Distance Education Using a Local Mass Storage Device

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Abstract

This paper presents a distance learning application currently under development at the University of Ljubljana as a part of the ACTS AC-018 SMASH (Storage for Multimedia Applications Systems in the Home) project. The application is based on WWW and Java programming language and serves as a general framework for development of courses on different topics. All the courseware is stored in what could be called a digital library, and is used as a basis for creating courses on specific topics. The application can be readily used over a high bandwidth network connection. The problem is, however, that learners usually do not have high bandwidth network connections to their homes. We are therefore investigating the possibility of using a local mass storage device at the learner's site. The purpose of this paper is to present the basic idea and the concept of a distance learning application, where such a local mass storage device is used to store all of the courseware data locally at the learner's machine.

1. Introduction

Development of computer technology, multimedia and the Internet enables new possibilities for distance education. Lessons are prepared from different type of materials to give learners a better insight into the topic and to enable them to be more creative in the educational process. This means that learners have possibilities to study from their home or their jobs without loosing the quality of the education. Many distance learning applications are based on the World Wide Web (WWW) to be platform independent and available to many learners. Distance learning can be performed on the learner's computer over the network. The problem is, however, that most learners usually do not have high bandwidth network connections at their homes. Since learning takes time, the cost of telephone lines used by modems for connections to the network also presents a big problem.

The overall need in distance learning systems is to enable the usage of a distance learning application terminal at the learner's site with only a narrow-bandwidth connection (or even without a connection) to the teacher's server. As a part of the ACTS AC-018 SMASH project, we are investigating the possibility of using a local mass storage unit combined with a low-speed connection (ISDN or a modem) to the network to improve the efficiency of distance learning. The mass storage device (called COMBO), can be used to store a large amount of multimedia educational materials. We are developing a distance learning application that can use such a mass storage device as the source of learning materials. If the learner also has a network connection available, the network link can also be used for retrieval of additional information or for communication between the teacher and learner.

2. Organisation of courseware within the application

Our goal is to develop a distance learning application, which would act as a framework for development of different courses; thus it is not meant as an application for teaching a specific topic. The basis of each educational application are the learning materials (courseware). This section describes the organisation of courseware within our application.

Materials are organised in two different ways (on two different levels). All the materials (on various topics, written by many teachers) are joined together and stored in what could be called a digital library of courseware. Within the digital library (lower level of organisation), these materials are organised in mind maps. Such organisation connects different topics and subtopics in a tree-like structure (although cycles are allowed). Materials on four topics (3D computer graphics, image processing, virtual environments, and robotics) are currently being

prepared at the University of Ljubljana and will be joined in a digital library. When developing a course on a specific topic (higher level of organisation), a teacher specifies a linear structure similar to the organisation of chapters, subchapters... in a book. Students are very familiar with such a linear structure and it encourages them to follow the course in an orderly manner, as proposed by the teacher. Linear organisation of courses is also preferred in some other distance learning environments [9].

When a teacher creates learning materials, he maps every topic to a concept in a mind map, defines its parent and child concepts (topics) and, if he wishes, defines several other attributes (such as importance, colour, picture...). These mind maps are used by the application to present the structure of each topic to students (see section 3 for more details).

To create a course on a specific topic, a teacher uses documents from the library and creates a list of references to these documents, structured as chapters, subchapters... This list defines the structure of materials in the course. The structure is linear (as in a book) and defines the path a student should follow in order to study through all of the required materials. No changing of materials in the library is necessary in order to make a particular course, a teacher simply defines the course's documents and their order.

Such organisation tries to solve two problems. The essence of hypertext is the ability to take a particular keyword within a document and assign it a link, which points to another document carrying more information on that keyword. This is a very fine concept, but can introduce a lot of confusion if not used properly. Hypertext nodes may be linked together in a manner that can leave students confused as to whether or not they made through all of the material they should have [6]. Such a system of links must therefore be carefully designed. Courses made with our application have a linear chapter-by-chapter organisation. Linear organisation can be easily followed by students and does not lead to confusions as can be the case in a network of hyperlinks. This does not mean, however, that documents in the library may not contain hyperlinks! These can still exist, they are just treated differently by the application (see the next section for more details).

