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E-Learning Tool and Statistical Analysis of Video Tace Files Over the Network

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Abstract

The following paper offers an overview on the e-learning tool "Dileco" system structure and the advancement of features of it. The main features of this tool aim to support operations, using unstable and limited Internet connection, utilizing novel solutions outlined in this paper. This system would be one of the best tools applicable for e-learning in countries with poor Internet. The paper pursues the objectives of showing some of the innovative features of the system and demonstrates the progress of the system starting from 2002. This paper aims to express technological aspects on building this system. It offers a snapshot of application areas of the system and provides suggestions for future expansion of application areas, and content creation, particularly, on topics of statistics and mathematics. It is provided with statistical analysis of H.263 video traces over the network.

Introduction

Moving forward on the journey into the 21st century, it's impossible to know with any certainty how this era will be characterized by those generations who will come after this one. But let's suggest that one feature of what is already being called the Information Age that surely will influence that human beings will become in the decades ahead, is people's relationship to technology. One of the fastest growing and most demanding areas in Information Technology field for the 21st century for all over the world is e-learning, which is a type of distance learning. E-learning is becoming increasingly important in today's technology era. It moves the learning experience out of the traditional classroom and into people's world. It's learning anytime, anywhere without geographical or scheduling barriers. It's learning that relies on the Internet for accessing studying materials and interacting with experts and fellow learners [11].

General Description

Armenia also had been successful in its first steps towards increase of e-learning awareness and implementation of it [1], [6], [8]. In Armenia also there were attempts of different initiatives regarding e-learning, like learning via e-mail, on-line messengers, and special tools for e-learning. Some of the attempts have been successful, others not. Although Armenia is and had

been considered the IT center of Caucasus and Ex-Soviet Union, still there are different barriers to implement e-learning in Armenia. Some of the barriers are:

- Internet bandwidth limitation, which may significantly decrease the throughput of the connection
- Unstable Internet connection
- Absence of software called especially for poor Internet bandwidth

Correspondingly, appropriate tools had been elaborated according to the development of Information Technology and the users' needs. One of such tools, called Dileco [1], is created and developed by the first author of this article, which provides several solutions for poor Internet bandwidth. The tool is universal and can be applicable using reasonable Internet connection too.

The aim of Dileco tool is to allow video and audio conferencing type e-learning within two points at different geographical location using the existing telecommunication system. The software enables educational institutions, SMEs (Small and Medium Enterprises), governmental agencies and international organizations of a country establish virtual links between its departments and other organizations across a country and elsewhere, facilitate communication and contribute to the advancement of IT infrastructure in the country. The tool aims to help individuals, students and trainers in their study process eliminating the geographical barriers and cost implication. The software is specifically important for the developing countries.

The creation and development of the tool Dileco has a history starting from 2002. Different articles about the tool are published in professional journals and conference folders (see [1], [2], [3], [4], [5]) and different aspects of the tool and its implementation had been presented in several conferences, workshops and scientific discussions. Besides successes of the Dileco tool and strong interest from different specialists, the tool is continuously being developed and becoming more and more advanced. After 2003 all the components are revised, better developed, and recreated by new and advanced programming means, in particular Java (JBuilder9 Enterprise), Java Media Framework (JMF), JavaMail API (Application Programming Interface), javax.comm. serial communication package, MS Project PRO 2005, TogetherJ6.0, design and architectural patterns.
The paper emphasizes some of the important features of the tool, which are considered as the solutions for the poor Internet bandwidth, the progression and advancement of the tool and some practical expertise and testing as detailed further in this article.

The system structure

The system consists of two main modules: Video and Audio Distance Learning and Conferencing and Video E-Mail. The first module provides functionality to allow video and audio conferencing within the professor and students situated in different geographical locations. The module allows the professor control the camera located in the classroom over the Internet, manually set presets. From the classroom side there is possibility to control the rate of frames over the internet which are sent to the professor. The second module, Video E-Mail, provides the functionality to send/receive the video/audio messages. Both modules are detailed described in the main paper.

