PC Based Multimedia Communications System Using Optical Networks

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INTRODUCTION

State University of New York Institute of Technology at Utica/Rome, located in Central New York, is one of the 64 campuses of the State University of New York System. It was founded in 1966, primarily to be an upper division transfer college for students who have completed their first two years of higher education at a community college. The department of electrical engineering technology is a part of the School of Information Systems and Engineering Technology and offers Bachelor's degree programs in electrical engineering technology, computer engineering technology, and photonics. A Master of Science in Advanced Technology is jointly offered by the departments of electrical, mechanical and industrial engineering technologies.

The SUNY Institute's electrical engineering technology curriculum includes theoretical issues, but our objective is to teach students to use current, state of the art equipment and emerging technologies to solve practical design and application problems. State of the art equipment and laboratories are critical for the electrical engineering technology curriculum because of the strong hands-on emphasis. The department of electrical engineering technology has been offering number of high level courses in the areas of fiber optics, data communications & computer networking, digital image processing & vision and data compression & multimedia technology and optical communications. Because of hands-on nature of the program each course has an assigned laboratory. Considering the rapid rate at which electrical engineering technology and equipment are changing, the existing equipment needs to be updated and improved to adequately prepare the students.

The purpose of this paper is to present the results of NSF-sponsored Instrumentation and Laboratory (ILI) program for equipment to link the electrical department's image processing & vision lab and fiber optic communications lab by an optical network. The proposal for the grant was submitted in 1993 and it was funded in 1994. The enhanced laboratory facilities help advance instruction for all undergraduate students who enroll in the courses mentioned above as well as majors in electrical engineering technology, computer engineering technology and photonics.

DEVELOPMENTAL PLAN

Our main objective of the project was to provide a facility where students from five different courses mentioned above, can integrate their knowledge and be exposed to hands-on experience in the current technologies with the state-of-art equipment. At the time of writing this grant, the lab for image processing & vision and data compression & multimedia technology courses consisted of one camera, one video and data compression card, one work station and an obsolete Vicom vision system. The labs for fiber optics and optical and data communication consisted of signal generators, analog and data communication systems, light sources, optical power meters, optical time domain reflectometers, bit error test meters, protocol analyzers, and oscilloscopes. In order to integrate the knowledge taught in these courses, it became apparent that processing of images, integrating them with voice and data and then transmitting them was an important technology needed by the industry.

Although the existing labs in these areas were fully operational, the equipment consisted of stand-alone pieces with minimal capability of storing, processing or networking. This meant that real time experiments involving the transmission of voice, video and data could not be performed due to lack of computing power for signal processing, storage and networking. In addition, the students were not exposed to design, interface, evaluation and communication of information in real time.

Transmission of multimedia information deals with elements of sound, text, graphics, still images and full motion video. Such a facility requires higher computing power and higher bandwidth to transmit and as a result places a heavy demand in hardware and software. For example, one second of high-quality 16-bit audio translates into 176.4 kilobytes, while one second of moving images at 30 frames a second demands up to 27,648 k bytes/sec. A color display of 1024 by 1280 pixels with 24 bits per pixel, requires almost 4 megabytes of memory. Running a series of still photos at 30 frame a second requires a bandwidth of 120 megabytes/sec. This problem of bandwidth is addressed first by compressing the video and audio data into small file sizes and second by expanding the bandwidth of buses and network links for the files to be transmitted. Joint Photographic Experts Group (JPEG) and full motion developed by the moving pictures experts are used to compress video at a ratio ranging from 20:1 to 200:1, depending on the quality needed. [1]

In the case of networking, the data rate for compressed full-motion video presentation is not the issue but it lies in the name of data being transferred. In LAN networking the data is sent in packets and bandwidth is shared assuming that data is time dependent. When network is busy carrying packets from one station, no other device can transmit as it occupies the entire transmission channel. Video, audio, and interleaved video/audio used in multimedia applications on the other hand requires simultaneous nonstop transfers. If the bandwidth of the LAN is narrow, the quality of video frames will be affected by the loss of video frames and audio file size. Improved hardware and modification of local-area networking is needed to transmit multimedia information.

