IGI PUBLISHING
701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.igi-pub.com

ITJ3735

This paper appears in the publication, **International Journal of E-Business Research**,
Volume 3, Issue 3 edited by **In Lee © 2007, IGI Global**

From Operational Dashboards to E-Business:
Multiagent Formulation of Electronic Contracts

Tagelsir Mohamed Gasmelseid, King Faisal University, Kingdom of Saudi Arabia

ABSTRACT

The unprecedented advancements witnessed in the field of information and communication technology over the last couple of years are significantly affecting the nature and magnitude of B2B interactions as well as their operational effectiveness and efficiency. However, interaction and contracting among global enterprises continued to be challenged by the difference of laws, authentication requirements, and endorsement constrains. With the rapidly increasing proliferation of mobile devices, wireless communication systems, and advanced computer networking protocols, the deployment of electronic contracting platforms and applications has provided many opportunities to enterprises, dictated new axioms for doing business, and gave rise to new paradigms. Together with the increasing institutional transformations, technological advancements motivated businesses to engage in an interactive process of contract formulation and negotiation.

Keywords: *electronic contracting; multi agent systems; telecommunication*

INTRODUCTION

The use of Internet technologies is enhancing distributed business processes through improved information generation, retrieval, and storage, cost reduction, disintermediation, and the transformation of organizational boundaries. The resulting global repositories of generic, volatile, and heterogeneous data originating from different systems are significantly affecting B2B interaction (Chrysovalantou & Petrakis, 2004; Daniel, 2003; Klusch, 2001) and are resulting in alternative e-business models, strategies, and enabling frameworks.

The use of such technologies in e-business allows firms to integrate core and support business processes and enhance information sharing efficiency. It addresses connections among enterprises (B2B) as well as between enterprises and customers (B2C) by speeding information processing and responsiveness and shifting the emphasis from optimizing the efficiency of individual enterprises to optimizing the efficiency of a network of enterprises in pursuit of improving competitive advantage (Xirogiannis & Glykas, 2007).

According to Lumpkin and Gregory (2004), there are seven e-business models that account for the vast majority of business conducted online. Commission-based models are used by businesses (third-party intermediaries) to provide services for a fee such as brokerage services. Advertising-based models are used by companies that provide content and/or services to visitors and sell advertising to businesses that want to reach those visitors. Markup-based (merchant) models are used by businesses that add value in marketing and sales (rather than production) by acquiring products, marking up the price, and reselling them at a profit for both wholesalers and retailers. Production-based (manufacturing) models are used by companies that add value in the production process by converting raw materials into value-added products. In this respect, the Internet adds value to this model by lowering marketing costs and enabling direct contact with end users to facilitate customization and problem-solving. Referral-based models are used by firms that steer customers to another company for a fee. Subscription-based models are used by businesses that charge a flat fee for providing either a service or proprietary content such as Internet service providers. Fee-for-service based models are used by companies that provide ongoing services similar to a utility company. Unlike the commission-based model, the fee-for-service model involves a pay-as-you-go system because activities are metered, with payment being made only for the amount of service used such as the application service providers.

However, the capacity of these e-business models to facilitate an organizational migration towards dynamic e-business and ERP applications will be improved with the existence of enabling platforms mainly electronic payment and contracting systems. Because dynamic e-business allows organizations to integrate systems across intranets, extranets, and the Internet in a dynamic fashion and permit them to modify existing systems quickly and easily when the business process requires (Andrew, Sagnika & Shao, 2006) enabling systems align e-business technologies with organizational processes and competitiveness.

Within the context of globalization and organizational transformations, firms are starting to use information technology as instruments to support their trading relations, manage their contractual matrix of rights-and-obligations and reduce risk. Electronic contracting that provides the means for a high level of automation of the contract establishment, contract management, and enactment processes presents significantly more opportunities to the trading parties (Angelov & Grefen, 2004; Sallé, 2002). However, the growing multiplicity of data modeling and organization tools, content representation algorithms, ontologies, vocabularies, and query languages that account for heterogeneity and global information overload is promising firms to gain much faster and cheaper processing than traditional contracts.

While different approaches are being used to conceptualize the context of electronic contracts, the basic aim of this article is to address the context of electronic contracting by using multiagent concepts to develop a framework that describes the process of formulation of these contracts using Sudatel as a case study.

ELECTRONIC CONTRACTING

Electronic contracting involves the exchange of messages between (the concerned parties), structured according to a prearranged format so that the contents are machine-processible and automatically gives rise to contractual obligations necessary for achieving a legally supported business relationship (Baum & Perrit, 1991; Milosevic, 1995).

While some firms use it to enhance their capacity to perform need identification, manage production and merchant brokering, and negotiate in the space of time as explained by the consumer buying behavior model, others are aiming for the dynamic customization of their "four Ps" (product, price, promotion, and placement) and "one C" (customer relationship) and the deployment of online flexible and efficient negotiation and electronic contracting

infrastructures (Dutta & Segev, 1999; Guttman, Moukas, Alexandros & Maes, 1998; Runge, 1998).

In addition to technological developments and institutional imperatives, the interest of firms in electronic contracting is enhanced by the willingness of governments to develop legislation that removes barriers to electronic commerce. The Electronic Signatures in Global and National Commerce Act in the U.S. and the European Electronic Signature Directive, among others, include provisions relating to the liability of network service providers, digital signatures as well as the duties of digital signature subscribers and certification authorities with regards to the creation or execution of, among others, a will, negotiable instruments, and indentures. The Model Law of Electronic Commerce (UNCITRAL) introduced the concepts of "functional equivalence" and "technology neutrality" as new axioms for contract formation, authentication, and implementation.

In dynamic e-business settings, electronic contracts help enterprises to (a) identify business partners, (b) match their individual offer specifications with complementary ones from other partners, (c) negotiate conditions and contractual terms, (d) collectively sign contracts, and (e) execute obligations and actions that are defined in the contract (Lai, Manfred, Jeusfeld & Paul, 2005; Merz, Frank, Tuan, Stefan, Harald, Marko & Winfried, 1998).

However, irrespective of the widespread use of electronic contracting, business enterprises have some worries. Electronic contracts are not "definite" enough as to whether a business trader is making an "offer" or "an invitation to treat." The information provided lacks the sense of absolute intent necessary to have a binding agreement and a conclusive intent of a binding offer in the sense that the offeror is willing and able to "deal" with all without any reservation. Such confusion affects the decision of the concerned parties as whether to communicate an "acceptance of an offer" or to discuss further. Jurisdictional concerns also arising from the disputes regarding the place where the contract is formed and the laws to be applied. Such concerns are directly related to contract validity and communication of acceptance in a legally binding form. In addition, some authentication and attribution concerns create some worries regarding the process of matching the parties contracting electronically by attributing electronic messages to the person who purports to send it. The contracting partners want to know that they can rely on the messages to be exchanged and avoid liability in case of messages being sent by an interloper or hacker.

To minimize these uncertainties, different solutions are being proposed. The use of browsing and downloading "facilitative" capabilities, "checkboxes," "disclaimers," and "technology filters" is relaxing some of the jurisdictional concerns by shaping out the inclusion or exclusion of certain transactions and/or specific locations. The use of metrics to account for the time in which the information is sent, received, and accessed using servers, routers, TCP/IP, packet switching, client and server technologies is another development that clears out some doubts about contract validity. The use of a wide range of Internet technologies such as EDI, EFT, and VAN has also enhanced universal availability of global repositories of generic, reusable transaction models.

