authorization, payment on-line, accounting and reporting, document handling and so on (S. Hamilton 1997; J. Hamilton 1997; Kambil 1997). These systems provide basic infrastructure for Internet-based commercial activity.

While E-commerce is expected mainly to benefit large companies, it also "localizes global markets" by opening remote markets to retail and to small companies. This drastically changes the conditions in which firms operate and customers make purchasing decisions. For example, it is possible to apply a software agent to determining the best deal. Andersen Consulting has developed Bargain Finder, a simple software agent that locates compact discs and allows price comparison (Andersen Consulting 1997). It gives the customer a list of stores that have the best price for a CD. Bargain Finder interferes with a common business practice (from the pre-Internet era) of heavily discounting several products to attract customers who then may also buy more expensive products. Several on-line CD stores now block Bargain Finder, but this countermeasure will not survive the onset of personal or personalized software agents that should soon become widely available. Jango (Doorenbos *et al.*, 1997; Jango, 1998), for example, addresses the merchant-blocking issue by having a request originate from the consumer site rather than one central site.

The availability of E-commerce tools allows individual and organizational customers to search for suppliers anywhere and make deals electronically. It is necessary to address two interrelated issues, arising from this trend, that significantly complicate the life of an Internet shopper.

- Companies aggressively try to attracts customers; in conjunction with the expansion of the markets, this sharply increases the number of companies a customer may have to deal with for *his* success.
- Business decision making and negotiations (conducted both by individuals and organizations) become increasingly complex as access to markets becomes faster and wider, and the amount of interaction shoots up almost uncontrollably.

The complexity of decision making and negotiations will further increase as software agents become more adept, electronic markets (where an increasing number of companies post services and products) get broader, and bidding systems proliferate. There will be demand for systems that not only seek deals, but also engage in business negotiations and make business decisions. Certain negotiations services are already available. Sun's Matchmaker allow customers and vendors to post offers (at various level of detail) and to receive prompt notification of close matches. PersonaLogic (1998) allows consumers to learn about products they wish to purchase and provides support by reducing the number of products through the introduction of constraints and bounds on the product's features.

Current work on the technologies that support consumers and businesses in making purchasing decisions is in the development of software agents and electronic markets populated by multiple interacting agents (Guttman *et al.*, 1998; Guttman and Maes, 1998). These programs are very simple from the point of view of decision making and negotiations. Most of them do not allow multi-issue negotiations, and typically employ one mechanism for offer evaluation. We propose a system that offers a significantly more elaborate model of negotiations. It allows both distributive and integrative bargaining, and does not assume negotiators' full rationality.

2. A representation of business negotiations

2.1. Business negotiation

Negotiations between buyers and sellers, both institutional and individual, involve several activities grouped in the value chain (Ruynon and Steward, 1987). The activities are parallel. They involve both the buyer and seller; some are undertaken only by one side, others involve both sides. In the value chain model the activities are represented as a sequence of steps illustrated in Figure 1.

We consider business negotiations from the point of view of a buyer, and we focus on the first three activities in the value chain: product discovery, evaluation, and negotiation of terms. E-commerce introduces qualitative changes to these activities.

In product discovery, the buyer recognizes a need and searches for products that will meet this need. Buyers now have access to many markets, previously unknown or not accessible. The

number of products (models) and sellers has also increased dramatically. Further, interaction with sellers may assume new aspects in dealing with different cultures and laws.

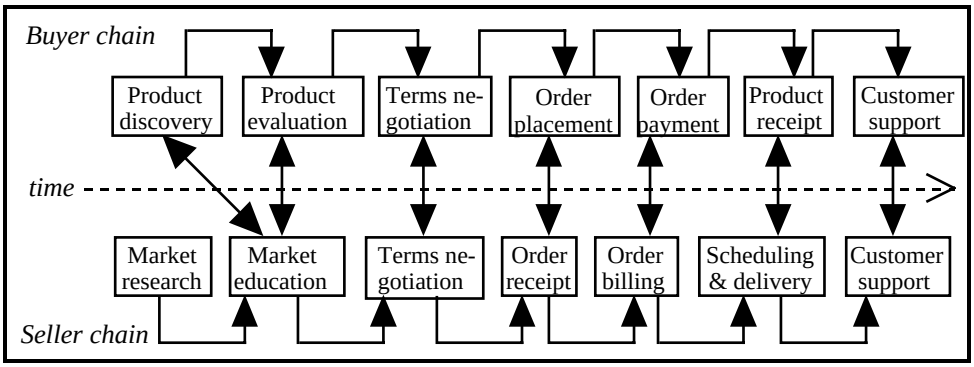

Figure 1. The value chain model

In product evaluation, the attribute levels specific to any given product are assessed. This activity also includes a comparison that allows products to be ranked in a manner related to the buyer's previously expressed need.

