InterNeg

The Science and Engineering of E-Negotiation: An Introduction

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Abstract

An increasing number of negotiations are conducted via electronic media allowing for an extensive use of software in negotiators' activities. Traditionally, negotiation support was based on normative and prescriptive research; its users were analysts and experts. The purpose of the recently developed e-negotiation systems is to provide negotiators with services and to satisfy their requirements rather than direct their activities so that they conform to rationality and optimality principles. This orientation is typical to software engineering. Due to the difficulties in reconciling results of prescriptive and descriptive studies the e-negotiation design specifications are often based on selected descriptive approaches at the expense of the prescriptive support. This paper presents selected results from negotiation and e-negotiation research and provides specifications for e-negotiation system design and development. Based on review of methodological foundations and a media reference model an e-negotiation view integration model that integrates behavioural, scientific and engineering views on e-negotiation support and media reference mode is proposed.

1. Introduction [1]

Negotiation is a process of social interaction and communication about distribution and redistribution of power, resources, and commitments. It involves two or more people who make decisions and engage in exchange of information in order to determine a compromise. Each participant is an independent decision-maker but they all are interdependent because none can achieve goals unilaterally.

The decision-making aspect of the negotiation process requires that participants collect and process information to determine alternatives, and to formulate offers and arguments. The communication aspect of negotiations involves exchange of offers, arguments and counterarguments. Collecting and processing new information involves learning, leading to modifications and adjustment of the decision problem, and the communication.

Internet technologies allowed deployment of decision and negotiation support systems (DSS and NSS) on the Web. E-marketplaces and virtual organizations, and the increasing collaboration among people and organizations using Internet have already led to the design and development of new e-negotiation systems [2]. Many of these systems were designed to meet users' requirements and solve their practical problems. This is the focus of the engineering approach [3].

Economic and social sciences recognized that people are often biased and make routine mistakes and misrepresentations. This imposes an important requirement on the e-negotiation systems; designers need to consider both qualitative and soft, and quantitative and hard aspects of the negotiation process. This paper briefly reviews results in negotiation research from the perspective of the design and development of e-negotiation tools and systems, and proposes *e-negotiation view integration* (ENVI) model. The purpose of ENVI is to provide a basis for the integration of perspectives, approaches and models from economic and social sciences, computer sciences and information systems, and management to design e-negotiation processes and systems.
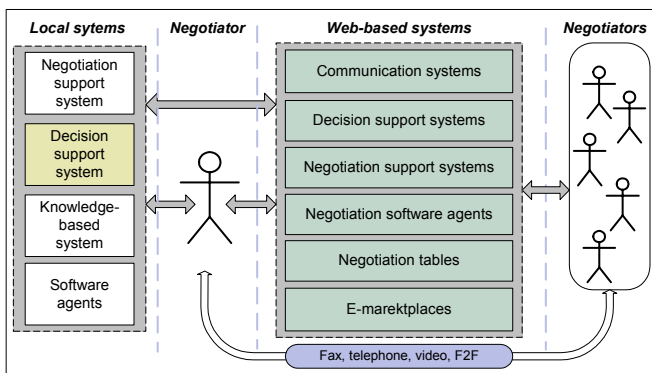
2. E-negotiation processes and systems

E-negotiations are negotiation processes that are fully or partially conducted with the use of electronic media (EM), which use digital channels to transport data. EM may support simple communication acts between the participants (e.g., email, chat) or provide tools that allow

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for complex, multimedia interactions (e.g., e-markets, electronic tables).

The concern of EM is to transmit and present content in a way that can be used by various participants, both human and artificial. EM are not concerned with the way this content is produced and with the use of resources required for production.

In addition to EM, there are several other systems that for some time have been used in decision making and negotiations. Some DSS, NSS, KBS, as shown in Figure 1, were developed to provide support to individual negotiators; others to facilitate activities involving two or more negotiators. These systems contribute to content production; through interactions with their users they formulate sets of feasible alternatives, choice functions, reservation levels, profiles of the negotiators and other constructs used in decision-making and negotiations. With the introduction of the reasoning capability such systems as negotiation software agent (NSAs) can engage in negotiations autonomously thus producing content with little or no input from people.

