DISTRIBUTED MULTIMEDIA APPLICATIONS
THEORY AND PRACTISE

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RESUME

L'augmentation rapide des capacités des ordinateurs et des réseaux de communication a entraîné un développement spectaculaire des applications multimédia distribuées. Cela suscite encore de nombreuses questions, tant sur le plan des technologies à employer que sur le plan de la réalisation et de l'utilisation de ces applications. Ces applications ouvrent de nouvelles possibilités dans la communication homme-machine, et également dans l'utilisation des machines pour la communication entre les hommes. Dans cette présentation, nous montrons quelques exemples de telles applications dont nous pensons qu'elles auront un impact sur l'évolution de nos méthodes de travail, d'accès à l'information et d'apprentissage. Nous sommes en train de créer un nouvel environnement, le Business Application Laboratory, pour utiliser les applications comme moteur des nouvelles technologies.

MOTS CLES

Applications multimédia, systèmes distribués, vidéo digitale, travail collaboratif, interface.

ABSTRACT

The rapid increase in the capacity of computers and communication networks has produced a spectacular development of distributed multimedia applications. This still raises a number of questions, at the technological level as well as on the realizability and usability of such applications. These applications offer new possibilities in the man-machine communication, and also in the man-machine-man communication. In this presentation, we show some examples of such applications that we feel will have an impact on the evolution of the way we find our information, the way we work together and the way we learn. We are establishing a new environment, the Business Application Laboratory, which takes an application-driven approach to designing new technology.

KEYWORDS

Multimedia Application, Distributed systems, Digital Video, Collaborative work, Interface.

INTRODUCTION

The 70's were the times of the mainframes, with ever increasing processing and storage capacities. The 80's have seen the computer becoming personal, with a direct access from every user's desk. The 90's are clearly the times of communications [14, 1], where, beside the possibility of processing information, it is indispensable to be able to communicate it, or to have access to remote information. At the same time, this information becomes multimedia, including not only electronic text and binary data, but also digital audio and video.

In this presentation, we briefly review some theoretical aspects of Distributed Multimedia Applications, with an indication of the technological issues they involve. Then we present a number of examples that illustrate the various possible types of applications, in order to give a picture of some emerging tools and situations that might become common in the future. Finally, we describe a new kind of laboratory we are creating where the focus is on applications and their integration into the work environment.

DISTRIBUTED MULTIMEDIA APPLICATIONS

What is Multimedia

Literally, Multimedia is a term that covers systems that are able to handle multiple media types (text, sound, image, video...). In fact, the most spectacular feature is certainly the digital video part, and to a smaller extent, the digital audio. Digital video is also the technically most challenging type, because the amount and rate of data that it involves pushes to the limit the capacities of computation, storage and communication of the current computers and networks. Another important aspect of Multimedia lies in the combined organization of multiple data types, in particular for synchronization, compression, format conversion etc...

In itself, Multimedia is just a set of technologies, and we should not forget that these technologies are only interesting in the perspective of applications. By nature, these applications are intended for end-users, so that the conception of these applications has to be done carefully, and the interface issues become very important for the usability of the application. The interface is not restricted to the man-machine communications itself, but it also extends to the communications between different people through the machine, as it appears in CSCW (Computer Supported Cooperative Work) applications.

Typology of applications

Multimedia Applications can be categorized into three generic types:

- in asynchronous applications, a user (the editor) creates and stores some informations, that are later retrieved by one or several other users (the viewers). Such applications covers all aspects of multimedia documents, hypermedia [12], and even CD-ROM based applications.
- in collaborative applications, two (or a small group of) users interact and work together. The basic example is desktop video-conferencing, where each user receives an audio-video stream from his correspondent. But this can be largely extended in applications that are able to share data (for example windows) and allow collaborative work among groups [2].
- broadcast applications, where a single source sends common informations to a (potentially large) group of users. This is the case for lecture-type applications,

where a speaker addresses a group of students, and for TV-like applications.

