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Towards Accessible Semantic Web Applications

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Abstract:

The importance for Web applications to reach all kind of potential users and customers is being stressed by companies and public sectors. The standardization initiative for Web applications, WAI and the Universal Design framework establish useful rules for building accessible applications for any kind of disabled and non-disabled users. The proliferation of Semantic Web technologies and formal ontologies offer a technological opportunity for establishing automatic and advanced methods for accessible Web applications. In this work we introduce a method for publishing Semantic Web content that establishes separated stages for content selection and its presentation, through Semantic Portal. We are applying some of those principles to a portal devoted to international affairs.

Keywords:

Universal Design, Accessibility, Semantic Web, Ontology, WAI.

1. Introduction

The rapid development of information technologies is changing the way service providers interact with their customers and users. The commercial effort is focused on mainstream customers leaving disabled people out of their target. Old people, sensorial disabled, digital illiterates or people in adverse conditions are being excluded from some services such as educational, job search and leisure applications. The so called, digital divide, excludes users that have problems of accessing information services. The parameters for the disability degree calculus vary from one country to other, but in all of them the disabled population is considerable (9% in Spain (1)). In the section 2 we introduce the accessibility requirements and the universal design paradigm concepts for building applications that would not leave potential users out of their target.

On the other hand the initiative of the Semantic Web offers an opportunity for standardization of Web content and to establish automatic procedures for offering accessible services for all kind of users. Even if the main goal of the Semantic Web is to establish a network, comparable to the current WWW, but oriented to applications or software agents, the very final user remains human. As we will explain in the section 3, the usage of formal underlying models, called ontologies, establishes a good chance for performing inclusive design on a low cost base.

The potential success and the increasing number of Semantic Web applications takes us to propose methods for offering accessible applications taking advantage of the existence of semantic models. In the section 4 we focus on the creation of Semantic Portals and we propose an automatic method for ontology publications in an accessible way.

2. Accessibility and Universal Design

Accessibility means granting flexibility for user requirements taking into account his/her limitations. Its goal is to avoid designing software targeting only a certain users' groups, imposing barrier from the very beginning.

Accessibility and usability are concepts that both have to be incorporated in the design phase of any software development process. The definition of usability taken from ISO/IEC 9126 claims "Usability refers to the capacity of software to be understood, learnt, and used as well as to seem attractive for the user, in a specific usage condition". This definition is focused on the quality and efficiency of its use but it does not guarantee the accessibility of the application. An application might be usable and still not accessible and vice versa. The overall aim is to have accessible

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application usable for any kind of users.

2.1. Universal Design

The Universal design paradigm consists on designing products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design (2). There are two main approaches on how to reach it. On the one hand Conell supports the idea of a unique design for all kind of users. On the other hand there are also experts that do not believe in having a single design for disabled and non-disabled users. Nielsen (4), (5) focused on Web applications, does not support that universal design would avoid accessibility barriers. He promotes the idea of adaptating dynamically application interfaces according to user needs and features. The multiplatform, multilingual and dynamic application described in (6) proves the feasibility of this approach. Stephanidis (7) refines the idea of 'Universal Design' into a new design 'philosophy' covering as much users as possible.

The term of 'Universal Design' needs to be interpreted in terms of the effort spent in the design phase of any project trying to achieve the largest accessibility as possible, and not as a constraint of having only one single final design.

2.2. Normalization and WAI Standards

The lack of standards on accessibility makes difficult the proliferation of products and applications that would include disabled people, causing in some cases non-desirable market segmentations. There exists a W3C (20) standardization initiative for Web applications called WAI (Web Accessibility Initiative) (21). WAI defines 14 rules indicating how to make Web content accessible as well as guidelines on how to promote expert and discussion groups for new tools and solutions development.

