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Supporting International Negotiation with a WWW-Based System

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Abstract

Support for international negotiations requires integration of decision-theoretic approaches with communication facilities, and different visualization modes. In addition, negotiation support systems (NSS) should also be tailored to different cultural and educational backgrounds of their users. While there have been studies on cross-cultural negotiations involving simple game or economic models, there have been no experiments with NSS in international and cross-cultural contexts. At the same time the emergence and quickly spreading use of the WWW and electronic commerce indicates the potential of NSS supporting commercial transactions across borders. This paper presents INSPIRE, the first Web-based negotiation support system that has been tested and used in teaching and training in several countries. The architecture of INSPIRE, which relies heavily on the net-centric computing paradigm and object oriented design, is also discussed.

Keywords: negotiation support; Web-based support systems; international negotiation support; preference modelling; object-oriented design; cross-cultural negotiation; net-centric computing

Acknowledgments

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1. Introduction

International negotiations have been studied from many perspectives including psychology, sociology, political science, economics, applied mathematics, engineering, computer science and artificial intelligence [1-11]. These perspectives have also been incorporated in negotiation teaching. Simulation is an often used vehicle to study and teach negotiation [12-16].

One of the dimensions adding to the difficulty and complexity of studying and conducting international negotiations is the fact that they involve people from different cultures and with different social and educational backgrounds. Studies of cross-cultural negotiations include analysis of cases involving two or more parties from different countries [17, 18] and interviews with, and written experiences of, experts and negotiators who participated in international negotiations [19].

Negotiation simulations allow for focused research and for analysis and verification of specific behaviors and interactions. However, simulations are usually conducted in laboratories, in unicultural environments. To obtain results pertinent to international and cross-cultural negotiation, experiments have been conducted in several countries in a manner that allows comparison of results (see, e.g., [12, 15, 20, 21]. These experiments often involve bargaining records enriched with questionnaires and reports from large samples and many countries [22, 23] but rarely involve negotiations between people from different cultures. There has been little comparative research, especially research involving inter-cultural negotiations. There has been no research that has considered the use of computers and other sophisticated communication media in negotiation, in terms of their relative effectiveness across users from different cultural backgrounds, as well as the effect of different cultural group decision making styles upon the design of electronic aids to negotiation.

The objective of the *InterNeg* project is to fill this void and develop an environment that supports remote negotiations over simple or complex problems, including real-life situations. This will be achieved through the development of a site on the World Wide Web that comprises electronic bargaining facilities, analytical tools, quantitative and qualitative models, summaries, abstracts, annotated bibliographies, research results, surveys, other forms of expertise, etc. InterNeg will allow negotiations in multiple locations by many people at the same time and with no additional cost to negotiators. By its very nature InterNeg has the potential to become accessible to everyone—lay people and experts alike—and provide them enabling tools and information to interact more directly and to bring negotiation expertise to lower level in social and organizational hierarchies.

The InterNeg site, and a prototype of one of its Web-based negotiation support systems, INSPIRE, have been operational since July 1996. In the first eight months, over 300 people from India, Canada, Finland, Portugal, U.S., Hong Kong, and Korea have negotiated through InterNeg. Because it is Web-based, inter-cultural negotiations are carried out as easily as intra-cultural negotiations. The negotiations include offer exchanges together with messages. Participants can conduct negotiations anonymously, not knowing their counterpart's country or background. There are facilities that help the user evaluate the goodness of an offer, review the history of a negotiation, and determine whether an agreement can be improved in a way that satisfies both sides. InterNeg provides systems and information that can be used at any place that has an Internet connection.

This paper describes the development of the InterNeg site and its current and future services, the architecture of the INSPIRE negotiation support system and the initial experiences with INSPIRE. It sets a basis for future research on the impact of computer and communication technologies on negotiations and international communication within and between cultures. It also aims at providing directions for the development of Web-based negotiation support tools for real-life negotiation with and between human and artificial agents.

2. Negotiation support via the Web

InterNeg is a computer-based environment that builds upon two emerging technologies: net-centric computing and negotiation support systems (NSS). Together, these technologies are integrated into a suite of resources that facilitate negotiation, training and research.

2.1 World Wide Web: technologies and services

Recent developments in computer and communication technologies have contributed to two trends that are critical to this research project:

1. Widespread use of networked computer systems—especially systems based upon the Internet—growing at a phenomenal pace, and

2. Flexible system-independent technologies and multimedia interfaces allowing for the use of the systems by anyone and on any computer platform.

The principal feature of the World Wide Web is that it allows people from different locations and time zones to communicate and to use previously inaccessible

computational resources. While the Web's greatest use currently is as a powerful source and means for dissemination of information, it is increasingly being used as a means for remote execution and control of complete software systems, thus adding another dimension to the value it delivers.

The Web permeates research and education. Its services include access to techniques and tools which are used in research (e.g., statistical packages and mathematical programming software), access to data and information for processing and analysis, and generation of massive amounts of data. In education, the ability to access and run remote programs and databases allows its users to extend classroom and laboratory boundaries across geographical and time zones. It allows instructors and students to retrieve and use resources from remote sites. However, to our knowledge, the Web is not used in studying and teaching negotiations. Extensive search of Web resources showed that there is a very small number of sites devoted to negotiation.[1] None of these sites use the Web for research or training activities that are accessible to students, researchers and practitioners.

2.2 Negotiation support systems

Negotiation support systems (NSS) are computer-based software tools typically used for training and research in a laboratory environment [4, 24-32]. In teaching and training NSS are used to:

- present and illustrate a particular problem solving technique,
- teach the analytical approach to problem solving,
- teach negotiation analysis and other decision analytic methods,
- teach different presentation techniques for problem structuring, analysis and solution,
- expand a student tool set for communication, conflict identification and resolution, and
- show the underlying assumptions and limitations of NSS and the analytical methods.

