

E-learning Adaptive Web System's Formal Design

Miroslav Bures, Ivan Jelinek

Abstract: *This article deals with formal description of the adaptive web system. Adaptive web system monitors particular user's behaviour and characteristics. Based on them, the system compiles a resultant adapted document. This document corresponds to user's qualification and capability, preferences and his/her specific needs. Formal description of adaptive web system is needful for exact description of adaptive document behaviour and consecutive automated implementation of adaptive web systems.*

Key words: *E-learning, Adaptive Web Systems, Formal Design, Accessibility*

INTRODUCTION

Since 1997 term Web Engineering has been appearing, this term represents application of systematic, disciplined and qualified attitude to development, performance and maintenance of web applications. Beside the contemporary Internet, the Web Engineering disciplines [1] deal with development of new conceptions and technologies for the web. One of them is adaptive, personalized web, for example [2].

Adaptive web system monitors particular user's behaviour and characteristics. The system uses characteristics of an user to compile resultant adapted document from a complex universal hypermedia document. Then, an adapted document is produced to user.

Basic motivation for creating adaptive web systems is the difference between individual possibility of perception of an individual users. For this reason, it's suitable to prepare specific adapted hypermedia document for each user. This document should correspond to user's qualification, capability, preferences and his specific needs. For example, we can adapt user interface of document, its information content and layout, topology of hypertext or other features.

Adaptive web systems can be effectively used in many cases. As an example we can give E-learning [3], adaptation of web to the disabled users or personal navigation to web [4].

The aim of our work is to create a system for automated implementation of adaptive web systems. The solution if this problem represents a non-trivial engineering process, which needs to establish a formal description of the realm, like in many other scopes of computer science (for example theory of grammars etc.). There are some advantages (and disadvantages that we can meet) of formal description:

We can exactly describe behaviour of adaptive hypermedia document produced by adaptive web system. As a formal tool we use known and reliable mathematical apparatus - the theory of sets.

Creating a unified communication platform for the realm of adaptive web, we will make easy to change the documentation and to describe the problems. Next, the formal theory is very suitable as a basis for functional and effective implementation of particular systems.

We can define quantities, which explicitly describe various properties of the adaptive system. These quantities will give image about system attributes, such as level of feedback and interaction with user, coherence and redundancy of information contained in the system, etc. This is very important for finding the level of adaptivity, which is productive for user and for finding the levels, over which the adaptivity can be contra-productive.

During implementation of adaptive system, deficiently general and limiting formal description could cause ineffective use of technological capacity of web.

PRINCIPLES AND CONSTRUCTS OF FORMAL DESIGN

We have designed formal description of adaptive web system. This formal description

is based on the mathematical logic and on the theory of sets. Because the complete formal description is too large to present in this paper, the full documentation is exposed on stable URL <http://webing.felk.cvut.cz/documents/adaptive.html>. In the following text, we will discuss its basic ideas and principles. The description of an adaptive web system consists of two main parts – a static one and a dynamic one.

The static part of system's description

In the static part of a formal description, we deal with compilation of adapted document according to values of user's parameters (see Fig.1). This part begins by some action on client (user) side. Processing of feedback follows there, possible change of user's parameters values, compilation of adapted document and producing compiled document to user.

