

Strategic Applications of Distance Learning Technologies

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<i>Sergio Deusdado, Instituto Politécnico de Bragança, Portugal</i>	
<i>Paulo Carvalho, Universidade do Minho, Portugal</i>	

Chapter I discusses a new generation of e-learning development, based on synchronous groupware applications integration, providing improved interactivity and pro-human relations, allows richer training experiences far beyond a virtual classroom. Despite WWW service evolution, e-conferencing multimedia applications remain “killer applications” and insensitive to resources degradation, in fact, the quality of service (QoS) provided by the network is still a limitation impairing their performance. Such applications have found in multicast technology an ally contributing for their efficient implementation and scalability. Additionally, considering QoS as design goal at application level becomes crucial for groupware development, enabling QoS proactivity to applications. Congregating these technological contributions, an adaptive platform has been developed integrating public domain multicast tools, applied to a Web-based distance learning system. The system is user-centered (e-student), aiming at good pedagogical practices and proactive usability for multimedia and network resources. The services provided, including QoS adapted interactive multimedia multicast conferences (MMC), are fully integrated and transparent to end-users. QoS adaptation, when treated systematically in tolerant real-time applications, denotes advantages in group scalability and QoS sustainability in heterogeneous and unpredictable environments such as the Internet.

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<i>Charlie C. Chen, Appalachian State University, USA</i>	
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Chapter II discusses the online training and the question of whether the most effective training methods applied in live instruction will carry over to different online environments in the long run. Behavior mod-

eling (BM) approach—teaching through demonstration—has been proven as the most effective approach in a face-to-face (F2F) environment. A quasi-experiment was conducted with 96 undergraduate students who were taking a Microsoft SQL Server 2000 course in a university in Taiwan. The BM approach was employed in three learning environments: F2F, online synchronous and online asynchronous classes. The results were compared to see which produced the best performance, as measured by knowledge near-transfer and knowledge far-transfer effectiveness. Overall satisfaction with training was also measured. The results of the experiment indicate that during a long duration of training no significant difference in learning outcomes could be detected across the three learning environments.

Chapter III

Challenges in Delivering Case-Based Teaching in the Online Asynchronous Learning

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Charlie C. Chen, Appalachian State University, USA

Albert L. Harris, Appalachian State University, USA

Rong-An Shang, Soochow University, Taiwan

Chapter III assesses and compares the efficacy of case method teaching in face-to-face and online asynchronous learning (OAL) environments. The overall findings of this study indicate that an online asynchronous environment can promote students' participation in certain cases. As most antagonists for the adoption of online asynchronous case method surmised, cognitive learning gains via this learning method do not seem to be as high as in the face-to-face environment. The findings provide ample room for a further exploration of creative online asynchronous methods to continuously improve cognitive gains of learners.

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M. A. Rentroia-Bonito, Technical University of Lisbon, Portugal

J. A. Jorge, Technical University of Lisbon, Portugal

C. Ghaoui, John Moores University, UK

Chapter IV discusses e-learning's challenge to promote effectiveness in order to fully get expected benefits. Achieving effectiveness will contribute to its establishment as a credible way to support educational endeavours. This work explores a variable called "motivation-to-e-learn," a key component to design technology-supported learning experiences. Our goal is to identify what motivation-related variables are critical for student engagement in learning online. We further explored the importance of a set of motivation-to-e-learn variables building on previous results in real instructional settings. From this activity, an exploratory two-factor structure emerged which explains 96% of motivation to e-learn construct. We discuss our results, together with their implications for learning-support design and future work. Our contribution is a step towards quantitatively understanding and cost-effectively improving the link among learning-design process, supporting systems and students into an effective and harmonious whole.

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Tomasz Müldner, Acadia University, Canada

Elhadi Shakshuki, Acadia University, Canada

Andreas Kerren, Växjö University, Sweden

Understanding of algorithms is one of the most challenging aspects of the study of computer science. In Chapter V, we present a new approach for explaining algorithms that aims to overcome various pedagogical limitations of the current visualization systems. The main idea is that, at any given time, a learner is able to focus on a single problem. This problem can be explained, studied, understood, and tested before the learner moves on to study another problem. The Structured Hypermedia Algorithm Explanation (SHALEX) system is the system we designed and implemented to explain algorithms at various levels of abstraction. Since the system is implemented using a client-server architecture, it can be used both through distance education and in the classroom setting. To aid and monitor the learner, we also developed an agent in SHALEX that provides help and monitors the completion rate.

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Iwona Miliszewska, Victoria University, Australia

Chapter VI presents the development of a conceptual, operational, and software architecture of a collaborative education model. The federated model, supported by agent-based communication over the Internet, can operate across geographical, cultural and organisational boundaries while promoting integration within those boundaries. Because of its potential ability to cross the various boundaries, the proposed model seems particularly applicable to distance education environments.

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Apple W. P. Fok, City University of Hong Kong, Hong Kong

Horace H. S. Ip, City University of Hong Kong, Hong Kong

Chapter VII discusses the requirement of continuous professional development (CPD) activities to stay qualified for membership. Modern day professionals who are very much mobile and work within tight schedules point to the need of an asynchronous learning environment that provides a learner-centered approach and offers learners greater flexibility and choices. In this article we argue that “personalization learning” (PL) that exploits the abundance of information and e-learning materials on the Web can be harnessed effectively to serve the diversity of CPD training needs. Moreover, we specialize in the concept of PL to Personalized CPD Learning and highlight the emerging technologies that are relevant to the development of personalized learning for CPD. We further proposed an agent-based architectural and conceptual framework for a personalized CPD learning portal (Personalized-CPD) which integrates these technologies to provide supportive functions for professionals to conduct CPD activities in a personalized manner.

Chapter VIII

Development and Evaluation of a Keyword-Accessible Lecture Video Player and Lecture Video

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Takahiro Yoshida, Tokyo University of Science, Japan

Seiichiro Hangai, Tokyo University of Science, Japan

In Chapter VIII the authors developed a lecture video player/maker system (Yoshida, 2002, 2003). In developing this system, we considered the usability for students and operability for teachers. The player includes a keyword access function, which enables the student to jump to scenes where one of the registered keywords was spoken. For this purpose, the lecture video maker realizes automatic index generation after continuous speech recognition of the whole lecture stream. Evaluations of the lecture videos and the player by students are discussed, and the desirable style of lecture videos for students is surveyed.

