Software Engineering for Adaptive Hypermedia Applications?

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Development of Adaptive Hypermedia Applications

The Programming and Software Engineering Research Group of the Institute of Computer Science of the Ludwig-Maximilians University of Munich is focusing on software engineering for hypermedia and Web applications in general and, particularly, for adaptive applications. One main goal of the software engineering discipline is to find techniques that support the development process of software applications. Our goal is to find, between others, appropriate analysis and design techniques that support development and authoring of adaptive hypermedia and Web applications.

General object-oriented software engineering approaches, such as the Unified Process (Jacobson, Booch & Rumbaugh, 1999) or specific methodologies for hypermedia like RMM (Isakowitz, Stohr & Balasubramanian, 1995), OOHDM (Schwabe & Rossi, 1998), and HFPM (Olsina, 1998) are not sufficient. They do not cover aspects relevant to personalization, i.e. user modeling and adaptation issues. A significant contribution in this field is AHAM (De Bra, Houben & Wu, 1999). AHAM is an application model for adaptive hypermedia that describe such applications from the authors' point of view.

We propose the UML-based Web Engineering approach (UWE) (Koch, 2000 & Koch et. al, 2001). UWE includes a design method for adaptive hypermedia applications and a development process for such applications. UWE is a systematic and object-oriented – in this way they differ from AHAM – design and development approach. We propose an integrated methodology for object-oriented development of adaptive hypermedia (Web) applications by presenting an extension to the Unified Modeling Language (UML). As basis for the software engineering approach we have developed the Munich Reference Model, i.e. a Dexter-based reference model which is formally specified using UML and OCL (Koch, 2000).

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Our Approach

By way of an analogy to hypermedia engineering (Lowe & Hall, 1999), *engineering for adaptive hypermedia applications* can be defined as a systematic, disciplined and measurable approach that supports the entire life cycle of adaptive hypermedia systems. This life cycle goes from conception through the elaboration, construction, delivery and maintenance to the cessation of the application.

The goal of an engineering approach is to support developers during these different phases in organizing mental activities, working at various levels of detail and abstraction, generating visual representations adapted to the designers level of experience, presenting the solution's constraints, building representations of the application and finally outlining plan structures and strategies.

The main motivation of our work was to define an engineering approach to adaptive hypermedia systems based on the object-oriented techniques that are state of the art in the software development (as schematically shown in Figure 1). The techniques used are UP (Unified Process, Jacobson, 1999), UML (www.omg.org/uml/) – a standard for object-oriented software design since 1997 that was chosen for all models and notations – and OCL (Object Constraint Language, Kruchten, 1998).

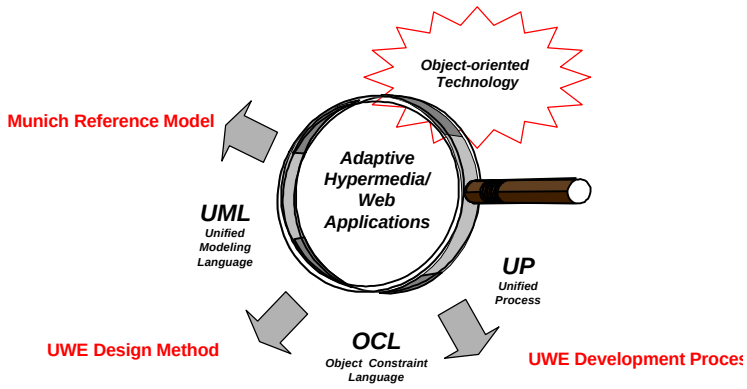

Fig. 1: UWE Software Engineering Approach

Reference Model

The aim of the Munich Reference Model is the formal specification of the features that constitute an adaptive hypermedia system and distinguish a high quality application. It is defined as an extension of the Dexter Hypertext Reference Model including a user metamodel and an adaptation metamodel. UML provides the notation and the object-oriented modeling techniques for the visual representation of the model. The Object Constraint Language (OCL), which is also part of UML, is used to supplement the semi-formal visual representation with semantic information. The formal description specifies invariants on the model elements and attributes as well as pre-conditions and post-conditions on the functions of the model. This formal specification is equivalent to a specification in languages, such as Z. A simplified user metamodel of the Munich Reference Model is shown in Figure 2.

