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The Next Big Thing: Adaptive Web-Based Systems

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Abstract

At the ACM Hypertext Conference a panel discussed "The Next Big Thing Inc." in the area of hypermedia. The Web has been the "Big Thing" during the past 10 years, but its success has also made two predictions for the future (within three to five years from publication):

1. Introduction

- the emergence of a mass market for hypertext;
- the integration of hypertext and other computer facilities.

It has taken a bit longer, but other than that the predictions were spot on. To some extent World Wide Web technology has been used come true. The Web itself is the best illustration of the mass market come true. With over 3 billion pages at the time of writing this paper then proposes a new, modular architecture that should lead to adaptive Web-based systems as the "Next Big Thing" indeed. I different applications can collaborate in creating and updating a user model. Shared user model needed for adaptive Web sites, but are also the key to enabling the development of ambient information systems then need to work together and base their actions on common knowledge about their models can of course cause a "big brother" problem. Legislation is already in place to protect legal limits on the kind of user modeling and sharing of user models that is allowed. The paper legal issues of user modeling and adaptation in order to provide not just a future outlook base but based on a realistic vision of what will not only become technically possible but also of which adaptive hypermedia has been used until now. The paper then proposes a new, modular architecture that should lead to adaptive Web-based systems as the "Next Big Thing" indeed. Hypertext, and the Web in particular, offers three ways to find information:

- When you know the precise location of the information you want, you type a URL in the browser's location field, and you have it available online as well as sometimes even only online. Traditional help systems, like Microsoft Windows help, also have hypertext functionality integrated with other computer facilities.

- When you have a good description of what it is you wish to find, the modern search engines are very good at finding the information. A bookmark list can help to remember the location of information you found before.

- When you want to explore the Web hoping to find interesting information, for instance hoping to find the sorts of things "Paul De Bra" has been mentioned on the Web, the real problem starts. You can browse and search all you want, but you will most likely not find the information you are interested in at that time. When you start browsing the search results for "Paul De Bra", the above appears to be among the first 50 hits (out of over 2000). Browsing may provide access to all the information (that is linked) but information you are interested in.

The core problem in finding the information you want, in all the above cases, is describing what you want. Results from search engine most search requests are too short and unspecific to yield good results. Once a Web site with interesting information is found, it is often interesting pages only, because the site can only be navigated using its predefined link structure, independently of the search request
The community of user modeling and adaptive hypermedia offers solutions for this problem: using information gathered about the user, the system can change the information content and link structure on-the-fly. User modeling captures the mental state of the user, and thus allows to query the explicit queries (or links) in order to determine precisely what the user is looking for. To support the design of this user model, several models have been developed, targeting various application domains, i.e. educational applications (ELM-Al Brusilovsky (1998), Interbook developed by Brusilovsky et al. (1998), KBS-Hyperbook by Herzog and Nejdl (2001), NetCoach by Weber et al. (2003), and others). The content and link adaptation rules are typically defined in the adaptation model (AM). In AHAM and other architectures, the adaptation model is typically an overlay model of the domain model "concept" in the domain model there is a corresponding "concept" in the user model that represents how the user relates to that concept. The adaptation engine will check whether the page is suitable in the domain model and if so, it will adapt the page according to the user model and the model is updated.

To become "The Next Big Thing", adaptive hypermedia systems need to open their architecture to allow collaboration between sites to become technically possible. The latest developments within the scope of the Semantic Web are leading adaptive hypermedia towards the "Adaptive Web" paradigm, an organized information in concept structures, where collaborative Web services allow for the encapsulation of the diverse knowledge, architecture, and for a more dynamic and sharable framework for automated personalization or adaptation. In this way, current adaptive hypermedia systems can be extended with powerful reasoning at the level of standardized concept schemes, as opposed to the traditional hand-crafting by author relationships, thus allowing adaptation generation in open information spaces on a higher schema level.