Users with different types of disability may access the Web in different ways and face several barriers in the information access (browsers, multimedia devices, screen readers, speech recognition, etc.). The purpose of WAI rules is to reduce those barriers allowing full access of disabled users to information and services on the Web. The most important challenge when making an accessible site is to understand that the information and services will be accessed in many different ways from any kind of device and software.

Each rule defined in the WAI specification has a list of checkpoints that describe in detail how to apply it to a specific Web content. There are three possible levels of achieving accessibility according to checkpoint application. The application of these rules does not (ideally) mean the loss of usability and creativity.

2.3. Methodological Framework for Universal Design

Universal Design is the methodological framework used for building accessible Web sites. Inclusive Design is derived from User Centred Design (UCD) that incorporates the active participation of the disabled user in the design process. Newell and Gregor (3) have proposed an extension for this framework called "User Sensitive Inclusive Design" that includes users with special needs as well as application experts. Universal design tries to cover all kind of users, far beyond the average user. It guaranties the accessibility for a wide range of disabled users and at the same time it improves the usability for any other kind of non-disable users.

There is a close relation between this methodology and Human Computer Interaction (HCI) area due to the need for the analysis of the user interaction protocols. Technological advances within the HCI area, such as multimodal interfaces, speech recognition, voice synthesis, image processing, adaptive interfaces, augmented reality, semantic web and natural language processing allows for valuable contribution towards accessible applications.

3. Semantic Web

The emerging paradigm of the Semantic Web offers a great opportunity for advanced application development based on a common, formal and shared formalism, called ontologies. The existence of domain ontologies gives us an opportunity to construct highly reusable knowledge bases.

An ontology is a shared and common understanding of some domain that can be communicated across people and computers (12), (13), (10) and (14). Ontologies can therefore be shared and reused among different applications (11). An ontology can be defined as a formal, explicit specification of a shared conceptualization (12), (10). "Conceptualization" refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon. "Explicit" means that the type of concepts used, and the constraints on their use are clear and fully expressed. "Formal" refers to the fact that the ontology should be machine-readable. "Shared" reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group. An ontology describes the subject matter using the notions of concepts, instances, relations, functions, and axioms. Concepts in the ontology are organized in taxonomies

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through which inheritance mechanisms can be applied. It is our experience that especially the social part for building a commonly agreed ontology is not easy (9).

The huge amount of information present on the current Web has boosted the appearance of new business models such as search engines and web portals. While search engines help users to find the desired content, web portals aggregate similar information in a user-friendly way. The proliferation of horizontal portals (i.e. generic purpose content, as opposite to vertical, domain specific, portals) has induced the standardization process for content specification.

Several tools for portal and web site developers have appeared on the market allowing quick setup of common online content. Nowadays, it is a matter of a few mouse clicks to publish a personal web site on the Net. Also for bigger projects such as corporate intranets or business web sites the effort needed is not so big, since the common content is not built from scratch. Parts of web sites, such as news headers, product or personal descriptions, login boxes, etc. are predefined and easily inserted into the final portal layout.

There exist several initiatives to model the standard portal content. These approaches are usually based on functional software pieces, sometimes called Portlets for java portals, Web Parts for Microsoft Technology, etc. These pieces allow including basic functional parts into the web portal configuring their behaviour and layout. While most popular approaches for content reuse are software based, there are some standardization efforts on a conceptual level. One of them is Web Modelling Language (8) based on explicit formalization for common content. WebML describes a Web application using several orthogonal dimensions, including: structure model, composition and navigation model, and operation model.

The upcoming next-generation web, the Semantic Web, has changed the purpose of the online content. Using ontologies we are now able to express also the meaning of the content we are going to publish. The method we propose here establishes an automatic publishing method that uses the semantic information for producing an accessible semantic web portal.

