

Supporting eLearning and eHealth in a Broadband Network Environment

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Abstract: The consolidation of broadband applications is clearly visible in overall market development. Services like eLearning, e-government, eHealth and e-work are trends, boosted by emerging technologies and circumstances (cost reduction pressure, restructuring, legal constraints and governmental initiatives), applied in different industry segments. In this context, the COBRA consortium conducted its work in order to define and implement a portfolio of broadband services, mainly oriented to distance learning for University students and telemedicine, but featuring also entertainment and communication facilities. The proposed solution will enable existing local carriers to smoothly migrate into new infrastructure and service areas and will facilitate potential service providers to enter the telecommunications market.

1. Introduction

In recent years, telemedicine has increased its influence in medical diagnosis and management [1]. It has only begun to demonstrate savings and clinical benefits related to allowing remote consultations and obviating the need for patients to travel from one hospital to another to find a suitable specialist.

On the other hand, distance learning revealed its potential in overcoming constraints in time and place imposed by the traditional face-to-face teacher-centred training method, contributing to the improvement of the training offered. The new educational marketplace attracts universities, thanks to the opportunity to serve more students. Coupled with the ability to share and combine resources among campuses, eLearning represents an attractive way to increase the quality of the education experience.

Nevertheless, studies conducted within the programs of the European Commission [2] reveal that the majority of universities face a major challenge in promoting ICT integration from a project level to a more strategic one, while clinical centres need to focus their effort in the eHealth field towards more homogeneous solutions [3].

The COBRA (COnnecting Local/Regional Communities for BRoadband Service Access) consortium [4], supported by the European Commission within the eTEN programme, tried to tackle these problems by fostering a capillary diffusion of broadband services by means of Digital Local Carriers (DLCs). For that purpose, a complete portfolio of attractive services running on a broadband network infrastructure, namely the Broadband Service Platform (BSP), was implemented. It was targeted to an easy adoption of telemedicine and eLearning solutions but included also entertainment and voice communication. This paper provides an overview of the efficacy, effectiveness and economic impact of the COBRA approach.

2. Objectives and Methodology

The COBRA Consortium, coordinated by the University of Pisa, Italy, included carriers (Agescom, Chemtel), telecom equipment providers (Marconi), consultancy (EDS, Lucense), and end-customers/service providers (University of Pisa, Klinikum Chemnitz).

The partners combined their experience to realize an experimental service of distance learning and telemedicine on two pilots located in Italy and Germany. The adopted business concept envisaged the European-wide growth of local carriers/service providers, to foster the deployment of alternative infrastructure – primarily in competition to the incumbent players – in order to promote the development of broadband related services.

Three important aspects were considered when defining the working methodology:

- the individuation of a business scenario, derived by an analysis of the technological, infrastructural, functional, financial and commercial aspects over both the project life cycle and the market deployment phase;
- the production of an economic plan to analyse acceptance of the services envisaged in the project on the basis of a commercial demonstration;
- the redaction of a detailed business plan addressing all elements necessary for investment decision, including economic and commercial aspects related to deployment of the service platform in view of the social/industrial development of the territory.

From a technical point of view, the efficacy and success of any remote collaboration environment is strongly related to the underlying network infrastructure, as connectivity is critical when delivering multimedia interactive services. BSP services were distributed on a high-performance, reliable broadband network connecting each site forming the pilots.

Trying to convey the crowded landscape of heterogeneous solutions to the consolidation of the strongest ones, the COBRA platform derived from the integration and customisation of existing software packages selected among the others for their conformance to mature industry standards (H.323 for VoIP, MPEG-4 for multimedia delivery, DICOM for telemedicine applications). When feasible, widely adopted Open Source tools were preferred to commercial products. The fulfilment of the above requirements was crucial to make COBRA products competitive on both a national and a global basis, adopting a forward-thinking approach in service implementation.

