Using XML messages in communication between elements of the eLearning system

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***Abstract*—** This paper presents the eLearning system developed at the Silesian University of Technology. The system consists of four parts: streaming server, client applet, control application and presentation application. The main purpose of the system is providing lectures for handicapped persons. The teacher can present the lecture in traditional classroom with concurrent transmission to remote students using the Internet. System uses audio, video and text messages channels in both directions, from teacher to students and reverse and in this manner it is similar to videoconference. The system has been designed to allow implementation of additional features needed by handicapped persons especially additional data streams. XML has been used for communication between element of the system. This paper describes these elements and presents usage of XML messages for communication between system modules.

***Keywords*—**eLearning, distance learning, videoconference, webcast, handicapped persons, XML

I. Introduction

IN recent years a lot of work has been done for developing systems that allow to perform lectures and training remotely. First commercial and later Open-source educational platforms appeared more than 15 years ago [1]. The Internet is considered as the first-choice medium, and most systems are Web-based with usage of the WWW technology [13]. There are two main kinds of web based learning systems. The first group, called learning management systems [2], are asynchronous 'content delivery' platforms working like knowledge databases with content prepared in form of static modules. Educational module represents one part of the training course and usually contains some theory material, presentations and tests. Static slides are sometimes extended with audio hearings and video presentations for making the learning process more attractive. Communication in such systems is provided with e-mails complemented sometimes with forums. The second group constitute more dynamic systems with some real-time synchronous tools like audio- and video-conferencing. Examples of systems of this type can be called active learning because they motivate teachers and especially students to take an active part in the educational process. These systems allow to contact the teacher remotely in real time using audio or video transmission. In some systems it is also possible to provide a kind of real time discussion between learners with multi-party video interactions or at least instant messaging tools [3]. Currently the content oriented static systems are replaced with communication-oriented ones that put students in the central point of the learning process [4][12]. The role of the teacher is not only to deliver the knowledge but also to activate creativity and critical thinking [1].

The eLearning systems are especially attractive for handicapped persons who have essential problems with attending to regular scholar courses. The possibilities of delivering educational materials and communicating between course participants have been significantly improved by Internet technologies. It would be highly desirable that student with disabilities reached the eLearning system in the same way that any another person [5]. Different user interfaces, adapted to individual kind of perception possibilities allow to present the same information through several media types [6].

At the Silesian University of Technology the work has been started to develop the system for remote teaching accessible for people with different disabilities. This paper presents the description of concepts developed and software implementation of the system. The main goal of the research is not only creation of the accessible static materials with preparing special versions of presentations and other documents, but to build the tool for handicapped persons for active participation in lectures using the Internet. From the beginning of the work the concept has been to create the system that can be used not only for distance learning by persons with disabilities but also for improving conventional methods of educational process at the university. The improvements to applications and content design in eLearning systems are the main development challenges for both now, and close future [7]. The approach used in the system, where students can attend lectures locally or remotely and use eLearning tools for deep studying topics is called blended learning and is considered to be one of the most effective learning modalities [8]. The work has been started with preparing the videoconference system that allows to perform lectures in regular classroom with special tools for taking part in classes remotely.

The system consists of four main parts. This paper describes elements of the system and presents details about the XML usage in communication between modules.

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II. Online eLearning tools

There are some possible scenarios of online eLearning systems: one to many without speaking rights, and many to many or one to many with the right to speak by participants granted [9].

A. One to many

One to many approach works in a very similar manner to standard classroom. There is a teacher who presents the lecture through audio and video data streams completed with text messaging utility. Lecturer is usually equipped with some electronic multimedia devices like notebook computer, multimedia projector and interactive electronic whiteboard. The lecturer often uses previously prepared presentations with the application that can display slides and sometimes allows to make some additional marks on the electronic whiteboard. Optionally, during such lecture the teacher can allow students to take active participation by answering, asking questions and making their own marks on electronic whiteboard with content transmitted to all logged-in users.

B. Many to many

Many to many scenario works in less centralized mode than one to many. Any participant can freely speak using audio or text messages. It is rather hard to perform such training activities using videoconference system, especially when many users are on-line simultaneously.

