29th Atlantic Schools of Business Conference (1999), with
5th Annual Atlantic Canadian Operational Research Society Conference
Halifax, Nova Scotia.

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NEGOTIATION IN ELECTRONIC COMMERCE: INTEGRATING NEGOTIATION SUPPORT AND SOFTWARE AGENT TECHNOLOGIES[1]

Software agent and decision support are rapidly developing information technologies due to their potential in supporting and conducting electronic transactions and other business activities. Negotiation via the Web is currently supported by several technologies, such as negotiation support systems, group decision support systems and negotiation software agents. Typically, and despite the fact that these technologies address different issues and can complement each other, they are used separately. A large experiment conducted in the InterNeg project led us to suggest a Web-based integrated software environment to aid negotiators and undertake certain activities autonomously. The architecture of the software environment, its components and their functions are discussed in the paper.

1. Introduction

The rapid adoption of the Internet as a commercial medium has brought a significant change to the traditional way business is conducted. In order to stay competitive many enterprises have established their presence on the virtual markets. (Applegate et al., 1996) identify three types of electronic commerce (e-commerce). The best known is customer-to-business, i.e., electronic shopping; it is widely discussed in both popular and scientific publications. The two other types, business-to-business and intra-organizational are less known, however, they have a significantly stronger impact on business organizations then the customers-to-business type. For example, the total 1998 revenue of U.S. retailers on the Internet is, according to Forrester Research, $7.8 billion and it is less than the total Internet sales of one corporation, Cisco Systems (Tedeshi, 1999). The total business-to-business Internet sales are estimated at $43 billion (op. cit.).

Transactions conduced on Internet include retail with electronic shopping baskets and auctions. These two forms of transactions are popular and well known. Many software tools, search engines and systems have been developed for both firms and customers to facilitate business transactions. Commerce negotiations that are typical to business-to-business commerce and also other transactions have not yet gained such attention.

Negotiations are considered a key component of e-commerce (Sandholm, 1999). Claims, however, have been made that auctions can replace negotiations and establish efficient markets (Beam, 1999). Interestingly, researchers and developers, who consider commerce negotiation as an important form of business transactions, design and implement systems that have little negotiation component and are similar to auctions (Guttman and Maes, 1998a; Guttman and Maes, 1998b; Sandholm, 1999). This is because the Internet auctions provide new efficiencies made possible by virtual markets allowing the customers from any place to join an auction. However, auctions cannot replace negotiations when the issue is not only to obtain the best price but also to

[1] Acknowledgement: This work has been supported by the Natural Sciences and Engineering Research Council of Canada.

establish the terms of transaction, features of a product or service, and—what often is the most important outcome of negotiations—a long-term relationship between business partners.

Business negotiations in e-commerce and the tools that can support them are discussed in this paper. The discussion is based on our experiences with the development and implementation of INSPIRE and INSS, two Web-based negotiation support systems (Kersten and Noronha, 1999a; Kersten and Noronha, 1999b), and INSPIRE's evaluation by over 2000 users. In Section 2 negotiation support systems are outlined and the design and use of the INSPIRE system is discussed in more detail. The software agent technology can provide new functions for the support and conduct of negotiations. Negotiation software agents are discussed in Section 3. The negotiation support and software agent technologies have different capabilities and both can be used in e-commerce negotiations. In Section 4 we outline a negotiation software environment in which both negotiation support systems and negotiation software agents provide support for, and act on behalf of, the negotiators. Discussion on the future work and planned experiments concludes the paper.

2. Negotiation Support Systems

A negotiation support system (NSS) is software designed to support various negotiation activities (Bui, 1994; Holsapple and Whinston, 1996; Kilgour, 1996; Kersten, 1998a). It comprises two components: a *decision support* component and *communication support* component. The decision support component enhances the information processing capabilities of the negotiators (Benbasat et al., 1995). The communication support component facilitates the exchange of offers and arguments thus decreasing the time to settlement and increasing satisfaction with the results (op. cit.).

