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User-Centered Navigation Re-Design for Web-Based Information Systems

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Abstract

Navigation design for web-based information systems (e.g. e-commerce sites, intranet solutions) that ignores user-participation reduces the system's value and can even lead to system failure. In this paper we introduce a user-centered, explorative approach to re-designing navigation structures of web-based information systems, and describe how it can be implemented in order to provide flexibility and reduce maintenance costs. We conclude with lessons learned from the navigation re-design project at the Vienna University of Economics and Business Administration.

Keywords

web site design, usability, web catalogues, web directories, navigation design, web site administration tools

Introduction

Creating a user-friendly navigation structure must be considered one of the most challenging aspects of web-based information systems design (Davenport and Laurence, 1998). Bad navigation design may lead to a substantial reduction in the total value of an information system (Kaukal and Simon, 1999) and can even result in system failure (Mahrer and Simon, 1999).

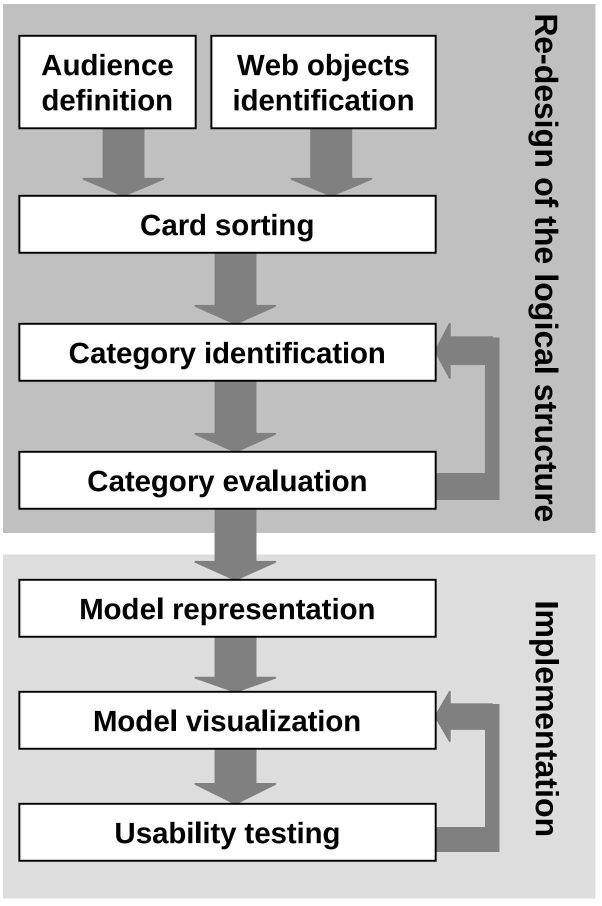
The most widely-used method of designing navigation for large web-based information systems is to fit all information sources (web objects) into a hierarchical classification scheme or directory structure. Although there are several schemes for classification purposes available (e.g. NAICS for industry classification, ACM's classification system for the computing field), they cover only very specific areas and thus are not likely to be usable for most web-based information systems. Moreover, Brin and Page argue that human-maintained directories are both subjective and expensive to build and maintain (Brin and Page, 1998).

In this paper we present a user-centered approach to developing a hierarchical directory structure suitable for organizing web objects. The high degree of user participation has the following rationale:

- *Increased usability*: the structure developed reflects the way users would organize information.
- *Reduced subjectivity*: the influence of the developers and interest groups is kept to a minimum.
- *Higher level of acceptance*: user participation in the design process results in a higher level of acceptance of the final web design.

The paper is organized in three main sections. In the first of them we present a user-centered approach to developing navigation structures for web-based information systems. In the following section we introduce two strategies for administering web-based navigation structures which reduce the maintenance costs of such systems. The paper then concludes with a summary of lessons learned from a re-design project conducted at the Vienna University of Economics and Business Administration.

Figure 1. Roadmap for user-centered navigation re-design



I. Re-design of the Logical Structure

The method presented here is derived from Fuccella and Pizzolato's approach to information organization (Fuccella and Pizzolato, 1998), which we expand by emphasizing user participation and by restructuring the approach from a re-engineering perspective. Figure 1 illustrates the roadmap of the re-design process.