Traditionally products could be evaluated directly by visual inspection, by trying them out, or by considering other buyers' evaluation. E-commerce, in which direct evaluation is not possible, requires buyers to rely on others or to assess similar products on local markets.

During negotiation of terms, the buyer and the seller interact and exchange information. Negotiation may concern only the price (this is typical to auctions), or a wider range of product attributes, product options, including warranty, delivery time, payment schedules, and service terms. Negotiation is often the first moment when the buyer and the seller interact. The result of this activity is an agreement followed by order placement. It is an important aspect of terms negotiation that it may establish a relationship between the buyer and the seller that leads to a continuing business.

As in the preceding activities, E-commerce introduces significant complexities to terms negotiations. The physical distance between the parties, the fact that they do not know each other and may be unable to find common relations, the possibility of different business practices, different culture—all this contributes to the complexity. We conclude that E-commerce significantly increases the complexity of buying and selling, but at the same time offer no less significant opportunities for buyers and sellers, large and small. Software agents may help make transactions more efficiently and overcome many of the traditional difficulties.

2.2. Negotiation participants

Research projects that develop agent technologies for electronic commerce include Doorenbos *et al*. (1997) and Gutman *et al*. (1998). The principle is that a buyer communicates with a software agent which then performs the buyer's activities autonomously. The agent gives the

buyer information needed to complete those steps of the value chain model for which it was designed. A seller's agent functions in a similar way, performing assigned actions.

Software agents are personalized, autonomous, proactive, and adaptive (Moukas *et al*., 1998). Decision support systems (DSS) have, however, the same attributes (El-Najdawi and Stylianou, 1993). The role of DSS is to support decision makers in solving ill-structured problems through the use of decision analysis. In negotiations, negotiation support systems (NSS) play this role; they implement techniques of negotiation and decision analysis (Kersten, 1997). In the proposed model of business negotiation, NSS plays the role of a front-end, interacts with the user and provides specifications for the agent which, in turn, interacts with other agents or sellers. We present the organization and roles of the entities in this process from the buyer's perspective, but this can be easily adapted to the seller's perspective.

We distinguish four entities in the negotiation:

1. the *user* is a buyer (**B**), a person who can commit resources (own or those of an organization) in order to procure goods;
2. the negotiating *agent* (**A**) is a system with which the user interacts and which represents the user in all other contacts;
3. the *messenger* (**M**) is a system that browses the Web in order to carry out the agent's requests and provides it with information given by the sellers;
4. the *sellers* ($\mathbf{S}_i$, $i = 1, \ldots, n$) or agents acting on their behalf inform the potential customers about products, services, and conditions of sales.

The two distinct classes of artificial entities in an organization are agents and messengers. In the literature on software agents messengers are often identified with the agents. We propose that messengers perform cognitively simple functions in information selection, relevant to the monadic stage of information processing (De May 1992). Agents process information about the structure and context of the decision situation, and may resolve ambiguities. Agents do not require the user's intervention for many decisions, such as offer analysis and selection, and counter-offer formulation. This is a deliberate minimization of the user's effort.

In this paper we concentrate on the specification and behaviour of a negotiating agent **A a**nd its interactions with buyer **B**. Gathering information about the product and selecting attributes relevant to **B** are not considered, nor are interactions between **A**, **M** and $\mathbf{S}_i$, $i \in I$.

2.3. The negotiation problem

We consider the following problem **P**:

> User **B** wants to purchase an item **I** characterized by k attributes and has preferences as to the attributes and their values. Agent **A** has information about the salient attribute values; for each attribute m_j ($j \in J$), it has l_j salient values $m^*_{j1}, \ldots, m^*_{jl_j}$.

A interacts with **B** and acquires information via support mechanisms necessary to initiate and conduct negotiations. The agent then activates the messenger **M** that searches for data on Web sites of potential sellers of the item; **M** leaves at these sites a note about the user's request. **M** returns a list of sites and initial offers to the agent, which analyses them and may reject some. Selected offers are taken up, and **A** prepares counter-offers to be carried to the sellers **S** by messengers. After a few iterations **A** presents the user with a short list, an assessment of the possible deals, or a completed deal. **A**'s degree of autonomy depends on **B**'s strategy.

