Pragmatic aspects in computer-supported negotiations of virtual enterprise contracts

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1 Introduction

In todays modern world, business organizations must concentrate on their core business ideas in order to remain competitive and at the same time outsource other functionality. The specialized enterprises need to network with other enterprises for the provision of competitive services. The result is a networked business organization, a virtual enterprise. The Internet has made it possible for organizations to search partners world-wide instead of only locally. The virtual enterprises are based on contracts that define the purpose of the virtual enterprise, the participants in it, and the rules of the virtual enterprise. The contract is expressed in an electronic form, as an eContract. Connecting organizations through the Internet requires new infrastructure support which consists of partner discovery and management of virtual enterprise life-cycle. A breeding environment is used to gather partners together and help through the early phases of the life-cycle, such as contract negotiation.

Pragmatic aspects in the virtual enterprise negotiations consist of issues like modeling the goals of participating enterprises, different social aspects in the negotiation process itself, and the execution of the negotiation process. The enterprises control their actions in a business domain using policies. The policies dictate which negotiations are taken part of and which issues are important in them. Social aspects include modeling and taking into account the business environment that an enterprise has. The enterprise might want to favor certain strategic partners that it already has. In the negotiation process itself it is important to solve dependencies between different issues or variables. Another important issue in the negotiation process is using a contract language to model the contract.

As a result of this work, we expect to create tools for enterprises to use during negotiations, and automating negotiation in routine cases, when entering business networks. The tools are used to model business policies and to help factor in the environment. A rule based system will provide the policy information for the automated negotiation system which will help in calculation of expected utility and risk in a given negotiation situation. Providing such assistance will help a decision maker in an enterprise to determine if joining a virtual enterprise is worth wile or not and what negotiation issues are important to consider.

2 Virtual Enterprise Management Environment

The Cinco research group has existing work on this area [5, 4]. The group has developed a middleware architecture and a prototype to address virtual enterprise management requirements. The middleware architecture describes a breeding environment and an operational time environment to facilitate the forming and management of virtual enterprises. The challenges on establishing virtual enterprises are as follows: interoperability and life-cycle management. Interoperability challenges are technical, semantical, and pragmatical. Technical challenges consist of low level technical problems such as mismatches on communication protocols. Semantical challenges include mismatches on knowledge representation and service semantics. Pragmatical challenges are related to the willingness of partners to cooperate and also business process management, non-functional aspects, and policy mismatches. Policy mismatches are situations where, for example, a partner has agreed to provide a certain document for another partner but refuses to do so because it violates its own local policies. Life-cycle management challenges consist of detecting and managing contract breach situations, partner changes, and updating the global state of the virtual enterprise.

The negotiation environment will be part of existing business-to-business collaboration middleware [5, 4]. Virtual organizations are comprised of independent participants with different services to provide, and thus jointly able to provide a more sophisticated and complete service. Partners for the virtual enterprise are selected using a population process which is based on meta-information regarding the topology of the virtual enterprise, the required service types, and the interaction properties of the service types. This PhD research aims to support forming of virtual enterprise by providing a computer supported negotiation environment.

Virtual organizations are modeled using a set of roles and connections between the roles. A role describes a set of requirements for the organization providing the role and the service that are provided in the network. The requirements describe how the role should behave in terms of technical communication by using, for example, a workflow description to determine which types of messages should be sent to and from the service and in which order they should be sent in order to get an expected result. The model also describes requirements for communication channels which are used for connecting two roles. Finally the model describes responsibilities for each role regarding for example data storage and other non functional aspects.

In previous work [7, 6] we have identified basic contents for virtual enterprise contracts. In summary, the contracts consist of behavior descriptions for each role, technical properties required by the communication channels, and policies which guide the behavior of the participating services. The behavior descriptions provide a basis for monitoring the services to detect breaches in contracts. The communication channel properties include transaction support and other low level communication properties.

In the Pilarcos middleware, a service called Populator [5] provides a set of technically interoperable service offers to be used in a virtual enterprise. The set

of interoperable services are used as a base for further negotiations between the selected partners to refine the contents of the contract. The finalized contract is then used for configuring the runtime environment [4] which monitors the behavior of the services, manages the global state of the virtual enterprise, and manages possible breaches detected by the monitoring services.

3 Challenges for the Negotiation System

The focus of the PhD research will be on developing a computer supported negotiation mechanism using multi-agent systems. The long term goal of this work is to build a system that is capable of independently deciding if an enterprise will participate in new virtual enterprises in routine cases. Routine cases are situations where the environment is well understood, risks are low, and the partners are previously known. The short term goal is to produce a decision support system to help determine if an enterprise wants to join a new virtual enterprise or not.

