Open Negotiation Environment: An Open Source Self-Learning Decentralised Negotiation Framework for Digital Ecosystems[1]

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Abstract— The Digital Ecosystem (DES) paradigm and consequently Digital Business Ecosystems (DBE) are powerful emerging inter-company cooperative structures. One of the main advantages of an ecosystem is the enabling of alliances among companies with complementary or even competitive competences in order to be able to provide complex offerings beyond the capabilities of a single company. The process of negotiation and contracting of complex services that can be provided in a cooperative manner by member companies of the ecosystem is an essential binding element among them. The intention of this paper is to explain how the Open Negotiation Environment (ONE) will extend DES research providing sophisticated negotiations processes and supporting tools, enriched by learning and optimisation capabilities, that will allow an organisation to dynamically package and compose complex services by negotiating alliances.

***Index Terms*—digital ecosystems, negotiation, contracts, open source, .**

I. INTRODUCTION

The James Moore[2] vision [i] of Business Ecosystems has been partially supported by the Web 2.0 and more recently by the achievements in B2B networking systems that have enabled enterprises to efficiently cooperate. An essential element of ecosystems is the negotiation of alliances, which enable companies to join competences as well as services and products into a complex offering. Given this, Business Ecosystems[3] should be empowered with a tool supporting tactical negotiation and agreement processes among participants. This environment shall support the creation of Virtual Organisations with a common business goal, and facilitate the building, stabilising and improving of the ecosystem performance on a more reduced time frame.

This aspect is also highlighted in the paper "Towards a network of digital business ecosystems fostering the local development"[4] where it is possible to read *"...the dynamic networking of the organisations, drives to the dynamic cooperation of the players"* and that *"This will dramatically affect the ways enterprises are constructed and business is conducted in the future, and the actual slowly changing organisations will be replaced by more, fluid, amorphous and, often, transitory structures based on alliances, partnerships and collaboration"*.

However, in most commercial negotiation environments, where some negotiation feature is implemented, the network of intermediaries/suppliers is static and centrally regulated. New entrants must strictly adhere to the centrally defined business rules and data formats of the technological infrastructure. In fact, current solutions (like the "marketplace") are proprietary, managed and pushed by strong intermediaries or big suppliers, and typically squeeze the small independent ones. The small suppliers cannot enter the network as full members and are faced with a severe digital divide: they are basically left out of large markets.

The first and prime example of a DES implementation, which tries to overcome the above mentioned drawbacks, is the Digital Business Ecosystem Project (DBE), which has been defined by the project team[5] as "*...an open-source distributed environment that can support the spontaneous evolution and composition of software services...*" [ii]. The ONE project aims to provide organisations in a DES (especially SMEs) with a sophisticated negotiation mechanism that will help SMEs in extending their portfolio of services, thus increasing their ability to fulfil more complex customer demands at a faster pace.

We will design a negotiation environment that has no central governance cockpit or console where to administer negotiation models and on going processes; ONE intend to avoid the "big brother" syndrome, which will jeopardize the level of adoption. The execution of the negotiation process will be hosted in participant's hardware resources, not in a central node; this will also reduce the concerns about privacy.

In addition, the supported functionality shall always be available to its users and must not suffer from the "single point of failure" issue. For these reasons the Technical Architecture will make use of a decentralised, peer-to-peer approach. ONE runtime components will not reside in a single central server but will make use of participants' resources as in a pure peer-to-peer network: the community has to own the environment as well as the data.

The content of the paper is structured as follows: First negotiation processes are defined and classified. Then an

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[3] The technological environment in which these organisations can "live" i.e. pursue their business and/or societal goals, exchange information, negotiate, transact and, simply stated, buy and sell

[4] EU Discussion paper, Bruxelles, September 2002

[5] http://www.digital-ecosystem.org

overview of the state of the art is given, and the intended improvement of the state of the art is described. Finally the architecture of the ONE platform is presented.

