A generic product ontology based on software agents incorporating negotiation and decision support techniques

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Abstract. The phenomenal growth of Internet-based information services and infrastructure in the recent years has provided a new technological basis for enabling and expanding the electronic execution of commercial transactions both on a business-to-business (B2B) and on a business-to-consumer (B2C) level. Electronic Marketplaces have increasingly played the role of an aggregator that merges potentially thousands of vendors and customers either as B2C virtual malls or as B2B electronic hubs. Virtually every working hub or marketplace focuses on either B2B or B2C business transactions. An integration of both categories would yield a generic e-hub made for all stakeholders across the process flows and covering every step of the way from production to consuming. The aim of this paper is to propose a novel architecture for the creation of economically viable e-hubs. We have argued that this can be accomplished through the ability of an agent-based electronic marketplace to transcend other taxonomical classification dimensions and, simultaneously, through the provision of an anthropocentric negotiation model and a flexible and "active" decision support. We have introduced a generic agent-based electronic marketplace architecture, comprising its three major components: ontology, negotiation and advising. According to the architecture proposed, we implemented the generic product ontology for the e-hub, focusing on its evaluation by using appropriate standards and widely accepted methodologies as well as other ontologies. We have also implemented a negotiation and a decision support system that come together and interact defining as a whole the functionality of the system.

Keywords. e-commerce, e-marketplace, e-hub, software agents, product ontology, negotiation, decision support

1 Dissertation Summary

The aim of this dissertation is the investigation of the electronic virtual communities and more specifically the application of software agents in electronic trade. Associated bibliography revealed the history of these societies, their growth, their technologies, their characteristics, their types as well as their margins of development [10], [13]. Thus general knowledge in the category of electronic marketplaces, a specialised sector of virtual societies was collected. Specifically, applications of software agents in the electronic trade and more specifically in electronic marketplaces were searched and developed [8]. These applications are generalised in three basic fragments of research: a) ontology, which is the heart of an electronic marketplace, b) negotiation, where all the activities of transaction are achieved and c) advisory services, which portray the supporting functionality of a marketplace. Combining these three technologies, a more general architecture in electronic marketplaces is proposed

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aiming at an essential confrontation of known problems and limitations that exist in them [11]. Then the classification of Kaplan & Sawhney [7] was studied, a classification standard for electronic marketplaces. The advantages and disadvantages of this classification were pointed out, as well as the possibility of transcending it through a generic architecture with the help of software agents [12]. By studying in detail this architecture, the three most important pieces of electronic marketplaces were developed. In the case of negotiation, a new anthropocentric system was developed and managed to put also in the game the purchaser with his rights, tactics, subjects and price limits [16]. In the advisory services, an economically viable marketplace with the help of a flexible and active department of support of decisions was proposed [3]. This system watches the actions of the user and gives advices according to his environment and demands. So through the systematic analysis, a generic product ontology that might include every possible product, every possible vendor and any prospective purchaser was developed [14]. Using techniques and already existing standards a new ontology development method was proposed and a general ontology was developed that includes negotiation and support of decisions transcending the Kaplan and Sawhney taxonomy.

1.1 Related Works

In recent years, electronic marketplaces have grown rapidly and formed marvellous giant marketplaces. For example, eBay, the most famous global electronic marketplace, has approximately 276 million registered users worldwide (http://news.ebay.com/fastfacts_ebay_marketplace.cfm). These users have posted a total number of 637 million new listings in the 4th quarter of 2007, i.e., averagely 6.7 million listings per day. In China, with an annual sale of RMB43.3 billion in the year of 2007, the dominant retail electronic marketplace—Taobao, defeated even the sum of local Carrefour and Wal-Mart and became the 2nd largest marketplace (http://forum.taobao.com/forum-14/show_thread----13526587-.htm). While the dramatically huge electronic marketplaces excite buyers by offering them abundant options, not surprisingly, they simultaneously make these options being too many to choose from. To help buyers locate their desired item, electronic marketplaces usually offer detailed item catalogues and powerful search engines. Even though, buyers still can find hundreds or thousands of items when search from electronic marketplaces.