3. Technology Description

The COBRA BSP built its strength on the contribution of technologically advanced network infrastructures and captivating end-user services. Dedicated server farms running customized Open Source components formed the platform. BSP features were mainly oriented to telemedicine and eLearning applications, integrated with enhanced voice communication opportunities based on Voice over IP solutions. Video on Demand and TV broadcasting applications were also provided. The BSP featured the following:

- Multicast, high-resolution multimedia services, applied to eLearning and eHealth.
- Broadcasting and Video on Demand (VoD) for MPEG-4 compressed video streams, forming the basic functional blocks for a wide range of possible services.
- Voice over IP (VoIP), which was both intended as a stand-alone service and used as a communication channel for other services requesting enhanced interaction among users.

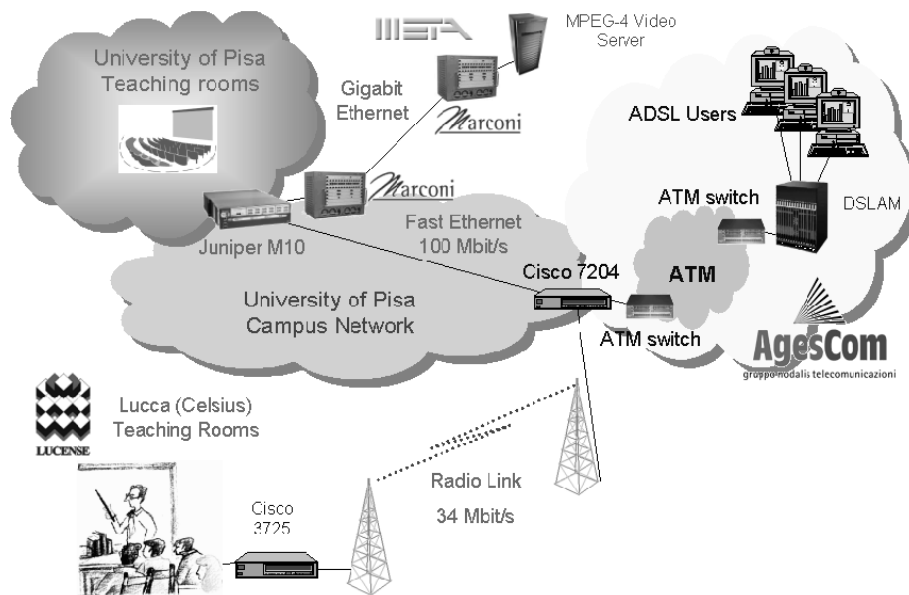


Figure 1: The Italian Pilot

Two pilots, in Italy (Figure 1) and Germany (Figure 2), embraced a wide range of network technologies, selected from a range of existing ones for their characteristics of reliability, feasibility and effectiveness.

