Enhancing adaptive capabilities of an adaptive hypermedia system

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Abstract

In a complex hyperspace, people may experience the problems of disorientation and cognitive overload[Conklin, 1987] and to overcome these problems, adaptive hypermedia technologies provide personalized information to learners with different learning paces, abilities, interests, etc[De Bra *et al.*, 1999]. However, it is difficult to predict complex situations that could arise during navigation in an adaptive hypermedia in advance. For example, users may want to extend the contents of an adaptive hypermedia when they find some information using a search engine. In this paper, we propose an approach by which adaptive capabilities of an exiting adaptive hypermedia such as adapting according to changes of a domain model or a user model can be enhanced.

1 Introduction

An adaptive hypermedia offers personalized presentation and navigation based on a user model that stores user's attributes[Wu *et al.*, 2001]. In general, an adaptive hypermedia system updates the attribute values of a user model by observing user's behavior, which is mainly browsing [De Bra *et al.*, 1999]. However, a user can use an external application and user's attributes of the user model can be affected by user's behavior that occurs in the application. (See figure 1.)

For example, a user can listen to music and read a musical note which is related to a composer while browsing contents about the history of music in an adaptive hypermedia. In this case, the user may be interested in or have some knowledge of the composer.

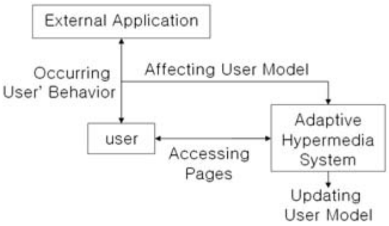

Figure 1: Update of a user model by observing user's behavior in an external application

In addition, the contents of an adaptive hypermedia can be limited because it is decided based on the author's knowledge about the domain. Users may want to embed external contents in the adaptive hypermedia. For example, a user can retrieve useful information using a Web search engine and the user may want to include the information among the contents of the adaptive hypermedia. (See figure 2.)

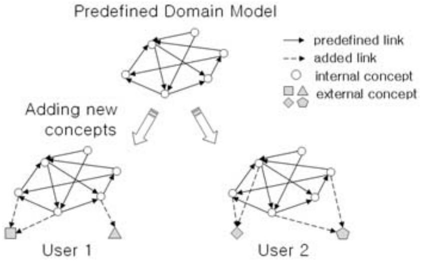

Figure 2: Extension of a domain model by adding new concepts

In this paper, we propose an approach by which various types of user's external behaviors can be reflected in adaptive functionalities of an adaptive hypermedia. The goal is to identify and design relevant functions to support more personalized and delicate adaptations than can be supported by an existing adaptive hypermedia system. To achieve this, we modify AHA![De Bra *et al.*, 2003] which is an open source adaptive hypermedia system.

This paper is organized as follows. In section 2, we describe related works. In section 3, comparisons between an adaptive hypermedia and an extended adaptive hypermedia using our approach are explained. Section 4 describes how a user model can change when a user uses an external application or a domain model needs to be changed because new contents are introduced inside an adaptive hypermedia. Section 5 concludes the paper.

2 Related works

[Aroyo *et al.*, 2004] presents an approach that embeds results of information retrieval in an adaptive hypermedia. It adds a retrieval model that obtains the relation between the retrieval content and the domain model of the adaptive hypermedia. The retrieval model describes the mapping between concepts from domain model and terms from the ontology which represents the retrieval content.

In [Keewoo *et al.*, 2005], a learning tool called NEO-VAM[Keewoo Lee and Seongbin Park, 2005] which was created for helping students learn the concepts of automata was extended. The extensions were made in order to provide students who have different backgrounds with appropriate contents to learn.

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In [Hyosook Jung and Seongbin Park, 2005], an approach that can observe and process user's behavior using a message hooking technique was proposed. The user model is updated by both browsing behavior inside the adaptive hypermedia system and behaviors that occur outside the adaptive hypermedia system.

3 Extending adaptive hypermedia

Extending adaptive hypermedia focuses on the extension of existing contents and handling of external behaviors.

For extensibility of a domain model, we insert information for added concepts in individual user models instead of changing the whole domain model whenever a user adds or deletes a concept. This is because users may be confused if different contents and links appear whenever they access the system. In addition, the added contents may be useful to some users but not necessarily for others because they may have different interests.

For utilization of the external user behavior, we extract information of external document, file, or program which users read or execute. For example, we can hook user's events in a local computer and check whether the events are relevant to the adaptive hypermedia. When a user accesses a Web page, we extract information from title or meta data of the page and determine whether it is relevant to the adaptive hypermedia

Table 1 shows the comparison between existing and extended adaptive hypermedia systems based on three factors. First, type of user's behavior means whether the system observes internal or external events. Second, structure of domain model means whether the contents are fixed or extendable. Third, observed user's behavior means which events the user model is updated by.

Table 1: Comparison of existing and new adaptive hypermedia system(ES : Existing System, NS : New System)

factor		ES	NS
type of user's behavior	internal event	O	O
	external event		O
structure of domain model	fixed	O	
	extendable		O
observed user's behavior user model	accessing pages	O	O
	adding concepts		O
	outside behavior		O

While ES processes the internal event, NS processes both new internal event to add new concepts and external event that occur in other applications. ES has fixed domain model whose structure is designed by authors in advance, but NS has extendable domain model because it allow users to add new concepts. ES updates attribute values of the user model each time a user accesses a page. However, NS updates them when a user add new concepts or user's outside behavior affects the user model as well as accessing pages.

