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THE SHOPBOT CAPABLE OF OVERCOMING LANGUAGE BARRIER FOR GLOBAL E-COMMERCE

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Abstract

Language is an enormous barrier to global e-commerce. Internet users favor visiting or shopping on Web sites presented in their native language. This research proposes a shopbot with a multilingual ontology to overcome this language barrier. The shopbot, called WebShopper, collects product data from online vendors over the Web and enables customers to execute semantic search using different languages. An empirical study is conducted to evaluate this shopbot. The result shows that customers are able to reach more products and find the real bargains using WebShopper, and the proposed semantic search can improve search results and user satisfaction.

Keywords: Shopbot, Comparison Shopping, Ontology, Semantic Web, Global E-Commerce.

1   INTRODUCTION

Global reach is a major advantage of e-commerce. An e-marketplace can be expanded to international markets, which enables organizations or individuals to buy cheaper and sell more. However, some barriers still exist in developing global e-commerce. These barriers include cultural, administrative, geographic, and economic issues (Ghemawat 2001). Culture is the first barrier to global e-commerce and has huge impact on trade. Cultural differences include religious beliefs, race, social norms, and language. Particularly, some researches reveal that trade between countries sharing the same language is three times greater than countries without a common language (Ghemawat 2001). Internet users also tend to surf Web sites presented in their native language (Lynch & Beck 2001, Grace-Farfaglia et al. 2006). These evidences show that language remains an enormous barrier to global e-commerce. This barrier probably can be alleviated by information technology and this research aims to address it.

One solution for overcoming language barrier is maintaining global Web sites with multiple languages. But in hiring human translators, cost and speed are critical considerations. Translation of a large-sized Web site may need at least one week working days and cost up to USD 500,000 (Turban et al. 2006). Some companies use machine translation software to translate Web contents. However, the accuracy of machine translation is only about 60% and commonly requires human translators to revise the results (Dubie 2004). Companies still cannot get rid of the high cost of language translation. This research directs to another solution to reaching global markets, which is using shopbots to search products without language barrier and then purchasing products through intermediaries' assistance. Shopbots help consumers to search demanded products over the Web no matter what languages the source e-stores use. After consumers identify their target products, intermediary companies can purchase or bid on behalf of them. Shopbots not only benefit customers by finding bargains but also helps vendors to reach customers all over the world.

Shopbots also known as comparison shopping agents are automated tools that collect product information from e-retailers. Shopbots allow customers to search and compare products and vendors according to user-defined criteria such as price. These tools not only help customers to find best products and vendors but also help vendors to monitor their competitors and reach more customers. Many shopbots or comparison shopping sites exist on the Web for commercial or academic purposes (Smith 2002, Fasli 2006). Unfortunately, shopbots to date only collect information from e-retailers that use common language or in the same nation so that customers are not able to find the real bargain over the Web and e-retailers are not capable of reaching global customers.

Enable shopbots to understand the concepts expressed in different languages is a major challenge to overcoming language barrier. A shopbot needs to identify the equivalence relations among concepts, for example, the concept "personal computer" or synonym "PC" has the same meaning with "個人電腦" in Chinese language. Additionally, a shopbot also needs to identify the subsumption relations among concepts. For example, the concept "personal computer" subsumes the concepts "desktop computer," "laptop computer," and "handheld computer," and have corresponding equivalent concepts such as "桌上型電腦," "筆記型電腦," and "掌上型電腦" in Chinese, respectively. The solution proposed by this research is constructing a multilingual ontology to describe the product domain and to enable a shopbot to understand relations among concepts expressed in different languages or synonyms.

2   LITERATURE REVIEW

This section briefly introduces ontology languages and surveys existing shopbots, comparison shopping sites, and contemporary e-commerce applications using Semantic Web technologies.

2.1 Ontology

Ontology, in the philosophical view, is a discipline that deals with the nature and the organization of being (Maedche 2002). In the field of Semantic Web, an ontology is a document or a file that contains a taxonomy and inference rules to formally define the relations among terms (Berners-Lee & Hendler & Lassila 2001). To make agents understand the meanings of Web documents, World Wide Web Consortium (W3C) released RDF (Resource Description Framework) and OWL (Web Ontology Language) as W3C Recommendations for the Semantic Web structure in February 2004. RDF is used to express information and to exchange knowledge in the Web. OWL is used to publish and share ontologies, which support advanced Web search, software agents, and knowledge management (Herman 2007).