Marketplaces can manage and present information about goods and trading status in different ways. Commodity markets typically offer a limited array of products, each described by a few parameters such as a stock name or a product grade. Other goods demand more extensive descriptions. On eBay, for example, there are usually more than four million different items for sale at any one time, and each is described by a few lines of text and perhaps a picture. Even if a user knows what item must be procured, there may be much difficulty in determining the identities of suppliers of that item and more importantly the suppliers that can supply the item with particular attributes at a particular price, for delivery before a particular date. Furthermore, even if the user is capable of determining an acceptable item-supplier combination, typically after a great deal of effort, the user is unable to determine whether a better overall deal could have been made through another supplier. As a result of any of these or other deficiencies, current procurement techniques have been inadequate for many needs. Electronic marketplaces are distinguished to controlled and uncontrolled marketplaces as shown in figure1 and discussed in [15].

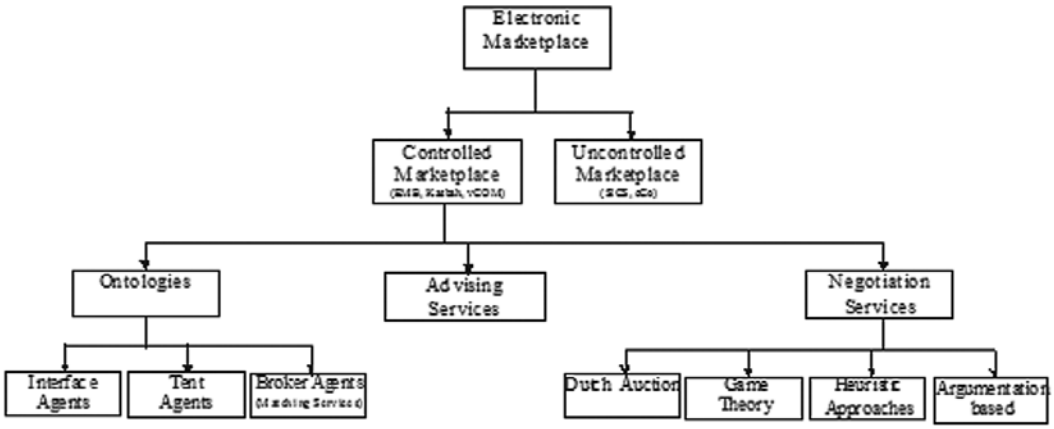

Figure 1: A categorization of the applications of agents in electronic marketplaces.

In a *controlled* marketplace the participants have to agree upon a certain set of rules concerning both what can be bought and sold and how this can be carried out. An *uncontrolled* marketplace is entirely open and decentralized; no single party for example sets the rules or controls the market. Each participant may initialize an agent that will act on its owner's interest using strategies uniquely defined for this agent. Uncontrolled electronic marketplaces are quite promising but they have to overcome an abundance of problems and are very difficult to implement. Although some interesting initiatives, such as the CommerceNet eCo System (www.commerce.net/eco/) exist, uncontrolled multi-agent marketplaces are still rather a vision than a reality. Agent-based functionality according to our research can be applied in the fields of ontologies, advising services and negotiations.

Most of current commerce agents like "shopping bots" only support the Product or Merchant Brokering stages, only two of the six stages of the CBB model [4] that is used to explain the different stages of a deal. Few systems go into the negotiation part and even fewer help anticipate consumer needs (Need Identification stage) and provide paths into the subsequent CBB stages. But a flexible marketplace needs to support more stages to be successful.

There is an ongoing research on the applications of agents in electronic marketplaces which was first proposed by [20]. The proposed architecture addresses four of the six stages of the CBB model. The problem with the marketplace proposed by [20] is that the agents are using a common syntax of a widely acceptable communication language. There is no ontology to strengthen the system making it rather difficult to become a widely accepted electronic marketplace architecture for agents to act.

Ontologies refer to models of a domain upon which agents rely for performing various tasks such as negotiation. Without defined ontologies, the application of agents in marketplaces and virtual communities will be severely limited and this fundamental need drives research on how ontologies can be shared and reused, how they can be revised when needed and how their consistency can be improved. Ontologies should be implemented in a way that they can be reused or even expanded with new terms but at the same time be resistant to structural revisions since they are created according to a logically consistent model [1]. For example the approach presented by [17] helps in maintaining large sets of transformation rules by providing for their decomposition into smaller and more understandable pieces and facilitating rule reuse.

