Web Authoring for Accessibility (WAfA)

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Abstract

Conventional thought from the Semantic Web community equates the use of ontologies with the representation of the meaning of content. Here, we skew this viewpoint by describing our ontology, Web Authoring for Accessibility (WAfA), which investigates the way ontologies can describe the semantic structure of documents. By understanding the way heterogeneous XHTML (Extensible Hypertext Mark-up Language) documents are structured we can better transform documents, currently inaccessible to visually impaired users. WAfA performs two tasks: (1) it allows us to flexibly model an XHTML document within the context of navigation and orientation through the Web resource; (2) it enables non-expert users to quickly annotate a Web document by providing a 'lingua franca' between author and Web Accessibility Domain Experts. Here we describe our ontology, its use, novelty, and importance.

Keywords: Web accessibility; Ontologies; XHTML; Semantics of document structures

1. Introduction

Access to, and movement around, complex hypermedia environments, of which the Web is the most popular example, has long been considered an important and major issue in the Web design and usability field. Navigation and orientation in such an environment requires a knowledge and an understanding of the visual objects encountered along with their properties and purpose. This understanding is not problematic when the user is sighted because any visual cues, or metaphors, presented to a user dovetail into their tacit understanding of the visual world. However, semantic annotation of Web document structure can provide a mechanism to enhance visually impaired peoples' access to information on the Web through an encoding of the meaning of that information [1]. Annotations can then be consumed by tools that restructure or reorganise documents in order to pull out salient information (for example, via some triage process [2]). The visual design of a Web page provides knowledge used by Web surfers to move around. Implicit to sighted users, this knowledge must be made explicit to visually impaired users. Our system, DANTE,[1] uses a conjugation of semantic technologies for doing just this. WAfA is key to realising DANTE as it aims to capture knowledge about that Web document in a manner that enables computational support for humans and technologies that cannot see the visual design. Here we investigate WAfA, an OWL DL ontology, of interest to Web page authors, designers, and visually impaired users, which describes: structure, structural abstraction, meta-knowledge, spatial knowledge and functionality. It was developed after consultation with the Web accessibility community including practitioners and users, but not as part of a specific community development. Designed with more than Web accessibility in mind it has been used by other groups[2] focusing on software engineering practice and content management.

2. Novelty and importance

Our main aim is to improve the mobility of visually impaired users around the Web and this was the reason for creating the WAfA ontology. Although the existing work to promote Web accessibility is good [3], it lacks an understanding of how visu-

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ally impaired people move around Web pages; what kinds of objects they need or use, and what kind of spatial environment is easier for them to journey through. Our previous work aimed to provide just such an understanding and knowledge [1]. Here, we draw parallels between travelling and movement in the physical and virtual environment [4]. Travellers use or may need to use environmental features or elements in order to make a successful journey. We call these features and elements *travel objects*. For instance, they use landmarks and memory objects to reassure themselves that they are safe to proceed and going the right way. If we look at the Web landscape from the *travel* perspective these objects also exist on the Web pages. For example the logo found on many Websites can be considered as a unique and memorable feature of that environment. These kinds of objects are considered as landmarks or reference points. They play an important role in acquiring spatial knowledge and provide users with information on where they are in a page, just as unique features aid navigation in physical environments. However, in audio rendering of Web pages, these objects cannot play their full roles. User agents do not treat them in a special and appropriate form, so their role in supporting travel is diminished [5]. They need to be presented in a way that they can fulfil their intended roles and support movement around the Web. In this case, the meaning of the structure plays a central role, and is represented using formal descriptions to conform to Web standards. Our structural information is processed to derive explicit structures, indeed, this semantic information processing plays a central role in our system as it gives us:

(1) *Manipulation accuracy*.
Current transformation techniques rely on creating best-fit semi-accurate templates to assist in transcoding.[3] These are not accurate and so an annotation based system to accurately tag visual areas is a logical extension. WAfA, provides the taxonomy to allow this accurate and uniform tagging.

(2) *Formalised concept checking*.
By adding additional ontological components onto our initial taxonomy we can enforce a strict logic. Indeed, meta-knowledge provides certain principles regarding the overall model, for instance, by enforcing *Disjoint* (*Header*, *Footer*) we can check for annotation accuracy such that a footer and header cannot be the same thing.

