Building an Ontology-Based Framework for Tourism Recommendation Services

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Abstract

The tourism product has an intangible nature in that customers cannot physically evaluate the services on offer until practically experienced. This makes having access to credible and authentic information about tourism products before the actual experience very valuable. An Ontology being a formal, explicit specification of concepts of a domain provides a viable platform for the development of credible knowledge-based tourism information services. In this paper, we present an approach aimed at enabling assorted intelligent recommendations services in tourism support systems using ontologies. A suite of tourism ontologies was developed and engaged to enable a prototypical e-tourism system with various knowledge-based recommendation capabilities. A usability evaluation of the system yields encouraging results as a demonstration of the viability of our approach.

Keywords: Tourism, Recommendation, Ontology, e-Tourism Services, Semantic Web, Knowledge-based Recommender Systems

1 Introduction

The tourism product has an intangible nature in that a prospective traveller cannot touch the product before the trip. This is one major reason why information about tourism and travel services (e.g. destination, hotel, restaurants, events, transportation etc.) must be accurate and credible, one that fosters users' confidence. One way to achieve this level of credibility is to engage knowledge representation formalisms that can sufficiently capture all relevant facts about tourism objects in a domain on which approaches to rendering tourism information services can be based. An ideal approach to achieve this is the use of ontologies which provide the platform on which recommendation formalisms that exploit deep knowledge of the user, tourism objects, and other relevant contextual information that closely model reality can be built.

An ontology is a formal explicit specification of a shared conceptualisation of a domain (Noy and Hafner, 1997). *Conceptualisation* entails the use of abstract models to depict what is understood about entities in a domain of interest. *Explicit* means that

the concepts used and the constraints on them are clearly defined while *formal* means that entities in the ontology are represented in full or semi-machine processable form. Also, the fact that it is shared means that the knowledge captured in the ontology is mutually agreeable to a group of people. This typifies an ontology as a deliberate semantic description of what is generally known about some real world phenomena in a domain of interest using concepts and relationship abstractions in a way that is readable by both man and machine. An ontology defines a vocabulary that encapsulates the body of knowledge for a particular domain thereby providing a platform for effective communication and knowledge sharing among stakeholders.

The use of ontologies has the potential to solve a number of problems in tourism. First, the fact that it allows the sharing of domain knowledge using a common vocabulary across heterogeneous platforms means it can be used to solve interoperability problems (Dell'Erba et al., 2002). Secondly, ontology enables the sharing of common understanding of the structure of information among people and software agents (Noy and McGuinness, 2003); this also can help to standardize business models, business processes and knowledge architectures in tourism. Thirdly, ontology serves as a model of knowledge representation from which knowledge bases that describes specific situations can be built. These reasons motivated our decision to develop a suite of tourism-related ontologies for the geographic context of Nigerian tourism. This is premised on our belief that an ontology-based framework that enables the leveraging of factual knowledge about a specific tourism context for recommendations has potentially high tendency to enhance the quality and credibility of tourism recommendation services for such a context.

Knowledge-based recommender systems though sometimes regarded as being fundamentally content-based systems are a class of recommender systems that exploit deep knowledge about the product domain in order to determine recommendations (Burke, 2000). They make use of knowledge about users and products to generate a recommendation and reasoning about what products meet the user's requirements. A knowledge-based recommender system avoids the problem of sparsity associated with both Content-Based Filtering and Collaborative Filtering systems (Sarwar et al., 2001). The recommendations of knowledge-based recommender systems do not depend on a base of user ratings. It does not have to gather information about a particular user because its judgements are independent of individual tastes. These characteristics make knowledge-based recommenders very valuable systems when used independently and also when used to complement other types of recommender systems (Burke, 2000). The usual concern about knowledge-based recommender systems is the expensive nature of knowledge engineering endeavours which makes the systems more costly to implement. However, to the contrary, relying on our experience we argue that the cost is not prohibitive, in particular when the currently available tool-support for knowledge engineering is used to maximum advantage (Farquhar et al., 1997; Knublauch et al., 2003, Fernández et al., 2006). Also, in the context of the focus of this paper, the fact that the features of the tourism product in a particular domain are well-known significantly minimizes the cost of knowledge acquisition which is a core activity of knowledge engineering. Moreover, the potential gain in the credibility of recommendations that can be realized will more than

sufficiently justify any effort expended on knowledge engineering. In this paper, an ontology-based architectural framework that enables the generation of various knowledge-based recommendations is presented. As a demonstration, two OWL knowledge representation ontologies were developed to enable a prototypical national e-tourism platform with destination and accommodation recommendation capabilities. A usability evaluation of the prototype system with selected users was undertaken to confirm the viability of the approach.

