Hybrid Approach for Designing Smart Adaptive Web Sites

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Abstract

The very beginning of the research on Smart Adaptive Web Systems *(SAWS). They are systems that adapt their response based on the context in which they are used. In AWS, three main sources of information have been identified are: user, environment, and technology. To design a site for adaptivity, the site's parts must be changeable according to users needs and interests. This paper represents a careful study of a large number of adaptive web systems which are used for adapting pre-designed web pages and automatic synthesizing web pages. It suggests a new approach to extract the user's interest without the need of many visits to the web site or viewing the catalog in details. Different E-metrics are measured to evaluate the user's history, extract users' interests, create adaptable interface, and synthesize a new page with special features referring to users' needs and interests and also predict the next step the user may need.*

Keywords: *adaptivity, smart, AI, prediction, approach, pre-designed, automatic synthesizing.*

1. Introduction

There are three fundamental questions that users might ask when they navigate a Web site. Where am I now?, Where have I been?, and Where can I go next?. Users enter to the Web site, go through multiple levels in the Web site, and find desired information in one or more pages. The more links users need to travel through to view a Web page, the less visits the Web page receives.

An AI community must be challenged to address the navigational problem and answer the third question, this by creating a new type of web sites to adapt to users needs which is called ***Adaptive Web Sites[1, 9, 10, 11].*** To design a site for adaptivity, There are two ways to the page adaptation: both the pages exist statically and they are generated dynamically.

This paper discusses different approaches which are used for designing adaptive web pages. The two types of adaptations are discussed in this paper [25]. Then the paper surveys the different approaches used for designing adaptive web sites. This survey is followed by an evaluation for these approaches and their pros and cons.

The rest of this paper represents the proposed approach which is concerns with studying users profiles and web page contents in order to modify the web page itself and predict the next link the user may visit according to different E-metrics used for extracting user's interests and needs. It also produce a smart web site to be fit with different users using Artificial Intelligence (AI) techniques.

2. Adaptation Approaches

2.1 working with pre-designed web page

There are quite a few adaptive Web systems developed by researchers during the last decade [13]. The web server forms a Web page as a result to the user's request. This Web page is created either dynamically or already exists as a static file. Adaptive Web systems should change the response based on some adaptation dimensions, such as user model, technology and environment [2]. Most of the systems use available pages and remove or add some elements to adapt to the user [3 - 5].

A. Adaptive Hypermedia Architecture (AHA)

AHA [7, 13] is a general adaptive hypermedia framework used in educational domains. In this framework, the domain is modeled through concepts and relationships between them. In AHA the adaptation model and the domain model are interwoven. There are two tools provided to facilitate the authoring: Graph Editor, which is a high-level tool for defining concept relations, and Concept Editor, which is relatively low-level and used for rule definition. However, the tool generate XML files that can be edited manually. The AHA has a predefined page structure in the sense that the pages are not synthesized. AHA has content adaptation and link adaptation. AHA uses Java language and Servlet technology and it is platform independent.

AHA system suffers from the lack of user interface possibilities. Adaptation has been based on the user's browsing behavior. AHA needs the user to visit the web site many times, but it is difficult to be guaranteed.

B. Adaptive Hypermedia Application Model (AHAM)

"Dexter model" [4, 11] was designed to be a common reference model for Hypermedia systems. The definition for the Dexter model states that "the history is a sequence of all operations carried out since the last open session operation". This and the placing of the history in the run-time layer implicitly disallow maintaining an inter-session history of user knowledge and actions, which is typical to Adaptive Hypermedia Systems (AHS).

AHAM [3], Similar to the Dexter model, focuses on the presentation specifications, anchoring and the storage layer. However, it deepens Dexter's storage layer by distinguishing a Domain model, a Teaching model and a User Model [3].

