Using Multimedia/Hypermedia Tools over Networks for Distance Education and Training

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Abstract

The rapid developments in the Information Technology sector as well as the deployment of faster networks brings us to the era of the New Information Technology (NIT). The citizen of the near future must be able to use them else he will be seriously handicapped in his everyday life. Thus NIT becomes part of the educational process while on the other hand offers the tools and the infrastructure for the establishment of the distance education process. The educators are one of the first professions that must learn to use NIT and its tools. Multimedia/hypermedia tools offer solutions to the problems posed by the distance education process. They can be user-friendly and enticing and they can cover most, if not all, the needs of their users. A lot of prototype systems (tools) for distance education have been developed, each offering a number of functions that aid the process of distance education. The rapid growth of World Wide Web is adding another factor that can lead to the wider deployment of distance education systems. Although the value of distance education is unquestionable there is still a lot of work to be done before a wide spread implementation platform emerges.

Introduction

The recent advancements in the field of the information and communication technology resulted in a revolution comparable to the industrial revolution. The basis of this revolution is the information and the value it has as the pure expression of human knowledge. The technological advancements offer us the ability to process, store, retrieve and transmit information in multiple formats (text, sound, image, video) independently of time, volume and distance.

The rapid technological advancements and their impact were recognized by the European Union which assigned the task of investigating the various trends and of defining the needed actions to the Bangemann Commission. The commission in its report [EU96] defined ten sectors to which priority should be given and in which the teleworking and distance education activities were included.

The aim set by the Bangemann Commission for the area of distance education is the provision of a continuous educational process which will satisfy the needs imposed by an ever shifting and changing society. The achievement of this aim is envisioned through the following actions:

- The establishment of distance education centers that will offer professional training services to Small to Medium Enterprises (SMEs), big corporations as well as to the public sector. These centers are expected to fulfill their purpose by making extensive use of Telematics and network-based distance education software.

- The establishment of advanced distance education techniques to schools and universities.

The application of the above structures is expected to offer advantages to:

- the industry, especially to the SMEs, and to the public sector since it will allow the education of staff members with lower costs and with better utilization of the finite available educational resources,
- the employees who need to upgrade their knowledge and skills,
- the people who are either unable to move outside of their houses or reside at remote geographical areas,
- the students who seek to have access to educational material of higher quality than the offered one.

The above mentioned trends result at the need for training people in the use of the New Information Technologies (NIT). Significant help, towards the satisfaction of this need, can be acquired by the use of Telematics as it is applied in the network-based distance education software.

Needs to be answered

The successful application of network-based distance education software demands that the expressed, by the various potential users, needs are met by incorporating them in the design of such tools.

A review of the EDUCATIONAL MULTIMEDIA (ED-MEDIA) 95 Conference Proceedings [EDM95] indicated a number of common user needs which have been expressed by educators as well as by students. According to the expressed opinions the following needs must be fulfilled by a distance education system,

- Ability to retrieve and edit files, send and receive electronic messages in a hypermedia environment.
- Ease of use of hypermedia systems thus requiring the provision of effective navigation tools.
- Communication and collaboration facilities offered to a group of students participating in the learning procedure over hypermedia platforms.
- Ability to attend lessons without this being a time consuming procedure.
- Maximization of the amount of educational material covered, minimization of the amount of time spent learning the material, maximization of the student's retention of the material.
- Provision of the students with as much control as possible over the time and the way they study the instructional material.
- The teacher must be able to broadcast information (lectures, examples, solutions) to every participating student.
- The teacher must be able to broadcast selected screen information, including the position of the pointing device.
- The teacher must be able to transmit multimedia courseware to the student.