This paper first briefly recalls and summarizes the overall architecture of (Web-based) adaptive hypermedia systems (AHSs) to show how architecture to enable different AHSs to work together at different levels: the conceptual structure, the user model, and the adaptation engine. This paper also presents some legal problems that arise as a consequence of opening the user model to be shared among various applications, which is technically unacceptable in the improved adaptive hypermedia architecture we propose.

2 Adaptive hypermedia architecture

On the Web personalization is being realized in two ways:

- Some Web sites require users to register and provide information about their interests. The site takes the interests into account when creating a user profile. The profile is only updated when the user revisits it to make changes.
- Some Web sites require users to register only so they can be identified. Identification is also possible through cookies, in which case the identification taking place. The site monitors the user's browsing behavior (and in particular the pages that are visited) in order to represent the user's interests and knowledge. The presentation is updated according to the user model and the model is updated.

The former category of systems is called adaptable, the latter adaptive. A lot of research has been performed in the field of adaptive focused on coming up with new ways of adaptation, to offer the user better, more suitable, more acceptable and more visible guides. Web sites have to offer. Another sub-area has focused on finding higher-level ways of describing aspects of the application domain and the basis for performing adaptation. In the AHAM reference model, by De Bra et al. (1999) and Wu (2002), the core of the architecture of adaptive hypermedia systems is given by three closely linked components: the domain model (DM), the user model (UM) and the adaptation model (AM). In AHAM and other architectures, the relationship between the three submodels of the storage layer, e.g. the user model is typically an overlay model of the domain model. In the domain model there is a corresponding "concept" in the user model that represents how the user relates to that concept. The adaptation engine will keep track of the user's knowledge of each of the concepts in the domain model. The interplay between the user request, the adaptation engine, and the presentation of the requested page can be adapted through adaptation rules in two ways:

1. The user requests a page by clicking on a link in a Web page. Every page corresponds to a "concept" in the domain model and a overlay model.
2. The system checks the suitability of the requested page for this user. For this it needs to look at concept relationships from the user model. A typical relationship that plays a role in determining the suitability is the prerequisite rules to check whether the page is suitable are defined in the adaptation model.
3. The system performs updates to the user model through (other) adaptation rules, e.g. the knowledge value of the concept page is increased, and is increased more when the page is considered suitable than when the page is considered not suitable. The knowledge value propagates from pages to sections to chapters.
4. The presentation of the requested page can be adapted through adaptation rules in two ways:
   - The information content of the page can be altered, e.g. by conditionally including or hiding fragments. When a prerequisite explanation can be inserted, or when an interest value is high, additional details can be shown. Another possible adaptation media item based on preferences of the user.
   - The links that emanate from the page can be manipulated. Links to pages that are considered not suitable can be hidden, or even removed. The link destination can be changed as well.
5. Optionally the adaptation to content or links (e.g. the inclusion of a fragment) can cause user model updates as well.

Many adaptive hypermedia systems have been developed, targeting various application domains, i.e. educational applications (ELM-Al Brusilovsky (2001), Interbook developed by Brusilovsky et al. (1998), KBS-Hyperbook by Herzog and Nejdl (2001), NetCoach by Weber et al. (2003), and others). The content and link adaptation possibilities given above are just a few from a much larger set. The latest developments within the scope of the Semantic Web are leading adaptive hypermedia towards the "Adaptive Web" paradigm, an organized information in concept structures, where collaborative Web services allow for the encapsulation of the diverse knowledge, architecture, and for a more dynamic and sharable framework for automated personalization or adaptation. In this way, current adaptive hypermedia systems can be extended with powerful reasoning at the level of standardized concept schemes, as opposed to the traditional hand-crafting by author relationships, thus allowing adaptation generation in open information spaces on a higher schema level.