2.1 InterNeg Project and the INSPIRE System

InterNeg is a research project that builds upon three emerging technologies: net-centric computing, decision and negotiation support, and software agents (http://interneg.org). One of the project's objectives is to develop an environment that supports electronic negotiations. The project began in 1996 with the development of INSPIRE, a Web-based negotiation support system to conduct bilateral business negotiations. (Kersten and Noronha, 1999a, see also http://interneg.org/inspire). Between July 1996 and August 1999, over 2,000 users from 80 countries have used the system.

The decision support functions implemented in INSPIRE include the preference elicitation, construction of the utility function, quantitative evaluation of offers, maintenance of the negotiation history and graphical representation of the negotiation dynamics. The communication support functions include the exchange of structured offers with accompanying arguments, free-text messages and the automatic email notification on the opponent's activity.

An important feature of negotiations with the use of the INSPIRE system is the structure of the process. The negotiation progresses through three distinct phases: negotiation analysis, bargaining, and the post-settlement. The objective of the first phase is to analyze the problem and decide on the negotiator's preferences and requirements. The second phase is the actual conduct of the negotiation. However, the negotiators may at any time use the support functions of the first phase and reassess their positions (e.g., modify the preference structure). The third phase is invoked when the negotiators achieve an inefficient compromise. In this case the system suggests several efficient offers and allows the users to continue negotiations and achieve a joint improvement.

2.2 INSPIRE Use and Assessment

INSPIRE bilateral negotiations are conducted over a simple case of business-to-business transactions. Typically they take up to three weeks. The process may result either in a compromise, or the parties may not reach a compromise before the deadline or one party may terminate negotiations at any time. This last possibility allows users to reject offers that are bad for the companies they represent. The user who terminates his/her negotiation may immediately request a new negotiation and is assigned another partner.

Upon completion of INSPIRE negotiations, users are requested to fill-in a post-negotiation questionnaire. One of the questions refers to the users' overall assessment of the system; they are asked if they would use a similar system in real-life negotiations, to prepare for a real-life negotiation, or as a practice tool to improve their skills. Generally, users find the system very easy to use, and their evaluation of the overall system is favorable. Over 75% of INSPIRE users stated that they would use a system like INSPIRE in real-life negotiations and over 85% would use such a system to prepare themselves to conduct actual negotiations (Kersten, 1998). While the feedback on the INSPIRE system conforms to our expectation, the absolute levels of user acceptance of the system are surprisingly high. These results led us to assume that a system like INSPIRE could be accepted in e-commerce negotiations.

2.3 InterNeg Support System (INSS)

The INSPIRE system was developed with the aim to teach and study negotiations. In order to allow users from various countries and with different levels of education to participate in negotiations, the system and the case are simple and easy to use. In order to study the negotiators' behavior and their use of the system's features INSPIRE is frozen and no changes are being made.

Many of the simplifications and inflexibilities present in INSPIRE have been removed from the InterNeg Support System (INSS) (http://interneg.org/tools/inss). INSS allows for the selection of cases or specification of the negotiation problem by the user. It also allows adding during the negotiation process issues (attributes) that may be continuous, discrete and qualitative; as well as options (attribute values) for an existing or a new issue. Further, the system extends the negotiation analysis phase by prompting users to define their best alternative to the negotiated agreement (BATNA), their reservation values and aspiration levels. The system has been designed using a method based on the object-oriented methodology extended with a rule-based control mechanism (Kersten and Noronha, 1999a).

The INSS system is more flexible than INSPIRE and it allows users to exert more control over the system and the process. One feature that it inherited from INSPIRE is the efficiency analysis. It requires information about the utilities of both users' and it is conducted without their approval. It is the users rather than the system that should control this function because it is a part of a facilitation activity. In the negotiation support environment discussed in Section 4 the facilitation and mediation functions are implemented in a software agent that is activated by the users.

3. Negotiation Software Agents

Business negotiations are often very complex and they involve various issues and multiple options. For example, the negotiation case developed by two negotiators representing a hospital and a health management organization (HMO) contained 7 issues, 5 options and 90,000 possible offers. The complexity increases if the problem is initially ill-defined, issues and options are added during the process and the negotiators seek integrative compromises. Some of the difficulties associated with complex negotiations may be addressed with the use of software agents (Guttman and Moukas, 1998a; Kersten and Szpakowicz, 1998; Maes et al., 1999). Automation of

some aspect of negotiations would, according to (Beam and Segev, 1997), result in time-efficiency, consistency and freedom from human errors.