The rest of this paper is organized as follows. In Section 2, we present a review of related work. Section 3 gives a detailed description of the procedures engaged in ontology development. Section 4 presents an overview of our ontology-based framework, prototype e-tourism system developed and the result of its usability evaluation. The paper is concluded in Section 5 with a brief note.

2 Related Work

In (Henrikson, 2005) the profile of some ontology-based EU projects that were aimed at enabling semantic web capabilities and semantic interoperability between e-tourism services and resources were given. These include the following: The HARMONISE project (Dell'Erba et al., 2002), which is a prominent ontology-based solution for the interoperability problems in the European travel and tourism market. The Harmonise project is aimed at providing a knowledge sharing and ontology mediation platform for the diverse e-commerce applications within the European e-tourism market sphere. The ontology used focussed specifically on the events and accommodation sub-domains of tourism. HI-TOUCH (Hi-touch, 2003) is the acronym for E-organisational metHodology and tools for Intra-European sustainable Tourism. The aim of the Hi-Touch project is to develop software tools to be used by travel agency sales assistants for providing a tourist prospect with the best-adapted offer. The developed tools leverage ontological databases and semantic descriptors, and multi-lingual thesaurus to deliver their functionalities. SATINE (www.srdc.metu.edu.tr/webpage/projects/satine/ [July 7, 2008]) is an acronym for Semantic-based Interoperability Infrastructure for Integrating Web Service Platforms to Peer-to-Peer Networks. The ongoing project will be used to create a semantic based infrastructure that will enable the Web Services on well-established service registries like UDDI or ebXML to seamlessly interoperate with Web Services on P2P Networks. Relevant travel ontologies will be developed and the semantics of the Web Services will be based on standard specifications like the one produced by Open Travel Alliance. The semantic infrastructure will be used to develop an innovative business pilot application in the tourism industry. IM@GINE IT (Moraitis et al., 2005) is the acronym for Intelligent Mobility AGents, Advanced Positioning and Mapping Technologies INtEgration Interoperable MulTimodal, location based services. The IM@GINE IT project aimed at developing one and single access point, through which the end user can obtain location-based, intermodal transport information, mapping and routing, navigation and other related ubiquitous services in Europe, at anytime, and in a personalized way. The technology relied on a common transport and tourism ontologies.

Examples of knowledge-based recommender systems that have been reported in literature include: The PersonalLogic recommender system that offers a dialog that effectively walks the user down a discrimination tree of product features (Bhargava et al., 1999). The restaurant recommender entree (Burke et al., 1997; Burke et al., 1996) makes its recommendations by finding restaurants in a new city similar to restaurants the user knows and likes. The system allows users to navigate by stating their preferences with respect to a given restaurant, thereby refining their search criteria. Other implementations of knowledge-based recommender systems are discussed in (Felfernig and Kiener, 2005; Jiang et al., 2005; Thompson et al., 2004).

In the travel and tourism domain, the TripMatcher (see www.ski-europe.com) from Triplehop and Me-Print (used by travelocity.com), which is an expert advice platform from VacationCoach (Staab et al., 2002) are notable recommender technologies. The two systems make use of a content-based approach for generating destination recommendations. However, recommendations on other forms of tourism objects such as accommodation, cruises, restaurants, event services and so on were not covered by these systems. Another successful recommendation technology is the trip@dvice (see http://www.nutking.ectrldev.com/nutking/), which has been applied in some e-tourism portals (e.g. visiteurope.com) (Venturini, 2006; www.ectrlsolutions.com [June 6, 2008]). Trip@dvice predominantly uses case-based reasoning as its recommendation technology but unlike TripMatcher and Me Print offers a range of recommendation services on several tourism objects. One characteristic common to all of these implementations is the fact that the parameters used for destination recommendation were strictly two-dimensional i.e. the user's travel preferences and the description catalog of travel destinations. The use of relevant contextual information that can improve the quality and dependability of recommendations was not considered (Adomavicius and Tuzhilin, 2005; Adomavicius et al., 2005). Hence, this work offers as its contribution a demonstration of an instance of ontology-based tourism recommender systems development that incorporates the use of contextual information for the generation of dependable tourism recommendations on various tourism objects.

