DOCUMENT RESUME

ED 364 188 IR 016 272

AUTHOR	Hobbs, Vicki M.; And Others
TITLE	The School Administrator's Primer on Distance Learning: Two-Way Interactive Television (I-TV) via Fiber Optics.
INSTITUTION	Mid-Continent Regional Educational Lab., Aurora, CO.; Mid-Continent Regional Educational Lab., Inc., Kansas City, Mo.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE	[93]
CONTRACT	RI91002005
NOTE	26p.
PUB TYPE	Guides - Non-Classroom Use (055) -- Reports - Descriptive (141)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Administrator Role; Budgeting; *Computer Networks; Cost Effectiveness; *Distance Education; Educational Planning; Educational Technology; *Educational Television; Elementary Secondary Education; Interactive Video; Retrenchment; Rural Schools; School Administration; Small Schools; *Systems Development; Technological Advancement
IDENTIFIERS	Fiber Optics; *Interactive Television; *Two Way Television

ABSTRACT

This guide is intended to provide assistance to educators interested in developing two-way interactive television networks, addressing the educational and cost issues of this technology. Interactive television (I-TV) offers smaller or rural schools the opportunity to offer a comprehensive program within budgetary restraints. I-TV refers to the ability to receive two-way audio and two-way video in the provision of stand-alone courses from a teacher at one site to students at (typically) one to three other sites. The creation of an I-TV network through fiber optic cables enables this sharing of instructional materials. Defined terms and issues for the educator that are discussed include: (1) multi-site use; (2) simultaneous viewing; (3) the meaning of two-way; (4) full motion; (5) multi-channel; (6) a television network; (7) separating the myths and realities of I-TV; (8) questions to ask; (9) cost comparison; and (10) network description. Three sample networks are described. The guide makes it apparent that I-TV is a complicated issue, requiring careful study and planning. Appendix 1 defines terms in distance learning, and Appendix 2 lists some implementation sites. Tables summarize details of I-TV technology and compare network types. (SLD)

THE SCHOOL ADMINISTRATOR'S PRIMER ON DISTANCE LEARNING: TWO-WAY INTERACTIVE TELEVISION (I-TV) VIA FIBER OPTICS

by

Vicki M. Hobbs
Educational Consultant
Mid-continent Regional Educational Laboratory
Columbia, Missouri
314-445-4940

Dennis Pellant
Vice-President
Tele-Systems Associates
Hastings, Minnesota
612-438-3510

Mel Chastain
Director
Educational Communications Center
Bob Dole Hall
Kansas State University
Manhattan, Kansas
913-532-7041

McREL
Mid-continent Regional Educational Laboratory

2550 S. Parker Rd., Suite 500
Aurora, CO 80014
303-337-0990

3100 Broadway, Suite 209
Kansas City, MO 64111
816-756-2401

This monograph was made possible through the assistance of the Mid-continent Regional Educational Laboratory. It is intended to provide assistance to K-12 educators interested in developing two-way interactive television networks.

"The School Administrator's Primer on Distance Learning: Two Way Interactive Television Via Fiber Optics," addresses the administrator's need to understand the **educational (and cost)** issues of two-way interactive television technology.

Appendix I, "A Discussion of Terms and Distance Learning Technologies," attempts to explain from a technical—but understandable—viewpoint the **technology** issues involved in selecting one of seven methods of video distance learning technology.

Appendix II provides a list of suggested Interactive TV visitation sites.

This publication is funded, in part, by the Office of Educational Research and Improvement (OERI), Department of Education, under Contract Number 91-002-005. The content of this publication does not necessarily reflect the views of OERI, the Department or any other agency of the U.S. Government.

THE SCHOOL ADMINISTRATOR'S PRIMER ON DISTANCE LEARNING: TWO-WAY INTERACTIVE TELEVISION VIA FIBER OPTICS

A common concern among many smaller or rural schools today is the ability to offer a comprehensive curriculum within ever-tightening budgetary constraints. One technology which has come to the forefront in assisting clusters of schools to do just that is two-way interactive television (I-TV).

The advantages of the this technology to rural schools are many:

1. Schools can share in the services of a single teacher in advanced or hard-to-fill positions without the prohibitive time loss and inefficiencies involved in transporting either students or teachers.
2. Schools can offer classes—in conjunction with other schools—in subject areas where low enrollments prohibit the hiring of a teacher for that purpose.
3. An interactive television class consisting of 2, 1, 5, and 3 students, for instance, at four different high schools can combine for much greater student interaction, joint problem solving, and better educational dynamics than a single class of 1-3 students.
4. Advanced science, math and foreign language classes, not always available in small rural high schools, can be offered through I-TV, giving rural students the ability to access virtually any course that they might be able to take in a large comprehensive high school.
5. Rural high school students, through I-TV, can access advanced placement, dual-credit, and college courses, giving them a much greater opportunity to succeed in college as well as the opportunity to receive college credit at a much lower cost.
6. For many schools, the ability to technologically share teachers may mean the difference between closing the school—and therefore the community—and remaining a viable educational entity.

Apart from the educational opportunities available to students, I-TV also allows a host of opportunities for community and economic development:

- adult or community education classes;
- GED classes;
- combined- school staff development training;
- intercommunity meetings or public forums;
- medical, legal, and other professional continuing education or recertification courses;
- consumer safety courses, such as pesticide use and hunter safety training;
- agricultural extension and community development activities;
- intergovernmental or interagency meetings; business training seminars or meetings across communities;
- community drug and alcohol abuse prevention and other health-related activities;
- emergency response training, e.g., EMT, volunteer firefighter, law enforcement, etc.; and
- manpower and job skills training or retraining, among many others.

The potential for linking hospitals, libraries, universities, colleges, area vocational schools, etc. into the networks with eventual interconnection across the clusters provides a virtually unlimited range of uses. Because the initial purchase and ongoing lease costs of the system are most often predicated on unlimited 24-hour usage, the incentive to fully utilize the system is substantial.

Rural schools in remote and not-so-remote parts of the U.S. are increasingly thrusting themselves into this new era of educational technology. While some schools have been participants in the near-decade history of utilizing two-way interactive television, many schools still have no idea this capability is immediately possible. While in some circles, school superintendents have had to become conversant in a new techno-language of analog and digital fiber optics, T-1 or DS-3 lines, CODECs and multi-point control units, *(see Appendix I)* others are caught in the time warp not really understanding what all the hoopla is about!

The following discussion of the technology and its cost implications attempts to bring the uninitiated administrator, as well as the potential adopter, into the technological arena of two-way I-TV.

Lest the reader confuse "I-TV" with Instructional Television (ITV), some definitions are in order. Instructional television, the closest many schools have come to video technology, refers to the viewing of televised programming in the classroom usually via videotape or cable TV. It may involve semester-long courses, in some instances, but it most often is utilized for occasional inclusion into a teacher-taught class. This use of Instructional Television is most often called "enrichment programming," and is, of course, not interactive. Students seeing the videotaped or cable programming participate in the one-way reception of video.

