Spatially Navigating the Semantic Web for User Adapted Presentations of Cultural Heritage Information in Mobile Environments

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Abstract. The integration of local and global information is an essential requirement for future location-based services. The development of two technologies for mobile devices, namely positioning devices like GPS and wireless communication networks, is encouraging the development of new kinds of spatial- and context-aware applications. The CHI project investigates the applicability of these technologies for context-aware mobile computing applications that take advantage of new metadata-standards to enable semantic, user and device adapted services in the field of Tourism and Cultural Heritage management and presentation.

1 Introduction

The ability to query hyper-linked cultural heritage data sets, based on the user's context is a crucial functionality of future location-based services. The local information here is information about a place with a unique spatial and temporal relationship, which can be used to distinguish between places or information that only exist with regard to an explicit reference to a place and time. Global information is information that exists as conceptual knowledge but does not bear spatial reference e.g. structure of organisations, abstract knowledge about something applicable to recognise similarities or analogies in other contexts. As emphasised by Dey [1], context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and application themselves. The primary context in the CHI (Cultural Heritage Interfaces) [2] system is the position of the user in a virtual environment and a specific mobile device, which are integrated together with the user's preferences. The rational of the CHI project is to retrieve automatically relevant data from a cultural heritage database based on the user's context, namely the current GPS coordinates, the display device limitations, the user preference and profile stored in a Vector data type. Furthermore, the system takes advantage of the available metadata information, encoded into the resource to extract the semantic value of existing documents for a selected area.

2 CHI System

The CHI project technology demonstrator (Figure 1) is implemented in a J2EE three-tier architecture, consisting of client layer, application server layer and database layer. The complete system communication between client and database layer is conducted through the application server layer. The Client VRML/JAVA sends the current location information in the form of Irish National Grid or Lat/Long coordinates via HTTP networking protocol to the Oracle application server along with the device characteristics and user profile and preferences. On the application server the query building and query result set formatting is executed against a spatially enabled Oracle database layer.

When the result of the query indicates the existence of content information, the system notifies the client about available documents with their respective Uniform Resource Identifiers (URI). The client then requests these documents automatically from the application server, which generates a XML JDOM document in memory and subsequently applies a specific XSLT style conversion to the resulting in a device-formatted document. The formatted document is then sent via HTTP protocol to the client device.

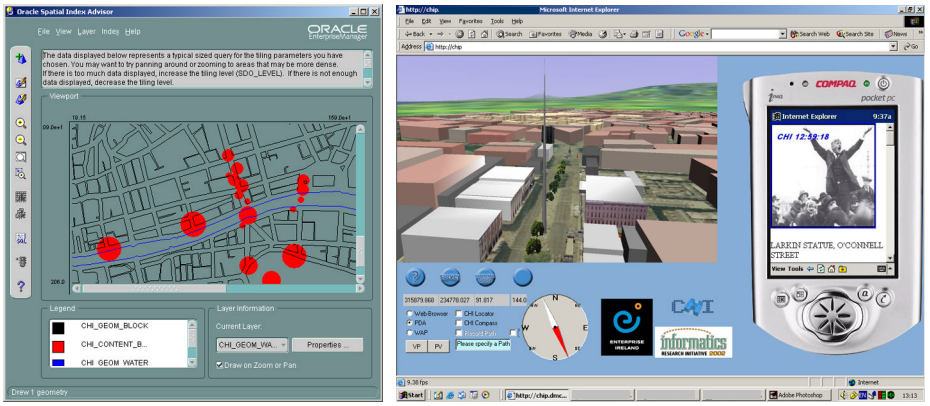

Figure 1 Oracle Spatial Index Advisor and CHI Technology Demonstrator

3 Semantic adaptation

After successful implementation of the spatial database components and visualization strategies and contextual information tailoring for mobile devices, the CHI project proposes the introduction of semantic layers to improve search query results. The concept of semantics has to be defined in the context of the CHI implementation. The use of the term “semantics” in regard to information systems is ambiguous and has led occasionally to false assumptions. Semantics in general describe the relations between

things and their varying significance for the receiver. This rather wide interpretation is not addressed in current research. However, one prominent and focused attempt at a pragmatic approach is the Semantic Web representation of data on the World Wide Web based on the Resource Description Framework (RDF). [3]

RDF integrates applications using XML for syntax and URI for naming. The Semantic Web therefore extents the current web where information is given well-defined meaning to better enable computers and people to work in cooperation. [4]

The accumulation of vast data resources on the World Wide Web has reached the limitations of conventional search approaches and new search strategies are needed. Current search procedures only account for simple string matching and boolean combinations of keywords. How much relevant information from unstructured data sources can be gained is up to the specification and capacity of the interpreter. To search for particular information in the current web architectures, the user is restricted to keyword matching or category browsing. The documents bear no explicit semantic information about themselves. To query documents on the web, search engines have to index available documents and this happens to be in most cases by parsing the complete document for keywords and Boolean combinations. Advanced search engines introduce new techniques like Latent Semantic Indexing where patterns in the text are recognized to assist in categorizing the document.

The semantics of documents and their respective knowledge domain relevance for the searching system remains untouched in most cases. Adopted approaches from artificial intelligence and knowledge management research promise to assist in exploiting the semantic value of online documents. For the most part the application of ontologies dominate present research where an ontology is used for the construction of complex models of relationships between data features and specialized domain area constraints to enhance query results.