RELATED WORK

Within the context of international trade the basic question in configuring contract negotiation is "what to be negotiated" (Grosof, Labrou & Chan, 1999; Reeves, Benjamin, Grosof, Wellman & Chan, 1999). In any contracting context, some features of the potential contract are fixed while others are variable and are expected to be determined through the contracting process.

The "phase model for commercial transactions" has been widely used to guide the process of decomposing architectural elements of electronic contracting services (Schmid & Lindemann, 1998). The model consists of three phases: information, negotiation, and execution. Such phases are supported by different computer-based services including online

catalogues, search engines, or banner advertising (information phase), telecollaboration, negotiation protocols and strategies (negotiation phase), workflow management, business process integration among market participants, electronic payment systems, and EDI-based message exchange functions (execution phase). Support functions like brokerage (i.e., to select and match respective offers and inquiries, to form a (service providing) consortium or to set-up the negotiation session for all parties of the commercial transaction) and signing (i.e., to enter the execution phase by establishing a contract and encouraging all parties to sign it) are being widely used also. This process has also been supported by trusted third parties such as certification authorities or electronic notaries.

Runge (1998) claimed that electronic contracting involves two processes: "agreement negotiation" and "agreement signing" through which the exchange of electronic messages among the contracting parties is supposed to lead to contract formulation and signing. The terms of the agreement (both fixed and those to emerge through negotiation) as well as the actions to be taken occur through "electronic records" or "data messages" that are generated, communicated, received, or stored by electronic, magnetic, or optical means in an information system or for transmission from one information system to another (Reeves et al., 1999).

According to Milosevic and Bond (1995), the contract cycle includes "establishment," "performance," and "post contract" phases with the rules and policies being stored in a Legal Rules Repository. The contracting process involves a contract validator (to perform contract validity checking), Contract Negotiator (to support contract negotiation), Contract Enforcer, and Contract Arbitrator. It also includes Contract Legality and Monitoring objects. Electronic contracting is guided by "contract templates" containing the roles of the contracting parties, the period of the contract, the nature of consideration, associations between "roles" and "obligations" and the semantics to be used for the representation of alternative contracting scenarios. Using these templates, contract validity can be established through the identification of a set of mandatory elements (agreement, considerations and competence). Contract monitoring, on the other hand, can be performed by the parties or by a third party acting on behalf of one or all the parties.

Similarly, Goodchild, Charles, and Zoran (2000) considered a valid business contract as being containing four elements: agreement, consideration, capacity, and legal purpose. Instead of using "contract templates," they proposed the use of a standard contract as a base for the contracting process. Such a standard contract can be provided by one of the parties, a third party or a commercial organization specialized in providing general–purpose contracts.

The Reference Model for Electronic Markets proposed by Lindemann and Schmid (1998), views electronic contracting within the context of an electronic market by using two dimensions (horizontal and vertical) and four views (business, transaction, services, and infrastructure) to reflect both organizational and technological aspects. Lindemann and Runge (1997) proposed the use of learning software agents to search for offers and negotiate on behalf of users. Because agents are not capable of signing reliably on behalf of their users, it may be necessary to enable the signature of electronic contracts by separating the negotiation process from the signing process.

Alternatively, electronic contracts can be established using CrossFlow Contract Manager Modules without human interaction (Koetsier, Paul & Jochem, 2000). The data structure of the CrossFlow contract model consists of five main parts: the concept model, the workflow definition, the enactment clauses, the usage clauses, and the natural language description. The architecture of the contract object model of the Common Open Service Market for SMEs (COSMOS) is composed of an online catalogue, brokers, contract negotiation support, signing support, and contract execution support. The project uses the CORBA Business Objects Architecture (Griffel, Boger, Weinreich, Lamersdorf & Merz, 1998).

The contract approach used to develop the TINA (Telecommunication Information, Networking Architecture) framework used the "metabroker" concept and is built around four modules: Validation, Negotiation, Monitoring, and Enforcement (Daoud, 1998). The metabroker concept is composed of a contract framework and catalogue facilities necessary for maintaining correct negotiation protocols, contract validation and the enforcement of constraints, and interactions with virtual catalogues.

In their previous work, Grosof (2001), Grosof et al. (1999), and Reeves, Wellman, and Grosof (2002), claimed that electronic contracts can be represented and communicated as modular logic-program and semantic Web XML rules by incorporating process knowledge descriptions and ontologies represented in DAML+OIL. This is to enable the representation of complex contracts that include provisions for addressing behavioral issues and exception-handling conditions that might arise during the execution of the contract.

In their work on using software agents for electronic contracting, Runge, Schopp, and Stanoevska-Slabeva (1999) and Griffel, Tu, Münke, Merz, Lamersdorf, and da Silva (1997) used the "Customer Buying Cycle" and the "Media Concept." The media concept is defined as an entity of a platform that facilitates the representation, processing, and communication of information using an organized community of agents. It consists of three components: the logic component (representing and formalizing information for agent interaction), a community of agents (processing information and using the medium as a common information and communication space), and a set of channels that carry information and enable agents to communicate over time and space barriers. It also includes four layers (or views): community, implementation, transaction, and infrastructure. Alternatively, Greunz et al. (2000) viewed electronic contracting using three layers: a logic layer (to manage the monitoring of the contracting process), an information layer (to provide data storage and contains the contract structured and unstructured information), and a communication layer (to include all protocols and security measures necessary for the communication among services and contracting parties). Lindemann and Runge (1997) viewed the layers differently as a business layer, a services layer, and a technical layer.

The multiparty contract model proposed by Lai et al. (2005) consists of three core components: actions, commitments, and a commitment graph. The contracting parties perform actions based on the definition of their roles and functionalities. A multiparty contract includes one or more commitments including some actions to be performed by the concerned parties. A commitment is a guarantee by one party towards another that some action sequence shall be executed completely provided that some "trigger, involve, and finish" action happens, and that all involved parties fulfill their side of the transaction. To finish a commitment, more than one party can be involved in different commitments and play different roles. A commitment graph shows complex relationships among commitments (Ervin, 2002; Verdicchio & Colombetti, 2002).

METHODOLOGICAL FRAMEWORK

The proposed multiagent framework attempts to approach the context of electronic contracting by using multiple methods to couple the functionalities of actors with the models that describe their interactions. The framework is basically based on the concept of "Management by Contracts" that aims at the development of a way for formalizing and analyzing contractual relationships and understanding their resulting impacts. This approach follows a utilitarian and deliberative approach that articulates and orchestrates objectives in pursuit of allowing the concerned parties to look at "meeting or not meeting" them as alternative viable business options (Sallé & Bartolini, 2004). It also incorporates the concepts of "Service Level Agreements" (SLA) and extends them to incorporate business level agreements (BLA) as well.

While the basic analysis and design is based on TROPOS (an agent oriented soft-

ware engineering methodology), the method of "information system work and analysis of changes" (ISAC) proposed by Lundberg, Goldkuhl, and Nilsson (1978) has been basically used for analysis. According to this method, the analysis comprises two parts. The first part is the study of the organization and identification of possible feasible types of development measures (changes or improvements) that should be incorporated into its activities to solve existing problems and fulfill needs. The second part of the analysis is carried out on the information processing activities to identify and classify subsystems, and finally design the overall architecture of the multiagent electronic contracting system. ISAC distinguished two main groups of activities in the analysis and design of information systems: (1) problem-oriented work directed towards the logical structure, and (2) data-oriented work directed towards understanding the physical structure of the entire system. Problem-oriented work refers to those activities associated with the functionalities of the information system from the user's point of view. Data-oriented work refers to the activities are concerned with the process of designing technical solutions that meet logical specifications. These are developed through implementation of the two methods: change analysis and activity study.

