COLLABORATIVE E-PLATFORM FOR SUSTAINABLE ENTERPRISE INTEROPERABILITY

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Abstract

The pursuit for better competitiveness has driven companies to develop dedicated business areas to handle the seeking for new partnerships, with its inherent need for interoperation. Current Enterprise Interoperability is sensible to the entropy associated to external factors, making it easy to break loose. In order to accommodate the changes that are needed, constant periodic adaptations must be performed. If this adaption imposes new concepts that conflict with the existing ones, this may implicate loss of interoperability with other partners or a massive change on all partners. This paper proposes a collaborative platform to support negotiations of the interoperability entities towards interoperability of organisations acting in the same industrial market, using a model-driven, cloud-based infrastructure and services.

Keywords: *ePlatform, Sustainable Enterprise Interoperability, Negotiation, Services, Network Enterprises, SME, Virtual Enterprise.*

1. Introduction

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. In a world where new solutions, platforms, trends, standards and regulations keep evolving, this task needs to be continuous, together with constant update of each enterprise's solutions, interfaces, methods and quality.

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].

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[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".

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

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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

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 contractor gas station, which defines the business process ***outsourcing*** jobs and a set of obligation relations among participants[4].

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.

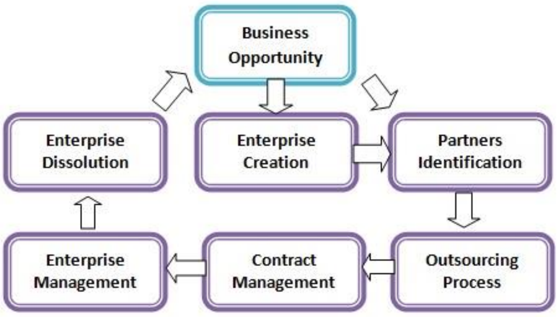
We are starting with a presentation in Section 2 of a VE life cycle model. In Section 3 we emphasize the importance of the Service-Oriented Architectures (SOA). Then, we are briefly describing in Section 4 the architecture of the collaboration system in which the interactions take place[5].

The main objective of this paper is to propose a collaboration framework in a dynamical system with autonomous organizations. In Section 5 we define the Coordination Components that manage different negotiations which may take place simultaneously. In Sections 6 and 7 we present the model of the negotiation process that can be used by describing a particular case of negotiation, and the negotiation algorithm. Section 8 describes the Infrastructure for Sustainable Interoperability and, finally, Section 9 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) <u>VE creation</u>

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.

b) <u>Partners search and selection</u>

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) <u>Outsourcing of tasks within a VE</u>

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) <u>Contract management in the VE</u>

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

[4] 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

[5] 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

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. Services over Cloud-based Systems

In the last decade, Service-Oriented Architectures have contributed to an extraordinary improvement towards interoperability. Web Services have reshaped the existing concepts of solution deployment and provisioning, and paved the way for other important concepts using the same paradigm, like functional discovery and subscription in common repositories, orchestration and composition of services into more complex ones (Papazoglou et al, 2008).

More recently, another important concept is rocking the standards and reshaping the face of the digital world. Cloud-based solutions or Cloud Computing is not actually a new concept or major breakthrough in terms of technology but rather a business concept towards the idea of distributed computing existing for ages. Cloud-based solutions may be roughly split into the concepts of on-demand storage and server availability (Infrastructure as a Service or IaaS), on-demand platform integration (Platform as a Service or PaaS) and on-demand processing availability (Service as a Service or SaaS) (Bui et al, 2003); this concept also boosted interoperability, with a special favouring for SMEs (Jeffery et al, 2010). Solutions can now be developed in small, inexpensive proof-of-concepts, and if proven correct, rapidly be scaled into large solutions, reducing dramatically time-to-market and allowing companies to be able to plan peak workloads without the burden of keeping infrastructures on lower workloads thus enhancing agility and flexibility for businesses. Interoperability using services in a cloud-based environment ensures flexibility towards changes due to e.g. new requirements, semantic heterogeneity, thus contributes to sustainable interoperability.

