Adaptive Electronic Institutions for Negotiations

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Abstract The expansion of web technologies pushes human activities over methodologies and software that could ease reactions by means of software transactions. Distribution of human and software agents over the web and their operation under dynamically changing conditions necessitate the need for dynamic intelligent environments. Electronic institutions can play an "umbrella" role for agents' transactions, where institutions' norms could protect and support movements and decisions made through negotiations. However, dynamic information provision may force changes in structures and behaviors, driving electronic institutions' adaptation to changing needs. Viewing negotiation structures as electronic institutions, this paper investigates the impact of a dynamically changing environment to negotiations' electronic institutions.

1   Introduction

The transformation of human transactions into electronic transactions is not an easy task, especially when the rules of the game are not moldable into specific rules and constraints, and when dynamically-appearing information affects these transactions. In this paper we investigate the development of environments for adaptive negotiations, through the incorporation of sources of dynamic information, by utilizing electronic institutions (eIs) [1], [5].

The changes in business conditions most of the times follow the news' speed, which is the main factor for making business negotiations adaptive, as future market situations could be affected from these news: Therefore, during negotiations the involved parties have to be informed online for specific news that could affect their rules of decision, their strategies and their actions. In human transactions, consultation of dynamically-appearing information is out of the negotiation table especially when the involved parties are in the final stage of negotiation, or when

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it cannot be utilized effectively in real time: The dossier of negotiating parties with all the available "movements" and rules almost is fixed. It is the aim of this paper to investigate the incorporation of dynamically provided information and its effects in negotiations' structure and function by means of electronic institutions' constructs.

In our case study we deal with a traditional chartering task, where Shipowners and Cargo owners have to reach, in a best price and under certain conditions and terms, an agreement for a contract for the transferring of cargoes. Let us consider five Shipowners' brokers, which have started negotiating with a specific cargo-owner to conclude in a contract [4]. During the negotiation procedure one Shipowner was informed that its vessel had stopped operating and that could delay its arrival in the cargo port. The remaining Shipowners' brokers continue to negotiate with the cargo owner, when again a market change or a specific exceptional occasion near the cargo destination pushed them to start the whole procedure under the light of the new conditions. Such conditions are affecting the negotiation procedures either by changing participants' strategic decisions and their related actions, or by militate against their scopes. In the worst case a participant could leave the process and search for a new negotiation place. The above generic scenario in the maritime sector is happening many times during negotiations and most of the times the negotiating partners are not in the position to control and filter external info/news that could affect their decisions in real-time. Being motivated by this real-life problem we are investigating the use of a framework that could support solving this type of negotiation problems by means of adaptive environments.

The paper is structured as follows: Section 2 analyzes the electronic negotiations and the missing adaptability. Section 3 proposes eIs as a solution for adaptive negotiations, and according to structure eIs we present the adaptation that can offer. Finally, in Section 4 conclusions and remarks are finalizing the paper structure giving future research topics.

2   Electronic Negotiations

In electronic negotiations, software agents prepare bids for and evaluate offers on behalf of the parties they represent, aiming to obtain the maximum benefit for their owners, following specific negotiation strategies. When building autonomous agents capable of sophisticated and flexible negotiation, the following areas should be considered [4]: (a) negotiation protocol and model to be adopted, (b) issues over which negotiation will take place, (c) events affect the negotiation process and drive adaptability, (d) negotiation strategies employed by agents, under what conditions, and how will be implemented and adapted to changing circumstances. Given the wide variety of possibilities for negotiations, there is no universally best approach or technique for supporting automated negotiations [8]. Protocols, models and strategies need to be set according to the prevailing situations and to adapt accordingly based on new information. The change of negotiation

conditions can move the whole negotiation phase in its starting point, maybe causing the adoption of new negotiation protocol/strategies for the involved parties. We consider a generic negotiation environment, covering multi-issue contracts and multi-party situations, where negotiators face strict deadlines: However we deal with a highly dynamic environment, in the sense that its variables, attributes and objectives may change over time. The trigger to this change is the time and the influence on chartering markets of external factors including catastrophes; political crises; environmental disasters; aid programmes. Dynamic changes of variables and conditions that affect negotiations cannot be easily incorporated in human negotiations' transactions. This paper concentrates on the incorporation of these changes in adaptive electronic negotiations in business-to-business (B2B) marketplaces through eIs. The negotiating agents may be divided into *Buyer_Agents*, *Seller_Agents* and *Information_Provision_Agents*. The *Buyer_Agents* (BA) and the *Seller_Agents* (SA) are considered to be self-interested, aiming to maximize their owners' profit. The *Information_Provision_Agents* (IPA) are signaling new events and the changing of conditions (eg. world news, market changes, etc.), that may affect the negotiation procedure or the participation of the negotiation agents.