While there is a large and growing number of NSSs, they are rarely used in real negotiations [33-35]. Moreover, systems that have actually been used in real negotiations are not of the NSS type. Rather, they are traditional model-based decision support systems allowing for what-if and sensitivity analyses, and simulation of potential effects of the contemplated compromises.

Two current trends that may potentially lead to widespread use of NSS in real negotiations are:

1. the maturity of formal methods for decision and negotiation analysis, and
2. expansion of the use of Web-based systems in business and other transactions.

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[1] A list of these sites is maintained at   and its associated Web pages.

Zartman [36] argues that decision analytic methods based on multi-attribute theory, simulation modeling, statistical analysis, and cognitive mapping have shown their usefulness. The INSPIRE system uses decision theory and supports construction of utility functions. The growth of Web-based commerce systems may be illustrated by the recently created corporations (e.g., UNIBEX) which provide businesses and other organizations with the electronic market and tools for exchanging information, and structuring and recording negotiations.

3. InterNeg: resources and services

The InterNeg project began in 1996 with the development of a simple Web-based negotiation support system prototype. The software, called INSPIRE (InterNeg Support Program for Intercultural REsearch), has been tested and enhanced since the Summer of 1996. In July 1996, the system became fully operational. The host InterNeg site also offers other services. It is the home site of two journals, *International Negotiation* and *Group Decision and Negotiation* where basic information such as the table of contents, abstracts, and calls for papers are maintained. Beginners' handouts, information on how INSPIRE can be used in different university courses, and examples of student assignments are available as well as several articles, an extensive bibliography and information about programs and organizations involved in negotiation.

The InterNeg site is a source and repository of negotiation-related resources and its home page is at   . The site is organized into five departments in addition to general information about the site, its history, users and developers. An overview of the site is presented in Figure 1.

Each department has a different focus:

- Reference desk: An archive of reference material on negotiation and negotiation support, including answers to frequently asked questions, bibliographies, software catalogues, glossaries and computing dictionaries.

- Research and studies: Research output from the InterNeg group, our world-wide collaborators and other researchers.

- Support tools and aids: Software that is usable on the Web. This includes software produced as part of the InterNeg project, e.g., INSPIRE and INSS, and tools contributed by other researchers.

- Learning and training: Negotiation learning and teaching resources, e.g., tutorials, essays on and guidelines for negotiation strategies, course information, university programs and other training aids.

- External links: Links to negotiation-related sites other than InterNeg, and to resources in other negotiation-related disciplines such as software agents, e-commerce, computer-supported cooperative work, etc.
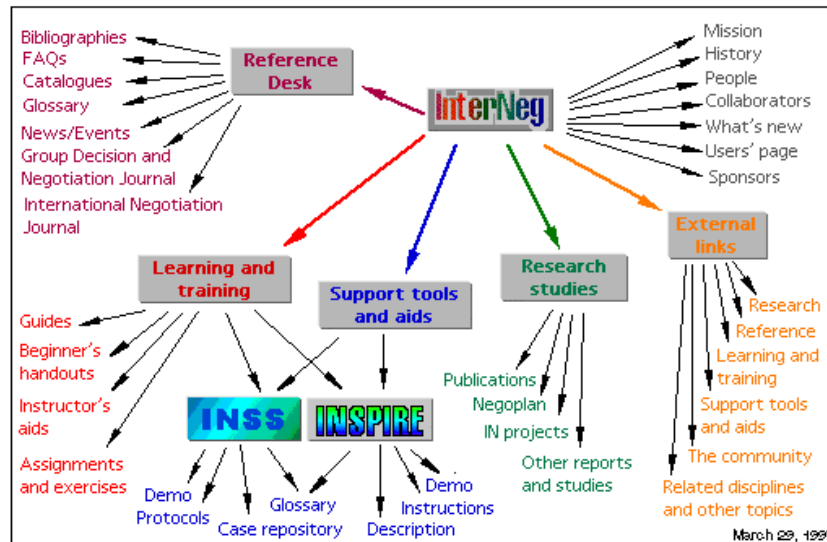
Figure 1. The basic structure of the InterNeg site.

4. The INSPIRE process model

INSPIRE is the first system designed to conduct negotiations on the Web. It is a support system based on analytical models rooted in decision and negotiation analysis [31, 32, 37-39]. Developed in the context of a cross-cultural study of decision making and negotiation, the system has been primarily used to conduct and study negotiation via the World Wide Web as well as in the teaching of information systems, management science, international business, and English as a second language.

INSPIRE views a negotiation as a process occurring in a particular context. It comprises a series of activities beginning with pre-negotiation which involves preparation for negotiation, proceeding through the actual conduct of the negotiation during which messages, arguments, offers and concessions are exchanged and evaluated by the parties until an agreement is reached, and finally, implementation of the agreement. It is usually inappropriate to assume that reaching an agreement is the goal of the negotiation, as is often assumed in low-context societies [2, 23] such as the American. Indeed, in many high-context cultures such as the Japanese, an agreement is viewed as merely the beginning. Revision of the contract and re-negotiation are integral aspects of the negotiation process.

INSPIRE currently addresses the preparation, conduct and post-agreement re-negotiation aspects of the whole process, i.e.,

1. preparation involves understanding the negotiation problem, issues and options, and preference elicitation via hybrid conjoint analysis leading to the construction of a utility function;

2. the conduct of negotiation involves support for offer construction and counteroffer evaluation by means of ratings based on the utility function, and graphical representation of the negotiation's dynamics; and

3. post-settlement involves computation of packages that dominate the most recent compromise.

In addition to the above three major functions there is a range of smaller support features. Also, during the offer exchange the user may re-evaluate issues and options and modify his or her utility function.