The Semantic Web efforts by the World Wide Web Consortium [5] represent the attempt to extend the current web to give information well-defined meaning, therefore allowing machine processing and human evaluation.

3.1 CHI Semantic Query Scenario

While the user navigates the CHI system the client layer dispatches a query to the EJB middleware. The documents in a selected area are passed on to the semantic interpreter to determine the conceptual environment. The user's agent (i.e. the client) evaluates the semantic property and compares the conceptual environment of the document(s). The result is compared to the agent's conceptual definition to satisfy the initial search context. However, in order for ontologies to be shared, they must be congruent with other shared ontologies, otherwise they have to be compared and integrated, which is an active ontology research topic. [6]

The Semantic Web goes beyond these limitations and introduces a predefined semantic markup for web resources. The semantics are encoded in RDF (Resource Descriptions Framework) statements triples, consisting of Resource, Property and Value sometimes termed 'subject', 'predicate' and 'object' to describe a particular relationship. Semantics encoded into RDF triples can not only be used by human readers but also processed by machines. RDF therefore is mainly a mechanism to represent resources and their description in a direct-labeled graph (Figure 2).

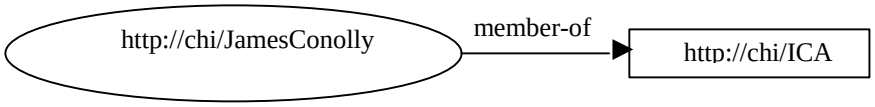

Figure 2 RDF direct-labeled graph

3.2 Ontology description and RDF Schema

To improve the information retrieval process and provide the user of the CHI system with more relevant information about available data resources the RDF metadata has to be related to the CHI domain ontology, which is implemented into a RDF Schema.

The query process (see figure 2) for semantic evaluation of RDF descriptions implemented on the Application Server session EJB and utilizes the Jena Java API for RDF [7] to generate the model graph depicted in Figure 3. For the purpose of the initial implementation of semantic exploitation, the CHI ontology only defines relationships between content documents stored in the Oracle database. Each content document can be accessed with a unique URL, which automatically adapts the database documents into a XML device independent tree structure and finally applies XSLT style sheet conversion to suit mobile device requirements for display.

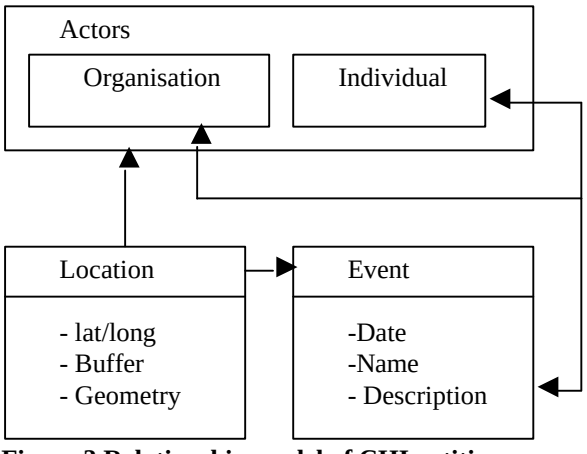

Figure 3 Relationship model of CHI entities

The introduction of RDF metadata allows the CHI System to locate, through querying RDF statements with RDQL query language, conceptual similar documents and selects only the spatially nearest related document for immediate display transformation. Additionally the user can take tangents and traverse the graph manually with the help of embedded hyperlinks in the cultural heritage document. The curator of cultural heritage content as well has the option to annotate data with time properties for allowing the introduction of narrative structuring of possible presentations resulting in predefined walk paths. The spatial database guides the user from one cultural heritage location to another with naive geographic directions: e.g. “go NE 300m” iteratively refined until the user has reached the next point of interest.

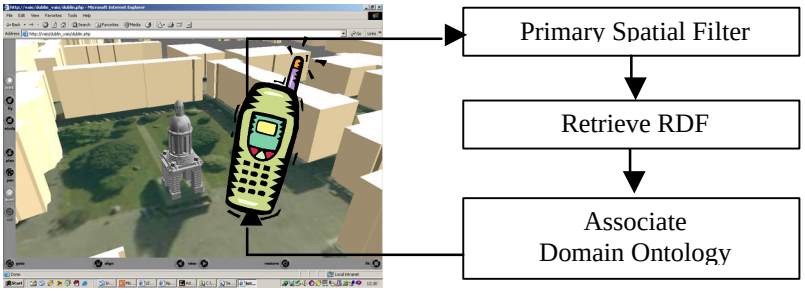

Figure 4 CHI semantic web information retrieval

4 Conclusion

In this paper we have presented the applicability of Semantic Web approaches to enhance query results within the CHI spatial database environments. The CHI project develops tools to respond to queries without the user of the system having to know about the conceptual structure. As noted in [8], given the lack of current approaches to exploit any form of semantics to assist users to accomplish their tasks, the introduction of metadata information capable of expressing the basic semantic relationships of resources and furthermore the integration into ontology-driven information systems is a desirable step to embrace decentralised web resources for information search. [9]
Future location-based services have to take advantage of intelligent information retrieval strategies to exploit the potential of augmented information systems in mobile environments. [10] The exploitation of metadata and their integration into domain conceptualisations is one necessary condition.

5 Acknowledgement

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