The next big thing: adaptive web-based systems

The Next Big Thing: Adaptive W Based Systems

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Abstract

At the ACM Hypertext Conference a panel discussed "The Next Big Thing Inc." in the area of hy hypermedia. The Web has been the "Big Thing" during the past 10 years, but its success has als to find the appropriate information in an ocean of over 3 billion pages. Whereas search engine precision, they suffer from the same "one size fits all" approach that characterizes the Web sit paper defends the position that personalization, and in particular automatic personalization o to reach the goal of offering each individual user (or user group) the information they need. D discussion there was debate about whether the user should always have access and control ove (hypertextual) information space. There were different views on whether the "right" to all the guaranteed by offering tools that reduce the information space the user perceives so that the and reach the information, or by offering unfiltered access to an ocean of information in whic but in which perhaps nothing can be found. We argue in favor of adaptation but at the same t the way adaptive hypermedia has been used until now. The paper then proposes a new, modu 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 mod needed for adaptive Web sites, but are also the key to enabling the development of ambient i 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 u 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 wh

1 Introduction

Nielsen (1990)

made two predictions for the future (within three to five years from publication):

- 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 usec 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 p indexed by the largest search engines according to Sullivan (2003) - the Web has indeed reached the masses and is widely used all ove prediction we look at help systems. Many software products come with documentation in (html) hypertext form, sometimes included available online as well and sometimes even only online. Traditional help systems, like Microsoft Windows help, also have hypertext f subsystems, hypertext functionality has been effectively integrated with other computer facilities.

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 ir information. A bookmark list can help to remember the location of information you found before.
- When you have a good description of what it is you wish to find, the modern search engines are very good at finding the locatior (the first draft of) this article the first author was watching a program on hackers on National Geographic and remembered that security problem in the Solaris "tar" program. Typing the search terms "Paul De Bra", "tar", "vulnerability" and "solaris" into Googl the CERT Advisory describing the problem that he reported 10 years ago.
- When you want to explore the Web hoping to find interesting information, for instance hoping to find the sorts of things "Paul De has been mentioned on the Web, the real problem starts. You can browse and search all you want, but you will most likely not f available about topics you are interested in at that time. When you start browsing the search results for "Paul De Bra", the above appear to be among the first 500 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 oft 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 use change the information *content* and *link structure* on-the-fly. User modeling captures the mental state of the user, and thus allows th the explicit queries (or links) in order to determine precisely what the user is looking for. To support the design of this user model-ba like AHAM (De Bra *et al*. 1999, Wu 2002) and Munich (Koch and Wirsing 2002), both based on the Dexter Model by Halasz and Schwartz an attempt to standardize and unify the design of adaptive hypermedia applications, used mostly in isolated information spaces such shopping site, an online museum, etc.

To become "The Next Big Thing", adaptive hypermedia systems need to open their architecture to allow collaboration between sites t currently possible. The latest developments within the scope of the Semantic Web are leading adaptive hypermedia towards the "Ada 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 adap be extended with powerful reasoning at the level of standardized concept schemes, as opposed to the traditional hand-crafting by au relations, 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 h architecture to enable different AHSs to work together at different levels: the conceptual structure, the user models, and the adapta out some legal problems that arise as a consequence of opening the user model to be shared among various applications, which is tec 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 registered *user 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 the identification taking place. The site monitors the user's browsing behavior (and in particular the pages that are visited) in or representing the user's interests and knowledge. The presentation is updated according to the user model and the model is upda

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 guidan Web site has to offer. Another sub-area has focused on finding higher-level ways of describing aspects of the application domain and basis for performing adaptation. In the AHAM reference model, by De Bra *et al*. (1999) and Wu (2002), the core of the architecture of by three closely linked components: the *domain model* (DM), the *user model* (UM) and the *adaptation model* (AM). In AHAM and other relationship between the three submodels of the storage layer, e.g. the *user model* is typically an *overlay model* of the *domain mode* "concept" in the domain model there is a corresponding "concept" in the user model that represents how the user relates to that conc instance, the user model will keep track of the user's knowledge of each of the concepts in the domain model. The interplay between by explaining how an AHS processes a user's request, using its *adaptation engine*:

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 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* fro from the user model. A typical type of concept relationship that plays a role in determining the suitability is the *prerequis* 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 suitab propagates from pages to sections to chapters.