4.1. Preparation

During the preparation phase each user individually performs activities that enable him or her to comprehend the problem, the main negotiable issues and options, the possible offers (packages) and criteria. This phase also involves specification of preferences leading to the construction of the user's utility function. These activities are depicted in Figure 2. While users may communicate with their partners, the communication at this stage is limited to unstructured messages.
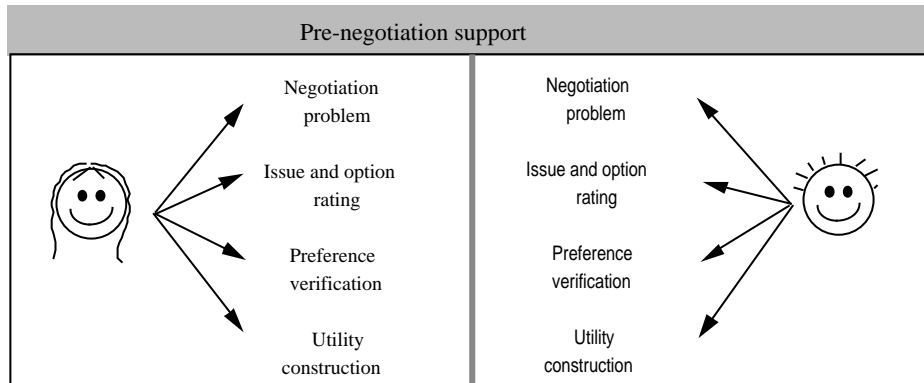

Figure 2. INSPIRE's preparation phase.

The currently implemented technique for construction of utility functions is based on conjoint analysis, in which the utility of a given package is determined from the user's preference orderings over a set of factorially designed alternatives (packages) [32, 40]. A hybrid (compositional as well as decompositional) approach is used and it comprises three steps:

1. The user evaluates the relative importance of the issues to be negotiated. The rating assigned to each issue is viewed as a component of the total utility of a package. The utility component of each issue is assumed to be independent of the other issues, i.e., any possible interactions are assumed to be insignificant. Therefore the utility components are simply added together to form the total utility function and this is called composition.

2. The user evaluates the relative importance of each issue's options. The rating of each option constitutes the utility component of an issue when that particular option is the one that's present in a package.

3. The user makes a comparative evaluation of several complete packages selected by INSPIRE, viewing each package as a whole. This is the decompositional step. The total utility of a package is decomposed into constituent option utilities using an additive model:

$$Rating(P) = constant + \Sigma_i \Sigma_j \; u_{ij} \, x_{ij} + error$$

where $Rating(P)$ is the total utility of a package P, u_{ij} is the utility associated with issue i and option j, and x_{ij} is a binary variable indicating whether the given option is present in the package.

There is a large number of packages that could be presented, and we need some way of selectively presenting just a few packages for the user to rate, yet obtain reliable utility values. This is a problem in the design of fractional factorial experiments. One of the most compact and effect designs is the orthogonal design, in which the packages are chosen such that the X matrix is orthogonal. INSPIRE uses the information obtained in the issue and option ratings steps to select the set of orthogonal packages presented to the user for the package rating step. Given the ratings for these packages, the weights u_{ij} are computed that minimize the error terms using linear regression.

Since the utility of every possible option is considered explicitly, the utility function for a given issue can be non-linear. This is an advantage since people usually do not have linear utilities as they traverse a given range of values. By default, issues are assumed to have "discrete" options, i.e., only a small number of explicitly listed options are considered to be meaningful as outcomes of the issue. These are also called salient options. However, some issues can also be "continuous" in the sense that any intermediate value can be meaningful. This is typical of quantitative issues such as the price of some commodity. In such cases, the utility function within an issue is assumed to be piece-wise linear, i.e., linear interpolation (or extrapolation) is used to compute the utility of intermediate points between salient options.

4.2. The conduct of negotiations

The conduct of negotiations is divided into four standard stages namely climate-setting, presenting, mid-point bargaining, and closing. These four stages are not clearly distinguished in INSPIRE. However the system's two modes of communication, that is structured   offers and free-text messages allow the users to perform activities corresponding all the stages.

Offers have a predefined format, that is they contain names of the issues and options (issue values). While constructing or analyzing an offer, users automatically obtain its utility value. An offer may be accompanied with a message, which allows for argumentation and backing. Users may also send separate messages in order to, for example, set the climate, request explanations, or press their counterpart for a reply. These and other activities that can be performed during the conduct phase are listed in Fig. 3. To support users in reviewing the negotiation and its dynamics, the system groups together all the past messages and offers, including utility values. In addition, a graph displaying negotiation dynamics is also available. It depicts all the offers made by both parties over time and the user's rating scale (see Fig. 11 for an example).

During negotiation users may review and revise their ratings, effectively updating their utilities, as indicated in Figure 3. We have observed that the graphical facility and offer scores become a focal point with some users and they tend to revise their preferences frequently, apparently with the objective of getting a satisfactory graph with high final scores. We speculate that this kind of preference migration may reflect the users' cultural background.

4.3. Post-settlement re-negotiation

Once a compromise has been achieved during the conduct phase, INSPIRE checks it for efficiency (Pareto-optimality). This is the stage when the system acts as a mediator and takes into consideration the utilities of the two parties. Negotiation ends if the

compromise is efficient. Otherwise the system computes efficient packages and displays several of them to both users. The displayed packages include those which increase one party's utility alone, as well as the mid-point solutions.
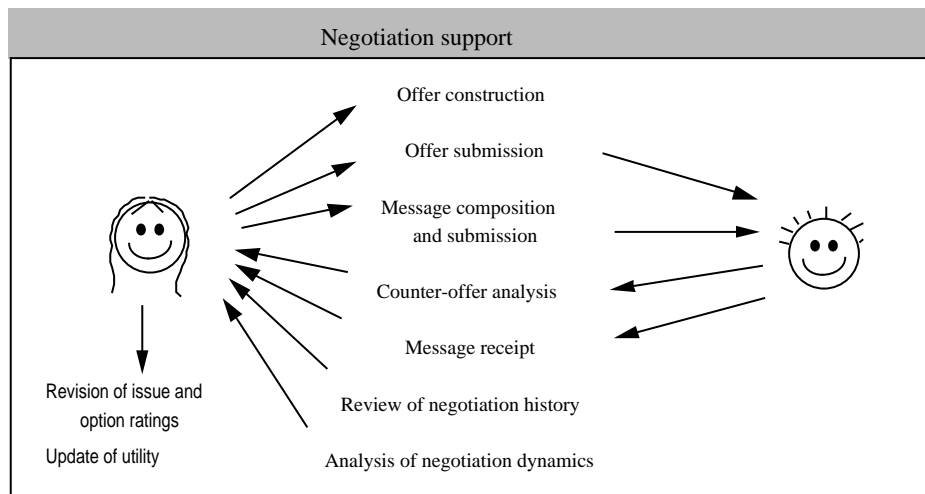