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Distance Learning in Business Aviation Industry: Lessons Learned and Implications for Theory

and Practice 124

Mahesh S. Raisinghani, TWU School of Management, USA

Chris Colquitt, National Aeronautics and Space Administration, USA

Mohammed Chowdhury, University of Dallas, USA

Chapter IX explores the expectations and behaviors of business aviation pilots towards online learning. The authors believe that the company that is able to offer an integrated, individualized, and useful online training experience will gain a significant competitive advantage. To that end, the authors have researched and synthesized studies that are currently available and relate to this important future product. In addition, an exploratory survey of business aviation pilots and interviews with key aviation industry players are used to determine current attitudes and expectations towards online learning. The scope of this chapter will be limited to exploring the niche market of business aviation pilots using the aviation training company CAE SimuFlite and their new Simfinity™ technology. However, the authors consider the concepts discussed to be applicable to all business aviation pilots.

Chapter X

SEAMAN: A Visual Language Based Tool for E-learning Processes 147

Gennaro Costagliola, University of Salerno, Italy

Filomena Ferrucci, University of Salerno, Italy

Giuseppe Polese, University of Salerno, Italy

Giuseppe Scanniello, University of Salerno, Italy

Chapter X concerns the design phase in the development of e-learning courses concerns. In this chapter we present a tool based on a suite of visual languages, which has been specifically conceived to support instructional designers in the definition and creation of learning processes. The proposed suite of visual languages includes the learning activity diagram, which extends UML activity diagrams to make them suitable for modelling e-learning processes, the Self-Consistent Learning Object language used to define knowledge contents, and the Test Maker Language for specifying assessment and self-assess-

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Bing Duan, Nanyang Technological University, Singapore

Habib Mir M. Hosseini, Nanyang Technological University, Singapore

Keck Voon Ling, Nanyang Technological University, Singapore

Robert Kheng Leng Gay, Nanyang Technological University, Singapore

With the goal of bringing e-learning to the traditional laboratory experiment, Chapter XI presents an architecture for an online laboratory e-learning system to facilitate the design and deployment of lab-based courses for e-education. The chapter provides an overall view of the system design and implementation so the Internet-based laboratory can be easily integrated with the e-learning infrastructure.

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A Virtual Laboratory for Digital Signal Processing	180
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Chyi-Ren Dow, Feng Chia University, Taiwan

Yi-Hsung Li, Feng Chia University, Taiwan

Jin-Yu Bai, Feng Chia University, Taiwan

In Chapter XII the authors design and implement a virtual digital signal processing laboratory (VDSPL). VDSPL consists of four parts: mobile agent execution environments, mobile agents, DSP development software, and DSP experimental platforms. The network capability of VDSPL is created by using mobile agent and wrapper techniques without modifying the source code of the original programs. VDSPL provides human-human and human-computer interaction for students and teachers, and it also can lighten the teacher's load, increase the learning result of students, and improve the usage of network bandwidth. A prototype of VDSPL has been implemented by using the IBM Aglet system and Java Native Interface for DSP experimental platforms. Also, experimental results demonstrate that our system has received many positive feedbacks from both students and teachers.

Chapter XIII

Information Retrieval in Virtual Universities	194
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Juha Puustjärvi, Helsinki University of Technology, Finland

Päivi Pöyry, Helsinki University of Technology, Finland

Chapter XII discusses information retrieval in the context of virtual universities which deals with the representation, organization, and access to learning objects. In this chapter, we give an overview of the ONES system, and analyze the relevance of two information retrieval models for virtual universities. We argue that keywords based search (i.e., the Boolean model), though well suited for Web searches, is overly coarse for virtual universities. Instead, the vector model, on which our implemented search engine is also based on, seems to be more appropriate as it provides similarity measure (i.e., the learning object having the best match is presented first). We also compare the performance of four algorithms for computing the similarities (matching).

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Henry H. Emurian, University of Maryland – Baltimore County, USA

In Chapter XIV students in a graduate class and an undergraduate class in Information Systems completed a Web-based programmed instruction tutor that taught a simple Java applet as the first technical training exercise in a computer programming course. The tutor is a competency-based instructional system for individualized distance learning with the capacity to generate meaningful learning (i.e., understanding of concepts) at the level of the individual student.

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Senteni Alain, University of Mauritius, Mauritius

Chapter XV proposes a framework for research in promoting personalisation in Web-based learning environments. The concepts of adaptability, adaptivity and the limitations of completely adaptive systems are discussed. The conception of more interactive environments that are both adaptable and adaptive, which can assist the teacher in making interesting pedagogical decisions while tutoring in a virtual environment is proposed. Two versions of an algorithm that can be used to offer personalisation in the framework described are developed and discussed in this chapter. The algorithm is basically a method devised to select the most appropriate learning object from a pool of potential objects that exist in the repository.

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Remote Mental Health Care Education	251
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Information technology (IT) can be helpful for remote mental health care education. Because there are very few mental health care specialists, it is very important to decrease their moving time. But it is not easy to use the conventional TV conference systems for ordinary people, mental health care specialists, and their students because they are not computer specialists. For this reason, we have developed a WWW conference system. Our system can communicate between the mental health care specialists and their students by using the live video on WWW browser. In this paper, we show the implementation and the evaluation of proposed system. The experimental results over the Internet show that our system can be used for real time communication between Fukuoka, Ishikawa, and Iwate prefectures.

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Degan Zhang, University of Science and Technology of Beijing, China

Yuan-chao Li, China University of Petroleum, P.R. China

Huaiyu Zhang, Northwest University, China

Xinshang Zhang, Jidong Oilfield, P. R. China

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In Chapter XVII, under the banner of seamless mobility, we propose a kind of approach supporting task-oriented mobile distance learning paradigm. Web-based seamless migration, which has the capability that task for mobile distance learning (MDL) dynamically follows the learner from place to place and machine to machine without learner's awareness or intervention by active service. Our key idea is this capability can be achieved by architecture of component smart platform and agent-based migrating mechanism.

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Jin Tan Yang, Southern Taiwan University of Technology, Taiwan

Huai-Chien Horng, National Kaohsiung Normal University, Taiwan

Chapter XVIII proposes a design framework for constructing digital rights management (DRM) that enables learning objects in legal usage. The central theme of this framework is that any design of a DRM must have theories as foundations to make the maintenance, extension or interoperability easy. Two algorithms for encoding and verifying rights in DRM are designed to deal with REL metadata in RDF format. This technological support also reduces the sophistication among role assignments, learning objects and task ontology of DRM. The DRM module is embedded to SCORM-compliant content repository management system (CRMS) for IPR (intellectual property rights) protection.

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Preface

EMERGING TECHNOLOGIES IN DISTANCE LEARNING

It is an established fact that for a successful distance education program we require technologies that provide increased interactivity between the learners and teachers. It is just about a decade since the understanding of technology for distance education were meant to include post, telephone, fax and limited use of the Internet. The rapid growth in computers, telecommunication technologies and capabilities, and change in nature of the information age has significantly changed the definition and technology requirements in distance education. Technologies considered as advanced for distance education in the recent past are abandoned and new technologies are demanded today. The advances in technology have caused paradigm shifts in distance education starting from correspondence courses, teleconferencing over speaker phones, teleconferencing via modem, transporting still pictures along with interactive audio, to the latest technology of two-way, full audio, full video communication. Current technological advances have generated a great deal of excitement and hope to overcome the walls and boundaries, the barriers of real time interactivity in distance learning education. Today development of learning modules that include elements such as video transmission, e-mail, the Internet, and the World Wide Web supported by multimedia are common. The goal is to minimize or overcome the limits of separation between the learners, educators and facilitators by time and distance.

