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E-negotiations: Towards Engineering of Technology-based Social Processes

Gregory E. Kersten

School of Management, University of Ottawa, 136 Jean-Jacques Lussier, Ottawa, Ontario K1N 6N5 Canada (Kersten@management.uottawa.ca)

Abstract. 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 discusses methodological foundations for e-negotiation system design and development. Based on review of methodological foundations and the scientific and engineering perspectives on negotiations, an e-negotiation view integration model is proposed. The purpose of the model is to allow for the integration of behavioural, scientific and engineering views on e-negotiations.

Keywords: Negotiation, electronic negotiation, modelling, negotiation analysis, decision support, negotiation support, social process engineering, systems engineering.

1. Introduction

Negotiation is a process of social interaction and communication that involves 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. Many important decisions have to be negotiated because people need to share and distribute scarce resources. The interpersonal character, the participants' independence as the decision-making entities and their interdependence in their inability to achieve goals unilaterally contribute to the negotiation complexity.

The decision-making aspect of the negotiation process requires that participants collect and process information to determine feasible alternatives, and to formulate offers and arguments. The communication aspect of negotiations involves information exchange, including offers and arguments, in order to influence and motivate the participants' counterparts. Collecting and processing new information involves learning, leading to modifications and adjustment of the decision problem, and the interaction and communication.

Several systems based on applied mathematics have been implemented and used in research and training (Yuan et al. 1998; Kersten and Noronha 1999; Bui et al. 2001). They show the potential of decision-theoretic models in e-negotiations. Software agents and choice models based on collaborative filtering and recommender models reinforce the engineering, user-oriented approach to negotiations. A number of prototype systems have been developed and tested with the purpose of providing a complete or partial automation of negotiations; these provide support, suggest offers and predict outcomes based on past experience (Guttman and Maes 1998; Maes et al. 1999; Sandholm 1999). The orientation on practical relevance and user satisfaction is even more evident in systems deployed on the Web that provide electronic negotiation platforms for business and other organizations (FreeMarkets 2002; Moai 2002; Ozro 2002).

These few examples illustrate efforts for the design of human-machine systems that incorporate certain results of applied mathematics. Some of these systems were designed from the software engineering point of view and their objective was to meet users' requirements and solve their practical problems. Others were designed with the perspective of teaching negotiators how they should make decisions and communicate with their counterparts.

Economic and social sciences recognized that people are often biased and make routine mistakes and misrepresentations. Tools that allow making decisions faster may amplify the impact of the mistakes because their users have less time to ponder and search for alternatives. This implies that, rather than focusing on decision-making speed and efficiency the effort may be focused on learning and understanding both the decision-makers themselves, their decision problems, and the solutions' narrow and broad implications.

Two points of reference may be thus identified:

1. The *pragmatic point* of reference is based on the identification of the needs of e-negotiation participants. It provides a basis for the information system (IS) research and software engineering efforts that are concerned with the identification of users and their requirements.

2. The *normative and prescriptive point* of reference is rooted in negotiation research and the identification of the negotiators cognitive and other limitations, misconceptions, and the impact of the negotiators' situation and their background on the process and its outcomes.

Ideally both points of reference should be used in the design of e-negotiation systems and their incorporation in negotiation processes. The difficulty is that IS research and software engineering have often narrow perspective of the users and their immediate needs. The studies of, for example, the user interface, technology adoption and software internationalization have mostly been concerned with the "surface-level" user requirements with little consideration to the richness and complexity of the users.

On the other hand negotiation research does not provide clear indication regarding the process complexity and the users' multiple and sometimes conflicted characteristics. During the past few decades a variety of approaches and models of negotiation process have been proposed. Researchers used different assumptions, terminologies and notions to formulate concepts and models. This led to inconsistencies and contradictions (Gulliver 1979, p. 69) making integration of complementary models difficult. Such integration is necessary to construct systems that meet all requirements of their users rather than a selected few.

The proliferation of electronic marketplaces and virtual organizations, and the increasing collaboration among people and organizations using Internet technologies will lead to the design and development of new systems. These efforts will be undertaken by computer scientists and software engineers because they have the required expertise. They build systems that meet various user requirements and facilitate efficient negotiations sometime using—as we witnessed in several studies and on-line systems—methods that are effective but not necessarily correct from the decision- or game-theoretical viewpoints. One reason is that there is a lack of methods and procedures that can be readily adapted to design systems capable of providing comprehensive support to negotiators or engaging in negotiations. Researchers in negotiations need to take a fresh look at their work and provide guidance regarding the implementation of methods and models they devised.