3 Ontology Development

We constructed two tourism-related OWL ontologies which are the Destination Context Ontology (DCO) and the Accommodation Ontology (AO) using the Methonthology methodology (Gomez-Perez et al., 2004) of ontology development. The OWL (Web Ontology Language) is one of the most recent and popular ontology languages. It is the semantic web standard for formally specifying knowledge on the web. OWL is a markup language for publishing and sharing data using ontologies on the Internet. OWL is a vocabulary extension of the Resource Description Framework (RDF) and is derived from the DAML+OIL Web Ontology Language. OWL facilitates machine interpretation of Web contents in a way that is better than XML, RDF, and RDF Schema (RDF-S) by making use of additional vocabulary apart from formal semantics (Knublauch et al.,2004). The DCO and AO ontologies were implemented with OWL DL using the Protégé 3.3.1 ontology editor tool. An OWL ontology essentially consists of classes (which represents the concepts in a domain), a

class-hierarchy (concept taxonomy), properties (slots), property values, relations between classes (inheritance, disjoint, equivalent), restrictions on properties (type, cardinality), characteristics of properties (slots) (e.g. symmetric, transitive) and individuals (for knowledge-bases). OWL also offers classification and subsumption reasoning capabilities (www.w3.org/TR/owl-features/ [May 13, 2008]).

3.1 Destination Context Ontology (DCO)

The motivation for the DCO was the quest to engage a multi-dimensional approach to destination recommendation with the use of contextual information different from the 2-dimensional approach currently engaged in most of the existing recommendation platforms (Adomavicius and Tuzhilin, 2005; Adomavicius et al., 2005). Indeed, many of the existing destination recommendation systems have placed more emphasis on user's travel activity preferences, the facilities and services, and the type of accommodation available at specific destinations without much consideration for the social attributes of such destinations. The social attributes of a destination such as the general scenery (atmosphere), security, population size, flow of traffic, behaviour of inhabitants, linguistic complexity and many other factors are very crucial to the outcome of peoples' touristy experience in most cases. We wanted to enhance the dependability of destination recommendations by incorporating contextual information about the social attributes of prospective destinations. Hence, DCO was conceived as a model of knowledge representation ontology that captures contextual information about the social attributes of possible destinations within the Nigerian tourism domain.

A conceptual taxonomy of Destinations was developed consisting of three class abstractions: *City, Town* and *Village* with *'ISA'* relationships. The five social attributes of a tourist location that were of interest were: *Weather Temperature, Scenery, Volume of Traffic, Crime Rate,* and *Status*. These attributes were modelled as properties of a destination using *'FeatureOf'* association. Each of the five attributes consists of a set of five possible values from which values that define the characteristics of a typical destination are derived. These are given as follows:

- Weather Temperature = {"Cold", "Mild", "Warm", "Hot", "Very Hot"}
- Scenery = {"Very Quiet", "Quiet", "Medium", "Noisy", "Very Noisy"}
- Volume of Traffic = {"Very Low", "Low", "Medium", "High", "Very High"}
- Crime Rate = {"Very Low", "Low", "Medium", "High", "Very High"}
- Status = {"City", "Urban", "Town", "Settlement", "Village"}

Such that, if C is a vector denoting the social attributes of a destination, then

$$\mathbf{C_{(Ibadan)} = <Mild, Medium, Medium, Low, City>}$$

connotes that *Ibadan* as a destination has *Mild* weather temperature, *Medium* scenery rating, *Medium* volume of traffic, *Low* crime rate and a *City* rating in terms of its metropolitan status. The semantic relationships that may exist between different instances of specific social attribute classes were modelled with the *'CloserTo'*

association. For example 'Hot Weather' is specified as symmetrically closer to 'Very Hot Weather', in order to provide adequate basis for reasoning about entities represented in the ontology. The relationships between the different destination abstractions were represented using *'PartOf"* association, whereby Villages and Towns are conceived as extensions of specific City destinations.