As a distance learning technology, most school administrators are now familiar with *instruction by satellite* which enables the reception of classes from a distant source. Instruction by satellite, however, enables at best only one-way video and intermittent two-way audio, meaning that a student from virtually anywhere in the country can see and hear their distant instructor, but at best is only able to talk to the instructor intermittently over separate telephone lines. The instructor, of course, does not have the ability to see any of the several hundred students concurrently taking the course. The advantage of instruction by satellite—namely, the ability to receive a course from any provider in the country—does allow any district to offer courses for which the hiring of a local teacher could not be economically justified. However, several detractors do exist—the local school has no control over the curriculum, the scheduling of the course (if offered live), selection of the instructor, or the difficulty level of the course. Students often find it difficult to get questions answered, are often reluctant to ask for help, and become frustrated at delays in the return of homework, quizzes or tests via the mail.

"I-TV" or *two-way interactive television* refers to the ability to receive two-way audio and two-way video in the provision of stand-alone courses (usually, but not exclusively, at the high school level) from a teacher located at one school with students located at one to three other sites. The creation of an I-TV network linked together via fiber optic cable enables this sharing of teachers and students. While a network may include up to sixteen different schools or receive/send sites, it is typical that only four sites be involved in any one course at any one time. This makes the job of the teacher in monitoring and interacting with all students at both originating and remote sites much more feasible. Stand-alone credit courses—in which a teacher located at one school may teach to students located in several other schools—need not be uni-directional. Any school on the network may teach or receive any course.

In its ideal form, each person involved—the teacher as well as students—can see and hear each other at all times, giving the technology the advantage of "the next best thing to being there." The technology in its ideal form most closely approximates the traditional classroom, with the teacher receiving both auditory as well as important visual cues from his/her students at all sites, remote as well as local. Students from any site can likewise continually see and hear—and therefore interact with—students from all other sites. The addition of an overhead camera allows the teacher to show remote students anything on his/her desk. Videotape, cable, computer, or live satellite transmissions can be "patched" into the system, allowing simultaneous viewing at all sites, as well. *(See Appendix I for further discussion of other I-TV technologies, along with their advantages and disadvantages.)*

The intent of this monograph is to enable the school administrator just entering the video technology arena the opportunity to understand—not the in-depth technical side—but the educational side of two-way interactive TV technology and to begin to look at it from a practical implementation standpoint, where cost is likely to be a determining factor. Unfortunately, schools are most often in a technologically vulnerable position without access to independent information on the many technical, design, and cost considerations which must be taken into account when implementing a *two-way interactive television network.*

The first contact point outside the school usually becomes the local telephone company (telco), but several obstacles may exist here as well. The local telco may not be knowledgeable about the technology, fiber optic cable may not be available or planned in a given area, or the telco may not be able to offer the service at competitive rates. Each of these problems are compounded when several schools working together to implement an I-TV network cross multiple telephone company boundaries. It becomes clear, very quickly that most school administrators simply do not have the expertise (nor time) to conduct all of the research and find answers to all of the questions which emerge.

Unlike so many of the technological advances with which school administrators have become familiar, *two-way interactive television* is not a "plug-in" technology. You cannot order it from a catalog; it doesn't come with a box and an instruction manual; and it's not available by model number. There are nearly as many nuances to the networks as there are I-TV networks. The catch-all term itself, *two-way interactive television,* means several different things to different implementors. While a college or university might consider their television classroom, from which a course originates to several outlying campuses or business sites as an example of I-TV, it may resemble a secondary school I-TV network in only some respects.

While one may use existing phone lines rather than fiber optic cable, the picture quality may be visibly inferior, unable to show motion in other than a blurred image. While one may have limited visual contact with persons at remote sites, another network may have constant visual and auditory contact. In short, it is the technical nuances or limitations of any system which dictate its educational capabilities.

Appendix I outlines the seven types of video technology in operation today: analog fiber, digital fiber, T-I compressed, microwave, ITFS (Instructional Television, Fixed Service), LPTV (Low Power TV), and satellite. While each has a role to play in educational technology, the focus of this monograph is the provision of two-way interactive television and, as such, limits this discussion to analog fiber, digital fiber, and T-I compressed technologies. T-I compressed technology is less expensive and more widely available, but does not allow for full-motion video nor can all sites be seen and heard simultaneously. Digital fiber optic technology does allow for near-full-motion video, but is very expensive to achieve simultaneous viewing and is most often used in situations where only one site need be seen at a time. Analog fiber optic technology is most commonly used in K-12 applications and does allow for full-motion video and simultaneous viewing.

Most helpful, however, is the administrator's ability to delineate what the school requires in terms of *educational capability*, rather than in terms of technical considerations. Every good school administrator can relate to vocabulary words. Below are a series of defined terms and related questions which each potential implementor should be able to answer prior to reaching outside the school for the technical expertise to implement the technology.

MULTI-SITE

Multi-site networks consist of clusters of schools, usually between three and ten schools in size.

- **How many schools do you want to include in an initial network?**

  While a total of four schools is the practical upper limit in order for the teacher to be able to visually address each student in their own classroom as well as at three remote sites, it is entirely feasible for 8- to 10-school networks to be set up. (The technical limit is 16.) The limitation of a larger network involving more schools is that only four schools can feasibly interact at one time. A first period class, for instance, may include schools A, B, C, and D while a second period class may include schools B, D, G, and J. Obviously, by definition, a network must consist of at least two schools in order to achieve two-way instruction, but with more than four schools involved in a network, multiple classes can be offered simultaneously over the system. With a usual 16-channel capability (for an analog system) this would mean a maximum of four classes could be simultaneously offered involving four different groups of four schools.

  The capability to interconnect networks—for instance, to link one 9-school network with another 4-school network—is certainly feasible and will undoubtedly be the norm at some point in the near future. It is probably of little immediate consideration, however, to the early adopter except where pioneering school clusters can take advantage of their position in order to impact statewide or "backbone" network development.

- **Which technology choices allow for multi-site capability?**

  All seven technologies listed in Appendix I have multi-site potential. See "Nominal Site Limits" in the Appendix for the number of sites to which a network is limited.

SIMULTANEOUS VIEWING

Simultaneous viewing allows a network to transmit and receive all video signals at the same time. There is no switching or sequencing required.

- **Is it important that the teacher and all students at each site be able to see and hear each other at all times?**

  Various combinations of visual and auditory capabilities exist within I-TV technology:

  Viewing Option I: Simultaneously viewing and hearing each site on the network.

  Monitor Configuration: This would usually require four monitors at each site for student viewing plus an equal number for teacher viewing. All sites on the network would be identically equipped so that one monitor would show the teacher and one monitor would show each of the three remote sites. (The fourth monitor allows for either viewing of the teacher, the home class, or the overhead display. It is interesting to note the extent to which students located at the teaching site still watch their instructor on television rather than watching him/her in person. This point can be taken as a valid testimonial to the workability of the system educationally.)

  Viewing Option II: Scanning each site on the network every 7-9 seconds—this technology does allow the teacher to interrupt the scanning sequence in order to manually show any site to all other sites, but normally each remote site sees only the teacher and the teacher sees each site one at a time for a few seconds each. With this option, interactive capabilities are obviously reduced.

  Monitor Configuration: This would usually require two monitors at each site for student viewing—one showing the teacher and one showing the site at which someone is currently speaking. One additional monitor would allow for teacher scanning of each site.

  Viewing Option III: Seeing and hearing only the site currently speaking—this technology can be manually switched by the teacher or automatically switched with a voice-activated sensor. This option further reduces the capability for potential teacher-student interactivity.

  Monitor Configuration: This would usually require one monitor at each site for student viewing and one monitor for teacher viewing.

