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Motivations for Using the Web in Teaching

Network-Based Distributed Learning Environment

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Guidelines for Constructing a Habitable Cyberspace

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Features

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Columns

Departments

Network-Based Distributed Learning Environment

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Today we can register a growing public interest in the Internet and especially in the World Wide Web (WWW or Web). At the same time, the computer networks are becoming increasingly fast with the use of new technologies. Moreover new Internet protocols like the RTP/RTCP (Real-time Transport Protocol/Real-time Transport Control Protocol), which have characteristics such as payload type, time-stamping, and numbering of data packets, make possible the transmission, over the Internet, of real time multimedia information offering Quality of Services (QoS). These achievements make possible the implementation of tools that offer teleteaching capabilities over the Internet with QoS characteristics. All the above described achievements make the implementation of tools that offer synchronous learning, asynchronous learning and Computer Support Collaborative Work for Learning (CSCW/L) capabilities over the Internet possible.

The advent of the Web has seen a tremendous expansion in use of the Internet teaching and learning. This article addresses the role of synchronous and asynchronous Internet communication in distributed teaching and learning and also presents an Integrated Distributed Learning Environment (IDLE). IDLEs are client/server applications using standard Internet protocols. Previously, most IDLEs had proprietary client-side applications which constrained the users to load special software onto their home or business computers. However, almost all IDLEs now have enabled their software to be accessible via common Web browsers, such as Netscape Navigator and Internet Explorer. The subject of distant learning and collaboration has engaged researchers all over the world. Different approaches for realising teleteaching have been discussed in other projects as well (Boegh, 1998; Faro, 1997; Katchoff, 1997; Smeaton, 1997; Stefanov, 1998; Levin, 1998; Wang 1996. In McGreal, 1998 someone can find a survey of available IDLEs.

The main feature of our tool is its fully integrated environment, which is flexible and adaptive to many possible requirements. In other words, our proposal aims at covering a wide range of related applications instead of limiting its capabilities to a specific operation, which is the case with other existing tools. For instance, the model that we propose can be used for virtual lectures, virtual conferences, collaborative work on projects which are shared among institutions, exchange of useful material, experiences among teachers, research results, and conclusions as well as versatile and more attractive presentations of the subjects taught. Our proposal is based on the needs of an educational network as they are described in the next section. An interesting approach about the application of a common methodology for users needs in distance education using Telematics is referred to in Antonis, 1998.

This article presents the motivation factors that motivate us to implement that tool, describes the model and the architecture of the system, the functionalites of the IDLE, some implementation issues, and finally presents the

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usage scenarios. This article is based on the following articles: Bouras, 1999a; Bouras, 1999b).

MOTIVATION

Teleteaching could be regarded as the process of learning with the use of Telematics that is the combination of telecommunication, information, and multimedia technology and its services. In such a scenario:

- all the interactions among trainees, trainers and instructional material, which are essential for the instructional process, can be implemented;
- the information and the knowledge, which are essential for the instructional process are accessible and readable; and
- the place, time, and the pace of learning are flexible.

Teleteaching has as a target the development and promotion of special methods and techniques for the increase of the quality, the effectiveness and the suppleness of the learning. The teleteaching has two main results:

1. The educational: The improvement of the existing learning methods and the development of new learning methods.
2. The technological: The provision with new distance learning methods with the use of Information and Communication Technologies (ICT).

Teleteaching has the following main goals:

- the development of learning environments and methods suitable for the use of information technology in different learning environments;
- the improvement of the organization environment, in which these new methods are applied, and the quality and manageability of the multimedia applications and the real time services;
- the encouragement achieved is recognizing the quality characteristics obtained through teaching with the use of new ODL technologies and services; and
- the encouragement of the recognition of the quality characteristics which are gained from learning with the use of new ODL technologies and services.

