SHAAD: Adaptable, Adaptive and Dynamic Hypermedia System for content delivery

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Abstract. To implement an efficient adaptation of content in the network, different variables can be analysed that involve the types of users, the devices used by customers to gain access, the types of access, the state of the network and the current load on the server. The increasing use of hypermedia objects for creating content and the fact that the variables above mentioned are not taken into consideration has led to the problem of inadequate content in many situations. In this paper, a model is suggested for the delivery of hypermedia content that considers these variables. This model, elaborated from an analysis of different research, considers the different points of view observed and has the end objective of defining a System which is Hypermedia Adaptable, Adaptive and Dynamic (SHAAD). This will be the starting point for considering the problem of content adaptation, by means of a totally modular system.

1 Introduction

At present, the enormous heterogeneity in terms of types and capacities of access devices, bandwidth of the network and needs/preferences of the users are not taken into account by a server when providing web content which is rich in images, audio and video. E.g., the server will deliver the document requested even if the terminal used (WebTV, Personal Digital Assistants (PDAs) or mobile telephones) can not access these content due to the limitations of the display, of the storage capacities, of processing or of access to the network.

To solve this problem, alternatives must be developed that allow universal access to any type of material, from any type of device and that take into account user preferences as well as the current load on the network and on the server.

The concept of *Adaptation* has been widely investigated in the field of hypermedia systems and it has been shown that in these areas it can provide better environments of use and performance. There are many groups dedicated to the task of solving the issue of adaptation of content and there are also different considerations with respect to the implementation of such adaptation.

Some of them are: *UMA (Universal Multimedia Access)* [1] takes the new classes of intelligent and portable devices into account; in *MONADS* [2-4] the adaptability of the data services to the changes of environment of the nomadic users is the main focus of this project; *Research Groups from Hewlet-Packard* [5-6] and *Microsoft Research*

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China [3] are working on Adaptive Delivery Systems and take into account the type of access device, the state of the network and user preferences; Paul de Bra [7] takes into account user preferences and suggests changing the content or the presentation of the nodes by altering the structure of the link.

In the studies mentioned different variables have been considered that influence content adaptation. They will all be adopted in our work:

- *The characteristics and preferences of the user* [7-9]. With this concept, we include everything referring to the preferences and information about the user. Preferences being everything related to the means of receiving the hypermedia material (e.g. explicit or summarized), the learning characteristics (e.g. if it is a textual or visual user), the personal characteristics (e.g. if it is an extrovert or introvert user), etc. Knowledge is everything to do with previous or evolving knowledge.
- *The customer's access device* [1-6]. Along with the increasing expansion of the Internet there has been wide-ranging technological development of the devices used to access the network. These devices vary enormously in terms of storage capacity, processing power, screen resolution, etc. This leads to a new problem: having to deliver the rich multimedia content available to a wide range of devices/customers which, in many cases, will not have the capacity to deal with them adequately.
- *Type of access to the network* [5-6]. Bandwidths that range from the 28.8K to 100M, mean another feature has to be considered: the speed of access to the network.
- *State of the network* [7], [10-11]. In addition to the diversity of types of connection, we have to consider the state of congestion of the connection being used at any given moment. The load on the connection is not uniform at all times. That is, a connection with a large bandwith does not necessarily mean a permanently optimised connection.
- *State of load on the server* [12-13]. Users know only too well the experience of unsuccessful or rejected access on the part of the server when it involves consulting certain multimedia material. This situation is often caused by an overload in these servers as a consequence of an unusual quantity of requests. To solve this overloading, it may be preferable to deliver content with reduced quality before having to reject or to generate a fault in the connections that are being made.

In Section 2 we take a look at adaptability versus adaptivity in order to clarify the terminology used. In Section 3 we define our SHAAD system and variants of the model are described for the different variables of adaptation. Finally a single model is presented for our system in Section 4. We conclude this paper in Section 5

2 Adaptability Versus Adaptivity

The term *adaptivity* has been used by different authors in different areas. Depending on the environment considered, the goals pursued by such an adaptation vary. For this reason, in the first place we need to agree on what we mean by hypermedia *adaptation* of content in an environment of changing variables, such as the ones mentioned in the previous section.