The commonly used LANs are Ethernet and FDDI and both of them use the principle of sharing medium among several stations. The Ethernet uses CSMA/CD method of accessing the medium which behaves in a probabilistic way. The FDDI, on the other hand uses a token passing ring and have a more deterministic behavior. Networks based on probabilistic accessing methods are not adequate for supporting multimedia real-time transmission. Automatic collision detection as used in Ethernet causes severe performance degradation in high traffic implementations. FDDI also has built-in network management features that helps to isolate faults. Because of higher bandwidth of fiber optic cable FDDI uses unilevel NRZI (non-return to zero inverted) format as compared to multilevel codes used in some of the new fast Ethernet systems. The FDDI, however is a complex protocol and is more expensive than the Ethernet. [2]

EXPERIMENTAL SETUP & IMPLEMENTATION

The enhanced laboratory facility consists of PC based multimedia communication systems fully equipped with hardware and software to digitize, compress and transmit video and audio files. It permits students to acquire hands-on experience using a real time system by transmitting the multimedia information using fiber based FDDI network. The system was developed by purchasing additional equipment and incorporating with the existing equipment. It consists of 2 PC based workstations each, located in the computer vision and fiber optic communications labs at two different floors of the College building. The two stations at different floors are connected by a fiber based FDDI network. These work stations are equipped with interface cards for video, and audio inputs as well as drivers and editing software. Their function is also to interface the video and audio input signals to the PC based workstation and compressing it for storage and transmission. Digital cameras, VCRs, CD ROMs, scanners and printers are the input and output peripherals. One FDDI hub each, is located in the vision and fiber optic communication labs. These hubs are interfaced with the PC based workstations by a network card. The workstations also contain object oriented authoring software to integrate audio, video, images, graphics and text. A server is also included in the network for distributing application software.

The components for FDDI network were purchased individually instead of buying a whole turn-key project. This enabled us to save money and to chose the state of the art equipment. FDDI network consists of the FDX-100 hub with two modules, a physical access module and media access control management module manufactured by RAD Communications. The modular multimedia FDDI hub using fiber optic link was implemented in a stand alone mode. Double ring FDDI is to be implemented by interconnection of the two hubs by additional fiber optic bus at two floors.

The FDDI network consists of FDX-100 and two modules, FDX-MAC-2 SNMP module and software and FDX-4 and EISA board for the bus. FDX-100 hub is a compact enclosure accommodating up to five plug-in modules. It incorporates one or two power supplies with built-in redundancy, and a common logic unit, which includes a control circuit for optional operation of an external optical bypass switch. FDX-MAC-2 SNMP is a media access control management module which provides management facilities for the FDX-100 FDDI hub and the associated FDDI network. The MAC module supports a single or dual MAC operation and provides several management functions like network monitoring including error monitoring, network control, including full control over the PHY-2 or PHY-4 modules, advanced diagnostics and hub management. [3]

The PHY-2 and PHY-4 physical access modules provide two or four FDDI ports, respectively. Each port provides physical access to FDDI station by providing a single or dual attached connection. Each port supports the ANSI X3.148-1988 physical layer as well as connection management protocols. The physical interface in our case is established by using a multimode fiber at the wavelength of 1300 namometer with MIC connector.

STUDENT ASSIGNMENTS AND PROJECTS

The following samples of the student assignments are developed. Additional assignments and projects will also be developed later on.

1. Real time digitization of full motion video and audio signals. Use of AVI compression cards and storage of digitized video and audio data. Real time digitization and comparison of frame rates, sample numbers and sampled frequency.
2. Application of object oriented software to edit the compressed video and audio data. Use of graphics to alter video and audio clips and add still pictures and text to generate data bit stream.
3. Study of FDDI interface and protocols.
4. Study of optical data generated and reception of signals due to coding and compression of video and audio signals.
5. Evaluation of network by measuring bit error rate, eye pattern and throughput capacity of the network.
6. Study of the FDDI network system for PC video conferencing. Use of CU-See Me software.

CONCLUSIONS

The proposal for the equipment was first submitted in the final months of 1993 and it was approved at the end of 1994. By the time we started to develop the project, the multimedia technology went through a rapid change. An extension for the completion date was sought so that new techniques and equipment could be incorporated. For example we were able to incorporate 4.1 NT server, PCI bus adaptors, smart camera and a new software CU-See Me for video conferencing after the extension date. At the start of the project the FDDI adaptors for PCI bus were not available.

We first developed a stand alone system as it took a long time to get the labs wired with fiber optic link. We are currently installing the second hub to complete our network. Due to the hands-on nature of our program, we actively involved the students in installing and testing the equipment and the software. Implementing the network also involved pulling the fiber, connectorizing it and testing its continuity. The students were then able to complete assignment 1, 2, 3 and 4 listed above by making use of this enhanced facility. The remaining assignments are currently being implemented. A group project has also resulted in the development of a web page with video and audio information for the department. In the following semester this project was changed to two lab assignments. Another project was completed on FDDI network and this will be incorporated in data communication and computer networking course in the next semester. A group of students are working to connect the network to the web by making the server a router for the College Ethernet LAN.

A number of employers came to the campus and were very interested in hiring the students with hands-on knowledge of networking. The project, as a result has provided not only an enhanced laboratory facility for a number of students in a wide range of courses but it has also afforded exposure to the current techniques for the prevailing network market.

References

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