CURRENT CONFIGURATIONS AND FIELD INSTALLATIONS OF MULTIPLE SERVICE COMMUNICATIONS SYSTEMS

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Slowly but surely, CATV facilities are being employed to carry new revenue-producing, non-entertainment services. While businesses are developing slowly, many believe that a large portion of the cable operator's revenue in the future will be provided by non-entertainment services. There have been quite a number of test projects and commercial efforts instituted where two-way cable transmission has been employed.

There are over 50 operational security, fire and burglar alarm systems on cable according to the January, 1983 NCTA Cable Enhanced Services Guide. These systems are largely residential in nature. Other systems addressing the residential market include energy management (utility meter reading and load shedding) and a range of videotex services including home banking and shopping plus informational services. Institutional networks have been established on both conventional CATV systems and private systems where all types of data are carried, ranging from energy management and status monitoring to extensive interconnection of computers and computer peripherals. All in all, there has been a good deal of activity and experience gained in utilizing the cable to develop new revenues and, in the process, serve the community. It is the purpose of this paper to briefly describe selected examples and to philosophize a bit upon the techniques and controls necessary to effectively and efficiently utilize cable networks for carriage of two-way non-entertainment services.

EXAMPLES OF CURRENT PROJECTS

The examples that follow have been selected to illustrate various phases of current activity in the field and to provide a backdrop for the following discussion.

Warner Communications has probably the highest deployment of two-way terminals which are involved in entertainment control (QUBE) and security. There are in the order of 100,000 interactive QUBE terminals controlling converters and allowing upstream ordering and opinion polling plus about 10,000 special terminals employed for residential security. The QUBE system is a good example of the utilization of the technology and hardware employed by one service to support a second. Businesswise, the entertainment control functions are totally separate from the security functions since security monitoring is implemented by a separate business entity. The QUBE system performs well, although a number of problems had to be solved in order to achieve reliable operation. Warner found it necessary to use feeder switches synchronized with the polled data system to reduce the amount of noise competing with the upstream signal. The noise problems encountered were predominantly the result of ingress rather than of noise floor summation from the high number of subscriber terminations. In the security services special provisions were needed to cut down the noise-induced false alarm rate and telephone dialers were redundantly employed to assure higher reliability of security alarm transmissions.

Manhattan Cable TV operates one of the oldest data transmission experiments in the industry, which has been operating as a business for about 9 years. This venture developed around the commercial data transmission market in Manhattan. Rather than being faced with noise contribution from every residential drop, the MCTV system was first configured with direct feeds back to bridger ports wherever possible, thereby eliminating the need for two-way capability in the distribution system. Later, as the business built up, Manhattan Cable was able to switch most of the data circuits to an institutional network thereby avoiding the entertainment system entirely. While most of the circuits in Manhattan Cable are point-to-point, they are being used for a range of service by totally independent customers. Frequency Division Multiplexing (FDM) is used throughout to separate the services in the dedicated mid-split system. While truly a multi-service network, this situation is somewhat special and does not represent a "typical" cable system configuration.

The Times Mirror experiment in their Mission Viejo, California system utilizes Telidon as the basic videotex format for information, shopping and bank-

ing services. Their experiment included customers served by both telephone and cable circuits. The cable circuits were implemented on a polled TRU-NET 100 system supplied by E-COM Corporation. This polled system was arranged to intercept user requests and provide transparent circuits from the users to the Telidon host computer via 28 telephone ports. The polled circuit included diagnostics which monitored performance with error counters for each customer modem and was capable of isolating specific modem responses individually to analyze levels, modulation, etc. While the system was not used for simultaneous meter reading and security, these functions were included in the interface modems and certain units tested throughout the project. Dynamic polling assignments were employed so that all units, whether active or inactive in the videotex interchanges, were polled no less frequently than every 10 seconds providing continuous status monitoring of the system. Had security been implemented, alarm status would also have been checked no less frequently than every 10 seconds regardless of the videotex loadings. A telephone modem was installed on a separate computer port so that system diagnostics could be performed from the E-COM plant in New Jersey. By monitoring the error counters which were kept on all units, it was possible (from New Jersey) to sense system ingress build-up and point out the area in the system where ingress was occuring. This was an important feature since the cable system was an older one and ingress was a problem. The section implemented for two-way was small, therefore, feeder switches were not employed. Had they been required, they would have come under the control of the same polling system and would not have posed a synchronization problem.