To make development of negotiation systems better informed we need to take a fresh look at the negotiation models and methods from the perspective of their design, implementation and use. On the one hand, recent work on negotiation support systems and negotiation software agents has created some new opportunities and posed new questions for negotiation research. On the other, the richness and complexity of negotiations is matched with multiplicity of research perspectives from many different fields. The results are often difficult to compare and integrate.

This paper makes an attempt to integrate a number of results in negotiation research from the perspective of their use in the design and development of information systems which aid negotiators and which undertake some or all negotiation activities. These systems participate in *electronic negotiations*, or *e-negotiations*: processes in which information is formulated, exchanged via and processed with, the use of software. The focus is on *multi-issue bilateral negotiation* supported or conducted by software.

In Section 2 e-negotiation processes and systems are discussed. Three perspectives on the study and model negotiations and negotiators are discussed in Section 3. They, together with briefly outlined methodological foundations, are used to formulate the scientific view of negotiations. The software engineering views on e-negotiations presented in Section 4 correspond to the scien-

tific views. The scientific and engineering views, and the five types of models, are used to propose, in Section 5, the *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. Section 6 presents conclusions and future work in e-negotiation engineering.

2. E-negotiation processes and systems

E-negotiations are negotiation processes that are fully or partially conducted with the use of software. The software may be dedicated systems, such as negotiation support systems (NSSs) and negotiation software agents (NSAs); systems supporting individual negotiators (e.g., decision support systems (DSSs) and knowledge based systems (KBSs)); systems that are used for communication purposes (e.g., email and chat); systems used for collaboration and organization of information (e.g., workflow systems, project management systems and group support systems); and various organization systems that allow for the verification of alternatives and assessment of their impact on the indices measuring organizations' performance. In e-business and e-commerce software tools may also be part of the infrastructure, for example, systems for auctions and bilateral negotiations available in a particular e-marketplace.

E-negotiations processes, as well as many other people-machine processes, may be considered from two perspectives: (1) processing which focuses on the use of various software engines and servers; and (2) interaction which focuses on the communication between people and systems. The first perspective pertains to the decision-making aspect of negotiations; the second—to the communication aspect.

The first perspective, briefly outlined above, is concerned with the construction, implementation and use of models that are used for information processing. The second perspective is concerned with *electronic media* (EM) which use digital channels to transport data; it is an extension of the active interface concept.

Table 1. Functions of e-negotiation media and systems

No.	Function	Typical activities
Communication, presentation and interaction		
1.	Transport and storage	Transport of information among heterogeneous systems; storage in distributed systems; security.
2.	Search and retrieval	Search of information; selection; comparison and aggregation of distributed information.
3.	Formatting, presentation and interaction	Data formatting for other systems use; data visualization, alternative data presentation, user-system interaction.
Modelling and content formulation		
4.	Decision problem formulation	Formulation and analysis of the decision problems; feasible alternatives; decision space, measurement.
5.	Decision-maker speci-	Specification of constructs describing decision makers; preferences,

	fiction	measures for alternative comparison; negotiators' models and styles.
6.	Offer and message construction and evaluation	Formulation of offers and concessions; analysis of messages and arguments; argumentation models.
7.	Counterpart analysis	Construction and verification of models of negotiation counterparts; evaluation and prediction of their behaviour, strategies and tactics.
8.	What-if and sensitivity analyses	Analysis of offer and counter-offer implications; analysis of the implication of different offers on the counterparts' reactions; assessment of the potential compromise solutions.
9.	Process, history and their analysis	Construction of the negotiation history; process analysis; progress/regress assessment; history-based predictions.
10.	Knowledge seeking and use	Access and use of external information and knowledge about negotiation situations and issues arising during the process; comparative analysis.
11.	Negotiation protocols	Specification of, and adherence to, the negotiation agenda and rules
12.	Strategies and tactics	Formulation, implementation and assessment of strategies and tactics

EM may support simple communication acts between the participants (e.g., email, chat) or provide tools that allow 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. Their objective is to provide (1) transport and storage; (2) search and retrieval, and (3) format and presentation, which are the first three types of functions listed in Table 1. To meet these objectives computationally complex activities may need to be undertaken. EM may also rely on models, but the difference between the processing and interaction perspectives is in the focus. The use of models is to provide insights and better understanding through, for example, the use of different visualization techniques, and search and retrieval of information.