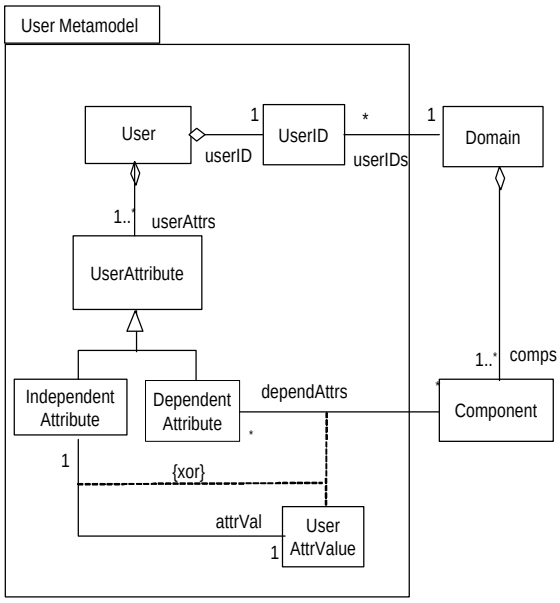

Fig. 2: Munich Reference Model: Simplified User Metamodel

Design Method

Visual modeling techniques are introduced in this work to define methodical analysis and design of adaptive hypermedia applications. The methodology of the UWE approach consists of modeling elements, notation and a method. The method is proposed to support the systematic construction of adaptive hypermedia applications and to identify as many steps as possible to be performed in an automatic way.

The notation and semantics of these elements define a "lightweight" UML extension, a so-called UML profile. It is defined as a set of stereotypes and properties for adaptive hypermedia that are used in some of the models proposed by UWE. These models are: a conceptual model to define the content, a user model, a

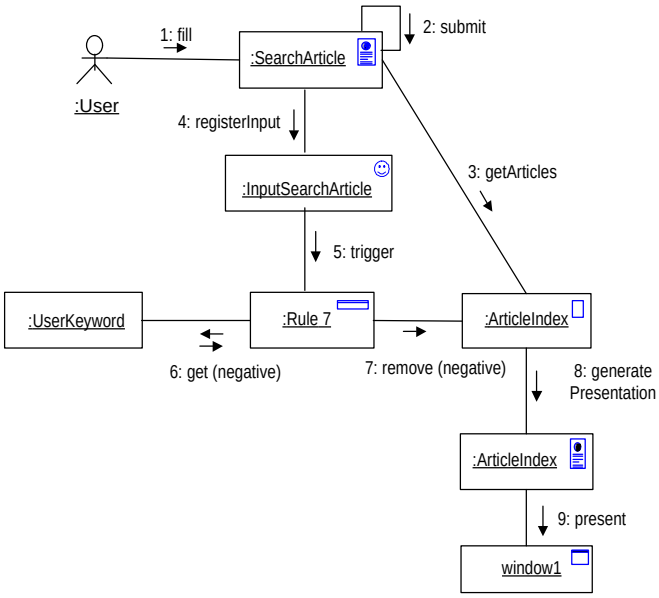

Fig. 3: UWE Design Method: Scenario of an Adaptation Model

navigation model, a presentational model to define static and dynamic aspects of the presentation and an adaptation model. Figure 3 shows – as an example -a scenario of an adaptation model of an Online Library application.

UWE is characterized by the separate treatment of hypermedia issues, such as content, navigation and presentation and from user modeling and adaptation issues.

Development Process

The development process of our approach, is based on the Unified Process, i.e. UWE adapts the Unified Process to support the development of hypermedia (Web) applications in general and to include special activities needed in the development of adaptive systems. Figure 4 shows an overview of the UWE development process and the supporting workflows.