Abdelzaher [13] considers the adaptation of web content to be a mechanism for improving performance in the face of server overload. Wei-Ying Ma [5] looks at the delivery of content adapted in heterogeneous environments in order to improve

content accessibility. Brusilovsky [9] defines an Adaptive Hypermedia System as one that builds a model of goals, preferences and knowledge, for every user. It uses this model, by means of interaction, to adapt to the needs of the user. Oppermann [14] takes the characteristics of the user into account and distinguishes between: *Adaptable Systems* and *Adaptive Systems*. On the other hand, De Bra [7], taking into account user preferences as a variable that decides the adaptation, classifies the hypermedia environments or web sites built according to their capacity to carry out some type of personalization in: *Adaptable Hypermedia*, *Adaptive Hypermedia* and *Dynamic Hypermedia.*

3 Definition of SHAAD

From what has been said in the previous section, we define our Hypermedia Adaptable, Adaptive and Dynamic System (SHAAD) as a *system that, taking into account the state of the variables we mentioned and the variety of multimedia in web content, tries to adapt the available information dynamically or statically and to deliver it in the most efficient way possible.*

The SHAAD model is made up of 4 modules:

1- Mechanisms for defining variables. The aim of these mechanisms is to define the variables we mentioned above: characteristics and preferences of the user, access device of the customer, type of access to the network, state of the network and state of load on the server.

2- Module of content. The function of this module is to deliver the content requested, either through a dynamic generation from the unit elements that make up the web page (on-line generation), or by selection from the various different static versions of this content which have been previously generated (off-line generation).

3- Decision Engine. This is the kernel of the system and the place in which the variables of decision and the available content are evaluated, from which are inferred the mechanisms for delivering the material in the form that best suits the end user.

4- Adaptation Mechanisms. Once the new web site generated by the module of content is available, this module implements the adaptation mechanisms decided upon by the Decision Engine.

We analyse the variables mentioned in the module *Mechanisms for defining variables* separately and define the model used in every case.

3.1 Characteristics and Preferences of the User

In a very general way, the concepts that allow us to describe our user are: goals versus tasks, previous knowledge or background, experience, preferences in the mode of receiving the information, interests, details of the user, etc.

These concepts take different types of characteristics into account [9]: the ones relating to knowledge (previous or evolutionary), those that consider the preferences on the mode of receiving the information (graphical or text, developed or summarized), those that take the personality of the user into account (introvert or extrovert, verbal or textual, ...), etc.

The particular modules of this model (Figure 1) are:

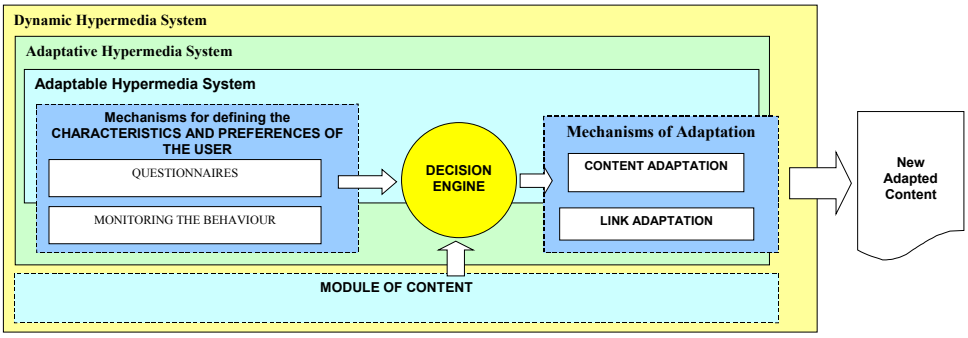

Figure 1 – Model for Content Adaptation according to characteristics and preferences of the user

- *Mechanisms for defining the characteristics and preferences of the user*:
  - *Questionnaires* for the user in order to get direct answers concerning his or her characteristics and preferences.
  - *Monitoring* the behaviour of the user in order to deduce his or her characteristics from the interaction that takes place.
- *Mechanisms of Adaptation* [7]:
  - *Adaptation of links*. The system tries to guide the user towards the most important aspects of the available information, moving him or her away from the less important.
  - *Adaptation of content*. The Adaptive Hypermedia System provides additional or alternative information in order to ensure that the user gets a complete understanding of the material offered.

The terminology used by other authors may differ what we are using, but the mechanisms involved do not differ substantially with regard to the ones we present here.

3.2 Access to the network: The Customer's Device and Type of Access / State of the network

Although these three concepts are different, we shall consider them jointly because they are intimately related in terms of technology. In the end, *the quality of the format of the content* delivered to the user will depend on these variables.

The range of existing devices capable of accessing the network is very wide. Chief among the differences are the information processing power, the availability of audio reproducers, the network access interface and the means of viewing video. This last feature plays an important role when it comes to the adaptation of the content.

Furthermore, these devices depend greatly on the type of connection available and on the speed of access. To these considerations we must also add the *state of the network* at a given moment.

As users, we know that, although we may have an *excellent access device and an excellent connection we do not necessarily have as a result, excellent content availability*. Furthermore, under certain conditions we have often experienced the frustration of not being able to enter the requested web site. This problem can arise because of the state of the network.