EM provide the basis for the activities focussed on information processing in that they allow for effective interactions. Nine types of functions that are specific to negotiations and based on theories of individual decision-making, communication and negotiation are identified in Table 1. Systems that undertake these activities provide content that is used by the negotiators and software agents.

Within each type there are various tasks; some require negotiator intervention, others can be conducted by software autonomously. The division of the scope of involvement between the negotiator and software in the activities depends on the *level of negotiation automation*. On one extreme, the negotiator controls the conduct of every activity. On the other end of the spectrum the negotiator provides the system with information about the problem, a measure for alternative comparison and the negotiation rules, the system then engages in the negotiation on behalf of the user. Based on the level of support and automation four broad types of e-negotiations are discussed below: communication systems, negotiation support systems, electronic negotiation tables and negotiation software agents. The distinction is from the perspective of the primary goal of the system rather than the set of technologies used.

Several different configurations of the software used in e-negotiations are shown in Figure 1. The local systems are developed to provide support to individual negotiators; the Web-based systems facilitate and support activities involving two or more negotiators.

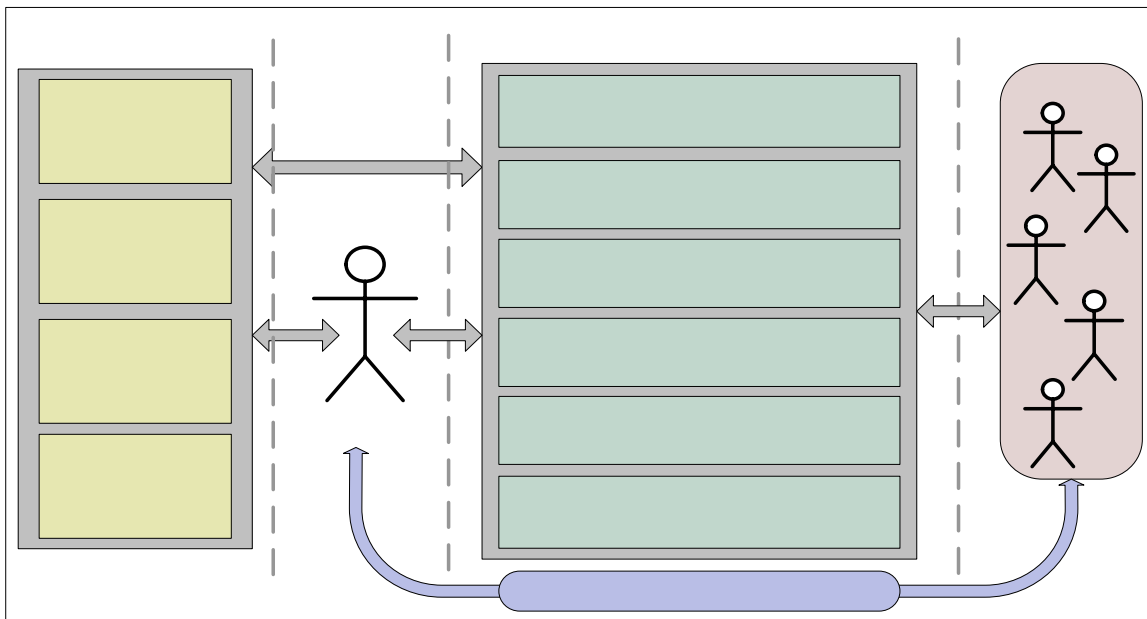


Figure 1. E-negotiation tools, systems and media

Tools, systems and media listed in Figure 1 may be configured in different e-negotiation platforms. The simplest platforms—from the perspective of providing services and support—are the communication systems and e-marketplaces. Platforms that include decision and negotiation support contribute to content production. With the introduction of the reasoning capability such systems as NSAs can engage in negotiations autonomously thus producing content with little or no input from people.

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. S/he may also use local systems for decision-making support (e.g., a DSS) or s/he 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.

3. The science of negotiations

Decision
support system

3.1 Three orientations

The engineering approach to e-negotiation systems design requires making use of models that describe different negotiation characteristics and processes. The richness and complexity of negotiations on one hand and the significance 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* (Bell et al. 1991).

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 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.

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 (Nash 1954; Young 1975; Munier 1993; Roth 1995b; Harsanyi 1997). 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 behaviours and decisions (Roth 1995a; Sethi and Somanathan 2001).

