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ABSTRACT

Equipment for two-way cable television (CATV) is becoming available and there are steps we can take to ensure that it is used efficiently. For example a possible obstacle to the orderly development of two-way CATV is competition between CATV and video cassettes. However the two could complement each other if videotape materials were prepared to be sent via CATV to a subscriber's home during non-prime time and recorded on a video cassette for later viewing. There are also several design characteristics that could be built into a two-way CATV system to maximize its long-range usefulness: (1) the subscriber's home terminal could be built so that additional features would be made available by adding rather than replacing equipment; (2) significant changes in the system's central equipment should bring significant changes in system performance without requiring changes in subscribers' equipment; (3) the transmission path connecting home terminals to the central equipment could have enough capability to meet any foreseeable demand. (MG)

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CENTER FOR POLICY RESEARCH, INC.

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The July 1970 Special Issue on Cable Television of the Proceedings of the IEEE confronted the Electrical Engineering community with the fact that a new type of engineer, the "cable television engineer" was hereafter to be a recognized part of the engineering community. As G.Norman Penwell, Chairman of the Guest Editorial Committee of the Special Issue wrote, "I had long felt cable television was too often considered a mere step-child of the broadcast industry."[1] In explaining why a decision was made to publish a special issue of mostly invited papers on a much tighter schedule than is common, with the understanding that a "strictly complete and definitive exposition of cable technology might not be the result,"[2] Mr. Penwell observed: "changes in the U. S. telecommunication policy were being discussed at the highest levels, alternatives to open-circuit broadcasting were being sought, and the time was ripe for the broaching of this new subject."[3]

Two years later, the wisdom of this decision has become dramatically apparent. Daily newspapers have been rife with constant reports on new proposals and regulations before the F.C.C., and the technical world has brought forth a proliferation of solid achievements and imaginative proposals for future developments. While indications of pending changes in government regulatory policy has hastened technological developments, in order to exploit the areas opened by the change in regulations, the technical progress being made has simultaneously been stimulating those forces tending to change the regulatory policies. Publications, both technical and non-technical, have proliferated, the public's interest in the new technology is being aroused, and to the engineer, the potential seems unlimited and slightly disconcerting.

Familiar terms, like "state of the art" lose their classic meaning, since technical progress has been so swift that the "state" at any given moment is hard to discern. The largest cable TV equipment manufacturer and the largest "turn-key" system contractor, Jerrold, reports in its annual report that "the Starline Twenty Push-Pull System is now the keystone of our main-line amplification and distribution equipment."[4] The published specs on the Starline Twenty system indicate a two-way capability on a single cable with twenty-eight TV channels for reception and a 4 channel downstream capability. Present practice is that their "two-way capability systems are operational in the forward direction only, pending the time when two-way service is required for the markets they presently serve."[5] This blunt admission by the largest U.S. manufacturer of cable TV equipment dramatizes the fact that the "crash program" nature of technical development in the past few years is not necessarily healthy for the orderly development of a great natural resource.

Ronald K. Jurgen, in an excellent survey of two-way applications for cable TV, states, "Cable television systems with 20 or more channels and two-way capability are now being designed. There are no major technical obstacles. But, even though the public as yet voices no great need for such systems, it is urgent that steps be taken now to protect the public interest..."[6] Jurgen's conclusion is "that there are a great many techniques being proposed or actively under field test for achieving two-way communication on CATV systems."[7] He further notes that "it is perhaps ironic that with so many different systems evolvingthere are so few customers demanding two-way services. But, as with all new developments, demand comes only when the public has been exposed to the advantages of such development."[8]

It is of course clear that the best way for the public to be exposed to the advantages of such development is through familiarity, either directly or indirectly, with the benefits that accrue to real people living in an actual communities that have been wired to provide these services. Since technological competence cannot operate in a vacuum divorced from political regulatory power and the opinions and desires of an informed citizenry, developments in any one of these three areas will further fuel thinking in the other two areas. The most natural environment for all to grow harmoniously will be in proper real-life testing situations or communities where various ideas and practices may be tested. These communities would serve as test facilities to simultaneous test configurations of different equipment as to their ability and ease in providing various services along with the extent to which people felt these services improved their quality of life. In addition the existence of these test facility type communications would educate people living elsewhere to the advantages and disadvantages inherent in these various schemes.