III. System architecture

The system developed at the Silesian University of Technology works like one to many scenario. A teacher keeps the control of process of the lecture with possibility of presenting material in the real classroom and transmitting it to remote students. The system consists of four main parts: streaming server, client applet, control application and presentation application.

The teacher can use two computers, with two parts of the system. One computer, usually teacher's notebook, with the presentation application installed on it, is intended for supporting lecturer during presentation. A computer with the control application should be bound up with the classroom infrastructure, forming the central point for connecting video cameras, microphones and the teacher's notebook. It is also possible to use both applications on one computer. Control application takes slides as pictures from presentation application, adds the audio and video streams from microphones and cameras and sends everything to the streaming server. The main goal of the server is broadcasting lectures to remote students using Internet. The server is prepared to operate with many lectures simultaneously so there can be just one server for more than one classroom.

Using the web browser students can connect to the server and take a part in the currently transmitted lecture. Making the connection one can choose interesting elements within the presentation slides, audio and video streams, adjusting their quality to the Internet connection bandwidth. For example for fast connection, with the transmission speed above 512 kb/s, student can receive all multimedia streams with high resolution and quality. For slower connection only slides and audio stream can be chosen or the quality of video can be lowered.

Taking part in the lecture in remote way is not limited to observing only. System has reverse transmission channels for interactive participation. Thanks to text messages students can ask their questions, and answer teacher's questions. If the student has the microphone that is connected to the computer the voice channel can be used for the same purpose. It is also possible to use the web camera for video transmission from student to the classroom. Video channel can help remote students to achieve the scholar and especially social integration. Method of the transmission is chosen by the lecturer who can make selection between active remote students and their transmission channels.

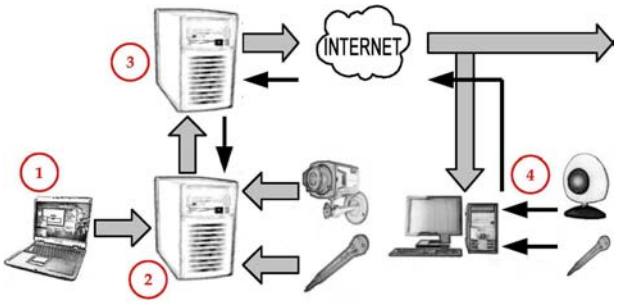

Fig.1 Architecture of eLearning system

In the Fig. 1 the computer labeled with the number 1 represents teacher's laptop. Computer number 2 is located in the classroom and has the control application installed. It is also the central point for connecting all audio and video equipment from the classroom. Computer 3 is the server that is connected directly to the Internet, and computer 4 is the student's workstation. The latter can also have the audio and video equipment connected.

IV. Realization of control application

The control application is the main part of the system because it centralizes all other elements in one place. Control application has been created according to MVC model (Model View Controller). Such application architecture is currently often used in creation of systems. General diagram of this architecture is presented in Fig 2.

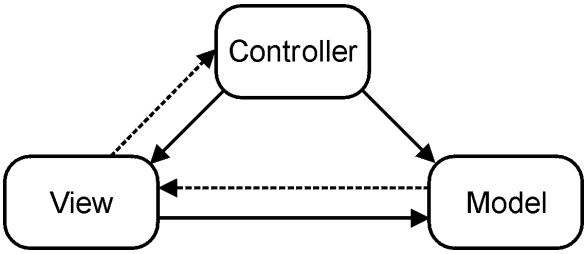

Fig.2 Model View Controller architecture

In Fig. 2 solid lines represent direct dependencies, dashed lines indirect ones. Such architecture divides the application into three independent layers:

Model – layer for representation of the data structures and dependencies between them. This is the only part of the project that permanently holds the data. Data can be stored in files, database or using some other method. Model layer should have data manipulation interface to other layers without any information about internal implementation.

View – is the user interface layer that is responsible for information presentation. View layer should use the model layer interface to collect data needed for displaying to the user. This layer should not modify the data in direct way.

Controller – is the control layer which main function is handling the events usually incoming from the user interface. Control layer has the possibility of modifying the data in the model layer and elements of the user interface in view layer.