When agent-based negotiation techniques were first proposed the requirement was reaching a better price for buying a product. As negotiation as a process evolved, additional information was needed so that a user could better decide for a purchase of a product and a plethora of negotiation objects appeared. These objects can be price, quality, timing, penalties, terms and

conditions or types of operation and are deemed as helpful in negotiating a product [6]. With agent-mediated negotiation, users need to be sure that the agent would achieve the best possible deal for them and that the product they are negotiating for is what they really want. Researchers emphasize on techniques that enhance trust amongst the user and his agent. This can be achieved by the continuous feedback given by the agent with additional information about the product and the negotiation phase. An agent should be able to support and advise the user for his/her actions.
A number of techniques have been proposed with each one aiming to enhance the efficiency and effectiveness of the negotiation process. The Dutch auction technique [6] is a very slow technique if none of the participants wants to buy the product. A viable solution is to provide the managing agent of the Dutch auction with additional meta-level information so as to speed up the process. Techniques borrowing principles from Game theory are generally regarded as much more efficient but suffer from one main limitation; the best possible solution is computationally intractable. With heuristic approaches, contracts that are closer to the opponent's last offer are provided but agents using these approaches often select outcomes that are sub-optimal so as to reach a deal. The best technique that has been proposed so far is the argumentation based technique where additional information over and above proposals is being exchanged.
The provision of advising services as a means for aiding the user to complete a specific task enhances the overall usability of a systems and is thus deemed critical. Traditionally, manuals and help files aided the user in the quest to find if a certain task can be performed by the system and how it can be done. Soon after, help files made their appearance enhanced with search and query capabilities. The main problem with these is that a user must know the syntax and semantics for asking the question or the answer will not be a good match to the original query. Research on agent-enabled advising services focuses on the intent, the timing and the level of intrusiveness of an advising service with researchers having proposed three styles of critic agents. These are 'Before-', 'During-' and 'After-Task' critics [19]. The main disadvantage of Before-Task critics is that as the information provided cannot be processed and filtered to match the exact user needs, redundancy and user overload is the result. During-Task critics are considered to offer the best possible advising service to the user; the drawback here being the user becoming fully dependent on the agent and the system without being able or willing to exercise any critical abilities or generate personal inferences. In contrast, After-Task critics do not distract the user, but they cannot prevent a wrong decision being made as any advice follows on the execution of the task. For agent-enabled advising services to advance in terms of usability future research should focus to a multi-style advising service using a mixture of 'During-' and After-Task style critics because the former can help in avoiding mistakes and the latter can add value in offering alternative solutions.

1.2 Innovative results of the dissertation

In this section we propose a generic and agent-mediated electronic marketplace architecture in an attempt to overcome existing impediments using latest research methods as shown in the previous section. The two main components in figure 2 are the buyer and the seller. They interact with each other via a negotiation and an active decision support system both exchanging data with the product ontology. We also show how the three basic components of an electronic marketplace (Ontology, Negotiation, and Decision Support) based on our previous research, come together and interact defining as a whole the functionality of the system. The first component is the Generic Product Ontology which is an ontology created so as to cover every possible product or input combinations which can be stored in the systems

database. The second one is the Negotiation Agent, who is responsible for managing the negotiation process between the buyer and seller using ontology attributes and for reaching a mutually acceptable promise which is then fulfilled through the logistics services. The third one refers to flexible and "active" decision support system. Flexible, in the sense, that it will accommodate all the diverse needs of the actors in the context of taxonomy classification transcendence and "active" in the sense that it will act proactively to support the decision making processes of the actors in contradiction with the traditional "passive" Decision Support Systems that required from their users to possess full knowledge of their capabilities and exercise initiative, something criticized since the late eighties [2].

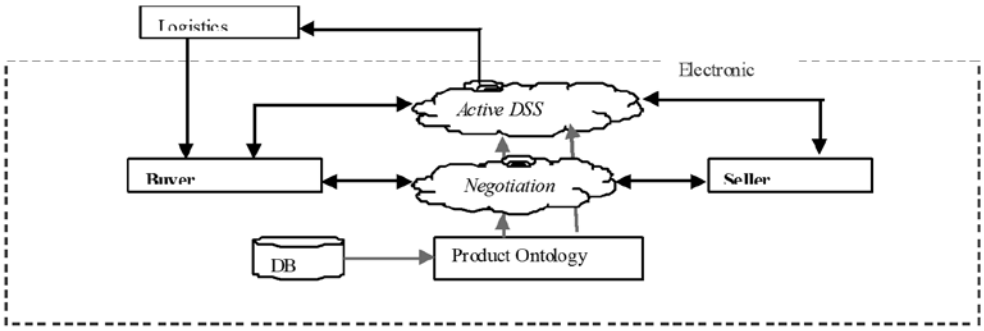

Figure 2: Generic and Agent-Mediated Electronic marketplace Architecture.

