APPLYING KNOWLEDGE BEADS FOR AUTOMATED NEGOTIATION

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Keywords: Automated Negotiation, Agents, Knowledge.

Abstract: A methodology called Knowledge Beads (KB) that was proposed in our previous paper features object-oriented formatting and expressive power in defining a complex bill-of-material. In this paper, we show how this knowledge representation methodology could be used in the design of automated negotiation systems and how KB helps in giving a unified approach for representing the data throughout the process that includes evaluation, negotiation, and post-negotiation. We identify two types of knowledge namely General Knowledge and Negotiation knowledge, in the negotiation process. A methodology is proposed on how these two types of knowledge can be used in automated negotiation.

1 INTRODUCTION

Previous research (Reeves et al, 2000) attempted fusing knowledge into agent communication languages and negotiation functions. They mostly based on rule-based and/or logic-based approaches. However, these techniques show their advantages in individual applications. Knowledge management is important in many scenarios where agent negotiation is performed based on knowledge instead of rules and logics alone. Furthermore those agents do not have self-learning ability if they cannot interpret knowledge.

Therefore, we opt for a model which can capture the key concepts and elements involved in multi-bilateral multi-attribute e-Procurement negotiation traces. Especially, these include the relationships among multiple negotiation parties, negotiation strategies for trade-off on multiple procurement attributes, and decision-action rules that drive an automated negotiation system (Jennings et al., 1996).

In essence, to automate the agent negotiation process, it has been widely accepted that two important technical tasks must be done: Firstly formulate the negotiation process; and secondly incorporate necessary negotiation knowledge.

Formalization of the negotiation process enables the software to automate the process by following some pre-defined algorithms. Incorporation of expert negotiation knowledge enables a negotiation system to conduct automated negotiations effectively and intelligently on behalf of its users. The knowledge of the human negotiation experts can be captured in some form of requirements, constraints, events, strategic rules, and preference scoring and aggregation methods. However, due to the diverse and complex nature of negotiation, the lack of knowledge interoperability and knowledge-reuse has posed certain difficulties to automated negotiation. Through this research work, we anticipate more efficient e-Commerce could be achieved with the support of the knowledge in automated negotiation.

This paper sheds some light on knowledge empowered automated negotiation in the multi-bilateral multi-attribute e-Procurement environment. The research aims are to formulate a complete negotiation life cycle with a knowledge framework for constructing both the negotiation context and the negotiation expertise; and to develop a model of automated agent negotiation based on the knowledge framework.

2 KNOWLEDGE IN AUTOMATED NEGOTIATION

In a negotiation session, there is plenty of data which can be collected, manipulated and utilized. Besides, domain knowledge and negotiation expertise are crucial for defining negotiation strategies, plans of actions, and preference scoring and aggregation methods. Both negotiating parties are responsible for collectively maintaining their own data, rules and knowledge repository.

2.1 Knowledge Taxonomy

The goal of a corporate taxonomy is to provide a list of authorized terms in knowledge management and information seeking (Conway 2002), as well as the mapping between concepts to connect negotiation parties with the right knowledge at the right time. Mainly two categories of knowledge are addressed in the proposed framework: (1) general knowledge and negotiation knowledge. General knowledge provides the specification of different categories of objects in the e-Commerce domain, which are the fundamental knowledge. An object can be a RFQ, a trader, a deal, or any object that associated with manipulation methods. (2) Negotiation knowledge, or negotiation expertise comprises knowledge of, or skill in observation of experience gained through negotiation in e-Procurement process. The concept of experience generally refers to know-how or procedural knowledge, which is the knowledge of how to perform certain tasks.

2.2 General Knowledge

General knowledge in the negotiation life cycle contributes to the formation of the fundamental knowledge framework of the current negotiation context. It mainly includes buyer's RFQ, supplier's quotes, negotiators' profiles, and negotiation traces.

Table 1: General knowledge in a negotiation context.

General Knowledge Item	Description of Knowledge Comprised
RFQ	Buyer's procurement requirement with respect to a certain concept.
Quote	Supplier's quotation based on RFQ.
Proposal/Bid	Trader's bargain exchanged in negotiation with respect to a certain concept.
Agreement/Contract	Deal settled at the end of a successful negotiation.
Procurement Concept	Trader's perception of the product.
Buyer Profile	Buyer's general preferences.
Supplier Profile	Supplier's credit in the current procurement domain.
Negotiation Trace	Logged messages exchanged between two negotiation partners during a negotiation process.

A negotiation trace is a log recording all the messages exchanged between two negotiation partners in a negotiation process. For successful negotiation in which an agreement is produced in the end, the negotiation trace contains useful knowledge describing the nature and progress of the negotiation.

2.3 Negotiation Knowledge

While general knowledge describes the whole negotiation context, negotiation knowledge provides the necessary knowledge used to carry out the negotiation in an automated way. It comprises business intelligence for negotiation including a variety of negotiation strategies and business conventions, as depicted in the following Table 2.

