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Performance methods in tele-lecturing via a public communication network

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Abstract. Lecturing is usually performed with all the contributors in the same physical space. All communication channels can be used because of proximity and, consequentially, the information given to the audience is most comprehensive. The process of lecturing can be most interactive, which gives means for building up the professional intuition. One trend in modern teaching methods is searching for higher productivity by decreasing the amount of commuting and dislocations of people – local education centres are set up and lecturers are commuting instead of the students. This puts more burdens on the lecturers who repeat courses for smaller groups. Less time is consequentially available for research. Modern information and communication technologies allow for distributed lecturing needing no course repetitions at different locations. Development of methods for achieving performance in tele-lecturing the working students at the Faculty of Mechanical Engineering in Ljubljana is a contribution to this pedagogical novelty.

Keywords: tele-lecturing, information and communication technology, videoconference system, distributed lecturing

1 INTRODUCTION

Many guidelines and rules exist on how to teach effectively. Graduates of the pedagogical faculties are equipped with pedagogical techniques that are needed for most effective teaching [1]. These graduates execute pedagogical processes from kindergarten to the end of high schools. On the university level of the educational system, professors are not involved in upbringing, but in education and research. They are required to improve their own educational skills by finishing a special course on didactics that is aimed at mastering teaching techniques at higher levels of education.

It might not look necessary that one is to learn teaching before exercising it. The main reason for learning teaching is that there are very different individuals in the audience, having different intellectual potentials and different characters – a successful teaching process needs to result in knowledge that each individual can demonstrate. A good lecturer needs to motivate and control heterogeneous audiences. If he is not successful in motivation and control, the audience can establish its own pattern of behaviour that can very easily disrupt productive learning and studying. This happens when the lecture does not appear interesting and the lecturer cannot control the auditorium.

The teaching process where the students and the lecturer share the same physical space is in its mature phase after many years of incremental improvements. One lectures, distributes tests, grades the solutions, analyses the results and distributes questionnaires on students' satisfaction. The outcome is within expectations most of the time. Any excessive event is immediately analysed and preventive measures are taken.

A distributed pedagogical process is far less practiced. We are reporting on our experience and findings from establishing a distributed pedagogical process. It is utilised to teach working students selected chapters of electrical engineering at the Faculty of Mechanical Engineering at the University of Ljubljana.

The distributed approach to teaching is a novelty in the established educational system for many reasons. Historically, teaching involved physical proximity among the knowledge givers and takers. The geographical distance is understood as a challenge and not as a contribution to the process. Distance relies on support of the Information and Communication Technology (ICT) and its utilization. A huge difference between the near-past and modern time is the current existence of the public network for data traffic at a practically nil cost and for nearly an arbitrary amount of propagated data.

To transport audio-visual contents in real time over the public communication network, at minimum the following requirements should be met:

- Timing characteristics of data transfer during the whole session should be stable.
- Transfer of the control data is to be reliable by its construction.

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– Transfer of the audio visual data is to be prioritized since this data is needed at the destination in real time.

1.1 Timing stability in data transfer

Timing stability implies small distribution of delays in transfer of different data packets, and not many data packets that would be quite late on arrival or even lost in transfer.

Internet was originally designed for data transfer among computers only. Real-time audio-visual applications, running on computers and transporting data via internet in real time were developed in the mature phase of internet development [2].

Figure 1 shows data transfer through different layers of communication in a distributed application. Data is transferred between the A and B systems in many data packets. These commute through nodes where the optimum data paths are selected for each packet in real time. Only one out of many possible paths between the A and B systems is shown in Figure 1.