From a technical point of view, the systems presently being studied range in scope from work describing how a satellite system could distribute six TV channels to 5,000-10,000 cable TV head-ends serving ten to twenty-five million subscribers by 1975-80 [9] to prototype testing of a switched cable system that could develop into a system giving any subscriber access to literally thousands of TV sources distributed nationally.[10]

While the prototype of the latter system, developed by the Rediffusion Corp., is serving less than 300 subscribers in Dennis Port, Cape Cod, and is wired to give access to a maximum of 36 channels, it is very distict from the standard frequency division cable TV system. These systems all have an upper limit in the number of TV channels they can handle which is somewhat less than 100.

The Rediffusion switched cable system has no intrinsic upper limit on the number of channels a subscriber can access. Cost is of course the major constraint, but it is reasonable to assume that each breakthrough in the techniques of switching video signals will allow an expansion in the numbers of video sources a subscriber could access. Obviously, the ability to access thousands of video sources opens a vista of video communication not likely to be opened by standard cable TV systems which have been likened to "broadcast over a cable." In particular, real time live cable-casting from one source to relatively small intimate groupings of interested citizens becomes a practicality not possible when system constraints dictate a limit of less than 100 accessible sources. Even the widespread use of home video recording equipment for viewing national material that is not live and does need to be live does not decrease the load on a frequency division cable system with under 100 channels to the point that it could support the type of small group viewing demands that could be satisfied with a system where each subscriber could access thousands of channels.

Though in partial eclipse presently, cartridge TV and cable TV interact to a much greater extent than presently realized. The problems besetting cartridge technology were vividly stated in a recent report in Electronics Magazine which stated: "The gospel according to most cartridge television manuafcturers as recently as a year ago was that inexpensive systems for consumers would hit the stores during 1971, presaging a potential billion-dollar market. But during the interim, the litany charted by enthusiastic salesmen went sour as a series of problems - including a potentially adverse ruling from the Federal Communications Commission, the economic slumps, and troubles with standardization, technology, and softward ganged up to postpone introduction of cartridge TV systems."[11]

The article continues by noting that major corporations like RCA, CBS, and AEG Telefunken are planning to introduce consumer units during 1972 that will sell for under $400.00 and have tape cost for an hour of color material of $4.00-5.00 in the case of RCA (in other systems the cost rises to close to $40.00/hr.).

Should cartridge TV develop a sizable following, it would provide an attractive alternative to accessing much of the prepared material presently available on broadcast TV and projected for viewing on most cable TV systems. The ability to watch pre-recorded network type entertainment at a day and time of one's own choosing would be attractive to many. Once on a cartridge, the material could be viewed again at leisure.

Merchandising by video catalog could be more attractive to the shopper than projected plans for use of cable TV channels. Except for the news and live TV coverage of timely events such as political addresses, sports events, and interviews, cartridge TV would have a convenience to the user way beyond that provided by ordinary cable TV.

In fact, if cable TV and cartridge TV should both aim to serve the same needs, it is conceivable that neither would develop their potential. Cable TV must be assured of a reasonable penetration percentage in order to support the local origination activities that would be possible beyond that provided by broadcast TV. Likewise, the larger the participation in cartridge TV, with the ensuing greater economic base, the easier it will be to provide the diverse and specialized software that would be a prime attraction of cartridge TV. Should both strive to divide a limited economic base by providing similar video material, only slightly different from what has traditionally been available over broadcast TV, it is not unreasonable to be prepared for achievements far short of expectations for both. A very relevant precedent is of course the manner in which the achievements of UHF TV have fallen far short of the original expectations. If, on the other hand, cable TV and cartridge TV should develop in such a way as to complement each other, thereby providing a co-ordinated video resource, the growth of one would aid the other and vice versa.