The use of hyperlinks to bind the materials together into a course (linking various topics using hyperlinks), can lead to difficulties when a teacher wants to prepare a new course by using materials from an existing course. If nothing else, he has to correct all the links within various documents to point to new materials. In our application, the structure of materials in a course is not directly related to materials in the library (it is specified separately). Therefore, materials can be reused very easily and no correction of hyperlinks, is necessary.

3. The user interface

Students can access the digital library with a WWW browser (e.g. Netscape) that supports Java. The distance learning application is written in Java programming language and handles student's interactions with educational materials. A view of the application's user interface can be seen in Figure 1.

The user interface is divided into 4 sections.

On the left side, students see the chapter-based linear structure of a course. This includes the title of the topic (chapter) a student is currently studying and its subtopics. Different colours are used to mark the level of difficulty of each topic.

The upper left part of the window contains a sort of a map (only text in the current implementation) that shows how students got to the topic they are currently studying.

The toolbar includes navigation buttons for moving to the next/previous subtopic or up to the title topic in a linear manner. Other buttons will also be included, such as a "send e-mail" button, or "start a teleconference" button (the latter if the student's computer is connected to a network providing enough bandwidth for teleconferencing).

The main part of the application's window, contains mind maps of learning materials (as can be seen in Figure 1) or learning materials themselves. Mind maps are drawn according to the organisation of materials in the digital library. The title of the topic a student is currently studying is displayed as the central concept of the mind map with its related subconcepts positioned around the centre. Note that these subconcepts do not necessarily correspond exactly with the subtopics of the main topic as displayed on the left part of the screen (they are usually a superset of subtopics). The subconcepts that do correspond are marked with a special tag. When mind maps are not displayed, this window displays the actual learning materials.

Students can navigate through a course in various ways:

- by clicking on the next/previous buttons, students can browse the materials in a linear manner, as recommended by the teacher. When navigating in this way, students can be sure that they studied through all of the required materials.
- when mind maps are displayed, students can browse the materials by clicking on concepts within mind maps. As noted before, it is not necessary for a topic and its subtopics, defined by a teacher as required materials a student should study (and displayed on the left side of the window) to directly correspond to the mind map of that particular topic. The mind map usually includes more items for a particular topic than students are required to learn for a course. Such organisation of materials encourages students to

