Adaptive Web server for On-line Information Systems

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ABSTRACT

Web servers supply with hypermedia tools for user-driven access to information. They provide a new information retrieval mechanism based on browsing into database or information systems instead of writing queries. Adaptive hypermedia increase the functionality of hypermedia. Indeed, they have a user's model based on some user's features like background, knowledge, preferences, goals, skills, ... and use it for adaptation to the user's needs. By means of user's models, adaptive hypermedia have the ability to adapt the information and links presented to a particular user and also support user's navigation in the hyperspace. In on-line information systems, users used to only access a fragment of information space according to their current goal. Then, user's goals are often used to design on-line information systems [1-10]. Goal analysis enables designers to specify relevant fragments and the navigation process. In general, goals provide navigation support. In this paper, we mainly focus on on-line information systems using a task model.

Keywords : on-line information system, adaptive web server, user modelling, task model, domain model.

1. INTRODUCTION

Due to new technologies in telecommunication, most of computer-based systems are available through Internet or Intranet. They are based on one or more web servers. Web servers supply with hypermedia tools for user-driven access to information. They provide a new information retrieval mechanism based on browsing into database or information systems instead of writing queries. One of the main advantages of browsing for users, in general, is that they are better to recognise the information they search that to characterise it in advance [1]. Nevertheless, hypermedia systems have some drawbacks : firstly, a user may become hopelessly lost in hyperspace when browsing in a large information space [11]. Then it is necessary to assist user's navigation for information retrieval. Reducing information space to access relevant information needed by users is a well known method to prevent from getting lost in hyperspace.

Most of Web servers provide predefined HTML pages, that is static hypermedia document. They are unable to cope with different users having different needs. They may be interested in different types or pieces of information, different layouts, maybe on different tools and they may use different links for navigation. Adaptive hypermedia increase the functionality of hypermedia. Indeed, they have a user's model based on some user's features like background, knowledge, preferences, goals, skills, ... and use it for adaptation to the user's needs. By means of user's models, adaptive hypermedia have the ability to adapt the information and links presented to a particular user and also support user's navigation in the hyperspace. According to Brusilovsky [12], the adaptive hypermedia definition is as follows: by adaptive hypermedia systems we mean all hypertext and hypermedia which reflect some features in the user model and apply this model to adapt various visible aspects of the system to the user.

Adaptive hypermedia systems are very useful in applications having users with different goals and knowledge and hyperspace reasonably big. When the hyperspace is large, navigation support according to user's features is particularly relevant. Then, there are used in educational hypermedia systems, on-line information systems, on-line help systems, information retrieval hypermedia, institutional hypermedia, decision support systems or problem solving systems using hypermedia as human computer interaction tools. In on-line information systems, users used to only access a fragment of information space according to their current goal. Goal analysis enables designers to specify relevant fragments and the navigation process. Then, user's goals are often used to design on-line information systems [1-10, 13]. In general, goals provide navigation support. In this paper, we mainly focus on on-line information systems using a task model. Some examples coming from the project swan are used to highlight some particular aspects of on-line information systems. SWAN project aims to design an adaptive web server for on-line information systems about nautical publications by means of user modeling.

First of all, as adaptive hypermedia are based on a user's model, we present different features of the users which are used in such kind of computer-based systems. Secondly, the main adaptive methods, which very useful in the hypermedia field, are analysed and discussed. Thirdly, the main characteristics of adaptive on-line information systems using a task model are presented. Fourthly a particular example is investigated, followed by a conclusion.

2. USER'S MODELING

Lost of different categories of features may be used by the system for providing adaptation. Nevertheless, we focus on those which are often used in adaptive hypermedia systems. In this paper, we present the following features of users: knowledge, background and hyperspace experience, preferences and goals.

