NEGOTIATION METHODS FOR COLLABORATIVE ACTIVITIES IN NETWORK ENTERPRISES

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Abstract

This paper provides a collaboration support for small and medium enterprises within a Network Enterprises which cannot or do not want to fulfill a major contract alone. In that case, in order to better meet a higher external demand, the managers are willing to subcontract parts of their contracts even to competitors.
This approach is illustrated by a business-to-business interaction, being proposed a scenario where partners are autonomous gas stations grouped in a virtual enterprise (VE). In such a VE, we present a schematic example of a collaboration process using negotiation and coordination mechanisms that we proposed in this paper.

Keywords*: Network Enterprises, Services, Cooperation, Collaboration, SME*

1. Introduction

Recent advances in the information technology have made possible the development of a new type of organization, the virtual organization. The concept of "Virtual Enterprise (VE)" or "Network of Enterprises" has emerged to identify the situation when several independent companies decided to collaborate and establish a virtual organization with the goal of increasing their profits. Camarinha-Matos[1] defines the concept of VE as follows: "A *Virtual Enterprise (VE)* is a temporary alliance of enterprises that come together to share skills and resources in order to better respond to business opportunities and whose cooperation is supported by computer networks".

Given this general context, the objective of the present paper is to develop a conceptual framework and the associated informational infrastructure that are necessary to facilitate the collaboration activities and, in particular, the negotiations among independent organizations that participate in a Network Enterprises.

The negotiation process was exemplified by scenarios tight together by a virtual alliance of the autonomous gas stations. Typically, these are competing companies. However, to satisfy the demands that go beyond the vicinity of a single gas station and to better accommodate the market requirements, they must enter in an alliance and must cooperate to achieve common tasks. The manager of a gas station wants to have a complete decision-making power over the administration of his contracts, resources, budget and clients. At the same time, the manager attempts to cooperate with other gas stations to accomplish the global task at hand only through a minimal exchange of information. This exchange is minimal in the sense that the manager is in charge and has the ability to select the information exchanged.

When a purchasing request reaches a gas station, the manager analyses it to understand if it can be accepted, taking into account job schedules and resources availability. If the manager accepts the purchasing request, he may decide to perform the job locally or to partially subcontract it, given the gas station resource availability and technical capabilities. If the manager decides to subcontract a job, he starts a negotiation within the collaborative infrastructure with selected participants. In case that the negotiation results in an agreement, a contract is settled between the subcontractor and the

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[1] Camarinha-Matos L.M. and Afsarmanesh H.,(2004), *Collaborative Networked Organizations,* Kluwer Academic Publisher Boston.

contractor gas station, which defines the business process outsourcing jobs and a set of obligation relations among participants[2].

The gas station alliance scenario shows a typical example of the SME virtual alliances where partner organizations may be in competition with each other, but may want to cooperate in order to be globally more responsive to market demand.

The collaborative infrastructure, that we describe, should flexibly support negotiation processes respecting the autonomy of the partners.

We are starting with a presentation in Section 2 of a VE life cycle model. Then, we are briefly describing in Section 3 the architecture of the collaboration system in which the interactions take place[3].

The main objective of this paper is to propose a collaboration framework in a dynamical system with autonomous organizations. In Section 4 we define the Coordination Components that manage different negotiations which may take place simultaneously.

In Sections 5 and 6 we present the model of the negotiation process, that can be used by describing a particular case of negotiation, and the negotiation algorithm. Finally, Section 7 concludes this paper.

2. The main steps of the Virtual Enterprise life cycle

The life cycle of virtual enterprise is classified into six phases. The relevance in different phases is shown in Figure 1 and the statement for each phase is given as follows:

