Negotiation Support and E-negotiation Systems♦

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Abstract

With negotiation being often difficult process involving complex problems, computer-based support has been in its various phases and activities. This chapter provides a historical overview of software used in supporting negotiations, aiding negotiators and automating one or more negotiation activities. First it presents several system classifications, architectures and configurations. Then, it focuses on NSSs and related systems introduced in the early 1980s and on the systems deployed on the web. These broad categories are discussed from four perspectives: real-life applications, systems used in research and training, research results, and a research framework

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1. Introduction

Our times are "technology laden". Technology has ubiquitous role and it is also increasingly proactive and even interventionist. This can be particularly well observed in such processes as negotiations which involve people communicating via and working together with software.

Since THE late 1970s many systems have been designed to undertake such complex negotiation tasks as conflict identification, management and resolution, search for consensus, assessment of agreement stability and equilibrium analysis. Some of these systems are mentioned in chapters of this Handbook; many *group decision support systems* (GDSSs), *group support systems* (GSSs), and *meeting support systems* (MSSs) have functions aimed at managing and resolving conflicts (DeSanctis and Gallupe 1987; Chidambaram and Jones 1993; Fjermestad and Hiltz 1999)

Despite some similarities between different types of computer-based support systems and certain confusion resulting from the use of the term GDSS for a negotiation support system (NSS) and vice versa, there are important differences between NSSs and other systems involving multiple decision-makers. These differences take origin in the processes the system supports.

The key assumption for a NSS system is that the decision process it supports is *consensual*. Participants of meetings and various types of group decision-making may attempt to achieve consensus but it is not the necessary condition for success. In negotiation, the achievement of consensus regarding an alternative decision is necessary for this alternative to become an agreement. This implies that tools and features of a NSS need to be designed taking into account that its users are:

- Independent in terms of their decision-making powers;
- Representing their own and/or their principals' interests;
- Interdependent in terms of their ability to achieve their objectives;
- Able to terminate the process at their will; and
- Abe to reject every offer, requesting another offer and proposing a counteroffer.

This chapter presents an overview of negotiation and e-negotiation systems: their types, architectures, applications and research. Different kinds of software used for negotiation facilitation and support are defined in this section. Differences between software-supported negotiations undertaken by a social system and a socio-technical system are also discussed. Section 2 presents several negotiation and e-negotiation classifications. They are based on the system activeness, its roles in the process and the activities it undertakes. In Section 3 we discuss models embedded in many NSSs and other systems used in e-negotiations, outline their architectures and briefly describe eight types of software configurations which determine the scope of human-software interaction and collaboration. Early applications of NSS and their use in research and training are discussed in Section 4. In Section 5, we discuss systems designed to support web-based negotiations and conflict resolution in commercial and non-commercial transactions, systems designed for research and training purposes and selected results of e-negotiation research.

1.1 Definitions

Decision support systems (DSS) are used by negotiators probably as much as by individual decision makers, or—in the early days—by analysts and other intermediaries. The need for negotiators' support was recognized in the 1970s (Nyhart and Goeltner 1987) and it led to the realization that a separate class of software is required.

Lim and Benbasat (1992) note that a negotiation support system requires all the capabilities of a DSS and, in addition, it has to facilitate communication between the negotiators. The "DDS + communication" is considered here to be a minimum requirement.

DSSs are both user- and problem-oriented. They are user-oriented because they help users to understand and formalize their objectives and preferences. They are problem-oriented because they help users to understand the problem structure, search for problem solution, and conduct sensitivity analysis. NSSs also may provide support which specifically deals with the negotiation processes and their participants. This includes the assessment of the negotiator counterparts and the negotiation process, providing assistance to the users in gaining understanding of the counterparts' priorities and constraints, predicting their moves, suggesting possible coalitions, and advising about making and justifying a concession. These support functions go beyond DSS and obviously they are not a part of the communication facility. Few systems however, provide all of the above kinds of support. Therefore, the definition used here follows Lim and Benbasat's (1992) minimum requirement with an addition of the coordination facility (Lai 1989; Holsapple, Lai et al. 1995).

> A *negotiation support system* (NSS) is software which (1) implements models and procedures, (2) has communication and coordination facilities, and (3) is designed to support two or more parties and/or a third party.

Initially, all NSSs relied on DSS technologies. Early systems were first designed for stand-alone computers and, beginning in mid 1980s, for local-area networks. Internet revolution and the ubiquity of software led to its promulgation and this included software used for negotiation. Systems designed for negotiation support in the 1980 and 1990s conformed the NSS definition (Kersten and Noronha 1999; Mustajoki and Hamalainen 2000; Bui, Yen et al. 2001). There have been however, systems which were not based on the DSS concepts, instead they focussed on communication effectiveness (Yuan, Rose et al. 1998; Schoop and Quix 2001) and the recognition of potential actions and reactions of the counterparts (Matwin, Szpakowicz et al. 1989; Sycara 1990). To include these systems, a term e-negotiation system was proposed (Bichler, Kersten et al. 2003; Insua, Holgado et al. 2003):

> An *e-negotiation system* (ENS) is software that employs Internet technologies and it is deployed on the web for the purpose of facilitating, organizing, supporting and/or automating activities undertaken by the negotiators and/or a third party.

Defining ENS as software used in negotiations and deployed on the web broadens the types of software to any software that is capable of aiding one or more negotiators, mediators or facilitators. The reason we propose to consider other than web-based NSSs software is that many research projects on software-supported negotiations (e-negotiations) do not use NSSs. This way we can include email, chat and streaming video used in negotiations (Moore, Kurtzberg et al. 1999; Lempereur 2004), software used for communication and facilitation (Yuan, Rose et al. 1998), automated negotiations and auctions (Jennings, Faratin et al. 2001), and software that combines negotiation and auction mechanisms (Teich, Wallenius et al. 2001).

In addition to NSSs there are also other kinds of software, successfully implemented and used, which have been specifically designed for negotiations. During the last few years several software tools have been deployed on the web with the specific purpose of providing negotiation support to consumers and businesses. These tools were not designed with a purpose of providing a comprehensive support, mediation or arbitration; their purpose was to facilitate a

selected activity, e.g., search for a partner, price comparison or value function construction. They could be seen being independent from each other, with users having to decide which and when any given tool was to be used. Using middleware or other software, one tool could access output produced by another tool or, if required, communicate with each other. Because of the tool compatibility requirement and the need to be accessible by various users, these tools are typically embedded in an environment, a type of a negotiation workbench, which has been called an e-negotiation table (Kersten 2003; Ströbel 2003).

> A *e-negotiation table* (ENT) is software that provides negotiators with a virtual space (bargaining table) and tools which they can use in order to undertake negotiation activities.

An ENT in its simplest form is a virtual meeting space where the parties can post offers and messages that only they (and possibly a trusted third party) can access. This service is provided by organizations which often provide additional services, including matching, mediation, legal and competitive analysis (Rule 2002).

Two other types of software systems which have been successfully used in various aspects of negotiations and have the potential to play important roles are based on software agent technologies. Software agent technologies have three key characteristics: (1) they act on behalf of other entities in an autonomous fashion; (2) they are able to be reactive and proactive in deciding on undertaking an action; and (3) they exhibit some level of such capabilities as learning, co-operation and mobility (Hewitt 1977). These characteristics led designers and developers to construct and implement software agents capable of collaboration and negotiation (Sycara 1989; Kreifelts and Martial 1991; Kraus 1995).

> A *negotiation software agent* (NSA) is software that is capable of conducting a significant part of negotiations on behalf of its human or artificial principal.

The purpose of NSA is to automate one or more negotiation activities. Agents are capable of conducting a complete negotiation, or selected negotiation activities on behalf of their principals (Jennings, Faratin et al. 2001). Other systems, albeit based on the same models and technologies, have been developed with the purpose of providing intelligent and independent advice, critique and support to one or more negotiating parties. These agents do not engage directly in the negotiation, instead they observe the process and provide their principals (negotiators) with information and knowledge (Chen, Kersten et al. 2004).

> A *negotiation agents-assistant* (NAA) is a software agent that provides human negotiator and/or third party with timely and context-specific advice, critique, and support.

The purpose of NAAs is to help the negotiators (third parties) to achieve agreements they wish for. These agents provide relevant knowledge and information about the counterparts, process and problem; they play the role of analysts and experts. They differ from NSSs in their autonomy and mobility, and in their possible partiality. An NAA may be designed to help one negotiator rather than all and to give the negotiator competitive advantage over others.

The relationships among and methodological bases of the various kinds of software systems designed to support negotiators, provide facilitation and mediation, and undertake activities on behalf of the negotiators are depicted in Figure 1.