The Cox INDAX system has been deployed in San Diego and Omaha. INDAX is implemented using a contention protocol. Indax controls entertainment services as well as provides banking and shopping at home and a wide variety of informational services. The home terminal includes the converter and generates both alphanumerics and graphics for display on the TV set in the videotex mode. Technically the system performs well and has experienced a minimum of ingress. This is due to the extreme care taken in preparation of the segments of the system which are in use. There are several hundred terminals in service in San Diego and Omaha. There are 40 channels available upstream and 80 downstream. Excess downstream channels are provided to carry broadcast information. Diagnostics to locate ingress include the use of geographic channel assignments as a means of sectioning the system.

Dow Chemical employs broadband networks (private CATV systems) in 26 plants around the world. The largest utilizes about 100 miles of plant and employs 550 point-to-point or multidrop modems. This system, which includes other (non-entertainment) services, is running out of spectrum. It is important to note that data transmission on private CATV systems is becoming increasingly important in a number of industries. As far as operational problems at Dow are concerned, there are enough data modems used on the more heavily loaded systems to make composite triple beat an important source of degradation. In order to control this problem, system balance must be maintained, and a constant vigil must be kept to assure that the modem operating levels are kept within a fairly narrow range. Ingress has often been a problem in their systems. It was soon determined that the cost of "shortcuts" is too high. The cable system must be built well using the best quality equipment including, of course, EMI connectors. Drop cables are run in quad-shielded RG-6/U and are kept as short as possible (usually no more than 25 feet). Good "F" connecters are a must. On the poles they have found that flooded jacketed cable is somewhat more durable, developing less cracks, probably due to the damping of the jacket and flooding compound in conditions of wind and vibration. As these systems are constantly monitored for leakage with equipment in trucks and carried by personnel, these systems are well-maintained and produce a very high availability which is a necessity in commercial applications.

OBSERVATIONS

Probably the major problem encountered in all of the systems listed above (and generally in implementation of two-way services) is that of ingress. It is the feeling of many that ingress can be controlled, and indeed it is being controlled in quite a number of systems. One cable operator who was interviewed during the preparation of this paper reported that, after solving the initial problems of two-way system integrity and establishing a comprehensive monitoring program, it was observed that there were more downstream system faults than there were in the reverse system. This speaks well to the point that two-way cable plant can be effectively constructed and maintained.

The data systems, however, must be robust enough to operate with finite error rates. If the data transmission system is equipped with provisions for error detection (and possibly error correction) then it can be reliably employed and function satisfactorily in all but cases of major ingress interference. Note that error detection provides a good handle on system performance and expected data integrity. Error correction, on the other hand, may or may not be required. For instance, in security and utility meter reading services, it is important that the data be correct. Security alarms should be immediately verified or contain error- correcting codes or redundancy to make the probability of error vanishingly small. On the other hand, a large videotex message which sustains a single or even a few errors often does not produce visible degradation in the displayed product. If the videotex is being employed, however, for banking or shopping, then at least certain portions of the message must have high integrity. These considerations lead to the requirement for flexibility in error control which is at the disposal of the cable operator and those to whom he provides transmission service.

E-COM has data transmission equipment installed on cable systems in the United States and in Europe. Our technicians have participated in data system start-ups in many of these locations. One of the first matters of concern is the "health" of the reverse transmission system of the cable network. In many cases a good deal of ingress is encountered. It is sometimes apparent that the cable technicians do not appreciate the impact of ingress on upstream services. Many of the signals that are seen vary considerably in amplitude, such as those originating from broadcasts and other services on the shortwave bands. To the uninitiated, the sub-band can be a very confusing combination of many signals coming from totally unknown sources. We have made it a practice to pick up a low cost battery-operated amplifier with built-in speaker from the local electronics store and use it to monitor the vertical output of a spectrum analyzer. Then, instead of viewing a nondescript blob of signals in one of the shortwave broadcast bands, we instruct the technician to narrow down the resolution of the spectrum analyzer, select a single signal and go to "zero sweep". In this mode, the spectrum analyzer becomes an AM detector and the modulation can be heard. This is a great help in identifying signals; as a matter of fact, these amplitude modulated signals include some unexpected signals such as wireless telephones, harmonics of broadcast stations, and the like. Identification of the signals by the modulation gives the technician a much better idea of where the signal originates and hence where it may be entering the system. Once a familiarity is gained with the general signal content of the sub-band and the times when certain types of signals are at maximum amplitude, these rough parameters can be used as an indication of the overall integrity of the reverse path in the cable system. Using the spectrum analyzer and the audio amplifier in a similar manner, one develops an ear for recognizing the cable data channel sounds. These are very distinctive, particularly in a polled system. A change in the character of these sounds can often signal certain types of malfunctions.