CHANGE ANALYSIS

The telecommunication market in Sudan is becoming increasingly competitive as it includes three companies offering cellular phone services with other two companies offering fixed lines services. The Sudanese Telecommunication Company (SUDATEL) was established in 1994 after the privatization of the Public Corporation for Wired and Wireless Communication with the objective of providing quality and affordable telecommunication services and penetrating the regional telecommunication market by acting as a trusted carrier among countries in the Arab and African world. The company offers fixed phone services and cellular phone services in collaboration of one of its subsidiaries. The company's investment in the acquisition and operation of telecommunication infrastructures (advanced operators, fiber optic networks, and early warning and response systems) is placed on the priority list of the company's financial plans. In addition to the provision of Internet services, the company is using HDSL, video-conferencing, and interactive real time communications to provide distance learning services and synchronous and/or asynchronous delivery across remote trajectories. The company is also implementing and managing an electronic library that includes more than 20 "accessible" databases. The Sea Cable, connecting Sudan and Saudi Arabia through the DWDM technology, is enhancing the capacity of the company as a regional information carrier.

Operationally, the company is currently using a multimodule computerized system to manage its functions. The "Payment" System Module (through the "budget" and "Expenses" programs) manages financial obligations including salaries, disbursements, and other financial obligations. It uses "an integrated" database to produce relevant management reports. The "Accounts" reports subprogram consolidates and collects accounting information from other programs and allows financial submodules to classify and tabulate it and produce the annual financial report. The "Invoices Subprogram" is linked to the "customer desks" and the "General ledger" program where the collected information is usually used for financial adjustment. The "Stores" Program maintains stock balances for reorder and stock-out considerations. Purchasing activities are managed through the "Purchasing subprogram" which includes submodules for domestic and international suppliers. The "Contracts" program is a submodule through which contracts' information (e.g., contractors, obligations, maturities) is recorded and processed.

Change analysis comprises assessment of the existing situation of contracting in the company to identify the problems, requirements, and the appropriate support tools. The final product of this activity is the identification of the appropriate measures including multiagent information systems. Analysis of the current

situation showed that the management devotes much attention to the use of a standard contracting process by giving a ready contract for contractors to use.

Activity Study

Activity studies define the functions that a multiagent information system may perform as well as information requirements. This can be achieved by detailed analysis and design of activities related to the planning, monitoring, and evaluation processes, based on the identification of problems and definition of information requirements for each activity. The functionalities of telecommunication companies are usually challenged by the failure to develop integrated information systems that relate different applications throughout the company. Based on their general use, individual applications and/or submodules are usually developed by end users and/or outsourced to vendors. The lack of an integrated framework makes the functional user-centered submodules to be underutilized particularly for strategic decision making.

The increasing deployment of electronic commerce and banking services urge the company to improve its operational efficiency to facilitate electronic transactions and clearing. The use of discontinuous plans and lack of concrete visions decreases customer satisfaction and the effectiveness of B2B interactions. Because the company has started to manage the provision of cellular phone services in other countries, its dependence on conventional supply chain management methodologies negatively affect operational efficiency and responsiveness.

MULTIAGENT FORMULATION OF ELECTRONIC CONTRACTS

The processes of electronic commerce have been supported by the growing deployment of software agents, particularly, in auctions, exchange, shopping, pricing, and contracting (Wu & Sun, 2002). According to Lee and Lee (1998), one of the most important applications of intelligent agents in electronic commerce is comparison shopping, in which agents assist in searching for product items on the Internet on behalf of a customer. After searching the relevant online shops throughout the Internet for the items that match the search criteria, the agent returns a detailed description and price of the sought items and addresses of the virtual stores that deal with the items.

The agent approach is characterized by the use of agents to save resources and carries out processes (Angelov & Grefen, 2001). An intelligent agent is as an autonomous, computational software entity that has access to one or more, heterogeneous and geographically distributed information sources, and which proactively acquires, mediates, and maintains relevant information on behalf of users or other agents. The autonomous behavior of these agents is determined by their proactiveness, reactive and deliberative actions, and social interactions. In a multiagent system, agents jointly use knowledge and resources to solve problems in a context-dependent way. Their use in a wide range of applications, such as electronic commerce, traffic control, health care provisioning, portfolio management, and telecommunications, revealed their suitability for complex, distributed problems involving a multiplicity of interconnected processes whose solutions demand the allocation of fusion of information and expertise from demographically distributed sources (Aaron et al., 2004; El Fallah-Seghrouchni, Degirmenciyan & Marc, 2004; Gasmelseid, in press). Multiagent systems (MAS) have been used for several years as a paradigm to develop complex systems for well known reasons like autonomy, reactivity, robustness, proactivity, and so forth. The different approaches in the field of multiagent systems, that is to say the reactive and the deliberative approaches, are used according to the level of autonomy given to the agents. Our field of application is the tactical aircraft simulation. This type of application is characterized by several properties that are answerable to the multiagent systems ones.

The use of multiagent systems in electronic contracting enriches the contractual context by viewing the contracting parties as sets of

agreements for satisfying the diverse interests of self-interested individuals and organizations (Dellarocas, 2001) and regulating behavior among them where agents can change the interaction with and within the entire contracting domain and create obligations, permissions, and new possibilities of interactions (Boella & van der Torre, 2004; Pacheco & Carmo, 2003).

Based on their characteristics, multiagent systems assist in the process of information acquisition, management, synthesis, and presentation. Viewing electronic contracting as a "phased" process, they can assist specifically in the discovery of potential contracting partners, negotiation of contract terms, and execution of transactions and other contract provisions (Reeves et al., 1999).

However, the deployment of agents in the formation of electronic contracting moved a wide range of issues to the front line agenda of the research, business, and legal community, including:

1. Procedural issues relating to dynamic negotiation and authorization, privacy, reputation, recourse (including deterrence and rollback), instant settlement and counter-party risk, decentralized access control, monitoring compliance, derived rights, and the operationalization of legal concepts of nonrepudiation.
2. Typological issues dealing with the types of contracts to be formed and enacted electronically such as trusted intermediaries, smart contracts, ricardian contracts, anonymous and pseudonymous contracts.
3. Technological issues relating to the technological infrastructure and the methodologies to be used for computer-aided negotiation, formation, and signing of electronic contracts. The list includes, among others, contract languages and user interfaces, electronic rights languages, electronic rights transfer and management, relationship of electronic and legal enforcement mechanisms, the interface between automatable terms and human judgment, electronic transjurisdictional commerce and contracting, decentralized data access and control, security, and dynamism.