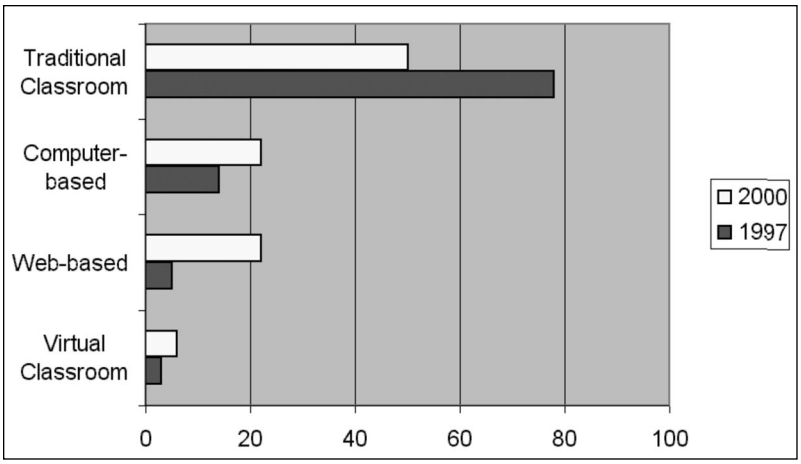

Figure 1. Shift to training delivery

In the last few years we have noticed a shift in the training delivery. As you can see in Figure 1 in the year 2000, 50% of the training delivery uses computer technology. This gives rise to the need to implement tools that support teleteaching (asynchronous learning, synchronous learning, and Computer Support Collaborative Work for Learning (CSCW/L). In the asynchronous distance learning the student selects the time, the duration, and the pace of the lesson. During the synchronous lesson there is live interaction between the participants (the teacher and the students). The CSCW/L functionalities include application sharing, bulleting boards, chat, e-mail, and sharing workspace.

A teleteaching environment combines various instructional scenarios such as collaborative learning and education with or without the live presentation of the Professor. The IDLEs provide a common environment for the implementation of all the above scenarios and the way to success in specific educational targets such as:

- the renewal of the pedagogical methods and environments in the educational institutes;
- the incentives for the diffusion of information among the educational institutes in the World;
- the encouragement of collaboration;
- the motivation of the trainees to use effective and modern equipment for the lessons; and
- the effective transmission and distribution of the instructional material to the trainees.

The IDLEs are primarily based on a collaborative instructional scenario (paradigm) rather than the self-instructional model of multimedia authoring systems, so they make extensive use of the existing asynchronous and synchronous collaborative tools.

The IDLE that is proposed in this article has the following goals:

- to meet the communication needs of a group, such as e-mail, discussion lists, chat, and videoconference;
- to fulfill the educational and instructional needs of the University of Patras, such as synchronous and asynchronous multimedia (audio, video, text, and graphics) lessons; and
- to provide a common and familiar user interface through common web browsers, such as Netscape and Internet Explorer.

IDLE DESCRIPTION

In order to achieve the above goals our proposal is based on the following concepts:

- An integrated communication environment that covers the communicational needs of a group of participants.
- A client server model. We propose a model that has one server and multiple participant clients.
- An open platform architecture in order to support different operating platforms
- International accepted standards.
- Access through Web pages.
- Object oriented design and implementation.
- Modular design to achieve the goal of easy extension.

The Proposed Model

The proposed IDLE is based on the concept of the session. One session is composed from the participants of the session and the information that the session contains. The participant who creates a session has full permissions on that session and manages that session. We call this the participant, leader, participant. The other participants (the participants except the leader participant) have the permissions that the leader participant has given to them. The information, which a session can contain, includes data files (in many different MIME types), hyperlinks, notes, and lessons. Lessons could be either synchronous or asynchronous.

Figure 2 displays the general client – server architecture of the IDLE.

The IDLE server consists of the WWW server, the Teleteaching server, the Media Server, and the Database of the system. Through the WWW server the clients access the capabilities of the IDLE server. The teleteaching server is responsible for the management of the educational process and it synchronises the interaction among the participants during a synchronous lesson. The media server is responsible for the transmission of the video and the audio over the network. In addition, the media server cooperates with the clients in order to achieve QoS; the QoS is achieved with the streaming capability of the media server. The IDLE server is using one database schema to store and manage information about the different session and the users of the system.

The participant client consists of a Java enabled web browser. If the participant wants to receive video and audio information, the participant must have installed the Real Player application onto their computer. If the participant wants to transmit video and audio information, the participant must have installed the Real Encoder application into their computer. The advantage of web browsers, as the interface for distributed learning environments, is that they are popular, easy to use, and require no additional proprietary software on a user's computer. Moreover, they provide access from different computer platforms such as Windows, Mac, and UNIX.