MULTIMEDIA TECHNOLOGIES

Multimedia applications have created a important need for certain technologies. We enumerate some of the most important:

Standards

Because multimedia applications involve creation, transport and presentation of different data types on various equipments, it is very important that the format of these data be standardized to insure a proper interoperability. Standardization has become a key issue in the expansion of Multimedia Applications. It concerns elementary data types (like JPEG for image, MPEG for video), but also multimedia structure (HyTime, MHEG), storage (CD-ROM), communication (protocols) etc..

Multimedia communications

Transmitting digital audio and video on a network puts strong requirements on communication protocols, in particular on the quality of service QOS (guaranteed bandwidth, delay, jitter, loss etc...). Multimedia streams are often continuous, providing sustained data rates for long period of time, which is quite different from the usual bursty file transfer. Synchronization is also an issue, both for inter-stream, e.g. where the audio should stay close of the corresponding video, and for intra-stream, e.g. where an image of a sequence which arrives too late is no longer of value.

Software technologies

Multimedia is entering into the Operating Systems [11, 3] (generally under the form of multimedia extensions) which include basic services for handling multimedia data. Collaborative applications have created the need for new systems capabilities, such as screen sharing which allows the same window to be displayed simultaneously on several screens. The Object -Oriented approach is also concerned, for example in the effort of the IMA (Interactive Multimedia Association) to design a common way of handling multimedia objects on a distributed system.

APPLICATION DESIGN CRITERIA

Two important criteria for designing business computer and communications applications are transparency and seamlessness. Ihde [7, p. 56] introduced the concept of "transparency of communication" and stated that we know we have done a good job at designing a communication system when it can be "functionally forgotten"(p.58). and the user can get on with his work, albeit mediated by the technology. So not only must the interface be "transparent" but it must not interfere with the work. The second criteria must operate at multiple levels. The user must (1) feel that the application integrates into the everyday work activity and environment; (2) be able to move within the application from working alone to working in a group; (3) be able to work across different media; and (4) be able to work across time. These notions will be amplified within the context of a number of examples. Besides these criteria the designer must be aware that the application will invariably change the user process and these changes must somehow be anticipated within the application.

EXAMPLES

THE EXPANSION OF INTERNET

Internet [8] is a network of computer networks (ARPAnet, NSFnet, ...) that connects people throughout the world. While the original users were mainly universities and research laboratories, the Internet is expanding rapidly towards commercial companies, and its size, however difficult to evaluate, is reaching several millions nodes, which represents tens of millions of users. The network is used for non-profit activities, although the question of commercial usage is regularly raised and debated.

Because of its strong academic and research environment, Internet is a marvellous field for experimentation of new concepts and services. With the general philosophy of making information (and often software) freely available, research prototypes of new applications can be easily distributed to volunteering users who will test and comment their usage.

Beside the basic applications that are electronic mail and file transfer, many new concepts are now emerging, of which we will discuss two that are particularly important:

- the MBone network, a subnetwork of Internet that uses a multicast protocol for broadcasting audio and video conferences,
- the World Wide Web, an hypermedia system that allows easy access to various informations structured by users.

MBONE

MBone is a virtual network that runs on the Internet. It is based on a set of nodes that are able to support the IP Multicast protocol. The multicast protocol allows broadcast communication, where a source sends information on a specified channel of the network. The multicast routers that receive this information duplicate it and redistribute it to all of their successors. The user nodes listen on a specified channel and gather the corresponding information as it comes. This process is completely different from the standard point-to-point communication process, where a source sends information to a specified location, and the routers have to direct the information to the next successor to the destination. The broadcast communication mode raises a number of technical issues for an efficient implementation, such as error treatment, optimization, channel allocation, etc... The MBone network is used to perform experimentations in this area, under the coordination of an IETF (Internet Engineering Task Force).

In particular, the MBone network is regularly used for digital audio and video conferences [9]. A number of software exist (PictureWindow from BBN, nv from Xerox Parc, ivs from Inria) to capture sound and video on a workstation, to broadcast it on the MBone network, and to receive it on a similar workstation. Because of the relatively low bandwidth that is available on long distances, the quality of the video is generally limited (a few frames per second at a low resolution), but the quality of the audio is generally considered as acceptable. This environment is used regularly for IETF experiments, for internal communications, or for broadcast of external events, such as space shuttle launch, panels etc....