User's knowledge is one the most important feature of the user in adaptive hypermedia systems. Generally, this feature has a particular property: it is not static but dynamic. Indeed, the user's knowledge may increase by using the computer-based system or decrease after a long time without using it. Then, adaptive hypermedia have to recognise the changes in the user's knowledge state and update the user model accordingly. It can be applied on an individual model or on a user's class. Knowledge used to be the knowledge about the domain considered by the application area, for instance medical knowledge about anatomy, or knowledge about a particular programming language - Lisp. The domain knowledge is represented as a network of concepts. They form a semantic network which represents the structure of the subject domain.

As an individual user's model, user's knowledge state is represented by an overlay model [14-18] which is based on the domain model. An overlay model is intended to be an « overlay » of the domain model. An overlay model stores a value which estimates or measures the user knowledge level of each domain concept. They are powerful and flexible and can measure independently user's knowledge of different concepts. As a user's class model, a stereotype model is used to represent user's knowledge [19, 20]. Stereotype user's model distinguishes several typical or « stereotypical » users. Classical user's classes are the following : novice, beginner, intermediate and expert. Stereotype, introduced by Rich [21], is an important element of user modeling and it has been extensively used because it gives a simple but powerful way for adaptation [22, 23]. This model is simpler but less powerful than overlay model. It is easier to initialise and to maintain. Some systems have a stereotype model to classify a new user and then, from the stereotype, initialise an overlay model which becomes the regular model [14, 15, 20, 24].

User's background and experience are similar to user's knowledge, but they functionally differ from it. User's background deals with all information related to the user's previous experience outside the subject of hypermedia system. It may include the user's profession, experience of work, user's viewpoint and perspective. User's experience take into account how familiar is the user with the structure of the hyperspace and then how easy can the user navigate in it. Indeed, the user may be familiar with the subject, but unfamiliar with the hyperspace structure and then can be easily lost in it [1]. Adaptive Hyperman measures continually the user's experience and adapt the navigation support according to this measure [25].

A user can prefer some nodes or some parts of a page or links over others and some pages' layouts [4, 25]. Preferences cannot be deduced by the system. The user has to inform the system directly or indirectly - feedback - about such preferences. Preferences can be absolute or relative to the current context, node or goal.

User's goals or user's task is related to the context of a user's work in hypermedia. The goal can be a search goal - in information retrieval system -, a problem solving or a learning goal - in problem solving systems or in educational systems and a goal depending on a particular application. The main drawback of this feature is that it is the most changeable : it can change from session to session, but also several times within one session. Then, it is not always easy to deal with user's goals. The user's goal is an important feature of the user in adaptive hypermedia systems. Nearly of these techniques are used for navigation support. To model the current goal, the system includes one of these goals into the users model. Some systems has a set of possible user's goals and are able to recognise the current one [1, 4-8, 10, 26, 27]. Otherwise, users have to select the current goal which can be represented implicitly as indexes in data description. The most advanced representation of user's goals is a hierarchy of tasks [1, 6, 8, 10, 27].

3. ADAPTIVE METHODS

Adaptive systems can have quite different methods for adaptation which depends on the system goals and its human computer interface. But, hypermedia systems have some particular adaptive methods corresponding to the specific tools offered for navigation and presentation. In this paper, we only focus on these methods. According to Brusilovsky, the content of pages called content-level adaptation and the links from pages, index pages and maps, called link-level adaptation can be adapted in hypermedia [12]. Content-level adaptation deals with different user's classes using the hypermedia, whereas link-level adaptation provides navigation support and prevents users from getting lost in hyperspace. Content-level and link-level, called respectively adaptive presentation and adaptive navigation support, are the two main classes of hypermedia adaptation.

