Structure of a Remote Education Application Using a Local Mass Storage Device

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Abstract

Remote education is usually based on the World Wide Web (WWW) and supported by multimedia. It can be performed on the server side from the student's computer over the network. The problem is, however, that most students usually do not have high bandwidth network connections at their homes or at the campus. Another problem is the cost of telephone lines used by modems for connections to the network. A possible solution is usage of a local mass storage device to store almost all multimedia data and only small amount of material is accessed remotely over the network. The purpose of this article is to present the basic concept of the interaction between a remote education application and a local mass device based on a linear tape.

1 Introduction

Remote education or distant learning has great potential to aid education, which is of critical interest due to the convergence of trends in education. First, occupational and personal success highly depends on education and formal education is becoming a lifelong endeavour for those in the professions. Second, education has become increasingly expensive and there are now increasing pressures to re-engineer the educational process to be significantly more cost effective. One of possible solutions is remote education, which will allow students and other people to study from their homes or from their jobs. Educational lessons can be very efficient if they are carefully prepared using multimedia, which enables usage of text, images, video, and audio materials together. The only problem is a huge amount of data, especially for video. A mass storage device, which is the goal of the project ACTS AC-018 SMASH, can help to develop another approach to the remote education. Instead of transferring all material over the network, multimedia lessons ares stored on a local mass storage device and only the modified material is obtained over the Internet. The Internet is also used for the interaction between the teacher and students, and between students themselves.

An example of a mass storage device suitable for remote education is a COMBO [1, 2] which consists of a linear tape with the capacity 13 GB (or even more) and a hard disk for caching data. The COMBO device is intended as a general mass home storage device for all multimedia equipment at home. It could be used as a digital video recorder, as a storage device for multimedia data from the WWW or for remote education.

For a remote education application, the COMBO could be a special storage device or an ordinary PC with a linear tape QIC-5010-DC (13 GB) [3, 4] and an additional hard disk, but such COMBO PC could not be used as a general mass home storage device. In this article, the concept of the remote education application (REA) and its interaction with the COMBO are presented. The main stress is on communication between the REA as a program application and the tape in the PC environment.

2 A Concept of a Remote Education Application

A remote education application (REA) is based on the WWW and the Java programming language, because this is the most usual way for distant learning [5, 6], which gives great possibilities for educational process. A graphical user interface is built under the Netscape as one of the most popular WWW browsers and the idea is to keep the application as general as possible. This means that the same concept of the educational tool can be used with or without a local mass storage device. To achieve such goal, the remote education application should provide an interface between the application level and the storage device to hide the storage from the application. A ba-

sic concept of the interaction between the REA and the local mass storage device is shown in Figure 1.

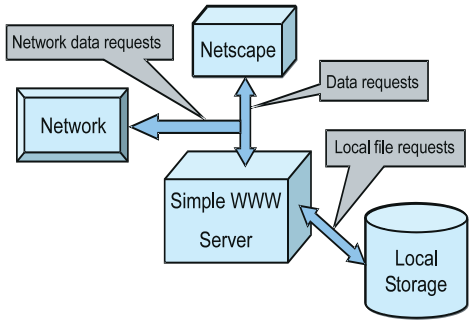

Figure 1: A basic concept of a remote education application.

All data requests from the REA, which is built under the Netscape, are reached over http links in document pages. Remote files are obtained in a usual way while requests for local files stored on a mass storage device are sent to a simple WWW server.

2.1 Communication between the WWW Server, the Hard Disk and the Controller

When the simple WWW server receives a local file request from the Netscape (REA), it tries to get the file from a hard disk of the local mass storage device. If the file is on the hard disk, the WWW server sends it to the Netscape. However, if the file is not on the hard disk, the WWW server receives an error message and after this, it sends a request for a file to the controller. The controller sends back a message that it needs some time to retrieve the file from the local mass storage device, which is a linear tape with an additional hard disk in our case. When the file is copied from the tape on the hard disk, the controller sends a message that the file is on a hard disk. Now, the WWW server sends the file to the Netscape. If the controller for any reason cannot retrieve the file, it sends an error message to the WWW server. The concept of the communication between the WWW server, the hard disk and the controller is shown in Figure 2.

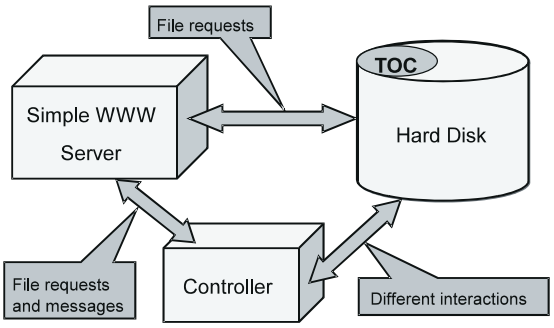

Figure 2: Communication between the simple WWW server, the hard disk and the controller.

