TOWARDS A FRAMEWORK FOR AUTOMATED E-NEGOTIATIONS

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Abstract: In this paper a framework to support fully automate e-negotiations is presented. A novel approach that exploits ontologies, Semantic Web Services and software agent platforms to define an architecture that favours flexible, dynamically created and adapted e-negotiations, is described. Negotiating agents can enter a negotiation area, acquire the negotiation protocol or even suggest their own in a widely understandable notation and participate. Rule-based protocol specification along with process specification for describing interactions during e-negotiations is presented.

1 INTRODUCTION

E-negotiations try to virtualize the real life negotiation procedures in the future internet-based world-wide market. Most of the negotiations used today are manual e-negotiations involving only human participants. However, the trend is to create systems able to participate in fully automated negotiation procedures. This means that the involved parties should behave as autonomous software agents. In the context of this paper only trade e-negotiations are considered, which are according to (Bichler et. al., 2002) "negotiation processes in electronic markets for the exchange of goods and services based on bargaining, bidding, or dispute resolution."

Except from the fixed-price sales through uncountable e-shops which involve no real negotiations, auctions are currently the most widely used form of e-negotiations. Due to the low cost server-based implementation, auctions have rapidly proliferated on the internet with multiple alternative schemes (Wurman et. al., 2001). E-negotiations can also take a more complex form called bargaining which involves proposals and counter-proposals until an agreement is reached. Despite the growth of e-auctions, complex negotiation systems have not been extensively studied and implemented and mature tools for such an effort are not available. The main objective of this work is to define a framework for an effective analysis, design and automated implementation of complex negotiations.

Negotiation protocols and negotiation strategies are the basic concepts of e-negotiation. A n*egotiation protocol* is a set of rules which govern the interaction, whereas a *Negotiation Strategy* is a decision making model that participants should employ in order to achieve their goal. The negotiation strategy is built upon the selected negotiation protocol and is private for each participant. The focus of this paper is on the negotiation protocol specification.

The remainder of this paper is organized as follows: In section 2 we discuss the state of the art and the related background work. In section 3 we present the proposed layered architecture and in section 4 we describe the negotiation process based on this architecture. In section 5 we present our approach on modelling the negotiation domain and processes specification, as well as the automated implementation with the use of Semantic Web Services (SWS). A simple negotiation example using the proposed notation is presented in section 6 and finally we conclude the paper in section 7.

2 STATE OF THE ART

Various research groups are working towards automated e-negotiations with most of them focussing on auctions. For example, in (Kersten, et al., 2004) a configurable e-negotiation server is proposed to support bargaining, splitting negotiation process into well-defined phases. A set of rules that govern the information processing, the decision-making, and communication acts is presented.

More recent research goes beyond auctions and considers more complicated negotiation schemes. In

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(Kim and Segev, 2005) a state-chart description of one e-negotiation protocol and the corresponding BPEL4WS process is provided. (Chiu et al., 2005) presents an approach for developing e-negotiation plans providing meta-models for e-contract templates and e-negotiation processes. A complete framework to the same direction is described in (Benyoucef and Rinderle, 2006). A service oriented environment is defined using state-charts for model-driven development as well as automatic generation of orchestration code for existing web services.

Advanced tools and technologies such as rules and ontologies are utilized to automate the negotiation process. Bartolini proposed in (Bartolini, 2002) a simple interaction protocol to support any mechanism that can be described with a taxonomy of predefined declarative rules A similar work based on Bartilini's approach uses agent technologies and tools to provide an initial implementation in (Badica et. al, 2006). Tamma in (Tamma et. al., 2005) also uses this taxonomy of rules utilizing ontologies to make the representation of the rules of encounter explicit, machine readable and sharable; agents willing to participate to a negotiation session commit to the shared ontology, which represents the mechanisms governing the negotiation.