While there are other technical options with respect to viewing capabilities, the three mentioned above represent the majority of interactive systems in place in secondary schools. It also is important to keep in mind that each option is a result of the technical limitations of the technology chosen and are not "add-on" features to be purchased peripherally.

Most districts, if given a choice, would choose to be able to have each site simultaneously see and hear all other sites. This most closely approximates the traditional classroom and makes the technology most "transparent," that is, you are most likely to forget that the technology is there. It is least obtrusive to the normal teacher-student interaction patterns. A further advantage of this arrangement, especially applicable to schools in some states which have mandated the presence of a certificated teacher in every distance learning classroom, is the very plausible argument that, since the remote teacher can constantly see and hear all students at all sites, student supervision by an additional certificated teacher is not necessary.

- **Which technology choices allow for simultaneous viewing?**
  Only fiber optic technology allows for simultaneous viewing. Simultaneity is the major advantage of analog fiber systems; achieving simultaneity in digital fiber systems is much more expensive.

TWO-WAY

Both audio and video may originate from any site to any other site on a given network at any time.

- **Do you want the capability to both originate and receive classes from any site on the network?**
  While a novice to the technology may be momentarily enticed by the ability to receive several classes from a larger district on the network, the shrewd administrator will quickly understand the benefit of an equal partnership status among the network schools. Where each school on the network originates one or more classes on the system, the partnership is much more likely to result in a long-term relationship to the <u>mutual</u> benefit of all schools.
  Many models exist for financial remuneration across districts on an I-TV network based on number of classes taught and/or number of students enrolled. Many networks, however, in which each school both originates and receives several classes, are perfectly content with allowing the costs to "even out" on their own.

- **Which choices allow for two-way audio/video?**

Analog fiber, digital fiber, T-I compressed, and microwave technologies allow for origination of signal from any site on the network.

FULL-MOTION

The video quality of the signal received is of full-motion television broadcast quality.

- **Is the quality of the television image important to you?**
  Technically speaking, the transmission of video images is possible through many different mediums, from ordinary T-I telephone lines to fiber optic cable, from microwave to satellite transmission, among others. What may differ, however, is the *quality* of the picture received. Television sets require an "analog" signal, but the conversions through which a video signal must go in order to be ultimately viewed on a TV can be many, depending upon the technology used. The quality of any video signal—and the transmission cost—is directly proportional to the space or "band width" used to transmit the signal. While one I-TV technology may utilize "compressed digital video" where a CODEC *(see Appendix 1)* is used to code and then decode the signal at various frame rates and resolution levels, another technology may utilize strictly "analog" signals requiring no conversion of signals. Of the several options, only the "analog" signal is true full-motion video. Recent advances in digital technology have made <u>some</u> digital systems, however, virtually indistinguishable from full-motion signals, albeit at a higher cost. What all of this technical mumbo-jumbo means is prior to deciding on any technology you should see an identical system in operation. Test its capabilities both on close-up and distant images, pay attention to how motion is seen on the screen, and observe the extent to which image distortions occur.

- **Which technology choices allow for full-motion video?**
  All technologies with the exception of T-I compressed are either full-motion or approximate full-motion video.

MULTI-CHANNEL

More than one channel may be transmitted or received at any time.

This capability is totally dependent upon your need to simultaneously originate multiple classes or broadcasts at any given time. With a multi-channel capability, one class may be offered at schools A, B, C, and D while another class could be offered at schools E, F, G, and H. If you are considering only a four-school network, the need for multi-channel capabilities is still important. You might want the opportunity for a teacher to tutor a student at one remote site, while two other sites might be similarly interacting. Furthermore, a multi-channel network allows for the possibility of eventual inclusion of other schools on the network or the interconnection of networks, since each school has their own—not shared—full-time channel.

- **Which technology choices allow for multi-channel transmission/ reception?**

  While all seven technologies can accommodate multi-channel use, cost becomes the predominant issue. Since analog fiber systems are based on full-time 16-channel capabilities (where each site has its own channel), usage of all channels does not incur greater costs.

TELEVISION NETWORK

A television network, in this context, refers to the physical connection of two or more schools by coaxial or fiber optic cable, microwave or satellite transmission, ITFS (Instructional Television, Fixed Service), or low-power TV. (See Appendix I for further discussion of each transmission medium.)

- **Do you have a preference regarding how your cluster schools are connected?**

  Several considerations come into play:

1. Microwave transmission is costly and usually requires higher maintenance costs. It is not easily adapted to two-way simultaneous networks.
2. Satellite linkage is not at all economically feasible for point-to-point connection of a few sites. Its advantage is clearly in the point-to-mass market, e.g., airing one German course to students in 40 states. [NOTE: satellite linkage will not allow for two-way audio/video without a satellite uplink at each site, a prohibitively expensive non-option.]
3. Because of the cost limitation and technical considerations, ITFS and LPTV networks are not feasible for two-way, multi-site, simultaneous networks. This technology is more appropriate for a system having a central sending site, e.g., a class could not originate from all sites.
4. Twisted pair copper cable, such as telephone company T-I or DS-3 *(see Appendix 1)* lines can be used to transmit signals between sites, but both quality (at the level of the T-I line) and cost (especially at the level of the DS-3 line) are significant inhibitors.
5. Fiber optic cable has become the medium of choice for most school districts implementing two-way interactive TV. Its capabilities far exceed the demands of the system; construction costs are decreasing and will continue to do so; and schools may be able to take advantage of fiber optic cable being installed as a telephone company or cable company upgrades. Local or independent phone companies are most likely to see the inclusion of the community school on fiber optic cable as an important community investment, resulting in a further decrease of costs borne by the school.
6. Coaxial cable, the common TV transmission method employed by the cable TV industry remains the most economical means of transporting television or video signals. Coax can be easily adapted to handle two-way TV signals, however, once distances begin to exceed 10 miles between sites, coax maintenance increases substantially and picture quality can suffer. Under the right set of circumstances, coax can favorably compete with fiber optic cable for video transmission.

The administrative response to the above questions will likely yield a decision to implement a...

SIMULTANEOUS, TWO-WAY, FULL-MOTION, MULTI-CHANNEL, MULTI-SITE, FIBER OPTIC TELEVISION NETWORK.

The only technologies which currently allow for that combination of characteristics are analog and digital fiber optic systems. The difference between the two technologies then becomes an issue of cost, flexibility, and ease of interconnectivity to other clusters.

SEPARATING THE MYTHS AND REALITIES OF I-TV

By early 1992, there may be as many as 100 two-way simultaneous television networks in operation in the U.S. Technology is not the only factor that has limited the development of these networks, however. Cooperation between school districts and access to funding also have contributed to their relatively slow development. When combined with the confusing assortment of technical equipment and the slow adaptation of many telephone companies to television technology, two-way networks are not likely to appear as plentiful as spring mushrooms. Leaving the funding issue aside for the moment, perhaps the single biggest inhibitor to *two-way I-TV* implementation is lack of appropriate information. Many schools have inquired of their local telephone company or cable television operator concerning the provision of a two-way video network only to come away confused by costs, terms, technology or all three.

