Towards Semantic Web-based Adaptive Hypermedia Model

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Abstract. At present, most hypermedia systems display the same content for all users. To allow users working effectively, we need adaptive personalization. We are developing a general model for adaptive hypermedia that should provide a formal description and allow simple development of such systems. We use an innovative approach of utilizing Semantic Web technologies to enable data reuse and system interoperability. In this work we give the description of the research problem, introduce our General Ontological Model for Adaptive Web Environments (GOMAWE), demonstrate experiments used for evaluations and indicate the steps leading to completion of the work.

Keywords: adaptive hypermedia, personalization, user modeling, general model, formal description, e-learning, Semantic Web, ontologies, interoperability.

1 Introduction

Humans constantly monitor the world around them. Computers, however, are built to do what they are told to do, nothing more, and nothing less. Generally, computers do not exhibit such modeling behavior as humans do [1]. Adaptive systems should remedy this by storing a user model containing each user's preferences. User adaptive systems perform incremental behavior analysis to model the user and using the stored information the adaptation is performed.

Many researchers are working on the development of solutions for content and navigation adaptation of hypermedia spaces. Adaptive systems are mostly used in the fields of e-commerce or e-learning. Several models have been proposed for the description of adaptive hypermedia architecture. However, most of the current systems are developed using ad-hoc approaches and as a result are unable to cooperate and reuse their data.

Our work is motivated by the state of the art in the area of adaptive hypermedia systems. There are still shortages which need to be addressed. One obvious problem is that authoring of adaptive system is a difficult task. Therefore we need automatic authoring techniques. The next problem is related to the reuse and exchange of data.

Current systems do not store the data in a machine-understandable way, which makes data reuse and collaboration impossible. This is where the latest research started to utilize semantic web technologies in the context of adaptive personalization.

We would like to be able to create good adaptive systems with the ability to reuse data and cooperate with each other. This includes more individual problems. We can define these problems as research questions which will be answered through the results of our work.

- *How to create a user adaptive system?*
- *How to store the data within the system to enable their reuse and interchange?*
- *How to evaluate the user adaptive system?*

A strong formal theory of adaptive hypermedia is needed to correct the aforementioned shortcomings. Such theory is still missing, although the first attempts have been made [2], [3]. We want to use Semantic Web to define a formal description of adaptive systems and throughout our work we want to answer the research questions based on such theory.

2 Related Work

Personalization is the activity where a system is changed to conform better to the user. This is typically performed by explicit user actions (e.g. preference screen). Opposed to this, *adaptive personalization* means that the user's actions are observed by the system and used to base a user model. Data in the user model is used to personalize the presented information.

Several approaches can be used to personalize the information presented to the user. In adaptive hypermedia that our research is focusing on, the content of regular pages can be adapted (*content-level adaptation*) as well as the links from regular page, index pages, and maps (*link-level adaptation*). The overview of the adaptation techniques can be found in [4], [5].

The user model is a representation of information about an individual user that is essential for an adaptive system to provide the adaptation effect. We can classify user models along three layers: what is being modeled, how this information is represented and how different kinds of models are maintained [4]. Important user features to be modeled are the *user's knowledge, user's interests, user's goals, cognitive styles* and *context of the user's work*. For the development of personalized web there have been designed several models. In our work we analyzed the most known of them and we compared their features [5].

Semantic Web technologies have begun to creep into use in the hypermedia applications. These technologies are becoming popular in the field of adaptive hypermedia, because they provide means to overcome the interoperability problems connected with current adaptive systems. Improved solutions will be based on ontologies and also take into account existing standards.

3 Contributions

The aim of our work is to develop a formal model for adaptive web systems and a methodology for the development of adaptive systems based on this model. In our previous work we have analyzed the most desirable requirements of good adaptive systems which are missing in most of the current systems. Based on these requirements we have extended the modeling loop of adaptive systems [5]. We based our work on the GAM [1] foundations and we intend to make it a powerful tool for designing adaptive systems, by extending this model with new functions, new approaches and Semantic Web technologies.

We will introduce the General Ontological Model for Adaptive Web Environments (GOMAWE[1]). The GOMAWE is a model based on the semantic data representation. Such representation can be utilized by machines in process automation, data integration and reuse of knowledge across applications. The machine understandable contents are called metadata and their semantics can be specified using ontologies. Ontologies play an important role in the Semantic Web as they provide a common shared model to represent a domain and to reason about the objects in the domain.

The architecture of GOMAWE can be divided into several layers as depicted in Fig. 1. Important part of the model is the storage layer. The data structure is represented by an ontology, which enables the storage of metadata together with the data. Furthermore, the ontology is not a monolithic detailed ontology, but the data structure consists of multiple lighter weight ontologies, which can be used together. These ontologies should be independent, modular and layered. The user model is in fact an overlay model consisting of instances of objects described by the ontologies.