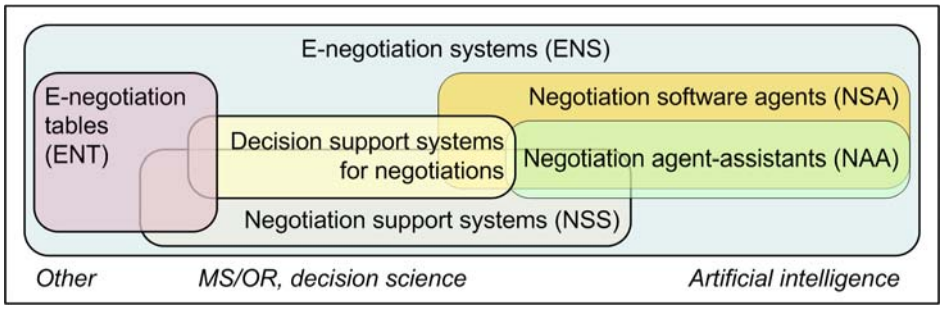

Figure 1. Software systems in negotiation facilitation, support and automation.

The four kinds of software designed specifically for negotiation support and automation (NSS, ENT, NSA, and NAA) and the DSSs which has been designed to support individuals in negotiations use overlapping models (primarily coming from MS/OR, decision science and artificial intelligence) and often similar software components for interaction with their users, and data collection, computation and storage. Some systems, e.g., NSS, may include agents-assistants to aid users and agents to automate simple but mundane tasks. Other systems, ENTs in particular, may use generic tools coming from software engineering and computer science, e.g., databases, SQL and security.

The positioning of different systems illustrated in Figure 1 indicates that ENS may be seen as an "umbrella" term for all types of systems used in e-negotiations. ENS includes systems designed specifically for negotiations and those which have been designed for other purposes but are used in negotiation (e.g., email).

1.2 Social and socio-technical systems

ENSs may be differentiated with respect to the degree of their intelligence and autonomy. Some systems may be able to conduct negotiations on behalf of their human-principals, others may undertake certain tasks and yet others may have no capabilities to undertake any tasks without the task's full specification. These different roles and abilities of negotiation software allow us to propose two types of environments in which they operate. These two types are meta-systems and they encompass the negotiators and any other entities that are involved in conflict management and search for an agreement. Thus:

> A *negotiation social system* is a system comprised of negotiators and possibly software used by one or more negotiators in order to resolve conflict.
>
> A *negotiation socio-technical system* is a negotiation system in which software participates in the conflict management and resolution processes.

The reasons for distinguishing between these two kinds of systems are both practical and theoretical. In many negotiations software is used as a tool, a notebook or a calculator. Software, such as email, a contract preparation and verification, and document management systems, is now routinely used in negotiations. But there is a difference between: (1) using software as a simple toolset and (2) relying on software that suggests a counterpart to negotiate with, proposes offers, analyzes counteroffers or even engages in offer exchange. In the case of active and capable software its design and implementation has to take into account the role it performs in negotiations and type of interactions with users, and they are different depending on the system. Therefore, we discuss here software systems which are part of negotiation social

systems and software systems that are part of negotiation socio-technical system. In social systems software is a passive tool, ready to be used but one that has to be fully controlled. Socio-technical systems comprise people and technological solutions–both actively involved in the negotiation–rather than in a social system which functioning is facilitated by technology (Nardi and O'Day 1999).

In the past, technical systems were mechanical and either could not make decisions at all or they were capable of adjusting to a few predetermined conditions (e.g., a pressure valve). The control of multiple mechanical systems engaged in similar or complementary activities was left to people. When the technical systems began to actively participate in their users' activities, when they became proactive in helping their users achieve their objectives, the two worlds became meshed and socio-technical systems emerged (Ropohl 1999).

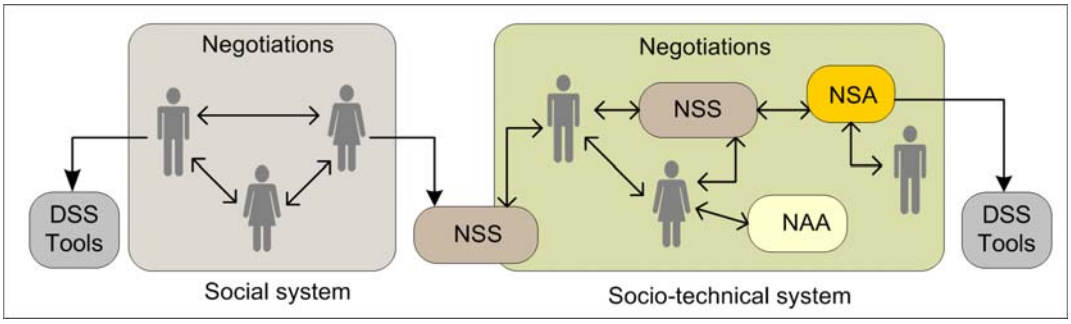

Figure 2. Negotiations as social and socio-technical systems.

The roles and relationships between various components of the two types of systems are schematically depicted in Figure 2. Note that one bidirectional arrows indicate communication among the active participants and single-directional arrows, participants' usage of tools and passive systems. Note also that the same system (e.g., a NSS) may be either a tool or a participant; this depends on the role the system plays in the process.

The distinction between social, technical and socio-technical systems is particularly useful in such processes as negotiations because of the variety of different roles software can play and behaviors it can exhibit. Software can be used as a simple or complex tool. It can support one or more negotiators; it can support a coalition, and perform one or many negotiation activities on behalf of the negotiator. Software may be used as a negotiation facilitator or a mediator. When the DSS is active and involved in many negotiation activities it becomes a member of the socio-technical system. The interaction changes from the always user-initiated communication to communication which can be initiated by the users as well as the system.

2. Classifications

The members of a negotiation socio-technical system are both people and software systems. The latter have to be able to actively participate in the process. In this section systems are considered from the point of view of their activeness, roles they play in the negotiation, activities performed in the negotiation process, and types of their users.

2.1 Passive, active and proactive systems

The typology based on participation also makes the distinction between software-as-tool and software-as-participant, which is introduced in Section 1. Following a similar categorization (Kersten 2005) three types of systems are distinguished: passive, active and pro-active.

1. *Passive systems* are single-purpose tools or systems which require that their users exert full control over their actions. They are not concerned either with the way the content is produced or with the use of resources required for production. It is up to the user to specify the requirements, select the requisite options and provide data necessary for the system to undertake its tasks. Taking into account that two major types of negotiation activities are communication and decision making and that both these activities may be easier to undertake when information is graphically displayed, it is useful to recognize the following three types of passive systems:
   a) *Passive communication system*s help users to interact with partners located in different places, and present them with ideas, offers and arguments. These systems may also provide support for the storage, organization and retrieval of information;
   b) *Passive calculation systems* help users to compute formulae which otherwise would take long time to compute. These, often complex mathematical and statistical formulae allow the users to summarize, test and compare solutions or offers. They do not have, however, the capability to verify assumptions and their completeness, seek for solutions that are similar to one contemplated by the user, and undertake any action without being given full specification from its users.
   c) *Passive visualization systems* help users to display data using various forms of graphs, maps and other data visualization techniques.
2. *Active facilitation-mediation systems* aid the users in formulating, evaluating and solving difficult problems, concession-making and construction of offers, and assessment of the process and the agreement. These systems often follow a process model of the negotiation that users need to conform to. They also have components for problem structuring and solving, and for assessing offers and constructing counter-offers. The models embedded in the active systems are the models of the problem, the negotiators and the process.
3. *Proactive intervention-mediation systems* have the same capabilities as the active facilitative-mediation systems, but they also are capable of coordinating the negotiators' activities, critiquing their actions, and making suggestions as to what offer should be made or what agreement should be accepted. To provide these capabilities the proactive intervention-mediation systems access and use knowledge and have certain intelligence so that they can monitor the process and the negotiators' activities.

Passive systems can be seen as fast and sophisticated messengers or calculators. Active systems can facilitate, support and mediate. They need knowledge to support their users and to assess the users' actions and the actions undertaken by others (e.g., counterparts). Systems which are able to access and process knowledge and work independently of their users are proactive. The key difference between passive and active systems is in the latter's ability to provide their users with information which they did not directly specify neither did they select a formula necessary to determine it. An active system obtains a general request from the user and seeks an answer using available data and formulae. The main difference as compared to the first two types is that a proactive system makes suggestions and critiques without any request from its user.

2.2 Facilitation, mediation and support

Negotiation support systems and other systems that participate in e-negotiations influence the process and its outcomes. Therefore, they can be considered as a neutral third party. The two key roles of a third party are facilitation and mediation. A role that traditionally has not been considered as that of the third party is the one of an expert and analyst. This role may also be played by DSSs, NSSs and other systems, either by advising the negotiators directly or by supporting human experts and analysts. Both human and artificial experts and analysts may provide advice and help one side only. They may also provide expertise or undertake technical activities to help all participating parties.

The three roles available to people as the neutral third party can also be made available to the computer systems. We thus distinguish between negotiations which are computer-facilitated from these which are computer-supported and which are computer-mediated.