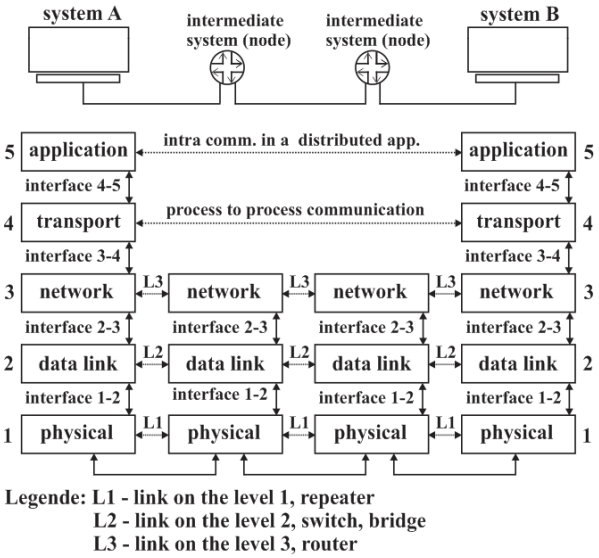

Figure 1: Data transfer via TCP/IP layers in a distributed application

Data layers 1 to 4 make the system level of data transfer. Reliability, high throughput of data packets and small jitter of delays are concerns on the system level. Data paths for different data packets are selected dynamically in network nodes for the best possible throughput in presence of other data transfers. Control data in the Network layer with the Internet Protocol (IP) data packets are utilised for routing.

When one must choose between a high data throughput and reliability of data transfer in real-time audio-visual applications, one picks the former choice. Therefore, a User Datagram Protocol (UDP) controls data transfer on the Transport level. UDP does not check for completeness of the received data and does not retransfer the missing data, but it is designed to have a high throughput.

The data receiving application first orders the received data packets based on the time stamps of sending. Some data packets travel through the network longer than others, some even get lost in transfer. A real-time audio-visual application has to perform without packets that arrive too late or do not exist at the point of destination.

From the user standpoint, the excellence of internet design shows in that the different parts of a geographically distributed application communicate to each other on the Application level only. All other intricacies of data transfer are managed on a system level which consists of data transfer levels 1 to 4 in Figure 1.

1.2 Reliability of the control data transfer

IP is a "best effort" communication protocol where different resources are considered for utilisation of any data transfer. Since the network serves to the public, one can only predict the required throughputs at certain times. Requirements on momentarily data transfer and their fulfilments are correlated stochastic variables.

Utilization of the UDP on the Transport level (Figure 1) yields high data throughput where data integrity cannot be checked [3]. Audio-visual applications prefer a high throughput of content data over its integrity.

Control and management have opposite requirements: reliability of control data transfer is mandatory; speed of control data transfer represents a secondary concern.

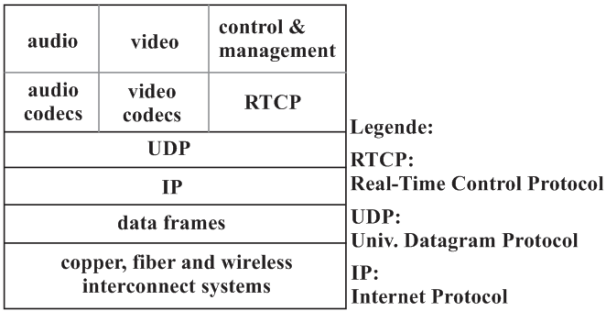

Figure 2: High data throughput for audio-visual transfer and reliable transfer of control data

A Real-Time Control Protocol (RTCP) is introduced in the Application layer of data transfer, Figure 2. RTCP delivers data integrity for those data transfers that are involved in application control and management. The same scheme of differentiating propagation paths into the fast and reliable ones is used in the Voice over IP (VoIP) telephony.

1.3 Prioritization of the audio-visual data transfer over other data exchange

The main difference between a data packet switched network (internet) and a circuit switched network

(telephone) is in utilisation of resources. The data path is fixed in the latter for the whole duration of the connection. In the data packet switched network, the best possible routing scenario is searched for individual data packets. This is why utilisation of resources can be much higher in the data packet switched network, compared to the circuit switched network. High utilization of resources implies a cost-efficient system, but also a small amount of free resources at most times. Merging high utilization (relatively lots of data in the system) with high efficiency (high data throughput) requires addition of a mechanism that can prioritise certain data transfers. Prioritization is to be reserved for real-time data transfers. The mechanism for differentiating the throughputs for different types of data is known as Quality of Service (QoS) [4].