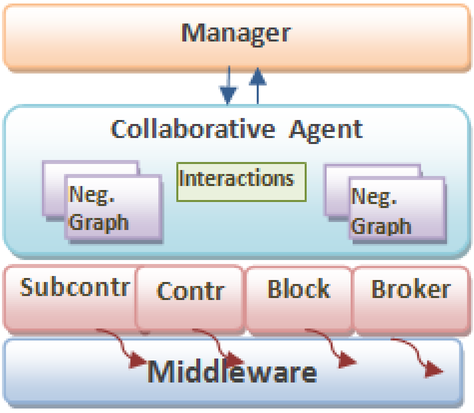
4. The Collaborative Infrastructure

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[6]. 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[7]. The initialization step allows

[6] 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

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

to define what has to be negotiated (Negotiation Object) and how (Negotiation Framework)[8]. 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).

5. Coordination Components

In order to handle the complex types of negotiation scenarios, we propose different components[9]:

- *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[10].

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[11].

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.

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.

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

[9] 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

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

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

6. 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[12];
- 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 | 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.

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.

7. 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:

- 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[13];
- Strategy/decision algorithm responsible for proposals creation;
- 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).

[12] Hurwitz, S.M., *Interoperable Infrastructures for Distributed Electronic Commerce.* 1998, http://www.atp.nist.gov/atp/98wpecc.htm
[13] Ossowski S., *Coordination in Artificial Agent Societies*. Social Structure and its Implications for Autonomus Problem-Solving Agents, No. 1202, LNAI, Springer Verlag, 1999.