THE WORLD WIDE WEB

The World Wide Web [8] is an hypermedia system designed by CERN to facilitate the

circulation of information among High Energy Physicists. Because of its general nature, and the availability of a nice user interface (Mosaic, developed by the NCSA, National Center for Supercomputing Applications), the W3 has reached a tremendous popularity, and a multitude of organizations and individuals now use it to give easy access to the information they want to publicize.

The W3 is based on three concepts:

- a communication protocol (Hypertext Transfer Protocol HTTP) that allows the user interface (client) to communicate with the server of information,
- a mechanism to identify objects anywhere in the network (Universal Relocatable Locator URL), where an identifier such as:

  http://www.eurecom.fr/intro.html

  designates the file intro.html that can be obtained from the server www.eurecom.fr through the protocol HTTP.
- a markup language (Hypertext Markup Language HTML, following the SGML conventions) that allows to easily create documents containing hypermedia links to other informations.

The major usage of the W3 is for organizations to publicize certain information, for example research laboratories give a description of their research activities, with pointers to some of their papers, universities give a description of their courses etc... It can be used for certain events, for example the material related to certain conferences (call for paper, instruction for authors, program, registration form) can be made available. But the W3 offers more than the simple visualization of existing documents. Because of the client-server architecture, it is able to access other information servers, such as gopher, or databases such as WAIS (Wide Area Information Server) servers. Mosaic also includes a form component which allows to define fields to be filled by the user, whose value is then sent to the server. The server itself allows the possibility of activating a script (sequence of commands) written by the user, which can perform any kind of processing required, provided it will format its results as a regular document.

The W3 can be now seen as a gigantic hypermedia network, composed of several hundred thousand nodes distributed throughout the world. As anyone can produce documents that include links to any other document on the W3, the network is constantly modified. The size of the W3 raises new problems: there is so much information available that it is too much information. After a period of fascination, wandering through the W3 and discovering so many informations available, the novice user will soon reach some common problems:

"I have seen some information about X, but I can't remember where it was",

"I need information about Y, where can I find it"

There is no definite answer to these problems as yet, however, a number of researchers have started the experimentation of Robots (or Wanderers, or Spiders) programs that automatically navigate through the W3 and gather summary information on the places they visit. Many of these agents build an index for all the document they visit, so that it is possible to search in this index for some keywords and have direct access to the corresponding parts of the network.

INTEGRATED RADIOLOGICAL INFORMATION SYSTEM (IRIS)

In 1988-89 a multi-disciplinary team at the University of Ottawa Medical Communication Research Centre investigated technologies for improving the communication of Radiological information (images and diagnostic reports) between the radiologist and the client physicians. To that end, the team designed and deployed an Integrated Radiological Information System (IRIS) built around experimental multimedia communication technology which supports the capture and distribution of digitized X-Ray images and voice reports as integrated "electronic" patient folders [10]. It also supports on-line consultation between the radiologist and attending physician by providing a multimedia "shared space" through synchronized workstation operation. User-centered design was used for specifying system functionality and developing the user interface [15].

IRIS is a multimedia system capable of handling patient files consisting of radiological images, documents, and voice messages. The system can be used in one of three modes:

1. The radiologist can read patient files and dictate a verbal report which then becomes part of the patient file.
2. The clinician can review a patient's radiological images and listen to the radiologist's report.
3. The clinician may leave a verbal query for the radiologist.
4. The clinician can have a conference (tele-consultation) with the radiologist through a shared visual and auditory workspace created on two workstations.

