How the Semantic Web revolutionizes Destination Management Systems

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Abstract

Tourism has a rather long business value chain and Destination Management Systems (DMS) have revolutionized the ways that the travel and tourist industry operates. Current web-based DMS cannot interoperate with other systems and data sources, as they are heterogeneous. In particular, DMS are based on different Information Systems (viz. hardware and software platforms), but mainly they use different data for representing tourism products and services. Data heterogeneity is a well-known problem, which is solved by providing semantic reconciliation among the different systems, with respect to shared conceptual reference schema: the domain ontology. DMS is a perfect application area for Semantic Web technologies, since information dissemination and exchange are the key-backbones of the destination management. DMS should take advantage of semantic services, interoperability, ontologies and semantic annotation. The Semantic Web could offer more flexibility to DMS through the use of new emergent Semantic Web technologies such as 'intelligent' software agents and annotation tools. In this paper we show how the Semantic Web technologies can be used for the next generation DMS. In addition, we propose an ontology for tourism destinations and we introduce the LA_DMS model.
Keywords: *Destination Management Systems; Semantic Web; Ontologies; Web Services*

1. INTRODUCTION

A tourism destination is a specific geographic area (e.g. a village, a town or even a country) chosen by visitors due to the attractions located on that destination. Destination Management Organizations (DMO) exploit tourism destinations developing marketing channels as tools to promote their destinations. According to Buhalis and Licata (2002), DMO use Destination Management Systems (DMS) (e.g. TISCover, VisitScotland, and Gulliver) to distribute their properties and to present the destination as a holistic entity.

DMS could be defined as the Information and Communication Technologies (ICT) infrastructure of the DMO, used for the collection, storage, manipulation and distribution of tourism information, as well as for the transaction of reservations and other

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commercial activities (Sheldon, 1997). DMS provide complete and up-to-date information on a particular destination. They should be capable of handling both the pre-trip and post arrival information, as well as of integrating availability and booking service too (Buhalis, 1997). DMS concentrate on the communication between local, regional and national tourist boards, the exchange of product description, marketing and statistical data (Werthner & Klein, 1999). Generally, DMS are government sponsored, and represent Small and Medium Tourism Enterprises (SMTEs). DMS can be categorized according to the following criteria:

- *Geographic area of coverage*: A DMS can be implemented at local, regional or national level.
- *DMS funding.* In Europe the majority of DMS are publicly funded; mainly by DMO budget or EU supported programs with few being privately owned.
- *DMS ownership:* Collins and Buhalis (2003) argue that there are three options available to establish a DMS: 1) DMS purchase, 2) DMS development and 3) outsourcing a DMS.

A DMS can handle bookings and perform reservation transactions. It is a full e-commerce system and consists of three basic modules:

a) A *knowledge base*, which is a subject-oriented, integrated, nonvolatile, time-variant collection of raw data (e.g. attractions, accommodation, travel information, etc.) that can be used to support destination management decision-making (Kasanava & Knutson, 1999).

b) A *users' database* containing the profiles for those users that access the tourism product.

c) A *booking-reservation module*: Reservation of tourism products can be achieved using Computer Reservation Systems (CRS) and Global Distribution Systems (GDS) (Werthner & Klein, 1999). GDS such as Sabre, Galileo, Amadeus and Worldspan dominantly provide travel information services. Particularly, they provide access to real-time availability and price information for flights, hotels and car rental companies.

Hereby we outline the weaknesses of the existing DMS and show how the Semantic Web technologies can be used for the semantic-based DMS.

The rest of this paper is organized as follows. Section 2 discusses the DMS weaknesses, while Section 3 presents semantics-based DMS. Section 4 proposes an ontology for destinations, which offers DMS adaptability to the users' needs. Section 5 introduces the LA_DMS model, while section 6 discusses benefits of semantics-based DMS.