S. H. Unger [12] has suggested such a system, whereby video material would be sent via cable and recorded in the subscriber's home during off-hours, for viewing at a later time. The additional facilities necessary would be: 1) a central library of pre-recorded video material; 2) a home terminal on which the subscriber can specify the material he wishes cable-cast for home recording and the time by which he wants to have received the recording; 3) a scheduling computer that would log requests of video library selections; it would monitor cable utilization and would schedule the video transmission to the home during off-periods where the cartridge would store it for subsequent home viewing; 4) a narrow band data link downstream on the cable to connect the home terminal with the scheduling computer.

The system provides an extremely flexible manner for viewing video material that need not be viewed in real-time; viewing time is completely under the control of the viewer and no longer limited to the arbitrary time-slots necessary when providing the same material by broadcast or cablecast, an intrinsic facility for storage of video material is inherent in the system, and no limit exists on the ultimate size of the library that may be accessed.

If we assumed a population with video viewing habits of six hours/day consisting of two hours of live programming and four hours of prerecorded programming that had been transmitted during the twelve hours from midnight to noon, then the size of the library that can be accessed by this group during one evening is three X (the number of channels on cable).

This library would contain less than 300 hours of viewing material and is equivalent to the reading time of sixty books. Most large university libraries have in excess of one million volumes available on demand. A respectable video library should be comparable to say a local small public library with, say, 6,000 volumes or 30,000 hours meaning a channel capacity of 10,000 channels. Only with a switched cable system and scheduling computer is it possible to make 10,000 channels available. During prime viewing hours, this would also mean a system that could eventually provide each viewer with access to any one of 10,000 live video sources.

Viewed nationally, we can speculate on the following uses of such a system: 1) Every elected official could report to his interested constituents on a frequent basis.

2) Continuing education could become a reality.

After spending a term studying with a favorite teacher it might appeal to many to be able to spend a few additional hours per year to maintain what presumably had once been a rewarding relationship. Instructors of a given course could for instance schedule bi-annual meetings of the course, via cable, for their former students who might be interested in maintaining contact after final exams. This could help former students to keep abreast in fields which are developing rapidly, to follow the work of a person whose field interests them, to learn the opinion of a respected teacher over a period of time, or to just drop in, video-style, on a subject that once occupied a major importance in their lives.

3) Small groups could afford to provide live video programming for their membership.

4) The benefits of field trips could be shared with those who could not practically make the trip, or could not afford to spend the time travelling.

5) Specialized interests with a limited audience could easily be accommodated.

6) In-depth coverage of an esoteric nature would be possible.

In short, we could have a system that had the capability of bringing into the living room programming that would be truly tailored to satisfy the desires of individuals.

Clearly, such a system cannot be installed or even designed over night, but should naturally evolve over a period of time (most probably decades). To allow the evolution to proceed, it is necessary not to constrain it in such a way as to limit its possibility for natural evolution.

During the 20th Century we have had the opportunity to watch a system somewhat similar evolve; to wit, the telephone system. Before turning our attention to the lessons to be drawn from the experience of the phone system, let us first note the crucial differences between a highly satisfactory phone system and a highly satisfactory video system; in particular, noting that where picture phone may become a logical next step for the phone system, picture phone is significantly different from the video system being discussed.

The salient feature of our national phone system is that it allows any one of 200 million Americans to decide at their convenience to attempt to converse with any other of 200 million Americans. Because people decide to make phone calls at random times the load on the switching equipment varies smoothly during the day from peak load to minimal load. In contrast, the load on the switching equipment for a video system would be abnormally high for a few minutes prior to the start of a very popular live video-cast and would be abnormally low during the video-cast until its end, at which time the switching requests would again rise dramatically. Switching equipment designed to satisfy one type of demand characteristics would be radically different from switching equipment designed to satisfy the other type of demand characteristics. Likewise, equipment designed to be able to connect any subscriber to any one of 100 million sources is radically different from equipment that will connect any subscriber to 10,000-20,000 different sources. And finally, the ability of the phone system to make its connections near instantaneously on the spur of the moment is vastly different from the type of response expected from the video system where a high degree of prior scheduling could be acceptable. (See Table I.)