Below are summarized some the common myths which you too may have heard:

MYTH	REALITY
Telephone companies can't provide television to customers.	Telephone companies can legally provide fiber optic service to schools, including all "head-end" transmission equipment allowing for two-way interactive television networks.
Digital is the future!. . .which usually means analog will be outdated.	99% of all TV's in the world are analog, as are nearly 100% of all cable TV systems. Analog TV pictures can be easily converted to digital and vice versa.
Our telephone company just put fiber in!. . .Interpretation: We will have easy access to fiber.	Having fiber "in" usually means fiber exists between telephone company central offices (COs). This does not necessarily mean that fiber exists from the school to the CO, often referred to as "the last mile." With a cost averaging $10,000-$20,000 per mile, the cost of laying additional fiber optic cable may be significant. Depending, however, on tariff restrictions and internal telco pricing policies, it may be preferrable to "own" your own cable. This option virtually eliminates any long-term costs other than maintenance or equipment upgrade.
Fiber optic terminal equipment is too complicated to maintain!	A significant number (100+) of U.S. schools own and maintain their own fiber terminals. The option, of course, is to lease the equipment from the telco or maintain a service contract.
Fiber is better than microwave or coax!	Under <u>certain</u> conditions, such as very short distances or mountains, both coaxial cable and microwave may be preferable alternatives due to cost. In fact, coaxial cable, remains the least expensive method to transmit television. The key is to use whichever technology is most appropriate.

MYTH	REALITY
T-I compressed video is cheaper!	T-I compressed video equipment may cost less than an analog fiber optic alternative in the case of a one-channel (duplex) system, however, costs increase dramatically per site for each channel added to the network. T-I compressed video is not appropriate for a simultaneous, multi-site, multi-channel, two-way network.
Digital is full-motion television!	DS-I video varies from poor slow motion quality to near full-motion quality. Cost rises according to quality. (Each CODEC, needed to transmit one video channel can range from $19,000 to $50,000 per unit per site.) DS-3 video is equivalent to full motion television in appearance. As a general rule, the greater the bandwidth (DS-I to DS-3) the better the quality and the more expensive the equipment. Analog video is full-motion TV.
The telephone company is the only vendor for two-way interactive television service!	While a local telephone company should be the vendor of choice—especially smaller, independent companies who retain a vital interest in their local communities—do not overlook the local cable company or even a local construction contractor who might be willing to assist in building a private network.
There is no choice but to pay what the telephone company quotes!	Never settle for the first price quoted by the telephone company. There is always room for negotiation. In the case of smaller, independent phone companies serving small, rural schools, two-way interactive television networks may indeed be seen as a way to increase the viability of the local school.

WHAT SHOULD I ASK?

Providing the decision has been made to lease rather than construct a school-owned fiber optic system, additional questions for which you as an administrator may want "up-front" answers from the telephone company or equipment provider include:

- Can I expand the system to add more video channels? What does it entail? At what cost per channel? At what cost per site?
- Can more sites be added to the I-TV network? At what fiber lease cost per mile? With what additional equipment costs per site?
- Can I own the transmission equipment if I choose? At what cost? Can the cost be prorated over several years? What are the terms of the agreement?
- If I lease the transmission equipment, who is responsible for its maintenance? How much down-time might be expected? Is there any additional cost for maintenance? What is the cost of the transmission equipment lease apart from any maintenance agreement?
- What specifically is the school responsible for maintaining, (e.g., which equipment; if fiber, to what point)? For what is the telephone company or cable company responsible?

COST COMPARISON

The following section depicts three separate examples of *two-way interactive television networks* which approximate the "typical" kinds of networks most often implemented. The data and cost figures are real—the examples chosen represent actual I-TV networks implemented within the last two years. Costs and capabilities are compared between each, showing the trade-offs and cost parameters which can be expected for other networks implemented under similar circumstances. Because of the wide divergence of systems operating across the country, it is believed that the subject of cost can best be viewed in the context of several different, but typical, networks, rather than as averaged data across very dissimilar circumstances.

NETWORK DESCRIPTION

In each example, assume that one classroom in each school is dedicated full-time to interactive television instruction. The classroom is equipped to transmit to and receive live programming from any other site on the network. Normally up to three remote sites may be simultaneously viewed. Live video is neither switched nor sequenced, with all three video signals being in continuous view. Each school is equipped with four monitors for student viewing, four additional monitors for teacher viewing, three cameras (one showing the teacher, one showing the students, and one overhead camera showing desktop instructional materials).

Network A

Technical Description of Analog Network [1991]

- 5 school sites
- 55-mile fiber optic network
- Initial design allows each school to view three other sites simultaneously
- Analog fiber terminals with 16-television-channel capacity
- Full-motion TV and audio, data, and FAX transmission capabilities
- Nonswitched TV network (system operates independently of standard digital telephone facilities)—all sites can simultaneously see and hear all other sites
- Fiber equipment located directly within each school

Nature of Telco-School Agreement

- Fiber leased from two local telephone companies for multi-year period
- Lease rate set by negotiation (non-tariffed)
- Analog fiber terminals are owned and maintained by schools
- Classroom equipment owned and maintained by schools
- Schools may not use system as telephone by-pass, e.g., in lieu of telephone calls
- Specific use governed by legal agreement between parties
- 15-year renewable lease agreement
- 24-hour, 12-month use capability

Financial Data

- Each school pays approximately $440/month for fiber lease (on-going cost) = $5280 per site per year
- Lease rate is based on $40/mile/month for fiber cable, which includes fiber maintenance
- Average classroom equipment cost = $20,800 per site paid by each school includes minor room modifications (one-time cost)
- Analog fiber terminals and initial equipment installation costs = $26,400 per site (one-time cost)
- Schools share equally in fiber lease and fiber terminal cost regardless of distance

Miscellaneous

- Project funded through combination of State Department of Education and local districts
- Schools organized under a joint powers agreement
- Consultant employed for term of project (2+ years) for system design, fiber and classroom equipment bids and design, contract negotiations with telco, financial advice, technical proof, teacher training, and overall project coordination
- Estimated annual operations budget for each member school = $12,000. (Operations budget includes network director salary and related expenses; classroom equipment repairs; and network maintenance, excluding fiber.)

Network Cost Comparisons Given Different Terminal Equipment:

Given the above network characteristics, the following comparison shows the actual costs involved for the analog equipment vs. the estimated terminal equipment costs if a switched or non-switched digital system were chosen:

With Analog Terminal Equipment (Actual):	Cost = $132,000*
IF Non-Switched Digital Terminal Equipment were used (Estimated):	Cost = $172,000
IF Telco-Switched Digital Terminal Equipment were used (Estimated):	Cost = $290,000

*The total network cost of the analog terminal equipment actually installed in Network A

Network B

Technical Description of Analog Network [1991]

- 4 school sites
- 36-mile fiber optic network
- Analog fiber terminals with 16-television-channel capacity
- Full-motion TV and audio, data, and FAX transmission capabilities
- Nonswitched TV network (system operates independently of standard telco facilities)—all sites can simultaneously see and hear all other sites
- Fiber equipment located directly within each school

Nature of Telco-School Agreement

- One-third of the fiber leased from one local telephone company
- Classroom equipment and 2/3 of the fiber owned and maintained by schools
- Analog fiber terminals are owned and maintained by schools
- Multi-year renewable lease agreement for that portion of fiber optic cable owned by the telephone company

Financial Data

- Project costs evenly divided among all schools
- Average classroom equipment cost = $18,300 per site paid by each school (does not include room modifications) (one-time cost)
- Fiber terminals and initial equipment installation costs = $23,800 per site (one-time cost)
- Over 25 miles of 4-fiber fiber optic cable installed for under $10,500/ mile at a total cost of approximately $262,500 (one-time cost)
- Monthly fiber lease cost (for that portion of the fiber leased from the telco) = less than $100/month (because of benevolence of phone company)

Miscellaneous

- Project funded by State Department of Education and local districts with tax exempt financing
- Schools organized under a joint powers agreement
- Consultant employed for network design, construction bids, classroom equipment specifications and bids, project coordination, teacher training and system proof
- Estimated annual operations budget for each member school = $9,000 per school per year (including network director salary and related expenses; classroom equipment repairs; and network maintenance.)