2. THE WEAKNESSES OF CURRENT DMS

Currently travelers must visit manually multiple independent web sites to plan their trip, register their personal information multiple times, spend hours waiting for response or confirmation, and make multiple payments by credit card. According to Buhalis (1997), previous DMS projects (e.g. Hi-Line project, Swiss-Line project and Bravo) have failed for the following reasons:

- SMTEs refused to contribute financially, as they demanded immediate ROI (Return of Investment).
- DMS could not interoperate with other systems and data sources, because they were heterogeneous in hardware, software, and data representations.

Technical limitations of current DMS solutions, based on software agents and e-commerce servers, come from their inability to work over complex tourism packages. Besides, current DMS are based on different hardware or software platforms, and they use different data representations for tourism products and services. *Data heterogeneity* is a well-known problem, which can be solved by providing semantic reconciliation between the different DMS, with respect to a shared, conceptual reference schema: the domain ontology.

On the other hand, current GDS have legacy architectures with private networks, specialized hardware, and limited speed and search capabilities. Furthermore, as GDS are legacy systems, it is very difficult to interoperate them with other systems and data sources (Dogac et al., 2004). To address the different data representation problems, the Travel Industry has formed the Open Travel Alliance (OTA) (http://www.opentravel.org), which adopted the Web Services technology in the travel domain.

3. SEMANTICS-BASED DMS

The Web Services model provides the travel industry with an ideal platform to confront the difficult problem of heterogeneity and semantics can be used in the discovery, composition and monitoring of Web Services. Semantically isolated pieces of destination information can be connected, and the user can find the information sources more easily, while individual offers can be achieved.

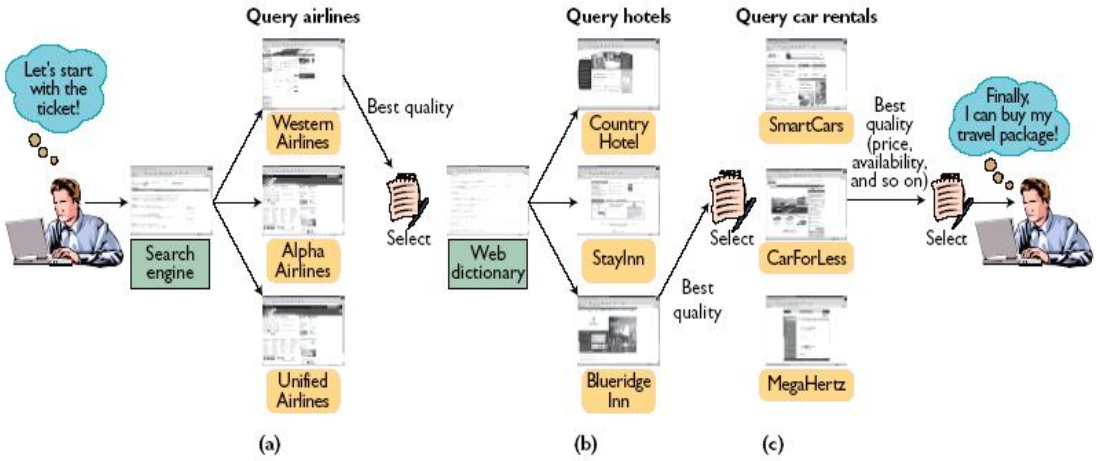
3.1 Web Services in DMS

Web Services are designed to wrap and expose existing resources and provide interoperability among diverse applications. In particular, the Web Services technology

can define a technique for describing web-based DMS services, methods for accessing them, and discovery methods that enable the identification of relevant DMS service providers. An example of Web Services is depicted in Figure 1. Web Services technology is a collection of standards that allows server DMS applications to "talk" to each other over the Internet. These standards are:

- XML (eXtensible Markup Language) for driving DMS application services, that is, XML schema is used in requests and replies. The OTA produced the XML schema specifications for exchanging standard messages in the travel domain.
- The SOAP (Simple Object Access Protocol: http://www.w3.org/TR/soap/) provides a means of messaging between a service provider and a service requestor.
- WSDL (Web Services Description Language: http://www.w3.org/TR/wsdl/) as the service description language.
- UDDI (Universal Description, Discovery and Integration: http://www.uddi.org/) as the service discovery protocol to find other DMS applications.