(3) *A common interface*.
By providing an interface for annotation (DANTE) we can assist the real process of the designer in annotating multiple pages. But by using our ontology we can enhance this interface while enabling modifications of the annotation terminology to take account of new knowledge discovery.

(4) *It enables non-domain experts to interact with DANTE*.
WAfA is a multidomain ontology, in that a number of authoring concepts from different domains are available. These range from hypertext and hypermedia, through typographical layout, to common Web design, and finally to digital libraries. These separate domains all map to the technological interface; the mobility model. This de-coupling means that the ontology can be extended based on the requirements of other specific domain terminology.

(5) *Provides generic tools for semantic creation*.
Our ontology can be used to annotate Web pages using different terminology for different purpose. While our work is focused on accessibility, third parties can annotate pages and take advantage of all the other points here, but transcode for a different purpose.

(6) *Freedom of manipulation* (*most importantly*).
Hinted at in point (4 and 5), because the transformation logic is separated from the annotation mechanism many different tools can make use of the WAfA ontology. This is a pragmatic point, in that we suspect the number of users who wish to annotate for Web accessibility is limited. However, those who may wish to use this ontology to annotate for other domains (such as the mobile Web) will be large. In this case we would be able to use these WAfA annotations for our domain, and they would be able to use our annotations for there's.

These six points are particularly important when trying to understand open-world, heterogeneous, real world Web documents, all from diverse sources without a commonality of ownership. In our case semantic technology plays a central role in achieving interesting new levels of functionality or performance and led us to the creation of the WAfA ontology.

3. The WAfA ontology

The WAfA ontology is an evolving ontology for the Web community, similar to DOLCE [6]. It is a foundational model of Web pages and is concerned with the representation of concepts and relationships necessary for the modelling of the structural and navigational organisation of Web pages into a computable form. We regard this model as foundational for two reasons: (1) the structural concepts and relationships are focused on providing basic components of Web pages and their relationships rather than addressing a specific type of Web page; (2) the concepts refer to vocabularies used in a number of domain such as hypermedia design, transcoding literature [7], mark-up languages, and content management systems, and are generalised to all these domains [8]. WAfA ontology is used as the controlled vocabulary to drive page transformations. Fundamentally, the ontology is a conjugation of three sub-ontologies (see Table 1):(1) authoring semantics, see Section 3.1; (2) mobility semantics, see Section 3.2 and (3) contextual semantics, see Section 3.3. We do not intent to explain all of the concepts within the ontology here, full details can be found within the complete ontology,[4] and a description of early work on the ontology can also be found in Ref. [9]. However, it is useful to remember that WAfA is an ontology as opposed to a simple taxonomy, XML schema or data-model because it makes use of a number

[3] Transcoding is the process of transforming the representation of the content into another format.

[4] See http://www.schemaweb.info/schema/SchemaDetails.aspx?id=275.

Table 1
The overview of the WAfA ontology

Part of the ontology	Concept (children of . . .)	Example children	Total children
	`Object`		
(1) Authoring semantics	`AuthoringConcept`		
	`Atom`	`Caption`, `Advertisement`, `Logo`, `Headline`, `Footnote`, `Label`, etc.	43
	`Chunk`	`Header`, `LinkMenu`, `Section`, `Abstract`, `SiteMap`, `Sidebar`, etc.	42
	`Node`	Represent a Web page (or parts of a Webpage)	0
	`Collection`	Represent a Web site (or collection of nodes)	0
(2) Mobility semantics	`MobilityConcept`		
	`EnvironmentalRole`	`WayPoint`, `TravelAssistant`, etc.	14
	`JourneyRole`	`Obstacle`, `Cue`, `OutOfView`, etc.	7
(3) Context semantics	`Purpose`	`ObjectPurpose`, `TravellerPurpose`	14
	`Connection`	`AssociativeConnection`, `ReferentialConnection`, etc.	3
	`Coverage`	`Inter`, `Intra`, etc.	3
	`Position`	`AssociativePoint`, `CurrentPoint`	2
	`Order`	`AlphabeticalOrder`, `TemporalOrder`, `SpatialOrder`	5
	`Structure`	`Hierarchy`, `Linear`, `Matrix`, etc.	4

of ontology specific components such as: inverse property and relations; transitive and explicitly non-transitive properties[5]; and distinct is-a and part-of relationships; these additional properties and restrictions can be viewed online but enable annotations to be machine validated removing the expert knowledge normally required of the user.