The clients and the server communicate over an IP network such as Internet. Figure 3 displays the protocols stack of the IDLE.

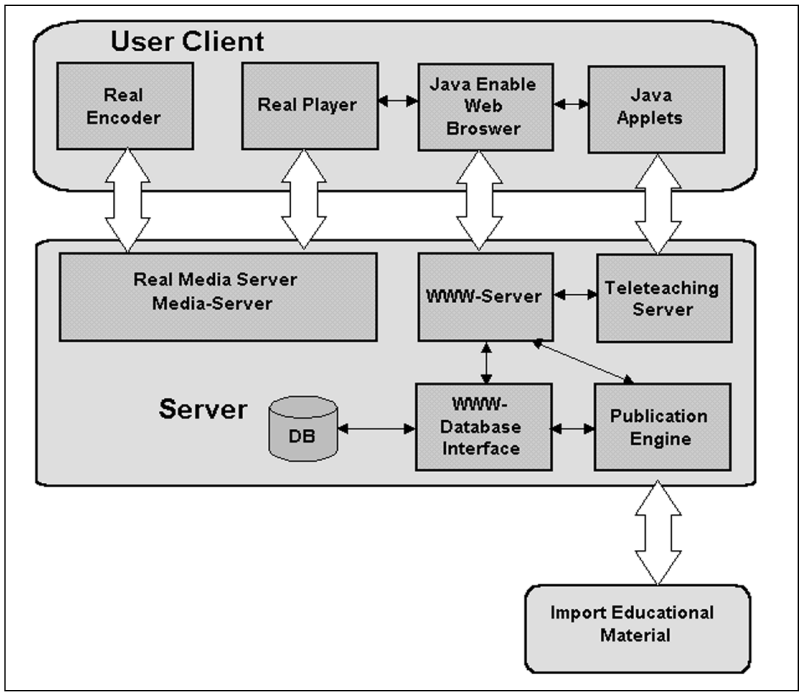

Figure 2. General architecture

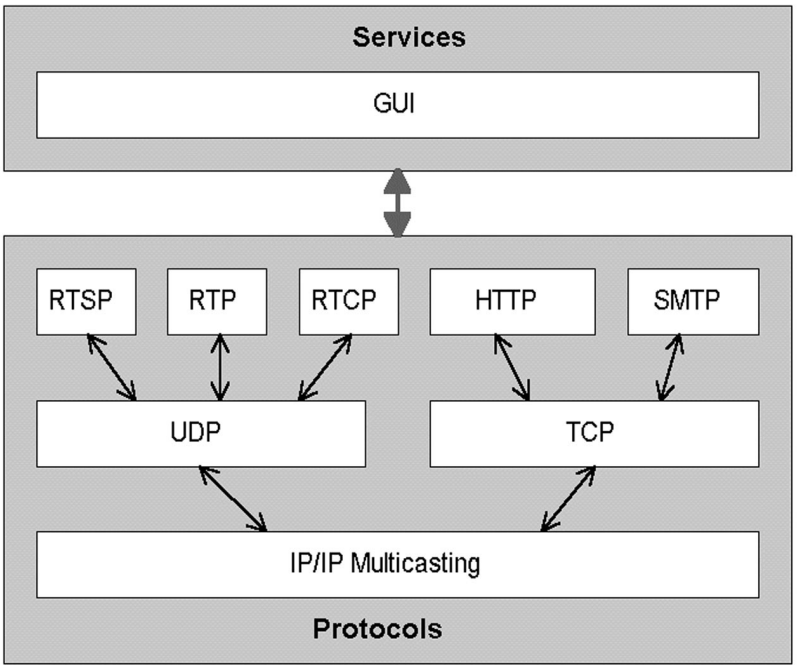

Figure 3. Protocols stack

The Role of Media Server

The media server is responsible for the transmission of the multimedia data over an IP network. As we already stated, the IDLE offers two kinds of lectures: the synchronous lecture and the asynchronous lecture. These two kinds of lectures need different handling for the transmission of their multimedia data because of their different characteristics.

Transmission of multimedia data during an asynchronous lecture. The transmission of multimedia data over the network during an asynchronous lecture is controlled by the Real Time Streaming Protocol (RTSP). RTSP is a client-server multimedia presentation control protocol, designed to address the needs for efficient delivery of streamed multimedia over IP networks. The RTSP specification contains a section on the use of RTP with RTSP. RTP is a transport protocol for the delivery of real-time data, including streaming audio and video. RTCP is a part of RTP and helps with lip synchronization and QoS management, among others. With the combination of the RTSP, RTP, and RTCP we can implement a QoS scheme for our application. The client is adaptive and could change the buffering time and the capacity of its buffer accordingly the condition of the network and the bandwidth requirements of the multimedia stream.

With this approach for any participant who wants to attend an asynchronous lecture, a different "tunnel" of RTP packets is create between the server and the participant's computer. As a result, the participant can attend the asynchronous lecture at his/her own pace.

Transmission of multimedia data during a synchronous lecture. The transmission of the multimedia data during a synchronous lecture is based on the technique of IP multicasting. IP multicast-based routing facilitates distributed applications to achieve time-critical, "real-time" communications over wide area IP networks, through a lightweight, highly threaded model of communication. The IP multicast routers take the responsibility of distributing and replicating the multicast data stream to their destinations as opposed to individual IP hosts. The IP multicasting topology of IP multicast routers is designed in such a manner that it facilitates "efficient" distribution of packets without congesting any node inappropriately. With this approach, we deal with the quality of the services and the network traffic in the best manner.

When a participant wants to join one synchronous lecture (and has the authority to do that) the participant client tries to join the multicasting session. If the participant cannot accept multicasting data for various reasons, (for example the router from which the participant accesses the Internet does not support multicasting) the server tries to transmit the multimedia data with the use of User Datagram Protocol (UDP). Finally, if the transmission with the use of UDP is not reliable, the server opens one Transmission Control Protocol (TCP) connection with the participant client and transmits the multimedia data. With this approach, we ensure that all participants, regardless of their network equipment, will have the opportunity to join one session. On a synchronous lecture all the participants attend the lecture at the same time and the use of IP multicasting reduces the network traffic.

The Role of the Teleteaching Server

The teleteaching server cooperates with the Web server and manages the live educational procedure. The teleteaching server consists of four modules: the session control module, the whiteboard module, the chat, and the synchronous lesson control module. Each module operates independent, and it is responsible for one particular part of the educational process. Each part of the teleteaching server communicates with the corresponding Java applets of the participant clients, in order to accomplish the educational process. With the above-described design we achieve the goals of modular design, easy maintenance, and easy extension of the teletraining server. In order to achieve fairness, the teleteaching server uses a time-stamping mechanism for the management of the permission requests.

Management of permission request during a synchronous lesson. The leader participant manages the lesson during the synchronous session. When a participant wants to speak, he/she must ask permission from the leader. When a participant asks for permission the name, the time when the permission was asked (as convention all times are computed based on the teleteaching server time), and the reason he/she asked permission, are recorded. The information about each permission request is displayed to the leader participant client in one list, where the permission requests are sorted by time. The leader participant has the ability either to give permission to the participant who first asked for it, or to give the permission to the participant that has the most important reason.

The above-described mechanism is based on the first come - first serve model. With the term "first come" we mean the permission that comes first to the teleteaching server, and that means that we consider the network delay between the server and the clients as zero. As a result, we consider the time of permission request as the

time when the packet with the permission request arrives from the participant client to the server. This approach has some drawbacks because does not consider the network delays but it has the advantages of easy implementation and reliability, which are very important aspects for an IDLE system. For the design of the above-described mechanism we use critical regions and semaphores.

The Role of WWW Server, the Database, and the Interface Between Them

The Graphical Users Interface (GUI) of the IDLE consists of HTML pages and Java applets that are stored to the WWW server. This GUI of the IDLE enables the participants to use all the functionalities of the IDLE. In addition the WWW server provides the authentication control mechanisms.

The database is responsible to storing and managing the information of the IDLE. Generally the database stores information about the management of the educational procedure such as participants' authorities, session, and lesson management.

The interface between the WWW server and the database is responsible for the interaction between them. In other words this interface is the layer that implements the linchpin between the GUI (WWW server) and the information pool (database). This interface follows open technologies to achieve interoperability.

