Improving the Usability of Hypertext Courseware through Adaptive Linking

Licia Calvi
University of Antwerp
Belgium
calvi@uia.ua.ac.be

Paul De Bra*
Eindhoven University of Technology
The Netherlands
debra@win.tue.nl

*Paul De Bra is also affiliated with the University of Antwerp and the "Centrum voor Wiskunde en Informatica" in Amsterdam.

keywords: hypertext courseware, adaptive interaction, dynamic link structure.

Abstract: Hypertext is being used more and more for on-line course texts. But the navigational freedom offered by a rich link structure is a burden on students who need guidance throughout the learning process. This paper presents a framework for adaptive link structures. By enabling links when a student is ready to read the pages these links lead to, and disabling links to pages that are no longer needed the student can rest assured that links always lead to interesting new information she is ready to read. This framework is illustrated by means of courseware for an on-line course on "Hypermedia structures and systems", developed at the Eindhoven University of Technology, and currently offered at six different universities in the Netherlands and Belgium.

1. Introduction

Hypertext is being used more and more often in distance education, as a replacement for paper course texts. A textbook usually suggests only one (linear) reading order. The student can of course elect to read the pages in a different order, but in many cases such alternative order does not make sense. A hypertext offers many intended different reading orders. Every page (or node) contains links to a number of different pages which can be read next. In many hypertext systems it is not easy to add or remove links automatically and dynamically while the student is reading, because they assume a static hyperdocument. This paper describes research on the enhancement of students' learning by means of a hypertext courseware that automatically modifies its link structure during the student's learning process.

A common problem with static hypertexts is the abundance of links. For the course *2L670, Hypermedia Structures and Systems* [DB94, DB96] at the Eindhoven University of Technology (and at five other universities) the students have to convert a linear document to hypertext. This document is a review of hypertext research [Bala94]. Experience has shown that students create a large number of links to pages containing definitions, like to a page that defines the term "hypertext" and to a page that defines the terms "nodes" and "links". The reason is that because of the navigational freedom generated by having a rich link structure, there are many pages that may be the first page the reader may read and that contain these terms. In order to present the reader with an opportunity to jump to the definition of these terms links are created from many pages containing the terms to their definition. Once the reader has read and understood a definition there is no need to still show these links in a prominent way, but in a static hypertext there is no way to hide these links. In World Wide Web some browsers will present links to pages that were already visited in a different color, but they also provide a notion of link expiry, which significantly reduces the usability of the coloring mechanism.

The InterBook tool [BSW96b], which evolved from the ELM-ART tutoring system developed at the University of Trier [BSW96a], uses *adaptive link annotation* to show the type and educational state of links. The link structure itself appears to remain static, but visual cues are used to advise the student to follow certain links and to avoid certain other links. In the ELM-ART course, and probably also in Interbook, links may first get a "red light" annotation, which is changed to a "green light" when the student is ready to follow them. Once a node has been given a green light it is never advised against any more. This paper describes an experiment in which *adaptive linking* is used to actually modify (and not just annotate) the link structure depending on the student's knowledge state. Links are not only added when a student is ready to follow them, but may also be removed when it is no longer appropriate to follow them.

The suggested framework for dynamic hypertext structure in courseware is currently being tested by means of a course text on the subject of hypermedia at the Eindhoven University of Technology [DB94, DB96]. This course was first offered in early 1994, by means of World Wide Web technology, using a static link structure. Experience with this hypertext courseware has led to the development of a new course text, with a dynamically changing link structure, depending on each individual student's progress.

This paper focuses on the use of *hypertext* for courseware. The fact that the actual implementation of our prototype uses World Wide Web technology is motivated by the wish to use the course for distance education through Internet. Besides Interbook/ELM-ART other courseware environments for World Wide Web have been developed, like the CyberProf platform [HA95], in which on-line homework and quiz problems and on-line grading play an important role, but that are typically used with mostly hierarchical course texts (divided into chapters, sections, subsections, etc.) As such, these courses or courseware platforms do not fully exploit the fact that World Wide Web offers a hypertext platform. Our framework can of course be enriched by adding features from CyberProf and similar systems, but its focus on the link structure of the information presented in hypertext form makes it unique.