In order to assess the clinical value and acceptance of these service concepts, the system was deployed in the Ottawa Civic Hospital to provide a real-time Emergency/Radiology link. A clinical trial of IRIS was conducted at the Ottawa Civic Hospital with the Emergency Department and the Department of Radiological Sciences between April 4 and May 12, 1989. Trials were subsequently carried out in the Department of Thoracic Surgery

As part of the trial, IRIS was evaluated in terms of usability and value to the user [5]. As regards transparency and seamless we can draw the following conclusions. The system is definitely not transparent for the Radiologist. The technology gets in the way of the Radiologist reading his films. He can see only a limited number of films at a time and manipulating the "digital" films is not as easy as the "analog" films. On the other hand, for the attending physician, the digital version of the film is adequate and because of its ready availability improves the patient care. In terms of seamless, (1) IRIS definitely integrates into the Physicians' environment and work habits as the films, reports, and remote consults with Radiologists are now available in the ward; (2) IRIS received high marks for affording a seamless transition between a Physician or Radiologist working alone on a case to a shared consult; (3) users found no difficulty in using the multimedia patient folders and in moving between the different components such as voice reports, images and textual files; and (4) Physicians and Radiologists were able to add and retrieve annotations and other information to patient files without any special effort and in fact were informed whenever patients files had been modified. The trials also demonstrated that there was a significant potential for changing the entire Radiology diagnostic process and in making it both more efficient and effective, this by providing instant access to patient files in multimedia format and in providing an effective communication link between the Physician and the Radiologist.

THE BETEL COOPERATIVE PROJECT

The Broadband Exchange over Trans-European Links (BETEL) project [13], funded by the European Commission and the Swiss Government, was one of the four projects which belonged to the DIVON program (Demonstration of Interworking Via Optical Networks). BETEL was a very short-term project, just one year, the aim of which was to run user driven applications over one of the first 34 Mbps international ATM networks. Our application was concerned with teleteaching and involved interactive communications between students at the Institut EURECOM in France and a teacher at Ecole Polytechnique Fédérale de Lausanne (EPFL). Students carrying out a computer-based laboratory exercise were supervised remotely from Lausanne.

An overview of the system is shown in Figure 1. The teleteaching application uses videoconferencing and shared workspace tools to allow interaction between a teacher and a group of remotely located students. The teacher at one site can teach a class or supervise students in their individual work in another site while the students can seek assistance from their teacher located several hundred kilometers away. The overall teleteaching application is based on two main services: video-conferencing, which enables the teacher and students to see / talk to each other and a shared workspace, which allows both student and teacher to work concurrently on the same application. The FDDI LANs at EPFL and EURECOM were interconnected to the BETEL network by means of Cisco routers. The network topology at EURECOM consists of an FDDI ring dedicated for high speed audio and video transmission, an Ethernet was used to connect student workstations to the BETEL platform, and to support connection control and shared workspace data communications, and an analog distribution of audio and video signals controlled through an analog audio / video switch. All the cameras, microphones, monitors, and loudspeakers were connected to the switch, which could be remotely controlled by the Professor in Lausanne. For long-haul transmission the video signal was JPEG compressed using a Parallax card on a Sun SparcStation.
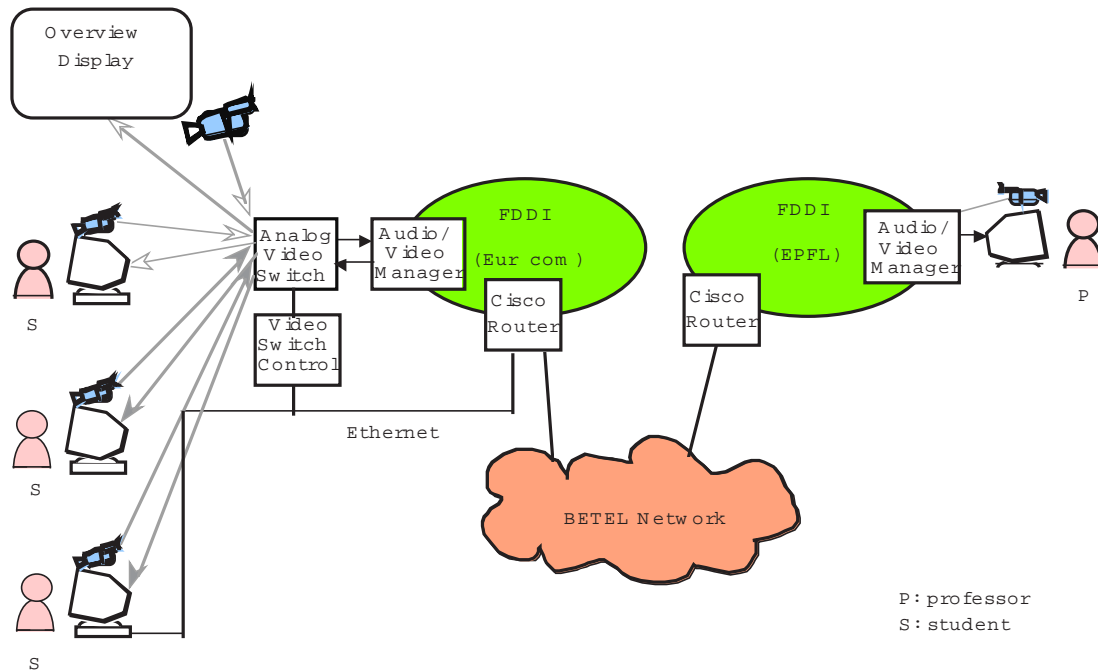