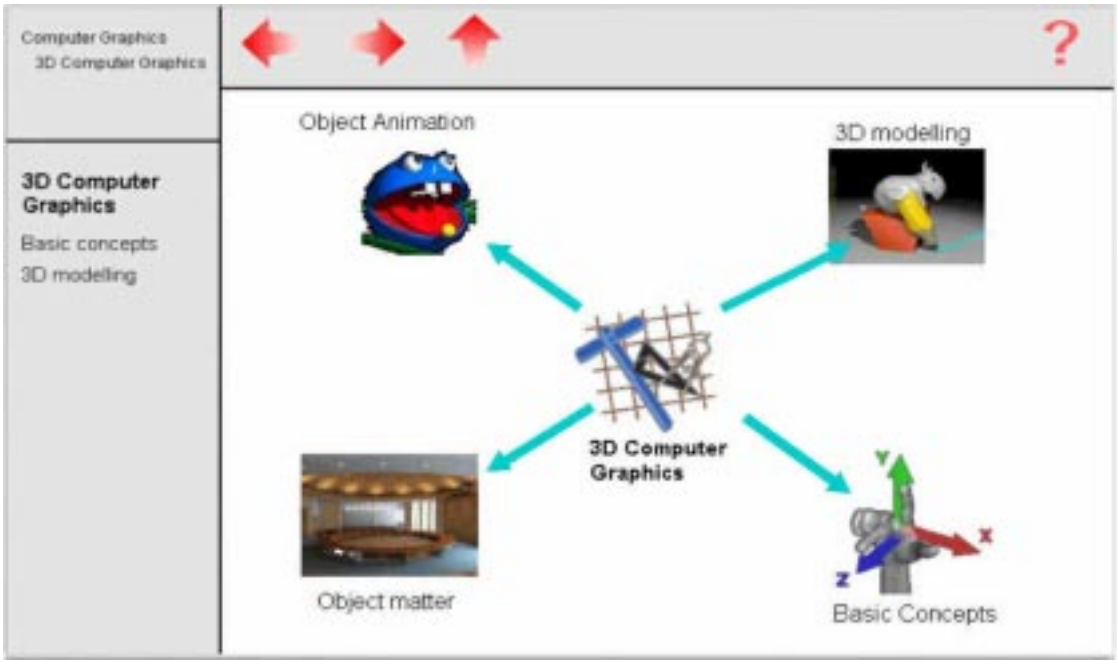

Figure 1: Application's user interface

explore new topics, which are related to a particular topic, but are not considered as required knowledge. When students choose a topic that is not part of a designed course, the topic opens up in a new window (containing only the hypertext and mind maps; without the toolbar and the list of chapters). Students are then free to explore that topic. When they finish, they simply close the window and continue where they left off (somewhere in the middle of materials they are required to study). This ensures that when students wander away, exploring new materials and following hyperlinks, they always come back to the topic in the required part of materials, they last studied.

- when materials are displayed, students can navigate by clicking on hypertext links within the materials. As when exploring non-required topics with mind maps, a new window opens up with the contents of hyperlink. When students finish with browsing, they close the window and return to the topic, they last studied.

In addition to all the features described, we plan to add the possibility of displaying lists of particular types of materials to students. For example: students might need a list of all the test questions in the course (multiple-choice questions or learn-by-doing examples), a list of all the movies or animations or a list of topics of a particular difficulty level. Such a list would then be displayed and students could quickly browse its content.

4. Making the application available to students

If we want students to be able to use our distance learning application at home, we have to provide them with access to the digital library. The application itself is based on WWW and Java, which are two Internet concepts and is therefore suited for use over the Internet. The idea of a large digital library, which would reside on a server somewhere on the network, further emphasises such a concept. If good network infrastructure is available, the application can be readily used over the network.

The only huge problem is that most students do not have high bandwidth network connections to their homes or at the campus. What they usually have is a modem connection or perhaps a basic-rate ISDN connection, but since learning takes time, these are far too expensive, and also do not have enough bandwidth for transfer of good quality video materials, that are an essential part of courses. Making CD-ROMs and distributing them among students might seem like a good solution, but CD-ROMs can be only be used for distribution of a single course or just a part of a course to students (video materials can also fill a CD-ROM very quickly). The concept of a digital library containing not only materials a student has to learn, but also other useful materials can not be supported using CD-ROMs, since they do not contain enough storage space.

A possible solution to this problem arose from University of Ljubljana's co-operation in the ACTS AC-018 SMASH (Storage for Multimedia Applications

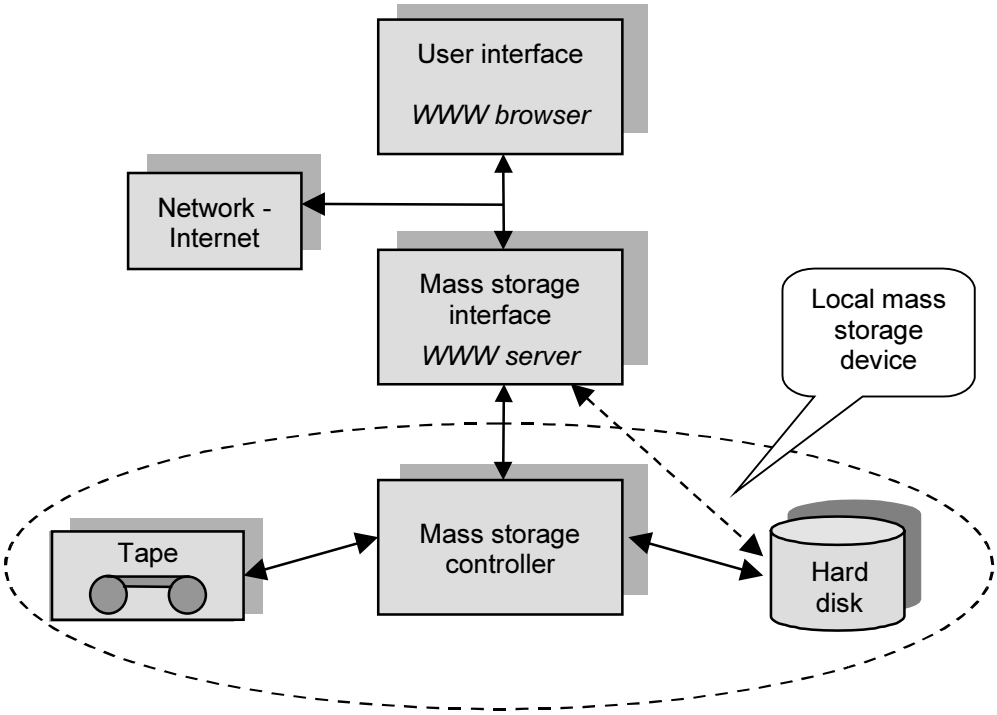

Figure 2: Structure of the remote education application.