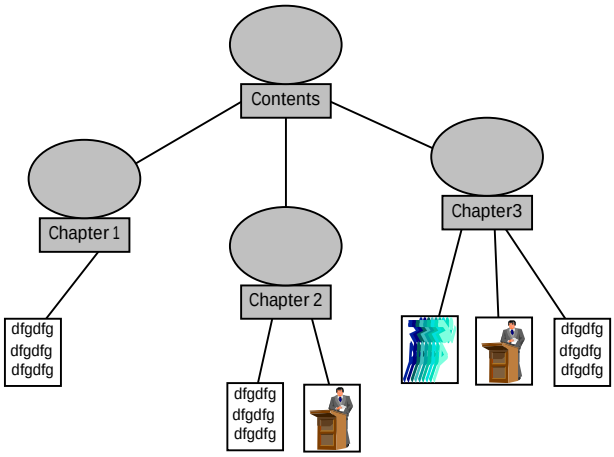
- Direct interaction of the teacher with the student's workstation. The teacher must be able to control the student's computer (mouse, keyboard, flow of material) in order to achieve interactive and collaborative work. Also the teacher must have the ability to capture a selected screen area from the student's workstation.
- Bi-directional personal independent communication between the teacher and the student through written message exchange and/or real time audio conversation.
- Students must be able to participate in discussion boards which are located at the teacher's workstation.
- Combination and exploitation of all document types in order to better convey the concepts of the instructional material and to assist the retention of the material by the student. Combination of all document types in their advantageous domains in order to achieve the best result in conveying the instructional contents.
- Support of collaborative authoring of courseware by several authors.
- Flexible reuse and adaptation of already existing material.
- "On the fly" courseware production.
- Storage of the full lecture including explanations and annotations given by the teacher during the duration of the lecture.
- Ability for direct and real time interaction between student and teacher.
- Support of active participation of the students by answering on-line questions set forth by the teacher.
- Support of note-taking capabilities in order to help students effectively organize the content of a courseware.
- Support of monitoring capabilities by the teacher. The teacher must be able to monitor the active participation of the student in the lecture and receive up-to-date information about him.
- Support of personal communication between the teacher and the student. The former can in this way help the latter overcome a problem or achieve a better understanding of the concept.

A number of these needs has also been identified by the users who took place in the survey of user needs that was conducted under the TRaining Educators through Networks and Distributed Systems (TRENDS - [TRN95]) project.

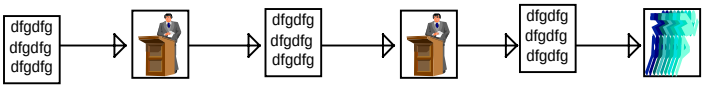
Hypermedia Tools for Distance Education

A Hypermedia Tool for Distance Education (HTDE) aims at providing its user with the ability to access educational material that has been created by experts and has been stored in hosts participating in a network.

The educational material is structured as a hypermedia document. This kind of document consists of simple and aggregate objects. The simple objects contain information of a single kind such as text, sound, still image and video. The aggregate objects consist of simple objects and/or aggregate objects that are connected with relational links. A visualization of a hypermedia document is given in the figure below.



Hierarchical Presentation



Conceptual Presentation

Visualization of a hypermedia document

As can be seen, the hypermedia document has a hierarchical structure that resembles an inverted general tree. At the top of the structure is the root of the tree, the entry point for accessing the document. The nodes of the trees are the aggregate objects while the leaves of the tree are the simple objects. The nodes and the leaves of the tree are connected with two kinds of relational links, the hierarchical links and the conceptual ones.

These links correspond to the two alternative methods that a user can use to browse the material. The conceptual links when followed provide the user with a guided tour of the material, while the hierarchical links provide direct access to the various parts of the document. The use of conceptual links gives to the author of the document the ability to define the viewing course of the material, while the use of hierarchical links allows the user to directly access parts of the document that interest him more or parts that he wants to review.

An HTDE must offer to the expert using it an authoring tool, which will provide him with the needed functions to create and connect, using hierarchical and conceptual links, the various simple and aggregate objects of the document. The material produced by the authoring tool must then be stored in a library from which any user will be able to access it.