   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 prer explanation can be inserted, or when an interest value is high, additional details can be shown. Another possible ada media items 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 an 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-AI Brusilovsky (2001), Interbook developed by Brusilovsky *et al*. (1998), KBS-Hyperbook by Henze and Nejdl (2001), NetCoach by Weber e systems, or general-purpose adaptive hypermedia systems, like AHA! by De Bra *et al*. (2002) and De Bra *et al*. (2003). A detailed taxo used in AHS is given by Brusilovsky (2001). The content and link adaptation possibilities given above are just a few from a much larger AHSs have been developed with one application or application area in mind. A notable exception is the AHA! system developed as a g centralized architecture shown in Figure 1.

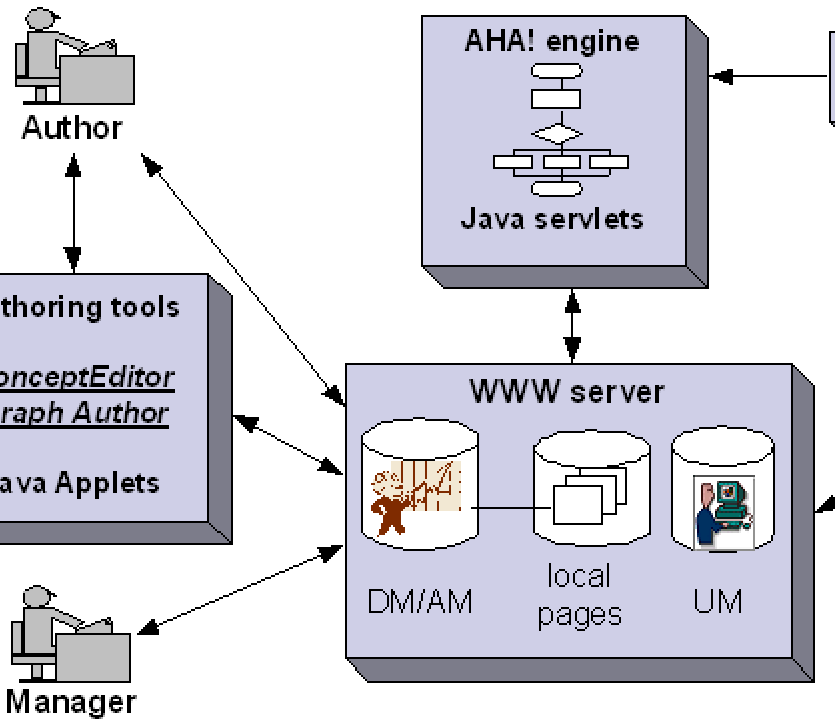

Figure 1. Overall architecture of the AHA! system

Figure 1 shows that the three submodels (DM, UM, AM) all reside on a central Web server, together with the "local pages" (content fra
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 relatic
difficult to "import" semantic information, e.g. an ontology, into an AHA! application. Also, the user model cannot be accessed by ext
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 v
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 adaptiv
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 19
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 applica
and realized with the notion of adaptive Web-based systems, defines the goal today: to provide adaptation within software environme
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 applicatior
within each system will be permanently evaluated and more detailed, and richer user models will be achieved in order to allow for er
personalization 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 aspe

- 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. coordination and orchestration, of the communication between the syst

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 i 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 f ontologies and Web services, provides a number of standards and accompanying solutions which can be used to achieve the above-me hand we have the notion of *ontology*, which plays a role in facilitating the sharing of meaning and semantics of information between number of representational formats have been proposed as W3C standards for ontology and metadata representation. The most curre 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 is the SHOE metadata annotation of Web content (Heflin *et al*. 1999). The idea was further elaborated in t *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 "closed" content spaces, and illustrates its difficult implementation in an "open" information space. Other examples of annotation syst project (Mulholland *et al*. 2000), the CREAM-based Ont-O-Mat/Annotizer (Handschuh *et al*. 2001), MnM (Vargas-Vera *et al*. 2002), Leti

As the annotation is only part of the content authoring, another rather labor-intensive part is the process of *linking* the annotated co Hypermedia Services Environment (COHSE) developed by Carr *et al*. (2001) introduces an ontological reasoning service over domain co combination with a Web-based open hypermedia link service: this enables documents to be linked via metadata describing their conte system. Another recent project inspired by COHSE and applying ontologies and semantic services for the automation of semantic cont *al*. 2003). This project facilitates various interpretation views on the same content with no prior mark-up, but by means of adding an (see Domingue *et al*. 2004). On top of this semantic layer Magpie deploys semantic services provided to the user as a physically indep resource.