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;
}
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
```

8. Infrastructure for Sustainable Interoperability

The framework that implements the underlying negotiation model shall rely on principles that allow interoperability to become reinforced, such as knowing as detailed as possible the interoperability model.

The first step is to model the basic foundations (services and infrastructure) of the framework in a MDA CIM which shall define the negotiation concepts (e.g. the IAM states), then transform it to a PIM (Grilo et al, 2006) to achieve a higher independence of external factors and to have a clear model of the negotiation partners' model; this PIM may afterwards be transformed for each negotiation partner into its platform-specific PSM set of services.

Another problem which is one of the most importantly blamed for loss of interoperability is about differences in other aspects e.g. business models, semantics, concepts, meanings and behavior. By using Model-Driven Interoperability (MDI), a CIM model shall be created consisting on shared understanding regarding concepts, business models, semantic reasoning, and related aspects of the negotiating parties (e.g. agreed term meanings, negotiation behaviours), which then is transformed into a corresponding PIM where semantic ontologies (Sarraipa et al, 2010) are defined, and furthermore, to each negotiation partner's specific PSM databases and services. This way, any interoperability change should be reflected in the corresponding model and thus be able to be assimilated by the other parties.

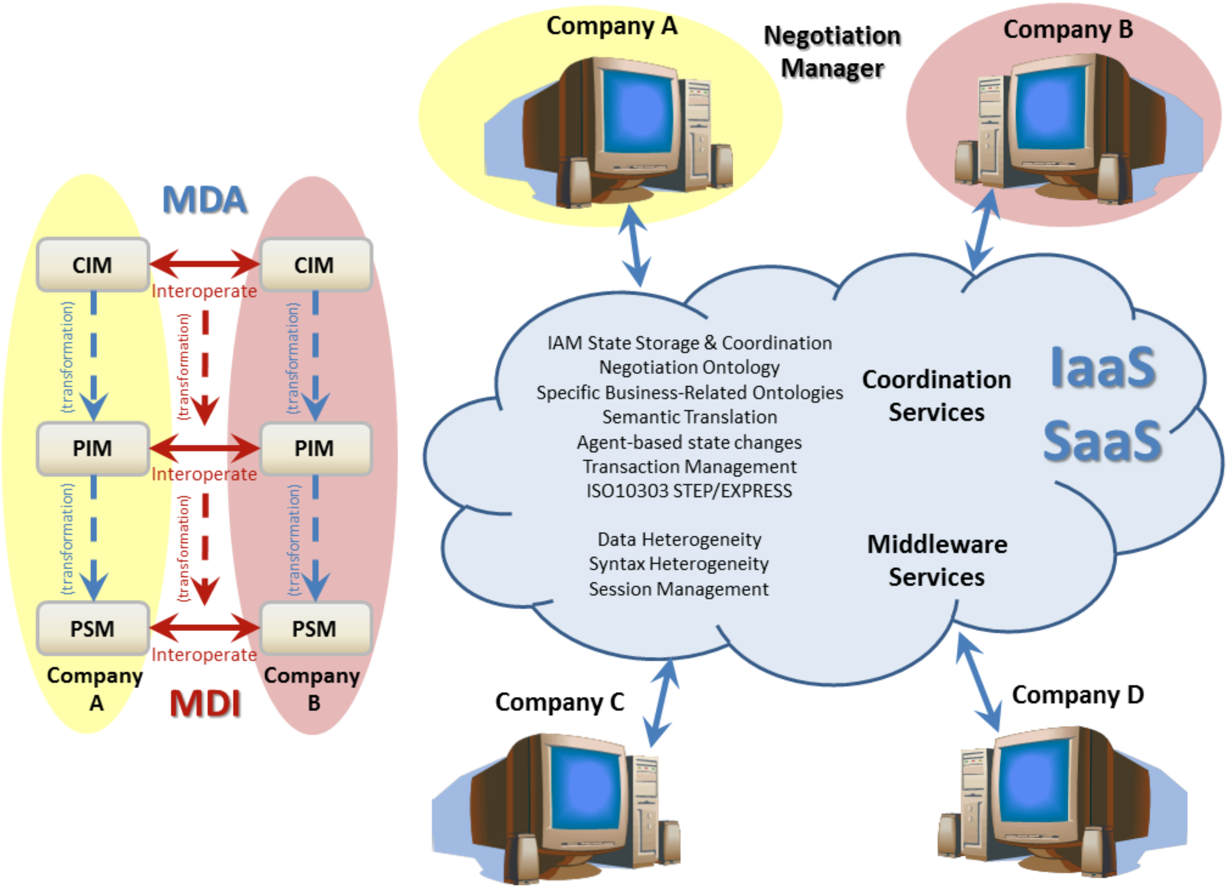
Regarding the information exchange, behaviour and other aspects of the interoperability itself, the negotiation framework shall be built using the popular, simple, flexible and robust Services and SOA (Papazoglou et al, 2008). In order to manage the issues regarding size and scalability, the SOA platform for the framework shall be implemented on top of a Cloud-based system (Jardim-Goncalves et al, 2010). The resulting infrastructure shall then be hosted by a SaaS business paradigm (Bui et al, 2003), ensuring the handling of all heterogeneity issues (e.g. communications, syntax, session, data) of the basic Middleware layer of the framework, on top of which a richer set of services (Coordination Services layer) shall be built. These services shall perform more complex activities like Transaction Management, the definition and management of the negotiation data model, storage and management of the negotiation data and business states which will implement the model rules.

The negotiation IAM states change accordingly to the defined logic; to implement this logic, the authors propose an agent-based environment where agents are programmed to be responsible in the monitoring and management of all changes in the environment that may lead to a state change.

Actually, data access, its models and data exchange can also be a problem for interoperability.

Negotiation parameters, Ontologies and other entities rely on data modeling, specification and consistency and therefore the best way to define the data models and the data exchange is to use a standard (Ciucu et al, 2013). In this case the selected solution is to model the data for databases and data access using the ISO10303 STEP (Jardim-Goncalves et al, 2006) and EXPRESS language specification. The database infrastructure itself, as well as the whole model-driven framework infrastructure shall also be implemented over Cloud, using an IaaS platform (Jeffery et al, 2010). Figure 3 shows the architecture of the Framework for Sustainable Interoperability.

Figure 3.The architecture of the Framework for Sustainable Interoperability



9. 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 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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