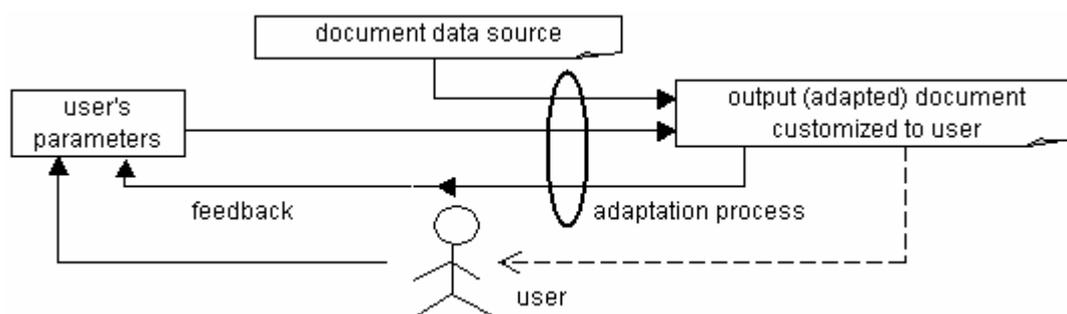


Fig. 1. Principle of the adaptive web system

The characteristic of particular user is stored in system via **user's parameters**. Level of former knowledge from the scope of produced information, quality of user's memory, capability of information absorption and many others can be parameters like this. There is a wide spectrum of user's parameters and we will not deal with individual sorts of them at this general level. We just specify them formally.

The **adaptive web system** compiles adapted document for particular user. Its inputs are values of user's parameters and universal source document, called **document data source**.

The document data source is divided into the **blocks**. The blocks fold up from elements. The **element** of document data source is a part of produced information text or control element. Element of document data source is greater quantum of data than for example element of XML language. When we implement document data source via XML language, element of document data source will fold typically of more XML elements.

During compilation of an adapted document, particular behaviour of element is determined by value of **control signal**. The way of element's reaction on control signal (for example if the element will be displayed whole, modified or will not be displayed) is described in **element metadata**. There is a metadata and one or more control signals assigned to each element. This set creates the complex element, which is basic building unit of adapted document.

Compilation of adapted document is realized by an **adaptation function**. Input of adaptation function can be zero up to some user's parameters, output of the function are one up to some control signals.

The elements are divided to feedback elements and non-feedback elements. As an example of feedback element, we can give a question in some test from interpreted theme, a choice from several ways of arrangement of information on the screen or a time counter, measuring time spent in individual sections of document.

Like the elements, we divide user's parameters to feedback ones and non-feedback ones too. Values of feedback parameters we get via feedback during the run of adaptive system, values of non-feedback parameters we get in advance (for example by student's pre-testing) or we get them by dependency of parameters.

The **feedback** in adaptive system is represented by a link between feedback elements and feedback user's parameters. Using feedbacks, adaptive system gets and gives precision to values of user's parameters. Based on these values, particular adapted document is prepared for particular user and his needs.

Next, we define a **dependency among parameters**. The dependency is represented by a function with one or more values of user's input parameters and one value of user's output parameter. There are two ways of using dependent parameters. The first possibility is to use them for modelling of real situation described by some psychological model or theory. For example, we are using two parameters describing some psychical properties of user in our adaptive system. According to psychological studies, they are related. So we can model this relation in adaptive system too, using later mentioned dependency of parameters. The second way is to use dependent parameters to create qualitative new data from values of user's parameters acquired for longer period.

The dynamic part of system's description

A process of adaptive system can be characterized as a sequence of iterations. The **iteration** of adaptive web system is current state of user's parameters values and resultant adapted document. We can imagine the iteration intuitively as one time shot from adaptive web system run.

As mentioned above, description of adaptive system is divided into **static** and **dynamic part**. In the static part we describe compilation of an adapted document. Adapted document is compiled from the document data source. The way of compilation depends to the values of user's parameters. This part begins by some action on client (user) side. There follows a processing of feedback, possible change of user's parameters values, compilation of adapted document and producing compiled document to user. In the dynamic part we deal with sequence of iterations and time aspect of the problem.

In the dynamic part of description, **system history** in current iteration is defined. It is a set of all iterations preceding this iteration. As an sample, we can give its definition:

$$H_i = \{ I_0, \dots, I_{i-1} \}$$

where i is iteration index and I_0, \dots, I_{i-1} are iterations preceding iteration i .