2 Results and Discussion

Ontology is a taxonomic catalogue of concept types and relation types and is a difficult, long and crucial part of the Knowledge Acquisition (KA) process (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/blazquez/#FernandezEtAl97). A few research groups are now proposing a series of steps and methodologies for developing ontologies. However, mainly due to the fact that Ontological Engineering is still a relatively immature discipline, each work group employs its own methodology. In recent years, product ontologies have attracted both industry and academia because of their potential contribution to solving integration problems in e-commerce systems [18]. The heterogeneity of product information is a critical impediment to efficient business information exchange. There is no uniform description for each product type among vendors. In electronic commerce activities involving interactions among different vendors (business-to-business model) or between one buyer and multiple vendors (consumer-to-business model), a common ontology for the products is critical. There are countless approaches for the categorization of goods, ranging from rather coarse taxonomies, created for customs purposes and statistics of economic activities, like the North American Industry Classification System (NAICS) and its predecessor SIC (http://www.census.gov/epcd/www/naics.html), to expressive descriptive languages for products and services, like eCl@ss (www.eclass-online.com), eOTD (www.eccma.org), or RNTD (www.rosettanet.org), UNSPSC (www.unspsc.org) and the Epistle (www.epistle.eu).
The EPISTLE (European Process Industry STEP Technical Liaison Executive) is a brand new research effort to create a generic product ontology that stems from the need of a place to store the meaning and map between different terminologies. Using STEP - ISO 10303 and Parts Libraries - ISO 13584 developers tried to create standard instances held in external files

(class libraries) , which are also standardised by ISO, using an externally maintained registry with continuous revision. There are some drawbacks though, that need to be dealt with as the developers themselves claim. At first, there are no generic tools for access and maintenance since merging different libraries is a particular problem. Secondly, a consistent format for all levels is needed. Thirdly, there is no sharp distinction between data and meta-data. Lastly, the domain class libraries are not yet published as an ontology on the web. Nevertheless, it is a worthwile research effort that may become a global standard for product ontologies.
The UNSPSC_v8 library, widely cited as an example of a product ontology, provides an industry neutral taxonomy of products and services categories, but no standardized properties for the detailed description of products [5]. The UNSPSC_v8 library was originally developed in 1998 during a collaboration program between the United Nations (www.un.org) and the Dun & Bradstreet (www.dnb.com) company. This ontology is today a worldwide standard that provides a wide range accurate categorization of products and services with a growing ratio of about 230 new classes per 30 days, showing significant maintenance of existing entries [5]. UNSPSC is used widely in business, especially in electronic commerce system. For example, Commerce One's Commerce Chain Solution (http://www.commerceone.com/solutions) and Ariba.com's Network have adopted it in their work on product content management.
For the development of our ontology, since we are interested in implementing software, we adopted the software development process standard (IEEE 1074 1996) which helped us through the procedure of developing and testing our ontology. In figure 3 we show the transformation of the IEEE directions into an ontology task analysis.