Figure 1. E-negotiation tools, systems and media

E-negotiation is a process in which both people and information systems (ISs) participate. In Figure 1, the possible interactions are indicated. A negotiator may use resources available on the Web (e.g., an NSS) to negotiate with other negotiators. She may also use local systems for decision-making support (e.g., a DSS) or she may act as a principal with a local system communicating with a Web-based system, possibly negotiating on her behalf. A negotiator may also hire an NSA and use local resources to communicate and supervise the NSA.

The e-negotiation may be undertaken solely with the use of Web-based systems or it may be augmented with traditional communication media, such as fax or face-to-face (F2F).

Traditional negotiations may also use local ISs; what distinguishes e-negotiation from them is the use of Web-based systems. All these systems use digital media to establish communication and interaction between people

and/or other systems. In this section we describe the systems used for e-negotiations.

2.1 Communication systems

The simplest form of the e-negotiation involves the use of email to exchange offers and messages. Email negotiations require a mail server and a client program, both of which are widely available; and no training is required to use the software. There is neither support nor automation available with the exception of the exchange and storage of messages.

Email negotiation, because of its minimal utilization of the capabilities of computer systems. It is probably a temporary form of negotiation and will be replaced with more advanced media that integrate communication systems with both local and remote information systems. Email is at present important because of its ease of use, popularity and very low cost. In negotiations it shares many characteristics with old fashioned mail and fax. Valley et al. [4] show that communication media influence negotiations and also that there are similarities between 'pen and paper' and email negotiations.

Descriptive studies of email negotiation resulted in three types of observations: (1) the need to increase the communication bandwidth; (2) the role of non-task related activities on the process and outcomes, and (3) the potential of support tools [5].

2.2 Negotiation support systems

Introduction of the electronic communication channel in DSSs led to early computer-mediated negotiation with NSSs. A number of NSSs were developed and used in research and training, leading to the construction of systems with active mediating and facilitating tools.

The Inspire system (www.interneg.org/inspire), arguably the first Web-based NSS (WNSS), was developed in 1996 to provide training resources and to study the use of support tools [6]. Inspire negotiations combine the phase process reported in the behavioral studies with decision analytic methods. The use of decision models in an instrumental rather than prescriptive manner allows for process-oriented support.

WebNS is another example of a WNSS [7]. It focuses on structuring of text-based exchanges and automatic process documentation. The system supports the specification of, and discussion about, issues. In WebNS each issue is separately discussed and the information is displayed in the window containing the user messages or in the window with the counterpart's messages. When the parties reach an agreement about an issue the agreement is displayed in the 'common' window. An interesting feature of WebNS is the possibility of introducing a facilitator or advisor into the process. The advisor monitors

the exchanges and establishes communication with one party; a facilitator interacts with, and provides advice to, both parties.

SmartSettle (www.smartsettle.com) is a commercial WNSS which is an extended and ported on the Web version of a research system ICANS [8]. The system uses decision analytic techniques to facilitate and support negotiations. It provides stronger support than, for example, Inspire; because it facilitates the process using users' private information. When the parties enter their offers, it searches for a feasible alternative that is not worse than their offers.

The analytical support of SmartSettle has its roots in decision and negotiation analysis and its objective is to direct the parties towards the Pareto-optimal frontier. It provides prescriptive advice but the parties need not follow it and they can select an inefficient agreement. It also makes use of descriptive concepts such as BATNA and satisfaction levels. In that the system utilizes both descriptive and prescriptive approaches to negotiations; it gives the parties freedom to make decisions but makes suggestions regarding possible compromises and directions for joint improvements.

2.3 E-negotiation tables

During the last few years several systems have been deployed on the Web with the specific purpose of providing negotiation support to consumers and businesses. An e-negotiation table in its simplest form is a virtual meeting space where the parties can post offers, messages that only they can access. This service is provided by organizations which often provide additional services, including matching, mediation, legal and competitive analysis.

CyberSettle (www.cybersettle.com) is an online system that supports its users to negotiate insurance claims over the Web. It implements conflict resolution process based on the parties' agreement zone. The parties follow a well-defined protocol: one party (the insurer) specifies three minimum levels, one for three rounds of bargaining. The claimant enters an offer and the procedure determines if the agreement zone exists, if it does not, the claimant enters another offer. This continues until the third round; if there is no agreement, the parties need to restart the negotiation or use other means.

