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Towards semantic modelling in mobile traffic information systems

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ABSTRACT

The traffic information exchange and its provision to different mobile devices through Web-portals is just one example of the many applications in need of "semantic treatment" of information. The impressive information volume and the great diversity of devices which can access this information create heterogeneity in different senses. This paper partly describes the process followed in the development of ontology for the management of collected traffic information which description is based on the principles of the semantic web and is described in a knowledge representation schema. Additionally it describes an integration architecture which permits access to semantic contents by means of web-enabled devices. The devices are characterized by their differences in hardware platforms and functional capabilities. To validate the proposed architecture, a prototype of a Multilanguage pervasive web portal for the dissemination of traffic incidents was developed. This portal can be accessed by a multitude of devices such WAP or I-Mode enabled phones, PDA's or even traditional phones with spoken information.

Categories and Subject Descriptors

I.2.12 [Intelligent Web Services and Semantic Web]: Internet reasoning services, Ontology design

General Terms

Design, Languages

Keywords

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Applications, Mobile computing, Pervasive computing, Semantic Web.

1. INTRODUCTION

The development of wireless web applications is evaluating from the automatic generation of contents for different devices, up to search for models and methodologies which permit the development of pervasive and intelligent web applications. The goal of Ubiquitous or Pervasive Computing is to obtain device interoperability under different conditions. The devices were designed for different purposes by different companies or from different "technological" generations. From the proposals inherited from the "man-machine-interface" community comes the context enabled approach. It considers elements such as the device, application execution, user preferences and the variation of the context over time. Other proposals suggest different dimensions of modelling, surpassing the separation of content and presentation, such as the solutions based on CASE tools. On the other side, knowledge representation and the semantic web enable an effective man-machine interface. In this sense the W3C envisaged the need to define vocabularies and ontologies which can be shared between different applications, just like the mechanisms to create the semantic data definitions. Finally, in the process of creating new applications, there is not sufficient clarity in relation to the basic question: "How to develop a pervasive semantic web application prepared for the future generation web?". This paper presents a proposal for the development of semantically described web applications, accessible with different devices. The new approaches in this work are the following:

- The proposal for an ontology for traffic data including the description of the followed process for implementation, based on the recommendations for the semantic web. At the moment there is a lack of a common vocabulary which includes semantic elements which can be selected as core and distribution point for content developers.

- The description of an architecture for the development of a semantic pervasive application. Which includes accessing the before mentioned ontology as well as the content generation depending on the specific requirements of the accessing device.

The article content is divided in sections which describe the different approaches in solving the problem: Section 2 describes the creation of the traffic ontology and it describes all considerations had during the process and the tools used for the development. Section 3 describes the architecture which includes different layers to permit the integration with the development of web portals and the interaction with different devices. Section 4 describes the prototype which was used to validate the proposal. Section 5 explains some considerations about the made testing, and finally conclusion and the definition of possible future work.

2. ONTOLOGY FOR THE HANDLING OF TRAFFIC DATA

2.1 Theoretical background

The general outline for the development of an ad hoc traffic information ontology is based on the principles defined by the W3C for the Semantic Web [1]. An ontology constitutes one of the layers of the proposed model of the Semantic Web and the details of how to implement semantic pervasive portals. In the development of a conceptual framework that allows the organization and interrelation of the information elements that constitute any information on road traffic, we can distinguish two levels:

- Structural Level, where the model of the structure resides
- Compositional Level, where the semantics of the different traffic information elements are defined, the relations between them is established, and the models, developed in such a way permitting the software agents to obtain and handle the traffic data when needed.

From the definition of these levels comes the semantic modelling of data sources, which later will be processed through software systems. Next the conceptual and technological requirements are described, which must fulfill the representation scheme and the software to provide intelligent services.

2.2 Development of the Ontology

The information and the related knowledge of the motorway traffic refer to certain concepts: Traffic state, restriction routes, weather etc. These concepts, their properties and their relations help to specify the different terms. In order to elaborate these vocabularies, a study of the different traffic sources have been made: Road Administrations Web sites, Traffic database models, accident information, general management plans, regulations, traffic simulator files etc. This data has allowed us to define the concepts and relations for each sub-domain. In order to approach the problem of development of the highway traffic ontology, the definition of related sub-domains have been considered. The included sub-domains are: Road classification, Vehicle classification, Accident Rate, Geography and Traffic modeling.

