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CABLE DATA COMMUNICATION SYSTEMS 1983

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FOREWARD

This report on broadband coaxial cable data communications systems has been prepared by the Cable Telecommunications Research Institute for the Department of Communications under Supply and Services Canada contract 0ST82-00140. It is based upon a 1983 survey of cable industry activity within Canada and the United States and represents a snapshot view of a rapidly emerging technology. The purpose of preparing this report is twofold: to comment on the problematic issue of innovation versus standardization and to increase awareness of the growing role of coaxial cable technology in the transmission of a new generation of signals and services.

Towards the end of the study period, the authors were increasingly tempted to delay completion of the text in order to add yet one more late entry to the survey lists of systems and components. Cable data communications is a natural complement to the relentless growth of microcomputer technology. The pace of this growth can cause embarrassingly rapid technical obsolescence in hardware, software and not least in human resources. The Institute has attempted to present a picture of a fast moving target and has done so with a relatively wide field of view. I hope the reader finds the result well composed and in good focus.

Terry Shepard

Terry Shepard,
Executive Director.

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1. INTRODUCTION

The spread of industrialized society in the nineteenth century was fueled by the primary industries of mining, refining and lumber and the giant secondary industries of manufacturing and construction. Growth was accelerated by the development of shipping routes and docking facilities and the construction of highways, canals and railroads to carry raw materials from natural resource centres to factories and finished products to centres of population. Following along the tracks of the railways came the electric telegraph of the 1840's, followed at the end of the century by the invention of the telephone. Communications smelled of the future. But transportation was king.

The early part of the twentieth century heralded the convenience of widespread electric power systems, the magic of radio and the growth of the automotive industry. As this turbulent century draws to a close, our children are familiar with the wonders of television, the romance of space technology, the realities of nuclear power, the unfolding secrets of the genetic code, the uncanny capabilities of microelectronics and the awesome power of the computer. Tertiary industries of communications and information processing are now basic to our modern economies. The products of the industrial revolution were tangible goods made of cotton and iron, manufactured in factories and distributed by sea and rail. The products of the information revolution are software, for example: radio and television programs, computer programs and alphanumeric databases.

The distribution of these new software goods is creating major new and vital industries. Indeed, with the widespread growth of affordable business and personal microcomputers, data communications needs and opportunities are steadily mushrooming. Improvements in semiconductor chip architecture continue to reduce the cost of 'dumb', 'smart' and 'bright' terminals. Access to specialized and well managed databases has become a question of providing suitable data transmission facilities.

The ability of the twisted pair telephone local loop to carry data signals is limited by its comparatively fast transmission performance degradation at frequencies above those used for analog voice communications. Specially conditioned dedicated local loops can offer enhanced data rates. But such traffic then requires special trunking facilities to escape from the traditional (3 KHz) bandwidth limitation of switched telephony. The regular telephone network's voice bandwidth system of twisted pair local loops is hard pressed to accommodate more than a small percentage of today's data communications traffic principally because of its limited (3 KHz) bandwidth. The speed of data transmission is just as much limited by bandwidth as it is by time constraints. Much of this report will be dealing with the data rates of specific systems.

When being transmitted, data are represented by "signalling symbols", typically a particular voltage level or a particular instantaneous frequency. With presently available technology it is relatively costly in terminal equipment to transmit data at a rate faster than 1 baud per Hertz of bandwidth.

1 baud = 1 signalling symbol per second
1 Hertz = 1 cycle per second

Data are measured in binary units (bits) each of which is the amount of information necessary to make a choice between two alternatives (eg: off/on). Furthermore, it is least costly to let each signalling symbol represent just one bit of information. As a result, a 3 KHz voice channel on a regular switched telephone network can only pass data economically at rates measured in hundreds of bits per second. This is however normally spoken of as so many hundreds of bauds (eg: 300 bauds, 1200 bauds) it being understood that, with the assumed technology, 1 baud = 1 bit per second.

Given more costly modulators and demodulators, it is possible to increase the number of bits per symbol. For example, a choice of 4 available voltage levels (instead of 2) will permit each transmitted symbol to represent 2 bits of information.

$$2 \text{ bits} = 2^2 = 4$$

As another example, a choice of 4 possible phases in which to transmit a "phase shift keyed (PSK)" data carrier will also allow 2 bits per symbol to be transmitted. Such developments, concerned with packing more bits per second into each available Hertz of bandwidth are open to narrow band (eg: switched telephony) systems and to broadband (coax and fibre optic) systems alike.

The distinct advantage of broadband systems is however that they are able to utilize their extra bandwidth for higher data rate capacity while maintaining relatively inexpensive modulators and demodulators (modems) for data insertion and extraction.

As a broadband transmission medium, a single half-inch diameter coaxial feeder cable can be compared favourably with a bundle of about one dozen fibre optic filaments. The capacity of each of these two types of system is sufficient to transmit approximately fifty conventional (NTSC) colour television channels. In Canada the average cable TV subscriber presently enjoys access to about half this number of channels thus leaving potential room for a further doubling of the number of TV channels or for an interesting mix of video and other future broadband information services. Cable's unique readiness to act as a general purpose broadband highway for the delivery of information services is further underlined by its penetration into over 60% of all Canadian households. Most Canadians already receive all of their television via cable.

Broadband coaxial cable offers an immediate improvement in data communications rates for applications both within large building complexes and across entire metropolitan areas. The technology to construct coaxial data networks is available and affordable and has been recognized as a natural business vehicle for the cable television industry.

It is against this background that we begin our study of Cable Data Communications Systems. The first part of the report deals with Local Area Networks (LAN's) and Metropolitan Area Networks (MAN's) which can be constructed using present coaxial cable technology. Their purpose is to provide intra-building and intra-city data distribution networks for information which is being generated, copied and presented in such volume and in so many places that previously constructed analog transmission facilities cannot satisfy the relentless demand for channel capacity.

These networks represent business diversification opportunities for the cable industry. Products already familiar to operators of CATV networks can be used in their construction. For example: coaxial cable trunk, feeder and drop cable, frequency translators, processing amplifiers, trunk and line-extender amplifiers, terrestrial microwave and satellite stations.

Added to this list are new products specially designed for the transmission and recovery of data signals: modulators and demodulators (modems), multiplexers and demultiplexers, controllers and addressing computers. Section 5 reviews a new category of data modems (modulator/demodulators) that have been developed especially for radio frequency (RF) applications on broadband coaxial systems.

Cable operators in Canada have already begun to carry a number of data signals on regular entertainment CATV networks in parallel with the customary television and FM radio channels. By these means a number of new, data-related services have been provided to Canadian households and, in some cases to small business subscribers. Sections 6 to 10 review this activity.

A concluding section deals with the issues of standardization and the difficult question of how much non-standardized free experimentation might be appropriate in the evolution of reliable cable data services. Some of these issues are unique to cable data systems. But many more are general data communications issues. It is appropriate to study all such issues thoroughly before adopting any final point of view. The entire data communications field is a hive of standardization activity in which more questions remain to be asked than have been answered.

Tables listing and comparing data communications products and systems for both private and CATV applications are contained in an Appendix together with the names and addresses of manufacturers and distributors of systems hardware and software.

2. CLASSIFICATION OF LOCAL AREA NETWORKS

It will be helpful to begin by defining in simple physical terms just what a coaxial cable Local Area Network (LAN) looks like. The accompanying sketch shows the essential parts of a coaxial cable LAN. The same illustration also describes the general features of a larger Metropolitan Area Network (MAN). The network consists of the elements within the dashed boundary, central to which is the coaxial transmission facility.

Normally situated at the centre or headend of the LAN would be the Controller equipment that manages the incoming and outgoing flows of data to and from the user terminals on the outskirts of the network. Also at the headend would normally reside any special Gateway equipment designed to accept data from and to transmit data to any higher level networks.

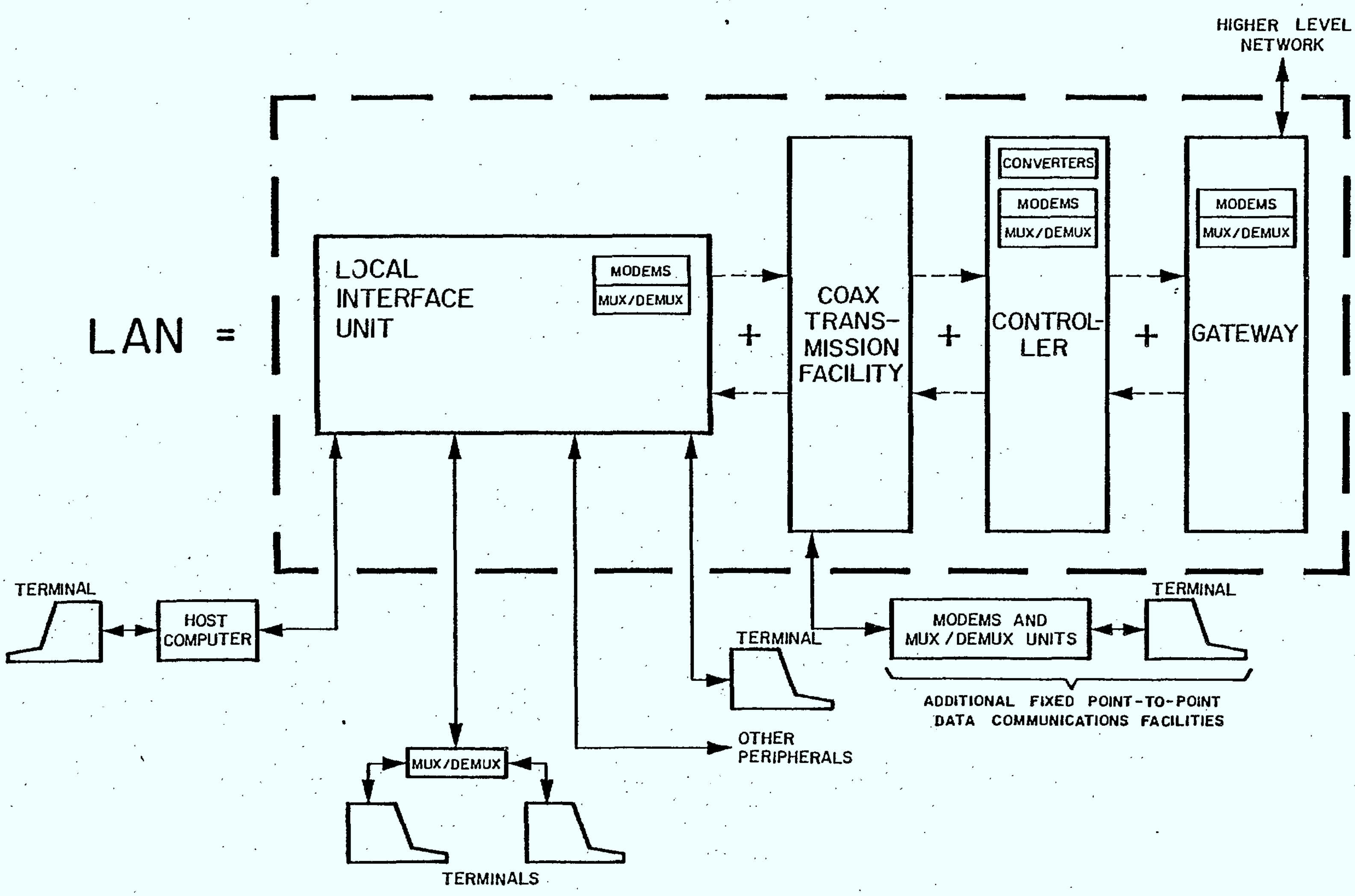
Notice that most subscriber terminal equipment is connected to the LAN via a box of equipment labelled Local Interface Unit (LIU). This is shown as part of the LAN. Those subscribers connected via these interface units form a group within which information can be shared. They can in general communicate with each other. They share the same "peer level". They are able to enjoy the same class of service.

Contrast the peer level group connected to LIU's with the fixed point-to-point outsider group, each one of which is connected directly to the coaxial transmission facility without any intermediate LIU. Such subscribers can only communicate with each other in dedicated pair groupings. A frequency translator (converter) at the headend turns all of their upstream traffic around and sends it back in the downstream direction on an appropriate channel. There is really no network management role played by the Controller for this outsider group. Each pair is assigned specially tuned modems permitting only their dedicated point-to-point communications.

The difference between the LIU's and the dedicated modems is that each LIU is a "smart" modem and is controllable as part of a network management system. The LIU enables the selection of an individual user channel. Once commanded to do so, it will assign time or frequency slots according to an "access protocol". The assignment of a user channel within a group of possible channels is achieved by means of a unit that we have labelled a "mux/demux". A mux/demux permits the sharing amongst a select group of users of a common "superchannel". The mux/demux assembles and disassembles user channels into and out of each superchannel.

Strictly speaking, this mux/demux is not functioning as a true multiplexer/demultiplexer unless it serves more than one user terminal. For a single user in a freqency division multiplex (FDM) system, the mux/demux within the LIU may be little more than a freqency agility circuit added to the modem.

LOCAL AREA NETWORK



At each subscriber location is a terminal typically consisting of a keyboard and a screen. Some subscribers may use more sophisticated arrangements consisting of both a terminal and a "host computer". The term host means that this particular subscriber is running (hosting) some sort of computerized service for the rest of the peer group to use. Some examples should make this concept clear.

Let us imagine that all subscribers on the LAN are using simple (dumb) terminals. They might use these terminals to send short messages to each other - but nothing very complicated. If you want to communicate with someone in this group you had better make sure that they are actually sitting at their terminal during the session. There is not necessarily any computer anywhere on the network to store and forward messages.

Some of the users might however have subscribed to a database service such as The Source. This is nothing more than a large host computer located outside the LAN and accessed via the headend Gateway (provided you know the appropriate password). In this case, this special user group might enjoy access to a computer mailbox facility or be able to interrogate a stock market database.

Now imagine that one enterprizing user buys his own computer and runs a service for some other subscribers to share. The service might be a buy/sell noticeboard for antique car collectors. This computer is properly called a host computer for the special service. It is not essential for every subscriber to have a host computer. However, where a subscriber can afford to add a computer facility to the terminal, it might then be left running to take and send messages automatically in its owner's absense. In this example, the computer would be programmed as a host running the software necessary to provide the service of an automatic answering machine.

The following table illustrates the size categories of data communications networks within which Local Area Networks (LAN's) and Metropolitan Area Networks (MAN's) fit:

DISTANCE BETWEEN PROCESSORS	PROCESSORS LOCATED IN SAME	EXAMPLE
0.1 m	circuit board	printed circuit
1 m	system	computer bus
10 m	room	LOCAL AREA NETWORK
100 m	building	LOCAL AREA NETWORK
1 Km	campus	LOCAL AREA NETWORK
10 Km	city	METRO AREA NETWORK
100 Km	province	long haul network
1,000 Km	country	long haul network
10,000 Km	planet	satellite network

One of the differences between a Metropolitan Area Network and a Local Area Network is that a MAN may also have lower level Gateways in place of some of its subscriber terminals. These Gateways afford access into LAN's. A large MAN may thus serve to interconnect several LAN's. At the same time the MAN may serve individual LIU's and some point-to-point subscribers directly.

```
                          LONG HAUL NETWORK
                                  |
                                  |
|---------------------------------|---------------------------------|
|                              GATEWAY                              |
|                                                                   |
|                    METROPOLITAN AREA NETWORK                      |
|                                                                   |
|    GATEWAY                                              GATEWAY   |
|-------|-------------------------------------------------|---------|
        |                                                 |
|-------|-------|                                 |-------|-------|
|    GATEWAY    |                                 |    GATEWAY    |
|               |                                 |               |
|  LOCAL AREA   |                                 |  LOCAL AREA   |
|    NETWORK    |                                 |    NETWORK    |
|---------------|                                 |---------------|
```

Within this general framework, baseband and broadband coaxial cable LAN's and broadband MAN's are being designed to take advantage of the flexible architectures the technology affords. Baseband cable can transmit data at rates up to about 50 Mbps in a half-duplex mode (only one party is allowed to transmit on the network at any one time). Broadband can transmit more than 100 Mbps in a full duplex mode. This means that data can be both transmitted and received simultaneously. Such simultaneous receipt of data affords a means of echoing back the transmitted data and permits extremely reliable communications. Baseband systems have a distance limit of about 1.5 Km. Broadband systems can cover radial distances of up to 50 Km and beyond.

Networks can be configured in various shapes, the most popular of which are Ring, Star and Bus topologies. These are illustrated in the three accompanying sketches. The choice of topology is dictated by the medium used, by the size of the network and by the access protocol to be used. Small networks typically within a single building might employ a ring structure and a "token-passing" access protocol in which each successive LIU around the ring is allowed to transmit only on receipt of a special block of data called a token. Upon completion of transmission, the token is transmitted to the next LIU along the ring.

```
                |--------|        |--------|
                |terminal|        |terminal|
                |--------|        |--------|
                    |                 |
|--------|      |--------|        |--------|
|terminal|---|  LIU   |        |  LIU   |       |--------|
|--------|      |--------|        |--------|       |terminal|
                  |   |             |   |          |--------|
       ........|   |............|   |.........         |
       :                                        :         |
       :                                        :...|--------|
       :              RING NETWORK              ....|  LIU   |
       :                                        :   |--------|
       :........   .............   .........:
                  |   |             |   |
                  |   |             |   |       note that each
|--------|      |--------|        |--------|      LIU has two
|terminal|---|  LIU   |        |  LIU   |      connections
|--------|      |--------|        |--------|      to this network
                    |                 |
                |--------|        |--------|
                |terminal|        |terminal|
                |--------|        |--------|
```

Ring structures are relatively inflexible if it is desired to expand the number of LIU's and to increase the size of the covered area. They are also prone to interruption should one node be faulty or a break occur in the medium.

```
            |--------|        |--------|        |--------|
            |terminal|        |terminal|        |terminal|
            |--------|        |--------|        |--------|
                     \            |            /
                      \           |           /
                   |------------------|          |--------|
STAR NETWORK:      | common interface |----------|terminal|
                   | &  control centre |          |--------|
                   |------------------|
                     /            |            \
                    /             |             \
                   /              |              \
           |--------|        |--------|        |--------|
           |terminal|        |terminal|        |terminal|
           |--------|        |--------|        |--------|
```

Star networks are typical of the local twisted pair network served from a single telephone switching centre. They are also used for private branch exchanges (PBX's) and computer branch exchanges (CBX's). Simple "dumb" terminals are able to share the facilities provided at the central control hub. Individual LIU's are located at this central point where they can be owned and maintained by the network operator. Note that a breakdown within the control centre can cause catastrophic failure.

The Bus structure illustrated below is typical of most coaxial cable networks:

```
BUS NETWORK:          |--------|          |--------|          |--------|
                      |terminal|          |terminal|          |terminal|
                      |--------|          |--------|          |--------|
                           |                   |                   |
   |--------|         |--------|          |--------|          |--------|
   |terminal|---|     |  LIU   |          |  LIU   |          |  LIU   |
   |--------|         |--------|          |--------|          |--------|
                           |                   |                   |
        coax bus           |                   |                   |
   = = ============tap==============tap==============tap==== = = =
```

Coaxial bus networks can be expanded by adding linearly to either end of the bus and by splitting the bus into branches to form a Tree/Bus. In its simplest form the bus consists of a single coaxial cable. If further extension is required, distribution amplifiers may be added to make an active network. When this is done, a complication arises in providing two-way communications since amplifiers impose directionality into the system. One solution to the problem of two-way communications within active networks is to use a bus consisting of two parallel coaxial cables. One is used for the "forward" path and one for the return path.

```
                              forward cable
   = = ==========tap==============>============================ = = =
                  |
   DUAL CABLE     |...|--------|    |--------|
                  ....|  LIU   |----|terminal|
                  |   |--------|    |--------|
                  |
   = = ==========tap==============<============================ = = =
                              return cable
```

An alternative solution is to employ just one cable and to split the frequency spectrum, using part for forward transmission and part for return transmission. In this case the network has become a frequency division system, using RF (Radio Frequency) carriers. Some carriers are used for forward transmission and some for reverse transmission. Full duplex communications can be readily arranged.

In both bus and ring networks, token-passing is a possible access protocol. However, for large tree/bus networks, the need to pass the token back to the headend between stations creates inefficient delays. Another access protocol is then preferred, notably Carrier Sense Multiple Access (CSMA). This will be explained in the discussion of Ethernet.

Ethernet, developed by Xerox, DEC and Intel in 1979, and based on the University of Hawaii's Aloha packet radio system, typifies the baseband LAN and has been adopted virtually unchanged by the IEEE 802.3 as its standard for baseband bus contention systems. The Ethernet LAN consists of a strictly passive (non-repeatered) cable bus into and from which Local Interface Units (LIU's) transmit and receive data at an instantaneous rate of 10 Mbps. Two LIU's may transmit simultaneously thus causing a collision and loss of data. This situation is allowed to occur but when it does the collision of data is recognized and signalled to all connected LIU's. The would-be transmitting stations then automatically wait for a random interval of time before attempting a further transmission. This procedure is known as Carrier Sense Multiple Access with Collision Detection (CSMA/CD). No station will transmit while it senses, from the presence of the carrier, that another station is already transmitting. If it does transmit and a collision results, it backs off and starts later.

Passive Ethernets are limited to a maximum station separation of 2.5 Km and to a limit of 1,024 stations. They can however be extended in range and capacity by joining two separate networks together via an active repeater as illustrated below:

```
|--------|  |--------|       |--------|  |--------|
|  LIU   |--|terminal|       |  LIU   |--|terminal|
|--------|  |--------|       |--------|  |--------|
    |                            |
    |                            |       Ethernet A
= = ===tap==========tap==========tap================= = =
                     |
              |-------|       |-----------------|
              |  LIU  |-------|                 |
              |-------|       |                 |
                              |    REPEATER     |
                              |                 |
              |-------|       |                 |
              |  LIU  |-------|                 |
              |-------|       |-----------------|
                     |
                     |                   Ethernet B
= = ===tap==========tap==========tap================= = =
    |                            |
    |                            |
|--------|  |--------|       |--------|  |--------|
|  LIU   |--|terminal|       |  LIU   |--|terminal|
|--------|  |--------|       |--------|  |--------|
    |
|--------|
|terminal|
|--------|
```

TWO ETHERNET SEGMENTS LINKED TOGETHER THROUGH REPEATER

A baseband system such as Ethernet makes use of only a fraction (say 30 MHz) of the 400 MHz bandwidth typically available on an active (repeatered) coaxial cable system. It is a cost effective and elegant means of moving data over small distances provided that the limitations of the half-duplex mode and the inefficient use of the cable spectrum are acceptable.

Baseband systems could be designed using Time Division Multiplexing (TDM) to provide full-duplex operation. This would result in a system considerably more costly than Ethernet and without its simple expansion flexibility. It is more practical for baseband systems to add a second cable where full-duplex operation is required. The two parallel cables operated (only) at baseband frequencies would however represent a waste of spectrum, unless an extremely wide baseband were used.

Of more interest are broadband systems that employ RF modulators and demodulators to access virtually any available portion of the cable spectrum. These broadband cable LAN's and MAN's are the subject of the next section of the report. The RF technology they use is familiar to the CATV industry manufacturers and cable operators. It is the application of this technology to create highly efficient LAN's and MAN's that represents a new business opportunity for the industry.

Local Area Networks can be expected to be privately owned by business corporations and contracted for as a turnkey project. Metropolitan Area Networks, on the other hand, might more logically remain under the ownership and control of a cable operator or subsidiary.

3. BROADBAND LOCAL AREA NETWORKS

This section reviews those LANs which use broadband technology as their physical media. It is the migration from these LANs to MANs that is of strong interest to the CATV industry during its entry into data communications markets. Samples of broadband networks from nine manufacturers have been selected for discussion. Some of these networks are in commercial production. Others are under development or undergoing field testing.

Each broadband network contains its own type of Local Interface Units (LIUs) to provide interconnections between the user equipment and the network media. The LIU contains the modem for transmission into the LAN and could possibly contain multiplexers (Muxs) to provide more than one terminal connection. These LIUs appear to function from the user's side as simple modems. They do, however, have built-in network intelligence.

CHART A - TRANSMISSION & DISTRIBUTION

Chart A in Appendix 1 shows transmission and distribution specifications. The chart divides the system characteristics into three broad categories:

Network Architecture - This section shows the type of network such as midsplit, sub-split, dual cable and the maximum radius allowed between any two users on the cable system.

Superchannel Parameters - A superchannel is classified as the main data channel to which network access is provided. A superchannel may occupy a full 6 MHz (video) bandwidth or less (for example: 300 KHz). Each superchannel can accommodate data traffic from many individual users simultaneously. There can be more than one superchannel per network.

Frequency allocation, channel-spacing, channel data rate, spectral efficiency in bits-per-second (Bps) per Hertz and Bit Error Rate (BER) at a specified Carrier to Noise Ratio (CNR) show the RF characteristics of the LAN.

Modulation terms:

ASK	-	Amplitude Shift Keying
FSK	-	Frequency Shift Keying
PSK	-	Phase Shift Keying
QPSK	-	Quadrature PSK
DQPSK	-	Differential Quadrature PSK
VSB	-	Vestigial Side Band
CPFSK	-	Continuous Phase FSK

Multiplexing terms:

FDM - Frequency Division Multiplex
TDM - Time Division Multiplex

Individual Channel Access Method - This section shows the method used by the LAN to provide a user access to the superchannel. The line protocol is the format of the information on the superchannel and may differ from the format used at the user interface.

Access Method Terms:

TDMA - Time Division Multiple Access
CSMA/CD - Carrier Sense Multiple Access/ Collision Detection
CSMA/ED - CSMA/Error Detection

Line Protocol Terms:

HDLC - High-level Data Link Control
X.25 - Packet Switching format

The last column shows the approximate number of systems in use. Alpha sites represent prototype units working within a lab-type environment. During this phase of development, product concepts are refined and technological problems resolved. Beta sites contain pre-production quality units installed in a customer test environment.

CHART B - NETWORK FEATURES

Chart B shows system specifications that describe the network features of the LAN:

Individual User Ports - This column describes the maximum number of user ports that the LAN can support without appreciable degradation in throughput. It also shows the number of user ports associated with each superchannel.

Number of Superchannels - This column shows the maximum number of superchannels supported by the LAN in both the upstream and downstream direction.

Network Control Features - This section describes additional equipment used with the LAN to manage the network. The name of the network control "manager" is specified. It can be placed in the system either at a central location such as a headend or be distributed throughout the network.

Network control features may include the provision of fault diagnostics and statistics. Dynamic control of Local Interface Unit (LIU) parameters could signify some control over the user data rate, transmit and receive levels, or the provision of downloading capability into the LIU to reconfigure protocols. The priority users/channels column indicates if the control manager or monitor can assign priorities to users to access a network channel and indicates whether or not it can assign priorities to channels on the network for access by specific users.

Gateways - This column indicates if the LAN supports other public or private networks within its own network by providing interface equipment and/or software. This does not mean that any port can be used as a gateway with users providing their own interfaces. The gateway must be supported by the vendor.

CHART C - LOCAL INTERFACE UNITS

Chart C in Appendix 2, identifies Local Interface Units by model name and lists their characteristic features:

Maximum Number of Users - This column shows the maximum number of ports available with each LIU model. The port data rate is shown in the next column.

Port Interface - This column specifies the physical and electrical properties of the port for interface to the user equipment (Data Terminating Equipment).

Port Protocol - This column specifies the user protocol at the port interface. This is usually different from the line protocol described in Chart A.

Protocol Terms:

FD	-	Full-Duplex
HD	-	Half-Duplex
async	-	Asynchronous
sync	-	Synchronous
HDLC	-	High-level Data Link Control
SDLC	-	Synchronous Data Link Control
BSC	-	Binary Synchronous Communication (developed by IBM)

The Notes column highlights additional information about the LIU or the LAN. For a more detailed description of features, see accompanying notes on each LAN manufacturer.

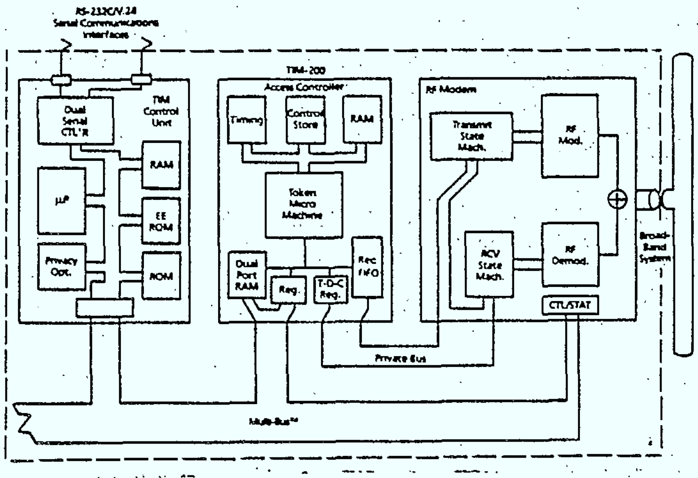
The charts also provide costing information for each LAN and give an approximate cost per port. The per port cost is dependent on the type of service provided and on the equipment in use. The figure gives a ball-park estimate for RS-232-C type interface equipment.

The following pages briefly describe each manufacturer's product by highlighting key network features.

3.1 CONCORD DATA SYSTEMS

Concord Data Systems is a new name in the data communications industry.

Their LAN, Token/Net, uses a token passing access method which implements the IEEE 802 token bus standard. The network is configured as a logical ring. Token/Net allows a network manager to set priorities and pre-defines the rules for sharing the network medium. Access to the network is deterministic and occurs only when the user has possession of the token. As a result, the network is collision-free.



TOKEN/NET INTERFACE MODULES (TIMs)

The Token/Net network is built around a family of Token/Net Interface Modules (TIMs). These units are automatically down-loaded with all of the necessary software. TIMs have the ability to measure receive power and control transmit power under software control, enabling the system to balance itself.

Other features include: priority control enabling real-time application; privacy, using DES encryption keys on a permanent or session-by-session basis; the use of more than one network monitor to share functional responsibilities; multiple connections, allowing permanent switched virtual circuits; multi-cast circuit operation (devices that share broadcast addresses); rotaries, allowing more than one port to respond to a common name; plus various network management/diagnostic tools.

The headend can operate in two modes:

Remodulator Mode - Currently under development, it provides a constant carrier, enabling modems to lock their transmit timing, permitting rapid network polling;

Translator Mode - The headend equipment does not provide a constant signal, but merely translates the upstream channel frequencies to downstream channel frequencies. Since timing is not locked, it takes longer for each modem to equalize. Each RF modem, when operating in the TRANSLATOR mode, sends an appropriately longer preamble pattern to allow additional time for the remote receiver to set up.

Modems have been designed with anti-jabber circuitry to prevent "stuck-on" status.

3.2 CONTEL INFORMATION SYSTEMS

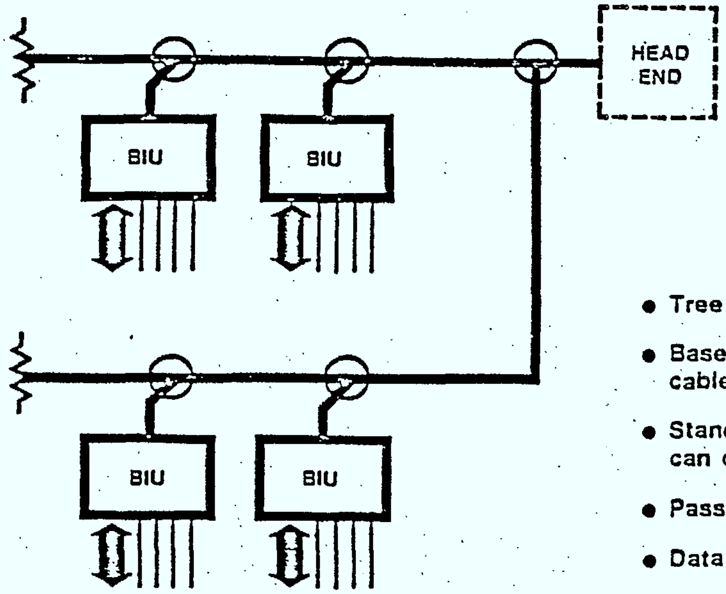
The company comprises four district divisions whose activities are co-ordinated by a headquarters group. They are:

1. Consulting and Technical Services Division
2. Software and Systems Division
3. Information Products Division
4. Government Systems Division

They provide customized real-time software, are a supplier of standard products, and are a turnkey systems vendor or a combination of these. The company has over 13 years of communications and software experience.

ContelNet offers the choice of baseband (BB) or broadband (RF) operation (BB to RF upgradeable by replacing the cable driver in the Bus Interface Units (BIUs)). ContelNet employs enhanced software modules from The Intelligent Cable (TIC), an earlier LAN system.

CONTEL NET™
NETWORK ARCHITECTURE



- Tree topology, up to 5 mile radius
- Baseband or Broadband, single 75 Ohm cable, mid-split (dual cable available)
- Standard CATV 6 MHz channels, each can carry data, video or voice
- Passive, isolated taps
- Data Channels: 2 Mbps and/or 10 Mbps

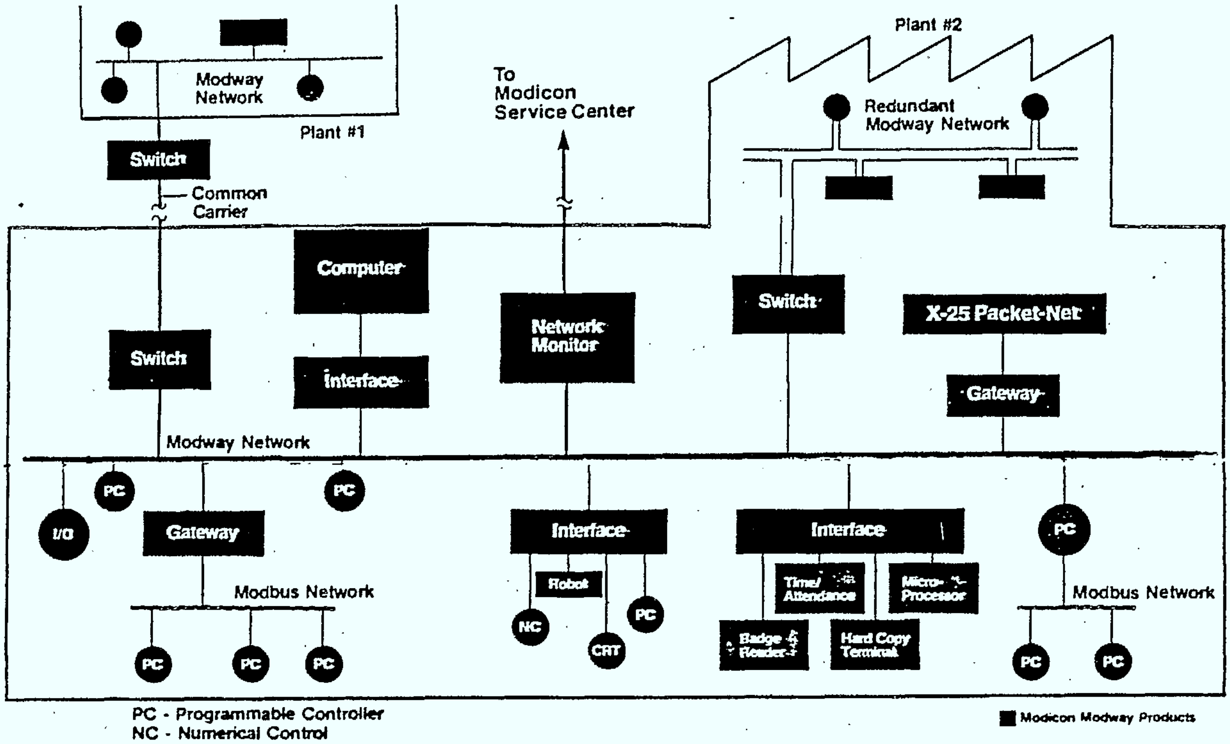
The Local Interface Units are called Bus Interface Units (BIUs) with modular architecture utilizing a multibus backplane. In its simplest configuration it contains only 2 boards, a CPU and cable driver. Additional CPU's, random access memory and software can be added for operator functionability. Add-on functions include protocol converters, gateways to other networks, a bridge to Ethernet, and concentrator capability.

ContelNet provides the user with the means for network configuration through its network control centre (NCC). It provides status monitoring, diagnostics, command processing, display/control, down-line loading, recovery alarms and more. The NCC is optional and is most cost-effective with networks employing more than 50 local interface units.

The operating system for ContelNet is called TICOS and offers TTY, X.25 and transparent domains (point-to-point connections). A modification of the TICOS operating system can provide not only CSMA/CD but IEEE 802 token passing (currently not available).

3.3 GOULD INC. MODICON DIVISION

Gould's Modway public industrial Local Area Network utilizes a token passing (IEEE compatible) network access protocol and can be made to operate at baseband or broadband.



Modicon Modway System Configuration

Three types of devices are used on the network:

Primary Token-Passing Devices that initiate communications.

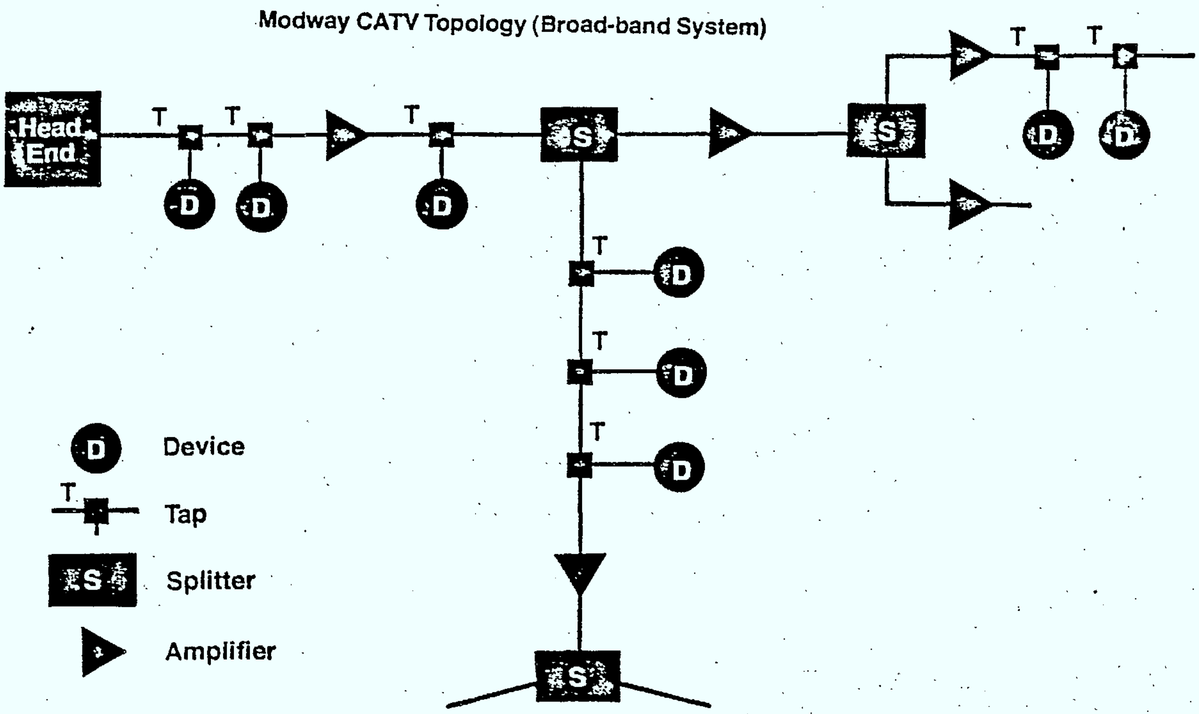
Secondary Devices that have only the ability to respond when queried.