Figure 3. The conduct of negotiation through INSPIRE.

The list of the post-settlement phase activities is similar to that of the conduct of the negotiation phase and is displayed in Figure 4. The system's additional activity is the computation, selection, and display of efficient offers. A notable distinction is that in the post-settlement phase, users cannot revise their preferences. This is because in this phase the system uses the preference information to determine and display efficient packages. If either party changes their utility structure, the current efficient solutions may become inefficient; in particular, the last-reached inefficient compromise may turn efficient, effectively terminating the negotiation in a way that would be considered unexpected by the counterpart. Apart from confusion, unilateral transformation of the efficient set under consideration can undercut the acceptability of the mediation process.
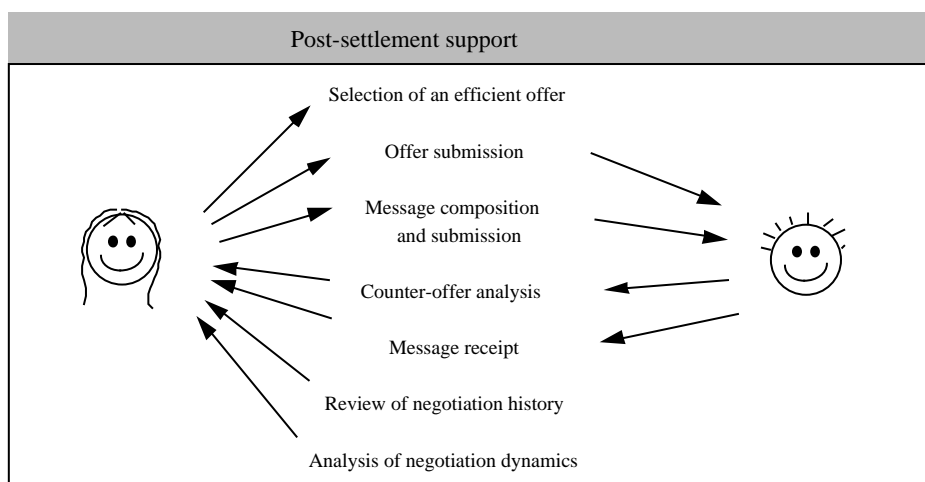

Figure 4. INSPIRE's support of post-settlement activities

Apart from utility modification, users can perform the same actions during the post-settlement stage as during the conduct of the negotiation phase.

5. INSPIRE's architecture

5.1. Client-server decomposition

The traditional view of a negotiation (or group) 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 5 depicts how INSPIRE's process model, conceptualized as a negotiation support system, has been translated into its implementation structure as a Web application. The system uses the client/server model of distributed systems to partition the main components.

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 conflict resolution service (or facilitator/mediator/arbitrator) is intrinsic to the group support methodology provided by the system. All services not involving a third party, e.g., preference elicitation, offer analysis and construction support, etc., can be implemented locally within each user's desktop application (and indeed 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 Pareto-optimal analysis during post-settlement) need be transmitted outside the desktop. However, this neat conceptual partitioning based upon functionality (which is useful for presentation to a lay user) disappears when translated into the physical implementation of INSPIRE; it is replaced by a two-component: *frontend* and *engine* model (see Fig. 5), that more closely reflects the realities of current net-centric computing technology.
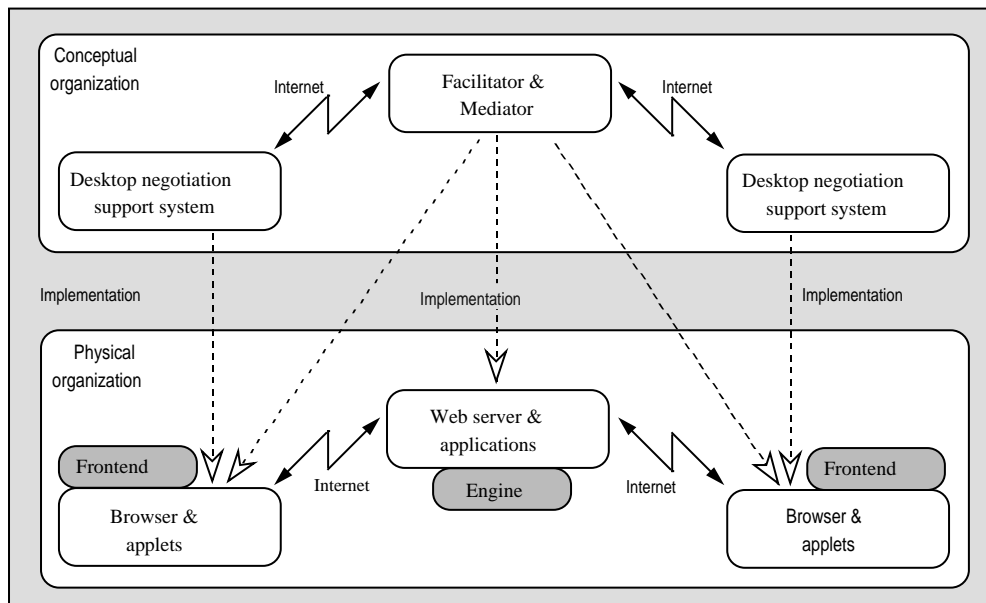

Figure 5. The INSPIRE client/server architecture

Three major factors affect the INSPIRE design:

1. We wish to enable users with nothing more than a Web browser and an Internet connection to avail of INSPIRE's services. This implies a tremendous degree of portability and gives the researchers access to users in remote countries with minimal computing resources.

