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The State of Minnesota is contemplating the establishment of a microwave system to transmit television signals between its institutions of higher learning. Factors to be considered in planning this educational interconnection system relate to the planning of similar systems and networks of systems by other aggregations of states, universities, and organizations. It is especially necessary to place such system-design development in the context of the rapidly changing technology of communication. The flexibility and variety of communication techniques provided by a network save money over the life of a system and improve educational performance. Other aspects of the new technology to be considered are sophistication in computer capabilities and cooperation among institutions of higher learning. Two specific problems must be dealt with: that of copyright laws, and that of laws related to common carrier tariffs. (MT)

New Communications Technology and Its Relationship to Instruction

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Prepared for the Feasibility Study of Inter-Institutional Television • University of Minnesota, Minneapolis, Minnesota

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The following is based on the assumption that the State of Minnesota contemplates the establishment of a microwave system suitable for the transmission of television signals between campuses of the State's institutions of higher education. It suggests that such a system should be used for several other purposes, and indeed that it should be seen from the outset as a broadband communications system rather than as a television system with fringe benefits. Seen in this light, the development of the system includes options of timing and structure which otherwise may not be immediately apparent.

It should be noted that Minnesota is not alone in the development of such a system. Through the Educational Communications System project, the CIC universities are investigating such an idea. The Eastern Educational Network, a group of educational television stations extending from Maine to Washington, D.C., is designing its interconnection system so that other services may be offered. Within the Midwest, the states of Indiana and Iowa are actively planning multipurpose networks. More than twenty states have educational television networks in operation or on the drawing boards, and many of them are investigating broader technological horizons. Within specific university systems, both the State University of New York and the University of California are planning multi-media networks. Such developments as the regional educational laboratories invite a new look at communication requirements. Some of these plans will be cited more fully below.

It is not the purpose of this paper to deal with the expansion of communication facilities in response to pressing enrollment problems, although these cannot be minimized. Rather, the intention is to place network development in the context of rapidly changing technology, the greatly increased quantity of information being generated, the need of students and many other citizens to cope with this information, and the dangers of the failure to see the problem whole.

Communication is usually such a personal matter that it is easy to become a victim of one's own parochialisms. The writer recently attended an interdisciplinary meeting which floundered badly because, while all the participants were discussing networks, each of the specialties represented had its own ideas about what a network is. Even when some common ground is found, it is sometimes difficult for a given professional group to see the relationship between its network requirements and those of, for example, the directors of computation centers, or librarians, or physicians, or broadcasters.

In designing communication systems for education, the first technological fact is this basic: Provided its capacity is great enough, a transmission system has very little interest in the nature of the signal being transmitted. An oversimple analogy might be made with a pipeline system. As long as the pipe is big enough, and as long as the valves are designed properly, many liquid cargoes can be pumped through. An electronic "pipeline" is even more accommodating, however, since several kinds of signals can be transmitted simultaneously, up to the total capacity of the "pipe." Donald R. Quayle, Executive Director of the Eastern Educational Network, discussing the multipurpose possibilities of his proposed interconnection system with a computer specialist, was asked: "How many times does a television program go to black in a half hour? How many microseconds might be available in which we could send data while you're not sending television?"

At rather little increase in system cost, it is possible not only to run the same system for television signals and digital data at core-to-core rates, but to stack "alongside" this broadband service a sequence of narrow-band paths to handle radio or high-quality audio services of various kinds, facsimile, teletype, slow-speed data, telephone-quality audio, slow-scan television (for still-picture transmission, rather like slides on TV), and other services.

A word may be in order about these services and their relative technical demands.

1. Broadcast-standard television, along with full-speed data transmission, takes the biggest share of the communication channel. It requires about six megacycles bandwidth. In passing, it should be borne in mind that for some closed-circuit applications, broadcast-standard television may not be appropriate. System design should take into account the possible need for high-resolution television for such applications as medical training, inter-hospital communication, etc. High-resolution television takes a larger share of the available bandwidth, and it cannot be broadcast, but it may be the right way to accomplish some very important things.[1]

[1] See also the NAEB study Standards of Television Transmission: Factors Affecting Microwave Relay and Closed-Circuit Transmission of Educational Materials, National Association of Educational Broadcasters, Washington, D.C., June, 1964.