This part of the re-design process employs user participation to produce a logical directory structure. After identifying relevant web objects and defining the information system's audience, suitable categories have to be identified. In addition, for each category a short description is written. This description is used to assign web objects to categories. Then the new navigation structure, which basically consists of categories and assigned web objects, is evaluated and adjusted in an iterative process.

1. Audience definition

As a first step, the target groups of the information system have to be defined. At this stage of the process the project team might use existing customer information. However, audience definition based on traditional market research may be insufficiently detailed to create a highly usable and competitive web site (Fuccella and Pizzolato, 1998). Only a precise knowledge of user needs enables the development of web sites with high user-value (Kaukal and Simon,1999). To obtain this kind of information market research data can be extended by user surveys and log file analysis to find group-specific usage patterns.

2. Web object identification

Parallel to audience definition, the project team has to identify the relevant web objects for inclusion in the information system. A web object is uniquely identified by a *URI* (Uniform Resource Identifier) and can represent a document or an interactive service. Some techniques for identifying such web objects are:

- log file analysis,
- analysis of search engine queries, and
- user survey.

Extracting a 'top hits' list by use of a log file analyzer is a very convenient and inexpensive way of identifying the most frequently accessed web objects. Unfortunately this technique can only consider existing objects. Furthermore, log files may not always be available and analyzing them is a privacy issue still to be legally resolved in some European countries. In addition, the results of a log file analysis might be misleading because of browser cache, proxy servers and hits caused by web spiders and web robots (Brin and Page, 1998).

The analysis of search engine queries helps to identify the most frequently requested keywords and thus the web objects associated with them. At the same time, web objects not yet offered by the web site can be identified by analyzing queries which did not produce results.

A user survey is a reliable method for identifying the most important web objects, although a very expensive one. Target-specific differences in demand for web objects can easily be established by this means. Log file analysis can only provide this kind of information if the data includes user identification combined with external data sources that provide information about the status of each user.

Since participants in the design process are subject to time restrictions, not all web objects can be considered in the subsequent stages of the design process. Consequently, the most important ones must be determined using the results of the techniques described above.

3. Card sorting

"The purpose of a card sorting activity is to better understand the user's concept of how the information on the web site should be organized" (Fuccella and Pizzolato, 1998).

At this stage of the process the name, the *URI* and a brief description of web objects are recorded on cards. The entire stack represents the most important web objects identified during the previous stage. A selected subgroup of 5 to 10 users per target group are asked to classify the cards into sets, and to provide each set with a unique name and a short description. To allow users to include a web object in several different sets, empty cards are provided.

4. Category identification

Based on the results of the card-sorting stage, the project team compiles a preliminary navigation structure, a challenging task which requires a considerable degree of creativity. Category identification comprises three tasks:

- identifying the categories needed,
- specifying category labels, and
- providing accurate category descriptions.

This stage starts with a review of the results of the card-sorting activity. Fuccella and Pizzolato suggest evaluating the cards by comparing each classification produced by an individual user with all others, in order to identify similarities and differences (Fuccella and Pizzolato, 1998).

While card-sorting can provide an initial idea of how to organize the web objects, navigation design is still up to the project team. In a worst case scenario 20 users might come up with 20 totally different suggestions for navigation design. Finding similarities between many different versions is not always easy. At this stage of the process cluster analysis can be used to break down the data produced by card-sorting into cross-subject clusters (Levi and Conrad, 1998).

Before naming the identified categories, the project team (especially if it is an external team) has to study major publications of the organization, in order to become familiar with organization-specific terms. The names and category descriptions suggested by the users provide useful hints for both naming and describing the categories.

The category descriptions serve as a guideline for integrating web objects that have not been included in the process due to the restrictions mentioned at the web object identification stage. During operation of the web-based information system the category descriptions serve as a formal handbook for maintenance work and for adding new web objects to the navigation structure.

5. Category evaluation

Evaluation of categories and the assignment of web objects is carried out by conducting a user survey. As part of this survey users are asked to assign web objects to categories (multiple assignments allowed) by answering questions such as *„In which category would you expect to find web object X?“*.