II. Definition and Classification of Negotiation

In literature there are many definitions for negotiations (see for example [iii], [iv], [v], [vi]. A common element for all definition is that negotiation is a process among two or several parties attempting to come to a common agreement on some matter [iv] or commitment to a course of action [iii]. The main features of the negotiation process are dealing or bargaining [iii] and communication [iv] among the involved parties. By combining the most important parts of the various definitions, the following definition will be applied in this paper:

"Negotiation is a process involving dealing [iii] and communication [iv] among two or more parties, which intend to reach a mutually accepted agreement [iii], [iv] on a given matter and commit to a course of action". Negotiations are common in various areas such as politics and business. In this paper business negotiations will be considered. Electronic negotiations or e-negotiations are business negotiations conducted electronically, for example via the Internet [vii].

Depending on the focus of the negotiation processes, they can be classified in quantitative (auctions) and qualitative negotiation processes. The main form of quantitative negotiations, i.e., auctions, focuses on price negotiation. Auctions follow a clearly structured procedure, for example Dutch or English auction, according to which competitive bids are placed until an agreement is reached. In addition there are also multi-attribute auctions, which try to take several attributes into account (see [viii]).

Compared to auctions qualitative negotiations do not have the competitive approach, but are based on a more unstructured dealing and bargaining negotiation process. The different negotiation processes can be classified according to the number of involved topics and the number of aspects that are under consideration. With respect to number of participants, bilateral and multi-party negotiation can be distinguished and with respect to the considered aspects in the negotiation, single and multi-issue negotiations can be distinguished. The more parties and aspects are involved the more complex the negotiation process gets.

III. Overview of documents and workflows involved in a negotiation

Business negotiations are based on specific legal documents and follow a specific workflow, which can vary in the number of iterations necessary to reach an agreement [ix] [vii]. The typical workflow and documents will be described below on the example of bilateral negotiation processes.

Negotiation is usually initiated by one party, who usually also coordinates the process. The negotiation can be initiated by a published tender, inviting offers from different parties. The party providing an offer is called the offeror. The counterpart, who receives the offer, is called the offeree. In a business negotiation one of these roles is taken over by a buyer, the other role by a seller.

The offeror is legally bound to his offer in the way he made it until the offeree responds to the offer. That means if the offeree accepts the offer a legal correct contract is established. Of course an offer will not exist eternally: The offeror is allowed to assume that the offeree did not accept the offer when he does not react in a reasonable length of time.

A negotiation can also start with publishing a tender and inviting interested companies to provide offers. The difference to an offer is that the originator of an invitation to treat is not bound to his declaratory act. He can revoke it at any time. When the addressee of an invitation to treat wants to accept this declaratory act he has to make an offer, and this offer has to be accepted again by the originator of the invitation to treat.

The addressee of an offer or of an invitation to treat can accept or turn down the received declaratory act. Besides this there is a third way to react: If the addressee is willing to enter into the proposed contract but wants to change the conditions he can make a counter invitation to treat or even a counter offer. This turns into a normal invitation to treat or a normal offer again when the addressee receives them. They can be accepted, turned down or answered with another counter invitation to treat or another counter offer. Whenever a new counter offer is created the originator of the former offer is no longer bound to his declaratory act.

So we can summarise that the contract negotiation starts always either with an invitation to treat or with an offer. There are several ways to react to those first declaratory acts. An unaccepted or a missing answer ends the contract negotiation. With a counter invitation to treat or a counter offer the contract negotiation continues. Only an acceptance to an offer establishes a contract. An invitation to treat cannot be accepted but must be answered with an offer if a contract will be established. This offer must be accepted by the originator of the invitation to treat in order to create a legally binding contract. The various stages of the process and the possible outcome documents are described in Fig. 1.

A multi-party and multi-issue negotiation consists of several interrelated bilateral negotiation. This could be illustrated with an example from the construction industry: The responsibility for building is usually taken by a coordinating architect. In order to build the house he needs expertise for windows, floors, roofs, etc. Each part has to be negotiated and is interrelated with the others. The overall constraints for all negotiations are usually the available time, financial resources and required quality. A multi-party and multi-issue negotiation consists therefore of several bilateral negotiations, that all together have common constraints that in sum have to be reached.

