A Study of Travel Agent System in Mobile Devices using Multi-Agent and Semantic Web Technologies

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ABSTRACT

The thesis work intends to provide the cost implementation method for the travel products from the travel agency to the mobile devices. Mobile devices are now capable of accessing the internet services as their considerable advancements are achieved in the wireless devices. The mobile devices are capable of searching through the web content for extracting the required data. But as the search engines face the problems due to their searching strategies such as keyword based search, semantic web has come into picture. This thesis work explains how semantic web technologies are integrated in the mobile devices for getting the desired products for optimal price. Semantic web is the suitable for the travel agent system as there is exchange of information. The data from the mobile devices is carried through the agents between the travel agency and the devices. This work intends to provide how the semantic web and the multi-agent systems are helpful for searching the desired products of the user (using mobile devices). The agents in the multi-agent system communicate with each other in the travel agent system through the ontologies which are written in the OWL ontology language.

Keywords: Semantic web, ontology, agents, travel agent system, mobile devices
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ABBREVIATIONS

1. MAS - Multi-Agent System
2. PDA – Personal Digital Assistant
3. HTML - Hypertext Mark-up Language
4. RDF – Resource Description Framework
5. OWL – Web Ontology Language
6. SWRL – Semantic Web Rule Language
7. XML – Extensible Mark-up Language
8. URI – Uniform Resource Indicator
9. ACL – Agent Communication Language
10. KQML – Knowledge Query Manipulation Language
11. FIPA – Foundation of Intelligent Physical Agents
12. OINK – Open Integration of Network Knowledge
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1 INTRODUCTION

This chapter explains the problem domain, problem area and research methodology in the area of the mobile devices using the semantic web technologies. The technologies and the mechanisms regarding to the research are explained in the next chapters.

1.1 Preface

M-commerce is gaining popularity as the usage of the mobile devices has been increased. M-commerce is the subset of the e-commerce applications [1]. As the searching is the core of the commerce applications, it should implement new technologies to yield better search results. As the traditional search engines have some difficulties, the web content is represented in the form of semantics. This is possible by the semantic web. Semantic web represent the web content in the form of machine understandable. The ontologies are the main component of the semantic web. In this thesis the author explains how the agents in the mobile devices use ontologies to produce results that are suitable for the user’s requirements. In this thesis the author aims how the ontologies are used by the agents to select the different packages available in travel agent system. Tourism industry is the becoming more popular and yielding more revenues. The tourist or the user search for the travel products such as flight tickets, accommodation, restaurants and so on in the internet by navigating through the travel agency websites such as Travelocity, Expedia. But the user has to spend more time for searching the products and to find the minimum price for the products. The author in thesis proposes a method for calculating the minimum cost of the travel products in the packages. The user using a mobile device can be able to get the minimum cost of the travel packages; this task is completed by the use of agents.

1.2 Background

E-commerce has increased and created opportunities for the business providers for providing their services mobile to the users. These applications require more search clarity for their products on the internet. As the time passing the price of the wireless devices are decreasing and the use of these devices have increased day by day [1]. In the present situation, it is not necessary to use the PCs for accessing the internet. The advancement in the technologies of the mobile networks has provided the ability to access the internet through the wireless devices. These advancements made the companies to promote business applications through the mobile devices such as mobile phones and PDAs. Therefore M-commerce has becoming popular for the business purposes. M-commerce applications are not different from e-commerce. The functionalities and the purpose of m-commerce are similar to the e-commerce [1]. M-commerce is gaining the popularity over e-commerce due to its features as defined in [1] Ubiquity which means the users can connect to the internet instantly and get the real time information at anywhere, the users can personalize their information on the devices and the services are localized prior to the location of the user. As to achieve better commerce applications the business providers should present information in well structured manner because the searching is the core of these applications. Other problem the users may face when they search for the products price in the internet. When they purchase one or two products they tend to search and compare the price of these products on the other internet shopping malls and to find the lowest optimal price for the product is tough task for customer [2].
Above two problems mentioned motivate a new generation web, which can be fulfilled by the Tim Berners [3] invention of the Semantic Web. The semantic web is the extension of the current web [3]. The semantic web is designed by structuring the content of the internet in which the software agents take care of the tasks for the users [4]. RDF, OWL and SWRL languages are implemented in the semantic web which play major role in this intelligent web. The author in thesis explains about how the agents and semantic web technologies are used for choosing the products and negotiate the optimal price for the travel products in the travel agent system. There is brief explanation about how the packages are formed using the bundling [5] concept which is a requirement for the travel agency. The author also describes about the agents role in decision making about the price of the products on behalf of the users.

1.3 Problem Domain

The advances in technologies of the wireless devices and networks made it possible for the mobile devices access the power of the internet. Present mobiles are capable to do the internet search. The companies like Google, AltaVista and Microsoft are already in the competition for developing the search engines for the mobile devices. As the screen size is smaller in the mobile devices the searching has becoming the main concern. As the internet search is based on the keywords which provide more irrelevant information. To overcome limitations of the traditional internet search there is an invention of the new web called the semantic web. Semantic web provides the services through which the devices can automatically get the required data or services without interacting with the other devices. Providing the information to the users about the products over the internet without much interaction with the devices is the main concern of this thesis. Through semantic web and web services may be more advantageous to the e-business as it can implement efficient and faster business [6].

1.4 Problem

Providing better searching and comparing the cost of available products in the internet create huge impact and yield success for the internet business such as e-commerce and m-commerce. As to be in the competition of the present markets, companies put on many offers to attract the users. The companies develop strategies for their products based on the costs. In this thesis the author describes mathematically for minimizing the costs of the products using the semantic web in which the agents take over the tasks of the users. The agents will search for the relevant product and compare the costs and search for the best suitable solution of all compared.

1.5 Aims and Objectives

The main aim of thesis is to propose architecture for the travel agent system and the implementation for minimization of the costs of the products according to the users and get the information to the mobile devices. The objectives which are to be fulfilled to achieve this aim are:

- Identifying the semantic data by implementing the intelligent agents.
- Identifying the products and the prices over the semantic web.
- Identifying the requirements of the travel agency.
• Studying about the semantic web.
• Implementing the method for reducing the costs of the products.

1.6 Research Questions

The following are research questions which are to be addressed in this thesis.
   a) What is the agent’s role in the semantic web and mobile devices?
   b) How the semantic data accessed in mobile devices?
   c) What are the requirements of the travel agency?
   d) Is the proposed architecture and cost minimization method suitable?

1.7 Research Methodology

The qualitative research methodology with a case study is done for evaluating the architecture used in this thesis. The case study is conducted with the students to analyze how effective is the architecture and cost minimization method for choosing the products from the travel agencies. The case study is done by using the questionnaire about method based on five factors. The results are collected and analyzed using a scale. The author will perform a literature survey to study theory about the semantic web and the multi agent systems.

1.8 Scope of Thesis

The thesis work addresses some of the challenges in searching products through the mobiles devices using semantic web technologies and multi agent systems. This is academic research based work as the author applies several concepts inferred from the literature survey. Some of the problems faced in the thesis are presented as the future as it not possible to address all in the duration of 20 weeks.

1.9 Structure of Thesis

The structure of the thesis is organized in the following chapters

Chapter 2: this chapter discusses about the current problems of the present web. It deals with the basic concepts of the semantic web and vision. It then addresses the semantic web technologies and ontology language.

Chapter 3: this chapter has provided the information about the multi-agent systems. Then it addresses the different agents and their role in the multi-agent systems. The author has provided information about the languages used by the agents to communicate between two agents.

Chapter 4: this chapter discusses about the internal and traditional approach of the travel agent system. This chapter deals with the mobile devices integration with semantic web in the case of travel agent system. This chapter also explains about the requirements of the travel agent system.

