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CATV : An Expanding Network For Tomorrow

BY

René Guindon
Stu MacPherson
João DaSilva

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INTRODUCTION

The rapid development and growth of CATV systems in Canada presents a unique communications problem. The CATV system, as a localized distribution network, has the potential for providing a broad range of community, regional and even national communications services. In this era of rapid technological change, it is insufficient to assume that this potential will remain untapped, and that this facility will remain as a predominantly entertainment medium. In the absence of severe regulatory restrictions, the present 12 channel TV network is certain to give way to 20, 30 and more channels of visual material. Limited 2-way capability already exists facilitating the introduction of such services as pay-TV and information retrieval.

Clearly, such innovations represent, at least in a localized or regional sense, a possible next-step in the evolution of local communications networks.

This paper is intended to provide a basis for understanding the technological potential and limitations of CATV systems. It will not address the problems of jurisdiction over such systems, or the potential disruption in the evolution of the telephone network by the unrestrained exploitation of this communications medium. *However these problems can only be discussed whilst in possession of an understanding of the true potential of the CATV system.*

I. CATV TODAY

Today's CATV systems provide service to specific local communities, their prime function being the extension of existing broadcast signals, falling under the jurisdiction of the Federal Government.

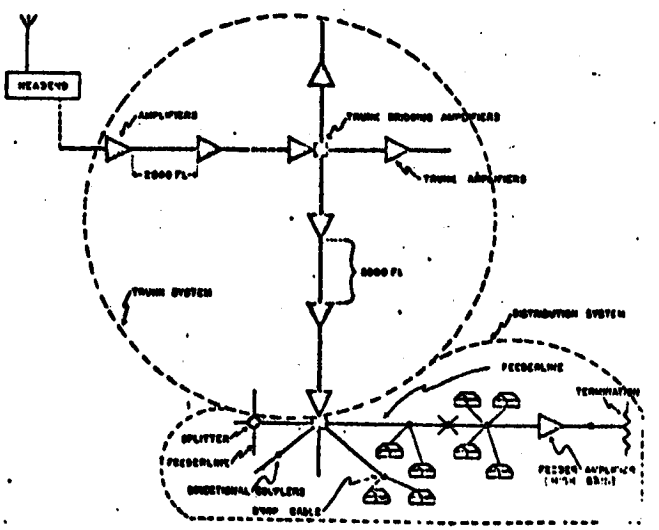
However, a second function is now emerging, namely the provision of certain "non-broadcast" services. These include pay-TV, educational programs, teleconferencing facilities, and services with subscriber response capabilities. It must be emphasized however, that the identification of clear trends in this evolutionary process is extremely difficult, primarily because the CATV industry is comprised of organizations with widely varying technical, financial and entrepreneurial skills. There is no coherent over-all plan for the orderly introduction of new services, which activity is restricted to the more adventurous, financially stable entities. It is in this context that the following section should be examined.

II. CATV SYSTEM CONFIGURATIONS

The conventional Community Antenna Television System, which originated some twenty years ago, has as its original justification the need to bring commercial television programs to isolated areas which could not receive a satisfactory "off the air" signal. CATV has since become popular in metropolitan areas because of the desire for a broader choice of programs than those broadcast in the local community. While the functions and technological limitations of today's CATV systems are well known, the broadband communication capability of the coaxial cable has led to a wide range of conceptual variations and differences which are briefly outlined below.

A) *CONVENTIONAL 12-CHANNEL CATV*

In a typical CATV network the broadcast signals received by individual antennas (usually one for each TV channel and probably one or more for audio channels) located at selected reception sites are processed at the "head-end" from which local and "off the air" FM and TV signals are carried to subscribers through "trunk", "feeder" and "drop" cables. (2) (see figure 1)



Trunk cables designed with considerable care to avoid signal degradation constitute the main distribution part of a CATV network. Branching out from the trunk cable and connected to it through bridging amplifiers are many cable branches called "feeders", usually not longer than 2,500 feet from which the signals are tapped and routed to the user's home through "drop" cables. The attenuation characteristics of coaxial cable vary with the type of cable used and the signal frequency. There are therefore signal losses which can be compensated for by using repeater amplifiers in the trunk cable and usually two or three repeater amplifiers in the feeders (called "line extenders"). Even though coaxial cable has a bandwidth of up to 100 MHz (over 160 TV channels), current amplifiers have a flat bandwidth of only 300 MHz (about 50 TV channels). Furthermore, problems such as accumulated non-linear transfer distortion and Johnson noise (snow) limit the practical number of TV channels to 20-30 for a single trunk cable network. Two frequency bands from 54 to 88 MHz and 174 to 216 MHz are used to carry VHF television channels of 6 MHz each yielding a total capacity of 12 TV channels.

B) *BEYOND 12 CHANNELS*

The channel capacity of the coaxial cable is limited primarily by the precision of the manufacturing process which today can guarantee approximately 300 MHz of bandwidth. Cable amplifiers offering acceptable performance up to 300 MHz and higher have become available. If the frequency band up to 40 MHz is reserved for upstream signals, the maximum number of TV channels that can be used is of the order of 43 channels for a single cable system.

However, a number of other factors limit the total number of channels to 25-30.

Another technique can be used to increase the total number of channels to 25-30. Two parallel cables are installed, each carrying different programs on the same VHF-TV channel. An A-B interface switch is provided at the back of the TV set to connect one of the two cables to the input circuitry. This provides 12 channels per cable but those channels with direct pick-up problems are eliminated from each cable. A converter may also be used with dual cable to provide twice the number of channels for which the converter was designed.

C) *TWO-WAY COMMUNICATIONS CAPABILITY*

Transmission of signals through cable, although almost exclusively unidirectional in the past, can be bidirectional with some cost and effort. There is a great deal of confusion regarding the definition of a bidirectional cable system. If two-way implies the existence of an upstream, narrow or wideband channel, at least three basic techniques are currently under evaluation. The first approach is to provide a separate cable with reversed amplifiers for upstream transmission. This solution is costly and somewhat wasteful of bandwidth because most anticipated applications need only a narrow band channel capable of transmitting audio or low-speed digital messages. The second approach uses a form of frequency division multiplexing on a single cable system. The upstream and downstream signals are run through the same cable on different frequencies. By using suitable frequency splitters at each downstream amplifier location, it is possible, by adding

reverse amplifiers, to transmit frequencies below the downstream frequency band. Frequencies below 54 MHz, say from 10 to 40 MHz are used for the upstream channels (about five 6 MHz video channels). The last approach uses a form of time-sharing in which to transmit information to the head-end or central collection point. Using suitable address code, the addressed terminal transmits a stores message, which might consist of a coded order for a pay-TV program, telemetering data or a status report for security alarms, to the central collection point.

D) *SWITCHED CATV SYSTEMS*

In the previous sections, conventional CATV systems and some possible extensions of traditional CATV technology were discussed. The idea behind a switched CATV system is the concept of providing a telephone-like system with greatly increased bandwidth capability. A system such as this would accommodate a whole range of new services. It is unlikely, however, that such systems will be developed in the near future due to the excessive cost of implementation. However, two existing networks which involve switching concepts will now be described.

1. Dial-A-Program

This system was developed by Rediffusion Ltd. in Britain, and started trial operations in mid-1970. In the Rediffusion system the channel selection is done remotely in a series of exchanges capable of handling 336 or more subscribers. (see figure 2)

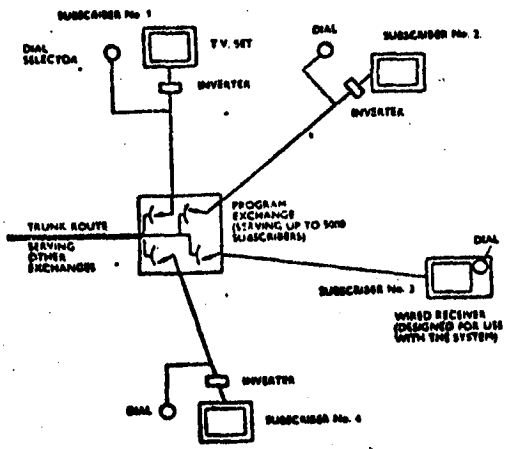


Fig. 2 Dial-A-Program System Layout

The channel selected by a subscriber is sent to him on a private house drop. A set of 36 possible channels is carried on 36 separate trunk cables consisting of low cost HF twisted wires (four wires twisted together) using the frequency band from 3.19 to 9.19 MHz. Because of this low frequency band, signals can be transmitted without amplification for distances up to 2,000 feet. Each subscriber is provided with a dial selector that generates pulses of direct current to operate the 36-position switch in the exchange. One wire-pair in each cable is reserved for control signals such as the choice of a channel, the other pair being reserved for the program channel. The Rediffusion system allows for any subscriber to be a program source to all other subscribers. The video signals from a particular subscriber are sent in the 9-15 MHz frequency

band to the exchange where they become available to all other subscribers who dial the proper code number. By paralleling exchanges, remote selection of 72,108 or more channels could be possible, opening the road to a point-to-point two-way video-phone service.

