AN ORIGINAL ADAPTIVE HYPERMEDIA AIRCRAFT HANDBOOK

Pascal Dayre
IRIT-ENSEEIHT UMR CNRS 5505
2 rue Camichel BP 7122 31071 Toulouse Cedex 7

Hadj Batatia
IRIT-ENSEEIHT UMR CNRS 5505
2 rue Camichel BP 7122 31071 Toulouse Cedex 7

ABSTRACT
Until recently, documentation in the industry was used mainly in paper format. With hypermedia, a new generation of documentation became possible. Currently, the documentation tends toward real intelligent application systems. Such systems are based on interactive and adaptive multimedia over the internet. The content is made of different types of media (text, graphics, image, video, sound, etc) and is adaptive to meet the specific needs of each user. This paper discusses this new and upcoming kind of system. It describes a concrete application using a generic browser, the already existing and well-established web standards and the SVG hypermedia application standardized by the W3C. In addition, the system is designed to make feasible adaptive browsing over mobile connections.

KEYWORDS
Documentation, Adaptive Hypermedia, SVG, machine learning, document mining.

1. INTRODUCTION
Traditional paper based information systems are being slowly replaced with electronic information systems. A new generation of electronic documentation made with adaptive hypermedia is developing. This paper contributes to this trend by examining some of the issues of concern during the development of an industrial adaptive hypermedia documentation system. A range of topics needs to be addressed, including hypermedia language, browser and plug-in choice, design and techniques for content authoring [1], adaptation, and integration. The adaptation issue is particularly important. Adaptive hypermedia systems use static user profiles or dynamic models [2, 3]. Static profiles are sets of attribute-value items created at the authoring stage. Dynamic user models are based on learning algorithms that process user interactions to derive user or group profiles [3]. Applications include navigation aid system [4], adaptive tutoring [5], and customer purchase behavior analysis [6].

Currently, there are few reference models for adaptive hypermedia systems [7, 8]. They address mainly educational applications and include several models like user modeling, domain modeling, and teaching modeling. These models make the content authoring complex and specific to the application domain.

Our proposed framework works with any content and has no specific requirements on the authoring process. It also requires no static user modeling. This approach has been implemented by developing a navigation aid system for an aircraft handbook, called NAVAIR.

Existing research work, in this domain, focus on generic models [7, 8, 9, 10]. During this case study, we dealt with technical and practical problems like the limitation of the standards, differences in the implementation of standards on the browsers and plug-ins, and the limitation of the network bandwidth.

This paper shows mainly the following aspects: the use of the W3C well-established web standards and common browser, the design of an architecture suitable for mobile device connection through low bandwidth
wireless network, the implementation of document mining, the justification of the choice of prefix-span algorithm \[11\] compared to other data mining algorithms, the distributed prediction agent, the dynamic discovery of the document structure, and the integration of the adaptation agent into the hypermedia content.

2. THE HYPERMEDIA AIRCRAFT HANDBOOK

As the scale of available information increases, managing documents so that the users find information easily becomes a critical issue. This paper examines how hypermedia can be practically used to develop an information system to reach this goal. The initial material for the hypermedia aircraft is made of 2D vector documents generated by CAD systems. These documents are processed to create a hypermedia content by linking the various graphics according to a predefined navigation design. The resulting content is enriched by incorporating adaptation agents in order to obtain an adaptive application. The following sections briefly present these three phases.

2.1 Hypermedia content

Hypermedia can be defined as interactive multimedia over the internet. The content is made of different kinds of media (text, graphics, image, video, sound, etc). It can be distributed on several media servers: streaming servers for the audio and video, image servers, CAD Design servers, etc. Our application uses rich hypermedia content including hypertext and hypergraphics. Traditionally, CGM and Flash are used as vector hypermedia solutions. CGM is usually used for technical graphics. Flash is used for web 2D vector animation. SVG overlaps CGM, so conversions from CGM to SVG is almost without losses. Through webCGM, CGM offers a poor DOM support comparatively to SVG. Another disadvantage of CGM and Flash is the impossibility of routing events between document items. Our application uses XHTML to represent documents. This solution allows an easy integration of varied media using XML modularization: vector graphics, virtual reality, etc. SVG \[12\] has been used to describe aircraft graphics. The XHTML documents hosts \[14\] multiple SVG items that can communicate via routed events (fig.1). This structure has the advantage of being easy and efficient to process using DOM and XML event model \[13\]. In the remainder of this paper, the XHTML document is called component. A component is composed of a number of SVG items. We distinguish two types of hyperlinks: intra and inter components hyperlinks. Intra-links connect items, whereas inter-links connect components.

