



Applying Aspect-Orientation to the Model-Driven Development of Ubiquitous Web Applications*

Andrea Schauerhuber
Women's Postgraduate College for Internet Technologies
Vienna University of Technology,
Favoritenstraße 9-11,
A-1040 Vienna
andrea@wit.tuwien.ac.at

1. MOTIVATION

With the emergence of mobile devices as new access channels to the Internet, we are now facing a new generation of Web applications, called ubiquitous Web applications (UWA). UWAs are characterized by the *anytime/anywhere/anymedia paradigm* [5], meaning that services are not exclusively accessed through traditional desktop PCs but through mobile devices with different capabilities, by users with various interests at anytime from anyplace around the globe. Services provided by UWAs are adapted to a certain context of use in order to preserve or even enhance their semantic value for users. Thus, knowing the *context* (e.g. user, location, time, device, etc.) and providing *adaptation* operations for *Web objects* (i.e. text, images, links, etc.) are the main prerequisites for *customization* of Web applications towards ubiquity. Thus customization denotes the *mapping* of the required *adaptation* of an application's services with respect to its *context* [5].

One major challenge in the area of UWAs is their model-driven development, which aims at counteracting the ad hoc, non-systematic, tool- and technology-driven approaches. There are already several approaches focusing on the model-driven development of traditional, i.e., non-ubiquitous, Web applications since the late 1990ies. Nevertheless, approaches dealing with the ubiquitous nature of Web applications - of which the most prominent examples are WebML [2], UWE [6] and OO-H [4] - are still in their infancy¹.

2. PROBLEMS

Limited Customization. Current model-driven approaches often focus on certain facets of customization, only. In particular, most of them deal with isolated context factors such as personalization or multi-delivery but do not consider customization comprehensively. This means that customization does neither cover all relevant context factors nor allows for a wide spectrum of adaptation operations [5].

Intermingled Representation. Second, the aspect of customization is not properly captured by current model-driven approaches. In

fact, it is often intermingled with the core Web application. This means that neither a *context model* nor *adaptation operations* enter Web application models in an explicit, self-contained and extensible way.

Disregarded Crosscutting Nature. Third, the provided customization mechanisms do not allow to influence the two orthogonal dimensions of a Web application namely *structure and behavior* for each Web application's *levels*, i.e., content, hypertext and presentation. This means that the crosscutting nature of customization is disregarded.

3. HYPOTHESIS

To cope with these problems, this thesis proposes to use aspect-orientation as driving paradigm for capturing customization of ubiquitous Web applications at the modeling level.

Aspect-orientation has been proven to be a promising mechanism that provides a new way of modularization by clearly separating crosscutting concerns, so-called *aspects*, from non-crosscutting ones. Although originally emerged at the programming level [6], aspect-orientation meanwhile stretches also over other development phases. Due to the rise of model-driven development, some approaches already exist for dealing with aspect-orientation at the modeling level [9].

For modeling customization, aspect-orientation is able to address the identified problems (cf. Section 2) by taking into account customization's crosscutting nature, and thus prevents an intermingled representation. This will also detach customization from the underlying Web modeling language and hence lead to a better focus on the full spectrum of customization capabilities.

4. RELATED WORK

While the majority of aspect-oriented modeling (AOM) approaches is designed as general-purpose languages with respect to the application domain, we currently only know one approach specific to the Web application domain [1], [9]. While in [9], the Web modeling language UWE has been extended with aspect-oriented concepts to model the *access control aspect* in Web applications, [1] identifies *adaptivity* as a crosscutting concern to Web applications. In particular, an extension to UWE has been presented that allows to make navigation in Web applications adaptive by relying on aspect-oriented modeling techniques.

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¹ For an overview of methods and tools for Web application development see [10].

5. GOALS

The goal of this thesis is to investigate the applicability of aspect-orientation and to propose an aspect-oriented approach for modeling customization in the realm of UWAs.