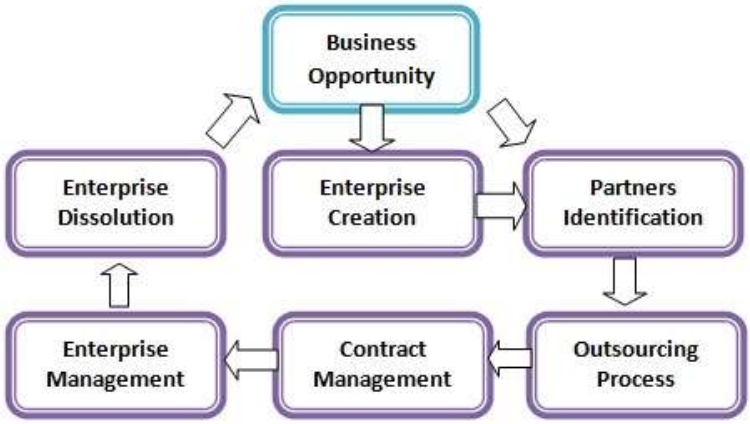

Figure 1. Life-cycle of a virtual enterprise

a) VE creation

When a business opportunity is detected, there is a need to plan and create the VE, identify partners, establish the contract or cooperation agreement among partners, in order to manage the processes of the VE.

[2] Singh M.P., (1997) *Commitments among autonomous agents in information-rich environments*. In Proceedings of the 8th European Workshop on Modelling Autonomous Agents in a Multi-Agent World (MAAMAW), pp. 141–155.

[3] Cretan, A., Coutinho, C., Bratu, B., and Jardim-Goncalves, R., NEGOSEIO: A Framework for Negotiations toward Sustainable Enterprise Interoperability. Annual Reviews in Control, 36(2): 291–299, Elsevier, ISSN 1367-5788, 2012, http://dx.doi.org/10.1016/j.arcontrol.2012.09.010.

b) Partners search and selection

The selection of business partners is a very important and critical activity in the operation of a company. Partners search can be based on a number of different information sources, being private, public, or independent. The enterprise's private suppliers' list is a data repository that contains information about the companies that have had commercial relationships with this enterprise. This information composes an *Internal Suppliers Directory (ISD)*. External sources include directories maintained by industrial associations, commerce chambers, or Internet services. This information composes the *External Suppliers Directory (ESD)*. Another emerging solution is the creation of clusters of enterprises that agreed to cooperate and whose skills and available resources are registered in a common *SME Cluster Directory* (CD).

c) Outsourcing of tasks within a VE

In this stage of a VE life cycle, we can assume that a gas station company receives a customer demand. In this respect, the Manager of this company may negotiate the outsourcing of a schedule tasks that cannot perform locally with multiple partners of selected gas station companies, geographically distributed. The Manager can select the partners of the negotiation among the database possible partners according to their declared resources and the knowledge he has about them.

The outcome of a negotiation can be "success" (the task was fully outsourced), "failure" (no outsourcing agreement could be reached) or "partial" (only part of the task could be outsourced).

d) Contract management in the VE

In case the negotiation process ends in a successful, a contract is established between the outsourcing company and the insourcing ones. The contract is a complex object, which is based of trust in this coordination mechanism. Moreover, it contains a set of specific rules, such as penalties, expressing obligation relations between the participants.

In case of failure of a partner, the Manager will have to supervise if the obligations are honored (for example to oblige the partner to finish his work or to set penalties) and to modify the business process renegotiating parts of the work that have not been realized.

e) Management of the VE

A VE is a dynamic entity in which a new company may join or leave it. Members may need to leave for many reasons, when they change their activity or when they don't want any more to collaborate with the partners of the VE. In case of departure from the VE, the leaving partner may either notify all the partners. It also may leave without giving any information. The departure of a partner from the VE will have an important impact on ongoing contracts especially when this partner is an insourcer of an important amount of task.

f) VE dissolution - after stopping the execution of the business processes.

3. The Collaborative Infrastructure

The main objective of this software infrastructure is to support collaborating activities in virtual enterprises. In VE partners are autonomous companies with the same object of activity, geographically distributed.

Taking into consideration, the constraints imposed by the autonomy of participants within VE, the only way to share information and resources is the negotiation process.