Thus, the next step in the process of opening up AHS architectures is applying a *Web services* perspective on the system components. above-mentioned semantics and offer means for flexible composition of services (system components) through automatic selection, i 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 the control flow in the case of a composite service, and the ServiceGrounding specifies the service access to information by communi mechanisms, etc.

Another relevant approach for describing the role of Web services in system architecture is the Web Service Modeling Framework (WS That research shows that Web services appear to be a useful solution for achieving *modularization*. We can achieve reasonable autom the main aspects of Web services (e.g. Web service location, composition and mediation) by extending them with rich formal descript standardized languages such as RDF or OWL). In this way we can allow adaptive Web-based systems to reason about the functionalitie services, to locate the best ones for solving a particular problem, and automatically to compose the relevant Web services for dynami

An interesting approach that could serve as the basis for a successful application of the Web service perspective on AHS architecture i framework like the Internet Reasoning Service (IRS-II) introduced by Motta *et al*. (2003). They show how we can support the publicatio execution of heterogeneous semantic-rich Web services. The service uses UPML (Unified Problem-solving Method description Language knowledge-based systems by defining how we can build elementary components and how these components can be integrated into on Fensel *et al*. (1999). The IRS-II approach supports *capability-driven service invocation* (e.g. find a service that can solve problem X) b *task specifications* (the problems which need to be solved), *method specifications* (the ways to solve problems), and *domain models* (problems need to be solved). This separation of system components actually fits quite nicely with the requirements for exploiting the context of AHSs, as shown by Figure 2.

