A Framework for Delivering Large-Scale Hypermedia Learning Material.

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Introduction

This paper discusses a resource-based approach to presenting learning materials. A platform for delivering such materials is introduced, and our early experiences of using this system in a teaching environment are summarised.

In the past, the time required to create computer assisted learning (CAL) material has limited its introduction into mainstream education. Typically 100-150 hours has been cited as the time required to produce one hour of instruction (Christie, 1990). Also, material produced in this way is difficult to update and becomes redundant as knowledge changes. Furthermore, no two teachers have exactly the same views on how a subject should be taught, which means that CAL material is not often used outside of the institution in which it was developed. A resource-based approach integrating current hypermedia practices can address all of these problems by permitting the creation and integration of new material and the customisation and easy updating of existing material. In this way it is possible to overcome the limitations of traditional CAL which have prevented the widespread use of computer-based materials in education.

In 1992 the U.K. Universities Funding Council (UFC), announced that it was making provisions for the development and delivery of computer based learning materials for higher education under the Teaching and Learning Technology Programme (TLTP). The aim of the programme was "to make teaching and learning more productive and efficient by harnessing modern technology" (UFC, 1992) and builds on previous U.K. funding initiatives such as Computers In Teaching Initiative (CTI) and Information Technology Training Initiative (ITTI). Funding was provided for subject based consortia, which consist of departments from several institutions working together to create courseware for a particular subject, and institutional bids, which involve the creation and delivery of courseware as part of an institutional infrastructure with backing from senior management. A number of the successful bids involved the use of Microcosm (Davis, Hall, Heath, Hill & Wilkins, 1992; Fountain, Hall, Heath & Davis, 1990), an open hypermedia system, as the delivery platform: in particular the University of Southampton was awarded a sizeable grant to integrate the use of technology into the teaching on a number of high profile undergraduate courses, using Microcosm as the central platform.

This paper describes the Microcosm model and philosophy, and explains the advantages of taking an open, resource-based approach to the development and delivery of learning materials over traditional CAL practices. We describe early experiences in creating materials for the Microcosm environment, paying special attention to the features of the system which make authoring in this way different from traditional practices. Finally, we look at the initial use of Microcosm by students of History and Biology at the University of Southampton.

The Microcosm Model and Philosophy

Microcosm consists of an open message passing system combined with a number of viewers and filters. Viewers are programs that can display the various formats of text documents, pictures, sound and video. They can communicate with the filters to establish what active areas exist in a particular document, and allow users to make selections within the document, then choose actions such as following a hypertext link. The information concerning the selection and action are then bundled into a message which is sent through a chain of filters, each of which has the opportunity to respond to the message by taking some action. Particularly important filters are the *linkbases* which contain all the information about links and which can respond by offering the user the opportunity to display the document which is the destination of the link. Other filters provide aids to navigation, dynamic link services and link creation facilities.

In brief the advantages that such a system offers when producing learning materials are as follows:

a. No Mark-up in Documents

All the information concerning links is held in link databases or linkbases. This means that by installing different linkbases, as appropriate, it is possible to provide different views on the same set of documents. It also means that it is possible to continue to view the document using the application that created it, which is necessary to keep the system open and to allow inter-application hypermedia functionality.

b. Open Architecture and Connectivity to Other Applications

It is possible to make links that dispatch other programs with a given dataset as a Microcosm viewer. More importantly it is possible to follow links from third party applications. In the Microsoft Windows version of Microcosm this may be achieved via the DDE where the third party application supports such communications, or else via the clipboard. The process of adapting an application to talk to the Microcosm message system typically involves writing a few lines of code in the application's macro language: currently we have added such functionality to Word for Windows, Toolbook, the SPANS Geodata system, Superbase, MS-Access and Autocad, as well as producing our own specialist viewers for around ten other common formats such as text, bitmaps and Windows Meta-files.

If learning at a computer is to be about more than simply absorbing information and responding to set questions, then the system must offer both the author and user a seamless interface to the normal applications and tools that make up the entire system; for example a mathematician may well wish to use a package to investigate the shape and behaviour of a function. In such cases it should be possible to link into and out of the required package.

Since the architecture and message system of Microcosm are open it is very easy to extend the functionality of the system to suit the needs of a particular application area: furthermore it is possible to distribute Microcosm functionality across different machines on a network, even where the machines themselves have differing architectures. Unix and Macintosh versions of Microcosm are currently under development.

c. Reduced Authoring Effort.

In most hypermedia systems links have specific source and destination anchors. Microcosm supports such "specific" links, but also supports more general links. "Generic" links have a fixed end point, but may be followed from any point where a given selection occurs within a

document or specified set of documents. This means that it is possible to create a single link to a piece of reference material, which may then be followed wherever the specified source selection occurs without having to re-make the link at every possible source point. This facility makes it possible to put together sets of reference material on a particular subject domain, and allow users access to this material from whatever point in whatever document they are currently examining. For example, we have made good use of a Dictionary of Biology, by automatically generating a set of generic links to each term in the dictionary. Now, by intalling this linkbase along with the others in any application in the biology domain, the user has immediate access to all this information from any document.