Network Cost Comparisons Given Different Terminal Equipment:
Given the above network characteristics, the following comparison shows the actual costs involved for the analog equipment vs. the estimated terminal equipment costs if a switched or non-switched digital system were chosen:

With Analog Terminal Equipment (Actual):	Cost = $110,000*
IF Non-Switched Digital Terminal Equipment were used (Estimated):	Cost = $140,000
IF Telco-Switched Digital Terminal Equipment were used (Estimated):	Cost = $240,000

*This amount does include the purchase of some redundant equipment ($14,800) to be used as "spares."

Network C

Technical Description of Analog Network [1990]

- 10 school sites
- 115-mile fiber optic network
- Analog fiber terminals with 16-television-channel capacity
- Full-motion TV and audio, data, and FAX transmission capabilities
- Nonswitched TV network (system operates independently of standard telco facilities)—all sites can simultaneously see and hear all other sites
- Fiber equipment located directly within each school
- Fiber equipment may be expanded to transmit and receive 16 TV channels

Nature of Telco-School Agreement

- Fiber leased from four local telephone companies for multi-year period
- Lease rate set by negotiation (non-tariffed)
- Analog fiber terminals are owned and maintained by schools
- Classroom equipment owned and maintained by schools
- Schools may not use network as telephone by-pass, e.g., in lieu of telephone calls
- Specific use governed by legal agreement between parties
- 10-year renewable lease agreement

Financial Data

- The schools utilized a 10-year prepaid lease option
- Lease rate of $48/mile/month for fiber cable = $552/month/site
- Average classroom equipment cost = $18,255 per site paid by each school (does not include room modifications) (one-time cost)
- Fiber terminals and initial installation costs = $23,350 per site (one-time cost)

Miscellaneous

- Project funded by private funding, State Department of Education, foundation, and local district effort
- Schools organized under a separate governing commission
- Higher educational institution is part of the network
- Consultant employed for telco negotiations, classroom design, teacher training, equipment specifications, project coordination, and technical proof
- Estimated annual operations budget for each member school = $5,740 (Includes network director salary and related expenses; classroom equipment repairs; and network maintenance.)

Network Cost Comparisons Given Different Terminal Equipment:

Given the above network characteristics, the following comparison shows the actual costs involved for the analog equipment vs. the estimated terminal equipment costs if a switched or non-switched digital system were chosen:

With Analog Terminal Equipment (Actual):	Cost = $233,500
IF Non-Switched Digital Terminal Equipment were used (Estimated):	Cost = $375,000 +
IF Telco-Switched Digital Terminal Equipment were used (Estimated):	Cost = $500,000 +

NOTES: The prices quoted for equipment should be considered representative. They are, however, subjective, since each network design requires the addition or deletion of certain components depending upon analog or digital format as well as other considerations. A factor of +/- 10 percent is a reasonable variance to expect.

In each example the pre-existence of some fiber optic cable had little, if any, effect on the costs borne by the network schools. Lease costs reflect ongoing fiber usage costs, rather than initial fiber installation costs.

Analog equipment is relatively inexpensive to expand and the addition of sites and/or number of video channels can be a straight arithmetic function. Adding sites or channels to a digital network can be complicated due to required upgrade of the "hub" site(s) and individual school sites. Each network must be evaluated individually in this regard.

SUMMARY OF COST ANALYSIS
I-TV NETWORKS A, B, and C

# of Schools	Miles of Fiber	Line Lease Costs per School — CONTINUING	OR	Cost of Laying/ Owning Fiber per School — ONE-TIME	+	Cost of Classroom Equipment per School — ONE-TIME	+	Cost of Fiber Terminals and Installation per School — ONE-TIME
NETWORK A:								
5	55	$[illegible]40/mo		—		$20,800		$26,400
NETWORK B:								
4	36	<$100/mo		$65,625		$18,300		$23,800
NETWORK C:								
10	115	$552/mo		—		$18,255		$23,350

TOTAL COST OF IMPLEMENTING AN I-TV NETWORK FOR EXAMPLES A, B, and C

Network A: $47,200 per school + $440/month/school

Network B: $107,725 per school + <$100/month/school

Network C: $41,605 per school + $552/month/school

NOTE: The above costs do not include consultant or engineering fees nor do they include any capital improvements (unless otherwise noted). Consultant and engineering fees will not normally exceed 5-7% of the initial project costs and most typically cover a period of 12-18 months from system design to system "turn-on."

Discussion of System Comparisons

Common Characteristics of Analog Fiber Optic Networks

- Negotiated rates are standard; tariffed rates are rare
- Usually expandable up to 16 channels
- Relatively inexpensive to add new sites
- Intended for use by clusters of 3 to 10 schools with a total distance of less than 250 miles
- Can be utilized in a number of network designs, e.g., "hub," "daisy chain," "bus," "ring," etc.
- Simple conversion to digital format if a "long haul" video transport is required
- Each school has a dedicated full-time video channel which may be viewed at any time by any school on the network

Common Characteristics of Non-Switched Digital Fiber Optic Networks

- Tariffed rates are uncertain; open to interpretation
- Digital video signals may not be compatible with standard telco equipment
- Normal use in a "central hub" design
- Few existing examples in a K-12 application
- Moderate expense to add new sites
- Does have "long haul" capabilities, e.g., signal capable of being transported over long distances

Common Characteristics of Telco-Switched Digital Fiber Optic Networks

- Tariffed rates are standard
- Video is routed through a standard switch at the telephone company, normally one DS-3 circuit per video channel is required
- Can be very expensive to add sites in simultaneous view
- Primary application appears to be in sequenced networks, where each site is intermittently viewed by other sites. Each site is not usually in continuous view of other sites.
- Does have "long haul" capabilities, e.g., signal capable of being transported over long distances
- Some state utility commissions are considering special tariffs for DS-3 educational networks which would reduce the cost
- DS-3 equipment from one manufacturer may not be compatible with DS-3 equipment from other manufacturers

The preceding information is intended to be representative of existing two-way interactive television networks which employ multi-channel television as described. Fewer than 80 of these networks exist throughout the country, with possibly 200 more in the planning stage. Though time consuming (15 to 24 months) and expensive to develop ($50,000 to $100,000 initial cost per site), these educational clusters of three to ten K-12 districts appear destined to form the backbone of educational telecommunications across rural and small town America.

Flexibility of the System

Analog fiber optic networks continue to be the most flexible in terms of transparency of use and ease of access. Since each site has its own channel, originating and receiving sites need only turn their TV to the same channel to share live, fully interactive programming. Any site can access any channel at any time.

Digital fiber systems, on the other hand, require a computer operator to input exact class times and to program which sites will be on-line for each class. Immediacy of access is deterred by the need to first alter the inputs to the computer program. Absolute synchronization of clocks is essential and spontaneous usage of the system, such as for student-teacher conferences, must be cleared through a central network programmer.