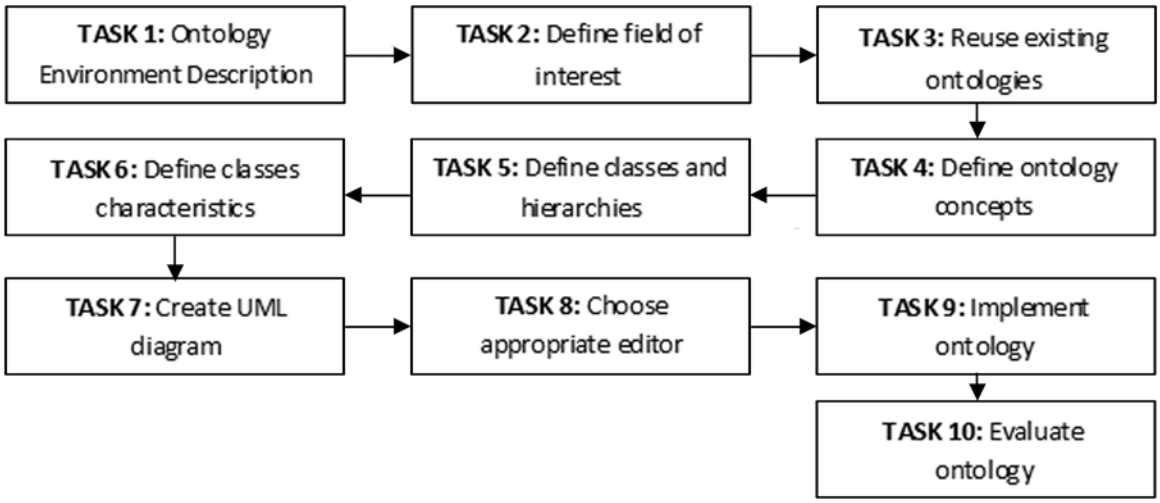

Figure 3: Ontology Task Analysis

According to the IEEE standard the first task belongs to the Pre-Development Processes. Accordingly, tasks 2-4, belong to Requirements Process, tasks 5-7 to the design process whilst tasks 9-10 refer to the implementation process. The last task is the one that was used for evaluation of the ontology and belongs to the Integral Processes. In the following paragraphs we deal with each task shown in figure 3 and gradually implement the system accordingly.

2.1 Environment description and field of interest

The generic product ontology aims to cover all products. This means that the ontology should describe the products, as well as aspects that concern their management. It might also provide information on the products that concern their natural characteristics. This information is extended by the product's materials, by its functionalism or even its presentation in the web. Moreover, through the ontology a product might participate in advisory as well as in negotiation processes. In this way, a complete knowledge of the product is defined, that gives the ability on the suitable users to handle with a dynamic and flexible way. All these dynamics of the proposed ontology will be used by all the likely purchasers and salesmen who will participate in one electronic marketplace. These will be also the users that will be responsible for the maintenance of the ontology. We will finally use the ontology as means of transcending the taxonomy of [7].

2.2 Reusing existing ontologies

The UNSPSC_v8 library is an invaluable tool for doing business globally although it has not addressed product attribute issues. Its hierarchical structure ensures that a company finds a meaningful level of product analysis conveniently. Its unique coding scheme makes it suitable for multi-language uses.
According to this ontology, products are taxonomized according to a general category (segment), a sub-category (family), a class of products and finally the product which is the general category of our implementation (Figure 4). This means that we are using an existent ontology as metadata for our own generic product ontology. This also means that the user of the ontology should have in his disposal nearly every product or service exists. This ontology is continuously updating which means that our ontology has no fear of not including every new product available, introducing standardized properties for the detailed description of them. Finally, we address the problem of the UN ontology by designing and implementing product attributes.

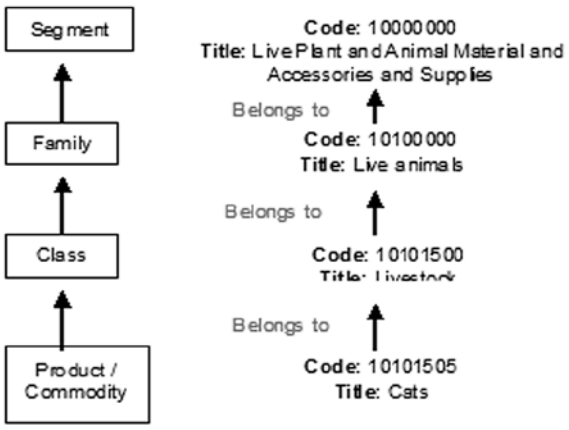

Figure 4: UNSPSC_v8 Ontology

2.3 Defining Ontology concepts

While the structure and properties of the standards such as the UNSPSC are known in advance and can be used for the comparison of alternatives, the actual coverage and level of