Software agents are computer programs that exhibit a certain degree of autonomy, are continuously active and interact with other systems on behalf of the user (Nwana, 1996; Bradshaw, 1997). They can be mobile, i.e., move between different computers or reside only on one computer. They also may have learning capabilities or base their actions on pre-defined rules of behavior.

3.1 Software Agents in E-Commerce

Software agents are playing important roles in e-commerce especially in the automation of mundane operations. Several software agents have been developed with the purpose to assist buyers in the search and selection of products; some facilitate the linkage of buyers and sellers, others search for products that are of interest to the consumers (Andrews, 1997; Caffrey, 1998; DeLoughry, 1998). For example, Firefly (1999) uses an automated collaborative filtering method to rate and recommend products to consumers. BargainFinder (1998) and Jango (1999) are systems that take a product name as input, search the Web to obtain price and perform price comparison for the user. In negotiation analysis these agents may help a negotiator to discover new alternatives and thereby improve his/her BATNA.

3.2 Bargaining and Negotiations

At any given time organizations and customers may be engaged in several different negotiations. The effort and time required to conduct negotiations led to the development of negotiation software agents that are capable of automating a significant part of the process. Software agents that can carry out bargaining on the part of users have been discussed by (Beam and Segev, 1997; Gazis, 1998; Guttman and Moukas, 1998; Maes et al., 1999). These agents, known as negotiation software agents (NSA), engage in the bargaining process that is characterized by several parameters.

The NSA represents its user and makes offers and counter-offers based on the parameters values supplied by the user, i.e., the agent's principal (Beam and Segev, 1997). The possible functions of the agents largely depend on their degree of autonomy, the type of the negotiation, and the specificity of the principal's directives. The functions depend also on the agent's interactions with other systems and agents. The agent may be highly specialized and co-operate with other agents; interact directly with the principal, or it may communicate via a DSS or an NSS.

There are several prototype software agents under development designed to conduct negotiations on behalf of their principals. MarketMaker is a virtual closed-market system, developed in the MIT Media Lab, where only a predefined set of agents abiding to a set of rules engaged can operate (http://agents.www.media.mit.edu/groups/agents/). A buyer needing to procure particular goods creates an agent, gives it basic pricing strategy, and sends it to the electronic marketplace. Agents operating in the MarketMaker environment seek agents representing potential sellers and engage them in negotiations on the buyer's behalf. They attempt to obtain the best deal, based on a set of constraints specified by the buyer, including a highest acceptable price and a transaction completion date. The process is similar for the seller and the selling agent. Both buying and selling agents of MarketMaker are autonomous and users can exert a high-level control only by making a final decision to buy or sell.

Zeng and Sycara developed Bazaar (1999), a multi-agent system for updating negotiation offers between two intelligent agents during bilateral negotiations (Zeng and Sycara, 1998). The main difference between the development of Bazaar and MarketMaker is the nature of the agent. While MarketMaker is a rule-based agent using a pre-defined set of negotiation strategy, Bazaar consists of learning agents whose performance improves over time. The agents learning capabili-

ties of Bazaar are based on genetic algorithms and they are capable of updating negotiation's tactics using Bayesian probability.

4. An Integrated Negotiation Environment

The experiences with the use of the INSPIRE and INSS systems, users' suggestions, and the evaluation of the existing NSA led us to consider integration of NSS and NSA in a single software environment. The architecture of this environment is based on the following three principles:

1. Separation of user support functions from the autonomous software activities;
2. Separation of the support for individuals from facilitation and mediation; and
3. Scalability and the ability to provide linkages with the existing software (simulation, financial, MS/OR and other programs).

The first principle recognizes the differences between the support of negotiators' own activities and the actions that can be undertaken on their behalf but without their direct involvement. The second principle takes into account the different role of the third party intervention from the negotiators' actions. The third principle is to allow the addition of new features to the NSS, new agents that perform specialized functions and linkages with software that the negotiators may use to assess the offers' implications for their organizations.