Figure 2 shows the architecture of the collaborative system:

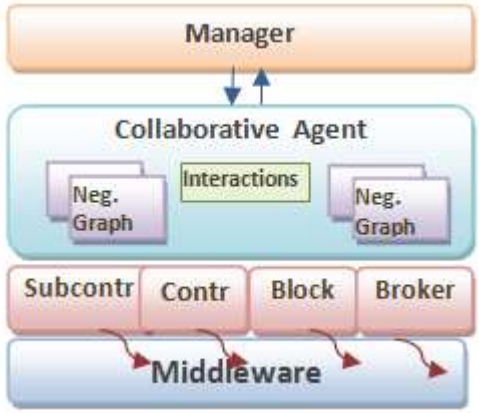

Figure 2. The architecture of the collaborative system

This infrastructure is structured in four main layers: Manager, Collaborative Agent, Coordination Components and Middleware. A first layer is dedicated to the Manager of each organization of the alliance. A second layer is dedicated to the Collaborative Agent who assists its gas station manager at a global level (negotiations with different participants on different jobs) and at a specific level (negotiation on the same job with different participants) by coordinating itself with the Collaborative Agents of the other partners through the fourth layer, Middleware[4]. The third layer, Coordination Components, manages the coordination constraints among different negotiations which take place simultaneously.

A Collaborative Agent aims at managing the negotiations in which its own gas station is involved (e.g. as initiator or participant) with different partners of the alliance.

Each negotiation is organized in three main steps: initialization; refinement of the job under negotiation and closing[5]. The initialization step allows to define what has to be negotiated (Negotiation Object) and how (Negotiation Framework)[6]. A selection of negotiation participants can be made using history on passed negotiation, available locally or provided by the negotiation infrastructure (Zhang and Lesser, 2002). In the refinement step, participants exchange proposals on the negotiation object trying to satisfy their constraints (Barbuceanu and Wai-Kau, 2003). The manager may participate in the definition and evolution of negotiation frameworks and objects (Keeny and Raiffa, 1976). Decisions are taken by the manager, assisted by his Collaborative Agent (Bui and Kowalczyk, 2003). For each negotiation, a Collaborative Agent manages one or more negotiation objects, one framework and the negotiation status. A manager can specify some global parameters: duration; maximum number of messages to be exchanged; maximum number of candidates to be considered in the negotiation and involved in the contract; tactics; protocols for the Collaborative Agent interactions with the manager and with the other Collaborative Agents (Faratin, 2000).

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[4] Bamford J.D., Gomes-Casseres B., and Robinson M.S., *Mastering Alliance Strategy: A Comprehensive Guide to Design, Management and Organization*. San Francisco: Jossey-Bass, 2003.

[5] Sycara K., *Problem restructuring in negotiation*, in Management Science, 37(10), 1991.

[6] Smith R., and Davis R., *Framework for cooperation in distributed problem solving*. IEEE Transactions on Systems, Man and Cybernetics, SMC-11, 1981.

4. Coordination Components

In order to handle the complex types of negotiation scenarios, we propose different components[7]:

- *Subcontracting* (resp. *Contracting*) for subcontracting jobs by exchanging proposals among participants known from the beginning;
- *Block* component for assuring that a task is entirely subcontracted by the single partner;
- *Broker*: a component automating the process of selection of possible partners to start the negotiation;

These components are able to evaluate the received proposals and, further, if these are valid, the components will be able to reply with new proposals constructed based on their particular coordination constraints[8].

From our point of view the coordination problems managing the constraints between several negotiations can be divided into two distinct classes of components:

Coordination components in closed environment**:** components that build their images on the negotiation in progress and manage the coordination constraints according to information extracted only from their current negotiation graph (*Subcontracting, Contracting, Block)*;

Coordination components in opened environment: components that also build their images on the negotiation in progress but they manage the coordination constraints according to available information in data structures representing certain characteristics of other negotiations currently ongoing into the system (*Broker)*.

Following the descriptions of these components we can state that unlike the components in closed environment (*Subcontracting, Contracting, Block)* that manage the coordination constraints of a single negotiation at a time, the components in opened environment (*Broker)* allow the coordination of constraints among several different negotiations in parallel[9].

The novelty degree of this software architecture resides in the fact that it is structured on four levels, each level approaching a particular aspect of the negotiation process. Thus, as opposed to classical architectures which achieve only a limited coordination of proposal exchanges which take place during the same negotiation, the proposed architecture allows approaching complex cases of negotiation coordination. This aspect has been accomplished through the introduction of coordination components level, which allows administrating all simultaneous negotiations in which an alliance partner can be involved.