Demander Devices that become primary devices for short-time periods in response to an event within the demander device.

The Modway system can perform Data Acquisition (event logging, management reports), direct control (distributing process I/O), supervisory control and distributed control (real-time capability, event synchronization).

Self-diagnostics are built into every Modway interface. The network monitor provides statistics collection, observation of transient phenomena, alarm monitoring, device configuration control and distributed device-testing.

The Modway system supports the physical, link, network and transport levels in Modicon's Network Architecture for Distributed Systems (MONADS).



Gould is also developing another Local Area Network called MODVIEW but no information is currently available.

3.4 LDD M/A-COM

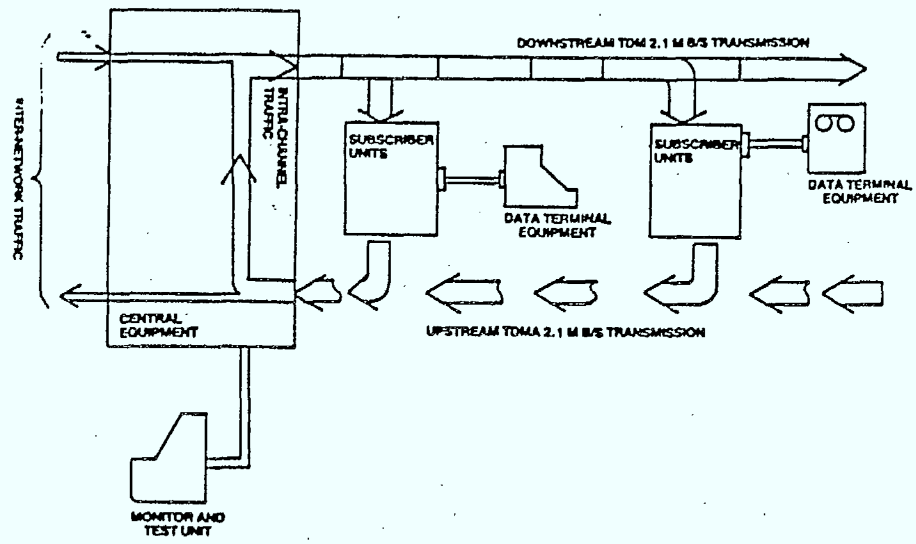
Local Digital Distribution Company was formed in 1980 as a partnership between M/A Com and Aetna Life & Casualty. M/A Com is an international designer and manufacturer of advanced telecommunications systems for commercial and defense applications. M/A is a major supplier of digital information processing and transmission equipment for satellite communications, data communications, fibre-optics, television broadcast and CATV. Aetna has assets of $40 billion and brings its expertise to LDD as a large and sophisticated user of business communications equipment.

Illustrated on the following page, LDD's local network, CAPAC, uses time division multiplexing (TDM) for downstream transmissions from the central hardware, normally located at the headend, to all subscribers. CAPAC uses time division multiple access (TDMA) burst transmissions for upstream communications from subscribers. The size of a burst depends on the number of ports supported by one Subscriber Unit (Local Interface Unit) and the speed of data transmission. The central equipment distributes the traffic either to a gateway or returns it in the downstream direction. The port rate of each Subscriber Unit can be remotely programmed from the central equipment and can support asynchronous terminals by using a statistical multiplexer (M9100). The units feature plug-in port cards and modem cards.

The central equipment maintains the network map, remembers subscriber unit parameters and keeps track of available capacity and of the user station propagation delays. Propagation delay is measured to ensure no overlapping bursts are generated. A delay of approximately 128 microseconds is adjustable under software control. A further 1 millisecond delay can be added at the time of installation.

A monitor and test unit (MTU) is available for operator access to status system configuration or information. Primary functions include the establishment of communications with hardware components, reconfigurations of the network, the generation of displays of the status of various components of the system, the processing of alarms, events, statistical messages and the provision of display functions to the operator.

The CAPAC network was designed for large geographical coverage and is similar in concept to their RAPAC system, a multipoint microwave radio communications network.



.OCAL DIGITAL DISTRIBUTION COMPANY'S CAPAC NETWORK

The following table gives the number of active frame channels required to support a total given number of ports. These channel requirements are given in terms of the "Erlang B" versus "Two State Markov Process Model" for different port occupancy percentages and blocking probability.

			No. of Active Frame Channels			
	Blocking Probability	Occupancy Percentage	10 Ports	30 Ports	50 Ports	100 Ports
Erlang B	1%	50%	10	24	36	64
		10%	5	8	11	18
	10%	50%	8	18	28	51
		10%	3	6	8	13
Two State Markov Model	1%	50%	9	22	34	62
		10%	4	7	10	17
	10%	50%	8	19	30	57
		10%	3	6	8	13

Number of Active Frame Channels
Required to Support
A Given Number of Ports

The table below shows the number of users that can be supported for 1% blockage for various channel rates and for various number of active channels.

		Number of Users (1% Blockage)	
Channel Rate	Active Channels	10% Occupancy	50% Occupancy
1.2 Kbps	200	255	255
2.4 Kbps	200	255	255
4.8 Kbps	200	255	255
9.6 Kbps	176	255	255
19.2 Kbps	96	255	162
56 Kbps	35	241	53
64 Kbps	30	201	44
112 Kbps	17	100	22
224 Kbps	9	43	10
448 Kbps	4	13	4

LLD M/A-Com's CAPAC system features a proprietary access protocol called Demand Assignment Multiple Access (DAMA), used for all upstream communications and by means of which subscribers originating data traffic can be assigned a suitable channel.

3.5 PHASECOM

Phasecom produces a variety of headend equipment for the CATV industry. Phasecom pioneered Harmonically Related Carriers (HRC) in 1972. Their products include modulators, demodulators and processors. They are relatively new in the data communications field and provide RF modems (see modem chart) as well as a local area network.

The Intelligent Cable Network Modem (ICN Model 425) is a self-contained broadband unit designed to support up to four independent users. The network uses CSMA/CD access method. The ICN units feature digitally-controlled frequency agility, self-diagnostics, code conversion and encryption, session control and display traffic and user statistics. The units work with an HRC headend, incorporate a watchdog timer to prohibit spurious transmission from an ICN unit and provide port reconfiguration. The network supports ISO level 5 network operation protocol.

Phasecom has designed the ICN modem specifically for CATV network compatibility. Another model (425-G) offers gateways to larger geographical networks and uses a polling access technique rather than CSMA/CD.

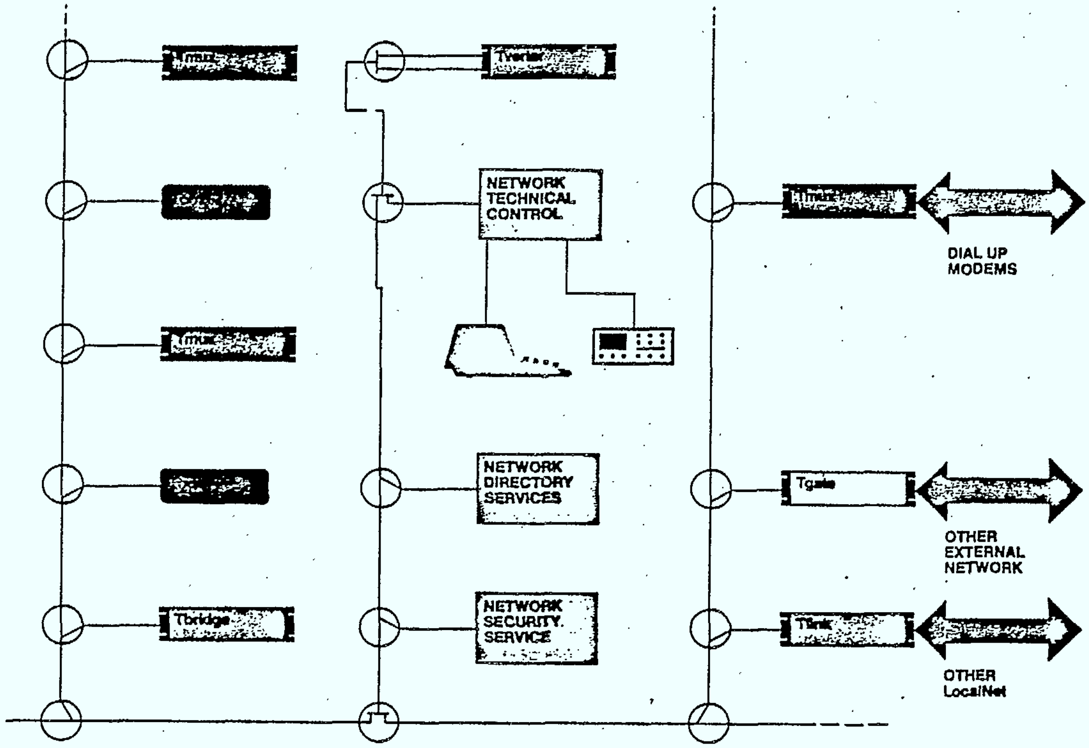
3.6 SYTEK INC.

Sytek is affiliated with the General Instrument Corporation, a major CATV equipment supplier. Sytek's Local Area Networks, LocalNet, are serviced nationwide through General Instrument's Data Systems Group. Sytek offers a wide variety of network-related services, including the specification of LANs and broadband system architecture design. They are prime contractors for turnkey local area network installations.

In LocalNet, the intelligence resides within the network. A Packet Communications Unit (PCU) is associated with each user device or group of devices. It handles network access, formatting, addressing and error checking. PCUs provide services and functions such as protocol translation, encryption, and virtual terminal support. LocalNet supports the upper 6 layers of the Open Systems Interconnection Reference Model (OSI). LocalNet 20 provides low speed (128 Kbps) networking for devices with serial (RS-232-C) interfaces.

The Local Interface Units for LocalNet 20 have frequency agile modems, automatic speed determination, self-test and diagnostics. LocalNet 20 can logically handle 64,000 users tied to a system, but for optimum throughput, approximately 24,000 users are practical. Below is an example of a LocalNet 20 layout.

System 20 Physical Layout with Enhancements



In addition to LocalNet 20, Sytek offers LocalNet 40, designed for relatively high speed (2 Mbps) devices with parallel interfaces and LocalNet 50 products that implement optional higher level functions such as access control, monitoring, failure isolation and security. LocalNet 50 products also handle internetworking linking functions (50/400), interchannel bridges (50/200) and gateways (50/300).

LocalNet 40 Attributes

DMA/CHANNEL INTERFACES
- DEC Unibus
- IBM Channel
- Multibus

HIGH PERFORMANCE
- 10 Mb/s Aggregate Capacity
- 1.5 Mb/s Throughput per Network Adapter

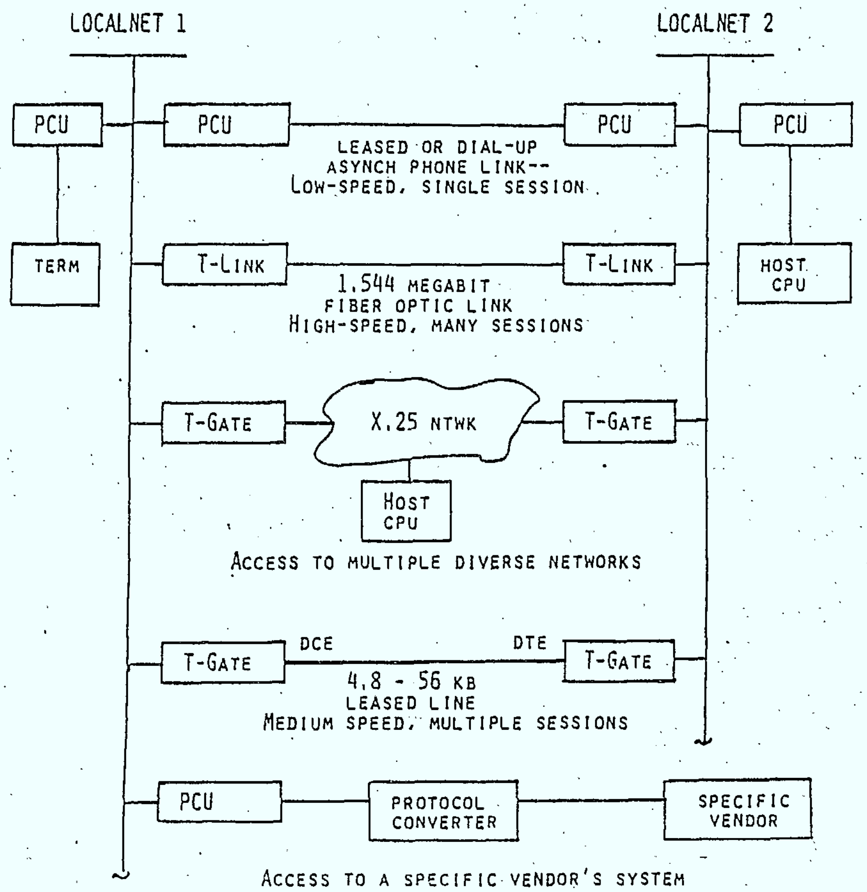
LOCAL NETWORK FRONT-END
- Offloads Host of Communications Processing
- Full Virtual Circuit Protocol Suite

COST-BALANCED

CHANNELS
- 5 Channels
- 6 MHz Each Direction
- 2 Mbps Channel Rate
- 256 Virtual Circuits per Adapter

CHANNEL-CHANNEL BRIDGE
- Can Bridge to LocalNet 20 Modules

INTER - NETWORK ALTERNATIVES



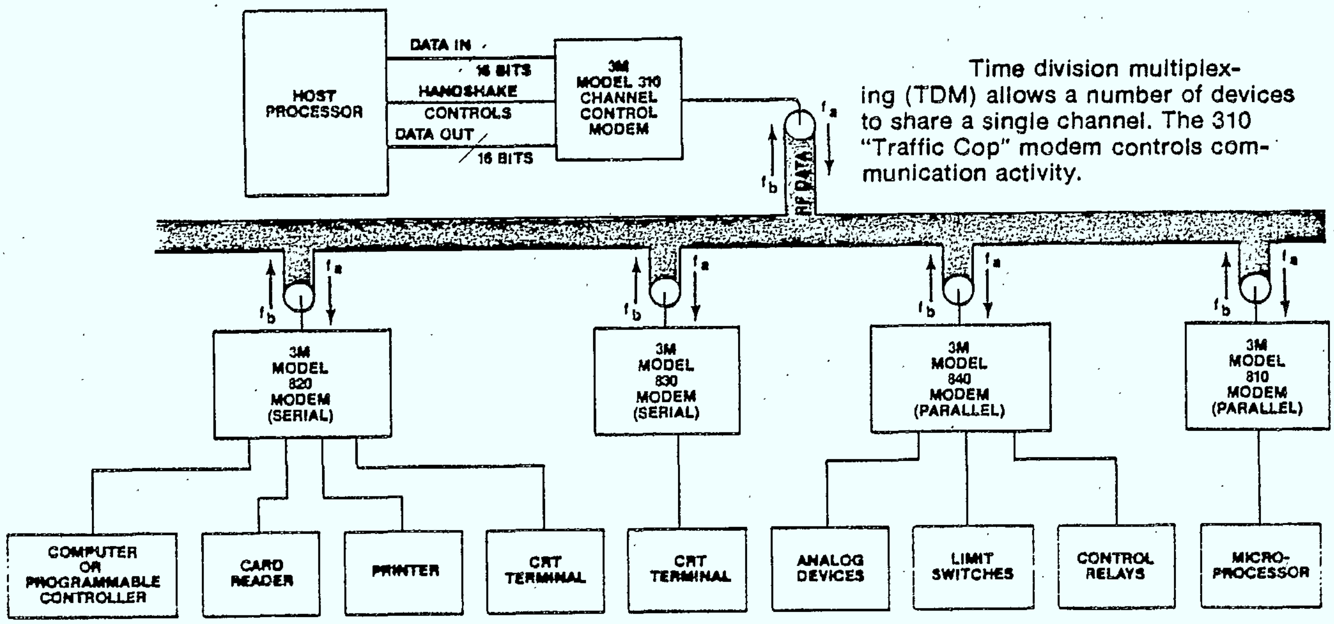
Sytek has developed a number of inter-network alternatives for two LocalNets to communicate with each other. This can be accomplished by PCU-to-PCU connect, low speed single session mode, or by using the T-Link or T-Gate for high speed, multiple session transactions (see accompanying diagram). Bridges supplied by Sytek provide for inter-channel traffic and can also connect a LocalNet 40 to a LocalNet 20 system. Technical, Directory and Security Services are provided by the network control center. These units can be placed anywhere in the system.

Sytek also offers multiplexers called T-MUXs which have a rotary call feature that allows channel allocation for active ports Also under development is a system called Metronet that will cater to a Metropolitan Area Network environment.

3.7 3M/INTERACTIVE SYSTEMS

Interactive Systems is part of the 3M Company, a research and service-oriented company with approximately 80,000 employees in 40 countries. IS/3M have been installing Videodata broadband networks since 1972. IS/3M have two broadband Local Area Networks, Videodata and Videodata LAN/1.

Their current video data network uses a time division multiplexing (TDM) transmission scheme called AutoPoll which allows up to 248 terminals to share the same channel at a data rate of up to 100 Kilobaud.



Time division multiplexing (TDM) allows a number of devices to share a single channel. The 310 "Traffic Cop" modem controls communication activity.

Time division multiplexing (TDM) allows a number of devices to share a single channel. The 310 "Traffic Cop" modem controls communication activity.

AutoPoll uses a channel control modem (model 310) for addressing remote device modems. Simultaneously, the 310 receives data from the remote device during cyclically recurring time slots. Usually, only one word is transferred during a given time slot. However, block transmission can be obtained. In a 100 CRT TDM system, operating at 100 Kbaud, each CRT is polled 3 times per second. A number of separate systems can be incorporated on a single cable using frequency division multiplexing. Series 800 type modems are used with the TDM system.

3M offers other auxiliary products such as a manual channel switch (Model 460) to be used as a 6 full-duplex data channel tuner allowing a remote modem to switch between 6 RF channels. This provides multi-host terminal networks, i.e. switched data networks.

Model 401 PTO is an auxiliary product that provides modem power (810 & 520) directly from the broadband cable system.

3M's other LAN, the Videodata LAN/1 is a high-speed LAN. The network uses a token passing protocol in the Network Interface Units (NIU's) providing switched point-to-point communications. Network performance can be analyzed by a Network Monitor Unit (NMU) that will keep statistics and facilitate routine maintenance and trouble-shooting. Network diagnostics and reporting are done via a specially configured IBM Personal Computer and 2-port NIU. (The IBM PC may also operate as a user terminal on the network.) The NIUs automatically shut off in response to a preset message length limit. An extra reconfiguration lockout prohibits network capture by one NIU. The LAN/1 is expected to be available in the third quarter of 1983.

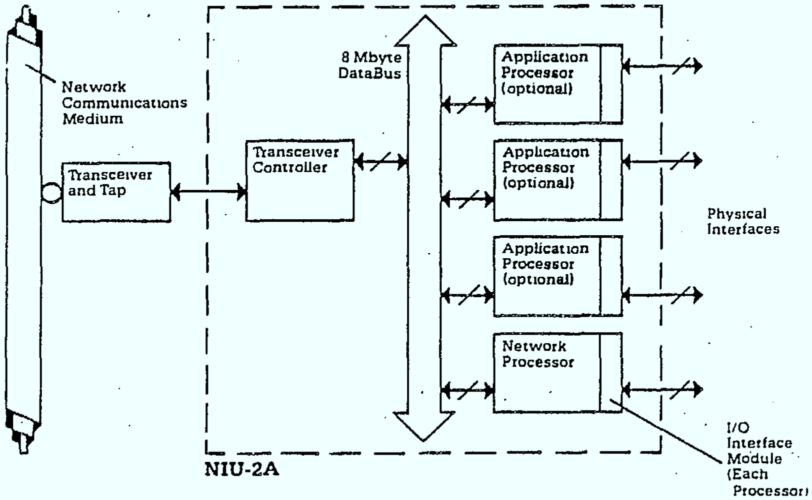
3M is also working on a Metropolitan Area Network (MAN) and have submitted portions of their specifications as a MAN IEEE 802.6 standard. The 3M proposal uses the IEEE 802.4 token bus draft standard as part of the framework for their MAN. The network uses an adaptive polled access method for a logical (virtual) ring on a physical bus architecture.

A centralized polling structure sends a Phase Continuous FSK signal (outbound) at 3 Mbps and receives a 3 Mbps differential PSK signal (inbound). This scheme occupies a pair of 6 MHz channels. For a higher data rate, 3M are offering a 10 Mbps AM-PSK modulated signal which has a 2-bit/Hz spectral efficiency.

3.8 UNGERMANN-BASS

Ungermann-Bass, Inc., began developing a general purpose, high performance data communications system called Net/One in July 1980. Ungermann-Bass has recently acquired Amdax Corporation, a manufacturer of RF modems and LAN's.

Ungermann-Bass offers the option of Net/One Baseband, an Ethernet compatible network system, Net/One Broadband, a CATV compatible network, or a combination of baseband/broadband networks. Network Interface Units (NIUs) serve as nodes for interconnecting distributed processing devices. The Model 2A NIU connects to either a Net/One transceiver and to taps for Ethernet type systems or to a Net/One broadband modem.

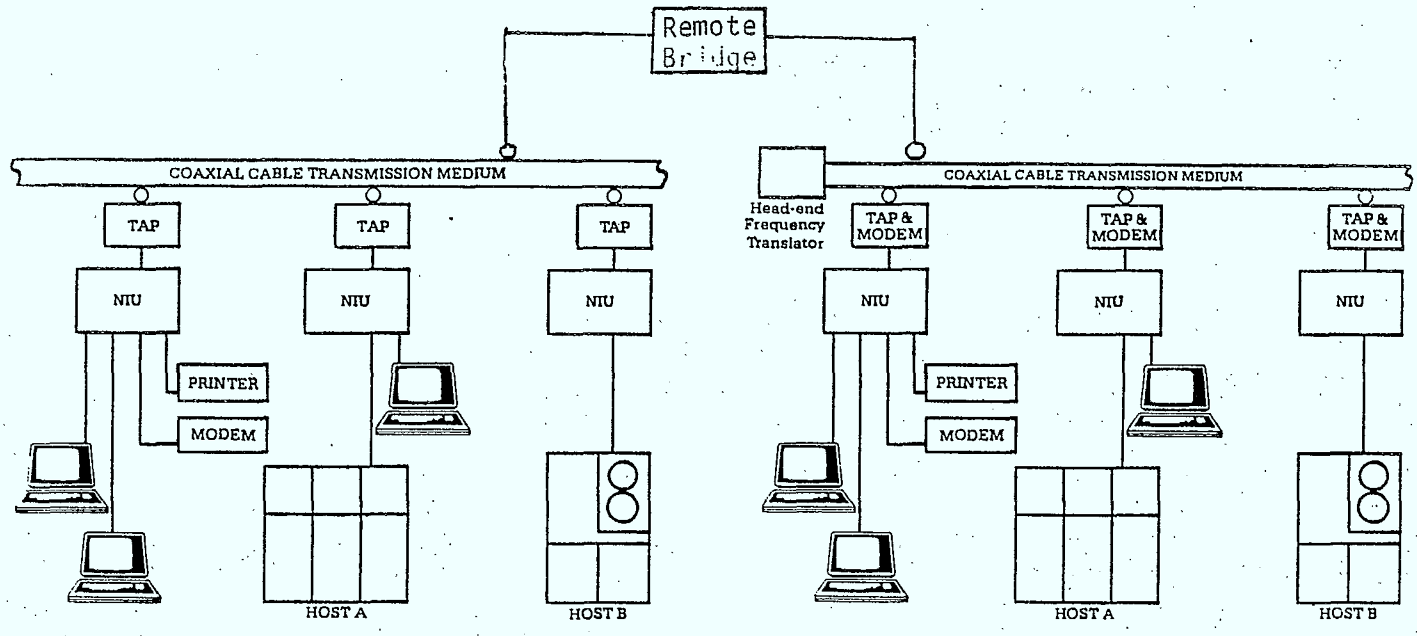


MODEL 2A NETWORK INTERFACE UNIT (NIU)

The transceiver controller provides the logic required for receiving and transmitting packetized data, and for using the CSMA/CD contention algorithm. On the broadband network, the transceiver and controller are replaced by an RF modem which uses a CSMA/ED contention algorithm. The contention algorithm varies slightly between the two networks because collision detection is more difficult to implement on a broadband system.

The NIUs are capable of datagram (stand-alone single packet urgent messages) and virtual circuit services. They support a range of device protocols, provide protocol translations, and programmable interface ports for speed and code conversion. They do not need continuous central process control, except for the initial downloading of data. Their additional application processors can be added for expanding user requirements.

The NIUs are downloaded with software by a network configuration facility, Model 2 (NCF-2). The download server mode automatically generates and loads protocol and network service software across the network to any NIU. This is a useful feature for system and NIU reconfiguration. The NCF-2 can also serve as a software development environment for user-generated application software.



Net/One-Baseband Net/One—Broadband

Ungermann-Bass also have a remote bridge that provides user-transparent interfaces between geographically separate Net/One systems. Any NIU can interact with any node in the internet. A powerful feature of the bridge is that it provides communications between any nodes on a 10 Mbps BASEBAND Net/One network and any node on a 5 Mbps BROADBAND Net/One network. A high-speed serial I/O module must be installed per NIU together with one copy of the remote bridge software per network. This Ethernet to broadband bridge enhances many useful network configurations and enables cable operators to possibly provide a broadband CATV gateway to interconnect two or more baseband LANS.

Ungermann-Bass have available a broadband frequency translator with a 192.25 MHz offset (Model 5501A 5502A) to work with the RF Modems in their LAN.

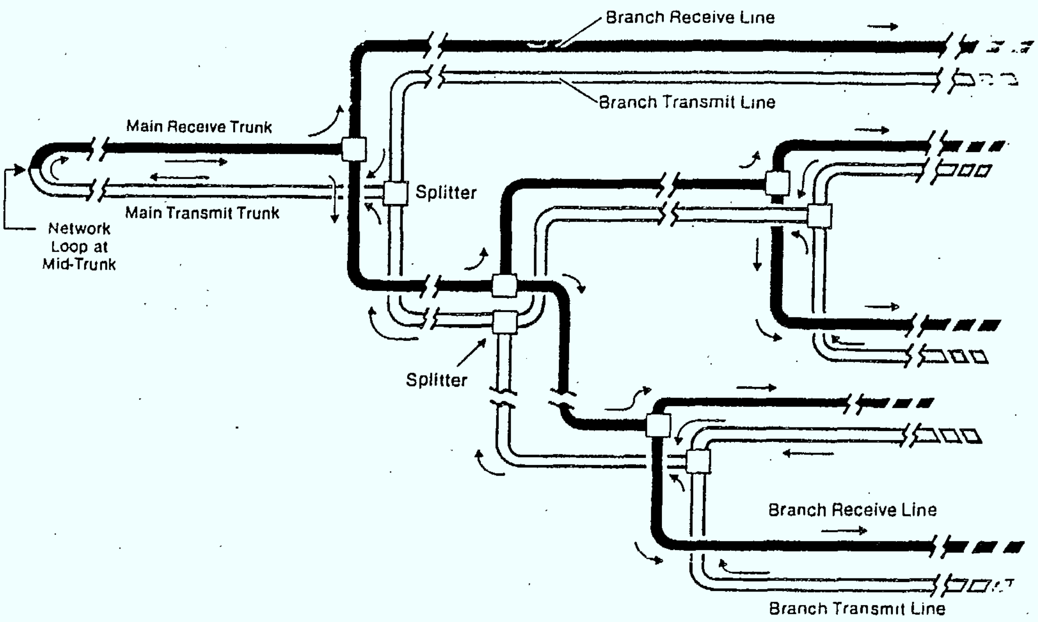
The use of Amplitude Modulation rather than Frequency Modulation (FM) in the modems should be more effective in detecting collisions because FM receivers are subject to capture effect. This occurs when a stronger carrier swallows a weaker carrier, masking out possible collisions.

In the first quarter of 1982, Amdax introduced a LAN called Cablenet which provided a switched service and offered two versions, Cablenet series 14 and series 7 (14 and 7 Mbps respectively). Ungermann-Bass continue the Amdax modem line but are not offering the Cablenet LANs.

3.9 WANG

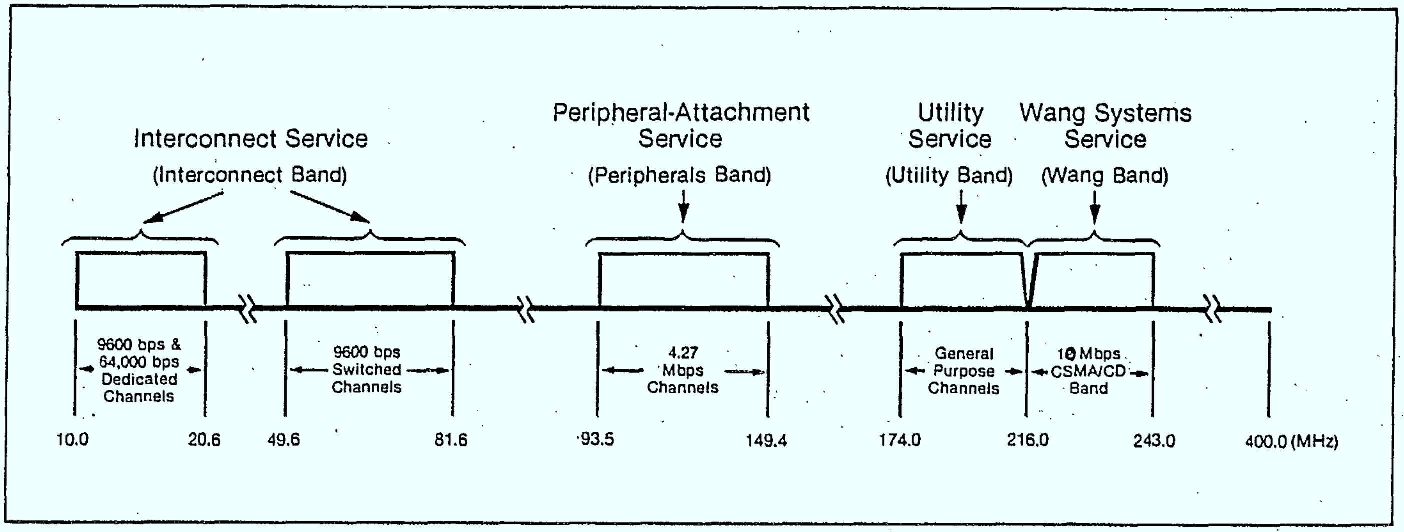
Wang Laboratories, Inc. was founded in 1951 in Boston, Massachusetts. From sales of $1.6 million in 1964, the company has grown to be a Fortune 500 company with sales of $1.1 billion in 1982. The company's product lines include word, data, audio and image processing equipment and communications network components.

Wang Laboratories, Inc. have developed a broadband LAN called WangNet, using dual cable, branching tree network topology.



WangNet Dual-Cable Branching-Tree Topology

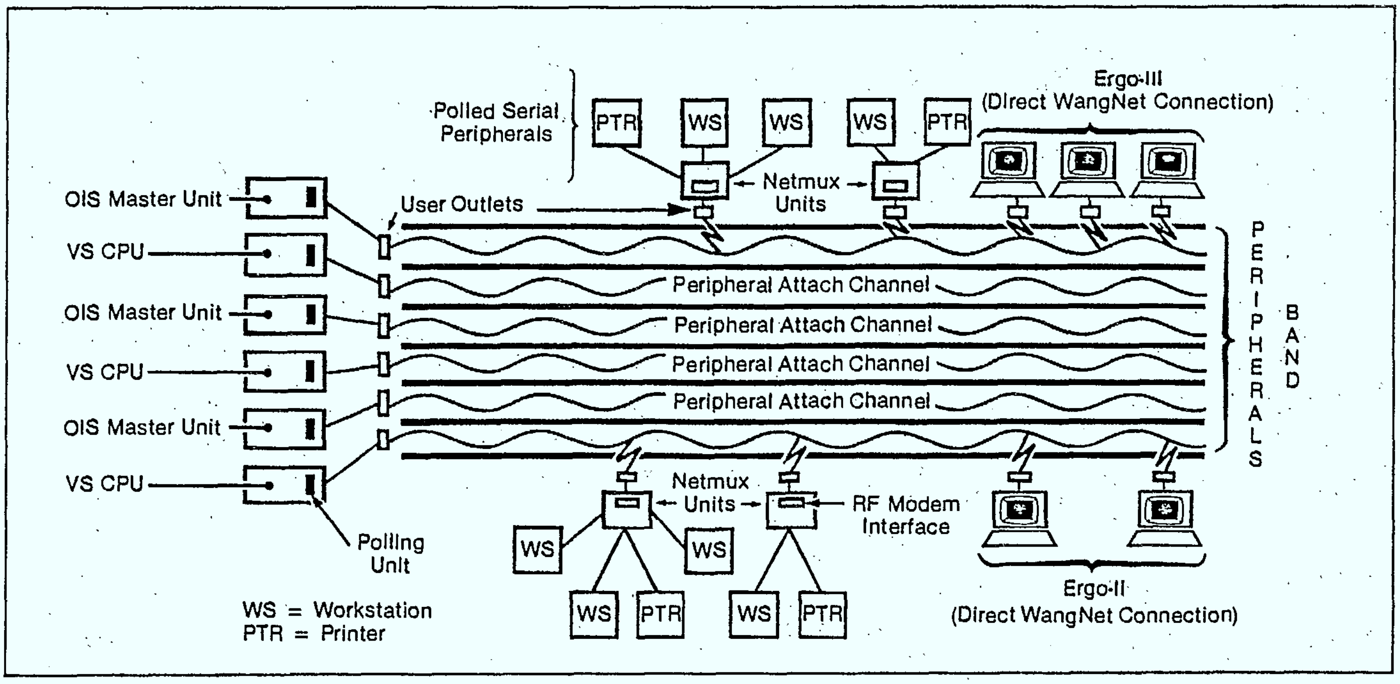
All transmit-line components are positioned physically adjacent and parallel to all receive-line components. WangNet uses both TDM and FDM techniques to support various WangNet services. WangNet segments the cable into 4 bands:



Allocation of Available Bandwidth

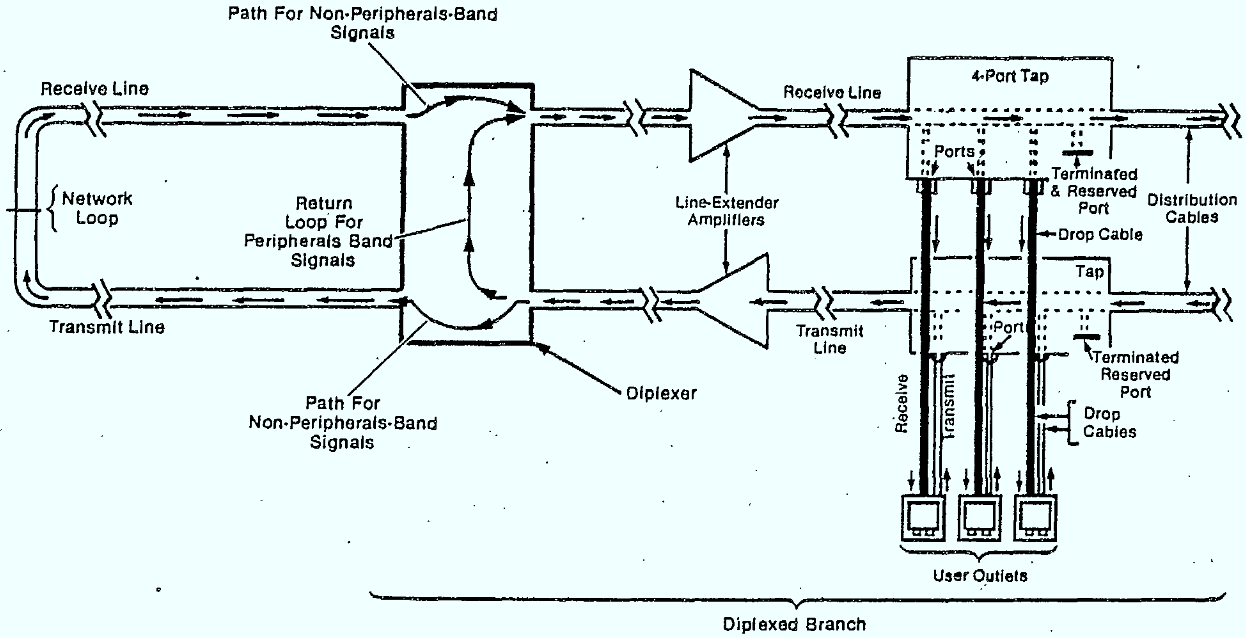
1) THE WANG BAND - is reserved for high-speed communications (Wang processing units).

2) PERIPHERALS BAND - contains 6 channels, each of which can be used as a medium for logical attachment of up to 32 Wang serial devices to a VS, OIS or Alliance System. The VS or OIS must contain a Band Polling Unit to communicate with the devices. See diagram below.



Peripheral Attachment Service

The peripheral band frequencies can be re-used on the same cable distribution system if diplexers are used to separate two 6-channel attachment services. A diplexer has no effect on other WangNet services.