2 PEDAGOGICAL REQUIREMENTS FOR A GEOGRAPHICALLY DISTRIBUTED TEACHING PROCESS

A geographically distributed teaching process has to meet the following requirements at minimum:

- Physical distance among the contributors needs to be virtually eliminated.
- Motivation and control of the students has to stay on a similar level as in a classical teaching environment.

2.1 Virtual elimination of distance

When it is about group communication, one chooses among different conference systems. Some representatives of these are Evo from Caltech and commercial systems produced by Tandberg, Polycom and Aethra.

For personal communication in a real time most people use Skype and MS Messenger.

The most popular application for virtual elimination of distances in distributed education is Moodle (Modular Object Oriented Dynamic Learning Environment) [5]. It is not a coincidence that most of Moodle development takes place in Australia which has large scarcely populated areas. Moodle is employed in many Slovene high schools as an optional supplement to a conventional educational process. In its current state of development Moodle cannot be utilised for a real-time audio-visual communication.

Tele-lecturing requires simple to manage and reliable audio-visual communication, the same as it is valid for a video conference. Sociological requirements of the two are different. Motivation of the video-conference and motivation of the tele-lecturing attendees can be quite different. Responsiveness of a tele-lecturer has to be on the same high level as it is at the classically conducted courses. This prevents occasional droppings of concentration and consequentially inferior test results.

2.2 Control and motivation of a geographically distributed group

Motivation of motivated contributors is not needed. Because of that, and to save commuting time and costs, tele-conferences successfully substitute many face to face meetings of executives, engineers and other professionals in modern geographically distributed companies.

Requirements for tele-lecturing are theoretically quite similar to requirements for conducting tele conferences in companies. Practical experiences with tele-lecturing show that it is substantially more difficult to keep attention and motivation in circumstances where all inter-personal communication channels are not present. Only video of selected areas and selected voices are transferred over distance. Control and management of the teaching process and of some of its contributors is much more difficult than in usual circumstances where all contributors share the same physical space.

3 TELE-LECTURING IMPLEMENTATION

A material base for tele-lecturing is a professional video-conference system. We were modifying such a system during a semester to compensate for inadequacies that were discovered.

3.1 A video conference system

Connectivity of different devices is regulated by the ITU (International Telecommunication Union) recommendation H.323 on audio and video communication through a data packet network [6].

Less ambitious conference systems are implemented in a form of dedicated software running on personal computers, which are equipped with custom peripherals. The professional systems are built as embedded systems running on dedicated hardware. Such systems are made for simple use and high reproduction quality. We acquired the professional Tandberg video conference system for our tele-lecturing.

One learns from experience that management and control of a conference system needs to be most intuitive and simple to execute. System operation needs to be reliable and data streams steady. Set up of a classroom is important. Many complex algorithms are used in order to avoid positive feedback when processing sound. Such a feedback manifests itself as a high pitch hiss when devices get to saturation. To prevent this effect, the microphones need to be positioned far enough from the loudspeakers. When one makes a movie, cameramen operate the cameras. In videoconferencing, the conference attendees operate the cameras or they are just set to fixed positions.

3.2 Modification of a conference system for the purpose of tele-lecturing

A teleconference system delivers live audio and video information to interested parties. Cameras can be remotely set to focus on certain objects and zooming is possible. Audio is captured with one or more microphones with different characteristics.

Practice shows that more than that is needed for productive tele-lecturing. A lecturer needs to keep the audience in attention, which implies his focusing on contents of the lecture. Micro management of the camera is only a side activity which implies that camera management is usually poor. When deriving procedures on the blackboard, one is limited with the view angle and resolution of the camera.