detail provided in a given category of products is not obvious. This leads to a situation where the decision for a standard is based mainly on its skeleton (e.g. whether it in general provides properties for a more detailed description of a category) and not on the degree to which such properties are actually defined for the product range of interest [5]. We therefore, after several interviews with stakeholders in the field and research co operations in negotiation and advising, developed a generic product ontology providing detailed description of products that are using the UNSPSC Ontology as meta-ontology and is shown in figure 5. The main class, common to the product class of the UNSPSC, is the **Product**. This class defines two subclasses which distinguish products to raw materials and final products. These are **Manufacturing Inputs** and **Operational Inputs**. With this simple categorization every product can be included in the ontology. The **Identifier** contains the product id along with some recognition details. These recognition details are dealing with the Name of the product, the Color, the Weight, the Size in all possible measurements, a description of the product, its packaging and of course detailed description of the Manufacturer of the product. The **Physical** property corresponds to a single material when we talk about manufacturing inputs or to a collection of raw materials or other products so that when synthesized an operating input is created. It contains a Code, a Name, the Origin which means the manufacturer of the product and the Type of product that is stating its input type. These inputs are also supported by the two isA relationships to the product. Simply stated, a company that in the past transcended these categories only in the physical world, it can now do it in the virtual. So both manufacturing and operating products are supported by the ontology. The Functional property refers to the possible applications of the product. This is crucial to the proper advising of a best fit product. The **Presentational** property is related to the way in which the product is represented to the user. It contains Type, Path, and Size of the file presenting the product. This means that the product can be seen from any known viewer on the internet. If any add-ons are required then the “Add_On” field is responsible for downloading the proper format or viewer to the system.

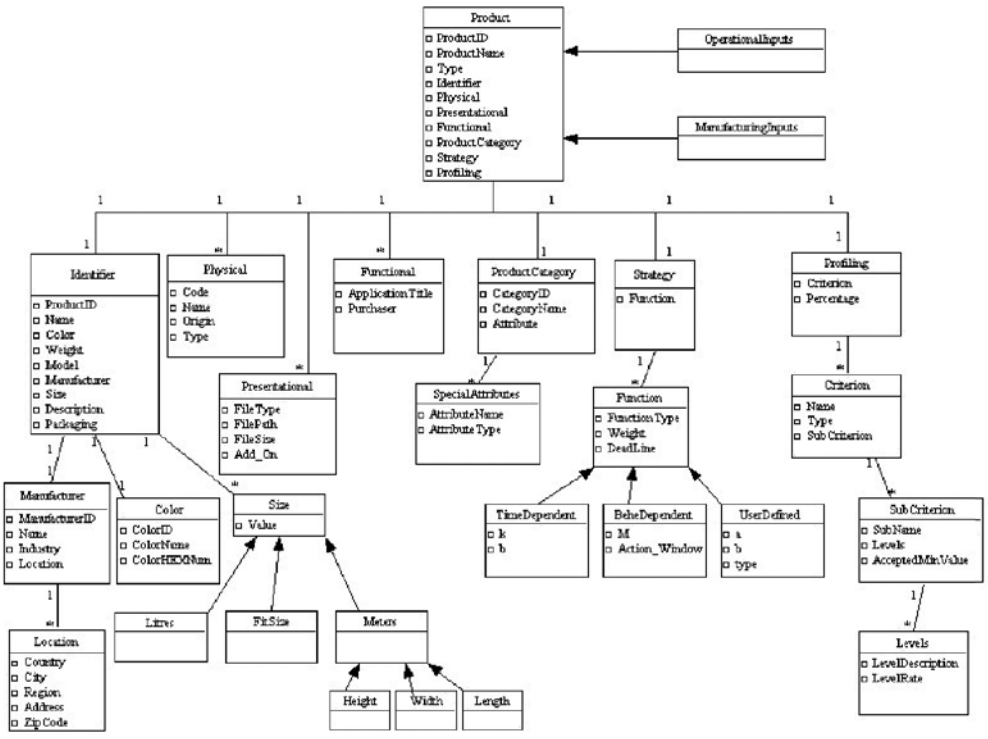

Figure 5: Generic Product Ontology (UML)

The **Product Category** property provides the vendor with the ability to classify his product into a broader category. Each category is assigned with specific properties called Special Attributes. The **Special Attributes** property includes alternate characteristics or meta-attributes of a product. This property contributes to producing a flexible system since additional product attributes are not predefined by the ontology, but can be created at run-time by appropriately configuring the Product Category. The seller is responsible to apply side-categories and product profiles, as well as the management and classification of the products he wants to sell. According to this ontology, the Product Category property provides the seller with the ability to classify his product into a broader category. Each category is assigned with specific properties called Special Attributes. The **Special Attributes** property includes alternate characteristics or meta-attributes of the product used for negotiation. For every characteristic a name and a permissible value type are inserted by the user. These include Fix Number for numeric values, String Sequence for one or more strings and Ranged Space for attributes within a specified set. This property produces a flexible system since additional product attributes aren't predefined by the ontology, but can be created at run-time by appropriately configuring the Product Category. In this way multiple issues can be negotiable facing the weakness of existing systems which use multi-issued negotiation with constant issues. Furthermore, taking into account that in manufacturing inputs quantity determines price, the ontology offering the Special Attributes property can accept ranged space attributes other than price, here quantity. In this way the E-hub supports both vertical and horizontal business purchases. In conjunction with the physical property it provides the flexibility to the user to promote his product or service in any way that he sees fit. It is worth mentioning that there is a predefined meta-knowledge given to the ontology automatically by embodying the UNSPSC_v8 library of products and services. So, the seller's product is probably included in the United Nations categorization. However, the company can incorporate into the hub products that differentiate her in comparison with other possible competitors.