Chapter 5: this chapter discusses about the proposed architecture of the travel agent system and explains about the cost minimization of the travel products.
2 SEMANTIC WEB

Internet has become the major source of information for the users. World Wide Web is the guide which serves the people by providing the information what they needed. In the earliest days the users used to navigate information through their known pages which are remembered or bookmarked. Search engines are introduced due to increase of web pages. Most of the users navigate the pages by searching for the relevant information through search engines. The traditional search engines usually follow keyword based search. Today Google and Yahoo are the leading search engines in web infrastructure [7]. The main problem of this search engines as the knowledge in the web uses the HTML language for the information publishing on the web which is easily understandable by the humans but not by the computers. This leads to inconsistent information by search engines as the computers cannot understand the meaning. To overcome the above problem there is need to present the web content that can be accessible by the machines, which means providing meaning to the web content [8]. The above solution is possible through the semantic web which adds the semantic annotations to the present web. Semantic web [3] is the extension of the current web. The semantic web uses the query searching instead of the keyword-based search. Semantic web contains the information which is machine-readable and human can also understand the information.

2.1 Problems of Current web

The WWW is an ocean consisting of information related to multimedia resources, business and contains documents almost an unimaginable data which is available with single internet connection. The size of the web has increased tremendously. Its size has become the main limitation as it has become to locate the relevant information. The data is represented in the form of HTML as a result the software agents cannot understand the information and process it. The problems of current web as defined in [3].

2.1.1 Keyword based search
We often end up with the irrelevant the information and do not find the documents which we are searching for. This is because we use the keywords for searching but the documents may use different terminology and representation.

2.1.2 Irrelevant information
When we search for the information over the web we get lot of unnecessary information, this is also the problem of the keyword based search as it retrieves the documents which have the same keyword. Mostly to separate the relevant information from these documents is time consuming.

2.1.3 Collecting information from different documents
We have to search many documents for the relevant information about the single topic. It is difficult to collect the information and retrieve the whole information at a time which is spread over more than one web page.
2.2 Semantic Web Vision

“The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation.”

Tim Berners-Lee, inventor of the World Wide Web

The problems mentioned above have created the platform for the researchers to get the initial idea and develop the semantic web. This version of this web is not the creation of a web but it is just an extension of the current web and it is an initiative to improve the state of the current web [3]. The main idea behind the semantic web is to provide the meaningful data for the computers as well as the humans. Semantic web is an evolution of the current web that provides the new information representation features. Semantic web also have web pages hosted on different computers and the documents can also point each other either on the same or a different computer, which is the decentralized design same as the current web. The data in the semantic web is represented by the ontologies which help the software agents understand the data and locate the data intelligently.

Knowledge Management
Semantic web will allow using the highly sophisticated and advanced knowledge systems for the management of the data [3]. The knowledge will automatically organize the data in an organized way according to its meaning. Automated tools will extract the new information and supports its management for checking the inconsistencies and provides the security in the form to restrict the certain parts of the information access. The keyword search which is used by the current web is replaced by the query answering.

Business to Consumer and Business to Business Electronic Commerce
The semantic web will allow the software agents to interpret information of the products available on the web. This will provide the correct pricing information of the products and delivery, privacy policy information is retrieved correctly according to the user requirements. The software agents provide the additional information of the reputation of the online shops and auctioning, negotiations and drafting contracts will be carried out automatically [3].
2.3 Components of Semantic Web

The components of semantic web are represented and shown in the layer cake figure 1 that is famous and developed by Tim Berners Lee [3]. There are so many updates to the structure of layer cake. The basic components of the semantic web are the XML, RDF and Ontology.

![Figure 1. Tim Berners Semantic Web “Layer cake” (2001) [3]](image)

Extensible Markup Language (XML) is derived from the Standard Generalized Markup Language (SGML). XML allows anyone to create their own design for document format and write the documents according to that format [13]. It also provides to create own tags which are called the mark-ups. The tags can be understandable by the machines. Anyone can use these tags to access the contents of the XML but they must have knowledge about what the tags mean. XML create structured tags and add content to the annotated web pages but they do not provide the meaning to the structures.

Thus we have to provide representation and meaning to the tags which are described above, which is possible by RDF, which encodes it in sets of triples, each triple contain the subject, predicate and object. These triples are written using XML tags. The RDF uses a particular terminology to describe the documents as the thing (web page in this case) has the specific property (creator) and has the certain value (who the creator is) [14]. This is the normal structure which describes the vast majority of the data on the web. URIs which are written in the form of XML tags identify the subject and object. Not only subject and object are identified by URIs, predicate are also identified, which makes anyone to define a concept, a new predicate and describe URI for it somewhere in the web.

RDFs are used to describe the information about the related things in the web by using triples. Through URIs one can identify the information about the related things on the web, as the RDF uses them as the unique identifier to identify content of the data [9]. By using this URIs we can identify the data on the databases by knowing the addresses of the people and the fields which represent their names or any other field name. RDF schema is introduced because RDF cannot make assumptions to the any particular domain nor it can define the semantics for the domain [3]. RDF Schema is introduced to the top of the RDF layer in the layer cake (figure 1). There is a need to express more semantic data.

Ontology is introduced to overcome the problems and it is used to express the semantic data. The ontology plays an important role in the semantic web and forms the basic component of Semantic Web. The development of semantic web is well attached with the ontologies.
Ontologies can enhance the functioning of the web in many ways. Searching can be more accurate as the web pages are defined based on a particular concept. Ontologies are attempts to more carefully define parts of the data world and to allow mappings and interactions between data held in different formats [10]. In knowledge representation ontology is the description of the concepts and relationships in the domain [11]. Ontologies are comprised of the set of classes of objects and the relation between them and set of inference rules. We can express the data by the relating and assigning the properties to classes and subclasses inherit their properties [9]. For example we define the university as the place for education and the students and lectures apply only to the university (in this case).

Ontologies are regarded as one of the foundational technologies for the semantic web: the ontology contain and share the meaning of the annotations of the web pages which are designed to be machine interpretable [11]. Research in semantic web led to standardize the ontology languages. The key ontology languages are the RDF Schema and Web Ontology Language (OWL).

The logic layer of the layer cake is used to enhance the ontology language further and to allow the writing of declarative knowledge which is application specific. The proof layer is responsible for the validation of the layers and contains the deductive process with the representation of the proofs in web languages. The trust layer comes into the picture for the use of the signatures, by the recommendations of the trusted agents.

2.3.1 OWL

OWL\(^1\) is a new formal language for representing ontologies in the semantic web developed by the World Wide Web Consortium (W3C). OWL is developed for the applications that process the content of information instead of just presenting the information. OWL is the based on the earlier languages OIL, DAML+OIL. As OWL is developed for the semantic web, the compatibility standards have to be maintained by OWL as considering the previous languages as OIL, DAML+OIL and SHOE [37]. OWL is a major implementation for the semantic web as the ontologies are very important in the semantic web. OWL takes the fact-stating capability of RDF and class and property-structuring capability of the RDFS and extends them in important ways [37]. OWL is being used to create standards that provide a framework for asset management, enterprise integration, and data sharing on the web. OWL ontologies may be subcategorised into three sublanguages OWL-Lite, OWL-DL, OWL-Full. Each of the language is defined by its expressiveness. OWL-Lite is less expressive than the other two sublanguages. OWL-DL falls in between the two sublanguages in context of expressiveness. OWL-Full is most expressive compared to the other two sublanguages.