4.1 Architecture

The traditional view of a negotiation support system is that of a desktop application: each user has one copy of the software on their personal computer, which communicates with the other users' copies over a network (typically a LAN), usually in synchronous mode (i.e., with both parties simultaneously logged on). Figure 1 depicts a negotiation support software environment translated into its implementation structure as Web applications. The system uses the client/server model of distributed systems to partition the main components.

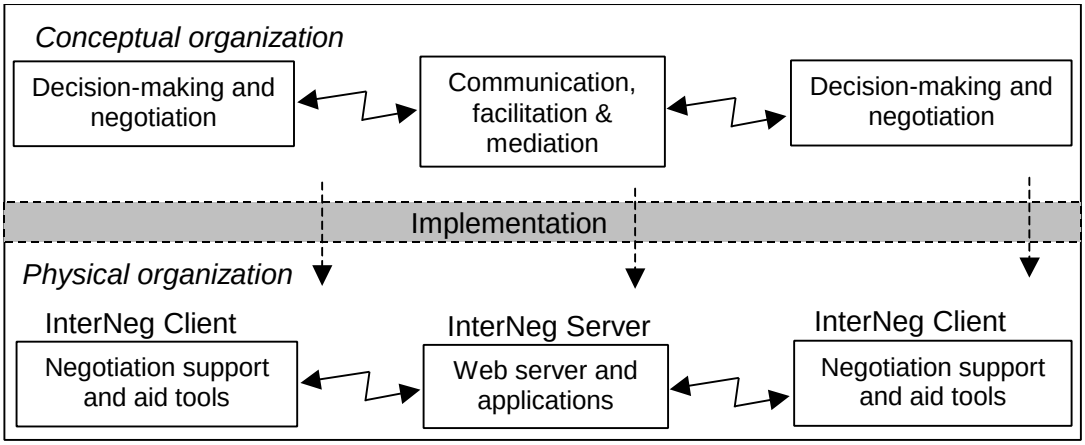

Figure 1. Conceptualization of the InterNeg Support Environment

The connection between the two sides can be either direct or through a common server program. Conceptually there is no reason to require the server program unless the concept of a third-party services like facilitation, mediation or arbitration are intrinsic to the support methodology provided by the system. All those services that do not involve a third party, e.g., problem structuring and analysis, preference elicitation, offer analysis and construction support, etc., can be implemented locally within each user's desktop application. It is desirable to implement such features locally for privacy and security reasons (the user's preference information, for example,

should not be accessible to anybody else). Only the objects explicitly exchanged during communication (e.g., offers and messages) and information required by the third-party facilitator (e.g., preferences for efficiency analysis during the post-settlement phase) need to be transmitted outside the desktop.

The architecture of the proposed software environment includes negotiation support systems, negotiation software agents, and databases, a case base and knowledge bases. The initial focus is on providing a range of services that are directly related to the negotiation process rather than to search, matching, or the verification of the opponent's reliability. The core of the environment is an NSS that directly interacts with the user and provides all key negotiation support functions. This system interacts with other systems, including a mirror system used by the opponent and it activates software agents. The agents facilitate communication, provide advice, suggest collaborative moves, interpret negotiators' actions and predict possible outcomes.

The overall architecture is presented in Figure 2. The individual negotiation support (INES) system is based on the present version of the INSS system and has all its functionalities with the exception of the efficiency analysis and the suggestion of Pareto-optimal offers. These tasks are taken over by the cooperative software agent (COSA) that also provides advice on the possible collaborative moves based on the rules of distributive and cooperative negotiations.