TradeAccess is an example of an e-negotiation table which, in addition to providing a meeting space gives access to a number of tools. TradeAccess was oriented to purchasing negotiation and provided an easy to navigate and well structured space for bilateral interactions. It maintained a database of potential buyers and sellers, and provided access to contract forms and access to lawyers in different jurisdictions. The company was bought by Ozro Inc. which closed TradeAccess and replaced it with an e-market discussed in Section 2.4.

2.4 Software agents

Negotiation software agents (NSAs) conduct autonomously selected tasks on behalf of their principals, that is, human negotiators. One of such tasks involves a selection of a product and its supplier; several agents were developed for this purpose. BargainFinder, the first shopping agent, has been used in merchant brokering. The objective of the BargainFinder agent, designed by Andersen Consulting in 1995 was searching the Web to provide the principal with the product she sought at the lowest price.

Jango is the first comparison shopping agent developed by Etzioni and Weld at the University of Washington and later sold to Excite.com [9]. It is capable of searching for different products with the use of a collection of "information adapters" which are written for each merchant site and product reviews site to identify and retrieve product information.

We mention here also PersonaLogic and Firefly because they are considered to be software agents capable of product brokering [10]. Because they are not autonomous and cannot undertake tasks independently they are more of Web-enabled DSSs which help users to make decisions. PersonaLogic is an early Web-based implementation of a simple preference aggregation model. Its user was asked to select a product-type from the available list, specify the feasible set of products, and select and weight product attributes. The system determined rating function and displayed top-rated products selected from the database. Firefly uses information about some products that the principal knows or owns, to suggest products that the principal may be interested to purchase.

2.5 E-markets

LiveExchange (www.moai.com) and EcommBuilder (www.ozro.com) are two examples of e-markets that—similarly to some NSS and e-negotiation tables—provide process-oriented support in e-negotiations. They are also capable of handling multi-party and multi-issue negotiations [1]. The focus of EcommBuilder is to facilitate various business processes involved in commercial negotiations. It provides users with databases of potential clients (buyers and sellers) and with information about products. The process-oriented support allows for secure exchange of information between the parties, logs of the exchanges, exchange of attachments, generation of orders and forms, and legal support.

The system provides forms for many processes, including purchase orders, order and contract volumes, sales terms, request for proposal, master purchase agreement, bill of materials, delivery scheduling, payment methods, and shipping and delivery terms. EcommBuilder enhances commercial relationships by managing rules and

processes at three levels: (1) the business rules of both the buying and selling enterprises; (2) the rules of the marketplace entity, whether public or private; and (3) the commercial rules of domestic and international trade with which all enterprises and marketplaces must comply.

Electronic markets can be used by both people and NSAs. Automated negotiations are conducted by NSAs who undertake all tasks required to determine a compromise. At present these agents operate in an electronic marketplace, however in future they may use the whole Web as their environment. They use the marketplace to seek other agents as their counterparts. Each agent conducts a search through a space of possible alternatives, makes offers and counter-offers, and reaches (or does not) an agreement [11]. The space of alternatives is well-defined so that the agents can interpret and evaluate offers using a rating function. The offers may contain a set of values or be specified in terms of an acceptable region. A counter-offer is accepted if it is an element of the acceptable set.

Kasbah is an electronic marketplace populated by selling and buying software agents who engage in a single issue negotiation [10]. The sellers and buyers provide their agents with price aspiration and reservation levels, and the strategy—represented as a concession function—for lowering (increasing) the price over the course of a negotiation. The agents are then loaded into the Kasbah system, search for agents who buy (sell) items of interest, and enter into negotiations. An interesting feature of Kasbah is a simple reputation mechanism based on the rating of participants; participants are asked to rate their counterparts and the aggregate rating is used to assess the participant's reputation.

Experiments with Kasbah led to a design of Tête-à-Tête, a system capable of handling multi-issue negotiations [10]. Based on the users' issue weights it constructs a rating function to evaluate offers made by other agents. User may also specify bounds on the issue values which describe their reservation levels (the use of bounds on a single issue and constraints on multiple issues is also known as the constraint satisfaction method). Bounds are used to reject offers and also to formulate counter-offers, for example, if the offer violates a bound defined on the issue levels a counter-offer is presented with issue values at the bound level.