Fuccella and Pizzolato argue that web objects are correctly assigned if a consensus rate (percentage of users that agree on assigning a web object to a category) of at least 70 to 80 per cent is obtained. Web objects that are consistently split across two categories are usually assigned to both categories. (Fuccella and Pizzolato, 1998)

If only a very low consensus rate is observed, the chosen categories and their descriptions are inappropriate, and the team must repeat the category identification exercise.

II. Prototype Implementation

User-centered navigation design results in a logical model, which fits all identified web objects into a high-level structure. This model does not include information about how the final web-based information system will look, or which navigation paradigm it will be based on; it merely represents where the average user would expect to find a particular web object in a hierarchical navigation structure.

Figure 2. Part of a navigation model

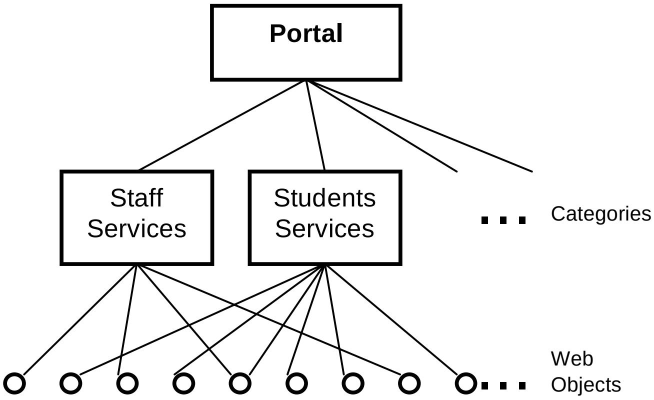


Figure 2 shows a small part of the model developed for the university re-design project. The model resembles a *directed acyclic graph*. The root node is the point where users start to browse the information system. The leaf nodes represent the available web objects. Below the starting point several intermediate levels are used to group the web objects in a logical way.

Since web objects can be assigned to multiple categories, it is not possible to represent the navigation structure by using *multitrees* (Furnas and Zacks, 1994). Multitrees are constrained to be *diamond-free directed acyclic graphs*, which means that each node can only be reached by one path. Our model, like the models of most other web-based information systems, violates this property. However, Furnas and Zacks addressed this problem and proposed the usage of duplicated nodes as a solution (Furnas and Zacks, 1994). Each node represents either a web object or a category.

This approach is used by the first web site administration tool described in the following section. However, as will be described in the next section, the technique of using duplicated nodes is prone to inconsistencies. Accordingly, a second administration tool that overcomes this drawback is also presented there. This second solution does not maintain the graph's structure explicitly, but builds it into the description (meta information) of each web object. This allows simple manipulation of one web object without corrupting the whole graph.

1. Storage of navigation model

The graph representing the navigation model has to be stored in a way which easily allows various forms of visualization. Maintenance is another important point. Since web objects (e.g. student services, publications) of a web-based information system tend to have short life-cycles, a high-maintenance solution would be inappropriate. To reduce maintenance costs, an administration tool for web-based navigation structures should have the following properties:

- user-friendly graphical user interface,
- support of multiple languages,
- frequent automatic validation checks for web object references,
- capacity to link users to web objects for which they are responsible,
- high performance.

1) Using bookmark files and web browsers for administering web-based navigation structures: First, we describe a simple solution using the hierarchical bookmark-mechanism of the Netscape Communicator web browser. A web object is represented by a bookmark that includes label and URI. The structure is modeled by using folders, which include bookmarks and/or other folders. For visualization purposes the navigation structure stored in a bookmark file is processed by a Perl application[1] which visualizes the model and thereby automatically generates the web pages of the portal (Simon, 2000). This solution, as well as being easy to implement, has the following advantages:

- The bookmark editor of Netscape is considered an easy-to-use interface.
- Updates and maintenance of the navigation structure can easily be carried out by changing the bookmarks and running the visualization application.
- The HTML files generated form a static system. This enables web servers to cache these files, which results in a higher performance of the web-based information system. The administrator updates the HTML files only after the navigation structure in the bookmark file has changed.