3.1 Adaptive Presentation

The aim of adaptive presentation is to adapt the content of a page to the current knowledge, goals, preferences and other characteristics of the user. Then, it is possible to give different levels of explanation to a user corresponding to its class novice, intermediate, advanced or expert. Different users in different time may read different texts as a content of the same page. At present, only text adaptation is used - for instance [17, 18]. The techniques used for adaptive presentation can be « conditional text », « stretchtext » or « frame-based ». With the « conditional text », information is composed of several chunks of texts. Each one is associated with a condition related to the user model. Then, only chunks, where the condition is true, are presented to the user. With « stretchtext », the result of clicking on a hot word - hyperlink - is the replacement of the hot word or the corresponding phrase by the related text, thereby extending the text of the current page. This extended text may be collapsed back to a hot word. In « frame-based » technique, all information about a particular subject is represented by a frame. This frame is composed of several slots which are able to different explanations about the subject, links of other frames, examples, ... Special presentation rules may be used to decide which slots has to be presented to a particular user and in which order.

3.2 Adaptive Navigation Support

The aim of adaptive navigation support is to help users to find their paths in hyperspace by adapting link presentation to the goals, knowledge and other user's features. The most popular methods are direct guidance, sorting, hiding and annotation. In direct guidance the system has to decide what is the next « best » node for the user according to its features. Then, the system generally outlines visually the link dedicated to the next « best » node or present an additional dynamic link connected to the next « best » node. In adaptive ordering, all links related to the following nodes are sorted according to the user's model : the closer to the top, the more relevant the link is. The main drawback of this method is that the resulting order is non-stable and then may disturb the user. Nevertheless, they can reduced navigation time significantly in information retrieval systems [4, 25]. In hiding, the navigation space is reduced by hiding links to irrelevant pages. Hiding protects users from the complexity of hyperspace and reduce their cognitive overhead [6, 8, 16, 18, 28]. But hiding may leads to a wrong mental models of the hyperspace for the user. In adaptive annotation, the links are augmented by some form of comments [6, 9, 16, 17]. These comments give the state of the node behind the annotated link to the user. In WWW, a simple history-based form of annotation has been applied - outlining the links previously visited. A simple two-state annotation appears to be useful. Some adaptive hypermedia systems can distinguish up to six states on the basis of the user model [9, 17].

4. ON-LINE INFORMATION SYSTEMS

In cognitive science, the comprehension of a document is often characterised as the construction of the mental model that represents it. The readability of a document can be defined as the mental effort spent on the construction process [29, 30]. It is necessary to increase the readability of a hyper-document in assisting users in the construction of their mental models. For this purpose, two main factors are coherence and cognitive overhead [30]. A document is coherent if a user is able to build a mental model from it that corresponds to facts and relations in a possible world [31]. To increase coherence, it is necessary to provide cues. These cues help the user to identify the major components of the hyper-document and how the overall structure is composed. For reducing the mental effort of document comprehension, it is not sufficient to impose a coherent structure; it is also necessary to convey that structure to the user. It can be accomplished by providing overview of the document components and their relationships in terms of graphical maps or browsers. To decrease the cognitive overhead, the user needs knowledge about the overall document structure and must keep track of their moves through that structure.

Adaptive hypermedia for on-line information systems are dynamic hypermedia ; all pages are computed on the fly instead of defined previously. To increase the document coherence and to decrease the cognitive overhead, static and dynamic hypermedia do not need the same tools. In static hypermedia, hyperspace can be represented by a directed acyclic graph. Each node is a HTML page. Vertices stand for links between pages. This graph can use to browse the hyperspace and enables the designers to convey to the user the overall document structure and to keep track of their moves. In dynamic hypermedia, it is not possible to represent hyperspace in such a way. Generally, the hyperspace is represented by the domain model which is a high level structure providing all the concepts of the domain and their relationships. The most advanced domain model are semantic networks. The least one are only a list of terms. A domain model - similar to an object-oriented scheme of a data base - gives an abstract overview of the hyperspace. This abstract is stable whatever the data are. Indeed, they are organised according to this model. The domain model is used to browse the hyperspace and to convey to the user the overall document structure and to keep track of their moves through it.

