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DISTANCE LEARNING ENVIRONMENT DEMONSTRATION

Interstate Electronics Corporation

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Rome Laboratory
Air Force Materiel Command
Rome, New York

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The Distance Learning Environment Demonstration (DLED) was a comparative study of distributed multimedia computer-based training using low cost high performance technologies. An all Pentium PC network ported to Novell/Ethernet and ATM/SONET (Asynchronous Transfer Mode/Synchronous Optical Network) environments used heterogeneous Commercial-Off-The-Shelf (COTS) products for computer-based training, multimedia communications, networking, and measurement.

The DLED project provides baseline research in the effective use of distance learning and multimedia communications over a wide area ATM/SONET network. The network performance of the NYNet using COTS software was examined along with a Local Area Network (LAN) migration path to the high bandwidth Wide Area Network (WAN) Infosphere.

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Abstract

The Distance Learning Environment Demonstration (DLED) was a comparative study of distributed multimedia computer-based training using low cost high performance technologies. An all Pentium PC network ported to Novell/Ethernet and ATM/SONET (Asychronous Transfer Mode/Synchronous Optical Network) environments used heterogeneous Commercial Off The Shelf (COTS) products for computer-based training, multimedia communications, networking, and measurement.

The project was a US Air Force Materiel Command Research Project at Rome Laborartory (RL), performed by Interstate Electronics Corporation's Multimedia Communications Group, and demonstrated over the New York Network (NYNet). The demonstration illustrated various interactive multimedia instructional modes with dual use implications, including interactive training modes and demonstration/simulation modes.

The DLED project provides baseline research in the effective use of distance learning and multimedia communcations over a wide area ATM/SONET network. The network performance of the NYNet using COTS software was examined along with a Local Area Network (LAN) migration path to the high bandwidth Wide Area Network (WAN) Infosphere.

IEC accomplished the DLED project objectives in two phases. First, a Novell/Ethernet LAN testbed was developed, integrated, and tested using the DLED hardware and software. In addition, courseware was repurposed from different media types to illustrate the migration requirements to a distributed environment and to demonstrate the use of multimedia elements. Second, the DLED LAN hardware and software was reconfigured for the ATM/SONET environment and, along with the courseware, was moved onto the NYNet WAN at RL. Measurement testing was embedded in the DLED that evaluated the virtual student performance, Human Computer Interaction, and system/network performance.

The study and demonstration took place over an eighteen month period at Interstate Electronics Corporation in Anaheim, California and at the US Air Force Rome Laboratory in Rome, New York.

List of Illustrations/Tables

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Key personnel at Rome Lab were:

Richard Butler	Program Manager

Key personnel at IEC were:

John Waters	Program Manager
Jim Buckner	Project Manager
Catherine Viren	Project Engineer
John Viren	Multimedia/CBT Engineer
Eric Gilfand	Computer Engineer
Laurel Perkiss	Computer Engineer
Dick Reid	Network Engineer

Their contributions enabled a successful completion to this project.

Introduction

In 1994, Interstate Electronics Corporation (IEC) was awarded a research and development contract by the US Air Force Materiel Command at Rome Laboratory (RL). This product was a distributed Distance Learning Environment Demonstration (DLED) developed using Commercial-Off-The-Shelf (COTS) software and hardware. The demonstration illustrated various interactive multimedia instructional modes that have dual use implications. Included in this demonstration were interactive training modes and demonstration/simulation modes.

The DLED had four sessions--scripted multimedia elements, freeplay multimedia elements, scripted courseware, and freeplay courseware. All sessions included the appropriate use of the multimedia elements (text, graphics, animation, audio and video). Each session also included measurement testing that was performed on both the IEC Local Area Network (LAN) and the NYNet ATM/SONET Wide Area Network (WAN) testbeds.

The demonstration testing measurements included virtual student performance, Human Computer Interaction (HCI) performance, and system/network performance. This demonstration was the first comparative analysis of testing measurements of the two multimedia learning/training environments 1) the IEC LAN and 2) the NYNet ATM/SONET WAN from the Rome Lab node.

Technical Discussion

The DLED resolved many of the limitations of the earlier systems by providing full multimedia functionality and provided student performance tracking and remediation. In addition, courseware was provided "on-demand"; that is, students could sign-up and take courses at their convenience and location. Student performance was saved in individual student files at the server.

Student-instructor communication was another important issue in distance learning programs. Messages (Email) were sent from the instructor to the students via the message handling area of the system, which was embedded in the courseware. Students could directly communicate with instructors.

An IEC Local Area Network (LAN) was established. The hardware and software was tested and demonstrated in an Ethernet LAN environment prior to the delivery of the same network to RL. At RL, the network was tested and demonstrated in an ATM/SONET environment on the NYNet. The hardware variable between the testing environments was the exchange of the network adapters and network lines. Ethernet 10 base T adapters were replaced with FORE PCI ATM adapters.

Network Configuration

Originally proposed, a high speed distributed multimedia distance learning training system utilized EISA technology with the latest in network technology. A PC solution provided a low cost high performance platform for the implementation of the multimedia distributed learning environment. The network interface would be the latest in ATM.

The Nodes

The three originally proposed nodes for the DLED would have been a 486 DX2 66/100 EISA VLB with the following attributes:

- 256k 15ns Cache
- 8 MB RAM
- 16 bit IDE/2 Serial/1 parallel controller
- 170 MB IDE HD
- VLB ATI Ultra Pro w/ 2MB VRAM
- 15" NI Monitor
- 3 1/2" 1.44 MB floppy disk
- MV Proaudio Spectrum Audio board
- 1- Roland MA 12 speaker
- ATM to EISA network card
- Microsoft mouse

101 keyboard
Desktop case w/220W PS
DOS/Windows 6.2/3.1

During the hardware and software review for the DLED, changes from the 486 DX PC architecture were made for the following reasons:

- Pentium computers had become the industry's COTS platform.
- At the time of purchase, costs of Pentium computers were slightly higher to the proposed 486 DX prices.
- ATM adapter manufacturers were considering dropping support for the EISA architecture (building for the "future"--PCI).

Three nodes were setup on the testbed. The nodes consisted of:

60 MHz ZEOS Pentium P.C.
8 MB RAM
528 MB IDE HD
PCI Video Card
15" SVGA Monitor
3 1/2" 1.44 MB floppy disk
4X Mitsumi IDE CD-ROM
Sound Blaster ProAudio board
Twin Sound speaker w/amp
SMC Combo PCI Ethernet network card
Microsoft mouse
101 keyboard
Desktop case w/200W PS
DOS/Windows 6.2/3.1

The Servers

Originally, only one courseware server was required. It was an Intel Pentium 66 Mhz EISA/PCI with the following attributes:

512k 15ns Cache
16 MB RAM
PCI 32 bit Fast SCSI-2 controller
Seagate Barracuda 1.6 GB 8ms 7200 RPM HD
SVGA 16bit video card
14" Monitor
3 1/2" 1.44 MB floppy disk

5 EISA, 2 PCI, 1 EISA/PCI
MV Proaudio Spectrum Audio board
1- Roland MA 12 speaker
ATM to EISA network card
Microsoft mouse
101 keyboard
Tower case w/10 drive bay
DOS/Windows 6.2/3.1
Novell 5 User Netware 3.11 software
Run time courseware

A high speed Novell courseware/data server connected to three node systems by a fiber optic line using ATM technology was proposed. ATM switches on the NYNet connected by SONET served as the distribution system between the nodes and the courseware server.

The courseware server hosted all multimedia training data, and the training application software. All user training responses were recorded on the courseware server hard drive. The server further provided access control to all software and data files established by the Novell Administrator. The nodes were configured with the DOS operating system and all drivers for the nodes were connected to the Novell server. No applications relating to the training system were stored on the nodes. Using a courseware server eased maintenance of all software and data for the DLED.

However, a second server (a LAN server) had to be added because the ATM adapter card manufacturer, FORE, did not provide .IPX drivers for the nodes to directly connect to the FORE ASX-100 switch.

