# AGENT-BASED NEGOTIATION PLATFORM IN COLLABORATIVE NETWORKED ENVIRONMENT

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**Abstract**

*This paper proposes an agent-based platform to model and support parallel and concurrent negotiations among organizations acting in the same industrial market. The underlying complexity is to model the dynamic environment where multi-attribute and multi-participant negotiations are racing over a set of heterogeneous resources. The metaphor Interaction Abstract Machines (IAMs) is used to model the parallelism and the non-deterministic aspects of the negotiation processes that occur in Collaborative Networked Environment.*

**Keywords**: *Negotiation model, Web Services, Collaborative Networked Environment, computing platform, multi-agent systems.*

## 1. Introduction

The advent of the Internet and of the cloud-computing trend have led to the development of various forms of virtual collaboration in which the organizations are trying to exploit the facilities of the network to achieve higher utilization of their resources. In this collaborative networked environment, enterprises are developing business areas dedicated to the purpose of finding and complying with the best set of partners and suppliers for solutions that are aligned with the enterprise's strategy.

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 this paper is to develop a software platform that facilitates the collaboration activities and, in particular, the negotiations among independent organizations that participate in a Network Environment.

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.

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

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 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.

In this respect, we present in Section 2 the theoretical background of this topic. 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 an IT collaboration platform in a dynamical system with autonomous organizations. In Section 4 we define the Coordination Services 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. Theoretical background

Ensuring sustainable interoperability among organizations in a networked environment is a crucial factor in order to successfully manage collaborations at all levels: abstract (business); concrete (technology), including informational (information vs. data); functional (activity vs. service); and behavioral (process vs. workflow). Outlining the crucial position of information systems (IS) inside an organisation, Benaben et al. (Benaben et al.,2012) state that the main issue is to ensure that IS of the partners involved in the collaboration are able to work together to constitute a coherent and homogeneous set of IS - the IS of the collaborative situation. To address this issue, Benaben et al. (Benaben et al. 2012) and Benaben and Pingaud (Benaben and Pingaud, 2010) propose the Mediation Information System Engineering Project (MISE Project) which aims at providing collaborating organizations with a mediation information system (MIS) able to support the interoperability of a collaborative network. The project takes a model-driven approach to develop a complete MIS design method, taking into account the semantic reconciliation between business and technical levels.

In the same area, Coutinho et al. (Coutinho et al., 2012) define a framework to support Sustainable Interoperability using Model-Driven Architectures (MDA), Model-Driven Interoperability (MDI), Service-Oriented Architectures (SOA) and Ontologies. The framework allows businesses to build higher inter-knowledge to achieve stronger interoperability. Agostinho et al. (Agostinho et al., 2011) propose a framework which applies MDA transformations to data models to maintain an interoperable peer-to-peer (P2P) connection between two applications. According to Panetto (Panetto, 2007) the Model Driven

[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

Interoperability (MDI) is considered a major methodology for achieving Enterprise Interoperability (EI), adopting the MDA layers for the development of a model-morphims that implements the transformations among different enterprise models in the deployment of interoperable enterprise systems.

Jardim-Goncalves et al. (Jardim-Goncalves et al., 2012) state that interoperability issues have arisen when using instances of meta-models from different sources, and identify semantic annotation, ontology harmonization, and merging as examples of important methods for the Enterprise Interoperability Science Base (EISB).

An enterprise information system is generally composed of a multitude of applications able to answer certain enterprise needs. Izza (Izza, 2009) considers the integration of enterprise information systems a crucial problem due to the applications composing the information systems of the companies that increasingly require working together. The author states that the heterogeneity of enterprise applications is the major challenge of the integration problem due to the multiple technical, syntactical and semantic conflicts that concern these applications. This requires a mediation process to deal with these differences.

Many research papers (Dutra et al., 2010) take the approach of using ontologies to address the semantic integration and interoperability issues, to deal with the se-mantic heterogeneity of such an environment. Zdravkovic et al. (Zdravkovic et al., 2011) takes the approach of semantic enrichment of the Supply Chain Operations Reference (SCOR) model using Web Ontology Language (OWL), enabling effective knowledge management in supply chain networks and facilitating the semantic interoperability of systems.

To support the continuous evolution of ontologies, Khattak et al. (Khattak et al., 2011) propose to reestablish the mappings among dynamic ontologies by using the changing history of ontology. This has the benefit of reducing the time required for reconciling mappings among ontologies, compared to already existing systems that completely reinitiate the process.