This book focuses chapters on different research, design and implementation aspects of technologies and methods with specific focus on distance education. These include:

- Development of integrated e-learning environment based on interactive multimedia services with proactive QoS; allowing development of end-to-end QoS-aware multimedia conferences, coordinating resources from network, end-system processing equipment and applications. One proposed system integrates public domain multicast applications for synchronous media communication, being supervised by a middleware-based QoS management framework intending to preserve the QoS of critical parameters for e-learning session's specificity.
- Studies to demonstrate how one of the most effective training methods, the behavior modeling (BM) approach, that is, teaching through demonstration, applied in live instruction will carry over to three different online environments: F2F, online synchronous and online asynchronous classes.
- Assessment and comparison between the efficacy of case method teaching in face-to-face and online asynchronous learning (OAL) environments. Four hypotheses are proposed on the correlation between these two delivery modes and studied the learning performance of students.
- Research on "motivation-to-e-learn," a key component to design technology-supported learning experiences, with focus on quantitative approaches to support learning-centered design by consid-

ering student needs and their immediate and broader contexts to promote effectiveness in order to fully get the expected benefits of e-learning challenges.

- New approach for explaining algorithms that aims to overcome various pedagogical limitations of the current visualization systems through design and implementation of Structured Hypermedia Algorithm Explanation (SHALEX) system to explain algorithms at various levels of abstraction.
- Presentation of a collaborative education model that would provide efficient communication services and an open scalable architecture for the uniform publication, management, and dissemination of distributed educational material developed by geographically dispersed educational providers, while maintaining the autonomy of the participating providers.
- Design of an agent-based architectural and conceptual framework for a Personalized Continuous Professional Development Learning Portal (Personalized-CPD) that, by harnessing the abundance of information and e-learning materials on the Web, can be effectively used to serve the diversity of CPD training needs.
- Discussion and development of a keyword-accessible lecture video player to enable students to view past lectures at any time and from anywhere on their PCs.
- Provide understanding of the expectations and behaviors of business aviation pilots towards online learning.
- Introduction of a tool based on a suite of visual languages, which has been specifically conceived to support instructional designers in the definition and creation of learning processes.
- Design and implementation of different Internet-based virtual laboratories, a rapidly growing research area in universities, to facilitate the designing and deployment of the lab-based courses for e-education.
- Implementation of a prototype of a virtual digital signal processing laboratory (VDSPL) by using the IBM Aglet system and Java Native Interface for DSP experimental platforms.
- Research on information retrieval in the context of virtual universities and dealing with the representation, organization, and access to learning objects. The representation and organization of learning objects should provide the learner with an easy access to the learning objects.
- One of the challenges in developing an automated distance learning system, which is to craft the instructional experience so that students acquire the capability to solve problems not explicitly taught or encountered in the system itself.
- Introduction to a series of formative evaluations to assess and enhance the instructional effectiveness of an automated and individualized distance learning system that is intended to assist information systems students in beginning their study of Java™.
- Investigation of the problem of personalization in Web-based learning environments.
- Development and evaluation of a WWW conference system in order to realize a remote mental health care education by providing communication between the mental health care specialists and their students in addition to providing communication between the mental health care specialists, patients and their families by using the live video on WWW browser, point-to-point communication, point-to-multipoint communication and multipoint-to-multipoint communication.
- Development of a kind of approach supporting a task-oriented mobile distance learning paradigm--Web-based seamless migration, which has the capability that task for mobile distance learning (MDL) dynamically follows the learner from place to place and machine to machine without learner's awareness or intervention by active service, which may be achieved by architecture of component smart platform and agent-based migrating mechanism.
- A design framework recommendation for constructing digital rights management (DRM) that enables learning objects in legal usage. The central theme of this framework is that any design of a

DRM must have theories as foundations to make the maintenance, extension, or inter-operability easy.

The chapters in this book reinforce the fact that the digital revolution, powered by the engines of information and communication technologies, has fundamentally changed the way people think, behave, communicate, work and earn their living. It has restructured the means by which the world conducts economic and business activities and runs governments. It has formed new ways to create knowledge, educate people and disseminate information.

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Mahbubur Rahman Syed

Editor

About the Editor

Mahbubur Rahman Syed is currently a professor of Information Systems and Technology at Minnesota State University, Mankato (MSU), USA. He has about 25 years of experience in teaching, in industry, in research and in academic leadership in the field of computer science, engineering, information technology and systems. Earlier he worked in the Electrical and Computer Engineering Department at the North Dakota State University in USA, in the School of Computing and Information Technology, Monash University in Australia, in the Department of Computer Science and Engineering in Bangladesh University of Engineering and Technology (BUET) in Bangladesh and Ganz Electric Works in Hungary. He was a founding member of the Department of Computer Science and Engineering at BUET and served as Head of the Department during 1986-92. He served as the General Secretary of Bangladesh Computer Society and also as the General Secretary of BUET Teacher's Association. He received the UNESCO/ROSTSCA' 85 award for South and Central Asia region in the field of Informatics and Computer Applications in Scientific Research. He won several other awards. He has co-edited several books in the area of e-commerce, software agents, multimedia systems and networking. He guest edited the 2001 fall issue of *IEEE multimedia*. He has more than 100 papers published in journals and conference proceedings. He has been serving in different roles such as co-editor-in chief, associate editor, editorial review committee, member of several international journals. Dr. Syed has been involved in international professional activities including organizing conferences and serving as conference and program committee chair.

Chapter I

Synchronous E-Learning Integrating Multicast Applications and Adaptive QoS

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ABSTRACT

A new generation of e-learning development, based on synchronous groupware applications integration, providing improved interactivity and pro-human relations, allows richer training experiences far beyond a virtual classroom. Despite WWW service evolution, e-conferencing multimedia applications remain “killer applications” and insensitive to resources degradation, in fact, the quality of service (QoS) provided by the network is still a limitation impairing their performance. Such applications have found in multicast technology an ally contributing for their efficient implementation and scalability. Additionally, considering QoS as design goal at application level becomes crucial for groupware development, enabling QoS proactivity to applications. The applications’ ability to adapt themselves dynamically according to the resources availability can be considered a quality factor. Tolerant real-time applications, such as videoconferences, are in the frontline to benefit from QoS adaptation. However, not all include adaptive technology is able to provide both end-system and network quality awareness. Adaptation, in these cases, can be achieved by introducing a multiplatform middleware layer responsible for tutoring the applications’ resources (enabling adjudication or limitation) based on the available processing and networking capabilities. Congregating these technological contributions, an adaptive platform has been developed integrating public domain multicast tools, applied to a Web-based distance learning system. The system is user-centered (e-student), aiming at good pedagogical practices and proactive usability for multimedia and network resources. The services provided, including QoS adapted interactive multimedia

multicast conferences (MMC), are fully integrated and transparent to end-users. QoS adaptation, when treated systematically in tolerant real-time applications, denotes advantages in group scalability and QoS sustainability in heterogeneous and unpredictable environments such as the Internet.