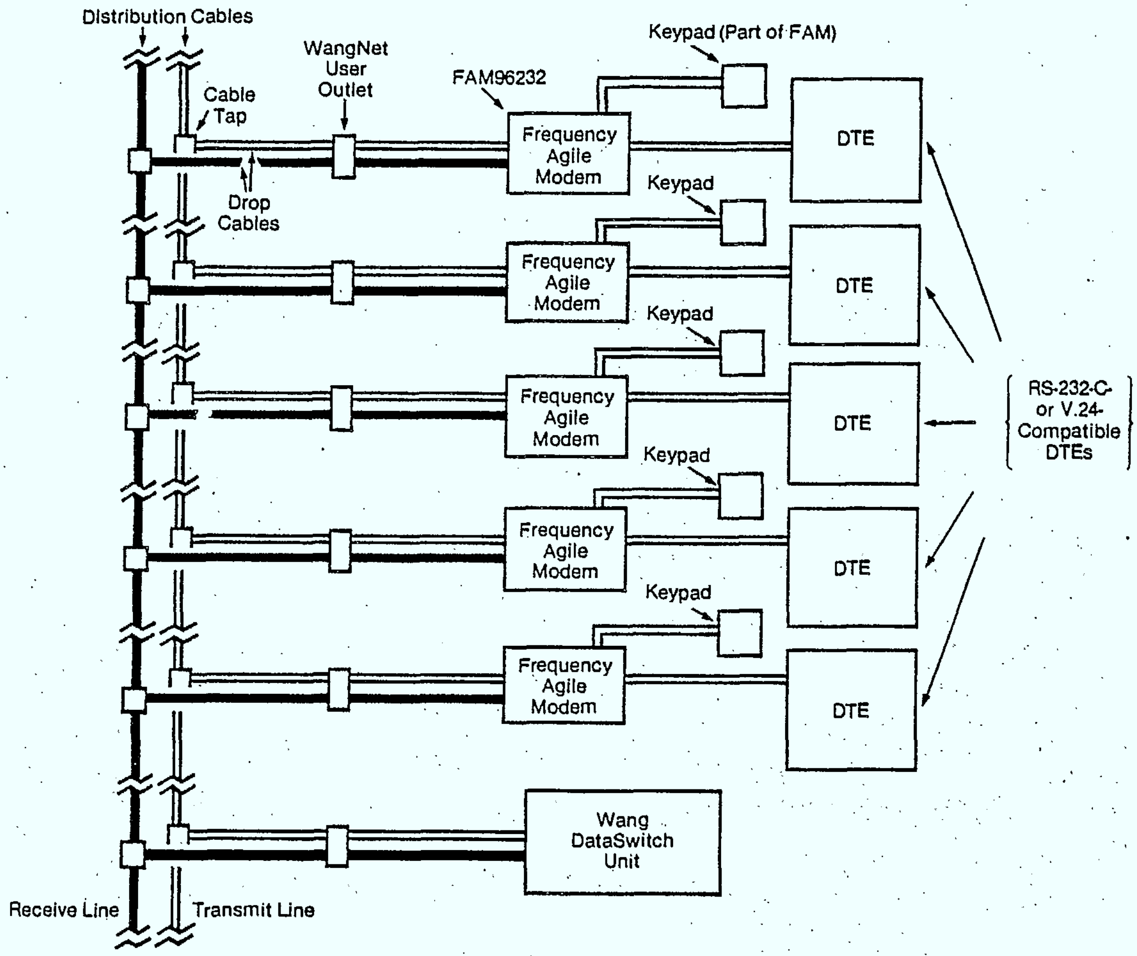
WangNet Diplexer

3) <u>INTERCONNECT BAND</u> - This band offers 3 services:

a) 64,000 bps Dedicated Interconnect - contains 16 channels, each of which can be used as an equivalent leased line. Wang Model FFM64449 Fixed Frequency Modem is the appropriate interface.

b) 9600 bps Dedicated Interconnect - contains 64 channels, each of which can be used as an equivalent leased line. FFM 96232 is the appropriate interface.

c) 9600 bps Switched Interconnect - A Wang Data Switch is connected which broadcasts a polling sequence to the modems. Supports up to 256 separate digital terminating equipment pairs (DTEs). Keypad can be used to initiate a call. See diagram on following page.



The WangNet DataSwitch

4) <u>UTILITIES BAND</u> - A 42 MHz band is reserved for user-defined video or non-video communications (i.e. up to 7 CATV channels can be supported).

The services described occupy less than half of the available WangNet cable bandwidth. The rest is reserved for new services. The following table summarizes the services.

Typical WangNet Services and Interface Requirements

Band	Capabilities	DTE-to-Modem Interface	WangNet RF Modem	Multiplexing Techniques
Wang 12-Mbps systems service	Wang VS and OIS inter-system communications	Serial peripheral input-output controller	CIU-A for OIS Masters CIU-B for VS CPUs	TDM (CSMA/CD)
Peripherals Single or multiple 6-channel attachment services	Wang VS, OIS, or Alliance serial peripheral configurations over the WangNet broadband cable	Each system must contain one Peripherals Band Polling Unit for control of up to 32 devices per channel. Standard peripherals are connected to a Netmux unit. Polling unit and Netmuxes are connected to separate user outlets.	Wang Netmux contains an rf modem for connection to a user outlet. Ergo-II and -III workstations with the WangNet connection option (WN2, WN3, respectively) each contain an rf modem for direct connection to WangNet.	FDM and TDM (Serial peripherals are polled.)
Interconnect 64,000-bps dedicated service	Emulation of 64,000-bps leased lines; suitable for RS-449- or V.35-compatible DTEs	RS-449- or V.35-compatible interface DTEs must also be protocol-compatible.	One FFM64449 Fixed-Frequency Modem per RS-449/V.35-compatible user device	FDM (plus TDM when DTEs are polled in a multipoint link)
9600-bps dedicated service	Emulation of 9600-bps leased lines; suitable for RS-232-C- or V.24-compatible DTEs	RS-232-C- or V.24-compatible interface DTEs must also be protocol-compatible.	One FFM96232 Fixed-Frequency Modem per RS-232-C/V.24-compatible user device	FDM (plus TDM when DTEs are polled in a multipoint link)
9600-bps switched service	Emulation of 9600-bps switched network; suitable for RS-232-C- or V.24-compatible DTEs	RS-232-C- or V.24-compatible interface for protocol-compatible DTEs RS-366- or V.25-compatible interface for autodial and auto-answer operations	One FAM96232 Frequency-Agile Modem per RS-232-C/V.24-compatible user device	FDM and TDM (FAMs are polled by the Data-Switch unit, which controls use of switched channels.)
Utility Video service	Standard video applications, or user-defined applications	User-supplied	Standard 6-MHz CATV-type modulators and demodulators, or user-supplied modems for non-video applications. (See all NOTES in the "User-Defined Services.")	User-defined

WangNet can be operated with either passive or active (CATV type) coaxial cable networks. In a CATV design, 32 amplifiers may be operated in cascade from the transmit connector of any user outlet, through the Network Loop, to the receive connector on a user outlet. Each pass through a duplexer must also be counted as one amplifier.

WangNet is primarily designed to work with Wang's product line of work stations, CPUs and peripherals. Although it utilizes a broadband scheme, the dual cable and non-standard frequency band assignment of, for example, the interconnect band make the network incompatible with current CATV institutional design. Wang's Fixed Frequency Modems require a 48 MHz pilot for synchronization and low-drift frequency translation. Conventional duplex filters on CATV amplifiers would attenuate this signal. Thus WangNet is not a general purpose network but aimed for Wang product support.

Wang Communications Inc., on the other hand, has developed CATV compatible modems and a translator for applications of point-to-point or multi-point dedicated service.

4. METROPOLITAN AREA NETWORKS

Local Area Networks (LANs) have evolved from private usage of data communications equipment within an office environment, a building or a building complex and have typically been restricted to a geographical radius of 5 km or less. Metropolitan Area Networks (MANs) are intended for a much larger geographical coverage of 50 km or more. MANs may be public or private networks depending upon the application.

The topology of a coaxial MAN may differ from a LAN due to the size of the cable system. A logical bus, for example, may be impractical on a large network. MANs serve both as a primary network and as an internetworking vehicle between lower hierarchy LANs. Two or more geographically separated LANs could be interconnected via a MAN which offers a gateway for each LAN.

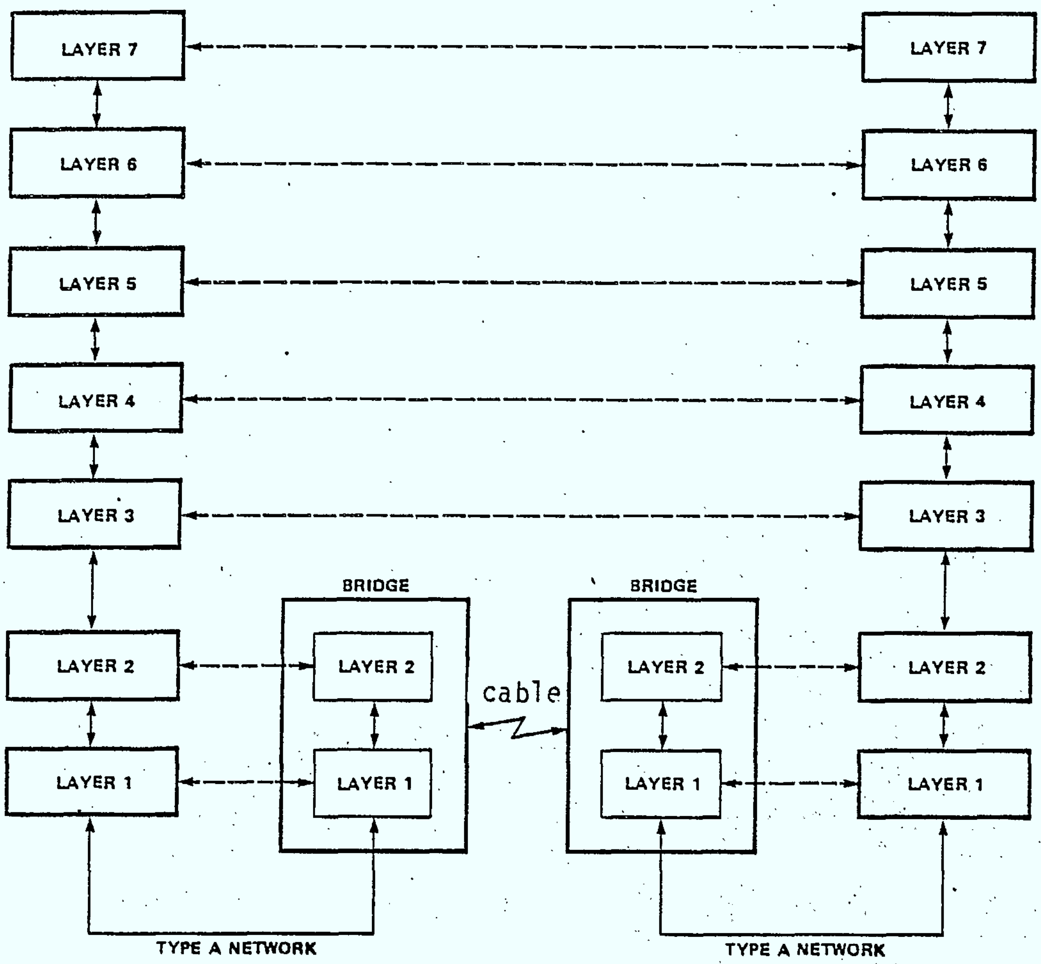
MANs can also provide "bridge" functions to enable two LANs to communicate by physically coupling them together via a simple repeater. This is done, for example, in extending the range of geographically separate Ethernets.

The internetworking of LANs by the provision of gateways, bridges and protocol converters represents an attractive business opportunity for the operators of traditional CATV networks. In order to explain these concepts, reference to the ISO layers is useful.

4.1 BRIDGE CONNECTION

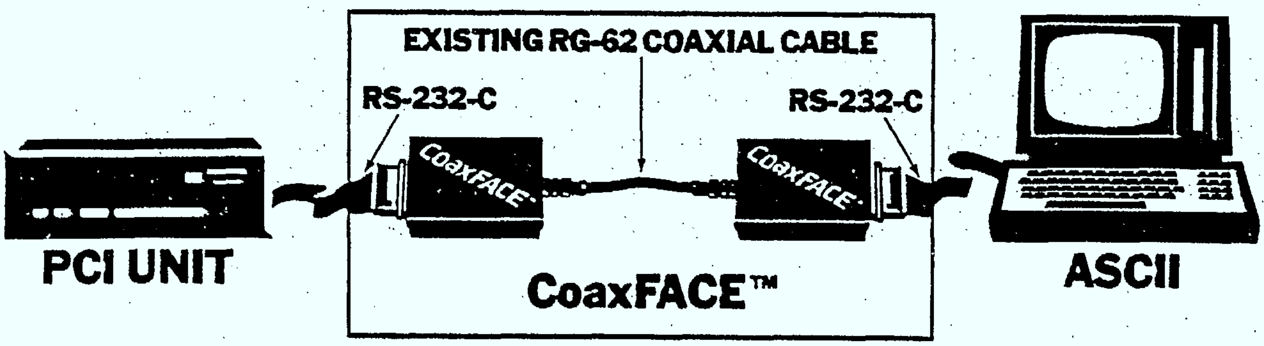
A bridge connection interconnects two networks employing identical transmission media, signalling and higher level protocols. Ungermann-Bass of Santa Clara, California, provide a baseband Ethernet to broadband CATV bridge via their Net/One local area network.

The bridge acts as a "line extender" to extend the physical and data link layers (levels 1 and 2) and increase the normal maximum end-to-end length of the network. The bridge connection provides a means of extending the same network. A penalty in the form of increased round trip delay must be paid when two LANs are bridged together. A MAN can easily provide this function for a network that is divided amongst various buildings in a city.



BRIDGE CONNECTION (Source: Bridge Communications Inc.)

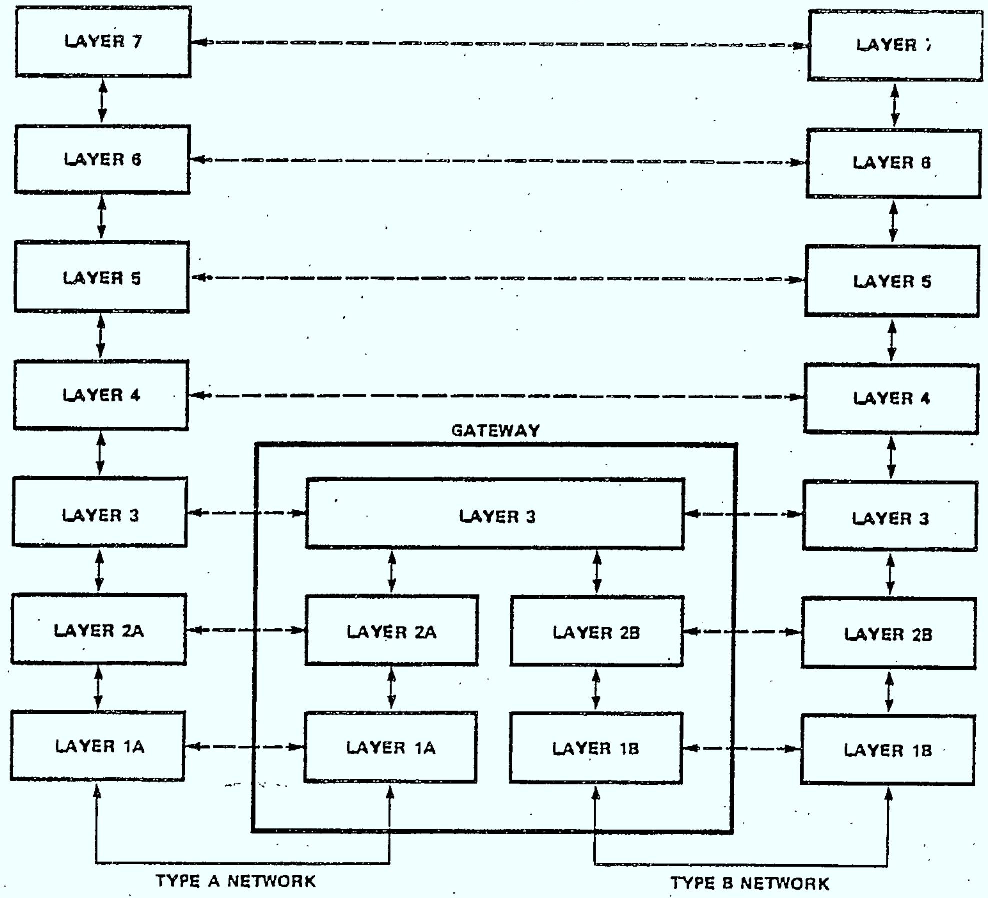
Another example of a simple bridge is shown below.



This bridge permits a 5,000 foot separation between a computer and 2 terminals and is therefore an example of a physical layer extension. The higher layer protocols (layers 3 to 7) are not affected by the presence of the bridge.

4.2 GATEWAY CONNECTION

This simplest form of gateway provides a connection between two networks with different media and signalling but with the same higher level protocols:

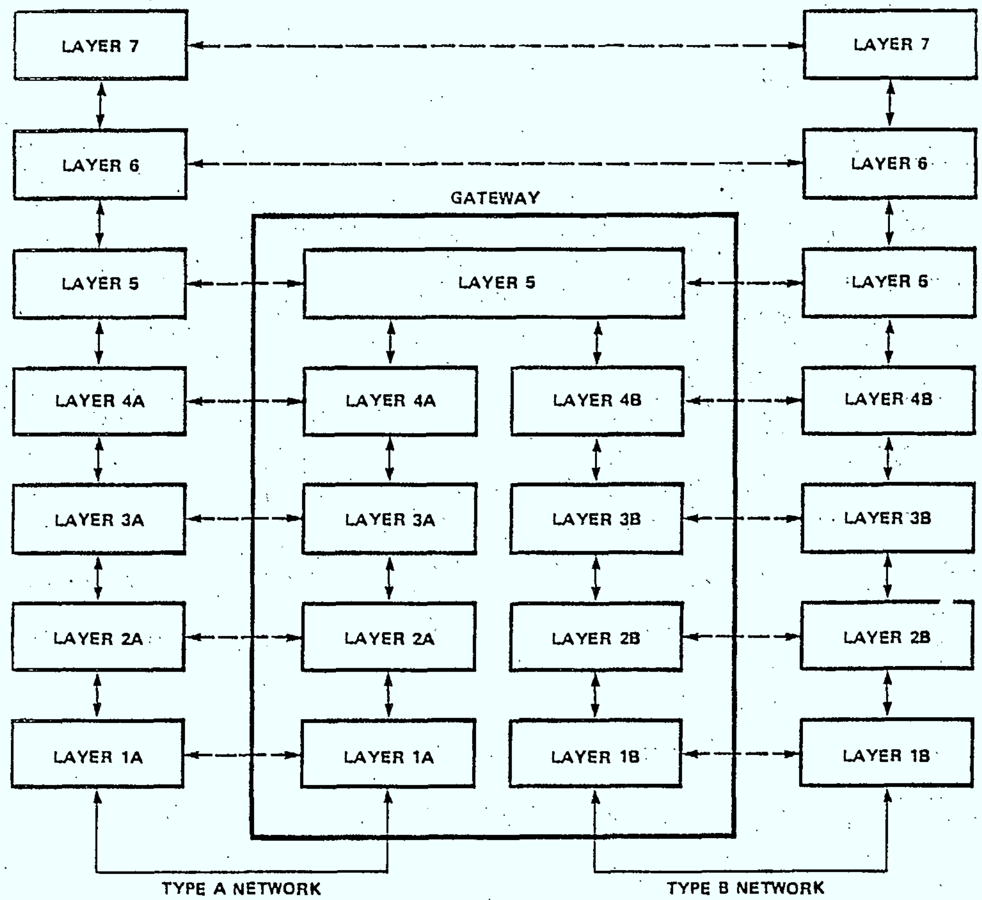


GATEWAY CONNECTION (Source: Bridge Communications Inc.)

4.3 MEDIA AND PROTOCOL TRANSLATION GATEWAY

This gateway interconnects networks using different media signalling abut the same applications level protocols. Examples would be the interconnection of a Xerox Network System (XNS) with an X.25 internetwork or of an XNS Ethernet with a Sytek Local Area Network. These networks employ substantial differences in transport level (4) protocols and require protocol conversions at this level.

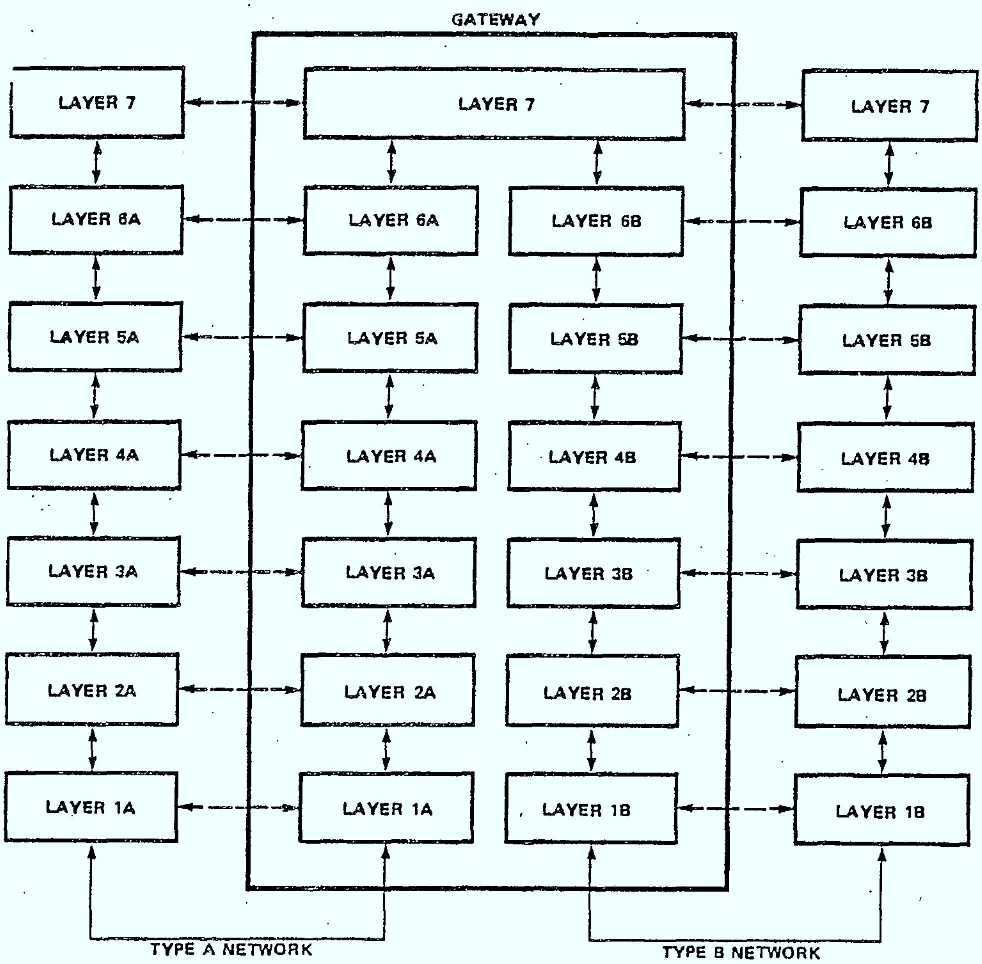
Metro Area Network operators could supply not only the transmission facility, but also the local interface units for this type of gateway.



MEDIA AND PROTOCOL TRANSLATION GATEWAY
(Source: Bridge Communications Inc.)

4.4 APPLICATION TRANSLATION GATEWAY

The final gateway to consider performs applications translation in addition to media, signalling and communications protocol translation. This gateway could perform document format conversion for different word processors or mail systems. Six of the seven layers are affected. Detailed knowledge of different manufacturers systems is needed and would require specialized departments by the MAN operator to support the applications layer. Extensive standardization, both domestic and international, is required to make a wide variety of systems accessible by a manageably small number of gateways.



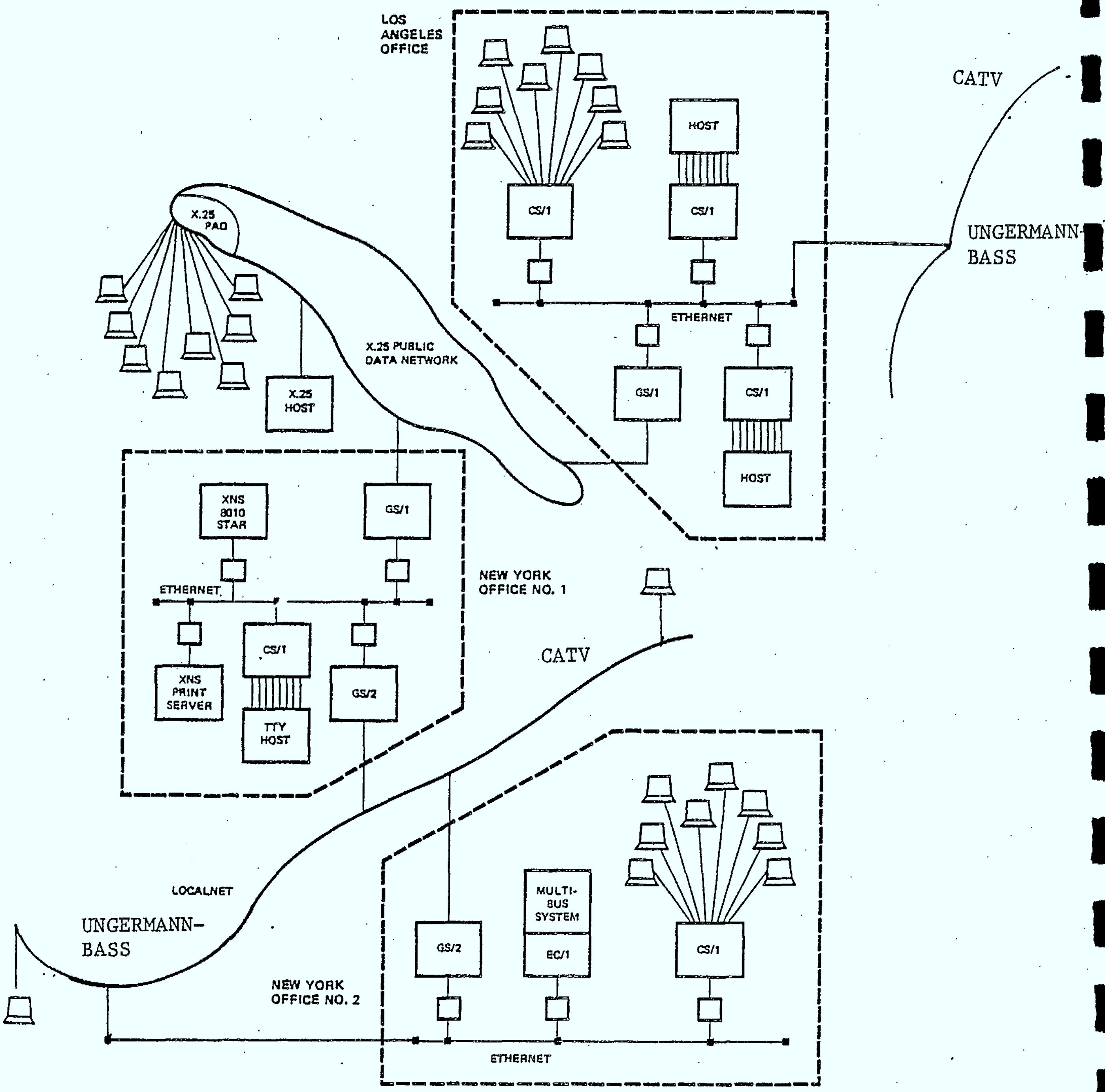
APPLICATION TRANSLATION GATEWAY
(Source: Bridge Communications Inc.)

As the need for internetworking emerges, manufacturers are providing some of the more commonly needed protocol converters, bridges and gateways. Bridge Communications Inc., of Cupertino, California, develop products which connect to and bridge between industry standard devices and networks. Bridge offer a product called the Gateway Server/1 (GS/1), which connects an XNS Ethernet network to an X.25 network and provides virtual connection and interconnection services.

The Gateway Server/2 connects an XNS Ethernet network to a Sytek Local Net broadband network thus enabling virtual connection and interconnection services between the devices on either network. Using Bridge Communications' Gateway Server/2, an Ethernet system could be connected to an institutional CATV network which has a Sytek and Ungermann-Bass local area network residing on the system. Any terminal operating on the Ungermann-Bass Network could communicate with any Sytek terminal by using an Ethernet bus as the common LAN.

The same type of intercommunications can be achieved by means of an X.25 gateway rather than by an Ethernet bus. This type of environment makes it possible to use a CATV broadband network to allow several different LANs to communicate with one another. The cable company offers the internetworking medium.

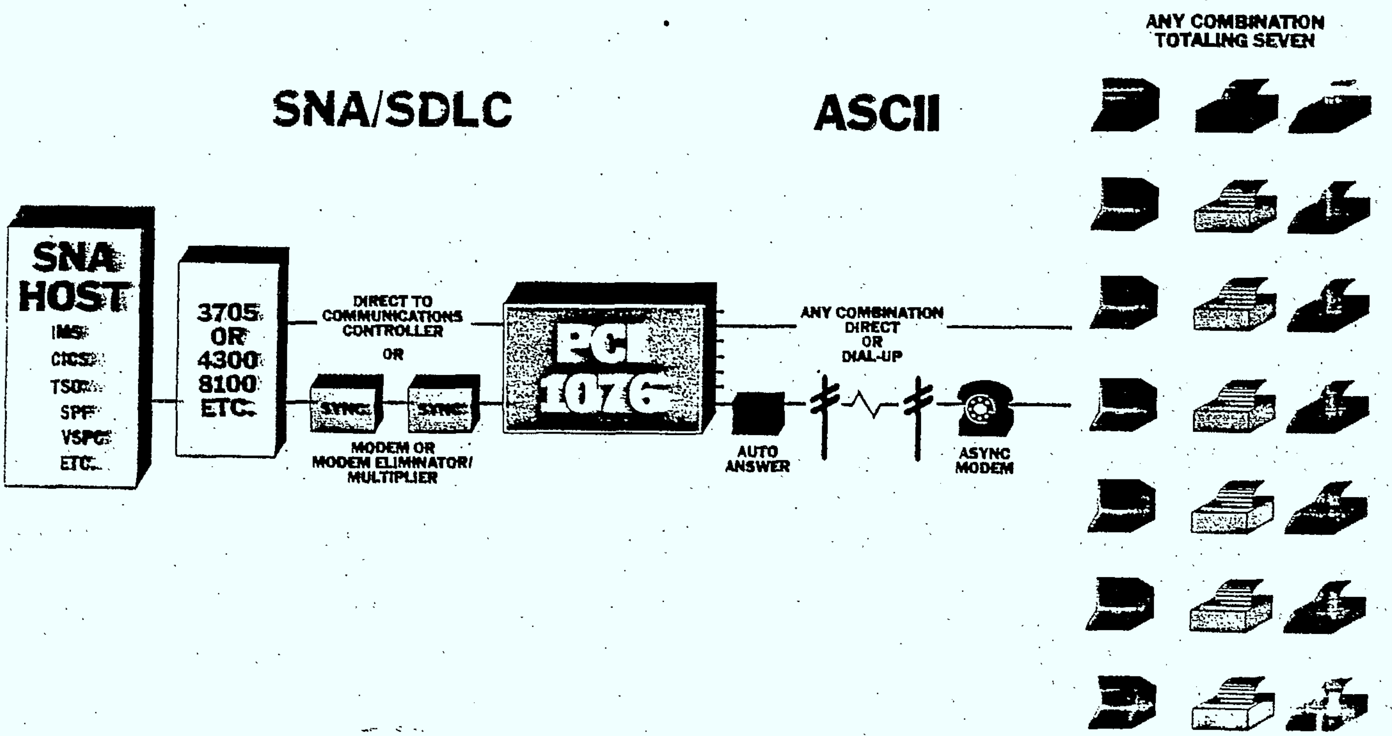
Shown on the next page is an example of a complete integrated environment.



A COMPLETE INTEGRATED ENVIRONMENT
(Source: Bridge Communications Inc.)

Another bridge alternative for CATV systems is the Hughes microwave distribution system for the extension of CATV networks. Hughes provide an AML/CATV interface unit that takes the microwave signals and makes them compatible for CATV. The microwave systems transmit the full bandwidth of the CATV cable. This technique further extends cable bridge and gateway possibilities.

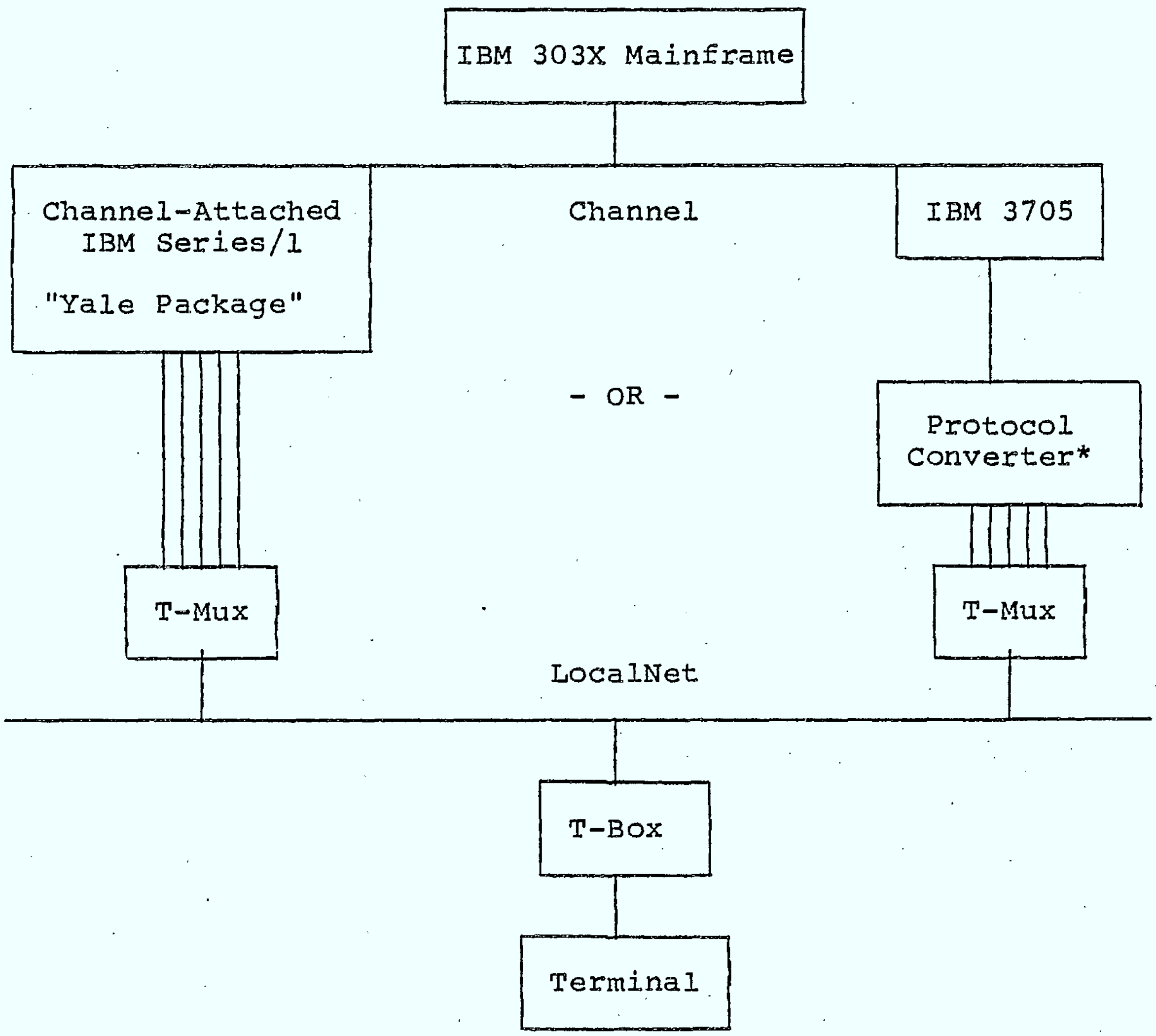
Protocol converters are offered by various manufacturers. An example is shown below, where a system using IBM SNA/SDLC protocol can communicate to the outside world of ASCII terminals.



IBM SNA/SDLC PROTOCOL CONVERTERS

Sytek provide an example of an IBM 3270 emulation on their LocalNet. Communications can be established between a terminal on their local area network and an IBM mainframe computer as shown on the next page.

CASE STUDY: IBM 3270 EMULATION



1. Any terminal on the LocalNet may call an emulated 3270 port.

2. The Rotary call feature of the T-Muxes allows port contention for available 3270 ports.

* - Protocol converters by Datastream, PCI, others. (Yale Package marketed by IBM)

In addition, Sytek's LocalNet System 40 communications processor provides bus control and status circuits needed to tie IBM mainframe input/output channels to (75 ohm) CATV networks.

Some other companies which provide protocol converters are listed below:

COMMETRICS LTD:

- SNA to BSC; Sync to Async
- Teletype and DEC VT100 Terminal use on same host

PERLE SYSTEMS LTD:

- Async to BSC; BSC or SDLC to ASCII
- Async to Sync

GANDALF:

- 3270 Protocol Emulators, ASCII Terminals
- MUXs for 3270 devices on coax (32 max)

PRENTICE:

- Statistical MUX's - RS-232-C

PROTOCOL COMPUTERS INC. (PCI):

- SNA/SDLC to ASCII (RS-232-C)

LOCAL DATA:

- Async to BSC batch emulator
- Async to BSC interactive emulator

By means of these facilities (a CATV coax facility acting as the spine for a multitude of baseband LANs), a cable system can provide a multitude of bridges or gateways to users wishing to communicate on a larger geographical area.

Network interconnection promises to be a key business opportunity that can provide cable operators with an opportunity to offer new and clearly needed data communications services in return for future additional revenues.

5. CABLE DATA MODULATORS/DEMODULATORS (RF MODEMS)

Integrated within the Local Interface Unit (LIU) of most broadband Local Area Networks (LANs) are the modem circuits that perform the function of modulating and demodulating the outgoing and incoming data signals. These integrated modems are special purpose, typically operating in a packet-mode and capable of being switched on and off rapidly. They transmit and receive in the VHF radio frequency bands and generally occupy broader bandwidth channels than do twisted pair (telephony) modems. Similar special purpose RF modems are found integrated into the LIUs used in telemetry, teletext and videotex applications within CATV networks.

In the few examples, where a special purpose RF modem is offered as a physically separate unit, it will have limited stand-alone utility. Such modems are made for one purpose only and intended to be used in conjunction with a particular LIU. Ungermann-Bass offer such a modem equipped with a special Ethernet connector.

In contrast to these, a growing family of physically and functionally standalone RF modems are of particular interest to the cable industry. The units can be used to provide dedicated point-to-point data communications services via coaxial cable networks, which may be simple passive bus structures or complex repeatered tree/bus structures as used in CATV systems. A single run of coaxial cable is commonly used in a split (up/down) frequency plan. Modems are, however, sometimes designed especially for use in dual-cable networks with no headend translators.

Single cable tree/bus networks require a translator at the headend in order to provide point-to-point communications paths for a pair of outlying subscribers. Two RF channels are then needed on the cable in order for data to be transmitted from subscriber A to subscriber B. Should subscriber B's modem send back a continuous stream of acknowledgement packets (full-duplex mode), one more upstream and one more downstream channel would be required for a total of four RF channels.

Most manufacturers' specifications indicate the amount of spectrum occupied by the RF data signal, and suggest a suitable guardband between adjacent channels. The result is a recommendation for channel spacing. All references to channel bandwidth in the tables of this report include guardbands. Note, however, that where data are to be transmitted on a channel that is adjacent to and below a regular video channel, a guardband of at least 200 KHz is recommended. Some TV sets do not have adequate adjacent lower sound traps and data carriers riding on the channel edge could cause interference.

The feature comparison tables (D1, D2 & D3) found in Appendix 3, list a representative sample of standalone RF modems from a dozen North American sources. In the notes that follow, the distinguishing features of these modems are discussed.