2.1.1 RDF

RDF provides a triple-based description language encoded in set of triples, each triple is made of subject, predicate and object. A subject or object can be a resource on the Web and a predicate describes the relation between two resources. Both of resource and property are labeled URIs (Universal Resource Identifiers) and everyone can link to it or retrieve a representation of it (Shadbolt & Berners-Lee & Hall 2006).

In February 2004, RDF Schema (RDFS) became a W3C Recommendation. RDFS took the basic RDF model and XML (Extensible Markup Language) syntax specification and extended it to support the expression of structured vocabularies. It has provided a minimal ontology representation language. Ontologies are used to capture knowledge about some domain of interest. An ontology describes the concepts in the domain and also the relationships between those concepts. Different ontology languages provide different expression capabilities. RDFS realizes ontology concept but still not represents meaning adequately, therefore, DAML+OIL and more recently OWL that are based on RDF appear.

2.1.2 OWL

OWL evolves from DAML+OIL that is a combination of OIL (Ontology Inference Layer) and DAML (DARPA Agent Markup Language). W3C slightly revised DAML+OIL to form OWL that builds on RDF and RDF Schema and adds more vocabulary for describing properties and classes. OWL can be categorized into three sublanguages according to its expressiveness: OWL Lite, OWL DL and OWL Full (McGuinness & van Harmelen 2004). OWL Lite supports those users primarily needing a classification hierarchy and simple constraints. OWL DL supports those users who want the maximum expressiveness while retaining computational completeness (all conclusions are guaranteed to be computable) and decidability (all computations will finish in finite time). OWL Full is meant for users who want maximum expressiveness and the syntactic freedom of RDF with no computational guarantees.

OWL DL is developed based on Description Logic (DL for short) which makes it possible for concepts to be defined as well as described. Furthermore, OWL DL allows the use of a reasoner to check consistency (whether or not one class is possible to have any instances) and subsumption (whether or not one class is a subclass of another class). To develop a software agent, OWL DL is useful to describe the domain knowledge and form a knowledge base supporting logic reasoning. Knowledge represented using Description Logic can be easily transformed to OWL DL. OWL uses tags instead of logic symbols to enable an ontology to be shared and accessed on the Web through an URI. The constructs in DL and their meanings are summarized as following:

- $\top$: universal concept, represents all the individuals in the domain.

- $\bot$: bottom concept, denotes the empty set.
- A: atomic concepts, contains all the individuals belonging to the set represented by A.
- $\neg A$: atomic negation, contains all the individuals not belonging to the set represented by A.
- $C \sqcap D$: intersection, contains the individuals belonging to both C and D.
- $C \sqcup D$: union, contains the individuals belonging to C or D.
- $C \sqsubseteq D$: inclusion, means C is a subclass of D.
- $C \equiv D$: definition, means C and D are equivalent.
- $C \equiv \{I_1, I_2, \ldots, I_n\}$: enumerated concept, means C precisely includes the individuals $I_1, I_2, \ldots,$ and I_n.
- $\forall R.C$: universal restriction, means all the individuals participating in the R relation whose range are all the individuals belonging to C.
- $\exists R.C$: existential restriction, describes all of the individuals that have at least one relationship R to an individual that is a member of C.
- $\geq n\ R$, $\leq n\ R$, $= n\ R$: cardinality restrictions, respectively represent the minimum, the maximum and the exact number of individuals participating in the relation R.
- $R \ni I$: has value restriction, describes an anonymous class of individuals that are related to another specific individual I along a specified relation R.

The DL syntax and corresponding OWL elements are listed in Table 1.

OWL Element	DL Syntax
Thing	$\top$
complementOf	$\neg$
intersectionOf	$\sqcap$
unionOf	$\sqcup$
subClassOf	$\sqsubseteq$
equivalentClass	$\equiv$
oneOf	$C \equiv \{I_1, \ldots, I_n\}$
allValueFrom	$\forall R.C$
someValuesFrom	$\exists R.C$
maxCardinality	$\geq n\ R$
minCardinality	$\leq n\ R$
cardinality	$= n\ R$
hasValue	$R \ni I$

Table 1.   Correspondence between OWL and DL Syntax.