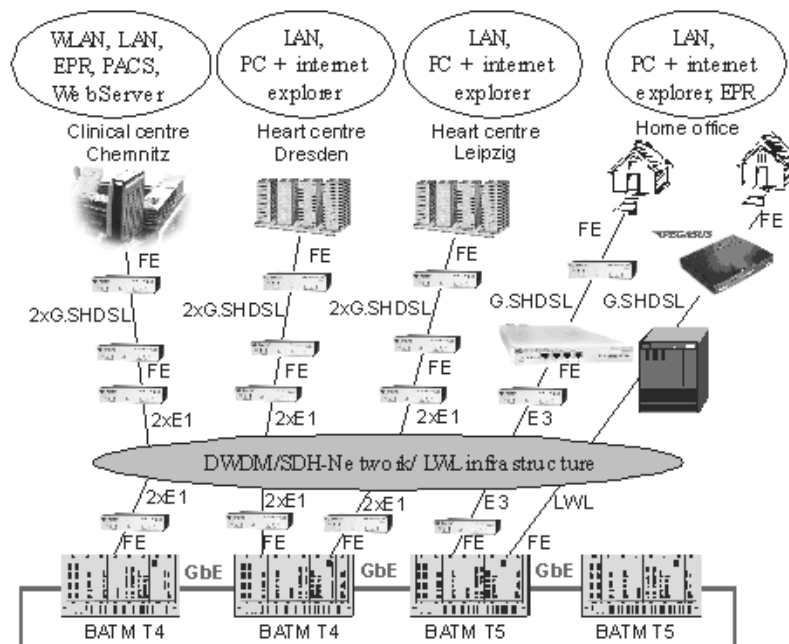


Figure 2: The German Pilot

4. BSP Implementation

After a thorough evaluation phase, the selected OS software components were integrated to obtain a global package satisfying the requirements and the objectives of the project.

4.1 Distance Learning

Consolidating the approach recommended, among the others, by the VIROR experience [5], the Distance Learning system overcame a simple coexistence of multimedia streaming and

web functionalities by providing a versatile Open Source integrated environment for automatic course production, comprised of the following blocks:

- an encoding system, providing live audio/video acquisition, encoding and multiplexing, as well as a mechanism to embed synchronous HTML references into the A/V stream;
- a streaming system, responsible for multimedia and data streams archiving and delivery and fed both by the encoding system and by pre-archived multimedia lessons;
- a web-based content management interface, offering authentication features, file storage, lesson access, communication facilities.

These components interacted transparently to visualize and access the multimedia contents available on the video server directly from the web pages, and automatically update the web pages when new lessons became available on the video server.

The streaming chain was realized by means of Helix DNA Producer and Helix DNA Server components of the Helix DNA Platform. On the client side, either RealOne player or an alternative OS player, retrievable as guliverkli on SourceForge, were used. They were preferred to Helix DNA Client because of their enhanced functionalities in terms of command manipulation and robustness.

A user requirement explicitly addressed the possibility to enrich the audio/video stream with didactic contents synchronized with the stream itself. This feature was not supported by the producer command line application (version 9.2 for Linux OS) and was introduced from scratch. The implementation was based on C++ classes included in the Producer SDK, which provided event management during the encoding process. Event objects corresponded to URLs of web pages, or to additional stream information such as author, copyright, and title. A new command line option, `-ev PORT_NUMBER`, was added to the producer. Its presence caused the launch of a thread listening on a TCP socket binding to the port indicated in `PORT_NUMBER`. This thread was in charge of including URL events into the stream when it received formatted strings on the socket.

Helix DNA Server 10.1 for Unix was configured to receive live streams from the producer and to support multicast delivery, increasing the audience of a live event by reducing the broadcasting bandwidth. Scalable multicast was chosen. An additional mount point, referring to the archive of registered lessons, was added to the server basic settings. It provided a way to retrieve contents, automatically saved by the producer at the end of the encoding, using the `/archive/` prefix in the URL linked by the player.

For the web interface, Dicole MimerDesk was adopted. It is an interactive collaborative learning environment that includes tools for personal information management, group and project work, setting up virtual communities and networked learning. For the COBRA purposes, the instant messaging feature was used for teacher-student interaction, while two new tools were developed to integrate the existing environment with the streaming system:

- Lessons: it is a tool to access live and archived lessons for a specific group/course. Links to multimedia lessons are displayed on the Group desktop; a simple click opens the media player and starts playback. During live lessons, this tool is associated to the Instant Messaging facility in order to send real-time text questions to the teacher.
- Slideshows: it is a personal storage space for teacher's slideshows. A user having access to that feature is able to browse HTML presentations loaded on the web server and see their preview. The Slideshows tool allows an easy integration of slides into live lessons. The selection of a specific slide within the presentation allows it to be opened in full screen mode and starts the slideshow. The presentation is driven either by the command buttons on the bottom of the page, or by mouse clicks on the page surface. The slides displayed for local fruition are contemporarily sent to the video server and encoded into the stream. The whole mechanism is transparent for the teacher, thanks to the similarity of usage between this web-based application and traditional presentation tools such as Microsoft PowerPoint.