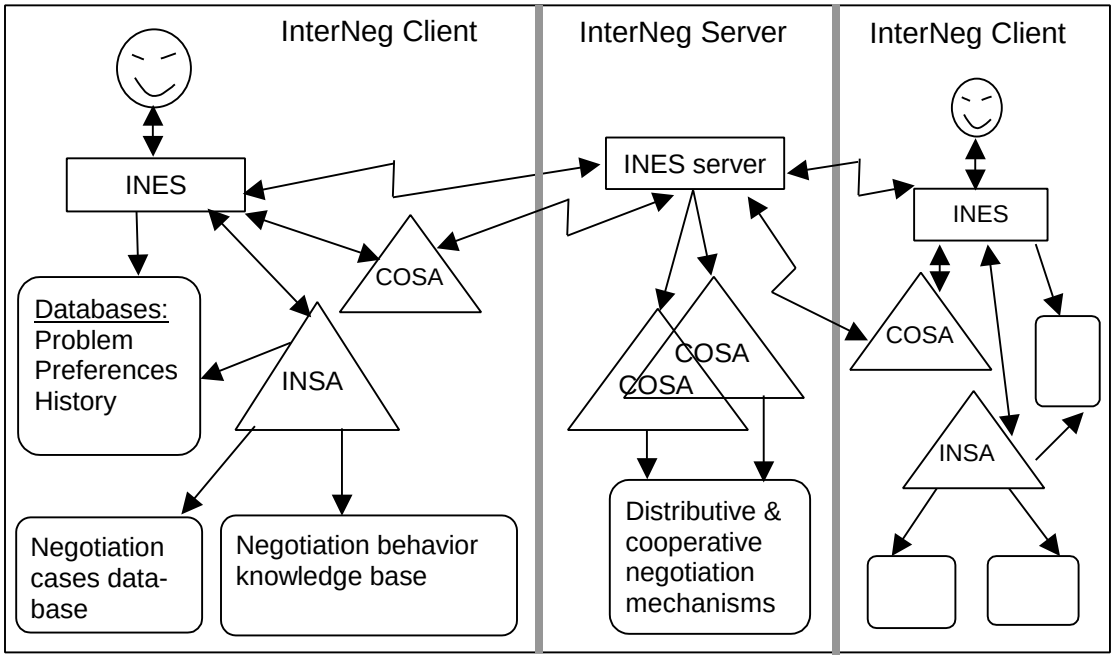

Figure 2. Architecture of the InterNeg Support Environment

The INSS system resides on the InterNeg server and its users communicate with it via a Web browser. This solution limits the number of tools that can be implemented and used, and also their richness due to the communication bandwidth that often is narrow. It also limits the access to local software and may introduce the security issues. As an alternative we suggest that INES is a desktop application that users install on their own computers and the communication is conducted via the INES server. The user creates his/her own space on the server and provides the email address of his/her counter-part. The server then communicates with the counter-part either via the counterpart's own copy of INES and email or—if she/he does not want to use the system—only via email. Email-based communication does not require that all sides have the same system, however, the messages have to be appropriately structured so that they can be read and interpreted by the INES.

The individual software agent (INSA) also resides on the user's computer. Its role is to provide assistance during all the negotiation phases. It aids the structuring and representation of

the negotiation problem using the database of past negotiation cases. It also interprets the opponent‘s actions and provides advice regarding the negotiator’s counter-offers. This agent uses a knowledge base derived from the analysis of over 2000 INSPIRE negotiations (Kersten and Noronha, 1999a) and it allows for evaluation and interpretation of opponents.

The INSA agent is not mobile and communicates with systems residing on other computers via INES. One of them is the COSA agent that, like the INES server, resides on the InterNeg computer. The key objective of COSA is to facilitate and mediate negotiations to the degree agreed by both sides. COSA may also provide suggestions regarding possible collaborative moves to individual negotiators. This agent passes information via the INES server that embeds it in customized Web pages.

4.2 Main Components

The four main components of the InterNeg support environment are negotiation support system INES, INES server, individual support agent INSA and collaborative support agent COSA. Each of these components plays different roles in the negotiation process.

4.2.1 Negotiation support system and server (INES).

One of the key functions of the INES system is to provide methodological support to the users. It includes the consideration of the three distinct negotiation phases and support for the activities in each phase. In the analysis phase, the system, guides the user through several steps. First, it requests a description of the problem and the specification of issues to be negotiated. For each issue the user needs to specify two or more salient values (options) and define its characteristics (continuous, discrete, qualitative). In the next step the user specifies his/her preferences using one of the available methods and, depending on the method, the system constructs a utility function or an order of the possible offers. In the last step of the analysis phase INES requests the user to formulate his/her BATNA and reservation and aspiration values.

