

Incorporating Knowledge into e-Commerce Automated Negotiation

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Abstract—Challenges in e-Commerce negotiation reside in two issues such as, automation and knowledge incorporation. In this paper, we describe how knowledge plays a role in automated negotiation. A methodology that uses Knowledge Beads (KB) as knowledge representation that would be suitable for the design of automated negotiation systems is specified. KB helps in giving a unified approach for representing the data throughout the process that includes evaluation, negotiation, and post-negotiation. We classify the types of knowledge namely Contextual e-Commerce Knowledge and Negotiation knowledge, in the negotiation process.

Keywords—Automated Negotiation, Agents, Knowledge

I. INTRODUCTION

A challenge in agent mediated negotiation in e-Commerce resides in inclusion of knowledge. A huge amount of data generated from transactions include but not limit to products, orders, shipping info, custom info, particulars of buyers, sellers and relating parties, but possibly dialogues of negotiations. It is a matter of what and how these data could be reused as some form of knowledge in subsequent dealings. Previous research [1] 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, and they still do have little support in knowledge management. 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 since 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. Realized that the business negotiation is not an once-off activity, it should be viewed as a continuous, iterative process. The negotiation outcomes of the current and past negotiations can and should leverage the future choice of negotiation policies and strategies, and, thus the behavior of

an automated negotiation system. A comprehensive negotiation model is needed to clearly define the different phases of a negotiation process and to show: 1) what information and knowledge should be specified or defined at different phases; 2) how they can be used by an automated negotiation system to conduct its negotiations with other automated negotiation systems, and 3) how the results of negotiations provide useful feedback to other phases of a negotiation process.

In essence, to automate the agent negotiation process, it has been widely accepted that two important 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 human and enterprise negotiation knowledge enables a negotiation system to conduct automated negotiations effectively and intelligently on behalf of its users. The knowledge and intelligence 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 in most agent-based services deployed 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 empowered automated negotiation.

This paper sheds some light on knowledge empowered automated negotiation in the multi-bilateral multi-attribute e-Procurement environment. The research aims 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.

II. KNOWLEDGE IN AUTOMATED NEGOTIATION

In the multi-bilateral multi-attribute negotiation life cycle, 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 repository, rule base and knowledge repository.

A. Knowledge Taxonomy

The goal of a corporate taxonomy is to provide a list of authorized terms in knowledge management and information seeking [2], 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: Contextual e-Commerce Knowledge and Negotiation Knowledge. (1) Contextual e-Commerce 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. Procedural knowledge is different from other kinds of knowledge in that it can be directly applied to a task. It includes the specification of different forms of relation existed among attributes represented as some form of Contextual e-Commerce Knowledge, which is necessary to carry out a specific task.

B. Contextual e-Commerce Knowledge

Contextual e-Commerce Knowledge (CCK) 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. Contextual e-Commerce Knowledge in a negotiation

Contextual e-Commerce Knowledge Item	Description of Knowledge Comprised
RFQ	Buyer's procurement requirement with respect to a certain concept.
Quote Proposal/Bid	Supplier's quotation based on RFQ. 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.

The proposed negotiation model supports multi-attribute RFQ. Typically a buyer creates a RFQ for a procurement request of product, be it either a goods or service. The RFQ consists of a list of attributes describing the product. Each attribute makes a reference to a physical characteristic or negotiable condition or term. Supplier's quote is created respectively based on what he can offer and what the RFQ is requesting. Proposals are messages bids exchanged between

two negotiating parties. For every proposal, the buyer will refer to the original set of attributes from RFQ, update the values of the attributes accordingly. This will repeat during the bargaining process. An agreement is the final proposal agreed by both parties if the negotiation succeeds at the end.