2.2 Interaction between the Controller and the Hard Disk

The most important part of the interface between a remote education application and a local mass storage device is a controller, which takes care about reading and writing files from a tape on a hard disk and back. Because the tape is a linear storage device and its primary goal is a backup, it cannot be used as a usual file system, and a tar format (or a similar stream format) should be selected to store files on the tape. During the preparation of the educational material, the controller takes care about creating a tar file on the tape from files stored on the hard according to the optimized list of files. The controller also retrieves files from the tar file on the tape. It copies them onto the hard disk during the remote education. Because it would take too much effort to implement functions to create and to restore tar files, a GNU tar program could be selected. The tar program would be called from the controller as a system command. The principle of the interaction between the controller and the hard disk is shown in Figure 3.

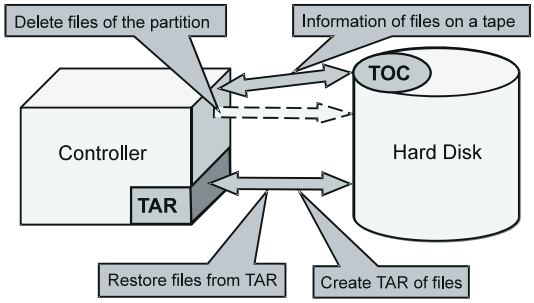

Figure 3: Interaction between the controller and the hard disk.

When the REA is started, the controller first reads a table of contents (TOC) from the tape and save it on the hard disk. The table of contents stores all useful information about files on the tape and it is used by the controller to find out in which partition the required file is. If any file is modified, the controller should store new information into the TOC on the hard disk and at the end of the session, the modified file and the TOC should be written on the tape. When the simple WWW server requires a file, the controller will first find the information in which partition the file is from the TOC on the hard disk, and then it will run the tar command to retrieve the whole partition from the tape onto the hard disk. The controller stores information which partitions are on the hard disk and when the hard disk has no space left, the controller will delete the partition with the most distant files regarding the required file. Information of files in the selected partition is obtained from the

TOC, which should be built in such way that searching is possible by file names and by partitions.

2.3 Interaction between the Tape and the Controller

Interaction between the tape and the controller, which is shown in Figure 4, is the lowest level of the communication. When the controller, according to

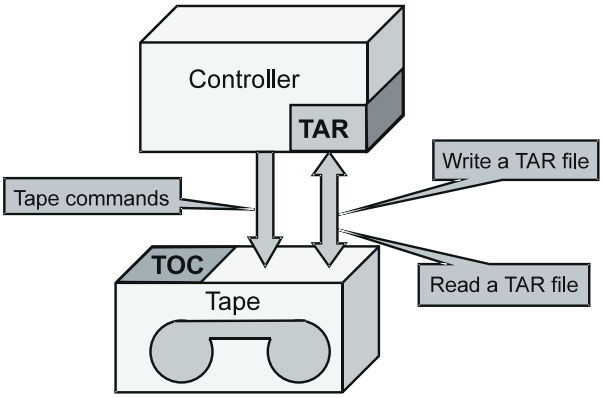

Figure 4: Communication between the tape and the controller.

other criteria, decides to restore files from the tape or to write a tar file on the tape, it sends commands to the tape drive to locate the head of the tape at the desired position first. A linear tape can have one or more parallel partitions [3] and the head is usually positioned at the beginning of the selected partition. After the controller gets the message from the tape drive that the commands have been successfully performed, it starts the tar command with proper options (to read from or to write on the tape).

2.4 A Complete Structure of the Remote Education Application

A complete concept of the interactions between the REA and the local mass storage device, which were

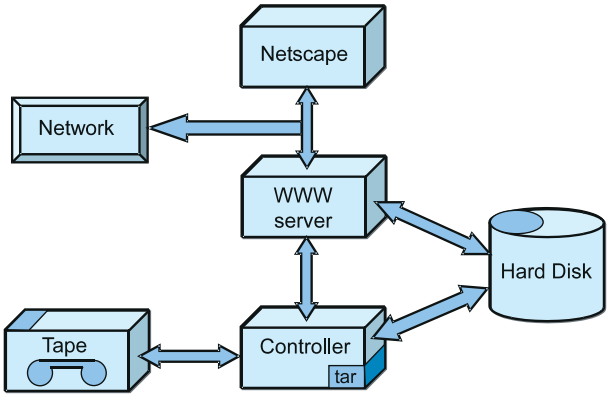

Figure 5: A complete structure of the remote education application.

discussed separately in the previous subsections, is shown in Figure 5.