Over a semester we extended the initial video services with live pictures of lecturers' writing, screen of his computer, and his face, Figures 3, 4 and 5. It is convenient to write derivations on A4 paper sheets positioned just under a dedicated camera. These sheets are scanned after each lecture and uploaded to a web server in a form of a portable data format document for individual downloading and studying.

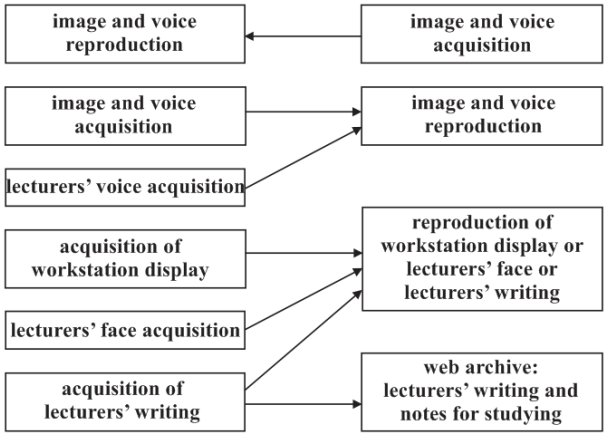

Figure 3: Schematic of a tele-lecturing system in the second half of the semester

Figure 4: Simultaneous capture of three live pictures: writing, auditorium, talking face, and capture of selected voice for transmission in a tele-lecturing session

One immediately infers that a live picture of the lecturers' talking face is not most necessary. It is a result of practical experience that we added the talking face to the tele-lecturing system. Facial expressions substantionally improve quality of the delivered information.

Figure 5 shows simultaneous reception of the two live pictures. One shows a lecturing room, the other one is being switched among the lecturers' writing, the display of his workstation and the lecturers' face.

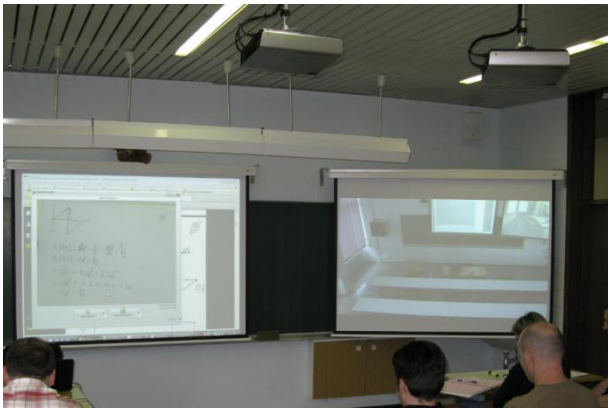

Figure 5: Simultaneous reception of the two live pictures

Our tele-lecturing course was conducted at Ljubljana and Tolmin locations throughout a semester. One half of lecturing was conducted at the Tolmin location and transmitted to the Ljubljana location and the other half was conducted with switched locations.

4 EVALUATION OF THE TELE-LECTURING QUALITY

The quality of tele-lecturing was measured by correlating test results at end of the semester to test results of previous five years of traditional lecturing. At end of the semester the students filled in a questionnaire on their satisfaction with the implementation of tele-lecturing.

Figure 6 shows final grades of the course in consecutive five years. The course was conducted in a traditional type of lecturing, with the lecturer and the students sharing the same room. Grading distributions are comparable, which shows good repeatability of the pedagogic process.

Figure 7 shows the mean values of Figure 6 grades and the grades after the tele-lectured course. Both distributions of grades are comparable. As expected, the number of students is slightly higher on the left after the tele-lectured course, compared to the average of five consecutive years.

Results in Figures 6 and 7 are adjusted for 20 students in a class.

Numerical results of the questionnaire filled in by the students are given in Table 1.