The lessons that can be learned from the evolution of the phone system can be introduced by first considering the status of the phone system fifty years ago.

If one had a phone terminal in the home, a handle was cranked to signal the operator, who was sitting by a manual switchboard. Most switchboards closed for the evening and were also closed on an erratic schedule at other times. If the operator responded, one asked the operator to make the connection to the desired subscriber who was typically located in the same geographic locality. Long distance calls were at that time unheard of. Most people shared a party line, eight parties on one line being typical. Assuming the called line was free, the operator rang till the called party answered. During peak busy periods, the operator tended to be overworked and wasn't able to service all the calls coming in properly. During slack periods, a strong temptation existed to take a break, again leaving calls to be unattended. If the called party did perchance answer, the quality of the audio connection was often very poor. Shouting into one's receiver helped, though not always. Audio quality varied dramatically as a function of climate. The ability of new subscribers to obtain their own home phone terminal was not taken for granted. Equipment breakage was common, adverse weather played havoc with the phone cables.

With this in mind, picture a reasonably prudent engineer attempting at that time to evaluate a proposal that would encourage evolution towards a phone system similar to what exists today. His most likely evaluation would emphasize the impractibility, if not the impossibility, of moving towards such a goal. Direct distance dialing, automatic switchboards, ESS, microwave links, conference call facilities, data transmission, automatic answering devices would rightfully have been rejected by a prudent person as far-fetched schemes of some starry-eyed dreamer.

Yet the transition did occur, even though the reality of today was not explicitly defined as the objective fifty years ago. The reasons this transition occurred are that every effort was made to provide a technological environment that placed as few constraints as possible on the capabilities of the equipment, that emphasis was placed on minimizing what constraints existed and on providing a system that concentrated in as few locations as possible those critical components whose occasional updating would result in significant increases in system performance.

Viewing this in more detail, and drawing the analogy with a video system, we note that both systems are comprised of the following parts whose general characteristics for growth are as noted:

1) The home terminal should change very infrequently,

typically over a time period measured in decades. Additional home capability should be accomplished as much as possible by adding rather than replacing equipment (i.e., add a second phone or extension phone; add a video recorder).

2) The nuclear equipment to which the home terminals connect should be conceptualized in such a way that significant changes in nuclear equipment and only in the nuclear equipment should result in significant changes in system performance; i.e., changing a manual switchboard to an automatic one, changing a mechanically slow video switching unit with limited capability to a solid state video switching unit with expanded capability.

3) The transmission path connecting the home terminals to the nuclear equipment should, insofar as is possible, never require change. They should have potential far in excess of what is minimally required. As soon as possible, replace those links which are obvious constraints. (I.e., run private lines and phase out party lines, don't build oneself into a corner with a national system of party line phones. The changeover to today's system would be horrendous.)

By having excess capacity in the subscriber links it becomes possible to satisfy unforeseen contingencies by <u>degrading</u> the quality of the links, i.e., phone cable was at one time run through conduits in the city streets with 22 gauge wire. As the number of phones in use skyrocketed it became possible to pull out the original cable and replace it with thinner cable (AWG#26), thereby fitting more links in the same size conduit. This eliminated the need to dig up streets in order to install additional conduits. This technique became possible through improvements in amplifier designs.

4) The transmission paths connecting nuclear equipment should be conceptualized in such a way that a dramatic breakthrough in performance through use of a new technology will result in significant increases in system performance, i.e., when the first telephone switching offices were interconnected, the connection was made with the same ordinary phone wires that connected the subscriber terminals. Use of coaxial cable and microwave links to interconnect nuclear equipment was hardly contemplated. Today, of course, it would be reasonable to consider interconnecting video switching nuclear centers via wave guide or light pipes. Though the techniques have not been developed, the concept is of course obvious. This was not the case at a similar stage in the phone system's development.