\(^1\)http://www.w3.org/TR/owl-features/
2.4 Semantic Web Technologies

The important semantic web technologies are the metadata, ontologies and agents [3]. As the information provided in the current web is understandable by the humans, but the machines cannot understand the content of the web as the information is provided in the HTML format. The main aim of the semantic web is to write the content which can be interpretable by the machines. This is possible through representation of the data through metadata. Metadata refers to the information data about data and capture the meaning of the data, thus the term *semantic* in the semantic web [3]. Ontologies consist of finite terms and relationships between these terms. The terms usually describe the classes of the objects. The relationships usually describe the hierarchies of the classes into subclasses. There are many languages to describe the ontologies.

The agents are very powerful in the semantic web which acts on the behalf of the person or some other agents for the execution of a certain task. Agent is defined as [12] "An entity within a computer system environment that is capable of flexible, autonomous actions with the aim of complying with its design objectives". Agents will use the metadata to identify and extract the information from the web and with the help of ontologies it will assist in searching for the information through interpretation and also to communicate with the other agents. Agents are briefly discussed in the next chapter.
3 MULTI-AGENT SYSTEMS

As the thesis concentrates on the commerce applications in the mobile devices in which there is need of agents to make the task simpler for the users, it is necessary to address the multi-agent systems and it is introduced in this chapter.

The advent of the multi-agent system (MAS) has made the companies to build robust, distributed and intelligent applications for carrying out their business [15]. As the name says multi-agent system consist of more than one agent where the agents will interact with each other and exchange messages for the completion of certain task. MAS distribute the resources and capabilities through the interconnected agents in the network of systems. These systems are built for solving complex problems, which are cooperatively solved by the agents. The agents in these systems represent the user for the execution of the task; they work behalf of users with different goals and motivations. To solve problem or a task efficiently and to fulfill the needs of the users independent of the situation, the agents must interact with other agents and to achieve this property the agents must have the ability to cooperate, coordinate and negotiate [16]. Coordinate mean the agents allocate tasks to the other agents and they together synthesize the results for the overall output. Negotiate mean agents are able to solve their conflicts and reach a compromise. For these two qualities aforementioned, communication is required and it is provided by the common communication mechanism. The communication between the agents is carried out by the agent communication language (ACL) for exchanging information and to achieve synchronization [17]. ACL defines the purpose and provide the meaning of the messages to the agents. Many languages are proposed for carrying out these tasks.

3.1 Agents

Agent is defined as [12] “An entity within a computer system environment that is capable of flexible, autonomous actions with the aim of complying with its design objectives”.

An agent is an entity capable of doing required tasks on its own on behalf of the users. The definition says that the agent is a system which is capable of fulfilling the tasks of the users and they act according to the situation at any time which is carrying out their objectives. Flexible in the definition, mean the system must have certain objectives as defined in [18]

a) Responsive which means the agent should respond according to the situation and in a timely manner
b) Proactive means that the agents should be take the appropriate initiative and proceed to the goal to meet the objectives
c) Be social means interacting with the other agents and the users to accomplish their goal

In [19] agents are classified into different types based on the study of types of entities and environment where it is used to perform the tasks and solve the problems, some of them are discussed. Firstly the agents are separated and defined as the static or mobile based on the moment. Mobile agents are capable to roam around the system when there is a need to contact with the other agents for performing the tasks, with its own decision making. Secondly the agents which are possessing the above three features the agents have to satisfy to achieve its objectives. Thirdly internet agents, which are capable of roaming through the
search engines in the WWW such as web crawlers, spiders for gathering information according to the various needs of the users.

All the agents mentioned above need to communicate with the other agents by exchanging their messages to attain their respective objectives. For the communication there is a need of language, which is possible through the expressive ACL. The agents can express their needs and capabilities more accurately through the ACL [18]. ACL provide the meaning for the messages sent between the agents. There are languages developed to meet the requirements and objectives of ACL and among them the major languages are Knowledge Query Manipulation Language (KQML) and Foundation for Intelligent Physical Agents (FIPA).

### 3.2 Agent Communication Languages

The agents in the MAS cooperate for solving the complex problems; if one agent finds the problem beyond its capability then the agent seek the help of other agent. In this process the agents need to communicate with each other for solving the problem, therefore the agents use the ACL as the common medium for communication. ACL is used to provide the interoperability between heterogeneous agents in the MAS [20]. There are certain methods proposed for the agent communication such as remote procedure call (RPC) or remote method invocation (RMI) to CORBA and object request brokers which serve the same purpose as ACL [21]. But the ACL is the high level perspective and differ from the above methods in the sense of two reasons as mentioned in [21]: i) in the aforementioned methods the only objects are used for the simple messages, but in ACL it handle the propositions, rules and actions instead of the simple objects and ii) the desired state in the ACL is described in a declarative language instead of the procedure or method. To have better communication the ACL provide conversations which are task-oriented, shared sequences of messages for example negotiation or an auction [21]. ACL message types are based on the speech-acts and they are in turn described in terms of belief, desire and intention (BDI). There are two major types of ACL as mentioned in [21] they are KQML, FIPA-ACL. These languages are described in the following sections.

#### 3.2.1 KQML-Knowledge Query Manipulation Language

KQML is a language for exchanging information and knowledge between the agents. It was developed and produced from the ARPA knowledge sharing project [17]. KQML consists of primitives for the interaction of the agents and messages contain performatives which are used to describe the facts and directive [17, 20]; for example

```
Tell: sender A
   : sender B
   : it is snowing
```

In this message A tells B that it is snowing and it is true. KQML has the ability to support wide range of agent’s architectures because of its extensible set of performatives. KQML contain three layers conceptually as mentioned in [20] content, communication and message. The content layer contains the content of the message which is represented in the program’s own language. The communication which is the second layer is used to describe identity of the sender and recipient. The third layer is the core of the KQML which is the message layer; this layer is identify the speech of act or performative which the sender attaches to the message and it also determines the interactions of the one can have with the agent.
Example: Query for the price of the IBM stock.

The example described in [20] is KQML message which is the query about the price of the IBM stock. Ask-one in the performative and the actual content of the message is the PRICE IBM. The communication layer identifies the receiver and sender as labrou and stock-sever respectively. The query is represented using the language LPROLOG.

3.2.2 *Foundation for Intelligent Physical Agents-FIPA*

FIPA is a non-profit organization whose objective is to promote the emerging agent-based technology [17, 20]. FIPA is very much similar to KQML and it defines the outer language for representing the intended meaning of the message based on the KQML approach. The syntax of the FIPA and KQML has resemblance and the set of performatives are less in FIPA but new performatives can be defined by formally combining the primitives [17].

(inform
  : speaker speaker
  : receiver listener
  : content (activity Price IBM)
)

The example is FIPA message which informs the content of the message to the listener, that is the speaker informs the listener. The outlook of the message is same as the KQML but some of the performatives are introduced in the FIPA.
Through the www and the internet technologies provided the customers use the services of e-commerce for example by which users can shop at home and pay the bills. Now as the advancement in the wireless arena and the user requirements has changed the environment of the commerce applications. Rapid advancements in the wireless networks have made the e-commerce available for mobile user (through mobile devices). The users of mobile devices have increased rapidly due to its personalized nature and communication technologies. The emerging technologies in the mobile devices and wireless arena, has provided the advantage for the consumers to concentrate on the m-commerce. M-commerce is defined by [22] as the delivery of services and products through the wireless technologies to enable e-commerce applications at any time or location. M-commerce is the subset of the e-commerce transactions. The mobile commerce is gaining popularity among the users due to its features ubiquity, instant connectivity, personalization and localization [1].

