Accessibility and Model-Based Web Application Development for eLearning-Environments

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Especially eLearning and eScience technologies offer a wide range of possibilities for pedagogical concepts supporting individual demands and interests. The two deciding factors are given by its interaction capability and the ability to adapt to the user, both practically unachievable using traditional media. These two features are the key to extend the methodology of teaching scenarios as well as the support of individual learning strategies - the integration of new media into the academic education thus possesses the potential to assist in transcending the disadvantages in the education of disabled people. Based on semantic content encoding and model-based development, a broad range of accessibility features can be supported. Within the BeLearning-Project at the Berlin University of Technology, these issues are investigated.

Keywords accessibility; model-based Web application development; conceptual modeling; user-centered design

1. Introduction

Learning and eScience platforms are characterized by non-linear information structures and intensive use of graphical and interactive components. Together with the dynamic generation of content are these the properties, which lead to new presentation approaches and new forms of learning environments. Unfortunately, the resulting Web applications are often not accessible for disabled persons. On the other hand, computer-based technology allow a complete separation between content and presentation. Therefore, new media possess the potential to adapt the presentation to individual users in principle. To build accessible Web applications, one has to respect the needs from the beginning of the design process. Based on recent proposals for a model-based Web application development, we discuss the essential modeling requirements to ensure enhanced accessibility in eLearning environments for education. A number of guidelines (designed and published by the World Wide Web Consortium (W3C), the European Commission, national governments and others) have been passed during the last years to address the issue of accessibility. The majority of the suggested rules focus on easy access to (more or less static, less interactive) information portals. Often, the paradigm of a universal design for all people is assumed. However, the existing concepts do not address the implementation of highly multimedia-based interactive learning and teaching contents for disabled persons, nor are they well-suited to this task. Advanced eLearning platforms are capable to adapt the presentation to the user and they can provide him with additional information about multimedia content, navigation and presentation suited to his own needs. Therefore, the universal design approach can be replaced by a user-centered or target-group-specific design which is based on two main paradigm:

Semantic encoding: The flexibility of the separation of content and representation requires extensive semantic encoding of the complete content: supporting the underlying semantic technologies is vital to the realization of a broad accessibility of highly interactive virtual knowledge spaces and incorporating intelligent tools for the development and administration of content. Here, it is important to mention that semantic encoding may not be restricted to the content elements themselves, but has to be extended to all aspects which are highly content-related as, for example, navigation mechanisms. Semantic encoding

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means explicitly storing all relevant knowledge concerning the Web application to provide the technology of the user with the needed knowledge to present the content in a proper way. Thus the encoding is presentation-oriented.

Model-based development: Model-driven development is related to a design process where all information is available to provide the designed application with the semantic information about the used objects, their relations and meanings. Storing this knowledge in a way enabling the compiler to automatically generate all required information, model driven design processes for Web applications are a promising approach to bring together the requirements of learning environments and accessibility.

More precisely, nowadays some approaches examine the possibilities of Web application development with Model-Driven Architecture (MDA). Web applications are at first designed in a precise Conceptual Schema (CS) described with the Unified Modeling Language (UML) which afterwards can be translated by a model compiler into the corresponding application. The design of a CS is, applied to Web applications, an even bigger challenge additionally complicated by some missing features of UML to model Web-based applications. Not only is it necessary to map the structure and behavior of the whole application but also that of the intended navigation and presentation. Prototypes of model compilers are already in existence.

Within the BeLearning-Project at the Berlin University of Technology (funded by the European Social Fund ESF), model-based development is investigated to enhance the accessibility criteria of eLearning platforms.

2. Accessibility

2.1. Universal Design

Different kinds of Web applications demand different paradigms to assure accessibility. The universal design is convenient for static content whereas eLearning platforms with dynamic content generation require other paradigms for an accessible design.

The recommendations of the W3C are based on the universal design paradigm. In general the Web presentation has to present all information readable for all users. That means for all multimedia content like pictures, graphics, animations etc. a textual pendant must be available. Even the input must be independent from the input device.

So far the existing standards do not state sufficient recommendations for knowledge, learning or expert portals. They are not particularly applicable to these areas as they barely integrate the characteristics of the new media like multimediality and interactivity.