The DCO was implemented using the Protégé 3.3.1 Ontology tool. The OWL ontology consists of five disjointed classes namely: *CrimeRate, Scenery, Traffic, CityStatus, Weather* and *Destination.* Three classes: Town, City, Village were defined as subclasses of the Destination class. The classes: *CrimeRate, Scenery, Traffic, CityStatus, and Weather* which represents the attribute features of a destination were defined as OWL Values Partition. A partition of a concept C is a set of subclasses of C that does not share common instances (disjointed classes) but cover C, that is there are not instances of C that are not instances of one of the concepts in the partition. The 'FeatureOf' relationship between a Destination and each of the feature classes were modelled using corresponding OWL functional Object properties of *hasCrimeRate, hasScenery, hasTraffic, hasStatus and hasWeather* respectively. This ensured that a particular functional object property maps to only one specific subclass of the corresponding feature values partition i.e.:

$$hasCrimeRate\ (Destination) \rightarrow Cri \in CrimeRate$$

which means that the object property hasCrimeRate must necessarily take its value from one of the values in the CrimeRate value partition. The 'CloserTo' and 'PartOf' relations between entities in the ontology were modelled as inverse and symmetric object properties. This ensures that if A is 'CloserTo' B, then B is 'CloserTo' A. As such, many of the subclasses in the feature value partition have specific 'isCloserTo' properties defined on them. The ontology was populated with OWL individuals representing concrete facts that pertain to specific destinations in Nigeria. A total of 37 cities and 100 towns and villages were covered. Fig. 1 and Fig. 2 are snapshots of our implementation.

Accommodation Ontology (AO)

The AO is a semantic representation of the attributes of the various types of tourism accommodation (see Fig. 2.). It was modelled following the Harmonise ontology (Dell'Erba et al., 2002), which captured facts about accommodation types and events in the European tourism domain. Five specific attributes of accommodation types (e.g. hotel, guest house, hostel, chalet etc.) were considered. These are 1) *Services*: the description of kinds of services rendered; 2) *Gastro*: profile of eateries, cuisines or restaurants nearby; 3) *Attraction*: special attractions within or nearby; 4) *State*: province or region where it is located; and 5) *Facilities*: physical facilities available.