There are a number of other ways of following links in Microcosm. Documents may have associated keywords which may then be used for link following. Also text documents may be pre-indexed to allow a built-in information retrieval system to attempt to match suitable documents or sections of a document from a query made from a text selection (Li, Davis & Hall, 1992). Authors find this facility particularly useful when attempting to produce links in very large bodies of material, and this feature is a fundamental tool for deducing relationships between various documents where no appropriate links have been previously manually authored.

d. Selective Browsing.

Both links and documents in Microcosm may have user defined attributes. These attributes enable us to attach keywords and descriptions to the documents and links. These attributes allow users to make queries of the system. It is possible to navigate the document collection entirely by document attributes.

The resulting Hypermedia system has an intrinsically different feel from most other Hypermedia systems. In effect Microcosm provides a link service which supplements the normal navigational facilities provided by the operating system, resulting in an environment in which the onus is on the students to interrogate the system in order to find answers to questions which are formulated either by themselves or by a tutor - i.e. the student must ask the system "what other information do you have about subject X ?"; most other systems take the opposite approach - i.e. they announce to the student "I have information on subject X", thereby reducing the degree to which the student dictates the course of the interaction, and reducing the requirement for the student to formulate and ask questions. This free-ranging environment is ideal for providing fast access to large volumes of multimedia material, as is often required in conducting research, but may however be either intimidating for naive users, or inappropriate for some teaching needs. In these cases, more formally defined routes through a body of information are required, which are provided in the form of Mimics. These are tours through a particular set of multimedia documents which may be defined by an author, and which may be followed by the reader, but without sacrificing the facility of being able to follow other hypertext links as and when required.

The requirements of the various TLTP projects

Microcosm is quite unlike packages such as Toolbook and Authorware. These packages concentrate on providing very smart delivery of carefully prepared material: Microcosm concentrates on allowing users to browse through large bodies of material in a seamless manner. Because of this fundamental difference we have only a little experience of the sort of techniques that authors will use in delivering teaching materials using the system. As the TLTP programme is getting under way and a number of lecturers in a number of subject areas are starting to

produce delivery materials using Microcosm, we are beginning to get feedback on the sort of special facilities that authors require.

Principally we have found that our user community has broken down into two distinct groups. The first group wishes to use Microcosm as the entire delivery mechanism. The second group wishes to use some other package (Toolbook, Authorware and Guide are notable examples) for the front end delivery of the teaching materials, but wishes to use Microcosm for linking together the materials. The advantages of this approach are:

a. Microcosm may be used to launch any application. A common requirement is to launch one application to simulate an experiment, while simultaneously launching a hypertext with explanatory notes.

b. Once Microcosm is running it can provide a link service over and above that provided by closed hypermedia systems. It is possible to follow links from one package through to another package. A common example of this is to have a set of reference material defining terms that will be used throughout a body of teaching material. Using Microcosm's generic links it is possible to follow links to the reference material from whichever package the student is currently working.

c. Microcosm allows separate logins for each user. (Windows and DOS do not have any concept of different users.) This means that Microcosm can keep track of who is using the system, and allow staff to configure the system in different ways for different users.

d. All Microcosm messages may be monitored. It is therefore possible to produce statistics of what information is viewed, and how that information is accessed.

In section 2 it was pointed out that the open architecture makes it easy to add new functionality. There have been three notable requests for enhancement of the basic model as described in the previous section.

a. A student progress logging system

Much importance has understandably been attached to measuring student progress through a body of materials. Microcosm has a logging filter, which saves a copy of every message that is sent through the filter chain. This allows open ended analysis of user interactions with the system. Teachers have asked us to provide specific tools to analyse these log files.

b. An event monitoring system with active buttons.

Currently Microcosm actions and buttons are actuated explicitly by the user. However, authors have identified occasions when they wish to make Microcosm take some action when a specific event occurs. An example of this is the request to load a text file to the screen at some specific point during the play of some piece of music or some video. These examples are being dealt with by introducing the idea of *automatic links*, similar to those described in Palaniappan, Yankelovich & Sawtelle (1990), into the appropriate viewers. More problematic have been some requests to monitor events in applications which are not Microcosm aware and cannot be programmed to send messages when the required event occurs.

c. Extended Mimics.

The current Mimic system allows an author to define a linear route through a set of documents. The author has limited control over the appearance of the document. There is a demand for greater control of the desktop from the Mimics, so that the author can control exactly what appears in front of the user. This is particularly important when a student is being introduced to the system, and we are attempting to provide such control initially by a simple scripting language. Later we will provide a graphical interface for the author to produce such scripts. A further enhancement we hope to introduce to the Mimic system involves allowing various branching and looping structures.