2.2   Shopbots and Comparison Shopping Sites

BargainFinder is the first shopbot developed by Andersen Consulting for online price comparisons (Maes & Guttman & Moukas 1999). BargainFinder compared prices on music CDs from online stores. Because BargainFinder only evaluated vendors according to their prices, many vendors blocked all of its price requests so that BargainFinder stopped operating. Jango exploited regularities that are usually obeyed by online vendors and used an automatic process for building wrappers to parse HTML (Hypertext Markup Language) documents (Doorenbos & Etzioni & Weld 1997). Jango avoided the vendor-blocking problem by sending product information requests from the customer's browser rather than the agent's server. In 1997, Excite acquired Jango and incorporated it into its search technology.

Comparison shopping sites do not use agent technology. They either rely on vendors to provide required information or operate as meta search engines and search vendor sites (Fasli 2006). BizRate (www.bizrate.com), mySimon (www.mysimon.com), Shopping (www.shopping.com), and Kelkoo

(www.kelkoo.co.uk) are typical comparison shopping sites. They gather prices on millions of products from thousands of stores and customers can get a list of all items with prices about the searched products. Then, customers can see who has the best price and link directly to those sites. Google Product Search (www.google.com/products), formerly known as Froogle, that indexes products on the Web by Google Web searches or the information provided from sellers. Customers can see photos of relevant products after entering a search and can link to the stores that sell them.

Generally, the existing shopbots cannot directly interact with the online vendors' databases. They operate by retrieving the Web pages that are generated from the databases. Consequently, developers must implement clever heuristics that help shopbots to extract product information from the HTML pages and these heuristics are sensitive to the layouts of the vendors' sites (Fasli 2006).

2.3 E-Commerce Applications using Semantic Web Technologies

Some researchers have devoted in semantic-enabled e-marketplaces. Tomaz and colleagues (2003) introduced a semantic matching method for clustering traders in B2B systems. The semantic matching engine defines the degree of combination between customer's request and supplier's advertisements and sends back to the customer a binary match-pair list containing the cluster of traders. Li and Horrocks (2004) proposed a software framework to support service advertisement and discovery in e-commerce. They also implemented a service matchmaker to enable agents to accurately locate suitable Web services by representing the semantics of service descriptions. Noia and colleagues (2003) developed a system for principled matchmaking in an e-marketplace. This system embedded a reasoner with structural subsumption algorithm to allow potential and partial matching of categories, and ranking of matches within categories. Colucci and colleagues (2005) introduced concept abduction and contraction approaches into an e-marketplace for semantic-based matching and negotiation. These approaches allowed adding negotiable and strict requirements in the demand or supply descriptions and some algorithms were proposed to find negotiation spaces and to determine the quality of a possible match. Huang and Lin (2007) designed a multi-agent e-marketplace in which buyer and seller agents can argue over product attributes. They adopted ontology and rule languages to express agents' beliefs and used an abstract argumentation framework with dialectical game approach to support defeasible reasoning.

Some researchers paid attention to semantic-enabled supply chain management. Grosof and Poon (2004) addressed the problem of how to represent exception-handling provisions in automated knowledge-based e-contracts. They presented an approach that used ontology knowledge about business processes to represent provisions for exception-handling to be a foundation for representing and automating deals about services. Paik and Park (2005) described an information infrastructure that integrates four attributes of product design and their relations and its software component architecture. They introduced simple ontology concepts for this information infrastructure, and created basic database schemas using the designed ontology for the information infrastructure for collaboration of supply chain management.

3 SYSTEM DESIGN AND PROTOTYPING

This research designs a shopbot architecture to support multilingual and semantic search, as well as global comparison shopping. A shopbot prototype called WebShopper is further developed to realize this architecture.