This paper first briefly recalls and summarizes the overall architecture of (Web-based) adaptive hypermedia systems (AHSs) to show how architecture to enable different AHSs to work together at different levels: the conceptual structure, the user model, and the adaptation engine. This paper also presents some legal problems that arise as a consequence of opening the user model to be shared among various applications, which is technically unacceptable in the improved adaptive hypermedia architecture we propose.
Figure 1. Overall architecture of the AHA! system

Figure 1 shows that the three submodels (DM, UM, AM) all reside on a central Web server, together with the "local pages" (content from Java Applets handles page requests. Pages can come from external servers, but the corresponding concepts must exist in the local domain model, updates to the user model. That user model is used to perform the adaptation.

The centralized architecture of AHA! (and several other systems) has the advantage that the DM, AM and UM can work closely togethe retrieve the DM and AM when the server starts, and the UM when the user logs on, and to keep all that information cached in memory UM to disk (or database). For adaptive systems to work together, as suggested in the introduction, a new, decentralized and modular presented in Figure 2. The issue of optimization is transferred towards the bridging protocols and the information request coordinatio that architecture. We recognize that performance remains very important as a key to the success of adaptive information services in performant as non-adaptive services.

Apart from the issue of collaboration between adaptive systems, the centralized architecture has some other drawbacks: the semanti domain is usually stored inside a local domain and adaptation model. Relationships between concepts are "hidden" inside adaptation r graphical interface - i.e. Graph Author in AHA!, Figure 1 - for the authors to define the concepts and relationships and make high-leve difficult to "export" the semantic information contained in the DM-AM combination to applications that deal with concepts and relati difficult to "import" semantic information, e.g. an ontology, into an AHA! application. Also, the user model cannot be accessed by exit by applications running on the same AHA! server. Knowledge gained by the user through an online course cannot be used by an online department in order to initialize the user model there.

The next section looks at various research efforts attempting to provide solutions for these problems while facilitating adaptation to\ and distributed open information space. Methods are proposed to improve the quality, consistency and linking of Web documents whil authors when creating the adaptation. Reflecting on this work we propose a new, modular architecture of an open Web-based adapti above difficulties.

3 Modular adaptive hypermedia

While ubiquitous computing was still a far fetched vision when introduced by Weiser at the Computer Science Lab at Xerox PARC in 1989 and a promising part of our everyday lives. After the age of mainframes (one machine - many people), and after the boom of personal person), now we are moving towards "the age of calm technology", as described by Weiser and Brown (1996) (one person - many comp refers to it: the "Third Paradigm" of computing.

The essence of ubiquitous computing is to offer to users systems with "invisible" (ambient) intelligence, which will be able to know ab desired service, content and presentation, without intrusion and unnecessary human computer interaction. Adaptation across app and realized with the notion of adaptive Web-based systems, defines the goal today: to provide adaptation within software environm interact simultaneously with various applications. For this we need open and modularized architectures, which are able to interact, e components. A fundamental issue in such architectures relates to the coordination, handling and control of all the components (servic biggest challenges in this context is the sharing, synchronization and interpretation of the user model among the different application within each system will be permanently evaluated and more detailed, and richer user models will be achieved in order to allow for peronalization of the content. This paper presents our approach for achieving this openness and modularity of the adaptive hyperme different AHSs to work together at different levels (e.g. conceptual, user model, and adaptation) we see the need for four main asp:

- supporting a strict separation of domain model, application model, adaptation model and user model, to ensure good modulariz
- maintaining generic sharable (dynamic) models, such as the user model, to serve as a communication point for different AHSs;
● providing semantically rich descriptions of the components’ functionality and their internal formats, to allow for interoperability
● providing mechanisms to describe the management, i.e. co-ordination and orchestration, of the communication between the system components.

The basic idea is that by augmenting encapsulated system modules with rich formal descriptions of their competence, we can further aspects of the system management. The role of sharable models such as the dynamic user model is crucial for enabling inter-system sharability and reusability of user-related modules. Finally, by applying open Web standards we can enable interoperability and wide hypermedia systems.