1. *Computer-facilitated negotiations* use software as tools which enable the parties to communicate and store and access exchanged information. In such negotiations only the communication and coordination components are required. The technology, for example, email, chat and video-conferencing, allows the parties to communicate. The communication channels and their bandwidth are determined by the technology and therefore may affect the ways the parties communicate. However, the premise is that technology may not affect the content of the communication either directly or indirectly. If the content is affected it is because of the choices made by the technology user. Technology in computer facilitated negotiation is mostly passive. Although it may notify its user that an activity takes place (e.g., email has been received) this action is not oriented towards the negotiation and thus does not help its user to achieve a better agreement.
2. *Computer-supported negotiations* rely on software in order to reduce the cognitive efforts imposed on the negotiators, expand their abilities to assess the problem under consideration and the possible implications of its alternative solutions. The purpose of software is to provide the negotiators with information which the negotiators would not obtain otherwise; it helps one or more negotiators to understand the problem better, to learn about own perspectives and about the perspectives of the other participants. In computer-supported negotiations software often affects the process through the purposeful organization of the negotiation activities. This way it actively participates in the process becoming a part of the socio-technical system. A computer system need not be designed specifically to support one or more negotiation activities but it has to be capable of supporting activities requiring cognitive efforts which take place in negotiations. A simulation system and software for preference elicitation are examples of such systems.
3. *Computer-mediated negotiations* use software to help the parties to achieve an agreement. Software identifies stumbling blocks and suggests directions of reducing the degree of the conflict. It offers potential compromises and proposes concessions which may lead towards an agreement. The purpose of the software is somewhat similar to a human mediator who actively influences the process and tries to shape it so that the parties reach an agreement. These types of software may try to explain the rationale behind counterparts' moves and predict their concessions.

The differences between software used for facilitation, for support and for mediation create two categories of systems: (1) software that extends our physical capabilities; and (2) software that extends our mental capabilities. Software facilitates communication in a similar manner as mail does; both store, sort and move information. Software plays a very important role making

asynchronous communication between people from afar possible. It also significantly affects the way people present their arguments and interact. Therefore, we may say that it affects users' capabilities but it does not aim at expanding users' cognitive faculties.

The distinction between two software categories is useful because the results of behavioral research on computer-facilitated negotiations (Moore, Kurtzberg et al. 1999; Thompson and Nadler 2002) should not be extrapolated onto the implication of computer-supported and -mediated negotiations for the process and outcomes and *vice versa*. Additional information (knowledge, intelligence) that is provided by technology introduces qualitative differences into the process.

2.3 Phases, activities and support

Negotiation process moves through phases and activities. For the negotiators the role a system plays in the process may be an important categorization criterion (Davey and Olson 1998). A system may be designed to provide support in or automation of one specific activity, several activities in a given phase or throughout the negotiation. One may classify systems according to the selected negotiation process model; they range from 3 to 10 phases.

This categorization may be too detailed if every phase and activity is considered. However, a simple categorization may be obtained if we use a three-phase model comprising pre-negotiation, negotiation and post-negotiation, and the users' types. Taking into account the user type: the negotiators and the third party, and the phase of the negotiation process, the following four types of systems may be distinguished:

1. *Planning and preparation systems* – designed to help one party to organize private and public information, specify the set of alternatives that are acceptable to this party, determine the utility function or decide on another alternative evaluation scheme, and prepare negotiation strategies and tactics. They are used during the pre-negotiation planning phase.
2. *Assessment systems* – designed to construct alternatives and evaluate their implications, select an alternative to be proposed as an offer and evaluate offers proposed by the counterparts. These systems are used by a single party. Assessment systems can be used during either all or selected negotiation phases.
3. *Intervention systems* –designed to support a mediator or arbitrator, or the system plays one of these roles. Intervention systems may be used during such activities as agenda setting, exploring the field, formulation, analyzing and exchanging offers and arguments and reaching an agreement.
4. *Process systems* – designed to aid the negotiators in both individual and joint activities; they influence the negotiation dynamics and procedures. They provide electronic communication media and may also provide all these support tools that the planning, assessment and intervention systems are equipped with. Process systems can be used during all or selected negotiation phases.

Support and automation of e-negotiation activities may also be considered from two technical perspectives: (1) processing that focuses on the use of various models and procedures; and (2) interaction which focuses on the communication among people and systems. The first perspective pertains to the decision-making aspect of negotiations; the second—to the communication aspect.

Table-1. Key functions and tasks of software in e-negotiations

No.	Function	Key actions
		Communication and presentation
1	Transport and storage	Transport of information among different systems; storage in distributed systems; security.
2	Search and retrieval	Extraction, selection, comparison and aggregation of distributed information.
3	Formatting and presentation	Data formatting; data visualization; alternative data presentation
		Decision problem
4	Problem formulation	Assumption formulation; model construction; completeness; adequacy; verification of assumptions.
5	Parameters	Collection of parameter values; parameter computation and verification.
6	Problem solutions	Assessment of decision space; solution accuracy.
7	Solution analyses	Sensitivity analysis; what-if analysis; simulation.
		Negotiator
8	Goals, objectives	Decision problem algorithm selection.
9	BATNA & reservation levels	Specification of BATNA type and values; mapping BATNA on decision or value spaces; reservation level selection and verification.
10	Preferences	Analytic or holistic preference elicitation, consistency assessment, preference verification, measures for alternative comparison.
11	Approach & profile	Specification of the negotiator approach and profile; profile assessment, modification and update.
12	Strategies & tactics	Formulation, evaluation and modification of strategies and tactics.
		Counterpart
13	Profile assessment	Prediction, evaluation and verification of counterpart's profile.
14	Strategies & tactics	Prediction, evaluation and verification of strategies and tactics.
15	Counterpart analysis	Construction and verification of models of negotiation counterparts; evaluation and prediction of their behavior.
		Process
16	Process management	Agenda formulation; construction of negotiation protocols; protocol analysis; threats management; deadline management.
17	Offer & message construction	Formulation of offers and concessions; argumentation models.
18	Offer & message evaluation	Analysis of messages; offer comparison; and assessment of arguments
19	Document management	Version management; consistency analysis; dissemination.
20	Agreement analysis, equilibrium and stability	Equilibrium analysis; assessment of the potential agreements; agreement efficiency; identification of unilateral and joint improvements.
		Knowledge and expertise
21	Process, history and their assessment	Construction of the negotiation history; process analysis; progress assessment; history-based predictions.
22	Negotiation knowledge seeking and use	Access to and use of local and external information and knowledge about negotiation situations; comparative analysis.

No.	Function	Key actions
23	Domain knowledge	Access to and use of local and external information and knowledge about problem domain and cultural, professional and other characteristics of the participants.

Communication in e-negotiation is done via electronic media which use digital channels to transport data (Schmid and Lechner 1999). Electronic media are extension of the active-interface concept and they provide three main functions: (1) transport and storage; (2) search and retrieval, and (3) formatting and presentation. These functions and associated key tasks are listed in Table 1.

To perform these three functions computationally complex activities may be undertaken. Electronic media may rely on models, but the difference between problem and process modeling and processing and interaction is in the focus. In interaction models of communication and presentation are used to provide insights and better understanding of data. This is achieved through, for example, the use of different visualization techniques, and search, retrieval and comparison of information (as opposed to production of data and information).

Electronic media are necessary for the purpose of system-supported decision-making but they are not designed with this purpose in mind. Dedicated systems and their components are designed to support decision-making; they include software used in the construction, implementation and use of models. The main software functions required for both general decision-making activities as well as these specifically associated with negotiation are listed in Table 1. Many of these functions and tasks are the same or similar to those encountered in individual decisions supported with DSS. Others stem from the communication activities which are a necessary ingredient of every negotiation and from concession-making, which is typically required in order to achieve an agreement.

3. Frameworks

Software is designed based on an abstraction of a certain problem or process. This abstraction used in decision and negotiation support systems comprises models and procedures constructed in different branches of science. The second type of frameworks used in system design concerns their architecture, the specification of the components comprising a system and the relationships between the components. How these components are constructed and how they interact is important because it affects the system's flexibility and expendability, and its ability to interact with other systems involved in decision-making and negotiations.

3.1 Models

The DSS roots of NSSs are due to their reliance on models coming from MS/OR and decision science (Figure 1). NSAs and NAAs rely on both quantitative and qualitative models, the latter coming from computer science and artificial intelligence. An overview of models used in early NSS and in recently developed e-negotiation systems is given here. In this overview we follow a simple categorization of models into three kinds: (1) models of the negotiation problem; (2) models of the negotiator; and (3) models of the negotiation process. Although some models incorporate two or three components, this distinction also affects the types of input and

interaction between the system and its users.

Many negotiations are conducted over highly complex problems, described with a large number of variables and constraints. Such negotiations include these conducted over environmental issues, international trade, mergers and acquisitions. Some of these systems are DSSs used to support one party; others have been designed by a third party and incorporate large simulation and optimization models (Nyhart and Goeltner 1987; Hordijk 1991). NSSs which incorporate these models have been often used by analysts-intermediaries who, through interacting with the negotiators, obtained from them data which described their requirements, and used it to generate solutions or scenarios. Examples of such models include the MIT Deep Ocean Mining model and IIASA RAINS model for cross-boundary air pollution (see in Section 4.1). Both models have been successfully used in complex negotiations; RAINS was over the years modified so that the optimization model had been extended with multiple objective functions and replaced with a large-scale mixed-integer goal programming model (Makowski 2001).