UWE describes an object-oriented, workflow-based, user-centric, systematic, iterative and incremental process. Each workflow is textually described and graphically represented by activity diagrams. Both include workers, activities and artifacts. UWE specializes the Unified Process for the development of adaptive hypermedia applications describing which "experts" (workers) are required, which activities they perform and which specific artifacts they produce. UWE extends the coverage of the Unified Process development cycle adding a maintenance phase and a quality management workflow. It changes the idea of quality control management incorporating workflows for requirements validation and design verification in addition to testing.

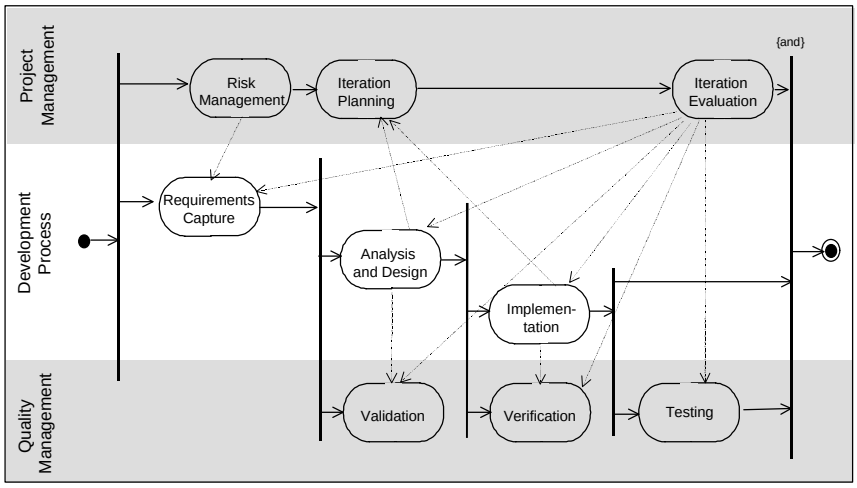

Fig. 4: Overview of the UWE Development Process

The design techniques are embedded in the UWE development process, which aims to cover the entire lifecycle form inception to maintenance of adaptive hypermedia applications.

Case Studies

The engineering approach was validated using several case studies, e.g. SmexWeb, an adaptive exercising system for students of a computer science introduction course

(pst1.pst.informatik.uni-muenchen.de:8000/indexE.html). SmexWeb is a framework developed at the Institute of Computer Science of the LMU that permits the development of teaching applications through instantiation. It supports adaptive content and adaptive navigation in all its variants (Brusilovsky, 1996). In addition it allows the system to take control over the process of navigation under special conditions, such as a period of user inactivity. This adaptive navigation technique is called passive navigation (Albrecht, Koch & Tiller, 1999). Figure 5 shows a screen shot of the EBNF application that has been developed using the SmexWeb framework. It is an EBNF (Enhanced Backus-Nauer Form) exercising session for an introductory course in computer science.

Currently we use the UWE approach in the LAMP project for designing and implementing an adaptive tutoring system for several Bavarian Universities (www.pst.informatik.uni-muenchen.de/projekte/lamp/index_e.html).