C. InterBook

InterBook is a tool for authoring adaptive textbooks on the Web. It uses a domain model of concepts and a user model to provide adaptivity. It provides two major parts, the glossary and the indexed textbooks. The textbooks are indexed so that each unit has a set of related concepts and the role of that concept. In addition to regular navigation support, InterBook provides an adaptive set of links between the textbook and the glossary based on the current user's knowledge. Also it provides visual cues about each link (adaptive annotation) and direct guidance about the suggested next place the user should visit. Another kind of direct guidance is used to provide prerequisite-based help for the user. Since the system knows the prerequisite relationships between concepts, when the user has difficulty understanding a concept or solving a problem, the system can suggest the unit that contain the concepts that are the prerequisite concepts of the difficult unit. InterBook is implemented based on CL-HTTP Web server using LISP language.

InterBook system has a rigid presentation structure. The author has no possibilities of adapting the user interface to the specific course which means that every course served by Interbook has the same look independent of the course characteristics.

D. Link Prediction using Markov Model

Using Markov Chains for Link Prediction in Adaptive Web Sites is an approach used for adaptation [3]. Markov chains have recently been used to model user navigational behavior on the WWW. By constructing a Markov model of a Web site based on past visitor behavior.

First construct a link structure that represents pages, hyperlinks, and users' traversals on the hyperlinks of the Web site. Then the link structure is used to build a Markov model of the Web site. The link information contained in an ECLF [4] can be used to construct a link structure, called a *link graph*. Only relevant pages and links are used for link graph construction, and all the pages relevant to users' visits are included. A record in an ECLF log file might look like as shown in Figure (1):

```
177.21.3.4 - - [04/Apr/1999:00:01:11 +0100] "GET
/studaffairs/ccampus.html HHTP/1.1" 200 5327
http://www.ulst.ac.uk/studaffairs/accomm.html"
"Mozilla/4.0 (compatible; MSIF 4.01: Windows 95)"
```

Figure 1. ECLF Log File

The records of embedded objects in the Web pages, including graphical, video, and audio files, are treated as redundant requests and removed. only the URLs of the requested Web page and the corresponding referrer are used for link graph construction.

For a Web site with only one major entrance people can come to it in various ways. They might come from a page on another Web site pointing to the homepage, follow a search result returned by a search engine pointing to the above example in figure(1). "-" in the referrer field of a page request record indicates that the user has typed in the URI of the homepage directly into the address field of the browser, selected the homepage from his/her bookmark, or clicked on a shortcut to this homepage.

Markov Chain is used in link prediction but it has two problems, they are:

i. ***Amount of training data*:** Since the approach is statistical, the goodness of the model is dependent on the amount of data available. This means that it will be efficient in the case of large number of visits to the web site.

ii. ***Dimensionality*:** Markov chain matrix is typically very large (N*N for N URIs). This is clearly not scalable for very large number of sites.

E. Adaptive Recommendations for Academic Scheduling (ARAS)

ARAS [8] provides planning support to researchers for their academic career. Students browse through books offered by a university and are given recommendations by the system on which books they should browse next. The recommendations are generated based on the individual students' book experience and their browsing behaviour in the current and previous sessions.

Finding the right courses to match the student's interest require laborious scanning through numerous pages of uninteresting courses. Creating an online browsing system for such an information space assists somewhat.

ARAS [8] is aimed at providing an online course catalogue which observes a student's course browsing behaviour and previously taken courses in order to learn in which course topics the student is interested. That information is used to generate customized course recommendations for that student. ARAS is implemented as an example of an AWS. AWS dynamically generates and modifies page responses for its users.

In ARAS, numerous adaptations are achieved, like Adding/removing links, Altering fragments, Recommendation generation, Inserting/removing fragments.

In ARAS, complex decision making and querying could be accomplished to provide the student with personalized experience.

2.2 Automated web page synthesis

Different systems generate the pages dynamically based on the users' model [6]. So the system study users' behavior in the web site and accumulate all information about users needs, environment, and devices. Adaptive Web systems, like any other Web system, produce a page and take into consideration the above factors.

A. Personalized Electronic News System (PENS)

PENS [19] is implemented to demonstrate how Web pages are synthesized with different attributes from the same description, and to show adaptation based on users' behavior and client-side characteristics. Adaptive Web systems are systems that adapt their response based on the context in which they are used [16]. In adaptive Web systems, three main sources of information are: user, environment, and technology [2].