Figure 1: *Web services example. Ravi's quest for a travel package takes three steps. He must locate (a) a ticket, (b) accommodations, and (c) a rental car.*
(Ouzzani & Bouguettaya, 2004)



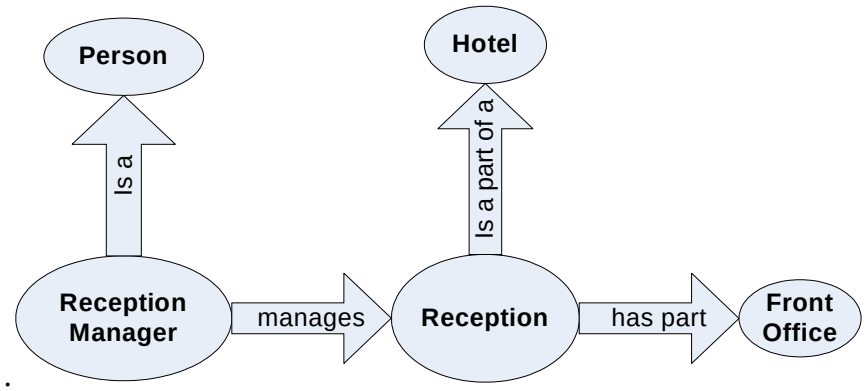
3.2 Semantic Web Services in DMS

Semantic Web technologies will influence the next generation of DMS by providing interoperability, reusability, and shareability among modular and service-oriented DMS. The Semantic Web is a concept that enables better machine processing of information (including DMS information) on the Web, by structuring documents written for the Web in such a way that they become understandable by machines. The Semantic Web allows

the DMS content to become aware of it. This awareness allows users and agents (viz. Internet-based programs that are created to act autonomously) to query and infer knowledge from DMS information quickly and automatically. The Semantic Web framework includes major components such as: *ontologies, ontology languages, tools, semantic annotations, logical support, software agents, and applications/services.*

Ontologies offer a promising infrastructure to cope with heterogeneous representations of tourism destination web resources. The domain model of an ontology can be taken as a unifying structure for giving destination information in a common representation and semantics. An ontology is a conceptualization of an application domain in a human-understandable and machine-readable form, and typically comprises the classes of entities, relations between entities and the axioms which apply to the entities which exist in that domain. Through the use of metadata organized in numerous interrelated ontologies (Mizoguchi, 2004), tourism destination information (e.g. hotel's information) can be tagged with descriptors that facilitate its retrieval, analysis, processing and reconfiguration. Figure 2 depicts an ontology in the hotel context.

Figure 2: *An example of ontology for the hotel context*



The creation of a single network of semantically related mark-up for tourism destinations requires:

- The development of appropriately scaled ontologies.
- Systems that relate and map different ontologies to each other.
- Systems that learn and mine ontology connections through use, and
- The development of working prototype semantic-based DMS.

Introducing semantics to DMS services brings the following advantages:

- Semantically enriched DMS services handle the interoperability at the technical level; that is, they make DMS applications "talk" to each other independent of the

hardware and software platform. But even for DMS applications interoperating at the technical level, there is still a need for semantic interoperability. This kind of interoperability can be addressed through ontology mapping. This is a process whereby two ontologies are semantically related at conceptual level, and the source ontology instances are transformed into the target ontology entities according to those semantic relations. An interesting approach to ontology mapping has been taken in the GLUE system (Doan et al., 2002).

- Semantics can be used in the discovery and composition of DMS web services.
- The main mechanism for DMS service discovery is service registries and semantics can be used in the discovery of DMS web service registries.