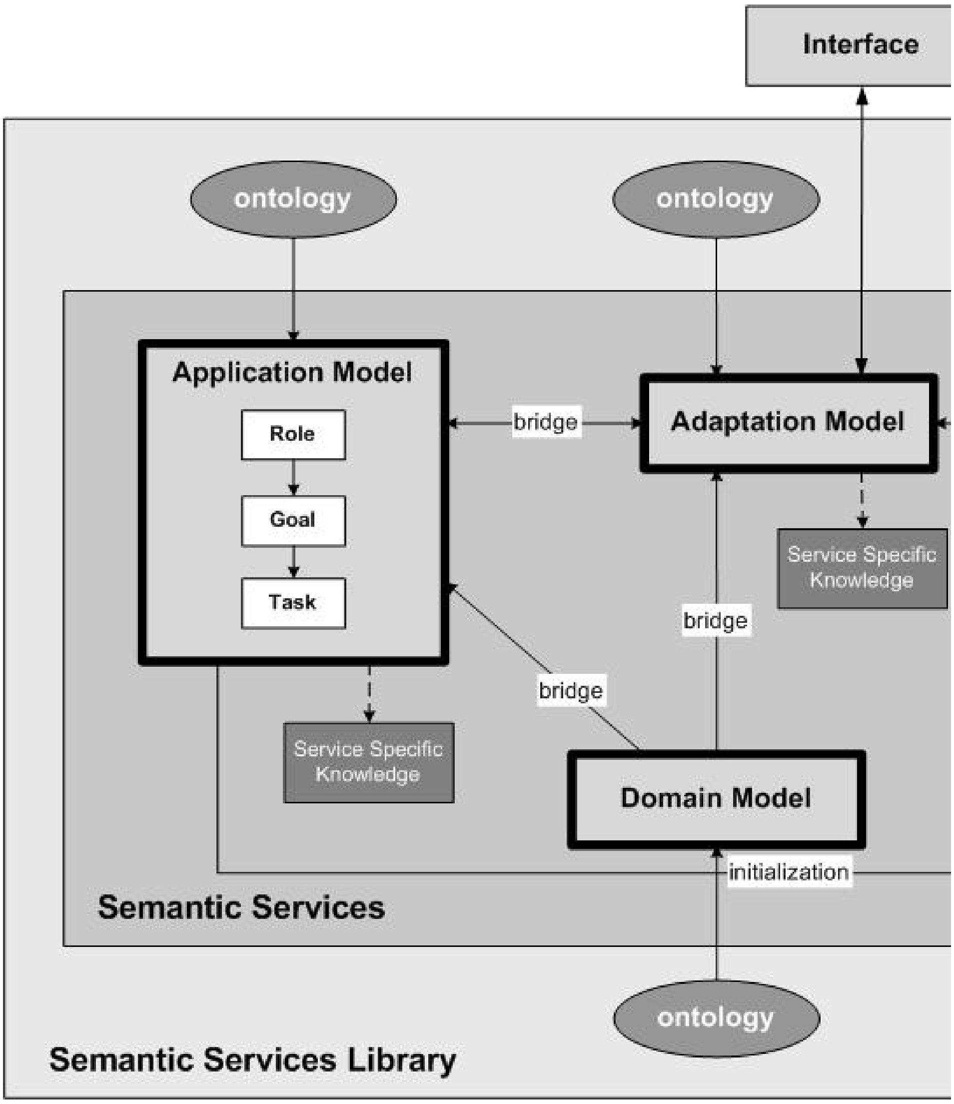

Figure 2. Architecture for adaptive Web-based systems (adapted from Motta *et al*. 2003)

Figure 2 illustrates our vision of the *modular architecture* for adaptive Web-based systems (Chepegin *et al*. 2003). One of the first cha that the different system components are all equipped with facilities to communicate with the (other) components in terms of service *bridges* are used in accordance with the UPML framework connector defined by Fensel *et al*. (1999), in order to specify mappings betw within the architecture. *Ontologies* also play an important role to define and unify the system's terminology and properties to describ service. Each service can be specified by means of a corresponding ontology, providing common ground for knowledge sharing, exploi the 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 designe interact with or react to the user intelligently without knowing anything in advance about that user, but simply using the knowledge c interpreting it in the context of the current application. Crucial for achieving such a flexible architecture is the need for a *standardiz* information about users. As mentioned above, open standards (e.g. XML, RDF, OWL) allow for the specification of ontologies to standa to enable reuse and interoperability. Another key aspect is to facilitate mobile user models that follow the user across applications. F agents provide implementation views supporting mobility and autonomous behavior. A final but important requirement is for the user reuse 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 b distinguished (section 2). When transforming these components into services the need for a fourth component, the *application model* lies in the fact that in the traditional AHS approach the adaptation model unites the actual process of *how* to adapt with the decision applications, e.g. those realized in AHA!, the designer's knowledge about why the user is served in a certain way is more or less left ir implements the way in which the information is adapted to the user and does so based on the designer's decisions, which are not mad we want to share and exchange the different functionalities between systems, it becomes relevant to separate the "how" and "why" in the designer's intentions about the roles, goals and tasks in the application (related to domain model concepts and user model values) itself to the actual realization of the adaptation to follow the directions given by the application model. In fact this aligns well with t approach, mentioned above. The application model service contains a generic description of the user tasks in the context of a Role-G

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 is performed by the *adaptation model service*, while the management of the service process is coordinated from The entire architecture as displayed in Figure 2 emphasizes the fact that the core knowledge about the application processes and the goals) lies in the application model service. In the interaction with the application the user is represented by a particular role (e.g. gu 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 mo *model service* in order to select the relevant content to be presented to the user. The domain model service is responsible for the exp 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 upda values. The user information is stored there and a reasoning engine infers new knowledge from it and makes predictions concerning fu 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 res and 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 m companies to perform *personalization* and adaptation for new and existing customers based on a "big brother" type of server that sells of everything a user has done online, it is only fair to summarize a few existing and emerging efforts to make offering such services ill so). Kobsa (2002) points out that whereas privacy laws vary between countries, there are common principles, and some countries dec everyone who performs actions that have an effect in these countries. As a result it is wise to abide to the strictest laws when creatin 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 of th 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 be legal to keep a complete log when the user agrees, but only if the system would offer the same functionality when the user c 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 modula model becomes a service that can be used by different and distributed applications. We would of course like to create user mod the user, gathered from different sites, but this may or may not be allowed depending on the interpretation of the word "servic course program is one service, thus justifying the sharing of user model information between applications or courses within that departments of an electronic shopping mall that interact with customers independently could be considered one service, and th user. However, it remains to be seen whether this interpretation will be followed by the courts.
- Users should have a real, voluntary choice between an "anonymous" login (or login using a pseudonym) and a normal login using version 2.0 anonymous logins are possible, yielding the same adaptation as non-anonymous logins. It helps to provide users with advance 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 m to *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 m 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 num clarified 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 multipl models and adaptation rules. The challenge for the future is to get research groups to work together to develop standards for exchang 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 moc with voluntary user consent some sharing will be allowed under controlled circumstances. With many applications of adaptive Web-ba collaborating, distributed, modular systems, the idea of adaptive systems can still become a "next big thing".

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