3.1 Architecture

Figure 1 illustrates the system architecture. WebShopper comprises a Web services requester and a Web spider to collect product data from e-stores over the Web. Product data is usually described in

semi-structured Web pages using HTML. This system uses a Web spider, a.k.a. Web crawler, to collect Web pages from online vendors automatically and periodically. A HTML parser is required to extract the data such as product names, prices, and specifications from these HTML documents. A HTML parser has to determine what data in a Web page is the required product data to retrieve. To achieve this, the parser must know what special characters or html tags wrap around the required data. These heuristics are learned or given by administrators in advance and they are sensitive to the layouts of the e-stores. Some e-stores begin to provide Web services that allow applications to request services such as call for product information from them. Web services provide a standard means of interoperating between different software applications running on a variety of platforms or frameworks (Lafon 2007). The key feature of Web services is that applications communicate with each other by exchanging data in XML formats. Data can be structurally organized by user-defined tags and therefore applications are able to correctly manipulate data by XML parsers and interact with each other to deliver sophisticated added-value services. WebShopper collects product data in XML format from e-stores with Web services, which is not sensitive to e-stores' layouts.
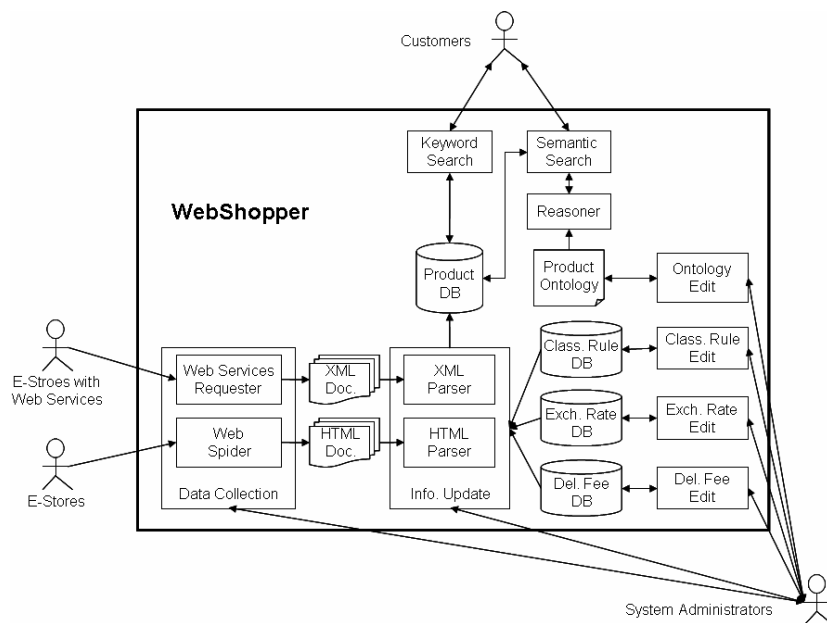

Figure 1.   System architecture of WebShopper.

After WebShopper collects and parses product data from e-stores, it classifies product records into corresponding classes predefined in the product ontology according to the classifying rules specified by system administrators. The ontology describes terms in multiple human languages and is inferred by a reasoner to support multilingual and semantic search. Because the same kind of products may locate in different e-stores at different countries using different currencies, WebShopper calculates the actual purchase cost by summing up selling price and delivery fee, and converts the cost into customer preferred currency. The brief procedure of collecting and updating product information is stated in Figure 2. All processed product data are stored in the product database supporting customers to search by keywords or semantic concepts. The function of keyword search is pervasive in existing Web sites that can find out product descriptions including the specified keywords. Semantic search on the other hand can find out all individual products that belong to the specified concepts and eliminate the language issue. When a customer executes semantic search with a concept name, the reasoner will infer all equivalent and included concepts and then the semantic search will retrieve and display the items belong to these concepts from the product database. After the search results are returned, customers can compare products and link to the corresponding Web pages in vendors' Web sites.