FUNCTIONALITIES

Due to the various kinds of communication in a classic situation of learning or collaboration, different mechanisms must be established for sufficing the needs of a educational community over the Internet by our proposal. Our proposal attempts to broaden the horizons for learning and collaboration. Thereby, optimized integration with simple operation mechanisms is an essential necessity. In order to create a complete communication system, able to satisfy the needs of an educational network, our proposal is designed as a simulation of a real situation.

As it has been already stated, our proposal follows the client – server architecture and has two environments; the server environment and the participant client environment. In the following sections we describe separately the functionalities of each environment.

Functionalities of the Server Environment

The server acts like a meeting point for the participants. The server is saddled with the functions of management of educational material, session creation, session announcement, session registration, and authentication control. The participants can be informed of the several sessions, register to one session, join one session, or create their sessions through the server. The functionalities for the server are the following:

- *Management of educational material:* The server with the association of the web server, where the educational material is stored as hypermedia, offers the participants the capability to access the educational material of the network.
- *Session creation:* One participant can create one session and become a leader participant of that session. Through the session creation procedure, the leader participant gives the necessary information for the announcement of the session in the electronic bulletin board.
- *Electronic bulletin board for session's announcement:* The server has an electronic bulletin board to inform the participants of the different sessions and for questions and replies for topics which are relevant to the specific session.
- *Session registration:* When a participant finds a session that interests him/her, he/she can register for it through the session registration procedure. Session registration procedure gives the leader participant the ability to know the other participants that register to his/her session.
- *Authentication control for a session:* A participant has to pass the authentication control in order to join a session. After the authentication control, the participant can access the pages of the session that he/she has joined. With the authentication control the server can recognize the leader participant and enable his/her session management module. The server handles the authentication control. This functionality

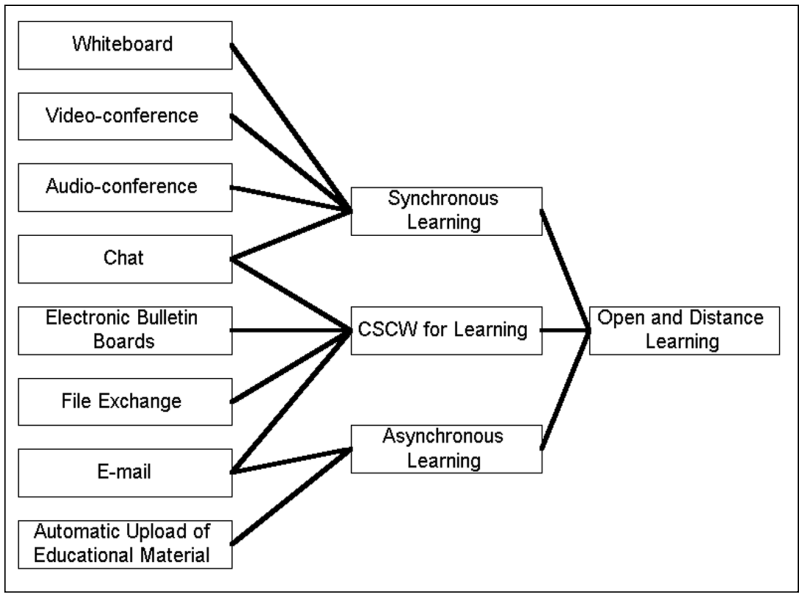

Figure 4. Services of the ODL

differentiates the participants and gives them a different user interface with different functionalities that are described in the following paragraphs.

Functionalities of the Participant Client Environment

Students and teachers access the capabilities of the educational network through the participant client. The client environment is the same for all the participants except the leader participant of a specific session. The difference between the leader participant and the other participants is that the session management module is active in the leader participant client. This approach is followed because a simple participant, in a session, can be leader participant in another session and the reverse. The participant client environment is friendly for the user and provides the following functionalities:

- *Video/Audio conferencing:* A participant can have visual contact with the other participants through video windows, if the necessary bandwidth is available. Through this capability the participants can communicate as if they were in the same physical place.
- *Whiteboard:* One participant can broadcast information to other participants, such as slides, shapes, and so forth by using the whiteboard. With the whiteboard the participants can exchange ideas. More specifically whiteboard is an effective way for communication.
- *Chat:* The chat function can work together with the audio capability or solely when the audio communication is not feasible. The chat function gives us a flexible solution for communication when the available bandwidth is limited.
- *Ability for bi-directional and multi-directional independent communication:* A participant has the authority to select the participants that he/she is addressing.
- *File exchange:* The ability to exchange files between the participants who contribute to the learning procedure.
- *E-mail:* The ability of the tool to support typical e-mail functions (sending and receiving e-mails) helps create the integrated communication environment that we want to provide.
- *Asynchronous learning:* A participant can view an asynchronous lesson which consists of two main parts: the professor's video window and the window with the instructional material. The video is synchronized with the instructional material.