The extension of RAINS with multiple objective functions allowed for the explicit consideration of the negotiators' objectives. This extension is an example of a model that combines formal representations of both the problem and the negotiator(s). ENSs which focus solely on the construction of the negotiator's representation interact with their users in order to elicit their objectives and preferences. This information is used to either construct a value (utility) function or aid the user(s) in their search for a non-dominated agreement (Raiffa 1982). Examples of NSSs which help users gain understanding of their wants and needs and help them search for a compromise are Negotiator Assistant (Rangaswamy and Shell 1997), ICANS/SmartSettle (Thiessen 2002), and Web-HIPRE (Mustajoki, Hamalainen et al. 2004) and Inspire (Kersten and Noronha 1999); the two latter systems are deployed on the web (Section 5.2).

Construction of the negotiators' representation together with such concepts of behavioral decision and negotiation research (see e.g., Lewicki and Litterer 1985; Fisher, Kopelman et al. 1994)as the best alternative to the negotiated compromise (BATNA), reservation and aspiration levels and the zone of possible agreements (ZOPA) provide the basis for modeling of the negotiation process. Systems which support the process of arriving at an agreement include NEGO (Kersten 1985), Mediator (Jarke, Jelassi et al. 1987) and RAMONA (Teich, Wallenius et al. 1995). The role of these systems is similar to that of a mediator who has no power to impose the agreement but who has knowledge of the parties' true interests and preferences.

Other models implemented in various ENSs include neural networks, genetic algorithms, rule-based models and fuzzy logic (Chen, Kersten et al. 2004). Rules were used to provide domain-specific expert advice to their users (Roman and Ahamed 1984; Rangaswamy, Eliasberg et al. 1989), conduct qualitative simulation of negotiations (Kersten and Michalowski 1989; Matwin, Szpakowicz et al. 1989), manage such documents as contracts (Schoop and Quix 2001), and help the parties to negotiate more efficiently and effectively (Chen, Kersten et al. 2004; Druckman, Druckman et al. 2004).

3.2 Architectures

For the purpose of describing the general form and place of interaction between users and systems two kinds of system architectures can be distinguished: tightly and loosely coupled. These two kinds represent two extreme generic NSS architectures. They are high level because no specific processes, data models or communication protocols are distinguished.

The tightly coupled architectural solution corresponds to a highly centralized model. This kind had fixed linkages between the components and it was typical for information systems designed to run on a single computer as it was the case in the 1980s and earlier.

The loosely coupled architecture corresponds to a decentralized model. This architectural solution is appropriate for modern distributed environments where many systems may reside on a single or multiple computers. The solution provides much more flexibility than a centralized system because one function of a component may be performed by one or several independent computers.

In Figure 3 a tightly coupled system is shown and compared with a loosely coupled system comprising six systems which may run independently of each other. The traditionally tightly coupled ENS is the architectural model of Lim and Benbasat's NSS (1992). Early systems discussed in Section 3.1 (e.g., MIT Deep Ocean Mining model and RAINS) had also tightly coupled architecture but without the communication and coordination component, which functionality was performed by the analysts-intermediaries.

A loosely coupled negotiation support system is a collection of software which resides on one or many computers. It is a federated system involved in aiding the negotiators and undertaking certain negotiation tasks on behalf of one or more negotiators. Because the major activity is the coordination of the tasks and actions performed by different systems this coordination may be performed by dedicated software which communicates with other participating systems.

Users of a federated system may not see a difference between such a system and the traditional tightly coupled NSS residing on s single server. They may access various systems via a common interface. They may also interact with the separate components using their own interfaces; this case is illustrated in Figure 3. The main difference however, is in the flexibility and expendability. Users of federated systems may directly access a particular system to perform a specific task, for example, translate a document and provide financial information. This increases the system flexibility. Expendability is achieved through the addition of new systems which either can communicate with the user directly or indirectly through, for example, the communication component.

The loosely coupled federated architecture is suitable for the design of systems which use internet technologies and are deployed on the web because they can pool computational resources, data, models and applications from anywhere.

The involvement of people and software in negotiations, which we illustrate in Figure 2, is at a very high level of abstraction, only people and systems are indicated. Figure 3 illustrates main components, the linkages between them and the user-component interactions. The components may be implemented in many different ways and currently the often used way is through the client-server architecture in which the client and servers represent different tiers. This *n*-tier software architecture is typical for loosely coupled systems and it is used in e-business systems development (Fournier 1998; Buffam 2000).

The *n*-tier architecture is based on the software server concept and it extends data separation to process models and applications. Examples of *n*-tier architecture are shown in Figure 4. This figure illustrates the complexity of many modern systems and their possible interactions. There are three negotiators A, B and C; each uses a client (e.g., a web browser). Negotiator A uses services of a NAA. Negotiators A and B communicate directly with the ENT, that is, they engage in

activities using the e-negotiation table. These two negotiators may use the ENT tools and they may also access an NSS. This may be the case when the company that provides the ENT also provides additional NSS-type services. These services may be necessary by negotiators who participate in the process using a NSA; this is the case of negotiator C.

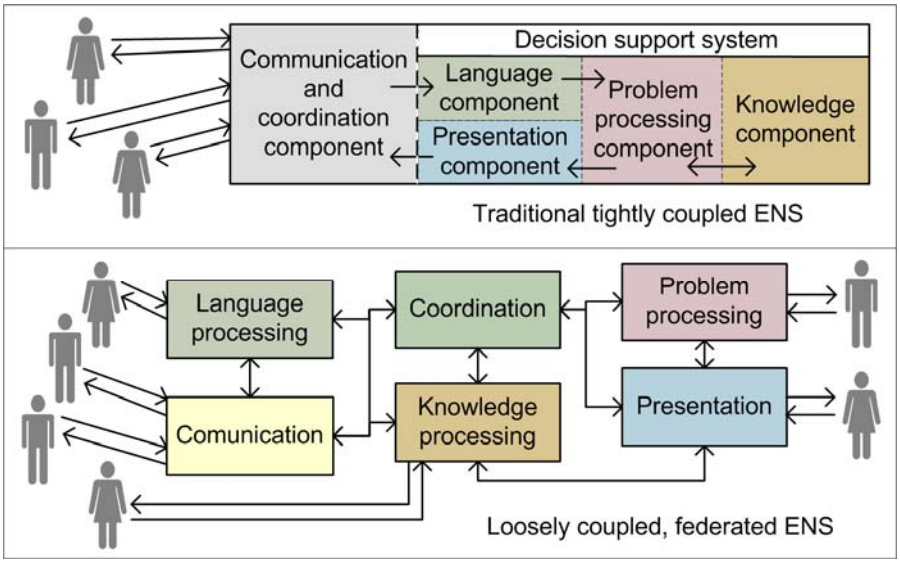

Figure 3. Tightly and loosely coupled e-negotiation systems.

There may be many different types of servers in *n*-tier architecture. In Figure 4 three typical servers are indicated: web server for communication, application server which selects and accesses various applications and database server for database management.

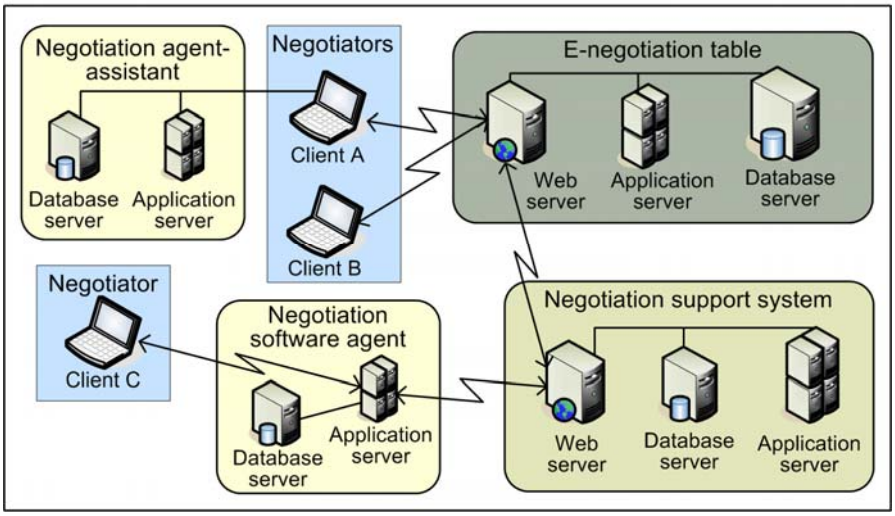

Figure 4. Example of *n*-tier ENS architectures.

3.3 Configurations

The roles an NSS can play in negotiations and the scope of its support depends partially on the configuration of the negotiation system which comprises software and people. A configuration of negotiation systems is defined by the relationship between systems, their users and other negotiation participants. Selection of a configuration depends on a number of factors, including the individual and organizational needs, available technologies and information, the complexity of the problem, and time pressure. The availability of various configurations helps the negotiators to select one that fits best their particular situation.

There may be several levels of detail in discussing a configuration. At the highest, most aggregated level the participating entities that are responsible for undertaking a negotiation activity are identified. In this way a group of people may be seen as a single negotiator, if they comprise one side of the negotiation and their internal decision-making activities are ignored. Similarly, different systems and components which jointly comprise a federated e-negotiation system (Figure 3) may be aggregated into one meta-system. For example, the ENT and NSS shown in Figure 4 may be integrated into one system providing both types of services.

In the consideration of the relationship between entities the focus is on the source and flow of information rather than the details, including the specific roles and actions. Eight basic configurations of negotiation social and socio-technical systems are presented in Figure 5.

Individual support with the use of DSS, NAA or a software tool is currently the most widely used of software technology in negotiations. A situation when one party is supported with a DSS, and another obtains advice from a negotiation assistant (NAA) is illustrated in Figure 5A. Examples of this and other configurations discussed below are given in Sections 4 and 5.

Figure 5B depicts a situation when a single DSS supports all participants; it is also possible that only a sub-group is supported and that this support is provided by other types of software, including NSAs. Two cases involving third party (a light-gray figure) intervention are illustrated in Figure 5C and D. In the first case the facilitator or mediator uses a NSS to communicate and confer with the negotiators, while in the second case the third party is involved in discussions with the parties directly, however she uses help and guidance from a NAA. The third party may use another type of software (e.g., DSS) and also the parties may use software in their deliberations.

If in the situation illustrated in Figure 5C, the third party is removed, then we have the case of centralized negotiation support; there is a single NSS which supports the participants and through which they communicate. A decentralized situation is depicted in Figure 5E; there are two systems supporting the parties. The reason for having two (or more) NSSs may be that each party represents an organization which has its own system and does not want to use an external neutral nss. It is also possible that the systems are highly specialized and provide different and complementary services, for example, one system supports negotiating the financial aspects and the other manufacturing and supply.

Decision and negotiation support may be provided to a subset of negotiators (Figure 5F). The purpose may be to help the negotiators to establish a coalition, support them in negotiating common proposals and in activities similar to these conducted by a single negotiator.

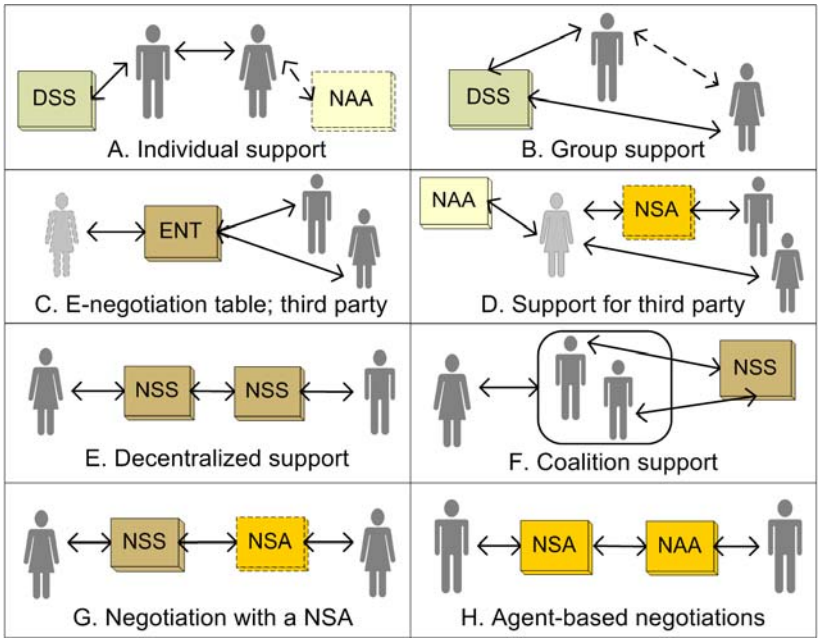

Figure 5. Configuration of negotiation software (dashed lines indicate optional systems and links).

Figures 5G and H show two possible configurations in which negotiation software agents (NSA) are involved. The first figure shows partially automated negotiation in which an agent communicates with a NSS. Figure 5H depicts negotiations in which two agents participate on behalf of their principals. This case may be fully or partially automated.

4. Early Applications and Research

With few notable exceptions NSSs and ENSs have not been widely used in negotiations. A recent popular article (Kettelle 2006) puts forward "The case for employing a computerized third party for group decision-making and negotiations." 30 years after the first highly successful use of computers in very complex negotiations discussed below. Over the years numerous systems were developed; most of them were used in research and for training. Some of these systems, however, were successfully used in business and governmental negotiations and others found their ways in e-marketplaces and supply chain management systems (e.g., SAP supplier negotiations and collaborative contract negotiations, and Oracle iStore 11i contract negotiation and re-negotiation).

4.1 Successful cases and success factors

A research project funded by the U.S. National Oceanic and Atmospheric Administration and initiated by Nyhart in 1976, brought results about two years later. The team led by Nyhart was from the Massachusetts Institute of Technology (MIT) and the purpose of the project was to construct a detailed model of a deep sea mining enterprise. This research sought to predict the economics of a commercial venture under a variable set of assumptions (Leitner 1998).

The model's purpose was a simulation of a future U.S. mining enterprise. It was not designed for international use, in particular, for use in the United Nations UNCLOS III negotiations (op. cit. 282). It was, however, a subject of discussion and refinements in graduate seminars led by Nyhart. The

model and discussions related to it led Nyhart and a group of his students to write a report "A Cost Model of Deep Ocean Mining and Associated Regulatory Issues"(after Charney 1982, p. 104) which the U.S. delegation gave the UN Secretariat for distribution among all of the national delegations to UNCLOS III. The report was introduced in one of the meetings; it attracted attention providing a point of reference for the assessment of the proposals presented by the participants (Sebenius 1984).

The MIT simulation system played an important role in the UNCLOS III negotiations. It helped to reconcile the widely different positions of several groupings of the developing and developed countries. Thanks to the system and its underlying model, these differences provided an opportunity for an agreement. For example—as Sebenius (1984, p. 57) describes in detail—some developing countries believed that there would be extremely high profits from deep sea mining and therefore wanted to have very high levels of profit sharing. In contrast, the developed countries expected modest profits and sought low profit participation levels.

The delegations learned, by using the system and generating different scenarios, that deep sea mining would be very expensive and provide small returns. This led them to understand that high participation in profits was not possible. These results contributed to an agreement on the financial arrangements.

Several years later, a similar approach was taken by a group of scientists at the International Institute for Applied System Analysis and it led to the RAINS system used in the negotiations at the Convention on Long-range Transboundary Air Pollution, the umbrella organization involved with air pollution across Europe (Hordijk 1991; Tuinstra, Hordijk et al. 1999). Recently, the system was adapted to simulate transboundary air pollution in South-East Asia (Carmichael, Calori et al. 2002).

The ongoing use of the RAINS system led to several extensions and modifications (Section 3.1) and porting from a centralized environment in which the analysts were the intermediaries between the system and the negotiators (Figure 5, configuration D), to the environment allowing the decision-makers as well as others directly access the system because it was deployed on the web (Figure 5, configuration C).

The third successful application involved GroupSystems, an electronic meeting system developed at the University of Arizona in 1985, which later became a product sold by Ventana and IBM corporations and eventually a web-enabled system maintained and sold by the GroupSystems Inc. The system was designed to facilitate and support face-to-face meetings and it was used in union-management negotiations (Carmel, Herniter et al. 1993). GroupSystems tools were used to provide an additional (to face-to-face) communication channel, meeting transcripts, documentation and editing. It also provided support for a three-step integrative bargaining approach which included the exploration of issues, development and ranking of issues, and the construction of criteria through electronic brainstorming. The success of the union-management negotiations reported by Carmel et al. (1993) did not lead, as far as we know, to the use of new versions of GroupSystems in other negotiations.

Critical success factors: There are several factors behind the success of the MIT model and the report associated with it. These factors are similar to the ongoing success behind the RAINS system and they are important in any effort to provide negotiation participants with advice and to design a system which they would accept and use effectively are listed in Table 2. Although

the explanation given for each factor pertains to the MIT model, it seem easy to adapt it to situations in which technology is being introduced to facilitate, support or automate high-level cognitive processes such as negotiations.

Table 2. Critical success factors and their illustration

	CSF	MIT deep ocean model illustration
1	Timelines	The report and support that followed it were timely; its introduction coincided with the time when the political disagreements among the participants came to the point that differences between their positions could not be resolved. The study gave an opportunity for the participants to view their differences in technical terms and to be able to verify their positions. In contrast the Canadian study was introduced earlier and when the participants were involved in a controversial political debates and probably not yet willing to resolve their differences.
2	Impartiality	The third-party approach who is recognized as being impartial and objective rather than involved participant, and whose credibility is generally recognized. This is because the report was presented as one that came from the MIT a well known and recognized university rather than from a governmental agency. The institution's credibility made its introduction first to the U.S. government and then to the UNCLOS III possible.
3	Objectivity	The support came from a U.S. sponsored group but it did not confirm the position taken by the U.S. was an indication of the group's objectivity. In fact it contradicted some elements of the U.S. proposal forcing the delegation to modify its position.
4	Staged introduction	The MIT study was introduced first to a small informal group of technical experts and those who were interested in technical aspects and only after it was accepted by this group it became available to the other participants. In contrast, the Canadian study was introduced to a large audience which included many politicians not interested in technical issues.
5	Availability; rapport	The principal author of the study and his colleagues were made available to the interested participants and the conference staff for informal discussions and other meetings so that questions could be raised about the report and interested participants could become well informed.
6	Individualization	Delegations could request that additional computer analyses be conducted and scenarios generated which would verify the delegations' assumptions embedded in their proposals. They also could assess the completeness of a proposal or its financial impact.
7	Preparation, ease of use	The report was very well prepared and structured. It contained a readable summary with conclusions and the key reasons leading to these conclusions as well as a complete and detailed explanation of the assumptions, approach and results
8	Competition	There was no competition; no other delegation or authority presented an analysis that would approach the level of sophistication of the MIT study.