PENS has been developed based on a framework for adaptive Web systems [10]. The core components in the architecture are:

User FrontEnd: (UFE) component is the initial point of contact where HTTP requests arrive. This front controller controls and manages Web requests from different clients [21]. The UFE basically transforms a Web request into a synthesis request and sends it to the Synthesis Engine.

Conceptual Tasks: (CTs) are sources of data that shape the dynamic aspect of the system. The SE uses data provided by CTs in order to make decisions for adaptation.

Synthesis Engine: (SE) [17] composes a Web page based on the incoming request, current context, and various information sources. For each synthesis process, the start point is finding the correspondence between the incoming URL and a concept in the Site Description (SD).

B. SETA

SETA [6, 8, 26] is a prototype toolkit for development of adaptive Web stores. It exploits a multi agent-based three-tier software architecture, and is designed to allow building different Web stores by authoring tools, that is, all the domain dependent knowledge about users and products can be configured by tools.

SETA [18] dynamically generates the pages of a Web store catalog and selects the content of the pages based on the user's interests and familiarity with the products. Also the system sorts the available items for a product class based on the user's preferences. During a session, the system monitors the user's selections to figure out her needs for product functionalities and recommends potentially interesting product classes.

SETA system is developed using JDK 1.2 and uses the Apache Web Server. It is suited to analyzing the behavior of a user who inspects the catalog in detail; instead, the interpretation of the actions is too pessimistic if the user browses the catalog without focusing on any product and this is SETA system disadvantage.

C. SeAN

SeAN [25, 27] is an adaptive system for personalized access to news. This system has a three-tier multi-agent architecture that is inherited from SETA project. SeAN has three goals: first, to select news topics relevant to the user. Second, to present an appropriate level of detail of the news based on the user model and third, to provide advertisement most relevant to the page and the user. SeAN uses a structured hierarchy to represent news. In fact, each news is considered as a composite entity having several attributes that define its components. For example, title, abstract, full text, author, pictures, video. Based on this representation, different levels of detail can be used for news according to the user model. SeAN has been implemented using Java.

SeAN system requires more efforts from the manager of the news server to collect information. In fact, filling in the repository requires adding the news items to the database and thus decomposing information according to the attributes of news and this is the main problem with SeAN system.

D. Automated Web Page Synthesis approach

Different approaches are used to implement the adaptation server in order to synthesize the web pages automatically [12, 16]. The following is the description for the system architecture for an Adaptation Server, which includes a Synthesis Engine. The system architecture is:

Client: is the user machine (Web browser) that uses the adaptive Web application.

Web Server: is the traditional HTTP server. It has **Filter:** which acts as a filter for all the requests to the adaptation server to keep track of the client's interactions.

Adaptation Server: (AS) is responsible for producing a page based on a client's request.

Automatic Web Page synthesis system has many problems when synthesizing the new page are:

A. How are the contents ordered?
B. What is the title of the page?
C. How are the hyperlinks on the page labelled?
D. Is the page consistent with the site's overall graphical style?
E. Is it appropriate to add the page to the site? If so, where?

3. Proposed Approach

According to the massive increase in the number of web sites on WWW, so web sites' designer require to challenge this problem and attract large number of users to use their web sites. Our work objective is to decrease ***Usability*** [21] which is concerned with how easy it is for the user to use the system and how much efforts are required to learn, operate and interact with the system.

The proposed approach represents an Electronic Library to show many information about different subject[27]. It aims at helping researchers and students select the required books which are suitable to their needs. The choice of which book or pages a researcher should select is a terrible problem, because many books and many alternatives are published. Finding the right book to match the researcher's interest can be time-consuming and require exhausting scanning through numerous pages of uninteresting books. This may lead to the user will leave the site without another return. So the site must help the user during his navigation and this can be done by studying users' behaviour in the site and applying different types of adaptation on the web site's pages in order to help users find their final aim faster. There is a sequence of steps must be followed to make adaptation. The rest of the paper will explain the adaptation techniques applied in the proposed approach.

