Desktop Synchronous Distance Learning Application enhanced with efficient chair control capabilities

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Abstract: *The use of multimedia in Telematics and new services has been greatly improved by the introduction of new systems and techniques. These new systems and techniques made the implementation of many telematic applications like Synchronous Distance Learning possible. In this paper, we present design, functionality and implementation issues, which concern a Synchronous Distance Learning application. The described application is a network-based application, which can be used over IP and ISDN networks. In addition the implemented Synchronous Distance Learning application uses an innovative chair control module, which does not require any support from the MCU (Multipoint Control Unit).*

Keywords: multimedia applications, architectures and protocols, chair control, IP and ISDN networks, distance learning

1. Introduction

The last years we notice a shift in the training delivery [9]. Also the costs are considerably smaller in distance learning than traditional learning ([6], [9]). This arises the need to implement tools and to design networks those support ODL services (asynchronous learning, synchronous learning and Computer Support Collaborative Work for Learning - CSCW/L).

An increasingly number of enterprises uses ODL for training their employees. Interestingly enough not all the enterprises that want to and can use ODL are doing so.

In this paper, we present the design and the implementation issues of a Synchronous Distance Learning application. A Synchronous Distance Learning application is an application that offers Distance Learning with the live presence of the trainer. In this category of Distance Learning, the lesson takes place at a predefined time.

The most prominent features of our application are the following: (1) it is full integrated environment, (2) supports both IP and ISDN networks, (3) it is a cheap solution because in based on typical desktop computers. In addition our application is trainer oriented, which means that the trainer has the full control of the educational procedure during the lesson. In order to implemented the above functionality we use a new innovative chair control mechanism, which does not require any support from the MCU (Multipoint Control Unit) and can be used both in ISDN and IP networks.

The rest of this paper is organised as follows: Section 2 presents our motivation. In section 3, we give a detailed description of implemented application architecture. Section 4 presents the system functionality. In section 5, we present the innovative chair control mechanism, which is used by the implemented application. In section 6, we give some implementation details. Finally, section 7 concludes the paper and discusses some of our future work.

2. Motivation

A Distance Learning environment combines various instructional scenarios such as collaborative learning and education with or without the live presence of the trainer. In this paper we present the design and the implementation of a Synchronous Distance Learning application. The trainees attend the lesson, listen to the trainer and have the ability to interrupt the flow of the lesson in order to submit a question. The trainer has all the necessary authority to control the flow of the lesson (like as in a conventional lesson). For saving network resources, every participant can see only one video every time (the Trainer, or a trainee that submits a question), Someone can find more information about Distance Learning technology and applications on [2] and [4].

To form a Synchronous Distance Learning application, a number of nodes, including multimedia desktop computers must participate over a distributed computing environment. In order to realize a Synchronous Distance Learning application, someone must implement not only tools for the presentation of the education material, but also a lesson control mechanism. The subject of conference control mechanisms has engaged researches all over the world ([6], [7], [9]). The lesson control mechanism must not only offer capabilities for the control of the conference like creating a lesson, adding or removing users form a lesson, but must also offer capabilities for the control of the educational procedure, like floor control capability. During a Synchronous Distance Learning session, one user, the trainer, must have the full control of the lesson's flow. Typical tele-conferencing tools regard all users equal, something that is not desired to a Synchronous Distance Learning application. Therefore, typical tele-conferencing tools are not suitable for Synchronous Distance Learning applications.

We decide to implement a new Synchronous Distance Learning application in order to overcome the limitations of that the current Synchronous Distance Learning applications introduce in to the Greek users. None of the international available Synchronous Distance Learning applications offer a GUI (Graphical User Interface) in Greek language, which is an important limitation, having in mind that ODL services in Greece targeting mainly in to SME environments where the knowledge of English language is not mandatory.

In addition today in the market there is not a chair control solution, which can be used in all the network environments (ISDN and IP) independently of the equipment, which is used. In ISDN networks (and H.320 videoconference), the H.243 chair control standard exits but not all the available MCU in the market support H.243. In IP networks (and H.323 videoconference) there is not a wide acceptable standard for chair control and each MCU developer uses its own proprietary (in most cases web based) mechanism for chair control. In order to overcome the above limitation, the implemented application uses an innovative chair control module (integrated to the application), which does not require any support from the MCU and runs in all MCUs independently of the proprietary chair control mechanism.

3. System Architecture

The Synchronous Distance Learning services have to be supported by a suitable network infrastructure. This network infrastructure has to satisfy some requirements i.e.