4. Accessible Semantic Web Applications

The evolution of web portals has reached a stage where it is possible to identify canonical content that constitutes typical portals. Examples of typical content include information about the organization, product descriptions, white papers, some personal information, news headlines, contact information, chats, etc. The Semantic Web approach, through the use of ontologies, provides several advantages for web portals. Firstly, ontologies are good candidates to formally represent the content of the portal such that software agents, when they access the portal, are able to automatically extract the information. Secondly, ontologies are interesting instruments to capture reusable information. That is, the classes of the ontology define and represent the generic information, while the instances represent the particular content of the portal at hand. Semantic portals allow for rich navigation and search (15). After all, all relevant concepts and relations are explicitly modelled. Moreover, export and import of external content becomes feasible through the notion of ontology import and export.

Although Semantic Portals are a step forward in the sense that their content is machine readable, most existing semantic portals have decreased their human readability. This is due to the fact that current approaches try to visualize the content of the ontology as it is, meaning that navigation has to strictly follow the ontological structure, and if not, the deviation from the ontological structure is hard coded in the user interface (e.g. JSPs or ASPs). In our approach, we introduce the notion of visualization ontology to decouple the ontology structure from its visualization (including navigation). The visualization ontology allows us to separate what we see from how we see it. Moreover, it supports the suppression of content represented in the ontology.

4.1 Accessible Visualization Ontologies

There is a need to differentiate between what is going to be modelled from how it is going to be visualized. That is why we introduce the concept of Visualization Ontology. This ontology, a publication schema, allows organizing the concepts and attributes to be published in the portal.

The visualization ontology represents publication concepts as they should appear in the portal. Those concepts define both, what domain information is going to be published (data grouping, possible content suppression, content relations) and how is this content going to be published (style, size, label language, etc.) It does not duplicate the content of the original domain ontology, but links the content to publication entities using an ontology query language. In this way, an ontology that represents a particular domain can be visualized through different views.

4.2 Publishing the Ontology about International Affairs

Based on interviews with experts of the Elcano Institute, we used the CIA word factbook (www.cia.gov/cia/publications/factbook/) as the basis

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Figure 1: Semantic Portal for International Affairs: Text based visual output for limited screen size

for the ontology of International Affairs. The CIA fact book is a large online repository with actual information on most countries of the world, along with relevant information in the fields of geography, politics, society, economics, etc.

We have used the competency questions approach (17) to determine the scope and granularity of the domain ontology. Some examples of competency questions that we considered include:

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What countries are participating on Iraq campaign?
Who is the head of the state of France?
What government type has Georgia?
How big is the population of Iceland?
Which are all European Union member countries?
Which are all agreements between Spain and Brazil subscribed during Da Silva's govern?
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An important design decision we took (based on (19)) was that relationships among concepts are modelled as first class objects. This decision was taken because often the relationships themselves have attributes that cannot be modelled by its involving concepts. Take for example, the relationship "in_favour_of" between an agent (person, nation, government) and an event (war, boycott, treaty). This relationship is qualified by a start and end date, which is not meaningful to agent nor event.

The ontology consists of several top level classes, some of which are:

- **Place**: Concept representing geographical places such as countries, cities, buildings, etc.
- **Agent**: Concept taken form WordNet (18) representing entities that can execute actions modifying the domain (e.g.: Persons, Organizations, etc.)

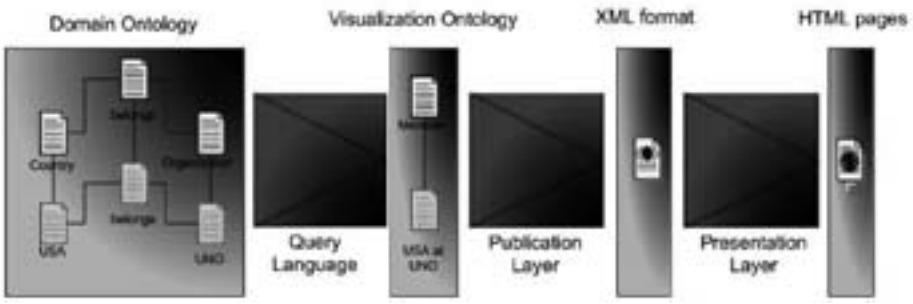

Figure 2: Visualization Ontology Conceptual Model

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- **Events**: Time expressions and events
- **Relations**: Common class for any kind of relationships between concepts.