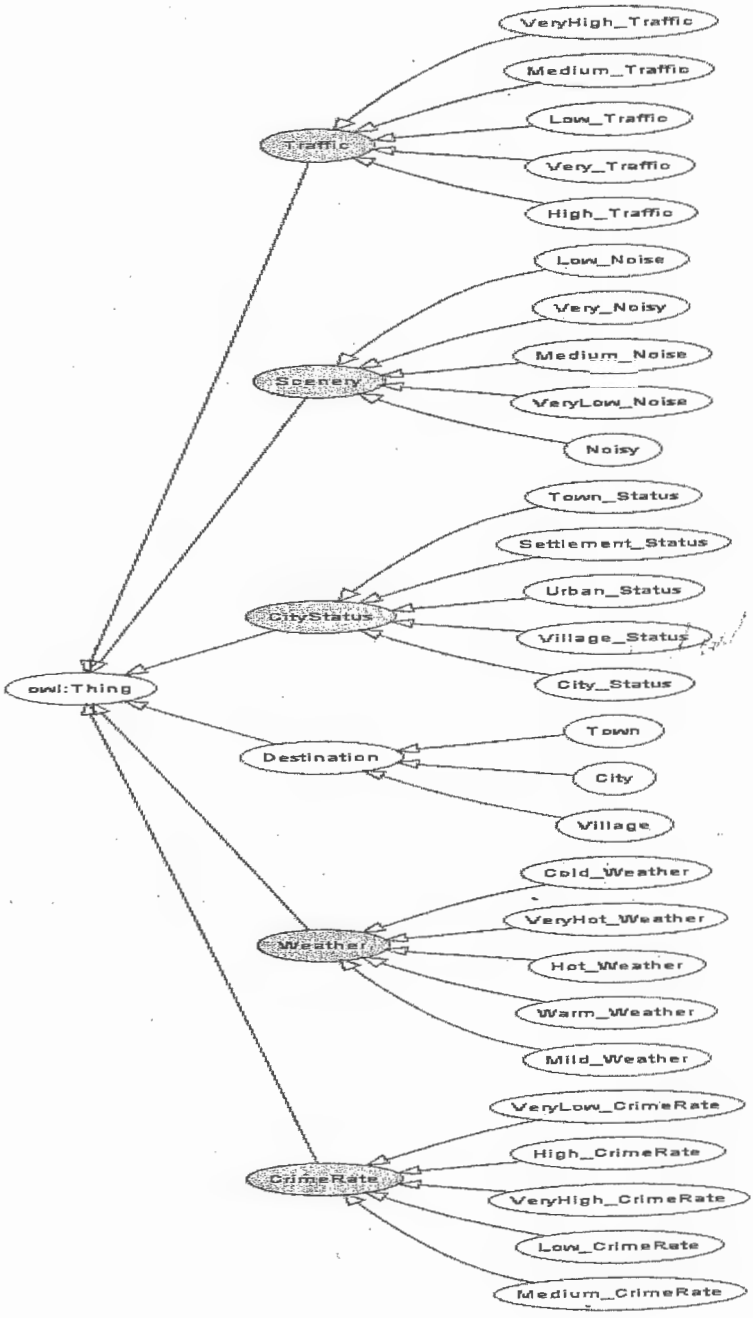

Fig. 1. A View of DCO Classes in Protégé

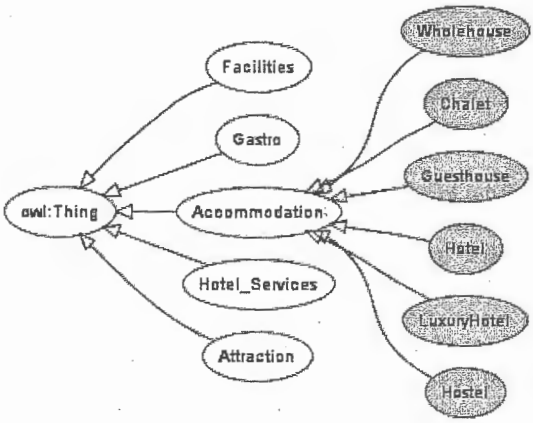

Fig. 2. A View AO Classes in Protégé

The AO was also implemented using Protégé 3.3.1 Ontology Editor. The ontology consists of six disjointed classes namely: *Accommodation, Attraction, Facilities, Services, Gastro* and *State*. Six classes: *LuxuryHotel, Hotel, GuestHouse, Hostel, WholeHouse* and *Chalet* were defined as subclasses of the *Accommodation* class. The classes: *Attraction, Facilities, Services, Gastro* and *State* which are the product features of a tourism accommodation were related to the *Accommodation* class by using OWL object properties. The object properties in the ontology are *hasServices, hasGastro, hasAttraction, hasState,* and *hasFacilities*. While *hasState* was defined as a functional property that maps an accommodation type to a particular state in the country, all the other object properties were defined as non-functional properties with a maximum cardinality restriction value of 20 imposed on each of them. This is to ensure that up to 20 different object property values can be specified for each of the attribute classes of *Attraction, Facilities, Services,* and *Gastro* for every instance of an *Accommodation* class. Just like the DCO, the ontology was populated with specific instances (OWL individuals) that pertain to hotels and various types of accommodation to create a knowledge base of accommodation. (See Fig. 2).

4 Ontology-based Tourism Recommendation Framework

Our ontology-based framework for various tourism recommendation services is presented in Fig. 3 as a functional architecture of three-layers. The first layer is the client-tier where specific kinds of recommendation services can be accessed. The second layer consists of a crew of embedded tourism recommender systems rendering knowledge-based recommendation services. A rule engine and a semantic matching engine constitute a body of necessary middleware infrastructures that enables each recommender system in this layer with semantic web capabilities (to read, and process facts stored in ontologies). The third layer which is the ontology layer consists of a suite of ontologies that can be leveraged for knowledge-based recommendations. A prototype e-tourism portal based on this framework was developed.

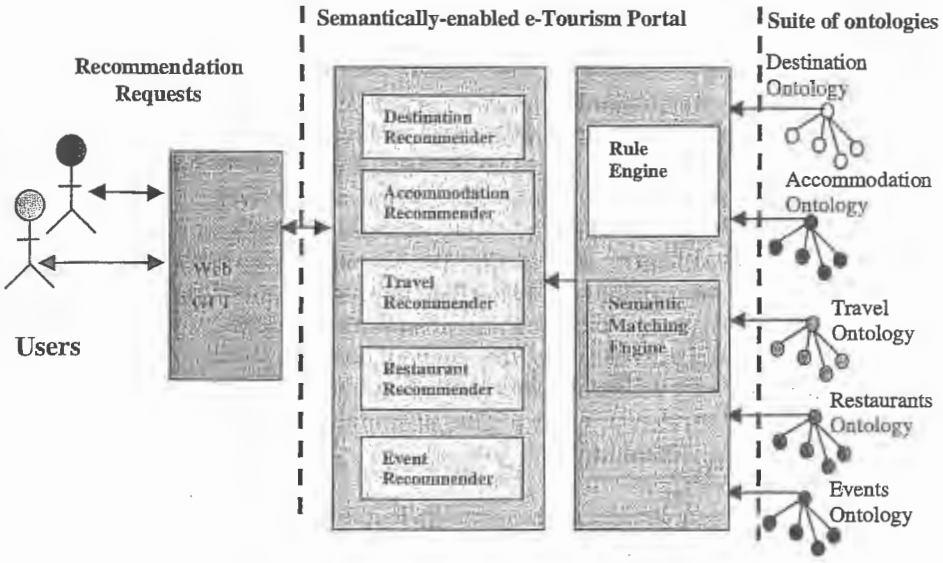

Fig. 3. A view of the Ontology-based Framework Architecture

4.1 Nigeria-Discover e-Tourism Portal

As a demonstration of our concept, an e-tourism portal prototype for the promotion of Nigerian tourism was built which encapsulated two knowledge-based recommender systems for destination recommendation and accommodation recommendation.

The Destination Recommender (DRS) has a hybrid architecture that leverages content-based filtering and case-based reasoning (www.etrlsolutions.com, [June 6, 2008]) for its initial recommendations. It takes a list of travel activity preferences of a user as input, which is then correlated with the content description of various destinations as captured in a tourism asset database to produce an initial ordered list of top nearest neighbourhood recommendations. Thereafter, the description of the social attributes of destinations as captured in the destination context ontology (DCO) are used to revise the initial recommendations based on the social attribute preferences of the user.

The Accommodation Recommender System (ARS) is a knowledge-based recommender system that leverages the knowledge captured about specific accommodation types to generate recommendations. By doing so deep knowledge filtered from the content description of key attributes of different accommodations types (e.g. hotel, guest house, chalet etc.) as stored in the accommodation ontology (AO) are used for recommendations. The Rule Engine associated with the ARS provides a basis for reasoning for decision making while its semantic matching engine executes an algorithm that matches the content descriptions of accommodation

instances with the specified preferences of the user to generate a list of Top–N recommendations.

Our implementations were based on Java Servlet technology, running on Sun Application Web Server 9.0 using the NetBeans Java IDE. The Web GUI and functionalities were implemented using Macro Media Flash and Dream Weaver web design tools, and Java Server Pages (JSP). The recommender systems were implemented as Enterprise Java Beans (EJB) components embedded in the web interface. Each of the EJBs references the specific ontology to which they were mapped using the Protégé ontology Java APIs (http://protege.stanford.edu/ [March 12, 2008]) to trigger ontology querying and reasoning capabilities. The Pellet 1.5 Descriptive Logics (DL) reasoner (http://pellet.owldl.com [May 16, 2007]) was used as the reasoning engine for the ontologies.

4.2 Empirical Usability Evaluation

Usability evaluation is an attempt to measure the user's perception of a system after an interaction experience. The essence of usability testing is to assess the quality of human-computer interaction properties of a system. According to ISO 924-11 (1998), usability is the extent to which specified users can use a system to achieve specified goals with effectiveness, efficiency and satisfaction. It is also a perception of a system's ease of learning and use from both the experienced and un-experienced users' viewpoint (Lindgaard, 1994).

A trial experiment was undertaken with 10 users, comprising of staff and students of the Science and Technology faculty of Covenant University. All the participants gave their informed consent to participate in the experiment, and were taken through a 15 minutes tutorial session at the commencement of the experiment. Participants were requested to respond to a pre-experiment questionnaire which was specifically designed to evaluate the background of the participants particularly in terms of their IT skills, knowledge of the Internet, familiarity with recommender systems, e-tourism portals, and general tourism and travel experience. They were asked to rate themselves on a scale of 100, which was graduated into 5 class categories. Our analysis of the characteristics of the participants showed that 80% claimed to be expert Internet users (indicating a rating of 70-100). 50% of participants claimed to have very good familiarity with recommender systems and e-tourism portals, 50% rated their travel and tourism experience as excellent while another 30% rated their travel and tourism experience within Nigeria as above average. 20% claimed to have little or no travel and tourism experience.

The post-experiment questionnaire was formulated based on the Post-Study-Satisfaction-User-Questionnaire (PSSUQ) standard (Lewis, 1995; Zins et al., 2004). The PSSUQ had 26 questions, which were specifically adapted to fit the scenario of our case study. The participants were required to rate each item in the post-experiment question on a scale of 1-5 (1-Excellent, 2-Good, 3-Satisfactory, 2-Unsatisfactory, 1-Poor) while 'n/a' was used for any questionnaire item they choose not to rate. The questions addressed various aspects which include: design layout,

functionality, ease of use, learnability, satisfaction, outcome/future use and reliability of the system. The post-experiment questionnaire was analysed statistically to determine the mean scores of user ratings of the system based on the seven usability metrics used for evaluation. Table 1 shows the mean scores obtained for each of the metrics used. From the result, the system had a mean score of above 4.0 in all of the 7 parameters used which suggests that the system is sufficiently usable and has an acceptable performance level. In our experiment, we sought to know what users feel about the fact that the recommendations were knowledge-based. From the feedback, we discovered that most of the users felt that the recommendation were accurate enough to earn their trust, because of convincing evidences that they were based on some facts that they are also aware of.

Table 1. Means Scores of Usability Metrics for e-Tourism System Prototype

	Usability Metrics	Mean Scores	Std. Deviation
1	Design/Layout	4.13	0.57
2	Functionality	4.19	0.63
3	Ease of Use	4.15	0.25
4	Learnability	4.00	0.56
5	Satisfaction	4.15	0.28
6	Outcome/Future Use	4.20	0.34
7	Reliability	4.02	0.68

Summarily, 80% of the sample population responded that they felt comfortable with the system by giving it a rating of 5 (excellent) or 4 (good). 20% of the participants gave the system a rating of 3 (satisfactory) or 2 (unsatisfactory). 60% of the sample population rated the recommendations of the system as excellent or good and claimed to believe it, 20% gave it a rating of 3 or 2 while 20% chose not to comment. 80% expressed general satisfaction with all aspects of the system.

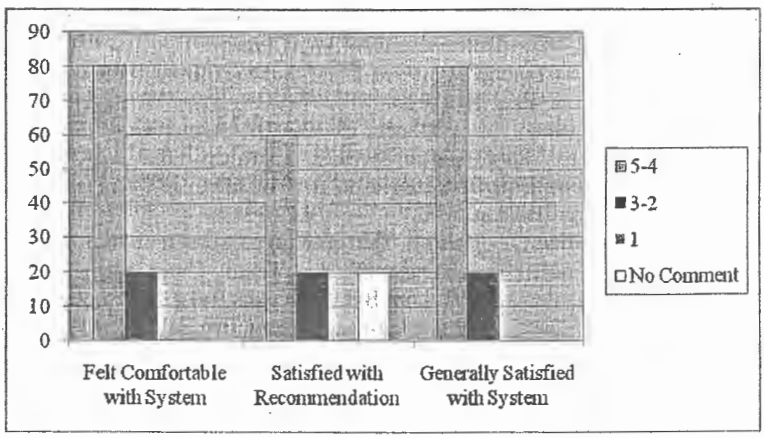

Fig. 4. A graphical View of User's Satisfaction Index for the System

Fig. 4 is a visualization of user's perception of the system. We consider the results of the evaluation experiment encouraging and supportive of our belief that the development of ontology-based platform will engender the delivery of assorted knowledge-based recommendations that will command users' confidence is indeed viable.

5 Conclusion

In this paper, an ontology-based framework that engenders the generation of knowledge-based tourism recommendations has been presented. The contribution of this approach is the creation of an ontological framework that is based on the use of contextual information for the generation of dependable knowledge-based tourism recommendations on various tourism objects. A prototype e-tourism portal that offers various recommendation services was developed based on the ontology-based framework, in order to validate the feasibility of our approach. A usability evaluation of the prototype system reveals users satisfaction with the quality and credibility of its recommendation services, which demonstrates the viability of our concept. In our future work, we will be looking to standardise and further expand the scope of tourism recommendation services currently covered by the prototype system.

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