Adaptive HyperMan:
A Customizable Hypertext System for Reference Manuals

Joshua Rabinowitz
Caelum Corp.
NASA Ames Research Center
MS 269-2, Moffett Field,
CA 94035, U. S. A.
joshr@ptolemy.arc.nasa.gov

Nathalie Mathe
San Jose State Univ. Foundation
NASA Ames Research Center
MS 269-2, Moffett Field,
CA 94035, U. S. A.
mathe@ptolemy.arc.nasa.gov

James R. Chen
Recom Technology, Inc.
NASA Ames Research Center
MS 269-2, Moffett Field,
CA 94035, U. S. A.
jchen@ptolemy.arc.nasa.gov

Abstract

We are interested in facilitating information access from large volume of reference information contained in technical and operational manuals. When a large volume of information is used on an everyday basis to perform one's job, the problem for users is to build and maintain an accurate cognitive model of the information in order to access it quickly. The problem is not to perform a search to discover new information, since they have already learned the information during their training. We have developed an adaptive hypertext system to help Space Shuttle flight controllers access operations documents in mission control center. We describe this intelligent system, called Adaptive HyperMan, which lets users incorporate their representation of the content and organization of documents over time. It provides sophisticated annotations and hyperlinking capabilities to end-users, and integrates an adaptive indexing and retrieval engine for managing annotations. This novel feature lets users assign topics to annotations, retrieve annotations by topics, and provide relevance feedback over time. Besides memorizing user inputs, the indexing engine also learns to generalize user inputs in order to facilitate retrieval from similar topics. We describe the Adaptive HyperMan system, then show how it provides a virtual "goody book" facility to flight controllers, and supports collaborative work.

1 The Problem

We are interested in facilitating access to large volume of reference information contained in technical and operational manuals. This type of information is used in many fields by professionals like airplane mechanics, pilots, astronauts, Space Shuttle flight controllers, power plant controllers, lawyers, doctors, etc. These persons need to use of large amount of technical information to perform their everyday job. However, as opposed to more traditional information retrieval tasks, they do not often need to search for information to answer their queries. They rather already know most of the information and where it is stored (it is part of their training), and just need to access it quickly to use it as a back-up to their memory (to prevent human errors).

For example, we are working with Space Shuttle flight controllers. It takes years of training to become a flight controller in the Space Shuttle Mission Control Center. As part of this training, people learn to use a large corpus of documentation to solve problems. They develop a deep knowledge of the organization and content of these manuals in order to access the proper sections as quickly as possible.

This knowledge, or cognitive map, is context- and user-dependent [Boy, 1991]. However, it does not persist very long unless the same information is accessed often under the same context. Users therefore develop artifacts to support their memory, like annotations, Post-It notes, bookmarks; or they create condensed representations of important information like cue cards, quick access guide, abbreviated checklists. For example, each flight controllers develops a personal "goody book", which is a personal collection of selected information from existing Shuttle operations documents.

Beside the volume of information to remember, another problem is due to the frequent updates and revisions of technical manuals. Users have to constantly revised what they know, as well as manually update their personal annotations and goody books. This is time consuming, and creates a potential safety risk. Currently the operational documentation used by flight controllers is paper-based, and goody books are paper copies of pages organized and annotated together in a binder.

Thus, the problem for technical users is to build and maintain an accurate cognitive model/map of the information in order to quickly access relevant information. We describe an intelligent system, called Adaptive HyperMan, which lets users incorporate their representation of the content and organization of documents over time. It provides sophisticated annotations and hyperlinking capabilities to end-users, and integrates an adaptive indexing and retrieval engine for managing annotations. This novel feature lets users assign topics to annotations, retrieve annotations by topics, and provide relevance feedback over time (to update the relevance of annotations to topics). Besides memorizing user inputs, the indexing engine also learns to generalize user inputs based on relevance feedback and previous retrievals, in order to facilitate new retrievals. We briefly describe the Adaptive HyperMan system, which builds upon the features of the HyperMan system, then show how it provides a virtual "goody book" facility to flight controllers.