For this model it is necessary to describe particularly two modules (figure 2):

- *Mechanisms for defining the characteristics of the customer's device, the type of access and the state of the network*. This module carries out a function similar to the module of Mechanisms for the definition of the characteristics of the user, shown in Figure 1. The methods available and those that we are considering for determining the type of device, connection and state of the network are [5]:

  - *Http protocol*. In the protocol used for the delivery of documents, the head of the http request contains relevant and useful information about the customer (e.g. information on the screen size being used by the customer) or indirectly, from the browser used, the type of device being used to access the page. On the other hand, the World Wide Consortium (W3C) is developing a standard to discover the capacities of the customer and the preferences of the user [13].
  - *The User's Suggestions*. In this case, as in the model for the characteristics of the user, questionnaires, or templates allowing the user to personalise the page, can be implemented that will help to define the characteristics of the user's access device.
  - Furthermore, it is necessary to generate specific *tools* to determine the state of the network. The technology of intelligent agents is one of the most interesting and most important tools that can be used.

- *Mechanisms of Adaptation* [5],[13]:

  - *Data Compression Algorithms*: these present summaries of the text to be shown, thumbnail images of the available material on the page, etc.
  - *Data Transformation Algorithms*: these modify the format of the multimedia material presented e.g. lowering the resolution of the images or modifying a video file to show a succession of still images.
  - *Data Classification Algorithms*: these classify the objects that are shown on a page, giving them levels of importance in order to decide whether these objects will be shown or not.

3.3 State of Load on the Server

The problem of server overload, [12-13], has also been one of the considerations taken in the model suggested for our SHAAD, since the capacity at any given moment

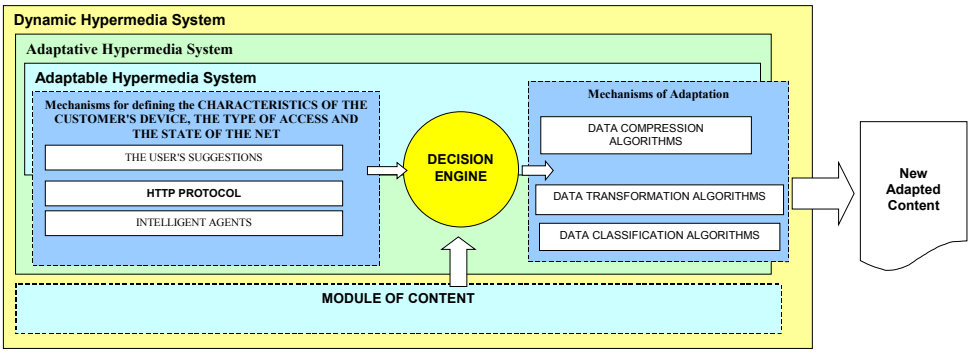

Figure 2 – Model for Content Adaptation According to Access to the network.

to deal with the quantity of incoming requests by users, will mainly depend on the server and on its current state.

In principle, these servers are sized in such a way that they can deal with all the demands made upon them. However, in practice, there are frequent cases in which, as users, we find it impossible to download a page due to the overloading on the server at that moment and to the fact that the server finds it impossible to attend to all the requests. As this overloading can, and does, take place, we need to find solutions for such situations.

The processing of the hypermedia content on the server can be carried out by *on-line or off-line transformations*. An *on-line or dynamic* process is one which is carried out when the load on the server allows the dynamic generation of the web page content from the unit elements that form it. In the *off-line or static* process, different versions of the hypermedia content are available, in different formats and qualities, in order to be able to select one of those versions when the overload conditions make it necessary. From this point on and taking into account the state of the variables mentioned in points 4.1 and 4.2, the resultant hypermedia content is adapted by means of the other mechanisms of adaptation.

The Module of Content interacts directly with the Decision Engine, to which it delivers the version of content that arises after considering the state of load on the server. This decision engine, with the hypermedia content selected and the state of the other variables defined, implements the mechanisms of adaptation to the degree that it decides is necessary.

In this case, we need to describe two modules (figure 3):

- *Mechanisms for the definition of the state of load on the server*. The tools evaluated to carry out the aforementioned definition range from the web server's own tools to the use of intelligent agents technology implemented in Java.
- *Module of Content*. This is responsible for generating dynamically, or else selecting from the static versions, the most suitable content.