SYSTEM ARCHITECTURE

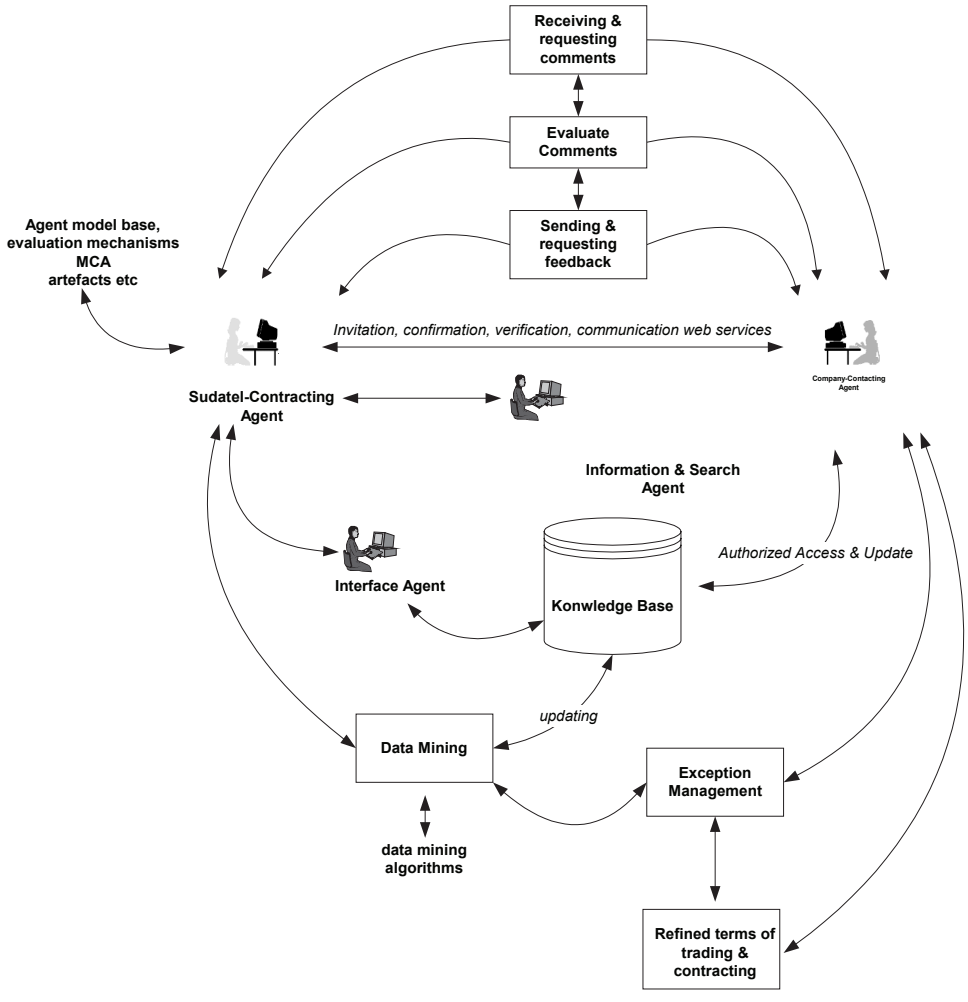
As shown in the architecture represented in Figure 1, the agent model of the proposed framework includes two types of agents: superior and subordinate. Superior agents (e.g., Sudatel-Contracting and Companies-Contracting) have the privilege to control, direct, and communicate in their own capacity as well as on behalf of their respective subordinate agent(s). Subordinate agents (e.g., search and information) act in a consultancy (staff) capacity to provide information necessary for the validation and verification of processes. As shown in Figure 1, the architecture, at the abstract level, includes two groups of process-centered functional agents: Sudatel-Contracting (SC) and multiple Companies-Contracting (CC) agents with the possibility to add more superior and/or subordinate agents. The basic objective of the SC agent is to locate and communicate with different companies-agents interested in the provision of services and ready to engage in the process of formulating and adhering to an acceptable electronic contract. On the other hand, each CC agent will be interested in achieving competitive advantages by engaging in international trade. Therefore, they will be concerned also about locating "customer" companies to whom they can sell their products. To enable the realization of these objectives, the proposed multiagent system must facilitate the formation of electronic contracts by focusing on the identification of the relevant agent, their functions, relations among them, and necessary cooperation mechanism.

A brief description of the system components is as follows:

1. Sudatel-Contracting agent:

It is the intelligent assistant of the "Contracts" (functional) manager to whom it dispatches its search results to enable him/her to crystallize relevant information about interested suppliers and use such information to create

Figure 1. A multiagent contract formulation architecture



and endorse Compnay-Contracting lists using multicriteria analysis. At the same time, this agent is also responsible for providing pertinent information requested by agents representing different contracting companies by exchanging messages with them and manages contract formulation based on these contacts, feedbacks, and comments received. Based on requests from the agents representing suppliers (i.e., CC) or SC agent, it can, as the stage of contract formulation permits (as the main contracting parties), terminate active contacts and discussions and make that termination public.

2. Company-Contracting agents:

These are the agents representing potential interested companies who can engage in the

process of formulating an electronic contract. The contacts initiated by all agents in the multiagent organization have to follow the rules of contracting to apply across several rounds of discussion. These agents also maintain their local (updatable) databases and models.

3. Information and search agent:

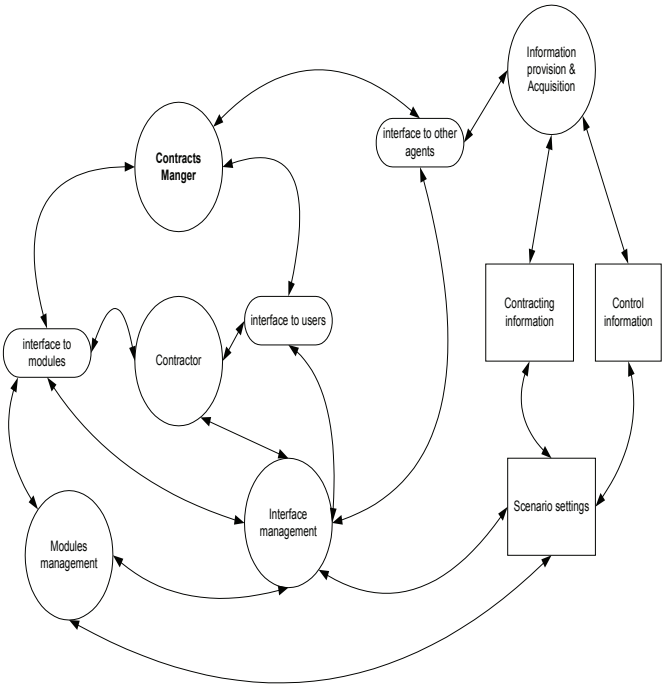
While they can also be used by contracting companies, the use of information and search agents in this article is limited to our classification of agents as either "superior" or "subordinate" from the point of view of Sudatel. Both agents are viewed as "subordinate" rather than "superior" agents. The main task of the information agent is to perform proactive searches, maintains and communicates information within the context of electronic contracting process on behalf of the task agent (i.e., SC) that supports the "Contracts" functional manager at Sudatel. The skills of the information agent include retrieving, analyzing, manipulating, and fusing heterogeneous information as well as enhancing visualization and guidance through the entire information space. Because it searches for information, it also maintains access to multiple, heterogeneous, and graphically distributed information sources on the Internet. The wide range of Web-based technologies currently made available at the disposal of information agents (such as Web services) provide considerable support in this regard. However, access to all data contained in the databases of Sudatel is provided through the respective subordinate agents to relevant Company-Contracting agents.

Actors Decomposition

Actors' decomposition provides more details about "system processes," "information elements," and "agent functionalities." The process of actors' decomposition is based on the understanding that electronic contracting and interactions among the contracting parties focus mainly on "what to be negotiated." In addition to its contribution to the development of implementation-related architectures, thorough actors' decomposition gives an insight about the ability of the concerned parties to acquire information by sending and/or receiving comments, evaluating them and sending or requesting feedback. Based on the propositions associated with electronic contracting described in this article, the actors' decomposition diagram includes two basic components: "information acquisition, provision, and management" and "information or comments, process handling, and evaluation" as shown in Figures 2 and 3. Information acquisition and provision focus on maintaining interfaces to agents (and their owners or users), other agents, and functional modules. Interface to users facilitates "unmodeled" interventions to be introduced by functional managers (i.e., Sudatel's Contracts Manager) to incorporate some changes and enables cross-user or cross-agent exchange of information and verification of alternative scenarios. Interfacing to modules enables users as well as agents to handle user and agent specific functions necessary for the management of their entire activities in accordance with the dynamics of the problem domain. Interfacing to other agents provides access to general nonspecific information and allows them to mutually access data from other sources in pursuit of facilitating transactions, communication, and improvement of awareness.

