CABLE TELEVISION - ITS ROLE IN DATA TRANSMISSION
A CASE STUDY AT BANKERS TRUST COMPANY

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INTRODUCTION

Commercial Data Transmission in dense metropolitan areas is a CATV "natural", both because the system capacity is there, and because coaxial cable is inherently one of the cleanest mediums for the transmission of computer data. Virtually any building in the CATV franchise area can easily be entered and cabled internally, thus making the system accessible to most business offices.

COMMERCIAL DATA TRANSMISSION REQUIREMENTS

Just ten years ago, low-speed teletype circuits comprised the majority of remote data processing line networks. Technological advances in equipment design have necessitated increased data throughput requirements, often to megabit per second transmission. Two years ago 2400 bps was the maximum through-put on private leased line circuits. It is now possible to transmit 4800 bps on dial-up lines and 9600 bps on private-unconditioned leased lines; a four-fold increase in just two years!
The data transmission environment in New York City is almost totally analog in nature, interconnected by telephone circuits. With the enormous growth of electronic data processing and on-line remote terminal usage over the past few years, the telephone network is having difficulty keeping pace with the ever-increasing network demands.

One group of typical data users are the banks. One bank might have as many as thirty branches in the Manhattan area that must communicate extensively with the central data file. Typically these networks are used to update savings, demand-deposit and installment loan accounts. They are generally polled networks, where the central computer interrogates the terminal at each branch office requesting a response back to the computer. Systems of this type often use medium speed transmission (1.2 - 4.8 kbps).

Another requirement is transmission between the data center and an operations center some miles apart. These systems currently utilize wideband synchronous data transmission with rates from 19.2 - 230.4 kbps. Remote job entry (RJE) sites would fit into this category. Many of these signals are carried in multiplexed form where several lower rate channels are combined into a single high data stream. The same type of service is often required by businesses for control of finances, inventories, shipments, etc. The financial community employs extensive data communications between branch offices and central computer.

Facsimile is another area of broadening interest. With the advent of high speed facsimile machines, letter size documents can be sent in just a few seconds; however, transmission bandwidths as high as 250 khz are required. Many firms have found facsimile transmission desirable over conventional forms of record transmission (TELEX, TWX) due to the convenience of obtaining standard forms rather than handling unwieldy lists of received data and obviating the cost of message preparation and transcription.

GENERAL OVERVIEW

As a Telecommunications analyst with Bankers Trust Company, I have been involved in a joint venture with Manhattan Cable Television for the past year employing their cable system for synchronous transmission at data rates of 50 to 230.4 kbps. Subsequently, I will describe in greater detail our network design and the results of our studies.

The CATV plant in NYC has enormous over-capacity for its basic purpose of distributing entertainment TV to 65,000 subscribers (a business that is only now showing a bottom line trend toward a profit) and Time, Inc. (parent company of Manhattan Cable) has been evaluating supplemental potential revenue-generating uses for the system.

Manhattan Cable Television is franchised to operate in New York City south of 79th Street on the West side and 86th Street on the East side. This area includes some 350,000 dwelling units and encompasses the entire midtown Manhattan business district and the concentrated Wall Street financial community. This represents one of the world's highest concentrations of business and financial offices. In seeking sources of revenue outside of domestic television service, carriage of commercial data became a prime candidate. A good deal of effort has been expended by Manahattan and other interested parties in surveying this market potential. The conclusions have been very encouraging to the point of initiating technical studies, tests, system design and equipment development.

CABLE TELEVISION AS A TRANSMISSION MEDIUM

INTRODUCTION

There are literally thousands of miles of wideband local distribution circuits in the U. S. potentially available to be used for business communications. The network is installed, under constant maintenance and ready for usage. This broadband plant is CATV. While most people think of it as a means of getting the Knicks and Rangers without "ghosts"; to engineers the CATV system is a rudimentary, frequency division multiplex transmission system with potential far exceeding the transmission requirements of 20 channels of entertainment television.

Cable television employs "coaxial cable" as its highway for transmitting signals. Coaxial cable consist of an outer conductor concentric to an inner conductor, separated from each other by insulating material. The outer conductor is called the "shield" and is covered by a plastic insulation.