4.2 Early NSS systems

Early configuration of computer systems was based on a mainframe computer and dumb terminals (Figure 5C). This configuration was used to develop NEGO, a system designed to provide support to all negotiators simultaneously (Kersten 1985). NEGO was developed in 1980 to train members of the Polish Solidarity trade union who at that time were negotiating complex

contracts with the management. Because the union members, in contrast to the management, had no prior negotiation experience the goal was to provide them with training that would encompass both theory and practical experience. This goal was not achieved due to the imposition of the martial law. Eventually the system and the training materials had been used for several years in management training.

NEGO supported between 2 and 8 users: some played a role of the management, others the role of unions. The negotiation case described a firm and the interests of the negotiating parties. There were two types of constraints, both assumed linear. Hard constraints described the available resources and their use in production, costs of production and other activities, and income. It was assumed that all parties agreed on these constraints.

Soft constraints described the users' objectives and their achievement values. The system searched for a feasible agreement which would meet values of all objectives. If such a solution was found, the negotiation was concluded. Otherwise, NEGO provided information on the limiting soft constraints allowing each party to identify values which needed to be changed in order to move closer to an agreement. On its part, the system proposed an agreement which met all current objective values of all users as close as it was possible.

NEGO was used in management training between 1983 and 1988; only after the Solidarity and other independent unions were dissolved. One of the earliest systems used in research was designed by Korhonen et al. (1986). It adapted an interactive procedure for the specification of efficient solutions in discrete problems from individual decision-making to bilateral negotiations. The procedure allowed for the participation of multi-person parties and had two main phases: (1) search for the intra-party compromise solution; and (2) search for the inter-party agreement. Because the individual utilities were assumed unknown, the support concentrated on the specification of sets of non-dominated solutions for the individual negotiators, as well as for each party separately and jointly.

Many procedures, some implemented in NSSs, have been formulated be members of the research community involved in modeling of multi-criteria/multi-attribute/multi-objective decision-making problems. This is because these types of problems could be relatively easily extended from a single to many decision-makers (Contini and Zionts 1968; Davey and Olson 1998). MEDIATOR (Jarke, Jelassi et al. 1987) supported the negotiators in the construction of their own decision problems and a third party in the construction of the negotiators' joint decision problem. The involvement of a third-party allowed the authors to address the issue of interpersonal comparison of preferences and utilities.

Studies of the application of multi-objective non-linear optimization to negotiations (Bronisz, Krus et al. 1988) led to the extension of RAINS discussed in Section 4.1. Saaty and Alexander (1989) applied the analytic hierarchy process (AHP) to multi-participant decision making. Hämäläinen and his colleagues extended AHP to the "interval AHP" and their work led to the HIPRE and Web-HIPRE systems (Hämäläinen 1996). A procedure for the construction of contract curves for the strictly opposing parties was implemented in RAMONA (Teich 1991) and experimentally applied in agricultural policy negotiation.

Game theory is one of the fields devoted to conflict and its resolution. Because of the restrictive assumptions and limited freedom left to the participants, games have not been implemented in many systems. One exception is conflict analysis program (CAP) designed by Fraser and Hipel

(1984) for bilateral negotiations. CAP, for a given set of pair of alternatives (one for each party), determines which pairs are in equilibrium and constructs paths from the initial set to an equilibrium. CAP has been tested with numerous cases and, after extensive modifications, it became known as graph model for conflict resolution (GMCR) (Kilgour 1996).

4.3 Studies on NSS use and usefulness

Arguably, the first use of a DSS-based support in negotiation research was undertaken by Blake, Hammond, and Meyer (1973). They conducted experiments in which labor and management representatives of a chemical company re-enacted their final week of negotiation in order to determine the degree of the negotiators' understanding of their own preferences and of preferences of their counterparts. Blake et al. compared the negotiators preferences obtained from holistic assessment of alternatives with preferences they assigned to each issue separately. They note (op. cit. 319) that self-understanding of the negotiators is poor and it leads to "unwitting communication of false information [which is] a barrier to the achievement of agreement, despite the best of intensions". They also determined that "The negotiators were confident that they understood their counterpart's policies, a belief based on years of association and negotiation. Yet they were wrong." Lastly, they found that the use of interactive graphics tools had a positive impact on agreement achievement, and it improved the negotiators' understanding of their own and their counterparts' judgments.

Research on the usefulness, effectiveness and other aspects of NSS use began in the early 1980s. Korhonen et al. (1986) used the system mentioned in Section 4.2 in two experiments reported in (Moskowitz, Wallenius et al. 1981). The participants were students and the case described a collective bargaining situation. The authors report that the system was found both easy to use and useful. This study is one of few which involved groups (6-10 persons) rather than pairs participating in bilateral negotiations.

In the experiment mentioned above support was focused on problem formulation and generation of alternative contracts. Jones (1988) used a similar approach when she designed the NSS which provided modeling support in the construction and presentation of near-optimal alternatives.

Jones's study was the first to consider the degree of conflict over the negotiated issues. She examined the system's effectiveness in situations of both low and high conflict of interest. The results showed that NSS support led to higher joint outcomes (sum of the agreement's utility values) in low conflict, but the negotiators required longer time to reach an agreement time. High-conflict dyads felt a more collaborative climate with NSS support while low-conflict dyads did not. Low-conflict dyads were more satisfied than high-conflict dyads.

A comparative study of face-to-face and NSS-supported negotiations showed that NSS allowed the negotiators to achieve higher joint outcomes and more balanced contracts (Foroughi, Perkins et al. 1995). This study also confirmed results reported by Jones (1988) that NSS users need more time to achieve an agreement. Delaney et al. (1997) compared three types of negotiations: (1) conducted via a NSS, (2) in which each participant used a DSS, and (3) with no computer-based support. They also included low and high conflict situations. Their results confirm that DSS improves joint outcomes and contract balance compared to no computer support. They also show that the comprehensive NSS reduces negative climate and increases users' satisfaction.

Rangaswamy and Shell's (1997) laboratory study compared four conditions; in addition to the above three they also included communication via email. The study focused on joint outcomes: dyads in the NSS and DSS condition achieved significantly higher joint outcomes than face-to-face or email dyads. There was no difference in the joint outcomes settlements reached by dyads in the two latter conditions. Software users found the negotiation process to be less friendly than those who negotiated face-to-face. They also perceived the negotiation to be more competitive, but felt more in control of the process.

Lim (2000) confirms the positive influence of NSS on individual and joint outcomes over both computer-facilitated and face-to-face negotiation. NSS reduces cognitive effort and allows for the negotiation over complete packages rather than individual issues separately. However, computer-facilitated negotiations, in which software is only used for communication, produce lower outcomes than face-to-face. Lim notes (op. cit. p. 335), that lack of the NSS tools that focus the participants' attention on the negotiation content results in limited exploration of issues and options leading to a premature negotiation termination and low outcomes.

4.4 Research framework

Empirical NSS research spans over more than two decades and many interesting results have been achieved in terms of the comparative studies and users' satisfaction. These results however, did not produce a consistent theory of computer-supported negotiations. The reasons for the differences in results are mainly due to the differences in the experimental designs and research instruments. In effect, we cannot claim that NSS have a positive impact on individual and joint outcomes, collaboration, acceptance or satisfaction. More importantly, we cannot provide prescriptive advice to the prospective NSS users regarding the conditions and problem-types in which these systems are effective and have positive impact on the process and its outcomes.

Empirical research requires well defined constructs and variables used for their measurement. Lack of consistency and even contradictions in behavioral research on negotiations make construct formulation difficult. Starke and Rangaswamy (Starke and Rangaswamy 2000, p. 57) point out "the central challenge that impedes the further advancement of NSS and their impact: insufficient theoretical foundation. … Currently, there is a theory vacuum in much of the NSS research, giving the tested hypotheses an "ad-hoc" flavor." More rigorous and systematic approach to designing experiments and instruments is required so that results can be verified, compared and generalized. Rigorous studies should focus on the ways the NSS impacts negotiator's cognition, attitude and choice and how NSS affects interactions between the negotiators.

The first steps have been made by Lim and Benbasat (1992) who hypothesized that: (1) the DSS component enhances negotiators' information processing capacity and capability leading to more efficient and balanced contracts and to higher confidence in the agreement; and (2) the communication component has positive effect on the perceived commitment of the counterpart, reducing the time needed to reach an agreement and increasing the level of satisfaction. These hypotheses have been studied with mixed results (Delaney, Foroughi et al. 1997; Rangaswamy and Shell 1997; Lim 2000). Furthermore, different experimental designs do not allow for the results' comparison.