On the other hand, the second basic functionality is "process handling and evaluation" which also incorporates multiple interfaces. The development of alternative scenarios necessary for an informed electronic contracting process depends on the nature of the task or processes to be adopted by the concerned contracting parties in their pursuit to achieve their objectives by mutually agreeing on the terms of the electronic contract. In addition to the interface management component, Figure 3 describes the task handling module that supports a wide range of tasks for multiple contracting partners, including their data processing activities and the scenarios they may choose.

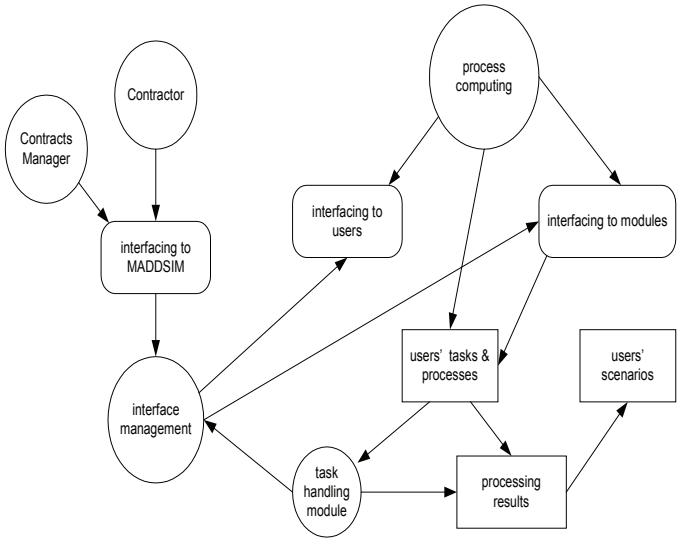
Figure 2. Actor diagram for information management (step 1)



Agent Interaction Process

As shown in Figure 1, the process starts by the search for potential contractors who can meet the requirements of Sudatel with regards to their willingness and ability to engage in the process of forming electronic contracts and providing goods accordingly. The information and search agent of Sudatel either searches a "roster list" of suppliers as included into its database or searches the Internet for "relevant" contractors in accordance with some metrics and benchmarks embedded into its knowledge engine. The results of the "search" significantly affect the decision of the Sudatel as whether to place a full-fledged or "conditional" invitation to offer. However, the capacity of the search or information agent to search the network and locate relevant information is contingent upon its capacity to use the appropriate means to, electronically, scan the environment, discover the appropriate information, and satisfy its information requirements. Despite the multiplicity of techniques being used, the capacity of such agent to learn how to locate and discover information is affected by a wide range of considerations. The use of monolithic Internet indices (such as Gopher and Harvest), search engines (bots), and "facilitators" to be used to search information for agents and obtain network locations is challenged by the overwhelming work to be done by the designer particularly for complex systems and the change of Internet addresses. Moreover, agents must have some "reasoning" and "coordination" skills that enable them to use the acquired information in the process of task handling. Efforts to resolve these problems have resulted into the development of different techniques such as rule-based inference, classification planning, and constraint satisfaction,

Figure 3. Actor diagram for process handling and evaluation (step 2)



organizational structuring, and contracting tools. In addition, the capacity of agents to search information is also affected by the challenge of the lack of generally accepted programming languages as well as the complexities resulting from the growing "ontological" and "semantic" considerations.

The Sudatel-Contracting agent then screens results and interfaces with the Contracts Manager to certify information accessed and incorporate any changes with regards to metrics, benchmarks, and models in the knowledge engine of the entire agent. It is only at this point where the decision is taken about the nature of interactions among the contracting parties and whether they incorporate an invitation to "treat" or "offer." The process is then "operationalized" by initiating contacts between Sudatel-Contracting agent and other potential Company-Contracting ones with the aim of framing out the context of contract formulation. If the Contracts Manager decided, from the beginning, to place an invitation to offer on the company's Web site, then it will be waiting for replies from potential contractors. However, particularly in international trade, it is necessary that the contracting parties have to know about each other's "way of doing business" before they can start electronic data interchange. This is necessary to facilitate reaching an agreement among the concerned parties with regards to the procedures and sequence of actions (sending and/or receiving of goods, documents, or funds) to be followed, documents to be exchanged, and rules that govern their activities in an integrated context of business transactions to avoid "battles of forms" and lack of standardization.

Sudatel-Contracting agent (based on the search results provided by the concerned subordinate agents and the cross-check conducted by the Contracts Manager) can prepare a list of potential trading and contracting partners with whom communication can be initiated. Company-Contracting agents are advised, at this point, by the Sudatel-Contracting agent to confirm their willingness and preparedness to engage in the process of formulating an electronic contract. Based on their response, the Sudatel-Contracting takes all necessary arrangements to enable them to access Zone (A)

of its corporate database in order to improve their knowledge about the entire context of contracting. Zone (A) is the publicly-accessible (online) portion of the corporate database which includes company information, nature of business, financial statements, standard operating procedures, technical specifications, nature of use associated with the items to be supplied, inbound and outbound logistics, and a general description of the criterion to be used evaluation. The Company-Contractor agents can, frequently, access Zone (A) and may call for "verification" or "further information." It is also possible for Company-Contracting agents at this point to decide whether to continue in the process of formulating an electronic contract, ask for modification (eg. invitations to treat vs. invitations to offer) or "decline." Such interaction increases the amount and richness of information accumulating in Zone (A) which can then be analyzed using appropriate data mining algorithms, multicriteria analysis, and other situation modeling techniques. The Sudatel-Contracting agent interfaces with the Contracts Manager to enable any possible modification on its model base or knowledge engine specifications to accommodate the requests and comments resulting from the interaction of multiple Company-Contracting agents across the landscapes of Zone (A) of the corporate database.

Such interactions can also be used to get an insight about serious potential Company-Contracting agents who are willing and capable of proceeding into the process of electronic contracting. Those "agents" are then provided, through the relevant subordinate agents of Sudatel, access to Zone (B) of the corporate database which includes more specific information relating directly to the contract and the offer. It includes, among others, a copy of federal and provincial clauses that govern international transactions, maps in different formats, as well as detailed information about the country's banking, financial, and prudential systems. Information about the nature of processes of the company and similar previous contracting terms can also be included. Zone (B) of the corporate database may also include a spatial data repository. Interaction among agents can also be supported by incorporating situation-specific model-coupling mechanisms within the data analysis methods in use. While such interaction enables the concerned parties to receive, evaluate, and communicate information and views, it also facilitates refining the whole context of contracting and managing exceptions.

With the facilitation of the Sudatel-Contracting agent, the agents interacting in the context of electronic contracting continue to collaborate in order to orchestrate the overall functionality by incorporating and updating their "learning skills and algorithms." The process of communication and data refinement continues until an agreement is reached with regards to the terms of contracting and trading between the Sudatel-Contracting agent and concerned Company-Contracting agents. While the process of contract formulation is separated from contract signing, as it has been proposed previously, the process of contract signing can be also agreed upon the context of contract formulation.