This problem involves both individual decision making and negotiations. Individual decisions include specification of the item's attributes relevant for the user, and of the user's preferences. Negotiations involve analysis of the offers, offer rejection or acceptance, and the construction of counter-offers. This is illustrated in Figure 2.

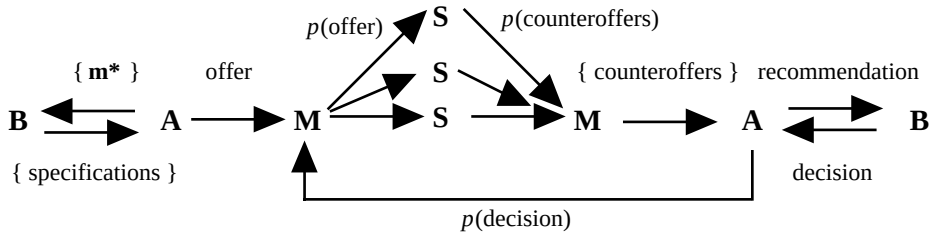

Figure 2. Schematic representation of the negotiation problem **P**

We will build a model of problem **P** in Negoplan. This is a system developed to represent and simulate negotiation processes and other decision processes that fit a broader negotiation paradigm (Noronha and Szpakowicz 1996).

2.4. Support mechanisms

An important characteristic of the proposed model is the incorporation of decision- and negotiation-theoretic constructs, and a methodology based on negotiation analysis (Fisher *et al*., 1994; Raiffa 1982). The agent follows the prescriptions of the decision theory and the negotiation theory, employing mechanisms designed within these theories.

The negotiation process comprises three phases: pre-negotiation, actual negotiation (offer exchange) and post-settlement. The negotiation literature indeed suggests three phases: *pre-negotiation analysis*, *conduct of negotiation*, and *post-settlement analysis* (Graham, Mintu *et al*., 1994; Kersten and Noronha, 1997; Kleindorfer *et al*., 1993).

In the pre-negotiation phase the situation and the decision problem are analyzed. This requires the knowledge of the problem attributes, the buyer's preferences and criteria for evaluating the options (sellers' offers). Criteria (m_j, $j \in J_B \subset J$) are those attributes (m_j, $j \in J$) that buyer **B** considers important. To facilitate agent **A**'s analysis and ranking of offers it is advisable for **B**

and **A** to interact. Interaction should lead to defining a utility function $u_B = f(m_j, j \in J_B)$ that represents **B**'s preferences and, if required, risk attitude. Utility is defined by a preference elicitation procedure (e.g., the analytic hierarchy process or hybrid conjoint analysis) using salient attribute values $m^*_{j1}, \ldots, m^*_{jl_j}, j \in J$, defined *a priori* or acquired from external sources.*

Agent **A** receives **B**'s reservation levels, $\underline{m_j}$, $j \in J_R$, for some or all attributes; these are the values below which **B** will not accept any offer. Another important mechanism is the best alternative to the negotiated agreement (BATNA) which may be formulated only in terms of the utility value u_{batna} or in terms of the attribute values $m_{j,batna}$, $j \in J_B$. Having the most preferred offer (the best possible product) may be important information for the agent. Constraints on a group of attributes may also be required, for example, a constraint linking all partial payments and an upper cost value.

Information used by **A** in negotiation and acquired from interactions with **B** is indicated in Fig. 2 as *specifications*. Specifications also include **B**'s statement of **A**'s degree of autonomy, and the negotiation strategy. **B** may be able to provide only a partial specification. This does not make **A**'s negotiations impossible but it may weaken **A**'s ability to make judgment.

Specifications are used to construct an offer. We use the term "offer" in a broad sense. An offer may be a proposal to buy a concrete product or a general request for proposals, or some intermediate form. As shown in Fig. 2, **A** formulates an offer and gives it to messenger **M** which initiates search for sellers. When **M**'s search succeeds, a message (p(offer)) is delivered.

M gets counteroffers from the sellers; they may be presented in different forms and **M** may need to transform them into a format acceptable by **A**. **A** analyses the counteroffers: determines their utility values, compares with BATNA, with reservation levels and with the most preferred offer. Depending on the degree of autonomy and the negotiation strategy, **A** may select several sellers, formulate counteroffers and ask **M** to send them to the selected sellers, request more offers, prepare a short list of sellers, or accept an offer.