The trainee can select the desired material and can connect to the library in order to access it. He can select the browsing method (conceptual or hierarchical) that he wants to use and he can also transfer part of the material to his workstation so as to access it at a latter time. An important advantage offered by the hypermedia format of the educational material is the ability to interlink different documents. In this way it is possible to provide learning by experience as the trainee gains knowledge by following a sequence of relational links that extend beyond the scope of a single document.

Also it is possible to approximate learning by simulation since the use of sequences of conceptual links can lead the trainee from one virtual event to another based on the choice he makes.

Multimedia Tools for Distance Teaching

A Multimedia Tool for Distance Teaching (MTDT) aims to lift the restriction for physical presence in an amphitheater, in order to attend a lecture. As a consequence an MTDT must give to the lecturer as well to the audience the feeling that they are present in an amphitheater. This functional requirement does not imply the use of advanced graphics techniques in order to create the illusion of an amphitheater although this may become a viable and desirable option when technology permits it. It rather implies that all the actions that are available to someone participating in a lecture, whether he is a lecturer or a member of the audience, must be supplied.

An MTDT must allow the presentation of the lecture's material which has been previously prepared by the lecturer. The lectures can consist of slides (still image) which can be transferred to the attendees of the lecture beforehand as well as sound and video data. During the lecture the slides are projected on the screens of the workstations of the attendees and their order of appearance is controlled by the lecturer. The lecturer can put annotations on the slides which are automatically projected on the screens of the attendees and can comment on the content of the slides. All the verbal comments and explanations he offers are transmitted to the other workstations participating in the lecture thus increasing the feeling of actual presence in a lecture hall.

It is also desirable for the attendees to establish visual contact with the lecturer. Thus an MTDT must offer, when such a service is supported by the network infrastructure, live video images of the lecturer to every participating workstation. In addition, in order to increase the interactivity of a session an MTDT must offer to the attendees the ability to submit, either verbally or in written form, questions to the lecturer which he can answer in real time. It is estimated that the ability to see the person that submits such a verbal question would enhance the simulation of the amphitheater environment.

The number and kind of functions that an MTDT can offer are mainly restricted by the underlying network infrastructure. Live audio can be transported over the Internet in most cases since audio transmission (not to be confused with CD quality sound) is especially fault tolerant. In order to transmit live video images special encoding and hardware components must be used in conjunction with high speed network links and protocols that offer Quality of Service controlling mechanisms.

The basic advantage of an MTDT is that even at its minimum functional configuration it can transfer enough information (slides, annotations, text messages) in order to accomplish an interactive distance training session

The World Wide Web as a Distance Education Tool.

The World Wide Web (WWW) started as a document distributing networked system. The initial implementation by Tim Berners-Lee soon became a prime-time tool for the dissemination of information in the Internet.

The WWW or Web is a client/server system that makes efficient use of the underlying network in order to deliver documents in hypermedia format. The documents are

described with the help of a special language called HyperText Markup Language (HTML). This language allows the creation of documents that can contain simple or formatted text, images, sounds, video, as well as links (which are called hypertext links) to other documents. These documents can reside at the same WWW server as the initial document or in a different server located somewhere in the Internet.

It is a natural effect of its wide spread use that the Web should be experimented with, for its usefulness as a distance education tool. There exist various implementations of distance education systems that use the Web as the underlying platform. A few such examples are:

- *Albatross* [Lai95, Yeh96], which is a WWW-based distance education system that aims to provide an integrated and distributed hypermedia information environment for the academic community. In this environment, instructors can construct course material and prepare some learning assistance for learners; learners can access course material and participate in on-line and off-line discussion. Learners can use ordinary WWW browsers or Albatross clients through which they can use several unique functions easier.

- *World Wide Web Course Tool* (Web-CT) [Gold96], which presents an environment that allows educators, with or without technical expertise, to create sophisticated WWW-based courses. These courses are available to the students as soon as they are completed from the same server that the Web-CT runs on. Web-CT offers a variety of tools such as navigation controls, searchable glossary of terms, automatic index generator, chat facility, timed quiz-taking facility, e-mail, multiple choice question generator, etc.

- *WebQuest* [Perr96], which combines the WWW with a SimCity(tm) - like interactive simulation game. WebQuest is implemented in Agentsheets [Repe93], a programming substrate developed at the University of Colorado. The author of a session can create a world which represents a quest containing little puzzles that need to be solved by the players of the game. The player sees both the game environment (Agentsheets) and the WWW browser on the screen at the same time.

  The players can choose their game identity from a palette of Renaissance characters and place it onto the gameboard which is a visual representation of the questworld. Each of the gameboard components (roads, lakes, trees, keys, dragons, etc) has associated behaviors and attributes that the player discovers as the game proceeds. Attributes of game objects can be connections to questpages, which are WWW pages that contain questions that must be answered to obtain an object for later use.

The question that arises is "How does the Web compares to custom implemented distance education tools". Unfortunately, as it is expected, there is no easy answer to this question at this time. Although this is the case, a straight through comparison between the Web-based and the custom-designed distance education software can give us helpful insights.

On the one hand, a Web-based system exhibits all the advantages that the Web itself has. These include native support of hypermedia documents and hypertext links, universal and standardized graphical user interface, excellent navigation control, adequate support functions (saving files in various formats, history of visited links,

etc.), independence of hardware platform, reusability of courseware, ability to connect to database systems.

On the other hand, a Web-based system also exhibits all the disadvantages that the Web itself has. These include poor support of stream data (e.g. real-time video/audio), small degree of interactivity, low degree of exploitation of the network characteristics, poor support of one-to-many sessions as is usually the case with a distance training setting, no or little control of the presentation characteristics of the various media (especially true for material that contains timing information about its components).

Most of these problems are solved with a custom-designed tool since they try to bring CD-ROM level of functionality in a networked environment. But these tools have as a main disadvantage their dependence to specific platforms and require a lot of implementation overhead especially for the deployment of their network services.

As it can be seen from this short analysis an answer cannot be given easily and it is our opinion that it is still early for one. There is a lot of research and development work invested in creating software development environments that will exploit the benefits of the Web as a platform for the execution of a new era of Web software.

The most successful, up to now, efforts are the JAVA programming environment created by Sun, the ActiveX development environment produced by Microsoft and the Javascript language developed by Netscape. These three development platforms have their pluses as well as their minuses.

Their common point is that they allow the development of sophisticated (in various degrees) networking applications that exploit the advantages of the Web. These applications can offer a high degree of interactivity which is an especially desired characteristic of a distance education tool.

These platforms are still undergoing development although they are in quite mature state. The exploitation of these development environments along with proposed changes to the network architecture of the Web are expected to drastically change the form of the Web applications.

Examples of custom-designed tools.

In the following paragraphs the description of two examples of network-based tools is given. These tools can be used to support distance education activities and are the results of related research and development that has taken place at the Computer Technology Institute in Patras, Greece.

HIPPOCRATES: A Multimedia Tool for Distance Education

Hippocrates [Bour95] is a software tool that aims at the use of telematics for the conduction of classes over computer networks and can be classified as a remote course delivery system. Hippocrates offers a number of advantages such as small demands on the bandwidth of the underlying network, ease of use, provision of interesting lessons, and modular design.

Hippocrates can be put into immediate use over the existing networks, and can greatly aid the implementation and realization of the distance education service. This use can offer a number of advantages to persons attending the classes. These can be summarized as follows,

- The trainees do not suffer from lost productive time, since they have the flexibility to attend the lessons in more negotiable time periods, even outside their work hours.
- Creation of friendly lessons, that can instigate the interest of the trainees for the classes, thus making the training process a more efficient one.
- Flexibility in the modification and updating of the lesson's material so as to include new methods and technologies.
- The use of Telematics for distance education solves the problem that is created by the limited number of expert trainers and reduces the cost of the education process.

Architecture

The components that comprise the system are the workstation on which a copy of Hippocrates is installed and the computer network whose facilities are used for the communication with the remote workstations.