The ontology has been constructed in Protégé 2000 (16). Figure 1 shows a fragment of the Semantic Portal.

The main purpose of building ontologies is to provide semantic content for intelligent systems. The knowledge models are designed to offer the appropriate information to be exploited by the software. No visualization criteria are used to build an ontology and often the information is not suitable to be published as it is:

Concepts may have too many attributes

When relationships are represented as independent concepts (first class objects) the navigation becomes tedious

Concepts to be shown do not always correspond to modelled ones.

Therefore, we felt a need for explicit visualization rules that allow the creation of views on the International Relations ontology, in order to visualize only the relevant information in a user friendly way. We introduced the concept of "visualization ontology" (Figure 2), which makes explicit all visualization rules and allows an easy interface management. This ontology will contain concepts and instances (publication entities) as seen on the interface by the end user, and it will retrieve the attribute values from the International Relations ontology using a query. It does not duplicate the content of the original ontology, but links the content to publication entities using an ontology query language. This way one ontology that represents a particular domain can be visualized through different views.

The visualization ontology (Figure 5) has two predefined concepts:

Publication entity: Concept that encapsulates objects as they will be published in the portal. Any concept defined in the visualization ontology will inherit from it and should define these attributes

- XSL style-sheet associated to the concept that translates its instances to final format (HTML, WAP, VoiceXML, etc.)
- Query that retrieves all attribute values from the original ontology.

Publication Slot: Each attribute that is going to appear on the web should inherit from this concept. Different facets describe how the attribute will appear on the page.

- Web label: The label that will appear with the value
- RDQL: reference to the query used to retrieve the attribute value
- Link: When the published value should perform some action on mouse click (link, email, button, etc...), the action is described here.

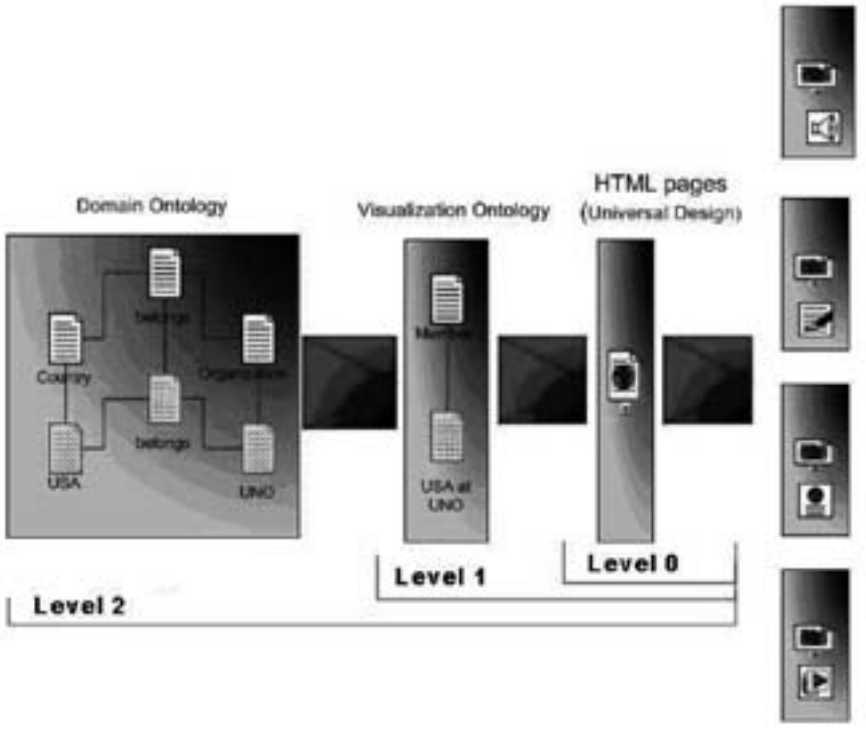

Figure 3: Accessibility through visualization rules in three levels

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Portal elements are described as children of the Publication Entity and their instances are defined according to the languages the entity will be published in (labels in English, Spanish, etc.), or the channel (whether the transformation style-sheet is going to translate into HTML, WAP, or just XML