2. The Discade System

This system was developed by Ameco Inc. It differs in the three important aspects from the Dial-A-Program system:

1. Discade uses coaxial cable rather than the twisted pair HF cable.
2. All switching and control functions are accomplished using a solid state RF crossbar switch.
3. The Discade solid state switching units known as Area Distribution Centers serve up to 24 subscribers.

In the Discade system, each channel or a group of 2 to 4 channels is carried on a separate cable at lower frequency. On one version of the Discade system, 10 coaxial cables run in parallel, each carrying two frequency multiplexed channels in the 5-50 MHz frequency band. From the Area Distribution Center, one cable goes to the subscriber's home through a cable selector. For each cable selection position the subscriber is capable of alternatively switching on and off one of the two available channels per cable. FM signals sent on an additional cable at low frequency (20-40 MHz) are up-converted to the 88-108 MHz band for reception by standard FM receivers. Because of the low range of frequencies carried by the cables,

smaller, less expensive coaxial cables can be used, and spacing between repeater amplifier increased. Even though upstream capabilities could be implemented, no attempt has yet been made to do it.

E) *COST COMPARISONS*

The following table summarizes the capital costs of the various Cable Television systems that have been discussed so far .

NUMBER OF CHANNELS	REDIFFUSION DIAL-A-PROGRAM SYSTEM	AMECO-DISCADE SYSTEM	VHF SINGLE COAXIAL CABLE	VHF DUAL CABLE
12	$110-$150	$120-$150	$100-$150	not applicable
More than 20	$180-$230	$250-$280	$175-$200 using midband	$180-$300

AVERAGE CAPITAL COST

PER SUBSCRIBER

ASSUMING 40 SUBSCRIBERS / MILE

III. OUTLINE OF POSSIBLE NEW SERVICES

This section outlines a range of possible new services for local community applications, some of which will require a communication medium with capabilities beyond the present capacity of either telephone or CATV systems. The purpose is to highlight the breadth of possible applications rather than describe them individually. (6)

A) Public Safety

1. Fire and Burglar Alarm Systems
2. Agency Communications
3. Public Safety Education

B) Criminal Justice Administration

1. Court Processing
2. Security in Correctional Facilities
3. Training and Rehabilitation Programs for Prisoners
4. Legal Services Training for Lawyers
5. Public Legal Information

C) Environmental Monitoring and Control

1. Utilities Monitoring and Control
2. Transportation Monitoring and Control
3. Pollution Monitoring
4. Sanitation Monitoring

D) Health Care

1. Telemedicine
2. Intra-Agency Communications

3. Continuing Medical Education

4. Public Health Education

E) Social Services

1. Intra-Agency Communications

2. Extending Person-to-Person Services

3. Neighborhood Centers

4. Social Service Information

F) Regional Communications

1. Interagency Communications

2. Facsimile Mail

G) Education

H) Financial Services

1. Banking

2. Credit Checking

3. Reservations

It should be noted that all the services mentioned so far can be grouped into four different classes:

1. Conventional One-Way Services: Using multiple cables, top-set converters or switched systems, more channels can be provided.

2. Special One-Way Services: Services directed to a selected audience (ex: Pay-TV). These types of services could be referred to as "narrow casting".

3. Narrow Band Two-Way Services: With the aid of a touch-tone type telephone, the subscriber can have access to computer files, ask for tax filing assistance or do some home computing.

4. Wideband Two-Way Services: Using a video-phone type device, the users can carry on a face-to-face conversation.

IV. EXPANDING CATV TECHNOLOGY [3], [4], [5]

This section provides an insight into the dynamic expansion of new CATV concepts which has already taken place on certain systems. In addition, certain future services which are being actively investigated at the present time are discussed briefly.