- It should cover a wide geographical area. The general network architecture is based on the public ISDN network and IP networks. Notice that this is in accordance with the practice applied by many enterprises that used the ISDN or IP networks to implement ODL.
- It should support both telephony and computer networking. Various nodes are interconnected using the network. These are either trainees' or trainers' nodes or supporting nodes.
- It should not be expensive to use. The supporting nodes contain the necessary equipment and server software in order to provide the services to the trainees (typically a MCU, a router with a Primary Rate Interface ISDN card, an enterprise server, server software etc.)

We implement such a Synchronous Distance Learning services, which is based on the public ISDN network infrastructure. It consists of a few central nodes (i.e. representing enterprises' premises) and several remote nodes representing the trainees and the trainer. The network architecture is shown in Figure 1.

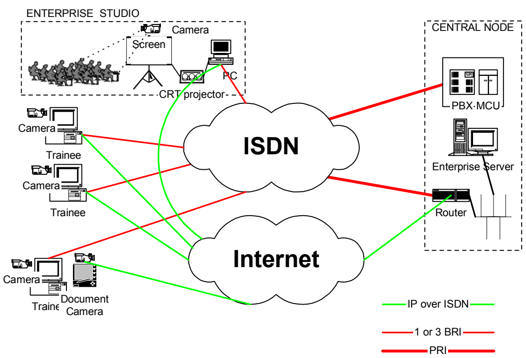

Figure 1: Network architecture

The central nodes are equipped with an ISDN PBX, an enterprise server (including all the necessary software packages), and a router. These nodes are connected to the public ISDN network via a few (one or two) Primary Rate Interface (PRI) ISDN links and the router is connected to the Internet. One of the central nodes is also equipped with an MCU.

If the Synchronous Distance Learning services offered using the ISDN services the central site uses MCU to interconnect the users. On the other hand if the ODL services offered using TCP/IP services and the participant connect either through the Internet or directly to the central site (in this case the central site acts like an Internet Service Provider (ISP)).

The trainees' nodes are equipped with a personal computer (equipped with all the necessary network communication hardware and the implemented Synchronous Distance Learning application). These nodes are connected to the public ISDN network via one or three Basic Rate Interface (BRI) ISDN links.

The proposed architecture follows the following standards: H.320 for audio and visual communication over ISDN networks, H.323 for audio and visual communication over packet (TCP-IP) networks, T.120 for data and application sharing.

The application that we implemented (and acts as client) characterized by ease of use and simplicity. The implemented application can be used for Synchronous Distance Learning over ISDN and packet networks. The server applications characterized by reliability, high performance and support large number of users. In the following paragraph we present the functionalities of the implemented Synchronous Distance Learning system.

4. System Functionality

The implemented Synchronous Distance Learning application had as target to provide a user friendly service to its users. In the following of this paragraph, we initially present the basic functionality of the implemented application and then we present the advance functionality. The basic functionality of the implemented applications consists of the necessary functionality in order to simulate the traditional classroom. The advance functionality has as target to enhance the Learning procedure and provide a user friendly and high quality service to the end user.

4.1. Basic Functionality

Through this basic functionality the conditions of a typical classroom are simulated. Basic Services include:

- Transmission of Multimedia data (audio – video). Transmission of audio and video covers the necessity for audio and visual contact between the trainer and the trainees during Synchronous Distance Learning. During Synchronous Distance Learning, video and more importantly audio are the dominant communication means.
- Whiteboard service: Whiteboard simulates the normal whiteboard that exists inside most classrooms. The various participants can project electronic slides on the Whiteboard, create all sorts of shapes and generally present their thoughts.
- Live demonstration of educational material: The Data and Application Sharing service helps to expand the educational procedure, since the participants can share applications

and remotely cooperate as if they were in the same physical room.

- Chat: This service is used so that the participants can communicate with each other and also place questions to their trainer during the presentation.
- File Sharing: This service allows participants to exchange files during the Synchronous Distance Learning.

Audio and video transmission is covered by a number of international standards (H.320, H.323 etc.), which ensure interoperability between products from different vendors. For Chat, Whiteboard, File Sharing and Data and Application sharing there is a number of international standards like T.120, which ensure interoperability between products from different vendors.