  It is made up of the following blocks:

  - *Dynamic generation from unit elements*. It generates the new page dynamically from the elements that compose the original page. The Content Analyser (fig.3) is

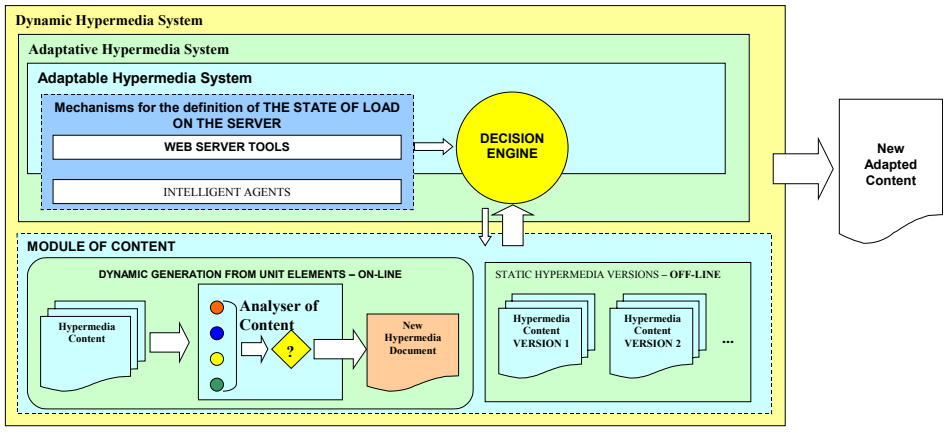

Figure 3 – Model for Content Adaptation according to State of Load on the Server.

a tool developed in XML and Java. The goal of the analyser is to convert a document from a traditional HTML format to an XML format and, with the advantages that the XML format gives us, to sort out the objects that make up the original document. Once this structure has been obtained, by means of meeting certain conditions and through the intervention of the decision engine, it selects the convenient objects to form the new HTML document.

- *Static hypermedia versions*. In this block, versions of the web pages, with different qualities in terms of format and content, are available. These static versions are available for the situations in which the Decision Engine decides to use one of these versions in the case that the load on the server so requires.

4 Architecture of the SHAAD

Through the models suggested in section 3, we have tried to explain by homogeneous blocks the obtaining of a single model. In the same way, Figure 4 represents our SHAAD proposal, with all the variables of adaptation considered taken into account.

For each of the different schematised modules we have given a corresponding analysis throughout the present paper. On the other hand, we established the prime importance, in our research, of the inclusion of the state of load on the server when considering a dynamic generation of content (on-line). A priori, this seems to be the best way of implementing our goals, but we can not lose sight of the fact that this solution cannot be the only one and the processes of our decision engine will, in the end, have to include mixed solutions, in which a combination of the states of the defined variables of adaptation are considered.

5 Conclusions

We have presented in this paper the SHAAD model (System which is Hypermedia Adaptable, Adaptative and Dynamic) for the dynamic adaptation of content. This model tries to cover, from different points of view, the wide range of related works on hypermedia adaptation of content. Thus, through the analysis of different techniques

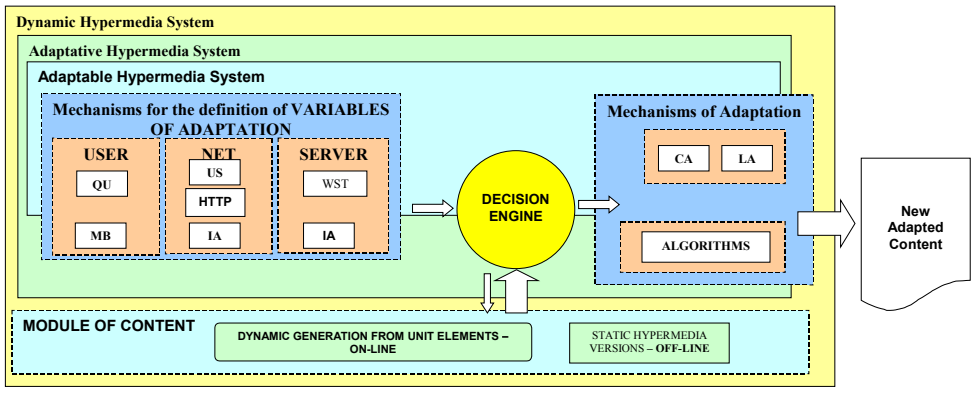

Figure 4 – Final Model for a SHAAD

for defining different variables (characteristics of the user, characteristics of the customer's access device, type of access, state of the network and load on the network) we have tried to encompass the different points of view and to define, through a single model, our starting point for the adaptation of content.

Some of the definition tools considered here are at the implementation stage. E.g., our Content Analyser, implemented in XML and Java, through which an intelligent selection of the objects that form a page can be carried out. Also, the tools investigated for an efficient testing of the conditions of the network that are being evaluated through the same http protocol as well as intelligent agents implemented in Java.

Our strictly modular model will allow us to work on the wide range of aspects we have analysed and in this way, help us to suggest partial solutions to a problem that globally can be excessively complex due to the many variables that have to be analysed.

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