To maintain corporate integrity and security of the entire framework, access to Zone (A) and (B) of the database demands the incorporation of relevant security measures including digital signatures, encrypted passwords and biometrics, among others, as means for strengthening control over information access and exchange by authenticating users "agents as well as their owners" and managing optimized access to computer networks. By using special software, the recipient of messages (i.e., contracting agents) compares the digitized representation of the entered signature with a stored copy of the graphical image of it so it is more reliable for authentication because there is a biometric component to the creation of the handwritten image. If the digital signature file is sent electronically, it is subject to interception, copying, and later resubmission by parties other than the signer. The use of biometrics ensures that the unique physical characteristics of individuals can be converted into digital format to be recorded in a file and interpreted by a computer. Among

the widely used biometrics measures are voice patterns, fingerprints, and patterns present on the retina of one or both eyes. In this technology, physical characteristics are measured by a microphone, optical reader, or some other device, converted into digital code, and then compared with an authenticated copy of that characteristic stored in the computer.

Within this context, both Sudatel-Contracting and the Company-Contracting agents are represented as "packages" known as Sudatel-contracting and Company-contracting packages respectively. Interactions inside each package (among superior and subordinate agents) and among the different packages, are regarded as "communication relationships" that take place among "sending" and "receiving" agents as shown in Figure 4.

The open communication and evaluation processes that take place within the context of the multiagent-based contract formulation process are regarded as a change-effect spectrum as shown in Figure 5.

Interactions are governed by a variety of situation-specific considerations:

1. Information accessibility, use, update, and the capacity to reconfigure processes. While different methods can be used by different enterprises, the optimality of the entire multiagent organization calls for sufficient standardization. Fortunately, such interaction is made possible by the existence of a wide range of standard protocols and technologies including Internet Open Trading Protocols (IOTP), Financial Products Markup Language (FpML), the Joint Electronic Payment Initiative (JEPI), Information and Content Exchange (ICE) Protocol, and Simple Object Access Protocol (SOAP). The development of different language specifications (E-commerce Modeling Language, ECML; Trading Partner Agreement Markup Language, tpaML; xCBL; eBIS-XML) and frameworks (ebXML; BizTalk; UDDI, Universal Description, Discovery, and Integration), and eCo Framework has also improved the ability of the contracting parties to acquire, share, and reconfigure data.
2. Corporate knowledge base and agent-specific databases to facilitate interaction

Figure 4. Agent interaction context

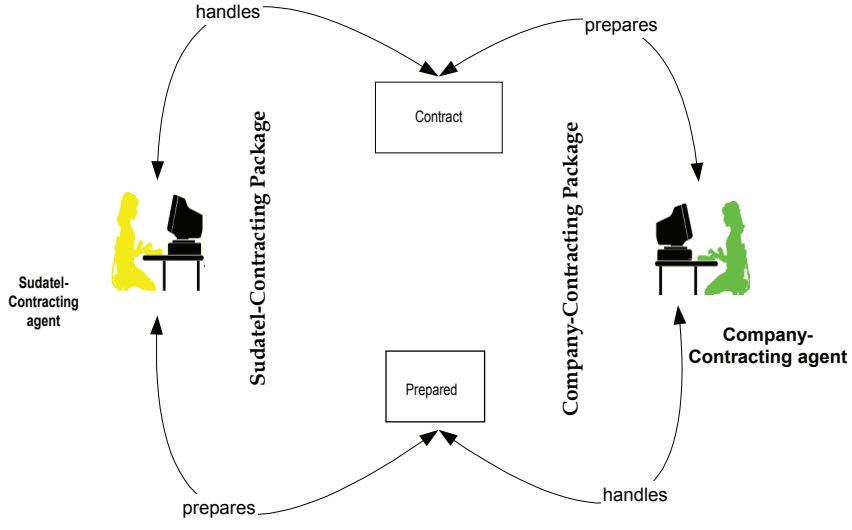
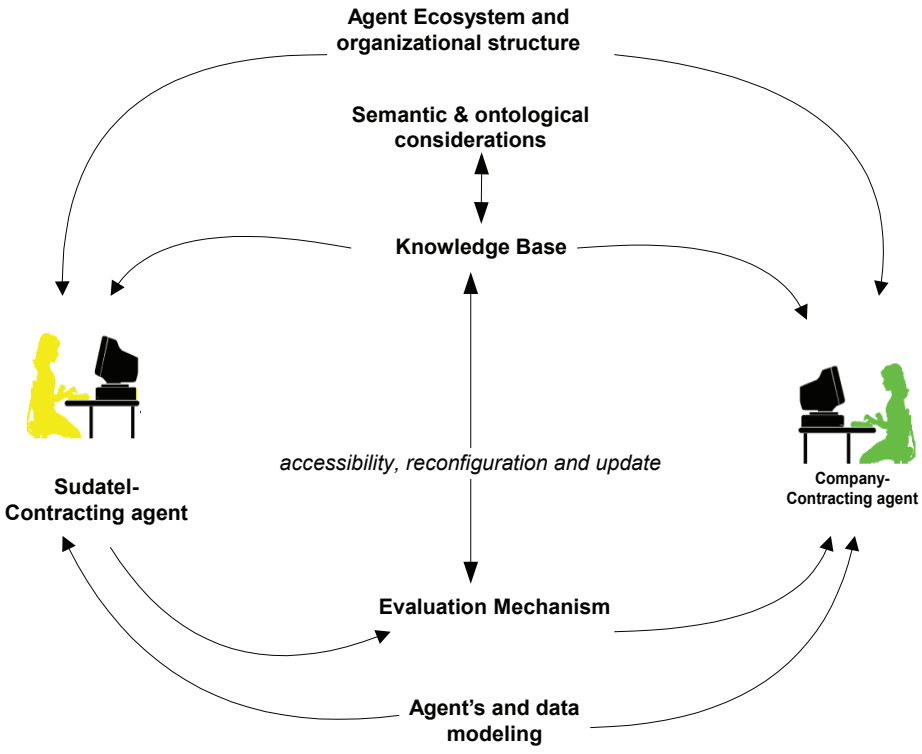


Figure 5. Agent interaction framework



and data processing. Data and knowledge bases are directly linked to the models used by agents (as individuals or groups) as well as to the dynamics of the ecosystem and interaction of the entire multiagent organization. It is also governed by some ontological and semiological artifacts.

3. An evaluation mechanism embedded into the agent's knowledge engine to guide efficient functioning within the entire context of multiagent data processing.

In addition to the concept of functional packages, interactions among agents are also viewed in terms of "comments" that describe the exchange of ideas and terms of trading, among others. As shown in Figure 6 the Sudatel-contracting-capability-hierarchy handles a capability named, for example, "evaluate comments" associated with [Sudatel-Contracting package].

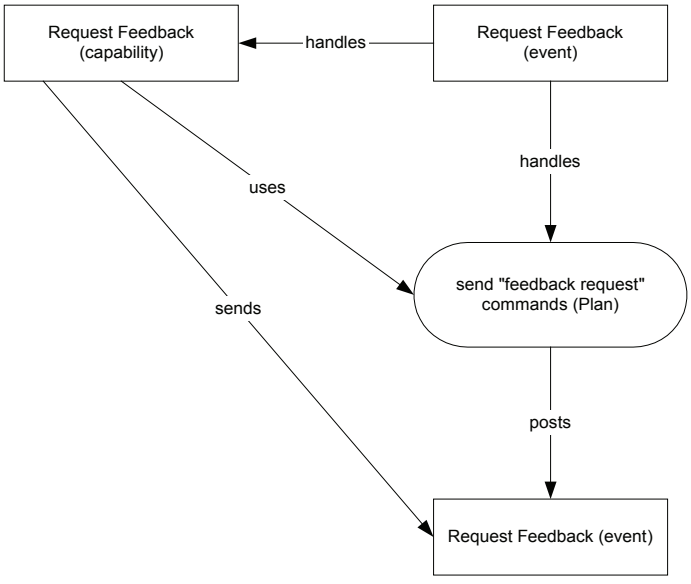
The implementation of such capability depends on the subsets of the final data-event-plan eiagram (DEP) that uses an "evaluate comment" plan to implement the "evaluate comment" event as shown in Figure 7.