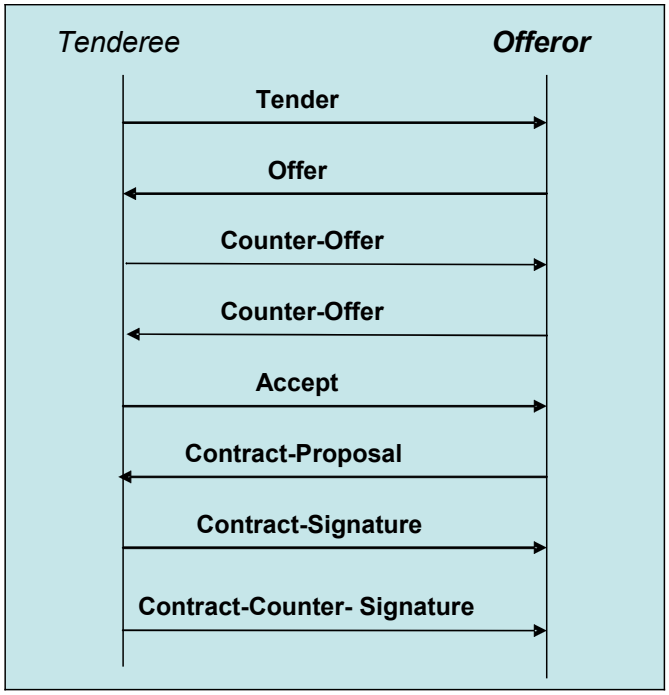

Fig. 1 Workflow of a negotiation process

IV. State of the Art of Negotiation Support Systems

To support humans involved in negotiations, two kinds of systems have been developed in the past: Negotiation Software Agents (NSA) and Negotiation Support Systems (NSS).

Negotiation software agents (NSA) are programs that carry out operations on behalf of a user with some degree of independence and autonomy [x]. Their purpose is to automate different negotiation tasks arising from buying and selling products over the Web [x]. In these systems the use of negotiation methodologies is often over simplified and they are basically engaged in bidding or in simple-issue negotiations with predefined behaviour, strategy and tactics. In this respect, Machine Learning research in automated negotiation, has focussed on optimization methods to improve an agent bid policy, either based on genetic algorithms or on reinforcement learning approaches [xi] [xii]. Hence, in these approaches the goal is to identify the optimal action for an autonomous agent that is supposed to act on behalf of the user, and the agent is not concerned with interacting with the user (principal). More in general, machine learning in multi-agent interaction (e.g. coordination, negotiation) is an extremely complex topics and only simple two-players games with fairly reduced set of actions have been addressed so far [xiii]. Hence, in order to build a practical solution in realistic context, as we aim in the ONE project, tradeoffs between optimality of the recommended negotiation strategy and feasibility of the approach must be considered.

As we noted above, negotiation software agents (NSA) may take over well-defined and structured activities in a negotiation but it is not necessary (or useful) for the agents to handle all the tasks [xiv]. The ill-defined and ambiguous issues, decision regarding relationship between parties, modification of the rules and parameters are better left to the human negotiators (principals). For these reasons Negotiation Support Systems (NSS) have been proposed to facilitate the various phases of the negotiation process such as understanding the negotiation case, assigning preferences for negotiable issues, and setting reservation levels before the negotiation begins. NSS ranges from systems that help negotiators prepare for a negotiation, to mediation and interactive systems that restructure the way negotiations usually take place [xv]. Process Support Systems are a particular type of NSS. They operate at the bargain table and can either provide a mediation function or an individual support function. In the ONE project we are particularly focussed on the individual support, which means (in general) to provide parties with analytical visualization tools and with communication facilities. In ONE we will extend these functions considering decision support, via recommender systems for negotiation task guidance. We note that none of previously developed NSS have used Machine Learning techniques to learn the system behaviour in support of the user. In classical NSS, the system behaviour is hard coded by the designer. Therefore, we now introduce the concept of recommender systems for multi-stage decision problems. These technologies are capable of learning an optimal behaviour for the recommendation agent, by analysing data related to previous interactions (recommendations) between the system and the user.