In addition, the leader participant client environment offers the following functionalities:

- *Session management:* Through this capability the leader participant can manage the session and determine the permissions of each participant.
- *Automatic upload of the material for the asynchronous lessons:* The leader participant can send his synchronized video and instructional material to create an asynchronous lesson.

IMPLEMENTATION ISSUES

In this section, we present some implementation issues, including the technical design and the programming languages that are used. As we have previously stated, our proposal is accessed through a Java enabled web browser. The user interface of the IDLE consists of web pages. For the development of the Web pages HTML 3.2 was used. Many of the functions of the IDLE (the session management, the discussion lists, etc.) were developed with CGI programming and more particularly with the use of Perl 5.0 language. Perl is one programming language, which is very popular for CGI programming. Moreover, Perl is one programming language available in many platforms including Unix based machines and Windows NT. We chose Perl for CGI programming because it is a widely used language for this scope, supports many operating platforms, and we are familiar with it. The web server that we use is the Apache web server. The Apache web server is one of the most popular web servers, which offers increased reliability, flexibility, and security.

In order to ensure the independence of the operating platform, on the programming level of the implementation, we use Java, which is a programming language independent of operating platforms. With the use of Java, different machines can access our proposal such as Windows-based or Unix-based machines. In addition, Java is an object oriented language and makes the design of systems with the use of objects easy.

For the implementation of the teleteaching server we use Java. The teleteaching server, as a servelet, cooperates with the Web server and manages the live educational procedure. Each part of the teleteaching server communicates with the corresponding Java applets of the participants clients, in order to accomplish the educational process. The communication between the teleteaching server and the Java applets of the participants' clients is based on the TCP sockets network communication model. For security reasons, the teleteaching server and the Web server, with whom the teleteaching server cooperates, must be installed in the same physical computer. For the implementation of the time stamping mechanism we use the Synchronized

Method Modifier of Java programming language. With the use of the Synchronized Method Modifier we ensure that only one permission request will be handled by the server each time and that no one permission request will have the same ID with another. In other words we implement the codes, which handle the permission requests as critical regions of the code.

For the transmission of the video we use the Real Media platform. The server consists of the Real Media Server and the client from the Real Player. We configure the Real Media Server and the Real Player for each lecture as we have described earlier.

The database that we use is Oracle Server 8. The technologies that are used for the interaction between the WWW server and the database are the DBI and the JBDC.

The Perl DBI is a database access Application Programming Interface (API) for the Perl language. The DBI defines a set of functions, variables, and conventions that provide a consistent database interface independent of the actual database being used.

JDBC is a Java API for executing SQL statements and makes it possible to write database applications using a pure Java API. Using JDBC, it is easy to send SQL statements to virtually any relational database. The JDBC API is implemented through use of a driver manager that can support multiple drivers connecting to different databases. JDBC drivers can either be entirely written in Java so that they can be downloaded as part of an applet, or they can be implemented using native methods to bridge to existing database access libraries.

USAGE SCENARIOS

Our tool is well suited for the communication needs of an educational community for various situations. In this section we describe usage scenarios of our tool for synchronous and asynchronous learning and collaborative work for a project.

Synchronous Learning

In the scenario of synchronous learning we have a teacher and his students who want to participate in a synchronous lesson. Before the lecture the teacher has to create a session through the session creation capability and become the leader participant for that session. The new session and the information for it (such as theme, teacher, day, and time) is announced in the electronic bulletin board of the server. The students can register to the session through the register procedure of the server. After the registration procedure, students become participants of the session. The teacher and the students join the session through the authentication control, at the arranged day and time of the lecture. With the authentication control, the server recognizes the leader participant, in this case the teacher. The teacher as the leader participant can determine, through the session management, the authorities of each student. The teacher can make his lecture with the video/audio applications and use the whiteboard, which simulates the blackboard of a traditional classroom. The teacher may project educational material on the whiteboard, which is available for all the students. The students can annotate the educational material during his/her lecture. The other functionalities of the client can help the learning process. Apart from a teacher's lecture, students can access the educational material on their own without the need of teachers being present (asynchronous learning scenario).