2.5 Preparation and Storing of Data

Prepared educational materials are stored in files on the hard disk or any other storage medium. The list of files should be optimized with a special optimization program to obtain an optimal sequence of files on the tape. The optimized list of files is used by the controller to create tar files on the tape. Only one tar file is written on one partition. The controller also creates the TOC and writes it on the first partition of the tape. The principle of the preparation and storing of data on the tape is shown in Figure 6.

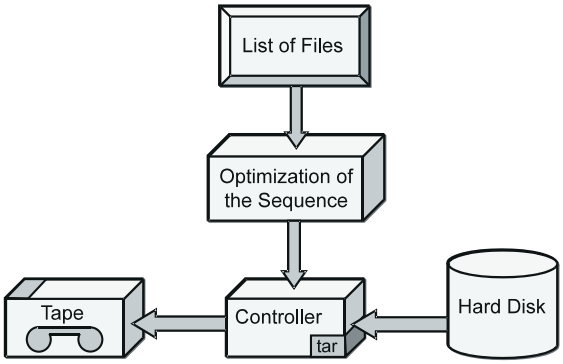

Figure 6: Preparation and storing of data on a tape.

3 A Layout of the Tape

The COMBO device, as an example of a local mass storage device, uses a linear tape QIC-5010-DC (13 GB) [3, 4], which influences on the data organization on the tape. The tape is divided into parallel partitions. The smallest partition has 361 MB and for the REA, it seems that there is no need to have larger partitions. This means that all partitions could be of the same size or the tape would be divided into the smallest partitions. As it was said before, the tar format or a similar stream format could be selected to store files on tape partitions. The first partition is used only for the table of contents (TOC), which stores all information of files on the tape. It would

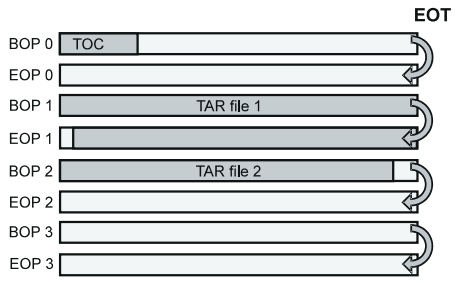

Figure 7: A layout of the tape.

be possible to have data files in this partition (a tar file with the TOC and data files), but in the case of editing the educational material, the whole partition should be rewritten because of the modification of the TOC. The layout of the tape is shown in Figure 7.

4 A Table of Contents

Information about files stored in tar files on the tape is required by the controller to properly work with the tape, the hard disk and the simple WWW server. The first problem is which information is really needed and the second question is what kind of a database would fit the requirements. A commercial database program could be selected as a solution, but such program would work only on a selected platform, for example on the PC with Windows 95. On the other hand, only a part of the performance power of the database program would be used in the REA. It seems that a better solution is to implement some kind of a table of contents (TOC), which will store:

- name of the file including the path,
- size of the file,
- partition where the file is stored on the tape,
- position of the file in the partition,
- maximum size of the partition, and
- used size of the partition.

When the TOC is copied from the tape onto the hard disk, additional two fields are added to the TOC:

- flag if the file was modified, and
- flag if the partition was modified (It is set when any file in the partition is modified).

A linear tape is a mass storage device but it cannot perform random access of files. This restriction can be avoided by caching of data on a hard disk and by storing the same file many times on the tape. If the educational material were stored on more than two or three partitions, it would be possible to group the data according to different criteria and store the same files more than once on the tape. For example, the educational material with a lot of movies could be stored twice, first according to the optimal order of passing through the whole material, and second, only the movies will be stored together. In such cases, the TOC should have the possibilities to store the information about more than one partition with each file, and it should store also the criterion which is used to access the file in one or another partition. This criterion should be sent with a file request from the simple WWW server to the controller.

The table of contents (TOC) could be kept in the RAM of the PC, but the REA uses small files and the expectation is that the size of the TOC would become too large when many partitions of the tape were filled with data. The solution is to store the TOC on a hard disk and to select such form that can be efficiently searched by the controller as a file without reading it into the RAM.

5 Conclusions

A concept of the remote education application, which uses a local mass storage device to store a huge amount of multimedia materials, is presented in the article. However, the concept keeps the REA as a general educational tool useful for distant learning, which can be used with or without a local mass storage device. The COMBO device [1, 2], which consists of a linear tape and a hard disk for caching data from the tape, is used as an example of a local storage device. For the implementation of the simple WWW server and the controller, the Java programming language is suggested because it is platform independent and it is very suitable for network programming.

Acknowledgement

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