There were two servers used for the DLED. A system listing for each server follows:

The courseware server consisted of:

60 MHz ZEOS Pentium Server
256 Cache
32 MB RAM
Adaptec PCI Fast Wide IDE controller
1.2 GB IDE Hard Drive
!.52 GB Fast Wide IDE Hard Drive (RAID 1 Subsystem)
PCI SVGA video card
15" SVGA ZEOS Monitor
3 1/2" 1.44 MB floppy disk

4X Mitsumi IDE CD-ROM
Sound Blaster Pro audio board
Twin Sound speaker w/amp
FORE PCI ATM 100 Mbps TAXI adapter
Microsoft mouse
101 keyboard
Tower case w/10 drive bay w/3 PCI /5 ISA ports
200W/5v ZEOS Power supply
DOS/Windows 6.2/3.1
Novell 5 User Netware 3.12 software
Runtime Courseware

The LAN server consisted of:

90 MHz ZEOS Pentium Server
256 Cache
32 MB EDO RAM
PCI controller
1.2 GB IDE Hard Drive
PCI SVGA video card
15" SVGA CTX Monitor
3 1/2" 1.44 MB floppy disk
4X Mitsumi IDE CD-ROM
Sound Blaster Pro audio board
Twin Sound speaker w/amp
SMC PCI Ethernet Combo 10base-T
FORE PCI ATM 100 Mbps TAXI adapter
Microsoft mouse
101 keyboard
Tower case w/10 drive bay w/3 PCI /5 ISA ports
200W/5v ZEOS Power supply
DOS/Windows 6.2/3.1
Novell 5 User Netware 3.12 software
Runtime Courseware

Network Performance Metrics

The DLED was based on Commercial-Off-the- Shelf (COTS) system software and hardware components integrated with Courseware developed through COTS authoring software. Application of the DLED COTS tools is equally usable for both military and commercial environments depending on the courseware topic. Thus, it was the metrics of performance based on the constraints of the COTS environment of the application that was of most interest in this study.

Three levels of performance were reviewed within the constraints of the environment.

At the highest level was student performance. The Computer-based training demonstration was concerned with the student and his or her performance on the courseware that provided learning through the viewing of animation, video images and audio assistance.

At the mid-level was system/network performance. The system was implemented across a local area network with a hub topology. The performance of the system interfacing with the network was pertinent to the performance of the Distance Learning application.

At the lowest level was the ATM performance. The Ethernet was interfaced to external nets, thereby expanding to a WAN through the use of ATM adapters. The ATM adapters assembled the packets into cells, transmitted the cells via SONET across the NYNet WAN and disassembled the cells into packets with each transmission.

The DLED showed that student performance can be continuously monitored through Computer Managed Instruction (CMI) for a number of students nodes at distributed locations. Therefore, Distance Learning across a wide area net was viable for random courseware selections. The demonstration also showed that the network performance offered by NYNet in concert with COTS software can support distance learning in a transparent fashion for multimedia applications.

The intent of the project was to focus on the many facets of performance of Distance Learning applications. The parameter measurements that supported the demonstration are discussed in the paragraphs that follow, beginning at the lowest level.

ATM Performance

At the transmission level, the lowest or data link/physical layer within the network, the system received packets from any of "n lines" and transmitted packets over the same "n lines". Two types of packets were received: data packets and control packets.

Control packets were required to set up a communication session between a transmitter and receiver, to acknowledge proper receipt of “m” data packets, and to conclude a communication session between a transmitter and receiver pair.

Data packets were made up of pieces of a message stream between a transmitter and receiver. Each transmitter and receiver session demanded one logical or passive resource, a virtual circuit that was set up over a single physical circuit to allow time division multiplexing or sharing of the physical circuit among multiple pairs of transmitters and receivers.

A nonpreemptive schedule was used: once execution began, a packet was processed to completion.

Two different physical layer measurements were collected. First, the Ethernet network packet transmission was measured using Observer software. Second, the ATM network cell transmission was measured using the FORE ATM adapter software, Forethought.

Packets were assembled into cells and transmitted over the NYNet, then reassembled into packets prior to reception.

Within the DLED environment, the packet header information (managed by the Novell Netware 3.12) satisfied the control requirements, and no additional acknowledgments were required for the transmission.

System/Network Performance

At the mid-level, system/network performance was monitored in the following areas.

- The throughput rate of executed couseware.
- The simultaneous courseware delivery to the student nodes.
- The throughput rate of transmission of multimedia elements.

Student Performance

At the highest level, student performance was monitored through measures embedded in the courseware. The courseware measurement was based on an answer judging format that provided templates to assess the student response, the student response over multiple events, and the student response for complex sequences. Student instruction management and record keeping (Computer Managed Instruction or CMI) was included in the design of the courseware.

With CMI capability, the courseware monitored student performance for each student node down to the question level and evaluated the effectivity of the course itself. The student performance was provided visually in the lesson frames as the lesson progressed and monitored through the use of Logon Scripts for each student node. The statistics of the student responses and random selections were collected in data files.

Courseware Strategy

Courseware was configured to run on the network using special file naming conventions and functions to prevent conflicts during development and delivery. The courseware resided on the server and provided seamless, transparent communication links to any of the nodes.

Several features of the distance learning environment were tested:

- The ability of the environment to handle multiple users.
- The Computer Managed Instruction (CMI) portion of the courseware which registers and manages the students, catalogs courses, makes assignments, handles e-mail, writes student performance data to ASCII files, and generates reports.
- The student tracking, testing and remediation, feedback features, and latency of the file fetching.

Over two hours of courseware was tested on the network. The courses were selected for their ability to test the multimedia elements (audio, video, graphics, data) on the network and the level of modification necessary to move existing stand-alone courseware into the DLED environment.

The courses selected for testing were: "An Introduction to DAMA"; "SPALTS: Strategic Program Alteration"; and "The Workbench Helper". These courses were selected for their mix of audio, video, text, animation, pictures, and graphics, and their "real world" repurposing characteristics.

In addition to these three previously designed courses, scripted and freeplay multimedia element testing sessions were developed for the DLED. These testing sessions were developed specifically for this project and to test the DLED networking environment. The testing sessions were developed with the same COTS tools as the courseware sessions that were selected for demonstration.

Network Configuration

Each node on the network had the same hardware and software configuration. There were two servers; a courseware server and a LAN server. The LAN server was not part of the originally proposed network. It was added because Novell IPX protocol drivers are not supported by the PCI adapter manufacturer, FORE.

Accessing Courseware

Access to the courseware was through the DOS path in the autoexec.bat file. The courseware was accessed by each student through a logon. Students were required to Logon with a provided name and password to gain access to the menu directory that provided a path to all courseware files.

Courseware File Configurations

All of the courseware files, such as lessons, libraries, audio files, etc., resided on the server and were flagged by Novell Netware 3.12 as shareable. Shareable files can be accessed by many users at one time, which is a key ingredient in network distributed courseware. Whether accessed in the "authoring" mode by courseware developers, or in the "learn" mode by students, all courseware files were flagged as shareable. This allowed several users access to the same course at the same time. Novell provided the "FILER" utility to make files shareable.

Data Types

Shareable files provided user connectivity, operated the courseware, and maintained multimedia courseware files. The multimedia files adhered to standard or defacto standard formats: animator .Fli files, VESA compatible graphics support, PCX or Img graphics and picture files, various text fonts, .wav audio formats (soon expected to be available as a VESA standard).

Interface Design

Courseware was accessed intuitively through the User Interface Design. Network protocols and system session setup were transparent to the user. The virtual desktop environment was tested in both DOS-based courseware and Windows-based courseware.

User File Read Access

Student users, as well as courseware developers, had read access to all the files in the courseware directory. The directory was setup at the setup window of the main menu. Student users had partial system privileges and the system manager had full system privileges.

File Write Access

Courseware development, maintenance, and use necessitated the ability to write to the courseware. A hierarchy of write capabilities was necessary to maintain courseware security.

Different user types, ranging from "Student" to "System Manager", were provided to control access to the software. Students were divided into two classifications, structured and unstructured. The most controlled of which was the structured student. A structured student could access only assigned courses. Assigned courses were presented to structured students in a specific order. The system manager had full access to the courseware functions and could register student/users. System managers could access different editors and utilities.

Authoring

System managers made courseware assignments to students and provided students with write access to the USERS.DAT file in the curriculum directory. The system managers could not author courseware files. All courseware authoring was completed by the courseware developers at IEC prior to the IEC LAN demonstration. This ensured that the only variable between the IEC LAN demonstration and the Rome Lab WAN demonstration was the ATM network adapters, switches, and fiber connections.