The coordination components have two main functions such as: i) they mediate the transition between the negotiation image at the Collaboration Agent level and the image at the Middleware level; ii) they allow implementing various types of appropriate behavior in particular cases of negotiation. Thus we can say that each component corresponding to a particular negotiation type.

Following the descriptions of this infrastructure we can state that we developed a framework to describe a negotiation among the participants to a virtual enterprise. To achieve a generic coordination framework, nonselective and flexible, we found necessary to first develop the structure of the negotiation process that helps us to describe the negotiation in order to establish the general environment where the participants may negotiate. To develop this structure, we proposed a succession of phases that are specific to different stages of negotiation (initialization, negotiation, contract adoption) that provided a formal description of the negotiation process.

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[7] Cretan A., Coutinho C., Bratu B. and Jardim-Goncalves R., *A Framework for Sustainable Interoperability of Negotiation Processes.* In INCOM'12 14th IFAC Symposium on Information Control Problems in Manufacturing, 2011.

[8] Vercouter, L., *A distributed approach to design open multi-agent system*. In 2nd Int. Workshop Engineering Societies in the Agents' World (ESAW), 2000.

[9] Muller H., *Negotiation principles.* Foundations of Distributed Artificial Intelligence, 1996.

The advantage of this structure of the negotiation process consists on the fact that it allows a proper identification of the elements that constitute the object of coordination, of the dependencies that are possible among the existing negotiations within the VE, as well as the modality to manage these negotiations at the level of the coordination components.

5. The Negotiation Coordination Model

This section proposes a formal model to settle and manage the coordination rules of one or more negotiations which can take place in parallel, by describing the basic concepts underlying the model, and the negotiation model using the metaphor of Interaction Abstract Machines (IAMs). The Program Formula is described to define the methods used to manage the parallel evolution of multiple negotiations.

Basic concepts

In this setup, at a local level, the model requires a formal description of the rules of coordination that manage the behavior of the agent in a negotiation; at a global level, the model must provide a global coordination of all negotiations of an agent.

The fundamentals of the negotiation model are given by the following basic concepts:

A *Negotiation Model* is defined as a quintuple M = <T, P, N, R, O> where:

- T denotes the *time of the system*, assumed to be discrete, linear, and uniform[10];
- P denotes the *set of participants* in the negotiation framework. The participants may be involved in one or many negotiations;
- N denotes the *set of negotiations* that take place within the negotiation framework;
- R denotes the *set of policies of coordination* of the negotiations that take place within the negotiation framework;
- denotes the *common ontology* that consists of the set of definitions of the attributes that are used in a negotiation.

A *negotiation* is described at a time instance through a set of negotiation sequences.

Let Sq = {si | i $\in \mathbb{N}$} denote the set of *negotiation sequences*, such that $\forall$si ,sj $\in$ Sq, i $\neq$ j implies si $\neq$ sj. A *negotiation sequence* si $\in$ Sq such that si $\in$ N(t) is a succession of negotiation graphs that describe the negotiation N from the moment of its initiation and up to the time instance *t*. The negotiation graph created at a given time instance is an oriented graph in which the nodes describe the negotiation phases that are present at that time instance (i.e., the negotiation proposals sent up to that moment in terms of status and of attributes negotiated) and the edges express the precedence relationship between the negotiation phases.

The *negotiation phase* (*ph*) indicates a particular stage of the negotiation under consideration.

The *Status* is the possible state of a negotiation. This state takes one of the following values (*Status* $\in${*initiated, undefined, success, failure*}):

- *initiated* – the negotiation, described in a sequence, has just been initiated;
- *undefined* – the negotiation process for the sequence under consideration is ongoing;
- *success* – in the negotiation process, modeled through the sequence under consideration, an agreement has been reached;
- *failure* – the negotiation process, modeled through the sequence under consideration, resulted in a denial.

[10] Hurwitz, S.M., *Interoperable Infrastructures for Distributed Electronic Commerce.* 1998, http://www.atp.nist.gov/atp/98wpecc.htm.

