A NEGOTIATION MODEL FOR COLLABORATIVE ACTIVITIES

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Abstract

This paper proposes a collaborativ system 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.

Keywords: *Negotiation, Collaborative Activities, Multi-agent system, Web components*

1. Introduction

To be able to perform, enterprises need to exchange information, whether this exchange is internal (among departments of the enterprise), external (between the enterprise or part of it and an external party), or both. Enterprise Interoperability (EI) is thus defined as the ability of an enterprise to seamlessly exchange information in all the above cases, ensuring the understanding of the exchanged information in the same way by all the involved parties[1]. Large enterprises accomplish this by setting market standards and leading their supply chain to comply with these standards. Small and Medium Enterprises (SMEs) usually don't have the empowerment to do so, and are therefore more sensible to the oscillations of the environment that involves them, which leads them to the need to constantly change to interoperate with their surrounding ecosystem. Sustainable EI (SEI) is thus defined as the ability of maintaining and enduring interoperability along the enterprise systems and applications' life cycle. Achieving a SEI in this context requires a continuous maintenance and iterative effort to adapt to new conditions and partners, and a constant check of the status and maintaining existing interoperability[2].

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 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[3] 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".

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.

In Section 2 we are describing the architecture of the collaboration system in which the interactions take place[4]. In Section 3 we define the Coordination Components that manage different negotiations which may take place simultaneously. In Sections 4 we present the negotiation approach that can be used by describing a particular case of negotiation, and, finally, Section 5 concludes this paper.

2. The Collaborative Negotiation Architecture

The main objective of this software infrastructure is to support collaborating activities in virtual

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[1] M.-S. Li, R. Cabral, G. Doumeingts, and K. Popplewell, "Enterprise Interoperability Research Roadmap," no. July. European Commision - CORDIS, p. 45, 2006.

[2] R. Jardim-Goncalves, A. Grilo, C. Agostinho, F. Lampathaki, and Y. Charalabidis, "Systematisation of Interoperability Body of Knowledge: the foundation for Enterprise Interoperability as a science," Enterprise Information Systems, vol. 6, no. 3, pp. 1-26, 2012.

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

[4] 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.

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:
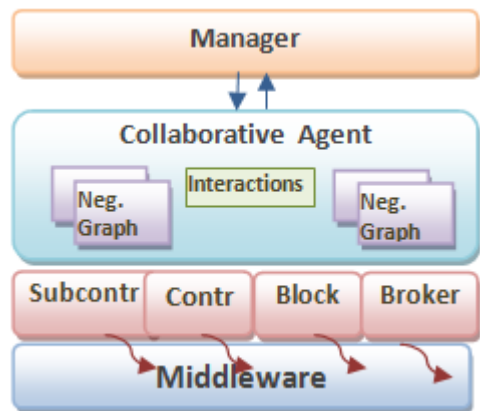

Fig. 2 The architecture of the collaborative system

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[5]. The third layer, Coordination Components, manages the coordination constraints among different negotiations which take place simultaneously.

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). 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[7].

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).

3. Coordination Negotiation Components

In order to handle the complex types of negotiation scenarios, we propose different components[8]:

o *Subcontracting* (resp. *Contracting*) for subcontracting jobs by exchanging proposals among participants known from the beginning;

o *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[9].

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

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[5] 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.

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

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

[8] 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.

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

constraints among several different negotiations in parallel[10].

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. In the next sub-sections we will describe the *Subcontracting* and *Contracting* components.

3.1. Subcontracting Component

The *Subcontracting* component is the main component of a negotiation. The automatic negotiation process is initiated by creating an instance of this component starting from the initial negotiation object. Further, this component must build the negotiation graph by following the negotiation requirements (i.e., assessment and creation of proposals and coordination rules). The component meets these requirements by manipulating the Xplore primitives [14].

Besides these functionalities, the *Subcontracting* component has to interpret and check the negotiation constraints, which are set up in the following two data structures : *Negotiation Object* and *Negotiation Framework*.

The information provided by the structure of the Negotiation Object on the possible values of the attributes to be negotiated allow easily the *Subcontracting* component to check whether the proposals received concern the attributes negotiated in the current negotiation and if they are associated to the values of the intervals specified.