INTRODUCTION

Technology has been a strong catalyst for educational innovation and improvement, especially when the World Wide Web is involved. The next generation Internet needs technological support to accommodate promising new applications, such as interactive real-time multimedia distribution. Next generation e-learning platforms will support cooperative use of geographically distributed educational resources as an aggregated environment, thus enabling a more effective knowledge exchange but facing several challenges, such as flexibility, extensibility, and scalability (Amoretti, Bertolazzi, Reggiani, Zanichelli, & Conte, 2005). Predictable bandwidth availability and capacity solvency imply QoS management to regulate resources in heterogeneous environments. IP multicasting techniques (Deering, 1998; Kosiur, 1998; Moshin, Wong, & Bhutt, 2001; Thaler & Handley, 2000; Ratnasamy, Ermolinskiy, & Shenker, 2006) are attractive solutions for the capacity shortage problem, as bandwidth consumption is reduced when network resources are shared. On the other hand, the QoS support (Moshin, Wong, & Bhutt, 2001) should be, in a first instance, inherent to applications in order to integrate conveniently enhanced real-time multimedia applications in the present Internet, barely QoS aware and increasingly heterogeneous.

With the advent of wireless and mobile networks, heterogeneity is likely to subsist; so envisioned applications should merge QoS adaptation and multicast in a proactive utilization of resources. Applications should be designed with adaptation in mind; they need to employ built-in mechanisms that allow them to probe the condi-

tions of the network environment and alter their transmission characteristics accordingly (Miras, 2002). Self-adaptive applications, in the sense of proactive behavior for transmission of continuous media in multiparty applications, are a well-accepted solution due to the correct integration of new services in today's Internet (Lubonski, Gay, & Simmonds, 2005; Deusdado, 2002; Li, Xu, Naharstedt, & Liu, 1998).

E-learning, as a component of flexible learning, encompasses a wide set of applications and processes that use available electronic media to deliver vocational education and training. It includes computer-based learning, Web-based learning, virtual classrooms and digital collaboration (Eklund, Kay, & Lunch, 2003). Our work aims to integrate interactive multimedia e-learning applications in a proactive fashion taking into account the available network resources and QoS sustainability. In this way, our motivation is to offer improved learning experience based on ultimate technology with QoS warranties.

The system architecture proposed in this work includes an adaptive module based on Java applets and embedded Javascript, responsible for assessing the existing operating conditions by collecting metrics reflecting the client's end-system performance (e-student's host), the current network conditions and relevant multicast group characteristics. The collected data is subsequently computed weighting parameters such as the available bandwidth at the client side, the round-trip time between the client and the e-learning server, the client's current CPU load and free memory. The obtained results are used for proper multicast applications scheduling and parameterization in a transparent way.

MOTIVATIONS

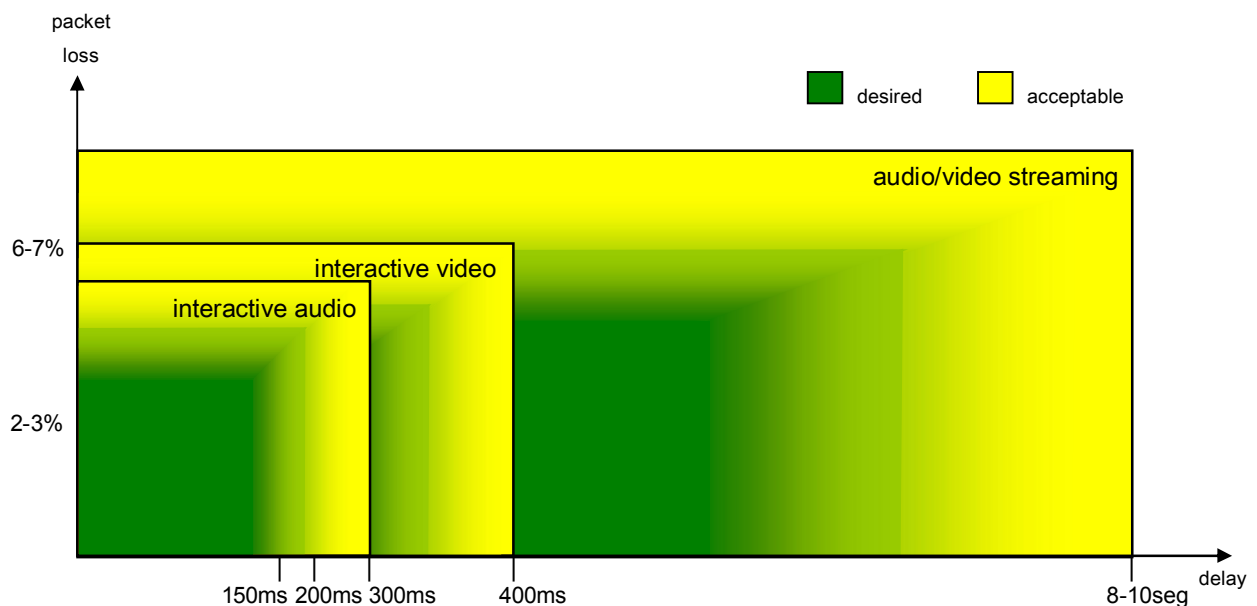
Basically, e-learning services are used to promote connections between people (e-students) and training resources (Steeple & Jones, 2002). E-learning research is wide and growing in importance, especially in higher education. Several institutions are developing interactive Web-based learning systems, integrating rich media streaming, which may compromise network performance. The design of e-learning systems should consider QoS as mandatory for successful learning experience, selecting the appropriate technologies and applications, and regulating proactively the information and communications technology (ICT) resources utilization (Lubonski, Gay, & Simmonds, 2005; Allison, Ruddle, McKechn, & Michaelson, 2001).

