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SPIE—The International Society for Optical Engineering

High-Speed Fiber Networks and Channels

Kadiresan Annamalai
Chair/Editor

4–6 September 1991
Boston, Massachusetts

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HIGH-SPEED FIBER NETWORKS AND CHANNELS

Volume 1577

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Conference 1577, *High-Speed Fiber Networks and Channels,* was part of a two-conference program on Networks held at SPIE's OE/Fibers '91, 3–6 September 1991, in Boston, Massachusetts. The other conference was:

Conference 1578, *Fiber Networks for Telephony and CATV*

Program Chair: **Dilip K. Paul,** COMSAT Labs.

INTRODUCTION

The nineties have ushered in very inexpensive but powerful desktop computing. This is also proving to be the decade of connectivity, with emphasis given to conformance and interoperability of high-speed networks like FDDI. There is also a lot of interest in looking beyond FDDI and standardizing high-speed peripheral interconnections to computers. These two developments are known as FDDI follow-on and fiber channel. Along with the above developments, the subject of internetworking to lower speed LANs and public data highway is also increasingly growing in importance. This conference endeavored to present the latest developments in this growing high-speed networks and channels arena.

The conference was split into eight sessions as follows: (1) Technology in Support of High-Speed Data Services, (2) Internetworking and Protocols, (3) FDDI, (4) High-Speed Network/Channel Components, (5) High-Speed Channel, (6) High-Speed Network Protocols, (7) High-Speed Network Architectures, and (8) Emerging High-Speed Networks.

The session on technology in support of high-speed data services presented papers on multimedia communication architectures, ATM-based SMDS networks, and misordered frame delivery in connectionless MANs. The internetworks and protocols session dealt with issues of internetworking in high-speed communication, internetworking between FDDI follow-on and B-ISDN, HIPPI as a backbone for multiple FDDI networks, and simulation studies of FDDI-based LANs. The session on FDDI had papers on adapter cards for VME and AT busses, campus FDDI networks, the use of FDDI physical layer components to deliver higher bandwidths, and building wiring standards. The high-speed network/channel components session presented papers on extending the bandwidth x distance product for multimode fibers, physical layer design considerations for 1 Gbps LANs, results on using unshielded twisted pair for FDDI, burst mode receiver for optical bus applications, highly integrated CD laser-based data links for up to 800 Mbps, laser safety control techniques, and a bipolar gate array for up to 1.5-GHz serial data stream.

The high-speed channel session dealt with the currently evolving fiber channel standard and the fabric services to support them. There was also a paper on the work performed in a national lab to demonstrate the fiber channel, and a paper on a serial HIPPI extender. The session on high-speed network protocol had papers on photonic networks, coding for high-speed networks, and transport services and protocols. The high-speed network architectures session contained papers dealing with current and future supercomputer network architectures, improvement of the throughput to the application, and a distributed network environment at a national lab. The final session on emerging networks highlighted development to remove the bottleneck of transport layer, a proposal of gigaplexing FDDI and FDDI II LANs, high-speed networking requirements for a research lab, and a multigigabit/second subcarrier multiplexed LAN for a heterogeneous traffic consisting of datagrams, ATM cells, and circuit-switched video traffic.

Overall, this conference had a lot of participation from end users, component, and product developers. Also, the latest research findings were reported in the area of components for fiber channel and fiber networks. I would like to thank all the authors of this conference for their participation.

Kadiresan Annamalai
TriQuint Semiconductor

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SESSION 1

Technology in Support of High-Speed Data Services

Chair

Andres Albanese
Bell Communications Research

Multimedia Communications: Architectural Alternatives

Terrence P. McGarty, Ph.D.

MIT, Cambridge, MA
NYNEX, Orangeburg, NY

S.T. Treves, M.D.

Harvard Medical School, Boston, MA
Children's Hospital, Boston, MA

ABSTRACT

Multimedia Communications systems are a combination of human interfaces and end users interacting with multimedia data bases and highly disparate but interconnected communications networks. This paper discusses several architectural alternatives and system requirements that will assist in the design and development of MMCS in actual environments. The approaches taken in this paper are based upon the development of such systems in both medical and printing and publishing environments. This paper develops several key concepts as how best to define and structure data in a multimedia environment, how best to integrate the communications elements, and how best to permit the maximum flexibility to the end user to utilize the system's capabilities in the context of a fully-conversational environment.