Next, we define user's parameters iteration, which is a current state of parameter values. Ergo, user's parameters iteration is a subset of defined iteration. By analogy, we define user's parameters history in given iteration as a set of all user's parameters iterations preceding given user's parameters iteration, because we need it for a formal description of user's profile.

The **user's profile** is a set containing current state of user's parameters in given iteration and selected parts of user's parameters history in given iteration. It specifies data, which we store for particular user in adaptive web system.

Finally, we can give a definition of adaptive web system's user session:

$$AS = \{ P, B, X, I, F \}$$

where P is the set of all parameters, B is the set of all blocks, X is the user's profile, I is the current iteration and F is the set of all adaptation functions.

The description of adaptive web system properties

The designed formal description contains the quantities, which unequivocally describes the properties of the system. The typical example is the level of feedback in system of the ration of metadata in the document data source. The next group of quantities partially describes information semantic in document data source. Here the formal description deals with content redundancy and coherence between information. Defined quantities are also used in the description of rightfulness in the adaptive web system.

CONCLUSIONS AND FUTURE WORK

We have verified one of the basic functions of designed formal description - exact description of the behaviour of adaptive web document. The task is to create adaptive hypermedia document for foreign languages teaching.

For describing the document data source we have used the XML. The result is satisfying. Usage of XML corresponds well with designed formal description. Next, we have implemented a visualization of document data source via XSLT stylesheet.

We have got the first values describing the document data source. In general, these values will be needful for finding the level of adaptivity, which is productive for user and for finding the levels, over which the adaptivity can be contra-productive.

The next step, intimately connected to the design of formal description of adaptive web system, is the support of adaptive web system's automated implementation. It means to use the formal description as basis in design and implementation of adaptive web engine, which will run on web server and provides users using the system with adapted documents. Formal description is going to be used also for designing of quasi-automated system to transfer educational documents to the document data source for adaptive web system.

The part of research in this realm is the beginning pilot project of adaptive web. The object of the pilot project is to get the feedback related to used implementation support and designed formal description. In the future, there are many iterations waiting for the whole system, that will lead to its improvement and increasing its effectiveness. Equally, we can't exclude that new possibilities and rightfulness will be disclosed. They could be included in the formal description consecutively.

Formal description of adaptive web system is needful for installation of an unified communication platform in the realm of adaptive web. Hereafter it is necessary as a basic theory for setting standards in this scope and next theoretical research. The main purpose of this theory is to run as a base for automated implementation of adaptive web systems. Using of well-known mathematical apparatus gives the theory the advantage of good understandability and makes it easy to apply.

Adaptive web systems can be effectively used in many cases, e.g. E-learning, adaptation of web to the disabled users or personal navigation to web. The aim of using of adaptive approach to student in E-learning is to increase effectiveness of E-learning process and to improve its ergonomic quality. Next, the goal is to present information in a way that is the most suitable for the particular user and to adapt the education process to the disabled students.

REFERENCES

- [1] Deshpande, Y., Hansen, S: Web engineering: creating a discipline among disciplines, IEEE Multimedia, April-June, 2001, pp.82-87.
- [2] Brusilovsky, P., Maybury, M.T: From Adaptive Hypermedia to the Adaptive Web, Communications of the ACM, Vol. 45, 2002, pp. 31-33.
- [3] Bures, M: Adaptivni systemy v internetem podporovane vyuce, In: Fenomen e-learningu v soucasnem vzdelavani, Prague, Czech Republic, 2003, pp. 49-51. (in Czech)

[4] Jones, K: Sun's Commitment to Education, Worldwide Education and Research Conference, Madrid, Spain, 2004.

ABOUT THE AUTHORS

Dipl. Ing. Miroslav Bures, PhD student, research group Webing member (<http://webing.felk.cvut.cz/>), Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University, Phone: +420 224 357 470, E-mail: buressm3@fel.cvut.cz.

Prof. Dr. Ivan Jelinek, head of research group Webing, Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University, Phone: +420 224 357 214, E-mail: jelinek@fel.cvut.cz.