Figure 1: Teleteaching network infrastructures at EPFL and EURECOM

The Professor's user interface is shown in Figure 2 and has the following functionality:

5. High level audio/video connections control: The state can be global (the teacher speaks to all the students) or local (the teacher speaks to one specific student). Both the student and the teacher always aware of their current state.

6. Audio-video output device control: The teacher can view the classroom either from a global camera or as a collection of images, one for each student, using a Picture-in-Picture service, or he can choose a global view of the classroom with a superimposed image of a single student. The can also see himself in his local monitor (mirror), and can also mute his audio device.

7. Shared workspace connection control: During global communication, the teacher may display his windows on a global monitor acting as a white board or on each student's workspace during private communication between the teacher and a student.

8. Student question support: The students may send questions to the teacher and these are displayed in a list, which the Professor can use to initiate replies.
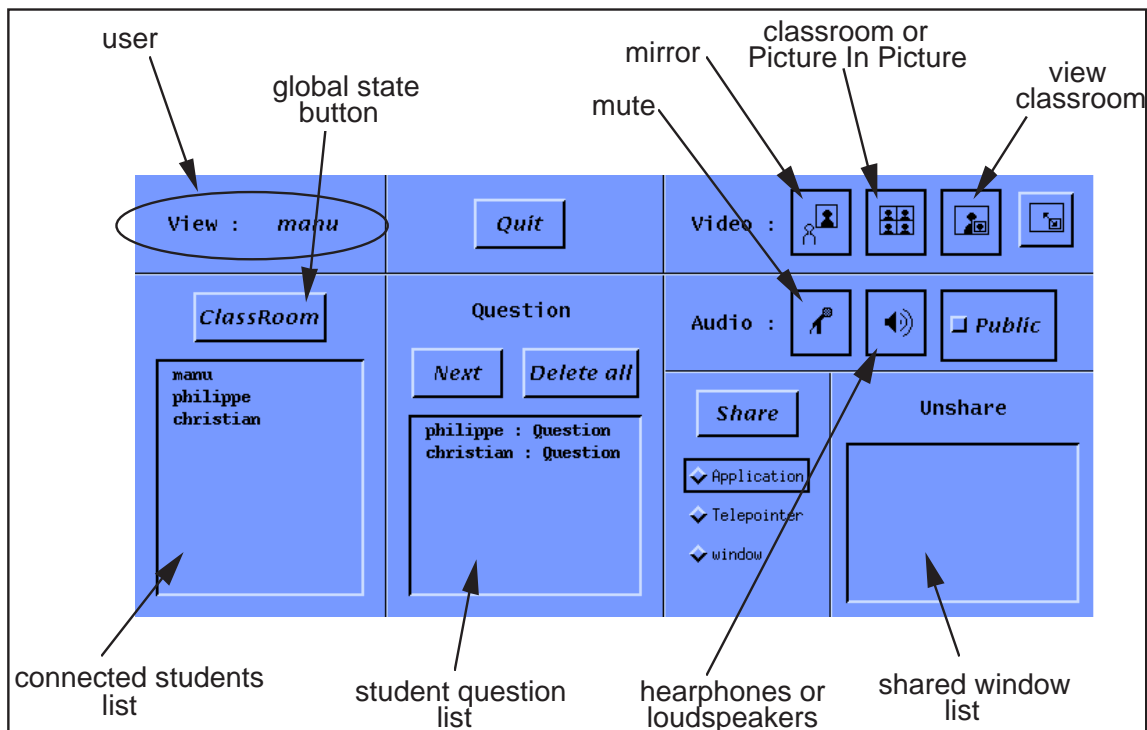

Figure 2: User interface for teacher

We did not have the time to arrange for real trials of the system. However, over a period of several months we were able to carry off-line experiments. Our preliminary impressions are as follows. The system very quickly, within one or two sessions, became quite transparent to both professor and students: interactions were very natural, in fact body movements were extensively used. The main reason for the acceptance seems to be that the ATM communication link did not add a perceptible delay to the video communication link and that the audio quality was very high. In terms of seamlessness, (1) the facilities offered by BETEL integrates into the student's environment and work habits when they are doing laboratory work based upon simulations; (2) the transition from a student working alone to one with the professor was extremely smooth; (3) users found no difficulty in handling the audio-video link and in sharing applications. In terms of process change, we can only ven-

ture to suggest that these kinds of facilities offer the potential for new forms of learning and interactions.

THE EURECOM VIDEO DESK[1]

The Eurecom Video Desk (EVD) is a variation on an old theme already played by Xerox [16]. The basic idea is to transform the surface of a regular desk into an interface tool by adding capabilities for capturing and displaying information that can be processed by a computer. The display function can be realized through screen projection (either from under or above the surface of the desk), or by using a horizontally-mounted TV display. Capture can be performed with cameras or sensing devices such as sensitive tablets. In our implementation, as shown in Figure 3, the EVD consists of a flat surface that includes a translucent glass. A projector with a LCD tablet sends the image of a computer screen on this glass, by reflection on a mirror located under the board. Overlooking the surface are two cameras, one right above the glass to manipulate documents on the electronic world, one above an area on the board to manipulate the physical documents.
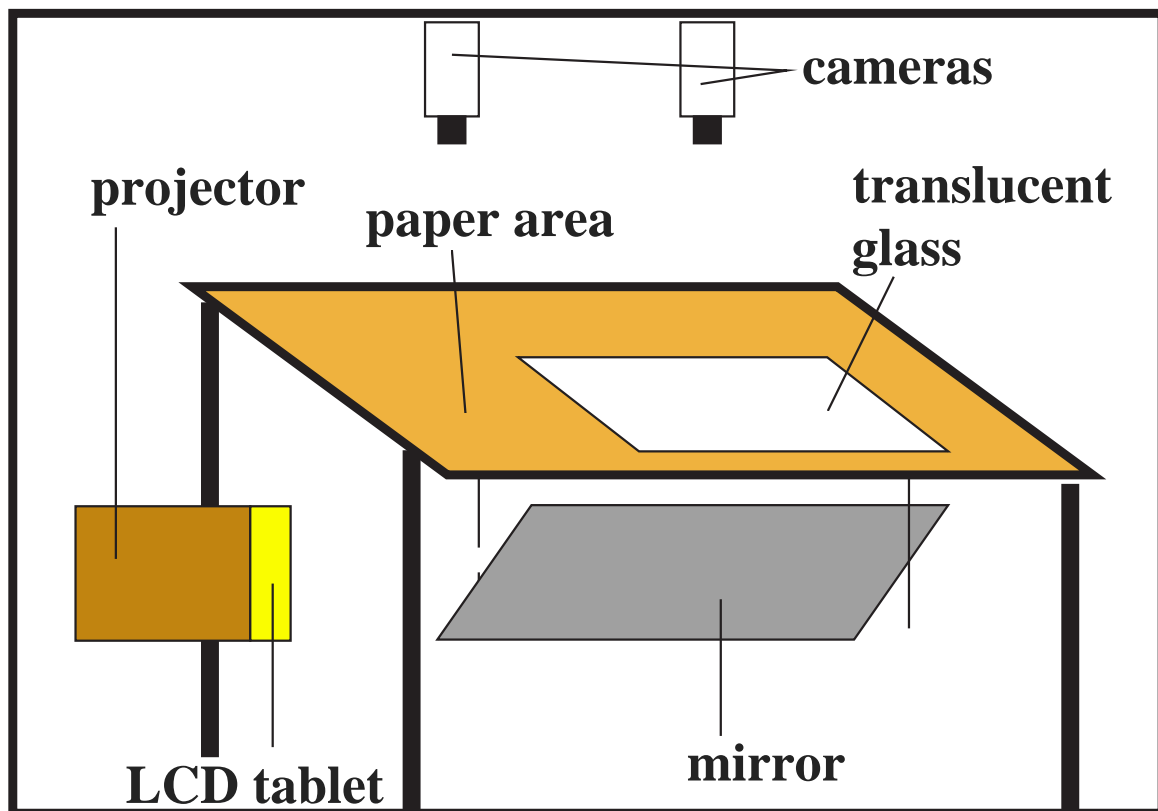