2. Current trends in net-centric computing are towards pay-per-use software: programs reside at their developers' home sites and are automatically downloaded and executed whenever the user needs a particular piece of functionality. This induces a tendency towards an architecture in which the server (INSPIRE's home site) plays a central role, regardless of the structure of communication needs.

3. Since one of INSPIRE's primary goals is to observe and log user activities as completely as possible for the cross-cultural study, and since it is difficult to monitor actions on the user's host machine, it is desirable that all nontrivial activities be conducted through the INSPIRE site.

One other factor that significantly influenced the design is the fact that the negotiations supported are asynchronous: since the two parties negotiating with each other typically reside in far away countries with different time zones, it is rare for both sides to be simultaneously logged on. Therefore, INSPIRE is designed to interact independently with each user, saving the state resulting from each user's actions in a form that can be retrieved when the counterpart logs on some time later.

Returning to Fig. 5, we see that while the functionality of the facilitator is implemented entirely in applications on the Web server side (as expected from the conceptual organization), the functionality of a desktop negotiation support system has been distributed between the browser on the user's desktop and the application programs on the INSPIRE server. However, examining the system's design in terms of the "browser side" and "Web server side application" implementation components is too fine-grained to convey its modular structure. The appropriate higher-level abstraction is a division of the system into "frontend" and "computational engine" components.

5.2. The frontend and engine

The distinction between INSPIRE's *frontend* and the *engine* corresponds roughly to the distinction between a traditional knowledge based system's visible user interface and invisible internal model base and reasoning engine. The frontend comprises dozens of HTML/JavaScript pages as well as Java applets. They reside on the INSPIRE site but are displayed or executed on demand on the user's host machine. The engine is a collection of programs in C++. These programs also reside on the INSPIRE site, but they are executed on the INSPIRE host itself and invoked via the Web server and the CGI protocol. The basic underlying mechanism that connects the two segments is the CGI protocol, but since this protocol is too primitive to directly handle negotiation-related objects, a new high-level tag-style mechanism has been provided on top of CGI, as explained in the next section.

One of the major goals that this architectural division addresses is that of supporting collaborative group development of INSPIRE by people with varying levels of familiarity with Web document presentation languages (HTML, JavaScript) and

programming languages and protocols (C++, Java and CGI). One of the most important reasons for the explosive success of the World Wide Web is the ease with which anyone can develop Web pages. INSPIRE's frontend, though sophisticated in organization and content, is amenable to design intervention by anyone with basic word processing skills and this has enabled people with wide ranging skills including behavioral scientists and decision analysts to directly modify and contribute to the design. This is possible because the frontend's interface to the engine resembles an extended set of HTML tags. The engine on the other hand comprises several thousand lines of C++, and along with the Java applets is accessible to development only by relatively experienced programmers.

All of INSPIRE's implementation is object-oriented, and each piece of functionality listed within the two major components in Figure 6, is provided by a group of object classes that is loosely coupled with the rest of the system. Therefore each of them has been implemented fairly independently of the others. At the heart of the system lies one segment, labeled "methodologies" on which we focus here and in Section 5.4.
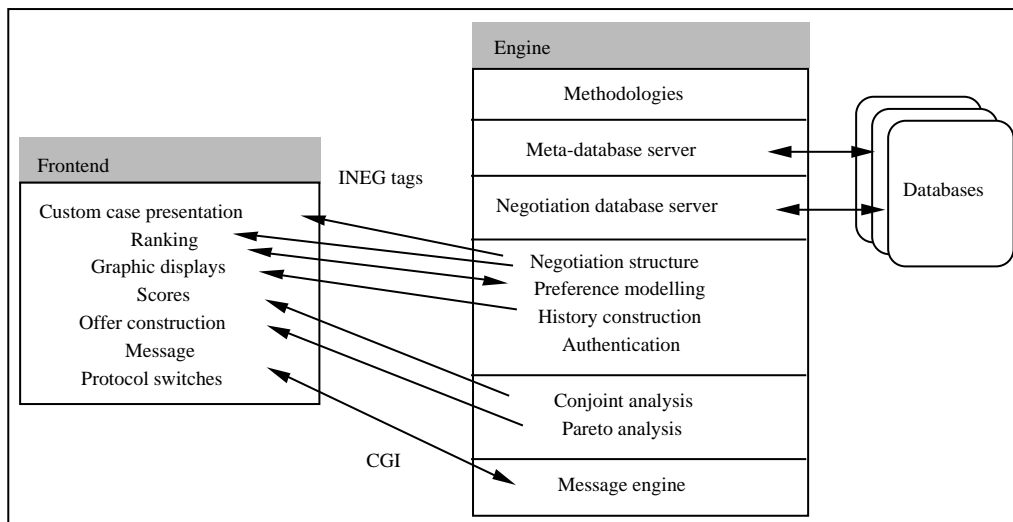

Figure 6. INSPIRE's main components

In this context, "methodologies" is an umbrella term for the sequence of activities performed by the users in conjunction with the system. This is the part of INSPIRE's architecture where it looks at the state of the negotiation and dispatches a page from the frontend to the user's browser or performs a short sequence of computational activities and typically displays their results. This is obviously an important part of the system and implicitly controls the invocation of much of the other functionality of the system.

In general, users always need to know "What can I do next?" and the answer depends on the context and any rules provided by the system's designers. In other words we have to deal with states and contexts.