3.1. Authoring semantics for conceptual structuring

These are primarily intended to be used by authors and designers in the annotation process. They encode information about hypermedia concepts, vocabularies used in previous work on transcoding, mark-up languages, and content management systems encapsulate information about how the objects are *structured* in Web pages to form the overall structure of the page. The concepts in this part of the ontology are subsumed by the concept `AuthoringConcept`. Additionally, the concepts subsumed by `Connection`, `Coverage`, `Position`, `Order` and `Structure` are used to define the `AuthoringConcept`. It aims to formalise the common understanding of a Web page structure. It defines a vocabulary that is already widely used within the Web community to describe components of Web pages which is not formally explained and defined. When we analyse XHTML source code, apart from the XHTML elements, designers encapsulate tacit knowledge about the meaning of the structure in their source code. Particularly, comments, class and id attributes, and file names provide a wealth of information regarding the structure. However, such knowledge is implicit and is not provided in a *controlled* way so that user agents can access and understand it [10]. Therefore, besides the research literature, we have analysed numerous webpages[6] to identify a common vocabulary used by designers. The high level concepts of this part of the ontology, which are considered as basic units of overall structural organisation, are as follows:

- *Atom*: A coherent object that cannot be logically decomposed. Physically we might be able to divide the object but the divided parts cannot be coherent and presented on their own (e.g., `Link`, `Caption`, `Footnote`, `Logo`, `Advertisement`, etc.). For example, an advertisement can be a composition of several images, but in fact they all represent only one advertisement.
- *Chunk*: Several objects grouped together to form a coherent unit (e.g., `Header`, `Footer`, `Section`, `Abstract`, `LinkMenu`, `SiteMap`, etc.). *Chunking* is a quite natural way of presenting information and such units are important to preserve the content integrality and ease the use and recall of information. In the literature, they are also referred as fragments, semantic textual units, block, unit or nodes.
- *Node*: A composition of atom(s) and chunk(s) to form a meaningful group which we use to represent a Web page.
- *Collection*: A collection of nodes, meant to represent a Web site. As well as capturing the ordering and grouping of constituent elements of the body of a Web page these higher level elements have a fundamental purpose in assisting the author or designer. In some cases it is not possible for a user to identify exactly what an object on the page is. In this case the author can select a more generic concept and although the full power of the agent cannot be realised (because we do not have an accurate description) a limited transcoding solution is possible.

3.2. Mobility semantics for navigational structuring

These are mainly used by tools and user agents which enable authoring terminology to be processed by mobility focused agents. They encapsulate a knowledge about the travel objects from real world mobility studies. This part of the ontology focuses on how the objects are typically *used*. Objects can have a journey role which depends on the context of the journey being

[5] We also need to create restrictions about the direct parts of certain kinds of objects; therefore, we introduced is-direct-part-of property which is a subproperty of the is-part-of and is not transitive.

[6] For example: Amazon, BBC, CNN, IMDB, and the like.

undertaken and can also have one or more environmental roles. Based on the model of travel, this part of the ontology holds information about the *travel objects*. Objects might have a specific role in an environment, referred as `EnvironmentRole`, and based on the context, they might have another journey role, referred as `JourneyRole` in the ontology. Depending on the context of the journey being undertaken an object can be either `Obstacle` or `Cue`. An `Obstacle` is an object that directly or indirectly obstructs the progress of a traveller to a specific destination and a `Cue` is an object that orientates and encourages onward navigation. The journey role is context dependent, for example a graphic site map could be a cue to a sighted user but it could be an obstacle to a visually impaired user. These objects are mainly grouped into three broad categories as follows:

- *Way points*: These are points within a journey at which a decision may be made that directly facilitates onward journey. Way points are also further classified and an example is `DecisionPoint` which is the point in the journey where a traveller has to choose from different possible paths (e.g., link menu).
- *Orientation points*: Knowledge about orientation suggests that a person needs information about location, distance and direction in order to be orientated in a journey and the objects that provide such information are orientation points (e.g., logo).
- *Travel assistants*: Sighted or visually impaired travellers experience problems in orienting themselves from time to time in both familiar and unfamiliar environments where they use different strategies to re-orientate themselves. The objects that they use in these strategies are grouped as travel assistants (e.g., site map). Fundamentally, a traveller navigates and orientates by consulting, detecting and identifying these travel objects. Consultation, detection and identification are accomplished through the mobility instruments of in-journey guidance, previews, probes and feedbacks.