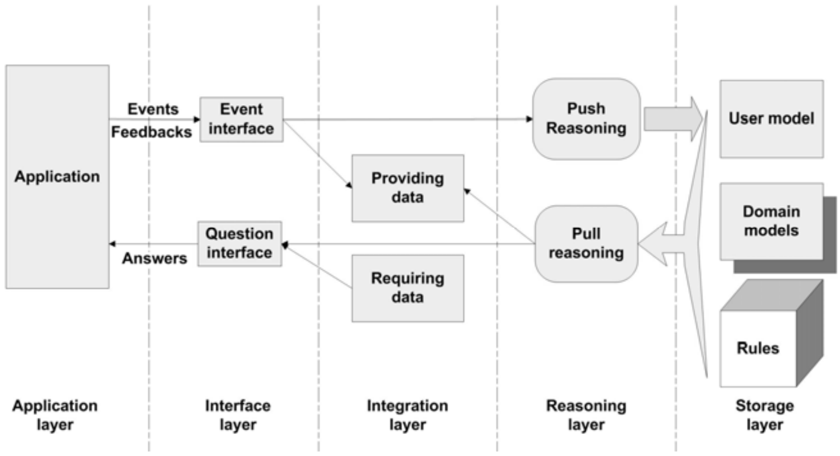

Fig. 1. Overview of the General Ontological Model for Adaptive Web Environments

[1] Gomawe is a New Caledonian god who created humans. Similarly, our model will be used to create adaptive web systems for humans.

To query for information from ontologies we have reasoning mechanisms derived from the description logic. However, we need rules to make further inferences and to express further relations not provided by the ontological reasoning. A rule is formed by an event, a condition and an action to be performed. Selected ontologies appear as layers on the dimensions of a multidimensional matrix. This was inspired by the semantic framework proposed by Italian researchers in [6]. Multidimensional matrix structure is used to select corresponding rules and thereby infer further information not included in the user model.

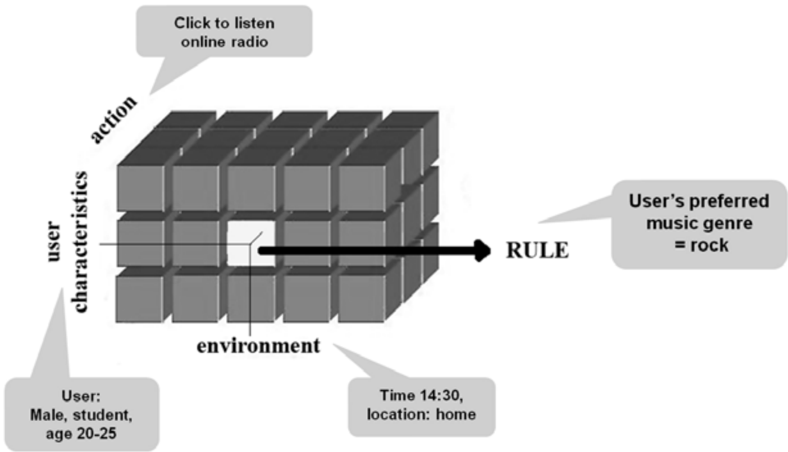

Fig. 2. Multidimensional matrix example (three dimensions)

The basic idea of the matrix is that the rules can be defined on the points of intersection between planes. The rule specifies classes of properties of classes that contribute to define the value of the inferred feature. For demonstration, let's assume situation on adaptive music web portal (Fig. 2). We will consider the following ontologies: *user characteristics*, *environment description* and *user's actions*. Then we can provide a rule that defines the property *user's preferred music genre* as an intersection of the planes.

4 Evaluation

To verify the theory, we need to perform experiments and implement a system based on this theory. This is an important step for making the model exercisable in practice. In the first phase of our research we have focused on the field of e-learning and developed ontologies of course materials and student progress in the course. We have also experimented with the tools for accessing the ontology data such as RDFReactor, RDF2GO and Jena semantic framework. Based on these experiments we are now developing a fully functional adaptive web portal. This web application is written in java language, is based on MVC architectural design paradigm, utilizes the Spring framework and the above mentioned tools to access ontological data in the database. With a functional adaptive system based on our model, we will have the possibility to perform further experiments.

5 Work Plan

Our work should be heading towards the development of a general model for adaptive hypermedia systems. We have identified six important steps leading to completion of our work. 1. We have analyzed requirements of adaptive systems. 2. We have proposed a general model for adaptive systems in correspondence with the requirements. 3. We have defined fundamentals of the formal description, which will be extended in our future work. Now is the appropriate time for the next step. 4. We are implementing a prototype hypermedia system based on the theoretical model. It will serve for further experiments and model verification. 5. During the experimental implementation we will define a methodology for the development of adaptive systems. 6. The last step of our work will be the evaluation of the experimental system to verify our theoretical proposals.

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