It should also be noticed that "evaluating a comment" demands an evaluation mechanism as shown in Figure 5.

The same process is applied for the activities labeled "sending feedback," "requesting feedback," and "getting comments" among agents. Figure 8 below describes a diagram for the "requesting feedback."

All events can then be completed based on different data types using alternative reasoning and posting methods. A "request feeback" event, for example, can be implemented using the following syntax:

Figure 8. "Request feedback: EDP"




```
RequestFeedback (data type variable)
{
Fines = f;
Message."RequestFeedback "+data type vari-
able;
}
```

Then posting can be done using a reasoning method as follows:

```
@send (ev.package name, ev1.package name1
(ev.data variable));
```

DISCUSSION

The unprecedented transformations exhibited in the digital market urge enterprises to augment technological developments and improve their competitive advantages. The use of multiple tools and techniques offers a considerable advantage with regards to the process of modeling e-business architectures and processes. While available approaches are focusing on technological integration of traditional business activities, they offer limited functionality in modeling enterprise-wide processes as they tend to visualize the enterprise as an isolated entity. Based on the need for sophisticated integration and coordination mechanisms in the digital marketplace, e-business practices build on horizontal interconnections between networks and coupling of value chains (Xirogiannis & Glykas, 2007).

The use of multiagent technology to enhance the process of electronic contract formulation and the enhancement of electronic negotiation supports the migration from "conventional" to contemporary e-business models and strategies by advocating. Because change is the key challenge in contemporary e-business (Jackson & Harris, 2003; Phan, 2003), enterprises could move from the quadrant of "providing information" to stakeholders and users in a supply chain to Web-based interactions oriented towards the development and deployment of "enablers" like electronic payment and contracting and understand their consequencies on existing business strategies.

Because the proposed framework is based on the integrated functionality of multiple autonomous and semiautonomous agents capable of modeling routine and time-consuming

e-business processes (Albrecht, Dean & Hansen, 2003), Sudatel could enjoy the benefits of improved transaction processing and collective decision making utilizing large amounts of pre-existing concrete knowledge.

The proposed multiagent framework is flexible enough to be extended to include additional agents, learning mechanisms and agent-oriented capabilities necessary for addressing complex contractual interactions. By giving agents the ability to do cross-referencing of contracting information, they can potentially improve the outcome of contract formulation processes. While such functionalities could potentially improve the overall system efficiency, it also enables decision makers to improve their e-business strategies and models as well as their capacity to make interventions and accommodate unpredicted changes that take place at the destination of each agent. Such interventions aim at refining e-business related decisions (taken by agents and/or their owners) while considering the complexities associated with modeling the entire process of contract formulation.

Incorporating multiagent technologies at the backbone of enabling (e-payment and contracting) platforms allows Sudatel to investigate its capability to strategically manage technology-intensive acquisitions by addressing implementation related issues such as programming, representation, and integration. The effectiveness of Sudatel to model interactions associated with the process of electronic contract formulation improves its capacity to create conducive environments for the inclusion of the interests of different contracting companies originating from different countries with varying legal and trading regulations. Because the structure of the multiagent framework is designed in a reasonably domain independent, the robustness of its agent and agent interaction models can be improved by understanding (and learning from) the dynamics of individual negotiation behavior of different agents on the behavior of other ones as well as on the overall behavior of the multiagent system as a whole.

Because electronic contracting in Sudatel and other similar application domains as a part of an integrated e-business, models and strategies emphasis should be made on data management and integration. Preserving the integrity of corporate (sharable) database, data processing methods and information retrieval, and update algorithms assumes considerable importance because it affects the availability of management information. Particularly in developing countries, gaps experienced in time series of data originate from the nature of data and the applications using them. Some data types, such as those making up the spatial repository of the corporate database, are difficult to update because they are presented in map formats that require different processes to convert them into usable forms from raster to digital images. Data management issues also relate to addressing complexities associated with database inclusion dependencies in order to allow flexibility and the inclusion of different "schema" necessary for electronic negotiation, learning, and reconciliation.

Because the mechanism depends mainly on the use of Internet technology, there are other factors that affect the contribution of electronic contracting to e-business processes. One of the most important of these factors is content because the Internet enables parties to capture vast amounts of content at a very low cost (Lumpkin & Gregory, 2004) in the form of feedback and expertise and consequently supports the formulation of electronic contracts.

CONCLUSION

This article presented a typical approach for the formulation of electronic contracts to support the formulation and implementation of alternative e-business strategies and models using multiagent technologies. The approach proposed a new domain-based mechanism to supplement the current phases of status analysis and objectives setting of a typical electronic contract. While the framework contributes to the infrastructure of electronic commerce it also aims at improving the competitive advantage of

Sudatel and its responsiveness. By using multiagent systems, the proposed mechanism drew a causal representation (based on the identification of a role-and-task matrix) of the principles of electronic contract formulation. Therefore, their use simulates the operational efficiency of complex e-business models and the ability of decision makers to precisely understand the quantified impact of strategic change associated with the deployment of these models.

However, the proposed mechanism should not be regarded only as an effective e-business modeling support tool but also as a strategic framework for enterprises to migrate from "operational dashboards" guided by ready made contracts to intelligent, participative, and situation-specific contract formulation processes. Its main purpose, therefore, is to drive strategic change activities rather than limit itself to qualitative simulations. Moreover, it should not be seen as an end as a single decision aid but rather as a means for setting a course for continuous strategic alignment.

While forecasts show that international trade will continue to be more and more fragmented, labor and knowledge intensive and customer-centered, the deployment of information and communication technologies as enablers is expected to continue to "reshape" electronic business transactions. The migration from "traditional" to "electronic" contracts preserves the basic elements of the traditional contract (offer, acceptance, and compensation) and, at the same time, dictates new axioms for deciding on the place, timing, form of making an offer, acceptance styles, and presentation. Although electronic traders are worried about the uncertainties associated with electronic contracting, the unprecedented advancements in the filed of artificial intelligence, computing paradigms (mainly mobile, ubiquitous, and intelligent), and programming languages are expected to relax architectural considerations.

REFERENCES

Albrecht, C.C., Dean, D.D., & Hansen, J.V. (2003). Using situation calculus for e-business agents. *Expert Systems with Applications, 24*, 391-397.

Andrew, C., Sagnika, S., & Shao, B.M. (2006). Strategies for effective Web services adoption for dynamic e-businesses. *Decision Support Systems, 42*(2), 789-809.

Angelov, S., & Grefen, P. (2001). *B2B econtract handling: A survey of projects, papers and standards*. CTIT Technical Reports, 01(21). University of Twente. Retrieved February 12, 2007, from http://www.ub.utwente.nl/webdocs/ctit/1/0000005e.pdf

Angelov, S., & Grefen, P. (2004). The business case for B2B e-contracting. In *Proceedings of the Sixth International Conference on Electronic Commerce ICEC04: Towards a New Services Landscape* (pp. 31-40). Delft, The Netherlands.

Baum, M.S., & Perrit, H.H. (1991). *Electronic contracting, publishing, and EDI law.* John Wiley & Sons.

