

A New Technology to Adapt The Navigation

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Abstract— In hypermedia systems, adaptive navigation support becomes a necessity because it helps the user to distinguish between relevant and irrelevant links. It can reduce the loss of time and resolves the disorientation problem. For this, several adaptive navigation technologies are proposed to be applied on simple links to support the user along his navigation. In this paper, we propose an adaptive navigation method based on a new adaptive navigation technology called “Extended Link Technology”, which allows restricting the navigation space by using the XLINK extended links. This technology can be applied on both simple and extended link by taking into account several parameters related to the user and the visited documents.

Keywords— *Navigation adaptation; adaptive navigation technologies; XLINK extended links.*

I. INTRODUCTION

Currently, data sources in digital format are growing. Therefore, the volume of data and the number of links that connect these data increase. So, the user may be lost in the huge amount of information and links which makes the access to the relevant information more difficult. Thus, navigation adaptation is the solution that supports the user to find pertinent links to the suitable information. Thereby, the user will not be lost in the hyperspace in front of the large number of links and the disorientation problem can be resolved.

Several adaptive navigation methods and navigation technologies have been proposed to help the user by guiding him from a document to another, providing him with a set of pertinent links leading to the suitable information. The navigation adaptation result varies from one user to another, generally according to his profile (needs, preferences, necessities, etc.). But these methods as proposed in [15][7] and technologies as proposed in [4][5] are applied only on simple links and do not take into account the extended links. So, to better reduce the disorientation problem, the navigation space and the number of pertinent links displayed to the user, we propose an adaptive navigation method based on a new adaptive navigation technology which takes into account the extended links. This method is an extension of our proposed method in [19]. Our proposed technology allows to reduce the number of pertinent links in document by using the XLINK extended links (W3C [17]). So, we will apply on documents both our new technology and the already existing technologies by taking into account several adaptation parameters. These parameters are related not only to the user but also to the visited documents.

In order to realize our method, we propose an algorithm that takes as input the adaptation parameters to outputting the

expected navigation adaptation. This algorithm uses two functions: the first function assigns scores to links in order to differentiate them (irrelevant, relevant, less relevant, more relevant, etc.) and the second function applies on document our new adaptive navigation technology in order to extract extended links from the simple links.

To evaluate our method, we perform a series of experiments on the INEX 2007 collection. The results of this evaluation are satisfying and prove the efficiency of our method.

This paper is organized as follows. Section II presents a state of the art of some works dealing with the navigation adaptation. In Section III, we expose an overview of our method. In Section IV, we detail the main algorithm and functions on which our method is based. In Section V, we evaluate our proposed method. Finally, we present the conclusion and our perspectives.

II. STATE OF THE ART

Navigation adaptation is mainly based on the adaptation of documents' links by using the adaptive navigation support technologies [4]. The most known and used technologies are the link hiding technology, the link annotation technology, the direct guidance technology, the link ordering technology and the link generation technology.

The AHA! [6], for example, applies the hiding technology to irrelevant links and the link annotation technology to the remaining links by using different colors depending on the user's model (preferences, knowledge). Hypadapter [9] introduced the link ordering technology; the idea is to put links in order of relevance according to the user's model. The direct guidance technology is used to provide only one direct link to the next document to be visited. Among the works that use this technology, we cite Web Watcher [1], ELM-ART [8] and Chiou et al. [7]. The most used technology is the link generation technology. It provides links to the best documents. These latter are identified by means of different methods that vary from one system to another. The adaptive system proposed by Verma et al. [14] calculates and ranks the weight of each web page in the priority of descending order according to click-count, hyperlink weight and most frequent visits to the webpage. Then, it proposes link to the first page. The system proposed in [15] analyzes navigation paths of website visitors to identify the frequent surfing paths and provides the user with a set of links that leads to the next visited web pages. Seo et al. [13] propose two methods based on the generation technology. The first one suggests the next link to be followed by the user and the second one generates quick links as additional entry points into Websites. The system proposed in [20] extracts the

links and the key words from the already visited pages in order to propose a set of links that lead to the relevant pages.

The already mentioned works apply the navigation adaptation only to simple links (lead to only one document or page). As a matter of fact, the number of the pertinent simple links is not reduced. Furthermore, these works adapt the navigation by taking into account only the user's parameters without caring about the documents' parameters. So, we propose a new adaptive navigation technology called "Extended Link Technology" based on the XLINK extended links which reduces the number of the pertinent simple links on document and can be applied on simple and extended links. Our new technology with the already existing technologies is applied to a document before being displayed to the user in order to support him along his navigation.