In On-line information systems, hyperspace used to be too big to leave the user browsing without help. It is not sufficient to give him guides by means of the domain model for two main reasons : first of all, the domain model may be too complex - a concept can be connected to each other - and secondly each concept may contain too much data. Then, other criteria have to be used to determine the relevant information space and to assist the user for navigation. In on-line information systems, users used to only access a fragment of information space according to their current goal. Goal analysis enables designers to specify relevant fragments and the navigation process. User’s goals are often used to design on-line information systems [1-10, 13]. The aim of a task model is to navigation support and to determine the relevant information space according to the current task. This relevant information space is assumed to be sufficiently small to enable the user to browse through it and to understand the hypermedia document. Domain and task models help us to give local and global guidance to the users in order to convey the overall document structure to the users and then to increase document coherence and decrease cognitive overhead in enhancing orientation and navigation. The domain model is only used when the relevant information space determined by the current task is required.

The most advanced representation of user’s goals is a hierarchy of tasks [1, 6, 8, 10, 27]. The hierarchical structure is based on a composition relationship between tasks. Generally, the task model has two kinds of tasks : abstract and atomic. Firstly, abstract tasks are used to declare the navigation process, and to build the global and the local guides and orientation. An abstract task is decomposed into sub-tasks which can be abstract or atomic. A control structure using standard operators determines the sub-tasks ordering. There are at least two main operators which are as follows : sequence (and), selection (or). Secondly, atomic tasks are used for information retrieval and sometimes for human-computer communication. They are not composed of sub-tasks, in fact they are the leaves of the hierarchical task model. An information retrieval task computes an hypermedia views allowing the user to browse in a small hyperspace. It determines the relevant domain concepts.

A hierarchical task model is very convenient for the designer to define the navigation support and also to provides relevant cues to the user to increase the document coherence and to decrease the cognitive overhead. Indeed, the different states of the tasks and the paths in the corresponding sub-domain model may provides such cues to the user. Now, we present a particular project called SWAN project, in order to give some examples of adaptive methods and task models

5. AN EXAMPLE: SWAN PROJECT

SWAN project (Adaptive and Navigating Web Server) aims to design adaptive web servers for on-line multimedia information systems about nautical publications [6, 13]. It is a joined project between the IASC laboratory and a private company called Atlantide. The project is funded by the west region council and supported by the French naval hydrographic and oceanographic service. At present, sailors have to find out the relevant pieces of information in different categories of publications (sailing directions, lists of lights and fog signals, tide and streams publications and Radiosignals publications, ..). The on-line information system will provide nautical information available in different types of publications for different classes of sailors and vessels to prepare a maritime navigation or to navigate on oceans.

The user’s model is composed of a user’s class, a task model and an individual model. Its structure is similar to the user’s model of Hynecosum [1, 32]. The user’s class consists of a sailor's class and a vessel's class. The former has only one feature, the sailor category which can be professional or yachtsman. The vessel's class features are the following : length, breadth, height, tonnage, draught, navigation category which determines maximal distances from a shelter, vessel type (military, fishing, cargo, yacht, ..). The maritime navigation context consists of a set of navigation condition features : tide, time, weather forecast, general inference, GPS position (Lat/Long) or position chosen by the sailor. The user's individual model enables the sailor to choose an adaptation method for a particular task or to specify some parameters of an adaptation method and to choose the minimal depth of route.

According to interviews, we find out four common goals for sailors - named Services - that are sufficiently general and high-level to be stable : route retrieval or creation, route information retrieval, port / anchorage, general information retrieval. Route retrieval or creation helps the sailor to find a route from a port/anchorage to another one. By means of the departure and arrival port/anchorage, the « Route Retrieval » task retrieves the routes between the two locations and associates to each route a state. There are four possible states: advisable, secure, non secure and forbidden. The route states are computed from the vessel's class features (draught, navigation category, vessel type), the individual model (minimal depth) and navigation context features (tide, tidal streams, time). The default adaptive navigation method is the annotation based on these states. But the user will be able to choose between annotation and hiding and partial hiding by means of the individual model. The four annotation states are computed as follows: i) forbidden route: wrong vessel's type, wrong route's category, minimal depth less than the vessel's draught or the user's minimal depth ; ii) non secure route: permitted route, port/anchorage non-allowed for the vessel, due to draught, tonnage or size, forecast an tide conditions leading to dangerous route ; iii) secure route : minimal depth equal or greater than that required by the sailor, permitted route ; iv) advisable route, a secure route which is advised in sailing directions.