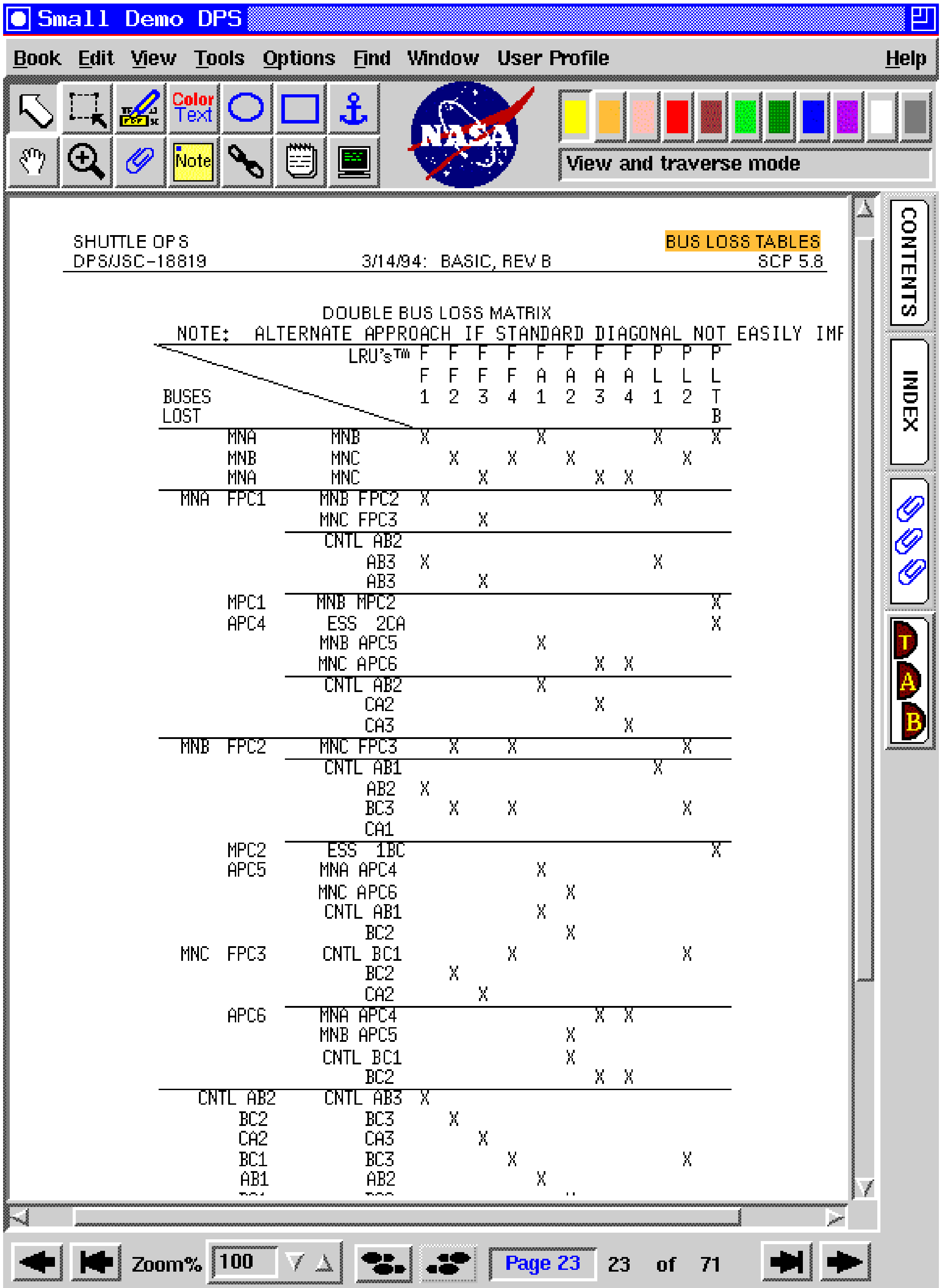

Figure 1: The HyperMan book window. The annotation tools palette is shown at the top left, below the menu bar. An example of a marker, the highlighted text "BUS LOSS TABLES", is shown at the top right of the page.