III. OVERVIEW OF THE PROPOSED METHOD

In order to help the user to easily reach the pertinent information by choosing the best link and to reduce the disorientation problem, we propose a method that adapts the navigation by using: (i) the already existing adaptive navigation technologies [4] and (ii) a new adaptive navigation technology called "Extended link technology". This method is used in our architecture MEDI-ADAPT [18] and it is considered as an extension of our detailed work in [19] which allows identifying the best navigation path between the result documents. So, after identifying the navigation path, we propose to apply to each document, at run time, our new method. This latter consists of 6 steps. The first step is to extract the links of document in order to apply to the irrelevant links the "hiding link technology" (Step 2). The third step is to calculate the scores of links (cf. section IV.2). In the fourth step, we apply the "Extended link technology" (cf. section IV.3). Then in the step fifth, the identified extended links are generated in the document. Finally in the last step, according to the obtained scores in step 3, we apply on simple and extended links the suitable adaptive navigation technologies.

The scores of links, which are calculated in the step 3, have a very important role in our adaptation process. When calculating these scores, we propose to take into account several parameters; parameters related to the user which are extracted from the user profile and parameters related to the links target documents which are extracted from their descriptive meta-documents. In the following, we describe the proposed user profile and meta-documents.

A. The proposed user profile

The user profile is a basic component in adaptive systems. It contains data that describe the user's characteristics. According to Brusilovsky [5]: "user profile is composed of a set of categories: personal data, user's knowledge, interests, history, and preferences". There are different models to represent user profile: the attribute/value model [10], the logical structure based model (usually in a tree form) and the semantic based model via standards e.g. FOAF [3], CC/PP [11], and CSCP [2]. In this paper, as we are interested in navigation adaptation, we consider only the profile's navigation part (the user's

navigation history). This latter is built from analysis and updates of previous navigation sessions. We represent the proposed profile as an XML tree as illustrated in the XML schema in Figure 1.

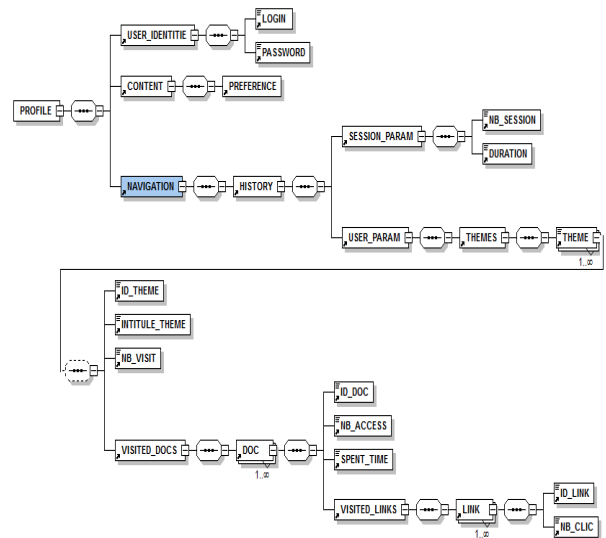


Fig. 1. XML-schema of the proposed user profile

To describe the user's history (HISTORY), we distinguish two parameters: one for the session (SESSION_PARAM) and another for the user (USER_PARAM). The first one consists of the number of sessions (NB_SESSION) and their duration (DURATION). As for the second one, it is made up by the visited documents (VISITED_DOCS) which are identified by (ID_DOC), the number of access to each document (NB_ACCESS), the spent time on each document (SPENT_TIME), the visited links (VISITED_LINKS) and the number of clicks (NB_CLICK) on each link (ID_LINK). In the end of each session, these parameters are updated or stored in the user's profile in order to be taken into account in next sessions.

B. The proposed meta-documents

Meta-documents [1] contain meta-data which are information that can identify a document and describe its content. These information are stored in a document called "meta-document". In this paper, we suggest to describe a document by three parameters stored in the XML meta-document illustrated by the XML schema in Figure 2. These parameters are taken into account in the navigation adaptation process.

