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How Ontologies Can Help in an eMarketplace

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HOW ONTOLOGIES CAN HELP IN AN E-MARKETPLACE

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Abstract

Recently, ontologies have been developed in various business domains with the recent maturing of the Semantic Web technologies. However, ontology-related researches have largely focused on the facilitation of successful matchmaking but not much on traders' requirement elicitation and potential negotiations in e-marketplaces. Because ontology provides the key knowledge about the inter-relationships among the issues and alternatives of the traders' requirements, we show how to elicit trade requirements, alternatives, and tradeoff from an agreed ontology. This facilitates the whole business process of the e-marketplace, from matchmaking, recommendation, to negotiation. We further propose a novel methodology for the elicitation of dependencies among traders' requirements for the formulation of an effective decision plan. As a result, traders can have a better cognition of their requirements and the overall operations of the e-marketplace can be streamlined.

Keywords: e-marketplace, semantics, ontology, matchmaking, recommendation, negotiation.

1 INTRODUCTION

Recently, Semantic Web technologies (Fensel et al. 2001, Daconta et al. 2003) have been maturing to make e-commerce interactions more flexible and automated. The Semantic Web provides explicit meaning to the information available on the Web for automated processing and information integration based on the underlying ontology. Ontology defines the terms used to present a domain of knowledge that is shared by people, databases, and applications. In particular, ontology encodes knowledge possibly spanning different domains as well as describes the relationships among them. Ontologies have also been developed in various business domains such as HIPAA (2003). Table 1 summarizes the contribution of ontology to some typical problems in e-marketplaces, which is detailed in this paper.

Function	**Traditional e-marketplace problem**	**Contributions of Ontology**
Match-making	Match-making is often ineffective because of the rigid definition of products of limited attributes.	Shared and agreed ontology provides common, flexible, and extensible definitions of products and requirements for match-making and subsequent business processes
	It is difficult to specify complex product requirements because the relationships among attributes and values are ignored.	Complicated requirements can be decomposed into simple concepts for streamlining the elicitation of options
	User interactions are limited to mainly manually, which is time consuming.	Accessible by automated agents through Semantic Web specifications for more business opportunities
Recom-mendation	Recommendations are often only possible within the same category.	Ontology helps elicit alternatives for recommendation.
	Pre-set formulae for every type of product are needed for evaluation.	Ontology help recommendation by evaluating offers in terms of flexible overall scaling
	Cross-sale and grouping of buyers and sellers with similar requests are difficult.	Matching grouping of buyers and sellers as well as cross-sale possible by inference with the ontology.
Negotiation	No implicit ordering of alternatives.	Implicit ordering of alternatives is elicited via inheritance.
	Manual negotiation or inadequate negotiation support cause inefficient process and ineffective recognition.	Machine understandable semantics facilitate negotiation and automatic configuration of products and services as specified.

Table 1. Contributions of ontology to e-Marketplaces: an overview

In particular, researches in Semantic Web for e-marketplaces have mainly focused on the facilitation of successful matchmaking but not much on the requirements elicitation for the traders or potential negotiations upon matchmaking failures and exceptions. Based on the discoveries of Chiu et al. (2005) on using ontology for the elicitation of negotiation requirements and the formulation of efficient negotiation processes, we adapt them to become the fundamental effective support for the elicitation of trade requirements. Ontology provides the key knowledge about the inter-relationships among the issues and alternatives of the traders' requirement so that object-oriented analysis of them can be streamlined and possibly automated in an e-marketplace. We further extend it for the evaluation of offers in the different business processes of the whole e-marketplace, namely matchmaking, recommendation, and negotiation. As a result, traders can have a better cognition of their trade requirements and therefore enable them to make better trading decisions. We also briefly explain how ontology helps increase trading opportunities through cross-sale as well as group buyers or sellers together for higher market efficiencies and increase the possibility of trade.

The remainder of this paper is organized as follows. Section 2 discusses background and related work. Section 3 presents a concept model of an e-marketplace based on ontology. Section 4 describes a motivating example ontology. Section 5 discusses how ontology is useful in the business processes of an e-marketplace. Section 6 outlines our system architecture and some implementation details, followed by discussions and summary in Sections 7.