The above diagram explains the reservation procedure for a restaurant which is an example of m-commerce application. In this example first the user selects one of the restaurants from the list of restaurants in the present location. Then the users book the timings for the restaurant and give the contact details and the quantity. Then the application checks the availability and sends the Short Message Service (SMS) as a confirmation message to the user’s mobile device. In the above example the searching is behind the information retrieval according to the user’s preference for example searching for the location. But for the complex requirements and information browsing the searching through the internet may give inappropriate results. Semantic web provide better searching options.
4.1 Searching Using Semantic Web in Mobile Devices

World Wide Web (WWW) is used for searching the information through the internet using the search engines. But the web faces the problems as mentioned in chapter 1. To overcome the problems of present web semantic web is invented, which provides better results for the searching. As the mobile devices are capable of using internet applications, the mobile devices are also facing the same problems as the web. Therefore semantic web is used in the mobile devices for searching the information existing on the web that find results according to the users which differ from the existing web environment. Joo-Seong Jeon and Gi-Jeong Lee in [24] have explained the difference between searching through the present web and semantic web. They have developed architecture for the local based mobile search through the semantic web. The search systems have used the relational databases for storing the information, for example in the Oracle the data is represented in the form of tables and the data is retrieved through the query which follows the keyword matching for the retrieval of information [24].

Semantic web use the ontologies for representing the information in the web. Different languages are used for writing the ontologies for instance OWL. These languages represent the information in the form of ontologies and agents use these ontologies to locate the information and provide to the users. The ontologies use the RDF triples for pointing the information and locating the information [24]. The question now raises how the semantic data is used in the mobiles and how the ontologies are useful for the mobile devices. This is explained in the next section.

4.2 Mobile Devices Accessing the Semantic Data

In this section of the thesis the author explains how the semantic data of the semantic web is integrated and interpreted which used in the mobile devices. This is explained using the architecture which is proposed in [25].

Mobile data communications has increased the demand in the mobile applications and services in the business world. There is a need to provide the applications available to people anywhere, anytime. To provide this we should achieve better interoperability between the systems. As defined by Ora Lissla semantic web represents a means to provide interoperability between systems, information sources and applications. As the mobile devices are capable of ubiquitous and personal computing there is an involvement of semantic web technologies such as ontologies. Now the problem comes how the mobile devices may be able to use the semantic web data i.e. how the mobile devices may be able to interpret and use the semantic data which has different rendering capabilities for enabling transparent access to the internet. To overcome this problem semantic mobility channel [25] (SMC) is proposed and it shown in figure 1.
The above architecture Semantic Mobility channel contains the content management, semantic mobility channel, knowledge base and ontologies. The main objective of the SMC is to provide the extend service accessibility to the whole range of mobile devices. This is possible by making the mobile devices to interpret and recognize the information which in turn provides the user to navigate and take actions on the information received. Content management system is the data source for the semantic information. The content manager has the ability to edit the data and enter the information. Semantic annotations are also provided to the data available in the content management. Through semantic annotations one can comment on the data available for example one can describe about its use. The content manager uses the ontologies for entering and editing the semantic contents. These ontologies can be used by the user to interpret the semantic data which is available from the SMC. The semantic information is available in the knowledge base component of the architecture which is the application data. For example SMC is used in application as TPI yellow pages mobility [25].

Now the scenario comes into picture how to browse the semantic data on the mobile devices. The Open Integration of Network Knowledge (OINK) browser architecture in [26] has provided the capability to browse the semantic information integrated from the different data sources on mobile devices. Semantic web information is represented in the RDF format. To enable the users browse the RDF data on mobile devices OINK tool is used. Through OINK we can view the nodes in the RDF graphs and visualize them as web page. The diagram below shows the OINK browser [26].
OINK browser was developed by the Nokia Research center for browsing the semantic web data on the mobile devices. The browser provides the simplified pages and the semantic data is very compact than HTML on the mobile devices [26].

4.3 Internal Approach of Travel Agent System

Tourism industry is one of the major industries for generating revenue for the companies. It is estimated by the World Tourism Organization that there may be increase of 200% tourist arrivals around the world in 2020 [27]. There are many web sites which provide selection for the tourist destinations and the user may select the tourism products such as the flights, accommodations, cars and so on from the websites like Expedia, Travelocity [28]. In these sites the customers or the users have to select manually for the products according to their destination. This process consumes lot of time and the user has to select items which are suitable. For example consider the tourist travelling from Ronneby to Paris for 4 days tour. The tourist has no information about the hotels and renting a car in the Paris. So he selects one of the travel agency website for instance Travelocity to get the proper details about the tour. In the website he enters the destination and source for the particular dates. The results are shown below in browser 1 (figure 2).
In the above webpage the he gets the information about the flight details. As he entered for the information about the hotel and renting a car, he gets the information about the different hotels displayed as the hotels present in the Paris area with the ratings. The tourist has to select the hotel as per his requirements. The hotel selected by the user is shown in another webpage as shown below in browser 2 (figure 3).
Figure 6: Users Destination Ronneby→Paris and accommodation [29]

The above webpage shows the flight details and information about the hotel which user has selected. The website below shows the details of the rental car, tours and activities and other services at the below the webpage. If the user is interested in the other activities he can select the activities under tour and activities. Travelocity website provides the details about the tour to the user but user has to spend more time for the selection of the products.

There are disadvantages for this process such as the searching for the products take more time and to overcome these limitations the websites are incorporating recommender systems [28]. The recommender systems first make a search through the websites and ranks the products based upon the similarities of the products according to the requirements of the users. As the travel products have complex structure, these recommender systems face problems such as searching for the information as they yield more similar products from the huge amount web content and users take more time for selecting the appropriate products. To overcome these limitations the semantic web technologies have been used in the travel industry.

Semantic web represents the web contents in a structured format. Tourism industry is the suitable application for the semantic web as there is exchange of information in the web [27]. The web data is structured and defined by which the data is processed by machines and the data can be reused by various applications. These features of semantic web create impact on the tourism.

In this thesis as we discuss about the mobile devices such as mobile phones, PDAs using semantic web for the travel agent system, the author explains about the travel agent system used in the mobile devices. As the emerging technologies of handheld mobile devices using the internet applications have created chance to embed the tourism applications for making
the applications mobile to the user. Mobile commerce applications are the subset of e-commerce applications. The users use the mobile devices for accessing the tourist sites to search the required information. Ubiquitous, localization and personalization features motivate the users to concentrate on the mobile devices. But there are some problems faced by the users as the travel information has a complex structure (representing the locations and price information). Therefore the semantic web technologies are integrated in mobile devices to decrease the complexity. The above problem motivates to introduce the semantic web technologies for implementing the travel agent system in the mobile devices. In the next section we discuss about the architecture of the virtual travel agent system [29] which provides the travel information to the users.

How semantic web technologies and agent technologies are useful for the travel agent system in the mobile devices?

The recent advances in the mobile technologies and usage of internet through the mobile devices have been increased. This provided an opportunity for the travel agency to present the information ubiquitously due to the growth of customer’s usage of mobile devices. The customers or the users find it difficult to fetch the information effectively regarding planning of the trip. To overcome this multi-agent system with the semantic web technologies has been motivated. Multi-agent systems are capable of communicating with the other agents in the network or in the internet for guiding the users to achieve their goal. In this thesis as we discuss about the travel agent system, there may be different agents for instance hotel broker agent, matchmaking agent, shopping agent and so on which form the whole travel agent system. As discussed in the third chapter the agents need to communicate with each other and to communicate they require ACL. Semantic web makes the agent understand meaning of the contents on the web and will make the agent process the data what customers want while the traditional approach can’t [30]. The different languages that are available in the semantic web are the RDF, OWL and Semantic Web Rule language (SWRL). RDF is used for representing the information resources on the web. OWL is an extension of the RDF and it is the language of ontology. OWL is used to create web ontologies for the objects that can be identified on the web and can be used by the applications. SWRL is the combination of the OWL and RuleML which is used to describe the relations between the web ontologies [30]. The ontologies created for the tourism can be used by the agents for identifying the data (products) according to the requirements of the user. There has been no complete travel ontology for the tourism developed, but a partially completed ontology is available which is created using the protégé tool [30].