Strategy is a property that helps the user to define his deal-making tactics based on the products' negotiable attributes. It comprises functions that are widely used during any negotiation nowadays. For every product inserted in the system, the seller can define tactics and strategies that will be used in the negotiation procedure. The ability of combining tactics such as time or behavior dependent is provided with the addition of a new tactic category we named "user-defined". This new tactic provides the ability to define a chosen function offers user the potential to actively participate in the negotiation process. This property could also be a property of the vendor as a whole but in real life and according to a shops stock, a vendor can have different strategies for example on a new model of a vacuum cleaner than on an older one.

Profiling is a property that allows one to define the characters of the people for whom the product will most likely have greater appeal, according to criteria defined by the users themselves. It consists of several criteria that can hold sub-criteria accordingly. These criteria can include cost reduction or discounts that can be handled at run-time favoring any side of the transaction. So the proposed architecture could prompt us to classify it as neutral but offering at the same time the flexibility to become either forward, reverse and biased.

Our goal is the generic product ontology to be used so that it can transcend the categorizations that [7] taxonomy imposes. Furthermore, it can unify all B2B and B2C mechanisms under one ontology and therefore under one E-hub.

3 Conclusions and further research

The aim of this dissertation has been to propose a novel architecture for the creation of economically viable e-hubs. We have argued that this can be accomplished through the ability of an electronic marketplace to transcend other taxonomical classification dimensions and, simultaneously, through the provision of an anthropocentric negotiation model and a flexible and “active” decision support.

We have introduced a generic agent-based electronic marketplace architecture, comprising its three major components: ontology, negotiation and advising. According to the architecture proposed we implemented the generic product ontology for the e-hub, focusing on its evaluation by using appropriate standards and widely accepted methodologies as well as other ontologies. We have also implemented a negotiation and a decision support system that come together and interact defining as a whole the functionality of the system.

The proposed electronic marketplace may provide enhancement of procurement experience amongst several sellers. It may also enable buyers to achieve optimal or near optimal procurement results with relatively little user interaction. This not only reduces errors and their associated transaction costs, but may significantly increase the speed, efficiency, and overall effectiveness of the procurement process. Buyers may also develop confidence that the procurement decisions made using this DSS and negotiation system result in the best overall deal. It may also provide the buyers with a much more detailed description of product, in terms of text, presentational and special attributes.

In terms of theory implications our research overcomes the most significant e-commerce issue: it can support both B2B and B2C e-commerce. In addition, it transcends a well-known taxonomy of e-hubs making the e-marketplace flexible to all possible market dimensions. It offers both systematic and spot sourcing, it supports both manufacturing and operating inputs, and it supports both neutral and biased behaviour. The ontology is by nature (UN taxonomy) continuously expanding and can be shared and reused. The negotiation system provides additional information without adding a considerable overhead to the system. The advising system matches exactly the user needs and present it in the most efficient and effective manner.

In terms of practice implications our research combines B2B and B2C marketplaces with the aid of a single ontology and not by trying to integrate differently developed ontologies (e.g. Alibaba). It also helps buyers locate their desired item effortlessly and with accuracy making the user able to determine the best overall deal. It can be used by any e-commerce vendors, whether small or large.

This work is just the beginning of a series of steps that must be done before this marketplace becomes a final product. The most important drawback is that it has not been tested in real time markets. To be tested in real markets this must include a huge effort of data entry that must be done by a series of businesses around the globe.

It is surely needed to use the ontology developed in a variety of case studies; typically these case studies should span multiple industries, since the ontology is meant as a generic product ontology. We should also check to what extend existing product ontologies (or reference models for product data) fit our own ontology.

Finally, it is of far most importance that the issue of trust in the context of this e-hub to be examined since trust is one of the most important factors for any successful software.

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