3. The science of negotiations

3.1. Three orientations

The engineering approach to e-negotiation systems design requires making use of models describing different negotiation characteristics and processes. The richness and complexity of negotiations on one hand and the sig-

nificance of the negotiated decisions on the other led to numerous studies in a number of research disciplines. One perspective for the studies' comparison is their *normative, prescriptive and descriptive orientation* [12].

The focus of normative studies is on the design of models of rational negotiators and procedures of interactions among them. Prescriptive studies are concerned with the design of procedures that define the goodness of the negotiation process and its outcomes, identify 'good' processes and compromises, and help negotiators to achieve good outcomes. Descriptive studies are involved with understanding of how people negotiate, why they engage in a particular type of a process, and why particular outcomes are achieved (references to different research directions and modeling approaches discussed in this section are given in [1]).

Studies in economic sciences concentrated on the design of formal models of negotiations which, under rationality assumptions, allowed for the selection of an efficient and stable compromise. Normative approaches, based on the economic rationality, have been expanded with studies in experimental economics seeking reasons underlying deviations from rationality and extending the problematique, from well-defined representations of negotiators and negotiations to situations in which previous and later events may influence behaviors and decisions.

Many of the developments in management science, decision analysis and negotiation analysis have prescriptive orientation. Models based on the multi-attribute utility theory, optimization models and multiple criteria decision making are examples of solutions proposed to represent and support negotiators. Being concerned with providing a meaningful and helpful support, they typically take external perspective, that is, models are developed to allow analysts to help negotiators to make good decisions.

Studies in behavioral sciences, political science and law concentrate on the description and analysis of negotiators' perceptions, assessments and interactions, and their implications for the process and outcomes. Individual differences, social influences and situational characteristics were discussed in many papers in psychology, sociology and anthropology. People's use of irrelevant information, their inconsistencies and deviations from rationality principles were discussed by Kahneman [13] and applied to the studies of negotiations.

Many descriptive studies of negotiations resulted in suggestions about "good" approaches and behaviors. The difference between prescriptive research and descriptive research is that the former proposes a model of a negotiator and the latter outlines activities that a negotiator should undertake. This difference is highlighted in negotiation analysis which is based on prescriptive/descriptive orientation concerned with providing advice to utility

maximizing negotiators given information about their (not necessarily rational) counterparts [14].

The results of normative, prescriptive and descriptive studies have been applied in numerous information systems developed to support one or more negotiators, and to conduct some or all negotiation activities autonomously. Normative models, mostly based on game theory, were used in research and simulation. Early decision and negotiation support systems (DSSs and NSSs) were based on prescriptive models; their role was to give users efficient solutions and indicate what is good for them. These systems were used to study and teach negotiations; hence their prescriptive orientation was justified.

Dramatic increase in computer literacy among managers, coupled with improvements in computer technologies (e.g., the user interface and context-dependent help) and the incorporation of artificial intelligence, allowed construction of systems that could take negotiators' requirements into account and provide advice that the users sought rather than ought to obtain. Some of the systems used decision and negotiation analysis in an instrumental manner without strict enforcement of logical consistency [15, 16]. The objective of these systems was to provide users with a structured process support and easy to use tools for preference elicitation and offer assessment. Other systems provided expert advice for a particular type of the negotiation [17], manipulation and synthesis of negotiation cases to provide support, and manipulation and assessment of negotiators' perceptions [18]. Although these systems used logically consistent procedures they were not based on rationality assumptions. Those which required preference formulation and utility construction used it as a rough and tentative measure rather than as an expression of the negotiator's true utility.

3.2 Methodological foundations

The three orientations in the science of decision making and negotiation can be used to formulate the scientific views on the participants involved in the processes, their characteristics, roles and theories, the approaches and the models used for the construction of their representations. Four views and two types of processes are presented in Figure 2.

The two types of processes are:

1. Pre-negotiation processes which include formulation and analysis of the negotiation *problem*, the incorporation of *context* of the problem, and in the access and use *knowledge* about the participants, problem and context.

2. Negotiation and post-negotiation *processes* which include strategies and tactics, *context* in which the negotiation takes place, and the *exchange* of information, including offers and arguments.

The four views take into account the following:

1. The *participants* involved in decision-making and negotiation include the negotiator, advisor, principal and an agent (e.g., NSA) who represents the principal. Third parties and stakeholders (e.g., public and interest groups) may also be involved.