Asynchronous Learning

In the scenario of asynchronous learning, the leader participant is the teacher and the other participants are his/her students who want to attend the asynchronous lesson. Before the lecture the teacher has to create a session through the session creation capability and become the leader participant for that session, or to create the lecture in a session in which he/she is the leader participant. The creation procedure consists of three steps: (a) the creation of the instructional material (docs, slides, etc.), (b) the creation of the video, the synchronization of the video, and instructional material, and (c) the transmission of the synchronized instructional material to the server. In the case that the teacher creates a new session this session, and the information for it (such as theme, teacher, day, and time) are announced on the electronic bulletin board of the server. The students can register for the session through the registration procedure of the server. In this scenario the participant gains the access to information resources and can attend the lesson at the space, time, and pace that he/she wants. Multimedia technologies such as Real Media are used in this scenario and the participant can attend and review the lesson as many times as he/she wants.

Collaborative Work

In the scenario of collaborative work for a project we have a group of participants who want to communicate through the distance collaborative network. One participant creates a session and becomes the leader participant of that session. The other participants register for that session. All the participants join the session through the authentication procedure. The leader participant determines the permissions of each participant. The participants can work and collaborate through the capabilities of the participant client. The partici-

pants can communicate through both the chat and e-mail capability, release solutions to a problem, or put a question in the electronic bulletin board.

CONCLUSION – FUTURE WORK

With the advancement of technologies, learning and collaborative work in the future can become radically different from what it is today. The implementation of our tool suffices the needs for collaborative work and for teleteaching in asynchronous and synchronous modes. Although no one can expect that educational networks will totally replace the traditional lecture and traditional collaborative work, it is likely that such applications will obtain more and more positive ground in the future. On the other hand, with the use of our proposal, the participants will have an integrated communication environment to cover several communicational needs such as CSCL/W.

The design and the open architecture of this teleteaching environment make it possible for the flexible enrichment of the environment itself and its services. Our next steps are the implementation of ITU T.120 specification and the enhancement of the GUI with Virtual Reality characteristics. With the implementation of T.120 the IDLE will support application and data sharing. For the implementation of the Virtual Reality characteristics will use VRML. With the VRML interface someone can implement a Distribute Virtual Environment (DVE) which will enable the students to feel that they are in a traditional lecture or collaborative work. The implementation of the T.120 protocol will provide the application sharing functionality, which will help the instructional, and the collaborative work procedure to be more functional.

Anyone can access our tool through the Internet at the following address: **http://typhon.ceid.upatras.gr:8080/teletraining** (login/password: guest/guest). The interface of our tool is in the Greek language.

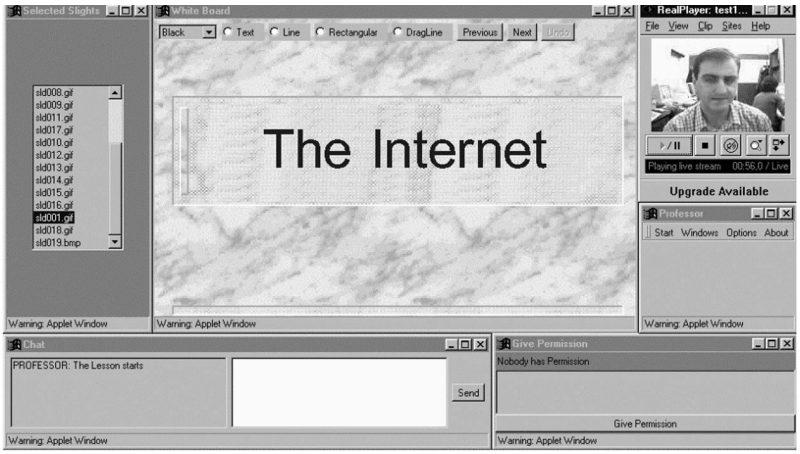

Figure 5. The synchronous learning scenario

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