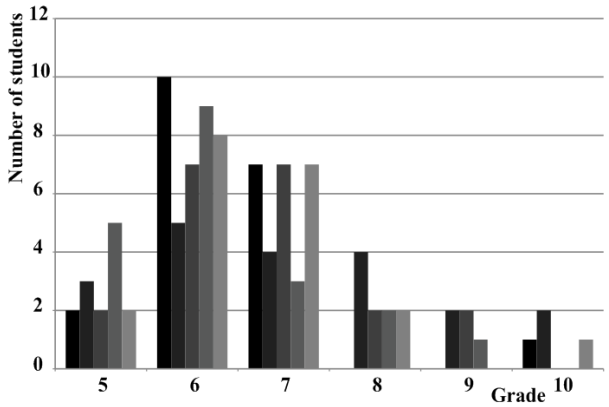

Figure 6: Grades in consecutive 5 years, with traditional lecturing

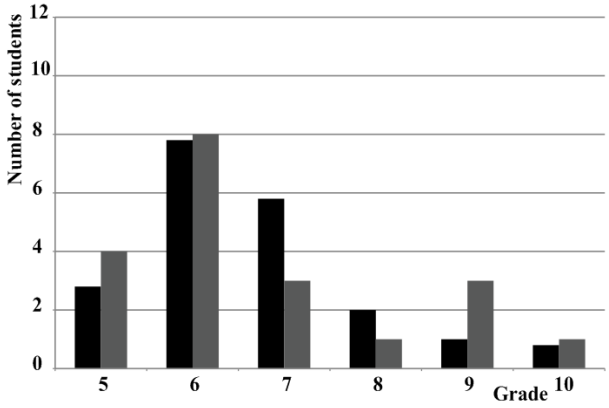

Figure 7: Mean values of grades in Figure 8 and grades after the tele-lectured course

	1	2	3	4	5
Grade for lecturing when the lecturer is at location [1..5]	0	1	2	12	3
Grade for lecturing when the lecturer is tele-present [1..5]	0	3	10	4	1
Level of satisfaction with tele-lecturing [1..5]	1	2	12	2	1
Grade for technical and organizational improvement from beginning till end of semester [1..5]	0	1	2	8	5

Table 1: Numerical results from the questionnaire on students' satisfaction with tele-lecturing

Individual students were reporting their observations on technical inadequacies. With their help we were able to be modifying the tele-lecturing system and methods of work throughout the semester. Figure 3 shows the system schematic at the end of the semester.

5 THE ACHIEVED EXPERIENCE

A videoconference needs data throughput of about 10 Mb/s with each location. This is not always granted. Different types of DSLs over twisted copper wires loose data throughput with distance rapidly. In our case, technicians' intervention at the Tolmin location solved the problem of poor data throughput.

At the beginning of tele-lecturing we were suffering occasional audio and video data loss. This is attributed to the problem of stochastic distribution of network loading. High network bandwidth yields high data throughput but increasing bandwidth increases costs. Operators have to optimise cost vs. performance ratio and keep overall expenses within sustainable limits. End user has no influence on data throughput (changing the data provider might have some minor effect).

In addition to taking costly measures, such as upgrading the communication infrastructure from DSL to FTTP, one achieves a higher data throughput for certain types of data by prioritizing their data transfer. Figure 8 shows mechanics of prioritizing certain types of data transfer.