2. Core-to-core digital computer data transmission requires about the same share of the bandwidth as television, but requires it only for short periods of time. At least one television/computer network has been discussed in which television would get its usual program periods, and computers would get the thirty-second station break periods when TV stations insert their own material and the network is usually blank. A number of multiplex techniques have been explored which would allow apparently simultaneous transmission of data and television programs.[1] And there is no existing television network that needs transmission facilities twenty-four hours a day.

3. Audio services come in a great many configurations, from the telephone company's Telelecture technique to administrative conferences to FM-quality music transmission. Compared to television and high-speed data, audio services (and the other services noted below) are extremely modest in their technical requirements. While television takes six megacycles (six million cycles), FM-quality audio requires only fifteen kilocycles, or one four-hundredth as much, and telephone-quality audio is only one-fifth as demanding as FM.

[1] By sending digital data while the television system is "unoccupied" between scanning lines, it is technically possible to transmit 112,000 bits per second, or more than two and a half times the capacity of Telpak A with type A2 termination. Further study would be needed to determine whether this technique is economically feasible within the present state of the art.

4. Facsimile and slow-scan television are means to transmit graphic information in still-picture form. The time needed for transmission of a single frame is a variable, depending on the resolution required and the amount of bandwidth one is willing to invest. In the Educational Communications System study, it is proposed that the nine libraries in the Oregon State System of Higher Education, and the State Library, be linked by a facsimile system. The system would be used not only to transmit print, but to process inter-library requests which, after all, can be handled more accurately by transmitting a call slip than by repeating the order verbally or re-copying it by teletype.

5. Such devices as the Electrowriter or the blackboard-by-wire system, which instantaneously reproduce handwriting, have been used successfully in instructional situations.

It is well recognized that many of these ideas are not new in Minnesota. In its meeting of February 24, 1966, the Television Feasibility Study's Statewide Advisory Committee heard a report concerning the interinstitutional planning of an instructional television series and, according to the minutes of the meeting, "A speaker-phone link between St. Cloud and Mankato will facilitate the inter-institutional planning and test the feasibility of an audio inter-connect." On January 18, 1966, Dr. Paulu, Dr. Thompson, and Dr. L. Smith, in a similar meeting, "suggested that immediate channels for an exchange of technical information be established between all state educational institutions, inclusive of the secondary and elementary school systems. The purpose of such conversations would be the standardization of technical facilities for future compatibility of all systems. The long-range economies of a standard code were outlined, including the need for adherence to such a code by all institutions in their individual ITV development." (Further notes about standards are included later in this paper.)

In an Advisory Committee meeting of October 19, 1965, Dr. John Bystrom, Assistant to the Under-Secretary for Educational Television, Department of Health, Education, and Welfare, indicated "that a statewide plan does imply a combination of systems," and that "in the end, the full potential of the electronic media will be achieved only through a statewide multi-media system which includes not only broadcast and closed circuit television, but radio, computer links, data retrieval systems, mail distribution of loop tapes and telephone."

These conversations (and undoubtedly many others) in Minnesota have counterparts in several other states. Some selected examples follow:

The Oregon model of the Educational Communications System study contemplates a link involving all public institutions of higher education in Oregon. At present, a state-owned microwave system connects the state's television stations at Corvallis and Portland; a one-way link feeds the state's FM station, KOAP, Portland, from the AM station, KOAC, Corvallis. Telpak and WATS telephone lines serve several of the state institutions, but only voice telephone use is made of these circuits. The smallest of the Oregon institutions, those at LeGrande (in the northeast corner of the state) and in Ashland and Klamath Falls (in the south) are isolated from the major resources in the system. It is not the ECS plan to propose full television coverage immediately, but to expand telephone company services to introduce several narrow-band modes of communication. The inter-library facsimile link has already been mentioned; experiments in the instructional use of slow-scan television are planned for larger institutions; administrative offices would have teletypes for exchange of written material within the administrative structure of the system and for slow-speed access to computers; numerous experiments have been projected for use of combinations of media in continuing education, either through small education centers or at home. The plan has been extremely well received. The larger institutions have found a way to share resources, the smaller institutions feel that they may be on-line to the outside world at last, the statewide administration may spend less time in automobiles, and the educational media executives are able to build a cohesive picture of educational requirements of the state system.