We can easily consider the half-inch diameter coaxial cable as the equivalent of 30,000 full duplex telephone pairs. This provides a great savings in space, cost and has capability of providing far more transmission than we normally consider as the capability of 30,000 paper insulated copper telephone pairs; copper pairs can carry video signals only short distances.

Although much developmental work is in progress, commercial data transmission on CATV is still in its infancy. Cable is in use as an industrial communications link within some dozen mid-USA industrial complexes. These include plants of General Motors, American Motors, Dow Chemical, and Kellogg Cereals. In these plants, Interactive Systems Inc., of Ann Arbor, Michigan, has installed their Video Data System. This technique employs a bi-directional CATV type system, in-house, to carry multi-channel closed circuit TV, digital data, and voice communications. The present installation handles data rates to 48,000 baud. I repeat again that this particular application is used for in-house services and is <u>not</u> on the general transmission system. At the present time, Bankers Trust Company, New York, has the only operational data network on a general entertainment network.

CABLE OPERATOR'S PERSPECTIVE

The cable systems and equipment designs which evolved over the past two decades concentrated on the wideband carriage of analog TV signals, little else was needed but the ability to carry as many TV signals as possible. In recent years, designs considered bi-directional service for a host of hoped for, "blue sky" interactive consumer services. Amplifiers were improved, cables shielding and installation practices made more consistent.

All of these actions and changes in design make the cable a far more useful conduit for business information than it was a few short years ago.

An important factor to be considered is the degree of the CATV operator's involvement in the sophisticated realm of EDP. Reviewing the applications previously discussed, it can be seen that many phases of data communications are involved. Such terms as Time Division Multiplex, store and forward, etc; are encountered and we find that the modes of transmission are far from uniform. In this regard it was the desire of Manhattan CATV that direct involvement in the details of user's data transmission systems, data formats, etc., be avoided. Standard established interfaces would be used (RS-232 for speed up to 9.6 kbps, 301/303 current interface-19.2 kbps and above).

The use of Time Division Multiplexing has been explored and suggested by some. This would mean that a basic system must be set up in the data channel of interest (this would have to be in some RF channel, or, for the sake of discussion, some television channel). Each terminal in the system would then be assigned a specific time slot and could transmit or receive its data, bit by bit, each time the assigned time slot occurred. There are two major disadvantages of this approach. First the timing of a "tree" type system, such as a CATV system, becomes quite complex. Secondly, the TDM "modem" becomes a rather sophisticated device especially when the timing system must include operation at RF frequencies. It is estimated that a terminal will cost in the order of $2000 in reasonable quantities after development. The TDM approach was seriously considered but was not accepted due to these limitations.

With all these factors in mind it becomes plain that the parameters for successful CATV data transmission are:

1. Provision of point-to-point (not switched) service.

2. Sold and utilized strictly on a bandwidth requirement basis, independent of user's data format.

3. Easy to operate, dependable, and easily maintainable by CATV technicians i.e. FDM analog.

THE OPERATION OF THE CATV DATA NETWORK

The Cable Television network employs Frequency Division Multiplexing (FDM) for the transmission of signals whether they be television, FM radio or data. In this method each signal occupies a different portion of the frequency spectrum. For example television channel 2 operates at a portion of the spectrum surrounding 54-60 Megahertz (MHz - million cycles per second) while channel 13 broadcasts at 210-216 MHz. In so far as television and FM radio broadcast is concerned, we are transmitting <u>to</u> the home consumer in a uni-directional mode.

While using the CATV system for data transmission we must have the capability of full-duplex operation; i.e., transmitting and receiving simultaneously. Previously, this was accomplished by using one coaxial cable for transmitting, and another cable for receiving: each cable is used uni-directionally. The most recent circuit

installed at Bankers Trust employed coaxial cable operation in a bi-directional mode.

To study the operation of the data network operation the starting point would be the Data Terminal Equipment (channel equipment). The data stream is encoded using four level Amplitude Modulation. The encoded data is then frequency translated on the "upstream" cable (transmit cable). A sub-low radio frequency (R.F.) in the 5.75-11.75 MHz band is used as the transmit carrier frequency. This upstream signal is sent to the Cable Television "head-end" located at Columbus Circle; here the signal is heterodyned (shifted in frequency) to the 246-252 MHz region. This signal is now impressed on the "downstream" (receive) cable, and down shifted in frequency in the RF section at the other terminal end. The receive signal is next decoded and sent to the data channel equipment.