1.0 Introduction

The development of both communications and computer systems have been driven by the need to increase the underlying performance of the technology. The pressure has been on producing more bits per second or more MIPS. Data base systems have also been directed towards a similar goal in that they are designed to store more data and to retrieve it faster. Only recently has there been increased interest in designing systems from the outside in rather than the inside out. That is, the old design methodology assumed that one designed from the technology out to the user, and that the user learned to adapt to the technology. UNIX (TM, AT&T) is an example of such a design. The new systems are more user driven, exemplified by the Apple MAC design.

In the last few years, the concept of multimedia systems has developed and is in its early evolutionary stages. Many authors have viewed multimedia as nothing more than a fancy display and several storage devices. In contrast, the seminal and brilliant work of Winograd and Flores has depicted the computer environment in a much broader context; one that recognizes the holistic interfaces necessary for the user, the designer, and the technology infrastructure. The authors develop a philosophy of design. It is this philosophy that we build upon in this paper with a view to developing an architecture.

2.0 Architectural Alternatives

To understand the overall concepts of multimedia communications, it is first necessary to place the total concept in the context of an architecture. We have developed such a construct as the basis of a philosophical approach to a system design. It has been argued persuasively in Winograd and Flores that having a philosophical set of underpinnings establishes a common set of beliefs that can be used for both building and expanding the body of knowledge as well as critiquing the concepts that evolve from it. All too often in the area of multimedia, there is the construct of the day in the absence of a base. The architecture developed in this paper is proposed as such a base.

An architecture can be defined as the conceptual embodiment of a world view, using a commonly-understood set of constructural elements, based upon the available set of technologies. To

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deconstruct this definition, we first indicate that our abilities to design and deliver functional systems are delimited by the set of operational technologies. These technologies may be hardware or software-related or a combination of the two.

The constructural elements of the architecture definition are the following:

(i) Human Interface: This is the end-user connection that allows the system to communicate directly with the human entities that are to be combined with the other architectural elements.

(ii) Interconnect: This element allows for the connection of all users, whether they be human, data bases, active data elements, or whatever, and support an underlying conversational element.

(iii) Data Bases: These are generalized storage devices for the retention, restructuring, and dissemination of the stored complex multimedia data structures. They may be embodied in the constructs of image storage devices or in voice storage devices.

(iv) Device Interface: These are the interfaces to non-human devices or users of the system. These elements are typically driven by the specific needs of the devices that are to be connected to the network.

(v) Transport: Transport is the element that allows for the data or other elements necessary for effective communications to move from one point to another.

(vi) Control: The control element is the element that allows for the underlying integrity of all of the other elements. It may be the network management control, the software processing control, the data element synchronization control, or an amalgam of all control infrastructures required to meet the anticipated level of network performance.

These six elements are integral in the design of any multimedia communications sytem. The interfaces (human and device) and the data bases represent the highest level of an architecture. They represent the visible elements that can be viewed as externalities of the system. In comparison, they may be viewed as the roof, walls, and floors of a building, all necessary elements, changeable by the technology and molded by the world view. The interconnect, transport, and control elements may be considered the wiring, heating, and foundation elements of the structure. They are not readily seen but are essential to the integrity of the architectural structure.

The architecture that we have developed for multimedia communications is a four-level structure. On the top level, we have called the elements the applications; namely, the externalities as viewed by the end user. These are the interfaces, both human and device, and the data base interfaces. The three applications of REVIEW, REPORT and CONSULTATION are described not only in terms of the applications software or the screen but in terms of the human interface externalities needed to ensure proper usage of the intended application.

The system services layer allows for the interconnect function. In this level, we place a set of clients that allow for the interaction of all elements at the top application layer. This architectural embodiment begs the question of centralized versus distributed. It clearly, in its very statement, indicates the need for a fully-distributed embodiment.

The network services layer is the control layer of the architectural elements. It is at this level that control over the integrity of all communications and data structures is maintained. It also is structured in a distributed fashion, recognizing furthermore that the system must function in a highly nonhomogeneous fashion.