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 (Bui 1994; Kilgour 1996; Teich 1996). 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 behavioural 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 (Rubin and Brown 1975; Druckman 1977; Gulliver 1979; Pruitt 1981; Bazerman et al. 2000). People's use of irrelevant information, their inconsistencies and deviations from rationality principles were discussed by Kahneman and Tversky (1979) and applied to negotiations by Bazerman (1998), Neale et al. (1987) and others.

Many descriptive studies of negotiations resulted in suggestions about "good" approaches and behaviours. 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 (Sebenius 1992; Young and Parks 1994).

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 ne-

gotiation activities autonomously. Normative models, mostly based on game theory, were used in research and simulation (Rapoport and Chammah 1965; Lendenmann and Rapoport 1980; Axelrod 1984). Early decision and negotiation support systems (DSSs and NSSs) were based on prescriptive models (Korhonen 1986; Jarke et al. 1987; Thiessen and Loucks 1994); 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 (Rangaswamy and Shell 1997; Kersten and Noronha 1999; Bui et al. 2001). 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 (Rangaswamy et al. 1989), manipulation and synthesis of negotiation cases to provide support (Matwin et al. 1989; Sycara 1989), and manipulation and assessment of negotiators' perceptions (Bonham 1993). 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 on 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.

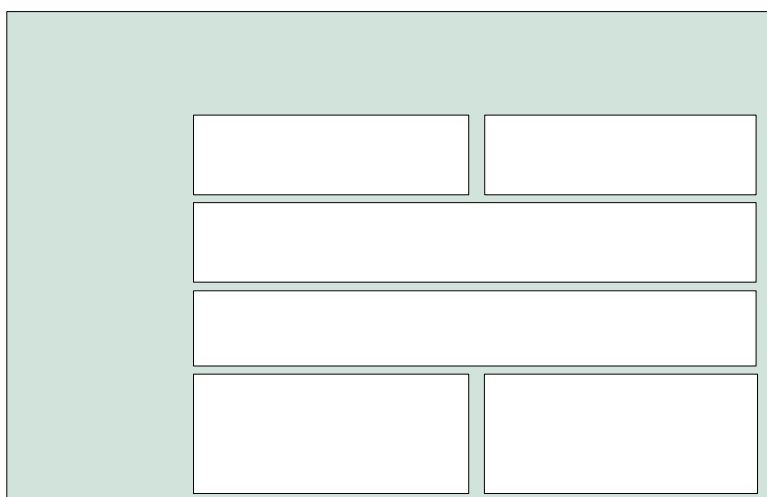


Figure 2. Scientific views on negotiations

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; and
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 set 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 modelling 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 formulate *theories*, *frameworks* and *models*. They represent the fourth view; they are tangible results of the scientific approach to negotiations.

The differentiation between two types of processes and participants, indicated in Figure 1, allows us to distinguish 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 modelling. Focussing 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

4.2 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 reflect 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." (ABET 1992). 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 (AIAA 2002).

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 (Gulliver 1979 30; Kersten 2001). The need to design useful systems meeting 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 (Pressman 2001). 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 on production of outputs. Three key elements considered in the definition phase are identified are presented in Figure 3.

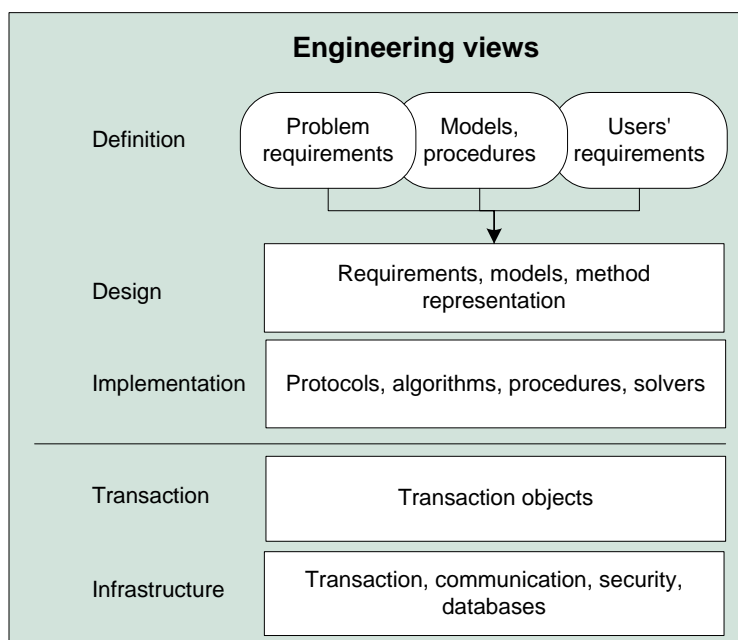


Figure 3. Software engineering perspective

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 (Pressman 2001).