Dennis et al. (1988) and Starke and Rangaswamy (2000) propose a framework for empirical

research oriented towards the outcomes and the process, and which includes commonly used measures. Vetschera et al. (2006) propose a framework that is oriented towards the assessment of the system usability and its usefulness in negotiations. The three frameworks are combined and presented in Table 3.

Table-3. Key constructs in NSS research

Context measures ⇨	**Process measures** ⇨	**Outcome measures**
User • Individual characteristics • Number of users • Knowledge of counterparts • Orientation Task • Problem type • Degree of conflict • Time pressure • Degree of anonymity • Complexity • Context • Communication modes System • DSS models • Input/output media • Communication media • Protocol • Mediation, intervention • Supported phases • Free text communication	Process • Concession pattern, type • Outside communication • Number and type of offers • Number and type of messages • Offer and messages frequency • Preferences, issue and option modification • Process length Perception • Expectation • BATNA • Reservation levels • Aspiration levels • Biases and errors • Preferences • Counterpart disclosure Approach • Degree of cooperation • Assertiveness • Task-orientation	Agreement • Negotiation result • Utility value • Efficiency • Fairness • Satisfaction • Confidence Counterpart assessment • Degree of cooperation • Friendliness • Willingness to work • Satisfaction • Confidence Process assessment • Process length assessment • Satisfaction with process System assessment • Ease of use • Usefulness • Intension to use • Effect on behavior and results

The key constructs presented in Table 3 are selected to propose measures that can be used in empirical NSS research. Because we move to web-enabled NSS and ENSs which range from passive facilitation tools to agents that automate negotiations, these constructs and the relationships between them provide a basis for e-negotiation research agenda.

5. E-negotiation Systems and Research

Negotiation systems deployed on the web are unlike the earlier systems deployed on stand-alone computers or local- and even wide-area networks. They are easier to use and manage thanks to their design flexibility made possible with the internet technologies, loosely coupled systems and n-tier architectures (Figures 3 and 4). They also differ in the implemented mechanisms and employed technologies. Some of these systems facilitate communication (Yuan, Rose et al. 1998), others are active mediators (Kersten and Lo 2003). There are also systems that facilitate joint preparation of documents' content (Schoop and Quix 2001), and commercial systems that allow the negotiators to enter offers which are forwarded to human experts (2006; 2006).

The common features of the software designed for e-negotiations are that they are deployed on the web and capable to support, aid, or replace one or more negotiators, mediators or

facilitators. The ubiquity and ease of use of the web-based systems contributed to the great expectations regarding the use of software in all human endeavors, including negotiations.

5.1 Successful and not so successful cases

The wide and fast diffusion of the web and the availability of internet technologies contributed to the emergence of dot.com firms involved in "all things electronic", including negotiations. During the late 1990s a number of dot.com companies were established but—as was the case with other dot.com firms—many folded down, changed their profile or were bought by others. TradeAccess.com, FrictionlessCommerce.com and Casbah.com were set up in 1998 with the mission of providing "sophisticated negotiation capabilities for Web-enabled commerce" (Accenture 2000). They were to completely (FrictionlessCommerce) or partially (Casbah) automated commercial negotiations in which human and/or software "buyers and sellers can negotiate in real time, making continuous bids contingent on timing of delivery, quality levels, volume and other relevant manufacturing parameters, not just price" (2000).

TradeAccess provided its customers with an ENT which, in addition to being a meeting space, gave access to a number of tools. The company was oriented to bilateral purchasing negotiation and it provided process-oriented support. TradeAccess maintained a database of potential buyers and sellers, and a detailed database for selected products. In 2001 the company was renamed Ozro and it extended its software-based services with secure communication between the parties, logs of the exchanges, exchange of attachments, agreement templates, generation of orders and forms, and legal support including access to lawyers in different jurisdictions.

FrictionlessCommerce technology was based on the MIT Kasbah project, which was a market populated by NSAs negotiating on behalf of their human principals (Maes, Guttman et al. 1999). The agents were to find the products their principals sought, compare a number of different issues (e.g., warranties and fulfillment rates), and engage in negotiations in order to create a "win-win situation" (Thompson 1999). The FrictionlessCommerce system relied more on the knowledge of the technical components than any other socio-technical negotiation system. Because of the insufficient capabilities of the agents representing buyers and sellers, the company moved to other types of services (e.g., hosting and customer support) and was bought by the SAP Inc.

The exuberance associated with the "dot.com revolution" led to confusion of terminology. For example, LiveExchange, the system designed by Moai.com was "automating contract negotiations and bringing traditional bidding to the web", using an auction rather than negotiation system (Accenture 2000). Prowess Software developed "buyer-supplier matching and online negotiation engines" (Reese 2001) which were presented as an application of complexity theory but they appear to consist of SQL statements and a multiattribute value function. Because of the opacity of description of these and similar systems, it is difficult to unequivocally state what models and procedures they use. This is not the case with ExpertCommerce.com another firm which ceased to exist and which used a well known AHP method to identify sought products and negotiate their terms (op. cit).

In addition to the systems which focused on purchasing negotiations, several applications which were oriented towards other types of commercial conflicts, were developed in the late 1990s. One successful example is CyberSettle (www.cybersettle.com) an online system supporting insurance claim negotiation. It implements conflict resolution process based on the parties'

agreement zone with a possible intervention of a human mediator. A similar system has been designed by the ElectronicCourthouse Inc. (www.electroniccourthouse.com) which is an ENT coupled with services provided by a human facilitator or mediator.

5.2 E-negotiation systems for research and training

Internet and the web introduced new opportunities for empirical research and training. It became possible to set up virtual laboratories and collect data from people across the world. Wide accessibility of web-based systems required friendly user interfaces and the use of multimedia. Changes in the ways research experiments could be conducted and people trained had strong impact on socio-economic processes which require interaction, decision-making and choice. In effect researchers became interested in the development of software to study communication and cooperation in virtual settings and, among others, negotiations. This included development of ENSs, some of which are briefly discussed here.

Inspire is an early ENS equipped with functions typical for NSS. The system was designed in 1995 and since 1996 it has been used to study bilateral e-negotiations, interactions between persons with different cultural and professional backgrounds, and the impact of graphical and analytical tools on the process and its outcomes (Kersten and Noronha 1999). In the period of ten years, over 6,000 users from 62 countries used Inspire.

There are three key support functions available in the Inspire system: (1) structuring of the process into discrete phases and activities; (2) preference elicitation and rating function construction mechanism; and (3) graphical representation of the negotiation progress. Process structuring guides the negotiators through the steps required to engage in negotiations. A simple method (hybrid conjoint analysis) to elicit the negotiator's preferences and construct the rating function was used to allow a large number of lay people to use the system without any training or external help. Graphical representation of the process's dynamics allowed the users to view their and counterpart's offers in two-dimensional (value-time) space.

Many approaches to model and support negotiations are based on explicit recognition of conflict and they focus on its management and resolution. Web-HIPRE takes a different approach in that it attempts to introduce a joint problem solving strategy from the outset. The system, developed by Hämäläinen and his colleagues in 1997 (Mustajoki, Hamalainen et al. 2004), uses multiattribute value theory based methods and the AHP method to construct a hierarchical model of the selected problem attributes and the participants' objectives. The interactive process aims at improving the purpose of the overall understanding of the problem and of supporting articulation and analysis of the values. It can also clarify the differences between stakeholders' values and their importance in the comparison of alternatives. The use of decision analysis methods and the construction of the value tree are difficult and therefore, a facilitator needs to be employed (Hämäläinen, Kettunen et al. 2001).

Kasbah is an ENT populated by NSAs; the agents engage in selling and buying on behalf of their principals (Maes, Guttman et al. 1999). The negotiations are over a single issue: price. The principals provide their NSAs with: (1) price aspiration and reservation levels, and (2) the strategy—represented as a concession function—for lowering (increasing) the price over the course of a negotiation. The NSAs search for other NSAs who buy (sell) items of interest and, upon finding a counterpart, they enter into bilateral 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. The system served as a prototype for FrictionlessCommerce (Section 5.1).

Experiments with Kasbah led to a design of Tête-à-Tête, a system capable of handling multi-issue negotiations (Maes, Guttman et al. 1999). 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.

WebNS (Yuan, Rose et al. 1998) focuses on process support, in particular on structuring of text-based exchanges and automatic process documentation. The system supports the specification of, and discussion about, issues. The focus on the process can also be seen in the sequential negotiation approach which is often used in real-life negotiation due to the difficulty in discussing all or many issues at the same time. In WebNS each issue is separately discussed and the information is displayed in the window containing user messages or in the window with counterpart's messages. 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.

Negoisst is an example of a system which has its roots in linguistics and qualitative modeling rather than decision science. The system has been initially developed to study the ways in which the Searle's theory of speech acts (1969) can be used in the design of an ENS which aims at supporting preparation of complex contracts (Schoop, Jertila et al. 2003). The utterances representing messages exchanged between the negotiators and the contract which they prepare comprise speech acts. Seven types of speech acts are used to provide the negotiators with message classification used to represent five types of formal commitments (request, offer, counter-offer, accept, reject) and two types of informal utterances (question and clarification). Negoiist imposes partial structure on the negotiated contract to allow its versioning according to the contract clauses, their authorship and time. Taken together the system provides extensive communication and document facilities. Recently, Schoop and her team (2004) extended the system with preference elicitation and value function construction tools.