The proposed system is implemented by ASP.NET framework with C# environment and SQL 2005 server for database (for high speed and large database purposes). The proposed approach follow different steps to recognize user's interests and apply different

modifications suitable to each user individually according to different E-metrics used in analysis.

3.1 Measured E-metrics definition

E-metrics [24] are one of data mining techniques and measured with which Web sites can be evaluated. They can be compared with regular metrics and ratios as these are used in traditional industry. As Web sites gain a more important position in companies, there emerges a need to evaluate these Web sites and quantify their performance.

Different kinds of e-metrics can be identified, those that can be applied to every Web site and those that were designed for a specific kind of Web site, very often e-commerce sites. These E-metrics are like:

A. Stickiness

It is a composite metric that indicates the effectiveness with which the content of the page or the Web site can keep the attention of the user.

Its formula is:

Stickiness = Total amount of time spent viewing all pages / Total number of unique users.

Usually stickiness is expressed in minutes per user.

B. Average duration

This metric expresses how long users view a certain page or site on average. In this work the following formula has been used:

Average duration = Total duration of site (or page) / Total number of page views

C. Page Rank

This metric calculate the page rank in terms of number of visits for the page and the time spent in the page by each user.

n: no. of visits to the page.

γ: constant (affected by page contents).

t: time spent in each page by each user.

V: visit number.

Vm: total number of visits.

P: page rank

$$P = \gamma * n * \sum_{i=1}^{m} \sum_{j=1}^{Vm} \left| Vj * ti \right|$$

D. Total Unique user

The number of different people that visit the web site over a period of time is a total unique user.

Total unique user = number of different visitor to each page

E. Page Views

Each time a Unique User explores your site they log a Visit. Ideally each User would have many Visits.

Page views = time spent in each page in a visit.

F. Loyalty ratio

Loyal customers not only make frequent visits and buy often, but they will also recommend the web site to others and are thus an excellent asset to the company.

Loyalty ratio (frequency) = percentage of users converted to customers after a period of time

Assume the user will be converted to a customer if:

1- He visits the web site 3 times or more.
2- And the total duration in the web site is approximately 30 minutes or more.
3- And visit 3 pages or more in the same field because it means he is interested in this field.

G. Churn ratio

Churning is the web site's customer turnover. The Churn ratio = percentage of users not converted to customer after a period of time.

= 1 – Loyalty ratio.

H. Velocity

Velocity = amount of times the user takes to reach his final aim.

Velocity decreases with the increase of visit number because of the adaptation effects.

I. Personalization access

The more information the system can gather about its users, the better it can tailor the website to the users' needs, and the more likely the system can convince them to complete desired actions [23].

Personalization access = larger amount of information collected is better.

1.2 Implementation Stages

This paper concerns with designing smart adaptive web site using intelligent techniques in order to let the web site respond to different users needs and interests and not remaining static with all users.

The proposed approach suggests an intelligent technique for extracting users needs and recommending the right route in order to narrow down the number of pages to view and find the required items quickly. The implementation of the proposed approach consists of the following stages:

3.2.1 Determining The User's Identity

When the user enters to the site's home page which is common for all users, it begins to automatically detect if the login user is new or old from cookies and direct the user to the suitable page.

3.2.2 User's Registration

The registration process usually involves providing information about the users' personality, interests and needs.

The proposed system will not use the IP to detect user's identity, but will know his language from his computer regional settings and forward him to the suitable version (Arabic, English, French).

If the user is new and visits the web site for the first time (s)he must fill in a small form with some of his personal information and unique username and password and the subject (s)he want to read about. After that, the user will be forwarded to the default home page and then navigate in the web site.

3.2.3 Collecting Information By Indirect Way

The main purpose of this stage is to avoid the invasive manner of the proposed system by avoiding the large number of questions the user must answer, so the proposed system will record different information about the user's device capabilities and his trace in the web site and he will not feel about this records.