4.3 Visualization Rules

We introduce accessible visualization rules that work on three levels (Figure 3). We assume that the final accessibility of shown information or service depends on three basic parameters. On the one hand, the most common accessibility parameter is the final look and feel of the application. This level (Level 0 or esthetical level in this paper) determines how the selected items are going to look for the final user. The second parameter (Level 1 or selection level, in this paper) determines what data or services are going to be shown to the final user. This level, commonly treated in multi-channel applications, where several final devices are considered (computer, PDA, phone, etc.), controls what data is shown in the users' interface. The last parameter (Level 2 or semantic level, in this paper) controls the nature and the meaning of the application data. This level takes into account the domain ontology where the meaning of each data is expressed in a formal way.

- **Level 0: Accessibility using style sheets (XSL):** Selected data or service is adapted for a proper look and feel using XSL style sheets. Features such as contrast, layout position, font size or type can be expressed here. The fact of having different XSL sheets according to the accessibility requirements fits the paradigm of universal design, since it allows a structured and transparent way of reaching users needs, without the need of having several complete designs for each accessibility profile.

Rule	Level	Action
Provide equivalent alternatives to auditory and visual content	Level 2	For each multimedia content type (domain ontology) there is an alternative description (in the visualization ontology)
Don't rely on colour alone	Level 0	XSL using alternatives for colour
Use mark-up and style sheets and do so properly	Level 0	XSL
Clarify natural language usage	Level 1	Each publication entity has 'lang' and 'title' properties
Create tables that transform gracefully	Level 0	XSL design
Ensure that pages featuring new technologies transform gracefully	Level 0	XSL produces self-content HTML output
Ensure user control of time-sensitive content changes	Level 0	XSL produces proper HTML output
Ensure direct accessibility of embedded user interfaces	Level 0	XSL produces proper HTML output
Design for device-independence	Level 0	XSL produces device dependent output
Use interim solutions.	Level 0	XSL produces proper HTML output
Use W3C technologies and guidelines	Level 0	XSL produces device dependent output (avoid using flash, PDF, etc. where possible)
Provide context and orientation information	Level 2	Thanks to domain ontology relations and context can be provided
Provide clear navigation mechanisms	Level 1	Visualization ontology defines the navigation map of the semantic portal
Ensure that documents are clear and simple	Level 0	XSL produces proper HTML output

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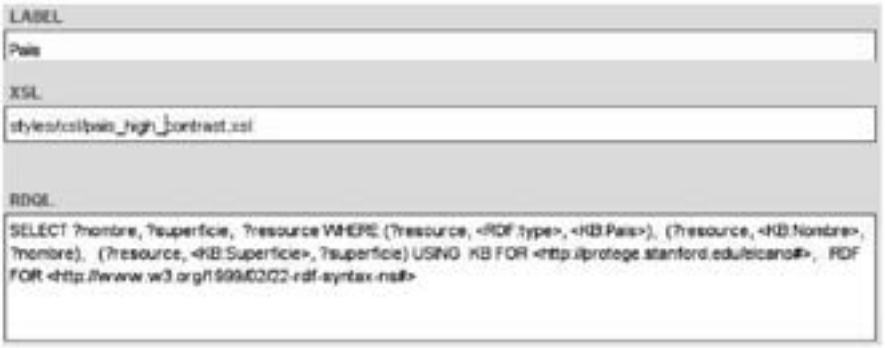