2. Adaptive Link Structures

The creation of links is by far the most difficult aspect of hypertext authoring. The decision whether or not to create a link between nodes A and B is influenced by several issues:

1. Is a reader of node A capable of understanding the information in node B, irrespective of the way she followed to reach node A?
2. Does node B provide interesting (new) information a reader of node A might want, irrespective of the way she followed to reach node A?
3. Will switching from node A to B disturb the reading process of the subject of node A?
4. ...

In many cases it is difficult, if not impossible, to answer these questions because of the phrase "irrespective of the way she followed to reach node A". What is often done is to create an abundance of links, keeping in mind the first question (can the reader understand node B), but ignoring the second question (does node B provide interesting new information). Such a rich link structure is a navigational nightmare. In InterBook [BSW96b and ELM-ART [BSW96a] *adaptive link annotation* is used in an attempt to provide guidance through the link-mess. De Young suggests that such annotation may not be sufficient:

> "(...) if a hypertext is a densely connected unstructured graph, no presentation of the

mess is going to clean it up or make it conceptually easier to understand" [DeYoung90]

Like in Storyspace [BJS90], the narrative we have been adopting presupposes two different pathways: a decisional pathway, which corresponds to the navigational choices foreseen by the designer, and which, as such, precedes the real interaction, and a presentational pathway, in which the actual interaction is immanent, and which consists of the set of links made visible, i.e., available to the user, at the precise instant when the interaction takes place. The hypertext author, creating that decisional pathway, is first concerned with creating a link structure containing all potentially interesting links. Whether links are actually interesting at the time when the reader visits the node containing their source anchor depends on the reader's state of mind. In our system this state is represented by a set of concepts the reader has "mastered" by reading other nodes, and by completing some tests. For the second phase, when deciding whether or not to present a link, the author has to indicate which concepts are needed to make a link useful, and also which concepts make the presentation of a link superfluous.

Irrespective of how rich the link structure of a hypertext actually is, it can be reduced to a very poor structure by means of required and forbidden foreknowledge. In the hypermedia course 2L670 for instance, when a student has just registered for the course the first page may look like the following:

Jane Doe read 0/163 nodes. (these read, these still to do.)

Hypermedia structures and systems

Welcome to course 2L690 at the Eindhoven University of Technology.

If you are just beginning to browse through this course, you should first read the instructions...

This course contains the following (not necessarily disjoint) parts:

- Introduction (it is advised to read this before the other items)
- Definition of hypertext and hypermedia
- The history of hypertext and hypermedia
- The architecture of hypertext systems
- Navigation (and browsing semantics) in hypertext
- Information Retrieval using hypertext
- Writing hypertext
- Distribution and Concurrency issues
- The Future of Hypertext and Hypermedia
- Assignment for this course

The "chapters" of the course text are not yet reachable. A linear reading order towards the "instructions" is enforced by requiring the knowledge conveyed by the instructions-page for every other page of the course.

Once the student has read the instructions and revisits the starting page it may look like the following:

tu/e Eindhoven University of Technology

discussion list

Jane Doe read 2/163 nodes. (these read, these still to do.)

Hypermedia structures and systems

Welcome to course 2L690 at the Eindhoven University of Technology.

If you are just beginning to browse through this course, you should first read the instructions...

This course contains the following (not necessarily disjoint) parts:

- Introduction (it is advised to read this before the other items)
- Definition of hypertext and hypermedia
- The history of hypertext and hypermedia
- The architecture of hypertext systems
- Navigation (and browsing semantics) in hypertext
- Information Retrieval using hypertext
- Writing hypertext
- Distribution and Concurrency issues
- The Future of Hypertext and Hypermedia
- Assignment for this course

The student may now continue in three different directions, browsing through the first introductory chapters. The more advanced chapters only become accessible after reading enough of the first three chapters.

Links not only appear after gaining knowledge, they may also disappear. For instance, throughout the course there are many links to the page containing the definition of the concepts "nodes" and "links". However, all but one of these links disappear when the student has read that definition. In addition, from the "these read" list one can always reach all pages that were visited already, and to which links may have disappeared.