However, for more complex models (e.g. those with many multiply assigned objects) this solution has the following drawbacks:

- Multiply assigned objects can only be represented by physical copies. The administrator has to know all multiply assigned objects and to change each copy individually. This inevitably leads to inconsistencies.
- There is no support for multiple languages. The model for each language has to be maintained separately. This also leads to inconsistencies between the different versions.
- Automatic validation checks of the URIs can only be carried out by a special agent, which has to be designed and implemented separately.
- Meta information is not supported. The underlying data structure cannot be extended. A separate database has to be maintained for persons responsible for web objects.

In the case of small- and medium-size navigation structures ease of implementation should outweigh these drawbacks. For larger navigation structures, however, the use of a virtual library is recommended.

2) Using a virtual library: The second solution we present operates with meta information (Dublin Core, 2000). The virtual library[2] (Hahsler, 2000) uses meta information not only to store object properties such as title, language and responsible person(s), but also to represent the navigation model. A special attribute stores all possible paths to reach a web object within the navigation structure.

Figure 3. Meta information for the web object ‘Research Information Center’

```
Title := {Research Information Center}
URL := {http://www.university.edu/research/}
Responsible := {forschungsservice@wu-wien.ac.at}
Category := {Staff/Research; Institutions/Service
Departments}
```

An example of meta information for a web object is shown in Figure 3. In this example of a multiply assigned web object all possible paths in the navigation model are represented by the contents of the field ‘Category’, which contains two values. These indicate the two paths in the navigation model by which the object ‘Research Information Center’ may be reached; either via the categories ‘Staff’ and then ‘Research’, or by first accessing ‘Institutions’ and then the subsection ‘Service Departments’. By using this method the full *directed acyclic graph* of the navigation model can be constructed by processing the meta information of all web objects. The field ‘Responsible’ stores the e-mail address of the responsible person.

The main advantage of this implicit method of graph representation is, that even with multiple assignments of objects, no inconsistencies arise, since each web object is unique and there is no need for physical copies or duplicated nodes. Thus a web object can easily be manipulated and assigned to new categories without affecting the consistency of the navigation structure.

2. *Visualization of navigation model*

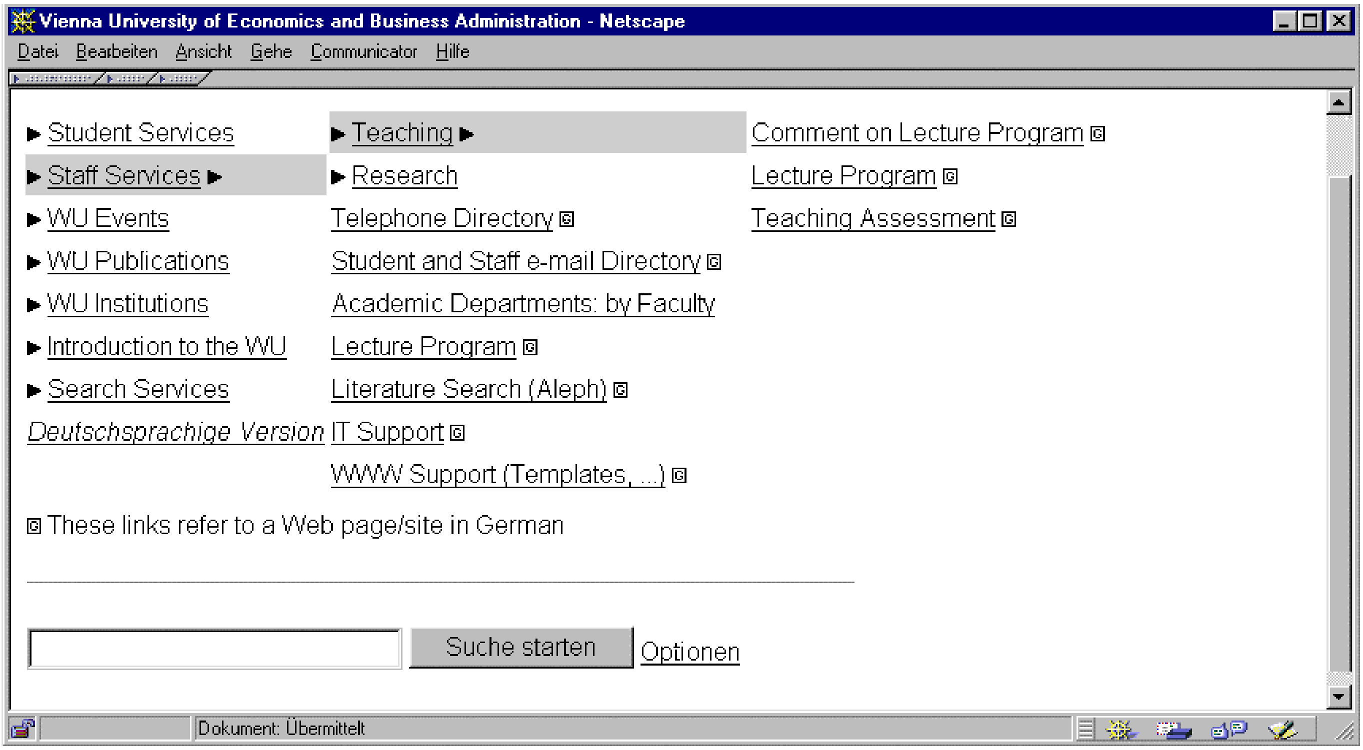
In this section we want to focus on simple ways to visualize a navigation model. The implementation of a hierarchical navigation model can be supported by either an overview diagram or an index.