3.3 Creating semantics on the DMS information

Some major technologies available to create semantics on Web are:

- *XML (eXtensible Markup Language)* and *XML Schema's* (Dell'Erba et al., 2002): XML is a markup-language for arbitrary document structure. An XML document consists of a properly nested set of open and close tags, where each tag can have a number of attribute-value pairs. Crucial to XML is that the vocabulary of the tags and their allowed combinations is not fixed, but can be defined per application of XML. With XML schemas we can structure data and documents according to a personal or community defined vocabulary.
- *RDF (Resource Description Format) and RDF-Schema* (Decker et al., 2000) is the metadata approach from the W3C. It does not structure the syntax of the data, but defines semantic meaning for data on the Web. RDF Schema is a set of predefined resources (entities with uniform resource identifiers) and relationships between them that define simple meta-model including concepts of classes, properties, sub-class and sub-property relationships. Domain schemas (i.e. ontologies) can then be expressed as sets of RDF triples using the (meta)classes and properties defined in RDF Schema. RDF is based on lower level technologies: *Universal Resource Indicator* (URI) to identify Web resources and Namespaces to identify different vocabularies.
- *DAML (DARPA Agent Markup Language)* is an extension of RDF and RDF Schema that will be able to express a much richer variety of constraints as well as support logical inference (Hendler & McGuinness, 2000).
- *Topic Maps* (ISO/IEC 13250, 2000) can be viewed as an interchangeable hypertext navigation meta-layer above diverse DMS information sources supporting topical

finding of various kinds of resources, such as documents, graphics, images, database records, audio/video clips, and so on. A special characteristic of the topic maps model is the clear separation between the description of the information structure and the physical information recourses (like web pages, multimedia content, images, and books). Topic maps define arbitrarily complex semantic knowledge structures and allow the exchange of information necessary to collaboratively build and maintain indexes of knowledge.

- *OWL (Web Ontology Language)* provides greater machine interpretability of Web content than that supported by XML, RDF and RDF-Schema (McGuinness & Van Harmelen, 2003). With OWL it is possible to implement a semantic description of a tourism/travel domain by specifying its concepts and the relationships between the concepts.

3.4 Software agents in semantic-based DMS

The Semantic Web can form a platform for search engines, information brokers and ultimately the 'intelligent' software agents. In semantics-based DMS, software agents can exploit semantics on the Web. The Semantic Web can utilize a variety of traveler, hotel, museum and other software agents to enhance the tourism marketing and management reservation processes (Hendler, 2001). For example, a hotel agent operating on the Semantic Web might undertake many of the routine administrative tasks that currently consume large amounts of a hotel manager's time. Besides, traveler agents can assist travelers in finding sources of tourism products and services and in documenting and archiving them. An additional capacity of the Semantic Web is realized, when software agents extract information from one application and subsequently utilize the data as input for further applications. In this way, software agents create greater capacity for large scale automated collection, processing and selective dissemination of tourism data.

3.5 Projects in defining semantics in Tourism

In the travel domain there have been efforts in defining semantics, such as the Harmonise and Satine projects. The Harmonize project (Missikoff et al., 2003; Dell'Erba, 2004) allows participating tourism organizations to keep their proprietary data format and use ontology mediation while exchanging information. The objective of the Satine project (Docag et al., 2004) is to develop a secure semantics-based interoperability framework for exploiting web service platforms in conjunction with peer-to-peer (P2P) networks in

the tourist industry. The essence of P2P computing is that nodes in the network directly exploit resources present at other nodes of the network without intervention of any central server. The EU-IST project SWAP (http://swap.semanticweb.org/) demonstrated that the power of P2P computing and the Semantic Web could actually be combined to share and find “knowledge” easily with low administration efforts. In the travel domain, the advantages of web semantics and P2P computing for service interoperation and discovery have been analyzed by Maedche and Staab (2003).

OnTour is a Semantic Web search assistant in Tourism. In the OnTour project framework, a working group at the Digital Enterprise Research Institute (Prantner, 2005) deployed an ontology for e-Tourism using OWL. Semantic Web methodologies and tools for intra-European sustainable tourism were developed in the Hi-Touch project (Hi-Touch, 2003). Dynamic packaging systems create customized tourism packages for the consumers. Cardoso (2005) proposed a platform to enable dynamic packaging using semantic web technologies. A dynamic packaging application allows consumers or travel agents to bundle trip components. FETISH project (http://www.fetish.t-6.it/) provides SMTEs and destinations with a European-wide infrastructure for spontaneous and seamless integration among tourism on-line applications, resources, processes and devices. FETISH infrastructure is based on Jini Network Technology™, and allows inter-operability between existing tourism services and new ones, and facilitates ad-hoc services.