3.2.4 Database Contents And Constructing Users Profiles

From the above two stages, there are enough amount of information about each user which can be used in constructing the user's profile [62]. All the collected information represent the users profiles which

will be analyzed in the next stages to decide the suitable changes which may be done on the web site pages.

3.2.5 Analyzing The Collected Information

The main purpose of this stage is to analyze users' profiles and decide the required changes to be applied in web pages' structure. Analysis can be made in two ways. ***First,*** Web page synthesis techniques, ***Second,*** Pre-designed adaptive web pages techniques.

3.2.6 User's Profile Revision

Users' interests may change by time [22], so the system must revise users' profile periodically. The revision of the user profile is organized in three phases: monitoring the user's actions and discovering patterns of actions to obtain a first synthesis of her/his behavior; processing the results of such analysis to obtain a contextual synthesis of her/his behavior, where the interaction history is considered, and interpreting the contextual synthesis in terms of the user features. Our goal is the continuous revision of the user's profile during the interaction with the customer [26].

3.2.7 Web site's customer

All the previous stages deal with the new users who enter to the web site. But the main purpose of this stage is to observe the user who enters to the web site for the second visit.

Figure 1 shows the proposed system steps and sequences as shown in the above steps.

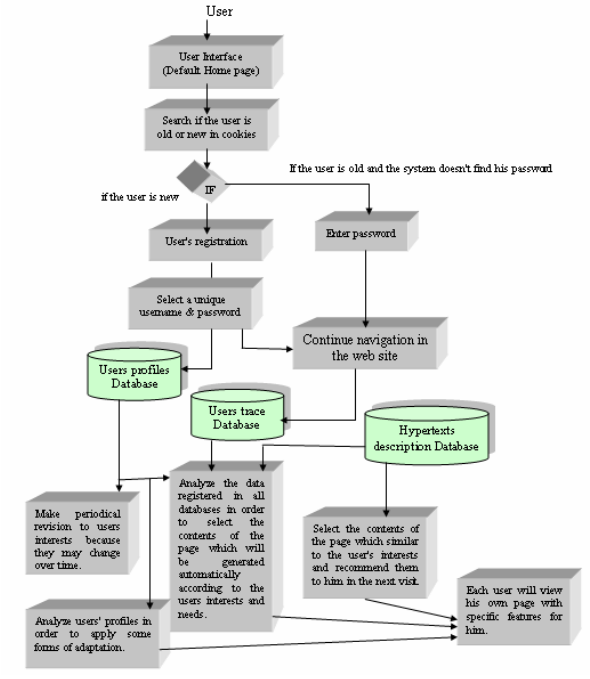

Figure 1. proposed approach sequence

3.3 Case study

From the above discussion, we find that the proposed approach has many advantages over other approaches and it avoids the problems the other approaches suffer from. And also apply different types of adaptation. This may lead to design an effective web site which is smart and at the same time adaptable to users' needs..

3.3.1 Ranking Different Pages In The Site

When studying a user's recorded data, it is found that the time he/she spent in the second visit is lower than in the first visit and the time in the third visit is lower than in the second visit. By calculating the page rank for all pages in the suggested web site as shown above. Pages with high ranks are the most important pages to users and must has the important information. Links can be ordered descending according to their rank in the user's home page according to his interests.

3.3.2 Calculating the velocilty Before and After Adaptation

One of the user's benefits from the proposed approach is decreasing the time spent in the web site searching for something. When the user want to see pages concerns with PCs, he/she will navigate through many pages in the web site to reach to the required page, so he will spend long time in navigating the web site and searching for specific information, but when the user visits the site again, he will arrive to his needs more quickly because the proposed system will recommend all the pages in the web site which related to the same topic and put links to them in the user's home page. Figure 2 shows the time spent to reach to the required page in the web site before and after adaptation.