2 The HyperMan Viewer

HyperMan 2.0 is a software tool for document viewing and parsing, developed as part of the Electronic Documentation Project (EDP) at the NASA Johnson Space Center (JSC) [NASA JSC-26679, 1994]. The goal of the EDP project is to provide an electronic capability to support authoring, distribution, viewing, and controlled revision of crew and ground controller operations documents, for use in the new Control Center Complex and in their office environment. EDP integrates the state-of-the-art hypertext document viewer, HyperMan, with JSC flight planning and scheduling tools, and commercial workflow automation tools. Starting with a literal representation of the current paper-based system, HyperMan extends that metaphor with hypertext capabilities. HyperMan is a full blown wysiwyg PDF (Portable Document Format from Adobe) viewer designed for hundreds of simultaneous users' accesses to operations documents. HyperMan is being used by flight controllers in support of Shuttle missions since July 1995. The current library contains the following books: Flight Data Files (FDF), Flight Rules, Operator Console Handbooks, and Space Shuttle System Handbook Drawings (a total of approximately 100 books.)

To answer flight controllers' need for intensive customization of documents, HyperMan provides the ability for end-users to create and store various types of annotations (Figure 1). Users can create visual markers on a page as color highlight (background color change of selected text or graphical region), as colored text (foreground color change), as icon anchor, or as bookmark; and users can create hyperlinks between any markers (both inter- and intra-book). To support collaborative work, users can publish their annotations, and subscribe to published annotations from various user groups.

Other useful features include full text search, automatic hyperlinking at parsing time, version control (to retain user annotations between versions of documents), and transportable annotations (each user's annotations are stored separately from the documents, so that the document itself is never altered by the creation or deletion of markers or hyperlinks). We do not have space to describe the HyperMan system in more details, and will focus in the next sections on the adaptive modifications we have made.

3 Adaptive HyperMan

Adaptive HyperMan (AHM) builds on the strengths of HyperMan by allowing users to assign subjective indexing information, called topics, to markers in documents, and to perform searches for markers that have been associated with particular topics[1]. It also lets users provide relevance feedback over time (to update the relevance of annotations to topics). The system utilizes an adaptive indexing and retrieval engine designed to learn from similar queries and relevance feedback [Chen and Mathe, 1994; Mathe and Chen, 1994].

3.1 Indexing

To help users build a cognitive map of the information, AHM provides the ability to index markers by topics. From the indexing engine point of view, a topic can be any word or sequence of words[2]. The indexing engine memorizes the exact set of topics defined by a user for a selected marker, so as to provide accurate retrieval later on. It also generalizes the indexing to subsets of the topics set, in order to facilitate retrieval with similar queries later on (similar queries are defined as sharing common topics). This indexing information is stored in a network structure, called user profile database.

3.2 Retrieval

To facilitate quick access to information, AHM provides the ability to retrieve markers by topics. The user specifies a set of topics as a conjunctive query. The engine retrieves a list of markers by exact match, if the exact same set of topics was previously assigned to some markers (memorization); or by derivation from previous queries (memorized or generalized) which contain subsets of the current query.

3.3 Learning

To help users maintain an accurate cognitive model, as the information is updated or the user knowledge evolves, AHM offers users the ability to give relevance feedback in order to modify the relevance of markers to given topics over time (users can always add new topics through the indexing capability). When users give positive or negative feedback to markers retrieved with given topics, the adaptive engine automatically adjusts its relevance measures for these markers and topics, and propagates feedback to all proper topics subsets (generalization). The adaptive engine also learns to improve its retrieval performance by usage. It automatically analyzes co-occurrence statistics of topics over a collection of previous queries, then selects and memorizes sets of topics with high co-occurrence value to improve the generalization process.

3.4 Collaborative work

To facilitate sharing of information among a group of users (e.g., flight controllers with the same console position), and to facilitate training of novice users, AHM combines inputs from all users in a separate system profile database (in addition to each user's profile database). This supports the creation of a corporate memory over time, which can be shared by all users, or used as a starting point to their individual indexing.

