MANHATTAN'S DATA-BY-CABLE - A BUSINESS REALITY

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ABSTRACT

During the last two years Manhattan Cable TV has taken positive steps to technically develop a data transmission system and to market the service in the New York City business community. The approach has been largely along the lines established at the outset of the project, but there have been several important technical and business departures from original plans. The data interface equipments have been developed and are now in production. New cable system maintenance instruments and procedures have been developed. System tests have shown excellent performance. A number of contracts for service have been negotiated and circuits are now in continuous operation. The outlook for a large user market is good.

Manhattan Cable Television is a wholly owned subsidiary of Time Inc. and operates the cable franchise in the southern half of Manhattan Island. Formerly known as Sterling Manhattan Cable TV, the company has for some time, with the assistance of Time Inc., sought to develop extra revenue producing services on the cable. As a result of various study programs concrete efforts toward development of a commercial data transmission system were instituted early in 1973. Original system concepts were established, breadboard equipment constructed and tested, prototypes developed, and finally production interface equipments procured. Concurrent with the technical development market surveys were carried out and a number of contracts for data services have been written.

A paper outlining the original system concepts was given at the 1973 NCTA meetings at Anaheim and an unpublished paper dealing with a variety of possible applications was distributed at the NCTA Chicago meetings in 1974. The purpose of the current paper is to summarize the progress of the project highlighting various technical and business matters important to the implementation and success of the enterprise.

BASIC ASSUMPTIONS

At the outset of the project certain basic assumptions were made which became the basis for system development. It is well to reflect upon these and to briefly comment upon the current status and validity.

1. Point-to point operation: After much consideration a generally switchable network was rejected in favor of point-to-point organization. This means that circuits would be installed so that point-to-point or poled operation was normal and there would be no ability to switch circuit terminations at will. This conclusion has been tested by many contacts with potential users who have had virtually no requirements for a switched service beyond that which is realized in the poled mode of operation. A poled system is under the control of a central terminal which commands a group of terminals on the same channel causing each terminal to transmit data in a noninterferring sequence. To date there has been no firm requirement for a system with flexible destination switching such as provided by the telephone dial network.

2. Frequency division multiplexing: At the outset there was a great deal of thought given to the method to be used to multiplex the various data signals onto the cable. There were many who recommended time division multiplexing. TDM boasted the advantages of better bandwidth efficiency at peak loading plus a system which could arbitrarily switch circuit destinations. After much deliberation FDM was chosen. The choice centered largely upon the lower initial cost per channel, the simplicity of the equipment and the similarity of FDM equipment (use of separate, preassigned r.f. channels) to cable TV r.f. hardware. The total dependency of the data system upon a foreign machine

like a sophisticated computer sounded like the "hard way" for a cable company to get into the data transmission. What is more it cost too much.

The decision in favor of FDM has been proven correct over the past two years. There have been no requirements for switched service. The up-front costs with the present hardware are quite reasonable. Concern over the efficient use of bandwidth has not hampered the sales effort. The data communications community presently uses leased, point-to-point facilities therefore equivalent service is offered on the FDM system at competitive costs. This is good for the user and profitable for the cable operator.

One side benefit of FDM's lower up-front cost is that a small cable system can afford to install one or two circuits since an expensive computer system is not required.

3. Full duplex capability: To date we have found some users requiring half duplex service (only one direction at any one time) and a few needing only simplex transmission (one direction only). In the case of the half duplex user we are supplying a full duplex channel but in the case of the simplex requirement we may remove parts of the interface hardware to decrease costs and to provide appropriately priced simplex service.

4. Transparent service: The reference to transparent means that the data signal provided at the circuit input will be recovered and presented back to the user at the receiving end without knowledge or manipulation of the customer's data or data format. Simpler equipment is required and the user need not divulge information about his data. This continues to be the preferred mode of operation.

5. Synchronous transmission only: The decision to provide only for synchronous transmissions was based upon the knowledge that most new equipments operate in this mode. (This means that there is a steady, clocked data stream with no start and stop pulses). The current service offering is for 1200 bits per second to 230.4 kilobits per second. Several requirements to handle asynchronous transmissions have been encountered. Because of these requirements a special asynchronous interface is being provided to allow conversion to synchronous at the input and reversion to asynchronous at the output. Although the trend is away from asynchronous transmission, there is a good deal of equipment in the field which still employs it. The accommodation of asynchronous signals is not an expensive modification.