Figure 4: XSL definition for publication entity

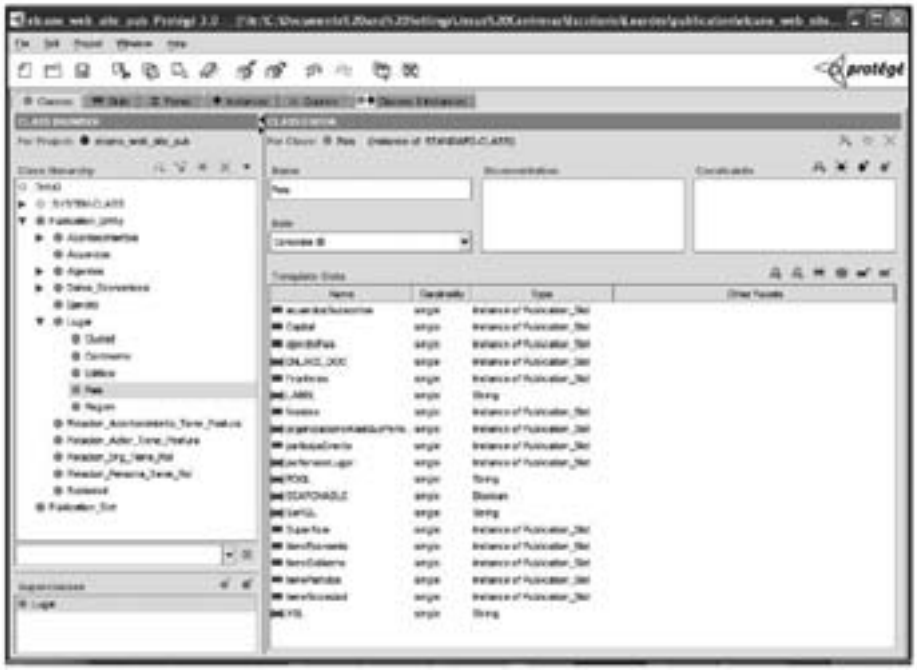

Figure 5: Visualization ontology definition using Protégé.

- **Level 1: Accessibility through visualization ontology**: The visualization ontology determines which data are going to be visualized and how to group them. In many applications this step is codified using programming logic where any change to fit accessibility requirements is very expensive since it requires reprogramming of application parts. Using the visualization ontology we can easily define publication entities where accessibility criteria are taken into account.
- **Level 2**: **Accessibility based on semantics:** The availability of underlying domain ontology allows for using the data meaning in defining accessibility rules. Each data or service that is going to be published has associated a formal and explicit description using the domain ontology. This information is valuable for automatic publishing with accessibility criteria.

Figure 6: Publication slot for national anthem as an audio element.

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There are 14 WAI rules for Web content. Most of them refer to general guidelines for Web pages' look and feel that can be solved using XSL HTML production at level 0 as is given below. For instance, at level 0, we can define that some publication entities require high contrast XSL style sheets according to the user profile (Figure 4).

At level 1, we define which data are going to be shown. We establish publication entities that retrieve data from the domain ontology and establish the navigation. The usage of explicit ontology for visualization purposes allows for extracting the publication logic from the application program and for easy adaptation and parameterization without the need for reprogramming.

The existence of the domain ontology allows for establishing basic data types for accessible publishing. We consider five basic types for Web applications: text, audio, video, image and video+audio. For instance a flash introduction would be classified as a video or video+audio. In Figure 6 we show there is a definition for the publication slot of the national anthem.

5. Conclusions

In this work we have established an automatic method for publishing ontologies through semantic portals in an accessible way. Unlike traditional Web applications, the semantic portal uses the concept of visualization ontology that separates the publishing logic from the business login of the portal. Thanks to this we can apply accessibility guidelines according to W3C WAI specifications and aligned within the Universal Design paradigm in order to obtain accessible web portals on low cost and automatic bases. The test performed on the Semantic Portal for International Affairs constitutes a first step for deploying a complete software platform for building accessible Web Applications using Semantic Web technology.

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