The proposed infrastructure for using eIs for the modeling of adaptive negotiation structures is depicted in "Fig. 1". Negotiations may adapt as a function of *Time* and *News Information*. Adaptation applies to negotiation areas (NA) and results in a new negotiation area: In the initialization of the negotiation phase (NA 2), negotiation involves five buyer agents (BA) and one seller agent (SA). Some of the BAs are also connected with their information provision agents (IPA): It is not necessary all BA and SA agents to be connected with an IPA agent. Each NA is specified to be an eI. As the conditions are changing, NAs adapt to new structures resulting to a different institution structure: From (NA 2) the negotiating procedures are moved into (NA 2.1) where different eI(i,j,…n) structures control the negotiation conditions and rules.
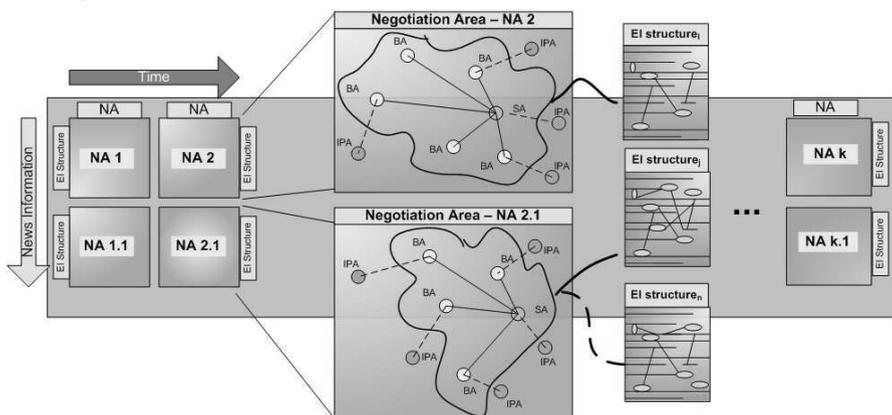

Fig. 1, Adaptive Negotiation Areas in the context of eIs

In the following paragraphs we are analyzing the points of the eIs infrastructure that can be adapted.

3   Adaptive eIs for Negotiations

This section describes how the different constituents of an eI may change due to eI's adaptation to new information provided.

3.1 eIs Roles

The main involved agents' roles in the eI structures are the already presented: BA, SA, and IPA. As in real life conditions, one or more IPA agents may provide information to a BA/SA agent, changing its behavior or strategy during the negotiation. IPA agents are reactive to stimuli from the environment. The BA and SA agents are agents of arbitrary complexity, as they can act autonomously and are able to achieve complex tasks, helping their human peers to achieve their goals and fulfill their commitments. The number of agents participating in the negotiation may change. BA agents may join or leave the negotiation: This may be caused by any condition considered by a BA (for instance a condition that negates its motivation to participate in the negotiation). This is also true for the SA: However its decision to abandon negotiation signals that dissolution of the current negotiation structure. IPA agents may also be dynamically connected or disconnected to BAs or SAs. Also, when the negotiation conditions are not complying with agents' goals, both agents' types (BA/SA) may leave the negotiating area.