Task analysis of services showed that it is quite natural to represent them by a hierarchical task model [33]. The task model consists of tasks hierarchically organised by a composition relationships (cf. fig. 1). Tasks are divided into two classes abstract and atomic tasks. Abstract tasks are used to declare the navigation process. A control structure using standard operators - sequence (and) and selection (or) - achieves the sub-tasks ordering.

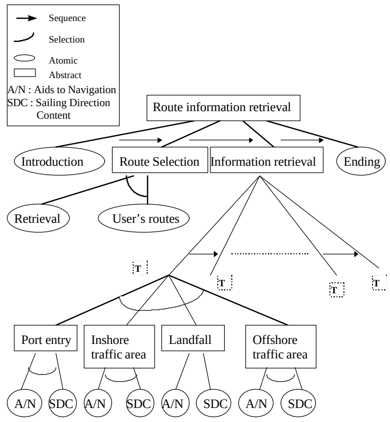

Fig. 1 Graph of the « Route Information Retrieval » service.

Each service begins with an « Introduction » task to explain the service's goals and a « Ending » task to close it, mainly for tutorial aspects of the first version. The « Route Selection » task is available to the sailor whether he has not previously chosen a route in the « Route Retrieval/Creation » service. Then, he can access the « Retrieval » sub-task to select a route. A route is composed of several route sections which are defined by two way-points, a compass course, a route section type (inshore traffic area, offshore traffic area, landfall, port entry), a minimal depth, a length, a sailing direction area, danger conditions. A route possesses some other attributes like: a departure and an arrival port/anchorage, a route category, a minimal depth, a length and advisable or not. After selecting a route, the sailor uses the « Information Retrieval » task to get relevant pieces of information corresponding to his route.

In our framework, two main information categories are provided to sailors: aids to navigation (buoys, lights, seamarks and alignments) and sailing direction content (texts, charts, images, drawings) which come from the sailing directions for professional or yachtsman and lists of lights and fog signals. This « Information Retrieval » task is composed of a sequence of sub-tasks, one task per route section type. A particular task class is associated with each route section type. Each class is composed of two sub-tasks, one per information category « aids to navigation » or « sailing direction content » to define the corresponding strategy for hyperspace views and adaptive method. Indeed, the two information categories are not processed in the same way because they are structured in a different way and are not accessed for the same reasons. Atomic tasks are used for information retrieval - all « aids to navigation » and « Sailing Direction content » tasks - and communication « Introduction » and « Ending » tasks. They are not composed of sub-tasks. A communication task gives some explanations to the user, specifies some user's needs and gathers data or information from users. An information retrieval task computes an hypermedia views allowing the user to browse in a small hyperspace. It determines the relevant sub-domain space, an adaptive navigation method and a way to compute hyperspace views according to particular sub-domain spaces.

6. CONCLUSION

Web servers supply with hypermedia tools for user-driven access to information. They provide a new information retrieval mechanism based on browsing into database or information systems instead of writing queries. Adaptive hypermedia systems are very useful in applications having users with different goals and knowledge and hyperspace reasonably big. When the hyperspace is large, navigation support according to user's features is particularly relevant. In on-line information systems, users used to only access a fragment of information space according to their current goal. Goal analysis enables designers to specify relevant fragments and the navigation process. The aim of a task model is to navigation support and to determine the relevant information space according to the current task. This relevant information space is assumed to be sufficiently small to enable the user to browse it and to understand the hypermedia document. The task model and the domain model are used to convey to the user the overall document structure and to keep track of their moves through it. Designing an on-line information system in such a way assumes that the domain and the task models are well understood by the user.

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