Models and Technologies for Adaptive Web Portals

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INTRODUCTION

In modern Web-based information systems (WIS), the personalization of presentations and contents is becoming a major requirement. Personalization means adaptation to user's requirements and goals, as well as adaptation to user's technology and environment (Levene & Poulovassilis, 2004). Application fields where content personalization can be useful are manifold; they comprise e-government, online advertising, direct Web marketing, electronic commerce, online learning and teaching, and so forth. The need for adaptation arises from different aspects of the interaction between users and Web/hypermedia systems. User classes to be dealt with are increasingly heterogeneous due to different interests and goals, large-scale deployment of information and services, and so on. Furthermore, WIS should be made accessible from different user's terminals, which can differ not only at the software level (browsing and elaboration capabilities) but also in terms of ergonomic interfaces (scroll buttons, voice commands, etc.). Finally, different kinds of network (e.g., wired or wireless) and other network-related conditions (e.g., bandwidth, latency, error rate, etc.) should be considered to obtain a comfortable and useful interaction.

To face some of these problems, in recent years the concepts of adaptive systems and hypermedia have converged together into the adaptive hypermedia (AH) research theme. An adaptive hypermedia system (AHS) is defined as "an hypertext and hypermedia system which reflects some features of the user in a user model and applies this model to adapt various visible aspects of the system to the user" (Brusilovsky, 2001). The AH approach is more and more used to support adaptivity and content personalization in modern WIS. An adaptive Web portal (AWP) is defined as an AHS which adapts and delivers the contents of an information systems through the Web, that is, by using the transport and application protocols of the World Wide Web.

Adaptive Web portals can be used in many application domains where users can be classified in different groups and they usually access the system through different devices. For instance, in e-government Web portals, users like administrators, managers or citizens have different informative requirements and goals, and they can access the system by using different devices and networks (Acati et al., 2005). This similarly happens in e-health, where doctors, health personnel and patients have to see different portions of electronic patient records.

The article introduces general aspects of adaptive hypermedia systems and adaptive Web portals, and presents a middleware software that can be used to implement adaptive Web portals. The main characteristics of the proposed system are the continuous detection of network and user's terminal features and the dynamic adaptation of the contents of an information system with respect to such quantities. Foundation model, architecture, and system prototype are presented.

BACKGROUND

The basic components of AHSs are the application domain model (DM), the user model (UM) and the adaptation model (AM) (Brusilovsky, 2001; Cannataro & Pugliese, 2004).

- **Application Domain Model:** Used to describe the hypermedia contents. In addition to well known data models, the modeling of AH must consider the different sources that affect the adaptation process and must allow for an effective observation of users' actions, with respect to each particular application domain, in order to gather significant data for user modeling.
- **User Model (or Profile):** Attempts to describe the user's characteristics and preferences and his/her expectations in the browsing of hypermedia; user models are generally distinguished into overlay models, which describe a set of user's characteristics (typically represented by a set of name-value pairs), and stereo-

type models which indicate the user's belonging to a group.

- **Adaptation Model:** Related to *content selection*, that is, a selection of parts of hypermedia to be presented to the user, *content adaptation*, that is, a manipulation of information fragments, and *link adaptation*, that is, a manipulation of the links presented to the user.

Whenever a user interacts with an AHS, the system builds a user model on the basis of user's interaction. When the user requests a new page, the Adaptation Model applies the adaptation rules to the portions of the page defined through the domain model. Finally, the adapted page is delivered to the user. In recent years many AHSs have been developed. Cannataro and Pugliese (2004) survey architectures and models used to build adaptive systems.

The *XML adaptive hypermedia model* (XAHM) is specifically concerned with a complete and flexible data-centric support of adaptation (Cannataro, Cuzzocrea, & Pugliese, 2002). It is focused on: (1) the description of structure and contents of an adaptive hypermedia in such a way that it is possible to easily point out the components on which to perform adaptation; (2) a characterization of the hyperlinks useful to single out users' preferences and goals in a non-invasive way; and (3) a simple representation of the logic of the adaptation process, distinguishing between adaptation driven by technological constraints and adaptation driven by users' needs.

In XAHM the application domain is modeled along three abstract orthogonal adaptivity dimensions.

- **User's Behaviour:** Comprises data about browsing activity and preferences of the user; such data are used to build the User Model as a stereotype profile.
- **External Environment:** Comprises data about the environment where the user is, such as time-spatial location, language, sociopolitical issues, and status of external Web sites.
- **Technology:** Comprises data describing the network and device technology used by the user, such as kind of network, bandwidth, characteristics of user's terminal.

Such adaptivity dimensions define the *adaptation space*, that is, the set of all information fragments of the application domain, such as pages, images, and so forth, that can be adapted with respect to the adaptivity dimensions. The position of the user in the adaptation space is denoted by a tuple of the form [B, E, T]. Each of the values B, E and T varies over a finite alphabet of symbols. The B value, related to the user's behavior dimension, captures the group the user belongs to; the E and T values respectively identify environment location and used technologies. As an example, B could vary over {*novice, expert*}, E over {*english-place, italian-place*} and T over {*HTML-low, HTML-high, WML*}. A personalized view over the application domain corresponds to each point of the adaptation space, for example, when the user reaches the point [expert, english-place, HTML-high], the adaptive system should deliver to the user the selected portion of the domain model, such as a page, adapted to those values of B, E, T.

Recently, there has been an effort in the World Wide Web (W3C) community to define a standard for the modeling of the contents of an AHS. In particular, the *Device Independence* group (W3C Device Independence Working Group) defined the *Content Selection for Device Independence* (DISelect) W3C Working Draft that specifies a syntax and a processing model for general purpose content transformation (filtering as well as manipulation) on an XML (eXtensible Markup Language) document (Lewis & Merrick, 2005).

Usually, the condition part of a DISelect construct is evaluated with respect to device and network conditions, as well as to other author-defined variables (e.g., user's profile). The *composite capabilities/preferences profile* (CC/PP) is a W3C recommendation that allows the expression of user device capabilities and user preferences, according to a shared structure and vocabulary of terms stored in RDF (resource description framework) format, that can be used to guide the adaptation of content presented to that device (W3C CC/PP, 1999). Figure 1 shows a fragment of content selection DISelect code that produces a non-empty result when screen width, that is, a CC/PP value, is greater than 800 pixels.

DISelect and CC/PP are the basic building blocks to develop novel and standard-aware adaptive Web portals:

Figure 1. An example of DISelect code showing a content selection construct

```
<sel:if expr="di-cssmq-width('px') &gt; 800">
      <p>
            Shown only when screen width is greater
            than 800 pixels.
      </p>
</sel:if>
```