Student

Student performance was tracked and written to a performance directory in the courseware stored on the hard drive of the courseware server. The performance directory housed all student data files (USERS.DAT) along with some temporary files used in menu memory swapping. This necessitated giving students write capabilities to the performance directory. The performance directory was specified in the Catalog program.

Courseware Administration

Developers and system managers had read and write capabilities allowing them all courseware privileges. Network accounts for courseware developers provided all rights to courseware directories for creating, modifying, and deleting files. The SYSCON command through Novell provided access to the developers. The developers, for example, were placed in a group and given rights to certain courseware directories.

Courseware students/users could read messages broadcast to courseware users (including students, teachers, managers, developers, and administrators). Messages were used to communicate among groups, such as to all students of a particular class (broadcast) from the instructor of a course. During the DLED, the message function illustrated the student-teacher communication functions important to this dynamic distance learning environment.

Messages were broadcast to members of a particular group, and targeted to an individual. When the system manager, for example, needed to communicate to all students, a broadcast message was sent to all students. Target messages, on the other hand, were also available if the student needed to communicate directly with a DLED course instructor via this message system.

Collaborative Workspace

Message handling was an important feature. Whether student to student or developer to developer, electronic messages were an important collaborative feature of the DLED.

Limitations and Shortcomings

At the beginning of this project, little was known about the hardware and software required to support a PC-based ATM/SONET multimedia distance learning program. COTS ATM products were in limited supply and expensive. Vendors for the PC-based-ATM/SONET networking products could not guarantee delivery dates, prices and full network connectivity. Although fiber optic LANs have been tested for distributed multimedia computer-based training using other hardware solutions, fiber WANs have not. The hardware limitations of the current technology primarily fell into the category of availability. The educational limitations were two fold: one on one communications, and real-time communications.

Successes/Failures of Previous Approaches

In the United States, correspondence-based courses were being offered as early as the 1700s. (Tompkins, 1993) Broadcast television improved the "mail order" structure (of correspondence school) by providing a "talking-head" to the student. Educators hypothesized that a motion picture of a teacher might explain the written text better than having the student work alone.(Tompkins, 1993)

Typical distance learning multimedia courseware was usually released on videotape, broadcast, or hardwired on CATV. Distance Learning course development for broadcast/VT/CATV required expensive facilities and large staffs. This limited the number of groups or individuals that could produce courses.

Courseware On Demand became possible because of personal video tape recorders. Students could record broadcast or CATV courses for playback at more convenient times. This approach worked well, however, the main drawback was the feedback, performance tracking, and remediation. We know the application of educational principles to distance education was the first and most important consideration when designing a distance education course. (Martin, 1994)

Most distance education systems share the following: (a) communication between the teacher and learners even though they are physically separated; (b) an organization responsible for planning and delivering the distance learning program; and (3) a technology-based delivery system including print, audio, video, or multimedia that carries the content of the instruction to the learner. (Martin, 1994)

Broadcast television and videotapes are fundamentally one-way delivery techniques. For student/teacher interaction, the student must take the initiative to call via phone, write by mail, or more recently, write by e-mail (electronic mail). (Tompkins, 1993) Students usually have to be very computer literate to participate in a distributed computer based distance learning program. Telecommunications, modems, Email, file transfers, etc. all require special protocols and knowledge.

The literature on distance education breaks the educational characteristics of successful programs into three broad categories: instructional considerations, personnel, and management of the instruction. (Martin, 1994) Studies have shown that "courses must teach the essential, current body of knowledge, skills, and attitudes to meet course objectives." (Distance Education)

Student tracking and Computer Managed Instruction (CMI) are important factors that have not been adequately addressed in most distance learning applications. The CMI handles all of the student records, control of user access, assignment of courses, catalog of courses, and setting up of individualized course structures. CMI functions collect data and generate reports to evaluate student performance or lessons.

The high bandwidth of fiberoptics (ATM/SONET) offers interactive multimedia computer-based training as a distance learning possibility. The DLED project illustrated the migration to this environment as a case study.

The courseware was designed using low cost commercial off the shelf (COTS) authoring tools that can be duplicated by other interested parties that want to develop distributed distance learning environments. This means that more educational/training groups/individuals can access these COTS tools. The DLED used "real world" COTS products and showed the migration path of current Pentium PC-Based Distance Learning COTS networks.

Tradeoffs

The initial entry into new technologies, such as ATM/SONET, was and is still expensive. The benefits, in this case, far outweighed the higher costs.

The country needs to re-tool for an information-based economy and the new skills for the workforce of the next century. The lean budgets of today's economy drive alternative training and educational delivery systems. Traditional stand-up instruction does not hold up to the scrutiny of the cost conscience business manager, or the individual seeking continuing training and education.

Training for the new workforce is still unevenly distributed throughout the country. Therefore, the pockets of advanced training and education, usually found in the center of major metropolitan areas, are out of reach of a large portion of Americans. The efforts of earlier distributed learning programs lacked the level interactivity, student tracking, and feedback available in desktop computer-based training courses.

Distributed multimedia distance learning programs close the gap between the need for a highly trained workforce and the availability of adequate training and education.

Theory

Distance learning requires well-planned instruction using learning activities, strategies, and media. Distance education programs are developed using a systems approach, including assessing needs, planning strategies, designing objectives, organizing objectives, and evaluating the results for redesign.

The success of distance learning programs, such as the DLED, has traditionally rested on the student's motivation to be a self-starter and self-learner.(Tompkins, 1993)

The typical profile of students who enroll in distance education courses include those students who are: older, above average in motivation, persistent, independent, married, parents, employed, and take classes on a part time basis.(Tompkins, 1993) (Wilkinson & Sherman, 1991) In 1987, fewer than ten states showed an interest in distance learning. Today, every state uses some form of technology to provide education at a distance. (Bruder, 1991)

Modeling

An instructional system is "interactive" if there is two-way audio and video transmission. (Tompkins, 1993)(Cisco, 1990)

"Computer networks and bulletin boards can do more than serve as vehicles of communication for enhancing learning. Evidence from the studies cited earlier indicates that these tools can also be harnessed to play a more direct role in instruction, one which should be particularly effective for teaching higher order thinking skills. (Steinberg, 1992)

Distance learning projects are continuously using fiber optics as the interactive network of choice. The Minnesota Department of Education, the Oklahoma Panhandle Project, Mississippi 2000, Southeastern Ohio Telecommunications Consortium, and the San Marcos Project are all examples of the use and implementation of fiber optic interactive distance learning.

Experimental Data

One of the key management factors is how quickly and efficiently instructors respond to student questions and how to provide fast and immediate feedback. (Stoffel, 1987; Martin, 1994)

"Designers, in this case pre- and in-service teachers, must do the following at a minimum:
1. Pre-plan the instruction. This includes specifying behavioral objectives and writing criterion-referenced measures.
2. Specify learner and environment characteristics, including learner prerequisites and the availability of media and support personnel.
3. Design learning activities that are appealing to learners and incorporate the following:
    a. active learning
    b. interaction among students and between students and teachers
    c. feedback and reinforcement
    d. motivational components
    e. spaced practice
    f. meaningfulness" (Martin, 1994)

A study on the impact of the computer as a medium of writing instruction by Schwartz, Fitzpatrick and Huot (1991) had shown that "whether (the students) did the computer or paper-and pencil task first, most students wrote longer responses in the computer program. Those who wrote computer texts tended to write longer responses to each question." (Steinberg, 1992)

Other Scientific or Engineering Practices

The DLED courseware development followed a software engineering approach. A five phase process was used in the courseware development life cycle. The five phases were: Analysis, Design, Development, Implementation, and Maintenance. Using stepwise refinement, the educational requirements were called out in the Analysis phase of the courseware life cycle. The courseware requirements were established, the user audience was identified, lessons and objectives were mapped out for the course, time tables and schedules were developed, and the overall courseware feasibility was determined. The milestones and deliverables were scheduled and released to the Design phase where the instructional content was developed to meet the educational requirements. Up to this point a paper (or ASCII-based) version of the courseware existed. At completion of the Design phase, the course was released to development for construction. In the Development phase the actual courseware was built and tested. In the implementation phase, all of the deliverables of the Design phase were tested and demonstrated. Finally, the maintenance phase began. In this phase the courseware is maintained for the remainder of the lifecycle. The DLED is currently in the maintenance phase.