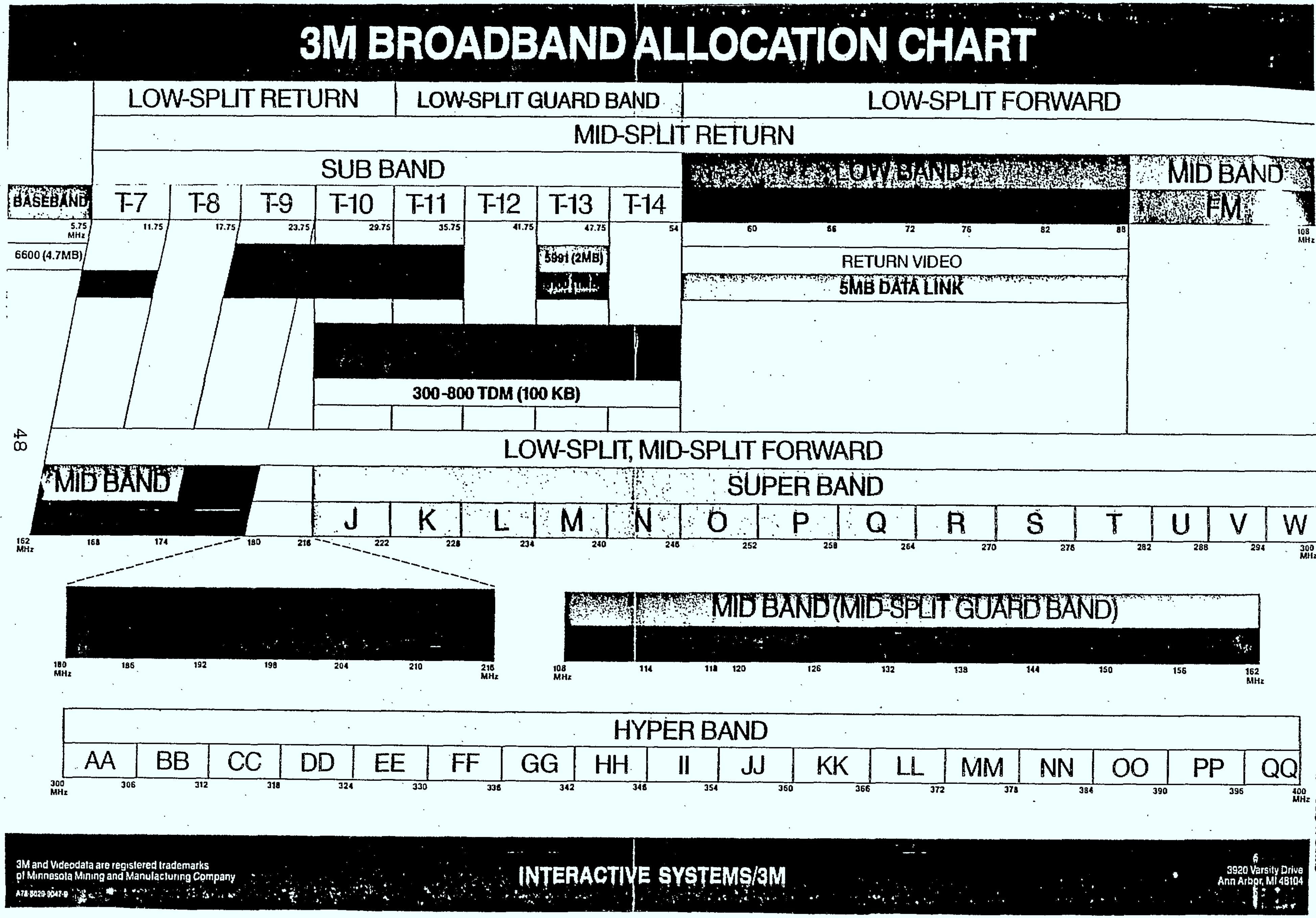
Both Phasecom and Scientific Atlanta (SA) specify a TV guardband. Phasecom's translator, called a Transverter, is a single channel unit which provides a 300 KHz guardband on the edge of an adjacent TV channel. Model 401 can support 53 full-duplex channels.

SA Model 6402 occupies 750 KHz per data channel, which is equivalent to 4 full-duplex channels within a 6 MHz bandwidth. If adjacent video is used, they recommend dropping two data channels, one on each edge of the data channel providing a 750 KHz guardband on either side.

If a cable system is using a standard mid-split design for data services, the available forward spectrum is from 160 MHz up to 300, 400 or 500 MHz. The return or upstream bandwidth allocation is from 5 to 108 MHz. By using a 156.25 MHz translator, T7 would convert to H, the beginning of the downstream bandwidth, T9 to 7, T10 to 8 and so on. Mid-split trunks do not provide equal upstream and downstream channel usage.

Systems that use a super-split or high-split design have a more symetrical frequency split. Downstream signals are carried in the frequency bands above 200 MHz. Upstream transmissions are in the band between 5 and 140 MHz. A 192.25 MHz translator is used, converting T7 to channel 11, T9 to 13, T10 to J and so on. The Translator Requirements OFFSET column shows the frequency translation needed at the headend for modem pair operation. The "avail Y/N? model" column shows if a translator is manufactured by the modem maker and if so, lists the model number.

The 3M Chart on the next page shows the different frequency channel combinations for two commonly used channel offsets: 156.25 MHz and 192.25 MHz. The IEEE 802 sub-committee recommends the 192.25 MHz translation.

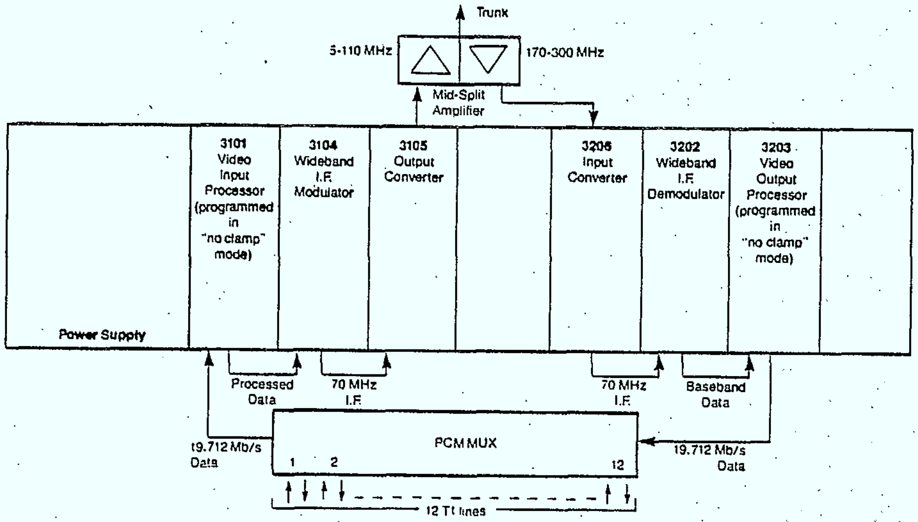


CABLE DATA COMMUNICATIONS

RF Modems

5.1 CATEL

Catel Series 2000 and 3000 modems employ a 70 MHz, IF broadband system, that uses modular plug-in units to achieve frequency conversion, fibre optic link interfaces, high speed data buses and T1 multiplexers. Shown below is an example of a 19 Mbps PCM Modem for telephony using a 3000 series system.

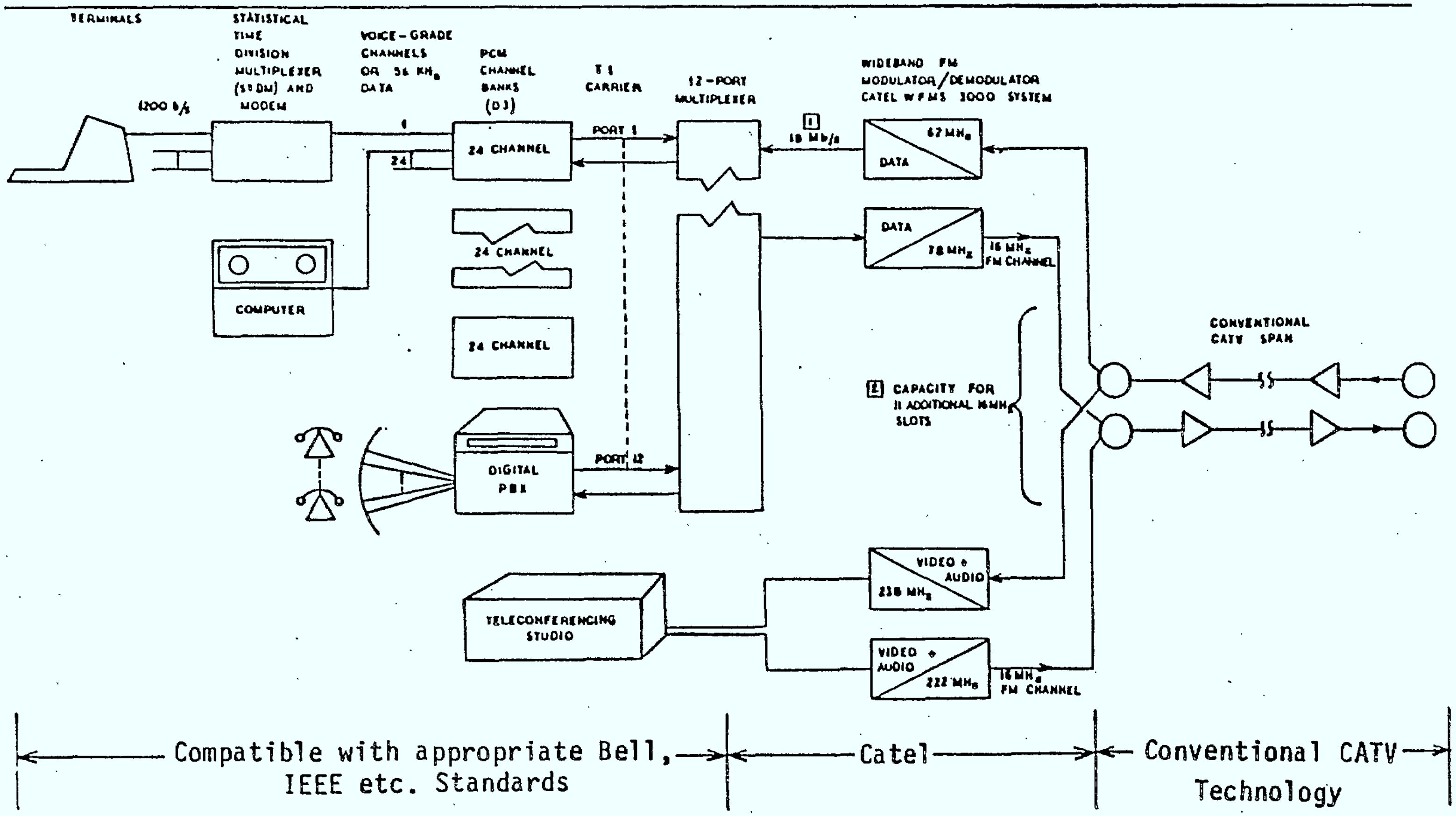


3000 SERIES 19 Mbps PCM Modem

The CATEL 3000 Series modems can be combined with a twelve-port telephony multiplexer (VIDAR DM12A) to handle twelve T1 lines in a full-duplex mode on one FM channel. Maximum capacity within a mid-split system is 6 full-duplex modes (i.e. 72 T1 lines or 1,728 voice channels). Maximum capacity on dual 50 to 300 MHz cables is 15 full-duplex channels (i.e. 180 T1 lines or 4,320 voice channels).

Catel and TRW Video have also experimented with a high capacity PCM multiplexing voice/data system using two wideband FM channels. The 288 channels were tested using a TRW Vidar PM-12A PCM MUX and two Catel WFMS-3000. The broadband network used in the TRW video tests is shown on the next page.

The input/output modules in the units can be changed to suit the cable system's frequency allocations. Catel also provide a lower-cost modem (Model OM 2100S) which uses a narrower channel bandwidth at a reduced efficiency.



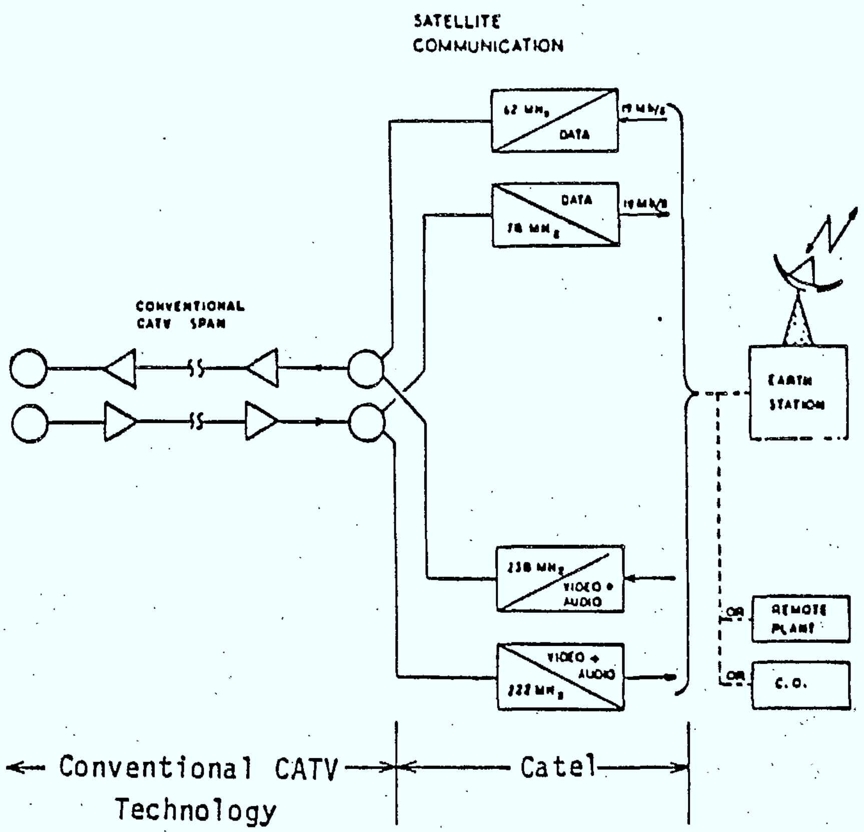
NOTES:

1) 18.528 Mb/s, 4-LEVEL CODED FOR 3 BIT/HERTZ EFFICIENCY

2) BASED ON 50 TO 270 MHz BANDWIDTH AMPLIFIER CASCADE. REPEATER AMPLIFIERS TYPICALLY SPACED 3200 FEET ON ¾" GAS INJECTED FOAM DIELECTRIC COAX.

TYPICAL BROADBAND NETWORK APPLICATION USING OFF THE SHELF HARDWARE

cont'd on next page



TYPICAL BROADBAND NETWORK APPLICATION USING OFF THE SHELF HARDWARE

5.2 C-COR

C-Cor, which manufacture broadband data CATV amplifiers have recently purchased the CableBus Labs at Beaverton, Oregon. CableBus Labs develop and engineer RF and digital equipment with applications in broadband coaxial cable communications systems. Products recently developed include a family of voice, asynchronous and syncronous point-to-point modems. C-Cor's modems are capable of receiving data carriers from a selection of translation frequencies by the use of single block converters placed at the headend.

C-Cor is also a major supplier of amplifiers and other components to Wang Laboratories' WangNet.

5.3 COMPUTROL

Computrol offers a dual cable modem developed by the Mitre Corporation. The Mitre modem is widely used by the U.S. Government. Computrol manufactures the modems as an Original Equipment Manufacturer (OEM) and provides a general interface (TTL) for customer addition of hardware interfaces. These modems have separate transmit and receive modules to suit a customer's particular configuration.

A CATV cable modem is under development that will offer a 4 Mbps data rate within a 6 MHz channel, using continuous-phase frequency shift keying modulation techniques.

5.4 COMTECH

Comtech Data Corporation specializes in high speed modems for satellite, terrestrial microwave, telephone and CATV applications. Comtech have changed their design philosophy from low cost, frequency agile modems to bandwidth efficent (higher cost), interchangeable (not frequency agile) modems with independent transmit and receive frequency selection.

In the Comtech Series 500 modems, they have changed their design from FSK modulation to QPSK and provided channel interchangeability by the use of plug-in input/output converter modules using fixed IF frequencies. This eliminates the need for a headend translator for point-to-point communications between one user terminal and the headend. Comtech claim that headend translators add additional noise and envelope delay distortion and that they weaken the system by offering a single critical point of failure.

5.5 E-COM

E-Com offer two types of modem design, a cost-effective model TRM-202 and a high-speed, bandwidth efficient, model TRM-159. The TRM-159 can be configured for coaxial applications in the band 5 MHz to 350 MHz, IF at 70 MHz and data above voice or for video at 2-12 MHz. The TRM-159 modulations scheme, a four-level double-sideband suppressed carrier has spectral characteristics that are dependent on the bit rate used. For example, the -3 dB points on the spectrum occur at the bit rate (BR) divided by 6 (BR/6). The -50 dB points are at BR/2. The lower the bit rate, the smaller the channel bandwidth. The receiver characteristics are also a function of the bit rate.

5.6 GANDALF

Gandalf, a Canadian manufacturer of data communication products is offering the LDS 500 Series of modems operating on a CATV mid-split system. These modems appear transparent to the user. Headend modem transmission is accomplished at frequencies of 156 MHz to 300 MHz while remote modems use frequencies from 5 to 112 MHz. A mid-range "guardband" of 112 MHZ to 156 MHz remains unassigned and acts as a buffer between forward and reverse channels.

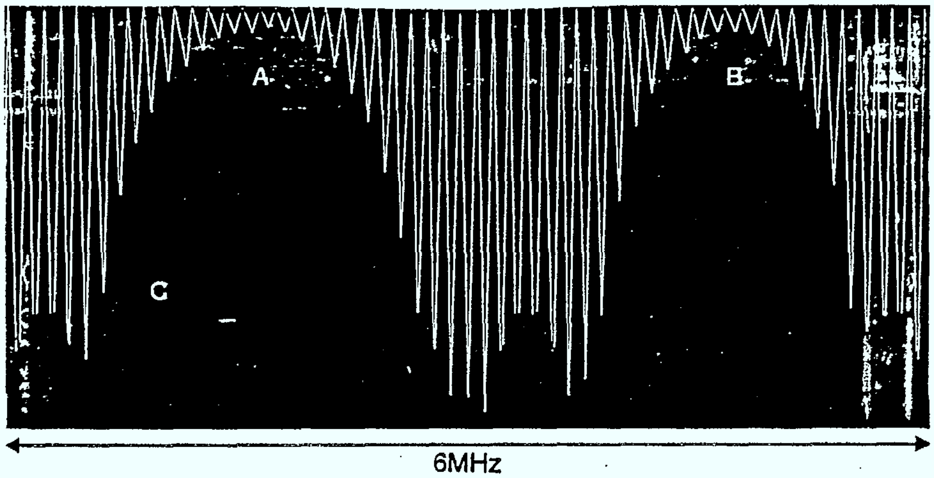
The LDS 500 Series encompasses several models, both synchronous and asychronous, ranging in speed from 96 Kbps to 100 Kbps. These units will be primarily used in conjunction with Gandalf's PACXNET, a local area network involving diverse communications technologies including broadband coaxial cable, packet switching network, IBM gateways and data over voice techniques.

5.7 PHASECOM

Phasecom's modem (Model 401) provides frequency agility within the passband of a CATV channel. Modems are used with the Phasecom Series 4000 transverters, a single channel translator. Either 156.25 MHz or 192.25 MHz offsets are available. The transverter provides a 300 KHz guardband at each edge of the TV channel to ensure compatibility with video signals on the same cable. The transverters have been designed for minimum intermodulation distortion of as many as 250 signals within one TV channel (-50 dB maximum for 250 carriers at 40 dbmv each). Phasecom also have available a T1 modem (Model 415) and a voice modem (Model 460). Phasecom's data products are marketed through General Instrument, Hatboro, Pennsylvania.

5.8 SCIENTIFIC ATLANTA

Scientific Atlanta's T1 data modem (Model 6402) uses a QASK-16 modulation technique that occupies only 750 KHz of spectrum. The modem is frequency agile across the entire range of the cable spectrum in 250 KHz steps and is compatible with HRC and IRC frequency allocation schemes. There are no fixed translation constraints. Frequency assignments are stored in a non-erasable memory and can be reprogrammed by a portable hand-held programmer that connects to the rear of the modem. Eight data channels can occupy one CATV channel as shown below.

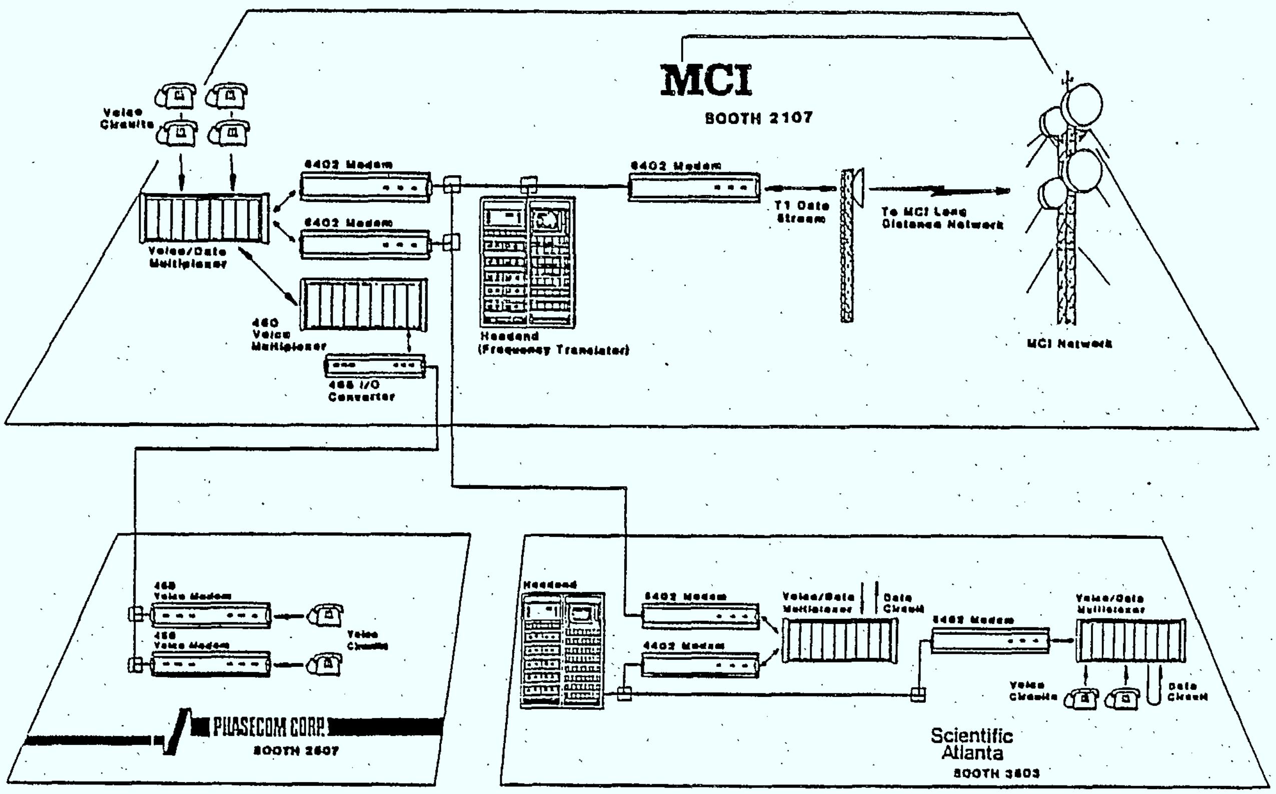


One video channel, comprised of a video carrier and an audio subcarrier, occupies 6 MHz of broadband spectrum. In comparison, as many as eight data channels can be allocated to the same 6 MHz of bandwidth. (Contact Scientific-Atlanta's applications engineering department about guard band requirements in operations using adjacent video channels.)

The data channels marked 'X' are removed for adjacent video operation.

At the 1983 NCTA Trade Show in Houston, Texas, MCI Communications demonstrated their CABLEPHONE concept. CABLEPHONE is a regional voice network, which uses cable TV coaxial connections. Scientific Atlanta's T1 modem (Model 6402) and Phasecom's voice modems (Model 460) were used in the demonstration. Calls were originated both at the MCI booth and the Phasecom booth, fed via a voice/data multiplexer into the SA modem, and then via a microwave connection to the MCI long-distance network (see diagram on the following page).

— MCI CABLEPHONE BOOTH AT NCTA



5.9 3M/IS

3M/IS offers a wide selection of data modems with over 24 models and accompanying accessories. The modem chart lists the basic series of modems, but does not list each modem by model number specifically.

One series of modems that is not covered by the modem charts, or by the data-enhanced CATV networks charts, is the 720 Series modems. These provide a low cost, easily interfaced and programmed, distribution data acquisition/control system. The 720 Series remote modems operate in conjunction with a Model 921 headend RF modem which interfaces to a host processor (RS-232-C or current loop). Communications between the headend and remote modems is via a serial full-duplex 1200 bps channel.

A lower cost Model 730 can be daisy-chained or driven by a 720. Up to 255 separately addressable modems can be used on one data channel. A CATV channel pair can support 37 full-duplex data channels. Applications include distributed monitoring and control, fire and security systems, facilities management, signalling systems or any other data control system. 3M also provides a voice modem (Model 520) for use on CATV networks (point-to-point). Chart D2 of Appendix 3 contains the parameters of this voice modem for comparison.

5.10 UNGERMANN-BASS

Ungermann-Bass, who have acquired the Amdax Corporation, are offering modems that were made by Amdax (Model Series 640 and 670). These are RS-232-C and V.35 compatible. Ungermann-Bass also provide an audio modem (Model 722). Frequency translation is accomplished by choosing either a 3 channel (Model 603) or 9 channel translator (Model 609). A translator switch-over unit (Model 615) has been designed to interface two translators and provides fault detection and automatic switching following loss of the pilot carrier, loss of phase-locking or power failure.

5.11 WANG COMMUNICATIONS

Wang Communications, Inc. a wholly-owned subsidiary of Wang Laboratories, has designed the DX9600 Series modems, with the cable operator in mind. Wang not only provide the hardware, but also offer support services such as, hardware maintenance, system analysis, user education and other support programs.

Wang's 9600 Series modems are frequency agile and tamper-resistant for security purposes. The modems require a Master Oscillator for a system with translators and contain a highly accurate frequency reference to maintain low frequency drift in the system. Visual alarms and external alarms warn the operator of a Master Oscillator failure. The Translator is phase-locked to the Master Oscillator. The standard translator offset is 156.25 MHz; but other frequency translation offsets can be used.

A pilot frequency, located 325 KHz above the bottom of each downstream channel (provided by the translator), locks all modems to the system pilot guaranteeing low drift for transmit and receive frequencies. Independent transmit and receive clocks accommodate differences in the upstream and downstream data rates.

The modems occupy a narrow bandwidth of 25 KHz for each data channel and can switch frequency to another data channel when a loop-back test is performed. This feature creates a dedicated point-to-point link between the modems in the loop-back configuration without affecting other multipoint modem operations.

Wang have a different price for the end-user ($1250) as compared to the CATV operator ($1400) to reflect the additional maintenance service provided to the cable operator.

The other Wang modems listed are used with WangNet, and are not highly suited for a CATV environment. The pilot frequency chosen for FFM 64449 and FAM 96232 modems resides at 48 MHz. These modems are for special purpose applications. Cable Systems Pacific (MSO-Rogers) in Portland, Oregon, is being used as the Beta site for Wang.

5.12 ZETA LABORATORIES, INC.

Zeta's modem products can be purchased with standard asynchronous data formats. These modems are frequency agile within the passband of a CATV channel. Modems can be ordered with options such as synchronous data transmission, voice data modulation, DC input power and customized frequency assignments. ZPSK is a proprietary modulation technique of Zeta Laboratories Inc.

6. DATA-ENHANCED CATV NETWORKS

A ready comparison can be drawn between the structure of a dedicated coaxial cable local area data network and that of a regular entertainment CATV network carrying additional data signals. The transmission media is the same. The major differences are due to the larger scale rambling tree structure of the CATV network and the fact that most such networks offer only one-way transmission to (but not from) the outlying subscriber.

The accompanying illustration shows CATV data signals arriving at and departing from the subscriber's premises via a specialized unit labelled "Local Interface Unit (LIU)". This is the same term used previously when referring to Local Area Networks (LAN's). The LIU acts as a 'smart' MODulator/DEModulator (MODEM). For one-way CATV systems, the LIU is simply a smart DEModulator. The smartness usually consists of its being addressable from the cable headend.

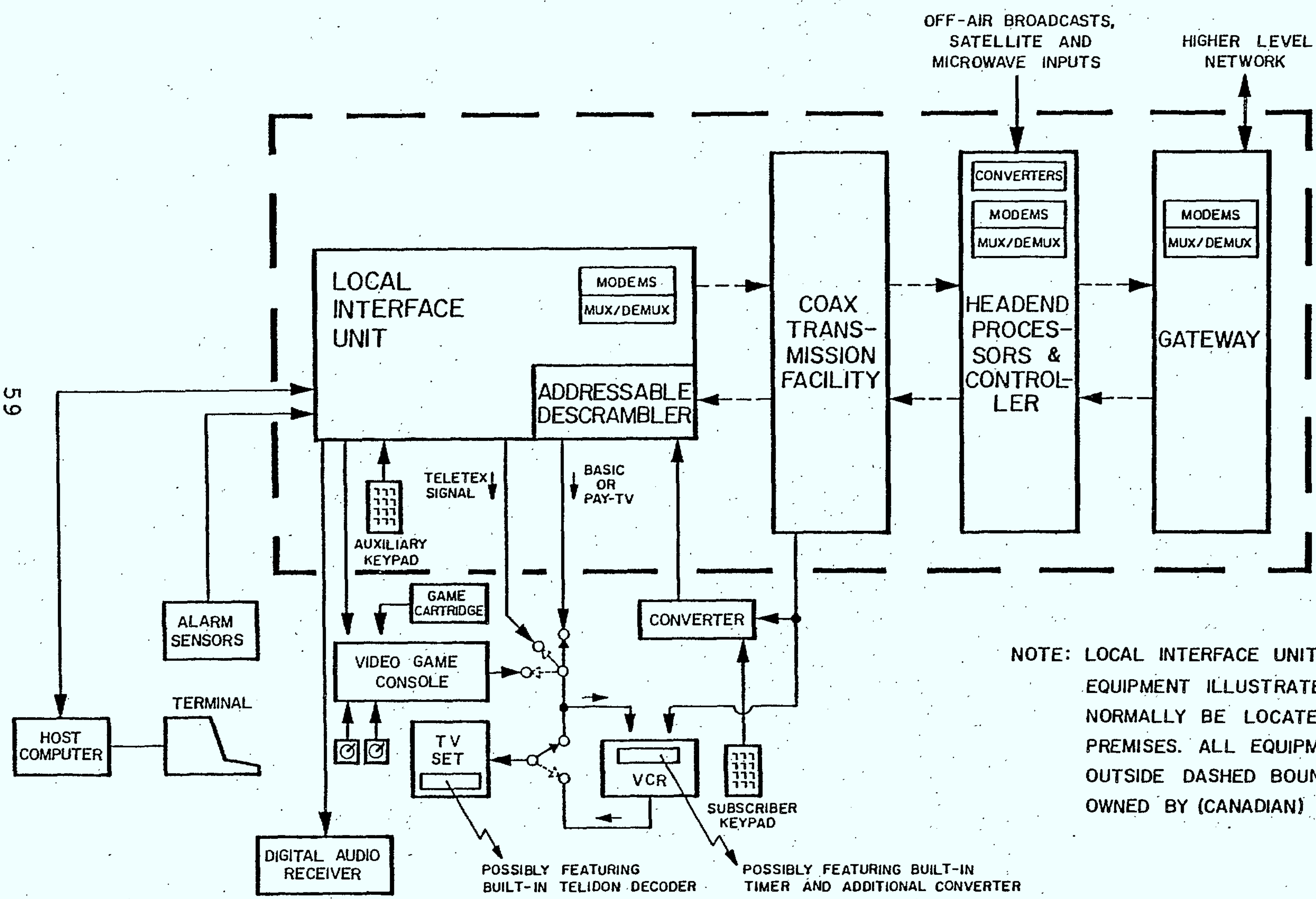
A secondary difference is that the CATV network can be accessed by a wide population of subscribers who may not be authorized users of all the specialized data services. To permit absolute control of access to the new data services, the LIU would normally be owned by the cable system operator. Addressable pay-TV descramblers fall into this LIU category.

Exceptions to the LIU interface must however be expected. A case in point is the outright ownership by a subscriber of a special television set equipped with a built-in Teletex decoder. Public ownership of such equipment implies strongly that the Teletex service being accessed is advertiser-supported and available to all cable subscribers at no additional charge.

Cable industry consultant, Dr. Israel (Sruki) Switzer, has pointed out that, despite the argument that operator ownership of descramblers is necessary to ensure service exclusivity, a case can be made for subscriber ownership given a suitably high level of pay signal encoding. By this is meant a near military level of signal encryption which requires parallel delivery of decryption authorization keys to decypher. Such keys would consist of specialized data unique to each subscriber. None-the-less, at least until such military security systems appear on the consumer market, most non-advertiser-supported new data services can be expected to deliver their signals into the home via a Local Interface Unit owned by the cable operator.

Appendices 4 and 5 list a representative sample of data enhanced CATV systems, some commercially available and some under development. They illustrate examples of both controlled access via a cable operator's LIU and of open access exhibition which might be advertiser-supported. Commercially available military type encryption systems are not yet in evidence.

DATA-ENHANCED CATV NETWORK



NOTE: LOCAL INTERFACE UNIT AND ASSOCIATED EQUIPMENT ILLUSTRATED BELOW IT WILL NORMALLY BE LOCATED ON SUBSCRIBER'S PREMISES. ALL EQUIPMENT SHOWN OUTSIDE DASHED BOUNDARY MAY BE OWNED BY (CANADIAN) CABLE SUBSCRIBER.

In examining the presence of data signals on regular CATV entertainment networks, it is helpful to separate applications in which the data are necessary for the exhibition of associated television video and audio programs from applications in which the data signals have an independent purpose. The descriptive "non-programming" has been used to convey this distinction by the CRTC and has gained some currency within the broadcasting industry.

A further subdivision of these non-programming applications can be made to distinguish between systems intended for one-way and two-way cable networks. This distinction is significant because the majority of Canadian CATV network feeders segments are constructed for one-way, downstream, delivery only.

Appendix 4 begins with a tabular survey of systems intended for one-way non-programming applications. The industry generic title for such services is TELETEXT. It includes systems that provide closed captioning (for the hearing impaired) and systems designed especially for the downloading of games and other software to home computers. Other more general purpose Teletext systems permit both captioning and software downloading along with the delivery of text and graphics.

The addition of upstream data communications channels, carried in the sub-band (5 MHz to 50 MHz) of an entertainment CATV network, makes two-way services possible. Two classes of two-way cable service can then be distinguished: VIDEOTEX service and TELEMETRY service. They differ in having distinct traffic patterns and data rate requirements, as follows:

	VIDEOTEX	**TELEMETRY**
TYPICAL DOWNSTREAM TRAFFIC	High speed, possibly encrypted, addressed to individual home. Long sequences of packets commonly forming single message.	Low throughput into individual home, using polling or scanning but not necessarily addressing. Two-level network hierarchies are common.
TYPICAL UPSTREAM TRAFFIC	Sporadic packets of about 50 bytes are common containing the originating address plus service request. Contention protocol is popular.	Continuous cyclical incasting of status information. Shorter packets are possible since status options are usually limited.

Videotex is a refined Teletext service in which subscriber requests can be sent to the cable headend. This allows individual demands for rarely needed information to be recognized. The wanted information may then be broadcast or narrow-cast. In the absence of requests, a Videotex system may revert to broadcasting a Teletext service to satisfy the average subscriber. Videotex systems further open the door to transactional services such as electronic remote banking, catalog shopping, travel reservation placement and the booking of theatre tickets.

Telemetery service consists of continuous central monitoring and remote control of such subscriber units as intrusion alarms, combustion alarms, medic alerts, utility meters, energy management systems and audience response devices. The pattern of data communications for such services is steadier and the data signalling speeds needed are generally much lower than those necessary for Videotex services.

Unlike the situation for one-way data service (Teletext), the provision of a data communications channel from the subscriber to the cable headend (incasting) appears to be exciting considerable regulatory attention, especially in the United States. Teletext transmission is usually classified as a form of broadcasting. But Videotex and Telemetry transmissions are more difficult to classify. The two-way nature of these services has raised the question of common carrier status for cable operating companies.

One of the problems with common carrier classification is in the design and control of the two-way system's local interface unit (LIU). For Videotex and Telemetry service, this is usually located within the home and provides channels only for a limited set of services. It does not in general offer third party access to spare up and downstream channels. Were a cable operator to be obliged to offer channel access to any third party, then it would seem logical to have available a suitably general purpose channel interface. Without such an arrangement, interconnecting parties would have little alternative but to splice on their own LIU using coaxial splitters and directional couplers. A proliferation of LIU's of various designs interconnected in this manner would raise serious network management and transmission integrity questions.

Appendix 4 contains comparative charts of ten Teletext systems, four Videotex systems and eight Telemetry systems currently under development or in commercial production for CATV networks. Some standardization of Teletext service is apparent and attributable to the work of the various committees responsible for the drafting of a North American Broadcast Teletext Standard (NABTS). Little or no standardization trends are noticeable in two-way system evolution although packet contention, also called statistical multiplexing, is the only reported upstream channel assignment procedure for Videotex systems.

7. TELETEXT SYSTEMS

Part I of Appendix 4 contains a chart listing ten systems intended for one-way non-programming applications. The industry generic title for such services is Teletext. It includes closed captioning systems and systems designed especially for the downloading of software (principally games) to home computers. Other more general purpose systems permit the delivery of alphanumeric text and alphamosaic and/or alphageometric graphics.

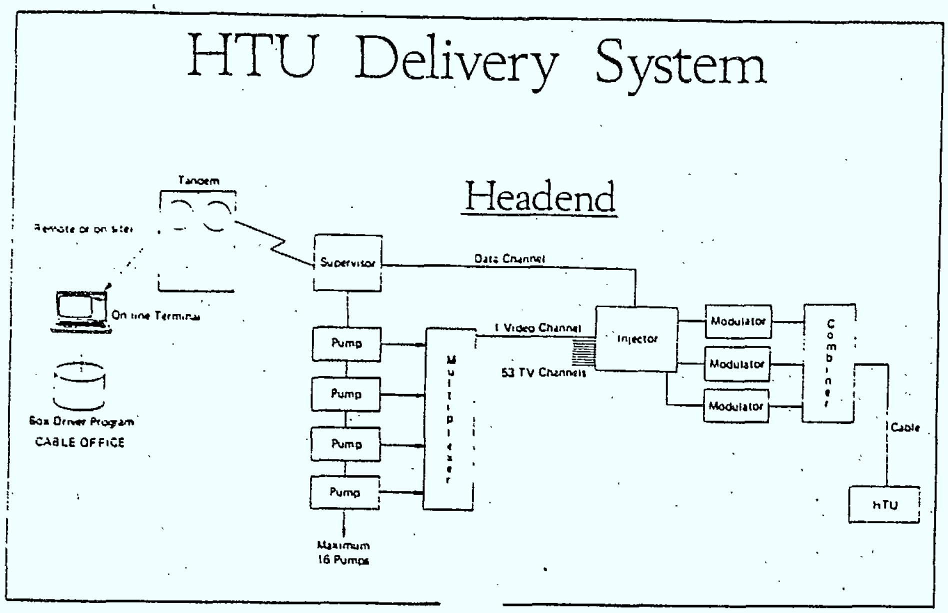
Teletext services operate by broadcasting data signals. The data are either contained within the Vertical Blanking Interval (VBI) of a television video signal or given a full dedicated (6 MHz) channel. The latter approach is practical on CATV systems where the required channel bandwidth is readily available.