The Multicast Backbone (MBone) is a network overlaying the global Internet designed to support multipoint applications. MBone tools comprise a collection of audio, video and whiteboard applications that use Internet multicast protocols to enable

multiway communications (point-to-multipoint and multipoint-to-multipoint), satisfying most of the needs of group communication, such as e-learning services. Using these applications by common e-students drives recurrently to poor QoS satisfaction due to the heterogeneity of resource conditions and the applications' inability to assess available conditions and adjust internal parameters before conference initiation. Without regulation, real-time transport protocol (RTP) traffic floods the network capacity insensitively, forcing network congestion in certain cases or inhibiting better performance. A coherent behavior of an application without adaptation is difficult in today's Internet.

Public domain multicast applications used in this work *vic* (McCanne & Jacobson, 1995), *rat* (Hardman, Kirstein, Sasse, Handley, & Watson, 1995) and Java Media Framework (JMF) (JMF 2.0, 1999) were designed with no QoS "sensors," so the communication dynamics are not automatically interdependent of end-systems or network conditions. Effectively, such applications allow

Figure 1. QoS tolerance for generic audio and video applications (Miras, 2002)



pre-parameterization to adjust critical parameters such as throughput, number of frames per second, video and audio encoding formats, and so on. Adaptation, in these cases, can be obtained by introducing a multi-platform middleware layer responsible for tutoring the applications' resources (adjudication or limitation) based on the available processing and networking capabilities (Miras, 2002).

Common interactive real-time applications are fault-tolerant but suffer from QoS constraints; low-latency requirements, and reliability are cumulative to achieve conference success. The diagram in Figure 1 attempts to illustrate the QoS tolerance, in terms of delay and packet loss, for generic interactive audio and video applications.

The main motivation of this work is to provide adaptive behavior to applications used on both sides of multimedia conferencing, focusing essentially on multicast members that initiate audio and/or video transmission. The underlying idea is to launch automatically MMC applications with proper audio and video codecs, bandwidth allocation inference, and other parameters that affect sustainability and scalability during an e-learning session. Our emphasis is on the concept of "interactive e-learning services," relegating the concept of "e-learning course" to a secondary goal, which will be considered in future work.

Most prominent related work on friendly multimedia transmission over the Internet, based on a combination of system and network QoS feedback, implementing equation-based adaptation is summarized in Bouras and Gkamas (2003) and Vandalore, Feng, Jain, & Fahmy (2001).

SYSTEM'S ARCHITECTURE

For multicast video distribution to heterogeneous users in an e-learning session, we assume that a class server (e-tutor's system) should be distributed and platform independent, considering inclusively multi-tutoring. Thus, a class server should con-

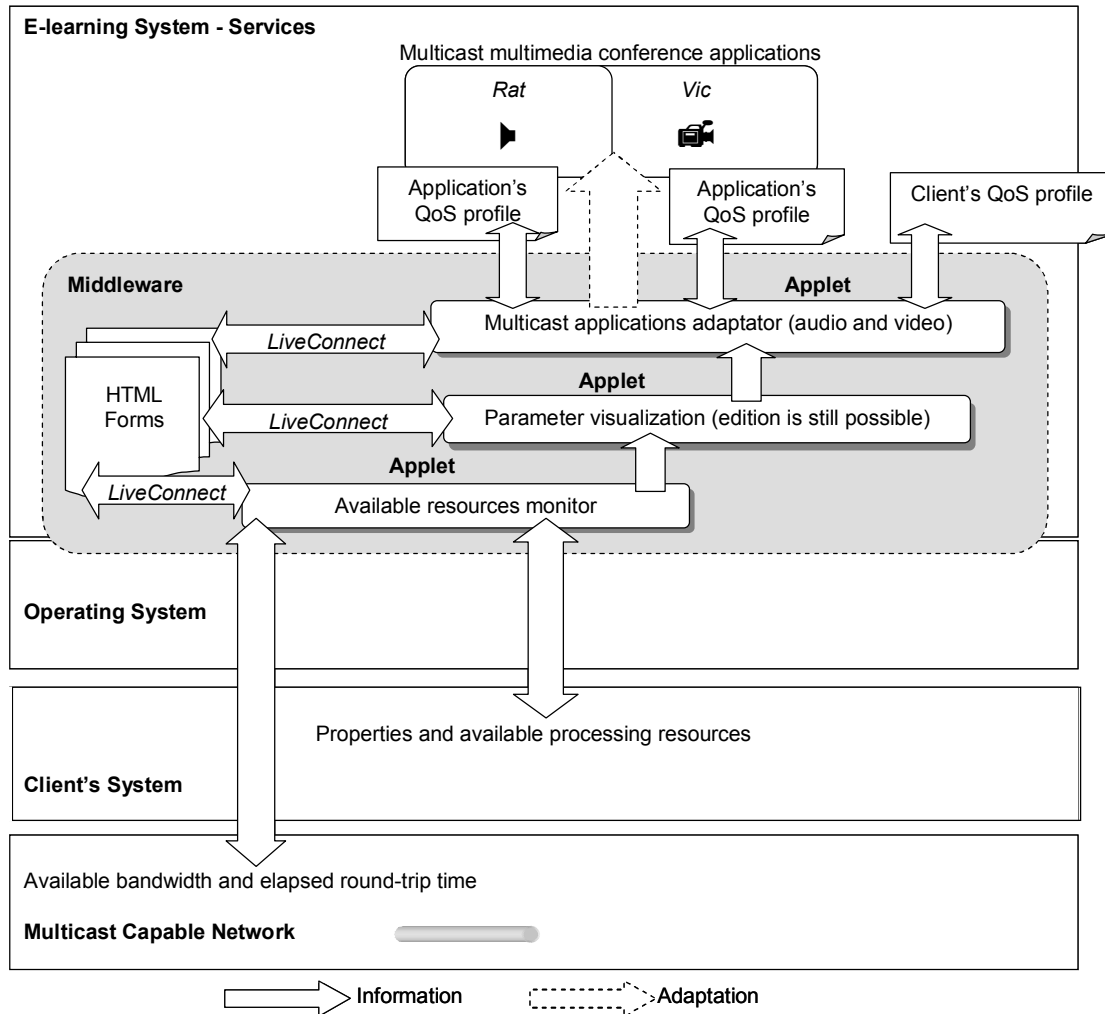
nect to an e-learning server (Web server) and be submitted to adaptation as a regular new sender. The QoS requirements for the class server, operating in a centralized fashion, may justify the need of layered multicast (Johanson & Lie, 2002; Liu, Li, & Zhang, 2004), enhancing the service's adaptation. However, this work aims at integrating e-students with heterogeneous equipment when they transmit audio and video to the group, as it happens in a conventional classroom. If a client (e-student) wants to interact and multicast video, then the system's architecture will integrate him with fair adjustments attending both to his connection to the server (e-tutor) network and to his hardware processing capabilities. Client's adaptation should not depend on the other group members because they are transient, and consequently stability of transmissions could be very poor.