V. Advancing the State of the Art

ONE will contribute to the scientific state of the art in several respects. The project will base its innovative solution on a number of cutting edge technologies and scientific results. In particular ONE will develop a meta model driven business negotiation engine, using a modelling language, that could give rise to a set of standard negotiation engines similar to what occurs with workflows (WFMC[6] XPDL and WF-XML) and business processes (OMG BPMN[7], OASIS[8] WSBPEL). A user can define a custom negotiation process taking into account for example, negotiation rules, legal rules, pricing policy, reserve price, logical process descriptions and other specification using a XML based scripting language. The runtime negotiation engine will be in charge of executing the defined process as a facilitator between parties that take into account the defined strategy and rules until the negotiation is -hopefully- closed successfully.

The platform will actively support the human negotiators by exploiting automatic learning techniques applied to the goal of learning the best negotiation strategies in a multi-agent environment. Recommender systems have been applied, until now, for supporting simple (non-sequential) purchase decision tasks, mainly for b2c applications in electronic storefronts [xvi] or for matching a service request with a service offer (a functionality already supported in DBE). The goal in classical recommender systems is to

[6] The Workflow Management Coalition, http://www.wfmc.org/
[7] Business Process Modeling Notation http://www.bpmn.org
[8] OASIS http://www.oasis-open.org

support one single decision and not a multi-stage and multi-agents process as we shall do in the negotiation process supported by ONE. Our basic reference model for modelling and solving multi-stage decision process will be that of Markov Decision Process and Partially observable Markov Decision Process (MDP, POMDP) [xvii]. In this setting, a set of state variables will describe a precise state of the user-computer interaction during a negotiation process (both the negotiator and recommending agent). We shall also identify the actions that the recommending agent can make, e.g., suggest the user to make an offer or to consider a new set of preferences. The role of the recommending agent is to identify for each possible state the action to take (strategy). In this context, we shall introduce model-based (i.e. with an explicit representation of the state transition probabilities) reinforcements learning methods. and we shall use them to learn the optimal policy for conducting the negotiation.

The personal negotiation recommender that will support a user will be hybrid [xviii] and conversational, and will compute the recommended actions exploiting a distributed knowledge base, which expands the personal knowledge base of an actor, and makes possible to speed-up the policy learning process, exploiting experiences gathered not only by the supported user but also by a community of trusted partners [xix].

Finally, methods for characterizing and analysing a large population of negotiating partners viewed as a complex ecosystem will be studied. The collective and emergent behaviour will be analysed, the heterogeneity and diversity of the ecosystem will be characterised and self–stabilizing methods, such as mechanisms to help the system to get rid of harmful behaviours, will be applied to the specific context of the negotiation. The challenge here is to gain capabilities of the design of a population of agents, which represent SME, introducing heterogeneity in such a way the full ecosystem will lead to “better” negotiations and higher rates of “good” contracts.

ONE supports a model of collaboration and trust based on the idea of "collaborative multi-agent systems", where agents can work and learn with other trusted agents and develop collaborative learning schemes. We will develop models of information and knowledge sharing, taking into account privacy concerns, based on a model of multiple agent clusters, characterised by different levels of trust.

Identity management has become a major security issue over the last years. Currently there are a number of efforts for providing a general identity management framework. However, most of them have remained within a federation-based principal where a coalition of trusted partners form a federation and a central identity provider manages partner’s identities within the federation.

ONE platform will provide an identity management model that supports management of partners’ identities in a decentralized and peer-to-peer fashion. As such, the model will provide a solution based on the existing technologies (e.g. X.509, PGP, SPKI, SAML) properly adapted to the needs of ONE negotiation platform. At the same time, the identity model will enable partners to control the privacy of identifiable information by means of pseudonyms. ONE will investigate the cutting edge result in FP6 projects like the DBE for possible adoption of identification frameworks.

ONE will also explore a novel research direction with respect to the state-of-the-art of reputation-based models – combining reputation mechanisms with the learning and evolution aspects of the ONE platform. It will explore possible synergies between the reputation techniques and the learning and recommendation approaches used in ONE. Those synergies are expected to evolve the reputation rating scheme to new evolutionary criteria. Thus, the reputation-based trust will evolve SMEs in a new dimension of establishing trust relationships.