Protégé tool is most powerful editor used to develop ontologies. Protégé tool is freely available [31] open source ontology editor and knowledge-base framework. Protégé tool contains special browsers for classes, forms and properties etc [31]. Figure 4 shows the browser which has some part of the travel ontology which shows the adventure, sightseeing, relaxation and sports as the subclasses of the activity class.
Figure 7: An example ontology classes for travel agency created using protégé tool editor [31]
4.4 Requirements of Travel Agent System

The travel agency website must provide the information about the different products in the web sites to the users, which are listed in the figure 5. These products are provided to the users by the travel agency in the form of packages. Products may be changed for different packages they may be quoted with various costs. For example the transportation may contain the flight, car, cruise and any other means of transport.

Figure 8: Different products provided by the travel agency [34]

As the requirements change from one user to another user the travel agency website must be able to provide information to each of the user. It is often difficult and time consuming to search the travel web sites for the required information. The advancements in semantic web technologies make the commerce applications flexible, reliable and automated [30]. Ontologies make the business applications to provide the information automatically to the user through the semantic web. Through the ontologies users can be facilitated with the appropriate information and the resources can be located in the semantic web. But as the preference and the requirements change from user to user we must accommodate the agents
for providing the information according to the user. The virtual travel agent system architecture (VTAS) proposed in [30] will be able to overcome the disadvantages of the travel agency websites.

Figure 9: Architecture of VTAS [30].

VTAS is built on the technologies Multi–agent information systems (MAIS) and semantic web technologies. VTAS can provide the tourist with the personalized and customized assistance [30]. The agents in the mobile devices such as the tourist assistant agents, calendar agents and reminder agents (shown in the figure 9) are capable of searching and gathering the information from the web, to plan, schedule, recommend and negotiate the activities based on the personal preferences [30]. There are many agent clusters accommodated in the VTAS architecture. Agent cluster consider group of agents. The components of the VTAS are described in the next section.

4.4.1 Processes of the VTAS

The important processes which are described in the architecture are discussed in this section. Ontology maintenance and search process component deals with the search of tourist information and helps with queries about the information of the users. The information for this process is provided with the ontologies and knowledge base. Ontology search agent in this process is responsible for searching the ontologies in the different web sites of travel agency for the required information. The central mechanism of the VTAS is the ontology [30]. Requirement and specification process deals with providing the information and help the user in planning, packaging and scheduling the trip. Package planning process helps the user to choose the mode of transportation such as flights, trains and accommodation and so on.

The information about the city or region is provided by the local tour planning process. Recommendation about the cinema houses, shops, restaurants is provided by this process to mobile tourist.

The agents are used for fetching the information from the different sources. The agents play a major role in these processes of the architecture. Each of the processes integrates several
agents based on their requirement. Different types of agents are integrated in the agent cluster. The different type of agents used in the architecture is discussed in the next section.

4.4.2 Agents Description

Agents are integrated in each of the processes in the VTAS architecture to provide better communication and for searching the information that is required for the applications. Multi-agent systems have been used for the agents to solve complex problems and to work cooperatively with other agents. In [33] the author has proposed architecture for the multi-agent systems in which each agent is autonomous, cooperative and intelligent and be able to communicate with other agents. The agents require language to communicate with other agents as discussed in the (multi agent system) section.

Different agents in the VTAS architecture

Ontology maintenance and search agent is used for searching the information based on the query posed by the user. The search agent gets the information from the various travel web sites. The agent uses ontologies for the communication between the other agents. Requirement and preference agents guide the tourists to specify the requirements and preferences in the requirement and preference management process. The criteria for the requirements and preference are formulated using the ontology based on the search criteria, options and alternative [30]. In package planning process there are different agents used they are matchmaking and confirmation agents. Matchmaking agents are responsible for selecting the suitable packages for the users based on their requirements. Confirmation agents provide the confirmation by waiting and sends alert to the users device through the alert agents for the selected package by the user. In this VTAS the author has mentioned about the cost evaluation agents but there is no process method described. In this next section author implements a method for the cost evaluation and describes how the method is used to minimize the cost.

4.4.3 Description of Packages

How are packages built?

Package is bundle of different similar products or separate products. Bundling of products is pervasive in the markets in one or the other form [34]. Bundle means grouping of the products which are similar in nature. For example in the travel agency the products like flights, renting a car from airport to the hotel and booking the room in the hotel may be bundled.

Bundling defined in [34] as “Bundling is the sale of two or more separate products in one package”.

The separate products mentioned in the definition define the products of the different markets. The good example for the bundle of separate products is the travel package. In the travel package the agency includes the products like tickets for the flight and renting a car from the airport to destination of the user. In this, ticket for the flight and renting a car are two different products of the different markets. The bundling consists of products from two different levels.

There are two different types of bundling, price bundling and product bundling as mentioned in [34] and defined as

“Price bundling is the sale of two or more separate products in one package at a discount without any integration.”
Product bundling is the integration of two or more separate products or services at any price.”

Price bundling is suitable for the firms or consumers for the promotional activities for the products as it based on the pricing. Price bundling can be easily implemented but for only a short duration. As the product bundling is integration of products, this type of bundling is suitable for the seamless interaction of the PC systems, interconnectivity of telecom systems and so on [33]. Product bundling is more of long term strategy and it is difficult for the firms to define strategies for the products.

Different forms of bundling

The firms for attracting the users and to promote the products use various types of packages that are to build packages based on the different strategies of bundling. Adams and Yellen in [34] have proposed three different forms of bundling of products unbundling, pure and mixed. The firm which follows the unbundling strategy can sell the products separately, and this is the strategy followed by most of the companies. In contrast to unbundling strategy the firm which bundle the products based on the pure bundling strategy will sell only the products which are bundled. Mixed bundling is a combination of both unbundling and pure bundling strategies, by which the firm can sell the products individually and products which are bundled.

There is another process of packaging which is built dynamically by the agents if there are no suitable products available. Dynamic packaging is one of the processes of bundling of products and the products are priced, but which is done dynamically by the agents according to the requirements of the users in real time [27]. For example, the tourist face problems from the traditional websites as the user have to visit multiple websites for gathering information and have to fill multiple forms. The travel assistant agents in [30] plan the suitable package for the users and result is forwarded to the mobile devices.

The firms can follow any of the above strategies for promoting their business. By following above packaging strategies the costs of the travelling products can be minimized. Relating this strategies to the VTAS, in VTAS the agents who are integrated in the processes are capable of forming the packages based on the user preferences. In the next section the author explains how the cost evaluation agent is able to minimize the cost of the packages (which are built on the above strategies).
5 SYSTEM ARCHITECTURE

In the previous chapters the author has discussed how the mobile devices access the travel information from the web. The author has discussed about the problems faced by the users relating to the information search from the internet and also explained how the journey has been done regarding the improvement of the internet search. There are limited numbers of architectures regarding the travel agency system using semantic web, but none of them could give the information regarding the optimal price for the travel products. The users have to rely on their approach to find the optimal price i.e. by manually searching the travel websites and get the information. In this chapter the author discusses the architecture for the travel agency system which uses the multi-agent technologies and semantic web technologies. By this architecture the users may be able to get the information to their mobile devices with the help of the agents. Agents will retrieve the information from the web and the travel agencies which is suitable and preferred by the user. The architecture has specific requirements which are explained in the next section. In this chapter the author discusses architecture requirements, architecture and components.

5.1 Architecture Requirements

The architecture has certain requirements which are proposed in the perspective of the business and the user. The requirements along with the classification are explained in following sections.

5.1.1 Requirements

- **Result set must be effective and accurate**: this business requirement is based on the user. As the decision making is dependent on the results, the results must be accurate and effective. For example the search result set regarding the travel information contain six results which are exactly suitable for the user which makes easy for making the decision.