3. Negoplan

Negoplan (1997) is a software system, implemented in Prolog, that supports the simulation of decision processes (Kersten and Szpakowicz 1994) by allowing a systematic analytical solution of sequential decision problems, of which negotiation is an example. Negoplan has been originally designed for bilateral negotiations (Matwin *et al*. 1989), where typically three different interacting entities are distinguished: a negotiator (the system's user), an opponent,

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* This may pose extrapolation or interpolation problems when values introduced in offers differ significantly from the salient values. A problem may also arise when an attribute is qualitative (e.g., colour) and an offer contains a value different from the salient values. In our experiments we made a simplified assumption that all attributes are quantitative. A simple but unappealing solution to both problems is to have the agent ask the buyer for input.

and the decision environment. Negotiations are conducted between the user and the opponent whose behaviour is simulated by the system; this occurs in an environment whose interaction with the negotiating parties is also simulated. The parties and the environment are represented by a variety of constructs: rules, metarules, procedures and functions. They have been designed to simulate behaviour, actions and reactions, and decision making activities. A set of constructs representing three interacting entities is called a *Negoplan case*.

Negoplan provides a framework in which any specialized solution procedure, usually externally implemented, can be applied when triggered by conditions that warrant the use of this specialized technique. Negoplan supports interactive exploration of decisions and their effects. In problem **P**, Negoplan provides a representation of the user's preferences and requirements. This is done in a similar manner as in Decision Support Systems (DSSs), that is, the system interacts with its user and constructs a utility function.

Negoplan's capabilities extend beyond those of conventional DSSs: it reasons about the qualitative aspects of a problem, and offers the representational precision of models expressed in logic. This allows us to represent a decision making agent that analyses situations, evaluates alternatives in a decision context, and makes choices based on the information provided by others; in problem **P**, this means the user and the messengers.

Negoplan has been initially developed to represent bilateral (*1-to-*1) negotiations, and recently modified to allow *1-to-n* negotiations, in which one agent (supported by the system) may conduct with multiple other agents negotiations about one issue or even several different issues (Erkol 1998).

4. A Negoplan case

Problem **P** serves as the basis for the development of a Negoplan *case* that we use to observe the behaviour of the negotiating agent **A**—denoted `neg_agent`—with different users and different offers identified by the messengers. We concentrate on `neg_agent` and do not represent all details of the messengers and suppliers. We can simplify the picture by not distinguishing these two classes of entities: in the Negoplan model we denote all of them company. The user's choices may be affected by familiarity with a supplier; to model this, we have known companies and unknown companies. All in all, we have two types of active entities in the Negoplan model, the negotiating agent and the companies that sell items the user wants to buy. The environment does not play a significant role. It may give the agent additional information about the market and the companies, and introduce small random distortion in the communication—for a realistic simulation. The latter helps observe the agent's reactions to ambiguous or incomplete information.

A Negoplan case is stored in five data sets. The two most important of them are a *rule base*, in which the initial state of the agent is specified, and a *metabase* (Negoplan rules and metarules that describe various behaviour of the agent).

The *rule base* for problem **P** comprises the following simple rules, which allow for the initiation of the agent's actions.

```
neg_agent <- negotiation .
negotiation <- pre_negotiation & offers & action .
pre_negotiation <- 'define preferences' .
offers <- 'no offers' .
```

These four rules can be loosely interpreted as follows: the agent is involved in negotiation; negotiation is characterized by the pre-negotiation phase, the set of offers (initially empty), and the activities (yet to be identified by the system); the pre-negotiation phase requires defining preferences; and there have yet been no offers to consider. When the user accepts this interpretation, Negoplan will continue and search for activities that the agent may undertake. These activities are described in the remaining Negoplan data sets.

The *metabase* is divided into *packets*. A packet is a group of metarules that represent one type of behaviour. In our model there also is a packet with metarules that determine the flow of control among other packets; this packet is called methodologies, to emphasize the fact that it imposes a structure on the decision and negotiation processes, following the analytical and formal literature (Kersten *et al*. 1991; Kleindorfer *et al*. 1993; Raiffa 1982). The metarules in the methodologies packet activate other packets, depending on the context. For example, after the agent has completed the pre-negotiation phase, offers will be requested for the item. The following simple metarule activates ("switches to") the packet called `send_request`.

```
neg_agent : 'I request offers' ::= true
==>
modify ( action <- 'Request offers' )
switch_to send_request
--- methodologies .
```

The metarule modifies the state of the agent by adding the rule

```
action <- 'Request offers'
```

and activates the packet `send_request` with activities related to sending offer requests. The packet `send_request` is activated after a dialogue with the user. The user chooses the option 'I request offers' when the following *selection* metarule has been invoked:

```
neg_agent : 'Whose first offer' ::= true
==>
select one ( 'I specify first offer', 'Request offers' )
--- methodologies .
```

The methodologies packet guides the agent through the phases of the negotiation process. In the pre-negotiation analysis the agent seeks information via support mechanisms. This information is used to analyze offers and formulate counter-offers during negotiations; these activities are done in packets in which offer utility is calculated, possible violations of the

reservation prices determined, different offers compared among themselves and with BATNA and with the possible best compromise. If the agent is given autonomy to construct counter-offers then offer construction is done in another packet.