6. Low speed circuits: In establishing a minimum data rate of 1200 bits per second a substantial section of the existing market is eliminated in terms of the various teletype and low speed terminals now in use. It was originally felt that it would be uneconomical to offer transmission of these services. This is still the case at least on a single circuit basis. The one situation where these low speed circuits can be accommodated is where a customer has a great number of parallel low speed lines running between the same two locations. This condition is encountered with the brokerage firms, etc. Here a simple, low cost, single purpose multiplexer is proposed which allows stacking of these low speed circuits in groups of 20 or 40 for transmission over a single higher speed channel. No contracts have been received for this service, hence the multiplexer design has not been carried to completion but is ready to move rapidly when needed.

The above summarizes the major decisions made and the opinion to date is that these early decisions were generally correct. (So far there are no major regrets.) From our experience it appears that the system which has been developed will serve this market well for quite a number of years. As the data business increases and its profile changes, as it is bound to, it is possible that more sophisticated circuits using TDM or TDMA may be required to serve the market. When (and if) these requirements become a reality, the additional business requiring this sophistication will be sufficient to support the required development.

BUSINESS OPPORTUNITIES

Before addressing the technical aspects of the hardware and cable system operation, a look at the MCTV business opportunities is in order. A large amount of effort has been expended in surveying the market and selling the service to potential customers. Mr. Joseph Kelly, who is Director of Cable

Services at MCTV, has spearheaded this effort over the last year. He has been in contact with virtually every major data user and potential user in the franchise area. Many prospective customers have telephone-based systems in operation. Some are interested in replacement or backup. Most are very conservative, wanting "to be shown," while a few have felt that cable represents a technological giant step and are eager to at least experiment or to order first line circuits. Initial experiments and first contracts were with Bankers Trust Company. The test circuits were two 50-kilobit links paralleling Telco wideband facilities from Midtown (58th Street) to the Financial District. These two 50-kilobit circuits were run for thousands of hours in a period of more than one year and one circuit was finally placed in service under contract. Performance on an error basis was excellent and the short downtime experienced in one case of catastrophic failure was very impressive to all concerned. In the Financial District, crosstown links were provided for Bankers Trust at 230.4 kilobits on dedicated cables between two buildings within a few thousand feet. Both circuits have been very successful and have been invaluable for reference purposes.

The major market to date has been with the banks. All of the major banks have been approached and MCTV is providing, or expects to provide services for several of them. One of the interesting new services is transmission of high speed digital facsimile signals utilizing 19.2-kilobit circuits. Another similar application is to transmit the Xerox LDX very high speed fax at 230 kilobits. The LDX signal is not truly synchronous and therefore requires a simple adapter for compatibility.

A number of the banks are involved in credit card verification and point-of-sale terminal activities. To date this market has not developed for MCTV in terms of carrying signals for the individual terminals. This is due to the low speeds used and the inability to provide competitive rates at these speeds. There are, however, a number of applications to provide the lines to interconnect concentrators to the main computer. These lines are generally in the 2400-bit category and seem to be the weakest link in the present telephone network.

An analog service is also offered. This is provided for a voice grade (3 kHz) equivalent or a 15 kHz analog circuit. The major use for this offering to date is for the lower speed facsimile machines which are quite prevalent.

Applications for high speed circuits are slowly coming. We find that there are relatively few 19.2, 50, and 230 kilobit circuits in the area. Communications managers are moving in this direction and are pleased to find that there is another means of transmission available to them. As a matter of fact, the circuit charges for 9600 Bps on the cable are considerably lower than telephone lines with Telco or customer-owned modems and the higher speeds are even more favorable.

The MCTV data service is sold on a "no mileage factor" basis and has no additional charges for multidrops. This is very appealing to the potential customer because these charges often constitute a large part of the bill. In general, the cable rates are more or less comparable at the lowest data rates, i.e., 1200 and 2400 Bps and to come in comfortably below the competition at higher speeds. Savings on distant and multidrop circuits are quite attractive.

The biggest selling problem is the up-front cost of getting out of the street into the building and through the building where no wiring has been done before. It often costs several thousand dollars to get into a building and a substantial amount, depending upon the building size, to wire it. This effect is often cancelled by the fact that once we are in the building we can install an additional new service at a very low installation figure and in a very short time. Where a customer is contemplating a number of circuits the unit installation cost becomes proportionately lower and hence less discouraging.