- **Cost Effectiveness**: this requirement is based on the agency. The agency must provide the software and be able to store the data regarding the travel information and should be able to update the data according to the user requirements and market situation i.e. for competence in the market. The agencies must be able to update the information and information should be available to the user at any time in a more cost effective way.

- **Maintainability**: this requirement is based on the agency. As the number of users may increase time to time the agencies must able to maintain database and provide information to the users. The agencies must be able to identify the real agents which query for the information as there may be chances of cheating agents enter into the system.

- **Robustness**: this requirement is based on the agency. The agencies must be able to sustain all types of changes in the system such as increase the databases and increase in number of the users requesting the service at a time.

- **Search time**: this requirement is based on the user. The time for searching to fetch the results and provide it to the user should be minimal. It should also provide exact and efficient result set in the short duration to the user.

- **Privacy and Security**: this requirement is based on the user. The agencies must provide security and privacy for the user related to the information exchange. This can be provided by subscribing the users before providing the service by the agency.
The other requirement for the architecture is that the mobile devices must be WAP enabled so that the devices can connect to the internet at anytime and anywhere.

5.2 Travel Agent System Architecture

The author has explained architecture for the travel agency system in this section. This study is mainly based on the experiences gained from travel agency providers which provide travel packages for the tourists. The tourist find information is insufficient which is provided by the service providers and think it is more time consuming. These service providers lack in providing the better customer relationship. This motivates the author to propose the architecture which provides better customer relationship by providing the services to the customer (user) who is using the mobile device, with minimum cost for his/her preferred choices for destination. The architecture has been proposed using the semantic web technology and the multi-agent system for calculating the minimum cost of the travel products. There are not so many architectures available which use the semantic web in the mobile devices for the travel information. The architecture is explained in detail below with figure.
Figure 10: Architecture for Travel Agent System
5.3 System Description with Components

The basic aim of the architecture is to provide efficient tourism information of the city i.e. facilitating services to the user at anytime and anywhere. This can be achieved by providing an agent to the user. As the services differ from user to user we provide personal agent to each user. Personal agent provides the information in the form of GUI on the mobile device such as mobile phone. In this architecture there are many agents available for providing the services to the user. Each and every agent has a part to do in the system. The agent advertises their respective service in the system with using ontologies. All the agents have to communicate and work together to complete the task; any single agent will not be able to complete the task as it does not have the whole information. Therefore agents in order to complete the task, they need to communicate with each other. To communicate they require an agent communication language such as KQML and FIPA explained in the chapter 3. For example a message in FIPA ACL is as follows

```xml
(Inform
   :speaker speaker
   :receiver listener
   :content (activity Presentation at the Museum)
)
```

These messages are interpreted by the tools which are provided by the ontologies [virtual travel agent system]. Ontologies are main part of the semantic web. In this architecture ontologies play a major role. The specific service provided by the agents is stored in the ontology and knowledge base of the architecture. Example ontology for activity of the travel ontology using OWL is shown below.

**Example Ontology for sport activity:**

```xml
<Activities>
  <hasSport>
    <symbol rdf: value="CricketMatch"/>
    <Location rdf: resource="#CricketMatch"/>
  </Sport>
</hasSport>

<hasCredentials>
  <MatchLocation>
    <Location rdf: resource="#Location"/>
    <MatchLocation rdf: value="#Ronneby"/>
  </MatchLocation>

  <MatchDate>
    <Date rdf: resource="#Date"/>
    <MatchDate rdf: value="#06/06/2009"/>
  </MatchDate>

  <MatchFee>
    <Price rdf: resource="#Fee_Kronor"/>
    <MatchFee rdf: value="#500"/>
  </MatchFee>
</hasCredentials>
```

The architecture is formed of eight different agents such as personal agent, controller agent, search agent, matchmaking agent, cost evaluation agent, preference agent, local tour agent, package planning agent. The functionalities of these agents are explained as follows:
- **Personal Agent:** This agent is provided to every single user which works on behalf of the user. The personal agent contains the user profile and obtains information regarding the preferences of travelling. The agent acts on behalf of the user such as querying and negotiations about the tourism destination.

- **Controller Agent:** As the name suggests the agent controls the whole system. It is the mediator between the personal agent and the other agents. The main service provided by this agent is to control and choose the agents according to the service needed by the personal agent. Controller agent has all the information in the form of class and subclasses. The functionalities and responsibilities of this agent are depicted by using use case diagram which is shown below.

![Figure 11: Use case diagram for controller agent](image)

- **Search Agent:** Search agent takes information regarding the user preferences from the controller agent. The agent forms a query based on the information available and searches through the tourist portal. The sequences of operations which are done by this agent are shown using a use case diagram.

![Figure 12: Use case diagram for search agent](image)

- **Preference Agent:** This agent is a part of the tourist portal. This agent facilitates with the information preferred by the users as they are unfamiliar with the destination. It communicates with the package planning and local tour agents.
and information is gathered which is sorted out and ranked according to the preferences. The preference agent makes the user to specify their requirements regarding the class of hotel, local tour transportation, local tour activities and discounts available on the local tours and so on. The tasks which are managed by the preference agent are shown in the use case diagram.

- **Package Planning Agent**: Package planning agent is responsible for the planning of the tour i.e. the formulation of the tour plans comprising of the flight tickets, booking of hotels and other transport means. This agent gathers the information from the websites in the internet, ontology knowledge base and other service providers.

- **Local Tour Agent**: This agent is very important as the travellers often request about the local tours and activities when they are in certain city or region. The local tour agent plans the local tour and activities according to the preferences of the user. The information is gathered from the internet and local tour database which is in the form of ontologies by the agent. The sequence of events which are performed by the local tour agent is shown through the use case diagram.
• **Matchmaking agent**: This agent is responsible for selecting and composing the packages that satisfy the user needs and requirements. This agent gets the information from the preference agent regarding the tour packages and the agent makes the selection of the packages form them. This agent confirms with the controller agent regarding the preferences and requirements of the user. The agent’s lists of activities performed are shown using the use case diagram.

![Figure 15: Use case diagram for local tour agent](image)

• **Cost Evaluation Agent (CEA)**: CEA agent calculates the cost of the various available packages. The packages information is given by the matchmaking agents to the CEA. The cost minimization of the packages is solved using the mathematical formula considering some of the factors. The process is shown below.

![Figure 16: Use case diagram for matchmaking agent](image)

5.3.1 **Cost Evaluation Agent (CEA)**

Cost evaluation agent is used for minimization of the cost of the products in the travel agency system. This agent is integrated in the package planning process of the VTAS [30]. In the package planning process the package is selected based on the different bundling strategies which are defined in the previous section. The cost evaluation agent is implemented in this section.
5.3.1.1 How the cost evaluation agent works

The cost evaluation agent (CEA) is defined to minimize the cost of the travel packages. CEA uses the mathematical formula (defined in the next section) considering the about factors and generate a package with the optimal price and the result is sent to the controller agent. The controller agent sends to the personal agent, which displays it to the user. The user if interested then selects the package.

The agent consider some factors for evaluating the cost of a travel package, like places offered for the travel package, the mode of the transport, the type of the accommodation, the time of the package. All the factors are necessarily important in calculating the cost of the travel package. There may be different packages which offer different places for different price. But the problem is which travel agency is best in offering a travel package from the user point of view. For this the cost of the travel package need to be evaluated. This contains various phases.

i) Identifying the user requirements.
ii) Extracting the cost factors.
iii) Evaluating the cost factors.