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, database management systems and so on.

4.2 Electronic media model

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 (EM), 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' atten-

tion to the issues of their design. Schmid and others (Schmid and Lechner 1999; Lechner and Schmid 2000) 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.

The MRM model, depicted in Figure 4, 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 MRM having two views that overlap with software engineering perspective (i.e., transaction and infrastructure views).

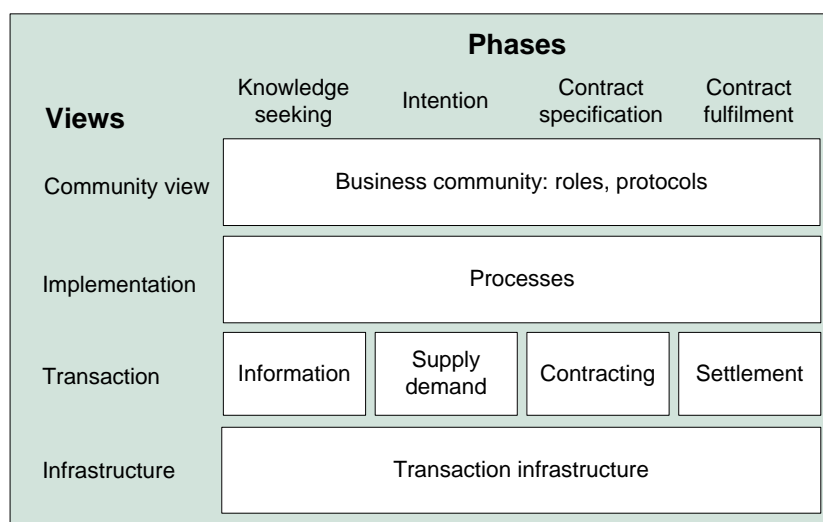


Figure 4. Media reference model (Schmid and Lechner 1999)

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 descriptive model of the community, its members and their activities is defined. For these reasons Ströbel (2001) 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.

Both the strength and the weakness of the MRM is its focus on media. The strengths are mentioned above. The weakness is to narrow a concept of community comprising agents and media 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 compari-

son 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 but 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 experts and using support tools. 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.

5. E-negotiation view integration

E-negotiation is a social process embedded in technology. The minimal technology-based functions are communication, presentation and interaction in a simple text-based form. At the other end e-negotiation may involve negotiators, decision and negotiation support systems, knowledge based systems and media, all of which are active and creating content. The participants of e-negotiations and the relationships among them comprise an *e-negotiation system* (ENS).

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 reference that integrates the scientific perspective discussed in Section 3 and the engineering perspective discussed in Section 4.

As the starting point we use the MRM model discussed in Section 4. This model is modified and extended in order to:

1. Incorporate the three orientations, theories and modelling 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—shown in Figure 5—has six views (three scientific and three engineering) and four negotiation phases (pre-negotiation, negotiation, post-settlement, and knowledge integration).

The three scientific views are: (1) theories, models and approaches (2) the user group; and (3) participants' and other stakeholders' roles and characteristics. The first view is used to formally define and represent decision makers, negotiators and other users who comprise the second view. These users have different characteristics and play different roles in negotiations. They need to be identified because of their different informational and communication requirements.

The three 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 modelling orientations and the underlying theories are used in theories, models and approaches.