3.3. Contextual semantics

This category is included for completeness. However, we do envisage an extension of the ontology and its use in other alternate contexts and so their inclusion is useful for extensibility. Contextual semantics can be important because a Web journey can take place in different contexts, and concepts within this group provide contextual knowledge about a journey such as the purpose of the journey being undertaken, etc. The concepts in this part of the ontology are subsumed by the `Purpose` concept. Web users have different skills, habits, motivations, intelligence, intentions and a whole host of other attributes that they bring to the computer when using the Web. It is highly possible that potential users will come from all walks of life and age groups. Obviously, these issues affect a users' experience of interacting with the Web because we do not all interact with the in the same way. Five issues are considered to be important for the journey experience: (a) the current travel purpose, (b) the user, (c) the presentation form, (d) the timelines of access and feedback, and (e) the user agent. This sub-ontology aims to address these issues, by particularly focusing on the purpose; this can range from the purpose of the traveller (information seeking, surveying, orientation, navigation, browsing, scanning, etc.) to the travel object's intended purpose; which is in fact the designer's purpose (see Table 1). One of the roles that this part of the ontology fulfils is to obtain enough knowledge regarding the purpose of a user and transform pages accordingly. For example, if the user wants to scan a page, we provide an overview of the page; if he (she) wants to orientate them-self in the environment (wants to learn where he (she) is in the environment) we provide objects that support orientational information such as a title, logo, etc. The main problem with this contextual information is that it is difficult to obtain. Typically, the traveller's purpose is not explicitly specified (or well-defined) and the traveller can engage in many different purposes as they travel through the environment.

4. Discussion and conclusions

So how is the WAfA ontology used? Consider the 'The New York Times' (NY Times) Website.[7] This page has a number of terms commonly found in many websites. In the case of the NY Times this includes classes called `story` and subclasses such as `callout`, `credit` and `summary`. Indeed, the NY Times even provides ID's for these stories giving an order such as `rank3`. For the 20 April 2006 the NY Times has a story called 'Nepal's Political Crisis Deepens' with a credit of 'Gautam Singh/Associated Press' and a summary of 'The coalition that organized the demonstrations demanded that the king restore Nepal's Parliament and relinquish control of the government.' In this case it is easy to understand the semantics (and may remind the reader of informal Dublin Core or RSS notation) and because they are logical and used in the news domain are encoded within the WAfA ontology. When the transformation logic process the page it can now formally identify these components and process them in a suitable manner. However, now consider CNN International.[8] In this case classes are called `cnnT1` and subclasses called `cnnT1Hd` and `cnnT1Blurb`. By looking at the content (`cnnT1Hd` = 'Nepal protests turn deadly' and `cnnT1Blurb` = 'Police open fire on pro-democracy activists on the outskirts of Kathmandu, killing three people and injuring at least 100 others as protests entered their third week.') and using our DANTE tool a user can annotate these pages such that CNN.`cnnT1Hd` $\subseteq$ WAfA.`callout` and CNN.`cnnT1Blurb` $\subseteq$ WAfA.`summary`. However, there are many possible valid terms used by authors, designers, journalists, and the like, that are recognisable and could be encoded within WAfA. Based on their order, sequence, and sub-class positions (derived from the 'box' structure of XHTML) within the Web document, DANTE can use WAfA to build the correct class/sub-class hierarchy from the XHTML as if it were an individual/instance. This is because after annotation each element that is tagged becomes an 'kind of' instance specific to that particular Web page. DANTE uses a common reason-

[7] http://www.nytimes.com/.
[8] http://edition.cnn.com/.

ing service, FaCT++ in this case, to decide how the authoring concepts equates to the mobility concepts. Because DANTE knows how to process these mobility concepts the transformation logic need only work on this constrained set of terms while the ontology is used to decide on exactly what mobility concept this set of authoring concepts should be classified as. We *conclude* that our work has produced an implemented and working application along with a foundational ontology and user evaluation [11]. When used by our tools, this ontology, provides visually impaired users with an accessibility advantage over and above un-transformed documents or documents processed using conventional transcoding techniques. While there are clearly limitations with our system in that each page must be annotated with WAfA concepts (taking time and effort), we suggest that this is just the kind of system, based on the conjugation of user and tool, which supports the semantic Web vision.

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