In Iowa, it has been recommended that an Iowa State Educational Communications Authority be established by the Legislature.[1] This authority would be "the means through which all statewide activities in educational communications are stimulated, developed, implemented, and coordinated." The proposed interconnection system would be multipurpose in nature, based on a broadcast system which would provide for color video, television audio, an FM-quality audio channel, two voice channels, two teletype circuits, and fault alarm. The report describes ways in which the system may include the services such as facsimile, electrowriting, etc., outlined above.

[1] A Plan for the Development and Use of Radio, Television, and Other Communications Services to Meet Statewide Educational Needs and Objectives in Iowa. Prepared by the Office of Research and Development, National Association of Educational Broadcasters, Washington, D.C., June 1966.

It is the writer's understanding that the recommendations have won preliminary approval and that a proposal for a fully developed system will reach the Legislature at its forthcoming session.

For several years the State of Texas has operated the Texas Educational Microwave Project, which has linked eight to ten universities and colleges for instructional television purposes. During the last two years, increasing attention has been paid to the non-broadcast uses to which such a system might be put. At the present time, the University of Texas is conducting an inter-connection study for the State,[1] and these "subsidiary" uses are receiving even greater attention.

Purdue University is conducting a statewide study in Indiana. The Project Director,[2] fresh from heading the Midwest activities of the Educational Communications System project, plans a system which is entirely compatible with the regional ECS plan.

Not all states are so neatly organized. For some years, the University of California has operated a university telephone system among its far-flung campuses. Plans are now underway to broaden that system in order to provide information transfer in a variety of modes. A separate state plan for educational television distribution in California has also just been released. Some officials of the extensive California state college system have expressed the view that the colleges should be linked, although the writer knows of no specific work undertaken to date. At least two junior colleges

[1]Robert Schenkkan and John Meaney are project directors.

[2]James S. Miles.

within the same district (Foothill College and the new De Anza College, of the Foothill Junior College District) plan local interconnection systems. Various elements of California state government operate specialized systems. The question there is whether all these disparate elements can be brought together, or whether the state's educational communication needs will ever be coordinated effectively. Those on the scene are not making optimistic bets.

Several other healthy state and regional developments could be cited, of course. The State University of New York is at work on an extensive system; the Eastern Educational Network was described above; representatives of the Georgia State ETV network have expressed interest in exploring other uses of their system; and so on. A recent meeting called by the governors of the Rocky Mountain states placed great stress on the development of educational television in their region, and at least one tentative plan calls for a regional interstate multipurpose network to help with the difficult problems of that sparsely populated area.

All of the above points out some applications that are possible and probably economical in a broadband transmission system. The factors that make such systems desirable include the following:

1. The enormous and expanding increase in the amount of information being generated.

2. The parallel rise of the place of technology in American life, specifically including the educational system, and with regard to the cost and sophistication of this hardware.

3. The increasing pressure to provide citizens with as much education as they are qualified to take, from early childhood through old age.

4. Related to all of the above: the administrative phenomenon of an accelerating trend toward interinstitutional cooperation at all levels.

The most important technological development of our day is not television (ubiquitous though it may be) but the computer. In its academic applications, the computer is only a transistor or two this side of the stone age, but some of its possibilities are becoming clearer. To the designer of a communication system, the computer and its attendant human beings constitute a difficult set of problems. In the course of developing the Educational Communications System designs within the CIC, meetings were held and surveys were sent to determine the needs of computer centers. The response to surveys was poor, and the meetings persistently veered off course. The reason seems essentially to be that computer technology is moving so fast, so many problems arise with such bewildering frequency, and so much money is involved, that the principals of computer centers have their hands more than full as they cope with today; the problems of tomorrow are so imcomparably more sophisticated as to defy consideration from within today's maelstrom.

That was the general situation within a major region, of which Minnesota is a part. Within the State of Oregon, on the other hand, the situation seems much more manageable. The ECS staff was regularly involved in the work of the interinstitutional group which is concerned with development, and the ECS transmission system is an essential part of the state computer plans.