As the involved applications are characterized by an intensive use of host and network resources, the purpose of the middleware platform is to achieve by computation, in a scale of five differentiated modes, the proper integration of new multicasting members. Within this thematic, it means implementing an adaptive learners' participation in e-learning sessions by starting MMC applications transparently, with their functionality optimized for the current operating conditions.

To clarify these aspects Figure 2 illustrates the system architecture. As shown, three applets, operating sequentially and interdependently, are responsible for monitoring and assessing QoS conditions; inferring, announcing and/or editing computed adaptation parameters. The process culminates with the initiation of MMC applications, depending on the host and network profiles and covering eventual end-user explicit requirements.

Audio and video encoding formats, frame rate, and other quality metrics may be chosen according to the resources' availability, providing coherent, friendly and fair participation in the network load balance. After monitoring sustainable network QoS with repeated measurements during

Figure 2. Proposed system's architecture



approximately 15 seconds before media transmission, the round-trip time (RTT) and bandwidth are calculated using a moving average. In addition, system's status variables such as processor load, free memory, processor performance, and so on are acquired taking advantage of operating system facilities.

The system is multiplatform as the included applets differentiate the most popular operative systems (Windows and Unix), invoking appropriate inner services to obtain instant measures for the processor's load and free memory. The col-

lected data constitutes another input to compute an adaptation index. Different compilations were produced for common browsers.

All the adaptation process is transparent, however, regarding the experimental nature of this work, each phase allows interaction with the user, providing technical information or even accepting user preferences. To achieve this goal, applets and HTML forms interchange data using Sun's *Liveconnect* technology.

ADAPTIVE QOS FRAMEWORK

In the proposed framework, QoS management is performed individually for each new conference member and occurs before the transmission's start, that is, MMC applications are launched adaptively facing the previous QoS sensing period conditions. QoS variability during the conference is not used to dynamically readapt the applications. If an e-student experiences lack of QoS while conferencing, his membership process should be restarted. Corroborating this practice, MMC applications, especially *vic*, are not stable enough. In fact, if some critical adjustments are made on the fly, the result is often the collapse of the application. Nevertheless, dynamic adaptation is currently subject of study within group communication applications (Layaida & Hagimonte, 2002; Tusch, Böszörményi, Goldschmidt, Hellwagner, & Schojer, 2004).

Considering the applications' specificity and type of traffic generated, adaptability only includes interactive audio (*rat*) and video (*vic*) applications and services. The heuristics regarding the choice of applications' QoS parameters emerged from experimental results and scientific references in this matter (Wu, Hou, Zhu, Zhang, & Peha, 2001). For instance, videoconference users typically require better audio quality than video quality (Bolot, Crépin, & Garcia, 1995). The success of videoconferencing communication also depends on factors such as received frames per second, image quality, resolution, size and illumination.

For this work, the representative parameters of *vic* and *rat* used to modulate QoS are presented in Table 1.

The values for these parameters, deriving from a mathematical expression that generates an adaptation mode based on the sustainable QoS level, compose a set of adjusting directives determining the applications' behavior. Each adaptation mode indexes the respective set of adjustments, which will then be passed to the application. Since QoS scale varies from mode 1 to 5, when the obtained result is under or over this range it will be assigned to the nearest limit. Equation (1) determines the adaptation mode to be applied:

$$M = (\text{int}) (B/(RTT/2) + FM/P) * K \quad (1)$$

where¹,

M = QoS adaptation Mode (Table 2);

B = Bandwidth (kbps); **RTT** = Round-Trip Time (ms);

FM = Free Memory (MB); **P** = Processor load (%);

K = 1/50 - constant to scale the result (1 to 5).

For *vic* (version 2.8), the video encoding formats H.261 (ITU-T H.261, 1993) and H.263 (ITU-T H.263, 1998) were those that revealed best performance for e-learning purposes, leading to low loss ratios and high reliability. H.263 is especially appropriate for low bandwidth environments.

Table 1. *vic* and *rat* QoS parameters used to adjust applications' profile

<i>Rat</i>	-f format	Indicates audio encoding format: <i>l16, pcm, dvi, gsm</i> and <i>lpc</i>
<i>Vic</i>	-B kbps	Sets the maximum bandwidth slider (kbps)
<i>Vic</i>	-c dither	On a color-mapped display, uses the algorithm indicated by dither (e.g., <i>ed, gray, od, quantize</i>) to convert to the available color palette
<i>Vic</i>	-f format	Indicates the video encoding format: <i>h261, h263, jpeg, mv, ...</i>
<i>Vic</i>	-F fps	Sets the maximum frame rate (fps)

E-LEARNING SERVICES AND FEATURES

The developed distance e-learning system presents numerous features providing distinct service levels, such as:

1. Virtual academy, Web-based with refined usability, integrating authentication and services for the e-learning community;
2. Registration, authentication and maintenance of educational agents;
3. Multicast sessions maintenance and scheduling;
4. Access to asynchronous material such as video on demand, slide presentations and other multimedia resources;
5. Interactive multimedia multicast conferences with QoS adaptation;
6. Other multicast tools for shared workspace;
7. Discussion spaces such as forum and multicast chat room.

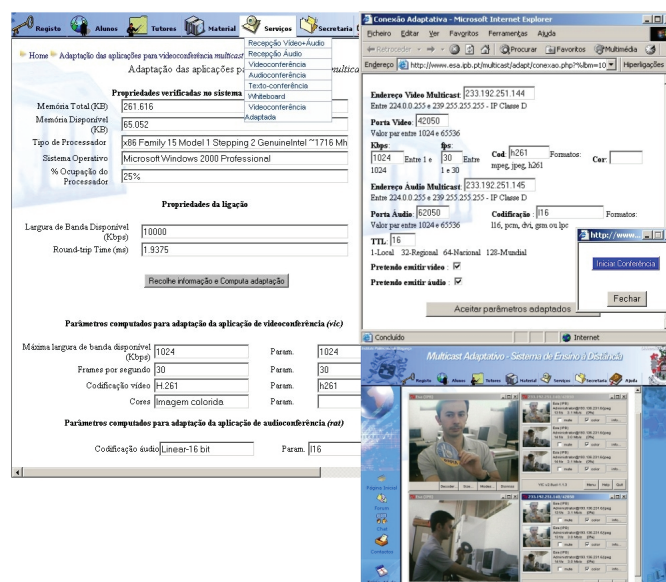
This information system incorporates online databases structuring courses, students, tutors and sessions' data. These resources were developed using MySQL/PHP. A Web site congregating all developed application component prototypes is available at www.esa.ipb.pt/multicast.

Certain processes for assessing hardware performance require user's explicit authorization, allowing extended security privileges to applets in order to perform system's inspection, collecting substantial data used by subsequent applets of the control path. The security certificates used in this work are not provided by official entities, but generated by applet compilation tools for testing.