Various other services somewhat removed from direct data continue to arise. There have recently been a number of requests for video trunking in connection with various television and network distribution applications. The new longhaul common carriers have shown interest in local loop circuits from their headends. There is now talk of higher speed service of 1.544 megabits (T1) and even T2 (600 mBs) service. It is fortunate that MCTV is in a phase of system expansion allowing simple addition of cable and spectrum to satisfy new requirements.

HARDWARE

In the paper of June 1973, there was a detailed description of the data system and the interface equipment. The final development of this equipment was contracted to Intech Laboratories of Ronkonkoma, New York. Development has been completed and production units are being purchased from Intech. The basic system approach outlined in June 1973 has been followed. However, certain significant innovations have been added by Intech and a very imaginative and efficient design has evolved.

The original system used a single r.f. pilot in the data channel for a frequency

reference. In considering the possible adjacent channel interference to television signals, it was decided that the pilot or pilots should be located at the standard video and audio carrier frequencies. This was instituted and the decision was made to run both pilots at audio carrier level (-15 dB referenced to normal video carrier level) thereby reducing what would have been the largest signal in the channel and hence the interference potential, system loading and intermodulation products. Instead of phase locking the receiver to a pilot at a high VHF frequency (TV channel "0" at Manhattan Cable) the entire 6 mHz channel is converted to a lower i.f. frequency and detected. The data channel is then extracted based upon the difference frequency between it and the pilot. In order to confine the difference frequencies to a reasonable range, the video pilot is used to recover all channels lying 3.25 mHz to 6 mHz from the lower channel edge while the other pilot is used to recover all frequencies between the lower channel edge and 3.25 mHz. The output of this detector is processed by a fixed tuned receiver capable of being set to any frequency from 2 to 5.75 mHz. The desired data channel is finally selected by phase lock techniques and demodulated.

In order to eliminate the need for a frequency determining crystal for each channel, a synthesizer technique has been employed. The two pilots are inserted at the headend (before translation) and very accurately controlled in frequency. Their difference frequency (4.5 mHz) is counted down to 600 Hz. This 600 Hz is used for a reference to synthesize the transmit frequency. Since all frequencies are now referenced to the same system parameters, if there are small frequency changes everything tracks so that there is no degradation in system performance. These modifications in the system frequency reference concept and receiver design have resulted in a lower cost unit with less critical parameters.

A second major change from the original concept involves the modulation technique. At first a phase-shift keying approach was selected. This was later rejected due to possible phase stability problems involved with low cost hardware and unknowns of cable system operation. The current modulation uses bandwidth compression as originally proposed but substitutes a 4 level AM, double side band, suppressed carrier modulation. Theoretically and practically, 4 level AM is slightly more noise sensitive than 4 level PSK. However, it is much easier to handle from the point of view of phase stability and demodulation techniques.

Intech has developed and applied for a patent on a system of modulation using highly effective coding and a unique filtering technique which have yielded a very powerful, all digital, modulation, filtering and demodulation system. As a result the difference in performance between DSSC and PSK is quite small and with the favorable signal-to-noise ratios present on the cable the error rate is vanishingly small. The initial prototype of the Intech equipment running at 50 kBs over an approximate 8-mile circuit length operated for 28 hours completely without error. In general, our tests have shown average error rates of a few parts and 10^9.

The Intech interface unit is packaged for desk or rack mounting. It has no front panel controls but displays five pilot lights on the front panel. These lamps are "POWER," "PILOT LOCK," "CHANNEL LOCK," "DATA," and "TRANSMITTER." The PILOT LOCK, CHANNEL LOCK and DATA lamps indicate the various receiver functions including acceptable received data patterns and when all are lit, give a nearly infallible indication of proper receiver operation. The TRANSMITTER light indicates correct transmitter operation and power output.

The whole unit is 16-3/8" wide x 14" deep x 5" high and weighs approximately 15 pounds and consumes approximately 100 watts of AC power. The transmitter output is the vicinity of +50 dBmV and the receiver accepts an input equivalent to a TV channel system level of 0 dBmV. This assures that the unit will function on any properly operating customer tap. The Intech digital interface units cost between $1000 and $2000 each, depending upon the data rate and optional features.

An analog interface unit is also available currently in 3 kHz and 15 kHz bandwidths. The cost of this unit is considerably less than $1000. This unit uses single sideband, suppressed carrier transmission.