2. Participants may have different sets of *characteristics* such as their preferences, attitude to risk, attitude and concern towards others, power, negotiation style, and culture. We also distinguish between people and NSAs as the approach to the modeling of their behaviour and actions differ.

3. The third view represents the participants' *roles* that define sets of activities, for example, analysis, decision-making or advice. The differentiation of roles is related to participants' grouping, however it is separated here because one participant may perform several roles (e.g., a negotiator may perform all roles), and a group of participants may jointly perform one role (e.g., an expert group providing advice to the negotiator).

4. Both characteristics and roles are studied and generalized in order to construct *theories*, *frameworks* and *models*. They represent the fourth view; they are tangible results of the scientific approach to negotiations.

Scientific views	Processes	
	Problem, knowledge	Process, exchange
Participants	Decision-maker, principal, agent	Negotiators, principals, agents, third parties
Characteristics	Preferences, risk attitude, power, style, culture, independence. Human-artificial	
Roles	Analysis, choice, assessment, advice	
Theories Frameworks Models	Problem models Choice models Expert models	Problem and concession models Argumentation models Expert models

Figure 2. Scientific views on negotiations

The differentiation between the two types of processes, indicated in Figure 2, allows distinguishing two categories of models. Models of the problem, individual choice and expert knowledge are used in pre-negotiation processes. The negotiation and post-negotiation processes are described with models that incorporate the dynamic aspect of the negotiation, choice and concession models, argumentation models, and models which describe the negotiation protocol. We also include expert models that can be used during the negotiation.

The two types of processes and four views provide the basis for the categorization of approaches to negotiation modeling. Focusing on a particular group of participants, their characteristics and roles, together with the selection

of a research orientation leads to the formulation of assumptions and construction of models that represent the participants' negotiation activities. We use this categorization to review models that have been used in negotiations and e-negotiations.

4. Engineering approach

4.1. Software engineering

The goal of the scientific approach to negotiation is to understand the participants' behaviour, and the impact of the situational, contextual, individual and group characteristics on the process and outcomes. Design of systems that are useful and can satisfy negotiators' requirements reflects the *engineering approach* to negotiation. The engineering approach is concerned with the use of every possible result in order to find solutions to practical problems. "Engineering is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind." [3]. The "benefit of the mankind" defines the purpose of engineering which often is formulated in terms of finding solutions to practical problems and satisfying customer requirements.

Software engineering is based on two principles: (1) the utilization of the mathematical results in the design and construction of systems, and (2) the use of behavioural and cognitive results to determine the needs, capabilities and requirements of the systems' users. This is of particular importance in the design of systems which are immersed in a social setting, address social problems and involve many different users. Thus negotiation engineering needs to incorporate the normative, prescriptive and descriptive orientations. The difficulty is that the results of these three orientations are difficult to reconcile, some are based on undefined assumptions, and others use ill-defined and contradictory concepts [19 30, 20]. The need to design useful systems that meet users' requirements resulted in arbitrary bundling of methods accompanied by claims of their usefulness in a wide range of negotiation processes.

Software engineering is composed of steps encompassing methods, tools and procedures that are used in the development process. The steps are referred to as software engineering paradigms, such as the classic life cycle, prototyping, rapid application development, and object-orientation. Every software project follows three phases: definition, development and maintenance, regardless of the paradigm selected [21]. The focus of the *definition phase* is the specification of the key requirements of the system, including definition of the problem, identification of users and their requirements, identification of the information the system will process, and models and procedures used for processing and production of outputs. The three key elements considered in the definition phase are identified are presented in Figure 3.
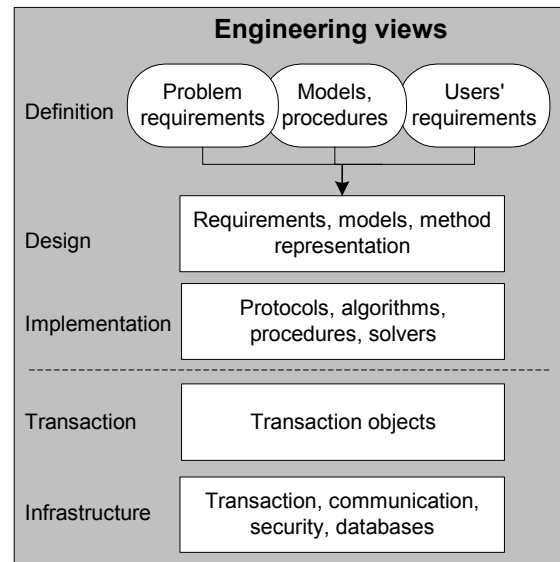