4.2 Telemedicine

Although European initiatives encourage the uptake of Open Source activities in health-care [6], they are still too immature to be adopted on a regular basis. In this field, the project's main purpose was to change the attitude towards ICT solutions instead of providing a state-of-the-art implementation. For that reason, and keeping in mind the effort towards a unified approach to telemedicine, two well-known tools, SIENET MagicWeb and Cerner PowerChart, were preferred to OS packages due to their consolidated credibility.

MagicWeb is a client-server solution, consisting of one or several web servers and a number of clients. The tool converts any PC into an image-viewing workstation capable of manipulating radiology or cardiology images over DICOM. An interface to MS Netmeeting enables videoconferences to share selected images and sequences with several colleagues.

PowerCharts offers storage and view of EPR (Electronic Patient Record) clinical data, allowing ordering in forms-based and structured-text approaches. Patient records can be accessed from physician home offices and clinics for acute patient care, critical care, and long-term and rehabilitation services. The software provides an intuitive interface to enhance its usability and to minimize clicks, with personalization based on the user's role.

Within the project framework, MagicWeb and PowerCharts were coordinated by a web interface to provide a powerful integrated environment. Personal data, results of exams and radiological images are accessible from the same web page and can be combined together to obtain the complete case history for the patient. With these applications it is possible to increase the efficiency of the medical equipment for the following advantages:

- image distribution over existing networks;
- simultaneous images in the radiology department and on the ward;
- accessibility from home;
- teleconsulting;
- savings on film, archiving facilities, developers, printers, and light boxes.

A particular advantage for use outside the clinic is the ability to define the quantity of data that has to be moved. The user's purpose decides whether the images will be highly compressed or less so. The compression can be set for all types of images depending on the quality required. Preview features enable the user to load only the images that are really needed. The standardized format of all the PACS (Picture Archiving and Communication Systems) images makes them compatible with any DICOM viewer, partially solving interoperability issues so common in the healthcare world.

4.3 Video on Demand and TV broadcasting

Video on Demand implementation reused the software used for Distance Learning. Helix DNA Producer was used off-line to convert media files available in AVI uncompressed format into RealMedia files. The film archive was browsed on the Web via a dynamic HTML page, capable of reading directory contents and showing them in a nested structure.

The TV broadcasting application retransmitted a satellite channel received in DVB-S format, the standard for satellite digital video delivery, on the packet network. The DVB channel was demultiplexed by a DVB-S card and processed by mp4live software from the MPEG4IP suite. It was used for real-time conversion of MPEG-2 streams (received by the DVB card) into MPEG-4 format, more suitable for IP delivery. The resulting streams were both written to .mp4 files for archival and transmitted onto the network via either unicast or multicast by means of Darwin Streaming Server, the Open Source version of Apple's QuickTime Streaming Server technology.

4.4 Voice over IP

The H.323 VoIP implementation was based on the OpenH323 project. The COBRA VoIP service (Figure 3) included H.323 endpoints communicating with each other through a broadband network. They all referred to a gatekeeper for call-management functionalities.

The gatekeeper used in the COBRA trial was a software application based on the Openh323 Gatekeeper software – the GNU Gatekeeper. The COBRA Gatekeeper implemented the standard gatekeeper features (e.g., address translation, admission control), and a GUI performing all the administration mechanisms enhanced its functionalities. This allowed the interaction with a Radius server (FreeRADIUS open source project) in order to authenticate users, realize call accounting and other management functions.

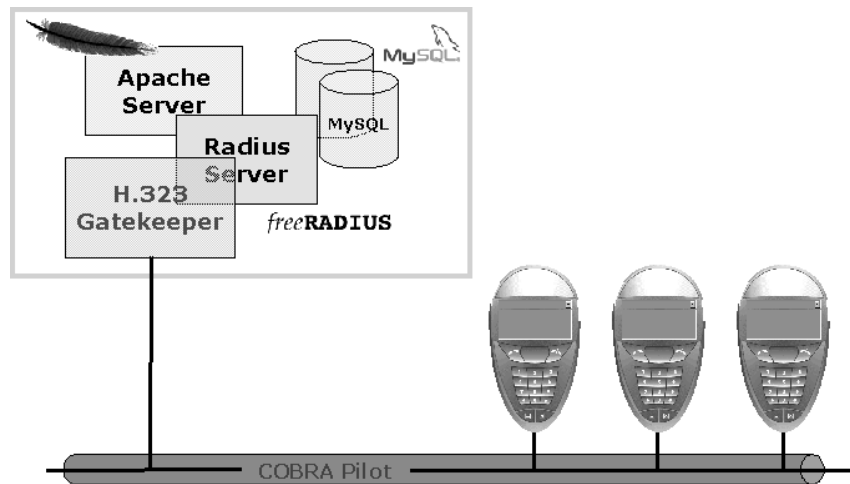


Figure 3: VoIP Service

5. Results

A number of experiences have been conducted in the eLearning and eHealth fields by many organisations and institutions on a global level. Most of them revealed that the introduction of innovative solutions encounters a certain grade of suspect even in so-considered “open-minded” environments such as Universities and Clinical Centres [7], where the proposal of IT services had to face consolidated working methodologies.

Being aware of that risk, the approach taken adhered closely to commonly used diagnostic and teaching instruments, by developing an easy-to-use, easy-to-customize web-based GUI. This allowed a fast response to specific user requirements without modifying the underlying applications. On the client side, a BSP end-user essentially needs only a web browser, a media player and a VoIP terminal to take advantage of the whole BSP portfolio.

BSP services were made available through a pool of servers, each one providing one or more functionalities. This modular structure was installed in different locations, introducing service redundancy and caching support by simply replicating elements. Moreover, different services reused, as far as possible, the same OS software packages. This led to a reduced overall complexity and an integrated platform concept.

From a networking perspective, some addressing issues were solved. Due to the bandwidth requirements of BSP applications, broadband traffic could not be routed through the common Internet, whose behaviour is unpredictable. Thus, dedicated Virtual Private Networks (VPNs) were set up to interconnect all the network segments interested by the services, including x-DSL home-users. VPNs also provided security features, particularly relevant for patient data management in the healthcare environment.

To date, the telemedicine system described in section 4.2 is running in Germany connecting Chemnitz, Dresden and Leipzig. The distance learning service was successfully

tested in two classes of Telecommunication Engineering at University of Pisa, and the faculty of Economics will evaluate it during the 2004-2005 academic year.

6. Business Benefits

As highlighted in the business analysis conducted, eHealth and eLearning are two of the most important markets for developing advanced technology solutions (Figure 4).

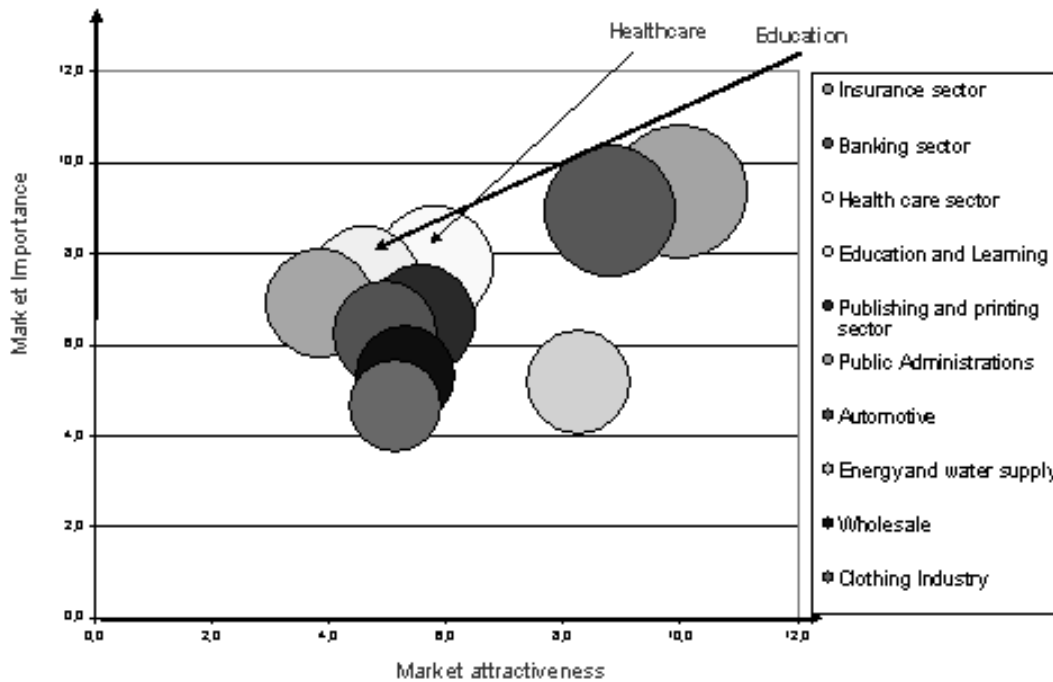


Figure 4: Top Ten of the Most Attractive Industry Segments for Broadband Services

The COBRA project intended to react to this specific market request offering a portfolio of ad-hoc services, including PACS, EPR applications in the German pilot and distance learning tools for University students in the Italian one.

In order to increase BSP attractiveness, other services were added, targeted to a wider market. From a carrier perspective, the BSP product represents a simple and cost-effective way to migrate to broadband service provisioning. All the BSP services are accessible through web-based interfaces and servers can be located anywhere. This allows service providers to take advantage of full service outsourcing, having the benefit of delivering services without having to make huge open-ended investments in personnel, systems, technology and maintenance. This is not only cost-effective, but also eliminates the burden of trying to keep ahead of the technology curve.

The modular software components and the web-based access interfaces on which services were built-up can be adapted to other application fields, such as distance training for delivering on-the-job training to bank employees, or for reaching remote officers of distributed organizations. Standards compliance and OS software selection represent an undertaking to guarantee long-term viability and cost reduction to BSP services.

7. Conclusions

This paper presented the experience achieved during the course of a European Commission co-funded project targeted at the market validation of broadband services mainly oriented to remote collaboration. The service platform and an overview of the network infrastructure was described. These are two complementary aspects of an effort towards the consolidation

of modern high capacity networks combined with commonly available Open Source tools, in order to respond to a precise market demand in the fields of eLearning and eHealth.

Several issues were faced during the exploitation of broadband applications. These related to acceptance of innovative approaches to traditional collaboration methods. They were solved by taking the heterogeneity of user requirements into account and offering customisable services. A smooth transition towards new applications is key to their success.

In the field of the integration of enhanced teaching instruments for eLearning, some work is still ongoing. It focuses on the remotization of free-hand drawing software (e.g., Windows Journal for Tablet PC) to implement powerful e-whiteboards.

Further analysis is needed to take the Broadband Service Platform into the commercialisation phase, where legal problems overtake technical ones especially in the field of content redistribution and patents. From this point of view, each specific implementation of BSP services requires a preliminary use-case investigation. Nevertheless, the business model addressed by the project, whose value chain includes consultancy, local carriers, service providers and end customers, provides enough flexibility to match a wide range of market solutions.

In conclusion, the COBRA framework constituted a valuable and effective instrument to select and validate a portfolio of innovative services delivered over broadband networks. Keeping in mind the lesson learnt by analogue experiences, it was an additional step to consolidate the adoption of broadband applications in collaborative environments.

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