3.2 Dialogical Framework Adaptability

The Dialogical Framework [9] for the negotiation area is defined to be

$$DF = <O, L, I, R_I, R_E, R_S>$$

where (O, is the eI domain ontology │ L, is a content language to express the information exchanged between agents │ I, is the set of illocutionary particles │ R_I, a set of internal roles │ R_E, a set of external roles │ R_S, a set of relationships over roles {ssd, dsd}). The *content language* must be able to express propositions, objects and actions between agents and should support any new type of message meanings that IPA or BA/SA agents could exchange. The *internal* roles define a set of roles that will be played by eI staff agents. In our case the BA and the SA are internal roles. An *external* role in the negotiation area is the IPA role. Since an eI delegates services and duties to the internal roles, an IPA agent (i.e. an agent playing the IPA external role) is never allowed to play any of them. The SA and the BA roles have a static separation of duties relation (ssd), as e-Chartering agents cannot play both of these roles at the same time within the institution. The IPA role has more than one child roles depending on the type of information provided. All the child roles have a dynamic separation of duties (dsd) relation as an IPA agent can play any of these roles. In each negotiating area, at least one eI describes the negotiation structure and function. Each eI is using a dialogical framework to support the

involved agents with the type of illocutions exchanged during the negotiation *scenes*. The external information will trigger the eI adaptability, informing agents playing internal roles. This may cause a transformation to a possibly new negotiation structure: This may cause changes in the number of involved agents, and changes in the agents' aims (e.g. utility functions) and negotiation constraints.

3.3 Negotiation Protocol

Although there are many works studying multi-issues negotiations carried out by autonomous agents [3], [6], [11], [12], we consider a generic framework for automated negotiation on multiple issues [8]. During the negotiation process there are several aspects that even though their values are not under negotiation and are not included in the contract parameters, affect the evaluation of the values of the contract issues. These aspects may consider the number of the competitor companies, information affecting the contract parameters, time until the negotiation deadline expires, resources availability and restrictions, and their impact to contract issues, etc. All the above issues are named *Adaptation Issues* (AIs). The values of the AIs may change over time, depending on the e-marketplace conditions and on the Sellers' and Buyers' state. The AIs affect the evaluation of the potential contracts, and they have an impact on the generation of subsequent offers and requests. The values of the AIs (imported by the IPA agents) do not depend on the actions of the negotiating parties, although they may affect one or both negotiators' decisions. AIs values should have a direct influence on the behavior of the negotiating agents, which should be able to evaluate the utility of the contracts under the current circumstances in the e-marketplace and act accordingly. From the above, it is clear that the negotiation protocol which supports and maintains the procedures that agents should follow in each eI, will not be affected in structure but only in time constraints that each agent reacts.

3.4 Scenes

The negotiation procedure comprises phases that can be modeled by scenes in an eI. A scene is a pattern of multi-agent interaction. A scene protocol is specified by a finite state oriented graph, where the nodes represent the different states and oriented arcs are labeled with *illocution schemes* or *timeouts*. Scenes allow agents either to enter or to leave a scene at some particular states of an ongoing conversation and can substantiate a negotiation procedure by splitting it in more than one scene. Its negotiation protocol has a defined scenes structure. The negotiation infrastructure that related agents follow is translated through the eI in a set of defined scenes graph. Scenes are the key points for eI's adaptability, as the AIs conditions affect the structure of the scenes graph.

3.5 Performative Structure

Based on [7], the parameters, upon which the performative structure of each eI in the proposed framework will be based, are as follows: *The negotiation model* (pri-

vacy of information, privacy of tactics and strategies, two-sided-uncertainty in negotiation, stochastic negotiation strategy)[2][10]. *Tactics and strategies* (time dependent, resource depended, behaviour depended). *Cost of agreement*, agents have to decide not only which tactic to choose next, but also whether it is worthwhile to go on with the negotiation. An agent under time pressure acts differently than an agent with no time pressure to reach an agreement. *Strategies*, where the decision trees of the agents decisions will be described. All of these parameters can be adjusted according to dynamically provided information, resulting to new performative structures, or to new agents' individual strategies, validation of proposals, and actions.