At first, the use of a hypertext with an adaptive link structure may seem confusing, because adapting the link structure during the reading process means the presentation of one and the same node may be different each time the reader visits that node. Reading such an adaptive hypertext becomes similar to playing an adventure game: access doors, traps and other ways of moving from one place to another may appear and disappear at will. However, there is one important difference. In an adventure game finding pathways that are meaningful and lead to victory are often hard to find, whereas in a (well designed) adaptive hypertext course text all pathways that are shown are meaningful. Any additional pathways the student might wish to be present have been deliberately disabled by the author because he considers these moves not to be useful.

3. Preliminary Evaluation, and Future Plans

The adaptive courseware has been used in a trial in 1996, before becoming the standard version as of January 1997. Organized user surveys still have to be completed, but we can already draw some (surprising) conclusions from informal meetings with students. (We still have to compare them to the log files from each student’s learning process.)

The carefully designed adaptive link structure both increases and reduces the user’s freedom:

- When it is uncertain whether links will lead to information the student can understand (and after following a few bad links this becomes apparent to her) she will exhibit a navigational behavior that is close to a linear reading order. Thus, a richer, static link structure does not lead to a varied navigational behavior.
- Strictly speaking the navigational freedom is reduced in the adaptive system, because not all links are available at all times. However, since the available links are all "safe" to use, the students are less afraid to follow links that move away from what they perceive as being the "linear" reading order.

Students like to glance at a textbook's content before actually starting to study the material. With a hypertext course text this is not possible. Even with the static version, in which all chapters become accessible right away, one can quickly look at a few nodes of each chapter, but this does not provide the same information as glancing through a book. Nevertheless students have complained that in the adaptive course text they could not glance through the contents, whereas they (actually different students from the year before) did not complain about this aspect of the static course text.

We believe that part of the problem with adaptive linking stems from the fact that while a link is hidden its link text and the sentence(s) surrounding the link remain unchanged. This text often strongly suggest the presence of the link. Adaptive node contents could solve this problem, and is being worked on for the next version of course 2L670.

4. References

[Bala, 1994]
: Balasubramanian, V., "State of the Art Review on Hypermedia Issues and Applications." Graduate School of Management, Rutgers University, Newark, NJ, 1994.

[Bolter et al., 1990]
: Bolter, J.D., Joyce, M., Smith, J.B., "Storyspace: Hypertext Writing Environment for the Macintosh." Computer Software. Cambridge, MA: Eastgate Systems.

[PB96a]
: Brusilovsky, P., Schwarz, E., Weber, G., "ELM-ART: An intelligent tutoring system on World Wide Web", Proceedings of the Third International Conference on Intelligent Tutoring Systems, ITS-96, Montreal, 1996. (Lecture Notes in Computing Science, vol. 1086, pp. 261--269).

[PB96b]
: Brusilovsky, P., Schwarz, E., Weber, G., "A Tool for Developing Adaptive Electronic Textbooks on WWW", Proceedings of the WebNet'96 Conference, pp. 64--69, San Francisco, 1996.

[DB94]
: De Bra, P., "2L670: Hypermedia Structures and Systems", Course at the Eindhoven University of Technology. http://wwwis.win.tue.nl/2L670/

[DB96]
: De Bra, P., "Teaching Hypertext and Hypermedia through the Web", Proceedings of the WebNet'96 Conference, pp. 130--135, San Francisco, 1996.

[DeYoung90]
: DeYoung, L., "Linking Considered Harmful. Designing and Reading Hyperdocuments." In Streitz, N., Rizk, A., Andre, J. (Eds.), Hypertext: Concepts, Systems and Applications. Proceedings of the First European Conference on Hypertext, Cambridge University Press, pp. 238--249, 1990.

[HA95]
Hubler, A.W., Assad, A.M., "CyberProf, an Intelligent Human-Computer Interface for Asynchronous Wide Area Training and Teaching." Proc. Fourth World Wide Web Conference, pp. 231--238, 1995.