New and Creative Solutions

Moving stand alone computer-based training into a distributed learning environment followed a natural flow of the technology. Using well developed CMI COTS authoring tools solved a number of distance learning obstacles: timely student performance feedback and analysis; a methodology for student-to-student and instructor-to-student communication; record keeping; and courseware availability.

The combination of high-speed, high-bandwidth technologies and mature low cost COTS multimedia computer-based training authoring tools, offered new opportunities for academia, commerce, industry, government, and military applications. The DLED was an example of providing subject matter experts on demand through training on demand.

Demonstration

The Distance Learning demonstrations took place over two five day test periods. One week was at IEC (Local Area Network - LAN environment) and one week was at Rome Lab/NYNet (Wide Area Network - WAN environment). These testing periods are comparatively analyzed in this Final Report.

The demonstrations showed the CMI capability using COTS multimedia authoring software to re-purpose existing courseware for an ATM SONET system. Student performance and feedback data were gathered from three different courseware examples and two multimedia testing element sessions. Unit data, lesson data, and answer data were collected from the three different courseware selections:

1. "DAMA: Demand Assigned Multiple Access"
   (four different courseware selections)
2. "SPALTS: Special Programs Alterations"

3. "The Workbench Helper"

Each course had one unit, at least one lesson, and at least one set of answer data. The demonstration showed the data gathering capability of the system and the centralized features of the CMI system. The CMI stored student data on the server.

The unit function tracked student performance for each unit. The unit CMI was able to list each Unit by name, the amount of time in each unit, the number of correct and incorrect responses, percent of responses correct, the score, the overall possible score, the percent of the score, and the number of times taken.

The lesson data gathering function collected data at the frame level of the lesson. The frame name, number of times each frame was entered, average time in each frame, the number of correct and incorrect responses, and the percent of correct responses were recorded.

Student responses to test questions were collected as answer data. When an answer was input, the CMI tracked the unit and frame the student was in at the time, the actual answer was entered, the amount of time answering the questions, the type of response (either correct, incorrect, or neutral), and the score for the frame.

The demonstration also included a system function test, scripted course tests, and freeplay (random) course demonstration testing.

System Function Test

The system function test became the scripted multimedia elements testing session of the DLED. During this test the server's simultaneous transmission of the same multimedia data types to all three nodes was monitored by the Observer software. The Multimedia Elements Testing session included the scheduled transmission of video, audio, animation, graphics, text, interactivity functions, computer managed instruction, and Human Computer Interaction (HCI) implications.

Course Testing

Each course was individually accessed for a testing period to assess the server's course transmission and receipt of CMI data.

Random Course Selection Testing

During the freeplay courseware session, users logged onto the three nodes to test the random selectivity of a typical ("real world") distributed distance learning environment. CMI, HCI, and network data was collected throughout this testing session.

IEC selected the student/users for the IEC DLED LAN demonstration. Rome Lab selected the student/users for the NYNet WAN demonstration. The student/users were novice to the various courses tested.

Technical Program Summary

During the first six months of the project, the appropriate network hardware and software for the IEC LAN was ordered, integrated and tested. Once the hardware and software was ordered, the reversioning of the courseware for the distributed environment began. The courseware repurposing occurred from month one to month eleven. The network hardware and software was installed on the IEC LAN beginning month four and lasted throughout month fourteen. Courseware testing on the IEC LAN began month six and lasted until month fourteen. At the end of month fourteen, the hardware and software was shipped for installation, testing and demonstrations on the NYNet, Rome Laboratory WAN environment. During month fourteen and fifteen, the courseware was setup and tested. Runtime versions of the courseware, the three nodes, and two servers remained at Rome Laboratory after the DLED WAN demonstration. During months sixteen, seventeen, and eighteen the results from the testing measurements were compiled, compared and analyzed. Completion of the final scientific and technical written report and recommendations occurred at the end of month eighteen.

DLED Development

Courseware Development

It was determined that using the CMI Quest shell was the most prudent approach to resolve resource allocation requirements.

Scripted and Freeplay Sessions

There were two types of interactive navigational environments developed for the DLED: scripted and freeplay.

Scripted Environment Sessions

The scripted environment sessions led the student/user through a predetermined path. In some cases, it would seamlessly cycle from course to course without the users awareness of the actual DLED navigation path.

The purpose of the scripted portion of the demonstration was to measure the bandwidth and data file sharability in the LAN and WAN environments for the comparative study. In order to investigate the shareability of data files, a scripted navigational environment was the approach used in this study.

In a scripted environment, all of the students accessed the same files and programs at the same time.

Freeplay Environment Sessions

The freeplay environment sessions were "real world" models of taking courses in a distributed distance learning environment. In the freeplay sessions, the student/users selected courses and navigated through the DLED program at their own pace.

In the freeplay environment, the students accessed the files and programs at different times.

Multimedia Elements Testing

There were two multimedia elements testing sessions: scripted and freeplay.

The first session was a scripted session. In this session, the students were simultaneously prompted to select text, graphics, animation, audio and video files.

The purpose of the scripted session was to test file sharability, network utilization and data transmission in the LAN and WAN environments for the comparative study.

In the freeplay session, students navigated to the areas of the DLED courseware at their own selection. This type of navigational model was used as a "real world" example of "training on demand".

In the "real world", students logon to servers at different times, access different courses, access video at different times, access audio at different times, etc.

This session was designed to test the ability of the server to access and transmit media without degradation of the throughput.

Both multimedia elements testing sessions were built in native Quest for DOS. It illustrated and tested the various multimedia elements: text, graphics, animation, audio, and video.

The multimedia testing element sessions included six animations, a matrix of various graphic files, hypertext, audio jukebox and video files.

Courseware Titles

Three courseware titles were demonstrated in the DLED project.

They are:

SPALTS

Special Programs ALTerations (SPALTS) is an overview of the Special Programs ALTerations process at Interstate Electronics Corporation. It introduces SPALT writers and SPALT workers to the SPALT process, the Trouble Failure Report (TFR) system, and the entire workflow and signature cycle. SPALTs was originally built with Quest for DOS for use with a video overlay board and laserdisc. The HCI evaluations were added on to the original program and used for the sole purpose of the DLED study.

First, the Special Programs Alterations laserdisc courseware was built using analog video and had to be converted to a compatible distributable format. It was a fairly straight forward process. Since laserdiscs provide high quality (24 bit) analog video, and the distributed environment did not support a laserdisc configuration, and Quest for DOS did not support any video data types, an alternative approach was required. It was decided to capture stills form the laserdisc, digitize the audio track, and replace the analog video with the new still images and digital audio.

The original SPALTS program had two main sections, the Overview of the SPALTS process, and an Introduction to SPALTS. The Overview was not part of this study. Focus was placed on the Introduction to SPALTS.

The SPALTS program was designed using standard VGA so the 24 bit still captured from Laserdisc (16 million colors) had to be converted to 4 bit standard VGA (16 colors). In addition, the DOS authoring software did not support mixed graphics mode. Because the program was built in standard 16 color VGA, all of the captured stills had to be converted to standard 16 color VGA format. Each of the new images were digitized and given appropriate file names. Likewise, the audio was digitized and given file names prior to reintegration into the program.

At the end of the SPALTS program, a Human Computer Interaction (HCI) online evaluation was built. After the student/user exited SPALTS, the student/user was seamlessly navigated to the HCI survey before being allowed to exit the entire DLED program.

SPALTS was converted from a Laserdisc delivery system to a standard VGA format in a distributed environment with the DLED HCI evaluation tag.

DAMA

The DAMA courseware consisted of excepts from a 35 hour satellite communications operation and maintenance Computer Based Training (CBT) course developed by IEC.

The excerpts were selected to illustrate the interactive capability of the distance learning environment and the student tracking capability of embedded computer managed instruction (CMI).

By using node specific logon scripts (available in the DLED Users Guide), students accessed the DAMA modules in either scripted or freeplay environment modes.

Because the primary focus of the DAMA courseware was to test the distributed tracking capabilities of the CMI in the DLED environment and not to test bandwidth utilization, the DAMA courseware did not include full motion video files in its program.

Conversion of the DAMA CD-ROM courseware excerpts to the DLED was simplified because DAMA was developed in a native Quest 4.2 environment. Minor program modifications were required to convert to the DLED.

Most modifications were based in navigational changes, distributed sharability changes, and tagging the HCI at the end of each module. After DAMA module modifications, module testing was done. Module testing included checking the navigational links, verification of CMI functionality, and confirmation of tracking and storing measurement data.

Workbench Helper

The Workbench Helper was built using the Windows based Quest 5.0 authoring system. It was a demonstration of an online subject matter expert.

The Workbench Helper was developed as an in house workmanship skills training program for IEC. It was originally built in a videotape format. It was later moved to both laserdisc and CD-ROM formats.

Experts in workmanship skills were videotaped performing various workbench processes. By viewing an online videoclip, a worker could review a required workbench procedure. The worker/user could stop, move forward, replay, etc. the videoclipped workbench process on demand in order to understand all the tasks in the process. This was illustrated in the DLED Workbench Helper module.

The Workbench Helper was incorporated into the DLED to test the file sharing capabilities, the CMI management capabilities, and the DLED network performance in both the LAN and WAN environments.

The Workbench Helper could only be launched from Windows. Because of resource limitations, it could not be launched directly from the DLED Quest Shell.

Included in the DLED Users Guide are the procedures to launch the Workbench Helper from DOS.

DLED Accomplishments

Demonstration Scope

This project was a Distance Learning Demonstration developed using Commercial-Off-The-Shelf (COTS) software and hardware illustrating various interactive multimedia instructional modes. There were four parts to the demonstration--scripted multimedia elements, freeplay multimedia elements, scripted courseware, and freeplay courseware. Each part was approximately 30 minutes of measurement testing on both the IEC Local Area Network (LAN) and the NYNet ATM/SONET Wide Area Network (WAN) testbeds. The demonstration testing measurements included virtual student performance, Human Computer Interaction (HCI) performance, and system/network performance. The outcome of the study was a comparative analysis of the demonstration testing measurements in the two environments 1) the IEC LAN and 2) the NYNet ATM/SONET WAN from Rome Laboratory's node.

Demonstration Plan

IEC demonstrated selected examples from three distributed interactive multimedia courseware programs--Demand Assigned Multiple Access (DAMA), Workbench Helper, and Special Programs Alterations (SPALTS). The courseware examples illustrated unique multimedia and instructional models in a distance learning environment. These courseware examples were selected for their ability to effectively demonstrate seamless interaction of the virtual student (node users/not real students for the demonstration and for the remainder of this demonstration plan simply called students) to the courseware and the courseware to the net. The feasibility of seamlessly integrating the various multimedia elements--voice, data, video, and student interaction data was also demonstrated. The courseware included individualized instruction, testing, and remediation.

IEC used commercial-off-the-shelf (COTS) multimedia authoring software and hardware to demonstrate the feasibility of moving the courseware from a LAN environment on a dedicated IEC testbed into a WAN environment using the NYNet ATM/SONET testbed.

Each of the four parts of the demonstration on both testbeds were approximately 30 minutes in duration and included courseware examples that were stored on the courseware server (a Pentium Computer). Student data was tracked and stored on the server.

There were three students (one for each node) required to interact with the courseware during each of the four sessions to complete the demonstration on both testbeds. The three students interacting on the IEC LAN testbed were provided by IEC. The three students interacting on the NYNet ATM/SONET WAN testbed were provided by Rome Lab.

The students at the three nodes logged on to the demonstration using a logon and password. Once logged on, the student was tracked and the interaction data was stored by a Computer Managed Instruction (CMI) reporting function on the server. The amount of time in each lesson, completion of each lesson, and student responses were a few examples of the CMI functions that were tracked during the demonstration. Human Computer Interaction (HCI) measurements were included in the demonstration using similar tracking functions. The HCI data recorded subjective information (student/user observations) about the demonstration. Reports were generated from the tracked data stored on the server. These reports were analyzed, and the results from the two testbeds compared in the Test Measurement Analysis section of this report.

The first part, Scripted Multimedia Elements Testing Session of the demonstration, tested the multimedia elements--audio, video, text, animation, pictures, and graphics for simultaneous element tracking. The student at each node was prompted by scripting (highlighting) the icon selection for specific multimedia elements.

The second part, Freeplay Multimedia Elements Testing Session of the demonstration, tested the multimedia elements--audio, video, text, animation, pictures, and graphics for random element selection and tracking. The student at each node selected various multimedia elements using a "real world" online model.

The third part was the Scripted Courseware Session of the demonstration. The student at each node was prompted by scripting (highlighting) the icons for structured courseware testing.

The fourth part was the Freeplay Courseware Session of the demonstration. The student at each node randomly selected the available courseware icons.

When each part was completed, an IEC Multimedia Engineer verified that all necessary measurement data was tracked on the server throughout the session. This timed demonstration process took approximately three hours.

The distance learning testbeds consisted of a courseware server, LAN server and three nodes.

The courseware server was a 60 MHz Pentium with two high speed hard drives (a RAID 1 subsystem), Super VGA VESA compatible, 15 inch .28 Monitor, Sound Blaster Pro audio board, speakers, keyboard/mouse, DOS 6.2, a runtime version of Quest, and a network board (PCI Ethernet at IEC, PCI ATM-SONET at Rome Lab).

The LAN server was a 90 MHz Pentium server with a high speed hard drive, Super VGA VESA compatible, 15 inch .28 Monitor, Sound Blaster Pro audio board, speakers, keyboard/mouse, DOS 6.2, and a network board (PCI Ethernet at IEC, PCI ATM-SONET at Rome Lab).

The three nodes were identical to each other. They consisted of a 60 MHz desktop Pentium with a high speed hard drive, Super VGA VESA compatible, 15 inch .28 Monitor, Sound Blaster Pro audio board, speakers, keyboard/mouse, DOS 6.2, and a network board (PCI 10base-T Ethernet).

Collaborative Workspace was available using message passing (Email).

Network Measurements

Network measurements were monitored throughout each demonstration part on both the IEC and Rome Lab testbeds. The measurement data was collected by selected COTS packages that will meet the requirements for this project. The COTS measurement packages were evaluated, purchased, and installed prior to the IEC testbed demonstration to insure state-of-the-art measurement applications.

The measurement data was collected at both testbed sites, compared, and evaluated.

Demonstration Tasks

Ordered\Received Hardware & Software
a) Ordered Hardware and Software
b) Received Hardware and Software

Reversioned/Built Demo
a) Selected appropriate segments
b) Planned reversioning
c) Built reversion
d) Tested reversion
e) Planned CMI reporting structure
f) Built CMI reporting structure
g) Tested CMI reporting structure
h) Planned HCI embedded testing
i) Planned HCI reporting structure
j) Built HCI testing instruments
k) Tested HCI testing instruments
l) Planned Script for Multimedia Element Demonstration
m) Built Script for Multimedia Element Demonstration
n) Tested Script for Multimedia Element Demonstration
o) Planned Script for Courseware Demonstration
p) Built Script for Courseware Demonstration
q) Tested Script for Courseware Demonstration

Installed Hardware and Software on IEC testbed
a) Installed LAN at IEC
b) Installed network software and tested nodes
c) Installed Novell software, tested server and nodes
d) Researched COTS network measurement products
e) Ordered network measurement products
f) Received network measurement products
g) Installed network measurement products
h) Installed demonstration software

Setup and Configured Network for IEC Demonstration
a) Setup servers
b) Tested servers
c) Setup node 1
d) Tested node 1
e) Setup node 2
f) Tested node 2
g) Setup node 3
h) Tested node 3
i) Tested server CMI reporting

j) Tested server HCI reporting
k) Tested Novell network data reporting
l) Tested Ethernet network data reporting

Demonstrated on IEC Testbed

a) Scripted Multimedia Elements Demonstration
b) Scripted Courseware Selection Demonstration
c) Freeplay Courseware Selection Demonstration

Collected Data on IEC Testbed

a) Collected Server Demonstration CMI Reporting Data
b) Collected Server Demonstration HCI Reporting Data
c) Collected Novell Network Data
d) Collected Ethernet Network Data

Dismantled and Shipped Network

a) Dismantled network-servers and 3 nodes
b) Shipped servers and 3 nodes to Rome Lab

Setup and Configured Network for Rome Lab Demonstration

a) Setup servers
b) Tested servers
c) Setup node 1
d) Tested node 1
e) Setup node 2
f) Tested node 2
g) Setup node 3
h) Tested node 3
i) Tested server CMI reporting
j) Tested server HCI reporting
k) Tested Novell network data reporting
l) Tested ATM/SONET network data reporting

Demonstrated on NYNet at Rome Lab

a) Scripted Multimedia Elements Demonstration
b) Scripted Courseware Selection Demonstration
c) Freeplay Courseware Selection Demonstration

Collected Data on Rome Lab Testbed

a) Collected Server Demonstration CMI Reporting Data
b) Collected Server Demonstration HCI Reporting Data
c) Collected Novell Network Data
d) Collected ATM Network Data

Compiled Data/Analyzed Results

a) Analysis of Distance Learning Environment Data
b) Compiled Results

Wrote Report/Recommendations

a) Reviewed Results
b) Reviewed Implications

c) Wrote Report
d) Wrote Recommendations

Test Measurement Analysis

ATM

An empirical review of the data suggests that ATM has a stabilizing effect on bandwidth utilization even in a LAN Ethernet environment. The native Ethernet environment shows wide fluctuation in bandwidth, easily spiking to 80% or higher. Although this is not unusual for high bandwidth utilization in the LAN environment, it appears that the ATM/SONET stabilizes Ethernet in the mid-range of bandwidth. In this mid-range, while in an ATM/SONET LAN configuration, bandwidth utilization does not vary from high to low as dramatically as it does in native Ethernet 10base-T.

The data also suggests that the "packet to cell to packet" conversion, required by Novell operating in the ATM/SONET/LAN configuration, helped the network maintain a more stable bandwidth than did the Novell Ethernet 10base-T LAN configuration. This research also revealed that during the native Ethernet test (on several of the nodes throughout the testing period) audio would break up and exhibit other anomalies when playing a file. This could possibly be due to the bursty nature of native Ethernet 10base-T. This poses a problem for multimedia playback over Ethernet LANs.

The ATM LAN environment audio file did not exhibit the same anomalies as it did in native Ethernet. Audio playback was without interruption suggesting that this environment may provide a viable migration path from Ethernet LAN to ATM/SONET WAN.

There are, however, some inherent difficulties using ATM/SONET for digital video. The ATM drivers provided by FORE did not totally support "packet to cell to packet" conversion for interleaved audio and video data streams. Interleaved audio/video data streams are data streams that have the audio data intermingled with the video data. Information found at the beginning of a packet, called header information, determines what type of data (audio, video, text, etc.) is to be found in that packet along with its destination.

The Intel Indeo software decoder, used in this project, could distinguish between different audio and video data packets while decoding them in real time. If the decoder could not keep pace with data decoding, it would skip decoding specific packets, either audio or video, depending upon which data type was most important (i.e. "key"). Determining which type of data, audio or video, has decode priority is made in advance in the decoder software setup.

When playing Indeo .avi files, the nodes were able to key in on either the audio or the video, but not simultaneously. If the video was selected as the key data type, the audio was intermittent, and if the audio was selected as key, the video was intermittent. The key data type played as designed, with the other data type being intermittent.

After several unsuccessful attempts to improve the video/audio performance, it was concluded that the packets coming from the server were transferring to cells properly and that they were transformed back to packets properly. The delay seemed to be in the FORE drivers which slowed the cell to packet conversion long enough to be apparent to the student/observer of the .avi file. All of the data was getting through and converting correctly, only at a rate unable to sustain concurrent audio and video playback.

This audio/video anomaly did not appear to be a product of the Novell LAN or the courseware software environment. During the two week test period, similar reports of video anomalies began appearing from projects that incorporated this data type. It has not been concluded beyond a reasonable doubt exactly where this trouble was centered. FORE, however, after a mounting body of trouble reports, informally recognized the possibility of a problem with their drivers.

The conclusion is that this issue needs resolution at the ATM PCI adapter provider level. IEC hypothesizes that problems associated with the playback of .avi files correlates to the bursty nature of ATM/SONET.

HCI

Online Evaluation Plan

The online evaluation plan for the Distance Learning Environment Demonstration was in the form of a questionnaire at the end of selected courseware segments. The students were asked to rate aspects of the program on a scale of one to seven. Selections were made with the mouse and the scale range was "one equaled Disagree" and "seven equaled Agree". One represented the lowest, or most negative impression on the scale, while seven represented the highest or most positive impression.

The Human Computer Interaction (HCI) evaluation portion of the DLED could not be considered a quantitative or qualitative analysis of the courseware. It is only presented as a demonstration that COTS tools are able to develop and distribute online evaluation instruments and collect data to a centralized remote location. This study showed that students in a distributed environment can provide evaluation data to courseware developers and presenters for later analysis and evaluation.

The small test population does not provide enough data nor did it follow standard scientific research protocol for data reliability and objectiveness. However, a brief discussion of the results of the survey is appropriate. Even though the user population was small, some interesting results are suggested.

An empirical review of the data shows a significant difference in overall scoring, with a mean of '6.0' for the ATM/SONET test group, as compared to a mean of '5.0' for the Native Ethernet test group.

The lowest score, 5.8/3.7 respectively, reflected an audio playback anomaly experienced by the Ethernet group during the demonstration. The mean data suggests that native Ethernet did not perform as well as ATM LAN emulation. However, only 40% of the statements related to system performance, showing a mean score of 6.05/4.77 respectively. Although these scores are significant and reflective of expected system performance, the statements related to the visual components of the courseware samples comprised 30% of the data collected and mirrored the overall mean score of 6.06/4.93 respectively. The visual statements could be affected by both system and courseware performance criteria. The design, also 30% of the sample data, showed a mean of 5.90/5.43 respectively.

HCI Survey Statements
Scaled Student Responses
(Disagree/Agree 1-7)

1. The screens appeared promptly.
2. The text is easy to read.
3. The visuals appear complete.
4. The colors in the visuals are appropriate.
5. The audio is clear.
6. The audio is synchronized with the video.
7. The interface is easy to understand.
8. The course has a natural flow.
9. After making a selection, system reactions are prompt.
10. The course was interesting.

Testing Scores

ATM/SONET LAN

Q	MTS1	MTS2	MTS3	SMTS1	SMTS2	SMTS3	S1	S2	S3	SS1	SS2	SS3	MEAN
1	6	7	6	5	6	6	7	6	6	6	6	7	6.1
2	7	6	7	6	7	6	6	6	7	6	6	7	6.4
3	7	6	6	7	5	6	6	6	7	6	6	6	6.1
4	6	5	5	5	4	5	6	7	7	5	7	7	5.7
5	7	6	7	6	7	6	7	7	7	7	7	7	6.7
6	6	5	6	5	5	5	7	6	6	6	6	7	5.8
7	7	7	7	7	6	7	6	5	6	5	5	5	6.0
8	6	6	7	7	7	7	6	4	5	5	6	6	6.0
9	5	5	6	6	6	6	5	5	6	5	7	6	5.6
10	6	6	6	6	6	6	5	6	5	5	5	5	5.6

Overall Mean Score 6.0

Q 1 -10 = Question 1, 2, 3, ...9, 10
MTS1, 2, 3 = (Multimedia Testing) Student at node 1, 2, or 3
SMTS1, 2, 3 = (Scripted Multimedia Testing) Student at node 1, 2, or 3
S 1, 2, 3 = (Courseware) Student at node 1, 2, or 3
SS 1, 2, 3 = (Scripted Courseware) Student at node 1, 2, or 3

NATIVE ETHERNET

Q	MTS1	MTS2	MTS3	SMTS1	SMTS2	SMTS3	S1	S2	S3	SS1	SS2	SS3	MEAN
1	5	N	5	5	7	5	N	4	N	N	5	N	5.1
2	5	N	6	5	6	6	N	5	N	N	6	N	5.5
3	3	N	6	5	6	6	N	5	N	N	5	N	5.1
4	3	N	5	4	5	5	N	4	N	N	4	N	4.2
5	5	N	6	5	6	4	N	5	N	N	5	N	5.1
6	3	N	4	3	5	4	N	2	N	N	5	N	3.7
7	5	N	6	5	7	5	N	4	N	N	6	N	5.4
8	5	N	5	6	6	5	N	5	N	N	5	N	5.2
9	4	N	6	5	5	6	N	5	N	N	6	N	5.2
10	5	N	6	5	6	6	N	6	N	N	6	N	5.7

Overall Mean Score 5.0

Q 1 -10 = Question 1, 2, 3, ...9, 10
MTS1, 2, 3 = (Multimedia Testing) Student at node 1, 2, or 3
SMTS1, 2, 3 = (Scripted Multimedia Testing) Student at node 1, 2, or 3
S 1, 2, 3 = (Courseware) Student at node 1, 2, or 3
SS 1, 2, 3 = (Scripted Courseware) Student at node 1, 2, or 3

Figure 1

Summary

Interstate Electronics Corporation Integrated Technical Services Department has designed and developed distance learning Videotape-Based Training (VBT) and Computer-Based Training (CBT) courseware throughout the last fifteen years of our forty year training history.

Today's thrust is the development of CBT courseware to provide full desktop multimedia capabilities:

- For stand-alone multimedia-based training.
- For networked distance learning.
- Through the incorporation of videodisc and the expansion into CD-ROM.
- Using commercial off-the-shelf (COTS) authoring software.

IEC's CBT distance learning program has benefited from earlier broad experiences of our earlier VBT distance learning experiences. The Distance Learning Environment Demonstration (DLED) featured our CBT capabilities and the benefits of the high bandwidth Asynchronous Transfer Mode/Synchronous Optical Network (ATM/SONET).

Using ATM/SONET for the DLED was compatible with the real time, global military network or "Global Infosphere". The Global Infosphere links soldiers at almost all levels of command to voice, data, imagery and video sensors in much the same way as the demonstration linked students to the courseware.

ATM has been identified as a key part of the global network. It is the next generation protocol for the future development of communication networks as it provides communications services on demand with voice, data, video and imaging all on the same network. It is true dual-use technology and Interstate is applying it to both fiber applications as well as satellite networks.

The DLED was designed for ease of use and focuses attention on Human-Computer Interaction (HCI). The DLED intuitive interface design and multimedia output offered students easy-to-use courseware that maintained their attention and interest.

The Computer-Managed Instruction (CMI) portion of the lesson set the courseware development apart from a multimedia presentation. The DLED had all the interactivity of a computer aided presentation with the added ability to track the users (students) performance and, in the case of the student, remediate them to finer levels of resolution.

This means that the student received automatic feedback, both positive and negative. A well defined instructional design for the courseware provided the student with a systematic learning process designed for the self-study environment.

Personal Computer (PC)-based desktop courseware has made tremendous strides over the past twelve years. The quality of the Instructional System Design (ISD) and HCI, coupled with a full array of multimedia data types, have established CBT as a viable tool for continuing education.

Moving learning from the desktop to a distributed environment, offers new opportunities for distributed courseware developers, distance learning centers, and students.

The DLED provided state-of-the-art computer-based learning over a high bandwidth network. Courseware constructed with COTS authoring tools, for stand alone delivery, was modified for a distributed network environment.

Courseware files resided on the server and were accessed by the nodes. The nodes had courseware specific executable files that allowed courseware logon and execution. Once a student had logged on, the CMI software allowed students predetermined access to the courseware.

Initial IEC Ethernet Local Area Network (LAN) demonstrations and tests were performed in Anaheim. IEC LAN measurement data was collected and compared to the demonstration data collected at the Rome Laboratory site. At the Rome Laboratory site, the DLED network was connected to the New York Network (NYNet/service provider is NYNEX). The NYNet is an ATM/SONET environment. By running the DLED on the NYNet, Wide Area Network (WAN) measurement data was collected.

During the DLED, three nodes were connected via 10base-T Ethernet to a hub and server. This LAN server acted as a router. The hub and server had to be added to the network in order to have all the communication drivers connect to the ATM switch, a FORE ASX-100. The server was connected to the ASX-100 switch via a PCI ATM adapter card using 100 Mbps TAXI fiber. A SONET WAN ran between the ASX-100 switch to another ASX-100 switch. A courseware server was connected to the second ASX-100 switch via 100 Mbps TAXI. All courseware and CMI transaction data was stored and collected on the courseware server. Novell Netware software administered the DLED network.

Several functions of the courseware were demonstrated:

- Reversioning of existing courseware for a distributed environment.
- Courseware setup and distribution.
- Logon, security, and assignment procedures and effectiveness.
- Perceived quality of the multimedia environment.
- Ability of network management software to adequately support the multimedia functions of the courseware.
- Student performance tracking and student record handling.
- Student record output such as database file and printouts.
- The collaborative environment of the courseware Email system.

Other DLED considerations included the integration and testing of hardware and software, functional aspects of the courseware, and the testing demonstrations in both the Ethernet LAN and NYNet ATM/SONET WAN environments.

Summary Work Statement

Interstate Electronics Corporation performed the following tasks in order to complete this project:

1. Specified and procured deliverable hardware and software.
2. Reversioned existing courseware and job aids that produced the test demonstrations.
3. Designed performance test instruments.
4. Demonstrated courseware on an Ethernet LAN at IEC.
5. Installed the deliverable hardware and software on the NYNet at Rome Laboratory.
6. Monitored and demonstrated the courseware on the NYNet.
7. Produced a report containing the results from the analysis of the two demonstrations with recommendations for further implementation of courseware on a ultra-high speed communications network using Synchronous Optical Network and Asynchronous Transfer Mode techniques.

Project Risk Analysis, Alternatives and Conclusions

The DLED project risks incurred were network integration difficulties. These risks were due to the following issues:

Changes in PC Architecture

486 DX PCs with EISA slots were proposed for the student nodes for the DLED. This was the standard COTS desktop computer delivery platform at the time of our proposal.

Prior to the equipment purchases, PCs with EISA slots were difficult to purchase in the market. Pentium PCs with PCI slots were rapidly becoming the new COTS PC standard. Although the cost of the Pentiums was slightly higher than the proposed 486 DX PCs, the project risks were lowered by using the new COTS standard.

PC architectural changes were discussed with FORE. At the time, FORE was not sure if they would continue to manufacture and support ATM EISA adapters. FORE representatives also recommended the change to the Pentium PCI architecture using their yet to be released ATM PCI adapters.

Because of this risk, constant review of integration requirements using PCI products was necessary.

Lack of standardization of ATM technology

Because a DLED requirement was to run on the NYNet, the need existed to connect to the FORE ASX-100 switches located at Rome Lab. Due to the proprietary switch design, FORE (the switch manufacturer) only provided drivers with their PCI ATM 100 Mbps TAXI adapters that would connect to this switch. FORE did not supply drivers with their other PCI adapters. ATM adapters manufactured by other companies were also a high risk because there was no testing data to support connectivity to the FORE ASX-100 switch. FORE was the sole source for the required adapters, which limited adapter functions, drivers, price, and support.

The FORE PCI ATM 100 Mbps TAXI adapters had not been developed when the DLED project began. IPX drivers were expected to be included with the ATM adapters, however, this was not the case. Only SPX drivers were provided by FORE with the adapters. Because there were no IPX drivers, the nodes could not be connected directly to the ASX-100 switch as originally proposed. An additional server (that used SPX drivers) and hub were added to the network in order to run the DLED. Figure 2 illustrates this revised networking plan.

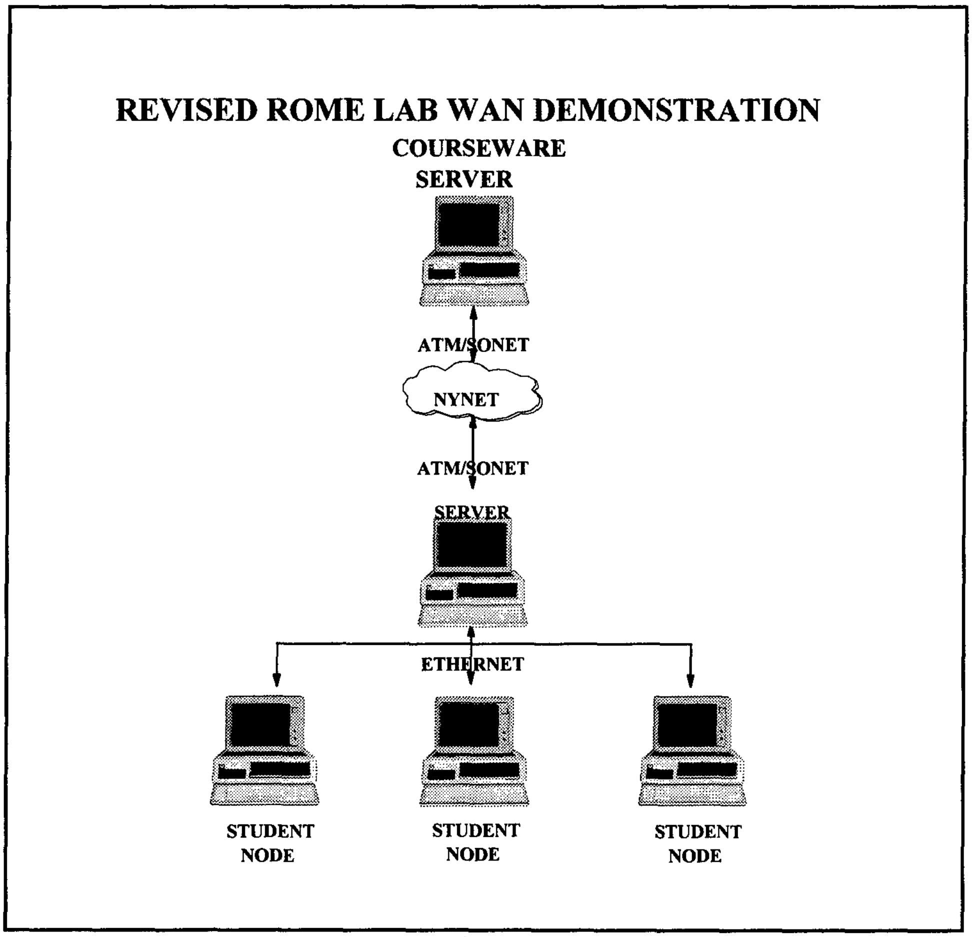
REVISED ROME LAB WAN DEMONSTRATION
COURSEWARE
SERVER
ATM/SONET
NYNET
ATM/SONET
SERVER
ETHERNET
STUDENT
NODE
STUDENT
NODE
STUDENT
NODE

Figure 2

Figure 3 was the proposed plan for the DLED, where the nodes would have directly connected to the FORE ASX-100 switch using IPX drivers. As the project proceeded, this was not a feasible option.

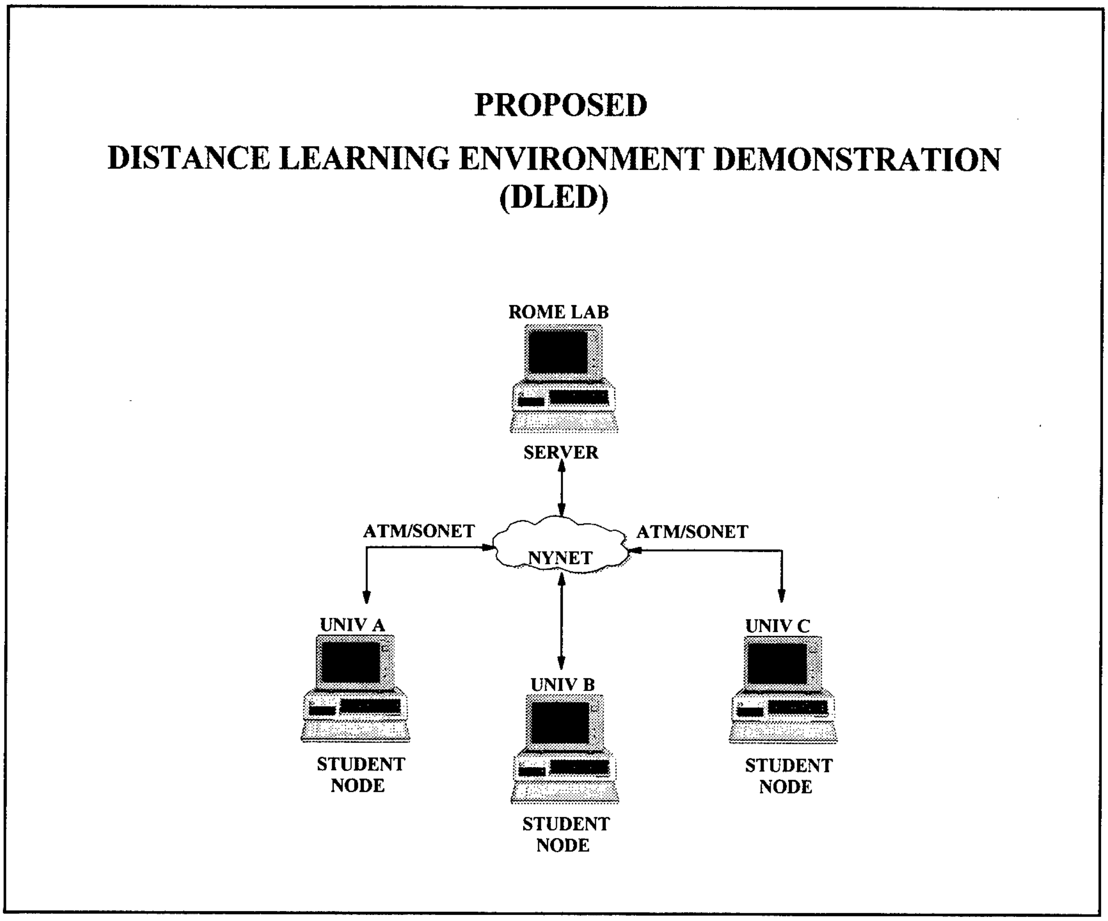

Figure 3

Finally, because the FORE PCI ATM SPX drivers were newly released, full testing results were unknown. During the ATM/SONET demonstration, anaomolies developed that may have been caused by the SPX driver connectivity. These drivers may still require some modifications for full connectivity to Novell 3.12. This is an area for further investigation.

Recommendations and Conclusions

This research has demonstrated that Commercial Off The Shelf (COTS) hardware and software can be interfaced to an ATM/SONET network in the real world. With small modifications to local area networks, such as the one used for the DLED study, connectivity to long distance ATM/SONET can be established. Using an ATM server with an ATM/Ethernet PCI board, LANs can communicate directly over long distances without restructuring their entire infrastructure.

Remote servers located anywhere on the ATM/SONET network can be accessed via LAN tied to the ATM/SONET infrastructure via a local ATM server. This allows the local area network a low risk migration path to high bandwidth communications. Management Information System (MIS) professionals seeking to move networks onto ATM can use information discovered during this research to provide baseline risk-analysis information for ATM/SONET migration.

There is evidence to support the hypothesis that ATM LAN emulation may offer a more stable bandwidth for local area network data streams and offer an improvement in overall multimedia data handling.

Since FORE did not provide IPX drivers to support the Novell network, the study was modified from its original proposal to provide a migration path from an Ethernet LAN to ATM/SONET. Although the migration was implemented successfully, it provided ATM LAN emulation and not native ATM connectivity. Because this research worked with Commercial Off The Shelf products, impacted by market share and market drift, manufacturers can quickly change strategies and approaches (to remain competitive and stay in business) affecting the direction of projects such as the DLED.

The industry shift is to a Microsoft/Intel solution for many real world distributed applications. Windows NT, with its OpenGL (graphics programming language) API (Application Programming Interface), has all the major software developers scrambling to port to NT. Hardware developers are building their products to GDI (General Device Interface) standards that talk to Windows NT. A Plug and Play (PnP) initiative forged by Microsoft/Intel/and members of the Peripheral-Component Interconnect Special Interest Group (PCI SIG) consortium in concert with Windows NT, is standardizing the PC industry, bringing the focus on to applications rather than the underlying hardware and infrastructure. The ramifications are already being felt throughout the community.

When FORE released the ATM PCI boards originally scheduled to be used in this demonstration, they announced that it would only support native ATM on a PC in a Windows NT environment. FORE had no immediate plans for supporting Novell IPX protocols. PC-based PCI ATM boards for Windows NT are currently available through

FORE and will operate on an Intel Pentium PCI system.

IEC recommends that a study be initiated to explore the Windows/Intel (WinTel) PCI in native ATM, focusing on high bandwidth multimedia applications such as: desktop videoconferencing; whiteboarding; virtual realities; video on demand; commercial 44.1 kHz audio compact discs; etc. There is a real need today to show that a low cost COTS native ATM WINTEL solution is a viable approach for the future of multimedia communications.

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