A) *PAY-TV SYSTEMS*

A fairly large number of pay-TV systems are now in operation. Some systems require the subscriber to pay a fixed rate for service independent of the number of programs watched, while others charge for actual programs watched. Some systems require a bidirectional capability to carry the two-way digital signalling between the subscribers and the central control located at the head-end. In one particular system during some designated time period before show times, subscribers select programs from a guide and enter their selection into the terminal units. The computer located at the head-end polls all terminal units, analyses the requests and makes up the evening's schedule to fill the maximum number of requests. Those subscribers whose requests cannot be filled are notified and provided with the opportunity for a second choice. At the beginning of the show, the central computer activates the tuners of the subscriber terminal units.

Another system designated for use in hotels and motels transmits three TV signals in the 26-52 MHz band. In each hotel room, program selector units convert the signals to a standard channel frequency for viewing. Two of the three TV channels are normally inoperative unless a request for service is telephoned to the hotel clerk, the third channel carrying

free program information. A third approach designated for use on one-way CATV systems offers the greatest security and flexibility; the service being sold for a fixed fee with no record of subscriber viewing time. Each service available from the head-end has a particular code, and each subscriber receives a special code card for each service bought. In order to receive a given service the subscriber inserts his code card into a slot of the decoder at his terminal unit. For each service the subscriber is provided with one code card which is periodically changed. Therefore, subscribers who have cancelled a service cannot continue to receive the service.

B) *MULTISERVICE SYSTEMS*

This category of systems includes those designed for providing services such as two-way message transmission, data retrieval, metering and restricted TV. Several systems proposed or in existence, have in common the fact that they are interactive systems such as:

- The VICOM System
- The TOCOM System
- The EIE System
- The Subscriber Response System

- The VICOM System is intended to be a complete interactive digital system and is being tested and demonstrated by VICOM [1]. It has two-way message capability, a flexible interrogation sequence, provision for channel-usage control, data transmission in digital format at a rate of 1 megabit per second and on-line interaction with the

viewing audience including keyboard and audio response. An audio modulator is built into the subscriber terminal and when specialized programs such as lectures are being transmitted to restricted audiences subscribers can use the audio talk-back capability for making comments and interaction with other subscribers. Video interaction is also possible and a portion of the upstream channel capacity is used to originate programs from any location with a terminal. A unique feature of the VICOM system is that viewing of a particular program (under the control of the head-end) can be restricted to a particular group of subscribers such as students, political organizations or club members through a digital interrogation link which can turn off the converter of those not authorized to view the program. This is designed for ready implementation of pay-TV. The system permits transfer of access-control over a given channel to any subscriber who might be the chairman of a conference, for example. He is allowed to enable and disable the microphones of the other subscribers on an individual basis. Currently, the VICOM system provides 25 downstream video channels, 3 upstream video channels, 3 upstream audio channels and 1 upstream and 1 downstream digital channel.

- The TOCOM System is a single cable two-way system providing 26 downstream and one upstream channel with a bandwidth of 24 MHz (6-30 MHz). In addition to regular television services, some features of this system include pay-TV, television rating surveys, meter reading, home protection services and subscriber response polls. Located at the CATV head-end is a computer which controls the flow

of digital data to and from the terminal units located in the subscribers' homes. A complete system is made up of as many links as desired with each trunk serving 30 groups of 1000 subscribers each. The signals from each group of 1000 subscribers interrogated sequentially, are separated by 0.5 MHz. Responses from 30,000 subscribers, therefore, occupy a bandwidth of 15.0 MHz. Subscriber messages are limited to "YES", "NO", or "NO OPINION".

- The EIE System [1] is similar to the TOCOM system in that a computer sequentially interrogates remote subscriber units which in this system are located at the cable tap, not in the subscriber's home. Each remote unit designed for 24-channel dual cable operation without a converter serves four subscribers. Like TOCOM subscriber message origination is limited to opinion poll responses.