Advancement and Offered Solutions

Step by Step Control

Figure 1 illustrates the structure of the video conferencing component of the system [1], [2]. The motor camera is connected to the server-computer situated in the classroom. The professor located at a distance can connect to the classroom via Internet just typing the appropriate URL on agreed time. The professor can control the camera using Remote Control interface through Internet. Here the professor has 2 options for remote control ("Continuous" and "Step by Step") dependent on the Internet bandwidth. If the Internet is not adequate for good quality of delivering vide/audio transmission and the professor does not have any idea about the correct latency, then he/she can choose "Step by Step" control option and click as many times to a certain direction (right, left, up, down) as he/she can consider the camera will move to the desired position. In this case, each click corresponds to 3 degrees, which gives an orientation to the professor. So, "Step by Step" Control is considered as one of the solutions for poor Internet bandwidth.

For audio transmission the modified JMStudio's audio transmission is applied. JMStudio is a stand-alone Java application that uses the JMF 2.0 API to play, capture, transcode, and write media data. JMStudio also uses the JMF RTP (Real Time Protocol) APIs to receive and transmit media streams across the network. JMF supports audio sample rates from 8KHz to 48KHz. As for video transmission, it is adapted and programmed JMStudio's visual component under H.263/RTP standard video compression for unstable and limited Internet connection ([1], [2]).

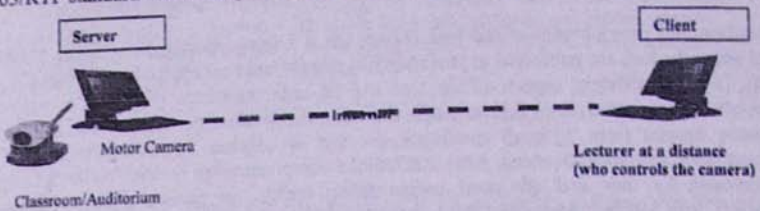

Figure 1: Client/Server (Professor/Classroom) Model

Presets

Another solution, while using non-reasonable Internet connection, is **presets** functionality. Preset is defined as a preliminary set position in the classroom programmed in the camera. This feature consists of two sections. One is a section, which provides 7 preliminary set positions – presets, located from the left to the right in the range of 100 degrees. Here the professor can control the camera moving it towards any of these 7 positions of the classroom. By clicking to any of the position, the camera moves and stops in the preliminary programmed position.

Second option for the presets is an option quite interesting and imaginative, called dynamic presets. This allows the professor (Client) to set the positions himself/herself making the list of presets dynamic. The professor can move the camera to the desired position and then save the position giving a name. For example, he/she can move the camera to the place of one of the students and save the position by the name of this student thus creating a list of set positions. For the next times he/she can choose any name of a student from this list and the camera will immediately go to the place of the chosen student. In this case, it is considered that each student has his/her own sit in the auditorium/classroom. Any time the professor can see any of the student's position regardless the quality of the Internet connection.

Frame Rate Control

When the Internet bandwidth is low, and the Client side (the professor) cannot obtain video stream of high quality([12], [13]); from the Server side (classroom) "Frame Rate control" feature is recommended to use. This feature lets the user from the Server side to choose the frame rate (1, 3, 5, 10, 15 and 20 ms) depending on Internet bandwidth and sending to the other side. This means that the system captures images from a video stream, for e.g. each 10 millisecond (when the user chooses 10 from the list), makes from this image JPEG compression and sends to the other side (the professor) through HTTP protocol. The professor will see the changes of movement each 10 millisecond but he/she cannot see a fluent movement. This is one of algorithms of image processing related to video compression, which is proposed to use. This compression engine is better in case of applying in this application, because it is small, fast and effective in processing serial of images captured from device in real time and gives out small enough data to be sent on low-bandwidth connection. The system is tested; it has a good quality under low-bandwidth and unstable connection; e.g. dialup line below 48kbps.

Video E-Mail

Other newly created and elaborated part of Dileco tool is video e-mail component [4] (architecture illustrated in Figure 2), which provides all the features of a traditional e-mail client and additionally it provides a functionality of automatic view of video/audio message, in case the sender recorded such a message and sent it to the recipient.

This component works in the following way: the sender can record a video/audio message and the system automatically saves it in appropriate format and then the sender can dispatch the message to the recipient either with or without text message. When the recipient opens the message and if the message includes a video/audio message, the recorded message automatically plays. The recipient can play the same message as many times as he/she wants. This component also contains innovative elements and can be useful in e-learning for short and important speeches, presentations or assignments. This is foreseen as a solution in case, the Internet connection cannot be adequate to support video/audio information transmission. An individuality of the tool is the video e-mail embedded system, described above. The Video E-Mail Client Part is designed and developed using two different Java libraries – JavaMail API and JMF(Java Media Framework). These two libraries - JavaMail and JMF are adjusted into a single application, which is another peculiarity of the tool Dileco, comparing with traditional e-mail clients.