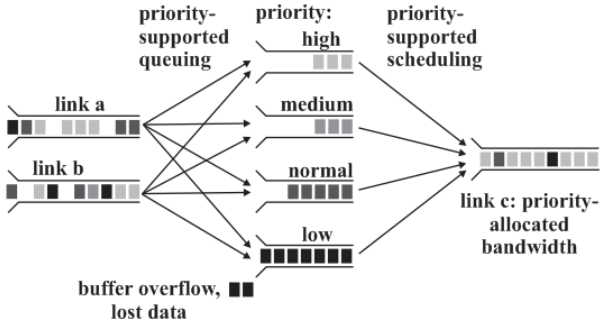

Figure 8: Priority-supported queuing and scheduling for different types of data in a node of a data packet network

In Figure 8 the data arrive via links a and b, and leave through link c. Prioritizing takes place in the Data layer (Figure 1). The incoming data packets are queued in different buffers, according either to their priority flag or their type. Priority supported scheduler assigns majority of the data packets to the output link c from the high-priority buffer. The low-priority data packets wait in the low priority buffers to be directed to the output link c when vacancy in the high-priority data stream allows doing so.

When there are not enough vacancies in the high-priority data streams, the priority scheduling algorithm searches for balance between decreased quality of the high-priority service and the amount of lost low priority data [7].

High-performance nodes, implemented as switches and routers queue data of different priorities into different buffers. Budget routers have one buffer only. Priority-supported scheduling is performed in embedded software.

Filing the throughput complaints to the service provider and assigning high-priority data transfer for the audio-visual data on the user premises (router with alternative shareware [8]) resulted in data throughput

that was satisfactory high and steady enough for tele-lecturing without interrupts and/or disruptions.

Sociological experience of tele-lecturing has more dimensions. Part of the population that likes, buys and uses the state of the art gadgets for communication, work and entertainment, uses internet by its entire means [9], has high level of functional literacy, accepts tele-lecturing as just another novelty in a daily routine. But most students were quite critical about the deficiencies. Had we not reacted promptly, the whole concept of tele-lecturing could easily get questioned.

The highly motivated students gain the required knowledge either by classical teaching method or by tele-lecturing. Less motivated students are more successful when they feel some formal pressure. Classical organization of lecturing helps with the issue.

When tele-lecturing, the body language can only be poor; raising motivation is difficult and interactivity decreases.

We understand tele-lecturing as a not applicable technology at lower levels of education where upbringing is important. Tele-lecturing is on par with classical lecturing at higher levels of education where knowledge transfer is a key component of the pedagogic process.

6 DISCUSSION

Tele-lecturing implements a pedagogic process for many small groups of dislocated students at a controlled cost. Existence of the communication infrastructure is granted and the cost of data transport is practically next to none. The equipment cost is decreasing steadily. Currently, it presents a moderate expense compared to the cost of a lecturer.

The extrapolated demographic growth data shows that in the period of the next ten years there will be up to 15 per cent less students then in 2012. Tele-lecturing will not be needed if the number of lecturers stays unchanged, which is a requirement of the strong syndicate.

Educational institutions autonomously handle their economics. Tele-lecturing has potential to lower the cost of education. Savings and saved time can be utilised in research.

Tele-lecturing is somewhat less effective than classical lecturing. This can be, in the authors' opinion, compensated with a cost-free change in the grading policy. When the same person does teaching and grading, results can be different from when one teaches and other grades.

Combination of a web conference and services for data exchange, known as webinar can be understood as competition to tele-lecturing [10]. Webinars are utilized in geographically distributed companies for internal education of the work force. Attendees need their personal computers and preparation of services needs more work than is the case with tele-lecturing. It is quite possible that the future of distributed learning will present a significant upgrade of combining tele-lecturing with webinars.

7 CONCLUSION

Experience-based development of methods for achieving performance in tele-lecturing is the contribution of this work. The initial set-up of the system requires nullification of the effects that the segments with a low throughput have on data transfer. Proper QoS setting on internet nodes significantly improves the throughput issue.

The teleconference equipment does not suffice for tele-lecturing. A live picture of the lecturers' derivations is needed. More task-oriented cameras need to be installed and simple switching among them is needed. Tele-lecturing requires more self-discipline from students than classical lecturing. The remote lecturer must compensate for his physical nonexistence at the location with thought-provoking, attention-grabbing and appealing style of lecturing to get the needed attention. Then, efficiencies of classical and tele-lecturing are on par.

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