

A Web-based Distributed Environment to Support Teleteaching: Design and Implementation Issues

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Abstract

Web based systems have been shown to be useful tools for supporting educational communication for teachers and students. In this paper we present such a system, which is an Integrated Distributed Learning Environment (IDLE). We present the technical description of this IDLE and we discuss its main characteristics like the transmission of multimedia data over the network, the manipulation of the educational procedure and the management of the users. In addition we list the functionalities of the IDLE and also discuss some implementation issues.

1. Introduction

Today we can register a growing public interest in the Internet and especially in the World Wide Web (WWW), which is a platform-independent, open standard for information providing, accessible from low-end computers up to workstations. Computer networks became increasingly fast with the use of new technologies. At the same time new technologies for the infrastructure of the computer networks are proposed. ATM (Asynchronous Transfer Mode) based networks, which offers speed up to 155 Mbps, are installed. Moreover new Internet protocols like the RTP/RTCP (Real-time Transport Protocol / Real-time Transport Control Protocol), which have characteristics like 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). All the

above described achievements make possible the implementation of tools that offer teleteaching capabilities over the Internet with QoS characteristics. Different approaches for realising teleteaching have been discussed in other projects as well [1,4,7-11]. In this paper, we present an Integrated Distributed Learning Environment (IDLE). IDLE is a suite of client/server applications using Internet protocols. Previously, most systems had proprietary client-side applications, which constrained the users to load special software onto their home or business computers. However almost all now have enabled their software to be accessible via common WWW browsers, such as Netscape Navigator and Internet Explorer.

2. 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.

Teleteaching has as 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)

A teleteaching environment combines various instructional scenarios such as collaborative learning and

education with or without the live presentation of the Professor.

The Integrated Distributed Learning Environments 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 for the collaboration
- The motivation of the trainees with the use of effective and modern equipment for the lesson
- The effective transmission and distribution of the instructional material to the trainees

The IDLEs 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.

3. 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 multiple participant clients connect with a server, in such a manner to gain QoS in the multimedia transmission and to implement ODL activities
- An open platform architecture in order to support different operating platforms
- International accepted standards. We use widely accepted network protocols for the interaction between the clients and the server
- Access through web pages
- Object oriented design and implementation
- Modular design, in order to achieve the goal of easy extension

3.1. 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 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 file (in many different MIME types), hyperlinks, notes and lessons. Lesson could be either synchronous or asynchronous.

The Figure 1 displays the general client – server architecture of the IDLE.

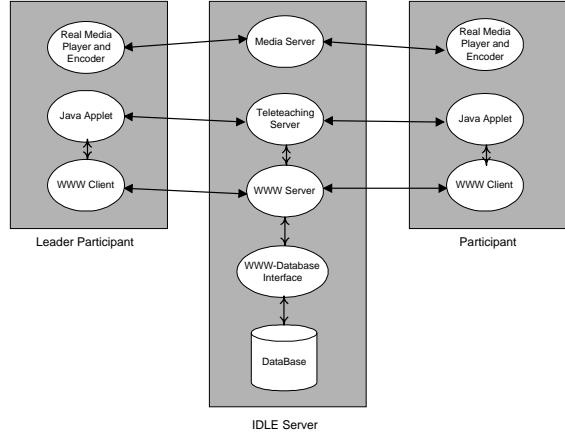


Figure 1. General architecture

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 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 enable web browser. If the participant wants to receive video and audio information must have installed to his computer the Real Player [12] application. If the participant wants to transmit video and audio information must have installed to his computer the Real Encoder [12] application. 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 like Windows, Mac and UNIX.

The clients and the server communicate over an IP network such as Internet. The Figure 2 displays the protocols stack of the IDLE.

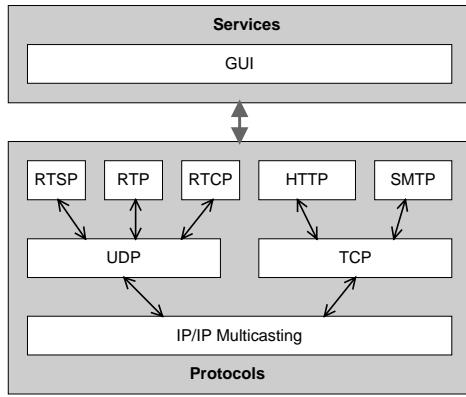


Figure 2. Protocols Stack

3.2. 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 lecture: The synchronous lecture and the asynchronous lecture. These two kinds of lecture need different handling for the transmission of their multimedia data, because of their different characteristics.