7.1 CABLEDATA: HTU DELIVERY SYSTEM

Cabledata of Sacramento, California, was founded in 1965 and provides order entry, scheduling, routing, dispatching, billing inquiry, payment processing, collection, refunds, addressing and reporting services to just under one thousand operating companies across the US, representing 13 million cable subscribers. Cabledata's DDP billing and accounting system has been interfaced to a variety of proprietary pay-TV addressing systems including Blonder-Tongue, Oak, Jerrold, Zenith and Tocom.

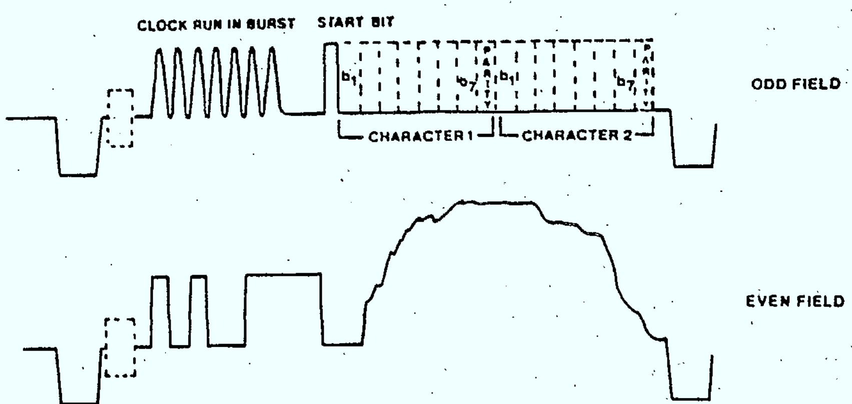
The Home Terminal Unit (HTU) data delivery system is a new product designed to combine Cabledata's own pay-TV addressing system with the ability to download billing status and other data to individual customer's premises. This enables subscribers to determine how much they owe via their own TV screens, to pay the bill the normal way and to see their credit acknowledged. The downloaded information includes 16-colour alphamosaic graphics. Each HTU contains 256 bits of non-volatile programmable memory able to store key items of information such as the box identification number, random descrambling algorithm and a list of authorized service tiers. It also contains a 16K RAM volatile memory to accept the regularly updated status information. The data rate for the VBI teletext signals is 3 Mbps at the same levels used within NABTS.

The accompanying block diagram of Cabledata's HTU system shows how the addressing data are separated from the graphic pages data at the headend. Separate microcomputers, each labelled 'Pump', are used to store and cycle up to 120 graphic pages each of approximately 2 Kbytes with a cycle time of 20 seconds. The multiplexer accepts the cycled pages from up to 16 Pumps and delivers a single output equivalent to one TV channel. This multiplexer output plus the addressing data are then inserted into the appropriate number of outgoing television channels in the 'Injector'.



7.2 EEG: CAPTIONING/TEXT SYSTEM

EEG of Farmingdale, New Jersey was founded in 1969 to design and manufacture signal processing, control and special test equipment for broadcasters, cable operators and production studios. It has become a major supplier of encoders and decoders for the FCC approved Line-21 VBI Closed Captioning system which is used in the US as an aid for hearing impaired TV viewers.



LINE 21 WAVEFORMS

The video signal conforms to the Standard Synchronizing Waveform for Colour Transmission given in Sub-part E, Part 73 of the FCC Rules & Regulations. The composite data signal contained within the active portion of Line-21 consists of a 7 cycle sine-wave clock run-in burst, a start bit and 16 bits of data.

These 16 bits consist of two 8-bit alphanumeric characters formulated according to the USA Standard Code for Information Exchange (USAASCII; X3.4-1967) with odd parity. The clock rate of 503.5 KHz is 32 times the horizontal scanning rate. The clock burst and data packets are 50 IRE units peak-to-peak and are filtered to a "2-T" response.

The encoding of captions into Line-21 of an uncaptioned video program can be done with an EEG SIMPLE ENCODER such as the EEG Model EN210. The Model EN230 SMART ENCODER is used to insert additional text data into Line-21 of a video signal which may already have some captioning data present. The smart encoder can be operated so as not to disturb the original data.

An addressable decoder (Model DE 201), to be used in conjunction with a new encoder (Model EN 232), was announced in April 1983 for private NTSC network communications. In this case the data line is selectable (Line-13 through Line-20) and uses the same data format described above. The decoder has an RS-232 output and is expected to be available in September 1983 ($1,500 US approx).

Also forecast for September 1983 availability is a Teletext Video Data Bridge (Model TE-510) that tranfers data from one video signal to another. This equipment will be compatible with the NABTS standard ($8,200 US approx). Compatiblity with other systems will be optional.

7.3 THE GAMES NETWORK

The Games Network (TGN) was incorporated in March 1982 in Los Angeles, California, and is expected to begin its national rollout to 41,000 cable subscribers in Southern California in the 4th quarter of 1983. Rogers' Huntington Beach, Southeast Cities and La Mirada systems could be the first to offer the video games service on a subscription basis. The service may also be extended to the Rogers' systems in Portland, Oregon and Minneapolis, Minnesota. Also under negotiation are contracts with Group W Cable for its systems in Fullerton, Newport Beach and Seal Beach, California. In Europe, SelectTV is scheduled to start tests in March 1983 in Milton Keynes, England, with possible interconnection to other systems in England and Wales.

TGN's video games service is based on the Apple computer and is expected to begin with a recycling library of between 15 and 20 games. The system uses 2 MHz of bandwidth and an instantaneous data rate of 2 Mbps. Launch of the new service is expected to take place as soon as an improved design for a 64K RAM home computer is completed. The computer is expected to feature a full alphanumeric keypad, 10 special function game-playing keys, and ports for joysticks, printers, disk drives and optical laser disc players.

Further technical details of TGN's addressable system are not yet publicly available. Piracy security is clearly based in part upon the proprietary modulation technique as is the case with other games downloading offerings.

7.4 JERROLD/MATTEL: PLAYCABLE

Since 1982, a joint venture by the Jerrold Division of General Instrument Corporation of Hatboro, Pennsylvania, and the Mattel Corporation has resulted in the installation of Playcable computer games downloading systems into approximately 20 cable systems throughout the US and Canada. The subscribing user population for these systems is currently estimated at 10,000 households, or about 5,000 subscribers per cable system.

This system is often contrasted with VBI Teletext as an alternative, lower-cost delivery technology. The table in Appendix 4 shows that the spectral efficiency of the Playcable FM downloading transmission channel is only 0.035 bps/Hertz compared to NABTS Teletext's instantaneous efficiency of 0.95 bps/Hertz. However in terms of characters per second, Playcable (at 1,500 characters per second using a single FM channel) compares favourably with a single-VBI-line-per-field Teletext system operating at 1,680 characters per second.

Playcable can use up to 8 parallel FM channels to increase throughput and service selectivity. The Mattel Intellivision home computer costs approximately $200 to produce while the service retails for $12 per month for access to a continuously recycling library of between 15 and 20 games. Subscribers to the service receive a special adaptor to plug into their Intellivision set in place of the set's standard game cartridges. Since individual game cartridges retail for about $30 (Canadian), subscribers could put a value on the library of over $500.

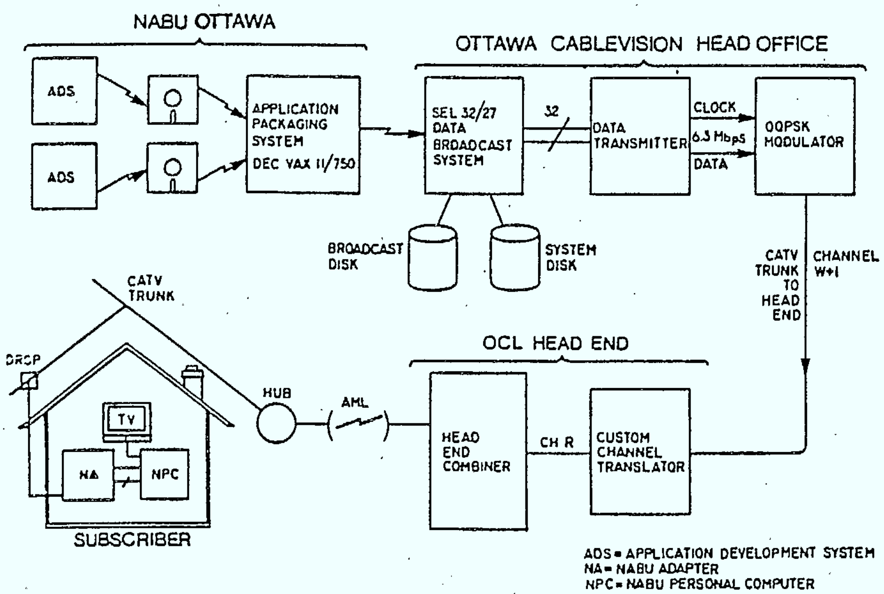
7.5 NABU: THE NABU NETWORK

Ottawa Cablevision is currently offering the facilities of its network (90,000 subscribers) as the beta-site host for the NABU Manufacturing Corporation's computer data and software broadcasting field trial of "The NABU Network". NABU was incorporated in 1981 specifically to enter this particular field. Approximately 100 households and one school are taking part in the present field trial which features, besides games, the downloading of MIT's educational programming language LOGO.

The home terminal is capable of being augmented by the addition of a printer and disk drives to function as a personal computer. Digital Research Incorporated's popular disc operating system CP/M and the scientific applications programming language Pascal are both to be made available via the network for users requiring applications beyond simple computer game levels.

NABU is unique in employing the highest data rate (6.3 Mbps) of any CATV network data downstreaming system. Offset quadrature phase shift keying (OQPSK) modulation is used to achieve this rate on a carrier that is 10 dB lower in power than a conventional cable video carrier. Since the NABU carrier is centered within a standard 6 MHz channel, it is capable of generating composite beat products outside the normal pattern dictated by regular video carrier spacing. The lower carrier power level helps to mitigate the effect of this potential non-linear distortion.

The sketch below illustrates the configuration employed by NABU in the Ottawa Cablevision field trial:



NABU Installation at Ottawa Cablevision

7.6 NORPAK: TELETEXT ENCODER/DECODER SYSTEM

The Norpak Corporation, founded in 1975, is a principal developer and major manufacturer of encoders and decoders for Teletext systems in Canada and the US. Approximately 10 Norpak based Teletext broadcast origination sites presently encode data onto TV VBI lines for reception by about 900 Norpak decoders. Norpak products implement the North American Presentation Level Protocol System (NAPLPS - pronounced "naplips") and are compatible with the North American Broadcast Teletext Standard (NABTS). In Canada NABTS is embodied in DOC provisional Broadcast Specification BS-14.

In September 1981, Noranda Mines, through its wholly-owned subsidiary Maclaren Power and Paper, acquired a substantial interest in Norpak. Two months later Norpak gained full ownership of the Hemton Corporation, thus acquiring valuable page creation and electronic slide projection capabilities.

Norpak's close involvement with the development of NAPLPS and NABTS places the corporation in an ideal position to take advantage of any upswing in this new market. The goodwill and financial assistance of the Canadian federal government have combined to promote the corporation's systems concepts and to open contractual doors for a significant sales volume.

Some of Norpak's recent ventures include an agreement with Consolidated Electronics Industries of Melbourne, Australia for the manufacture of videotex products, an agreement with Infomart of Toronto regarding a broadcast teletext system for Time, Inc. of New York and an agreement with the Graham Poulter Group (UK) to distribute Norpak products in Europe.

7.7 TIME INC./MATSUSHITA: TIME TELETEXT SERVICE

In December 1982, the world's largest manufacturer of electrical and electronic products, the Matsushita Electric Industrial Company Limited of Japan, signed a long term agreement with the New York publishing conglomerate Time Inc., under which the companies will co-develop hardware for consumer information services. Matsushita is to manufacture and market the products under one or more of its well known brand names: Panasonic, Technics and Quasar.

The first product to be developed is a reliable, low-cost terminal for the teletext service that Time Inc's subsidiary, American Television and Communications Corporation (ATC) is field testing in San Diego, California and Orlando, Florida. Time Inc. is conducting the market tests of its 24-hours-a-day teletext service in partnership with The Orlando Sentinel in Florida and The Copely Press in San Diego, California.

The teletext market trial started in November 1982, one month before the Matsushita announcement. The service uses existing cable converters coupled to an addressable decoder and can cycle up to 5,000 pages (10 Mbytes) using full field delivery rather than VBI line techniques. Full field teletext to the NABTS standard can transmit 220 (2 Kbyte) pages per second, so that the cycle period for 5,000 pages would be 23 seconds. The average page access time would be half of this period.

Time Inc. is betting on the success of this one-way service concept and is aware that even AT&T does not expect more than a 7% to 8% videotex (telephone-based two-way interactive) penetration before 1990. Time Video Information Services President, Larry T. Pfister, at the Videotex '82 Conference in New York, explained the company's preference for cable delivery as follows:

"In my opinion, the cable industry is better positioned for text services than are either the broadcaster or the telephone company...

- o Technically, cable already offers a broadband communications delivery system into over 1/3 of American households today, and penetration is increasing at a geometric rate.

- o Broadcasters have only the Vertical Blanking Interval of a television signal, or sub-carrier of FM radio, to transmit text, severely limiting the amount of information they can carry. Further, it is doubtful whether broadcasters will jeopardize the primary business by promoting text competition for their commercial viewing audience.

- o Telephone companies may have broadband interstate and intercity communications, but that "last mile" in the switched network to the subscriber is still twisted copper pair, and will probably remain so for years.

- o For VBI teletext to grow, broadcasters are dependent on set manufacturers to provide built-in decoders in sets for the retail consumer market. If the AM stereo situation is any indication (and I think it is), it may be years before manufacturers start delivering sets in quantity.

- o On the other hand, it is entirely logical and relatively inexpensive for the cable industry to add decoding capability to a set-top converter in every home.

- o In fact, several addressable converter designs already have much of the added circuitry required for teletext, and the incremental cost to add decoding and graphics is reasonable."

"For our market tests, we have used this approach to add Norpak teletext decoder boards inside set-top converters built by Zenith. We have also added additional memory to monitor subscribers during the trial, in effect making every TV a fully metered set for measuring not only teletext usage but other viewing as well. For example, we will be able to watch "commercial zapping" on regular television, and see if users switch out of a broadcast commercial to check the sports scores or their horoscope."

This move into electronic publishing by Time Inc. and Matsushita represents the marriage of two giants in the consumer marketplace. Time Inc. owns both ATC (the world's second largest CATV multiple system operator) and Home Box Office (the world's largest Pay-TV distributor). With a potential base of 2.2 million cable subscribers, they are indeed well positioned to make a full-field teletext service a commercial success.

7.8 TOCOM

Tocom, Inc of Dallas, Texas, have designed an optional Teletext package that can be added to their 55-Plus addressable baseband pay-TV exhibition system. The design is based on a lower data rate than the presently proposed North American Teletext Standard (NABTS) and is intended for both VBI and full field applications. The Tocom data rate is 1.7 Mbps, as compared with the NABTS proposed rate of 5.7 Mbps. At the time of writing Tocom had received no orders for this Teletext package. It is probable that further development might be undertaken to make the product NABTS compatible.

7.9 THE VIDACOM SYSTEM

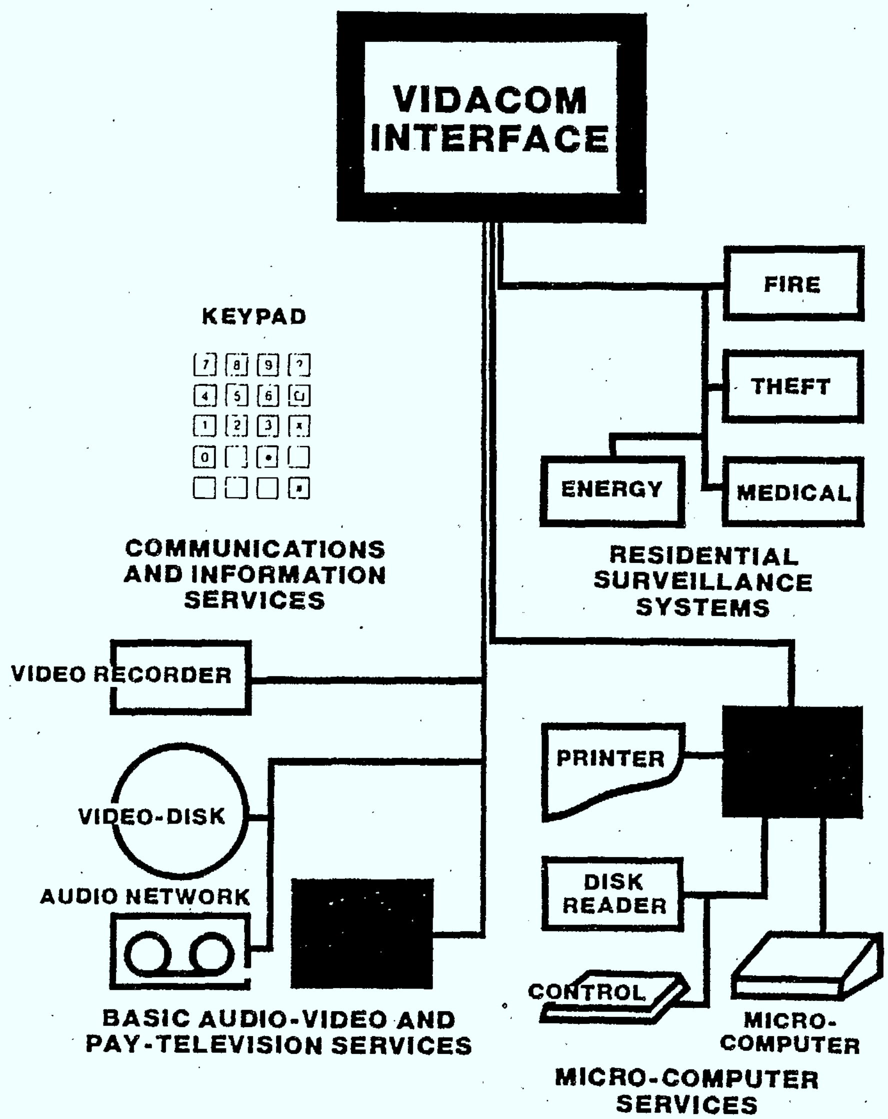
On June 20th, 1983, The Groupe Videotron of Montreal, in agreement with the Societe de Developpement Industrielle of Quebec and in partnership with the G-Tech Corporation of the US launched a joint high technology enterprise called VIDACOM. The Groupe Videotron is 60% owned by its President, Andre Chagnon. The company owns 100% of Cablevision Nationale Limitee, also of Montreal and represents over 540,000 cable subscribers.

G-Tech was founded in the mid-seventies in Rhode Island as Gaming Dimension Inc. and merged in 1979 with one of its major customers, Datarol, a leading manufacturer of on-line terminals. In 1981, the two founders of the original Gaming Dimension bought back the business with the backing of a major financial partner, Bass Brothers of Texas, part owners of Marathon oil. In 1982 the gross sales and royalties of the new G-Tech Corporation were $33 million.

Vidacom is the result of a cooperative project that began in 1980 with the sustained support of the DOC within the framework of its high technology Telidon development program. The federal government, the Cable Telecommunications Research Institute (CTRI), and several cable TV distributors were partners in the development of this project which required an initial investment of $8 million.

Vidacom is about to begin construction of an assembly plant in Montreal backed by an additional $10 million. The new plant is expected to create over 300 permanent new jobs. The Vidacom Company is owned 33.9% by Le Groupe Videotron, 42.4% by the G-Tech Corporation and 15.3% by the Societe de Developpement Industriel. Initiators and employees control the remaining 8.4% of the stock.

DISTRIBUTION SYSTEM



On the cable subscriber's premises, the Vidacom data processing circuits and telecommunications interface are housed in a single piece of equipment that permits control of both analog and data signals for home television screens. It provides the user with a high-speed data transmission channel capable of accepting downloaded packets at 4 Mbps. This provides access to a menu of selective information services, including pay-TV, external databases and an internal 20,000-page teletext database.

The Vidacom terminal provides channel interfaces for various peripherals (VTR, personal computers & printers), access to an electronic user's manual and the capability of accepting downloaded video and audio cassettes.

In a later phase, it will provide the subscriber with two-way interactive cable services, including teletransactions. The user will be able to communicate with a central computer, take part in electronic polling and make special individual requests. This capability opens the door to new and interesting options in the field of teletransactions: shopping from the home, instant theatre reservations, train and airline reservations, banking and instant financial transactions.

As with the NABU system, the Vidacom system employs a unique downstream data modulation system, in this case operating at a data rate that is lower than the NABTS standard. A full 6 MHz channel is however utilized for this transmission without the overhead of NTSC horizontal or vertical synchronization intervals and pulses. This has advantages in both spectral efficiency and cable amplifier power requirements. The carrier level can be 2 dB below that of a normal cable TV video carrier and, since the downstream data carrier occupies the normal TV carrier frequency, non-standard beat products are avoided.

7.10 ZENITH: Z-TEXT

The Zenith Radio Corporation of Glenview, Illinois, is engaged in the design and manufacture of consumer electronics products, with colour television sales accounting for 60% of total revenues. The corporation has a long-standing agreement with the American Television and Communications Corporation (ATC) concerning the use of the ATC patented SSAVI (synchronization suppression and active video inversion) pay-TV scrambling system. This patent, US patent number 4,222,068 dated 9 SEP 80, is the basis for the Zenith Z-TAC baseband scrambling units.

The Z-TAC system features an 8-pin DIN connector (Redi-Plug) that permits it to interface at baseband to operate directly with a video monitor. The Redi-Plug also makes the Z-TAC system upgradable to (Z-Text) teletext service including a full-field NABTS compatible version. Zenith's expertise in designing addressable baseband scrambling systems and its Redi-Plug interface concept explain the corporation's involvement with the Time Inc./Matsushita teletext trials, previously discussed.

Zenith's original Z-Text design implemented only the alphamozaic graphics capability of NAPLPS and was based on the British Prestel system. Cooperative participation with Norpak in the Orlando and San Diego field trials should permit extension of the earlier presentation level protocol to include full alphageometric graphics.

8. VIDEOTEX SYSTEMS

Videotex systems are the flagship subscriber data systems of the cable industry. They require two-way facilities to permit subscribers to interact with a large variety of databases. The cable industry's approach to these interactive systems is to employ the cable sub-band for upstream communications. This is in contrast to the alternative telephone/broadcast hybrid approach which requires use of the dial-up switched telephone network for the upstream data path. Hybrid methods have yet to solve the problem of priority conflict in the common use of telephone switching exchanges for this purpose. Cost-effective in-band telephone solutions, that permit upstream data flow in parallel with the normal use of voice facilities, have not matured rapidly enough to offer serious competition. The question of cost-effectiveness remains problematic even within the two-way cable approach. Regulatory approval to tap new revenue sources (eg: advertising) for Videotex services would however go a long way to overcome this obstacle.

Part IIa of Appendix 4 contains a chart showing the features of four Videotex systems currently under development. Little or no standardization trends are noticeable although packet contention, also called statistical multiplexing, is the upstream channel assignment protocol in three of these systems.

8.1 COX CABLE: INDAX SYSTEM

Cox Cable Communications Inc. of Atlanta, Georgia, with over sixty cable systems and 1.3 million subscribers, is the fourth largest multiple system operator in the United States and a pioneer in the construction of 54 channel (400 MHz) cable plant. Their successful franchise proposals for the cities of Omaha, Nebraska and New Orleans, Louisiana, have been based in part on their ability to provide a Videotex service called INDAX (Interactive Data Exchange) for the purpose of providing data retrieval and banking to business and residential users. Development costs for the Indax system have been estimated at over $10 million. Cox new-builds have also featured twin coaxial networks with a 'B' cable installed to serve as an institutional network offering both data and voice services.

Initially, the Indax communications channels were to be 1.7 Mbps downstream and 31 Kbps upstream. This is close to the configuration that Telecable Videotron was considering at the start of the SID project that eventually resulted in the present downstream and upstream channels and frequency agile receivers. Channel tuning on the Indax system is under software control and is completely transparent to the user. One channel acts as a master menu to which subscriber sets are initially tuned. The protocol study for the Indax system was carried out by Sytek, Inc., the designers and manufacturers of LocalNet.

The provision, in the fall of 1982, of data and voice service to the MCI Telecommunications Corporation, via the CommLine and Indax systems operated by Cox of Omaha, has resulted in an order from the Nebraska Public Utilities Commission (effective 30 APR 83) to cease and desist from supplying these services because the Commission considers Cox to be a common carrier. Issuance of the required common carrier certificate to Cox is considered unlikely since Northwestern Bell is already licensed in the Omaha service area.

Cox Cable recently announced (Multichannel News, 13 JUN 83) that it will be at least 1985 before they introduce their Indax system in five cities as promised in franchise proposals. Some of the difficulties the service has faced are due to faulty converters and difficulty in developing the information banks.

8.2 JERROLD: COMMUNICOM SYSTEM

Jerrold is the RF Division of the General Instrument Corporation of Hatboro, Pennsylvania, and a manufacturer of cable distribution amplifiers and addressable descramblers. In September 1982, General Instrument entered into an agreement to acquire 51% of Sytek, Inc. a leading designer of broadband digital networking systems and a supplier of modems and multiplexers. Jerrold and Sytek are working jointly on the development of the Communicom system.

Communicom is a distributed packet switched data communications system for residential and small business applications in CATV systems. It consists of the MetroNet, an expansion of the Sytek LocalNet product line, and a low cost home terminal family. The basic module in the home terminal family is the Subscriber Access Unit (this is Communicom's Local Interface Unit).

```
                              |--------------|
 CATV                         | RAM and Boot |
 system                       | Boot ROM     |
 drop                         | Memory       |
 cable                        |--------------|
   |                                /\
   |      |-----|                   ||
   |      |freq |                   \/                   |-----|====RS-232
 ------|agile|/----------------------------\| I/O |====inter-
          |modem|\----------------------------/|logic|====face to
          |-----|                   /\                   |-----|====terminal
                                    ||
                                    \/
                              |---------------|
                              | microprocessor|
                              |---------------|
```

BLOCK DIAGRAM OF COMMUNICOM SUBSCRIBER ACCESS UNIT

The Subscriber Access Unit interfaces to the MetroNet through a frequency agile RF modem and performs the physical and some of the data link level functions. The remaining data link functions through to the session level functions are achieved by software downloaded from the control nodes when power is turned on.

A restraining order was placed on Jerrold by AT&T and Western Electric to stop them from working on Communicom because of alleged infringements concerning presentation level protocol patents. This restraining order has now expired but a lawsuit is still pending and the project has been moved back several months. Commercial launch of the system could be in Sacramento in 1984.

8.3 PACKETCABLE

Packetcable of Cupertino, California, plans to start field testing its Videotex system at the end of 1983, with large scale production scheduled for 1984. The company has recently received $7 million in private funding with major contributions from Standard Oil of Indiana and a "Fortune top-20" insurance company. Regis McKenna (who helped Apple, Tandem and Intel) has agreed to handle advertising and promotion.

The system is based upon a two-way addressable CATV converter and is capable of supporting impulse pay-per-view TV, selective videotex retrieval and other computer-based services.

Components of the system include a remote keyboard, set-top unit, control processor, corrective regenerator and headend computer. A full alphanumeric keyboard is optional for use in text intensive applications such as sending electronic mail. The set-top unit and additional devices provide connections for home computers and services such as appliance control, alarms, energy management and meter reading. It can also be used to connect stereo speakers to high quality FM music channels.

The corrective regenerator is a small packet switch used to control the flow of upstream data to the headend. It passes video and audio signals unaltered while checking data packets for errors and eliminating defective packets so that they do not constitute unnecessary interference.

Little technical detail has been released to date on the Packetcable approach other than the data rate figures shown in Appendix 4.

8.4 VIDACOM

The Vidacom Network, previously described in the Teletex section, is to be expanded, as host cable systems are converted to two-way operation, into a multi-purpose Videotex system. To achieve this a sub-band busy-tone-multiple-access (BTMA) packet contention sub-system is to be added for upstream communications. The data acquisition chips, to be mass produced for the Teletext version, will have built-in circuits for the real time processing of certain status bits. These bits have been reserved to signal to each subscriber the status of the future upstream channels.

One of the possible status conditions is "channel busy" and is intended to eliminate further contention for the 500 Kbps upstream facility. Collisions, that must none-the-less occur some of the time, are to be recognized at RF by testing for the simultaneous presence of more than one of the tones used in the upstream frequency shift keyed channel.

The first beta-site testing of the Vidacom Videotex system is expected to take place in Montreal in 1984. Present estimates put the cost of a basic version of the local interface unit at less than $300 (Canadian).

9. TELEMETRY SYSTEMS

A Telemetry system performs routine monitoring functions of, for example, alarm sensors and remote meters. The average amount of data to be extracted from each subscriber location per day is typically less than 2 Kbytes (2,000 characters) even when polling as frequently as once every 10 seconds. Since the inbound flow of data is fairly uniformly distributed, it is possible to design such systems with a low peak upstream data rate. This approach enables relatively low cost cable Telemetry systems to be produced.

Noise in the cable sub-band is usually combatted by operating the upstream Telemetry data channels at low efficiencies of typically 0.1 bps per Hertz or less. Table IIb in Appendix 4 illustrates this feature in eight system examples from seven manufacturers.

9.1 CABLEBUS: CABLEALARM SYSTEM

The CableBus Systems Corporation was incorporated in Beaverton, in 1979 as a research, development and manufacturing company. CableBus now offers a complete line of cable security products (modems, computer equipment, sensors & sounders), some manufactured by CableBus and some made to CableBus specifications under sub-contract. The company is majority owned by Pacific Telecom, Inc., a subsidiary of the Pacific Power and Light Company.

Only one piece of CableBus equipment is absolutely required at the cable headend. This is the MOD-1 Headend Master Modem, which serves as the serial data interface between the coaxial cable plant and the monitoring equipment. On the monitoring equipment side, the modem signals conform to EIA standard RS-232C for full duplex, asynchronous communications. On the cable side, the modem transmits FSK-modulated RF signals and receives pulsed-CW RF signals. The standard transmitting frequency is 73.5 MHz with custom frequencies available in the range 50 MHz to 136 MHz. The standard receiving frequency is 31.4 MHz with custom frequencies available in the band 5 MHz to 40 MHz.

Data rates for the modem are selected on the front panel and include 1200 baud, 2400 baud and higher rates for specialized applications. An array of light-emitting diodes on the modem front panel indicates the status of the data and control lines. The display also indicates the relative carrier level of the upstream signal. It can be set remotely in any given subscriber location from the central (MICRO-2) console.

Each MOD-1 modem has a capacity of several thousand subscribers and is thus limited by the addressing capacity of the MICRO-2. Therefore, at the point in growth of 1,000 subscribers, a decision will be required:

1) To add a second MICRO-2 Automatic Alarm Controller, thus requiring another MOD-1 modem and another allocation of a 250 KHz carrier downstream and a 30 KHz upstream band.

or 2) To trade up to a CableBus MICRO-1 or MICRO-1.5 Central Alarm System having expanded computer capacity including on-line demographics and computerized database management.

A MOD-1 modem used in the second alternative could be used for as many as 2,500 subscribers and the additional 250 KHz downstream and 30 KHz upstream bands would not be required until 2,500 subscribers are exceeded.

9.2 E-COM: TRU-NET SYSTEM

The E-Com Corporation of Stirling, New Jersey, manufacture two telemetry systems for CATV use:

Tru-Net 100 - for up to 4,000 subscribers

Tru-Net 500 - for up to 250,000 subscribers

The smaller system is intended for: "utility meter reading, energy management, smoke and fire alarms, data acquisition, industrial process control, traffic control, point of sale terminals, pay cable control, hotel room services, intercom control and CATV system control." It features 38.4 Kbps, 250 KHz wide data channels in both directions. The Tru-Net 100 has been installed in about thirty cable systems, mostly private networks, serving a total of about 1,000 subscribers. This yields an average of approximately 33 subscribers per system.

The larger system adds an upper hierarchy to the network operating bi-directionally at 307 Kbps in 1.5 MHz wide channels. The nodes between the two levels are called Area Control Units (ACU's). They serve a function similar to that performed at the central node of the smaller system. E-Com offers an additional expansion module for the Tru-Net 500 system called a Videotex/Data Interface. The larger system is thus able to blur the distinction between pure Telemetry and Videotex networks. The Tru-Net 500 system is presently installed in one (field trial) beta site. Commercial availability is expected in the third quarter of 1983.

9.3 JERROLD: CABLE SECURITY SYSTEM

The Jerrold Division of General Instrument has two beta sites in operation testing its Cable Security System. Quite distinct from Communicom, this is designed for Telemetry purposes only and, at a forecast $100 US per Local Interface Unit, is claimed to be the lowest cost standalone solution on the horizon.

The system operates downstream within the FM band and features continuous polling and frequency agility with channel switching from the headend. Upstream signalling is accomplished by using two 13.9 Kbps, 400 KHz wide, channels in parallel within the T9 sub-band. One channel is used to respond to polling from the headend while the other channel is used for alarm transmissions (if the response is positive).

The Cable Security System has a cut-cable alarm and optional telephone autodialer backup. In normal operation the polling rate of the cable system would offer subscribers a superior speed of response. The basic system is intended to handle 16,000 subscribers and to be expandable to 65,000.

CABLE SECURITY SYSTEM HOME TERMINAL

```
                 |-------------|             |--------------------|
to/from          |    alarm    |             |                    |
/----------\|  processing |/-----------\|      control       |
\----------/|     unit     |\-----------/|      console       |
cable            |             |             |                    |
network          |-------------|             |--------------------|
                  | | | | | | |               Control point
                  | | | | | | |               for activating
                  X X X X X X X               and monitoring
            Sensor inputs connected           system status
              to modem located in
              basement or closet
```

Within the subscriber terminal a tamper alarm is activated if the control unit is opened (for example, by intruders), alerting the headend and sounding an alarm at the subscriber's home. The terminal also features a low power alarm to be used in conjunction with battery backup powering.

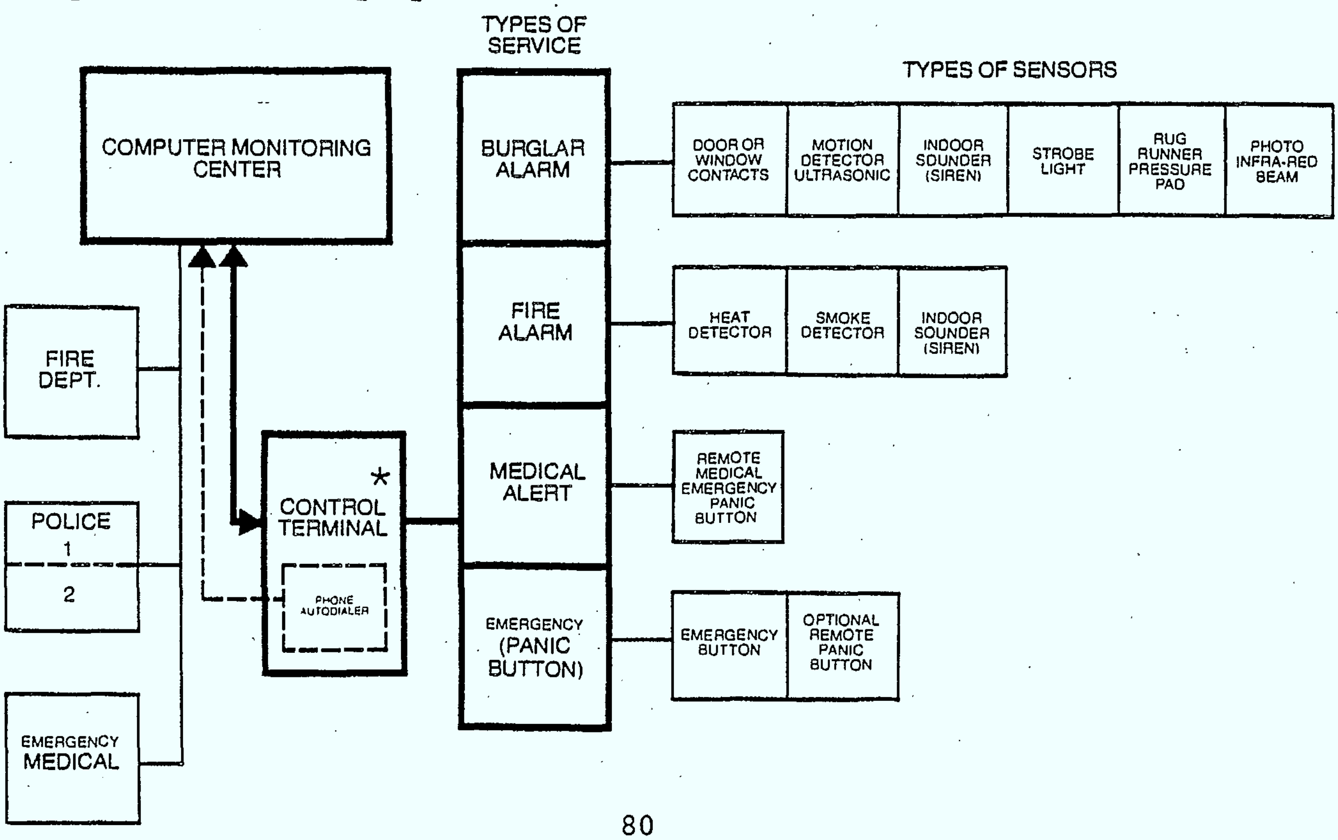
Headend reliability is based on two DEC mini-computers and a controller that can report alarms if the customer service computer is not functioning. Dual disk drives provide data storage redundancy.

JERROLD CABLE SECURITY SYSTEM HEADEND

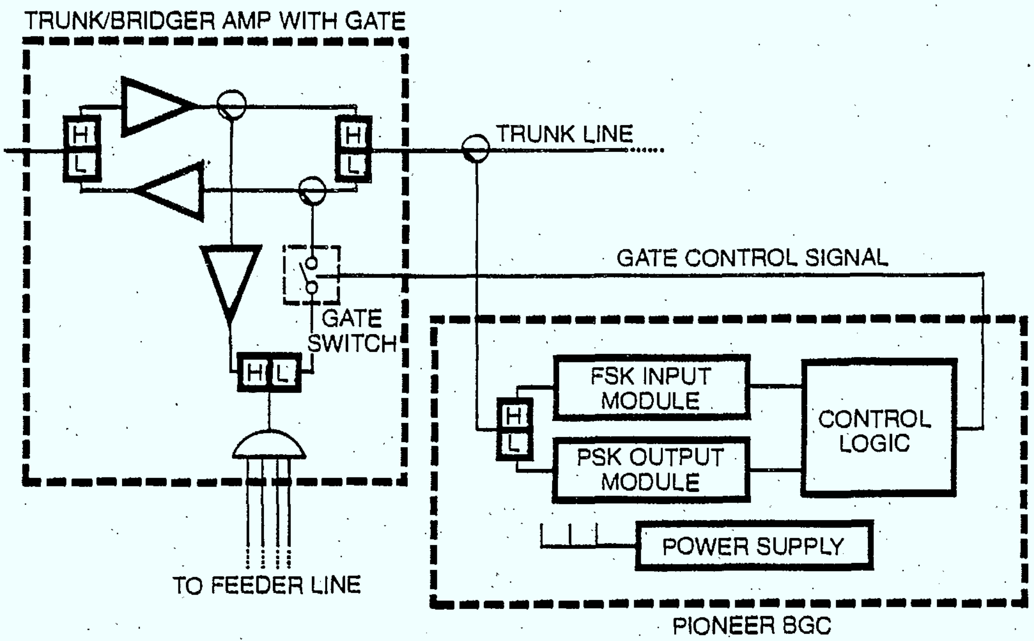
```
|------|        |-----------|         |-----------|        |--------|
| disc |        | customer  |         |           |        |   RF   |
|------|<---->| |  service  |<------->|controller |<----->| modem  |
| disc |        | computer  |         |           |        |        |
|------|        |-----------|         |-----------|        |--------|
                  /\      /\                                  /\
                  ||      ||                                  ||
                  ||      ||                                  ||
                  \/      \/                                  \/
                 CRT    printer                            to/from
                                                            cable
                                                           network
```

9.4 PIONEER: VIP HOME SECURITY SYSTEM

In 1961, Fukuin Denki Kabushiki Kaisha, a successful Japanese manufacturer of loudspeakers and integrated amplifiers, became known as the Pioneer Electronic Corporation. A decade later in 1973, Pioneer Communications of America (PCA) was created as a wholly owned subsidiary devoted to the development of CATV products. By 1977 PCA was engaged in the development of the first large-scale, operational, two-way, interactive cable system. This system is perhaps better known as the Warner-Amex QUBE system than under its Pioneer product name "VIP". Besides providing pay-TV exhibition facilities, the VIP system features a separate Telemetry system:



To implement this system requires some special CATV plant enhancements prior to installation. Reverse amplifiers are added together with Bridger Gate Controls to limit simultaneous upstream noise ingress. It can also be used to isolate a malfunctioning terminal so that it does not affect the remainder of the system.