It was noted in the preceding paragraph that computers are in their academic infancy. They are presently used mostly for computation and not, for example, as central parts of a library's equipment. In the library or in the information center, many computer applications are discussed and few are executed at the present time. But it is apparent from history that today's blue sky idea is tomorrow's fact. The computer uses described in J.C.R. Licklider's Libraries of the Future, and under development in such projects as MAC and INTREX at MIT, are harbingers of the future.

From the standpoint of the designer of electronic transmission systems, what are the present requirements of the computer? To be used efficiently it needs high speed input and output; machine time is more expensive than transmission time, and so we indicate above the use of a full television-capable channel for transmission of digital data between computers. For time-sharing access, such as those developments which are central to Project MAC, and most present programs of computer-aided learning, only undemanding teletype connections are necessary. Some current projects include computer-generated graphic displays which appear on command at remote stations. Such a system, providing graphic representations of mathematical equations, is in use between the Bolt, Baranek and Newman computer in Southern California and some mathematics classes at Harvard (and some other locations as well).

Futures are another story. Computers will be used to choose material recorded by video or other highly flexible techniques and play it back selectively. The computer is likely to become a sophisticated switching center which selects and directs the transmission of displays in various media: computer-generated graphics, video, audio, typed print, ultra-high speed facsimile, etc.

The moral to this story probably is: don't design anything that cannot be expanded. Towers, transmitter buildings, power availability, intra-building and intra-campus distribution systems, etc., should be built with the spectre of expansion constantly at one's shoulder. Perhaps the one available truth is that the problem is not going to become simple or less demanding.

There is also no point in waiting until the situation settles down: there is no indication that it will do that in the foreseeable future.

One philosophical aside. The belief was stated here that the most important technological advance of our age is the computer. There followed a discussion of the enormous problems of dealing with computer technology. The fact that must make life bearable for computer experts is that their work, baffling as it is to most of us, and frustrating as it is to them, should eventually lead us out of the information chaos that presently afflicts us. Since the eighteenth century, the educated man has been more and more of a specialist. Jefferson effectively mastered all the western world's knowledge; for all practical purposes, he knew all there was to know. He wrote the Declaration of Independence, designed the University of Virginia, conducted extensive meteorological and horticultural experiments, was a leading politician of his day, a connoisseur of food, wine, and conversation, a student of history and contemporary sociology, and master of Monticello.

With the industrial revolution came the knowledge revolution, the information deluge. There grew specialties within specialties within specialties. Humanists called for "the educated man," by which they often meant a man at best semi-literate in the sciences, mathematics, and unconventional arts. It became apparent that the educated man, in the Jeffersonian sense, was no longer possible.

But there are other ways of looking at that situation. An educated man is one who is master and not slave to his information context. He sees relationships; juxtaposes unlike ideas in creative bursts; knows how to ask questions, where to ask them, and what to do with the answers. Jefferson could do it with a talented, trained mind and a gentleman's library. A future Jefferson, with inconceivably more information to control, will do it with a talented, trained mind plus electronic recall and simulation, in a man-machine relationship as yet unknown. The gentleman's library will be an advanced communication center.

That is a very long way down the road, but some significant steps in that direction will have been taken by the time the presently proposed Minnesota system has been amortized.

Meanwhile, it seems likely that computers will be used more and more in education for instruction as well as for administrative functions. Much work has been done in recent years in the area of programmed instruction. The field, however, has probably been slowed by insufficiently flexible equipment and by the great difficulties of writing really good programs. The computer, of course, will permit programmed instruction to follow its logical development. And the economics are such that one computer will often serve many students in many locations through the use of time-sharing computer techniques and appropriate communications. The programming difficulties are still great, and computer-assisted learning no doubt faces some rocky times, but the logic of the situation seems clear, and this development should be taken into account as communication plans are made.