The bottom layer is the transport layer. This layer also goes directly to the heart of the world view taken in the architecture. It is a world view that states that there will be multiple overlay networks, with capabilities for high-speed transport, but operating at different speeds and controlled by varying protocols. It also assumes, contrary to a hierarchical telephone world view, that the users will want to control their destiny, not a centralized telephone authority. Once liberated, the end users will want only more freedom, not less.

3.0 Human Interfaces

The importance of interfaces between human beings and these systems cannot be emphasized enough. Successful interfaces permit the use of computer systems to their fullest potential. Conversely, poor human interfaces can prevent the optimal utilization of a good computer system and can even completely discourage potential users to use such systems. Those users will find ways to avoid the system and work "around" it. Human interface designs must be viewed as solutions to existing problems, rather than as partial technical solutions looking for problems which they may solve. A successful interface is simple, intuitive, easy to learn and to remember, and it provides advantages over manual systems.

Putative advantages of good human interfaces include:

a) time and cost savings
b) improved data processing capability
c) completeness of transactions
d) improved access to same or even greater amounts of pertinent information, normally not easily available
e) improved quality of the end product
f) elimination of redundancies
g) improved human communications.

Depending on the user, many or most of these features are needed in order to make a human interface successful.

The design process of a system provides a good opportunity to re-evaluate established work habits and workflow, of which the human interface is an essential component. Human interface design should not necessarily aim at just replacing the older, manual system, but to improve on it. Human interface designs should be the result of a combined effort between ultimate users and designers of the interface. During the process of studying the design of a user interface, active interaction of an informed user and the architect will likely unveil newer approaches to methods and procedures that may be an improvement over older or purely manual procedures.

Development and introduction of new systems human interfaces must take into consideration present workflow and work habits of the local culture, must identify and anticipate perceived and real needs, and aim to avoid adding a new process into an already busy environment. The application must represent a replacement of current activities and routines and prove to be an improvement over old methods. (See McGarty and Sununu)

During the early process of human interface design, it is important to consider the most generic aspects of applications, the kind of people involved, and the environment in which these will exist so that these are not forgotten while designing the very specific user needs. Modular designs with a very broad range of options are much better than rigid designs. Special subsets of such modules can be then concatenated for specific users. It is important to consider the actual means of interaction such as keyboard, joystick, mouse, touch screen, voice, etc.

The authors have observed that implementation of certain commercial products in the areas of radiology information systems and image storage and transmission systems which were expected to improve work, reduce redundant tasks, increase efficiency, or reduce the number of employees have, in fact, produced the opposite effect. That is, these new systems have failed to replace older systems, have added new processes, more paper work, and increased the level of complexity of work. In addition, implementation of these commercial systems have required additional people in order to support their operations and to maintain them. These factors resulted in more confusion, lengthening of the overall process, and increased expenditures.

User interfaces should adapt to the user's functions and needs and not the other way around. Interface designs must consider the user's needs first and the technical idiosyncrasies second. Although design of user interfaces must take into consideration the perceived current technical limitations of existing software and hardware, it is important to keep in mind the rapid evolution of systems that is occurring at present, and that in, fact, additional solutions and tools may be available. Meticulous attention to user needs is paramount. The design should come from careful examination of the system and process that the interface aims to address. In concentrating on the specific needs of a user in an organization, one must evaluate the effect and interrelations of such application in the global functions of the organization of which the user is a part.

There are independent, highly-specialized, human interfaces that serve a rather homogeneous and specialized group of users within a highly-sophisticated local culture. These are relatively easier to design. There are also human interfaces that must address the needs of larger and heterogeneous populations with varying levels of education, cultures and habits. These interfaces, which should be simpler, are, in fact, much more difficult to design.

The most common user interface is a workstation, the simplest of which consists of a video display monitor and a keyboard. The interactions are limited to typing commands on the keyboard and reading the text responses on the monitor. This type of human interface may suffice in a number of applications, such as word processing and electronic mail.

Other applications require display of images as well as text. Some applications may only require image representation of a pixel resolution in the range of 256 x 256. There are applications that require the representation of images of high spatial resolution in the range of 1,000 x 1,000 or even 4,000 x 4,000 pixels. In addition to display of text and images, other applications require voice recording and playback, and the representation of moving images, video, and three-dimensional images. Diagnostic medical imaging is an example of an area where these features are needed.