PIONEER BGC AND TRUNK/BRIDGER AMP CONNECTION

With this type of cable system in place, the VIP Security System can provide burglar alarm, fire alarm, medic alert and emergency (panic) button security service that meets standards established in the USA by the National Burglar and Fire Alarm Association (NBFA) and by the Central Station Electronic Protection Association (CSEPA).

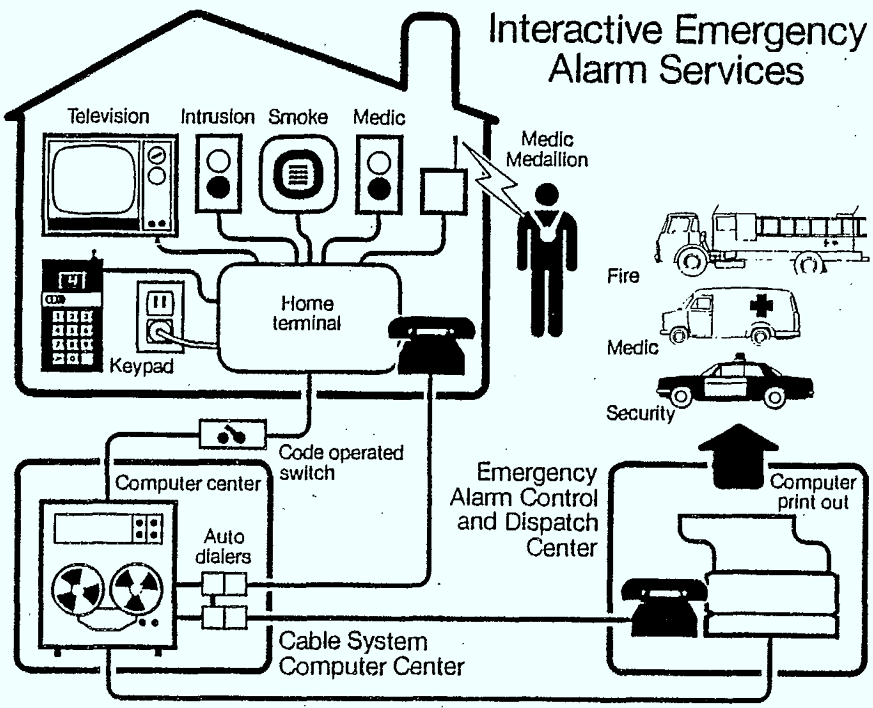
The VIP Home Security System presently enjoys a penetration of approximately 5,000 subscribers in Warner Cable Columbus. Roughly 25% of these subscribers lie outside of the area served by the cable system and use an autodialer and telephone modem to link them with the applications computer at the cable headend. The remaining 75% are connected via the two-way cable system which serves 42,000 households. The VIP system thus serves about 10% of the cabled households.

This represents over three times the penetration that similar two-way cable Telemetry systems have reached in Canada. The success of the service is due, according to Pioneer spokesman Larry Shredl, to sound marketing practice and the presence of a well designed two-way cable network.

9.5 ROGERS: INTERACTIVE SYSTEM

Rogers Cablesystems Inc. is the largest multiple system operator (MSO) in Canada (1.3 million subscribers) and the eighth largest MSO in the United States (0.7 million subscribers). In London, Ontario, a wholly owned subsidiary, Cablesystems Engineering Limited, is the organization's research and development centre.

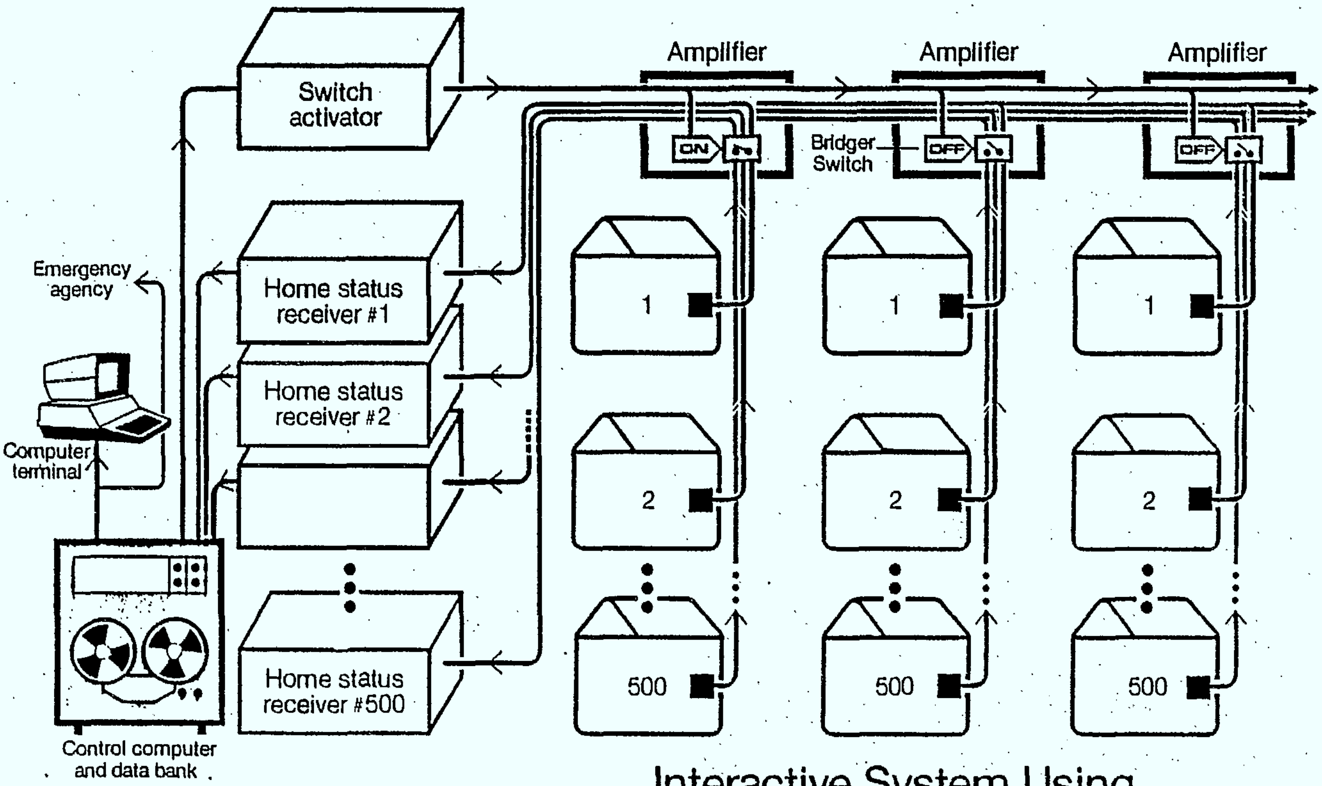
Rogers' Interactive System was developed by Cablesystems Engineering to provide public opinion polling, impulse-buy pay-per-event TV, telemetry and channel monitoring facilities. The telemetry, channel monitoring and public opinion polling features were field tested using Rogers Cable TV London as a beta site.



The Home Terminal Unit (HTU) consists of an oscillator, frequency shift keyed (FSK) modulator, data encoder and interface circuits. The oscillator is controlled by a plug-in crystal tuned to a particular channel. The channels are spaced 15 KHz apart within the band 5 MHz to 13 MHz. The FSK deviation is 3 KHz (+/- 0.5 KHz).

A telephone auto-dialer at the headend is used to communicate with any home signalling a fire, medic alert or intrusion alarm in order to allow confirmation (or denial) of the alarm status.

The system controls upstream noise ingress using a technique called Area Multiplexing:



Interactive System Using Code Operated Bridger Switches

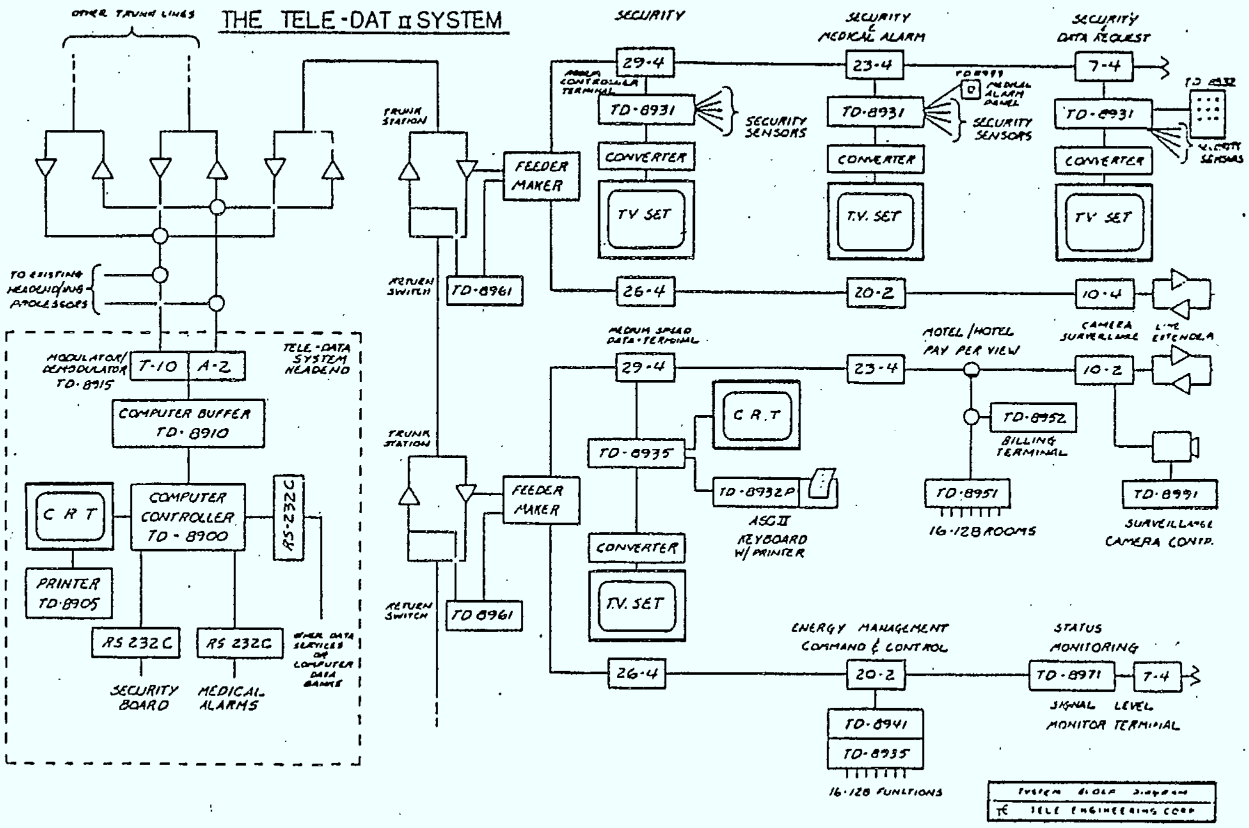
CODE OPERATED SWITCHES Each bridger amplifier in the subscriber network is equipped with special code operated switches which make possible a range of interactive services. Each switch serves a group of 500 homes. The central computer scans through the network turning on one switch at a time. Interactive information from each group of homes is transmitted to the computer in 20 milliseconds. The computer then moves on to the next switch and group of homes. In this way the entire subscriber network is scanned within a few seconds.

A Code Operated Switch (COS) in each bridger amplifier serves a group of 500 subscribers. The switch activator at the headend enables one group at a time to transmit their upstream FSK data signals through to a bank of 500 separate home status receivers. Each Home Terminal Unit transmits continuously.

The bridger amplifiers thus act as intelligent nodes in the data collection system. The bridger filter contains two separate switches, a data switch and a video switch, which gate the upstream signals into the trunk cable. The data switch controls the flow in the 5 MHz to 13 MHz band and automatically opens 20 milliseconds after it has been addressed. The second (video) switch is built-in to control further possible upstream transmission in the 21 to 33 MHz band. Once addressed this second switch will remain closed until deactivated from the headend.

9.6 TELE ENGINEERING: TELE-DAT II

The Tele-Engineering Corporation of Framingham, Massachussets, was incorporated in 1973 to develop ancillary products for data transmission on coaxial cable systems. Their Subscriber Transmission System has been designed to accommodate the transmission of bidirectional data over cable telecommunications systems equipped with sub-low return paths.



In the downstream direction, normally on channels A-1, A-2 or G, Tele-Dat II carries the following data transmission sequences:

- addresses for terminal modem controllers
- up to 128 switch commands per modem controller
- low & medium speed ASCII data

In the upstream or return direction, normally on channels T-9, T-10 or T-11, it carries:

- security sensor information
- medical alarms
- status monitoring data
- opinion polling responses
- low speed data from a 12-function keyboard
- low & medium speed data from a full ASCII keyboard

The TD-8910 computer buffer is the heart of the system. It is responsible for the scanning cycle, delay recognition and variable address formatting. This latter feature permits grouping of users by their characteristic traffic demands.

System architecture can be selected to accommodate growth in user demand. Security alarm monitoring, energy management, data retrieval requests and opinion polling responses give rise to slow speed upstream data flows from users equipped with only one address and covered by the standard scanning cycle having a period of about 2 seconds.

Medium speed users are assigned multiple addresses and multiple scanning by the computer buffer. As a result, it is possible to transmit and receive data in ASCII format at speeds up to 4800 bps.

9.7 TOCOM: CABLEGUARD SYSTEM

Tocom, Inc. of Dallas, Texas manufactures the Cableguard CATV telemetry product line. The first operational system to be installed in Canada is owned by Ottawa Cablevision Limited in Ontario. A block diagram of the subscriber equipment configuration of the Tocom Cableguard telemetry system is shown below:

```
          |------------|
          |            |<-------door switches
          |   ARMING   |<-------infra-red detector
          |   PANEL    |<-------ultrasonic detector
          |            |<-------combustion detector
          |------------|
               /\
               ||
               ||
               \/                            |----------|
          |------------|                     |    TV    |
          |    HOME    |                     |   SET    |
          |  TERMINAL  |-------------------->|          |
          |------------|                     |----------|
               /\
               || drop
               || cable
               ||
               \/
            |------|
- - ---\|   multi |/-----------------feeder------- - - - - - - - -\
- - ---/|    tap  |\-----------------cable-------- - - - - - - - -/
            |------|
```

The central component in the home is the Arming Panel which allows the subscriber to activate the system using a digital code key. Sensing devices are connected to the panel by a loop system which can be configured to detect open or closed circuit contacts as the normal monitored condition. The panel cannot be armed until each of the activated monitoring devices has been reset to normal (eg: by closing a window equipped with a plunger or magnetic contact to detect its open condition). Protection systems in the main living area might be deactivated when the family is at home, while a garage or swimming pool sensor might continue operating.

The headend equipment configuration is depicted below:

```
              |----------|         |-------------|
              |          |         |             |
              |   CRT    |         |   PRINTER   |
              |          |         |             |
              |----------|         |-------------|
                  /\                    /\
                  ||                    ||
       ........   ||  ...............   ||  ....................
       .          \/                    ||                     .
       .      |------------------------------|     DATA        .
       .      |     ZILOG MICRO-COMPUTER     |     SYSTEM      .
       .      |------------------------------|                 .
       .           ||                   /\                     .
       .           \/                   ||                     .
       .      |-------------|  |--------------|                .
       .      | TRANSMITTER |  |   RECEIVER   |                .
       .      |-------------|  |--------------|                .
       ........    ||  ...............  /\  ....................
                   || 157.25 MHz        || 18.2 MHz
                   \/                   ||
               |----------|         |---------|
               | VHF/sub  |------\ |   PRE   |
               | splitter |------/ |   AMP   |
               |----------|         |---------|
                   /\
                   ||
                   \/
    drop       |----------|                  Regular
<------------>| combiner |-----------------> (one-way)
    cable      |----------|                  CATV services
```

The Data System illustrated above can be implemented initially with the capability to accommodate up to 2,000 subscribers. Should service penetration demand expansion beyond this capacity, the unit (then called a Remote Data System or RDS) can be relocated within the cable system, typically at a suitable hub, to operate under the control of a mini-computer based Central Data System. Under these conditions the Remote Data System can be reprogrammed to relieve it of the central data processing functions. When this is done its monitoring capacity can be increased from 2,000 subscribers up to 8,000 subscribers. Each Central Data System can then control up to eight RDS's (64,000 subscribers total).

10. PAY-TV EXHIBITION SYSTEMS

Data signals are already common on most North American CATV networks as a result of the exhibition of pay television channels. Most, but not all, pay-TV systems generate data signals to serve various special purposes. The presence of these programming-related data transmissions should not be overlooked, since the systems that generate them can, in some cases, be used to provide other data services. In particular the addressing data, associated with an addressable descrambler unit, are capable of controlling general purpose local interface units (LIU's).

Appendix 5 lists a representative sample of seventeen pay-TV exhibition systems, including thirteen addressable and four non-addressable systems. They can be divided into three categories:

SWITCHED CONTROL	RF SCRAMBLING	BASEBAND SCRAMBLING
C-Cor	Jerrold	Cabledata
DBC	Microcom	Hamlin
Electroline	Oak	Telease
Texscan	Pioneer	Tocom
	Scientific Atlanta	Viewstar
		Zenith

The data signals needed by these pay-TV systems serve one or more of the following functions:

ADDRESSING: needed by all addressable systems to activate a particular subscriber's equipment for the purpose of changing its tier authorization status.

RESTORATION: needed to provide timing or decryption key information for RF & Baseband Scrambling systems

TAGGING: needed by most addressable scrambling systems to identify a particular channel or program for the purpose of restricting access to an authorized tier.

Each exhibition system manufacturer has deliberately taken a different design approach in order to offer cable operators a unique blend of piracy protection versus cost. The situation is analogous to the great variety of door-locks and padlocks on the market. Ideally no two are exactly alike, although standard types can be recognized and categorized in order of the security afforded. Not surprising therefore is the variety of auxiliary data signals associated with the various pay-TV exhibition systems. A detailed technical explanation of the different types of pay-TV exhibition systems can be found in references (1) and (2).

A study of the tables in Appendix 5 reveals that amongst the various pay-TV exhibition systems, the following three data transmission techniques are presently being used:

(1) **VERTICAL BLANKING INTERVAL video baseband signalling:** Used by all baseband scrambling systems for all three functions: Addressing, Restoration & Tagging. Hamlin also uses technique (2) for Restoration.

(2) **AMPLITUDE MODULATION (AM) OF THE FM AUDIO SUBCARRIER:** Used for Restoration and Tagging and mostly confined to RF scrambling systems.

(3) **ADDITIONAL FREQUENCY-SHIFT-KEYED RF CARRIER:** Used for addressing in all switched control systems and RF scrambling systems. Sometimes used for restoration timing in RF sync suppression scrambling systems.

10.1 VERTICAL BLANKING INTERVAL USAGE

In one-sixtieth of a second the single flying spot, that illuminates a conventional television screen, traces out the 262.5 raster lines that make up a video field. Two successive interlaced fields form a complete picture or frame. Thirty (still) frames are presented each second and create the illusion of a continuous video motion picture.

When the flying spot reaches the bottom of the screen it normally requires several lines worth of time to be swept back to the top of the screen to begin another field. The exact number of lines needed for this flyback is a feature of the TV set. In general older sets require more time to retrace than later models. TV sets can be adjusted by means of the vertical synchronization control to make the flyback begin at the end of any line of the field. It is preferable and intended however to adjust the set so that flyback takes place during the 21 lines of the Vertical Blanking Interval (VBI). The reason for this is that these 21 lines originally carried no luminance signals and would remain invisible during flyback. Nowadays luminance level signals are being inserted into the VBI to carry data. Present practice avoids such 'bright' signals within the first fourteen lines of unscrambled fields to allow invisible retrace for older model sets. Most modern sets can be adjusted to complete flyback by line 14 so that VBI lines 15 to 21 have become candidates for the ancillary data signals.

Broadcast Specification BS-14 - "Ancillary Signals in the Vertical Blanking Interval for Television Broadcasting" (Issue 2 - June 3, 1981) - recommends specific assignments for lines 15 through 21 inclusive in both the odd and even fields of a television broadcast transmission. These recommendations and additional comments are summarized in the following table.

VERTICAL BLANKING INTERVAL USAGE (USA and CANADA)

LINE	ODD FIELD	EVEN FIELD	
1	equalizing pulses	equalizing pulses	
2	equalizing pulses	equalizing pulses	
3	equalizing pulses	equalizing pulses	
4	vert sync pulses	vert sync pulses	
5	vert sync pulses	vert sync pulses	
6	vert sync pulses	vert sync pulses	
7	equalizing pulses	equalizing pulses	
8	equalizing pulses	equalizing pulses	
9	equalizing pulses	equalizing pulses	
10			these fives lines are unassigned in Canada
11			
12			
13	teletext in USA	teletext in USA	
14	teletext in USA	teletext in USA	
15	teletext in USA	teletext in USA	approvable for general public use (teletext) by CRTC
16	teletext in USA	teletext in USA	
17	VITS	VITS	
18	VITS	VITS	(optional)
19	VIR	VIR	
20	SID	unassigned in USA	approvable for general public use (teletex) by CRTC except that half of line 21 in the even field remains unassigned in Canada
21	captioning in USA	captioning in USA	

VITS = vertical interval test signal (for quality monitoring)

VIR = vertical interval reference (for auto chrominance & auto luminance circuits)

SID = source identification (for network control purposes)

In the United States, the FCC allows Teletext transmission on lines 13, 14, 15 & 16, whereas in Canada the corresponding lines are 15, 16, 20 and 21 with lines 10 to 14 unassigned. With year by year improvement in TV-set flyback speed, more VBI lines can be expected to be freed for ancillary signal carriage.

When considering the use of the VBI for the carriage of data, it should be remembered that the individual delivery of any specific line or even of any specific full frame of video is not guaranteed. This is because of the necessary practice of using time-base correctors and signal processing amplifiers by both broadcasters and by cable television operators. Some processing amplifiers and time-base correctors completely reconstruct the entire VBI and in so doing remove any previous ancillary signalling: Teletext, Closed Captioning, Source Identification (SID), Vertical Interval Test Signal (VITS) and Vertical Interval Reference (VIR). Other models reconstruct only lines 1 through 16 and pass the remaining lines unaltered.

Time-base correctors have an additional feature of being able to correct the frame synchronization rate of a television source that is running faster or slower than a desired reference rate. This feature is required, for example, in "sync-locked" cable headends where it is arranged to transmit the peak RF power associated with the horizontal synchronization pulses simultaneously on many or all channels. This has the advantage of causing all peak power loading to occur outside of the active video line intervals. Another example would be to sync-lock a channel to a master for the purpose of inserting a common stream of pay-TV addressing data.

Whenever such time correction is used, the possibility exists of occasionally discarding an entire frame, VBI's included. If a TV source is running faster than desired, it can only be delayed within a time-base corrector up to a limiting "window". Further slowing down entails discarding two consecutive fields.

Besides Teletext, VITS, VIR, SID and Closed Captioning signals, the VBI is commonly used for certain data signals associated with cable pay-TV exhibition systems. The Vertical Blanking Interval (VBI) pay-TV data signals are given priority by cable exhibitors over other VBI signals which might be present on the original video. This priority is however not protected by any CRTC recommendation.

The following examples of VBI use by cable pay-TV exhibition system manufacturers are listed in Appendix 5:

COMPANY	DESCRAMBLER	VBI LINES USED
Cabledata	Home Terminal Unit	?
Hamlin	MLD-1200	1 & 2
Telease	MAAST B	?
Tocom	55 Plus	17 & 18
Viewstar	PICS	14 & 262 *
Zenith	Z-TAC	10, 11, 12, 13 & 20

(* line 262 is not strictly part of the VBI but will be masked from view on the majority of TV screens)

Of the above manufacturers, both Hamlin and Zenith provided scrambling systems for the 1983 Canadian pay-TV launch.

It can be seen from the variety of line occupancy illustrated above that use of the VBI for other ancillary data signals during the exhibition of pay-TV cannot be assured. Each proprietary baseband scrambling system prescribes VBI use in a unique manner. An important distinction in the treatment of the VBI for scrambled pay-TV video transmission is that invisible retrace is no longer a requirement. Any specially inserted luminance level data signals can be removed at the descrambler.

In general both vertical and horizontal blanking intervals can be looked upon as playing a role similar to that of the framing border around the edges of a photograph upon a printed page. These time slots may be used differently under different exhibition systems. The analogy is that the borders of a printed page may also be used differently in books having different types of binding.

Generalizing yet further, modern broadcasting practice does not guarantee delivery of every single frame in a given video sequence. What is actually transmitted to a viewer's receiver is simply a statistical average number of lines and frames. Sufficient information is presented to recreate an illusion of the original video material.

In the much more precise world of data communications such statistical uncertainty has the effect of complicating the definition of service quality for information services that rely on ancillary data signals. On the one hand, redundant transmission can be used to compensate for possible omissions within sequential blocks of data. If a block is missed due to deletion within a particular processing circuit, it can in theory be picked up later if it is cyclically retransmitted.

Perhaps the ultimate solution is to dedicate entire 6 MHz cable (television) transmission channels exclusively to the carriage of data. In this way conflict with other legitimate technical usage of blanking intervals, and of the VBI in particular, can be completely avoided.

10.2 AMPLITUDE MODULATION OF THE FM SUBCARRIER

Amplitude modulation of the audio sub-carrier is a technique that normally performs satisfactorily, provided that the minimum sub-carrier level remains within acceptable tolerance. Unwanted AM to FM conversion in the audio detection circuits must be watched as a possible source of audio program degradation.

The performance of systems of this type could become a critical issue if Multichannel Sound (eg: stereo audio) systems, using additional sub-carriers on the FM channel baseband, are introduced at some later date for pay-TV channels (3). The carriage of stereo audio in this way amounts to squeezing an additional (L-R) difference channel into the existing monaural TV sound channel and requires special receivers.

10.3 ADDITIONAL CARRIERS

The use of separate out-of-band FSK'd carriers to carry addressing data raises problems of suitable spectral assignment. Most manufacturers provide cable operators with a choice of frequencies for these transmissions. The FM band (88 MHz to 108 MHz), the experimental band (108 MHz to 118 MHz) and midband channel A are popular choices for such carriers, as can be seen from a study of the systems listed in Appendix 5.

One of the problems faced in utilizing the experimental band for additional cable data carriers is due to the fact that the band is used off-air for the transmission of Instrument Landing System (ILS) glide path beacons and Very High Frequency Omnidirectional Radio Ranging (VOR) beacons. Care must be taken in the carriage of cable data signals at these frequencies because of radiation egress and possible interference with aircraft navigational systems. None-the-less, low level cable data signals can be carried safely in this band if suitable precautions are taken. This is a possible area for further research and standardization recommendations involving both the Ministry of Transport and the Department of Communications.

11. DATA COMMUNICATIONS STANDARDS

Communications of any description is based on the acceptance of some common language and procedures. Knowledge of a popular tongue that crosses national frontiers makes possible international commerce and the gathering and dissemination of valuable information. Being restricted to a little known language is a major handicap that results in isolation or at least the expense of interpreter services. These same arguments apply to expanding technology of data communications. Nowhere are the benefits of standard language and procedures more immediately apparent.

The following is a chronological list of the founding of some of the more important organizations and committees for the establishment of data communications protocols:

1865 - International Telecommunications Union (ITU).

1901 - National Bureau of Standards (NBS)

1918 - American National Standards Institute (ANSI)

1924 - Electronic Industries Association (EIA)

1926 - International Standardization Organization (ISO)

1957 - International Telegraph & Telephone Consultative Committee (CCITT), established by ITU

1961 - X3 Committee on Computers & Information Processing, established by ANSI

- TC 97 Committee on Computers & Information Processing established by ISO

- European Computer Manufacturing Association (ECMA)

1980 - IEEE Project 802 (Local Area Network Standards)

These organizations and committees have been established as a result of technological change and development within the private sector. For example, the Institute of Electrical and Electronic Engineers (IEEE) convened its 802 Committee following the Xerox Corporation's successful pioneering development of its passive coaxial cable local area network (Ethernet).

Standards establishment, especially within the USA, is a losely orchestrated activity involving professional organizations within both the federal government and industry. The Federal Communications Commission (FCC) follows a policy of awaiting the recommendations of the private sector before final rulemaking. This means each new measure of federal standardization encourages the production of commercially successful products and services.

The private sector of the telecommunications industry in Canada contributes significantly to the work of private sector standardization organizations and committees in the USA. FCC rulemaking is then normally paralleled by the publication of corresponding technical regulations by the Canadian DOC and by the policy decisions of the CRTC. To be in the forefront of any data communication standard creation to be applied in Canada implies direct involvement with the private sector in the United States.

In the early days of data communications network development several independant manufacturers each established their own "Network Architecture" to permit an orderly structure to evolve. Examples of such proprietary standards are:

Burrough's Network Architecture (BNA)
DEC's Digital Network Architecture (DNA)
IBM's Systems Network Architecture (SNA)
NCR's Distributed Network Architecture (DNA)

This gave rise to the problem of making interconnections between these various data networks and the need for some unified approach to the network architecture problem. The Institute of Electrical and Electronic Engineers, the American National Standards Institute, the International Federation of Information Processing Societies, the Electrotechnical International Committee and the Electronic Industries Association have set up committees to work out standards for local and metropolitan data communications networks. The committees have a general model of an architecture developed by the International Standards Organization. It is called the ISO DP7498 Reference Model for Open Systems Interconnection (OSI) and is intended to make the standardization of data communications manageable.

The model encourages manufacturers to choose from an approved set of protocols in the construction of their systems. Where common protocols are used, interconnection between different systems is possible. In this sense the independant networks are "open" to each other. The OSI model is none-the-less only a framework for the collection of approved standards. Any real interconnected series of networks can be expected to employ several standards and each standard may have something to say about more than one of the protocol levels.

Standards establishment, especially within the USA, is a loosely orchestrated activity involving professional organizations within both the federal government and industry. The Federal Communications Commission (FCC) follows a policy of awaiting the recommendations of the private sector before final rulemaking. This means each new measure of federal standardization encourages the production of commercially successful products and services.

The private sector of the telecommunications industry in Canada contributes significantly to the work of private sector standardization organizations and committees in the USA. FCC rulemaking is then normally paralleled by the publication of corresponding technical regulations by the Canadian DOC and by the policy decisions of the CRTC. To be in the forefront of any data communication standard creation to be applied in Canada implies direct involvement with the private sector in the United States.

In the early days of data communications network development several independant manufacturers each established their own "Network Architecture" to permit an orderly structure to evolve. Examples of such proprietary standards are:

Burrough's Network Architecture (BNA)
DEC's Digital Network Architecture (DNA)
IBM's Systems Network Architecture (SNA)
NCR's Distributed Network Architecture (DNA)

This gave rise to the problem of making interconnections between these various data networks and the need for some unified approach to the network architecture problem. The Institute of Electrical and Electronic Engineers, the American National Standards Institute, the International Federation of Information Processing Societies, the Electrotechnical International Committee and the Electronic Industries Association have set up committees to work out standards for local and metropolitan data communications networks. The committees have a general model of an architecture developed by the International Standards Organization. It is called the ISO DP7498 Reference Model for Open Systems Interconnection (OSI) and is intended to make the standardization of data communications manageable.

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In the illustration of the OSI model shown below, the various layers are numbered 1 through 7. Any layer with a lower numbered layer below it can derive a "service" from that sub-layer. Such service is requested and acknowledged by the transmission of "primitives" across the layer boundaries.

Typically what happens when two subscribers to a LAN communicate is that some "user data" are prepared by the sender who, in the hierarchic sense, sits above all the protocol levels at the sending station. These data are "passed down" to level 7, in the sense that the layer 7 protocol structures the data in a special way by adding suitable "headers" to it.

7	APPLICATION		APPLICATION	Application levels
6	PRESENTATION		PRESENTATION	
5	SESSION		SESSION	
4	TRANSPORT	messages	TRANSPORT	Transport levels
3	NETWORK	packets	NETWORK	
2	DATALINK	frames	DATALINK	
1	PHYSICAL	<====bits====>	PHYSICAL	

Seven Layered OSI Architecture. As originated data flow down the layers, each layer adds its own "header". As received data flow up the layers, each layer reads, interprets and discards its appropriate header.

Likewise, protocols at each subsequent layer are responsible for adding more headers to the original data. Layer 2 also adds a "trailer" which divides the data into a series of "frames". Layer 1 adds no more overhead to the data but simply passes them across the physical boundary between the terminal and the Local Interface Unit.

From here the data are carried into the network where the control messages in the various transport level headers assist in routing the message to its intended destination. During this process the transport level headers will be read, acted upon, and discarded. In complex networks a particular transport level header may be discarded and then replaced with another for the next leg.

Finally the applications protocols within the receiving station strip off the remaining headers and are responsible for interpreting the message as suitable images or sounds or other presentation during the appropriate "session". Authorization protocol, including encryption procedures, may also be used to ensure that the message is received by the intended party.

11.1 PHYSICAL INTERFACE PROTOCOLS

The protocols at the lowest layer (Layer 1) define the function, mechanical and electrical characteristics of the bit-transfer interface to the communications medium. In other words they define the connection between the user's terminal equipment and what in this report has been called the Local Interface Unit (eg: smart modem).

```
                  PHYSICAL INTERFACE PROTOCOL
                  |                          |
                  |  eg: EIA  RS-232-C       |
                  |       CCITT V.24         |
                  |                          |
                  GOVERNS BIT TRANSFER ACROSS
                      THIS INTERCONNECTION
                              //
                             //
                             \\
        /-----|               \\       |------------------|
       /      |=>>===//====|                  |
   /--/       |=====//==<<=|                  |--------cable----
   -----------|              \\       |------------------|
      terminal               \\     local interface unit
```

An ISO level 1 protocol is not concerned with the physical characteristics of other interconnections that exist deeper within a complex network. Indeed such physical characteristics as the frequency plan of a cable network or the modulation techniques employed over a terrestrial microwave link or satellite link lie outside the present OSI framework.

An example of a physical level protocol is EIA RS-232-C or its CCITT counterpart V.24. The physical characteristics of an RS-232-C interface consists of many parallel wires each carrying distinct bits of data or distinct control bits to operate the "smarts" of the modem. This is in keeping with the role of level 1 protocols: to establish, maintain and disconnect the physical link so that bits of data can be moved over it.

The RS-232-C interface standard was conceived in the early 1960's and promises to survive for many years to come as the workhorse interface for terminal-to-modem connections. It does however have its limitations. Signalling of bits over the parallel lines of this interface takes place typically at +/- 12 VDC using unbalanced circuits. Signalling speed is limited to 20 Kbps and the distance separating the terminal from the modem is limited to about 50 feet using unshielded cable. RS-232-C does not specify any particular mechanical connector. Furthermore the standard makes no reference to frequency agile modems.

The standard known as EIA RS-449 is intended to overcome these deficiencies and supercede RS-232-C. Balanced circuits are specified with signalling rates of up to 2 Mbps. Separations of 4,000 feet are possible at data rates of 100 Kbps. The modem can be switched from the terminal side of the interface between two possible frequency bands designated simply high and low. It can also be switched between high and low data rates.

In the United States the federal government has made RS-449 interfaces mandatory on all relevant procurements after 1st June, 1980. None-the-less the RS-449 standard itself faces criticism. The recommended 37-pin connector is considered by some terminal and modem manufacturers to be too expensive and too bulky. Some argue that technology has surpassed these protocols and that the industry should adopt an approach that encodes control functions on a single lead. Such an approach would allow the use of a 15-pin or even a 9-pin connector.

11.2 DATA LINK PROTOCOLS

Protocols of the second layer perform tasks that take a raw transmission facility and transform it into a line that appears free of transmission errors. This means free of errors as far as the next level up (the Network layer) is concerned. It does this by assembling the input data into data "frames", transmitting frames sequentially, and processing the "acknowledgement" frames sent back by the receiver. In some link protocols the acknowledgement may be piggybacked onto a data frame coming in the opposite direction.

The data link layer adds addresses to outgoing messages and decodes the addresses of incoming messages. It also detects and may correct errors in both incoming and outgoing streams of data.

Character (or byte) oriented data link control protocols have existed for a long time. One of the most widely used is IBM's Binary Synchronous Communication (BSC). It can be implemented using control characters from any of three code sets including the popular American Standard Code for Information Interchange (ASCII).

Ten ASCII characters are designated as control characters as follows:

BITS 7654321	ABBREVIATION	FUNCTION
0000110	ACK	Acknowledge
0010000	DLE	Data Link Escape
0000101	ENQ	Enquiry
0000100	EOT	End of Transmission
0010111	ETB	End of Transmission Block
0000011	ETX	End of Text
0010101	NAK	Negative Acknowledgement
0000001	SOH	Start of Heading
0000010	STX	Start of Text
0010110	SYN	Synchronous Idle

BSC uses nine of the standard communications control characters, supplementing them with six two-character sequences.

Other examples of character oriented data link control protocols include:

ANSI X3.28 - "Procedures for the use of the communications control characters of the American National Standard Code for information exchange in specified data communication links."

DDCMP - Digital Equipment Corporation's Digital Data Communications Message Protocol.

ISO IS1745 - "Basic mode control procedures for data communication systems"

Some problems arise with the use of character oriented protocols due to their inherent inflexibility and the penalty that the assignment of characters for link control subtracts from the set available for message information transfer.

Bit-oriented data link protocols are the result of attempts to overcome these deficiencies. Instead of assigning characters, the new protocols assign certain positions in standard data fields to specific control functions.

The following are the more important bit-oriented protocols and their year of adoption:

ORGANIZATION	BIT-ORIENTED PROTOCOL	YEAR ADOPTED
IBM	Synchronous Data Link Control (SDLC)	1973
ANSI	Advanced Data Communications Control Procedures (ADCCP)	1979
ISO	High Level Data Link Control (HDLC)	1979

CCITT has recommended a subset of HDLC as the link access control within the framework of its (X.25) public data network interface.