- The Subscriber Response System provides video and digital downstream signals and digital upstream channels. The downstream digital signals use pulse code modulation with frequency shift keying (occupying a bandwidth from 108 to 112 MHz) at a one-megabit-per-second rate. The upstream digital PCM signals also occupy a bandwidth of 4 MHz (from 21 to 25 MHz) but use phase-shift-keying at one megabit per second. From a processing center, interrogation signals are sent to each subscriber in sequence at a periodic rate. If a subscriber terminal is not being used for one of the available services, its responses to the interrogation consists of an address code and a short message reporting the condition of the terminal circuits. When the subscriber terminal is active it will answer the interrogation by notifying the processing center that there is a message (like a request for pay-TV or an alarm)

to be read out of the terminal. After a group of 1000 subscribers has been processed the subscribers requests are served. The process is repeated for another 1000 subscribers until the system limit of 65,000 is reached. It is estimated that for a 10,000 active subscribers system, the time required for any one subscriber to receive a response to a request is less than 2 seconds.

C) *FUTURE SERVICES*

A wide range of services exist other than those mentioned in the preceding sections. Most anticipated services require only a narrow band upstream channel capable of carrying audio and digital signals. Wideband upstream channels do not seem to be required, at least now, by the general public. Only certain groups of subscribers such as schools within the area served by the cable system show a need for interactive video channels. Some services which may be required in the near future using a two-way interactive cable system include:

- Computer Assisted Instruction, sometimes called computer aided learning, is a highly efficient and personalized method of teaching using the computer. Still pictures are shown on the multichannel receiver with built-in memory at the subscriber's location. Answers are "typed" on a keyboard and the computer decides what step to take next. Moving pictures as in television programs may be required in certain applications, but the student process is the same as with still pictures.

- Data Request: - uses the same process as above with still pictures being sent to the subscriber's home as an answer to particular requests.

- Reservation and Shopping: purchases from shops, reservation of seats at a theatre, cashless settling of bills can all be possible; the subscriber using the keyboard at his terminal to submit a description of the goods or the type of seats he wants to buy.

- Medical Services: can take various forms. Information services could be provided from hospitals located in the area served by the cable system. For example, a subscriber may wish to make an appointment or obtain information regarding visiting hours. Pre-medical services providing computerized preliminary diagnostic services make it possible to alert a hospital regarding the existence of an emergency case or save pre-admittance formalities. A third range of medical services, known as telemedicine, permits a physician to provide medical care at a distance. Dialog between doctors and disabled persons, or computer control of rehabilitation facilities within the home can be included.

CONCLUSIONS

The foregoing has presented a picture of CATV technical developments, and the potential for expansion into a range of new subscriber services. While it is true that some, or perhaps the majority of these new services can, or will be implemented on some CATV systems, it is unlikely that there will be an orderly introduction of such services on a broad provincial or national scale. Furthermore, it is possible that the application of particular subsets of subscriber services will preclude the introduction of others, for reasons of system capacity or economics.

Great care must be taken by all levels of government when considering the adoption of regulatory restrictions, which while well-intentioned, could inhibit the development of important services such as telemedicine, for example. On the other hand, the absence of positive policies relating to this facility will surely give rise to the introduction of a variety of ad hoc solutions to subscriber service requirements which in the long run may not be beneficial to the public. This is equally undesirable.

It may be concluded therefore, that the adoption of policies aimed at establishing priorities for certain classes of services is a logical first step.

Joint studies will be needed, involving the industry, the Provincial and Federal governments, to more clearly identify areas where standardized approaches to the provision of high priority services are desirable. For example, certain medical applications may be best implemented in a manner to allow limited interconnection of CATV systems.

The implementation of educational systems is another area where such an approach may be feasible.

It must also be recognized that the telephone industry is planning the introduction of new subscriber services. The nature of these services will be largely dependent on the capabilities of the present telephone distribution system. The natural evolution of telephone and CATV systems will not likely produce conflicting service offerings for some time, due to the inherent differences between the two systems. However, the implementation of more sophisticated interactive services will require significant modifications to both systems. Thus, the long range implications of a laissez-faire position must be carefully considered, in view of the fact that duplication of some services may not be in the public interest.

Finally, in spite of a growing awareness of the broader implications inherent in the growth of CATV in Canada, there is still a preoccupation with the broadcasting or "mass-media" aspects of CATV. This paper has shown that the true potential of CATV goes far beyond this principle. The question remaining is; to what extent are the various regulatory organizations prepared to recognize this fact, and what measures will be taken to ensure that this potential is realized for the improvement of communication facilities in Canada ?

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