Overview diagrams (Nielsen, 1995) are the first representation form that come to mind. These diagrams work like maps for exploration of the web-based infor-

[1] The Perl application is available free of charge at: www.wu-wien.ac.at/about/script_e.html

[2] The virtual library is available at: miss.wu-wien.ac.at/~virlib/

Figure 4. Visualisation as a multilevel overview diagram



mation system. Since most navigation structures offer more links to web objects than fit on a single screen, visualization of the whole navigation structure at once is not feasible. To overcome this problem sub-overviews have to be introduced, which show only a selected part of the navigation structure.

An alphabetical index is another useful navigation tool. Often a user knows roughly what the information required is called, but has no clue where to find it in the hierarchical structure of the web-based information system. An index is also very important if, as in our re-design project, user-groups are used as categories to model navigation. A person who is not represented by the user-group influencing the navigation structure may run into difficulties using the system without an index.

In order to visualize the representation model stored in a bookmark file or in a virtual library, the corresponding HTML files can be generated automatically. An automatically generated visualization of the navigation structure of the re-design project is shown in Figure 4 (see also: web site of the Vienna University of Economics and Business Administration at www.wu-wien.ac.at).

3. *Usability testing*[3]

The prototype should be subject to accurate usability testing. Usability can be defined as the degree to which a given piece of software assists users to accomplish a task, as opposed to becoming an additional impediment to such accomplishment (Levi and Conrad, 1998). Usability testing should start with an expert review, to be followed by a user test. Five to eight users per user group should be sufficient to identify the most important usability flaws (Spool, 1998). Prototype implementation and usability testing are an iterative process which leads to final implementation.

III. Lessons Learned from a Re-design Project

The project to re-design the web portal of the Vienna University of Economics and Business Administration was based on the approach described above. The following paragraphs summarize the lessons learned from this project and are intended to provide hints to practitioners with responsibility for re-design of a web-based information system.

[3] For a comprehensive introduction into usability testing see (Redmond-Pyle and Moore, 1995)

1. Audience definition

Right from the beginning we defined three major user groups: students, staff members, and the external public. Throughout the process the distinction of these three user groups proved to be very useful since each group displayed different needs and different - sometimes contrary- ideas about how the information should be organized.

2. Web object identification

Obtaining access to web server log files proved quite troublesome for the project team, owing to the computer center's doubts about the legality of such action. Finally, however, the team was able to get a copy of a log file, in which user data, including the IP address, were replaced by a character indicating whether the web object was requested from a machine outside ('e' = external request) or inside the organization ('i' = internal request). Due to a lack of hard disc space we were able to store only a small extract of the log file. These restrictions on access to the logs increased doubts about the quality of the 'top hits' list derived from the log file extract. As a result, the follow-up user survey was not only to evaluate tool the category identification process, but also to verify the 'top hits' list.