Also, ontologies play an important role in the development of Multi-Agent Sys-tems (MAS) for the semantic web due to the heterogeneity of agents. Thus, Laclavík et al. (Laclavík et al., 2012) state that the lack of the interconnection with semantic web standards such as OWL is the main disadvantage of MAS. In this respect, the authors develop a semantic knowledge agent model that can be used in an agent-based application where such interconnection is needed.

The issue of using a common ontology has been approached in many works, such as the one of Torres and Wijnands (Torres and Wijnands, 2011). Although benefi-cial in many ways, the use of a common ontology becomes much more complex when it deals with multiple application fields in what regards creation, updates and efficient structure. In this respect, Sarraipa et al. (Sarraipa et al., 2010a) present MENTOR methodology based on the mediator ontology concept which assists the semantic transformation among each organization’s ontology and the referential one. Additionally, the authors (Sarraipa et al., 2010b) propose to use MENTOR as the collaborative ontology-building methodology, enriched with Qualitative Information Collection Methods (QICM), in order to improve the approach to elicit knowledge from business domain experts.

The increasing exchange of knowledge, resources and expertise among virtual organisations in a collaborative environment has led to many conflicting situations. For solving the conflicts, different kinds of research approaches have been applied, from automatic resolution (Haya et al. 2006) to mediated resolution approach (Shin et al. 2007). Later works (Shin et al. 2008, 2010) combine automatic resolution with social mediation for resolving conflicts among users. According to the authors, the automatic resolution approach is used when the decision is simple or close to what all users expects, while the social mediation involves negotiating a resolution, and is performed by recommending possible candidates. It is used when the decision is complex or different from what at least one of the users expects.

The negotiation approach plays a key role in solving the conflicts that may occur in a collaborative dynamic environment (Oliveira and Camarinha-Matos, 2012). However, the inadaptability of agents to evolving negotiation protocols, and the ambiguity of the agents' negotiation term are the main issues that can arise during agent interactions (Dong et al., 2008), (Mazuel and Sabouret, 2009). Thus, semantic interoperability is an important issue in a networked enterprise (Jeon et al., 2011). The same idea of using of ontologies technology in order to settle the knowledge conflicts and to solve semantic ambiguity has been extended into the field of automated negotiation research (Chen et al., 2012). In this regard, Wang et al. (Wang et al., 2011) propose an ontology-based knowledge representation approach to provide a semantic interoperable environment to realize automatic negotiations in a virtual collaborative environment.

The final goal of the negotiation process consists in reaching a common agreement among parties in order to support possible collaborations. In this respect, Oliva et al. (Oliva et al., 2010) propose a framework, called SANA (Supporting Artifacts for Negotiation with Argumentation), that incorporates intelligent components able to mediate the agents participating in negotiation to reach an agreement by inferring mutually–acceptable proposals. This solution of using an artificial intelligent mediator can be found in other researches on argumentation based-negotiation, particularly in systems designed for public deliberation (Ahmadi and Charkari, 2010), (Tolchinsky et al., 2011). Although beneficial in many ways, the approach of using an intelligent mediator for guiding the participating agents in the decision-making process would limit the autonomy of participants while increasing the power of the mediator. In the later work, (Ahmadi et al., 2011) the proposed e-negotiation system solves the problem of multi-issue negotiations. In addition, the system is based on the multi-agent systems approach in which agents can make autonomous negotiation decisions.

Many recent papers (Jazayeriy et al., 2011), (Oancea et al., 2011), (Ciucu et al., 2013), (Oancea et al., 2013a), (Oancea et al., 2013b) provide a review on the progress of soft-computing (SC) techniques used in e-negotiation. Their approach is based on the idea that using a combination of soft computing techniques, such as: Fuzzy Logic (FL), Neural networks (NN), Genetic algorithm (GA) and Probabilistic reasoning (PR) can decrease the complexity of negotiation making it closer to real world negotiation.