Currently research in the area of the Semantic Web, originating primarily from the knowledge engineering and artificial intelligence field, ontologies and Web services, provides a number of standards and accompanying solutions which can be used to achieve the above. We have the notion of ontology, which plays a role in facilitating the sharing of meaning and semantics of information between systems. A number of representational formats have been proposed as W3C standards for ontology and metadata representation. The most current existing Web standards (e.g., XML, RDF and RDFS) and add the primitives of description logic as powerful means for reasoning services. Initiatives to illustrate this are the SHOE metadata annotation of Web content (Heflin et al., 1999). The idea was further elaborated in a recent project (Mulholland et al., 2001), with use of ontology concept instances, considering evolving ontologies and offering annotation in a semi-automated way.

Several other annotation tools are known to the research community, e.g., the Amaya Web editor for RDF-based mark-up of resources points out the advantages of a centralized server, and its unapplicability in "open" environments. It exemplifies a good scenario for co-located "closed" content spaces, and illustrates its difficult implementation in an "open" information space. Other examples of annotation systems include the COHSE (Carr et al., 2000), the CREAM-based Ont-O-Mat Annotizer (Handschuh et al., 2001), and the Lett project (Vargas-Vera et al., 2002), Lett.

As the annotation is only part of the content authoring, another rather labor-intensive part is the process of linking the annotated content. Hypermedia Services Environment (COHSE) developed by Carr et al. (2000) introduces an ontological reasoning service over domain knowledge combination with a Web-based open hypermedia link service: this enables documents to be linked via metadata describing their context. Another recent project inspired by COHSE and applying ontologies and semantic services for the automation of semantic content (Carr et al., 2003). This project facilitates various interpretation views on the same content with no prior mark-up, but by means of adding an above-mentioned semantics and offer means for flexible composition of services (system components) through automatic selection, verification of service properties, and execution monitoring. In an approach such as DAML-S/OWL-S (DAML for example, the ProcessC definition in terms of its state, initial activation, execution, and completion. The ServiceModel, on the other hand, provides a means to control the flow in the case of a composite service, and the ServiceGrounding specifies the service access to information by communication mechanisms, etc.

Another relevant approach for describing the role of Web services in system architecture is the Web Service Modeling Framework (WSMF). That research shows that Web services appear to be a useful solution for achieving modularity. We can achieve reasonable autonomy at the main aspects of Web services (e.g., Web service location, composition and mediation) by extending them with rich formal descriptions of their functionality and the context of AHs, as shown by Figure 2.
Figure 2 illustrates our vision of the modular architecture for adaptive Web-based systems (Chepegin et al. 2003). One of the first characteristics is that the different system components are all equipped with facilities to communicate with the (other) components in terms of service bridges. This is in accordance with the UML framework connector defined by Fensel et al. (1999), in order to specify mappings between components within the architecture. Ontologies also play an important role to define and unify the system's terminology and properties to describe services. Each service can be specified by means of a corresponding ontology, providing common ground for knowledge sharing, exploitation of services. This leads to a highly modularized architecture which offers a high degree of flexibility.

In the case of adaptive systems access to the user model via a Web service is a good example of this flexibility. It means that designers can interact with or react to the user intelligently without knowing anything in advance about that user, but simply using the knowledge they have of the user interpreting it in the context of the current application. Crucial for achieving such a flexible architecture is the need for a standardization of information about users. As mentioned above, open standards (e.g. XML, RDF, OWL) allow for the specification of ontologies to stand as a basis for reuse and interoperability. Another key aspect is to facilitate mobile user models that follow the user across applications. Agents provide implementation views supporting mobility and autonomous behavior. A final but important requirement is for the user to access system and knowledge components, and thus benefit from other applications.