Although the adaptation process is totally transparent, effectively, the users may edit QoS parameters suggested by the system. If editing occurs, correctness and validation are assured by embedded *Javascript* code for parsing purposes.

All MMC applications need to be previously installed and accessible through the command

Figure 3. E-learning system screenshots and MMCs adaptation HTML forms based on available QoS



line interface, configuring the PATH environment variable properly. If we want to transmit audio or video the required equipment must also be ready. Gathering these basic requirements it is possible to participate in e-learning sessions, having adapted QoS in a transparent way, with great usability. Figure 3 integrates system's screenshots, illustrating step by step, when a QoS adapted videoconference is selected from the "Services" menu.

PERFORMANCE STUDY

Applications that use voice, video streams, or multimedia must be carefully managed within an IP network to preserve their operational integrity. Beyond routing improvements, QoS in a multimedia conference needs primarily to deal with several sources with different characteristics, shifting large amount of traffic competing for network capacity. MMC applications may easily absorb all network resources and the subjective quality sensed by users would remain poor if the available resources are used indiscriminately. As mentioned earlier, the adaptation purpose, with e-learning in mind, was to integrate MMC applications with QoS conscience, preserving resources in order to maintain conference quality and improve scalability.

In order to test the framework, different scenarios were simulated and the corresponding resources' consumption verified considering the QoS limitations associated with each QoS mode defined in Table 2. For videoconferencing, regarding e-learning purposes, it is widely accepted that reference values correspond to "Maximum quality, few action scene." Bandwidth consumption in *vic* default mode is 128 kbps. When adaptation is requested, the different adaptation modes use the values charted in Figure 4. For instance, the best quality mode consumes around 400 kbps, allowing better image and motion.

Different equipment was also tested in order to validate the rank of the defined adaptation modes. We observed that modern high performance equipment tends to be neutral, in this case adaptation will be influenced overall by network conditions, but with mobile computation in mind, PDAs and cellular phones, CPU performance should not be relegated.

The experimental results were obtained varying the number of new multicast members transmitting voice and video, considering that all the multicast group members are multimedia receivers and transmitters capable using any source multicast (ASM) technology via *vic* and *rat* applications. Due to the limited number of multicast monitoring tools publicly available, we use embedded applications resource meters and

Table 2. Set of parameters for different QoS adaptation modes

ADAPTATION	MAXIMUM	FRAME RATE	VIDEO CODEC	COLOR	AUDIO CODEC
5	1 Mbps	30 fps	H.261	Yes	L16
4	512 kbps	25 fps	H.261	Yes	PCM
3	256 kbps	20 fps	H.261	Yes	DVI
2	128 kbps	15 fps	H.263	Yes	GSM
1	64 kbps	10 fps	H.263	No	LPC

Figure 4. BW needs for each QoS mode

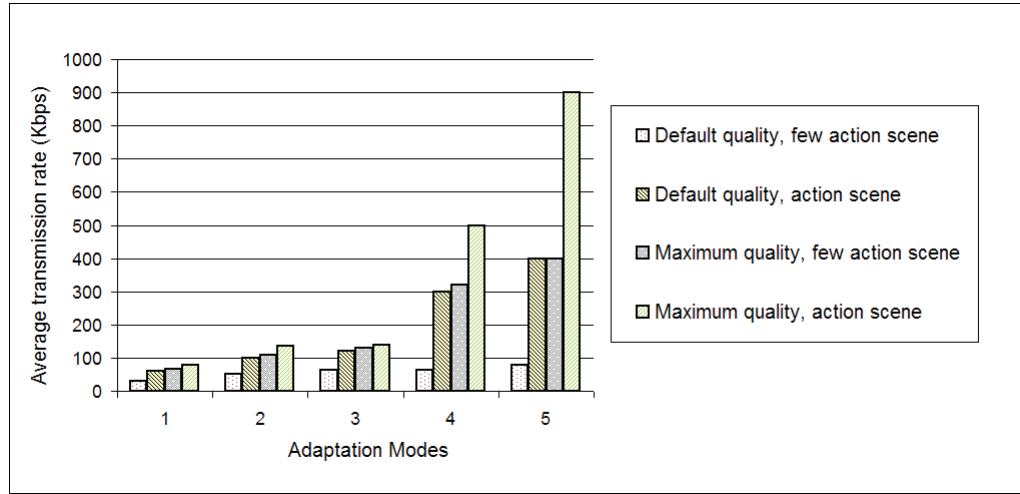
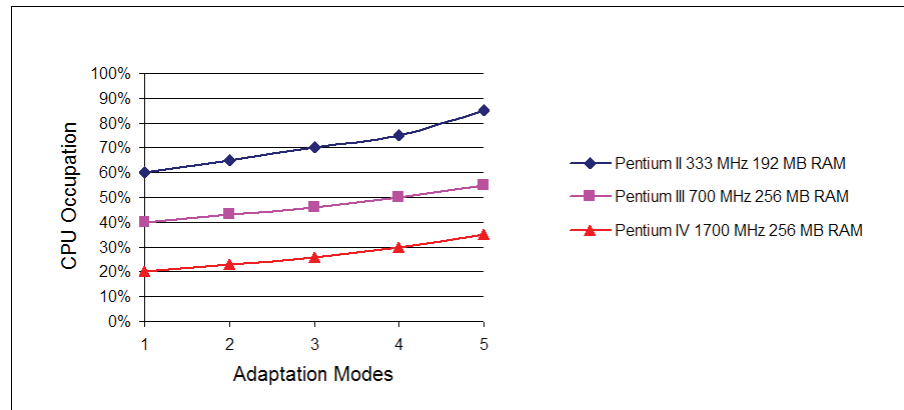


Figure 5. CPU needs for each QoS mode



the Multicast Monitor (www.multicastmonitor.com) to collect and handle the resulting data.

The e-learning system, more concretely the tested prototype, showed good performance indicators that validate the architecture model proposed. Because video traffic is quantitatively more representative of resource consumption, it was analyzed preferentially. Figures 4 and 5 exhibit the levels of resource consumption for each QoS mode considered. Here, the overhead introduced by middleware to prepare applications is marginal as it occurs before transmission time.