Ease of Interconnectivity of Clusters or Connection to a Statewide Network

Beyond the obvious first stage of linking several schools together into an I-TV network, comes the potential for the interconnection of clusters. While most coursework will initially originate from within a cluster, the potential, through cluster interconnectivity, for aligning different schools at different times of the day across cluster boundaries make the number of courses or special programming to which access might be gained only limited by the need for common class times.

Statewide network planners have begun to consider the potential use of multi-channel video. Previous statewide designs were primarily audio/data networks with extremely limited video capacity. Consideration of the K-12 educational arena has influenced this change in attitude. The concept of joining multi-site K-12 clusters to a statewide fiber optic backbone may be gaining acceptance. Digital-based video is undoubtedly the direction in which telecommunications research is heading, but cluster use of analog signals is by no means outdated and can be converted to digital signals for long-distance transmission with the easy addition of a CODEC at the sending and receiving site. In other words, the linkage of an analog system with a digital statewide network would entail the installation of a CODEC at one of the schools within a cluster and at the hub of the digital network. While the cluster-backbone concept definitely should be taken into account in planning, it is estimated that 90 percent of the educational content of any network will originate within a given cluster with 10 percent or less dependent on the backbone for course origination or special programming from outside the cluster.

A Word About Assistance!

If you choose to interview and hire a consulting firm to assist you with the project, there are several important factors to consider:

- The consultant should provide current references for similar projects
- The consultant must show experience in the technical and educational subject areas you require
- The consultant must not be affiliated with any equipment vendor, telephone, or cable television company which may be considered to provide your system. Seek an independent consultant!
- Insist on a detailed and specific list of the services which will be provided by the consultant, along with a firm price quote
- Ask for assistance only in those areas in which you have neither the time nor the expertise to do yourself
- The consultant report should be suitable for presentation to prospective funding agencies

CONCLUSION

This monograph will conclude with what you already knew prior to reading this article—two-way interactive television networking is a complicated issue. We have covered only a small portion of the technical considerations involved in network selection, choosing rather to emphasize the educational and cost considerations involved. The equally time-consuming issues of financing, educational coordination, and teacher selection and training have not been broached.

The selection of a given technology should not be an automatic decision, but one which is given careful consideration based on the appropriateness of the technology to the outcomes desired. It is most important to first determine what you want out of a *two-way interactive system* and secondly to determine which technology offers the optimum combination of capabilities and cost.

Fiber optic technology has been a major breakthrough in terms of interactive television. It is rapidly becoming to telecommunications what the interstate highway system was to transportation. Analog fiber technology is generally less costly to achieve simultaneity of viewing and more flexible in terms of operation. Digital fiber technology, while more costly to achieve simultaneity and less flexible for cluster use, serves much better for long distance interconnection of clusters or for a statewide backbone system.

Over the past seven years, the time from project conception to actual "turn-on" of a network has averaged 15 months. This time frame holds true even though financing and technology selection are immediately available. Even with the best of intentions and working relationships, it may be difficult to short-circuit the negotiation procedure among schools or between schools and telephone companies. It is important to enter the world of *two-way I-TV* viewing it as a long-term investment, not a whimsical "purchase."

Many schools have employed consultants to assist them is obtaining funds, offering technical design assistance, handling negotiations, and providing teaching training. While not essential, independent consulting firms can protect the schools' interests and provide experienced guidance over the course of the project.

The application of *two-way interactive television networks* to the provision of stand-alone courses, especially at the high school and college levels, will continue to grow. A cohesion between rural education and economic development will undoubtedly occur, significantly enhancing the infrastructure of rural America. Ideally, not only the equality of K-12 education can be further realized with the increased ability of small rural schools to offer a wide array of subject matter to their students at both the secondary and post-secondary levels, but of undeniable importance is the ability to extend "education" beyond the school day and beyond school-age youth. The linkages between school and community made possible through two-*way interactive television* can only be strengthened.

Much more experience is needed before schools can maximize their use of what some have called "an almost unlimited educational tool." It would be a mistake, however, to ignore this option until "the technology settles out." Need must be the basis for adoption of interactive TV and for some schools the need is immediate. Those schools who move forward now will have a significant impact not only on the future of I-TV, but on the future of their own school and community—and for some communities tomorrow may be too late.

Appendix I

A Discussion of Terms and Distance Learning Technologies

Seven video technologies are examined in the accompanying table (Analog Fiber, Digital Fiber, T-I Compressed, Microwave, ITFS, LPTV, and Satellite). Each has its advantages and disadvantages. The following definition/discussion of terms explains the basic differences between those technologies.

Definition/Discussion of Terms:

Analog In the United States, a single frame of video seen on broadcast television consists of 525 lines of information, placed close enough together to create a single image. By transmitting 30 of these images per second, the illusion of "full motion video" is created. This system, called **analog** video, requires a great deal of space, or "band width" to transmit the video information to the receive set, or TV monitor.

Analog vs. digital video Until a few years ago, **analog** video was the only choice, and could not be easily manipulated. Recently, however, the television industry has developed a device which translates, or "codes" an analog video signal into its **digital** equivalent, enabling nearly the same information to be transmitted over a much narrower band width to a receiver, which "decodes" the signal back to its analog form for viewing over an ordinary TV set, resulting in greatly reduced lease charges for the medium (cable, fiber, etc.) over which the signal passes.

CODEC and compressed video This "coder/decoder" device is called a **CODEC**, and the image it produces is called **compressed video.** The typical CODEC will generally transmit at several different frame rates and resolution levels. . . with predictable savings and trade-offs. The lower the resolution and frame rate, the less "band width" required, and the greater the savings. . .but the poorer the quality.

T-I and DS-3 telephone lines Some of the slower frame rates can be transmitted over single telephone lines. Near full-motion picture quality images can be transmitted over bundles of telephone lines (called **T-I** lines). At its fastest frame rate and resolution (called a **DS-3** rate), the digital signal is considered to be the equivalent of an analog signal, and requires band width which approaches that required to transmit analog video.

Fiber optic cable The introduction of fiber optic cable during the past decade has revolutionized "wired" signal networking around the world. A tiny strand of clear fiber can transmit a hundred full-motion video signals simultaneously, taking the place of huge bundles of conventional twisted copper pairs of telephone lines. Though not available everywhere, **fiber optic** cable is the "medium of choice" for most video, voice and data applications. . .particularly "point-to-point" situations.

Microwave transmission Before the age of fiber optic cable and satellite communications, commercial television stations were linked together by a network of land-based **microwave towers**, each of which picked up the signal transmitted from the nearest tower, amplified the signal, and re-transmitted that signal to the next tower, usually about 30 miles away.

Satellite communications The age of communications satellites, placed in geosynchronous orbit above the earth's equator, eliminated much of the need for land-based microwave networks, since a single "uplink" could transmit a signal back down to earth. Most domestic satellites have a "conus footprint", which means the signal can be picked up by a receive dish anywhere in the continental United States. Since it costs the same to broadcast to thousands of sites as it does to broadcast to one site, **satellite communications** have become the most cost effective point-to-mass technologies to date, and many national distributors of live and pre-taped programs to the public schools utilize satellite broadcasts to distribute their programs.

ITFS and LPTV Though separate technologies, these distribution devices are often described together, because of their similarities. ITFS, or "Instructional Television, Fixed Service", refers to a particular set of frequencies that have been set aside by the U.S. government to be used for instructional purposes. Operating in the 2.5 MHz band, these "open circuit" television stations have a 10 to 25 mile broadcast radius, and can be received only by schools or factories with antennae that are designed and built to receive those frequencies. ITFS signals cannot be received by conventional TV sets.

Low-Power Television (or LPTV), however, can be received by conventional TV sets. Designed to do exactly what the title implies, LPTV stations are low in power (100 watts or less for channels 2 through 13, 1,000 watts for channels 14 through 84) and designed to provide service to small areas. Many public schools, businesses and industry use LPTV to broadcast educational programming to a school, office or factory. Because it operates "over the air" on channels that can be tuned in by any TV set, there are no receive networks to wire within each building. LPTV becomes the least expensive single-channel "network" in existence.

Leased vs. purchased media Regardless of the medium by which the television image is transmitted (over the air, through fiber optic cable, via land-based microwave, hops, etc.) the "space" required to transmit that signal must be either leased (from a "common carrier", like the phone company), or purchased (by laying one's own cable, constructing microwave relay towers, etc.).

The cost variables generally associated with any method of transmitting signals between two or more locations, then, relate to the type of signal being transmitted, and the amount of "band width" needed to be leased or purchased in order for that transmission to take place.

Interactivity Since interaction implies a mutual or reciprocal action or influence between two or more parties, any "interactive" linkage, network or device is one which permits such reciprocal action... usually (but not always) in real time. (Interactive video discs and many computer networks, for instance, provide for the recording of information on some type of medium, for recall, manipulation, and "interaction" at the convenience of the learner's schedule.)

For the purpose of this discussion, however, the term "interactive" is defined as a connection or network that permits real-time simultaneous action by two or more parties. This interaction is generally achieved in layers . . . of sophistication, band-width requirement, and cost to the participants.

For instance, "voice interaction" or "2-way audio" requires only the equivalent of a voice-grade telephone line.

Likewise, most kinds of computer linkages between PC's can be accomplished over phone lines, by using a device called a "modem" (for "modulator/demodulator") to hook each of two or more computers together over a conventional phone line.

"Video interaction", however, or "2-way video," requires much greater bandwidth, since even a compressed video signal requires at least a portion of a "T-I line", which is the equivalent of 24 telephone lines, and a full-motion color video signal requires the equivalent of a DS-3 line, or 28 T-I lines (672 times the bandwidth requirement for "2-way audio")

Manufacturers, vendors, and common carriers all market "fully interactive" systems to educators, but as the above description indicates, "fully interactive" means different things to a computer salesperson, the phone company, and a video conference representative. Be certain you understand how much interaction you need, and don't install or pay for more than is required.

Simultaneity "Simultaneity" refers to the ability for each site on an interactive video network to continually see and hear all other remote sites. While full simultaneity is a major advantage of analog fiber networks, simultaneity in digital systems can only be achieved with multiple DS-3 lines and multiple CODECs, e.g., equal to the number of sites on-line at any one time. This greatly increases the cost of a digital network.

Definition/Discussion of Video Networks:

Analog Fiber Video Network Implies a network in which fiber optic cable links public schools together, with the video transmitted in its original analog format. Many of these systems use an "everybody on" philosophy, in which each participating school on the network has its own "channel", and the other schools simply purchase a "modulator" (like a television tuner, for about $250) for each of the other schools, or "channels" with which they wish to interact. The practical and pedagogical limit to such a system is 16 channels, though most analog fiber networks link up no more than four schools at a time, so that the students see four monitors (TV sets) in the classroom... one for each of the "live" participating sites.

The advantages of analog fiber over digital fiber is the cost savings of not requiring an expensive ($35,000 and up, per unit) CODEC at each school. The disadvantage is the relatively large band width requirements which drive fiber lease costs high. It is not surprising, then, that many analog fiber networks are found in networks that are "owned" by a school consortia, since the likelihood of the fiber capacity being taxed by the system is slim.

Digital Fiber Video Network Also a fiber optic cable network, but one in which the signals are "coded" to the digital domain by CODEC devices at each school. The advantages of a digital fiber network are the enormous savings in bandwidth lease charges, since a switched CODEC system requires much less bandwidth than an analog "everybody on" network. Logically, most digital fiber networks are found in those systems where the school consortia lease the network, rather than own it. Most CODECs have a finite number of "ports" (usually 8) which limit the number of schools that can be linked up at one time.

While this issue receives much discussion, it should be pointed out that from a pedagogical standpoint, it makes very little sense to try and connect more than 3 or 4 schools together in a truly interactive mode (regardless of transmission media), since most typical single teachers cannot meaningfully interact with more than one "home" classroom and three "remote" classrooms at once. Therefore, the port limitation on CODEC compressed video systems is usually a non-issue.

An additional cost requirement of a digital network is the requirement for a manual-controlled or computer-controlled central "switch", sometimes called a "Multipoint Control Unit", or MCU (at up to $65,000) to enable all receive sites to see who is talking, as well as the location(s) with whom the teacher is engaged in dialogue. Several switching styles exist, including:

The "timed switch," which rotates through the several network locations at time intervals.

The "voice actuated switch," which switches the "on air" monitor to whichever room has the person talking, and shows the "last speaker" on the other monitor.

The "lecture controlled switch," which leaves one monitor on the lecturer, and the lecturer controls the other monitor, switching to whomever is talking to the lecturer.

Several variations to this plan exist, but each requires some type of central "switch" to make the selections.

A major drawback to most fiber networks is the cost of leasing or installing the network line itself. Purchase and installations of fiber optic lines begin at $5,000 per mile and go up, and lease figures from common carriers are often in the "thousands per month" category. Many public school consortia have pledged from $5,000 to $25,000 per district per year, often for a 10-year period, to finance the purchase or lease of fiber optic lines over which to transmit interactive TV.

An "owned" network is obviously expensive to construct, but relatively inexpensive to operate, while a "leased" line carries no initial cost, but is expensive to lease each month and year (and the payments never stop).

T-1 Compressed Networks Implies compressed video operating over T-I lines. In many smaller communities where fiber optic cable is not available to lease and not practical to construct, the use of compressed video over T-I lines may be the best available alternative. Although every small-to-medium-sized community is not served by T-I lines, more are, and rates are much more reasonable (as low as $10 per hour per leg, in some cases, with lower hourly rates if dedicated T-I lines are leased by the month or year). The same advantages and disadvantages to compressed video apply over T-I lines as was the case for compressed video over fiber optic cable.

Microwave Networks As explained earlier, land-based microwave towers and network systems are an old technology. Since they require a 250' to 350' repeater tower approximately every 30 miles (at a cost of up to $250,000 each), microwave technology can be expensive, with a high monthly upkeep and preventative maintenance cost. Occasionally, public schools find "bargain" microwave systems for sale from common carriers who have upgraded to fiber or satellite communications, but in most cases, microwave transmission is not worth the investment.

ITFS/LPTV Networks Found most often in larger communities, school districts or campus locations (where cabling costs would be prohibitive), ITFS and LPTV are inexpensive "last mile" technologies. Though only one-way video, they can be used with various audio networking schemes to provide two-way audio. ITFS and LPTV transmitters are relatively inexpensive (about $25,000 per channel), and often broadcast from small (50' for shorter) antennae atop tall buildings, water towers, etc., usually at a relatively low cost (around $15,000 for the tower and antenna).

Satellite Networks Most commonly found in full channel applications, satellite delivery of educational programming tends to be the best buy for the dollar, with average one-time receive dish and electronics costs of $7,000 to $10,000, and full-year courses at $500 to $750 per student. Most systems are one-way video, two-way audio, though several new applications include individual response stations for every learner, and new "picture phones" by return phone lines or VSAT technology provide the potential for two-way video between the instructor and remote students.

Considerations:

1. As with any tabularized information, some "averaging" and "generalizing" was done to simplify comparisons between system components and characteristics. Exceptions exist to nearly every generalization, and each public school network is "unique," and may not fit every descriptor in its category.

2. The technology is generally ahead of its application. It is easier to link two or more schools together than it is to use the linkage in a way that is creative, stimulating, and pedagogically sound. To invest thousands of dollars in a system, only to present "talking head" instruction is less than imaginative, and cheats the students, teachers, and the schools involved.

3. There is a difference between what is technically possible and what is pedagogically sound. It is possible to link a hundred schools together, but to assume that one teacher can effectively deal with more than three or four distant classrooms at once is not realistic. Regardless of the technologies used, the tried and true lessons about student-to-teacher ratios are still valid. The larger the ratio, the less interaction possible.

4. Investing in communications technology will probably not save money. It will enable greater utilization of existing funds and resources, if properly designed, organized and managed. While not replacing teachers, it will provide access to the teacher by more students, thus making the offering of primarily advanced courses much more economically feasible.

5. When trying to determine which system is best for your school district, seek out those who have experience, and whose opinions are objective. Common carriers want to sell you whatever type of service they have available. Vendors want to move existing inventory. Other school districts will tell you what works and what doesn't, based upon experience. Since a network linking several schools will probably require a consortia approach, involving the districts, perhaps the State Department of Education, common carriers and/or independent telephone companies, and the private sector (if long-range financing is involved). Be sure each player is motivated by what is in the best educational interests of the school district.

6. The technology is only a pipeline that can connect the teacher and the learner. Success is still determined by the human element. . . a caring, resourceful teacher, working patiently with positively motivated students. When those ingredients are present, technology becomes transparent to the educational experience and learning is best achieved.

Interactive Video Networks—A Comparative Table

Network Type	Full-Motion?	2-Way Audio?	2-Way Video?	Network Type	Special Equipment Required	Network Switching	Nominal Site Limits	Up-Front Costs	Long-Range Cost Considerations	Advantages	Disadvantages
ANALOG FIBER	yes	yes	yes	fiber optic cable	modulator (1)	'everybody on'	16*	network installation (if owned)	annual lease (if leased)	closest to 'being there'; full simultaneity **	cost of network lease or purchase
DIGITAL FIBER	yes	yes	yes	fiber optic cable	DS3 CODEC (2)	Multipoint Control Unit (MCU)	8*	network, CODEC	annual lease, CODEC upgrades	simultaneity** possible with multiple DS-3 lines & CODECs	cost of DS-3 CODEC, cost of network lease or purchase; computer-controlled***
T-I COMPRESSED	no	yes	yes	T-I phone lines	CODEC (3)	MCU	8*	CODEC	CODEC upgrades	less bandwidth; less expensive to operate. . . compressed video keeps "getting better"	CODEC costs high; compressed video still inferior to full motion analog or digital
MICRO-WAVE	yes	yes	yes	land-based microwave hops	microwave transmitter/ receiver & tower (4)	video audio switcher	unlimited	towers, dishes, repeaters	path maintenance	excellent quality	old technology. . inflexible, costly to install and operate
ITFS/ LPTV	yes	yes	no	over-the air broadcast	transmit/ receive antenna (5)	none	unlimited	receive antenna	relatively little	low cost, low maintenance	no 2-way video
SATELLITE	yes	yes	no	geosynchronous orbiting satellites	receive dish (6)	none	unlimited	receive dish	dish, receiver maintenance	least expensive, lots of quality instruction from which to choose	2-way video, through VSATS, is expensive

(See following page for footnotes)

Footnotes:

(1) Each site requires on modulator (at about $250) per school, since each school occupies a separate channel.

(2) Each site requires a DS-3 CODEC (at $35,000 to $85,000). One Multipoint Control Unit (MCU), at about $65,000 is required to serve the entire network. The MCU "switches" between participating sites.

(3) T-l compressed video CODECs are dropping in price, with many in the $30,000 range. CODEC and MCU requirements for T-l networks are similar to those required for digital fiber networks.

(4) Microwave networks are land-based "line-of-sight" systems, with a 250-350' tower required approximately every 30 miles. Costs, per tower and transmit/receive relay electronics system, average $150,000-$250,000 per location.

(5) Both ITFS and LPTV systems require a transmitter (at about $25,000 per channel), plus a short tower and antenna at about $15,000, if a short (50' or less) tower can be installed atop an existing building or water tower.

(6) Typical 12' C-Band/Ku-Band steerable receive dishes, including wiring, monitors, a receiver, VCR, and support electronics, are $7000 to $10,000 per receive site.

* "Limits" are relative, since systems can technically be linked with other systems for a virtually limitless network. However, most analog fiber systems which use one channel per school district consider 16 sites to be the practical and pedagogical limit. Digital compressed systems generally have "port" limits of four-to-eight inputs, though each "input" could be from another eight input system, which again can lead to "limitless" network sizes and numbers of locations. Most educational practitioners view four sites (one origination site and three participating sites) as the optimum configuration, regardless of the technology employed.

** "Simultaneity" refers to the ability for each site to continually see and hear all other remote sites. While full simultaneity is an advantage of analog fiber systems, simultaneity in digital systems can only be achieved with multiple DS-3 lines and CODECs, e.g., equal to the number of sites on-line at any one time. This greatly increases the cost of a digital network.

*** Digital systems must rely on a central control mechanism for system turn-on/off and site availability. System must be scheduled through central or remote computer access with specific turn-on and turn-off times and designation of sites to be included during each transmit time. Any variability in the schedule must be re-entered by computer. Scheduling flexibility or impromptu use of the network is therefore limited

Appendix II

Suggested Visitation Sites

All networks listed below involve full, simultaneous two-way interaction, with each site capable of transmitting a television channel onto a fiber optic network while simultaneously receiving a channel from no fewer than three remote sites:

Location	# of Sites	Name/Sponsor	Director	Telephone
Hamden, Connecticut	3	ACES Distance Learning Consortium	Walter Mills	203-248-9311
Greenbush, Kansas	5	Southeast Kansas Education Service Center	Deanne Gotheer	316-724-6281
Coldwater, Kansas	11	A-PLUS Network	Dick Unruh	316-873-2391
Moundridge, Kansas	4	The Learning Consortium (TLC)	Paula Patton	316-327-7128
Mulvane, Kansas	5	[Network Turn-on, March 1992]	Gary Detwiler	316-442-0430
Upsala, Minnesota	11	Mid-State Education Tech. Coop. (M-SET)	Jerry Abraham	612-573-2177
Stephen, Minnesota	6	Northwestern Educ. Tech. Coop. (NETC)	Jane Schindele	218-478-3315
Albany, New York	4	Rensselaer-Columbia Greene BOCES	Bob Naumowicz	518-477-8771
Binghamton, New York	3	Broome-Tioga BOCES	Ron Kovac	607-729-9301
Ashtabula, Ohio	10	Ashtabula Co. Interactive TV Network (ACITN)	Randall McCaslin	216-576-9023
Johnson City, Tennessee	5	Upper East Tenn. Education Coop.	Vernon Wells	615-929-0125