Issues is the set of attributes with associated values that describe the proposals made in a negotiation phase.

Snapshot is the set of combinations between a negotiation aspect (*Status*) and the information that is negotiated (*Issues*).

The functions *status* and *issues* return, respectively, the state (status) of a negotiation instance and the set of the attributes negotiated (issues) within a negotiation instance.

Metaphor Interaction Abstract Machines (IAMs)

The metaphor Interaction Abstract Machines (IAMs) will be used to facilitate modelling of the evolution of a *multi-attribute, multi-participant, multi-phase negotiation*. In IAMs, a system consists of different *entities* and each entity is characterized by a state that is represented as a set of *resources*. It may evolve according to different laws of the following form, also called "*methods*":

A1@…@An <>- B1@…@Bm

A method is executed if the state of the entity contains all resources from the left side (called the "*head*") and, in this case, the entity may perform a transition to a new state where the old resources *(A1,...,An)* are replaced by the resources *(B1,...,Bm)* on the right side (called the "*body*"). All other resources of the entity that do not participate in the execution of the method are present in the new state.

The operators used in a method are:

- the operator @ assembles together resources that are present in the same state of an entity;
- the operator <>- indicates the transition to a new state of an entity;
- the operator & is used in the body of a method to connect several sets of resources;
- the symbol "T" is used to indicate an empty body.
- In IAMs, an entity has the following characteristics:
- if there are two methods whose heads consist of two sets of distinct resources, then the methods may be executed in parallel;
- if two methods share common resources, then a single method may be executed and the selection procedure is made in a non-deterministic manner.

In IAMs, the methods may model four types of transition that may occur to an entity: *transformation*, *cloning*, *destruction* and *communication*. Through the methods of type *transformation* the state of an entity is simply transformed in a new state. If the state of the entity contains all the resources of the head of a transformation method, the entity performs a transition to a new state where the head resources are replaced by the body resources of the method. Through the methods of type *cloning* an entity is cloned in a finite number of entities that have the same state. If the state of the entity contains all the resources of a head of a cloning method and if the body of the method contains several sets of distinct resources, then the entity is cloned several times, as determined by the number of distinct sets, and each of the resulting clones suffers a transformation by replacing the head of the method with the corresponding body. In the case of a *destruction* of the state, the entity disappears. If the state of the entity contains all the resources of the head of a transformation method and, if the body of the method is the resource T, then the entity disappears.

In IAMs, the *communication* among various entities is of type broadcasting and it is represented by the symbol "^". This symbol is used to the heads of the methods to predefine the resources involved in the broadcasting. These resources are inserted in the current entity and broadcasted to all the entities existent in the system, with the exception of the current entity. This mechanism of communication thus executes two synchronous operations:

- *transformation*: if all resources that are not predefined at the head of the method enter in collision, then the predefined resources are inserted in the entity and are immediately consumed through the application of the method;

• *communication*: insertion of the copies of the predefined resources in all entities that are present in the system at that time instance.

6. Negotiation Algorithm

In the proposed scenario, a conflict occurs in a network of enterprises, threatening to jeopardize the interoperability of the entire system. The first step consists in identifying the Enterprise Interoperability issue. The following steps refer to analyse the problem, evaluate possible solutions and select the optimal solution. The proposed solution for conflict resolution is reaching a mutual agreement through negotiation. The benefit of this approach is the possibility to reach a much more stable solution, unanimously accepted, in a shorter period of time.

The design and coordination of the negotiation process must take into consideration[11]:

• Timing (the time for the negotiation process will be pre-set);

• The set of participants to the negotiation process (which can be involved simultaneous in one or more bilateral negotiations);

• The set of simultaneous negotiations on the same negotiation object, which must follow a set of coordination policies/ rules;

• The set of coordination policies established by a certain participant and focused on a series of bilateral negotiations[12];

• Strategy/decision algorithm responsible for proposals creation (Olteanu, 2012);

• The common ontology, consisting of a set of definitions of the attributes used in negotiation.