Based on the state of a negotiation, differing sets of activities are proposed to the user. Web pages are very good at representing and presenting context. So methodologies can be implemented by a dispatching system that determines which page to present based on a given situation. One of the principles learnt from the INSPIRE implementation is that a rule-based structure works surprisingly well for implementing methodologies. In fact the whole section comprises a series of if--then--else statements in C++ and stands out from the otherwise characteristically object-oriented code in the system.

This part of the architecture can be summarized as follows: pages in the frontend represent contexts; states are represented by (mostly Boolean) expressions in the engine. While the latter is obvious, it helps in understanding the former to observe that each page displays text and images describing (part of) the current situation and gives the user options (clickable links, prompts and other widgets) to perform only those activities that are relevant to the given context.

5.3. The coupling mechanism

The Web pages that comprise the user interface are generic in the sense that they can be reused for arbitrary negotiation cases. However, an unchanging Web page cannot reflect the dynamics of a negotiation. The dynamics inherent in the process manifests itself in two ways:

1. different Web pages must be displayed to the user in response to different actions, and

2. the contents of a given Web page itself must adapt to the latest situation. For example, a page displaying the issues under negotiation cannot have the issue names hard-coded since they differ from negotiation to negotiation; the names must be generated on the fly.

In short, Web pages have to be constructed on the fly by the programs in the engine to display dynamic or adaptive responses. However, hard-coding the contents of Web pages into the software would be a very poor approach to system development as it requires program recompilation for the slightest change, suffers loss of readability and maintainability, and prevents non-programmers from directly working on the contents of the pages.

It is clear that a means must be found to generate only those parts of a Web page that absolutely have to be computed by the engine (e.g., information that is specific to the users or the negotiation, utility values, etc.) and retain the rest as a proper Web page. The solution we found is to support new HTML-like tags in the Web pages that are understood by the INSPIRE programs. These special tags begin with <INEG> and end with </INEG>; for example <INEG>user_id</INEG> denotes the name of the user accessing the INSPIRE system. A Web page containing such <INEG> tags is called a *dynamic page* (because it adapts to the situation as explained in a moment), whereas a page without these tags is called a *static* or normal HTML/JavaScript page. Dynamic pages are not meant to be directly accessed on the Web via their URLs; rather, dynamic pages are meant to be processed by the INSPIRE engine before being displayed to the user. When any program in the INSPIRE engine *pipes out* a dynamic page, it substitutes each <INEG> tag by something appropriate (in the above example, the user's name). This simple "macro substitution" mechanism enormously simplifies the interface between Web page developers and program developers. All that is required to keep the user interface and the engine fully synchronized with each other is a well-designed catalogue of <INEG> tags and their semantics.

There are four categories of <INEG> tags in INSPIRE: identification, version management, history (state) recapitulation, and negotiation object embedding (e.g., offers, messages, rating tables). For example, <INEG>issue_rating</INEG> generates the HTML table used during the preparation stage to rate the issues <INEG>offer_construction_box</INEG> generates a table containing menu selections for each of

the issues, by which the user can construct an offer; <INEG>engine_url</INEG> identifies the location (URL path) to the engine programs on the INSPIRE site, enabling them to be freely moved around.

5.4. The main components

The DSS architecture has traditionally been neatly divided into three components Dialog, Data and Model, i.e., the "DDM paradigm", with clearly defined roles for each component [41]. We found this architecture restrictive and inflexible. The DDM concept does not sufficiently address the need for flexible use of multiple—complementary as well as competitive—analytical methods. The traditional DSS architecture limits communication between the system's components and also the components' communication with external systems in ways independent of any pre-specified control mechanism. In the development of INSPIRE an effort was made to construct software objects that can be used and reused in different conditions and in different configurations. Moreover, we aimed at a system which in future can be expanded and use new and additional components. Thus, we were looking for a system which allows for:

1. the situation-dependent use of different decision, negotiation, and data analysis and visualization support methodologies (defined by available data or meeting specified constraints or is specified by the user),

2. management and visualization of a potentially very large set of solutions,

3. private and content rich communication between the users, other systems and Web sites as well as the ability to communicate with users through e-mail,

4. use of specialized models for dialog, solution and communication components, in addition to those used in the Model component,

5. expandability in directions not necessarily envisaged by the developers and the ability to use external services provided by other Web sites.

The main component of the INSPIRE system that is instrumental in obtaining the above characteristics is the *Methodologies and control* (M&C) component.

Figures 7–8 depict the INSPIRE architecture in two main modes: the support of a single party in the negotiation (individual support mode) and the mode in which the system determines and presents efficient solutions (joint support or mediation mode). At a high level, as discussed in Section 5.2, the architecture comprises the engine and the front-end. Currently, the frontend functions as a Dialog component with limited computational capabilities. However, with the introduction of Java applets and coupling with local client applications, the frontend functions will encompass some of the functionality of the Model and Data components.

The Model component is represented by several separate objects used for preference elicitation, utility and history construction, and also other objects which are activated by the M&C component at different stages of the negotiation process. The M&C component of INSPIRE decides on the system's behavior; it takes information from the frontend (Dialog) component.

The negotiation process supported by INSPIRE can take several different forms. Negotiations can be sequential, that is parties discuss about one issue at the time,

parallel, and mixed. They also can be conducted with or without messages. Other options, which are not yet implemented, include the addition and/or deletion of issues and options, addition of separate objects (e.g., price lists, pictures) to the messages, voice and video, etc.

A major problem with the DDM is that it doesn't have a plug-and-play philosophy. The system should be viewed and implemented as a collection of loosely-associated smart objects (the DSS as toolkit metaphor). DSS and NSS design always *must* be open-ended—amenable to change, but most DSSs are weak in providing a methodology for change. We view system change as an upgrade in the attributes or behaviors of *individual* objects (occasionally, modules), independently of other objects or modules, rather than one synchronized change across the whole system.