Figure 3. Engineering views on negotiations

The *development phase* comprises software design and implementation, see Figure 3. Design translates the requirements, models and methods into the set of representations that are subsequently implemented, i.e., coded and tested [21]. The outcome of the implementation phase is a software program. Its activities result in transaction objects and it uses different forms of services provided by other programs, including transaction processing systems, communication and security systems, DBMSs and so on.

5. Electronic media

Communication, one of the key elements of every negotiation, is conducted with the use of one or more media. Traditional negotiations are conducted face-to-face, via telephone, or paper and pen. E-negotiations are processes that use *electronic media*, i.e., media with digital channels to transport data and to allow the negotiators to communicate and coordinate their activities.

Media used in traditional negotiations are not designed specifically to help negotiators and support the process. Therefore, while they may require engineering, the purpose is general communication rather than negotiation. In contrast, in e-negotiations the issue of media design and their relationship to other participating components gains importance. This is because the medium may: (1) be constructed for the specific purpose of supporting or

facilitating one or more of e-negotiation activities; (2) it is either a software program or it is generated by software so it is—directly or indirectly—constructed by software engineers; and (3) it is a component of a complex engineered system in that it uses, controls and is controlled by other programs.

The role of electronic media on all activities conducted with the use of Internet technologies (e.g., e-business, on-line learning, virtual communities and e-government) led researchers' attention to the issues of their design. Schmid and others [22, 23] propose a *media reference model* (MRM) in which media are described in terms of (1) language employed in communication, (2) channels transporting information, and (3) an organization describing the roles of the participants and protocols defining the permissible interactions.
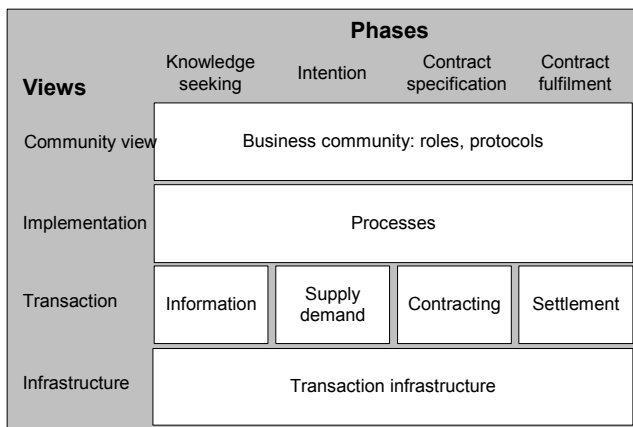

Figure 4. Media reference model [23]

The MRM model, depicted in Figure 3, is used to describe the role of media in a community that, according to the model, comprises agents and media. The community members (i.e., agents) undertake activities that belong to one of the four phases: (1) knowledge seeking, (2) communication of intentions and requests, (3) specification of contracts and agreements, and (4) meeting obligations and performing contract tasks. The agent's activities are implemented in media. This means that virtual communities can exist, if appropriate media are built allowing for communication, coordination and access to storage facilities. Also in the implementation view the model is represented in software leading to the software engineering two views: the transaction view and the infrastructure view.

The importance of the MRM model is its focus on the integration of social and engineering perspectives through linking the community view, describing the members' needs, interests, roles and also protocols that they have to conform to, with the implementation view in which a descriptive model of the community, its members and

their activities is defined. For these reasons Ströbel [24] adapts the model to construct a media-implementation SilkRoad platform where the exchange of objects is coordinated through an agent (human and artificial) interaction. The novelty of SilkRoad lies in its ability to generate different e-negotiations media for a given requirement set. Another application of the MRM phases and media-types is the Montreal e-negotiation taxonomy proposed by Ströbel and Weinhard [25].