Table 2: Negotiation knowledge in negotiation context.

Negotiation Knowledge Item	Description of Knowledge Comprised
Attribute Constraint	It defines a valid range for an individual attribute, or an inter-attribute relation.
Knowledge Item Constraint	It is to define relationship between a particular knowledge item and other relevant ones.
Attribute Rules	Negotiable conditions that govern the attribute requirements.

Negotiation knowledge are formulated and specified as procurement rules and constraints by negotiation experts. There are two types of constraints. The fundamental type of constraint is to define a valid range for an individual attribute, or an inter-attribute relation for multiple attributes within the same knowledge item. Another type of constraint is defined between a particular knowledge item and other relevant ones. This kind of constraint usually exists in a Bill-of-Material (BOM) consisting of multiple RFQs defined for different product items respectively. Constraints are usually used in quotes evaluation and ranking phase for screening qualified quotes. They are also used in negotiation to screen for attributes that fall within predefined ranges. Besides constraints, rules are widely used to describe the negotiation knowledge about relationships.

2.4 Knowledge Representation

Knowledge Bead (KB) as an object-oriented knowledge representation scheme was defined in (Fong and Zhuang, 2002), as an encapsulation of definition, behavior, and data: KB = Definition + Behavior + Data.

A KB can be a composite object, or a simple, atomic part object in most cases; each has their own methods and data. Definition means a static unique description; this can be a UPC (Universal Product Code) or a unique index implemented at the ontology databases for referencing this KB. Behavior is described by a set of possible methods and rules manipulating KB's and their attributes. Some typical ones include KB formation, duplication, attribute alteration, pruning and linking to other KB's. They are analogous to class functions in object-oriented programming, and can be inherited from base classes. Data consists of a group of attributes defined for the KB. Associated with each attribute, a weight is given as a relative priority indicating how important this attribute is in the current KB.

The use of KB in representing general knowledge about the negotiation context is shown in Figure 1. KB is created first by the user through some user interface. The data on the submitted web-page (form) is extracted into the construction of a KB object that resides on the server. The KB object is then used in the quote evaluation and negotiation processes. Note that KB is a general data representation format that can define the general knowledge items, and that can be implemented in object-oriented languages such as Java.
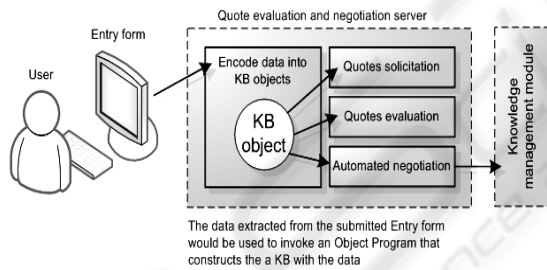

Figure 1: Representation of General Knowledge in KB.

Every general knowledge item can be represented in a certain template. The main categories of domain correspond to the types of general knowledge items including RFQs, quotes, proposals, agreements, profiles, and traces as listed in Table 1.

The product space is represented as a labeled, directed graph with two types of nodes: a leaf node and a category node, as depicted in Figure. 2.. Every leaf node in the product space is represented in a KB template developed by the system. It inherits attributes and behaviors from its parent category node, along with new features and operations added. Each KB template has an identity number composed

of the category name and the name of the leaf node. The category name provides the basic domain information about a general knowledge item which makes use of the KB template. It is represented as a sequence of labels corresponding to the edges in the path, e.g:

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/ProductCategories/Electroics&Computers/Cameras&Photo/DigitalCameras
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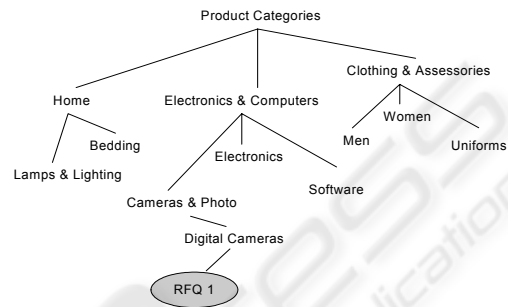

Figure 2: Part of the product space of KB templates.