In general we use proposal or bid to denote RFQ, quote, agreement, and contract. Not only that all types of proposals are defined within the appropriate domains, each proposal is subject to a particular concept. A concept in the procurement context is the buyer or supplier's perception of the product specified in the proposal. For example, it is a norm for suppliers to consider purchasing orders that could only be fulfilled by a stringent time constraint. For orders that must meet a deadline, we call them urgent orders otherwise normal orders. Therefore we have two concepts urgent and normal in this case. They have different specifications, e.g. a large quantity is not required if the materials cannot be delivered on time for the forthcoming round of production, and a discount is not of a relevant attribute for negotiation in urgent orders. The supplier can then specify the conditions under which a specific concept could be offered. By preparing the possible concepts, their corresponding specifications, and associated constraints in advance, the process for choosing the best deal could be delegated to the negotiation agents rather than involving both the supplier and buyer in time-consuming negotiation rounds.

Traders' profiles are established to keep track of both buyer and supplier's information. In our negotiation model which is buyer-centric, buyer's profile is created to describe the common procurement preferences of a specific buyer. Supplier's profile is created to record the supplier's credit which is used for assessment of a particular supplier by the buyer. It is also used for the buyer to choose the appropriate negotiation strategy in negotiating with the supplier.

A negotiation trace is a log of 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.

C. Negotiation Knowledge

While Contextual e-Commerce 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. For example, a constraint defines that the delivery date of two specific items, among all the RFQs in a BOM, should be the same. Then every bid containing the two items will be checked against the constraint during the evaluation and negotiation phases.

Besides constraints, rules are widely used to describe the negotiation knowledge about relationships. Example rules to represent conditional relationships are as follow:

- Rules for personalized price discounting, refunds, lead time to place an order, canceling orders, etc. e.g. 10 percent discount if buyer has a history of big spending at the store.
- Rules about discounting for groups or preferred customer organizations, e.g. 5 percent discount for the club members.
- In RFQs and responding quotes, rules about conditional relationships between price, quantity, and delivery date, e.g. if the order quantity is between 400 and 1000 units, and the delivery date is between 15 and 30 days from the order date, then the price is \$49 per unit.
- In product catalogs, many properties of a product are most naturally specified as conditional on other properties of that product, e.g. all women's T-shirts are available in sizes XS, S, M and L.
- Policies about creditworthiness, trustworthiness, and authorization are often naturally expressed in terms of sufficient and/or necessary conditions. Such conditions include: credentials, e.g., credit ratings or professional certifications; third-party recommendations; properties of a transaction in question, e.g., its size or mode of payment; and historical experience between the agents, e.g., familiarity or satisfaction.

It is a natural way to represent negotiation strategies and business conventions using *if-then* rules and apply them in automated negotiation. They are often called business rules or business policies. In principle, an *if-then* rule specifies an action triggered by an *if* condition. A condition is predefined on a particular attribute or across multiple attributes. Attributes associated with rules are called pivot attributes. During negotiation, opponent's bid is evaluated attribute by attribute regarding the specification in buyer's proposal. When the negotiation executing subsystem detects that a rule is associated with a pivot attribute and the *if* condition is satisfied, the corresponding *then* event will be triggered to respond to the opponent's bid. Based on the negotiation protocol, the event can be one of the four negotiation

primitives: propose a counter-proposal, accept the opponent's proposal, reject the opponent's proposal, or terminate the current negotiation process. Especially in proposing a counter-proposal, the rule's triggering property provides an efficient mechanism to automate the concession process. For example, a rule defined on the attribute of delivery date is specified as: "If the delivery date offered by the supplier is late but less than 5 days, then the buyer should ask for a reduced price with 20% off for the requested product". Following the rule, buyer's negotiation agent can automate the construction of counter-proposal to the supplier by modifying the last price offered with the appropriate amount.

D. Knowledge Representation

Knowledge Bead (KB) as an object-oriented knowledge representation scheme was defined in [3], 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.