2.2. Target-Group-Specific Design

Dynamic Web applications allow to adapt the presentation to the needs of the users and additional information about multimedia content, navigation and presentation can provide him. The first paradigm based on this is a target-group-specific design which classifies the users in different groups with specific characteristics. For disabled people a useful classification should starting from functionality and not from medical diagnosis such as visually, hearing, physical and mental impaired people.

The flexibility of the separation of content and representation requires, however, extensive semantic encoding of the complete content: supporting the underlying semantic technologies is vital to the realization of a broad accessibility of highly interactive virtual knowledge spaces and incorporating intelligent tools for the development and administration of content. Here, it is important to mention that semantic encoding may not be restricted to the content elements themselves, but has to be extended to all aspects which are highly content-related as, for example, navigation mechanisms [3].

But in general it is not possible to classify disabled persons in some groups and therefore this paradigm is only an intermediate step.

2.3. User-Centered Design

Between disabled people almost everyone has his specific limitations. User centered means that the user can specify his needs particular. This is the most flexible paradigm but difficult too because estimations about the requirements of the user are hardly to made. Here the transition to usability is seamless. The changeover from a universal design to a universal presentation process cannot be made in one step. The following course of action is useful: At first forms of presentation that are accessible for all users are integrated. That means text, navigation, links etc. Second, forms which can be transformed equivalent to other presentation modes. In principle these transformations are technical problems. At last forms without a possible equivalent transformation to other modes of presentation include questions of pedagogy and higher level approaches as well as further research. In the beginning these presentation forms cannot be used for essential information but for additional support.

In general the user centered design is more capable than the universal design to fulfill the requirements of the intensive use of multimedia and interactivity in eLearning environments. As an intermediate step the target-group-specific design can reduce complexity.

2.4. Summary: Demands of Accessible Dynamic Web Applications

Dynamic Web applications storing semantic information demand new forms of this development too. In order to store the descriptions of multimedia objects and interactions in a semantic way, a development process is needed which supports a "semantic thinking" to generate these information. Thus, generating the information additionally during the development process without extra effort will be possible. The process of developing the Web application has tot be schematic and requires specification tools which are powerful to describe complex Web applications and abstract enough to be processed by a compiler or similar. UML and model-based Web application development extending MDA for the Web use offer these features. The additional information which makes the Web application accessible can be derived from an extended CS. This approach is presented in the next chapter.

3. Conceptual modeling

Different recent projects examine the possibilities of conceptual modeling to develop Web applications. The MDA-methodology has been extended to accomplish these needs. Existing approaches commonly use UML and some extensions to develop a CS describing not only structure and behavior of the Web application but navigation and presentation as well. Two examples are Object-Oriented Web Solutions (OOWS) [4] and the WebSite Design Method (WSDM) [6].

Among the approaches for model-driven Web application development examination of accessibility is still unusual. Currently some other problematic points are: The Modeling of dynamic Web applications since current approaches are often intended for more or less static informatory Web applications. Then the integration of later modifications of the model has to be possible and the compiler process should enable the opposite direction. And models are necessary to describe flexible interactions with the user.

Here two projects are presented. They are focused on the enhancement of navigation models to support accessibility and on adaptive linking. First, based on WSDM the Dante-project [6] aims to support technologies like screen readers with additional information about the navigation. Second, the OOWS-approach includes the description of adaptive navigation techniques in the early process of Web modeling [10].

3.1. WSDM and Dante - Additional Information about Navigation

The WSDM is a user centered Web page design method. WSDM is focused on the presentation of information thus interaction beyond linking is not supported. Starting from a clarified mission statement describing purpose and subject of the Web application intended, possible users are identified and separated into different audience classes in a hierarchical way. The characteristics of each class are

specified. During the conceptual design phase the task and information modeling and the navigational design is elaborated. Finally the implementation design and the Web application will be developed.

The Dante-project is based on WSDM and aims to improve the access for visually impaired people to Hypermedia environments - especially the Web - for visually impaired people. It allows semantical annotation of Web pages to explicitly provide knowledge about structure and to provide screen readers with semantical knowledge to better facilitate the audio presentation of the content.