3.6 Performative Structure and Transitions

The sequence of scenes through a negotiation procedure is based on an eI performative structure. Each eI must include basic negotiation scenes and the rules that trigger the succession of scenes of the negotiation scenario. Scenes and transitions are connected by means of directed *arcs*. The adaptation of the eI is done by means of the scenes' states as well as by means of scenes' dynamic transitions. In "Fig. 2", the negotiation *scene_k*, includes all the agents in the dialogical framework. Concerning this scene as a particular example, in stage *s_0* all the negotiation agents are being involved. In *s_1* we assume that *role_IPA_BA_market* and *role_IPA_SA_market* are providing information to the agents playing the *role_BA* and the *role_SA*. In this case, the *role_BA* can stay or leave *s_1*. If negotiations move to stage *s_2*, the *role_SA* may leave the stage and the whole negotiation procedure will close in stage *s_3*. This result will drive the performative structure to another scene, possibly the *root* scene. The illocutions matching arcs 1 and 3 are bringing new info for *role_BA* and *role_SA*. During stage *s_1*, the arc 3 presents the import of new info that is adapted into the scene by new *role_IPA_BA_market* or *role_IPA_SA_market*. Also new agents by using *role_BA*, could be inserted into the negotiation stage *s_1*.
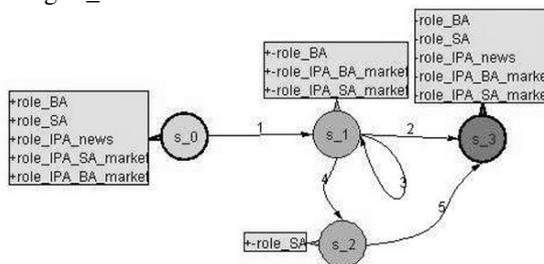

Fig. 2, States of scene_k, using Electronic Institutions Development Environment (EIDE)

Illocutions for arcs 2 and 5 are the transitions for closing negotiation scene. The move from stage *s_1* to stage *s_3* means a positive negotiation result that will be used as an input to a new *scene_l* of the performative structure. The transition arc 4 expresses the attitude of SA agent to leave (*role_SA* live) or stop a negotiation

when the conditions from the *role_IPA_SA_market* are not satisfactory and close to its market and profit intentions.

From the above specific example of negotiations through the eIs structure, it is clear that the adaptation could be incorporated during scenes' come round.

3.7 Negotiation Status Snapshots

During the negotiation phases that are involved through the eIs' scenes, the negotiated parties are having the adaptation support of the external IPA agents. The effect of this adaptation could effect the commitment of a contract, with a cancellation or with a new startup using as base the 'snapshot' of the agreements and as a new parameter, the newly added external information. Negotiation status is an information tuple that presents the status of the negotiation phases in a specific time, like a snapshot. During an external event what was previously negotiated and agreed, what were the accepted parts (components and attributes)? This information should be manipulated by the proposed infrastructure giving the opportunity to negotiating parties to restarting with a new session of negotiations following a new possible eI scenario. This snapshot is specified as follows:

$$Snapshot = <LA, A\text{-}P/S, Contract\_status >$$

Snapshot represents a set of agents' commitments. *LA*, represents the list of Agents involved in that contract. *A-P/S*, ties each agent together with the contribution (product or service) that is committed to give. *Contract_status*, presents the agreed attributes of products or services until the time slot, where:

$$Contract\_status=<Pre\text{-}cond, Rule\text{-}set>, Pre\text{-}cond \in \{Event, time\_slot\}$$

Event is a specific type of arrived external messages and *time_slot* is a specific point in time that represents current condition.

$$Rule\text{-}set = \{<Cond_i, Action_i>\}$$

Cond$_i$ is a set of conditions to be checked after *Pre-cond* is true,

$$Action_i \in \{Re\_negotiation, Ch\_negotiation\_rules, Cancellation\}$$

Re_negotiation, represents the re-negotiation action, *Ch_negotiation_rules* represents the change of the negotiation rules so that the involved parties will follow different eI rules/norms, and *Cancellation_rules*, represents that the external event causes a full abort from the negotiation process, for one or more of the negotiating parties. The above rules are describing the adaptive negotiation phases that the proposed infrastructure should follow to support the adaptability.

4   Concluding Remarks

This paper proposes an infrastructure for adaptive negotiations using the context of eIs. It is analyzing the negotiation aspects and based on a maritime case study tries to analyze all the eI aspects that could support the external information into the negotiation area. In the context of this paper, was investigated the issue of the different eIs structures that should support the negotiation areas. There is a need

for a mechanism responsible for the creation of an eI that links different eI structures and negotiation areas. Agents according to their profile characteristics and the negotiation market domain should be forwarded into specific NAs that according to the market constraints will be supported by one or more eI structures. The external info and news adaptability using multi agent systems and through the eIs are an add-on for the electronic negotiations. The design and the creation of a prototype of the proposed infrastructure using technologies that support the adaptability, like Jadex and XML, is our future objective.

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