As an example, consider the problem of making INSPIRE qualitative-information–capable, i.e., able to handle missing information such as incomplete preference ratings. This can be implemented by a series of independent changes: upgrade the PreferenceStructure object classes, which deal with storage and retrieval of preferences, to accept holes in the data; then upgrade the UtilityFunction objects to interpolate for missing preferences instead of asking for additional information; then upgrade post-settlement algorithmic classes to deal with interval ranges; then experiment with alternative preference elicitation strategies that optimally use qualitative information. A good (sufficiently general and abstract) set of object interfaces and loose coupling between components are critical to achieving this kind of open-endedness.

One of the main characteristics of the INSPIRE system is its expandability. Figure 7 illustrates the loosely coupled architecture of INSPIRE. This is also depicted in Figure 8, where some objects are introduced and other removed due to the change of the system's mode of operation (from individual support to mediation).

It may appear that Figures 7 and 8 depict two different (though similar) systems. This is of course not the case, but reflects the ability to use the same components to perform similar functions but for different users, or the use of the system's other components which previously were not available. For example, the same engine can be used by each user separately (in the individual mode) to rank offers or it can be used in the mediation mode and order offers using both utility functions.

In the mediation mode the system can be viewed as comprising three Engine and two Frontend entities. This mode is entered only when the users achieved a compromise. The components involved in these activities are depicted in Figure 8. Note, however, that the smaller and larger components with the same names are "clones" of the same program but used for different users or different other components. At this stage, the system verifies the efficiency of the compromise using—for the first time—the utilities of both simultaneously. If the compromise is non-efficient, the system asks users whether they want it to search for efficient solutions. Upon obtaining a positive answer from both users, the system determines efficient solutions and selects and displays five solutions for each party.

Once the negotiation is concluded, INSPIRE informs the users and asks them if they agree to provide their counterparts with their negotiation dynamics graphs and other graphs that describe the negotiation dance [10]. The graphs are displayed only if both parties agree.
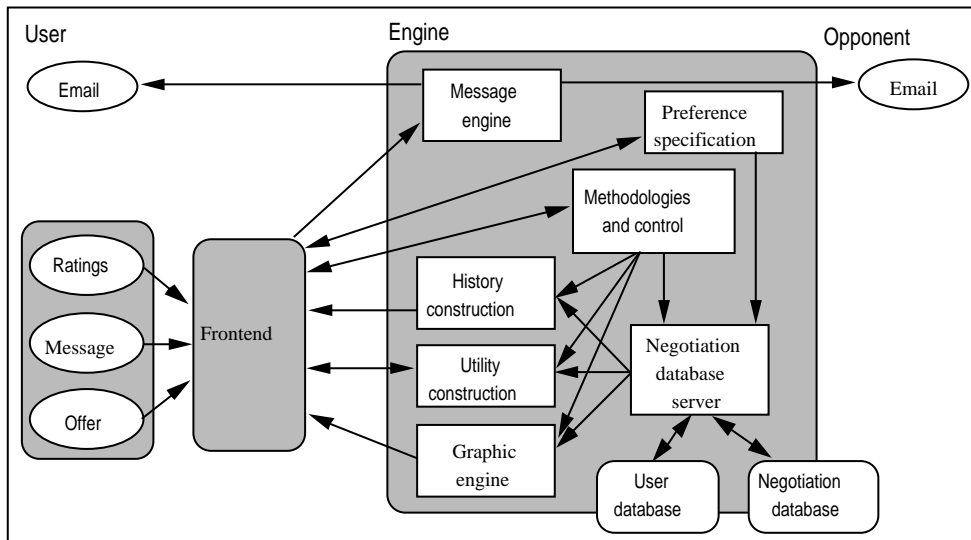
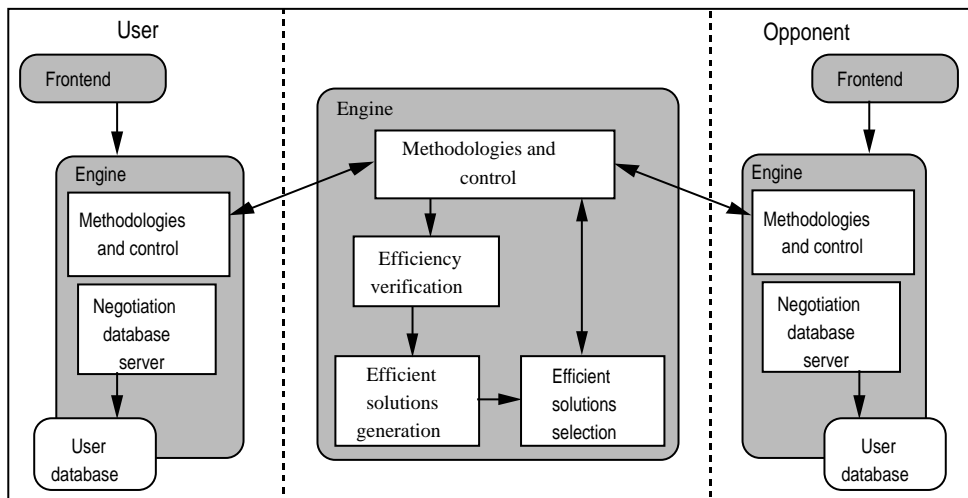Figure 7. INSPIRE's architecture: Individual support mode.

Figure 8. INSPIRE's architecture: Mediation mode.

6. An example from a real negotiation

The illustrations in this section are intended to provide the flavor of an INSPIRE session. An example of one of the user activities during the pre-negotiation stage is given in Fig. 9. Having read a description of the case—which specifies the four issues being negotiated (the purchase price of the bicycle parts under negotiation, the delivery and payment schedules, and the return policy for defective parts) and the options available for each issue—the user is requested to compare each of these options against the others and specify their relative importance. The ratings supplied by the user during this and subsequent steps are used to construct a utility function.