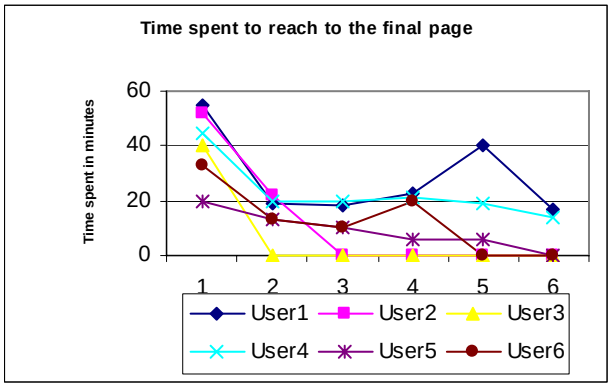

Figure 2, the time spent to reach to a specific page decreases after adaptation for different users.

3.3.3 Calculating the Number of Pages Traversed Before And After Adaptation

The proposed approach may help the user to reach to the required pages more quickly by decreasing the number of pages traversed in the way to the required page. If the user want to read some information about PCs, he/she will navigate through many pages in the web site to reach to the required page where if the user travel through seven links in the first visit, but when he enters to the site as an old user, his pages will have high rank and the home page in the site will contain recommendations him according to his interests and previous visited pages, and he can reach to the same page immediately through one link only, so the time spent and efforts done to reach to this page will decrease by 70% from the ordinary previous case, so usability will decrease. Figure 3 shows the number of pages traversed to reach to the required page before and after adaptation.

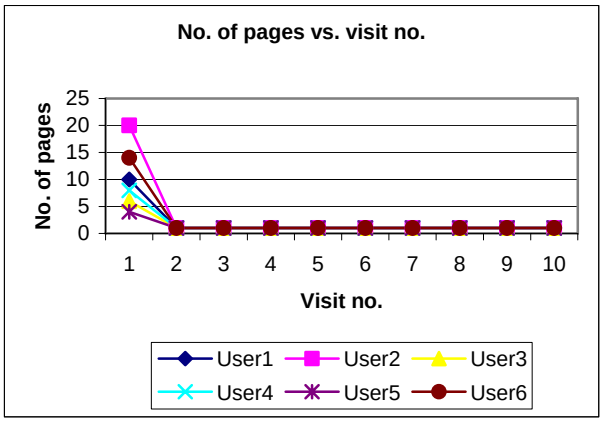

Fig. 3, Number of pages that must be in the way to the required page before and after adaptation.

3.3.4 Stickiness for unique users

The total unique users is the number of site's visitors either customers or not, and the stickiness is the time spent approximately in the web site by each user. This time will decrease after adaptation when calculated for all users in the first visit and in the second visit because of the proposed system work to facilitate users navigation in the web site and save not only their time but also efforts.

3.4 Performance Comparison Between Different Approaches

This thesis studied different approaches which are used for designing AWS and then tried to solve their disadvantages such in the following:

1. **SETA approach:** The proposed system can collect many information from the user navigation and analyze his behaviour without the need of reviewing all details about the product.
2. **SeAN system:** The proposed system not need many efforts from the manager except the designing of the system.
3. **Automatic Web Page synthesis system:** The proposed approach order the page contents according to the visited pages ranks, and select a suitable title for the page due to the user's interests. Also select labels for each hyperlink, and a suitable template to the user's interests.
4. **AHA system:** the proposed system will apply analysis from the second visit and no need for the user to visit the web site many times.
5. **InterBook system:** Proposed approach designs an adaptive interface for the system which can be changed according to users needs and interests.
6. **Markov Chain:** The proposed approach will provide the user with different types of adaptation after collecting some information in the first visit with the registration form and from user's navigation.
7. **ARAS system:** The proposed system apply periodical user's profile revision.

3.5 Types of Adaptation Applied in the Proposed Approach

Different criteria have been used for adaptation, including user location, user navigation history, and different types of devices.

3.5.1 Adaptation to User Location

Our system detects users identity and language from the user's computer regional settings and not use IP addresses because of many users can use the same IP address and also the same user can use different IP addresses. Users from different countries will see different front pages according to their language.

3.5.2 Adaptation to Different Devices

Mobile devices have a smaller display compared to the desktop PCs. Therefore, the components of a page should be adapted to the client device, so that the final presentation remains elegant. Besides, some devices accept pages in different markup languages such as WML. Thus, if a device's preferred language is WML, then the final presentation will be generated in WML.