Figure 3: Schematic of the Eurecom Video Desk

The EVD operates as follows:

- the user comes with a paper document, places it under the physical camera,
- he selects an image within the physical document by placing his fingers on top of diagonally opposite corners,
- he drags this image onto the glass surface by moving its hands (fingers) to the proper position, adjusting the position and size of the virtual image over a window in the
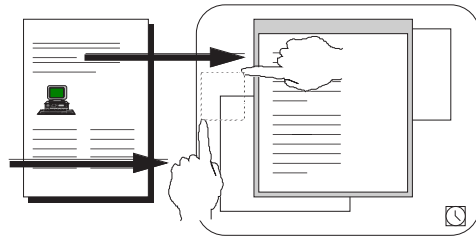
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1. This project was done in collaboration with P. Gros, A. Aime, P.E. Gros, M. Nimhauser, P. Osseland, R. Swierk, H. Syfrig, P. Vildier.
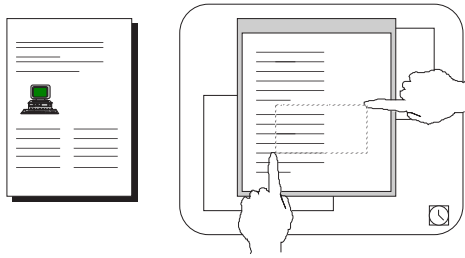
virtual world,

• when the location and size are correct, he simply holds his fingers in place for one second to initiate the transfer, and the image is automatically included in the electronic document.
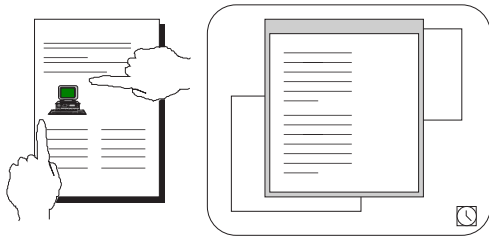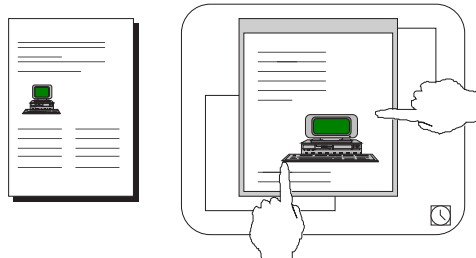
1: selection of image on paper document

2: drag of image using fingers

3: adjusting image size and position

4: image insertion into electronic document

The EVD was designed following a fast prototyping technique, where we first created a paper version of the interface to simulate its behavior. The physical prototype was actually built to validate the concept, and some shortcuts were taken to achieve reasonable feasibility:

• the paper document had to be previously scanned (using a scanner),
• the positions of the images on the paper document were given a priori (we had no software for automatically partitioning a scanned document into text and images), so that the hand would just indicate which of the identified images was selected,
• in the electronic world, the window containing the virtual document had to be opened using regular keyboard and mouse interaction, and the editor positioned at the proper page of the document.