Hippocrates has been developed under the UNIX operating system and its user interface has been built on the X Window system with the use of the facilities offered by the OSF/Motif, Xtoolkit and Xlib. It has been installed and successfully tested on a variety of SUN SPARCstations with different memory and processing power characteristics.

Communication layer

The implementation of the mechanism that manages the network connections that are needed for the realization of the distance education service, is based on the TCP/IP protocol suite and makes use of the client-server model. The various workstations communicate with each other with the use of the socket mechanism, in connection-oriented mode of operation, and well-known ports.

Also, in order to take advantage of the multitasking capability of the UNIX operating system, the network connection mechanism has been implemented as three separate processes that run in parallel. This solution has been chosen because of the nature of Hippocrates, which demands concurrent communication (transmission-reception of messages) and management of the graphical user interface.

Offered services

The services offered by Hippocrates include the creation of a lesson, transmission of a lesson's material, teaching a lesson, attending a lesson and reviewing an already conducted lesson.

The teacher can project transparencies on the screens of the students' workstations and can lecture on them through the use of suitably created voice files. He can also emphasize or indicate regions of interest on them by using the facilities offered by the application. Thus the lesson's material is a set of files that contain the bit-mapped images that will serve as the transparencies and the voice segments that accompany them. The participants are the free form names of users, which have been registered for the course and which are translated in network addresses by the system.

Telemathea - An Interactive Cooperative Teleworking Environment

Telemathea [Bour96] offers tools that support the communication and the teleworking between tutor and trainee, who may reside in remote geographical regions. This environment offers audio communication over the network as well as support for joint

editing of text documents and still images. It supports different audio coding techniques so as to adjust to the available bandwidth, and makes use of the RTP [RTP94] protocol in order to facilitate the exchange of audio and, in the future, video packets. Telemathea offers a number of advantages which include an interactive one-to-one communication, enhanced by audio over the network, modular design and open architecture, provision of a shared text and image editor with the ability of document conferencing. and ease of use.

Telemathea has been developed under the UNIX operating system and its user interface has been based on the X Window system with the use of the facilities offered by the OSF/Motif , Xtoolkit and Xlib. It has been installed and successfully tested on a variety of workstations with 486DX processor, and SCO Unix/SCO Open Server operating system.

Communication modes

There are three different modes of communication between the two counterparts:

- *Interactive mode*. It is the most important mode of communication, and it is used when a user desires to have a direct communication with another user. For this mode, a client-server model has been implemented, where the requester of the communication is the client and the respondent of the request is the server.
- *Batch mode*. This mode of communication is used when there is no need for immediate response by the receiver of the message. The communication process in this case is the following: The sender selects the information to be sent (some data files, or images followed by explanatory textual information and topics for discussion) and after specifying the peer's address he transmits them. The receiver will be notified for the new message as soon as possible and will reply at his own will.
- *Mixed mode*. This mode of communication is the combination of the two previously described modes. In this mode the initiator starts a batch mode communication and the receiver is informed immediately for the message. The batch session is followed by an interactive session, provided that the receiver is able to reply immediately.

Offered services

Communication can take place by means of interchanging textual messages, still images, audio and data files. Also, cooperation can take place by means of joint-editing of text files and still images (document conferencing). The services provided by Telemathea include the following,

- *Transferring of text and still image files*. This service is offered in both interactive and batch mode. When two Telemathea applications communicate in interactive mode, any user can select a set of text and/or still image files and send them to the remote peer. Telemathea supports ordinary ASCII files and GIF and X11-bitmaps for still images. Provided that enough bandwidth is available, the file transfers take place within short time limits.
- *Interchanging text messages*. This service offers a trivial way for interactive communication between two users. This service is offered only in interactive communication mode when the available bandwidth cannot support audio communication.