[1] This supplements the full text search ability, as markers may have been indexed under topics that never appear as words on that page, or may be associated with graphics.

[2] We do not currently represent semantic relationship between topics, but plan to do it in our future work..

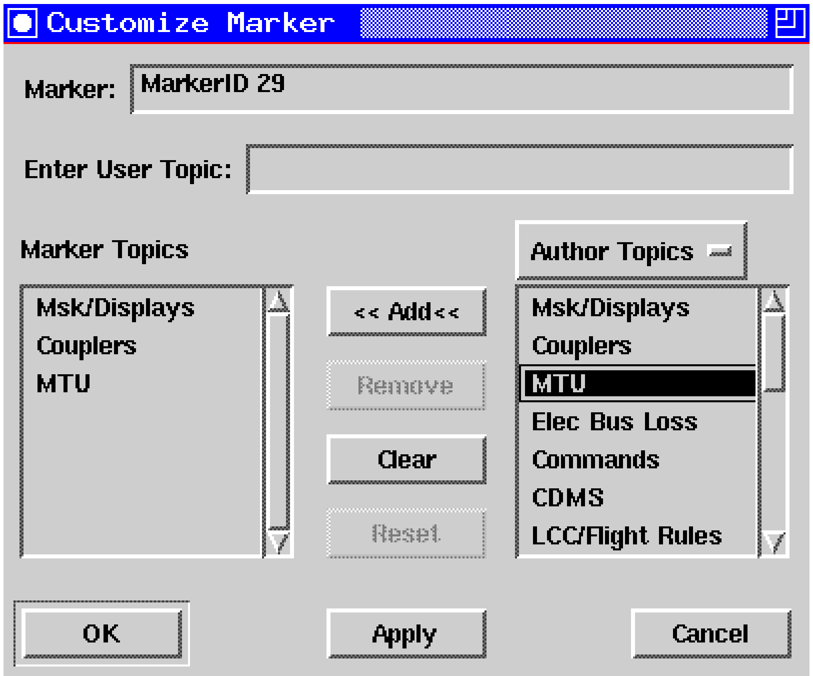

Figure 2: The Customize Marker window. The user selects from the list of topics on the right and assembles a list of topics to associate to the marker shown on top.

4 The User Interface

This section describes how users interact with our system. An explicit design goal was to change the HyperMan user interface as little as possible, so as to not confuse novice HyperMan users. The only visible difference we made to the book window is the additional *User Profile* menu (Figure 1), which provides access to four new windows: *Customize Marker* (Figure 2), *Marker Retrieval* (Figure 3), *Marker Retrieval Results* (Figure 4), and *Markers Basket* (Figure 5). The features of Adaptive HyperMan fall into three categories:

1) Assigning topics to markers:

The user can associate any list of topics, either pre-defined (called author topics) or user-defined topics, to a selected marker (Figure 2). The user can also assign topics to a marker by clicking on the "success" button (Figure 4), specifying that the selected marker is relevant to the last topic search.

2) Retrieving markers by topics:

The user can search all books in the current library for markers relevant to a list of selected topics (Figure 3). This search can be performed on either the user profile or system profile databases. In addition, the user can specify the maximum number of markers wanted, whether to use full match (match all topics) or partial match (at least one topic) algorithms. The list of retrieved markers is displayed in the Marker Retrieval Results window (Figure 4).

3) Setting aside interesting markers:

The Markers Basket is a place where users can store a list of markers belonging to any book. We envision that users will use this to recall markers that they wish to assign topics to later; but it can also be used like a hotlist in Netscape or Mosaic to store a list of markers for quick reference.

The Customize Marker window (Figure 2) allows users to assign list of pre-defined topics (Author Topics) and strings of free text (User Topics) to markers. This is performed by first selecting a marker in the HyperMan book window, then choosing the Customize Marker option from the User Profile menu. The Customize Marker window will be opened or brought to the foreground with the selected marker in the top line[3]. The user selects from the list of Authors topics on the right and assembles a list of topics to associate to the selected marker. To assign topics that aren't expressed by any of the Author Topics, users can type them into the Enter User Topic field. The selected marker will then be automatically indexed under the list of topics specified by the user, and this customization will be stored in both the user profile database and the system profile database.