Systems in the Home) project. The goal of this project is to develop a mass storage device (called COMBO) for home usage, that can store 13 GB (or even more) of data. The device consists of a linear tape drive, coupled with a hard disk used for caching data from tape (this gives it near-random access to data). The storage device's main purpose is to record cable-TV MPEG-2 digital video streams, but it can also be connected to a computer and used as a mass storage device.

For our application, this means, that the whole digital library could be stored on a single tape. Each student would then obtain a copy of such a tape and (provided he/she has the mass storage device at home) could run our application at home without the need for a constant high bandwidth network connection. We are investigating the usability of such a system for distance learning.

5. Integration of the distance learning application with the mass storage device

When we designed the structure of the distance learning application, we tried to make it as general as possible. This means that the application can be used with or without a local mass storage device. In order to run the application over the network, a student only needs a WWW browser. If a student wants to use the mass storage device, an additional interface between the application and the storage device is needed. This interface hides the storage system from the application.

The whole distance learning application can be divided into three software layers:

- the application's user interface running in a WWW browser and handling learner's interactions with learning materials;
- the interface layer running as a WWW server on the learner's machine and handling interactions between the user interface and the mass storage device (requests for data,...);
- the mass storage device management layer.

When a student interacts with the user interface (learns), requests for different education materials are generated and transferred through the interface layer to the management of the local mass storage device, where file requests are processed. This structure is shown in Figure 2.

The interface between the application and the storage unit is a simple WWW server, which is used to redirect file requests to the controller of the storage system and to send files back to the WWW browser.

The last software layer is the mass storage device controller. Controller communicates with the WWW

server on the upper layer and controls the operation of the storage system. The tasks of this software layer are:

- organisation and storage of multimedia files into appropriate structures on the tape;
- management of data files (on disk and magnetic tape);
- copying of files (caching) from tape to disk and vice versa;
- management of the table of contents with information about files stored on tape.

The distance learning application runs in a WWW browser and can access data either from the network (Internet) or from the mass storage device (called COMBO). The COMBO device consists of two different storage units: a magnetic tape providing large storage capacity (13 Gb) and supporting exchange of different tapes and a hard disk with much faster access and smaller storage capacity (2 Gb).

All of the courseware files are stored on tape, while hard disk is used for caching these files and thus providing near random access to learning materials. When a learner requests a file to be loaded from COMBO, the request travels from the WWW browser to the simple WWW server. The server tries to load the requested file from the COMBO's hard disk. If the file is on the disk, it is sent to the browser immediately, otherwise the request is sent to the tape controller. The controller then copies the required file from tape to hard disk. When the file is successfully copied, the WWW server sends it to the browser.

We are also working on some pre-caching strategies, that would optimise the process of copying files from tape to disk and reduce the need for such copying. These strategies take into consideration the structure of learning materials, their division into mindmaps and the linear structure of individual courses. An optimised algorithm can be used for initial storage (writing) of files to tape as well as retrieval of files from tape to hard disk.

6. Conclusion

The motivation behind the development of our distance learning application is to increase the interest of teachers for development of interactive multimedia materials and also to encourage the co-operation among teachers when developing such materials and courses. We feel that our idea of a digital library of courseware provides good basis for such co-operation. It allows materials in the digital library to be used and reused very easily and also encourages students to explore new topics as they study through the required path of a course.

On the other hand, we are trying hard to make this application accessible to students everywhere, not just at the university, where good network infrastructure is present, but also at home. We hope, that our involvement in the ACTS project will make this possible.

Currently, we are gradually improving the application, adding new features and improving the response of the COMBO system. User trials will be carried on in the 1998 spring semester with 4th grade students of computer science at the University of Ljubljana.

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