3. Card sorting

Some 20 users (10 students and 10 staff members) were asked to classify cards representing the most important 120 web objects. It took a user approximately 40 minutes to bring the 120 cards into some kind of order. Some of the users lost patience. One user did not finish the card sorting exercise at all, while another did not provide category names. Accordingly, we suggest that the number of cards used should not exceed 100, which should mean that the sorting exercise takes approximately 30 minutes.

The cards were produced with a word processor. After being printed out and cut into pieces they were distributed to users. One staff member re-entered the web objects into a word processor, because she felt more comfortable by using an electronic tool for the sorting activity. To increase the efficiency of the process, we suggest that re-designers should distribute the cards together with an electronic version. An interesting alternative way of organizing this stage would be to use a web-based tool. If this were combined with automatic category identification (e.g. cluster analysis) a large sample of users could be involved in the process.

4. Category identification process

The re-design team had a hard time creating the first model representation of the navigation structure, because the 20 users came up with quite different suggestions. As a first step similar categories were identified. At this stage the project team identified 14 sub-categories derived from the results of card-sorting carried out by the staff members, and 12 sub-categories derived from the results of the 10 students.

Quite soon it became apparent that staff members and students had totally different views of a user-friendly navigation structure. The re-design team therefore decided to split the navigation structure into student and staff versions. The two were re-merged by introducing the two main categories "Student Services" and "Staff Services". The category "Introduction to the University" was added to serve the needs of visitors interested in general information about the university. The category "Institutions" meets the demand for an organizational view of the university and its services. In addition, the categories "Events", "Publications" and "Search Services" were added on the top level.

Since many web objects have to be accessible from several sub-categories (e.g. the telephone directory is important for both students and staff members), the re-design team had to make heavy use of multiple assignments. As far as the group description was concerned some general rules, such as :"*The groups 'Student Services' and 'Staff Services' enable user-group-specific, functional access to the web site*" were documented in the first draft of a maintenance handbook.

As well as the results of the card-sorting activity, designers could visit web-based information systems of competitors. Analyzing these sites might provide valuable hints for a user-friendly navigation structure.

5. The user survey

The project team surveyed 1,140 users (103 assistant professors, 63 members of the administrative staff, 12 full professors, 4 adjunct professors, 929 students and 21 unidentified users) using an online questionnaire.

The questionnaire included some general questions about user satisfaction with the content of, and services provided by the university's existing web-based information system. The survey also verified the results of the category identification process. In this way we used a single survey in various stages of the re-design process.

The survey confirmed the findings of the log file analysis only in part. The importance of web objects that consist of multiple web pages or even dynamically generated content (e.g. electronic version of the lecture program) were hard to identify with a standard log analyzer. Whereas the use of the electronic version of the lecture program was underestimated, the usage of a web object showing updated pictures taken by a web cam in one of the PC labs was heavily overrated by the log file analysis; automatic re-load of the pictures resulted in a very high number of hits. The four most-used services of the web site turned out to be the telephone directory, the lecture program, the list of professors and electronic class enrolment.

The survey unveiled an interesting difference in user preferences. While students preferred colorful, graphic-oriented web design, employees had a strong preference for fast loading text-oriented web objects. This difference was even more astonishing given that about 61 per cent of the students surveyed used a rather "slow" dial-up connection to access the web.

In order to evaluate the categories chosen users were asked to assign a web object to one of the main categories by answering the question: "To which category would you assign the following web objects (multiple assignments allowed)?". Twenty-three web objects were assigned in this way. Unfortunately the re-design team did not ask the assignment question in precisely the same way as suggested in section II („In which category would you expect to find web object X?"), which probably led to more multiple answers.

Although there were some major differences in the way users assigned web objects to the categories at first glance, a user-group specific look at the data showed a higher degree of consensus on assignments. For some web objects, however, the consensus was significantly below the 70 to 80 per cent proposed by Fuccella and Pizzolato (Fuccella and Pizzolato, 1998). Frequently these web objects were assigned to more than one category.

IV. Future Research

In this paper we have presented our first experiences with this user-centered navigation re-design method. However, there are many areas left where future research is needed. Some of these areas are: review of the psychological background to the card-sorting activity; the significance of the consensus rate suggested by Fuccella and Pizzolato; and the usage of web tools and clustering methods to support card sorting and category identification.

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