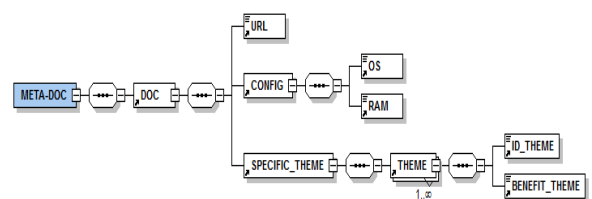


Fig. 2. XML-schema of the proposed meta-document

As we can see in Figure 2, we propose three parameters: (i) the Unified Resource Locator (URL), (ii) the required device configuration (CONFIG) which is limited to the Operating System (OS) and the Random Access Memory (RAM) and (iii) the specific themes (SPECIFIC_THEME), knowing that a document can belong to one or several themes. These themes are consequently used to apply the “Extended link technology”: simple links belonging to the same theme are grouped into one extended link. For each theme (ID_THEME), we specify the benefit of the document (BENEFIT_THEME) which depends on the theme. It is similar to the “profit of learning object” proposed in [7]. It is a value ranged from 0 to 1. It can be identified by the document’s author based on the relevance of the document’s content to each theme.

IV. THE ADAPTIVE XLINK EXTENDED LINK TECHNOLOGY

The originality of our method lies in the use of the new adaptive navigation technology “Extended link technology”. This technology is based on the idea of the XLINK extended links. W3C [17] “An extended link is a link that associates an arbitrary number of resources. The participating resources may be any combination of remote and local”. This technology allows to reduce the navigation space by reducing the number of links in the document and enables the user to have an idea about the related theme of each link.

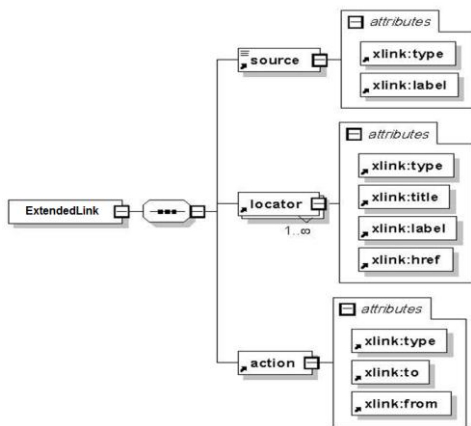


Fig. 3. The XML schema of the generated Extended Links

The basic idea of this technology is to regroup several simple links that belong to the same theme into a single extended link. The founded extended links in document will be generated according to the XML schema illustrated in Figure 3, and take the theme’s name as a title. Then, the resources of each extended link are subsequently reordered by using the "ordering link technology" and annotated by the "annotation link technology". We will apply, at run time, this technology on links with the already existing adaptive navigation technologies [3]. In the next section, we will present in detail the main algorithm which performs our proposed method and the two basic functions. The function that calculates the scores of links and the function that applies to document the “Extended link technology”.

A. The main algorithm of the proposed method “ANT”

To apply our method, we propose the algorithm called “ANT” (Apply the Navigation Technologies) which applies the adaptive navigation technologies on the documents (cf. Table I). This algorithm uses two functions. The first function, called “CLS” (Calculate Link Score) (cf. Table II), which calculates the scores of links. The second function, called “ELT” (Extended Link Technology) (cf. Table III), which allows to apply the Extended link technology.

TABLE I. ALGORITHM ANT

```

1.Algorithm 1: ANT
2. Input: theme,list_themes,selected_doc,
3.         user_history
4. Output:adapted_selected_doc
5. Begin
6.  i=0;
7. for each(link in selected_doc)
8.  begin
9.    if(link not in (theme||list_themes)) then
10.     Hiding_technology(link,selected_doc);
11.    else
12.     begin
13.      i++;
14.      remaining_links[i]=link;
15.    end
16.  end
17. for each(link in remaining_links)
18.  begin
19.doc_target_link=Determinate_doc_target(link);
20.benefit=Extract_benefit(doc_target_link);
21.Doc_Score=Calculate_Doc_Score(doc_target_link,
    benefit,user_history);
22.Link_Score=Calculate_Link_Score(Doc_Score,
    user_history);
23.  end
24.Extended_link_List=Extended_Link_Technology
    (remaining_links,Link_Score);
25.Generate_Extended_Link(Extended_link_List);
26.end.
    
```

For each link related to themes other than the requested by the user, the algorithm applies the hiding technology (lines (7) to (10)). Then, for all the remaining links (line (14)), it determines the target document (line (19)), the benefit of this document (line (20)), calculates its score (line (21)) [5], and calculates the link’s score (line (22)) by using the function “CLS” (cf. Table II). After that it extracts and generates at run time, if exists, extended links (lines (24) and (25)) by using the function “ELT” (cf. Table III).