Notably, an ontology can describe not only concepts and relations but also individuals in a domain. This system puts individual product data into the database instead of the ontology because of the following reasons: (1) the reasoning speed of existing reasoners is not fast enough hence we make the ontology as compact as possible to increase the performance; (2) database can be maintained easily and support keyword search.
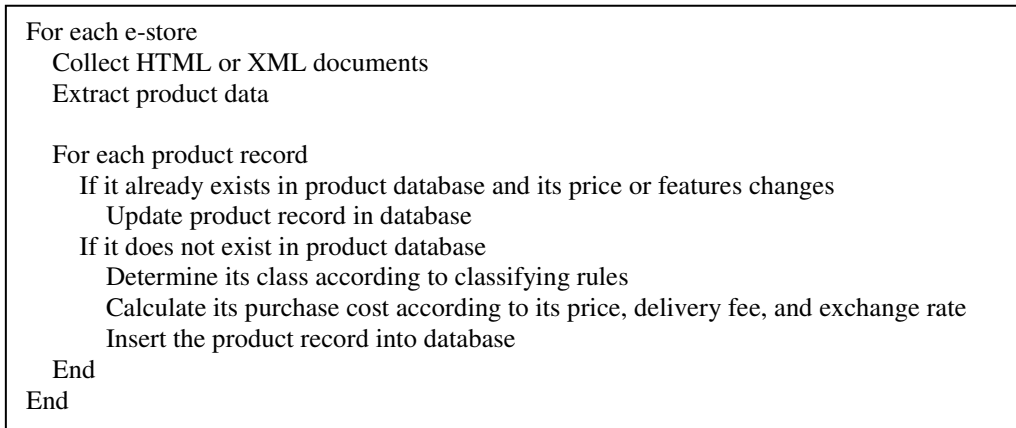
```
For each e-store
    Collect HTML or XML documents
    Extract product data

    For each product record
        If it already exists in product database and its price or features changes
            Update product record in database
        If it does not exist in product database
            Determine its class according to classifying rules
            Calculate its purchase cost according to its price, delivery fee, and exchange rate
            Insert the product record into database
    End
End
```

Figure 2.   Procedure for collecting and updating product information.

3.2   Prototype

A prototype system was developed to help customers to search and compare computer books and vendors. This research chose computer books for prototype development because of our familiarity with this kind of products and books are popular products purchased on the Web. WebShopper collects product data from most popular book sellers, they include Amazon US (www.amazon.com), Amazon UK (www.amazon.co.uk), eBay US (www.ebay.com), eBay UK (www.ebay.co.uk), Yahoo! Auctions Taiwan (tw.auctions.yahoo.com), Books Taiwan (www.books.com.tw), and Kingstone Taiwan (www.kingstone.com.tw). Among them, the first four Web sites use English and the last three Web sites use Chinese. Additionally, Amazon and eBay provide Web services to access their product data. This prototype dealt with new books and excluded used books. This prototype was implemented by Java programming language with Protégé-OWL API and used Racer OWL reasoner.

The ontology described concepts in OWL tags and using English and Chinese languages. This prototype dealt with these two languages because they are the most-used languages on Internet (Fallows 2007). If we want to describe the two concepts "personal computer" and "個人電腦" are equivalent, for instance, this knowledge can be represented by an equivalence logic symbol $\equiv$:

$$\text{Personal\_Computer} \equiv 個人電腦$$

This logic sentence translated into OWL tags is represented as:

```
<owl:Class rdf:ID="Personal_Computer"/>
<owl:Class rdf:ID="個人電腦">
  <owl:equivalentClass rdf:resource="#Personal_Computer"/>
</owl:Class>
```

Therefore, the shopbot is able to understand the two concepts are equivalent. All synonyms in a same language can be expressed in this way, too. We can also describe the concept "desktop computer" is a subclass of the concept "personal computer" using the subsumption logic symbol $\sqsubseteq$:

Desktop_Computer ⊑ Personal_Computer

This sentence translated into OWL tags is represented as:

```
<owl:Class rdf:ID="Desktop_Computer">
  <rdfs:subClassOf rdf:resource="#Personal_Computer"/>
</owl:Class>
```

Of course, a reasoner can infer that "desktop computer" is also a subclass of "個人電腦" according to this ontology even though we do not explicitly describe this relation in this ontology. In this way, the multilingual ontology can support customers to do semantic search using both English and Chinese. For example, if a customer searches for books about "personal computer" the search result will contain all books about desktop computer, laptop computer, and handheld computer written in English or Chinese. A professor and six students majored in Information Systems constructed the product ontology by firstly referring to the taxonomies of computer books adopted in these e-stores, and secondly developing the whole ontology through brain storming.