3.2. OOWS - Adaptive Linking

Object-Oriented Web Solutions extends the object-oriented software development approach OO-Method [7] with additional capabilities to capture the navigational and presentational requirements of Web applications. Since it extends an object-oriented design approach it seems more suitable for the conceptual design of complex server-based Web applications. Combined with the navigational model is an approach to include the description of adaptive navigation techniques in the early process of Web modeling [8]. Three techniques of linking are included: link-annotation, link-hiding and link-ordering. Even if this technique is not intended to improve accessibility it can be extended to support orientation for visually impaired users.

3.3. The Approach of the BeLearning-Project

The field of navigation is one of the major issues to support accessibility. Another one is multimedia content. Starting from the both presented approaches to improve navigation techniques the BeLearning-project examines the possibilities to extend the accessibility features for multimedia content too.

Current discussions concerning presentation are usually focused on the meaning to be conveyed by the objects as the description of a visual object is meaningless to visual impaired people if it is not related to concepts available to their imagination. Otherwise it is important to communicate the significance of the picture so that the user can understand why the image is there and if it is necessary to recognize all details. In fact that does affect only a portion of all pictures.

Images, graphics etc. have different functions in Web content:
- Decoration: The image carries no additional information.
- Representation: The image accompanies the text and amplifies information.
- Organization: The image clarifies the structure of the text.
- Interpretation: The image explicates complicated parts of the text.
- Transformation: The image convert the information of the text to support memorizing of information, to combine single parts etc.

Even if lot of these aspects can be carried by text too or are not necessary to understand the content a complete substitution is not possible. If the Web application model declares the function of an image it can be decided which substitution can be applied. To make this kind of content accessible at first function and intention must be clear for the user. This sort of "semantic information" is available from the Web model too and can processed by the model compiler.

According to the presented processes an approach (see Fig. 1) is presented to explicitly address the main fields of accessibility - perception and interaction - and to meet the demands of complex server-based Web applications like eLearning-environments. Therefore it is necessary to design representation and interfaces too. In the representation model images are combined with objects from earlier models like the functional model and the navigational model which declares the function represented by the image. In most of the cases alternatives are possible.

The development of the user model and the conceptual design of the application as well as interface design and navigation design are parallel operations affecting each other. Additionally, the distinction between navigational links and other actions will become less and less pronounced in the near future as currently demonstrated by the AJAX-technology (Asynchronous JavaScript And XML).

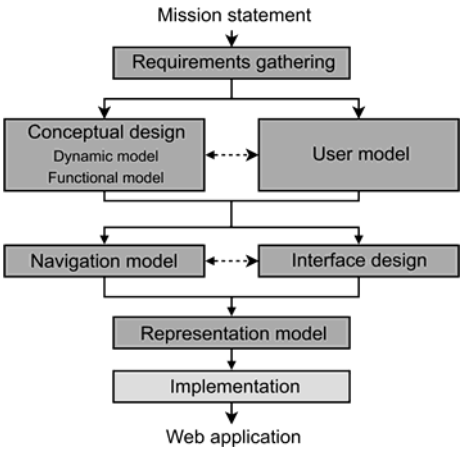

Fig. 1 The BeLearning-Process

4. Conclusions

With all presented approaches together model-driven Web development can support accessibility in the fields of navigation and illustration. This is not a general approach to support accessibility in all aspects since the support of interaction is not discussed and also multimedia includes not only images. However the basic idea is applicable to other fields too: Accessibility at first is not a question of a simple replacement with other media but to extract the function and purpose of information and find ways to describe these information with models understandable for compilers. Even if interactions with the user are not discussed here in detail they are affected by the issues of perception too. Often the problems of interaction are at first not problems of input but orientation, explanation etc.

Within the BeLearning-project is subject of further examination the concept of mental models for use with user classification to support accessibility, the model-based development of dynamic Web applications and the integration of interactions in the model-based Web application development process

More issues for future work are other kinds of multimedia content like applets, the use of SVG (Scalar Vector Graphics) to enhance accessibility etc.

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