One of the interesting side-effects of present trends is that we are forced from time to time into a fresh look at the contents of our technological arsenal. The purpose of the Minnesota plan, after all, is not television or radio or computers; the purpose is effective instructional and administrative communication. It's all too easy for specialists in given media to become so committed to the medium that there is a loss of perspective regarding its purpose. Much work on audiovisual information transmission, particularly that by Travers and his colleagues[1] suggests that some instructional media overload the student on occasion. Where the organism can best deal with a line drawing and a simple verbal explanation, we sometimes go to great trouble and expense to provide color, motion, realistic sounds, etc. This is not to suggest that color, motion, and realistic sounds should not be available to education when needed; indeed, it was recommended above that attention should be given not only to television, but to high-resolution television. The point here is that system design should permit the use of technology and techniques to fit the task; it should not be assumed that television, for example, is _the_ resource that is needed in all cases. Television, unlike most other placebos, is too expensive for that.

[1]Travers, Robert M.W. and others, _Research and Theory Related to Audiovisual Information Transmission_, University of Utah, Bureau of Educational Research, 1964.

Will the inclusion of these other media make the system unnecessarily expensive? On the contrary. At slight additional expense, the system becomes enormously more flexible. With a good educational research and development program, and with some discipline against the use of television when other media can do the job as well or better, money can be saved over the life of the system while its educational performance is improved. Some examples are in order:

1. The Iowa mathematics project is one example of the use of telephone techniques plus the electrowriter for the transmission of handwritten equations, formulas, notes, etc. When the task requires voice plus "blackboard" notations, this technique offers real promise. It is very inexpensive, and its transmission demands are only the equivalent of two voice-grade telephone circuits: one for the lecture and one for the writing. There has been trouble from time to time in getting circuits of sufficiently high quality to keep the electrowriter from developing a sort of electronic palsy. This situation can be much more easily controlled when the circuit is part of a state system: it can be checked thoroughly in advance, or special circuits of better-than-telephone quality can be assigned.

2. Through speakerphone techniques, students may join seminars which take place at remote campuses. This is a more practicable variation of some small scale "traveling scholar" programs, which have sometimes found that scholars are not as portable as they used to be.

3. Language laboratories are calling attention once again to the virtues of audio-only systems. Radio instruction has been a fact in America and Europe for forty years. By and large, America

has not done well in this field, but there is no reason why blunders of the past should inhibit use of this unsurpassed medium in the future. Radio (and for "radio" one may read a wide variety of high-quality audio services) has a unique capacity to speak directly to the mind, with no intermediate clutter.

4. Research remains to be done on one of the most promising fields, the combination of slow-scan television and high-quality audio. Slow-scan, still-picture television, with reasonably high transmission rates and accompanied by a good sound track, provides the television equivalent of a slide presentation. It is likely that at least half of the instructional television production now underway can be done better with the simple combination of audio and still pictures, which would force attention on the subject matter and remove the temptation to take the easy way out by using an expensive television system to watch a lecturer talk. This would also be much less expensive than conventional television.

Parenthetically, this general concept is used by Albany Medical College in its radio series for postgraduate medical education. During the radio lecture, physicians gather in hospitals to watch a synchronized slide presentation. This period is followed by a seminar conducted via two-way radio. The program has been in operation at Albany since 1955, with considerable success.

5. As we begin to apply computer technology to a wider variety of educational tasks, new media combinations will become available. For example, it may be possible to attack the broadcaster's old problem, the lack of immediate feedback. A start on this problem is already within the state of the art, but it will remain experimental and expensive until communication techniques make it possible to use

both the broad dissemination powers of television (or radio) and the great capacity of computers to receive and analyze signals from a great many sources virtually simultaneously and instantaneously.

These five examples are by no means an exhaustive list, and they deliberately omit administrative and research communication, which are mentioned elsewhere.

Part of the context of this technological development is the trend toward increased academic cooperation. Traditionally, the university has been a cultural island, "entire of itself." No more. The university is so involved in society that many faculties joke about holding department meetings in airline terminals. The concept of lifelong learning has been a great influence, and will become greater. But the knowledge explosion, not to mention the population explosion, has provided perhaps the greatest impetus to cooperation among educational institutions. It has been noted many times that no library - not the library at Harvard, not the library at Berkeley, not the Library of Congress, and not the library at the University of Minnesota - can hope to deal adequately with the world's knowledge. In the development of the Educational Communications System study, the librarians (in spite of all the stereotypes which are occasionally justified in individuals) were among the earliest and most enthusiastic advocates of a multipurpose network that could provide graphic transmission and eventually foster computer services. The reason is clear to these people who spend their lives coping with information. A current example goes like this: if the Harvard library grew at its present rate for another century, it would have a hundred million volumes and would require a structure the size of the Empire State

Building just for stacks.