3.5.4 Adaptation According to Users' Interests

Without adaptation, items shown on the site's home page are sorted based on the designer point of view. But after adaptation, most of the items shown in the front page will refer to user's needs.

The system can help the user to select the suitable link to visit, by recommending to him the link similar to his needs, and make any effect on it like changing its color. This response do not need many visits to the web site in order to take the decision of adaptation.

2. Conclusions

This papers discussed the smart adaptive web sites that are used for designing web sites to facilitate users navigation in the web site to reach to the required information, and return to the site many times instead of leaving the site without another return. Different AI techniques were used to design the smart adaptive web sites and applying many types for adaptation either to the pages themselves or by synthesizing new pages.

Our evaluation for the previous approaches showed that they need to collect many information about the user through his visit many times to the web site or the user need to browse each catalog in details in order to know what is his interests, and then analyze them using very complex methods which make the site's administrator work hard. The proposed approach solves these problems and extracts user's interests and needs without too many visits, then analyze the collected information using different E-metrics and apply different adaptive modifications to the web site.

REFERENCES:

[1] Mike Perkowitz Oren Etzioni. "Adaptive Web Sites: Conceptual Cluster Mining", in Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence, IJCAI 99, (1999).

[2] Mario Cannataro, Alfredo Cuzzocrea, and Andrea Pugliese, "XAHM: an adaptive hypermedia model based on XML", In proceedings of the 14th international conference on Software engineering and knowledge engineering, ACM Press, pp. 627–634, (2002).

[3] I. Schwab,W. Pohl, and I. Koychev, "Learning to recommend from positive evidence", in *Proc. 2000 Int. Conf. on Intelligent User Interfaces*, pp. 241–247, New Orleans, (2000).

[4] De Bra, P., G.J. Houben, and H. Wu. "AHAM: A Dexterbased Reference Model for Adaptive

Hypermedia". Proceedings of the ACM Conference on Hypertext and Hypermedia, Germany, (1999).

[5] Paul De Bra and Natalia Stash, "Aha! adaptive hypermedia for all", pp. 411– 412, (2002).

[6] Liliana Ardissono, Luca Console, and Ilaria Torre, "An adaptive system for the personalized access to news", AI Commune. no. 3, 129–147, (2001).

[7] Hossein Sadat and Ali A. Ghorbani, "Automated Web Page Synthesis in Adaptive Web Systems". Workshop in conjunction with AI 2004. pp. 73–83. (May 2004).

[8] Mark Kilfoil, Wenpu Xing and Ali Ghorbani, NB, E3B 5A3, Canada, "ARAS: Adaptive Recommender for Academic Scheduling", (2005) IEEE.

[9] I. A. S. group. "Adaptive web sites (AWS) framework high level design document". Technical Report TR03-102, Intelligent and Adaptive Systems Research Group, Faculty of Computer Science, University of New Brunswick, Fredericton, NB, Canada, December, (2003).

[10] A. Jameson, R. S¨ahafer, T. Weis, n A. Berthold, and T. Weyrath, "Making systems sensitive to the user's changing resources limitations", *Knowledge-Based Systems*, this paper published in the proceedings of IUI99 (1999).

[11] G. Paliouras, C. Papatheodorou, V. Karkaletsis, P. Tzitziras, and C.D. Spyropolous, "Large-scale mining of usage data on web sites", in *Working Notes of the "Adaptive User Interfaces" Spring Symposium of AAAI* , Stanford, CA, (2000).

[12] Paul De Bra, Ad Aerts, Bart Berden, Barend de Lange, Brendan Rousseau, Tomi Santic, David Smits, Natalia Stash "AHA! The Adaptive Hypermedia Architecture". *HT'03*, August 26–30, , Nottingham, United Kingdom. ACM. (2003).

[13] H. Sadat and A. A. Ghorbani. "On the evaluation of adaptive web systems". Intelligent and Adaptive Systems Group Faculty of Computer Science, University of New Brunswick In *WSS04, The Second International Workshop on Web-based Support Systems in conjunction with AI 2004*, pages 127–136, Beijing, China, (September 2004).