During the negotiation phase the system provides ratings of all offers and counter-offers, maintains a complete history of negotiations, notifies the user when BATNA and reservation values are violated, and provides different forms of visualization of the offers and of the process. It conducts simple analysis of the offers and counter-offers and informs the user about possible similar interests of the parties. Further, it provides the user with alternatives that have similar utility to the alternative s/he wants to submit or that s/he received. If the user is able to assess the opponent's priorities the system searches for offers that for the user are no different (have the same utility value) as the previous offer but can be considered an improvement by the counterpart.

Communication between the negotiating parties is achieved via the INES server. If the user wants to submit an offer or send a message the INES system requests Web pages from the server. The server also provides the system with offers and messages sent by the user's counterparts.

4.2.2 Individual negotiation software agent (INSA).

The INSA agent provides assistance to the negotiator. During the problem structuring step the user may ask the agent for advice on the negotiation issues and options. If the negotiation problem is similar to one or more of the cases stored in the negotiation case database, the agent informs the user on the possible issues and salient options. The agent may also help the user in preference elicitation and utility construction steps. Similarly, it may help in setting the BATNA and reservation values.

An important function of the agent is to assess the activities undertaken by the user and her/his counter-part and provide interpretation of these activities. For example, one can judge the

negotiator's range of flexibility based on the differences between the utility value of BATNA, and the reservation values of the issues. The differences between the utility of the aspiration values and the highest utility value may indicate the strength of the negotiator. These values also allow evaluating the offers that the negotiator wants to submit and to assess her/his tactic.

Suggestions and assessments of the activities are derived from a knowledge base that is being build from numerous INSPIRE negotiation cases using data mining and statistical methods augmented with negotiation rules extracted from text-books and other sources. This knowledge base is used to evaluate both the user and her/his opponents' activities, and predict their possible implications for the settlement. It may also help the negotiator to understand possible implications of such endogenous variables as the opening offer, size of concessions, tactics as well as the impact of exogenous variables such as culture, gender and education on the process and outcomes of the negotiation.

4.2.3 Co-operative software agent (COSA).

Haugeneder and Steiner (1997) suggest that co-operating agents need to know the goal of co-operation and how to achieve it efficiently. The purpose of the COSA agent is not efficiency but rather effectiveness of the negotiation and facilitation of the process. The agent is designed to facilitate and mediate between the parties with the assumption that the parties themselves define the scope of its activities. COSA resides on the user computer and can be activated via the INES system. When activated it provides the user with information on the possible integrative moves using information about the parties' concessions and the counter-part's priorities assumed by the user.

The COSA agent that has been provided with a given degree of autonomy and information about its principal preferences migrates to the InterNeg server. If the counter-part's COSA agent is present, the two agents collaborate within the framework defined by their principals. The collaboration may include exchange of information about the degree of the agents' autonomy and the type of information their principals agreed to share. The agents may continue the negotiations on behalf of their principals or they may establish the collaborative activities that are undertaken by the INES server. The reason for involving the server is that it can play a role of a third party rather than act on behalf of a negotiator. The server obtains information from the COSA agents (the priority issues, reservation values, utility functions, trade-offs, etc), and depending on the type of information it can determine whether a compromise is possible, if the achieved settlement can be improved, if there are possible integrative moves and so on.

The COSA agent acts as a mediator in this environment. In Section 3 we said that the level of autonomy of agents might vary. With respect to this agent, the users can define its scope of mediation, i.e., the degree of intervention. At the low end of intervention, the users have full control of the negotiation, and the agent operates only as an advisor using its knowledge base that contains rules of distributive and cooperative negotiation tactics and strategies. On the other hand, COSA can operate autonomously but within certain restrictions set by the users.

4.3 Design Issues

Rapid prototyping, simplicity, and extensibility are among the most important design criteria in building our integrated software environment. Therefore, in the design of the components of the integrated negotiation software environment, the object-oriented and rule-based methodology that we have used to develop the INSPIRE and INSS systems will also be used (Kersten and Noronha, 1999b). The use of object-oriented techniques could benefit us from code reusability, since a design pattern is a set of co-operating objects or classes in a particular structural pattern that reappears in many implementations. Rule-based methodology is easy to understand; each rule can be viewed as a unit of information in a knowledge base, which can be easily added or removed (Bigus and Bigus, 1998). However, the difficulties with encoding knowledge in the knowledge base of the agents need to be addressed.