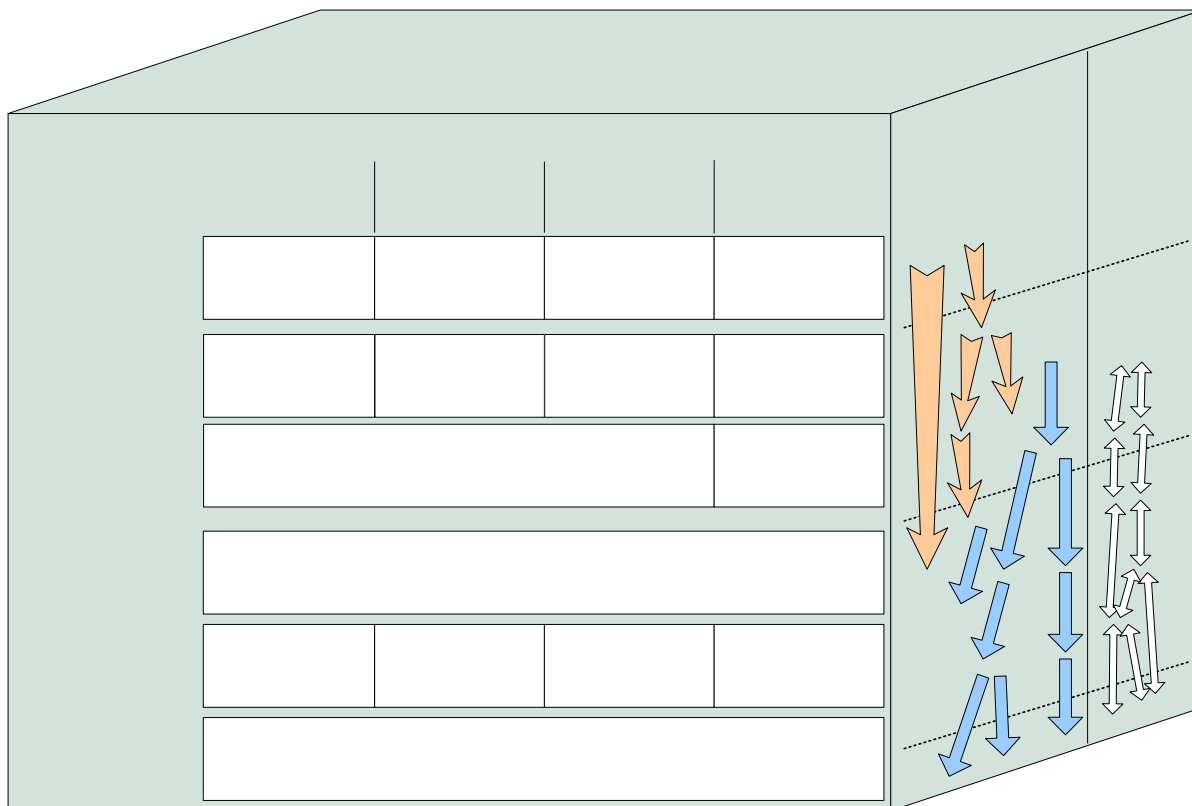


Figure 5. E-negotiation view integration (ENVI) model

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.

The MRM model groups all services in four action types (Schmid and Lechner 1999). 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 phases 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 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 ENVI model.

To illustrate the relationship of the scientific and engineering views the relationships between them are illustrated with several arrows. The arrows that correspond to the negotiation studies show illustrate the use of theories in constructing models and solution procedures. The arrows that indicate engineering activities present the use of models and procedures in the design and implementation of tools and systems. In addition, arrows are added to show interactions between the users, tools and systems. While the first two sets of arrows represent the integration of the scientific and engineering processes in order to construct ENSs, the third group of arrows represent their use.

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.

6. 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. Not all developments in negotiation and e-negotiation research are presented in this review. Similarly, not all approaches to modelling and representation to NSSs and NSAs are discussed. The effort was on providing specification of ENSs functions and configurations followed by selected perspectives and models led to the e-negotiation view integration model (ENVI) in which the scientific and engineering views and phases are identified.

Negotiation process is often fluid, multifaceted, rich in content and context, involves negotiators and other stakeholders. It has been considered an art of interpersonal skills, persuasion, motivation, understanding, body language, etc. Raiffa (Raiffa 1982), 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 made it possible to match the richness of the negotiation with configurations of complementary models. More work on the integration of the existing normative and prescriptive models to represent both the art and science of negotiations is necessary. 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 ENM and to establish some form of synergy between the user and the system. The ENVI model provides a framework for the positioning of various models and procedures, specification of their roles in the e-negotiation process, and specification of the relationships among them. Through integration of the scientific and engineering views the model also provides a consistent progress from theoretical solutions to their implementations in the form of tools, systems and protocols.

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 ENSs that support, and in NSAs that represent, people and organizations. Descriptive research provides strong arguments for culturally- and socially-sensitive ENSs 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 their influences on the behaviour of the participants is required. Another research direction is to use ENVI to classify models and procedures, and tools and systems, and to propose architectures for ENSs that correspond to different types of negotiations.

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