A very interesting approach for a general description of processes and protocols is OWL-P presented in (Desai et. al., 2004). Ontology Web Language (OWL) and Semantic Web Rule Language (SWRL) are used to specify interactions as rule based commitment protocols. The authors separate public protocols from private policies thus allowing protocols to be easily reused and extended.

3 ARCHITECTURE OF THE PROPOSED FRAMEWORK

The layered architecture shown in figure 1 was defined to favour flexible, customizable and automated e-negotiations.

The bottom layer is the basic interaction protocol that provides the basic required functionality for e-negotiations. This protocol based on existing Web Service protocols encapsulates well defined in agent standards communication acts. The description of SWS, which will implement the proposed negotiation scheme is given in OWL-S (language for describing Web Services) (http://www.daml.org/services/owl-s/). Messages exchanged among negotiating participants are a subset of the Fipa agent interaction patterns (http://www.fipa.org/repository/index.html) and are formulated using an ontology.

The basic negotiation protocol, in the second layer, is a rule based protocol specification. Rules are used to define and constraint the context of the interaction for the participants. These rules are expressed with the use of concepts from the well defined negotiation domain. Constraints can be broadly classified as either enabling or limiting. They provide all the appropriate freedom within predefined rules for the participants to behave according to their strategy and achieve their goals.

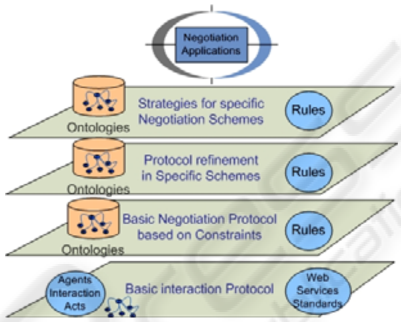

Figure 1: The proposed Architecture.

The third layer uses the same concepts to define a specific negotiation scheme in consistency with layer two constraints. Rules are also used but a way to describe interaction processes is a key issue for the negotiation scheme description.

In the fourth layer, i.e. the negotiation strategy layer, private strategies are defined for each participant. These strategies are based on the specific negotiation scheme that was adopted for the interaction. The description of strategies will again use the same tools and vocabulary forming a flexible and easy to understand negotiation architecture.

The specification of the basic negotiation protocol is a difficult task since it has to provide the infrastructure required by all possible general interactions that any negotiation may use. Such a specification may have the form of transition diagrams (stds) to fully describe the states of the protocol. This is the approach used in (Su et al. 2000) where an FSM was used to model bilateral bargaining negotiations. Another approach adopts a rule-based framework to define the appropriate behaviour according to the protocol that these rules specify. Rules in (Bartolini et. al. 2002) are used for enforcing the negotiation mechanism and are organized into a taxonomy. Rules compared to STDs have the advantage of giving simple, easy to understand and modify, description of the protocol specification. The same protocol needs a large number of states and very complicated description if expressed using STDs. This is why rules and constraints are our preposition for the basic negotiation protocol that is used as basis for the above layers to further specialise the negotiation process.

4 THE NEGOTIATION PROCESS

According to our architecture the involved negotiating parties, i.e., a consumer and a merchant should follow a well defined interaction process, depicted in figure 2. According to this the Consumer may use a predefined negotiation scheme or define his own. Well defined knowledge bases are exploited to select a predefined negotiation scheme (1A), while model- driven development techniques are used to aid the development process of a new scheme (1B). Basic protocols and named negotiation schemes, such as the English and Dutch auctions, are already defined. After selecting the scheme an appropriate negotiation strategy can be adapted or a new one constructed (2). Fore the case a new scheme is created, this will be published to the knowledge base (3).

At this stage the consumer is ready to negotiate with the selected scheme the location of which (URI) he sends to the merchant (4). The merchant acquires the OWL description of the negotiation scheme (5) and designs a strategy for it (6). After that both parties automatically generate a SWS (Semantic Web Service) described in OWL-S based on OWL description of the negotiation scheme (7) and the negotiation between SWS begins (8). Merchant can publish the negotiation service in a semantic annotated UDDI with references to all available negotiation schemes (9).

In the context of the proposed architecture: a) semantics offer machine understandable concepts, and b) XSLT-based OWL to OWL-S transformation offers the ability to automate the whole process after the negotiation scheme and strategy selection.

5 MODELING E-NEGOTIATIONS

5.1 Modeling the Negotiation Domain

In the e-negotiation context there is need for a basic vocabulary that can be understood and used by all participating agents. Such a vocabulary will be part of the modelling of the e-negotiation domain which is a very complicated task. Several attempts were made to this direction each with a different point of view of the domain. In (Wurman et al., 2001) the focus is on auctions, whereas in (Lomuscio et al., 2002), they stresses on automation aspects.

We adopted the Montreal Taxonomy (Strobel and Weinhardt, 2002) which can be considered an abstract collection of the most important views which provide a framework that can be used for descriptive and prescriptive purposes. It covers aspects such as the negotiating participant roles, processes (offer specification, offer submission, offer analysis, offer matching, offer allocation, offer acceptance), information revelation, and business model implementation of e-negotiations.

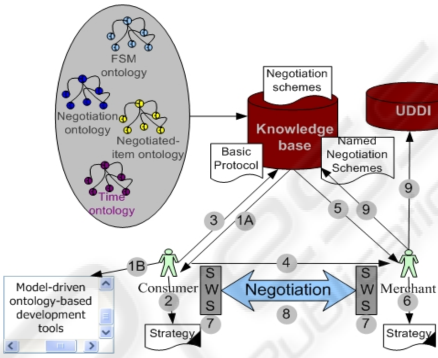

Figure 2: The negotiation process.

Based on the Montreal Taxonomy a negotiation ontology was developed to exploit the reasoning capability that is provided through a generic reasoning engine, a great advantage of an ontology compared to a simple taxonomy. Moreover, inference can be used as an extension to the proposed framework to draw conclusions which will drive decisions in strategy and negotiation scheme selection.

The Negotiation ontology captures, except from the important concepts of the domain, the well-known named negotiation schemes like English auction, Dutch auction and many others. For the description of complicated negotiation schemes, such as bargaining, other ontologies are also required, as for example the time ontology or the ontology describing the item to be negotiated. Moreover, a message ontology was defined exploiting the Fipa ACL (Agent Communication Languages) messages, to represent the messages that can be exchanged between participants.

Among the classification criteria in the negotiation area modelling we have adopted, we discriminate: the number of participants, the bid privacy, the number of items to be negotiated, the attributes of negotiated items, the number of suppliers, and the use of a broker or mediator.

Participants have to execute, during a negotiation, certain well-defined actions. For example every participant in any kind of negotiation has to process the received proposal and decide his next action based on the negotiation protocol and the adopted strategy. We have collected the most important actions and depicted them as concepts in our ontology in an attempt to describe internal behavior in each phase of the negotiation for each participant. Among the concepts we discriminate: Prepare Preference, Send, Receive, Prepare Proposal, Make Choice, Matchmaking-Critic etc.

Negotiations depend a lot on the modeling of the item that is under negotiation, since different approaches can be adopted depending on the negotiated-item. For example, negotiation schemes for multi-attribute items can become very complicated. An agreement on the negotiated object properties that should not be altered, such as minimum and maximum values of properties and flexible or “don’t care” properties, has to be established in an early step. Participants may express these constrains upon the concepts of the negotiated item ontology.

Every negotiation can be modeled as a peer-to-peer interaction. Based on that, we decided to model the negotiation process as peer-to-peer interaction in flexible way that can be extended.

5.2 Modeling Interactions

The above defined representation of the negotiation domain captures the static view and not the dynamic view that is very important in interactions. The FSM ontology was defined to address this requirement. The most important concepts of the UML FSM notation were used to describe the negotiation process as an FSM diagram. Such an attempt that led to an FSM ontology based on UML FSM notation is also presented in Dolog (2004).

Negotiating participants go through a process that can be described as a sequence of states. Each state describes the exact phase of the negotiation. During a state one or more activities are performed by each negotiating party. Usually one participant performs some activity while the other waits for an event to occur. The description of the activity will come from the negotiation ontology. Entry actions of states can be used to perform the setup needed within a state, as for example the check for validity in an incoming message. Exit actions can be used for the required clean up before exiting the state. Transitions can also have actions which usually produce a message from the message ontology for the waiting participant. The transition guards contain SWRL rules in order to create Boolean Expressions for the firing of transitions. It should be noted that the Completion Transition has no explicit trigger event but it is fired by the completion of the activities of the current state.

FSM notation has already been used for modeling the negotiation process domain (Kumar, 1998 - Su, 2000). In (Kumar, 1998) a very simple representation is presented trying to catch only basic states in an English auction negotiation mechanism. In (Su, 2000) again the possible phases of the negotiation are represented as FSM states and the transitions between states are fired from “send” and “receive” proposals. The diagram produced is more complex and uses numerous states trying to catch the internal behaviour for each participant for the bilateral bargaining negotiation scheme. Our approach uses: a) a rule-based basic negotiation protocol to give the desired generality, and b) the FSM notation for specific scheme description able to catch all important details using well defined semantics.

Benyoucef and Rinderle stating the FSM limitations propose Statecharts due to their advantage in executability, popularity and completeness. The Process Specification Language (PSL- http://www. mel.nist.gov/psl/) provides another alternative for modeling interactions. PSL was used for this purpose in (Tamma et al., 2005) although the applicability is not proven.

5.3 Automated Generation of Stateful Web Services

One important issue towards automation is the translation of the OWL document describing the overall negotiation process, to an OWL-S document that will give the semantic description of the SWS created to handle the negotiation for each party. What is needed is to translate and map between XML-based (OWL and OWL-S) documents. For this, XSLT will be used to grasp all appropriate information from the OWL document and generate the OWL-S SWS description. In this way our engine will only have to be in position of using a simple XSLT engine and understanding and using the well known ontology concepts.

Web services, by their nature, typically do not maintain state information during their interactions. However their interfaces must frequently allow for the manipulation of state, that is, data values that persist across and evolve as a result of SWS interactions. Especially in our case a way of remembering previous proposals must be implemented. We could leave this job to the private negotiating engine but selecting stateful resources is another way of taking burden from the internal proprietary engine of each party and injecting it to the automated web service interaction. Stateful resources will be mapped to state variables used in FSM process ontology.

6 AN EXAMPLE NEGOTIATION SCHEME

An example negotiation scheme for acquiring an Service Level Agreement (SLA), for an internet access service, from an ISP is used to demonstrate the applicability of our approach. The example is a “small” auction that allows service providers to

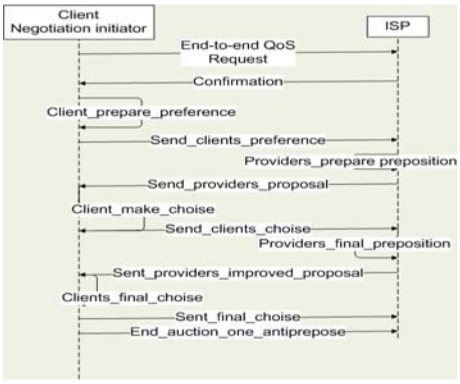

Figure 3: Example scheme interaction.

improve their proposal only ones before the final decision is made (figure 3). Before the actual propose-counter_propose process begins, the client-initiator sends his preference which is the ability of the provider to guarantee the end-to-end Quality of Service (QoS). The SLA and QoS ontologies that were imported in our framework during the design of the example negotiation scheme are utilized along with SWRL for describing constraints upon concepts. After the confirmation the client sends the complete preferred SLA as an SLA-ontology instance asking for the providers to make their suggestions. Involved ISPs answer with their preposition and the client sends back the best choice after comparing. An improved preposition is allowed to be send by ISPs before the small auction is terminated.

Figure 4 presents the example negotiation scheme using an FSM diagram with concepts from fsm, negotiation and SLA ontologies. It is the representation of the OWL document describing the whole interaction. There we can see how each state, transition, event, action etc bears the appropriate semantic annotation in order to be easily recognized and translated by the engine of the participants. In each state a fundamental activity or activities from the negotiation ontology is given that must be performed in this phase of the negotiation by participants. For this simple example in each state only one participant is performing an activity while the other is in the wait state. Each transition has also actions which is usually the Send action of a message between participants.

For example the first state is annotated with *State: Initial* from the FSM ontology and *Role: initiator* from the negotiation ontology meaning that it is the starting state and the initiator performs an activity during it while *Negotiation: Role: Participant* is at wait state. The following transition bares an *Action: Send* from the Initiator which is a *Start* negotiation message to participant. In the second simple state the Initiator executes one *Activity: Prepare_ Preference* for the *Service: End-to-End QoS* concept from the Service ontology. In order to enter the second state our *Guard: Condition* must be true which is an *Event: Receive: Start* message from participant. In the second transition a *Query_if* is sent by the Initiator-client about the discussed concept and we enter the third state when this preference is received by the Participant-ISP. There the Participant performs a *Matchmaking* Activity for the particular concept and answers with a *Confirm* or *Disconfirm* message in the following Transition. After another *Prepare_Preference* for a complete SLA instance which is send to Participant with a *Call_for_Proposal* message, we enter the states where they exchange Proposals and *Counter-Proposals* in Composite states where more than one activity is performed. At the end the *End* state with all appropriate messages follows the *Accept_Proposal* message. In the particular figure only some basic concepts are depicted from the selected ontologies in order to keep it simple and readable.

7 CONCLUSIONS

In this paper an approach to automate negotiations between machines acting on behalf of their users has been proposed.

An FSM and a negotiation ontology were defined and utilized to construct negotiation schemes that can guide the interaction of negotiating parties that has no previous knowledge of the negotiation scheme. This entire infrastructure can be used along with semantic web services to automate the generation process of negotiating interface of each participant.

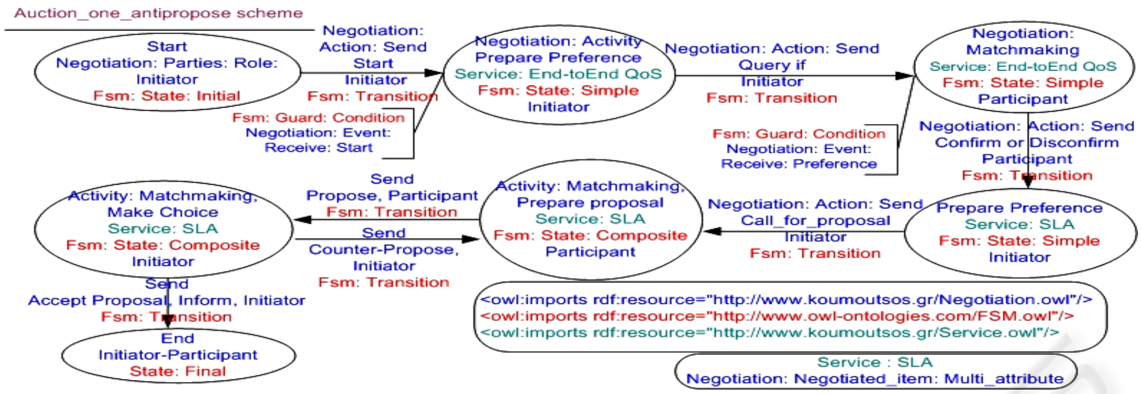

Figure 4: The example negotiation scheme.

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