With its computerized Medlars system, the National Library of Medicine in Bethesda, Maryland, each month publishes "Index Medicus," which is somewhat larger than the Nevada phone book and carries nothing but bibliographical references to current medical research literature.

With the knowledge explosion has also come highly specialized, and highly expensive, research. Not every university can carry on research in every major field, if only because the equipment that is required nowadays costs too much. Various research consortia and interuniversity cooperative arrangements have been devised to help overcome this problem.

In parallel with that development is the need of universities to expose students to professors or equipment unavailable on the home campus. There arose traveling scholar programs, dual registrations, etc.

University systems such as the University of California have peak data processing and communication needs at registration time, so that qualified incoming freshmen will not be excluded only because the appropriate program of one particular campus is filled. By statewide matching of students and availabilities, the university does its best by the students and keeps its facilities operating most efficiently.

All these administrative and research requirements can be helped by a well-designed communication system, built to transmit information in whatever medium is appropriate, whether that is television or audio or digital data or facsimile or any of the other techniques in the arsenal.

As educational communication technology develops, there exists a constant need for coordination. This is certainly true within the various components of a state, and it is equally true (though more difficult to achieve) on a regional or national basis. Cooperative work implies a common approach, a common base. This leads quickly to various questions having to do with standards. The issue of standards tends to be misunderstood because specialists in many areas tend to see the problem in their own terms. In the context of a broad, flexible communication system, questions of standards arise in the design of compatible transmission equipment, in coding procedures for information, in relatively simple operational formats that make cooperative work run more smoothly. (An example might be a simple item like agreeing on leader signals to be used on all instructional television programs.) Some questions of standards may be resolved through easy gentlemen's agreements. Others involve fundamental approaches to technology, and they are very difficult to resolve. For the purposes of this paper, the central fact is that they must be resolved, or further planning is a waste of time.

It should be reiterated that resolving these questions for Minnesota is useful but not enough. The Minnesota system will certainly become part of a regional system, then a national system, and conceivably an international system. On a national basis, several groups are already interested in the problem. Probably the most prestigious is the Joint Council on Educational Telecommunications,[1]

[1]The members of the JCET are American Association of Land-Grant Colleges and State Universities, American Association of School Administrators, American Council on Education, Association for Higher Education, Council of Chief State School Officers, National Association of Educational Broadcasters, National Education Association of the United States, and National Educational Television.

which has broadened its sights (it was formerly the Joint Council on Educational Broadcasting) to include this wider field within the past year. The Interuniversity Communications Council (EDUCOM) is also concerned with questions of standards, as are numerous individual agencies such as NAEB, DAVI, etc.

Questions of standards are often filled with nitpicking details and are drudgery at best. But, to cite a current example from instructional television, one of our most serious problems of today is that there was no mechanism that required the establishment of standards for the new, inexpensive, helical scan video tape recorders as they developed during the past five years, with the result that most educational institutions cannot exchange tapes with others because they were recorded on incompatible machines. This inconsistency does not exist in broadcast-quality studio machines: Ampex and RCA are fiercely competitive in the sale of quadruplex tape recorders, but tapes recorded on one such machine can be played on any other.

This question of standards is lent even greater weight by two developments. In the midwestern context, it appears that Minnesota may have for its use an operating Educational Communications System, linking together the member universities of the CIC. While that interconnection plan overtly involves only the University of Minnesota, it is obvious that the entire state should be served. Operating standards in Minnesota, then, affect the standards in the half-dozen other states the universities of which are CIC members. The other major development--eventually a more important one--is the development of communication satellites for domestic use. In the fall of 1966 we are faced with a number of competing ideas about ways in which a satellite system should be developed, but in every proposal education is a basic part of the planning. The advent of communication satellites will not adversely affect the relatively short-haul systems such as those within states. Rather, satellites will make it possible for those systems to deal with others around the country or around the world. In order to make these great leaps, it is of course necessary for all the systems on the "party line" to use compatible procedures and compatible hardware. Establishing that compatibility is no easy stunt, but it is essential.