5.3.1.1.1 Identifying the user requirements

This is the starting phase of the cost evaluation part. It is a kind of analysis done by the travel agent before actually offering a travel package. Each travel package contains different kinds of requirements like for example if a travel agency A wants to offer a tourism package, the requirements to be identified by the agency are the source of the travel, the destination of the tourism package, the distance, the mode of the transport (typically be a train, or an airplane or a bus or a cruise), the accommodation that is being offered, the local or non local costs. If the offered package is a tourism package or if the package offered is not a direct package then the customer may incur local or non local costs. For example for tourism package in that case the customer may be offered few places that has to be visited locally or nonlocal. And the local or non costs for this include the transport costs and accommodation costs that are required for a customer. Or if the package offered is not a direct package in that case the non local accommodation and transport if any are considered.

5.3.1.1.2 Extracting the cost factors

In this phase the agent make a query and search through the tourism ontology for identifying correct factors that are related to the product costs. In general some travel agencies for some packages they mention the local or non local costs as the cost factor. Local costs are the costs which are applied to the user from his source to destination. The non local costs are the costs which are applicable for the visiting the places at the destination.

Considering the above two factors the customer must bear his own costs. In this case the agent makes a tie up with the local agency in the destination place and may offer it in the different price.

We consider an example for explaining the above situation; for an instance, the user wants to travel from Sweden to France. In this case the agent has retrieved two packages which are suitable for the user with different costs.

Package -I:
Source: S → Stockholm.
Destination: D → Paris.
Mode of transport: Flight
Distance covered: X km  
Accommodation costs: C (A1) 
Local or non Local costs: C (L1)  
Transport costs: C (T1)

Package -II:  
Source: S → Stockholm  
Destination: D → Paris  
D → Orleans → Paris  
Mode of transport: Cruise  
Distance covered: Y km  
Accommodation costs: C (A2) 
Local or non Local costs: C (L2) 
Transport Costs: C (T2)

The agent has retrieved two packages with same source and destination for the user, but as the user is looking for the minimum cost package we have to calculate the minimum cost which is explained in the next phase.

5.3.1.1 Evaluating the minimum cost

When once the cost factors are identified and extracted, they need to be evaluated for calculating the total cost. Total cost is calculated as follows

Package -I:  
Total cost = $\sum [C (A1)] + \sum [C (T1)] + \sum [C (L1)] + \ldots$  

Package -II:  
Total cost = $\sum [C (A2)] + \sum [C (T2)] + \sum [C (L2)] + \ldots$

Now for calculating the minimum cost of these packages we form the equation as

Minimum cost $M = \text{Min} (\sum [C (A1)] + \sum [C (T1)] + \sum [C (L1)] + \ldots), \sum [C (A2)] + \sum [C (T2)] + \sum [C (L2)] + \ldots$.

For calculating the minimum cost for n packages and considering the factors affecting the cost of the package the equation is

$$\text{Optimal Cost} = \text{Minimize} \sum_{i=1}^{n} \sum_{j=1}^{n} P_i C (A_j)$$

In the above equation P represents the package and A represent the different factors of the package. C (A) represents the cost of the factor in the respective package. Here i and j represent the numbers from 1 to n.
5.4 Sequence Diagram

The sequences of events that will take place in the architecture are explained using the sequence diagrams.

Figure 17: Sequence of events occur between agents
Figure 18: Sequence of events occur in the tourist portal
5.5 Evaluation of the Architecture

Architecture evaluation provides us the basic and important properties of the architecture by analyzing it well. Evaluating the architecture is very cost effective when we evaluate it in the early stages rather than the final stages, as the problems found in the early stages can be solved by making changes to the design, requirement or specification that are necessary[39]. In this thesis the author has performed a case study for evaluating the architecture. The following steps are used for the case study.

5.5.1 Process

The case study is conducted on the business man and students of university to get a clear view of the situations on the architecture. The case study is conducted in the form of questionnaire based on some factors. The participants must answer the questions on a given scale, ranged from 1 to 5. The participants are allowed to compare the architecture with the traditional way of selecting the travel packages i.e. through the available web sites.

5.5.2 Factors for evaluation

Theoretical constructs are considered for the evaluation of the cost evaluation agent which are perceive of relative advantage, ease of use, user intention [35] and reliability, flexibility and comfortability. The construct perceive of relative advantage is defined as the degree “to which an innovation is perceived as better than the idea it supersedes” [36]. It means that the proposed architecture for the travel agent system is better than the traditional web sites. The second construct ease of use is defined as the “to which a person believes that using a particular system would be free of effort” [37]. Here the definition means that how easier it is to use the system with the available architecture compared to the other travel web sites. The third construct depicts the interest of the user in the cost evaluation agent for some time, that is the customers are interested in it or not.

Reliability factor is concerned with how reliable is the travel agent system for choosing the travel package and whenever the user wants to choose the travel package can get the suitable package in certain time. This factor may change for business man and student; for example a student will book in advance as he wants to get minimum price package but in contradiction business man as he will be busy, he may wants to travel in next two days or in a week. So the architecture may be able to choose the packages considering the preference of the user.

Flexibility factor defines how flexible is the system to choose the packages i.e. considering the time constraints. For example the user may be able to get the package details within certain time. The user may able to cancel the package and able to changes in the preferences.

Comfortability factor defines the comfort levels of the user be maintained when selecting the certain package for the user by the agent system. For example the business man does look for the star hotel and car from the airport. In contrast the student may prefer the star hotel or a car from airport to the hotel; student may choose a normal hotel or a bus or a train if available from the airport to the hotel.

5.5.3 Method for evaluating

Based on the above factors a case study is conducted for gathering the qualitative data for studying the performance of the travel agent system. The case study method is conducted in the form of questions for each factor that are aforementioned. These questions are adopted from [35].
For analyzing perceive of relative advantage the questions are:
   a) Will the above system makes me to buy a product very quickly than other traditional travel sites?
   b) Will the above system makes me easier to buy a product?
   c) Will travel agent system makes me to buy a product cheaper than buying from other traditional sites?
   d) Is it very useful to find the products?
   e) Is it very helpful to know about the products?

For the factor ease of use the questions are:
   a) Is it easy for me to remember how to buy a package?
   b) Is it easy to operate for buying a package is easy for me?
   c) Overall, I believe it is easy to use for buying a package.

Reliability factor questions are:
   a) Is it reliable by this system to buy the products?
   b) Is it faster than the other traditional sites?

Flexibility factor questions are:
   a) Is it easy to choose the timings for the tour?
   b) Is it flexible to change the plan and preferences?
   c) Is it possible to cancel the tour in time?

Comfortability factor questions are:
   a) Is it possible to get the offers and discounts available?
   b) Is it easy to tour the plan according to my requirements and preferences?

Considering all the above factors in detail the user is also stated to give intention is the factor user intention. For the user intention the questions are a) I want to use the system for 1 year and b) I intend to use the system for 1 year. These two questions are related in the sense of buying the product using the CEA.

Before giving the scaling for the questions the users are given brief knowledge of the travel agent system and the factors which are aforementioned.

5.6 Results and Discussions

The architecture proposed in this thesis is evaluated based on the above factors for the example case of users travelling from Sweden to USA. The results of the proposed architecture and the results of the traditional travel websites (there are many travel websites available, but here we are considering Travelocity for comparison) for the case Sweden to USA. Then the above results are evaluated and discussed using the factors which are mentioned in the previous section (section 5.5). For comparing the results the author an experiment is performed with 10 students of Blekinge Tekniska Högskola (BTH) who are from computer science background.

The students are given the required information about both the systems, by explaining about the interfaces of the system work and select the choices. They are provided with the interface of the system. The results of the system are extracted and they are evaluated using the factors reliability, comfortability, flexibility and ease of use.

In this section we compare the results for set of the requirements of the students. For example the requirements for the case study which are listed below.
   i) Traveling from Stockholm (STH) to New York (NY) by flight in the economy class with cheaper cost.
ii) Reside in a hotel near to the airport with rating 3 and which is cheaper.
iii) Travel from the airport to the hotel by any means of transport which is cheaper and faster.
iv) Give the list of activities which are present in the city.
v) Select transport means for the user if the user selects any activity which is cheaper.