3.2.1. Transmission of multimedia data during an asynchronous lecture. The transmission of multimedia data over the network during an asynchronous lecture is controlled by the RTSP (Real Time Streaming Protocol). 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 want to attend an asynchronous lecture a different “tunnel” of RTP packets is create between the server and the participant’s computer. As result the participant can attend the asynchronous lecture with his own pace an asynchronous lecture.

3.2.2 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 with the best manner.

On a synchronous lecture all the participants attend the lecture on the same time and the use o IP multicasting reduce the network traffic.

3.3. 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 (4) 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 participants 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.

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

3.4. 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 (see paragraph 4) of the IDLE. In addition the WWW server provides the authentication control mechanisms.

The database is responsible to store and manage 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 in order to achieve interoperability.

4. 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 will attempt to broad the horizons for learning and collaboration. Thereby, optimized integration with simple operation mechanisms is an essential necessity. In order to create a complete communicational 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.

4.1. 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, and session registration and authentication control. Through the server, participants can be informed about the several sessions, register to one session, join one session or create their sessions. The functionalities proposed for the server are: Management of educational material, Session creation, Bulletin board for session's announcement, Session registration and Authentication control for a session

4.2. Functionalities of the participant client environment

Students and teachers access the capabilities of the educational network through the participant client. All the participants use the same client environment. The difference between the leader participant and the other participants is that in the leader participant client the session management module is active. We follow the above mentioned approach because a simple participant, in one session, can be leader participant in one other session and the reverse. The participant environment is displayed in Figure 3.



Figure 3. The GUI of the Leader Participant

For the participant client we propose the following functionalities: Video/Audio conferencing, Whiteboard, Chat, Ability for bi-directional and multi-directional independent communication, File exchange, E-mail, Asynchronous learning, Session management, Automated transmission of the material for the asynchronous lessons. The last two capabilities are active only in the leader participant client.

5. Implementation issues

In this section, we present some implementation issues, including the technical design and the programming languages that are used.

As already we have stated our proposal is accessed through a Java enabled web browsers. The user interface of the IDLE consists of web pages. For the development of the web pages was used HTML 3.2. Many of the functionalities of the IDLE (the session management, the discussion lists, etc.) was developed with CGI programming and more particularly with the use o 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 choose Perl for CGI programming because is a wide used language for this scope, it 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.

For the implementation of the teleteaching server we use Java. The teleteaching server, as a servlet, 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 reason the teleteaching server and the web server, with whom the teleteaching server cooperates, must be installed to 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 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 code, which handle the permission requests as critical region of code.

For the transmission of the video we use the Real Media platform [12]. 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 describe in the paragraph 3.2.

The database that we use is Oracle Server 8 [13]. The technologies that are used for the interaction between the WWW server and the database are the DBI and the JDBC.

6. Usage scenarios

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

In the scenario of synchronous learning we have a teacher and his students who want to communicate through distance learning. 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 information for it (like theme, teacher, day and time) is announced in the bulletin board of the server. The students can register to the session through the register procedure of the server, and the register procedure gives them a login and a password for joining the session. After the registration procedure, students become participants of the session. The arranged day and time of the lecture, the teacher and the students join the session through the authentication control. 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 can use the whiteboard which simulates the blackboard of a traditional classroom. The teacher may project educational material in the whiteboard, seen by all the students and annotate this material during his 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).

In the scenario of asynchronous learning the leader participant is the teacher and the other participants are his 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 is the leader participant. The next step is the leader participant to upload the educational material for that lesson to IDLE 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 and have the authority to attend the asynchronous lesson.

In the scenario of collaborative work for a project we have a group of participants who want to communicate through the distance collaborative work. One participant creates a session and becomes the leader participant of that session. The other participants register to that session and receive a login and a password in order to join the meeting. 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 participants can communicate through the video/audio capability, represent their thoughts in the whiteboard and share applications and collaborate as if they were in the same physical place.

7. Conclusion - future work

With the advancement of technologies, learning and collaborative work in the future can become radically different from what it is today. 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 like CSCL/W.

The design and the open architecture of this teleteaching environment make possible 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 Graphical User Interface 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.

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