The use of systems that utilize the variety of models described in Section 3 is not necessary for e-negotiation. Negotiations that use streamlined video use electronic channels, are conducted via e-mail, or engage NSAs that interact on the e-marketplaces and convey requests made by their principals (e.g., Kasbah) are examples of e-negotiations. In these cases the MRM model is sufficiently rich to describe interactions among community members.

Both the strength and the weakness of the MRM is its focus on media. The strengths are mentioned above. The weakness is the concept of community comprising agents and media that is too narrow to account for systems that support the negotiators and facilitate the process. The computational processes that aim at such activities as the specification of decision alternatives, their comparison and evaluation, integration of interests, and interpretation of offers, and which are undertaken by DSS, NSS and software agents need not belong to the community but their importance and impact cannot be ignored. Although the MRM allows for the community members to search for information and knowledge, these activities need not be done by the members themselves but by others: people, software agents and/or support systems. Extension of the community with these entities, while possible, makes little sense because—in the on-line environment—its boundaries would disappear.

The MRM model is concerned with transport and presentation; it is not sufficiently rich for the purpose of e-negotiation which can be conducted by people and software agents belonging to different communities, communicating with human and artificial experts, and using support tools and systems. The significance of the e-negotiation is that the processing and storage of information and production of knowledge becomes possible. The loss of a wide communication bandwidth that allows for the use of all senses and the use of media that use much narrower bandwidth can possibly be offset with the computational capabilities coupled with access to information and knowledge stored in computer networks.

6. E-negotiation view integration

E-negotiation is a process and it is also a complex system which consists of the negotiators, models, decision

and negotiation support systems, knowledge based systems and media. If the negotiators are software agents then the whole system needs to be engineered. If the negotiators are people then the remaining components of the system need to be engineered to meet the users' needs and requirements. To achieve this we need a comprehensive e-negotiation model that integrates the scientific perspectives discussed in Section 3 and the engineering perspective discussed in Section 5. As the starting point we use the MRM model discussed in Section 4.

The model is modified and extended in order to:

1. Incorporate the three orientations, theories and modeling approaches;

2. Position e-negotiations in a broader organizational and social context;

3. Strengthen the role of processes which may incorporate different action types;

4. Differentiate between users and other participants, and their roles and characteristics; and

5. Establish the relationship between the scientific and engineering approaches to e-negotiations.

The proposed e-negotiation view integration (ENVI) model has six views (three scientific and three engineering) and four negotiation processes (pre-negotiation, negotiation, post-settlement, and knowledge integration).

The three scientific views are (1) the user group; (2) participants' and other stakeholders' roles and characteristics; and (3) theories, models and approaches. These views now correspond to the definition and design views in the engineering model illustrated in Figure 3. Therefore, the engineering views comprise now three views (4) implementation; (5) transaction; and (6) infrastructure.

The *user group* view identifies all participants and stakeholders, including organizations and social groups, who are involved in the negotiation process, evaluation of agreement, its implementation and the codification of acquired knowledge for further use. The participants and stakeholders have different *roles and characteristics*. The theoretical views depend on the users' type, their characteristics and processes. The normative, prescriptive and descriptive modeling orientations and the underlying theories are used in *theories, models and approaches*. These orientations allow distinguishing five categories of negotiation models [1].

The implementation, transaction and infrastructure views correspond to the engineering approach to e-negotiation. The *implementation* view identifies protocols, algorithms and procedures necessary to realize different models, define the sequences of tasks, actions and services, and bind models to service providing modules. The *transaction* view provides various generic services, including communication, interaction, solution, storage and retrieval. Finally, the *infrastructure view* provides the

means for the physical implementation of the selected services, databases and knowledge bases.

Processes				
Views	Problem Context Knowledge	Exchange Assessment Reasoning	Agreement Implication Implementation	Integration Learning Knowledge
User group	Decision-maker	Negotiators, third party	Negotiators, principals, stakeholders	Organization, others
Roles Characteristics	Support, advice, analysis, choice. Attitude, power, style, culture, independence, human-artificial			Organization size, culture, type
Theories Approaches Models	User, problem, expert	Process, argumentation, protocol, expert	User, problem, planning, control	Learning and knowledge management
Implementation	Protocols, algorithms, procedures			
Transaction	Information	Offers, arguments, documents	Documents, plans	Business rules, knowledge
Infrastructure	Transaction, communication, security, database, knowledge base			

Figure 5. E-negotiation view integration (ENVI)

The MRM model groups all services in four action types [23]. In an effort to relate the scientific and engineering approaches the processes required to construct, analyze and solve models of the problem, user, argumentation, negotiation process and so on are distinguished from services which implement these processes. Note that the meaning of "process" is generic and it involves a series of activities and interactions leading to the achievement of a specific goal, for example, a model, solution, expertise or argument.