4 Design of adaptation

For performing the extended adaptation, the adaptation engine has to contain new modules. We add several modules to adaptation engine of AHA! which are Java servlets that perform adaptation. (See figure 3.)

First, we include the module that handles the user's behavior that occurs in the external application. We can call local pages on purpose[Keewoo *et al.*, 2005] or use the message hooking technique[Hyosook Jung and Seongbin Park, 2005] for detecting the user's behavior. It checks whether user's behavior affects user's attributes of the user model and updates the attribute values if the behavior is meaningful.

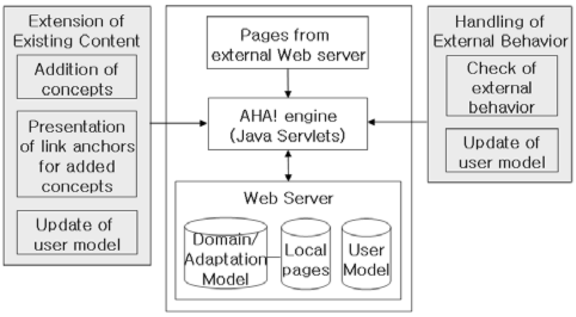
Extension of Existing Content
Addition of concepts
Presentation of link anchors for added concepts
Update of user model
Pages from external Web server
AHA! engine (Java Servlets)
Web Server
Domain/ Adaptation Model
Local pages
User Model
Handling of External Behavior
Check of external behavior
Update of user model

Figure 3: Including several modules in the adaptation engine of AHA!

Second, we include the module that extends the content of the adaptive hypermedia for each user. It represents a Web page which is retrieved by users as a concept and adds the concept to the predefined domain model. Because users want to add different contents according to their features, it saves attributes of the added concept at the user model. The original structure of a domain model remains the same and presents the link anchor to move to the Web page. Users can construct different structure of the domain model and see different link anchors although they request the same page.

4.1 Extension of existing contents

When a user retrieves information using search engines, the user considers a Web page as a new concept of the domain model. Users will add different contents according to their background, interest, or goal. Therefore, we insert attributes about the new concept at each user's profile and the structure of the existing domain model does not change. The users are provided their own additional contents.

Addition of concepts

When a user searches a useful Web page, the user enters URL of the page, names the page a abstract concept, and defines the concept which is related to the page out of concepts of domain model. The system receives the data from the user and stores the data in the profile for the user.

For example, if a user finds AHA! Web site while learning the concept about adaptive hypermedia, attributes of the user's profile is inserted as in Figure 4. Also the system modifies and deletes the attributes of the added concept.

Figure 4: Insertion of the attribute

```
<record>
 <key>AHS.addedlink.AHA</key>
 <type>string</type>
 <persistent>true</persistent>
 <value>http://aha.win.tue.nl</value>
</record>
```

Presentation of link anchors for added concepts

The system has to allow users to access the added Web page (i.e., it must present a link anchor for accessing the Web page). To achieve this, the system reads user profiles each time they require a local page in the adaptive hypermedia. If there are added Web pages which are related to the local page, the system presents the link anchors to jump to the Web pages at the local page. The system first searches the concept name of the local page in the index file of the domain model. If there are added links for the concept name, the system presents the local page, containing link anchors to move the added Web pages.

Update of a user model

The fact that a user adds new concepts means that the user is interested in or has knowledge about the related concepts. That is, the behavior can increase user's knowledge or interest. Therefore, the system has to update user's attribute values of the user model. When a user adds a new Web page to the current local page, the system updates attribute values which are related to the concept of the current local page.

4.2 Handling of external behavior

When a user uses external applications, user's behavior in the external applications can affect user's attributes of the user model such as knowledge or interest about an adaptive hypermedia. The system has to update attribute values of the user model by observing meaningful user's behavior.

The system can observe the behavior by applying two approaches, which are to allow the external application to call the related local pages on purpose [Keewoo *et al.*, 2005] and to use the message hooking mechanism [Hyosook Jung and Seongbin Park, 2005].

Check external behavior

The system receives information which is related to the user's behavior in the other application such as running a certain program or file. The system checks whether user's behavior is relevant to the adaptive hypermedia.

For example, it is meaningful that the user reads PDF file which is Bach's musical note or executes a MP3 file while browsing contents about the history of Baroque music in an adaptive hypermedia.

Update of user model

According to the type of the user's behavior, the system updates user's attribute values. In the above example, we can infer that the user is interested in Bach. The system increases values of user's knowledge or interest.

5 Conclusions

In this paper, we present an approach by which various adaptive features can be introduced into an adaptive hypermedia. There are two ways that a user model can change; one comes from the fact that a user uses an external application and the behavior of the user is reflected in the user model. The other stems from the fact that a user accesses an external web page and the contents need to be included in the adaptive hypermedia.

We note that there are many difficulties that need to be overcome when we wish to exploit external user behaviors in an adaptive hypermedia.

Our approach can extend the adaptive hypermedia system in various ways. First, because users can add useful information to the contents that the author designed according to their attributes, they can construct a different domain model which is suited to the structures of their own knowledge. Second, because the system updates user's attribute values of the user model by adding new content and user's external behaviors can be utilized, it can offer the adaptation that is more appropriate for the current user's attribute than existing adaptive hypermedia systems can provide. Third, because we support combining an external application with adaptive hypermedia, we can help developing various applications.

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