2 BACKGROUND AND RELATED WORK

Analysis by Forrester (2000) estimate that 18% of global exports will flow online by 2004 and that cross-border e-Marketplace trade will surpass $400 billion. Despite technical challenges, e-Marketplaces have emerged to be important trading platforms in recent years. The popularity of e-Marketplaces is largely attributed to their improvement in economic efficiency, reduction in margins between price and costs, and speeding up complicated business deals (Feldman 2000). However, there are also drawbacks when online e-Marketplace are implemented and used for business transaction. Apart from technological capability, the motivation of the adopting organization is central to its success in entering the e-marketplace (Grewal et al. 2001). Even devoted to the involvement, obstacles such as boardroom conflicts, integration hurdles, and unprofitable business models still have to be overcome (Forrester 2002). Due to its immaturity, e-Marketplaces are often industry-specific with competitors joining forces to aggregate their purchasing power operating both horizontally and vertically (M2 Presswire 2003). Because of cost, organizations in all sizes are expected to purchase a significant amount in order to gain benefit by adopting e-Marketplaces in their procurement process (Lassen et al 2002). Organizations dedicated to it still have to modify its business process in a number of areas including changing internal procurement processes, integrating e-Marketplaces within internal systems, purchasing B2B applications, and paying e-Marketplace transaction fees (CC News 2001).

On the other hand, although Semantic Web technologies are maturing, ontology standards are still forming (Fensel et al. 2001). Challenges remain for reusing available ontological information and researchers focus on information integration. In the past years, there are different standardized languages proposed. For example, DARPA Agent Markup Language (DAML, 2004) is a language created by DARPA as an ontology language based upon the Resources Description Framework (RDF, 2004). DAML-S was designed to serve as the basis for representing descriptions of inverses, unambiguous properties, unique properties, lists, restrictions, cardinalities, pairwise disjoint lists, and data types. The Web Ontology Language (OWL, 2004) is an eXtended Markup Language (XML) proposed by the World Wide Web Consortium (W3C) for defining Web ontologies. OWL ontology includes descriptions of classes, properties, and their instances, as well as formal semantics for deriving logical consequences in entailments. Van den Heuvel and Maamar (2003) propose that intelligent Web services using ontology can help service composition and the formation of new types of e-marketplaces. Edgington et al. (2004) point out that adopting ontology can facilitate knowledge sharing. He et al. (2003) has surveyed a large number of researches on agent-mediated e-commerce and point out that semantic interaction and personalization are the main problem. However, at the time of writing and as far as we know, no other publications in major journals detail the applications of ontology in e-marketplaces.

Cho (2001) studies various requirements of negotiation support in e-Marketplace and evaluates some popular e-Marketplaces. Despite rapid automation of the other phases of e-commerce transactions, negotiations are often done by using emails or traditional manual communication technologies such as phones or face-to-face meeting, causing serious overhead costs. The work further provides a framework for designing and evaluating a multi-dimensional auction model. However, these studies do not cover different modes of negotiation comprehensively in one complete framework nor negotiation based on e-contracts. Yen et al. (2000) propose an intelligent clearing-house approach that supports both data and textual information about dynamic markets during negotiation, and develops an agent-based prototype Virtual Property Agency. Negotiation support is mostly limited to simple bidding functions. There is a lack of general support for bargaining like the proposed mechanism in this paper. Schoop and Quix (2001) present the negotiation process as the exchange of contracts between the parties in an e-Marketplace. The contract contents are presented as extensible semi-structured documents. During the negotiation process, the contract evolves over time until a final agreement has been reached or the negotiation is terminated. All these works do not consider traders' requirements elicitation or other fundamental mechanisms relating to the effectiveness of negotiation.

Yu and Mylopoulus (1996) consider the dependencies of business goals but not down to the practical details of traders' requirements elicitation. Phelps et al. (2004) suggest the use of ontology for agent-based negotiation with a focus on the heuristics of bidding strategies of auctions instead of negotiation plan for bargaining support. Lee (2000) points out the use of semantic value and ontology servers with the help of context agents to avoid inconsistency in the exchange of offers during e-negotiation, but not further for requirements elicitation. Ontology negotiation enables users to cooperate in performing an activity based on different ontologies (Bailin and Truszkowski 2001). Modeled on the patterns of successful human communication, ontology negotiation consists of a series of interpretations and clarifications intended to locate common vocabulary and assumptions (Bailin and Lehmann 2003). However, these studies concerned with how consensus of ontologies can be arrived at. They do not consider further how an agreed ontology can help the requirements elicitation as well as the formulation of matchmaking, recommendation, and negotiation processes in general, as our novel attempt in this paper.