11.3 NETWORK PROTOCOLS

Third level protocols are concerned with the routing of packets of information between nodes within a network. In this report, the nodes of a Local Area Network have been called Local Interface Units (LIUs). Much of the pioneering work on packet networks was done for the Advance Research Projects Network (ARPANET), which became operational in the US in 1969. In an Arpanet the nodes are called IMPs (Interface Message Processors).

The major task of a network protocol is to divide responsibility between the LIU and the attached hosts and terminals for the conversion of messages into packets. The protocol must also direct these packets to their appropriate destination. Sometimes an accounting function is built into a network protocol to count how may packets are sent along a particular route for billing purposes.

In 1976, CCITT adopted Recommendation X.25 - "Interface Between Data Terminating Equipment for Terminals Operating in the Packet Mode on Public Data Networks". Public packet data networks such as Telenet (USA), Tymnet(USA), Uninet (USA), Transpac (France), Datex/P (Germany), Datanet-1 (Netherlands), PSS (UK), DCS (Belgium), Datapac (Canada) and Infoswitch (Canada), offer attractive rates for users with the appropriate bursty traffic requirements. Occasional users are probably better off using the regular dial-up telephone network, whereas consistently frequent point-to-point users might be more economically served by leasing dedicated real circuits.

The X.25 protocol spans levels 1, 2 & 3 of the OSI architecture and introduces the concept of a virtual circuit. Each packet entering the network is assigned a logical channel number which identifies the "conversation" to which it belongs. Individual packets within the same conversation may take different routes to reach their common destination. The three levels of X.25 are:

Level 1 (X.21 bis) - compatible with RS-232C.

Level 2 (Link Access Procedure) - compatible with HDLC.

Level 3 - the heart of X.25. This covers the establishment of virtual circuits, the definition of the packet structure and procedures for recovering from abnormal conditions.

Because X.25 is intended to work with special intelligent terminals, the CCITT created a further set of recommendations describing a facility called a Packet Assembler/Disassembler (PAD) to enable non-X.25 and less intelligent terminals to be connected to the public data network. The PAD recommendations are useful in designing interfaces between small local area networks and large public data networks. Examples of large public data networks presently operating in Canada are Bell Canada's Datapac and CNCP's Infoswitch.

11.4 TRANSPORT PROTOCOLS

Fourth level protocols are concerned with the moving of complete messages between separate Local Interface Units. The transport layer creates a distinct (layer 3) network connection for each transport connection required by the session layer (layer 5). If a high throughput is required, the transport layer might create multiple network connections and divide the data amongst them. Low average throughput, on the other hand, might be accommodated at minimum cost by multiplexing together data from several low throughput users onto one network link.

Since the transport layer must be able to establish and disconnect connections across the network, it is a level concerned with addressing systems. It must also look after problems associated with the flow of data and the avoidance of data overflow. If the underlying network is unreliable, the transport layer might have to arrange for duplicate delivery of data so that the resulting flow of messages is smooth and uninterrupted.

The transport layer is expected to optimize the use of available resources to meet the needs of the session layer above. Simple transport protocols can be used when the network provides a high quality, reliable service. More advanced protocols are needed when the underlying service is poor. In effect, the transport layer duplicates recovery mechanisms and other features that should have been provided by the lower layers.

A transport layer protocol is often implemented by part of the operating system software within a host computer. Several tranport protocols are nearing completion under the auspices of the ECMA, NBS and ISO. The US Department of Defence has a version called Transmission Control Protocol (TCP).

11.5 SESSION PROTOCOLS

Layer 5 protocols enable users to establish and terminate (bind and unbind) complete "sessions" with other users or with machines. In most types of session, a dialogue takes place between two users and the protocol must decide who speaks when and for how long. In some cases the two users speak alternately. In others one user may send many messages before the other replies. In some sessions one machine may interrupt another. The protocol determines the rules for this message exchange.

When two users are speaking alternately, they are conducting a session in a "half-duplex" mode. None-the-less, while this is happening, a "full-duplex" data link protocol may be used in which acknowledgements being returned as packets are being originated. There is no inconsistency here. It is however necessary to specify the level at which the terms apply. Where no level is mentioned, the terms half-duplex and full-duplex normally refer to the data link level. As an exercise, the reader should be able to imagine a half-duplex data link being used to support a full-duplex session protocol.

Another important function of a session protocol is to arrange that any breakdown in the lower communications layers does not result in a dangerous partial message being received by an end user or host computer. The session layer often provides a facility whereby a group of messages can be bracketted, so that none of them is delivered to a remote user until all of them have arrived.

11.6 PRESENTATION PROTOCOLS

Sixth level protocols perform functions that are requested sufficiently often to warrant finding a general solution for them. Frequently used expressions may be compressed into an abbreviated shorthand form so as to save time and bandwidth. Data may also be encrypted at this level to permit a measure of communications privacy amongst authorized users.

A recent example of data compression is the joint ANSI/CSA standard "Videotex/Teletext Presentation Level Protocol Syntax (North American PLPS)" which includes a scheme for the coding of Teletext records. This protocol enables graphics to be transmitted as a compact series of data signals.

Included within NAPLPS (pronounced "naplips") is the Canadian Telidon standard for the "alphageometric" encoding of pictorial elements into a series of precise instructions for the drawing of coloured arcs, circles, lines and polygons. This particular part of the protocol represents a coordinated effort on the part of the Canadian Department of Communications and is a rare example of standard creation by a government body acting in the vanguard of a technological development.

11.7 APPLICATION PROTOCOLS

The seventh and highest level of protocol sets out the communications procedures that are most directly comprehensible to the system user. It is concerned with the selection of a specific service or application and permits checks to be made on the availability of resources such as the existence of the latest versions of continuously updated databases. Methods for accessing and tranferring information amongst particular files are specified and any special security access codes added at this final level.

Work on formal definition of this layer is only just beginning although many proprietary data communications systems have already established working rules for specific user groups. Typical specialist user groups include those concerned with Banking, Airline Reservations and Manufacturing.

12. CONTENTION VERSUS POLLING

Most communications systems have to share a limited number of channels amongst a much larger number of subscribers. To assign a separate channel to each user would be impractical and uneconomical. This is the usual situation in the upstream design of Local Area Networks (LANs), where for most of the time few of the users have any information to transmit.

Two methods of sharing upstream channels are possible. In one the users transmit when they like. In the other they only transmit when authorized to do so. These two approaches are called contention and polling respectively and give rise to systems with quite different properties.

A contention system, in its crudest form, is rather like a room full of impolite people, each speaking a different language, talking via one central interpreter simultaneously. More refined versions are analagous to the same scene with polite people. If two begin to talk at once, both stop immediately and try their best not to interrupt each other again. A polling system is analagous to a strict classroom environment in which each person answers a roll call and is allowed to initiate a conversation with someone else via the interpreter (headend) only when addressed.

IEEE Project 802 has recognized the pros and cons of contention versus polling in its efforts to formulate protocols for Local Area Networks and Metropolitan Area Networks. Two of the "access methods" recommended for LANs are a form of polling. A third LAN access method is a contention system. The (802.6) subcommittee considering access methods for Metro Area Networks (MANs) has not yet drafted its findings.

The expression "access method" is used together with "logical link control" to define two parts of the second OSI layer:

DATA LINK LAYER = logical link control + access method

The various IEEE 802 subcommittees have agreed to standardize one logical link control and four access methods. Each standard describing an access method also includes a description of the physical layer associated with it. The common logical link control defines the "primitives" to be used in a "bit-oriented" data link protocol. The subcommittees have agreed to use one such data link protocol throughout. The one they have chosen is the High Level Data Link Control (HDLC) mentioned in the previous section.

The relationships amongst the standards being prepared within the IEEE 802 Project can be perceived by examining the sketch below:

```
: . . . . . . . . . . . . . . . . . . . . . . . . :
: 802.1                                            :
:                                                  :
:       . . . . . . . . . . . . . . . . . . . . . :
:       : ....................................... .  ---------------
:       : |        802.2 Logical Link Control     |
:       : :.......................................: Data Link Layer
:       : ........ ........ ........ ........
:       : | 802.3 | | 802.4 | | 802.5 | | 802.6 |
:       : |. . . .| |. . . .| |. . . .| |. . . .|  ---------------
:       : |       | |       | |       | |       |
:       : |       | |       | |       | |       | Physical Layer
:       : |       | |       | |       | |       |
:       : |       | |       | |       | |       :
: . . . : :.......: :.......: :.......: :.......:  ---------------
```

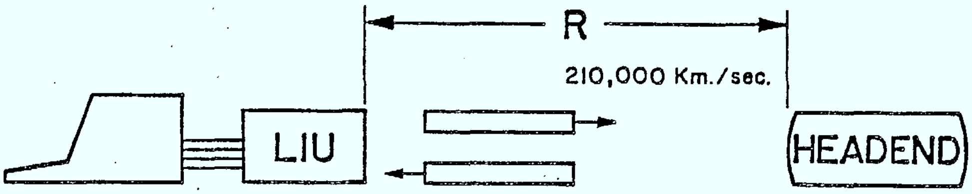
The four standards defining media access protocols are:

- IEEE Standard 802.3 a bus using CSMA/CD
- IEEE Standard 802.4 a bus using token passing
- IEEE Standard 802.5 a ring using token passing
- IEEE Standard 802.6 a Metropolitan Area Network (under study)

Token passing is a particular form of polling in which receipt of an access code (the token) authorizes a subscriber to begin transmitting. When transmission is completed, the subscriber transmits the token to the next subscriber in a preset sequence.

Certain factors such as network size, data rate, packet size and the number of active subscribers effect the performance of a network. One of the most influential of these is network size because it controls average propagation delay. This expression refers to the length of time it takes for a signal to pass from subscriber A to subscriber B. An average is quoted to reflect the propagation delay between a pair of subscribers who are an average distance apart.

The table on the next page shows (average) round trip delay as a function of the (average) radius of a coaxial network. Round trip delay is two propagation delays, the second trip permitting an acknowledgement to be sent from B back to A. Systems the size of large urban CATV networks, with over 10 Km average radius, have round trip delays equivalent to the time taken to transmit several TV lines. This influences the minimum practical size for a packet of data. If the packet is too small compared with the delay, the network is inefficient.



RADIUS R Km.	ROUND TRIP Km.	ROUND TRIP DELAY	
		µS	EQUIVALENT NUMBER OF TV LINES
1·5	6	28	0·4
10	40	190	3
50	200	950	15

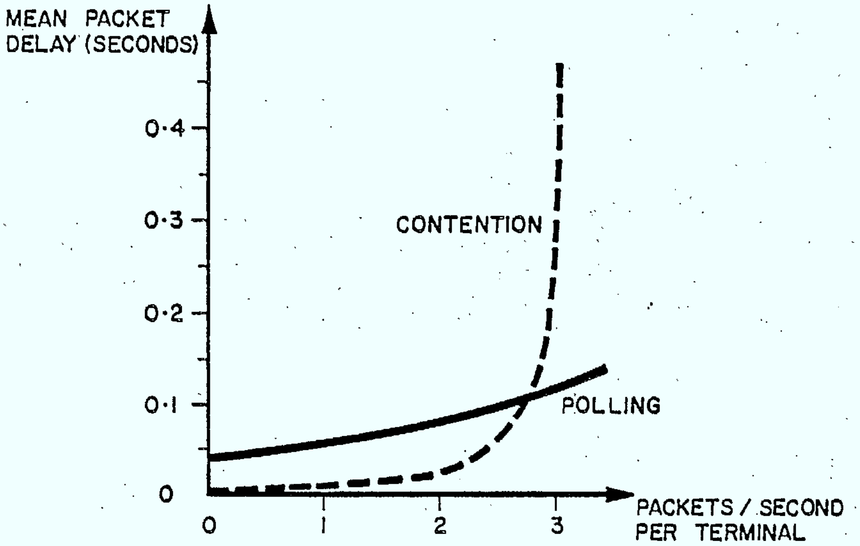
Thus in large systems, it is appropriate to work with large packets. Small LANs within an office building can operate efficiently with much shorter packets. The argument applies to both contention and to polling systems. But the performance of these two types of data network, as size and user load increase, is quite different. Simulations by Quelly and Frech of the E-Com Corporation illustrate these differences.

Consider the example of a 38 Km radius system with a mean propagation delay of 182 microseconds (3 TV lines). If such a system carried upstream data at 307 Kbps in packets of 100 bytes (characters) mean length, the mean packet duration is 2,600 microseconds. Because the packet duration is large compared with the propagation delay, the network can be considered efficient as long as it is not overloaded.

The simulations show what happens to mean packet delay (delivery time) as the volume of traffic is increased. When the throughput is less than 2.5 packets per second per terminal, the contention system offers a slightly better performance than the polling system. But as the average throughput increases, a crossover point is reached at which both access schemes offer equal mean packet delay.

With increasing usage the contention system can be said to break down because its mean packet delay rises towards infinity. Even in these circumstances some users, who happen to have captured a channel, do succeed in getting their packets delivered. The average user is none-the-less blocked. The polling system's average delivery time deteriorates more gracefully as the traffic load rises.

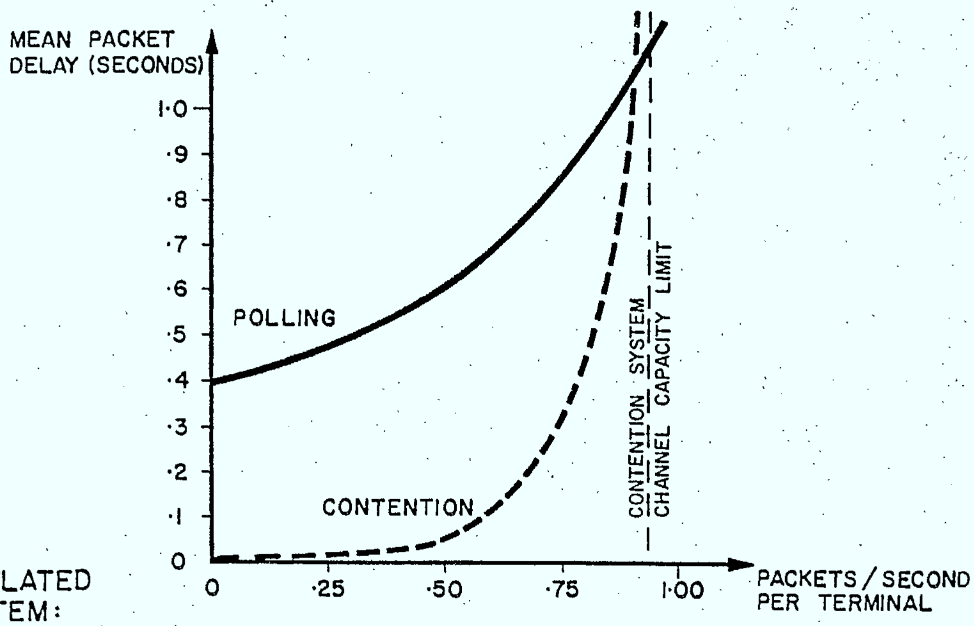
CONTENTION VERSUS POLLING



SIMULATED SYSTEM:

MEAN PROPAGATION DELAY = 182 μ sec. (MEAN RADIUS: 38 Km.)
MEAN PACKET LENGTH = 100 BYTES = 2,600 μ sec.
DATA RATE = 307 Kbps
NUMBER OF TERMINALS = 100

source: Quelly & Frech
E-COM (1983)



SIMULATED SYSTEM:

MEAN PROPAGATION DELAY = 182 μ sec. (MEAN RADIUS: 38 Km.)
MEAN PACKET LENGTH = 10 BYTES = 260 μ sec.
DATA RATE = 307 Kbps
NUMBER OF TERMINALS = 1,000

source: Quelly & Frech
E-COM (1983)

The lower of the two graphs on the previous page shows further simulation results. In this second example, the system size has been maintained the same. The number of user terminals has, however, been increased by a factor of 10 and the average size of the data packets has been decreased by a factor of 10. Packets now average only 260 microseconds. This is commensurate with the average round trip delay (still 182 microseconds).

With this new simulation, the contention system holds its own against the polling system for mean packet delays of up to one second. Traffic loading which produces mean delays beyond this certainly breaks down the contention system. But, since the polling system has also become frustratingly slow, it can be concluded that the contention system may be a better choice for many applications.

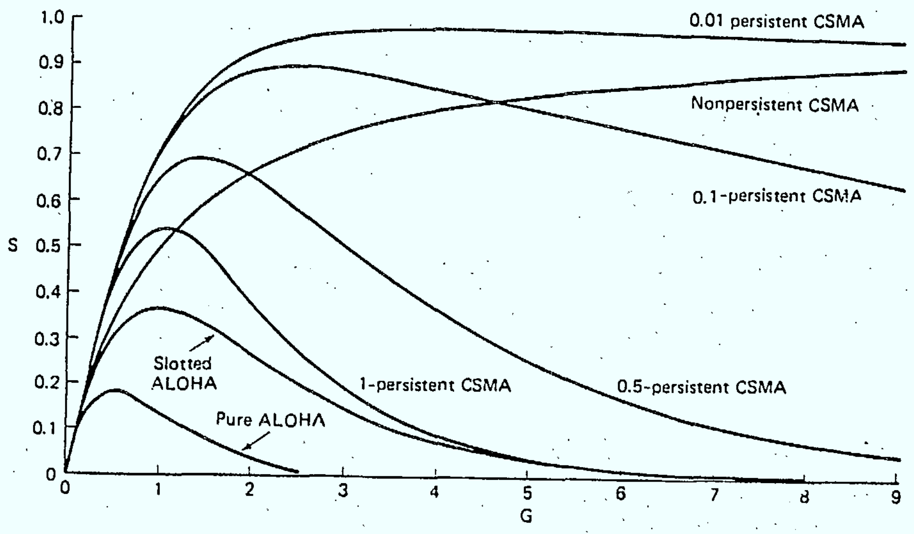
In general it can be said that the performance of a polling system degrades significantly when some upper limit of terminals are added to the network. It is then essential to keep the average round trip delay small, compared with the average packet size, in order to maximize the efficiency of the polling network.

12.1 CARRIER SENSE MULTIPLE ACCESS (CSMA)

Collisions are avoided in this contention access protocol by special circuits within each user terminal that listen for the presence of another user's carrier. Terminals then refrain from transmitting if the channel is sensed busy. The results that have already been examined included simulations of just such a system. It should be apparent that a lengthy round trip delay must adversely affect the ability of the special circuits to guard against interfering packets that are "only just starting out" from another terminal. If the round trip delay is sufficiently long, many such packets could be already in transit as the home terminal begins to transmit on what it thinks is a clear channel.

The graphs on the next page illustrate traffic (G) versus throughput (S) for several versions of CSMA/CD. The CD stands for Collision Detection and the differences amongst the variants have to do with the method used to determine when to attempt a retransmission after a collision is detected.

In a "1-persistent" CSMA/CD scheme, the user listens first, then retransmits immediately if the channel is perceived to be clear. Users thus have a 100% probability of retransmitting on (what they think is) a clear channel. The curves range from this certainty retransmission system to a "0.01-persistent CSMA/CD". In this latter case the probability of retransmitting on a "clear" channel is deliberately reduced to 1% by means of random timers. These timers delay retransmission in an arbitrary random manner.



Contention System Throughput (S) v. Traffic Load (G) source: Tanenbaum

Notice that low persistance CSMA/CD can accommodate a higher average throughput under heavier traffic conditions than can a high persistance version. For comparison, the lower left corner of the throughput graph illustrates the performance of "pure Aloha" and "slotted Aloha" access protocols. These are contention systems that do not feature the "carrier sense" logic. Users transmit whenever they have data to be sent. Collisions occur as a result of this and packets are destroyed. The sender determines whether or not the packet was destroyed by listening to the rebroadcast downstream one round trip later.

In a slotted Aloha system, it is impermissable for a terminal to begin transmitting except at the start of well defined time slots. Each slot has a duration equal to an agreed upon fixed packet duration. By this means, many collisions can be effectively prevented. The avoided collisions are of the type in which a fraction of one packet overlaps with a small fraction of another packet:

```
- - - - ----------------
    PACKET 1           |
- - - - ----------------
            ---------------------------------- - - - - - - - -
            |     PACKET 2
            ---------------------------------- - - - - - - - -
```

The Aloha procedures were the earliest of the packet protocols. CSMA/CD can be seen to outperform both pure and slotted Aloha. The price paid for this superior performance is the increased complexity and cost of the terminal.

In a baseband contention system, such as Ethernet, each user terminal is able to recognize the presence of a collision on the network by detecting a DC component that would otherwise not occur. Broadband cable systems using CSMA/CD need to detect collisions at the headend before signalling their presence downstream to the user terminals. The user terminals in broadband systems are unable to detect collisions directly, as in Ethernet, because they do not "hear" the upstream transmissions.

This gives rise to a problem. Some broadband contention systems rely on detecting the presence of simultaneous frequencies to indicate that a collision has taken place. In an FSK system, for example, only one tone should be present instantaneously. Two tones together signify that two terminals are transmitting. However, unless all signals arrive at the headend at equal strengths, a danger exists that the stronger signal will overpower the weaker one. No collision will be registered and some users will enjoy an unfair priority over others.

The collision of two or more RF carriers can cause a "frequency splatter" effect within any non-linear components of the distribution system. This can cause interference in channels other than the CSMA channel in use.

Because CATV systems are normally designed to give equal downstream signal strengths at subscriber TV sets, the provision of equal upstream signal strength at headends should not be taken for granted. If no precautions are taken, distant terminals will actually be received at stronger levels than those closer to the headend. This is a result of the lower loss characteristics of sub-band frequency (upstream) signals.

In looking over the LAN charts, it is apparent that several manufacturers use CSMA for upstream access. Some offer a full 6 MHz superchannel and some a fractional (eg: 300 KHz) superchannel within which the contention must take place. A discussion of the pros and cons of these two approaches reveals several major differences between them.

In a full channel design, a large group of users share the same upstream superchannel and corresponding complementary downstream superchannel. They are able to "talk" to one another using only the CSMA access protocol. Narrower superchannel systems have difficulty accommodating an interactive user group of the same approximate size. This is because, for each communications session, users must not only use CSMA, they must also agree which of the several possible narrow superchannels to employ.

While they are communicating within a selected superchannel, they are temporarily out of touch with the rest of the larger group. Frequency agile modems are required to give the larger group access to one another.

Not only is the access protocol complicated by the additional need to control frequency agility, the entire communications data rate is limited by the narrower bandwidth of the superchannel. This limitation can typically limit the use of high data rate physical interfaces, such as the RS-449 standard. In order to overcome this type of limitation, some manufacturers provide two separate networks operating on the same coaxial cable. Bridgers are then required to establish links between the two networks. Bridgers represent possible single points of failure and add complexity and cost to the networking operations.

If two or more users have to share the same LIU and if this LIU has only one frequency agile modem, then these users are not only contending for time within a channel, they are also contending for the frequency setting of their shared modem.

12.2 TOKEN PASSING

The sequential ring of subscribers, through which the "permission-to-transmit" token is passed, can be formed as a physically linked circle of Local Interface Units. It can, however, also be created out of a network of any shape by means of an arbitrary routing procedure:

A passes the token to B, B to C, C to D, etc., even though A, B, C and D are located far apart. This is called a virtual ring. Any sequential polling system can be said to create a virtual ring out of the polled subscribers.

Note that simple polling does not give each polled terminal the right to transmit for an above-average duration. In a simple polling system, the expected messages are of fixed maximum length. Token passing gives a measure of control to the terminal to hold onto the channel until the transmission is completed. This access protocol is useful where a system of user priorities must be established. Certain users can be given terminals offering special privileges to "hog" the channel.

Token rings can suffer from initialization and clock coordination problems when power is first switched on. This problem increases with the size of the ring.

Because each link in a physical token ring network is a separate entity, it is possible to engineer interfaces for different media between different pairs of adjacent terminals. This feature of a physical token ring would enable, for example, a fibre optic link to be spliced into a ring, which in other sections employs coaxial cable. Remember that physical token rings have separate input and output ports on their Local Interface Units (see page 8 for illustration).

13. NETWORK MAINTENANCE

As cable operators in the United States begin to offer high speed data communications to commercial users, both parties face the problem of network maintenance and the division of responsibility. One issue that surfaces frequently concerns the ownership of cable data modems. This can be looked upon as a most general issue affecting any data communications network. In its broadest interpretation it is a question of who should own the Local Interface Units for a Local Area Network.

One school of thought argues that the cable operator should simply lease channel space on the coaxial network and have the end user own and maintain all interface equipment, including the data modems. Proponents of this approach point out that it relieves the cable operator of a large volume of capital expense. End users can arrange service contracts with manufacturers or third parties. The analogy often drawn is that of the telephone interconnect market. In this light, the ownership of coaxial cable modems is looked upon as the same type of issue as that concerning the ownership of telephone data modems.

On more careful examination, however, the analogy breaks down and exposes a fundamental difference between switched telephony interconnect issues and those of the cable industry. The difference is in the ability of a star-shaped telephone network to isolate individual subscribers whose terminal or interconnect equipment might be malfunctioning. It is an easy matter to disconnect the subscriber loop in such situations thus ensuring that the remainder of the subscribers can carry on their communications undisturbed. This is not the case when dealing with broadband coaxial cable plant.

A malfunctioning or unauthorized cable modem can detract from the integrity of the network by causing interference with channels required by other users. If a cable operator is to retain responsibility for some of the services being provided over the coaxial plant, then steps must be taken to control or remove any local interference as quickly as possible.

Manhattan Cable, who in 1981 contracted with the City of New York to transmit data on their coaxial data network instead of on the nine high speed Bell System lines previously used, maintain a strict policy of modem ownership. So also does Cable Systems Pacific with approximately 40 customers on almost 900 miles of institutional cable.

Admittedly the supervision and maintenance of network service quality implies creating suitably trained trouble shooting teams with the necessary inventory of monitoring equipment, test sets and possibly order-wire communications facilities. Adequate quantities of spare modems and spare interface units are also required and the network might need standby pairs of channels for temporary use.

If one modem has to be replaced, it might prove to be most practical to recall a modem pair for a complete laboratory check-out. The sparing of modems thus becomes slightly more costly. Should tests reveal that it is not the modem pair but the cable system channel itself that is at fault, then it might be necessary to assign differently tuned modems operating on a standby pair of channels. Such service provisions are only possible under cable operator control.

When planning the data service, an operator might well consider the advantages using frequency and speed agile modems. Then, if one fails, a spare can be created by retuning and perhaps by resetting the data speed at which the modem operates.

Frequency agile modems can, in general, be retuned to operate within the passband of one CATV channel. Even so this gives a large measure of freedom to search for clear channels. One of the obvious problems concerns who has control of the frequency agility. Should it be relatively easy to change frequency, this might be attempted by the subscriber, even though the cable operator might own the modem.

Similarly if the data speed of a modem can be adjusted on the unit itself, by means of say a dipswitch, there will be an obvious temptation presented to the subscriber to use the highest speed possible. If such freedom is unbounded, the network operator might find it difficult to set a rate structure for the service based on user data rates.

The usual means of retuning and of changing the operating speed of a modem is for the subscriber to preset a manual switch as required. A more elegant and powerful method is to permit such retuning to take place automatically either under the command of signals sent to the modem from the subscriber's terminal or directly from the headend. Some standardization questions remain to be answered, however, concerning a suitable protocol for achieving such remote control.

The amount of automatic (remotely controlled) modem frequency and speed agility allowed for across, for example, an RS-449 physical interface is small compared with the range of possibilities found in modern broadband RF cable systems. This is not surprising considering the limited use for such agility in most telephony applications. On a typical telephone connection, for example, the speed and frequency agility of the subscriber's modem might be used simply to switch between full-duplex and half-duplex operation. A more serious limitation for the purpose of the present discussion is that this automatic interface is on the side of the modem facing the subscriber. For headend remote control a completely new approach might appear to be called for. The whole design philosophy for remote controlled agile cable data modems might follow that of the addressable cable pay-TV descrambler. This type of smart modem would then more correctly be called a Local Interface Unit.

The above discussion has raised examples of some of the new issues that must be dealt with when planning a multi-client cable data communications network. The new areas of responsibility certainly involve additional investments and expenses. But these should be looked upon as business opportunities.

The additional cost of taking responsibility for overall network maintenance can of course be recouped. The obvious vehicle for achieving this is by a suitably structured rate schedule augmented perhaps by some installation and service charges. A secondary source of revenue can be created simply by the continued growth of the subscriber base if the network offers first class maintenance and minimum downtime. Because of the critical nature of digital communications, a reputation for good network maintenance can be expected to become the single most important distinguishing feature of a successful operator.

14. CONCLUSIONS

As reflected by the material presented in this report, new system and product developments are occuring in several significant cable data communications areas: Local Area Networks, Metro Area Networks, Teletext, Videotex, Telemetry and Pay-TV. The activity is recent. Many of the manufacturing companies involved were not even incorporated in the 1970's. The standardization issues are being dealt with by committees convened for the first time in the 1980's.

A survey of these developments reveals the complexity of data communications technology and its evolutionary bond with the computer industry. Indeed, the solid groundwork laid down by the International Standards Organization in 1961, when it established the X3 Committee on Computers and Information Processing, promises to pay handsome dividends as its seven-layered Open Systems Interconnection (OSI) reference model gains widespread recognition and acceptance.

It is apparent that the development of communications standards in North America normally follows moves initiated by the private sector in the United States. None-the-less the Canadian federal government has taken considerable initiative in its successful efforts to promote the Telidon standard for alphageometric graphics within the North American Broadcast Teletext Standard (NABTS). The momentum gained in this direction is clearly the beginning of what could become a more broadly defined set of standards for full Videotex services.

The Canadian cable industry's participation in the development of both Vertical Blanking Interval (VBI) and full field Teletext and Videotex services is of particular importance in view of the high (60%) penetration of cable to households throughout the country. It is possible, in the foreseeable future, that a "North American Cable Videotex Standard (NACVS)" might be created to further the development of two-way and perhaps hybrid data services to homes and small businesses. Such a standard would probably combine NABTS with recommendations issued by the IEEE 802.6 subcommittee on Metropolitan Area Networks.

It would be premature to recommend exactly what roles the government and private sectors might play in achieving a set of standards for cable videotex services. Probably the wise approach is to encourage both sectors to experiment, to stay informed and to discuss their interests in the fullest possible detail with each other. By funding a study such as this, the Department of Communications has already played a most constructive role in furthering discussion and the exchange of informed opinion.

The issue of frequency allocation for CATV data services is certainly a candidate for further work. Optimum use of the sub-band for upstream data signalling and of the experimental and FM bands (for example) for downstream data traffic are areas worthy of careful study.

Ancillary data signalling within the VBI and on supplementary carrier facilities represents another category of possible research. Of especial interest are the compatibility questions raised when several such new ancillary signals are carried simultaneously.

At the beginning of this report, it was pointed out that the material collected could be looked upon as a shopper's guide to cable data products. As such it is a first step towards a rational appraisal of a series of new business opportunities for many sectors of the economy. A logical follow-on to this work could be undertaken by both private and government sectors to evaluate the viability of the various service enterprises that the new data communications technologies suggest.

Given the support of an informed regulatory climate, many new opportunities for wealth creation could be found within Canada's emerging information economy. Encouragement to invest and develop these opportunities can only come from the elected government. The cable industry stands ready to play its part in the development of domestic and foreign markets. Let us hope that the balance of the decade will find Canada strong on encouragement and active, but judicious, in all aspects of standardization.

APPENDIX 1

LOCAL AREA CABLE DATA NETWORKS

SYSTEM SPECIFICATIONS CHARTS

CHARTS A1 & A2:
Transmission & Distribution Parameters

CHARTS B1 & B2:
Network Features

A1 - TRANSMISSION & DISTRIBUTION

DESIGN AUTHORITY	SYSTEM	NETWORK ARCHITECTURE		SUPER-CHANNEL PARAMETERS							INDIVIDUAL CHANNEL ACCESS METHOD		NUMBER OF SYSTEMS IN USE
	and year of availability	TYPE	MAX RADIUS Km	MODUL-ATION TYPE	SUPER CHNLS SPACED	DOWNSTRM ALLOC-ATION	UPSTREAM ALLOC-ATION	Bps per Hertz	BER & CNR	DATA RATE Mbps	ACCESS METHOD	LINE PROTOCOL	
Concord Data Systems	Token/Net 1st QTR 84	mid split BUS	40	AMPSK (IEEE 802)	6 MHz	P Q,R,S,T.	59.75 to 65.75MHz etc. to 89.75MHz	0.83	10^{-8} at 36 dB	5	TDMA/token passing (IEEE 802 ECMA)	as per IEEE 802 and ECMA	alpha sites
Contel Inform-ation Systems	ContelNet (800 Series)	mid split TREE	8	FSK	6 MHz	156 MHz to 300 MHz	12 MHz to 156 MHz	0.33	10^{-9} at 30 dB	2	CSMA/CD, token passing (IEEE 802)	as per IEEE 802	?
	High Speed	mid split TREE	8	QPSK	12 MHz	156 MHz to 300 MHz	12 MHz to 156 MHz	0.83	not avail-able	10	CSMA/CD, token passing (IEEE 802)	as per IEEE 802	?
Gould	Modway 3rd QTR 83	CATV BUS	5 active 2.5 nonamp	*	6 MHz	*	*	*	*	1.544	token passing similar to IEEE 802	extended HDLC similar to IEEE 802	?
LDD M/A COM	CAPAC	mid split TREE	no limit	DQPSK	2 MHz	160 MHz to 300 MHz	6 MHz to 120 MHz	1.05	10^{-8} at 26 dB	2.1	FDM/TDM downstream FDM/TDMA upstream	frame; demand assignment upstream	3 systems
Phasecom	Intelligent Cable Network (ICN)	dual mid 802 SUB TREE	4 to 80*	VSBASK	6 MHz	50-440, 160-440, 162-300, 50-440.	50-440, 5-120, 5-108, 5.75--29.75	0.26	10^{-13}	1.544	CSMA/CD	X.25	beta sites
Sytek	Localnet 20	mid split or sub split TREE	50	FSK	300KHz	226-262 midsplit 226-244 subsplit	70-106 midsplit 10-28 subsplit	0.43	10^{-9}	0.128	CSMA/CD	HDLC derivative	300 systems 10,000 units
	Localnet 40		10	FSK	6 MHz			0.33	10^{-13}	2.0	CSMA/CD	HDLC derivative	5 alpha sites: 20 units
3-M/IS	Videodata	mid/ sub split TREE	no limit	FSK	800KHz	216 to 246 MHz	23.75 to 53.75 MHz	0.125	10^{-9} at 30 dB	0.1	FDM/TDM	auto poll	300 systems in US & Europe
	Videodata LAN/1 3rd QTR 83	mid split TREE	11	CPFSK	6 MHz	0 to S	2, 3, 4, 4A & 5.	0.417	10^{-13} at 26 dB	2.5	token passing	non IEEE 802	beta sites

* see notes on chart C1

? information not available

A2 – TRANSMISSION & DISTRIBUTION (continued)

DESIGN AUTHORITY	SYSTEM and year of availability	NETWORK ARCHITECTURE: TYPE	NETWORK ARCHITECTURE: MAX RADIUS Km	SUPER-CHANNEL PARAMETERS: MODUL-ATION TYPE	SUPER CHNLS SPACED	DOWNSTRM ALLOC-ATION	UPSTREAM ALLOC-ATION	Bps per Hertz	BER exp't & CNR	DATA RATE Mbps	INDIVIDUAL CHANNEL ACCESS METHOD: ACCESS METHOD	LINE PROTOCOL	NUMBER OF SYSTEMS IN USE
Ungermann Bass	Net/One	mid split TREE	16	AM	6 MHz	156 to 300 MHz	5 to 120 MHz	0.833	10^{-9} at 26 dB	5.0	CSMA/ED (IEEE 802)	HDLC derivative (IEEE 802)	13 CAN, 200 US, +100 other.
Wang	Wangnet Interconnect Band	dual cable TREE	22	FM&FSK	20 KHz to 187.5 KHz	10-20.6 and 49.6 to 81.6MHz	10-20.6 and 49.6 to 81.6MHz	0.48 to 0.34	?	1200 bps to 64 Kbps	FDM & TDM	Polling for FAM. Requests by data sw	approx 20 full systems plus many individ-ual service band install-ations
	Peripherals Band			?	8 MHz	97.5 to 145.5 MHz	93.5 to 149.4 MHz	0.534	?	4.27	FDM & TDM	band polling	
	Wang Band			PSK	27 MHz	216 to 243 MHz	216 to 243 MHz	0.4 apprx	?	10	CSMA/CD	HDLC	
	Utility Band		no limit	—	6 MHz	channels 7 to 13: 174-216 MHz	channels 7 to 13: 174-216 MHz	—	—	—	—	—	

B1 - NETWORK FEATURES

DESIGN AUTHORITY	SYSTEM and year of availability	INDIVIDUAL USER PORTS: TOTAL PORTS MAX	INDIVIDUAL USER PORTS: PORTS/SUPER CHNL	NUMBER OF SUPER CHANNELS: DOWN STREAM	NUMBER OF SUPER CHANNELS: UP STREAM	NETWORK CONTROL FEATURES: CONTROL MANGER OR MONITOR: NAME	NETWORK CONTROL FEATURES: CONTROL MANGER OR MONITOR: LOC	EVENT AND STATS KEPT?	FAULT DIAGNOSTIC HELP?	PRIORITY USERS/CHNLS?	DATA SECURITY ENCRYPTION ?	DYNAMIC CONTROL OF LIU PARAMETERS?	GATEWAYS AVAILABLE FEATURING SPECIAL PORTS & SOFTWARE ?	TRANSLATOR NEEDED ?	APPROXIMATE COST: NETWORK $ US	APPROXIMATE COST: PER PORT $ US
Concord Data Systems	Token/Net 1st QTR 84	no fixed limit	no fixed limit	5	5	NHP 1 needed minimum	DIST	yes	yes	yes	yes	yes	currently not available	yes	6,500	500 to 2,000
Contel Inform-ation Systems	ContelNet FSK (800 series)	4K	250 BIU's	1	1	NCC optional	DIST	yes	yes	yes	yes	yes	TTY X.25	yes	5,500 to 20,000	625
	ContelNet QPSK (High Speed)												Ethernet		?	?
Gould	Modway 3rd QTR 83	10K	10K	1	1	Network Control-ler	CENT	yes	yes	no	no	yes	X.25	?	?	500 to 4,000
						Network Manager	DIST									
LDD M/A COM	Capac	8.13K	255	60	60	Network Control-ler	CENT	yes	yes	no	yes	yes	supports all types by means of synchroniz-ation method	yes	43K	3K approx
						MIU optional	DIST								25K	
Phasecom	Intelligent Cable Network (ICN) mid-split	19.4K apprx	1020	19	19	425M ICN	DIST	yes	yes	yes	yes	yes	no	yes	3,975	1K
Sytek	LocalNet 20	24K apprx	200 approx	120	120	NCC	DIST	yes	yes	yes	yes	yes	X.25	yes	20K to 25K	500
	LocalNet 40	*	*	5	5	—	—	—	—	—	—	—	Broadway (DECNET)	yes	see Loc-alNet 40/100	—
3-M/IS	Videodata	9176	248	37	37	CCM model 310	CENT & DIST	no	no	no	no	partial	X.25	no & yes	2145	460 to 1,300
	Videodata LAN 1	10K	2K	5	5	Network Monitor (IBM PC)	DIST	yes	part-ial	no	no	yes	no	yes	4300 sftware only	425 to 825

B2 – NETWORK FEATURES (continued)

DESIGN AUTHORITY	SYSTEM and year of availability	INDIVIDUAL USER PORTS: TOTAL PORTS MAX	INDIVIDUAL USER PORTS: PORTS/SUPER CHNL	NUMBER OF SUPER CHANNELS: DOWN STREAM	NUMBER OF SUPER CHANNELS: UP STREAM	NETWORK CONTROL FEATURES: CONTROL MANGER OR MONITOR: NAME	CONTROL MANGER OR MONITOR: LOC	EVENT AND STATS KEPT?	FAULT DIAGNOSTIC HELP?	PRIORITY USER CLASS?	DATA SECURITY ENCRYPTION ?	DYNAMIC CONTROL OF LIU PARAMETERS?	GATEWAYS AVAILABLE FEATURING SPECIAL PORTS & SOFTWARE ?	TRANSLATOR NEEDED ?	APPROXIMATE COST: NETWORK $	APPROXIMATE COST: PER PORT $
Ungermann Bass	Net/One	36K	7.2K	5	5	Network Config'n Facility (NCP)	DIST	yes	yes	yes	no	yes	All common carrier services (eg: X.25)	yes	8,490 (CAN)	650 (CAN)
Wang	Interconnect Band: 64 Kbps service	–	–	16	16	–	–	–	–	–	–	–	–	no	–	1,200
	Interconnect Band: 9.6Kbps service	–	–	64	64	–	–	–	–	–	–	–	–	no	–	850
	Interconnect Band: switchd service	512	1	256	256	data switch unit	DIST	yes	yes	no	station lockout	no	no	no	12,000	1,300 for 512 ports
	Peripheral Band	192	32	6	6	band polling unit	DIST	no	no	no	station lockout	no	no	no	2,300 to 4,100	peripher-al depend't
	Wang Band	16K	16K	1	1	CIU	DIST	yes	yes	no	no	no	no	no	3,800 per CIU	depend't on system
	Utility Band	–	–	7	7	–	–	–	–	–	–	–	–	–	–	–

APPENDIX 2

LOCAL AREA CABLE DATA NETWORKS

LOCAL INTERFACE UNITS

CHART C1:
Manufacturers (A to S)

CHART C2:
Manufacturers (T to Z)

DESIGN AUTHORITY	SYSTEM	LOCAL INTERFACE UNIT MODEL	MAX NO OF USER PORTS /LOCAL INTERF UNIT	PORT DATA RATE bps	PORT INTERFACE	PORT PROTO -COL	FREQ AGILE	NOTES	APPROXIMATE COST OF LIU QUANTITY	APPROXIMATE COST OF LIU $ US
Concord Data Systems	Token/Net	TIM-200	2	75 to 19.2K	EIA RS-232-C (CCITT Rec V.24)	FD: async sync	yes	Smallest base unit. Port data rate up to 9.6 Kbps for synchronous operation via RS-232 interface,	each	3,485
		TIM-220	2 to 10					Similar to TIM-200 except it provides 2 extra optional board positions. (see last 2 rows of this Concord entry)		3,950
		TIM-800	2 to 32					Rack-mounted assembly (EIA 19") with up to 8 optional board positions.		not available
	options	Quad Board	4				—	Quad serial board and high speed serial board can be added to any TIM unit. Additional NMP can be added to network.		995
		High Speed Board	1	56K to 230.4	EIA RS-449 (CCITT V.35)	FD: sync				500
Contel Inform -ation Systems	ContelNet 800 series	BIU	4 to 16	up to 19.2K	RS-232-C parallel port	FD:HDLC SDLC async & BSC	no	Future products will operate at 56 Kbps. Baseband version also available (series 700). Token-passing model not yet available.	each	2,500 to 7,000
Gould	Modway	?	?	up to 1.54M	RS-232-C with special control -er interfaces	FD:HDLC SDLC async & sync	no	Port interface supports special industrial controller protocols. * Customer users own modem.	each	?
LDD M/A COM	Capac	Subscriber Unit	32	1.2K to 2.048M	RS-232-C RS-449	FD: sync	no	Demand or fixed assignment of upstream channel allocation. Async statistical mux available. Additional port cards: $800 each.	each	5,250
Phasecom	Intelligent Cable Network	425 ICN	4	50 to 19.2K	RS-232-C 12 bit parallel	FD:SDLC async, sync, BSC, & mono-sync	yes	Unit is entirely self-contained and behaves like a modem to the user. * Model 425-G offers gateway to geographically large networks using a polling access technique.	each	3,975
Sytek	LocalNet 20	LocalNet 20/100	2	75 to 19.2K	EIA RS-232	FD:sync async BSC	yes	Sub-split system has half superchannels as mid-split.	each	1,090
		LocalNet 20/200	8	75 to 9.6K		FD: async	yes	Queuing functions & rotary functions offered in the transmit mux port selection process. * 64K max - 24K ports for optimum throughput.		3,750
	LocalNet 40	LocalNet 40/100	256	up to 345K	unique interface (DEC compatible)	FD: Sytek	yes	Offers basic datagram service, transaction, stream-transfer, DMA to/from host. * No limit on number of units per channel (dependant on user/host system).		10,000

Note: From the user side, the local interface unit appears to function as if it were a simple modem. It differs in having built-in "network control" intelligence.