VI. A Model Driven Architecture

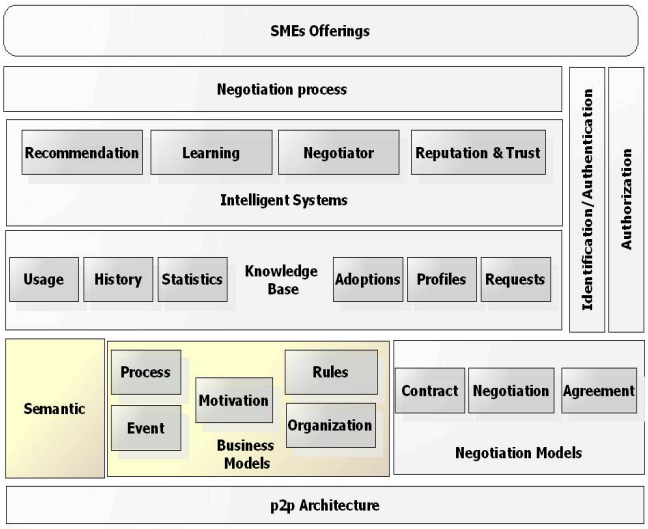

Fig. 2 ONE architecture layout

ONE will not be built around a set of predefined and fixed number of tender types, or negotiation strategies (e.g. English Auction), instead it make use of a modelling language for describing negotiations processes, formation of contracts, agreements and all the required models we will identify. To this extent ONE will made extensive use of the Model Driven Architecture (MDA) [xx]. One of its most important properties is the possibility to automatically generate applications or models from other models. In ONE, the ability to generate code from models, will be used to support automated implementation of the negotiation process.

We will specify the necessary mechanisms for extensibility of the environment and create guidelines, to allow developers (possibly, contributors from the open source community) to plug-in new components. MDA and UML will provide the standard foundation for expressing meta-models and for supporting their translation and refinement into application domain specific models. Employing Meta Object Facility (MOF), the OMG founding language of MDA, essentially achieves this.

By adopting MDA, we will also make use of standard model encoding called XMI (XML Metadata Interchange) that will guarantee the ability to interchange models (as well as meta models and data) between other XMI compliant tools like repositories and modellers. ONE will also adopt standard MOF based interfaces for accessing models from repository like Java Metadata Interface (JMI), hence allowing an application integration approach with MOF based model repositories. We expect that this ability will ease the integration with current digital ecosystems implementations.

DES technology integration

The negotiation environment will be deployed as a DES service reusing its execution infrastructure (ref. Figure 2 below). Front-end negotiation consoles will be delivered lo local user's Internet workstations as DBE services while the negotiation environment will be available as a remote service.

It is fundamental to highlight that, in compliance with the Ecosystem Oriented Architecture (EOA) principles, the negotiation engine is not a central server. As such the topology is not a star based, but on the contrary it spouses the de-centralized architectural approach. There is not a single point of failure in the environment: any negotiation engine available in the network could be used, and beside the obvious advantages regarding reliability, it avoids the political issue called “big brother syndrome”. In presence of single central node, an organization could control or spy the entire environment. ONE will be implemented using the peer-to-peer based technologies, which is already available in the DBE project.

The adoption of MDA features addressing model storage, processing and encoding will greatly facilitate the integration with DBE business models.

VII. ONE STAKEHOLDERS AND WORKFLOW

Within ONE, intermediaries will define the procurement process by reusing and adapting tender descriptions they created in the past (for similar tenders). ONE will also allow the specification of ‘tender templates’. As such there is no need to create a negotiation model every time a tender starts. ONE design tool will provide extensive support for model creation.

After completing the creation of a formalised specification for the tender, the SME user asks ONE to generate an executable negotiation process from such a model and deploy it on the execution platform.

The negotiation run-time platform and the negotiation components will be installed in a peer-to-peer network and will run collaboratively. SMEs not having the skills or equipment for managing such a software infrastructure, will be able to use the ONE platform using thin clients accessing the platform facilities run by another ecosystem participant.

Optimising Negotiations through Adaptive Strategies

When the negotiation process has been deployed to the ONE run-time negotiation environment, the intermediary can start negotiations with SME service providers, aiming at creating a best offer for the tender, optimising costs, quality, reliability of providers etc. Negotiation will ultimately result in a signed contract agreement. This phase includes searching for service providers able to provide the services according to the constraints and preferences implied by the tender, running auctions, negotiating detailed conditions with individual service providers, comparing alternative hypotheses, etc.

Strategies are configurable and even autonomously adaptable to other bids being made by other parties. The recommender system will help users to process in the right order the business tasks and take appropriate decisions when needed. This level of automatism applies also to security and trust aspect. The agent will carry on all the technical and cumbersome details of building and synthesizing a trust indication about the service provider/user that the user/service provider can simply accept or reject.

Rating and trust management

During or after completion of the service, as normal business practice, intermediaries collect service rating information from customers. Customer surveys or other tools are used for this purpose. An intermediary usually builds internal repositories of reputation data. However, often they need to partner with providers whose performance record is completely unknown to them. Other mechanisms are then needed to collect ratings, which ensure wider availability of trust and reputation information. ONE supports both a peer-to-peer approach for collaborative sharing of reputation information, and also aims at empowering third-party rating agencies. Based on the performance on the last negotiation and service delivery, the rating agencies or the shared collaborative network of peer can upgrade/downgrade automatically the trustworthiness of each service provider registered with them.

Note that such mechanisms require sophisticated privacy and knowledge sharing policies, which must be used for controlling the disclosure of sensitive information. The identity of intermediaries, consortium members and service providers will be managed in a secure and private way. When sensitive information or also the negotiation itself is security sensitive, ONE will protect against unauthorised disclosure that could harm any of the actors. In addition, we stress that the project has adopted an Open Source Licence strategy as defined by the Open Source Initiative [xxi].

Evolution and growth of the environment

The functionalities provided by the ONE environment are expected to grow as result of two forces.

1. Sharing of models. ONE will support knowledge sharing through a shared, distributed information repository. An example of the openness of the platform is that every SME may reuse and adapt the models defined for tenders by a partner. Over time, libraries of specifications for contracts, tenders in different service domains (e.g. public health system tenders) etc will emerge and will be available for community use. This will drastically reduce the time re-

quired to deal with new tenders.

2. Development of plugins. The set of negotiation components which will be available to users, as reusable building blocks in the design tool (e.g. interaction protocols – auction types, or specialised recommenders) is expected to grow using a community-based, open source approach.

VIII. CONCLUSION

ONE's strategic objective is twofold: on one hand it wants to create a flexible negotiation environment mechanisms that would decrease, and hopefully eliminate, the barriers hindering SMEs to come to an agreement via a assisted negotiation process; on the other it wants to provide a technological medium, a negotiation platform, based on the open source paradigm and the "evolutionary" software concept that would reassure users of their technological choices.

The techniques we propose to develop are meant to suggest to the user a better negotiation strategy, reached through a learning process based on the observation of user behaviour and of the other partners' actions as perceived by the user. The policy learning algorithms will be based on the observation and storage of real interactions between the user and the negotiation service and between the user and other players (Trust), as these are performed in the Negotiation Execution Environment. Learning will also benefit from the sharing of experiences between users, such as sharing of policies or simple description of previous interaction histories along with the outcome of the process.

In addition, the consortium will provide on top of the technical infrastructure a set of negotiation processes derived from a deep investigation of real negotiations in the facility management industry of three EU countries.

ONE will actively participate in the expansion of the Digital Ecosystems concept by providing a new element to the current DES technologies, the Open Negotiation Environment, which will extend the Digital Ecosystems infrastructure (DE). ONE, though designed and implemented as a platform independent system, will be pluggable in DES implementations extending their capabilities making possible to support almost entirely the business life cycle of a service: modelling, implementation, publication, search, negotiation, contract signature and consumption.

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