Several packets are used to get from buyer **B** information needed to conduct negotiations. Support mechanisms discussed in Section 2.4 are implemented in these packets. For example, there is a packet called batna in which the BATNA values are determined. Information is acquired via a selection metarule. Selection metarules request input from the user and pass on to the agent the details of actions it should perform. The metarule, a little more complex, belongs to a packet called batna:

```
neg_agent : 'batna specification' ::= true &
neg_agent : 'Unit pref'(price, PricePerUnit) :: true &
neg_agent : 'Unit pref'(delivery, DelPrefUnit) :: true &
neg_agent : 'Unit pref'(payment, PayPrefUnit) :: true
==>
select (     'Price ($)'(BatnaPrice) +
                    ask_real(batnaPrice, 3.45, 5.50),
             'Delivery(Days)'(BatnaDel) +
                    ask_int(batnaDel, 20, 60),
             'Payment(days)'(BatnaPay) +
                    ask_int(batnaPay, 0, 60) )
 with_message
 'Select option you can achieve with no negotiations' &
{ BValue is 100 - ((3.45 - BatnaPrice) * PricePrefUnit +
                  (20 - BatnaDel) * DelPerUnit +
                  (60 - BatnaPay) * PayPerUnit) ),
  BatnaValue is integer(BValue) } &
neg_agent : 'BATNA'(BatnaValue) ::= true
--- batna .
```

This selection metarule is invoked when the agent has already acquired information about the user's preferences. The preferences are expressed as parameters price, delivery, payment for a linear utility function (for simplicity, we assume linearity). The user has specified the unit price of the item, delivery time and payment time, which may be obtained even if the current negotiations break down. BATNA is now calculated by a *Prolog embedded call*—in curly brackets—and asserted in the knowledge base.

5. Simulation

We have conducted several preliminary simulations with a fixed number of suppliers (two known, two unknown). At this stage we have simplified the experiments: we generate only complete, well-structured offers in a strict representation, rather than partial offers or offers that

include such additional information as free text. The simplifications allow us first to study several possible negotiation tactics.

A negotiation is initiated by the agent sending an offer for purchase of the item or requesting offers from the companies. The companies' offers are randomly generated. For each offer a utility value is calculated and compared with BATNA. Next the agent considers several tactics. One tactic varies the selection of companies with which the agent continues negotiation at each stage. Only one or two best offers may be selected; or bad offers may be rejected and negotiations continued with companies that submit offers exceeding BATNA; or negotiations may continue with all companies. Another tactic varies the construction of counter-offers. One counter-offer may be sent to all companies, or a separate counter-offer prepared for each company taking into account the offers. The agent may also send the best offer received from one company to all other companies and ask for a better offer with an appropriate justification.

Finally, user involvement must be considered. We have to identify conditions in which the agent continues negotiations autonomously, and those in which user intervention is requested. In an extreme case the agent may conduct automatic negotiations and present the user with a ready compromise. Another extreme would be to require the user to approve every counter-offer and every compromise worked out by the agent.

6. Future work and conclusions

The model of multi-party business negotiations for electronic commerce, proposed in this paper, has been implemented in Negoplan. This is a prototype that will serve as a vehicle for experiments with negotiation tactics, the level of user participation, the number of parties, the nature and values of parameters. We have not yet implemented the post-settlement analysis phase, because it requires additional non-trivial mechanisms. In this phase the agent may assess the efficiency of the compromise and try to suggest improvements. This requires prior assessment of the utility function of the other parties, about which little information is available. We plan to adapt techniques for the assessment of the strength of opposition between negotiators (Kersten and Noronha, 1998) and equip the agent with an ability to suggest Pareto-improvements in the post-settlement state.

A Web-based implementation will follow; we plan a version of Negoplan that will be act as a clearing house for an exchange of offers and counter-offers. They will have to be filtered from a raw state—text messages—to an exact representation as a flat or nested list of parameter values. The long-term plans include a non-trivial natural language processing component.

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