Engineering Adaptive Concept–Based Systems for the Web

Geert-Jan Houben
Vrije Universiteit Brussel, Belgium

Lora Aroyo
Technische Universiteit Eindhoven, The Netherlands

Darina Dicheva
Winston-Salem State University, USA

INTRODUCTION

In recent years we have witnessed a growing interest in adaptation and personalization in numerous application domains including business, education, and so forth. Applications that offer large bodies of information have in the Web era turned into systems with a significantly different nature than two decades ago. Think of the typical book catalog database from 20 years ago and the Web site of a book seller nowadays. A characteristic aspect of the restyling is the attention paid to the individual user. Technology has evolved and now allows application designers to include adaptation and personalization in the applications. This is especially important in the field of e-commerce, where users (customers) expect personalized services similar to those they receive in a conventional store.

Typical e-commerce systems employ large bodies of information. In the case of a bookstore Web site, the designer defines an appropriate structure for the collection of books with all relevant properties. Generally, the design uses structures of concepts, where the concepts represent the actual information objects. The adaptation engineering is later performed on the level of these (abstract) concepts. We refer to these applications as *concept-based systems*.

Adaptive concept-based systems are especially accepted in areas where the main goal is to tailor large amounts of information to the individual preference and knowledge state of the user. Besides electronic commerce, other examples include online museums (the visitor wandering through the collection on an individual basis) and e-learning applications (the student being involved with learning material in a way that the teacher thinks fits the student's situation).

BACKGROUND

Concept-Based Systems

Most concept-based systems use navigation in one way or another to structure the information they present. The design of navigation is not trivial, and including adaptation in it increases the complexity quickly. A nice example for adaptation and personalization in a business context (customer management) is ATG's Dynamo Personalization Server (http://www.atg.com): explicit user data from marketing databases is combined with implicit information gathered from the user's browsing behavior to provide dynamic content adaptation. Educational applications based on the adaptive hypertext architecture AHA! (De Bra et al., 2003) show how adaptation platforms are successfully used for presenting personalized learning environments.

The typical concept-based system on the Web is a data-intensive information system that contains content retrieved dynamically from a repository and uses hypermedia to present the output:

- The system is *data intensive*. There are classes of adaptive concept-based systems where handcrafting is possible, but typically the collection of information objects is so large that designers cannot do this organization by hand and have to rely on schematic designs.
- The system holds the data elements in a *repository*. Systems differ in the way they materialize this repository. Some assume a fixed set of data elements that are all individually known to the designer. In others the properties of the data elements are known and available for the designer at schema level (like

in databases). Some systems retrieve data in the way we know from search and retrieval engines, leading to yet another engineering process.

- The system uses *hypermedia* to present the output to the user. Systems differ in how they use hyperlinks to structure the output information. Note that this structuring is crucial in communicating the semantics of the output.

Development of Adaptive Concept-Based Systems

Adding adaptation and personalization to the picture influences the three issues mentioned above. Adaptation plays a major role in the hypermedia construction. For example, one might want to look at the user's platform, such that the application presents the (conceptually) same information differently for PC, personal digital assistant (PDA), phone, or other viewer, considering screen size or bandwidth. A different kind of adjustment would be based on the user's previous actions in the application. It is obvious that with the data-intensive nature of the application, including adaptation and personalization in the requirements, immediately leads to a much more complex *development and authoring process*. This presents the need to find a systematic and application-independent approach to adaptation engineering:

- Obviously, general object-oriented software engineering approaches, such as unified process (Jacobson, Booch, & Rumbaugh, 1999), lack the specific hypermedia aspect. On the other hand, specific methodologies for hypermedia like relationship management methodology (RMM) (Isakowitz, Stohr, & Balasubramanian, 1995) or object-oriented hypermedia design methodology (OOHDM) (Schwabe & Rossi, 1998) do not cover significant aspects related to adaptation (like user modeling and personalization).
- There are efforts that systematize the engineering (lifecycle) process and offer an integrated methodology, for example, the UML-based Web Engineering (UWE) approach (Koch, 2001). We observe that UML gives only a specification of the process, but not the semantics to perform the reasoning required for adaptation: semantically richer approaches are needed and current research on Semantic Web (Berners-Lee, Hendler, & Lassila, 2001) and ontologies (Sowa, 2000) offer solutions.
- The hypermedia community has defined reference models for adaptive hypermedia systems (e.g., the AHAM model (De Bra, Houben, & Wu, 1999) and

the Munich model (Koch & Wirsing, 2002)). Although the number of adaptive systems grows, their development process is still rather ad-hoc, without a lot of re-use, and therefore difficult to manage.

We observe a lack of uniform methods to describe the functionality of adaptive concept-based systems for analysis and comparison. The target is a systematic, unified, and measurable approach for engineering adaptive concept-based systems, starting from the *conceptualization* of the domain through application modeling, maintenance, and upgrade (Lowe & Hall, 1998).

ADAPTATION ENGINEERING

Principles of Adaptation Engineering

Modeling the Domain

The specification of concepts and their structure is a crucial aspect of concept-based system design. Concept-based systems, whether adaptive or not, commonly employ a well-specified subject *domain model* to define the information processed in the application. Traditionally, content descriptions are expressed in terms of concept structures, such as concept maps, semantic networks, or conceptual graphs (Sowa, 1984).

Modeling the User

The user plays a fundamental role in the system and therefore in its design. The system might want to record the user's presentation preferences (e.g., for platform, layout, font size, or other presentation aspects), as well as content preferences. Typically, the systems maintain a model of the individual user as an overlay of the domain model to record the current state of the user w.r.t. his/her preferences/knowledge of domain concepts. This *user model* is the basis for adapting the content presentation.

Modeling the Adaptation

The challenge left is to combine the information domain and user model when generating the appropriate adaptive presentation. This adaptive presentation includes individualized content selection and/or individualized navigation paths/links. Phrased differently, the main adaptation design challenge is to define *content selection* and *navigation* through adaptive methods and techniques (Brusilovsky, 2001). Typically this is done in the *adaptation model*.

Related Content

Study on the Influencing Factors of Mobile Users' Impulse Purchase Behavior in a Large Online Promotion Activity

Qihua Liuand Fuguo Zhang (2019). *Journal of Electronic Commerce in Organizations (pp. 88-101).*

www.irma-international.org/article/study-on-the-influencing-factors-of-mobile-users-impulse-purchase-behavior-in-a-large-online-promotion-activity/223099

Collaborative Tagging for Collective Intelligence

Kwan Yi (2016). *Encyclopedia of E-Commerce Development, Implementation, and Management (pp. 1957-1969).*

www.irma-international.org/chapter/collaborative-tagging-for-collective-intelligence/149092

Typology of Online Reviewers Based on Their Motives for Writing Online Reviews

Sai Vijay Tata, Sanjeev Prasharand Chandan Parsad (2021). *Journal of Electronic Commerce in Organizations (pp. 74-88).*

www.irma-international.org/article/typology-of-online-reviewers-based-on-their-motives-for-writing-online-reviews/274271

A Study of e-Commerce Transaction Risk Assessment Model in Mobile Internet

Zhihong Huang (2017). *Journal of Electronic Commerce in Organizations (pp. 1-10).*

www.irma-international.org/article/a-study-of-e-commerce-transaction-risk-assessment-model-in-mobile-internet/188833

Web Server Security for E-Commerce Applications

Kannan Balasubramanian (2016). *Cryptographic Solutions for Secure Online Banking and Commerce (pp. 61-69).*

www.irma-international.org/chapter/web-server-security-for-e-commerce-applications/153492