[14] Perkowitz, M., Etzioni, O.: "Adaptive web sites: an AI challenge". IJCAI97 (1997).

[15] Joao M. B. Cavalcanti and David Robertson, "Synthesis of web sites from high level descriptions", Lecture Notes in Computer Science 2016 (2001).

[16] M. Kilfoil, D. A. Ghorbani,W. Xing, Z. Lei, J. Lu, J. Zhang, and X. Xu. "Toward an adaptive web: The state of the art and science". In *Proceedings of Communication Network and Services Research (CNSR) 2003 Conference*, pages 108– 119, Moncton, NB, Canada, May 15–16, (2003).

[17] W3C, http://www.w3.org/RDF/. *Resource Description* Framework (RDF).

[18] L. Ardissono and A. Goy. "Tailoring the interaction with users in web stores. *User Modeling and User-Adapted Interaction*", 10(4):251– 303, 2000.

[19] Mehran Nadjarbashi-Noghani, Jie Zhang, Hossein Sadat K.M. and Ali A. Ghorbani, "PENS: A Personalized Electronic News System", IEEE Computer Society 2005, ISBN 0-7695-2333-1. Faculty of Computer Science, University of New Brunswick Fredericton, NB, E3B 5A3, Canada. (2005).

[20] Hossein Sadat and Ali A. Ghorbani, "Automated Web Page Synthesis in Adaptive Web Systems". Business Agents and the Semantic Web (BASeWEB'04) Workshop in conjunction with AI 2004 (Ontario, Canada), pp. 73–83. (May 2004).

[21] Theodore Frick, Michele Elder, Christopher Hebb, Ying Wang, Sangil Yoon. " Adaptive Usability Evaluation of Complex Web Sites: How Many Tasks?", Indiana University, W.W. Wright. Education 2276, 201 N. Rose Ave. Bloomington, IN 47405-1006, (2006).

[22] Raymond Raymond K. Pon, Alfonso F. Cardenas, David Buttler, Terence Critchlow. "Tracking multiple topics for finding interesting articles". International Conference on Knowledge Discovery and Data Mining, Proceedings of the 13th ACM SIGKDD international conference on Knowledge discovery and data mining. ISBN: 978-1-59593-609-7. Pages: 560 – 569. (2007).

[23] Ranieri Baraglia, Fabrizio Silvestri. "Dynamic personalization of web sites without user intervention", ISSN:0001-0782 , Commun. ACM, Pages: 63 - 67 , Vol. 50, No. 2. (February 2007).

[24] Christian Doerr , Daniel von Dincklage , Amer Diwan . "Simplifying web traversals by recognizing behavior patterns". Conference on Hypertext and Hypermedia, Proceedings of the eighteenth conference on Hypertext and hypermedia. Pages: 105 - 114 , ISBN:978-1-59593-820-6. Manchester, UK, (2007).

[25] Peter Dolog, and Wolfgang Nejdl, "Semantic Web Technologies for the Adaptive Web". Book Series: Lecture Notes in Computer Science, Publisher: Springer Berlin / Heidelberg. ISBN: 978-3-540-72078-2, pages: 697-719. (2007).

[26] Alade Rahman, M.; Ahmad, H.F.; Suguri, H.; Sadik, S.; Longe, H.O.D.; Ojo, A.K.. "Supply chain optimization towards personalizing web services". Intelligent Systems, 2008. IS '08. 4th International IEEE ConferenceVolume 3, 6-8 Sept. 2008 Page(s):19-17 - 19-22. (2008).

[27] B. Chadwick. Karl Lieberherr. "DemeterF: The functional adaptive programming library". (2009).

[28] Antony Jsmeson DFKI, German Research Center for AI/ International University in Germany. "User-Adaptive and Other Smart [36] Adaptive Systems: Possible Synergies". Plenary Session and Panel Discussion First EUNITE Symposium, Tenerife, (14 December 2001).

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