During the conduct negotiation stage users construct offers, analyze counter-offers, send and receive messages, and review the negotiation dynamics. Figure 10 is a snapshot of the offer construction screen; it illustrates how the users can communicate either by plain messages or structured offers, and how the score attached to an offer helps select a good offer.

Figure 9. Rating the options of each issue.

Figure 11 is a graph of the dynamics of the negotiation process; such graphs are generated on the fly throughout the negotiation, and the one in the figure was generated at the very end of the negotiation. The user names displayed on the graph ("*misty*" and "*ldias*") are pseudonyms adopted as INSPIRE login names by the users in order to protect their anonymity. The little numbered triangles denote offers; the X axis shows the time at which each event occurred and the Y axis represents the score associated with an offer. Note that though the offers of both parties are shown, only a single utility function (*misty*'s) has been used to evaluate all of them. (For two reasons: each party's preference information is private and unavailable to the other side; nor is it meaningful to make interpersonal utility comparisons).
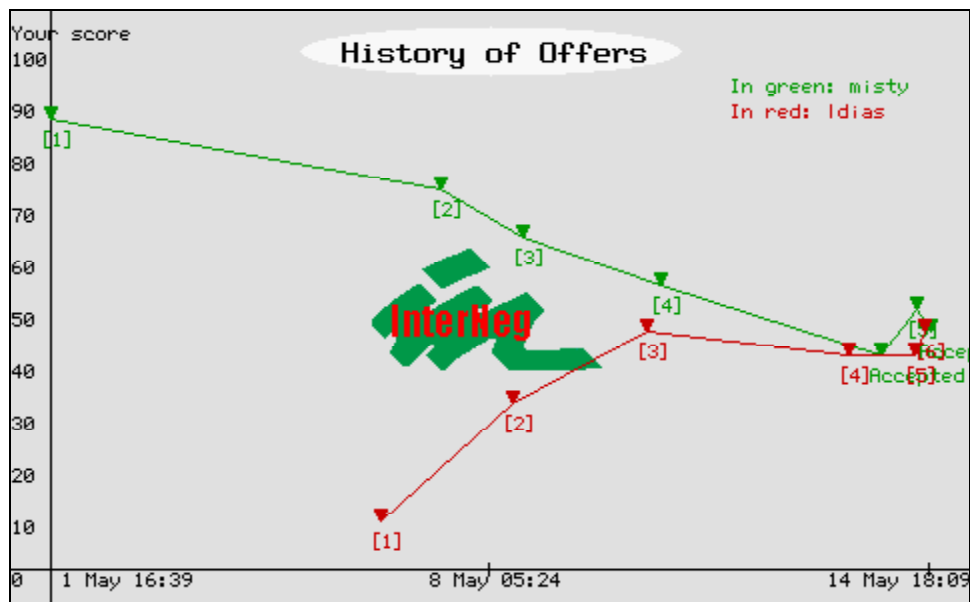
Figure 10. Offer formulation.

Figure 11. Graph of negotiation dynamics.

Note that while *misty* makes concessions right till her fourth offer, *ldias* makes concessions until his third offer; then he appears to make a reverse concession between his third and fourth offer. This worries *misty* into thinking that *ldias* has hardened his position, and she quickly accepts his fourth offer. In truth, *ldias* did not make a reverse concession; his graph (not shown) indicates that his fourth offer was indeed worse for himself than his third—*from his point of view!* In other words, when he thought he was giving away value to *misty* in order to reach a compromise, he actually appeared to her to grasp value and take a tougher stance. This pattern is very common in the negotiations observed via INSPIRE and underscores natural misunderstandings as a cause of negotiation failure.

As a consequence of *misty* 's accepting *ldias'*s fourth offer which was worse for both of them than his third, INSPIRE automatically enters the post-settlement phase and recommends several better compromises. *Ldias* and *misty* continue negotiating, making their fifth offers each, and finally reach an optimal compromise as shown in the figure.

7. Future work

The INSPIRE system has been developed as a tool for research and also used for training. Because of the cross-cultural research function we do not plan to change the system; its specification has been frozen so that we can compare the conduct of negotiation by different users and at different times. However, our experience with this system, both in terms of the research output from analyzing international negotiations conducted through INSPIRE and the experience gained from building and deploying a negotiation support system, as well as the feedback from our users, motivate and inform the design of a new system, INSS (the InterNeg Support System), which is currently under development. INSS will have all the features of INSPIRE and many more.

Using Java applets, users will be able to add new values (options) to the negotiation issues. If, for example, a user begins with five salient values for the price, she may add new price values during negotiation. New values will require to recalculate the utilities for both parties and we will use a simple approximation of piece-wise linear utilities. However, both the user and her counterpart will be able to modify their preferences if they wish to do so. Further, we plan to introduce an option to add values for the discrete issues. In this case both users will have to specify the relative preference for the new value.

Issues themselves may be introduced or removed dynamically during the course of the negotiation. In particular, allowing the two negotiators to dynamically define the set of negotiable issues at the beginning requires (1) value focused analysis to be performed as a pre-negotiation step by the individual negotiators, and (2) a new initial protocol during which the issues are proposed and negotiated by all the parties.

We also plan to enhance the pre-negotiation phase with support for specification of reservation levels and the best alternative to a negotiated agreement (BATNA). Once these two constructs have been elicited from the user, the system will flag any offer or counteroffer that violates either the BATNA or any of the reservation levels. Further planned enhancements include context-sensitive advice; users will be able to obtain information explaining their opponent's behavior, assistance in interpreting offers, suggestions regarding available strategies, etc.

An important factor that we have observed as influencing the negotiation process in INSPIRE is the availability of means for exchanging different kinds of structured objects during communication between the negotiators (e.g., formally specified offers versus free-text messages). INSS will be enhanced with facilities to transfer price lists, balance sheets and other multimedia documents such as pictures and video clips.

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