4.2. Advanced Functionality

Advanced functionality aims at increasing the quality of the Synchronous Distance Learning and aims at improving user friendliness. Advanced Services include:

- Educational procedure control: This service is only be available to the trainer and not the trainee. It includes:
  - Chair Control: The trainer has absolute control of who is going to speak next. Whenever a trainee wants to speak, he has to ask the trainer first. The trainer can choose whether the request will be accepted, and he can reclaim it anytime.
  - The trainer can approve or deny trainee requests for the speech.
  - Exchange of written messages can be used as a communication means before the speech is granted.
  - The trainer can determine if he will accept interruptions during the lesson.
- Automatic Sharing: The trainer can choose a file and this file is automatically executed (with the appropriate program based on its extension, using the information in the Windows registry) and then shared. This functionality is especially helpful to new and less experienced users.
- Lesson choice: When the trainees are connected to the service they can choose one of the available lessons at that given time, and they are automatically connected to the chosen lesson. This service is implemented using the MCU functionality for choosing a session. We have therefore the capability of hosting a number of concurrent lessons, with the upper limit determined by the MCU capabilities.
- Use of local PTZ (Pan Tilt Zoom) camera: The application offers the capability of handling the local PTZ camera and focusing it on predetermined spots (e.g. where trainees are or on specific spots on a slide). This functionality is based on the H.281 standard for PTZ Camera Control, and is available for both the trainee and the trainer.
- Use of remote PTZ (Pan Tilt Zoom) camera: The application offers the capability of handling the remote PTZ camera and focusing it on predetermined spots (e.g. where trainees are or on specific spots on a slide). This functionality is based on the H.281 standard for PTZ Camera Control, and is available only for the trainer.

5. Chair Control

The chair control is an important component of all Synchronous Distance Learning applications. Unfortunately, today in the market there is not a chair control solution, which can be used in all the network environments (ISDN and IP) independently of the equipment, which is used. In ISDN networks (and H.320 videoconference), the H.243 chair control standard exits but not all the available MCU in the market support H.243. In IP networks (and H.323 videoconference) there is not a wide acceptable standard for chair control and each MCU developer uses its own proprietary (in most cases web based) mechanism for chair control.

In order to overcome the above limitation, we implement a new innovative chair control mechanism for our Synchronous Distance Learning application. The innovated aspect of the implemented chair control mechanism is that supports all the networks which is used today for videoconference (ISDN/H.320, IP/H.323, others) and does make any assumption for the MCU which is used(like H.243 or any other chair control mechanism) except that the MCU is supporting voice activated video changes (which is common functionality of all the available MCUs). The implemented Synchronous Distance Learning application supports both the H.243 chair control standard (for use during H.320 lessons) and the new innovative implemented chair control (for use in all cases, H.320, H323, other).

In order to implement the chair control mechanism, we have utilized the data channel in order to transmit the messages of our mechanism. A message consists of its message type and probably some message data. Data contained in a message can identify a participant in the conference, or contain some message-specific data. There are 9 types of messages:

- Mute: used to mute one or more trainees. If it contains no data it is considered to mean "mute all". Otherwise it contains identification for a specific trainee that is to be muted. This message is always broadcasted, so that each participant knows the states of all others.
- Unmute: used to unmute one or more trainees. If it contains no data, it is considered to mean "unmute all". Otherwise it contains identification for a specific trainee that is to be unmuted. This message is always broadcasted, so that each participant knows the states of all others.
- Speech: sent by a trainee who requests permission to speak and it is broadcasted to every trainee in the conference. Its data contain the reason why the trainee wants to speak (if given).
- DelegateData: sent by the trainer to another trainee to notify that the current trainer is releasing chairmanship (and becomes trainee) and handing it over to the new trainee (which becomes the new trainer). Upon the reception of this message, the application, at the side of the trainee selected to become trainer, obtains full trainer functionality.
- Forced: this message is broadcasted by the trainer whenever a participant's video is forced, in order to notify everybody who is the forced participant. When the application receives such a message, it mutes sound from the local participant (except if the local participant is the participant whose video is going to be forced) so that the voice activating feature of the MCU starts sending the forced video. The data part of the message contains identification of the participant whose video will be forced.
- Unforced: sent to everyone to notify that nobody's video is forced any more.
- MutedInfo: sent by the trainer of a lesson whenever a new trainee joins the conference to inform the new trainee about the trainees, in the lesson, that are currently muted. The data of this message contain pairs of trainee’s identification –trainee’s state (muted or not).
- CommentInfo: sent by the trainer of a lesson whenever a new trainee joins the lesson to transmit to the new trainee a previous speech request by some participant, along with the requesting trainee’s comments. The trainer will send to the new trainee as many CommentInfo messages as the number of speech requests that the trainer has stored.
- ForcedInfo: sent by the trainer of a conference to a new trainee in order to inform the new trainee whose video is forced. (if such a trainee exists). The data of this message contain the identification of the forced participant.

Identification of a participant is made based on both the name (ISDN case) and the IP address (IP case).