MVC architecture is currently used in web applications because of simplicity of creation and maintenance of large systems. Due to logical independence of three layers of the application modification of one layer has minimal influence on others.

A. Available technologies

System which uses data streaming for media transmission like videoconference system needs the proper choice of the technology for data transmission. There are two most important competitive technologies that can be used for live video transmission through the Internet and these are Java Media Framework and Windows Media Services.

Java Media Framework

JMF is the universal application programming interface designed for handling different multimedia data. It is intended for creating Java-based programs. Using this tool the programmer can easily play multimedia clips in Java applets or applications, play streaming media, record and store pictures, video and audio acquired from external devices, process multimedia data, perform transmission of streaming media in local networks and in the Internet [10][11].

JMF uses object model that is similar to reality, which contains such elements as Data Source, Capture Device, Player, Processor, Data Sink, Format and Manager. Data Source is the object that represents the data intended for playing, transmission, or processing. Capture Device is the object representing the real device capable of recording the video or audio data. The Player is the object which can play the data from the data source. Processor is the object that can process the data or transmit the data from the source. Data Sink is the object with the main goal of transmitting the data to specified target, for example remote computer in the Internet. Format defines the methods of recording, storing, processing and playing the data. The last object, Manager, is the interface between any other JMF objects. JMF operates on wide spectrum of different data compression formats. Some of the most popular are MPEG Layer-3, GSM, G.723.1 as audio formats and MPEG-1, H.263, JPEG, Indeo as formats of video data.

RTP is used as communication protocol between application that transmits the data and the receiving application. Sender can transmit data separately to every receiver using unicast addressing or perform multicast transmission that saves the network bandwidth. It is very important that JMF is offered without charge by Sun and is well documented.

Windows Media Services

Due to this technology streaming server can broadcast multimedia data in the computer network. It can work in the local networks as well as in the Internet. In the player application Windows Media Player special buffering has been implemented. Before beginning of the clip application preloads some data from the server filling part of the buffer. This mechanism helps eliminating picture stalls and makes the jitter of the speed of data transmission practically invisible to the user.

The data sent by Windows Media Server is dependent on the configuration of the distribution points. The data can carry video stored in the file, it can also be the stream acquired live by the capture device. It is also possible, using the playlist, to aggregate different media to form single compact presentation. Playlists are saved using Synchronized Multimedia Integration Language (SIML) standard, that allows to create any combination of packets forming the output stream. Communication between servers is performed using UDP/TCP protocols. Communication between server and client application is done using one of the following protocols: RTSP, HTTP or MMS.

Windows Media Services Server can send data separately to every client or all connected clients using multicast addressing. In multicast mode division of the data stream is performed by devices used in structure of the network. There is possibility of extension of multimedia services. A programmer can use API built with more than 60 interfaces containing over 500 different properties and methods. This API can be also used to monitor the state of the Windows Media Server and automatic configuration of the server. It is also possible to create the mechanisms for content licensing and paying per view.

B. Technology used

The Java Media Framework has been chosen as the technology for realization of the control application for eLearning system. This choice determines the set of possible tools for building the application. Because of popularity resulting in large amount of available help documents Eclipse has been chosen as the programming environment for writing the control application.

C. System requirements

For proper execution the control application requires some components to be installed in the system. Because the program has been written in Java language, the Java Runtime Environment is the first of the mentioned components. The version of JRE should be 6 with the update 1 or newer. It can

be downloaded without any charge from Sun website. Additional component essential for handling the multimedia, including the streaming media, is Java Media Framework. The version of the component should be 2.1.1e or newer. This packet can also be obtained free of charge from Sun website.

D. Implementation details

Control application is one of four elements of eLearning system. As the main part of the system it is responsible for collecting the audio and video streams from microphones and cameras installed in the classroom and slides from teacher's computer, usually notebook. The number of audio streams is configurable and not limited. Audio streams can be originated by microphones or files. The teacher can switch microphones on and off and choose previously prepared audio file for the transmission. The number of video streams is also configurable. These streams can be obtained from cameras or files. Incoming stream of slides can be only one because there can be only one computer with presentation application which is the source of this stream.

Every incoming and outgoing stream can be separately configured. Incoming input audio or video stream can be acquired with one set of quality parameters and later internally transformed into stream with different set of parameters. Thanks to parametrization the administrator can set the quality of incoming streams according to the hardware used and quality of outgoing streams according to the remote users requirements. Internal transformation of audio and video data streams is performed by codecs which are installed in the system. Incoming stream with presentation slides is always received with fixed set of parameters and splitted into many streams with different resolution. It is possible to set the resolution separately for every output stream of slides to allow remote users for choosing the slides quality according to their Internet link bandwidth.

The control application is also responsible for setting the parameters of the eLearning server. The administrator can configure IP addresses and port numbers used by the server for audio and video data transmission. Configuration data is send to the server so setting the parameters of the eLearnig system can be done from one place using one application. Before sending the configuration data is verified for errors. Configuration parameters can be saved into file for easier usage, and default settings are send to the server automatically during startup of the control application.

The teacher has the possibility of asking remote students the questions. Communication with the student can be provided using audio or video stream or with text messaging. The student can select the transmission methods he wants to use according to his Internet connection speed. The teacher can make the choice of transmission type from student's alternatives. In the eLearning system the reverse questions are also allowed. It means that students can ask teacher questions using one of alternative transmission methods. Like students, the teacher can also make selection within available communication types. If the student wants to ask the question he sends the request to the teacher who can grant or reject the question. The teacher can also chose the communication method for the question the student asks.

User interface of control application is clear and comfortable with large buttons developed for accurate and fast using with both mouse and touch panel mounted on the monitor. It is important because during the lecture the teacher cannot afford to waste the time for using the system but has to pay attention to the lecture process.

V. Realization of other elements of the eLearning system

A. Realization of streaming server

Streaming server is the point for accessing the lectures given at the school with usage of the eLearning system. It receives streams with slides, audio and video data from control applications and transmits them to remote students. The main features of the server are as follows.

Streaming server is prepared to operate with many lectures simultaneously so there can be just one server for more than one classroom. Many control applications can connect to the server with the possibility of separate transmission of every lecture to different group of students. A student who wants to take a part in the lecture through the Internet can make a choice from the list of currently available lectures.

The internal implementation of the server allows for simultaneous transmission of many audio and video streams. The server can also transmit many streams with slides to the end-user. This feature can be used if the control application delivers more than one stream with presentation slides of different quality or resolution.

Changes of slides in a presentation do not happen with constant frequency. For preventing unnecessary usage of the network slides are sent only while changing their content. Such approach can be problematic while connecting remote student between transmission of the slides and in the situation of dropping one slide due to transmission delay or network error. Communication method must be reliable to deliver the newest slide to the client independently of the situation.

Streaming server does not have any graphical user interface. It is intended to work as the background process without any interactive mechanisms. Configuration of the server is stored in the XML file. This file contains only the basic set of parameters, essential for starting the server program. Other configuration parameters are sent to the server by control application. Due to such approach the administrator can set most of the parameters of the server and control application from one place. Lack of user interface causes the need to log the events from server's work. The server program generates the text file with messages reporting its own activity and errors.

Streaming server has the access control mechanism built in. A teacher can set the password for every lecture. Only these students who know the password are authorized to get the access to the system during lecture.

The streaming server works in close cooperation with the control application. It receives the configuration data and sends the information about students connecting to and disconnecting off the eLearning system. The server assigns the unique identification number to every connecting client to enable the control application distinguish between all remote participants of the lecture. Data channel between control application and the server is responsible also for transmitting the text messages from students to the teacher containing information about the sender of the message.

B. Client applet

To connect properly to the eLearning system student's computer should have the client application installed. The application has been created as the Java applet to be executed in the web browser environment. Such approach minimizes the administrative job on client's computer and allows for upgrading the program to a new version without any installation. The main purpose of this application is to receive the data stream with the presentation of the lecture. The applet also allows to receive audio and video streams if the teacher configured the lecture to be performed with microphones and cameras installed in the classroom. A student can make a choice between slides transmitted with different quality and resolution to effectively use available network bandwidth. Also the quality of audio and video streams can be chosen for the same purpose.

The student can ask the teacher some questions using text messages, audio and video channels. Methods of transmission are set during configuration of the applet. The teacher decides what method he wants to use. The same applies for questions asked by the teacher.

Client applet is able to acquire audio data using sound card with microphone connected to it. It can also record the video stream from web camera connected to the computer using USB. Both audio and video channels can be configured. The student can choose the audio quality and codec used for data compression. For the video channel the codec, quality and resolution can be configured.

C. Presentation application

During the lecture the teacher usually uses the multimedia projector for displaying slides but sometimes uses also blackboard or whiteboard for drawing some details about presented topics. The presentation application concatenates both functions. It allows for displaying slides in the background and to draw additional figures on the slides or on white screen as the virtual whiteboard. The input device can be the mouse, tablet or interactive whiteboard from which the last seems to be the most comfortable. The lecturer can switch between slide and whiteboard modes using only one icon on the presentation application task bar. Presentation application sends pictures with slides to the control application. It analyzes the pictures and re-sends the current slide with modifications if the teacher makes any additional marks or drawings on it. Slides are sent using JPEG format encoded on three bytes with 8-bits color depth

Presentation application has been written in C# with Visual Studio 2005 environment. In this environment the regions can be defined. The regions allow to divide program source into logical parts, grouping together functions responsible for similar functionality. To run the application user needs only the .NET framework 2.0. It does not need any installation, user can start the application with executing the program file only.

VI. XML USAGE IN THE SYSTEM

eLearning system consists of four main modules so it was necessary to develop the schema of communication between them. The communication between modules is performed with messages based on XML format [14]. Internal structure of every type of message is defined in corresponding XSD file. Such definition clearly and unambiguously describes the structure of used XML message. Every message has the format containing several fields. The general format of the XML message is as in the following example.

```
<?xml version="1.0"?>
<message messageType="x">
   (message content)
</message>
```

Symbol x in the example above is equal to the number of type of the message. There are several types of messages defined for the purpose of communication. Messages numbered 0 to 19 are reserved for communication between control application and the server, messages with the numbers from 20 to 39 are reserved for communication between server and client applet. Not all numbers are currently in use.

A. Communication between server and control application

Messages defined for the communication between server and control application have meaning as follows:

type 0 – eLearning system configuration. This type of message is sent from control application to the server during system startup.

type 1 – answer for the configuration message. Such message is sent from server to the control application informing if the server accepts or rejects configuration parameters.

type 2 – start or end of the lecture. This message is sent from control application to the server while teacher starts or ends the presentation during the lecture.

type 3 – connection of new remote student. Message sent from server to control application in case of connecting of new remote student.

type 4 – remote student asks for permission to send the message. This type of message is sent from the server to the control application.

type 5 – text message from the remote student. Incoming message from student is resent to the control application.

type 6 – disconnection of remote student. Message sent from control application to the server in case of remote

student's disconnection.

type 7 – the teacher grants student permission to send message. Control application generates this message if the teacher allows remote student to send his message.

type 8 – text message from teacher to remote student. This kind of message is generated by the control application and contains the message written by the teacher.

Definition of message of type 2 with information about beginning or finishing the presentation is shown below.

```
<xsd:schema xmlns:xsd=
     "http://www.w3.org/2001/XMLSchema">
<xsd:element
        name="message"
        type="messageContent"/>
<xsd:complexType
        name="messageContent">
<xsd:sequence>
<xsd:element
        name="transmissionRunning"
        type="xsd:boolean"
        minOccurs="1"
        maxOccurs="1"/>
</xsd:sequence>
<xsd:attribute
        name="messageType"
        type="xsd:byte"
        use="required"/>
</xsd:complexType>
</xsd:schema>
```

Example of message of type 2 defined with above schema:

```
<?xml version="1.0" encoding="UTF-16"?>
<message messageType="2">
<transmissionRunning>
        True
</transmissionRunning>
</message>
```

Format of the message is checked by the control application after receiving of the message. Improper format of the message generates information about the error for the user of control application.

B. Communication between server and client applet

Messages defined for the communication between server and client applet have meaning as follows:

Type 20 – list of currently active lectures. This message is sent from server to the client applet.

Type 21 – connection to the lecture. This type of message is sent from client applet to the server if the student wants to connect to chosen lecture.