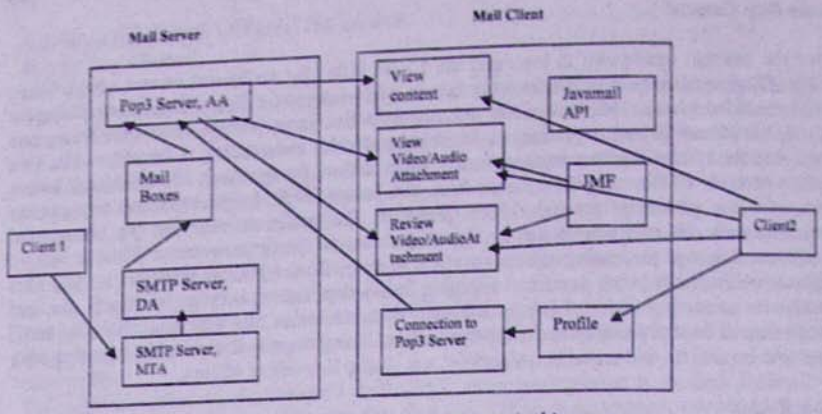

Figure 2: Video E-Mail System Architecture

Statistical Analysis of H.263Video Traces

As mentioned before in this paper, for the video/audio transmission in Dileco system, it is adapted and programmed JMStudio's visual component under H.263/RTP encoding technology for unstable and limited Internet connection ([1], [2]). Telecommunications Network Group of the Technical University of Berlin together with Diplnge, Universita di Ferrara (Italy) and Department of Electrical Engineering of the Arizona State University (USA) developed encoding approach for H.263 and evaluated network performance ([12, 13]). This approach and evaluation scheme is investigated and adapted for Dileco tool. It is obtained data for Dileco tool and statistical analysis is given for video traces using Dileco tool.

It was collected over 10 pre-encoded video sequences from the WWW, generated the trace files and conducted a thorough statistical evaluation. Because the pre-encoded video sequences are encoded by different users they differ in the video settings in terms of codec, quality, format, and length. After having investigating over 5 video sequences at different quality levels, it was conducted that video traffic characteristic depends on not only the network speed but also the video content itself and the chosen encoder settings (frame type used, quality, and variable or constant bit rate).

For example, for H.263 measurements it was encoded with 16k, 64k, 256k (all constant bit rates) and variable bit rate. The encoded bit stream was parsed into bit-wise to retrieve the video trace file. Each video codec has its own parser following to appropriate standard. The video trace file was used for the statistical analysis for the encoded video data. Afterwards it was decoded the encoded bit stream and obtained the decoded bit stream. By comparing the original and the decoded bit stream, it was possible to calculate the peak signal to noise ratio (PSNR) [14].

For the measurements these 10 pre-coded videos were fed into mplayer tool [15] version 0.90 by Arpad Gereoffy. Using this tool during the lay of the video sequence, it was simultaneously

printed each frame with the frame number, the play-out time, the video frame size, and the cumulative bit size into trace files.

The trace files are used for the statistical analysis of the video data. In case of multimedia streaming the video and audio information is packetized into RTP frames. The RTP header contains all important information for the playout process at the receiver

For the statistical evaluation of the traces consider the following notation.
Let N denote the number of considered frames of the given video sequence.
The individual frame sizes are denoted as $X_1, X_2, \ldots\ldots, X_N$.
The mean frame size $\bar{X}$ is estimated as

$$\bar{X} = \frac{1}{N} \cdot \sum_{i=1}^{N} X_i \qquad (1)$$

The variance S_X^2 (or D_X) of frame size trace is estimated as

$$S_X^2 = D_X = \frac{1}{N-1} \cdot \sum_{i=1}^{N} (X_i - \bar{X})^2 \qquad (3)$$

More convenient expression for S_X^2 (or D_X) for computation is

$$S_X^2 = D_X = \frac{1}{N-1} \cdot \left[\sum_{n=1}^{N} X_n^2 - \frac{1}{N} \cdot \left(\sum_{n=1}^{N} X_n \right)^2 \right] \qquad (4)$$

The coefficient of variation

$$C_V = \frac{S_X}{\bar{X}} \qquad (5)$$

The maximum frame size is defined as

$$X_{max} = \max_{1 \le n \le N} X_n \qquad (6)$$

For notations and detailed explanation of each formula refer to [10]. Detailed analysis is given in the PhD research of the author.