3 E-MARKETPLACE CONCEPTUAL MODEL AND OUR METHODOLOGY

In this section, we extend the conceptual model of Chiu et al. (2005) for an e-marketplace and an overall process model as a methodology to support all the main business processes (instead of just negotiation), starting from traders' requirement elicitation, to matchmaking, recommendation, and negotiation using ontology.

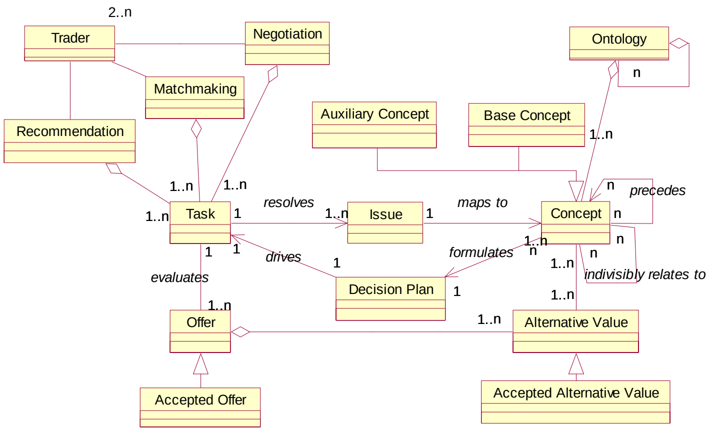

Figure 1. Conceptual Model of an ontology-based e-Marketplace in UML Class Diagram

Figure 1 presents a conceptual model for an e-marketplace in the Unified Modeling Language (UML)(OMG 2001) class diagram based on ontology. Traders are involved in the three main business processes of an e-marketplace, namely, matchmaking, recommendation, and negotiation. Each process is made of up tasks, each of which aims at resolving a requirement issue or a collection of co-related issues. The elicitation and evaluation of these issues is facilitated by mapping each of them to a set of concepts and their relationships based on an agreed ontology. If an issue is mapped into exactly one concept in an ontology, we call this concept a *base concept*. However, if an issue can break down into several concepts according to an ontology, we call these concepts *auxiliary concepts*. In this way, the agreed ontology help the traders to elicit their requirements before evaluating and making their decisions, that is, identify the inter-relationships among the issues and concepts, as well as possible alternatives for the issues (as explained in Section 4).

A decision plan can thus be formulated based on the relationships across these concepts. The plan presents a strategy to drive and organize various tasks in the e-marketplace. The e-marketplace's intelligent software considers multiple offers and bids in a matchmaking task or a recommendation task until results are found in is. On the other hand, a task for e-Negotiation represents some work that needs to be executed by a set of parties that can be a negotiator, or even a program such as Negotiation Support Systems (NSS) to resolve some specific issues.

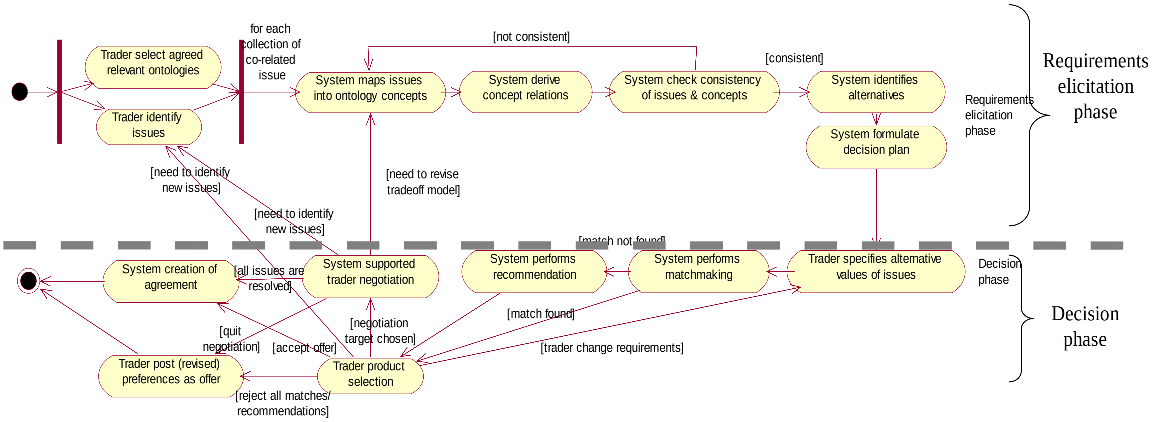

Figure 2. Ontology Based e-Marketplace Process Model in UML Activity Diagram

Figure 2 depicts (in the notation of UML activity diagram) the overall process model for an e-marketplace as well as our proposed methodology for the elicitation of traders' requirements based on ontology. The overall e-marketplace business process is driven by our conceptual as described in the previous sub-section. Traders have to participate in each constituting activity of the process, which consists of two major phases: requirements elicitation phase and decision phase. The requirements elicitation phase is based on the most common and logical way of analyzing the issues with ontology (as detailed in Section 4). We do not preclude other possible sequences for a feasible decision plan formulation. In particular, decision plans once elicited can be stored in a repository for reuse and adaptation. That means, traders may just pick a decision plan from the repository and starts right away. Therefore, our approach is suitable for e-marketplaces of more complicated B2B e-commerce, where semi-structured decision making are often repeated and efficiency is also important.

The decision phase is also heavily supported by the e-marketplace, which first suggests matching offers, and then if not found, recommend those near misses for selection or potential negotiation. Note that only through mutual concessions can the negotiation process reach an agreement. This process eventually leads either to a successful creation of an agreement or the trader may insist in posting the requirements as a new offer in the e-marketplace for other traders, without accepting any existing ones. The following steps further elaborate on our methodology. In Phase 1, the *Requirement Elicitation Phase,* a trader has to determine the issues of requirements.

1. At the same time, the trader selects a commonly agreed ontology from the e-marketplace's ontology to help the elicitation of requirements.
2. The requirements are related to the concepts in the selected ontology.
3. The system checks all the dependencies of concepts that constitute the requirements from the (refined) ontology map. Mutually dependent clusters of concepts determine the indivisible groups of requirements that have to be considered together so that effective tradeoff can be evaluated.
4. The system checks the consistency of all the concepts, issues, and their dependencies (Cheung et al. 2002).
5. For a consistent plan, the system can proceed to elicit the possible alternatives; otherwise we have to re-iterate from step 3.
6. According to the dependencies, the system can formulate a precedence graph of the requirements and requirements groups. Based on the precedence graph, an efficient decision plan can be determined.

In Phase 2, the *Decision Phase*, not only does the effective decision plan help systematic stepwise evaluation in match-making (instead of considering an exponential number of alternative combinations) and recommendation, the progress of a negotiation can also be visualized and exploited with the maximum possible concurrency.

7. The system searches for the matching offers based on the trader's preference and attempt to rank them for the trader to choose. The trader may then either (i) accept any matched offers or (ii) chance his reservation price and attempt a negotiation with those offers in order to seek for a more favorable one.
8. If no matching offers are found, the system identifies near misses and also attempts to rank them for the trader to choose. The trader may (i) change his mind to accept a near miss, or (ii) choose a near miss for negotiation.
9. During negotiation, the system supports the user to make and evaluate offers / counter-offers based on the decision plan (from step 6) in a negotiation session as follows (Chiu et al. 2005).
   - Each negotiation cycle starts with the identification of a set of interrelated requirement issues to be next negotiated, according a negotiation plan based on that from step 6.
   - Each party will then prepare the reservation alternatives (reservation price) of these issues. After that, they may either make an offer to or wait for some offers from counterparties.
   - If a party is not satisfied with the (counter-) offer, another counter-offer or a failure message will be received.
   - A negotiation cycle finishes successfully if an acceptance notification of previous (counter-) offer is received.
   - Finally, the negotiation process succeeds when all issues have been successfully negotiated. An agreement is successfully created when all issues have been resolved.
   - However, as the traders may relax their requirements during the negotiation process, some other offers in the e-marketplace may satisfy one or both of them and therefore cause them to quit the negotiation process. This is an extension to the approach of Chiu et al. (2005).
10. In step 7 to 9, the trader can always quit the process, insist on a different requirement, post it to the e-marketplace, and wait for some other traders' responses instead.
11. Should new requirement issues arise in the decision phase (say, due to incomplete specification), the trader can repeat from step 2 to analyze the new issue and its relationships to the existing ones. In real-life, the formulation of a decision plan may involve several iterations. This reflects the traders may not be able to understand all the inter-relationships among the issues in one shot.

4 HOW ONTOLOGIES HELP

In this section, we first present a motivating example and discuss how ontology helps the overall operations of an e-marketplace instead of just for negotiation (Chiu et al. 2005). Though the use of ontology in groupware and collaboration systems is not new, we show how ontology can be applied in a much wider and important scope in an e-marketplace.

4.1 A sales example

Ontology help e-commerce activities through mutual understanding and the facilitation of information exchange (Fensel et al. 2001). Figure 4 presents an example ontology for a selection of concepts for the requirements of a sale order of clothing (adapted from Chiu et al. 2005). Concepts are represented in rectangular boxes. A *Sale Order* may consist of multiple *Clothing* requirements, each comprise the *Quantity* to be ordered, *Appearance*, and *Unit Cost*. Appearance consists of *Size* and *Color*. The former may attain a value ranging from *small* to *extra-large* while the latter can further be classified into different specific color concepts such as *Red*, *Purple*, and so on. Besides the clothing requirements, a *Sale Order* is characterized by the information about *Payment Terms*, *Discount*, *Refunding Policy*, and the *Total Amount* of the order. *Delivery* involves three issues: *Shipping Cost*, *Delivery Date*, and the associated *Insurance*. In addition, directed lines show the dependent relationships among concepts and lines without arrows denote bi-directional relationships.

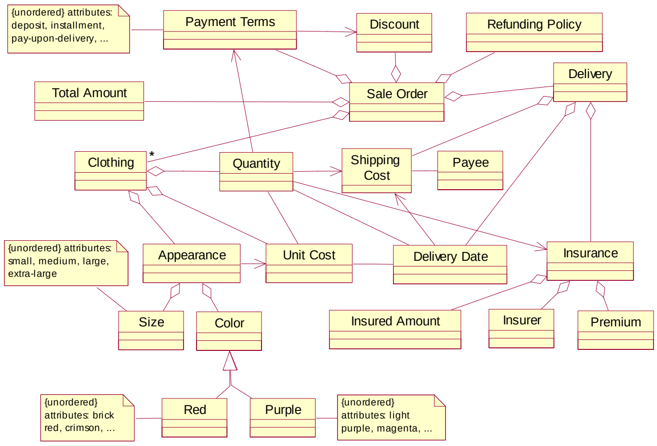

Figure 4. A Simplified Ontology of Clothing in UML Class Diagram

4.2 Understanding requirements from ontology

The main difficulties during the traders' communications are the inconsistency in the represented values and how to make the data interchange meaningful. To address this, ontology presents machine-understandable semantics of the requirements about the products as well as helps automatically configure products and services according to specified requirements. In particular, shared and agreed ontology provide common definitions of the terms to be used in the subsequent business processes of the e-marketplace. We propose the following methodology extended from well-known graph search algorithms (Cormen 2001) to enhance the completeness of issues in requirement elicitation:

1. Key requirement issues such as unit cost and quality are preliminarily identified in the first round.
2. For each identified issue, check if a direct mapping to a concept in the ontology is possible. If not, see if an issue can be refined into a set of more specific concepts in the ontology, which combined can represent the issue. A typical example is that a cost can be refined into constituent costs that sum up to it.
3. Ontology is often incomplete and therefore subject to further refinement. New concepts can be introduced to the ontology upon mutual agreement. However, upon such refining, the relation of a new concept to the existing ones should be elicited to help understand the new concept itself as well as determine the potential dependence of issues for the traders. For example, the *refunding policy* requirement (together with its relation to sale order) could have been introduced into the ontology during the maturing of ontology in order to arrive at the one shown in Figure 4.
4. For each identified concept *c*, examine every un-visited node *n* adjacent to *c* in the ontology map.
5. For each such node *n*, see if the new concept is relevant to the trader's requirements.
6. Repeat step 4 and 5 until no more related new concepts can be identified.
7. Only after a successful deal (matched, recommended, or negotiated) do we need to consider combining the newly identified concepts back to specify a more concise agreement, because we advocate decision centered on concepts.

4.3 Understanding dependencies of requirements from ontology

As we are mapping requirement issues to concepts in the ontology (as described in the above sub-sections), we also discover their inter-relationships at the same time. Based on principles in databases and artificial intelligence of computer science, we identify the following typical categories of dependencies among requirement issues.

- *Functional dependency* – This is the main type of dependence that motivates this research. The concept is borrowed from fundamental relational database concepts (Elmasri and Navathe 2000). The alternatives for an issue are determined by the alternatives(s) of other issue(s). For example, the cost of production depends on the delivery date and the quantity.
- *Computational dependency* - This is a more obvious type of functional dependency, which has a hardwired computational formula. For example, insurance amount = percentage * cost of goods.
- *Requirement dependency* (constraint satisfaction) – Only after the determinant value is known can other viable alternatives be determined. For example, whether a customer may pay by credit card, bank draft, or remittance is evaluated according to the total amount. Therefore, only after the total amount is determined can the decision of payment method take place.
- *Classification dependency* – This is a special type of requirement dependency in which the classification of another issue is dependent on the outcome of a satisfied issue.