B. The CLS function

The CLS function calculates the scores of links. These scores allow to distinguish between links and choose the suitable adaptive navigation technologies. These scores depend on the already cited parameters in the previous sections (cf. Sections III.1 and III.2) and are calculated by the calculation equation (1).

$$Link_Score(li) = \frac{\sum Doc_Score(target_doc)}{nb_target_doc} + link_freqm(li) \quad (1)$$

$Doc_Score(target_doc)$ is the score of the link target document. It is detailed in [19]. In the case of an extended link (having more than one target documents), we proceed to sum the scores of all target documents. $Doc_Score(target_doc)$ then divide it by the total number of the target documents (nb_target_doc). $link_freqm(li)$ is the average frequency of clicking on the link during all sessions. It is calculated by the calculation equation (2).

TABLE II. CLS FUNCTION

```

1.Function 1: CLS
2. Input: Doc_Score,user_history,link
3. Output:Link_Score
4. begin
5. nb_clic=Extract_nb_click(user_history,link);
6.nb_total_click=Extract_nb_click(user_history);
7.nb_session=Extract_nb_total_session(user_history);
8. calculate link_freqm;           //(cf. Equation2)
9.Return Link_Score;             //(cf. Equation1)
10.end
    
```

$$link_freqm(li) = \frac{\sum \frac{nb_click(li)}{nb_total_click}}{nb_session} \quad (2)$$

$nb_click(li)$ is the number of clicks on the link in one session, nb_total_click is the total number of the visited links and $nb_session$ is the total number of sessions.

The CLS function (cf. table II) takes as input the score of the document Doc_Score , the history of the user $user_history$ and the link $link$. Firstly, it extracts, from the user's history, the number of clicks on the link and the total number of clicks. Secondly, it calculates, by means of the equation (2) the average frequency of clicking on the link (line (8)). Finally, it uses the equation (1) to calculate the link's score $Link_Score$ (line (9)).

C. The ELT function

The ELT function (cf. Table III) extracts, if exist, extended links from the simple links in order to be generated in the

document before being displayed to the user. It takes as input the simple links of a document and their scores $Link_Scores$.

TABLE III. ELT FUNCTION

```

1.Function 2: ELT
2. Input: links,Link_Scores
3. Output:Extended_link_list
4. begin
5. Themes=Extract_themes(links);
6. j=0;
7. i=0;
8. for each(Theme in Themes)
9.   begin
10.    j++;
11.    for each(link in links)
12.     begin
13.      if(link in Theme) then
14.       begin
15.        i++;
16.        Extended_link_list[j][i]=link;
17.       end
18.     end
19.   end
20.Extended_link_list=Reorder_links(Extended_link_list,Link_Scores);
21.Annotate_links(Extended_link_list,Link_Scores);
22.end.
    
```

The basic idea of this function is to regroup all simple links that belong to the same theme into a single extended link (from line (8) to line (19)). Then, the resources of each extended link are reordered and annotated according to their scores (lines (20) and (21)).

V. EVALUATION

In order to evaluate our proposed method, we use a corpus of 110000 documents of INEX 2007 [16] French version, which is a part of the collection WIKIPEDIA XML. Documents in this corpus contain only XLINK simple links.

Given a user launches this query: "Documents related to the norms and computer standards", the system provides 11 documents called (XML, ASCII, SGML, HTML, XSL, ANSI, 10B5, 10BT, 10B2, Vietnam, SAMP)

When we apply the "Extended link technology" to the XSL document, for example, we will have 2 extended links. A part of the obtained result is shown in table IV (Knowing that the XML and XPATH documents belong to the same theme named "XML").

TABLE IV. EXAMPLE OF AN EXTENDED LINK

Post-adaptation extended link	<pre> <ExtendedLink xmlns:xlink="http://www.w3.org/1999/xlink"> <source xlink:type="resource" xlink:label="source">XML</source> <locator xlink:type="locator" xlink:label="destination" xlink:href="3338.xml" xlink:title="XPath" /> <locator xlink:type="locator" xlink:label="destination" xlink:href="3332.xml" xlink:title="XML" /> <action xlink:type="arc" xlink:from="source" xlink:to="destination" />... </ExtendedLink> </pre>
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We evaluate the use of our proposed method and especially the "Extended Link Technology". This evaluation is performed by computing the obtained links number firstly without navigation adaptation, secondly with well-known (The already existing) navigation adaptation technologies and thirdly with these latter and our proposed technology "Extended Link Technology" (cf. Table V).