Some user interfaces require highly-sophisticated access to data, including high-resolution images. The requirements for these kinds of human interfaces are highly complex and sophisticated. Image enhancements, display of several images, image processing, display of several imaging modalities simultaneously, image quantification, cinematographic, and 3-D displays are but a few of the features required. The issues of display resolution, number of displays, voice annotation, text annotation, integration with other processes relating to the workflow, must all be addressed in order to achieve true integrations and, therefore, the two goals stated above.

Other human user interfaces require "view only" features; that is, these interfaces need to allow the user to recall in a rapid, easy, and straightforward way the data, including images, voice, text, etc. These user interfaces should be as easy to operate as the automatic teller machines (ATMs) widely installed in banking institutions.

Other user interfaces will require the additional complexity of providing real-time consultation among two or more persons who could be viewing the same data (images, etc.) on-line, in order to add their individual knowledge to these data (Session). Synchronized pointers should be available so that several users could concentrate on specific features of the data. During these sessions, data exchange may take place where several dispersed pieces of information could be shared by the group of consultants. This interaction could occur, as I mentioned, on-line, or even on a time delay, such as electronic mail is used commonly in large corporations today.

Issues of security, access and confidentiality remain important considerations in the technology, design, and development of human interfaces and exchange of data of a sensitive nature.

Example: Diagnostic medical imaging. Diagnostic medical imaging encompasses several kinds of modalities. These include radiography, nuclear medicine, computed tomography (CT), ultrasonography, magnetic resonance imaging (MRI), digital angiography, etc.

During the past two decades, impressive developments in several areas of medical imaging technology have taken place. The amount of information about the human body that is being produced is enormous. Unfortunately, this fantastic progress in the technology of medical imaging has not been paralleled with a similar improvement in our ability to manage the very vast amount of information produced by this advanced and multifaceted technology. Information overload has taken place. Unfortunately, it is difficult to convert this massive amount of information into knowledge. It is only with the intelligent introduction and implentation of excellent computer systems that this information overload can be tackled.

Except for conventional radiography, some of these areas of imaging are highly specialized and require complex computer processing of images in order to extract useful information. Images are stored on film and on magnetic or optical storage in local applications. Each of these imaging modalities have their specific acquisition, storage, retrieval, and image format. Image formats and communications standards are not yet fully realized. Manufacturers typically retain their proprietary stance, making it difficult or nearly impossible to represent, manipulate, store, transmit, or retrieve images from these modalities in the same format. Even conventional radiography is expected to become computerized during the next decade (computed radiography). Often, several kinds of images of the same patient need to be evaluated in conjunction in order to arrive at better diagnoses, rather than by looking at one of these images only. At present, these consultations occur while physicians are looking at films. Often, films are not available or have been lost. In addition, films can only be at one place at a time.

As the specialist in medical imaging evaluates images from a particular patient, he will need to have available other pertinent data such as demographics, referring physician's name, address and telephone number, the reason why the imaging examination has been requested, and also images and interpretations of previous imaging procedures performed on the patient. In addition, the imaging specialist may require results of non-imaging tests that the patient had such as blood tests, urine tests, etc. Having access to pertinent additional information helps the imaging specialist to produce a more accurate and specific diagnosis or recommendation. In the hospital of today, typically this additional information is not easily available and it may be dispersed over several departments in the hospital. The process of producing a diagnostic report usually consists of a dictation on magnetic media, and this dictation is then transcribed by a transcriptionist. Such transcribed voice is reviewed, edited and approved by the imaging specialist, either on paper or on a video display terminal. Such review and approval typically takes several hours or several days and is usually done without the images, so that the physician has to rely on his memory of the case. Because it takes so long for the printed, approved report to be produced, the information in such documents may be irrelevant to the immediate care of a patient. By the time the paper report is mailed and received by the referring physician, the report may be perfunctory. In many instances, the results of imaging examinations are reviewed by the referring physician and the imaging specialist, either in person or by phone. Many medical decisions take place based on this immediate interaction/consultation between the referring physician and the imaging specialist.

For example, in diagnostic medical imaging, a design could serve a specialist in computed tomography quite well; however, the functionalities developed may not be adequate for a specialist in ultrasonography, magnetic resonance imaging, nuclear medicine, etc.