## 3. The IT Collaborative Platform

The main objective of this software platform 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 1 shows the architecture of the collaborative system:

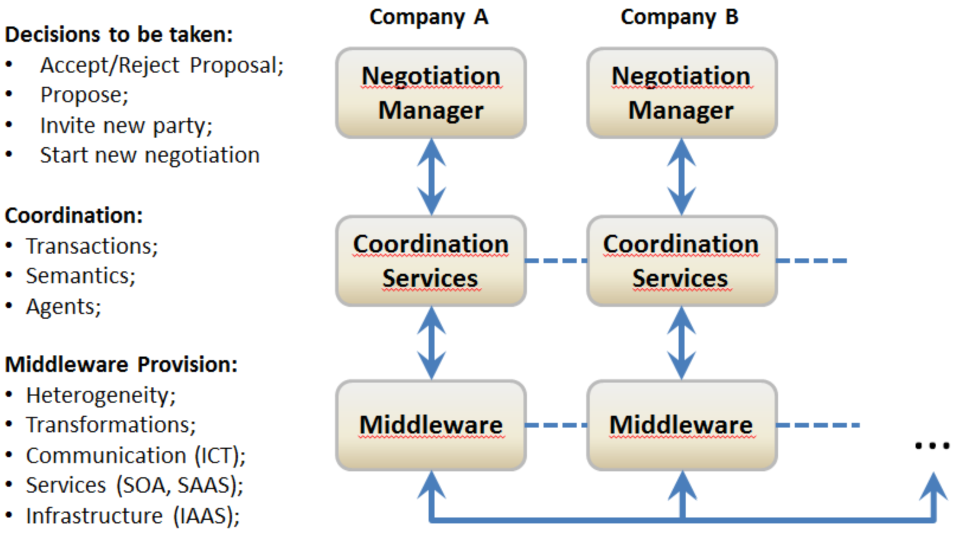


**Figure 1. The architecture of the collaborative system**

This architecture is structured in three main layers: Negotiation Agent and Manager, Coordination Services and Middleware. A first layer is dedicated to the Negotiation 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 Negotiation Agents of the other partners through the third layer, Middleware[4]. The second layer, Coordination Services, manages the coordination constraints among different negotiations which take place simultaneously.

A Collaborative Negotiation 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).

[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 Services

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

- *Subcontracting* (resp. *Contracting*) for subcontracting jobs by exchanging proposals among participants known from the beginning;
- *Block* service for assuring that a task is entirely subcontracted by the single partner;
- *Broker*: a service automating the process of selection of possible partners to start the negotiation;
- *Split:* a service manages the propagation of constraints among several slots, negotiated in parallel and issued from the split of a single job.

These services are able to evaluate the received proposals and, further, if these are valid, the services 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 services:

- Coordination Services in closed environment**:** services 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, Split)*;
- Coordination Services in opened environment: services 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 services we can state that unlike the services in closed environment (*Subcontracting, Contracting, Block, Split)* that manage the coordination constraints of a single negotiation at a time, the services 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 Services level, which allows administrating all simultaneous negotiations in which an alliance partner can be involved.

The Coordination Services 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

[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.

negotiation (initialization, negotiation, contract adoption) that provided a formal description of the negotiation process.

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 Services.

## 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 $M = \langle T, P, N, R, O \rangle$ 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;
- O 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 $Sq = \{si \mid i \in \mathbb{N}\}$ 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;

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

*failure* – the negotiation process, modeled through the sequence under consideration, resulted in a denial.

*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. The Negotiation Scenario

In the proposed scenario, a conflict occurs in a network of enterprises, threatening to jeopardize the interoperability of the entire system. According to our proposal regarding the negotiation, the participants to a negotiation may propose offers and each participant may decide in an autonomous manner to stop a negotiation either by accepting or by rejecting the offer received. Also, depending on its role in a negotiation, a participant may invite new participants to the negotiation. In order to illustrate this approach, we present a schematic example of a negotiation process (Figure 2).