The four processes identified in the ENVI model describe: (1) preparation to negotiation; (2) negotiation; (3) agreement and post-settlement activities; and (4) integration of lessons learned from the negotiation.

The goal of negotiation and other decision processes is to determine a solution in which possible implications are assessed and which is implemented. Negotiations are undertaken in a particular context that needs to be recognized. Through the agreement implementation the parties change this context. This often requires preparation of documents and plans which can be undertaken with planning and control models.

The direct outcome of the e-negotiation may be an agreement or a deadlock. In many situations, however, there is also another outcome often of no less importance, namely knowledge that the participants and stakeholders gain and which can be used in the future. Therefore the processes involved in learning and knowledge management are identified in the proposed e-negotiation reference model.

7. Conclusions

The objective of this paper is to build a case for e-negotiation engineering which—as we tried to show—can and should integrate various results from all the fields of negotiation research, including behavioural studies and qualitative research. Negotiation is a social process but e-negotiations, while inherit the social aspects also involve a significant technological component. Software engineering approach with justified concern to the users' requirements and abilities is not sufficient.

Negotiations being a complex social process require knowledge and understanding of the pitfalls, human biases and misconceptions. E-negotiation systems that have capabilities to support and facilitate the process need to play a role similar to this played by an analyst or an expert. That is they need to be capable of analyzing and verifying users' input, their reasoning and consistency, and understanding of all aspects of the negotiation problem and process.

Not all developments in negotiation and e-negotiation research are presented in this review. Similarly, not all approaches to modelling and representation negotiation systems are discussed. The effort was on providing several classifications that, in our view, support the case. These classifications accompanied with the scientific and engineering views, and the media reference model led to the e-negotiation view integration model (ENVI) in which the behavioural, scientific and engineering views and processes are identified.

Negotiation process is often fluid, multifaceted, rich in content and context, involving negotiators and other stakeholders. It has been considered an art of interpersonal skills, persuasion, motivation, understanding, body language, etc. Raiffa [26], in his seminal work on studying and representing negotiations using applied mathematics, affirmed the role of the scientific approach.

Advances in decision and negotiation analysis, behavioural research, cognitive science, AI and computational linguistics allowed that the richness of the negotiation can be matched with configurations of complementary model. More work is necessary on the integration of the existing descriptive and prescriptive models to represent both the art and science of negotiations. I think that the review of models presented in Section 4 gives grounds to believe that this is feasible. Models that are proposed in experimental economics, anthropology, psychology and other areas that incorporate the social concepts as fairness, reciprocity, attitude and culture allow to enrich the expressive powers of e-negotiation systems and to establish some form of synergy between the user and the system.

Advances in system design and development methodologies, and in information and communication technologies made it possible to implement these models and to introduce a meaningful user-system dialogue. From the engineering perspective, one direction is to use new software engineering paradigms like aspect-oriented programming and subject-oriented programming [27]. They recognize the cross-cutting and similarity of objects and therefore may be used to construct systems capable of adapting themselves to different user styles and cultures, and model configuration during the negotiation. A step in this direction is Ströbel's SilkRoad platform designed to generate, at the run-time, a number of different ENM for different types of negotiation processes [24].

Several research directions may be suggested. Behavioural studies of users who engage in e-negotiations link the engineering with descriptive perspectives. More research on protocols, in particular comparison and integration of protocols proposed in behavioural studies and those designed for NSAs is required. People have different agendas, expectations, attitudes; they also differ in their cultural, social and educational backgrounds. The same goes for organizations. It is an open question if these differences ought to be incorporated in WNSSs that support, and in NSAs that represent, people and organizations. Descriptive research provides strong arguments for culturally- and socially-sensitive negotiation systems but software engineering recognizes these differences at the interface level through software internationalization architecture. More research on the roles that systems play in negotiations (and other social processes), their impact on these processes, and shape the behaviour of the participants is required.

8. References

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