Figure 2 illustrates the basic functionality for some of the messages. When a trainee enters the conference, the conference trainer is responsible for updating the new trainee with the information exchanged while he was absent. This is achieved with the MutedInfo, CommentInfo and ForcedInfo messages. Whenever a trainee has something to say he requests permission (Speech message) from the trainer. The trainer has the option of accepting or rejecting the request. If the trainer accepts the request, a force message is sent to all trainees and the requesting trainee's video is seen by everybody in the conference. After a while the trainer can send an Unforce message, and the trainee's video is no longer imposed on all participants.

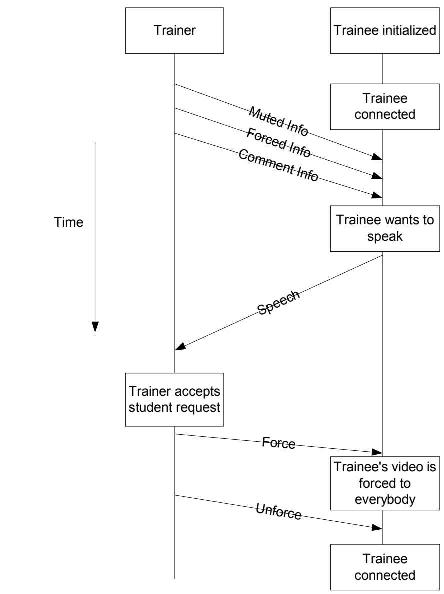

Figure 2: Messages exchanged between trainer-trainees

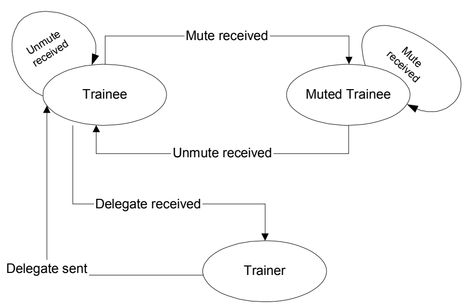

Figure 3: State transitions

Figure 3 shows the state transitions and explains the use of the three final messages, the Mute/Unmute pair and Delegate. Whenever a trainee receives a Mute message, the microphone is muted and the trainee can no longer be heard by the other participants. This is inversed whenever the trainee receives an Unmute message. Both of these messages come from the conference trainer. Finally, the Delegate message is used to transfer conference trainer's rights between participants. If a trainee receives a Delegate message, then the trainee can accept the control of the conference and becomes trainer. The trainer that sends the Delegate message loses the control he previously had (and becomes a trainee), so that at a given time point there is exactly one conference trainer, which controls the lesson.

6. System Implementation

For the implementation of the Synchronous Distance Learning application we use the VDK 4.51 software development kit from the VCON company ([10]). The programming environment was Microsoft C++ 6.0 ([11]).

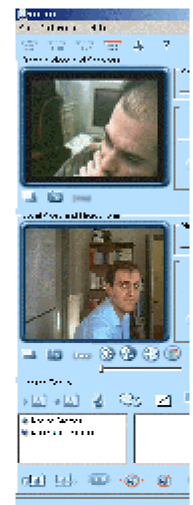

Figure 4 The Synchronous Distance Learning Application

The implemented application has the following technical characteristics:

- Supports Distance Learning over ISDN networks (point to point or multipoint with the use of H.320 MCU) based on H.320 standard with the use of one BRI connection (128Kbps) or with the use of three BRI connections (384Kbps).
- Supports Distance Learning over IP networks (point to point or multipoint with the use of H.323 MCU) based on H.323 standard. The implemented application support videoconference up to 1.5 Mbps bandwidth for high quality distance education.
- Support of QoS characterizes over IP networks. The implemented application support DiffServ and IP Precedence.
- Support of data and application sharing based on T.120 standard.

- Support of H.243 chair control and support of new innovative chair control mechanism.
- Support of Far End Camera Control (FECC) based on H.281 standard.
- High Video quality with frame rate up to 30 frames per second.

Figure 4 shows the implemented Synchronous Distance Learning application.

7. Conclusion

Many enterprises showed interest to use implemented application in order to train their staff. Today takes place the integration of the network and the services as well as the instruction of technical people in order the ODL service become widely available to the Greek SME (and not only). Today these services are available to the public and the Greek enterprises can find an easy way to benefit from the advantages that ODL has. The next steps are the promotion of the ODL service to other target groups except companies (educational organisation, universities, etc), which can benefit from the use of ODL services.

In addition the implemented chair control mechanism can be used in other Telematic applications like virtual meeting with the use of videoconference and Telemedicine. Our future work includes the implementation of the above described chair control mechanism as a plug-in which can be used in order to provide chair control capabilities to other Telematics applications.

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