WebShopper must determine which books are the same books. One kind of books may have one to many vendors and prices, and these data presented in the corresponding Web pages. Figure 3 illustrates the product database schema. One book has one to many Web pages provided by different e-stores. The first heuristic to determine whether collected book records belong to the same book is their ISBN. ISBN (International Standard Book Number) is a unique commercial book identifier and the same kind of books and versions have the same ISBN. Unfortunately, not all vendors provide ISBN on their Web pages especially the auction sites. The second heuristic is book titles since the probability of different books have the same title is low and vendors always provide these data on their Web pages. Although checking both book titles and authors is more accurate than only checking book titles, Web pages in auction sites maybe do not reveal book authors or do not have fixed location to present these data. Figure 4 illustrates the procedure for updating book information in WebShopper.
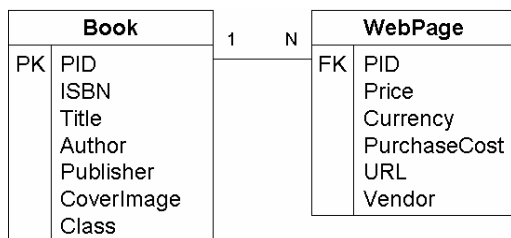
Book		1	N	WebPage	
PK	PID			FK	PID
	ISBN				Price
	Title				Currency
	Author				PurchaseCost
	Publisher				URL
	CoverImage				Vendor
	Class				

Figure 3.   Product database schema.

```
For each book record
   If it has ISBN
      If this ISBN already exists in the Book table
         Update the Book table and corresponding webpage information in the WebPage table
   Else if its title exist in the Book table
      Update Book table and corresponding Web page information in the WebPage table
   Else
      Determine its class according to classifying rules
      Calculate its purchase cost according to its price, delivery fee, and exchange rate
      Insert the book record into the Book and WebPage tables
End
```
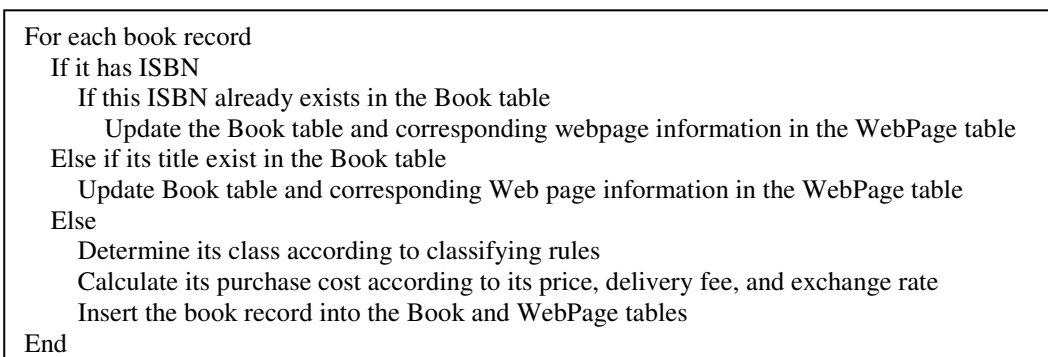
Figure 4.   Procedure for updating book information.

4   PROTOTYPE EVALUATION

To evaluate WebShopper, the prototype system collected about one hundred thousand kinds of computer books from the e-stores, in which one hundred kinds of books were randomly selected for evaluation. After evaluating these data, two interesting findings can be summarized as follows:

(1) Most products only exist in common language e-stores. English e-stores rarely sell Chinese books and Chinese e-stores only sells popular English books. 85% books exist in either English e-stores or Chinese e-stores, which means customers cannot reach 85% of the products if there is no mechanism to help them reach foreign e-stores.

(2) Differences in purchase costs between e-stores are pervasive. Theoretically, e-commerce reduces search cost and increases market efficiency that lead to a lower price variance. Because of barriers to global e-commerce we can see that the price variances still exist even among low-priced products such as books. 80% books exist at more than one e-store and their average difference between highest and lowest purchase costs is NTD 739 (about USD 22.64). For instance, the best price of the book "Informing Digital Futures: Strategies for Citizen Engagement" at English e-stores is USD 76.46 offered by Amazon US. If a customer in Taiwan wants to buy this book from Amazon US, his purchase cost is USD 76.46 plus a shipping fee of USD 11.98. This purchase cost is about NTD 2,887 using the exchange rate 32.64. The best price to purchase the same book in Chinese e-stores is NTD 4,048 offered by Books TW and no shipping fee is required for domestic order. The customer can save NTD 1,161 (about USD 35.57) if he buys this book from Amazon US instead of Books TW.