- *Interchanging audio messages*. This service is the default way for the communication of the trainee and the tutor during the interactive mode. The audio stream to be transmitted is coded in a suitable form. Available coding at the current stage are Pulse Code Modulation (PCM), Adaptive Delta PCM (ADPCM), Variable ADPCM (VADPCM). The audio packets are transmitted with the use of the Real Time Protocol.
- *Joint-editing of text files and still images*. This facility is offered in the interactive mode of communication. It allows the concurrent document processing by adding or making changes on textual information and still images. This service is referred to as Joint Editing and Document Conferencing and is a major part of a CSCW tool. The model used for the communication in this service is the master-slave model, where the roles of the master and the slave are interchanged between the two communicating peers.

Future improvements for Telemathea

In the future the joint-editing facility should be augmented so as to support image and text formats of well known word/still images processing applications (e.g. Microsoft Word, Xpaint, Xfig, etc.). Also the communication process can be enhanced by video communication, provided that the network infrastructure will be able to support such a facility. Moreover, the communication protocols should be enhanced in order to exploit the characteristics of the broadband networks and especially of mechanisms that are offered by them and provide real-time control of the QoS.

Another future improvement is the integration of Telemathea with other multimedia applications in a unified multimedia applications library and the interaction with distributed Multimedia DBMS's for the easier access to public, raw, multimedia material. Finally, the cooperation of more than two persons is a very important point for future work, thus Telemathea must be augmented so as to support multi-personal audio/video conferences and joint-editing.

TRENDS[1] - An example of a distance education network

The TRENDS [EDN96,TRN95] project aims at the in-service, distance training of 2,400 school teachers in Secondary Education, and the use of Information Technology and Telematics in the learning process, by six countries (Greece, Italy, Spain, Portugal, France, and United Kingdom). The training process will be implemented by flexible and distance learning methods, through the development and use of an in-service, school-based training system.

The system will be based on multimedia telematics and existing mature network technologies, and on the establishment and operation of a European Teacher's Training Network which will consist of six interconnected National Sites (Training Center, schools and teachers per country). Each Training Center in the Network will act as service provider to the schools and the teachers.

The major aspect of the project is to provide the educator and their trainers, with various services including : e-mail contact with other educators and trainers, access to multimedia information, forums for the discussion and debate on educational projects,

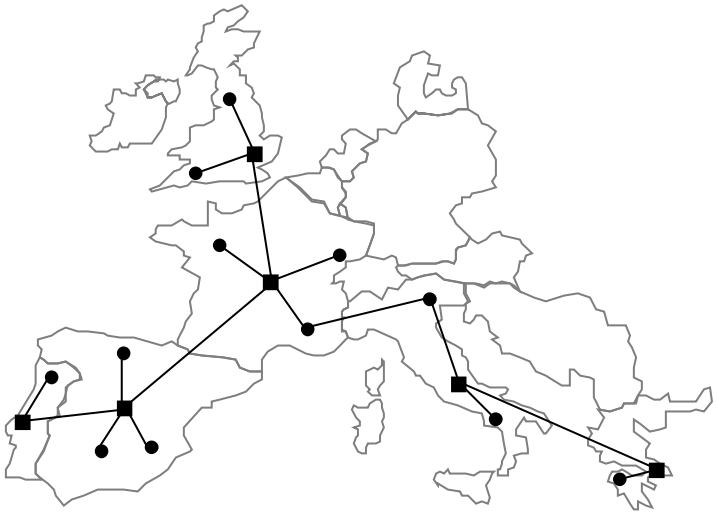
[1] TRENDS (ET-1024) is funded by the TELEMATICS APPLICATIONS PROGRAMME of the European Union

access to curriculum-related information for the educators, and multimedia tele-training for the conduction of lessons over the network.