Reviewing the four key components, the crucial component is obviously the link from subscriber to nuclear control point. The case in which a national system of party lines might have been allowed to develop to a late date illustrates dramatically the difficulty that would have appeared if a decision were then sought to reach the present system. The cost would have been to literally tear up every street in every city to lay individual phone lines. In addition, every phone pole and every buried telephone cable in rural and suburban America would have had to be rewired. A strongly analogous situation will exist if this country builds a national cable system of a tree-type whose capacity is 100 channels or less. Since a video system of obvious merit has been proposed which cannot be supported by this type of cabling from subscriber to nuclear equipment, prudence would indicate that the time will come when pressure will mount to change the cabling. It is of course possible that pressures from other sources would by then have simplified the problem of digging of city streets.[13] But even with underground urban utility tunnels, the labor involved plus the cost of scrapping thousands of miles of cable would be a waste and extravagance that would argue against conversion. In fact, it can be argued that it is more common for a decision that determines the more mundane characteristics of a system to eventually impose a significant system constraint than the absence at a given time of a sophisticated technological solution to an imposing technical problem. If four times as many VHF channels had been allocated in the early days of TV, before color, before UHF, before the 15" screen, it is clear that the present status and development trends of both broadcast TV and cable TV would have been significantly different.

In conclusion, it is recommended that the limitation of a tree-type frequency division cable system with a capacity of 100 or less TV channels be repeatedly stressed. That, in addition, any proposals for the development of cable TV give careful consideration to a harmonious relationship with home recording and playback equipment. Finally, it is urged that decisions be made that will result in the laying of an individual private cable for each subscriber which will connect the subscriber terminal equipment (home TV set with or without cartridge) to the local nuclear switching equipment. Over a period of time, this poling will result in a growing national inventory of already laid private coaxial cable, and its very existence will tend to encourage development work on the technique of video switching and the means of interconnecting switching centers. By making the provisions for laying private coaxial cable now, we will be removing a constraint that would definitely limit the development of a national video system with the capabilities that technology will surely present in the coming decades.

FOOTNOTES

1. "Special Issue on Cable Television," Proceedings of the IEEE, vol. 58, no. 7 (July 1970), p. 961.

2. Ibid.

3. Ibid.

4. "Annual Report," General Instrument Corporation (February 28, 1971), p. 8.

5. "Jerrold System," 1971 NCTA Convention Report, p. 2.

6. Ronald K. Jurgen, "Two-Way Applications for Cable Television Systems in the '70's," IEEE Spectrum, vol. 8, no. 10 (October 1971), pp. 39-54.

7. Ibid.

8. Ibid.

9. Q.B. McClannan and G.P. Heckert, "A Satellite System for CATV," Proceedings of the IEEE, vol. 58, no. 7 (July 1970), pp. 987-1001.

10. R.P. Gabriel, "Dial a Program -- an HF Remote Selection Cable Television System," Proceedings of the IEEE, vol. 58, no. 7 (July 1970), pp. 1016-1023.

11. M. Offenheiser, "Cartridge TV Rush Loses Momentum," Electronics, vol. 44 (October 25, 1971), pp. 105-106.

12. Private Communication.

13. W.J. Boegly, Jr. and W.L. Griffith, "Engineering a Better Environment, Underground Utility Tunnels," Mechanical Engineering, vol. 93, no. 9 (September 1971), pp. 27-32.

TABLE I

	Phone	Video
Any subscriber can connect to	2×10^8 200×10^6 sources	10^4 10×10^3 sources
Desired Response Time	Near instantaneous	Can be scheduled in manner somewhat similar to airline reservation system
Switching Demands	Smooth continuous variations over 24-hour period	Very sharp increases localized during few minute intervals. These intervals would tend to occur on the hour and half-hour

Characteristics of a national phone system compared to the proposed video system