4.4 Indivisible requirement components for tradeoff evaluation and decision plan

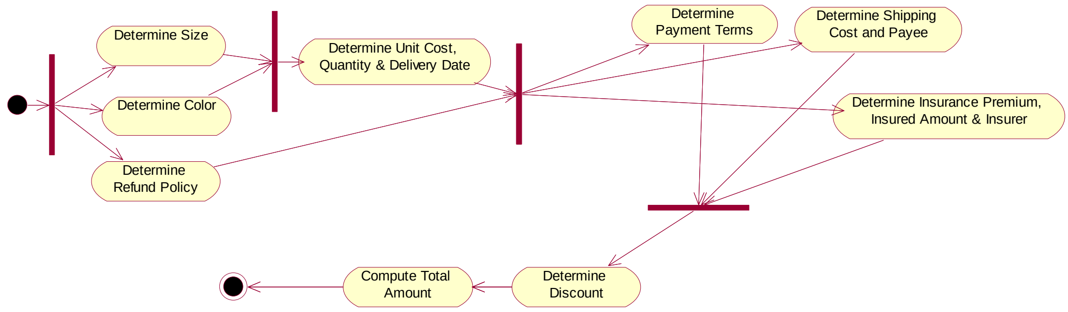

Figure 5. A Possible Decision Plan for Clothing Sale in UML Activity Diagram

Some concepts (and therefore requirement issues) have to be considered together at the same time. It occurs when there are cyclic dependencies among the concepts. Such group of concepts is mutually dependent and therefore must be consider altogether for tradeoff as they cannot be individually or sequentially considered during decision. After eliciting the dependencies, we can therefore draw a precedence graph (Cormen 2001) of the requirement issues and groups for formulating a decision plan.

Note that in the task "formulate decision plan", we construct a detailed process to realize the activity "make offers and counter offers" (cf. Figure 3). Figure 5 gives a possible decision process for a scenario of the sale of clothing. The decision process may start with the issues *Size*, *Color*, and *Refunding Policy* concurrently. Once the *Size* and *Color* are decided, the trade can proceed to decide the issues of *Unit Cost*, *Quantity*, and *Delivery Date*. The process succeeds with computing the *Total Amount* of the order.

4.5 Understanding requirement alternatives from ontology

Often, alternative for requirement issues cannot be expressed in numerical values. They are often in discrete values by its nature, such as country of origin, shipping company, and so on. Sometimes, they are not quantized in normal practices because of difficulties in recognizing them. For example, color is specified by its common name or more professionally in a color code, but rarely expressed in the wavelength of its constituent light-waves. In many other occasions, alternatives are not quantized for simplicity and convenience. For example, alternatives for size may be just *small*, *medium*, *large* or *extra-large* because either this is not important in the context or a precise value is not necessary.

When a complicated issue is decomposed into concepts, the elicitation of options can be much streamlined. For example, when the issue of appearance is decomposed into the concepts of size, color, and packaging, the alternatives of each concept can then be easily elicited.

Not only can ontology provides sets of alternatives for issues from membership relations, but often also partial or even total *explicit* ordering of them (e.g., small < medium < large < extra-large). In addition, *implicit* (partial) ordering may be elicited via inheritance ("is-a") or composition hierarchies. Thus, such extra knowledge provided by ontology can further assist traders to evaluate offers against their preferences and determine which counter-offers are decreasing the indifferences rather than increasing them.

4.6 Exploring more trading opportunities with the help of ontology

With the help of ontology and appropriate ontology languages, more business opportunities can be realized through improving the accessibility of automated agents to match functional specification in the Semantic Web. Agents could represent buyers or sellers. To utilize the most benefit from ontology, the e=marketplace is the best to act as "broker" between the selling and buying agents. For example, Li et al. (2004) describe a process called syntactic brokering which maintains a repository of them and enable the querying of all agents that provide the appropriate products or services, based on their classification and features as recorded in the e-marketplace. By doing this, the e-marketplace can increase business opportunities such as mapping of cross-sale as well as grouping buyers or sellers together for higher market efficiencies. This can be easily and efficiently done by considering the shared ontology attributes and constraints.