![SVG Spies agent](image)

2.2 Adaptation

As HTTP is a stateless protocol, it is necessary to manage a session layer at an upper level. This is usually made on the server side with PHP or servlets for instance. However, HTTP server is unaware of intra component interaction. For this reason, the session needs to be managed on the client side. The approach adopted in NAVAIR is to separate the content authoring process from the adaptation process. The XHTML document is transformed dynamically to make it adaptive. At the HTTP request, the server adds a software component to the document that consists of java applet. This applet plays the role of a session manager and implements three agents: an event spy agent in charge of recording the user interactions, a prediction agent...
that maintains the user model, and an adaptation agent. In addition, the server includes javascript functions
that implement event listeners and event handler. These handlers allow the navigation within the SVG
components by manipulating the DOM. They also route the events to the session agent. This agent process
the navigation sequence, predict the most appropriate item and changes the graphics by highlighting it to suit
the user’s intention. This approach makes dynamic authoring of the content easy. The content can be adapted
by adding or removing event handlers.

3. SYSTEM ARCHITECTURE

The NAVAIR system has a distributed architecture as depicted in figure 2. The CAD production systems
provide raw graphics material. This material is processed by an authoring tool to create the hypermedia
documents. These documents are then transformed by adding the adaptation software agents. The resulting
components are managed by the component server which is able to distribute them over the internet. During
the browsing session, the spy agent incorporated into the component records the user’s interactions and
communicates them periodically to the adaptation server which maintains all browsing logs. A sequence
mining algorithm runs on this server to compute a prediction model for each component. The prediction
models consist of software objects representing navigation prediction data and heuristics. These models are
stored by the adaptation server. The prediction agents included into the components on the client side
requests, at loading time, the prediction models and exploits them to calculate the next navigation step
suitable for the user. Based on this calculation, the adaptation layer modifies dynamically the content and its
presentation.

This architecture makes feasible mobile connections. The components can be downloaded to the client
using a prefeching technique. In case of mobile communication disruption, the user can continue browsing
adaptively the content.

4. DOCUMENT MINING AND THE PREDICTION MODEL

Classical hypermedia applications offer the impression that there are numerous meaningful ways to navigate
through a large body of information nodes. The rich link structure creates orientation problems. NAVAIR
offers guidance to technicians who explore the information space of an aircraft for maintenance procedures
and improves their search time and satisfaction.

Most existing adaptive hypermedia systems are based on webmining which analyses only http server
logs. This technique is not able to make real advanced adaptation as local interactions are not recorded.
NAVAIR uses document mining [15] by analyzing all user interactions. Intra and inter components links activated by the user are recorded and represent navigation sequences. These sequences are analyzed by prefix-span sequence mining algorithm [10]. This algorithm has the advantage of having a low complexity and can, therefore, handle large number of browsing sequence records, ensuring the system scalability. In addition, other techniques such as Markovian models handle large graphs resulting in heavy communication loads between server and client. Prefix-span algorithm generates a light weight prediction model consisting of remarkable sequences with the frequency of their occurrence, and a simple decision heuristic function such as the longest sequence, or the most frequent sequence. This solution permits the system to discover dynamically the document structure. Beyond this choice, the modular architecture of NAVAIR system makes possible the use of other data mining techniques with no significant changes. It is important to notice that the prediction model is the basement of the adaptation process.

5. CONCLUSION

This paper has briefly presented a practical approach to the development of a new framework for adaptive documentation system using a generic browser, the already existing and well-established Web standards. The framework presented has been implemented and tested as a hypermedia aircraft handbook. The chosen architecture highlights the fact that document mining is necessary for adaptation and more appropriate than web mining. It is based on the components structure of the content. This allows the use of a local adaptation agent improving interactivity. It also makes possible realistic adaptive browsing over mobile connections. The adaptation is made on the basis of the prediction of navigation sequences with a powerful sequence mining algorithm that automatically discovers the content structure and the remarkable navigations without any external knowledge. The main contribution has been the integration of different technologies and tools to create an adaptive documentation system in an industrial context. Future work includes the evaluation of the application by measuring the user search time and satisfaction. We also plan to investigate the creation of a rigorous methodology for the design of adaptive hypermedia content. Combining our approach with semantic web techniques could lead to a more general framework.

ACKNOWLEDGEMENT

We would like to thank EADS Toulouse for their support during this project. For confidential reasons, we were unable to include aircraft drawings.

REFERENCES