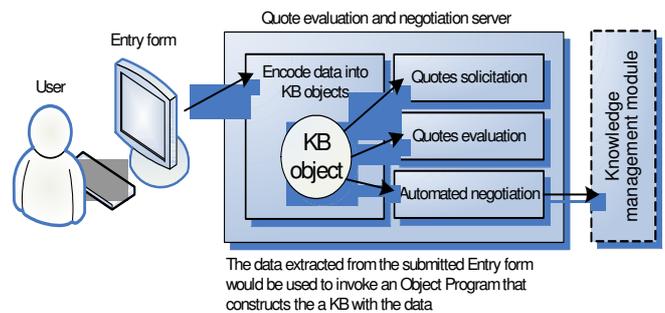


Fig. 1. Representation of CCK in KB

The use of KB in representing Contextual e-Commerce Knowledge about the negotiation context is shown in Fig. 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 Contextual e-Commerce Knowledge items, and that can be implemented in object-oriented languages such as Java.

Every Contextual e-Commerce Knowledge item can be

represented in a certain template. The main categories of domain correspond to the types of Contextual e-Commerce Knowledge items including RFQs, quotes, proposals, agreements, profiles, and traces as listed in Table 1.

Template domains of RFQs, quotes, proposals, and agreements are organized based on the product categories or themes, such as those listed on eBay (<http://www.ebay.com>). 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 Fig. 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 Contextual e-Commerce 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.

/ProductCategories/Electronics&Computers/Cameras&Photo/DigitalCameras

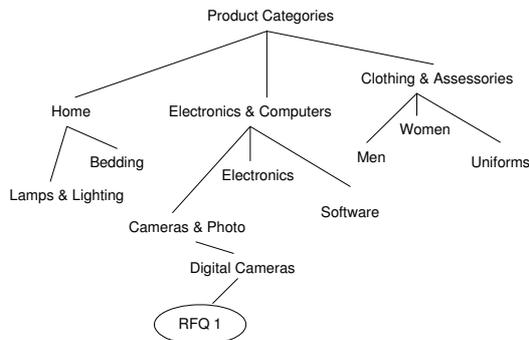


Fig. 2. Part of the product space of KB templates

Fig. 3 illustrates the states at which KB would manifest its form. When it is coded into a static RFQ, it is in some object-oriented program code in the Ready State. When the object is initiated to run, it runs as an operating system process in the computer memory. When the KB process terminates, it produces a number of files in data form, they could be the negotiation agreements and a collection of negotiation traces

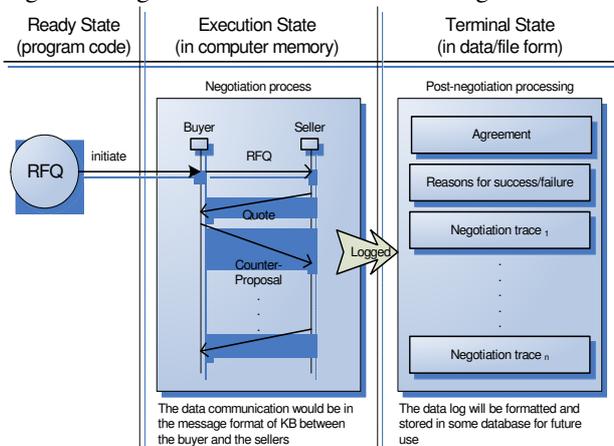


Fig. 3. A RFQ KB in different states.

III. METHODOLOGY OF KB'S FOR AUTOMATED NEGOTIATION

Most multi-agent systems which have applied ontology design focus on the use of domain ontology. In contrast with domain ontology which characterizes the domain knowledge where the task is performed [4], task ontology characterizes the computational architecture of a knowledge-based system which performs a task.

To establish the task ontology based on KB's framework, we propose the methodology of KB's for automated negotiation. Here the methodology is defined as a set of procedures employed by a discipline that is used in the negotiation life cycle. The discipline is determined on the function making use of the knowledge.