A second characteristic seen in Figure 2 is the separation of the different components. In the traditional AHS approach, exemplified by the work of de Bra (section 2), when transforming these components into services they need for a fourth component, the application model service lies in the ability to adapt the actual process of how to adapt with the decision. In addition, when designing in AHA!, the designer's knowledge about why the user is served a certain way is more or less left to the application itself, while in the traditional AHS approach the adaptation model unites the actual process of how to adapt with the decision about who the user is and what they want. In the traditional AHS approach the adaptation model service contains a generic description of the user tasks in the context of a Role-Goal-Task (RGT) model. It is clear that this gives the application model service a crucial role in the system architecture. It divides the adaptation process into technical adaptation performed by the adaptation model service, while the management of the service process is coordinated from the application model service. In the interaction with the application the user is represented by a particular role (e.g. customer).
administrator (student). This role defines for him/her a corresponding behavior in terms of goals to achieve. To accomplish the user's applications are used, which realize one or several corresponding methods. The adaptation model service receives the direct user in application model service in order to define the context for the user input for its most precise adaptation. Further the adaptation model service in order to select the relevant content to be presented to the user. The domain model service is responsible for the extension domain knowledge in terms of concepts of a domain ontology. Finally, it updates the user model with new values. For instance, when application, every action they perform on the user interface is communicated to the user model service, which is responsible for updating the values. The user information is stored there and a reasoning engine infers new knowledge from it and makes predictions concerning it.

User model service allows for sharability of the user model between applications by following the user (inside and outside the system) analyze data about the user's activities.

The following section discusses some possible disadvantages and legal problems raised by this open modularized architecture with respect to access by various collaborating parties.

4 Legal issues in adaptive hypermedia

We do not claim to have any meaningful expertise in legal matters. However, before people start envisioning a great future for user modeling companies to perform personalization and adaptation for new and existing customers based on a "big brother" type of server that sells everything a user has done online, it is only fair to summarize a few existing and emerging efforts to make offering such services illegal.

Kobsa (2002) points out that whereas privacy laws vary between countries, there are common principles, and some countries demand that everyone who performs actions that have an effect in these countries. As a result it is wise to abide by the strictest laws when creating user profiles.

Some noteworthy issues are:

- Usage logs must be deleted after each session. This implies that adaptive systems may store the effect of user actions in a user "raw" actions. AHA! version 1.0 for instance kept a permanent log of user IDs and timestamps of every access to a page and the AHA! version 2.0 the logging functionality has been removed, and in a future version we will introduce a log that is kept for the long-term to keep a complete log when the user agrees, but only if the system would offer the same functionality when the user does not keep a log.
- Usage logs of different services may not be combined. It is still unclear what the impact of such laws is on the proposed modular model becomes a service that can be used by different and distributed applications. We would of course like to create user models that are gathered from different sites, but this may or may not be allowed depending on the interpretation of the word "services" course program is one service, thus justifying the sharing of user model information between applications or courses within that department of an electronic shopping mall that interact with customers independently could be considered one service, and the user. However, it remains to be seen whether this interpretation will be followed by the future.
- Users should have a real, voluntary choice between an anonymous "login" (or login using a pseudonym) and a normal login using the version 2.0 anonymous logs are possible, yielding the same adaptation as non-anonymous logs. It helps to provide users with standard notice about the data that is to be collected, and to indicate the purposes for which this is being done.
- User modeling should be "transparent", or "scrutable": users should be able to inspect their user model and understand what it is that is being change or erase data, especially the assumptions the system inferred about them.
- The user models should be protected using adequate security measures. When user modeling becomes a service, accessible by non-trivial to shield user models from intruders and eavesdroppers.

This short list is far from complete, but it already shows that for adaptive Web-based systems to become a "big thing" there are a number of clarifications and then implemented into the systems.

5 Conclusions and future work

Adaptive Web-based systems are ready to make the jump from single applications to modular distributed frameworks in which multiple models and adaptation rules. The challenge for the future is to get research groups to work together to develop standards for exchange and adaptation model level, so that different systems can indeed start to share user modeling and adaptation information. While new also need clarity in the legal issues involved in sharing user modeling information. We are opposed to a "big brother" style of user modeling with voluntary user consent some sharing will be allowed under controlled circumstances. With many applications of adaptive Web-based systems, the idea of adaptive systems can still become a "next big thing".

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Links

Amaya Web Editor http://www.w3.org/Amaya/

Annotea http://www.w3.org/2001/Annotea/


DAML Services http://www.daml.org/services/