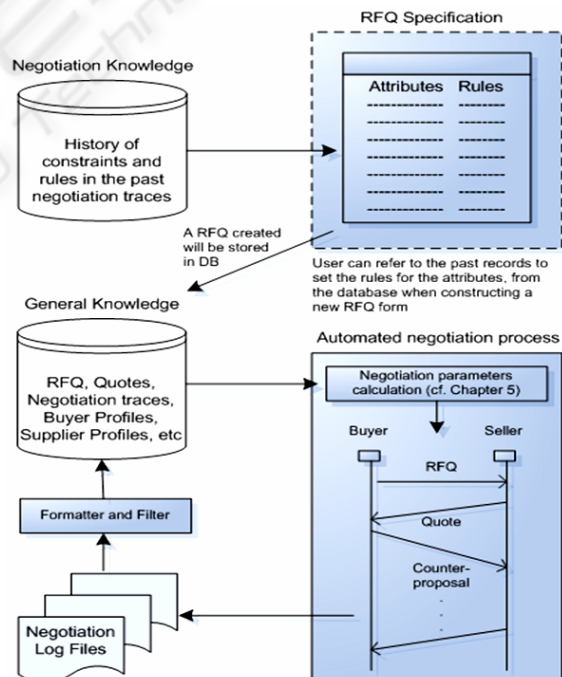## 3 METHODOLOGY OF KB'S FOR AUTOMATED NEGOTIATION

Figure 3: Methodology of KB's for automated negotiation.

As general knowledge items are represented by KB's and negotiation knowledge are specified as

constraints and rules that defined on attributes in KB's, the classification and clustering of KB's helps to manipulate and present the knowledge whenever it is needed by the system. Figure 3 shows how negotiation knowledge and general knowledge are used respectively for assisting the user to create a RFQ, and for the automated negotiation process. At the end of the process, log files are generated and added to the general knowledge database.

To make use of the knowledge contained in KB's, the negotiator first identifies the function that he need to do in the negotiation process. Then it's the knowledge agent who provides a concrete plan of utilizing the appropriate knowledge in the specific function. The proposed model also provides the negotiator the flexibility to adjust the weight of the knowledge factors which affect the function result. To our knowledge, most current automated negotiation systems lack the ability of specifying the explicit use of knowledge in a systematic way, thus lack an efficient knowledge assisted automatic negotiation process. For this purpose, we define **meta-KB** as a meta-object for describing the procedural knowledge necessary to perform a certain task in the e-Procurement context. It contains the meta-knowledge about KB's, which is knowledge about knowledge. The function which makes use of the meta-KB determines its discipline. Like an ordinary KB, a meta-KB contains attributes forming the knowledge. The attributes are either inherited from an existing KB or defined especially for the specific function, depending on the meta-KB's discipline. For each attribute, the meta-KB specifies how the attribute value is obtained.

Several typical functions are executed many times in different phases or in parallel during the multi-bilateral negotiations. These functions include supplier credit evaluation, quote evaluation, and negotiation result assessment.

The meta-KB for evaluation of a supplier inherits the attributes from the KB comprising knowledge about a supplier's credit as shown in Table 3. It is illustrated in the following table.

Table 3: Meta-KB for supplier evaluation.

Meta-KB	
Use: Supplier Evaluation	
Inherited From: Supplier Credit Profile	
Attribute	Derived From
Base Reputation	Input(Negotiation Expert)
Number of Contracts Made	f(Negotiation Log)
Average Utility	g(Negotiation Log)

The tag 'Meta-KB' denotes it a meta-KB, and the use of the meta-KB is declared at the top of the table. It then specifies from which KB template that the meta-KB inherits its attributes. The value of *Base Reputation* is input from a Negotiation Expert manually. The attribute *Number of Contracts Made* has a returned function value evaluated on the negotiation log. The function is denoted by f in the table. The attribute *Average Utility* also has a returned function value evaluated on the negotiation log. The function is denoted by g in the table. The negotiation log is a log containing all the past successful deals committed with the particular supplier. Weights associated with attributes are also inherited from the supplier credit profile, which are not shown here. Detials of the evaluation functions f and g can be found in (Zhang, 2006).

4 CONCLUSION

We discussed issues of applying Knowledge Beads (KB) into automated negotiation for e-Commerce. A methodology that is based on Knowledge Bead, an object-oriented ontology-based building block for knowledge representation, is proposed. Using KB and its methodology, quote specification and bargaining process can be streamlined, and data resulted from negotiation can be reused as knowledge in future negotiation. This provides a foundation for the knowledge management life cycle designed for coexisting with the negotiation life cycle.

REFERENCES

Reeves, D., Grosof, B., Wellman, M., and Chan, H., 2000. Towards a Declarative Language for Negotiating Executable Contracts. IBM Watson Research.

Jennings, N., Faratin, M., Johnson, T., Norman, J., O'Brien, P., and Wiegand, E., 1996. Agent-based Business Process Management. *International Journal of Cooperative Information Systems*, 5(2&3), 105-130.

Conway, S., and Sligar, C., 2002. Unlocking Knowledge Assets. Knowledge Management Solutions. Microsoft Corporation.

Fong, S., and Zhuang, Y., 2002. Enabling Agent Negotiation in e-Trading Environments Through Knowledge Beads. *IEEE International Conference on Intelligent Engineering Systems*.

Zhang, Y., 2006. Knowledge-Empowered Automated Negotiation System for B2B e-Commerce. PhD Dissertation. Tsignhua University. Dec 2006.