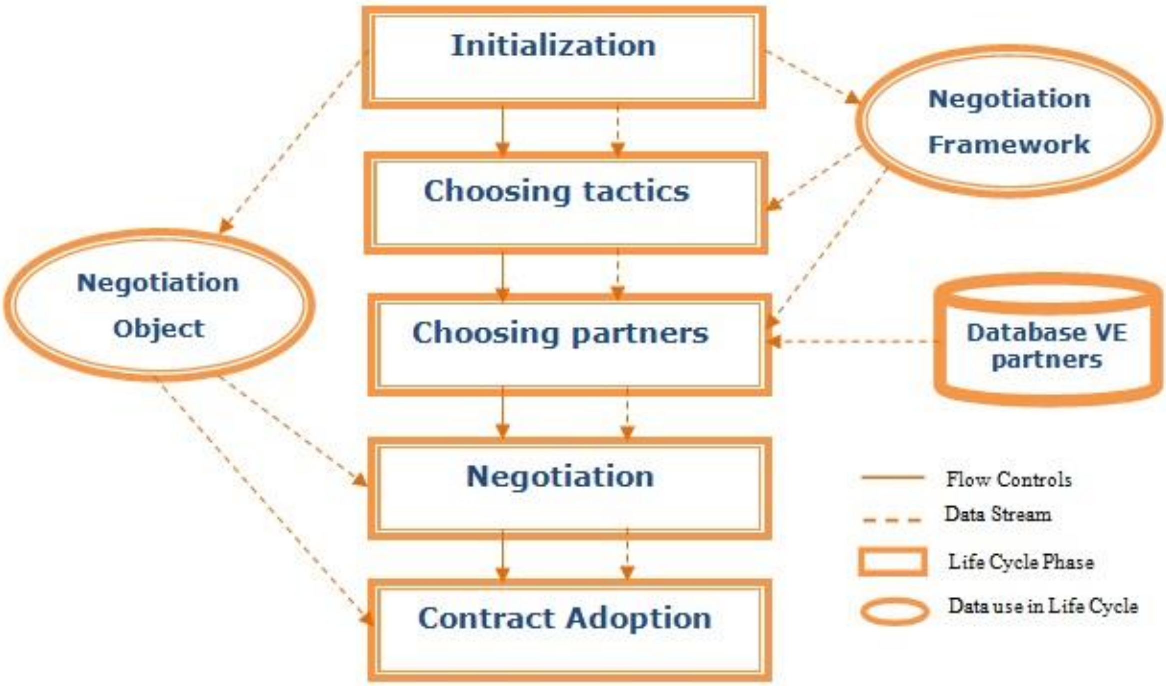


**Figure 2. The structure of the negotiation process**

The negotiation process is divided into five parts (initialization, choice of tactics, choice of partners, negotiation and contract adoption).

*Initialization*. The Manager initiates a subcontracting of a task, defining and communicating to the Collaborative Agent the properties and the constraints of the negotiation object and the negotiation framework. The negotiation process begins by creating an instance of the component Subcontracting. This instance will initiate other stages of negotiation, based on constraints provided by the Manager: the invitation of the coordination components (*Contracting*, *Broker*, etc.). Moreover, this instance will conduct negotiations in terms of construction and evaluation of proposals for subcontracting proposed task;

*Choosing tactics:* Using the negotiation tactics specified in the framework, the coordination is decomposed into several coordination schemes. Two tactics correspond to two coordination schemes: Block and Split;

*Choosing partners:* The possible choices of partners are: i) Among known partners:

The Chief Negotiator initiating the outsourcing can specify any constraints on the set of possible contractors. To do this, the Chief Negotiator uses the description of the job to be outsourced and also the database partners within the collaborative networked environment and/or the different adhesion contracts they signed; ii) Among unknown partners: in this case, the entire research activity of the potential partners is managed by the infrastructure through the Broker component;

*Negotiation:* At this stage, during the exchange of proposals, the negotiation object evolves according to the constraints imposed by the Chief Negotiator on the negotiated attributes of the outsourcing task. The objective of the negotiation stage is to build an Instantiated Negotiation Object (e.g., a negotiation object whose attributes have been accepted by all partners) from the initial specification of the negotiation object. After that, this object will be used to establish a contract;

*Contract Adoption:* In this final stage, the negotiation object has fixed values. The Chief Negotiator validates the result of negotiation and makes contact with other partners within the Negotiation Environment. Thus, the Chief Negotiator may decide: i) To restart or to suspend negotiations; ii) To enable the contracting process that will state an agreement.

The negotiation process involves several parties (for several bilateral negotiations), each having different criteria, constraints and preferences that determine their individual areas of interest. Criteria, constraints and preferences of a participant are partially or totally unknown to the other participants. The job under negotiation is described as a multi-attribute object. Each attribute is related to local constraints and evaluation criteria, but also to global constraints drawing dependencies with other attributes.

In conclusion, the proposed architecture manages in a decentralized manner the coordination of multi-phase negotiations on a multi-attribute object and among several participants, featuring:

- The definition of the negotiation process structure: participants, interaction protocol, negotiation protocol, tactics and coordination services, the negotiation object and the negotiation strategies;
- Modeling of all negotiations in which a participant may be involved in the form of a set of bilateral negotiations.

Thus, we can say, that we have proposed an infrastructure that manages, in a decentralized manner, the coordination of multi-phase negotiations on a multi-attribute object and among a lot of participants.

## 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 platform aims to help the different enterprises 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 platform 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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