3.6 Application scenarios of Semantic Web in Tourism

According to Maedche and Staab (2002) some application scenarios of Semantic Web technologies in Tourism are: a) Semantic search engine for tourism information, b) browsing topic portal, c) Web services for tourists and d) Semantic-based electronic market.

Semantic search enhances current search engines with semantics: It goes beyond superficial keyword matching by adding semantic information, thus allowing easy removal of non-relevant information from the result set. Semantics-based search can be provided by semantic web tools, such as the Ontobroker System (Fensel et al., 1999). This tool provides an ontology-based crawling and answering service. In addition, semantic ranking is useful in those cases, when too many results are returned.

Semantic browsers, such as Magpie (Dzbor et al., 2003), use ontologies to identify important concepts in a document and provide access to relevant material. Semantic browsing locates metadata and assembles point-and-click interfaces from a combination

of relevant information: It should be able to allow easy navigation through resources, since users with any level of computing knowledge may use it.

Semantics-based electronic markets are very useful as there is a large volume of transactions in DMS. In particular, there is a need for a fast match between providers and requestors, as late vacancies of rooms, flights or lodging are easily lost and new offers and requests come in by the minute. Sycara et al. (1999) described a comprehensive agent framework that allows the set up of semantics-based electronic markets. In addition, Sycara et al. (2003) introduced a vision for semantic web services, which combines the growing web services architecture and the Semantic Web. They proposed the DAML-S as the prototypical example of an ontology for describing semantic web services. Kanellopoulos et al. (2004) proposed a novel management system of semantically enriched web travel plans, which evaluates how on-line travel plans are consumed and identifies the individual differences among the users in terms of travel plan content usage

4. AN ONTOLOGY FOR TOURISM DESTINATIONS

In this section we propose an ontology for tourism destinations, which is able to answer four types of questions that can be asked. These questions involve the predicates: *what, where, when and how.*

- *What are the available activities and attractions on a tourism destination?*
- *Where are these attractions and activities located?*
- *When do the tourists visit this destination and its points of interest?*
- *How can the tourist get to this destination to participate in an activity?*

```
DESTINATION_id = {
    what_services_are provided,
where_these_services_are_provided,
 when_these_services_are_provided,
  how_these_services_are_consumed
}
```

To resolve the differences among the data present in distinct destination websites, we rely on the semantic annotation techniques introduced by Kyriakov et al. (2005). Semantic annotation is the process of inserting tags in documents in order to assign semantics to the text. Our destination ontology is used for the annotation of unstructured web pages at the destinations web sites. Then the semantically annotated pages are stored in a knowledge database.

Semantics-based DMS can be adaptive to users' needs: *information for transportation, restaurants, accommodation, services, weather, events, itinerary tips, shopping, nightlife, daily excursion, car rental, sport activities* etc. Prerequisite for this is to attach semantic meta-data to tourism destination components. DMS adaptation requires the destination content (e.g. a cultural event) of knowledge base to be modeled using multiple descriptions (viz. various templates associated with the user needs).

Knowledge discovery in database (KDD) with *data mining* is a useful tool for destination management (Pyo et al., 2002). Data mining process is applied to record and analyze users' preferences regarding the tourism destination components. It allows precise targeting, personalization of tourism products, and measurability; tools for effective destination marketing strategies. Semantics-based DMS can generate users' profiles by recording users' preferences. User profile is used for expressing the characteristics and features of a person. A user profile consists of a static part (demographic info such as name, sex, age, country of origin etc) and a dynamic part (interests, filters, traces). *Filters* describe the mechanism for expressing user's interests. For example, a filter expresses the fact that a user is interested in museums. *Traces* describe the interactions of users with the DMS and the mechanism for recording these actions.

5. LA_DMS: THE ADAPTIVE DMS FRAMEWORK

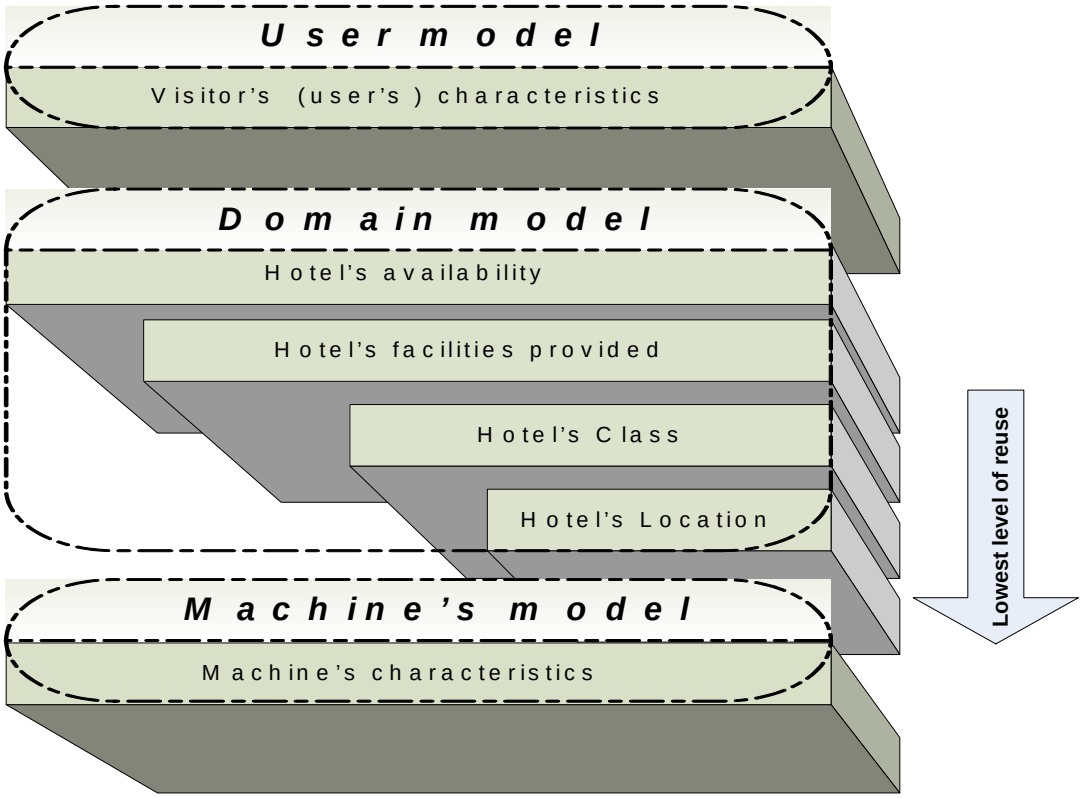
Frequently the DMS content (e.g. a hotel's availability) is changed. Therefore, it has to be sufficiently malleable so that it can be reused in different settings. This kind of change can focus on the new issues of the tourism destination and refine the old. Therefore, we propose a layered approach with appropriate semantic labeling. These layers should reflect a higher level of semantics, such as domain model (e.g. hotel's class), user characteristics (e.g. visitor's profiles) and machine characteristics.

We introduce the LA_DMS (Layered Adaptive DMS) model that consists of three layers:

- *Domain model* (DM): containing a collection of linked DMS resources.
- *User model* (UM): containing user-related information, such as information about the visitor.
- *Machine model* (MM): containing display and machine related information, such as the foreground-background colour scheme for the destination presentation. It addresses the specifications of views for DMS web sites, induding navigational structures and detailed user interfaces.

In Figure 3 the LA_DMS model architecture is depicted for the hotel context.

Figure 3: *The LA_DMS model architecture in the hotel context*



At a lower level, the semantics have to be applied all the way to the lowest level of modification (and thus of reuse). For example, the hotel's availability is frequently changed and it should be appropriately labeled in order to be easily retrieved according to its semantics.

Semantics-based DMS will include: ontology-driven subject domain, repository of tourism destinations, destination presentation, adaptation and personalization. Typically, destination tasks are annotated in terms of subject domain concepts and some instructional relationships between the involved concepts. The domain concepts (e.g. a hotel's availability, facilities, location, class etc) are also used as a basis for implementing DMS' adaptive behavior. As a consequence, context specific configuration of DMS modules and their adaptation to the specific user needs can be enabled, as semantics meta-data are attached to DMS modules. For achieving this, ontologies being used must be aligned with the ontologies defining the context and user profile.

Sakkopoulos et al. (2006) proposed techniques to facilitate semantic discovery and interoperability of web services that manage and deliver web media content. These techniques are adopted in our framework.

Semantic labelling: If we author DMS content collaboratively, then appropriate semantic labeling becomes crucial, and the use of internationally adopted semantic standards is beneficial for the scalability of people and rdes involved. Moreover, semantic labeling is necessary, if we need to export between different DMS systems.

6. BENEFITS OF SEMANTIC-BASED DMS

A semantics-based DMS application allows consumers or travel agents to create, manage and update itineraries. Moreover, it permits the customer to specify a set of preferences for a vacation and query a set of information sources to find components such as: air fares, car rental, and leisure activities in real-time. Semantics-based DMS offer full integration, flexibility, specialization and personalization.

Full Integration: semantics-based DMS can integrate the management and marketing of the various local tourism products and services (Bussler, 2003). They can facilitate interconnectivity of SMTEs via full integration in order to increase margins on the products sold. Tools for sales assistance, such as 'intelligent' software agents, can provide various products and services into an integrated tourism package, which is personalized to tourists' needs.

Flexibility: semantics-based DMS can combine the individual tourism products and services. They are platform independent and can change their data without affecting the data representation.

Specialization and personalization: Precise targeting, personalization, privacy and measurability can be achieved through web direct marketing that is interactive, immediate, and accurately timed. Through web direct marketing, tourism products and services can be personalized to the user's needs (Murphy, 2003).

The utilization of semantics-based DMS offers better information management and achieves automatic intra (or inter)-organizational communication of a higher quality. DMS utilization improves the destination image and contributes to its promotion concerning the following areas:

a) Tourist flow: semantics-based DMS can increase visitors' traffic, attract the right market segment with the provision of an accurate and up to date comprehensive database.

b) Marketing: Tourism destinations will be unable to compete effectively, unless they are able to promote themselves in the emergent semantic network. Semantics-based DMS will enhance destination representation, boost its image and attract direct bookings by providing specialized and personalized services. Market segmentation and targeting will be more precise.

c) Management: semantics-based DMS may create more efficient internal and external networks, which can have long-term positive effects on the local economy by achieving competitive advantage (WTO, 2001).

CONCLUSIONS

The capacity of the Semantic Web to add meaning to stored information, so that it can be searched and processed, provides greatly expanded opportunities for DMS anywhere on the Internet. DMO need to realize that semantics-based DMS can act as an enabler in sustaining competitive advantage. DMO need to manage tourism destinations effectively utilizing semantic web technologies, which will re-engineer their role as planners, coordinators, regulators and promoters of tourism destinations.

DMS should take advantage of semantic services, interoperability, ontologies and semantic annotation. The Semantic Web could offer more flexibility in DMS through the use of new emergent semantic services such as intelligent software agents and annotation tools. Context specific configuration of tourism destination modules and their adaptation to the specific users' needs can be enabled by attaching semantic meta-data to tourism destination modules. For achieving this, the ontologies being used have to be aligned with the ontologies defining the context and user profile.

The Semantic Web forms a platform for search engines, information brokers and ultimately the 'intelligent' agents. It propagates interoperability, reusability and shareability, all grounded over an extensive expression of semantics with a standardized communication among modular and service-oriented DMS. The methodology of applying the Semantic Web in DMS needs to mature and methods for achieving scalability and robustness need to be developed.

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