5 SYSTEM ARCHITECTURE AND IMPLEMENTATION

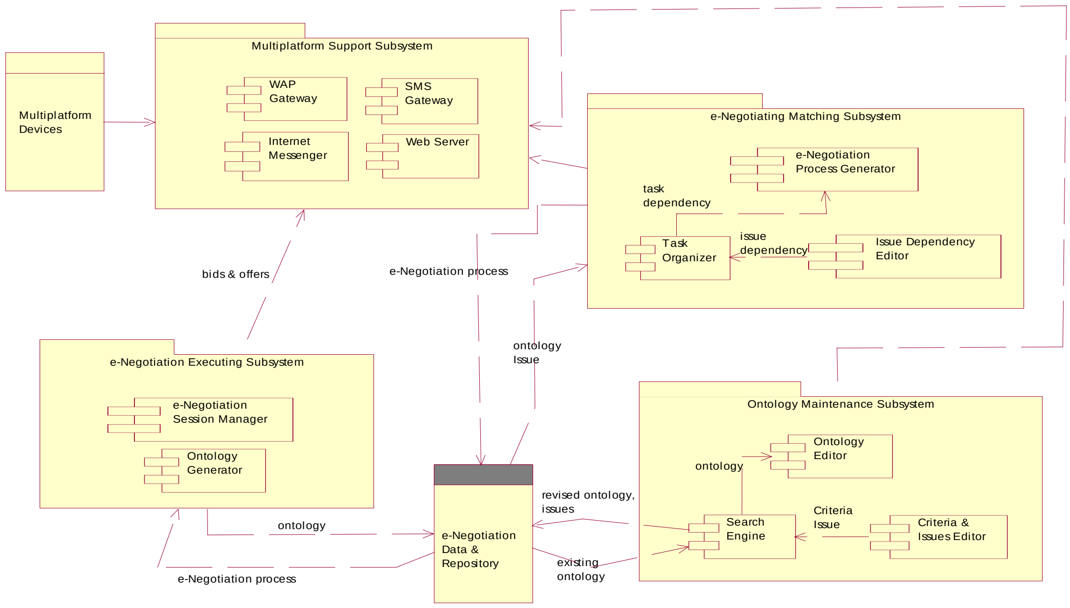

Figure 6. System Implementation Architecture

Figure 6 shows the implementation architecture for our e-marketplace based on ontology. The architecture is designed to support the business processes instantiated from the e-marketplace conceptual model in Figure 1 and the system flow in Figure 2. The design aims to provide flexible and reusable components. The proposed system is acting like an intelligent embellisher who knows the values, beliefs, and constraints of traders in order to increase the trading opportunities.

The architecture is made up of four subsystems. The *Ontology Maintenance Subsystem* allows traders to specify and edit their requirements issues and alternatives based on ontology. The *search engine* selects the most appropriate ontology based on a given set of criteria and issues. The retrieved ontology may be further revised using the *Ontology editor* to address all major required issues and alternatives. Revised ontologies as well as the issues and their alternatives thus derived may be stored in the repository for later retrieval. These data is then used by the *Matching Subsystem* to find matches and / or near misses for recommendations as well as to determine a suitable e-Negotiation process based on the issue dependency supplied. The selected e-Negotiation process is then enacted through the *e-Negotiation Executing Subsystem*. The *Multiplatform Support Subsystem* provides front-end supports to multiple platform devices, such as WAP, SMS, and Web browsers.