TABLE V. NUMBER OF LINKS IN THE RESULT DOCUMENTS

Document Title	without adaptation	with adaptive navigation technologies	with the extended link technology
XML	39	27	6
ASCII	18	2	1
SGML	10	3	3
HTML	72	10	5
XSL	5	5	2
ANSI	4	1	1
10B5	10	3	2
10BT	9	3	2
10B2	13	4	2
Vietn.	5	1	1
SAMP	10	2	1

The variation in the number of links is illustrated in Figure 4. The obtained results show that the use of the well-known navigation adaptation technologies reduces the number of links from 195 to 61. But by applying our proposed technology "Extended Link Technology" we achieve the low number of pertinent links (from 195 links to 26). This means that, by applying our technology with the already existing technology the number of links can reduce to 86.666667%.

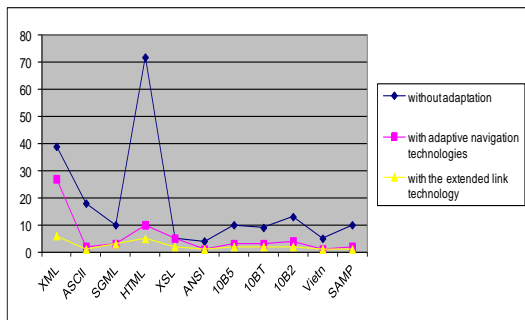


Fig. 4. The variation in the number of links

To evaluate the user's satisfaction, we have given him two document versions: a version without applying our technology and a version with applying our technology. Then, he tries to indicate the relevant links and the irrelevant ones. For him, these latter are links that should have remained simple and not hidden within an extended link. Table VI illustrates the number of relevant links and the number of the irrelevant links.

TABLE VI. NUMBER OF RELEVANT AND IRRELEVANT LINKS

Document title	Number of links without adaptation	Number of links with our technology	Number of relevant links	Number of irrelevant links
XML	39	6	30	3
ASCII	18	1	17	0
SGML	10	3	5	2
HTML	72	5	60	7
XSL	5	2	3	0
ANSI	4	1	3	0
10B5	10	2	6	2
10BT	9	2	6	1
10B2	13	2	8	3
Vietn.	5	1	4	0
SAMP	10	1	8	1

Based on the number of links shown in Table VI, we calculated the precision of the extended links in each document (cf. Figure 5).

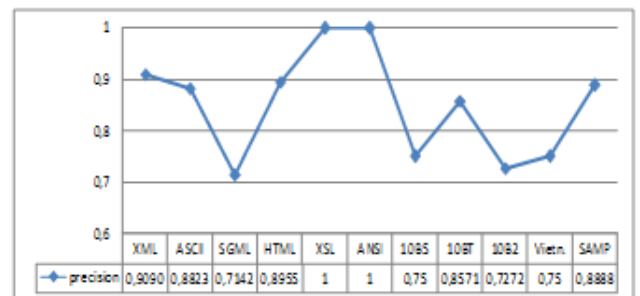


Fig. 5. The precision rates of the extended links

The evaluation of the user's satisfaction allowed us to obtain 0.85223 as an average precision. This can confirm the user's satisfaction. So, the user will have a limited number of well annotated links and can have from the extended links title an idea about the themes of the target documents. That's why; the probability of being disoriented is very limited.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a method of navigation adaptation which is based on the already existing adaptive navigation technologies and on a new adaptive navigation technology called "Extended Links Technology". This new technology is mainly based on the idea of the XLINK extended

links and can be applied at run time to simple and extended links.

As it is shown in the evaluation, our new adaptive navigation technology allows to reduce the number of pertinent links in document. Thus, the navigation space and the disorientation probability can be reduced.

In the continuation of our work, we aim firstly to evaluate our method with more than one user and evaluate their satisfaction. Secondly, we intend to improve our proposed method by taking into account other parameters. Finally, we are going to suggest and implement a learning method that reduces the profile to the most relevant content.

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