Experiences of Authoring

Many of the problems which are experienced when using hypermedia are in part due to the fact that not much serious authoring has been done on material which is intended for users rather than on material which is intended for research purposes (Hutchings, Hall, Briggs, Hammond, Kibby, McKnight & Riley, 1992). However, some work has been done on hypertext authoring and patterns are beginning to emerge about how authors go about creating hypermedia learning materials (Kidd, Hutchings, Hall & Cesnik, 1992). Previous experience indicates that the authoring process is as follows:

a. define the content in general terms
b. create a pictorial overview of the main topics
c. begin to create material
d. level of detail increases
e. new links and content are incorporated into structure
f. refine and update as you go

It is important to note here that whereas in the past content has been defined completely before any programming or work on the computer began, with the highly interconnected information environment that is possible with hypermedia systems, the design process is an ongoing one, with the need for new links and content areas only becoming apparent during the process of authoring.

Establishing a resource-based approach to the creation of learning materials is different again from the task of authoring closed hypermedia applications. It comprises two parallel and continuous processes. First, the resource material must be collected together and made available in a suitable format. Links are created between individual pieces of information to create what might be referred to as 'raw hypermedia'. However, as has been pointed out before, this is not a suitable environment for learning to occur (Hutchings, Hall, Briggs, Hammond, Kibby, McKnight & Riley, 1992) . Educational hypermedia must support a variety of purposes, from providing introductory material for naive learners, through to a general information resource for experienced learners or even those who are experts in their particular field.

The second stage is therefore one of refining or tailoring the resource-base to meet specific needs, for example by providing guided tours, or creating alternative link sets for different groups of users - one set for introductory learning, another more extensive set for experienced learners. Thus the same basic material is available to both groups, and inexperienced learners have access to the same information as experienced learners, but the complexity of the overall resource-base is hidden from them until they can 'find their feet' in the system.

First Experiences of Using Microcosm in a Learning Environment

At the time of writing this paper we have completed three surveys with students, the first of which involved using Microcosm to store and deliver notes for a course introducing computer programming (Davis, Hall, Hutchings, Rush & Wilkins, 1992). There were about 50 students on the course and they were required to use the system for at least one session in order to complete some coursework: many used the system more than this. From this exercise we learned important lessons about how to present the features of Microcosm to the user, and also about how to log the system use so that all a complete reconstruction of a session would be possible. These lessons have been fed back into the system, and we are now piloting work for the TLTP project. Currently the system is subject to much more extensive use by both students and courseware developers.

Another group of users of the system have been History students (Colson & Hall, 1991), and this year they have produced dissertations in Microcosm. *Cell Motility*, an application for undergraduate Biology students developed using StackMaker (Hutchings, Carr & Hall, 1992) a Macintosh based toolkit, has been extensively tested (Hall, Thorogood, Hutchings, & Carr, 1989; Hall, Thorogood, Sprunt, Carr & Hutchings, 1990; Hall, Hutchings, Carr, Thorogood & Sprunt 1993; Hutchings, Hall, Colbourn, 1993). The content and structure of this application has been ported to Microcosm, and this system is being used with undergraduate biology students for first time this year, and students' reactions to the system have been interesting (Hutchings, Wilkins, Weal & Hall, 1993). Responses regarding the effectiveness of the system were encouraging: 80% of users enjoyed using Microcosm, 88% felt that Microcosm was an effective learning resource, and 85% said they would use it again as a general source of reference. However, only 65% disagreed with the statement "This 'high-tech' route to information is intimidating", suggesting some unease with the Microcosm environment. 82% found manipulating windows easy, so the intimidation must have been due to factors other than the multiple windowing environment. Only 9% of students using the original StackMaker version of Cell Motility said they felt intimidated by the technology, and since the two systems offer essentially equivalent functionality, the cause of this problem is not immediately apparent. However, the overall reaction to Microcosm was extremely positive.

As the TLTP projects continue to prepare courseware we will gain further experiences of how authors wish to use Microcosm, and how we can help them to make best use of the system. A large part of the problem that we face in introducing such a system into the university is in overcoming entrenched attitudes. Many believe that prior failures using traditional CAL demonstrate that technology offers no added value in teaching, at least at university level, and others have fixed ideas about the sort of delivery system they wish to use and are unwilling to explore other routes.

Conclusions

In the future there is a good chance that a large proportion of learning in higher education will be via technology based systems: the fact that the UFC has initiated the TLTP in the U.K. is evidence of this. If this endeavour is to succeed, the obstacles encountered with traditional CAL - large authoring times, difficulties with updating and personalising material, the prescriptive nature of the delivery medium, etc. - must be overcome. We believe that a resource based approach such as that encouraged by Microcosm will provide a basis from which many of these problems will be solved.

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