Web Design Dimensions and Adaptation

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INTRODUCTION

Recent developments in the World Wide Web infrastructure enabled the development of highly interactive hypermedia systems for e-commerce, e-government, and mobile commerce. Such applications have much to gain exploring adaptation, through the use of adaptable and adaptive mechanisms to customize services and interfaces.

Adaptable systems are those that can be configured by the user before or during their use. Adaptive systems automatically acquire input data in order to infer adaptation opportunities and react accordingly. Adaptable and adaptive systems consider three different adaptation targets: human matters, interaction matters, and computer matters. The first target regards preferences, interests, and other personal information to allow system personalization. The second target regards goals and activities that are intended by the user in order to adjust the system according to the dialogue with the human being. The third target regards resource-availability discovery and optimization, such as needed by mobile applications due to limitations in computation and communication infrastructure.

The design of modern hypermedia systems requires an integrated approach contemplating modeling principles, evaluation frameworks, and reference models. Several approaches and methods exist, but it is difficult to understand how they complement or interfere among themselves during a design. Fischer (1989) considers that systems with strong interactive requirements, such as those related to usability, lack structure and present design instability. Adaptation aggravates this difficulty.

Tobar and Ricarte (2005) believe that one of the main reasons behind the difficulty in developing and evaluating adaptable and adaptive systems is the absence of a *reference* (normative) *model* for describing them from different perspectives. They provided some clues toward this missing type of model through the E-ACM (extended abstract categorization map), used to present modeling dimensions. It is a graphical representation to capture different aspects of hypermedia systems and models, considering all types of adaptation. It can be used before system authoring and design to a broad spectrum of hypermedia applications including e-commerce, e-government, and mobile commerce.

BACKGROUND

Complementing design dimensions is a strategy to model complex systems. For adaptable and adaptive systems, these dimensions help to:

1. identify coverage overlapping between modeling methods or systems, aiming potential integration;
2. compare modeling methods;
3. specify a new authoring methodology; or
4. assess the adherence of modeling methods to specific available tools.

Four dimensions concerned with adaptable and adaptive hypermedia design are considered: services, traditional concerns, abstraction levels, and goal conditions.

Services

Services, such as navigation and presentation, offer representation mechanisms to establish how users perform different data manipulation activities. They also support problem-modeling issues that are the kernel of some hypermedia modeling methods.

The Dexter reference model (Halasz & Schwartz, 1994) pioneered a dimension for modeling separating navigation from presentation and interaction issues. Brusilovsky (2001) also considers a similar dual vision for adaptive hypermedia services. This dimension is the most commonly used as orientation to develop and assess adaptable and adaptive systems.

Traditional Concerns

The traditional concerns dimension includes representations for structure (data), behavior (process), and constraints. It is the usual modeling dimension to develop software.

Oppermann (1994) introduced a *process-oriented* approach for adaptive systems, with three main components: to gather observation data (afferential), to deal with user characteristics (inferential), and to adapt the system (efferential). Several other authors, inspired by Oppermann's proposal, use layers for dealing with processes behind adaptivity, such as Weibelzahl (2003).

Other proposals presented *data-oriented* approaches. De Bra, Houben, and Wu (1999), based on the Dexter model, proposed the AHAM (adaptive hypermedia application model) reference model. It focuses on the storage functional layer, with models for domain, user, and teaching.

There are also hybrid approaches, such as the one proposed by Paramythis, Totter, and Stephanidis (2001) with two data-oriented components and several others process oriented.

Abstraction Levels

Different models can represent the same aspect, each with a different abstraction level. A pioneer work regarding abstraction levels is the reference database architecture defined by the American National Standards Institute (Tsichritzis & Klug, 1978).

Stephanidis and Savidis (2001) considered abstraction by proposing three levels of interaction at which adaptation is applied: semantic (different metaphors), syntactic (dialog patterns), and lexical (grouping and spatial arrangement). Benyon and Imaz (1999) exploited modeling methods developed toward one of three abstraction levels: intentional, conceptual, and physical. They consider *goals* as guidelines for the specification of entities at the intentional level.

Transitions between levels have been used in approaches for bottom-up or top-down development. Some proposals define mappings between adjacent levels to smooth detail generation (Tobar & Ricarte, 1999).

Goal Conditions

Goals are what the user has to accomplish using the application and represent the *why* of the system existence. Although important, the goal dimension is not well exploited in the literature.

Goal conditions are underneath application descriptions, and are related to external concepts to be considered by an application realization, such as a collaboration requirement to take into account. For instance, this goal condition affects the way services are provided to users, imposes new data and behavioral requirements, and requires ad hoc computational mechanisms.

Combination of Dimensions

Separation of concerns—that is, the use of dimensions—facilitates the reuse of successful design practices (Karagiannidis & Sampson, 2000). Mutually influenced design dimensions have long proved to be a powerful and helpful strategy.

Efforts to combine dimensions were initially directed toward open hypermedia systems (Rossi, Schwabe, & Guimarães, 2001) and required a combination of modeling methods. This same idea of combining methods has been exploited in development methodologies and respective supporting languages, such as the Unified Modeling Language—UML (Fowler, 2003).

A HYPERMEDIA AUTHORING SYSTEM: AHA!

AHA! (De Bra et al., 2003) is a representative tool to build adaptive Web applications. It is a generic and open adaptive hypermedia platform, originally developed to support educational applications, composed of an authoring system and an adaptive support system. Its goal is to offer guidance through explanations and conditional navigational options during user interaction. AHA! uses three techniques to achieve this goal:

1. a user model based on concepts,
2. the use of adaptive link hiding, and
3. the conditional inclusion of fragments.

To construct applications with AHA!, an author creates concept and page templates. Page templates contain the fragments to be conditionally included, coded with the standard language for Web pages, XHTML (W3C, 2002). Concept hierarchies and relationships are created using the *graph author,* a tool to create a domain-adaptation model in a high level of abstraction. AHA! also provides a *concept editor,* which offers low-level access to define condition-action rules and conceptual attributes.

The AHA! platform, in which adaptive applications are processed, has as its main functional component an inference engine, and as its main data components a user model and a combined domain and application (adaptation) model. The AHA! engine, responsible by adaptive effects, uses a Web server to provide user interaction and