Based on this architecture, we are extending an e-Negotiation support system to a full-function e-marketplace with contemporary technologies, including Java applets, Java Server Pages, and Enterprise Java Beans. We are extending the system with support for ontology with the OWL Web Ontology Language (OWL, 2004) (instead of DAML) because W3C has designed OWL as a standard (Web-Ontology Working Group 2004). Figure 7 lists partially the example ontology used in this paper.

```
<owl:Ontology rdf:about="#Clothing">
      <rdfs:comment>Sample Clothing Ontology</rdfs:comment>
      <owl:Class rdf:ID="Clothing" />
      <owl:Class rdf:ID="Appearance" />
      <owl:Class rdf:ID="Color">
            <rdfs:subClassOf rdf:resource="#Appearance" />
            ...
      </owl:Class>
      <owl:ObjectProperty rdf:ID="hasAppearance">
            <rdfs:domain rdf:resource="#Clothing" />
            <rdfs:range rdf:resource="#Appearance" />
      </owl:ObjectProperty>
      <owl:ObjectProperty rdf:ID="hasColor">
            <rdfs:subPropertyOf rdf:resource="hasClothAppearance" />
            <rdfs:range rdf:resource="#Color" />
            ...
      </owl:ObjectProperty>
    <owl:DatatypeProperty rdf:ID="size"> <!-- Enumeration --!>
      <rdfs:domain rdf:resource="#Appearance"/>
      <rdfs:range> <owl:DataRange> <owl:oneOf> <rdf:List> <rdf:rest> <rdf:List> <rdf:rest><rdf:List> <rdf:rest><rdf:List>
           <rdf:rest rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#nil"/>
             <rdf:first  rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Small</rdf:first></rdf:List></rdf:rest>
           <rdf:first  rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Medium</rdf:first></rdf:List></rdf:rest>
             <rdf:first  rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Large</rdf:first></rdf:List></rdf:rest>
             <rdf:first rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Extra Large</rdf:first></rdf:List>
          </owl:oneOf></owl:DataRange></rdfs:range>
    </owl:DatatypeProperty>
    <owl:Class rdf:ID=" UnitCost"> …
      <owl:equivalentClass> <!-- unit cost depends on appearance -->
        <owl:Restriction> <owl:someValuesFrom rdf:resource="#Appearance" /> </owl:Restriction>
      </owl:equivalentClass>
    </owl:Class>…
</owl:Ontology>
```

Figure 7. Partial Ontology Listing of the Sale of Clothing

As such, a flexible e-marketplace for different e-Commerce domain with different ontology and different decision plans can be supported, without modifying the underlying system. The traders only need to define suitable ontology and derive an effective negotiation plan. This tremendously reduces the development time and costs, and therefore provides a big competition edge under this fast evolving digital economy.

6 DISCUSSIONS AND SUMMARY

In this paper, we have shown that ontology provides the key knowledge about the inter-relationships among the issues and alternatives of the traders' requirements so that object-oriented analysis of them can be streamlined and possibly automated in an e-marketplace. We have developed a conceptual model for an e-marketplace and proposed a pragmatic methodology for determining the traders' requirements and for formulating effective decision processes with the help of ontology. In particular, we have shown how the elicitation of requirement issues, tradeoff, and alternatives can be streamlined based on an agreed ontology. We further develop a novel way for the elicitation of dependencies among issues so that traders can have a better cognition of their requirements and focus particularly on tradeoff among inter-related issues. The openness of issues can be controlled and our algorithm verifies the completeness of elicited requirements. Observing the logical order across different groups of issues, more efficient algorithm could also be formulated for the system to carry out the matchmaking and the recommendations of near misses. We can also formulate an effective decision or negotiation plan with tradeoff support in this way.

Through our proposed mechanisms, the requirement elicitation and decision processes are properly guided, recorded, and managed. It also helps simplify the communication messages required across organizations during negotiation activities, as e-commerce activities are usually more structural and repeatable, thereby fitting well into our assumptions. As the traders of e-marketplaces often have to evaluate a large number of offers with different options while they are updated frequently of the market news about substitutive products, ontology help them better understand the offers as well as evaluate and specify their preferences in a stepwise manner. During negotiation, as traders relax their requirements, the e-marketplace can immediately look for offers that can match the traders' updated requirements in order to increase trading opportunities. This is one major advantage of our integrated approach over stand-alone negotiation support systems. On the other hand, ontology help better understand the products and offers so that the e-marketplace may cross-sale to traders as well as group traders into large transactions in order to increase the trading efficiency.

Most of the tasks in the requirements elicitation phase of our negotiation methodology can be prepared by e-marketplace administrators based on policies and their domain knowledge. Ontologies are specified with reference to relevant industry domains for different categories of products or services. At the same time, common issues and criteria can be identified with the typical requirements of the target users. Sample decision plans can therefore be formulated are then stored in a repository and available for reuse and user adaptation. Therefore, traders of a well-managed e-Marketplace not only enjoy convenience but also the pre-programmed knowledge thus obtained.

This work can be expanded in several directions. We are working on the enhancement of ontology-based matchmaking and recommendation algorithms for an e-marketplace environment. We are also working on the details for ontology-based cross-sale and up-sale as well as grouping of buyers and sellers for combined quantity deals. We are investigating formal logical models for ontology-based negotiation with reference to the work of Ramesh and Winston (1994). On the other hand, we are looking into further issues of e-Marketplaces, especially those related to mobile clients and constraint-based requirement specification.

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