[3] The current implementation displays only the marker internal ID, the next implementation with display the marker name, book, and page location.

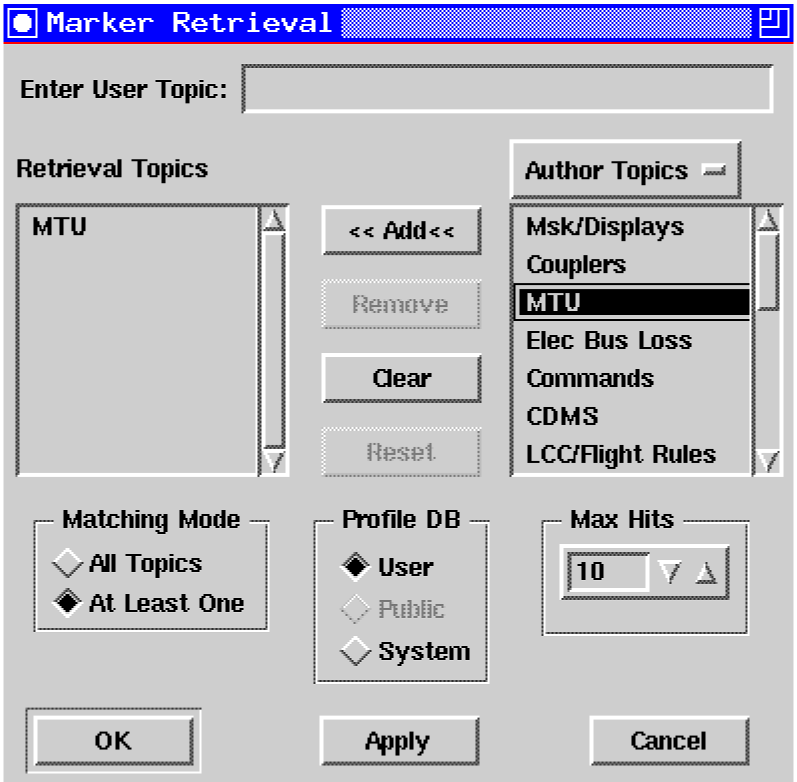

Figure 3: The Marker Retrieval window. The user assembles a list of topics describing the markers they are looking for.

The Marker Retrieval window (Figure 3) allows user to search all books in the current library for markers relevant to a list of topics. The user assembles a list of topics describing the markers they are looking for. This window gives several options specifying how to perform the retrieval. The matching mode specifies whether to retrieve markers that have been assigned every topic in the list or those that include at least one.

The profile database specifies whether to consider input learned from all users relevant to the search (System), or only input which has been learned from that particular user. The user can also specify the maximum number of markers to be retrieved (upper limit is set to 1024). After submitting the search, the Marker Retrieval Results window will display a list of relevant markers.

The Marker Retrieval Results window shows a list of retrieved markers relevant to the selected set of topics. The user can select a marker and directly go to this marker in a book. The list of markers is ranked by relative relevance to selected topics (most relevant first). The user can adjust the ranking of a particular marker by giving relevance feedback (Success and Failure buttons), which will move the marker up/down the list. The user can also associate additional topics to a marker using the Customize button, which sets up the Customize Marker window to customize that marker.