With respect to this overall goal the thesis will aim at the following subgoals:

- Providing a detailed *investigation of existing customization approaches* based on a structured evaluation framework to yield the requirements for comprehensive coverage of customization.
- Developing a *unified reference architecture* for AOM to put forward the common understanding of aspect-orientation at the modeling level.
- Investigating the *strengths and weaknesses of existing AOM approaches* by applying an evaluation framework for aspect-oriented modeling (based on the unified reference architecture).
- Proposing an *aspect-oriented design approach for ubiquitous Web applications* in the form of an AOM language (possibly a UML profile), which is dedicated to the crosscutting concern of customization.
- Exemplifying the applicability of the proposed approach in terms of *examples and best-practices* in order to indicate how to appropriately apply aspect-orientation for customization.
- Providing *tool support* based on the Eclipse Modeling Framework (EMF) to allow for an easy application of the proposed design approach.

6. METHODOLOGY

In order to achieve these goals, the following methodology will be employed:

- *Investigation of the state-of-the-art* in designing UWAs as well as in AOM by applying structured evaluation frameworks.
- *Re-use of common concepts* identified through a survey on AOP and AOM approaches, and abstracting them to a higher level in terms of a common reference architecture.
- *Definition of the AOM language on the basis of a standard modeling language* using either a heavy-weight or a light-weight approach depending on the aspect-oriented modeling concepts needed.
- *Application of the proposed approach to a well-established web modeling language* (e.g. WebML) by introducing aspect-oriented concepts.
- Evaluation of the proposed approach through a *case study* in the realm of tourism information systems (TIS) together with domain experts.

7. EXAMPLE

The customization of a TIS will serve as an example to demonstrate the applicability of the proposed approach. TISs are able to individually target customers who access their services through different clients at varying locations. Consequently, such a TIS needs to take into account various context factors. Based on the context information, appropriate adaptation is performed in terms of, e.g., composing the visual appearance to meet the user's preferences, tailoring the navigation possibilities to reflect the

restricted space on small screen devices, or filtering tourist services within the user's proximity.

8. WORKPLAN

Along with the goals the following steps can be identified:

In an initial step, an *overview of already existing aspect-oriented modeling approaches* needs to be prepared. The completion of this provides the basis for the *development of a common reference architecture* for aspect-orientation, in the next step.

In an additional step, *current developments* on customization need to be investigated which can be done independently from the two steps described above. These three steps have already been addressed, resulting in first publications [8], [9].

The findings of both, the surveying steps and the completion of the reference architecture are the prerequisites for *defining the aspect-oriented modeling approach for customization*. In a next step, a supporting modeling tool will be provided.

Applying examples of the case study in previous steps will provide input to, and at the same time, allow for an early evaluation of both, the development of the aspect-oriented modeling approach for customization as well as for the EMF-based tool support.

9. RISK ANALYSIS

Amongst all the obstacles we are currently aware of, we identified the following as particularly influential.

- *Customization immature.* The domain of UWAs is fairly young. Consequently, customization as a mechanism to deal with ubiquitous web applications is still under development and the concepts which shall be captured through the aspect-oriented approach are quite immature.
- *Complexity of customization.* Customization influences the core functionality – it is not only an add-on such as e.g. logging. We therefore expect that customization is a rather complex crosscutting concern, which presumably has to be split into several sub-aspects (maybe along with the supported context factors, i.e. a location-customization aspect etc.).
- *Unconsolidated understanding of AOM.* Up to now there exists no common understanding of aspect-orientation at the modeling level.
- *Applicability of existing AOM approaches.* It is not yet clear whether an existing AOM approach can be applied or whether a new AOM approach needs to be developed for capturing customization.
- *Dependency on an existing Web application modeling language.* The aspect-oriented design approach is going to be based on an existing Web application modeling language. Shortcomings of this language as well as the evolution of the language will have a rather strong influence on our approach.
- *Availability of real-world example.* A successful development of an aspect-oriented approach to UWAs as well as its evaluation of applicability requires the availability of real world examples that provide sufficient diversity with respect to customization requirements.

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