The negotiation system needs to take into account the needs and business goals of a partner and the benefit of a given commitment for the partner. A participating organization has multiple policies directing its behavior in the business environment. The participants can participate in multiple virtual enterprises at the same time. The policies of a virtual enterprise can be in conflict with the policies of the local organization. The conflict can be created because local policies change over time or because the organization has decided knowingly to join a virtual enterprise despite the conflict. When negotiating a contract to establish a virtual enterprise, the enterprise must take into account its own organizational policies and goals when deciding if a contract and its values are acceptable or not. The organization can also have existing business relationships with trusted partners. Because of this they may want to take into account the needs and goals of the trusted partners in some other virtual enterprise.

The formal basis for the negotiation system will be in distributed constraint satisfaction problems [9, 3] (DCSP). The basic model in DCSPs is distributing constraints to multiple agents, one constraint with each agent. There can be any number of variables which need to be consistent. Virtual enterprise negotiations are an extension to this model with multiple constraints for each agent (participant in a VE) and multiple variables. In the case of VE negotiations each agent has its own constraints for the variables and not all variables are shared by all parties. There can be different groups interested in different sets of variables. The constraints in VE negotiation are dictated by internal policies of a given participant and legal constraints from the business domain and area of the VE. The variables in VE negotiations can be multi-linked [10]. This means that there are dependencies between the variables and they cannot be ordered by importance in a clear and straight forward manner. Multi-linked variables also increase the complexity of inferring the optimal set of values for the variables. One example of two linked variables is price and quality. Usually one wants to maximize quality but not at any price.

Social aspects have an effect on the behaviour of a negotiation strategy of an enterprise. When a business is participating in multiple simultaneous virtual enterprises, it cannot be only self-interested. Self-interested means that an agent is only interested about maximizing its own gain in interaction with other agents. When forming new virtual enterprises the enterprises might want to favor their existing partners in other virtual enterprises. They might also use their existing knowledge of other participants to determine the risk levels in participating a new virtual enterprise. These aspects need to be taken into account when developing an environment to support multi-agent negotiations. An example of favoring a partner during the negotiation process is adjusting the expected gain of the enterprise to take into account the needs and gains of valued subcontracting partners.

Although there currently are many multi-agent platforms available [2, 8], it appears that the technique has not been applied to peer-to-peer business negotiations [1]. Most of the multi-agent negotiation systems focus on tasks such as scheduling jobs for execution between the agents or producer-consumer auction situations. Auction situations can be, for example, finding the lowest bidder for a subcontracting task and job scheduling is usually based on a set of tasks with deadlines and they must be distributed to a number of agents for execution and completed before the deadline of an individual task. Multi-agent negotiations for virtual enterprise forming differ from both examples in complexity and social aspects. Complexity is greater because you have to take into account more than just a price when considering a potentially long lasting business relationship between a number of partners. The participants have to take into account the social aspects created by multiple existing partners and the possibility of favoring already existing business relationships.

The foundation provided by DCSP will be extended to take into account the above stated issues. In particular the multi-linked variables and other social aspects have an effect on how expected utility is calculated during the negotiations. Another extension is to provide tools for the enterprises which allow them to model their policies in such a way that they can be used in the negotiations.

The research can be divided into three steps: state of the art survey, modeling of the negotiation environment and negotiation protocols, and experimentation and evaluation. The goal of the survey phase is to get a good overview of current multi-agent negotiation research and currently available multi-agent negotiation systems. During the survey a taxonomy of negotiation models will be developed. Another goal in the first phase will be identifying the different social aspects in the negotiations. In the modeling phase the goal is to produce a design for negotiation environment and model the negotiation protocols. The environment should be able to integrate a number of negotiation protocols which can be chosen based on the negotiation situation and its requirements. Petri nets will be used for modeling the negotiation protocols which will allow computational verification of some useful aspects of the protocols. These aspects include liveliness, boundedness, reachability and others [11]. The goal of experimentation

and evaluation phase is to do a concrete evaluation of the software design and do required refining of the concept modeling.

Currently the work is at an early state of the state of the art survey step. First ideas for the taxonomy have been developed. The main interests in the taxonomy are the concept of eContract, mechanisms for eCommunity creation, and the quality of the mechanisms. Interesting for eContract concept is what is it used to have control over: people, services, or enterprises. How the eContract is represented and what are the participants in the contract are also interesting. The mechanisms include negotiation models, how the eCommunity is established or the eContract signed, and how the structure of the eCommunity and eContract is defined. In the quality of the mechanisms we are interested in how the mechanisms take into account trust, privacy, and security; non-repudiation in the negotiations and overall; how they take into account business values; and correctness and efficiency of the mechanisms.

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