These findings tell us the shopbot is able to help customers to reach more products at foreign e-stores and to purchase products in their lowest cost. To measure user satisfaction with this shopbot, this research conducted an empirical study in which subjects were asked to search their desired computer books using both keyword search and semantic search. A short questionnaire was filled out to measure their satisfaction. This questionnaire contained five questions each with seven interval scales ranging from 3 to -3. A higher value represented a more positive response. We set a booth on campus and invited passing people to use this system. 43 subjects participated in this test and their responses are summarized in Table 2. The subjects felt that semantic search, which can be executed by both English and Chinese language, is very useful in finding their demanded products. Moreover, participants indicated that a comparison shopping agent really should provide semantic search to improve search results and user satisfaction.

Item	Score [mean (standard deviation)]
I1: Does the semantic search help you to find out the books you want?	1.26 (1.16)
I2: Does the semantic search help you to find out books through specifying Chinese and English concepts?	1.09 (1.15)
I3: In addition to the keyword search, do you feel the semantic search can improve search results?	1.98 (1.01)
I4: In addition to the keyword search, do you feel the semantic search can improve your satisfaction with the shopbot?	1.79 (0.94)
I5: Do you feel a shopbot should provide not only a keyword search but also a semantic search?	2.05 (1.02)

Table 2.   Subjects' responses about user satisfaction with the prototype.

The Cronbach's alpha value for this questionnaire is 0.73. This result indicates that this questionnaire has good reliability. To test construct validity, factor analysis with principal component extraction was used. The result shows that the eigenvalue of the first factor is 2.47, which explains 49.31 percent of the variance. The eigenvalue of the second factor is 1.32, which explains 26.36 percent of the variance. The eigenvalues of other factors are lower than 1, therefore this questionnaire has two main factors. The first factor includes items I3, I4, and I5, and the second factor includes items I1 and I2. Since items I1 and I2 are used to measure the performance of semantic search and items I3, I4, and I5 are used to measure whether semantic search is necessary, this questionnaire has good construct validity.

In summary, the prototype equipped with a multilingual ontology to support semantic search can help customers to reach more products located in e-stores over the Web, improve search results, and find out the real bargains. The shopbot also benefits vendors by exposing products to more customers and revealing product prices and customers' purchase cost for global competition.

5 CONCLUSIONS

This research proposed a shopbot architecture and developed a prototype called WebShopper to help customers to compare products that located in e-stores using different languages. An empirical study was conducted and the result shows that this prototype is able to reach more products, find real bargains, and improve search results and user satisfaction. Although this prototype only addressed English and Chinese languages and computer books, the system architecture can be easily expanded to all human languages and all kinds of products. This study is a beginning of multilingual shopbot researches. In the future, this prototype can be improved by automatically constructing a multilingual ontology and classifying rules using text mining techniques. More rigorous experiments are also needed for evaluation.

Most industries contain millions of products but majority of them cannot create great sales. These unpopular or niche products form a long tail in a demand curve (Anderson 2006). Traditionally, vendors are not willing to invest their resource in the niche products because high inventory and distribution costs erode the small revenue. E-commerce decreases shelf-space and distribution costs and makes niche products profitable. The power of a long tail comes from aggregating millions of small profit to create a huge profit. For instance, a book in Amazon is only a record in database and the store cost is nearly zero. Actually, a large proportion of the book sales in Amazon come from unpopular books that are not available in brick-and-mortar stores. Distribution cost also can be nearly zero when it comes from digital products such as music in iTunes and videos in YouTube. In addition to the supply-side drivers, the demand-side drivers of the Long Tail are aggregators and filters. An aggregator is a company or a service that gathers various products and enables consumers to search them easily, and a filter is a tool or a service to recommend satisfying items to consumers from lots of choices. This research has shown that a shopbot capable of overcoming language barrier can aggregate products distributed over worldwide e-stores and help customers to search and compare products using different languages. The shopbot not only serves as an aggregator and a filter to help customers choose products globally but also help vendors to reach more customers without increasing cost.

To overcome the barriers to global e-commerce, intermediaries that can stand for customers to shop and bid on foreign e-stores are also needed. After customers find out the demanded products and vendors through a shopbot, these intermediaries are responsible to communicate with vendors and deal with international payments, deliveries, duties, and laws. This kind of intermediaries are emerging and becoming more and more important to global e-commerce. Combining sophisticated shopbots and these intermediaries will realize global e-commerce economically.

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