The proposed architecture is modular so that all the components and their objects can be developed independently. The system requires nothing more than a Web browser and an Internet connection thus enhancing portability for our end-users (Kersten and Noronha, 1999b). Users could download knowledge bases from the INES Server, and store them locally on the client machine. We identified a list of major design considerations, based on the proposed architecture:

1. A simple and user-friendly interface for user input. We do not want users to spend too much time to learn how to use the system. The GUI design of INES should be similar to the current INSS interface.
2. Redundant error handling. Verification of user input (e.g. such as preferences) is required.
3. "Size" of the components. Since users have to download several desktop components to their desktop computer, the size of certain files could not be too large.
4. Data transferred via Email. Section 4.1 indicates that users have the alternative to do negotiation via email, thus a structured message system is required. A Web-based email system could be designed to enhance the message to be in INES-readable format.
5. Flexibility of the system to allow future upgrades.

The front-end design includes a visible Web-based interface of INES, which handles user interaction. The front-end comprises of XML/Perl pages as well as Java applets, and the user interface is a browser that resides on the client computer. XML will be used instead of HTML since it allows developers to create documents that both humans and machines can read (St. Laurent, 1998). Any document written in XML with Extensible Style language (XSL) style sheets can be used to produce HTML pages that could be viewed in a standard browser. The inference engine will consists of two independent software agents, and a number of knowledge bases. The back-end will be implemented with Java so that the agent can "live" on different operation systems.

4.4 Testing and Evaluation

The environment proposed here will be developed and tested in several stages. In the first stage we will modify the INSS system so that it will become the core of the INES client and server (see Figure 2) and develop the COSA agent. Although the client application is to reside on the users' desktop, initially all the systems will reside on the InterNeg server. This will allow us to conduct a series of testing and negotiation experiments in a manner similar to testing of the INSPIRE and INSS systems. We plan to run several parallel experiments using both the INSS and the InterNeg support environment and compare the impact of the COSA (and later INSA) agents on the negotiation effectiveness and users' satisfaction with the process and results. We also plan to study whether negotiators behave differently when they have online negotiation support. The evaluation will be done with the use of online questionnaires, similar to those currently used in the INSPIRE negotiations.

One of important issues to be tested is the ability to manage complex negotiations. We have found that the INSS users often increase the complexity by adding many new issues to the table. This leads to their loosing track of the negotiation progress and dissatisfaction with the process. We will study if the software agents can help the negotiators to better manage the process and maintain focus on the issues they consider important. We will also evaluate the impact of the agents on the achievement of a compromise and efficiency of the achieved compromises. 41% of the INSPIRE negotiators do not achieve an agreement and only 43% of the negotiated agreements are efficient. Noting, that the case and the INSPIRE negotiations are simple this latter number suggests that the negotiators need additional support to improve their agreements.

5. Conclusions and Future Work

A rationale and a framework for an integrated negotiation environment have been presented in this paper. The rationale for the environment is based on the development of two Web-

based systems and the experiences with INSPIRE by over 2,000 people. The environment comprises negotiation support systems, a negotiation server and several software agents. The systems and agents collaborate in order to provide negotiators with support and aids to perform selected activities autonomously and to guide the negotiators through the concession making process.

The INSS system provides basis for the negotiation support and server systems. In the first stage of the development of the software environment the INSS objects will be decoupled and they will be used to construct the individual support system and server. The server will reside on the InterNeg computer from which users will be able to download the individual support system. The next stage of the development process is to construct the two agents INSA and COSA.

The work described in this paper is in progress. The initial negotiation environment will consist of the two INES components and the COSA agents. Currently the effort is concentrated on the development of COSA. This includes the specification of a methodology for agent development, definition of all objects and the collaboration threats between the agent and other components. Once implemented, COSA will be used in a series of experiments to study its functionality and its impact on the behaviors of negotiators.

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