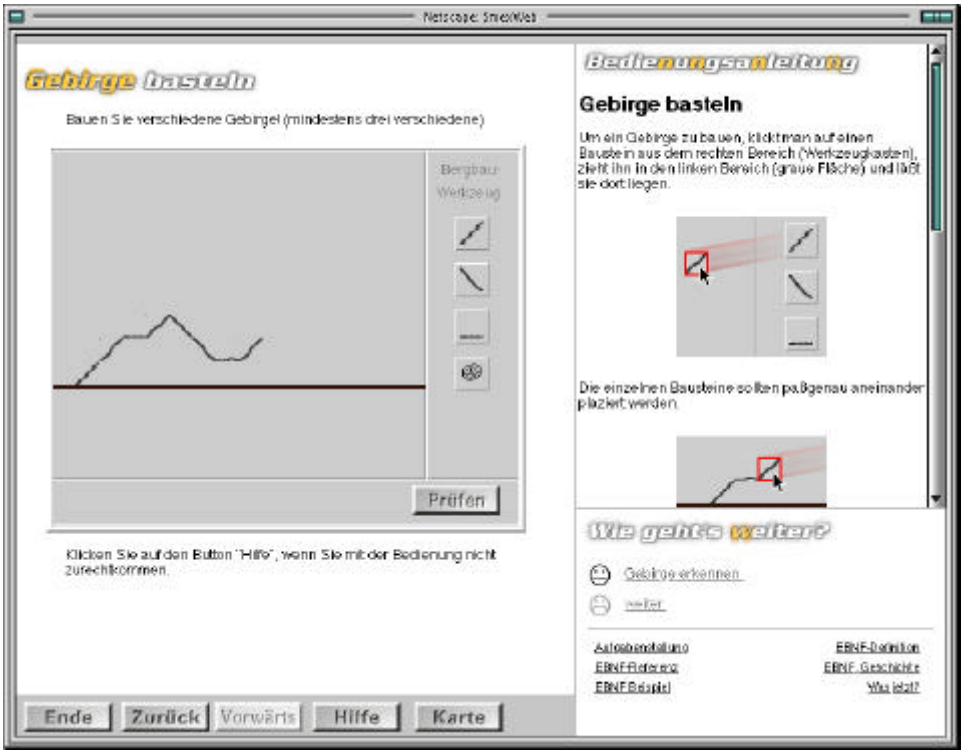

Fig. 5: SmexWeb: Task of the EBNF Application

Open Issues

The proposed engineering approach focuses on modeling and processes, but there are many open issues from the software engineering point of view, which still need to

be addressed and integrated, such as implementation techniques for adaptive hypermedia or personalized Web applications.

The development process requires case tool support. Tools for UML are developing fast, but they need to include special features for Web development since Web applications are becoming in a near future the most frequently developed software applications.

Our objective is to implement the stereotypes defined for (adaptive) hypermedia and Web applications (Koch,2000) as plug-in features of different case tools, such as for the open-source tool ArgoUML (argouml.tigris.org).

References

Albrecht F., Koch N. & Tiller T. (1999). Making Web-based training more effective. *Proceedings of the Seventh Workshop ABIS-99*: Adaptivität und Benutzermodellierung in interaktiven Softwaresystemen, T. Joerding (Ed.).

Brusilovsky P. (1996). Adaptive Hypermedia: An attempt to analyze and generalize. Proceedings of First Conference on Multimedia, Hypermedia and Virtual Reality 1994. Brusilovsky P. & Streitz N. (Eds.) LNCS 1077, Springer Verlag, 288-304.

De Bra P., Houben G.-J. & Wu H. (1999). AHAM: A Dexter-based Reference Model for adaptive Hypermedia. *Proceedings of the ACM Conference on Hypertext and Hypermedia*, 147-156.

Hennicker R. & Koch N. (2000). A UML-based methodology for hypermedia design. *Proceedings of the Unified Modeling Language Conference, UML´2000*, Evans A. and Kent S.(Eds.), 410-424.

Isakowitz T., Stohr E. & Balasubramanian P. (1995). A methodology for the design of structured hypermedia applications. *Communications of the ACM*, 8(38), 34-44.

Jacobson I., Booch G., & Rumbaugh J. (1999). *The Unified Software Development Process.* Addison Wesley.

Koch N. (2000). Software Engineering for Adaptive Hypermedia Systems: Reference Model, Modeling Techniques and Development Process. PhD. Thesis, LMU Munich.

Koch N., Kraus A. & Hennicker R. (2001). The Authoring Process of the UML-based Web Engineering Approach (Case study). Proceedings of the 1st International Workshop on Web-oriented Software Technology, 2001, to appear.

Lowe D. & Hall W. (1999). *Hypermedia & the Web: An engineering approach.* John Wiley & Sons.

Olsina L. (1998). Building a Web-based information system applying the Hypermedia Flexible Process Modeling Strategy. *1st International Workshop on Hypermedia Development, Hypertext´98.*)

Schwabe D. & Rossi G. (1998). Developing hypermedia applications using OOHDM. In Proceedings of *Workshop on Hypermedia development Process, Methods and Models, Hypertext´98.*

Wirsing M. & Knapp A. (2001). A Formal Approach to Object-Oriented Software Engineering. Theoretical Computer Science, 35 pages, to appear.