2.3 Stages in the development of a traffic ontology

At the moment the specific domain and scope of the ontology are determined, you have to determine the usage and the questions of interest which the ontology must be capable to answer, and who is going to use and maintain it. In every logical sub-domain we have to follow the necessary steps which have become the methodological standard [5,7]. The previous comments, led to a further study on the different mark up languages for the semantic web, and the tools used for its edition and treatment [2,3,7,10].

2.4 Implementation of the Ontology

2.4.1 Characteristics of the concepts and terms

Different data sources were used to create our ontology. For example, for the classification of routes mainly the "General Regulation of Highways" was used. It is a classification of routes and their elements. Also the Spanish Real Decree 1231/03 of 26 September of 2003 was used. It defines the nomenclature and the catalogue of the Spanish highways. Analyzing these sources we realized that we could establish a taxonomy of the different elements that constitute the ontology.

2.4.2 Specifying Hierarchies of classes

For the definition of classes we distinguished between primitive concepts or complete definitions of classes. In order to handle primitive concepts the information must be provided using restrictions. If we are dealing with defined concepts, we will have to ask if the information that we want to add is relevant for the definition, otherwise this information will be created using axioms and not by means of the use of restrictions. Due to the great computational cost that supposes the defined classes, we have considered most of the concepts as primitive and only in some cases a complete definition has been specified [6]. In Figure 1 we can see a partial view of the hierarchy of classes elaborated for the sub-domain Roads:

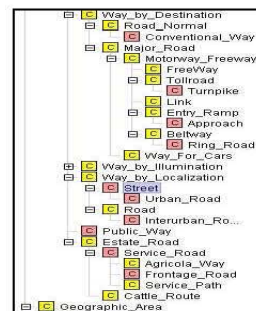


Figure 1. Partial view of the hierarchy of classes for the sub-domain "Road classification".

2.4.3 Inclusion of axioms

By means of the use of axioms we can distinguish in our ontology certain types of concepts: "Independent" or "significant" concepts by themselves (independent concepts), and the "refining" or

“modifiers” concepts”. [6]. In the development of our ontology, independent concepts with primitive subclasses have been used. We also use individual concepts to describe some classes by means of restrictions on properties whose rank will be only able to belong to an enumerated set of values. Our Knowledge Base has been expressed by means of Description Logic [4].

3. ARCHITECTURE FOR THE DEVELOPMENT OF A SEMANTIC PERVASIVE PORTAL

3.1 Concepts related to the modelling of the device context

3.1.1 Delivery Context [8]

A general solution for addressing the problem related with device heterogeneity, is that the client encode its delivery context.

Delivery context includes the device's capabilities, the user's preferences, the network characteristics, etc. - in such a way that a server can use the context to customize content for the device and user.

3.1.2 Composite Capabilities/Preference Profile (CC/PP) and User Agent Profile (UAProf) [9]

CC/PP is a specific data format for expressing delivery context information. For the adaptation of content and presentation to be effective, there has to be a way to describe both the content of a document and how to match it with characteristics of the device. CCPP provides the equivalent of database fields and associated model for formalizing the device profiles. The protocol is a particular application of RDF metadata and is based on a description of the capacities of the devices and the known user preferences like the user agent profile. Different devices and user agents may refer to the same schema and support the same vocabulary but communicate different profiles to the origin servers. Vocabularies that conform to CC/PP have to be created as an RDF Schema. On the other hand the Open Mobile Alliance has defined the UAProf - a framework based on CC/PP that includes a vocabulary to describe capacities of the device, capacities of the user-agent, network characteristics, etc., as well as a protocol to transport a profile. For the development of the semantic pervasive portal we used three layers as described in figure 2.

In this architecture some fundamental components are present:

- **Semantic Components:** This layer contains the semantic description corresponding to an ontology associated with the data.
- **Context Components:** This layer contains the context treatment, which up to this point was focussed on the device context, which actually extends to other context elements.
- **Data Components:** This layer includes the data repository, which is represented by means of XML documents. In the case of an existing database system a representation in XML would be needed for the later treatment by means of transformations that allow content to be generated in a required markup language.