Another phenomenon that occurs in the sub-band is the appearance of signals at 6 MHz intervals (referred to zero frequency). These signals are the result of intermodulation between the downstream TV carriers. This intermodulation is usually due to rectification in poor or corroded joints such as connectors on tap housings and is much more prevalent in older systems. In one such system, this effect was used as a monitoring parameter since when everything was tight, the intermodulation was absent. As time went by, corrosion in the fittings would build up and the 6 MHz "markers" would appear. The engineer on that system had set his own limits; after these "markers" exceded a certain threshold, he would dispatch technicians to affected areas of the system to tighten or replace fittings.

Before we leave the matter of ingress, there is a final point which must not be overlooked. Where ingress is present so is egress. Egress in the vernacular is simply "signal leakage". Signal leakage from cable systems interferes with over-the-air communication and broadcast services. Signal leakage is illegal. It is constrained by two sections of FCC Part 76. Under part 76.605 (a) (12) you must conform to the standard of "20 microvolts per meter at 10 feet", etc. This is an onerous task but it is possible in a well constructed and maintained cable system. Under part 76.613 you must cease operations if you interfere with any other service licensed by the FCC. In many cases, elimination of such interference can be extremely difficult and requires diligent effort and a good deal of statesmanship. Failure to comply with the above will sooner or later result in many segments of the communication community battering the cable industry, probably to the point of losing channels. The FAA and Amateur Radio situations have already become very significant. It does not take much imagination to see that many other radio service users could follow suit. Some operators are successfully coping with these problems (which include one-way systems as well as two-way); those who do not address them effectively will doubtlessly cause the entire cable industry to suffer for their shortcomings.

E-COM's TRU-NET 500 system is now being deployed in the field to handle a variety of services including utility meter reading, load shedding, security, pay television control, home computer interfacing and videotex. This system is polled and utilizes distributed intelligence. At the headend the System Communication Controller (SCC) communicates with Area Control Units (ACU's) throughout the system which, in turn, communicate with discrete modules that interface the various services. The system utilizes a three-position feeder switch in each Area Control Unit which is controlled as a function of the normal polling sequence. Use of feeder switches is usually unnecessary for normal operation although they are essential for the isolation of ingress.

The TRU-NET 500 system checks errors on all messages and accumulates error counts for each unit in the system. Analysis of these error counters often gives warning of major difficulty providing time to service developing system leaks. The diagnostic package for the TRU-NET 500 stores the cable network topology which is constructed through entry of the actual cable system elements (including cable, amplifiers, passives, power supplies, etc., as well as the TRU-NET system components). In other words, the SCC contains a "map" of the entire cable system. In the case of mass failures, additional software compares the fault distribution with the actual system configuration and can thereby pin-point the problem. The Area Control Units tend to segment the system so that communication failures between customer modules and the ACU (due to ingress on the customer drops, for example) are limited to a maximum of 250 customer modules. As a matter of fact, when the Tier-Guard Tap (TGT) is employed for premium TV control, the upstream path of each drop may be turned off, thereby restricting ingress over the entire sub-band. The TRU-NET 500 system has been designed with maintenance of real life CATV systems in mind, while simultaneously accommodating a wide range of subscriber services.

The title of this paper includes the term "multi-service". It is more and more apparent that there will be multiple services to be carried on cable systems. Even though the future services are as yet undefined, it is apparent that their numbers will continue to increase. In addition, certain services produce only moderate revenues that often make them economically unacceptable if implementation is performed on a stand-alone basis. We feel that these factors and the problems that exist in attempting to mix multiple stand-alone services in the cable network should guide the development of flexible data systems which can handle a variety of services. Properly configured, such systems can be high in capacity and low enough in cost that virtually any service can be operated economically and thereby justify the initial installation. Additional service can then be added later with even better economics leading to higher revenues as these new services are implemented.

CONCLUSION

Multi-service communications systems are a must for the future of ancillary service carriage on CATV systems. They must be two-way and therefore demand designs capable of operating and controlling real life CATV situations, not the least of which is the presense of ingress. Cable systems must be designed and monitored to eliminate ingress to the greatest possible extent in order to support these communications systems and to protect the industry from outside pressure as the result of leakage interference.

Many pioneers in new services have at least partially reached these goals. Success in these areas means more cable system revenues and more service to the community.