Finally, it is necessary to mention briefly two specific flies in the ointment. Communication systems such as those discussed here will find their development complicated by two specific problems in addition to standards, costs, and other ogres. These two problems are copyright laws and the legal framework of American communication, particularly common carrier tariffs.

At this writing the new copyright law is still under discussion in the House of Representatives, and the Senate has yet to make a real start at considering it. It has been under development, however, for a decade. Copyright is a general framework for an overwhelmingly complicated set of problems, and modern technology is making the problem worse every day. Essentially, modern copyright law is based on the right to publish. Teachers have been breaking the law technically for generations by writing poems on the blackboard, making ditto copies of excerpts, jotting down pieces of music for the school band, and in many other ways. Until now, these were all small and well within a generous interpretation of fair use, which has been a court touchstone for many years. But modern technology has turned these innocent educational uses into something different.

Electrostatic copies of book pages can be made cheaply, quickly, and in quantity. Instructional television presentations use pictures from magazines in hundreds of classrooms at once, and an electromagnetic "copy" of the picture is stored on videotape. More and more publications will be found in microforms rather than on slick paper, and hard copies will be made on demand.

Perhaps the stickiest copyright problems are posed by the computer. The computer can ingest vast amounts of copyrighted material and reproduce it in bits and pieces on demand. In answer to a given question, a computer may "refer" to many sources and quote several in an answer which integrates several excerpts or even the ideas from several excerpts. Hard-line copyright holders insist that, unless there are licensing agreements to the contrary, copyright is infringed when material is fed into the machine, again when it is processed within the machine, and still again each time the machine uses the material in making a response, even though the quotations may be very brief indeed. The writer observed that copyright is the specific concern of a separate paper, and only wishes to note here that a multimedia communication system offers a great range of opportunities to get into exotic trouble with the copyright law.

The second major area of difficulty involves the legal framework which surrounds large-scale communication in the United States. For present purposes, we are concerned with the legal tariffs of communication common carriers (principally the American Telephone and Telegraph Company) and the Federal Communications Commission rules and regulations concerning the use of microwave frequencies.

The FCC rules and regulations essentially spell out which services will be accommodated in which areas of the spectrum. A system such as that described in this paper requires a new look at some of these rules. Since it can be demonstrated easily that a multipurpose system makes better use of the frequencies than does a set of side-by-side single-purpose systems, it seems likely that requests for rule changes or waivers will find an interested audience. But it should be recognized nevertheless that FCC's present rules and regulations have some thorny patches that need to be cleared away.

A more difficult time is likely with the common carriers. A common carrier tariff is a mixture of company policy, FCC policy, and a compromise between the company and the commission on what constitutes the public interest, convenience, and necessity.

Under present tariffs, a multipurpose system such as that discussed here would not be possible under telephone company microwave leasing arrangements. By and large, common carriers adhere to their basic tenet that they do not lease facilities; they provide specific services for a fee. Telephone companies can easily provide all the communication services described in this paper. But generally speaking, they provide them one at a time, as individual services, covered by individual tariffs.

It should be said at once that the telephone companies are well aware of the design of multipurpose systems, and they are unwilling to see privately owned systems replace them. Throughout the course of the Educational Communications System study, for example, the telephone companies have been interested and helpful. In certain specific and not unimportant areas, company policy has moved to accommodate the ideas generated in the ECS study and in parallel developments. The fact remains, however, that fully developed multipurpose transmission systems are not consonant with the common carrier philosophy at the present time.

In conclusion: in spite of the difficulties just described, in spite of the bewilderingly rapid development of new communication and computer technology, and in spite of the fact that we have not yet explored all the instructional possibilities of all the media available to us, the logic of the present situation demands that any educational interconnection system designed today should provide for a wide variety of communication techniques. In today's technological environment, a flexible system capable of many tasks, present and future, is not much more expensive than a basic television system. A system which is not flexible, which cannot easily grow with developments in educational technique and educational hardware, is very probably obsolescent before the draftsman's ink is dry.