In medical imaging there are some common functional features to the work in all imaging modalities. That is, there are common transactions that have to do with admitting the patient into the imaging department, specific clinical and examination features, resource utilization capture, image processing, image viewing, image recall, interpretation, voice and/or text (knowledge) annotations, billing, transmission of information to referring physicians. Therefore, in the human interface design, one should think of the totality of the process of patient care, department and hospital functions, as well as the individual imaging specialist's needs. Major and necessary goals in the design and implementation of human interfaces and of their underlying systems are that they produce one or both of the following results: (1) economies and (2) improvements in patient care.

Functional specification and early prototypes of three applications have been developed for medical imaging. These are REPORT, REVIEW and CONSULTATION.

REPORT: This application provides a single environment for the imaging specialist to evaluate images and pertinent non-imaging information in the process of producing a multimedia report. REPORT provides a convenient environment where the knowledge of the imaging specialist is attached to the image. The following is available to the reporting physician:

1) Patient name and demographic data
2) Referring physician's name, address and telephone contact
3) Reason(s) for the patient's referral
4) Working diagnosis
5) Images and pertinent quantitative data obtained during the current encounter and from previous encounters
6) Other imaging modalities.

The following processes are available to the REPORT application:

1) Image display, enhancements, and other manipulations
2) Image fusion (current and other modalities)
3) Single and multiple serial images
4) Cinedynamic display
5) 3-D imaging
6) Freeze image/publish image
7) Add brief voice annotation
8) Pointers and text annotation on the image
9) Final voice report, review, edit, and approve
10) View, edit and approve final transcription text
11) Multimodality display and review
12) Ability to enter text report directly
13) Create final multimedia report (image, voice and/or text).

Once the multimedia report is completed, reviewed, and approved, the report is "published." This means that the multimedia report now becomes available for review by other members of the patient-care team. The multimedia report so created is part of the patient's electronic medical record and, as such, is subject to view by other physicians. In this way, final reports are available to the referring physician without the delay experienced with current methods and without the confusion that can occur with"preliminary" reports.

REVIEW: This application is designed to be used by any member of the patient-care team with appropriate access, including imaging specialists. This application enables the physician to view, read and listen only to the multimedia report. If the hospital has an integrated electronic medical record environment, REVIEW could be a special subset of a physician's workstation, where any information in the medical record could be reviewed, including images.

CONSULTATION: This application is designed to enable communications of imaging and other information by two or more individuals; for example:

1) Two or more imaging specialists are evaluating the imaging studies of a patient;
2) Imaging specialists and non-imaging specialists are evaluating images and other information about a patient. These work groups could share and exchange patient information in order to arrive at a diagnosis and/or to plan therapy.

The CONSULTATION application can be invoked directly, or it can be invoked at any time while in the REPORT or REVIEW applications.

CONSULTATION may occur on real time, or on a time-delayed basis. CONSULTATION can produce a REPORT that can be REVIEWED. In some ways, REPORTS resulting from consultations among various imaging specialists could be conceptualized as "super-reports" as they contain the combined knowledge of two or several imaging specialists.

The implementation of these applications can result in economies due to the fact that they avoid unnecessary duplication of data entry, permitting efficient management of the data within the working environment. Many steps are saved and the information is available on demand at many places simultaneously. Expensive travel time by physicians and other members of the care teams is reduced. Quantitative analysis of the cost savings resulting from the introduction of these systems is possible and should be conducted. In order for these projected economies to be crystallized, these applications should work well and be integrated into the workflow in such a manner as to replace previous work habits completely. The applications must be well-integrated with departmental and hospital information systems. Incomplete and partial systems will only add more processes and frustration and will be more expensive at the end.

In addition, patient care should improve as the information generated is easily available for review and analysis when it is needed and where it is needed, avoiding unnecessary delays, phone calls, potentially reducing the number of patient visits to the physician's office or hospital, reducing patient anxiety and waiting. Studies demonstrating these putative studies have not been conducted extensively and are difficult to quantify.

4.0 Data Base Elements

Data elements in a multimedia environment must take on a different and expanded role as compared to those in a more classical computer environment. Consider the needs of the user of data in such an environment.

First, the data elements are of differing forms and include video, voice, text, image and even tactile responses related, for example, to pointers and other tactile interfaces. The system must be able to store and retrieve these elements that may reside on different devices, as well as having the capability to ensure the temporal, spatial and logical relationship of these data elements.