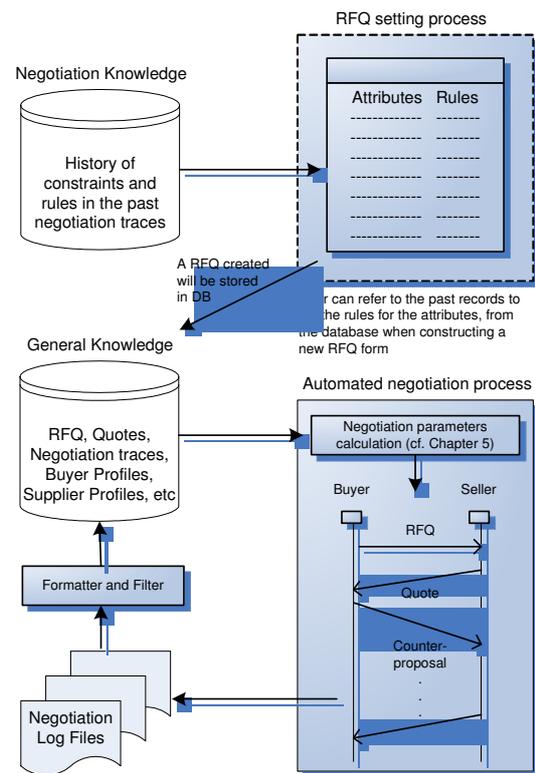


Fig. 4. Methodology of KB's for automated negotiation.

Fig. 4 shows how Negotiation Knowledge and Contextual e-Commerce 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 Contextual e-Commerce Knowledge database.

A. Meta-KB

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. 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. 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 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. Details of the evaluation functions f, g can be found in [5].

Table 3. Meta-KB for supplier evaluation

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

B. Knowledge Management Life Cycle

Knowledge management is performed throughout the proposed negotiation life cycle. Correspondingly, we propose the concept of knowledge management life cycle in automated negotiation. Our proposed knowledge management life cycle aims at facilitating the creation of negotiation expertise learning in automated negotiation. It comprises the following three phases: knowledge creation, exchanging and use of knowledge, and knowledge evaluation and renewal.

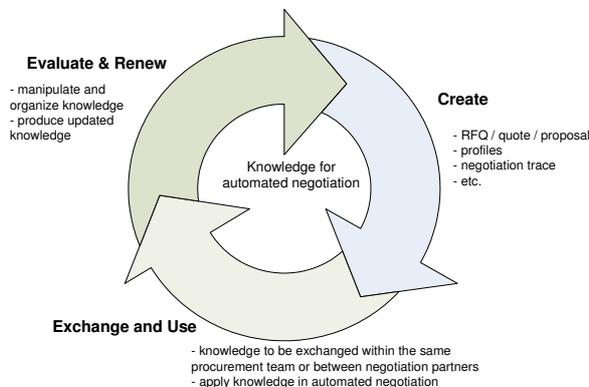


Fig. 5. Knowledge management life cycle

Knowledge Creation

The knowledge creation phase corresponds to the specification and design phase in the proposed negotiation life cycle. It executes knowledge management tasks to assist in the specification of negotiation context. Old and existing knowledge which is relevant to the current negotiation context is identified. New knowledge is then created with respect to the procurement requirements and constraints. This phase involves mainly the manipulation of the Contextual e-Commerce Knowledge items, which are represented in different KB's

Exchanging and Use of Knowledge

The phase of exchanging and use of knowledge corresponds to both the quotes evaluation and ranking phase and negotiation execution phase in the proposed negotiation life cycle. The knowledge management task to verify selected knowledge is performed in screening and evaluation phase, which is the core model of the quotes evaluation and ranking phase. The task to learn and apply negotiation knowledge from the history is performed in the negotiation execution phase.

Knowledge Evaluation and Renewal

The knowledge evaluation and renewal phase corresponds to the post-negotiation procession phase in the proposed negotiation life cycle. The knowledge management tasks mainly involve the capture and organization of knowledge, and the production of updated knowledge. This last phase involves re-evaluating old knowledge used in the past and using the evaluation result to create updated knowledge.

II. CONCLUSION

We discussed issues of incorporating knowledge into automated negotiation for e-Commerce. A methodology that is based on Knowledge Bead (KB), 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.

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