Boella, G., & van der Torre, L. (2004, July 19-23). Contracts as legal institutions in organizations of autonomous agents. In *Proceedings of AAMAS'04*, New York.

Chrysovalantou, M., & Petrakis, E. (2004). Business-to-business electronic marketplaces: Joining a public or creating a private. *International Journal of Finance and Economics, 9*, 99-112.

Daniel, B. (2003). *Electronic contracting in cross-media environments*. Retrieved February 12, 2007, from http://VirtualGoods.tu-ilmenau.de/2003/econtractingmedis.pdf

Daoud, F. (1998). A business contracting model for TINA architecture. *International Journal of Electronic Markets, 8*(3), 10.

Dellarocas, C. (2001). Negotiated shared context and social control in open multiagent systems. In R. Conte & C. Dellarocas (Eds.), *Social order in MAS.* Kluwer.

Dutta, S., & Segev, A. (1999). Transforming business in the market space. In *Proceedings of the 32nd Hawaii International Conference on System Science.*

El Fallah-Seghrouchni, A., Degirmenciyan, C.I., & Marc, F. (2004, July 19-23). Modelling,

control and validation of multi-agent plans in dynamic context. In *Proceedings of AAMAS'04*, New York.

Ervin, R. (2002). Chains of commitment software architecture. *ACM SIGecom Exchanges, 3*(1).

Gasmelseid, T. (in press). Engineering multiagent systems. *Encyclopedia of information ethics and security.* Hershey, PA: Idea Group Publishing.

Goodchild, A., Charles, H., & Zoran, M. (2002, June 5-6). Business contracts for B2B. In *Proceedings of the CAISE*00 Workshop on Infrastructure for Dynamic Business-to-Business Service Outsourcing*, Stockholm, Sweden.

Griffel, F., Boger, M., Weinreich, H., Lamersdorf, W., & Merz, M. (1998). Electronic contracting with COSMOS: How to establish, negotiate and execute electronic contracts on the Internet. In *Proceedings of the 2nd International Enterprise Distributed Object Computing Workshop (EDOC '98).*

Griffel, F., Tu, T., Münke, M., Merz, M., Lamersdorf, W., & da Silva, M. (1997, October 20-24). Electronic contract negotiation as an application niche for mobile agents. In *Proceedings of the 1st International Workshop on Enterprise Distributed Object Computing.*

Grosof, B.N. (2001). Representing e-business rules for rules for the Semantic Web: Situated courteous logic programs in RuleML. In *Proceedings of the Workshop on Information Technology.*

Grosof, B.N., Labrou, Y., & Chan, H.Y. (1999). A declarative approach to business rules in contracts: Courteous logic programs in XML. In *Proceedings of the 1st ACM Conference on Electronic Commerce (EC-99).*

Guttman, R., Moukas, H., Alexandros, G., & Maes, P. (1998). Agent-mediated electronic commerce: A survey. *Knowledge Engineering Review, 13*(3), 1-18.

Jackson, P., & Harris, L. (2003). E-business and organizational change. Reconciling traditional values with business transformation. *J. of Org. Change Management, 16*(5), 497-511.

Klusch, M. (2001). Information agent technology for the Internet: A survey. *Data & Knowledge Engineering, 36*(3), 337-372.

Koetsier, M., Paul, G., & Jochem, V. (2000). Contracts for cross-organizational workflow management. In *Proceedings of 1st International Conference on Electronic Commerce and Web Technologies* (pp. 110-121). London.

Lai, X., Manfred, A., Jeusfeld, A., & Paul, G. (2005). Detection tests for identifying violators of multi-party contracts. *ACM SIGecom Exchanges, 5*(3), 19-28.

Lee, J.K., & Lee, W. (1998). An intelligent agent-based competitive contract process: UNIKA-GENT. *International Journal of Intelligent Systems in Accounting, Finance & Management, 7*, 91-105.

Lindemann, M., & Runge, A. (1997). Permanent IT-support in electronic commerce transactions. *Electronic Market Architectures, International Journal of Electronic Markets, 7*(1).

Lumpkin, G.T., & Gregory, G.D. (2004). E-business strategies and Internet business models: How the Internet adds value. *Organizational Dynamics, 33*(2), 161-173.

Lundberg, M., Goldkuhl, G., & Nilsson, N. (1978). *Information systems development: A systematic approach.* Royal Institute of Technology and University of Stockholm, Dept of Information Processing and Computer Science, Stockholm, Sweden.

Merz, M., Frank, G., Tuan, T., Stefan, M., Harald, W., Marko, B., & Winfried, L. (1998). Supporting electronic commerce transactions with contracting services. *International Journal of Cooperative Information Systems, 7*(4), 249-274.

Milosevic, Z. (1995). *Enterprise aspects of open distributed systems*. Doctoral thesis, University of Queensland, Australia.

Milosevic, Z., & Bond, A. (1995). Electronic commerce on the Internet: What is still missing? In *Proceedings of the 5th Conference of the Internet Society* (pp. 245-254).

Pacheco, O., & Carmo, J. (2003). A role based model of normative specification of organized collective agency and agents' interaction. *Autonomous Agents and Multiagent Systems,* 6, 145-184.

Phan, D.D. (2003). E-business development for competitive advantages: A case study. *Information and Management, 40,* 581-590.

Reeves, D.M., Benjamin, N., Grosof, M., Wellman, P., & Chan, H.Y. (1999). *Towards a declarative language for negotiating executable contracts* (IBM Research Report RC 21476 (96914)).

Reeves, D.M., Wellman, M.P., & Grosof, B.N. (2002). *Automated negotiation from declarative contract descriptions* (Working Paper 4188-01, eBusiness@MIT;114). MIT Sloan School of Management.

Runge, A. (1998). The need for supporting electronic commerce transactions with electronic contracting systems. *Electronic Markets, 8*(1).

Runge, A., Schopp, B., & Stanoevska-Slabeva, K. (1999). The management of business transactions through electronic contracts. In *Proceedings of the 10th International Workshop on Database and Expert Systems Applications (DEXA'99),* Florence, Italy.

Sallé, M. (2002). An agent-based framework for the automation of contractual relationships. In *Proceedings of the AAAI-2002 Workshop on Agent-Based Technologies for B2B Electronic Commerce,* Edmonton, Alberta, Canada.

Sallé, M., & Bartolini, C. (2004). *Management by contract.* Palo Alto, CA: Trusted Systems Laboratory, HP Laboratories.

Schmid, B.F., & Lindemann, M. (Eds.). (1998). *Proceedings of the 31st Annual Hawaii International Conference on Systems Science, HICCS'98* (pp. 193-201).

Verdicchio, M., & Colombetti, M. (2002). Commitments for agent-based supply chain management. *ACM SIGecom Exchanges, 3*(1).

Wu, D., & Sun, Y. (2002). Cooperation in multiagent bidding. *Decision Support Systems, 33*(3), 335-347.

Xirogiannis, G., & Glykas, M. (2007). Intelligent modeling of e-business maturity. *Expert Systems with Applications, 32*(2), 687-702.

Tagelsir Mohamed Gasmelseid holds BSc, MSc, postgraduate diploma, MPhil and PhD degrees in information systems. He published several articles in referred journal and contributed to some international conferences. His research interests include multiagent, mobile and context aware systems, agent oriented software engineering and simulation, service oriented architectures and the use of software agents in management and decision support systems for electronic commerce and electronic government. He acted as head department, information systems in higher education institutions in Sudan and is currently teaching for the Department of Information Systems, College of Computer Sciences and Information Technology, King Faisal University in Saudi Arabia.