Now considering the above requirements of the user first we search through the Travelocity websites and compare with the architecture proposed.

The steps involved in searching for the above information through Travelocity are:

- First we have to give the details of the flight information such as the economy class and details about the travelling time. After giving these details we get information regarding the flights and we have chose which is suitable and cheaper.
- Secondly for selecting the hotels we have to the give the details regarding the ratings and travelling details.
- After the above two we have to select the activities chosen by the user and we have to get the information about the travelling to the location.
- For all the above the activities the user must select the means of transport.

In general users must spend more time for selecting the products according to meet their requirements through the Travelocity website. The user must be patient and spend his/her precious time for selecting the products.

Now we search the results through the architecture proposed in this thesis and compare with the results from the Travelocity website. As we search through the mobile device and by the architecture the details are given in the table with list of options. The user has to simply fill the form and press search button. For example some of options are filled according the requirements of the user which are above mentioned are shown below.

For example the requirements of the students may be list of choices which are shown below

```
Source: STH
Destination: NY
Class: Economy
Trip: Round
Departure Date: 09/09/09
Arrival Date: 18/09/09
Hotel: Downtown
Hotel Rating: 4
Transport Means: Car
Activity 1: Football
Travelling to the Activity Place: Bus
Expected Cost: 2000$
```

For the travel agent system proposed in the thesis an interface is provided for choosing the options to travel from one place to another. The interface is shown below
Figure 19: Interface of the travel agent system

Now as the user press the search button we get the required results which are not higher than the cost 2000$ for all the products. As the system uses the ontologies for searching through the web, the meaning of the example Hotel in the downtown area can be understood and the results suitable for the search are provided by the system. As we have explained in the above section different packages are provided for the set of requirements as we search from which the user can select any of the package and the user can confirm and can pay directly. The results for the above choices are provided as shown in the figure 20. As the travel agent system is based on the semantic web and ontologies the system provides exact results for the choice which are provided by the student in the interface of the system.
<table>
<thead>
<tr>
<th>Offers</th>
<th>Flight</th>
<th>Hotel</th>
<th>Rental Car</th>
<th>Activities</th>
<th>Price</th>
<th>Overall Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[LH1001] Lufthansa Economy</td>
<td>Hotel 3 Rating **** Meals: None Location: Downtown Model: Ford Scorpio Compact Car</td>
<td>Sports: Football Activity: Available Transport: Available Location: Downtown</td>
<td>1705.00</td>
<td>****</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 20: Results View of the travel agent system**

If the results are not available which are matched to the student requirements then the system offers desired offers which are suitable but with slight variations in some of the requirements for example instead of hotel with rating 4 is provided with hotel rating 3.

For the above requirements of the student if the choice are not matched then the result view of the system is provided as shown below

**We cannot make an offer, which perfectly match your preferences. If you are willing to pay more price for your journey we can make an acceptable offer**

**Top Offer**

<table>
<thead>
<tr>
<th>Offers</th>
<th>Flight</th>
<th>Hotel</th>
<th>Rental Car</th>
<th>Activities</th>
<th>Price</th>
<th>Overall Rating</th>
</tr>
</thead>
</table>

We compare and evaluate the results of both the travel agent system and traditional web sites using the above factors ease of use, relative advantage, comfortability and reliability.

**Ease of use:** the users feel easier to yield the products easily using the architecture than the Travelocity. Using Travelocity it takes more time for selecting and waiting for the results to be provided for each and every product. The performance of the architecture is good as compared to the Travelocity because of its extended functionality.

**Relative Advantage:** The gain in the relative advantage factor in our architecture is mainly due to the various packages that are offered by this architecture, so that user can compare the available packages according to his or her requirement.
**Reliability:** Users tend to use the system as the architecture’s performance is better than the previous system. This shows the reliability is better for the system than the normal searching through the Travelocity website. The products are available for the users as the system searches through the whole web for the products.

**Comfortability:** This factor can be influenced by the architecture mainly due to the factors which are provided by our architecture which is easiness to tour the plan according to the requirements of the users. The other factor is that the user can get the discounts and offers regarding to the category of the users, for example students tend to search for the cheaper offers whereas the business men doesn’t consider about the costs.
6 CONCLUSION AND FUTURE WORK

6.1 Conclusion

Mobile e-commerce (m-commerce) is gaining popularity due to the ubiquity, personalization and localization of the mobile devices. Advancements in the wireless networks and wireless devices making the mobile devices use the internet services anywhere and anytime. In this thesis the author discusses about the mobile devices accessing the travel agent services. Travel agent system facilitates the mobile tourist with services during the trip. The travel agent system discussed in this thesis is based on the multi-agent system and the semantic web technologies. Semantic web is suitable for the tourism industry as it deals with the exchange of information. The ontologies are the main part of the semantic web in which the information is represented. The agents use the ontology for the information exchange between the other agents. We have also shown how ontology helps agents to improve planning as well as help tourist to better understand and specify their requirements and preferences. The main aim of the thesis is reduce the cost of the travel packages which are provided to the users. This is proposed by mathematical formula to evaluate the minimum cost of the packages. Finally the author concludes the chapter by explaining the unaddressed research gaps in the current thesis as the future work. The following sections explain the aim and objectives, and research questions along with explaining how the research questions are answered in the thesis work.

6.2 Aims and Objectives

The main aim of this is to propose an implementation for minimization of the costs of the products according to the users and get the information to the mobile devices. The objectives which are to be fulfilled to achieve this aim are:

- Identifying the semantic data by implementing the intelligent agents.
- Identifying the products and the prices over the semantic web.
- Identifying the requirements of the travel agency.
- Studying about the semantic web.
- Implementing the method of reducing the costs of the products.

6.3 Research Questions

The following are research questions which are to be addressed in this thesis.

a) What is the agent’s role in the semantic web and mobile devices?

b) How the semantic data accessed in mobile devices?

c) What are the requirements of the travel agency?

d) Is the concept which is proposed is suitable for minimizing the costs?
Addressing Research Question 1:
The agents play a major role in the semantic web and the mobile devices. Through the agents there is an exchange of information. How the agent with other agents communicates is explained in the section 3.2. How the agents are capable of fetching the desired results based on the preferences and requirements of the user is explained in the 4.3.

Addressing Research Question 2:
The mobile devices needed to integrate the semantic web content as there are problems with the current web; mainly the problem of the current web is the searching of the required data. The integration of semantic data and the interpretation of the data by the mobile devices is explained in the section 4.2. As the semantic data is represented in the form of XML format, the mobile devices may not be able to browse the data, therefore in the section 4.2 we have explained about the OINK browser through which the mobile devices can browse the semantic data.

Addressing Research Question 3:
As we discuss mainly about the travel agent system which provides the travel services to the users. The requirements of the travel agent system are mentioned in the section 4.3.

Addressing Research Question 4:
The travel agent system architecture is discussed in the fifth chapter. The calculation of the optimized cost is formulated using the mathematical formula in the fifth chapter. The evaluation of the architecture is discussed with a case study on certain users and based on the results; the performance of the proposed architecture is evaluated.

6.4 Future Work

The thesis discusses mainly about the minimization of the cost of the travel packages. The user tends to choose the package which is recommended by the agent. As there is a deal with the price constraints, there is a need of cash transactions. Due to the openness of the MAS there is possibility of cheating agent enter into the system. There is a possibility that the agent can cheat with the user in the transactions i.e. by cheating agent and give the user undesired results. Thus there is a need to implement security in the agents. The security features can be enhanced by specifying the security requirements for the agents in the ontologies.

References


[29] www.travelocity.com