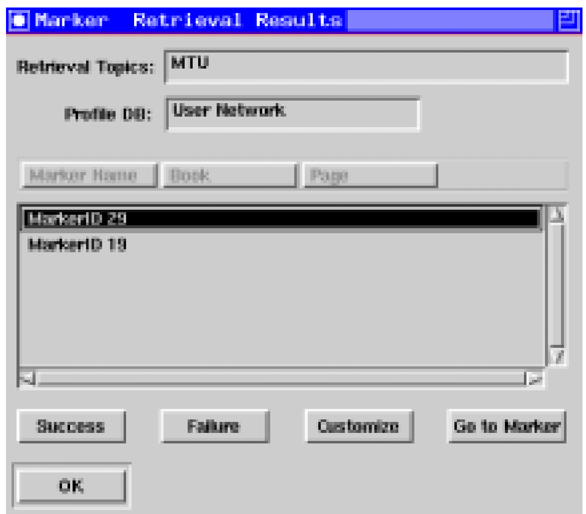

Figure 4: The Marker Retrieval Results window shows the results of a search for markers associated with the retrieval topics listed on top.

The Markers Basket window is used to set aside/store a set of interesting markers (belonging to any book in the current library). It can be seen as the equivalent of the Hot List in Netscape or Mosaic (World Wide Web browsers). This can be used as a quick access tool to directly go to markers attached to specific pages in books. This can also be used as a tool to set aside interesting markers, to be indexed or worked on later on (flight controllers might not have the time to index markers during a mission)

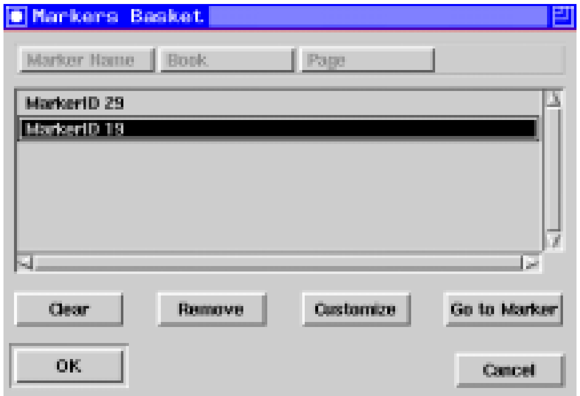

Figure 5: The Markers Basket window stores a list of markers for quick access or future indexing.

5 Virtual "Goody Book"

Adaptive HyperMan was tested in April 1995 with three flight controllers. Their response to the additional marker indexing and retrieval capabilities described above was very positive. In fact, they requested to be able to use these capabilities for the next Shuttle flight. The reason for this success is based on the idea of a virtual "goody book". A paper "goody book" is a personal collection of selected pages from existing Shuttle operations documents, assembled by each flight controller to perform their task more efficiently. In order to ensure using only up to date information, mission control management decided to have only version controlled operations books be accessible in HyperMan, and to not allow the parsing of any user assembled "goody book". A simple solution would be to provide the equivalent of a Netscape hierarchical hotlist in HyperMan, but this forces the classification of markers under unique headings. Instead, flight controllers create markers for multiple purposes: quick access (goody book), highlighting critical information, writing down comments during a mission (post-flight actions), which are later used in collaborative reviews to revise documents. Therefore being able to index markers under multiple topics is very valuable, as it gives them capabilities to retrieve markers for a given flight or simulation, for a particular problem to share in collaborative review, for a particular system, and to combine these topics to narrow down the list of markers. It gives them a virtual "goody book" which is dynamically computed and always up to date.

6 Conclusion

Adaptive HyperMan was designed to facilitate information access from large volume of technical and operational manuals, by helping users build and maintain an accurate cognitive model of the information. The system provides sophisticated annotations and hyperlinking capabilities to end-users, and lets them assign topics to annotations, retrieve annotations by topics, and provide relevance feedback over time. Besides memorizing user inputs, the underlying indexing engine also learns to generalize user inputs in order to facilitate new retrievals. We briefly described the Adaptive HyperMan system, its user interface, and showed how it provides a "virtual goody book" facility for Space Shuttle flight controllers.

We plan to enhance the system in two major directions. First we will support collaborative work by providing a publish/subscribe mechanism to develop users group indices for markers. Second, we are studying the idea of a virtual goody book being displayed as a book (with pages to flip) instead of a list of markers, and of providing an authoring facility to let users edit this virtual book (adding their own new pages, or reordering pages). Finally, we are developing a World Wide Web Hotlist Organizer based on our adaptive indexing and retrieval engine.

Acknowledgments

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