SYSTEM CONSIDERATIONS

In introducing the data service to the Manhattan system it became obvious that tight system control would be necessary to achieve the reliability required by the sophisticated New York City data market. Many construction and operational techniques and procedures have been tightened up in the company so that better control of the system is possible. With nearly 300 trunk amplifiers, mostly in hard to reach places, special steps must be taken to assure system quality.

The conventional summation sweeping technique was expected to cause data errors as it swept through the data channel. These expectations were borne out. Steps were taken to block the sweeper at the data channel frequencies. However, the ultimate solution has the implementation the Avantek low level sweeper system. This system has been well accepted by our service personnel

and can be used in the presence of the data transmissions.

The major method of trunk maintenance has traditionally been constant alignment using sweep techniques. Obviously only so much of this can be done since it takes a great deal of time to get through all the amplifiers in the system. Many amplifiers which are in good alignment still must be accessed and measured consuming much unnecessary time and effort. With this in mind, a system for remote spectrum analysis was conceived and given to Intech to develop and produce. This system employs remote spectrum analyzer units packaged in trunk amplifier housings. These units are located throughout the system at critical points such as ends of trunks, branch points, and the like. They are connected back to the laboratory on dedicated telephone lines (reverse cable carriage could also have been used but it was decided to defer that sophistication for the time being). At the lab there is a central controller which on command, or periodically, interrogates each remote analyzer unit sequentially. Upon interrogation the remote analyzer sweeps the spectrum and feeds this information back down the telephone line as a frequency modulated tone signal. The controller receives the signal, demodulates it, and drives a strip chart recorder which plots a spectrum of the signals received at the remote point.

The resolution of the analyzer is approximately 200 kHz, its dynamic range is 70 dB and slightly over one minute is required to make the printout. The printout can be in the form of a chart about 6 inches long or where more detail is required, the chart speed can be increased and the printout becomes nearly 30 inches long for the 50 to 300 mHz range. (Other analyzer models are used for sweeping other frequency ranges such as 5-120 mHz for upstream trunks.)

There is a status monitor feature in each remote unit and a status monitor readout in the controller. If the composite system level changes by ± 3 dB at any remote analyzer, the controller is immediately alarmed and switched to the alarming location nearest the headend. The spectrum at that location is immediately plotted. In this way real time warning of catastrophic failures is achieved at all analyzer points. By use of the charts, which come at periodic intervals, the maintenance crew can see those sections of the system where performance is degrading and concentrate upon them in their maintenance scheduling.

One final problem which is of obvious concern on any two-way system, is that of locating interfering signals arriving on the upstream trunk and quickly locating them and eliminating their effects upon system performance. The MCTV solution to this problem is a remotely controlled switch which may be installed in the reverse system at the points necessary to isolate individual branches or whole sections. This switch has the unique feature of controllable attenuation. One command will insert approximately 6 dB of loss in the local circuit. The 6 dB change will not affect the operation of the data circuits in that path but when viewing the interference problems on the spectrum analyzer at the headend a level change of 6 dB in the interference signifies that the trouble is coming from that branch. When the individual area is located, a second command will turn that switch completely "off" and remove the interference from the system. Only those circuits in the branch where the interference is introduced will be interrupted. These units are also being supplied by Intech.

As far as basic system problems are concerned, to date few have been encountered. Much of our upstream carriage has been on a dedicated trunk used for origination. This wiring is some of the oldest in the system and not equipped with RFI type connectors. Still there has been a minimum of intrusion. This trunk is in the process of being replaced so it is expected what few problems exist will be further diminished. In other sections of the system, the Anaconda 2200B series trunk amplifier stations are capable of accepting diplexing filters and reverse amplifiers. These are being installed as new data customers are added and new areas activated.

MCTV is in the process of changing its backbone distribution to a supertrunk down Broadway from the headend to the financial district. Concurrently trunk is being extended down 8th Avenue and will act as a backup for the Broadway supertrunk. Automatic trunk switchover equipment will be installed so that loss of signal on the supertrunk will initiate immediate changeover to the backup trunk with only momentary loss of continuity.

In summary, it appears that the development of MCTV's commercial data communications system over the past two years has been well spent. The initial predictions seem to have been relatively accurate and the effort involved in equipment and market development has established a sound base for a profitable business. The ultimate "proof of the pudding" involves securing a sufficient business volume and providing highly reliable and customer satisfying service. The present outlook is optimistic. We trust that we have done our homework carefully and that these questions will be answered affirmatively within the next 12 to 24 months.