Hopefully, Figure 1 will clarify the description in the above paragraph.

THE ADVANTAGES OF CATV AS A DATA TRANSMISSION MEDIUM SERVICEABILITY

Inherent in the CATV scheme lies the fact that all signals, whether they be television, radio or data are transmitted on the same coaxial cable. While this might appear as a shortcoming, it in fact adds to the reliability and serviceability of the system.

Manhattan Cable's primary trunk line now runs down 9th Ave., and they are presently installing a redundant cable down Broadway. Monitoring equipment located in the head-end will automatically switch between these two trunk cables in the event of signal degradation; providing complete redundancy on signal paths.

REPAIRABILITY

The restoral time in the event of service outages on the CATV system is generally better than that on the equivalent Telephone Co. circuit. Since all signals on the CATV system are transmitted on just a single coaxial cable, disasters such as a cut cable can be repaired with only one connection. In Telephone cables, on the other hand, as many as two-thousand twisted wire pairs need to be spliced when damage occurs. The inherent ability of a CATV technician to pinpoint network problems quickly and <u>without</u> the customer's intervention, is a marked advantage for the system. The performance of the cable system is inherently better, but the burden falls on the cable operator to maintain it this way.

3. COST

The excellence of the medium allows less terminal equipment complexity for services such as high speed data transmission. Bankers Trust Co. has realized savings of 25-50% over the cost of equivalent Telephone Company wideband channels.

4. FLEXIBILITY

Once again, since all transmissions are sent on one cable; once a building is wired, all new requirements can be accommodated with a minimum of additional cabling.

5. INCREASED THROUGHPUT

There are apparently many misconceptions on the viability of using FDM for data communications, a carry-over from the days of low-speed teletype transmission. The CATV hardware employs a highly effective coding technique and a unique filtering method resulting in a high-performance data highway.

The high signal-to-noise ratio on the CATV network, makes it an inherently clean medium for the transmission of computer data. Tests at Bankers Trust indicate that bit error rates are two orders of magnitude better than can be expected on conventional analog data lines.

A CASE STUDY - BANKERS TRUST CO., NEW YORK

BACKGROUND

Back in 1971, Bankers Trust was plagued by excessive downtime on private voice-grade data lines: they were not providing the highly reliable, error-free performance required for on-line banking applications.

Specifically two 2400 bps conditioned voice grade lines to 1775 Broadway from Wall Street servicing IBM 2848 CRT controllers for BankAmericard credit card authorization were frequently out of service. Participating BankAmericard merchants in the tri-state area of New York, New Jersey and Connecticut were calling the Authorization Center while their customers were waiting. While the lines were down, the cards could not be properly verified: long waits and irate customers ensued.

At the same time the bank was employing a New York Telephone 50 kbps "Wideband Data Line" interfacing to a IBM System/360 Model 20 when operating in a remote job entry mode to the Data Center S/360-65. Experience proved that the 50 kbps line was consistently solid while only 19.2 kbps of the total bandwidth was used for the RJE operation.

A time division multiplexed network was proposed, utilizing the existing 50 kbps wideband line, permitting the multiplexing of both the RJE and authorization applications on the same wideband link. (I might add that the Multiplexing of a wideband Common Carrier line by a user was a pioneering first by Bankers Trust). The network was configured to accommodate not only the two existing CRT controllers and the Model 20 but also another Model 20 and one more CRT system.

It should be noted that the same TDM network is still in use today linked by a 50 kbps CATV channel, backed up by the Telco wideband line, providing reliable service to our users.

MULTIPLEXING WIDEBAND SERVICE

Until recently, almost all TDM networks available to the EDP community were configured to operate over voice-grade private lines with aggregate bit rates of 2400-9600 bps. Such

multiplexers have found wide spread use in applications involving low-speed teletypewriter terminals. More and more applications are now appearing where low-speed communications facilities are not able to satisfy user needs. Applications involving RJE line printers designed to run at 300 lines per minute will not operate at desired speeds if the communications channel's throughput is less than 4800 bps.

One of the more important design criteria faced by designers of on-line teleprocessing systems is to make a clear distinction between the volume of traffic to be carried on the data communications links and the response time required by the operators of the various terminal equipment. Much too often, teleprocessing systems have been designed using the historical precedent of teletypewriter networks, which concentrates on the total volume of information to be transmitted over a relatively long period of time. The fact that a single message often takes several minutes to be transmitted; and messages must line up in a queue is of secondary importance. In on-line teleprocessing systems, response time considerations demand a whole new approach to the engineering of communications circuits. Facilities with data rate capabilities significantly higher than teletypewriter speeds are becoming mandatory requisites of these systems. These facilities are attainable by efficiently multiplexing wideband service, readily provided by existing common carriers - and now offered by CATV, at least within the confines of the Manhattan Cable franchise area.

NOTE: Wideband channels are data lines which operate over more than a single voice-grade channel bandwidth within the common carrier facilities. For example, a Type 8801 channel with an aggregate data rate of 50 kbps has the analog equivalent bandwidth of twelve voice-grade channels.

A PILOT VENTURE WITH CATV

In 1973, Time, Inc. (parent company of Manhattan CATV) was conducting interviews with Telecommunications Managers as part of a survey to assess the commercial potential of the transmittal of data over CATV facilities.

With the ambitious forward planning in progress at Bankers Trust concerning on-line branching and point-of-sale terminals in retail locations; Stevens H. Harrison -V.P., Telecommunications viewed CATV as a possible significant alternative to Telephone Company circuits for a widely deployed intracity point-of-sale network: provided CATV's projected performance, pricing and marketing claims proved true.

The talks that ensued led to a joint pilot venture wherein Bankers Trust would parallel their existing 50 kbps Telephone Co. wideband links between 1775 Broadway and the Wall Street Data Center with a Manhattan CATV data channel. The Bank would offer 'live' data and their existing multiplex channel equipment, while CATV would develop the necessary interface devices and arrange to pull cable to both sites.

In April, 1974 the CATV 'modem' equipment had been designed and built. It had been 'cooking' in the E-COM laboratories (consultants to CATV) with success for months. Now was the time for the real test.

Two 50 kpbs CATV channels were to parallel existing telephone wideband channels, to be driven by Computer Transmission Corporation (TRAN) multiplex equipment. To be quite honest, the CATV Data Interface was somewhat clumsy looking -- it housed the data encoder/decoder; the R. F. Transmitter/ receiver, and the front panel had large 'bat-handled' manual switches permitting the multiplexer to run on either CATV or Telco.

The CATV channel interface equipment was installed on Saturday April 6, 1974. It was an instant success. Our first and only failure during a test period of four months (to August) occurred just four days after installation - a line amplifier lost power near City Hall. The trouble was reported at 9:45 A.M.; cleared at 11:00 A.M. - time to repair just a little over one hour. For our twelve hour day, six-day a week operation we had an uptime factor of 99.9%!

Using a test device capable of transmitting and detecting a pseudo-random data bit pattern we observed one bit error in 100 million bits transmitted (10^{-8}). We did have periods where zero errors were detected in a 36 hour period.

'MOVING' A DATA CENTER

During the Summer of 1974, Bankers Trust moved its downtown operations center from the 16 Wall Street location to it's just completed building, 1 Bankers Trust Plaza. A multi-million dollar Data Center was established at the Plaza site paralleling the existing location. All applications had to be fully tested with the new equipment before the final "switch" was thrown.

Two high-speed (230.4 kbps) CATV channels and two Telephone Co. wideband links mutually backing up each other were established between the existing and the new data center. By use of a TRAN custom designed switching array, applications could run from the old site during the day and be switched to the new system at night for testing.

The CATV channels were private, point-to-point cables driven by INTERTRAN line drivers. The channel equipment used was TRAN Multiplexers providing synchronous channels of 19.2, 9.6,4.8 and 2.4 kbps.

It is difficult to relate in a paragraph or two the intense involvement of all parties concerned in making this move go. The bottom line -- the data center was established at the new location one month ahead of schedule! These CATV links are still in use today supporting applications located at 16 Wall Street. There has not been a single outage on these CATV facilities in over a full year of operation!

FURTHER SYSTEM REFINEMENTS

Now that the move to the new Data Center was complete it was time to reterminate the data links from 1775 Broadway (which at the time were going to the now non-existent 16 Wall Street

Data Center) to the Bankers Trust Plaza Operations Center.

A CATV data channel paralleled by a Telephone Co. Wideband link was established to the new data center. The CATV channel equipment was now beginning to look like a commercial offering; it was rack-mounted, with a plexiglass cover.

One of the shortcomings with the original network was the manual switching required between CATV and Telco, in the event of a facility outage (we did not normally staff our 1775 Broadway location). For this new link we requested a remote switching arrangement which would permit the switching of the multiplex channel equipment to either CATV or Telco from either terminal location. Figure 2 depicts the existing network configuration between our Data Center and our 1775 Broadway operations center.

This equipment was installed in November, 1974 and as of this writing (late - April, 1975 we have had two CATV outages, total downtime was six hours, for a 99.6% performance record. I might add at this point, that with the remote switching capability, downtime to our users in this period was measured in minutes.

The latest CATV data 'modem' housing the data encoder/decoder, and the necessary RF equipment fits in a standard 19" rack, and measures just 5" high. Quite a change from the original 'basement special .

CONCLUSIONS

While the specific data transmission services discussed in this paper are presently offered only in the confines of lower Manhattan, it is encouraging to note that these services can be profitably offered in much smaller urban (and even suburban) communities. The decision to employ Frequency Division Multiplexing with its low up-front costs makes it feasible for a small cable company to install one or two circuits profitably since no expensive computer system is required.

INTERCONNECTION - THE SPECIALIZED COMMON CARRIERS

Within the last few years (as a result of the landmark Carterfone case - 1969) there has been a birth of a new telecommunications industry - the Specialized Common Carriers (SCC's). These carriers, regulated by the FCC, offer private line voice/data service, primarily between large urban areas. While the marketing impetus for these vendors has primarily been for voice applications, it is interesting to note that a cable system can quite easily interface to these analog circuits.

SCC's provide interstate microwave radio channels between central city locations. It is now necessary to connect the microwave radios located in some tall building (say the Empire State) with the customer's location, say Wall Street. This portion of the circuit, while only a small fraction of the overall circuit mileage, comprises the Telecommunications manager's nightmare, the infamous "local loop"; it is this section of the circuit that tends to cause a majority of the recorded outages. Presently the Bell System usually provides these local loops for the SCC's probably at an economic loss, because of the amount of maintenance required. There are presently many requests for increased tariffs for these loops by Bell System operating companies across the coutry.

While it would probably be uneconomic for a CATV company to provide a single loop between microwave hub and customer, it would seem quite possible and plausible for a Cable System to provide loops for multi-channel customers or those with broadband requirements. An example of this could be local interconnection of a television broadcast studio for nationwide transmission.

The future of Cable Television in this area depends not on the ability of the system to handle this requirement, but on the future demand of the SCC's for local distribution facilities independent of the Telephone Company.

POINT-OF SALE APPLICATIONS

The introduction of point-of-sale terminals at merchant locations and the growth of branch bank automation within the last few years present an interesting application for the cable system.

These networks typically operate in a polled environment wherein the central-site computer sequentially interrogates the terminals/branches eliciting responses. The FDM approach employed suits these requirements ideally, since these locations can be assigned to a single data channel. The terminal devices would be equipped with the necessary control circuits to raise a "Request-to-send" when a transmission is desired.

Typical credit-card verification systems employ leased voice-grade circuits configured in a multi-drop configuration, using polled operation through audio tones. These terminals with their built-in modems could economically operate via "voice-grade" cable links.

The fact that Manhattan Cable's data service is sold on a "no mileage" basis and with minimal additional charges for multi-drops make it a viable alternate to the telephone network for POS applications.

SUMMARY

In recent years, there has been considerable speculation concerning the viability of CATV systems, designed to transmit television programming, in the transmission of computer data.

The CATV network, it turns out, because of the innate cleanness of the medium, the ample bandwidth and low incremental costs, its reliability and ease of repair is ideal for this purpose.

The joint Bankers Trust-Manhattan Cable pilot effort is the country's first successful, large-scale application of this technology and the implications are significant. It has now been proven feasible to communicate between intracity locations at data transmission speeds that have not been economically practical in the past.

It is also safe to say that the growth of data communication requirements will provide a real need for a more reliable local distribution system complementing the Specialized Common Carrier's interstate network.

The next few years will tell.

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