For example, assuming that the Negotiation Object requires that the price should be (*cost <= 10k)*, the *Subcontracting* component can stop the continuation of the negotiation in the phases associated to the white nodes where the proposals are outside the interval.

Also, by using the *partner* coordination attribute, the *Subcontracting* component can make known to the other components the participants imposed by the Negotiation Object or whether other components instantiate this attribute. In this regard, the *Subcontracting* component can easily check if the associated value confirms the constraints imposed by the Manager.

At middleware level, the *Subcontracting* component has also the function of administrating the transactional aspect of the negotiation. This component is seen like a *coordinator* and has the role to conclude an agreement among the component instances participating in the same negotiation.

Another *Subcontracting* component functionality is to interpret and execute the tactics specified in the Negotiation Framework structure by connecting a combination of different instances of the other components.

Thus, the *Subcontracting* component as well as the *Contracting* component described below are those connecting the aspects specified at the Negotiation Agent level and their implementation at the coordination components level.

3.2. Contracting Component

The *Contracting* component manages the negotiation from the organization side deciding to accept a task proposed in the collaborative networked environment, with some functionalities similar to those of the *Subcontracting* component.

The differences come from the fact that this component does not have a complete picture on the negotiation and that, at the beginning of the negotiation, it has no information about what is negotiated or about the constraints of its Manager.

Therefore, looking to the differences, we can say at first that the image of the *Contracting* component on the negotiation graph is limited to the data referring only to its direct negotiation with the *Subcontracting* component or with another component negotiating for the organization having initiated the negotiation.

Secondly, unlike the *Subcontracting* component, which, from the beginning, has constraints specified by the Manager within the data structures of the *Negotiation Object* and the *Negotiation Framework*, the *Contracting* component has a close interaction with its own Manager on the new aspects required in the negotiation.

Thus, depending on attributes required by the negotiation initiator the *Contracting* component is able to progressively build the data structures describing the Manager's preferences on the negotiation object and on the negotiation process.

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

4. Negotiation Approach

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:

1. Timing (the time for the negotiation process will be pre-set);
2. The set of participants to the negotiation process (which can be involved simultaneous in one or more bilateral negotiations);
3. The set of simultaneous negotiations on the same negotiation object, which must follow a set of coordination policies/ rules;
4. The set of coordination policies established by a certain participant and focused on a series of bilateral negotiations[11];
5. Strategy/decision algorithm responsible for proposals creation;
6. 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.

The algorithm is shown below: 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;
}
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
```

5. Conclusions

This paper proposes a collaborative e-platform for sustainable interoperability by modeling and managing of parallel and concurrent negotiations, which aims to open the market to broader discovery of opportunities and partnerships, to allow formalization and negotiation knowledge to be passed to future negotiations and to properly document negotiation decisions and responsibilities. The negotiation activities typically fail because they are often based on tacit knowledge and

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

these activities are poorly described and modeled. Also as negotiations occur in a closed environment, many external potential interested parties are not aware of them and do not subscribe them. This makes negotiations reach poorer results or fail by disagreement or exhaustion. The integration of formal procedures for modeling, storing and documenting the negotiation activities allows an optimized analysis of the alternative solutions and by adding the analysis of lessons-learned on past activities leads to maximized negotiation results, stronger negotiation capabilities and relationships.

Currently, interoperability among the involved parties in a negotiation is often not reached or maintained due to failure in adapting to new requirements, parties or conditions. The use of an adaptive platform as proposed will result in a seamless, sustainable interoperability which favours its maintenance across time; the ability to reach and interoperate with more parties leads to more business opportunities and to stronger and healthier interactions.

The sequence of this research will comprise the completion of this negotiation framework with the contract management process and a possible renegotiation mechanism.

With respect to the framework middleware, future research shall include handling issues regarding the security and resilience of the stored negotiation data in the cloud, and managing privacy aspects as the negotiating parties should be able to seamlessly interoperate but still to maintain their data free from prying eyes; also several issues need to be solved from non-disclosure of participating parties to secure access to the negotiation process.

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