The purpose of Negotiator Assistant (Druckman, Druckman et al. 2004) is to provide a diagnosis of a conflict situation. This is a rule-based system which asks its user a series of questions about the negotiating parties, issues, delegation activities, situation, and process. Based on the user's answers it ascertains the degree of flexibility of the conflicting parties. The underlying assumption is that agreement is possible if one or more parties are flexible; willing to move from their initial positions or willing to search for new solutions. Negotiator Assistant computes for each party a "flexibility index" and based on its values it selects a diagnosis which ranges from agreement, to capitulation and termination with no agreement. The system has been used in training but it can also be used to assess alternative negotiation theories by comparing the results of different diagnoses (process vs. issues, parties vs. situation) with obtained outcomes in historical cases.

Loosely coupled systems (Figure 3), new generation internet technologies which allow ad hoc integration of systems residing on different computers and the introduction of web-services

made possible construction of software platforms which are capable of constructing in real time a system according to the specifications provided by its users. ENS platforms are capable of running different types of negotiations, for example, bilateral, multilateral and multi-bilateral, with single and multiple issues, and with alternatives specified explicitly or computed from a model. They can provide services that can be customized to the requirements and preferences of their user. They also allow their users to choose between different communication modes, preference elicitation procedures and utility construction models, strategies and tactics, and between different mechanisms such as mediation, arbitration and auction. For team negotiations ENS platforms can provide communication facilities and dedicated support tools for intra- and inter-group activities. Examples of such platforms include an auction-oriented SilkRoad (Ströbel 2003) and Invite which allows generation of both auction and negotiation systems based on predefined negotiation protocols (Kersten and Lai 2007). Invite can generate, among others, several versions of the Inspire system (e.g., with and without analytical and graphical mechanisms).

5.3 E-negotiation research and training

The definition of ENS formulated in Section 1.1 is deliberately broad so that it allows us to include a type of systems which are most widely used in negotiations. These systems are various email servers and clients and their wide spread use led to studies on negotiations via email (see e.g. Croson 1999; Thompson and Nadler 2002).

Experimental studies of email negotiation resulted in three types of observations: (1) the need to increase communication bandwidth; (2) the impact of non-task related activities on the process and outcomes, and (3) the potential of support tools. Narrow communication bandwidth and the non-task related activities are of particular importance for negotiators who need to establish rapport, trust and reduce the social-distance with the other party, and who employ positive or negative emotional style as opposed to the rational style. Email negotiations contribute to more equitable outcomes than face-to-face and increase exchange of multi-issue offers but require more time and more often result in an impasse. This indicates that asynchronous exchanges allow for reflection and consideration of several issues simultaneously rather than sequentially. It also shows the need for: (1) support to increase process efficiency; (2) search for agreements; and (3) provision of facilitation and mediation.

The communication bandwidth and the richness of media used in e-negotiations affect the process and its outcomes. The experimental results are, however, mixed because of the use of different systems and tasks. Purdy and Nye (2000) conducted experiments in which negotiation via a chat system was compared with face-to-face, video and telephone. They found that, in comparison with persons who negotiated face-to-face, chat users were less inclined to cooperate, more to compete, needed more time to reach an agreement, negotiated lower joint profit, were less satisfied and had lower desire for future negotiations. Interestingly, telephone and video conferencing produced mixed result; in some cases one medium was better than chat but another medium was worse, in others—vice versa. We note that although chat and email have the same communication bandwidth, the results observed are quite different. Although one reason may be due to media (a)synchronicity, this comparison illustrates the difficulty in making conclusions regarding the relationship between media richness and social interactions.

We should note that email and chat systems do not provide any decision and negotiation support and their communication support is limited to exchanges of text and storage of

unformatted transcripts. This may be one reason for negative impact of chat on negotiations.

Yuan et al. (2003) conducted experiments using the WebNS system which provides process-oriented support, including organization of exchanges, formatting of text and alerting. They report that users prefer text with audio or video communication over text alone. They also observe that the addition of video to text and audio communication in a negotiation environment was not found to be beneficial.

Weber et al. (2006) conducted experiments using two versions of the Inspire system: with and without graphical support. No difference was observed in the proportion of dyads that reached agreement with graphical representation compared to the system without graphical support. For dyads that reached agreement, participants using the system without graphical support submitted a lower number of offers. The average message size per dyad was 334 words greater, on average, for successful negotiations without graphical support. The incongruence between the information presentation format and the negotiation task is thought to require more extensive textual explanation of positional and offer rationalization to compensate for the lack of graphical support.

Data obtained from negotiations via Inspire was also used to study the relationships between the user characteristics and the use of different features of the system and the reasons underlying differences in the negotiation processes and the achieved outcomes. The results of the analysis of the Inspire data show that user characteristics and, in particular, previous negotiation experience, the use of internet and culture, influence perceptions of usefulness and ease of use, as well as the actual use of the system (Köszegi, Vetschera et al. 2002). Previous negotiation experience has a positive influence on the perceived ease of use of the system; however, it has a negative influence on the usefulness of its analytical features (Vetschera, Kersten et al. 2006).

Lai et al. (2006) studied the influence of cooperative and non-cooperative strategies on e-negotiations and their outcomes. Less cooperative negotiators tend to submit more offers but fewer messages and consider having less control over the negotiation process than more cooperative negotiators. Cooperative negotiators view the process as friendlier and are more satisfied with both the agreement and their own performance. The researchers found an association between the negotiators' own strategies and their perceptions about counterparts' strategies and also between the pairs of strategies and final agreements. The proportion of negotiations reaching agreement is larger for the cooperative cluster than for the non-cooperative cluster.

The Aspire system (Kersten and Lo 2003) is one example of a design that addresses the needs of inexperienced negotiators. Aspire is an extension of the Inspire system with a NAA. The agent provides methodological advice during the negotiation. A comparison of e-negotiations showed that the negotiation effectiveness (measured with the percentage of users who achieve agreements) and the users' willingness to improve the compromise is higher in negotiations supported by a NAA. Similar results were obtained by Chen at al. (2004).

The use of ENSs, in particular those which provide problem and process support and automate some tasks depends on their adoption. The experiments which use and adapt models of information systems adoption and fit focus on the factors that affect the ENS user intentions regarding system use and usefulness. Vetschera et al. (2006) formulate and test the assessment

model of internet systems (AMIS) which is an extension of the technology acceptance model (TAM) (Davis 1989). The purpose of AMIS is to determine the measures of a web-based system success based on its actual and reported system use. The model has been validated, and one important result of the analysis is that the communication and analytical tools need be considered separately in the measurement of the system's ease of use and its usefulness. Lee et al. (2007) replace the original TAM model's independent variables with playfulness, causality and subjective norms and show that they have a positive effect on the ENS intention to use, through their effect on perceived ease of use or perceived usefulness. They observe that persons may use ENS because: (1) they have been persuaded that using it is an enjoyable thing; (2) its use will increase their performance; (3) their supervisors, peers, or subordinates think they should use an ENS; or (4) because of the causal nature of their negotiation tasks.

5.4 In search of research frameworks

There have been many studies of ENS design, development and deployment, e-negotiations and automated negotiations. The constantly increasing use of internet, growth of e-business, emergence of new e-marketplaces and interest in using web-based systems for participatory democracy contributes to more studies. These studies are predominantly interdisciplinary; they are undertaken at the juxtaposition of psychology and sociology, information systems and computer science, management and economics, engineering, ethics and anthropology (Bichler, Kersten et al. 2003). New concepts, methods and models are being proposed. Some are studied from the theoretical viewpoint others are experimentally verified. All these efforts and various perspectives and research paradigms contribute, on one hand to the liveliness of the e-negotiation field and, on the other hand, to the need for research frameworks. Such frameworks are necessary in order to study and compare various ENSs, compare different experimental results and conduct comparative studies in market mechanisms and the use of negotiation models in conflict management.

We are increasingly enmeshed in a variety of socio-technical systems and one may project that negotiated social systems will also gravitate towards their socio-technical counterparts. One may also expect that this transformation may bring negative along the positive changes, some of which have been mentioned in Section 5.3. In order to identify both types of changes and their underlying causes we need to learn a lot more about negotiators and their interactions with the system and with their counterparts via the system. We also need to learn about the relationships between support and advice from and automation by an ENS and the users' perceptions, trust, rapport and satisfaction. These and similar efforts require building on the results obtained from the "before internet" era, including the re-evaluation of the research constructs presented in Table 3. We do not aspire to propose concrete frameworks; rather we wish to stress their need and mention two ways to construct them. One approach is through the taxonomy development and its use to construct comprehensive models of e-negotiation systems and processes. Ströbel and Weinhardt (2003) proposed Montreal taxonomy for e-negotiation with optics on economics and technology rather than the socio-psychological aspects. Another example is coming from an on-going work on the comparison of auction and negotiation mechanisms in e-business. This work involves: (1) specification of mechanisms and ENSs in which these mechanisms are embedded; (2) model development which combines models from information systems (which in turn adopted some socio-psychological models) with models from behavioral economic; and (3) experiments in which the models are verified and mechanisms are analyzed and compared.

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