The negotiation process begins when one of the enterprises initiate a negotiation proposal towards another enterprise, on a chosen negotiation object. We name this enterprise the Initiating Enterprise (E1). This enterprise also selects the negotiation partners and sets the negotiation conditions (for example sets the timing for the negotiation) (Schumacher, 2001). The negotiation partners are represented by all enterprises on which the proposed change has an impact. We assume this information is available to E1 (if not, the first step would consist in a simple negotiation in which all enterprises are invited to participate at the negotiation of the identified solution. The enterprises which are impacted will accept the negotiation) (Kraus, 2001).

After the selection of invited enterprises (E2 … En), E1 starts bilateral negotiations with each guest enterprise by sending of a first proposal. For all these bilateral negotiations, E1 sets a series of coordination policies/rules (setting the conditions for the mechanism of creation and acceptance of proposals) and a negotiation object/framework (NO/NF), setting the limits of solutions acceptable for E1. Similarly, invited enterprises set their own series of coordination policies and a negotiation object/framework for the ongoing negotiation.

After the first offer sent by E1, each invited enterprise has the possibility to accept, reject or send a counter offer. On each offer sent, participating enterprises, from E1 to E2 ... En follow the same algorithm:

Algorithm: Pseudocode representation of the negotiation process

Inputs: Enterprises *E1...En; NO(Negotiation Object); NF(Negotiation Framework)*

Outputs: The possible state of a negotiation: *success, failure*

```
BEGIN
on receive start from E1{
      send initial offer to partner;
```

[11] Oancea B., Andrei T., Rosca Ion Gh., Iacob A., *Parallel algorithms for large scale econometric models*. 1st World Conference on Information Technology 2010, published in Procedia Computer Science, volume 3, pp. 479-483, 2011.

[12] Ossowski S., *Coordination in Artificial Agent Societies*. Social Structure and its Implications for Autonomus Problem-Solving Agents, No. 1202, LNAI, Springer Verlag, 1999.

```
}
on receive offer from partner{
      evaluate offer;
      if(conditions set by the NO/NF are not met){
            offer is rejected;
            if(time allows it){
                  send new offer to partner;
            }else{
                  failure;
            }end if;
      }else{
            send offer to another partner;
      }end if;
      if(receive an accepted offer){
            if(offer is accepted in all bilateral negotiations){
                  success;
            }else{
                  if(time allows it){
                        send new offer to partner;
                  }else{
                        failure;
                  }end if;
            }end if;
      if(receive a rejected offer){
            if(offer is active in other bilateral negotiations){
                  failure in all negotiations;
            }end if;
      }end if;
}
END
```

7. Conclusions

The functioning of this kind of alliance suppose task achievement, which cannot be individual treated, by a single participant for better adjustment of the clients requirements.

The proposed infrastructure aims to help the different SMEs to fulfill their entire objectives by mediating the collaboration among the several organizations gathered into a virtual enterprise.

A specific feature that distinguishes the negotiation structure proposed in this work from the negotiations with imposed options (acceptance or denial) is that it allows the modification of the proposals through the addition of new information (new attributes) or through the modification of the initial values of certain attributes (for example, in the case of gas stations the gasoline price may be changed).

The business-to-business interaction context in which our activities take place forces us to model the unexpected and the dynamic aspects of this environment. An organization may participate in several parallel negotiations. Each negotiation may end with the acceptance of a contract that will automatically reduce the available resources and it will modify the context for the remaining negotiations.

In the current work we've described in our collaboration framework only the interactions with the goal to subcontract or contract a task. A negotiation process may end with a contract and in that case the supply schedule management and the well going of the contracted task are both parts of the outsourcing process.

In order to illustrate our approach we have used a sample scenario where distributed gas stations have been united into virtual enterprise. Take into consideration this scenario, one of the principal objectives was related to the generic case and means that this proposed infrastructure can be used in other activity domains.

Regarding research perspective continuation, one first direction which can be mentioned is the negotiation process and the coordination process taking into consideration the contracts management process. In this way the coordination can administrate not only the dependence between the negotiations and the contracts which are formed and with execution dependences of those contracts.

Another perspective is to deliver to the user one instrument which allows him negotiation protocol definition according with the restrained negotiation interactions possibilities. Consequent, this will be a problem of coordination on which the infrastructure must solve on negotiation protocol administration and protocol build perspective.

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