WORK-IN-PROGRESS

We are currently engaged in two applications oriented projects. The technology to carry out both these project is in-hand, the real challenge is in mastering the application and its introduction into the field.

1. BETEUS, for which Eurécom is the project manager, is the 16 month continuation of the BETEL project, the main goals of which are to extend the technology developed under BETEL to real world business applications. The notion of a "virtual community " has been retained. A virtual community consists of a group of individual who are geographically dispersed but yet have some purpose. Examples in the business world abound; e.g. a team of engineers working on product development, marketing groups, crisis teams, and so. Carrying out such an experiment in a real setting is beyond the means of the consortium, instead an executive training application has been chosen as the vehicle for demonstrating the virtual community concept in business. One format used for executive training is a workshop spaced over a number of days during which are scheduled various inter-linked

activities, such as formal lectures, panels, group assignments and presentations, business games featuring activities such as negotiations, and informal meetings. Underpinning all these activities is the accompanying administrative support. During the time of the workshop a real community is created with the attention of all the participants and support staff centered on the workshop itself. These workshops normally take place in one location as presently available technology cannot overcome the barrier of space to create a community atmosphere. The objective of the Beteus application is to show how the community atmosphere can be extended across the different locations.

2. AREA is an application oriented European (RACE R2102) project to develop and demonstrate a distributed service environment for the agricultural sector. Specifically AREA focuses on (1) providing remote expert support for phytologies which combine a multimedia expert system for diagnosing infestations with a two-way video voice and data communications facility which allows users to consult with remotely located experts; (2) offering real-time distance training together with computer based courseware; and (3)a specialized timely information service.

THE BUSINESS APPLICATION LABORATORY (THE BAL)

In today's business environment, technological and organizational innovation are key to survival and growth. However, simply acquiring new technical systems and organizational solutions does not lead, per se, to success and a sustained competitive edge. There is however a large conceptual gap between the solutions offered by technology and the development of new business models which can exploit these possibilities. It is easy enough to look at individual pieces of technology and to understand what they offer, it is much more difficult to see how an innovative use of these technologies will change current business practices. Without this mental picture, development of strategy becomes difficult.

Rather, it is the effective learning and implementation of the new socio-technical solutions which makes the difference between success and failure. We claim that this perspective is central to success in the new business economy, thus requiring a different attention to design and implementation of the socio-technical systems. This has implications on how systems are developed, how new organizational forms are tested and evaluated, how innovation is transferred and how suppliers and customers interact. Users will influence the design process at a fundamental level, as such the need for user-centered approaches returns the technology to the root competencies of the organization.

Theseus has established the Business Application Laboratory (The BAL) as a place where the user/customer and supplier are brought together to envision, learn and identify new services, products, and work and business practices, all through experimentation. The BAL will develop envisionment techniques based upon scenario building, fast prototyping and iterative design, where validation is carried out both at the "product" and "business process" levels.

The following two hypotheses are central to the BAL lab concept. The first hypothesis is that the efficiencies obtained by business process engineering (BPR) will soon reach their end-of-cycle [6]. At the heart of BPR is transaction processing, which concentrates on the what-to-do part of the process. The second hypothesis centres on the notion of communicating which covers to a large extent the how-to-do part of the business process. It is claimed a large portion of enterprise activity consists of communicating and that these activities have not been engineered. Communicating occurs within a company, between a company and its

suppliers, between a company and its customers, etc. Multimedia technology will play a central role in helping companies achieve new and more efficient organizational structures.

CONCLUSION

We have shown some examples of new applications using the Multimedia technology. These applications are only the tip of the iceberg, the real applications will only emerge after the real usages of these early prototypes show more precisely how these are to be designed and integrated into the work world. In return, we think that these applications and the real usage of the technology will indicate new directions of research for these technologies.

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