The services will be implemented by education tools, which include among others the following:

- multimedia education tools and specifically a tele-training tool that will make use of images and voice for the conduction of on-line lessons and a distance education tool that will offer remote access to multimedia-based lessons stored in geographically distributed databases
- remote access to distributed databases that will store research results in various research areas.
- basic network services like access to World Wide Web, multimedia e-mail, news groups, etc.,

An example of the proposed topology for TRENDS is shown in the following figure,



Proposed topology for TRENDS

TRENDS, is complementary to most of the related projects, because of the following characteristics,

- The tools that will be used/implemented have a refined, and thus less generic, purpose and are targeted towards the satisfaction of the educators' user needs.
- The tools will be integrated, thus creating an environment that will offer various services over a common infrastructure and with a common design philosophy.
- It addresses a well defined user group which has not been previously considered under this framework. This group has the special property that it needs continuous training

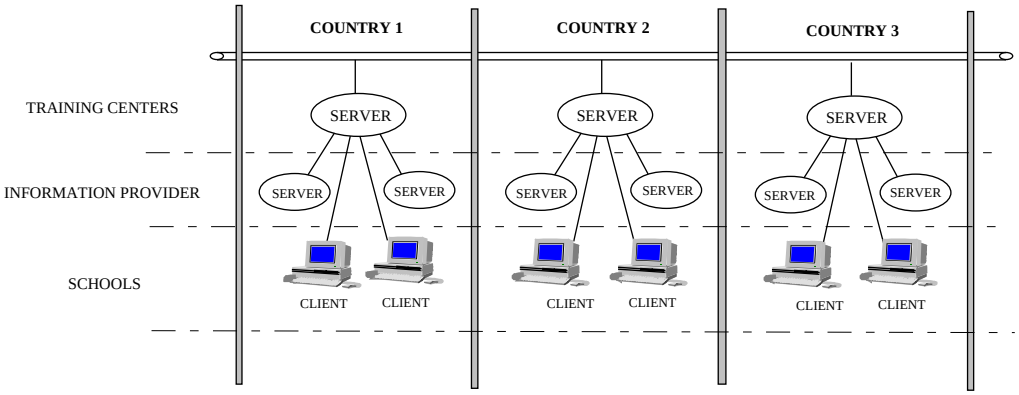
General Design

The TRENDS project, will establish a network based on existing technologies of EURO-ISDN. The connections will have a minimum bandwidth to guarantee the proper delivery of the services (e.g. 64 Kbps). The underlying network will support various services that aim in the training of educators. The implementation of these services is based on the use of existing software tools (modified for the purposes of the project) that are integrated under a common user interface. These services are

complemented by the organization of already existing education material and the implementation of new material mainly concerned with the use of New Information Technologies by the educators in the educational process.

Teachers' Network

The network will consist of six Centers, one in each of the six national sites, in Greece, Italy, Spain, Portugal, France and United Kingdom, which will act as service providers to the teachers in their schools. In each of the Centers a WWW Server will be set up and the appropriate administration and authoring software will be installed. In each of the 120 schools client software will be installed. The following figure shows the configuration of the Teachers network.



Configuration of the Teachers Network

User Services and Tools

The demonstrator will offer an integrated environment that will provides to the educators and their trainers the following services:

- *Personal communication services* such as e-mail, access to multimedia information, forums for the discussion and debate on educational subjects and access to educational networks
- *Multimedia tele-training tool* that will allow the delivery of remote training sessions from the trainer to the educators.
- *Multimedia distance education tool* and distribution of lessons that will offer a way to access off-line lessons that reside in remote servers.
- *Tool for accessing distributed databases* with research results on specific subjects.
- *Off-line contact with a trainer*. This service will offer the ability to educators to register questions concerning the material studied by them. The trainers will be able to answer them and clarify any difficult points. This service will be implemented by employing the basic network services, such as e-mail, news group, etc.

Conclusions

Distance education and training network-based services are being envisioned as a flexible and cost effective solution for the realization of the life-long educational process. Current developments in the field of networking technology are giving to the developers of such services more powerful tools in order to meet the expressed user needs.

Custom designed and implemented, multimedia and hypermedia, distance education tools offer specific solutions that exploit the advantages of the underlying network infrastructure. On the other hand, the explosive growth of the Web introduces a new factor in the deployment of distance education and training services. Although the current architecture of the Web cannot support on-demand and real-time interaction, the projected changes to the underlying protocols as well as the exploitation of new programming languages are expected to address and solve these deficiencies.

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