The encoding approach for H.263 developed mentioned in the beginning of this chapter is applied. It is encoded and uncompressed YUV information into an H.263 bit stream. It was encoded a video at 4 different target bit rates: (1) 16 kbit/sec, (2) 64 kbit/sec, (3) 256 kbit/sec, and (4) Variable Bit Rate (VBR), i.e., without setting a target bit rate. The following results had been obtained and then calculated mean, coefficient of variation and Peak/Mean ratio.

Rate	Trace	Comp.ratio = YUV: H.263	Mean = $\bar{X}$ (byte)	$C_V = S_X / \bar{X}$	Peak/Mean = $X_{max} / \bar{X}$
16 kbps	X	476.43	369.85	0.67	33.90
	Y	476.43	326.02	0.61	11.32
	Z	476.36	476.36	0.67	20.83
64 kbps	X	118.95	1129.94	0.41	11.10
	Y	118.95	1153.32	0.43	7.11
	Z	118.96	1132.02	0.36	7.89
256 kbps	X	29.73	4533.67	0.35	2.61

	Y	29.73	4563.53	0.33	3.58
	Z	29.73	4533.67	0.35	2.61
VBR	X	25.19	2703.46	0.99	10.27
	Y	65.79	1048.21	0.66	8.58
	Z	17.08	3999.31	0.64	4.55

Table1: Overview of Frame size statistics of H.263 traces

The Table1 gives and overview of the statistics of the frame sizes X_n. In this table it is illustrated only the values for 3 traces which provide the complete picture of the test. Comparing the 256 kbps target rate encodings with the VBR encodings it is observed that some VBR encodings have higher compression ratios that the corresponding 256 kbps target rate encodings. For example, the VBR encoding of trace Y has a compression ratio of 65.79. while the 256 kbps encoding 29.73. The more efficient VBR encoding has a larger variability of the frame sizes. *The main conclusion here is that the trace files are typically highly variable in their frame sizes and bit rates, especially the traces of low quality encodings.*

Application Areas of the Dileco and Future Plans

The tool Dileco had been tested and used for e-learning purposes starting from 2003. Very successful e-learning pilot project had been conducted in 2003 in the framework of Armenian Development Gateway (E-Armenia Foundation) executed in several universities in Armenia. The tool had been used in the European Regional Academy of Caucasus of Information and Communication Technologies (ERIICTA) in implementation of distance learning, distance workshops and seminars in summer 2003. Dileco is tested at the American University of Armenia (branch of UCLA, USA) used for distance learning purposes. After advancing the system, in the near future it is planed to continue e-learning program in the European Regional Academy of Caucasus using Dileco system. It is also planned to put the tool into practice in several other educational institutions located in Armenia, which expressed their readiness and interest to perform e-learning based on appropriate e-learning assessment ([7], [8]). For the near future the focus will be also on the content development of e-learning using Dileco tool. Until now there were mainly Computer Sciences courses, which were subject of utilization of Dileco tool. From now on it is planed to develop content for e-learning using Dileco with the help of the "Armenian Statistical Web Lab" (see [9], [10]), which provides complete information and references about the modern statistical methods and computer packages in Armenia. For the future expansion of application areas, it is planned to involve different countries with low Internet bandwidth interested in the usage of Dileco system.

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Հեռաուսուցման ծրագրային գործիք և ցանցերի միջոցով տեսային հետագծերի վիճակագրական վերլուծություն

Գ. Սարգսյան

Ամփոփում

Հոդվածն առաջարկում է Դիլեկո հեռաուսուցման ծրագրային փաթեթի միջոցների կատարելագործումը ցածր որակի ինտերնետային կապի դեպքում: Ստեղծած համակարգը կարող է լինել հեռաուսուցում իրականացնելու լավագույն գործիքներից մեկը: Հոդվածը նպատակաուղղված է ներկայացնելու համակարգի որոշ նորարարական հատկություններ և գործիքի զարգացման առաջընթացը սկսած 2002-ից: Համառոտ ներկայացված է համակարգի կիրառության ոլորտները: Առաջարկված են կիրառության հետագա ծրագրեր և բովանդակության հագեցում, մասնավորապես, վիճակագրության և մաթեմատիկայի թեմաներով: Քննարկված է ցանցերի միջով H.263 տեսային հետագծերի վիճակագրական վերլուծություն: