

A Multimedia Distance Learning Trial Using ISDN BRI

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Distance Learning using multimedia communications can be conducted in a point-to-point or multipoint mode. Trials were conducted at California State University in Chico to assess the viability of using Integrated Services Digital Network (ISDN) Basic Rate Interface (BRI) for transmission of voice, data and video. A prototype multimedia bridge was developed for the multipoint trial based on Definity® telecommunications system technology.

Introduction

Distance Learning (DL) is an application of multimedia communications in which an instructor is able to teach students located in distant classrooms. *Multimedia* involves the use of audio, data, graphics, and compressed or uncompressed full-motion video. DL would allow students in remote areas access to teachers and courses that might not otherwise be available locally. With improvements in video compression technology, increasing availability of ISDN, and development of conferencing bridges for multimedia communications, it is possible to configure multimedia DL networks at a reasonable cost.

Background

Distance Learning can take many forms. It may be as simple as a correspondence course where the instructor and students communicate exclusively through written materials, or as technically advanced as a course delivered worldwide via high-bandwidth satellite communications. Depending on the sophistication of the DL system, the media involved may include audio, video, still and motion images, interactive graphics, and hard copy.

A major disadvantage of options such as correspondence courses or audio-only broadcasts is the lack of instructor "presence" in the classroom. It is much easier for students to develop rapport with a teacher they can see, than one they cannot. Similarly, a teacher is better able to gauge the class' progress or attentiveness if he or she can see the students.

DL networks using only audio and interactive graphics have been successfully

used in rural school districts in North Dakota and Utah.¹ The AT&T Scanware® software and Overview® Scanner have been used in these networks to allow several PCs to share scanned images, computer graphics, and free-hand drawings. The Overview scanner is used to scan documents and small three-dimensional objects and these images can then be shared with other workstations using the Scanware software, which provides the user interface to direct the workstation (image sharing, annotation, etc.) and to set up and manage the network connections.

Growing interest in the use of motion video for DL is being stimulated by:

- Advances in image and voice compression techniques that reduce the bandwidth requirements for a given picture and voice quality;
- Increasing availability of ISDN, utilizing digital telecommunications technologies in switches, access loops, and networks;
- Emergence of audio/video service standards² which allow vendors to develop interoperable standard products and;
- The expected efficiency of using video as part of a multimedia conference.

While video networks operating at 45 megabits per second (Mb/s) provide high-quality video, the cost is high compared with an ISDN BRI line operating at a total of 128 kilobits per second (kb/s) on its two bearer channels. BRI is the fundamental unit of access to the ISDN network and supplies two 64 kb/s B-channels along with a 16 kb/s D-channel for out-of-band signaling and X.25 data. The cost is expected to drop further with deployment of National ISDN.³

Trial Participants

AT&T worked together with Pacific Bell, California State University at Chico (CSUC), and the Chico public school system to trial a DL network using ISDN rate video, audio, still images and interactive graphics. The trial's primary goal was to assess the feasibility of using the relatively low bandwidth of ISDN BRI lines to carry all the media between the instructor and the classrooms.

The Communications Design Department of CSUC is nationally known for its expertise in instructional technology. CSUC operates a distance training network based on satellite and microwave links. Use of ISDN-based links offers the promise of drastically reducing network operating costs. Fairview High School in Chico, California, agreed to participate because of its interest in developing innovative approaches to instructional delivery. In addition, the school is interested in identifying changes to the mathematics curriculum that might be recommended to the California State Education Department's Mathematics Curriculum Committee.

Pacific Bell shares an interest with AT&T Network Systems in encouraging use of ISDN: Pacific Bell as a service provider and AT&T Network Systems as an equipment provider. Network Systems' Strategy and Market Development, the Switching U.S. Customer Business Unit, and the Pacific Regional Marketing Team organizations were also involved in the trial. AT&T Global Business Communications Systems provided workstation software, which was based on an extension of the AT&T Scanware conferencing software. It also supplied the multimedia bridge, which was based on Definity telecommunications system technology.

DL Trial Description

The DL Trial was divided into several parts. Phase I involved a point-to-point trial between two locations. In the point-to-point configuration, the instructor, located at the CSUC campus, taught a single science class to Fairview High students across town for a one-week period in May 1991.

Phase II, which was a demonstration of inter-local access transport area connectivity, consisted of a seminar delivered from the Chico campus to the California Polytechnic State University campus in San Luis Obispo in August 1991. Phase III involved the use of consumer-premises and network-based bridging equipment to accommodate simultaneous instruction to three

Panel 1 Abbreviations, Acronyms and Terms in This Paper

ARC	—	Audiographic Remote Controller
ASAI	—	Adjunct Switch Application Interface
BRI	—	Basic Rate Interface
CLI	—	Compression Labs Inc.
CSUC	—	California State University at Chico
DL	—	Distance Learning
ISDN	—	Integrated Services Digital Network
MMCB	—	Multi Media Conferencing Bridge
TA	—	Terminal Adaptors

fifth-grade science classes in Chico in May 1992. The results of Phase III will be reported in a jointly authored AT&T and Pacific Bell report, which was not available at the time of this publication.

Description of the Point-to-Point Trial. Figure 1 shows the configuration for one of the endpoint workstations. There are two types of endpoints: the conference controller or teacher and the participants or students in the remote classrooms. The equipment used at each type of endpoint was similar, but not identical, because of the special requirements of the instructor. The equipment used included:

- An AT&T 6386 personal computer (PC) with color monitor and VGA card.
- A PC/ISDN platform card and supporting software to provide the communications link between the PC and the CSUC 5ESS® Switch.
- An Overview overhead scanner and scanner interface card which was used to scan objects and drawings and to scan student answers to the instructor's questions.
- A laser disk player which was used to show pre-recorded video clips.
- An auto-focus, fixed-placement video camera which captured live pictures of the students in the classroom.
- A large-screen video monitor placed at the front of the classroom to display video output either from the codec or the laser disk player.
- A video codec to process video signals received from the local video camera. This was a Compression Labs Inc. (CLI) Rembrandt II/06® video codec configured to operate at 128 kb/s. (Rembrandt II/06 is a registered trademark of CLI.)
- An Ascend Multiband™ ISDN Terminal Adapter (TA) connected to the ISDN BRI line to provide a V.35 data

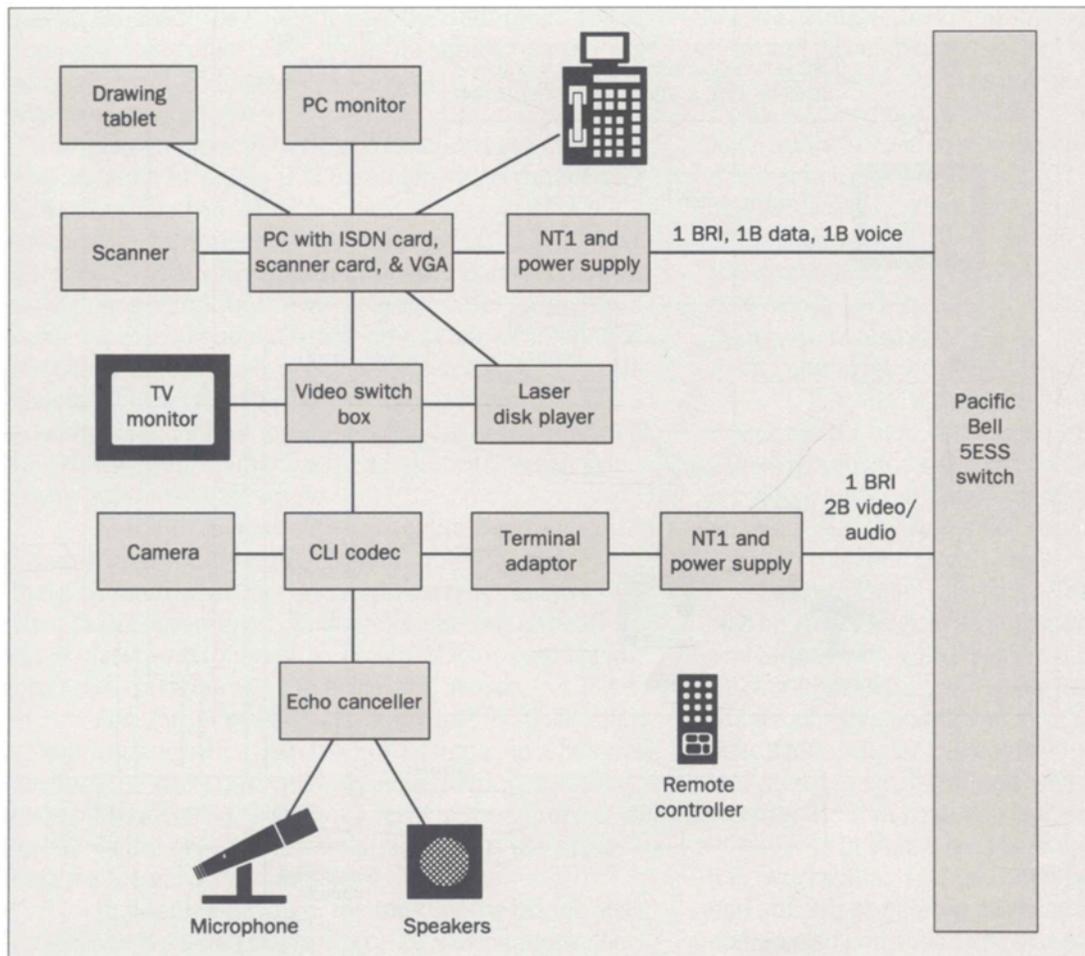


Figure 1. The instructor and student workstations used in the Distance Learning Trials were similar but not identical. The workstations included a personal computer with VGA monitor and ISDN card, overhead scanner, laser disk player, large-screen monitor, video codec, video camera, terminal adaptors, and multimedia conferencing equipment.

interface to the codec. (In Phase I, the video call was manually initiated by keying in the far-end telephone number on the TA keypad.)

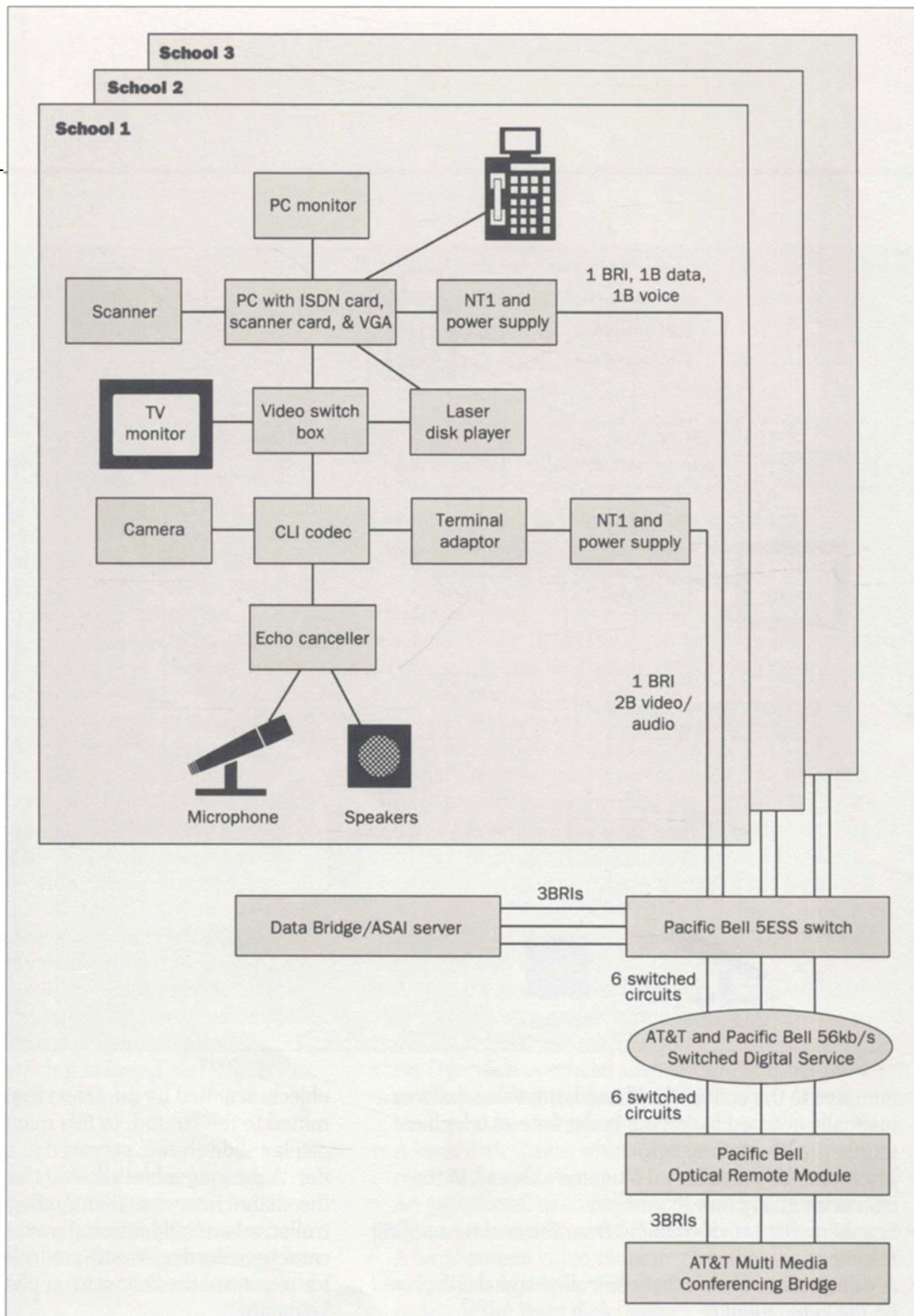
- Microphones that allowed students to speak to the instructor at any time.
- Speakers that provided audio from the remote sending station.
- A video source switch that controlled signals displayed on the video monitor.
- Echo cancellers, and other ISDN equipment, including power supply, cords, and ISDN phones to support connections for two BRI lines.

The PCs ran an enhanced version of the AT&T Scanware conferencing software. This software used a BRI line connected to the AT&T PC ISDN card to call the remote PC. Once the connection was made, the images of

objects scanned by the Overview scanner could be transmitted to the far end. In this manner, the instructor could display slide shows, prepared in advance, on the PC monitor. A drawing tablet allowed the instructor to annotate the shared images and an Audiographic remote controller, a handheld infrared transmitter similar to a video cassette recorder remote controller, allowed the instructor to control the Scanware application without using the keyboard.

A laser disk player at each location was used to provide high-quality, pre-recorded video. Since video from the player did not pass through the video codec, the instructional laser disks could be viewed without any loss of image quality. In addition to commercial disks, custom-produced disks on special topics were also used during the Phase I trial. The Scanware application

Figure 2. In Phase III of the trial, three instructors took turns teaching their own and two remote classes. Support was coordinated from separate facilities linked through Pacific Bell's Chico, California, central office 5ESS® switch. Data conferencing was handled by the Data Bridge/Adjunct Switch Application Interface (ASAI) server located in the CSUC campus library. The video conferencing was provided by a Multi Media Conferencing Bridge (MMCB) prototype at the AT&T office in nearby San Ramon and accessed through Pacific Bell's 5ESS Optical Remote Module (also in San Ramon) via 56 k/bs switched digital services.



allowed the instructor to control which sequence of video should be viewed as part of the prepared slide show. A PC-controlled video switch was used to select either the laser disk video or the codec video for display to the class. The codec video was transmitted over a second BRI line.

Description of the Multipoint Trial. The Phase I and II trials involved point-to-point configurations. However, in Phase III, students in three separate classrooms were able to communicate with the instructor. In this trial, the classroom teachers each took a turn as lead teacher for their and two other fifth-grade classes. A

multimedia bridge was needed for this multipoint voice, video and data conference, just as an audio-conferencing bridge is required for multiple parties to participate in a voice conference.

The multimedia bridge's functions are different from an audio bridge in that incoming video cannot simply be combined and directed back to each endpoint. Instead, the multimedia bridge must select which individual video stream should be sent to each party. This can be done in several ways. One is to allow the parties at each endpoint to choose which other endpoint they wish to view. Another is to broadcast the video from one endpoint to all others. A third approach is to reformat all incoming video streams and present them in windows on the same screen, so that each endpoint can see all the other endpoints at all times.

In the DL trial, the teacher controlled the session from the instructor's workstation. Ordinarily, the Phase III multimedia bridge would carry the instructor's video to the classrooms, while he or she can choose which classroom to monitor. The instructor could also select one classroom as the broadcast source.

A different selection strategy may be desirable for applications other than DL. For example, in a business meeting, the party currently speaking loudest could be the one broadcast to the other sites. On the other hand, the role of the broadcaster could be fixed at the beginning of a formal presentation.

In addition to video, the multimedia bridge also bridges the data streams from the PC workstations. The strategy selected for the Phase III trial was to send to each endpoint the interleaved sum of the data arriving from each of the other endpoints. Each endpoint's data application must cooperate with the others so that only one is transmitting at a time. This can be done very simply by having each endpoint wait for the data channel to be idle before transmitting.

Naturally, audio must also be bridged and this can be handled in a conventional manner. The voice conferencing feature available through the Definity telecommunications system was used in the DL trials.

The Multipoint Trial Bridge

The Phase III trial involved three classrooms in the DL network, with the originating teacher instructing the students in his local classroom and two remote classrooms. The key additions to the equipment configuration

were a MultiMedia Conferencing Bridge (MMCB) prototype and a Data Bridge/Adjunct Switch Application Interface (ASAI) server shown in Figure 2. The MMCB is a Definity telecommunications system-based bridge that links audio and video streams from the endpoints. The data bridge provides bridging for the data streams and also provides a gateway into the MMCB call set-up and video broadcaster selection functions. Call set-up and control commands pass from an endpoint's workstation to the data bridge and then to the MMCB via the ASAI call control interface. This interface is an extension of D-channel signaling and is provided on the Definity G1 system.

The MMCB responds to call setup commands issued via the ASAI connection from the data bridge. These commands initiate the calls to the three endpoints for video, audio, and data. In addition, the instructor is able to select the broadcast origin and the viewed parties through this interface.

The Data Bridge/ASAI Server used in the trial was an AT&T 6386 WGS PC running on the UNIX® system and Simultask®. (Simultask is a trademark of Phoenix Technologies Limited.) Using an AT&T PC/ISDN card, the data bridge connected via a BRI D-channel to the MMCB ASAI link for call control functions. BRI B-channels were used to carry bridged data streams from the Scanware application running on the endpoint PCs.

As in Phase I, each endpoint was equipped with a PC workstation that provided the interactive graphics and still-image sharing application. In addition, the workstation also controlled call setup for the data, voice, and video connections. The Scanware application was modified to run as a Windows 3.0® application and all the call-control functions were provided in a window separate from the data-sharing window. (Windows is a trademark of Microsoft Corporation.)

Overall, the capabilities of the Phase III DL network were similar to Phases I and II, except that the instructor was able to work with three classes.

A Multipoint DL Scenario

As an example, consider the setup involved in a multipoint call. A total of three or four calls are involved:

- a data call to/from the data bridge for control and data conferencing,
- an audio call to/from the bridge, and
- one or two B-channel data calls to/from the bridge for video.

The instructor establishes the call using the call setup application on the PC to select the parties to be called from a list. Then, the PC calls the Data Bridge/ASAI server. The instructor's PC passes the selected list of names and numbers to the data bridge. Through the ASAI link, the data bridge instructs the MNCB to establish the audio conference, the video conference and the data conference. For a video conference, there may be one call for 56/64 kb/s video or two calls for 112/128 kb/s video.

Once the call has been established, the instructor can choose the broadcast site and which site he or she will view. Using the graphics-sharing application, prepared slide shows can be shown on the monitor at all sites, material can be scanned and sent to all sites, and the laser disk players at each site can be controlled by the instructor.

Conclusions

Phase I of the trial was evaluated by direct observation, reviewing video tapes of the classes, interviewing the participants, and reviewing written comments from the participants. Based on this evaluation, the following was concluded:

- Audio quality is very important. Even though the video, still image, and graphics media are available, the overall perception of the service is greatly affected by the quality of the voice communications.
- For DL applications, the ISDN bandwidth of 112/128 kb/s delivers adequate real-time video quality. Video is used primarily to establish the instructor's "presence" in the classroom and to monitor student reactions. Detailed graphical material is shared using the graphics-sharing application.
- Animated graphics (i.e., data), audio, and two-way video are effective ways to instruct students in remote classes.
- When it becomes available, an evaluation of Phase III should provide technical and marketing information, including the utility of multipoint video in the DL environment; the requirements for instructor and classroom workstation conference control; bridge features and networking requirements; and operations, administration, and maintenance considerations.

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