Type 22 – transmission of encrypted key or password. Key is sent from server to client applet, password in reverse direction.

Type 23 – information about acceptance or rejection of the password. Message sent from server to client applet.

Type 24 – information about streams with slides, audio and video available in the lecture. Sent from server to the client applet.

Type 25 – list of identifiers of streams chosen by remote student. Sent from client applet to the server.

Type 28 – title of the lecture and password to the lecture. This kind of message is sent to the server from presentation application through the control application.

Type 33 – name of the student. Connecting student sends his name and configuration of client applet.

Type 34 – remote student asks for permission to send the message. This type of message is originated in the client applet and sent to the server. Next, as message number 4, is resent by the server to the control application.

Type 35 – text message from student to the teacher, or from teacher to the student.

Type 37 – the teacher allows remote student to send messages. This message, originated by the control application is resent by the server to client applet.

Format checking is performed with the usage of XSD files containing definition of particular message. Example of definition for message of type 35 used in text communication between student and the teacher is shown below.

```
<xsd:schema xmlns:xsd=
     "http://www.w3.org/2001/XMLSchema">
<xsd:element
        name="message"
        type="messageContent"/>
<xsd:complexType
        name="messageContent">
<xsd:sequence>
<xsd:element
        name="messageText"
        type="nonEmptyString"
        minOccurs="1"
        maxOccurs="1"/>
</xsd:sequence>
<xsd:attribute
        name="messageType"
        type="xsd:byte"
        use="required"/>
</xsd:complexType>
<xsd:simpleType
        name="nonEmptyString">
<xsd:restriction
        base="xsd:string">
<xsd:minLength
        value="1"/>
</xsd:restriction>
</xsd:simpleType>
</xsd:schema>
```

Message defined using above schema is shown in the following example.

```
<?xml version="1.0" encoding="UTF-16"?>
<message messageType="35">
<messageText>
        Sample Text from Student
</messageText>
</message>
```

C. Communication between control application and presentation application

There is only one type of message defined for communication between control application and presentation application. The type is numbered 28 and message of this type is used for sending the title of the lecture and password to get access to the lecture. Definition of schema used for creating the message of type 28 is shown below.

```
<xsd:schema xmlns:xsd=
     "http://www.w3.org/2001/XMLSchema">
<xsd:element
        name="message"
        type="messageContent"/>
<xsd:complexType
        name="messageContent">
<xsd:sequence>
<xsd:element
        name="lectureTitle"
        type="nonEmptyString"
        minOccurs="1"
        maxOccurs="1"/>
<xsd:element
        name="lecturePassword"
        type="xsd:string"
        minOccurs="1"
        maxOccurs="1"/>
</xsd:sequence>
<xsd:attribute
        name="messageType"
        type="xsd:byte"
        use="required"/>
</xsd:complexType>
<xsd:simpleType
        name="nonEmptyString">
<xsd:restriction
        base="xsd:string">
<xsd:minLength
        value="1"/>
</xsd:restriction>
</xsd:simpleType>
</xsd:schema>
```

Message with the title of the lecture and the password based on the schema shown above can look like in the following example.

```
<?xml version="1.0" encoding="UTF-16"?>
<message messageType="28">
<lectureTitle>
     Theory of Logic Circuits
</lectureTitle>
<lecturePassword>
     TLCpasswd
</lecturePassword>
</message>
```

XML is not used for the communication purposes only. All parameters of eLearning system are also saved in the file of this type. As for communication purposes internal structure of configuration file is defined in XSD file.

VII. Summary

Remote learning systems can improve significantly accessibility of knowledge for persons who are not able to attend classical studies. Especially web based systems which use multimedia webcast technologies offer not only the knowledge but also the impression of participation in real lectures and social integration. Mentioned above systems are particularly important for persons with disabilities. eLearnig system developed at the Silesian University of Technology is prepared for transmission of additional streams with data dedicated to this group of persons. Thanks to usage of the XML technology for implementation, the communication layer of the eLearning system can be easily extended with new functionality and every module of the system can be easily replaced with newer one. Because XML is technology and language independent new modules can be written in different programming language then original.

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