QoS adaptation, when treated systematically in tolerant real-time applications, denotes advantages in group scalability and QoS sustainability in heterogeneous and unpredictable environments such as the Internet and Mbone. Figures 6, 7 and 8 illustrate a comparison between two simulated sessions, the first without QoS adaptation and the second including adaptation managed by the developed middleware layer. The results show that scalability is increased, but equally important is the fact that applications may benefit from resource availability what does not occur when using the

Figure 6. Linear bandwidth distribution using applications' defaults, no adaptation is used

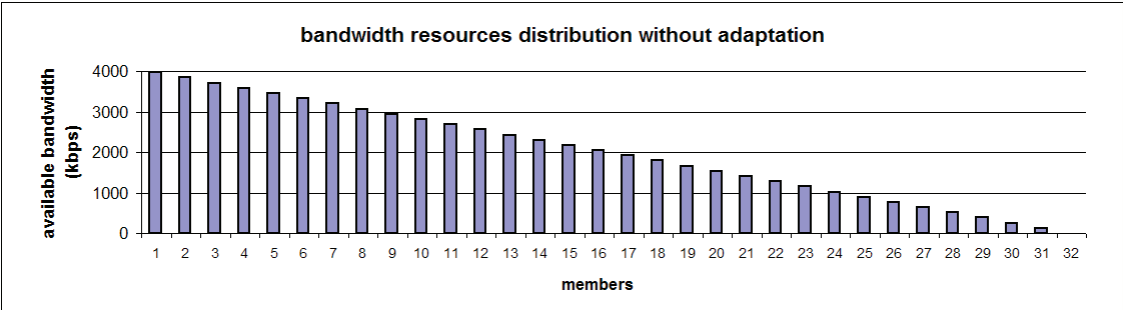


Figure 7. Increasing the number of active group members using adaptation to distribute network resources

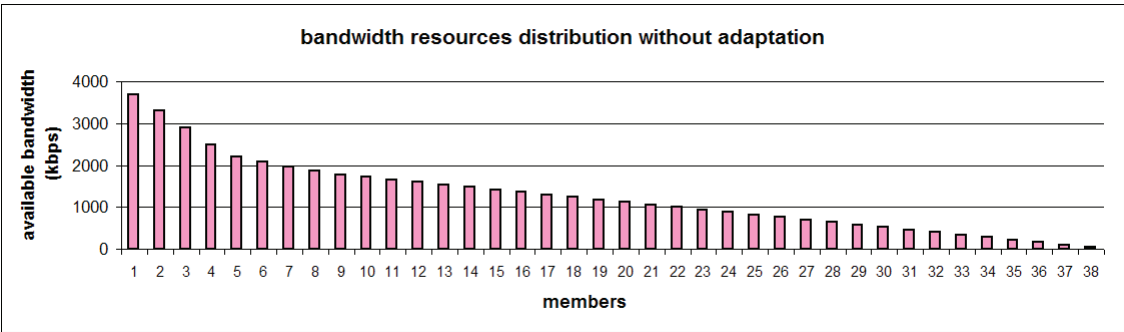
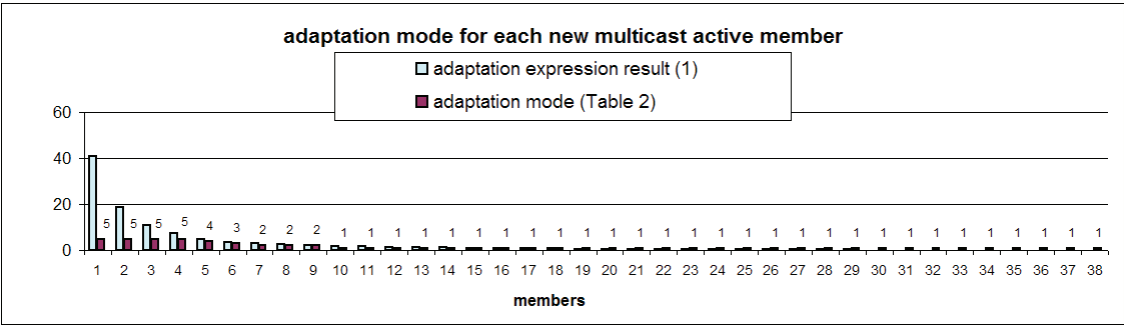


Figure 8 - QoS mode adopted by the system facing the available resource conditions.



default applications' configuration. When the available resources decrease, the system allocates them to critical parameters. For instance, while the frame rate should not be below 10 fps, the

image quality may be poor or monochromatic if the contents are correctly perceived.

Limiting bandwidth to applications, not only with explicit parameterization but also choosing

the right encoding format for e-learning sessions, allows efficient resource utilization and proactive usability, avoiding network overload and congestion. If the network load remains high it is easier to recover if adaptation is used.

The experience with Mbone showed that e-learning groups tend to be small, usually less than twenty members. Effectively, e-learning communities, as in traditional training methods, need a tutor, who is mainly an educational agent and not necessarily a learning technologist. Indeed, questions related with communication technologies won't constitute pedagogical limitation if intelligent QoS management autonomy is provided natively or by middleware to applications.

E-learning conferencing specificity requires appropriate video encoding formats able to achieve low loss ratio and fast recovery from congestion. We compared H.261 and Motion JPEG (ITU-JPEG, 1992) performance in experimental sessions, using a modest PC (PIII 0.7GHz - 256 MB RAM). The results were penalizing for MJPEG, where loss was about 30%, in opposition to 1% for H.261.

CONCLUSIONS AND DISCUSSION

The goal of this work was, in one topic, to foster "ecological" practices in the Internet when using MMCs applications in e-learning services. The proposed system integrates public domain multicast applications for synchronous media communication, being supervised by a middleware based QoS management framework, intending to preserve the QoS of critical parameters for e-learning session's specificity.

As main contributions, this work:

1. Provides an integrated e-learning environment based on interactive multimedia services with proactive QoS;
2. Improves the usability of MMC applications;

3. Allows the development of end-to-end QoS-aware multimedia conferences, coordinating resources from network, end-system processing equipment and applications.

Middleware adaptation is a solution that suits the present state of Internet and the requirements of new multimedia distributed applications. We use a middleware layer to manage QoS adaptation in interactive audio and video applications coordinating resource demand, monitoring and adjudication. Substantive results were obtained in group scalability, QoS sustainability and proactive resource utilization.

Comprising multiple sources (even unauthorized ones), ASM involves high complexity and may compromise the success of e-learning conferences. Future work includes the use of SSM (source-specific multicast) (Holbrook & Cain, 2006) in order to overcome this limitation. Multicast communications could also benefit from other implementation simplifications, namely the recently proposed FRM (free ride multicasting) (Ratnasamy, Ermolinskiy, & Shenker, 2006). The development of new multilayer video encoding formats could also increase the flexibility when using QoS adaptation. When cumulative layers are transmitted avoiding redundancy, using different SSM groups or channels, adaptation can be performed in a transparent way in order to achieve efficient resources utilization (Johanson & Lie, 2002; Liu, Li, & Zhang, 2004).

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ENDNOTE

- ¹ **RTT** and/or **P** values will be, if necessary, assigned to 1 to avoid division by zero. To prevent incongruence, the maximum bandwidth allowed cannot exceed the detected value (**B**), otherwise the computed mode will suffer cyclic decrements while the excess remains and **M**>1.