- **Logic Components:** In this layer, the connection between the data and the presentation layers takes place, this can be developed using diverse technologies. As a consequence of this, the proposed architecture does not depend on any of these technologies.

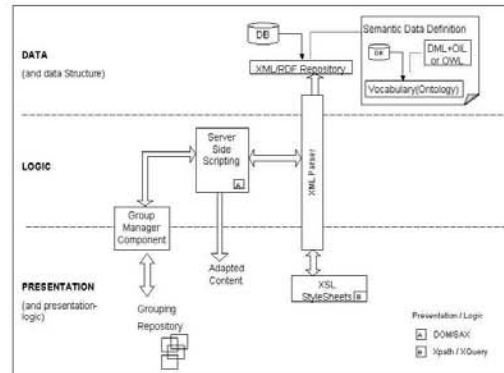


Figure 2. Architecture for semantic modelling of pervasive portals.

- **Presentation Components:** This layer contains the stylesheets with the format associated to the different groups of devices determined in the analysis phase, as well as the description of the properties of the different groups

4. IMPLEMENTATION: PROTOTYPE OF A PERVASIVE APPLICATION BASED ON SEMANTIC INFORMATION

The prototype has been based on the generation of content of traffic incidents for several types of devices. The graphic user interface can be seen in Figure 3. They correspond to the selection of provinces with the purpose of visualizing the existing incidences in a selected province.



Figure 3. WAP 2.0 mobile phone Interface of the semantic pervasive prototype.

The implementation in the different layers includes:

- Data Components: XML file that is updated each 5 minutes.
- Semantic Components: Traffic ontology. The existence of this layer facilitates enabling the interaction of other applications with the data handled by this application, avoiding translation tasks of content to semantic descriptions.
- Context Components: In relation to the context of the device, a repository of profiles (legacidevices.xml) has been used. This repository is included with the distribution of the Java API DELI (Delivery Context Library). This API allows the definition and access to groups of devices and is based on the UAProf vocabulary and CC/PP.
- Presentation Components: These components include the different style sheets containing the associated presentation formats corresponding to each one of the groups of devices.
- Logic Components: They include scripts developed in Java Servlet Pages that are used to obtain the interaction with the data and the style sheets from XSLT transformations. Additionally DELI and JENA libraries for the device context processing and the ontologies are used.

5. TEST-BED

Diverse tests of migration were performed, using different environments, such as Solaris and Windows, with the purpose of verifying the viability of the application running on other platforms. It was verified that - except for some minimal configuration modifications, the developed system could be ported without problems. From the tests made it was verified that the solution established in this work was used as basis for the development of a ubiquitous web application of traffic incident information. This application is based on dynamic and multilingual interaction and its performance has been tested both with emulators, mobile phones, PDAs and conventional telephones based on voice applications. The above-mentioned proposals are characterised by the independence of server platforms and commercial technologies, which facilitates its use in different projects. It is possible to have real-time access to the information of traffic incidences classified by regions as well as by highways. The information is presented in five languages: English, French, German, Italian, Portuguese and Spanish, and the interface has been generated keeping in mind the style guides provided by the Spanish mobile telephone operators. With this application it has been possible to prove that the approach and guidelines included in the general framework of this work have been of use in real cases, which constitute a type I+D+I work.

6. CONCLUSIONS

The proposal described in this article describes the way in which it has been possible to integrate the development of a traffic information ontology with the development of a pervasive web, interacting semantically with the described information. We described the use and development of this ontology to make automatic data processing that allows handling distributed and

heterogeneous information. Taking specific traffic information, a conceptual and methodological tool is available that allows producing a representation in the form knowledge base that could be operated by different software applications to provide intelligent services. In addition, we described an architecture that serves as a guide for the development of contents based on semantic Web which can be accessed from different device types. From the presented architecture we can implement applications that deal with semantic descriptions of the information using the ontology, as well as a model for the treatment of the context associated with the accessing device. Finally, it was possible to verify how - from the development of pervasive web applications based on this approach - it is possible to obtain interaction with external applications that require detection of the semantics associated with the data for their processing.

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