DESIGN AUTHORITY	SYSTEM	LOCAL INTERFACE UNIT MODEL	MAX NO OF USER PORTS /LOCAL INTERF UNIT	PORT DATA RATE bps	PORT INTERFACE	PORT PROTO -COL	FREQ AGILE	NOTES	APPROXIMATE COST OF LIU QUANTITY	$ US
3-M/IS	Videodata	Model 810	2	up to 100K	an 8-bit // port provided and one optional extra	FD	no*	* Freqency agility available using Model 460. (selects one of 6 pairs of data channels)	each	810
		Model 820	4	150 to 19.2K	RS-232-C	FD: async		RTS/CTS protocol		1,860
		Model 830	1	150 to 9.6K		FD: async		RTS/CTS protocol		1,190
	Videodata LAN/1 3rd QTR 83	NIU	2	110 to 19.2K		FD:HDLC SDLC async sync	no	4 Kbytes/port. IEEE 802 compatible at user port only. Chaining of NIU's possible. Local data packetizing with echo feature.		1,400
		NIU	4							2,100
		NIU	8							3,200
Ungermann Bass	Net/One	NIU 150	6	up to: 6K, 19.2K, 56K, 900K, 2M.	V.35 RS-232-C RS 449/422 IEEE 488	FD:HDLC SDLC async sync	yes	Bridges available for: BB-to-RF, RF-to-RF, and (BB or RF)-to-fibre-optics virtual connections. User flexibility via choice of interface cards.	each	2,870 =3.1K CAN taxes inc
		NIU 2	24		32 bit DMA	BSC DR 11W	no	User can select up to 4 DMA channels. A 6-port RS-232 interface card costs $1K (CAN)		8K CAN taxes inc
Wang	Intercon'ct Band: 64Kbps	FFM 64449	1	9600 to 64K	EIA RS-449 CCITT V.35	FD: async sync	no	Dedicated fixed frequency modem service. Equivalent to leased line support. Requires 48 MHz pilot to operate.	each	1,200
	Intercon'ct Band: 9600bps	FFM 96232	1	1200 to 9.6K	EIA RS-232-C CCITT V.24		no	Dedicated fixed frequency modem service. Equivalent to leased line support. Requires 9.21 MHz pilot to operate.		850
	Intercon'ct Band: switched	FAM 96232	1		RS-232-C / V.24 RS-366 / V.25 (auto-dial)		yes	Dial-up data service by using keypad on FAM. Auto-dial & auto-answer optional support. Polled for FAM connect requests. 48 MHz pilot.		1,250
	Peripherals Band	Netmux Unit	8	Wang	Wang VS and OIS or alliance serial periph'ls	Wang	yes	Single Wang work station units (serial) can be connected by WN2 & WN3 units. Multiple bands reusable by means of Wang diplexers.		1,050
	Wang Band	CIU	1	12Mbps	Wang VS and OIS Master Units (serial)	Wang	–	High Speed Communications Band. Each CIU can handle up to 24 virtual circuits.		3,800
	Utility Band	–	–	–	–	–	–	Provided for user-defined video communications.	–	–

Note: [redacted]he u[redacted]e, th[redacted]l in[redacted] unit[redacted]rs t[redacted]ion a[redacted]t wer[redacted]mple [redacted]
It differs in having built-in "network control" intelligence.

APPENDIX 3

CABLE DATA NETWORKS

DATA MODEM SPECIFICATION CHARTS

CHARTS D1:
Manufacturers (A to E)

CHARTS D2:
Manufacturers (F to T)

CHARTS D3:
Manufacturers (U to Z)

DESIGN AUTHORITY	MODEL	MODULATION	CHNL BAND WIDTH KHz	DUPLEX CCTS PER UP&DWN TV CHNL PAIR	CHANNEL ASSIGNMENTS			SIGNAL LEVELS		DATA TRNSMN PERFORMANCE		TRANSLATOR REQUIREMENTS		PORT SPECIFICATION			COST OF MODEM (approx) $
					CHOICE DOWN STREAM	CHOICE UP STREAM	FREQ AGILE Y/N	MAX TXM dBmV	MIN RCV dBmV	Bps per Hz	BER exp'nt & CNR	OFFSET MHz	avail Y/N?, model	DATA FORMAT(S)	DATA RATES bps	DATA INTER-FACE	
Catel	Series 3000	FM PCM	16000	6 for mid split system	14 MHz to 450 MHz	14 MHz to 450 MHz	yes being added	+54	-10	0.5 to 1.2	–	any	yes 3000	FD	up to 19.7M	coax BB input	6,550 CAN
	Series 2000				62 MHz to 334 MHz	62 MHz to 334 MHz	no		+10		–						5,000 CAN
	DM 2100S		200	15	4 MHz to 200 MHz	4 MHz to 200 MHz	no	+45	-10	0.145	10^{-8} at 25 dB			FD: async sync	2.4K to 28.8K	RS232 V.24	2,935 CAN
C-Cor	7130	ASK	21 for 19.2 Kbps	120	T11 to 13	T7 to T13	no	+45	-20	0.457	10^{-8} at 16 dB	any	no	FD: async	300 to 19.2	RS232	625
	7120 voice	AM	21, to 50 for 10KHz	120						–	–	any	no	FD	base-band to 10KHz	2 or 4 wire	675
Computrol	11-0020	CPFSK	6,000	1	T14	T14	no	+60	0	0.167 0.257	10^{-12} at 20 dB	dual cable	no	FD: async FD: sync	0 to 1Mbps 1.54M	TTL	755
Comtech	CDM 1120	QPSK	?	?	52 MHz to 88 MHz	?	no	?	?	?	10^{-7} at 13.4 dB	?	no	?	up to 1.54M	CCITT V.35	?
	M500C (M500 is three units in one)	QPSK	0.7x data rate	data rate dep'nt	5 MHz to 440 MHz	5 MHz to 440 MHz	no	+45	-12	1.4	10^{-9} at 30 dB	any	no	FD: sync	56K to 10M	V.35 RS449 DS1/2	4,650
E-Com	TRM-202	3 level PSK	100	30	5 MHz to 250 MHz	5 MHz to 250 MHz	no	+40	-20	0.096	10^{-7} at 30 dB	any	no	FD: async sync	50 to 9.6K	RS232 or current loop	800
	TRM-159 High Speed	4 level DSSC	funct of bit rate	funct of bit rate	5.75MHz to 350 MHz 8 or O typical	5.75MHz to 350 MHz T7 or T8 typical	no	+50	funct of bit rate	1.0	funct of bit rate	any	no	FD: sync	9.6K to 1.54M	RS232 MIL-188 Bell 303 CCITT V.35 TTL DS-1	4K to 6K

DESIGN AUTHORITY	MODEL	MODUL ATION	CHNL BAND WIDTH KHz	DUPLEX CCTS PER UP&DWN TV CHN PAIR	CHANNEL ASSIGNMENTS: CHOICE DOWN STREAM	CHANNEL ASSIGNMENTS: CHOICE UP STREAM	CHANNEL ASSIGNMENTS: FREQ AGILE Y/N	SIGNAL LEVELS: MAX TXM dBmV	SIGNAL LEVELS: MIN RCV dBmV	DATA TRNSMN PERFORMANCE: Bps per Hz	DATA TRNSMN PERFORMANCE: BER exp'nt & CNR	TRANSLATOR REQUIREMENTS: OFFSET MHz	TRANSLATOR REQUIREMENTS: avail Y/N?, model	PORT SPECIFICATION: DATA FORM-AT(S)	PORT SPECIFICATION: DATA RATES bps	PORT SPECIFICATION: DATA INTER-FACE	COST OF MODEM (approx) $
Gandalf	Series LDS 520	NSFK	100	37	J, K	T10,T11	no	+45	-15	0.125	10^{-9} at 30 dB, 26 KHz	192.25	?	FD,HD async sync	up to 9.6K	EIA	1,800 CAN
	Series LDS 525	NBFSK			7, J to N	T9 to T14				0.120	noise band-w	156.25 and 192.25		FD,HD async			1,225 CAN
	Series LDS 530	NFSK	800	3.75	J to N	T10 to T14				0.125	10^{-9} at 30 dB, 200KHz	192.25			up to 100K		1,895 CAN
	Series LDS 560									0.120	noise band-w			FD,HD sync			2,010 CAN
	Series LDS 565									0.125				FD: sync		V.35	2,495 CAN
Phasecom	401	BPSK	50	60	H to 13 or 11 to O	T7 to 2A	yes	+35	-26	0.385	10^{-10} stated input level	192.25	yes for 4100 modls	FD,HD async sync	110 to 192K	RS232 V.24	825
	415		2,200	1	H to 13 or 11 to EE	T7 to C	no	+45	0	0.7		192.25 or 156.25		FD: sync	T1, 2.048 Kbps optnl	DS-1 NATD HDB RS232	1,750
	460 voice	FM	25	120	K, L	T11,T12	yes	+35	-26	0.385	10^{-10} stated input level	156.25		FD	300 to 3KHz BW	2 or 4 wire	<1,0000
Scient -ific Atlanta	6402	QASK 16	750	4, 3 with adj'nt video	162 MHz to 440 MHz	5 MHz to 120 MHz	yes	+50	-10	2.1	10^{-9} at 33 dB	156.25	yes for model 6441	FD: sync	T1 1.54M or T2 6.3M	RS442 RS449 V.35 DS1.052	T1: 3,665 T2: 4,780
3-M/IS	920	NFSK	100	37	7, J to N	T9 to T14	no	+45	-15	0.125	10^{-9} at 30 dB, 26 KHz	156.25 and 192.25	yes 450	FD,HD async sync	50 to 10K	RS232	890
	925/926	NBFSK			7 J K	T9 T10 T11				0.120	noise band width			FD,HD async	50 to 9.6K		590
	930	NFSK	800	3.75 approx	J to N	T10 to T14				0.125	10^{-9} at 30 dB, 200KHz	192.25			50 to 100K		925
	960									0.120	noise band width			FD,HD sync	1.2K to 96K		980
	965/966									0.125				FD sync	48,50 56 & 100K	V.35	1,190
	520 Audio	AM	60	50	H	T7				—	—	156.25		FD	100 to 6 KHz	2 or 4 wire	870

CHART D3 – DATA MODEM SPECIFICATIONS

DESIGN AUTHORITY	MODEL	MODULATION	CHNL BAND WIDTH	DUPLEX CCTS PER UP&DWN TV CHN PAIR	CHANNEL ASSIGNMENTS			SIGNAL LEVELS		DATA TRNSMN PERFORMANCE		TRANSLATOR REQUIREMENTS		PORT SPECIFICATION			COST OF MODEM
			KHz		CHOICE DOWN STREAM	CHOICE UP STREAM	FREQ AGILE Y/N	MAX TXM dBmV	MIN RCV dBmV	Bps per Hz	BER exp'nt & CNR	OFFSET MHz	avail Y/N?, model	DATA FORMAT(S)	DATA RATES bps	DATA INTER-FACE	(approx) $
Ungermann Bass	NM 640	BPSK	96	28	H, I, 7 to 13	T7 to T13, 1A, 2A	no	+40	-20	0.20	10^{-8} at 24 dB	156.25	yes 1009 1009W	FD,HD async sync	110 to 19.2K	RS232 V.24	1,325 CAN
	NM 670	BPSK	192	14	H,I,7	T7, T8, T9		+35	-17	0.292				FD,HD sync	50K & 56K	V.35	3,250 CAN
	NM 722 Audio	FM	24	124	H, I	T7, T8			-30					FD	300 to 3 KHz	2 or 4 wire	800 CAN
Wang	FFM 64449	FM	187.5	16	14.4MHz 17.4MHz 17.6MHz 20.6MHz	10 to 20.6MHz	no	+20	-30	0.34	not avail-able	dual cable	dual cable	FD,HD async sync	9.6K to 64K	EIA 449, V.35	1,200
	FFM 96232	FM	20	64	10.075 11.965 11.995 13.885					0.48					1.2K to 9.6K	RS232 V.24	850
	FAM 96232	FSK	see LAN section under WANG Interconnect Band (switched service)				yes										1,250
	DX 9600 M series	FSK	25	100	H to 11 pilot 325 KHz above bottom TV channel	T7 to T13	yes	+35	-26	0.38	10^{-8} at 24 dB	156.25	yes HE 1100	FD,HD async sync	up to 9.6K	RS232 V.24	1,400 to CATV 1,250 to enduser
Zeta Labs	219	ZPSK	50	50	H to N	T7 to T14	yes	+50	-20	0.40 approx	10^{-8} at 25 dB	156.25	no	FD,HD async sync	up to 19.2K	RS232	?

APPENDIX 4

DATA ENHANCED CATV NETWORKS

NON-PROGRAMMING APPLICATIONS

PART I - ONE-WAY (TELETEXT) SYSTEMS

PART II - TWO-WAY (VIDEOTEX & TELEMETRY) SYSTEMS

IIa - Videotex Systems
IIb - Telemetry Systems

TELETEXT SYSTEMS

DESIGN AUTHORITY	SYSTEM and year of availability	INSTALLED TO DATE: HEAD END EQPT	INSTALLED TO DATE: SUBSCRIBER EQPT	CHARACTERISTICS OF TRANSMITTED SIGNAL: MODULATION	REC'D CARRIER: FREQ MHz	REC'D CARRIER: LEVEL dBmV	DATA LEVELS AS % CARRIER	DATA LINES PER FIELD	NUMBER OF SUB CHNLS	INSTNT DATA RATE Kbps	BAND WIDTH needed MHz	BITS /SEC /HERTZ	THRU-PUT CHARACTERS/SEC cps	ADDRESS-ABLE SYSTEM? (Y/N)	APPROXIMATE COST: per HOME $	APPROXIMATE COST: per HEADEND $
Cabledata	HTU Delivery System 4th QTR 1983	0	0	VSB/AM	normal TV vid	0	75.0 -31.25 =43.75	10 lines per field		3000	6 TDM	0.5	192K	Yes	25 units plus HE offered at $20Kus as experimental (alpha) test site	
EEG	Captioning/Text System 1980	300	70,000 approx	VSB/AM	normal TV vid	0	75.0 -37.5 =37.5	21 odd field	4	503.5	6 TDM	0.08	60 2B/line	No	725 us	6,000 us to 14,000 us
The Games Network	The Games Network **** 4th QTR 1983	0 Huntington Beach, et al introduction	0	?	?	?	N/A	N/A	?	2,000	2.0	1.00	240K approx	Yes	$50us instaln + $14us per mon	offered free of charge
Jerrold /Mattel	Playcable **** 1982	20	10,000 approx	FSK+/- 75Khz dev	107.5 homing ch + 7 others	-15	N/A	N/A	5	14	+/- .2	0.035	12K aprx using 8 channels	No	$199 cmptr $12/mon adaptor	$15K cmptr (PDP-11)
Nabu	The NABU Network **** 1983	1 Ottawa Cable field trial	100	OQPSK	centre of any video chan.	-10	N/A	N/A	31 tiers	6,300	6.0	1.05	750K max per vid channel (6 poss)	Yes	$975 cmptr $10/mon /tier	$140K to $200K
Norpak	Teletext Encoder System (TES-2) 1st models 1979	10	900 approx	VSB/AM	normal TV vid	0	75.0 -31.25 =43.75	1 of 10/20 or FF	4096 data ch's	5727.3	6 TDM or FF	0.95	1.68K to 441K(FF) 28B/line	No	500 Mark IV	90,000 approx
Time Inc Matsu-shita	Time Teletex Service 1982	2 beta sites	100 to 400	VSB/A	normal TV vid	0	75.0 -31.25 =43.75	Full Field	4096 data ch's	5727.3	6 Full Field	0.95	441K(FF) 28 bytes per line	Yes	100 target (10/m)	?
Tocom	Tocom 55 Plus optional subsystem 1984	0	0	VSB/AM	normal TV vid	-10 min	75.0 -31.25 =43.75	17/18 or FF 200 l	1 per TV ch	1736	6 TDM or FF	0.29	0.7K to 138K FF	Yes	375 us approx	?
Vidacom	Vidacom phase I (1-way) 1984	0	0 500 sample plan'd	VSB/AM no vid sync.	normal TV vid	-2 min	100.0 -12.5 =87.5	FF	?	4000	6	1.00	418K max less games data etc	Yes	300 approx	?
Zenith	Z-Text 1984	0	0 900 ex	VSB/AM	normal TV vid	0	75.0 -31.25 =43.75	14-20 or FF	2	5727.3	6 TDM or FF	0.95	1.68K to 441K(FF)	Yes	?	?

(FF = full field)

**** The Games Network, Playcable and the Nabu Network are software (principally computer games) downloading systems

IIa – VIDEOTEX SYSTEMS

DESIGN AUTHORITY	SYSTEM and year of availability	INSTALLED TO DATE: HEAD END	INSTALLED TO DATE: SUBSCR-IBER	DOWNSTREAM: RECD FREQ MHz	DOWNSTREAM: CARRIER LEVEL dBmV	DOWNSTREAM: MODULATION TYPE	DOWNSTREAM: MODULATION BWDTH KHz	DOWNSTREAM: BIT RATE bps	DOWNSTREAM: Bps per Hertz	UPSTREAM: TRXD FREQ MHz	UPSTREAM: CARRIER LEVEL dBmV	UPSTREAM: MODULATION TYPE	UPSTREAM: MODULATION BWDTH KHz	UPSTREAM: BIT RATE bps	UPSTREAM: Bps per Hertz	NODES SERVED and upstr'm protocl	APPROXIMATE COST: PER HOME $	APPROXIMATE COST: PER HEADEND $
Cox Cable	Indax 1981	2 beta sites	300		-15 min	bi- phase	300	28K	0.09			bi- phase	300	28K	0.09	CSMA/CD	300 us target	
Jerrold	Communicom 1984	0	0		-15 min		400	128K	0.32				400	128K	0.32	16,000 homes CSMA/CD		
Packet-cable	Packetcable 1983	0	0	Features strand-mounted Control Processor			6000	2M	0.33				6000	1M	0.167			
Vidacom	The Vidacom Network 1984	1 beta site	450 when cmpltd	108 to 120	-15 min	NRZ nosync	6000	4000K	0.67	any sub band		MSK	1000	500K	0.50	65M homes BTMA/CD	<300 target	

IIb – TELEMETRY SYSTEMS

DESIGN AUTHORITY	SYSTEM and year of availability	INSTALLED TO DATE: HEAD END	INSTALLED TO DATE: SUBSCR-IBER	DOWNSTREAM: RECD FREQ MHz	DOWNSTREAM: CARRIER LEVEL dBmV	DOWNSTREAM: MODULATION TYPE	DOWNSTREAM: MODULATION BWDTH KHz	DOWNSTREAM: BIT RATE bps	DOWNSTREAM: Bps per Hertz	UPSTREAM: TRXD FREQ MHz	UPSTREAM: CARRIER LEVEL dBmV	UPSTREAM: MODULATION TYPE	UPSTREAM: MODULATION BWDTH KHz	UPSTREAM: BIT RATE bps	UPSTREAM: Bps per Hertz	NODES SERVED	APPROXIMATE COST: PER HOME $	APPROXIMATE COST: PER HEADEND $
CableBus	CableAlarm 1980	40 (mostly private)	2,000	73.5	-20 min	FSK +/-50K async	250 spaced	1.2K to 9.6K	0.0048 to 0.0380	31.4	+41 max	CW	30 spaced	1200 to 2400	0.04 to 0.08	17,500 homes 64K pos	110 us	60K us (Micro-1)
E-Com	Tru-Net 100	30 (mostly private)	1,000	any	-20 min	FSK	250	38.4K	0.15	any	+40 max	FSK	250	38.4K	0.15	4,000 homes	635 us i/p inc	7K us comp+modem
	Tru-Net 500 (upper level)	1 beta site		any		FSK	1500	307.2K	0.20	any		FSK	1500	307.2K	0.20	250 areas	1.5K us /area	50K us
	(lower level) 3rd QTR 1983			any	-20 min	FSK	250	38.4K	0.15	any	+40 max	FSK	250	38.4K	0.15	1,000 homes	335 us /home	+area cost as shown.
Jerrold	Cable Security System 1982	2 beta sites	200	FM band	-15 min	FSK	400	13.9K	0.035	T9 2 chs used in //	+50 max	FSK	400	13.9K	0.035	16,000/ headend x8 max	100us plus sensors	10Kus for modem & cmptr + controller
Pioneer	VIP Home Security	1	3,000 approx	121.3	-7 min	FSK	4000	256K	0.064	24.0	+54 max	PSK	6000	256K	0.004	1,000 homes & up	280 us /home	13K us for 1,000 homes & up
Rogers	Rogers Interactive System	2 op +2 beta sites	7,200 mostly poll'g &PPVTV	any	-20 min to COS (COS=Computer-operated switch)	FSK	60	19K	0.32	below 13.0 above 5.0	+40 max	FSK +/-3K	15 x500= 7500 total	2K	0.13	500 hs/ bridger switch	25 us for add on to Z-TAC	100K approx
Tele Eng	Tele-Dat II 1984	1 beta site		A-2 band	-20 min	PWM	2000	9.6K	0.0048	T-10 band	+50 max	PWM	2000	9.6K	0.0048	65,500 homes		
Tocom	Cableguard	1 CAN 3 USA	8,000 approx	217.3 typ	-5 min	FSK +/-.1M	400	56K	0.14	18.2 to 26.2	+55 max	FSK +/-.1M	400	28K	0.07	2,000 to 64,000	150 without sensors	30K approx for 2K hhs

APPENDIX 5

DATA ENHANCED CATV NETWORKS

PROGRAMMING APPLICATIONS

Pay-Television Exhibition Systems (A to M)
Pay-Television Exhibition Systems (N to Z)

PAY-TELEVISION EXHIBITION SYSTEMS (A to M)

DESIGN AUTHORITY	SYSTEM	UNITS INSTAL'D - FEB 1983				SCRAMBLING SYSTEM			TAGGING SYSTEMS			ADDRESSING SYSTEM				APPROXIMATE COST scrambling system included	
		CANADA		USA			RESTORATION										
	and year of availability	HEAD END EQPT	SUBSCR-IBER EQPT	HEAD END EQPT	SUBSCR-IBER EQPT	TYPE	MODULATION TECHNIQUE USED	IN/OUT BAND	NO. DIFF TAGS	MODULATION TECHNIQUE USED	IN/OUT BAND	NUMBER OF SUBSCRIBERS ADDRESSABLE	NUMBER ADDRESSED PER MIN	MODULATION TECHNIQUE USED	IN/OUT BAND	PER HOME $	PER HEADEND $
Cabledata	Home Terminal Unit 4th QTR 1983	0	0	0	0	BB sync den'l	VBI:3 Mb/s	IN		VBI:3 Mb/s	IN			VBI:3 Mb/s	IN	25 units + HE offered at $20Kus as an exptl test bed	
							Features 5 digitally scrambled audio channels + 10 teletext lines/field										
C-Cor	Scat Series 10 strand mounted converter 1983	0	0	0 Orders are being taken for US systs	0	EXTNL SWTCH for 1 ch/HH	N/A		Switched converter can be programmed to provide 20 tiers of channels (no tags)			64,000 per trunk system	3,200	FSK: 120.3 +/-.25 MHz	OUT	$200us	$24Kus for 149K subs $76Kus for 150K+ subs
													Upstream command of convr is 40 MHz +/- 2KHz FSK				
Delta Benco Cascade	Indoor Addressable Tap (IT-1) 1977	Used for control of basic cable service only		Used for apartment SMATV pay-TV applications		SWTCH * see below	N/A		Switched wallplate can control basic plus 6 pay-TV channels (no tags)			127 sectors each with 12,288 taps	5,000 taps	220 MHz to Data Contr-oller FSK 60/120 Hz to taps	OUT	$81	$500 per Sector Commander $3,000 per System Commander
						* Video carrier trap for LO VHF & midband. Hard jamming for HI VHF & superband											
Electro-line	Electronic Addressable System (EAS)	6	?	7 SMATV	?	SWTCH	N/A		Switched multitap controls 3 tiers of channels (no tags)				36,000 taps	73 MHz FSK +/-227 KHz to decoder	OUT	$25 /tap/ tier	$2K
						Hard jamming by injection of interference at multiptap switch assembly										for 400 unit apt	
Hamlin	MLD-1200	14 FE 83 38 MY 83	24K ?	?	800K	RF sync den'l	AM on audio sub-carrier. PLL allows sync restn	IN	any 4 of 12	Equalizing pulses are modified in VBI lines 1&2	IN	N/A	N/A	N/A	N/A	$40 for add-on descr	$1,990 for scrambler
Jerrold	Starcom addressable	9	25K approx	240 apprx	1M mostly c-desc	RF sync suppr	AM on audio sub-carrier	IN	128	AM on audio sub-carrier	IN	250,000	20,000	FSK: 106.5 +/-.075MHz vid-15dB	OUT	$70 add-on	$40,000 per addressing computer
Jerrold	Starcom non-addressable	36	120K approx	200 apprx	500K mostly c-desc	RF sync suppr	AM on audio sub-carrier	IN	8	AM on audio sub-carrier	IN	N/A	N/A	N/A	N/A	$43 add-on	$2,250 per scrambler

PAY-TELEVISION EXHIBITION SYSTEMS (N-Z)

DESIGN AUTHORITY	SYSTEM and year of availability	UNITS INSTAL'D - FEB 1983: CANADA HEAD END EQPT	CANADA SUBSCRIBER EQPT	USA HEAD END EQPT	USA SUBSCRIBER EQPT	SCRAMBLING SYSTEM: TYPE	RESTORATION: MODULATION TECHNIQUE USED	IN/OUT BAND	TAGGING SYSTEMS: NO. DIFF TAGS	MODULATION TECHNIQUE USED	IN/OUT BAND	ADDRESSING SYSTEM: NUMBER OF SUBSCRIBERS ADDRESSABLE	NUMBER ADDRESSED PER MIN	MODULATION TECHNIQUE USED	IN/OUT BAND	APPROXIMATE COST scrambling system included: PER HOME $	PER HEADEND $
Microcom	Stars	29	26K approx	20	?	RF randm syncr suppr	Decryption sync key during VBI line 10&11	IN	8	Details of system not publicly disclosed	IN	N/A	N/A	N/A	N/A		
Oak	Total Control Dimension 1(A)	6	4K approx			RF sw sync suppr	AM on audio sub-carrier	IN	8	AM on audio subc during VBI	IN	8K per $15K computer. 4M maximum.	12,500	AM on audio sub-carrier	IN	$199 conv/ descr	$5K/ scr $3.2K/modr $15K/cmptr
Pioneer	VIP 2-way equipped	0	0	9	400K	RF sw sync suppr	AM on audio sub-carrier	IN	7 +4 PPV	AM on audio subc during VBI	IN	65,000 per hub	18,000 to 60,000	121.35 MHz +/- 5 MHz FSK	OUT	$210us QTY 20,000	$400Kus typical
Scientific Atlanta	Series 8500	0	0			RF sync suppr	AM on audio sub-carrier	IN	Individual channel control via PROM or addressed data to conv/desc (no tags used)			120,000	5,747	FSK:within 108-120MHz	OUT	$120 r/ctrl add-on	Headend prices on request
Sylvania	Pathmaker 4058	0	0			RF sync suppr	91,92 & 93 MHz FM crs +89MHz LO	OUT	Hard-wired prog'mble for pay channel mix (no tags used)			N/A	N/A	N/A	N/A	$85us conv/ desc	$16.8Kus (3 ch)
Telease	MAAST B 3rd QTR 1983	0	0	0	0	BB sync denial plus 5 channels of digitally scrambled audio.	VBI	IN		VBI	IN	16 million	57,000 per VBI line used	2.5 MBps bi-phase during VBI	IN	$175us approx	$50Kus + 25Kus for HP1000 +sw
Texscan	TRACS remote convtr	0	0			EXTNL SWTCH	N/A		Switched converter remotely controlled (no tags used)			20K using Apple II control	1,333	FSK up&dwn .5MHz rqd 19.2Kbaud	OUT		
Tocom	55 Plus	0	0			BB inv'n	Decoding data in VBI 17&18	IN	32 + 4PPV	Tagging data: VBI line 17&18	IN	1 million		Addressing data in VBI 17&18	IN	$58us QTY 25K+	$3K/scrblr $125K prgm controller
Viewstar	PICS 3rd QTR 1983	0	0	0	0	BB rm line delay +sync strip	Decryption key in VBI lines 14 & 262	IN	16 or 32	Tagging data: VBI lines 14 & 262	IN	8.4 million	14,400	Addressing data: VBI lines 14 & 262 at 2.8 Mbps	IN	Prototypes in beta sites. Prices not yet available.	
Zenith	Z-Tac	25	170K approx			BB inv'n +ss	Reversion data in VBI 20	IN	5 to 20	Tagging data: VBI 10,11&12	IN	1 million	10,000	Addressing data: VBI line 13	IN	$80 add-on	$7K scrblr / channel + comptr

APPENDIX 6

CABLE DATA COMMUNICATION EQUIPMENT SOURCES AND USEFUL CONTACTS

LOCAL AREA NETWORK SOURCES:

Concord Data Systems,
303 Bear Hill Road, Waltham,
Massachusetts 02154, USA. tel: (617) 890 1394
Mr. Steve Puchoff, VP Marketing.

Contel Information Systems Inc.,
130 Steamboat Road, Great Neck,
New York 11024, USA. tel: (516) 829 5900
Mr. Norman Brust.

Gould Inc., (Modicon Division, Canada Limited),
1850 Champlain Avenue, Whitby,
Ontario L1N 6A7, Canada. tel: (416) 571 1084
Mr. Peter Anderson, Sales Manager for Canada.

Local Digital Distribution Company / M/A Com,
1350 Piccard Drive, Rockville,
Maryland 20850, USA. tel: (301) 258 8848
Mr. William F. Gray, Director of Marketing - CATV.

Phasecom Corporation,
6365 Arizona Circle, Los Angeles,
California 90045, USA. tel: (213) 645 5622
Mr. Bradford S. Anderson, President Wideband Data Corporation.

Sytek Incorporated,
1225 Charleston Road, Mountain View,
California 94043, USA. tel: (415) 966 7300
Mr. James Hunter, Director of Marketing.

3M/Interactive Systems,
3980 Varsity Drive, Ann Arbor,
Michigan 48104, USA. tel: (313) 973 1500
Mr. James R. Fischer, Manager Tech/Mktg Services.

3M Canada Inc.,
PO Box 5757, London,
Ontario N6A 4T1, Canada. tel: (519) 451 2500 ext 2727
Mr. S. R. Alexander, Project supervisor.

Ungerman-Bass Inc.,
2560 Mission College Boulevard, Santa Clara,
California 95050, USA. tel: (408) 496 0111
Ms. Beverly J. Toms, Manager Corporate Communications.

Ungerman-Bass Canadian Distributor: Impact Information Systems,
402-601 West Broadway, Vancouver,
British Columbia V5Z 4C2, Canada. tel: (604) 875 1466
Mr. Roy L. Pepper.

Wang Laboratories Inc.,
One Industrial Avenue, Lowell,
Massachusetts 01851, USA. tel: (617) 459 5000
Mr. Bob Reason, Communications Product Marketing.

RF MODEM SOURCES:

Catel-Division of United Scientific Corporation,
4800 Patrick Henry Drive, Santa Clara,
California 95054, USA. tel: (408) 988 7722
Mr. Dan Lusky, Special Product Engineering/Marketing.

CATEL DISTRIBUTOR: Source Communications,
48 Galaxy Blvd., Rexdale,
Ontario M9W 6C8, Canada. tel: (416) 675 9222
Mr. John Crisp, Regional Manager.

C-Cor Electronics Inc.,
60 Decibel Road, State College,
Pennsylvania 16801, USA. tel: (814) 238 2461
Mr. John Stedman, Corporate Planning Manager.

Computrol,
15 Ethan Allen Highway, Richfield,
Connecticut 06877, USA. tel: (203) 544 9371
Mr. Garry Stephens.

Comtech Data Corporation,
350 North Hayden Road, Scottsdale,
Arizona 85257, USA. tel: (602) 949 1155
Mr. Allen R. Scharf, Director.

E-Com Corporation,
320 Essex Street, Stirling,
New Jersey 07980, USA. tel: (201) 647 6700
Mr. A. Roy Dietrich, Director of Marketing.

Gandalf Data Communications Limited,
Gandalf Plaza, 9 Slack Road,
Ottawa, Ontario K2G 0B7. tel: (613) 225 0565
Mr. Jeremy F. Skene.

Mitre Corporation,
PO Box 208, Bedford,
Massachusetts 01730, USA. tel: (617) 655 8000
Mr. Bob Fontaine.

Phasecom Corporation,
6365 Arizona Circle, Los Angeles,
California 90045, USA. tel: (213) 645 5622
Mr. Bradford S. Anderson, Pres. Wideband Data Corporation.

PHASECOM DISTRIBUTOR (data products): General Instrument,
220 Byberry Road, Hatboro,
Pennsylvania 19040, USA. tel: (215) 674 4800
Ms. Colleen D'Agostino.

Scientific Atlanta Inc.,
One Technology Parkway, Box 105600, Atlanta,
Georgia 30348, USA. tel: (404) 925 5528
Mr. Bob Schack, Marketing Manager.

Scientific Atlanta (Canada) Limited,
1640 Bonhill Road, Mississauga,
Ontario L5T 1C8, Canada. tel: (416) 677 6555
Mr. John Fazackerley, Sales Manager.

3M/Interactive Systems,
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Michigan 48104, USA. tel: (313) 973 1500
Mr. James R. Fischer, Manager Tech/Mktg Services.

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Mr. S. R. Alexander, Project Supervisor.

Ungermann-Bass Inc.,
2560 Mission College Boulevard, Santa Clara,
California 95050, USA. tel: (408) 496 0111
Ms. Beverly J. Toms, Manager Corporate Communications.

Ungermann-Bass Canadian Distributor: Impact Information Systems,
402-601 West Broadway, Vancouver,
British Columbia V5Z 4C2, Canada. tel: (604) 875 1466
Mr. Roy L. Pepper.

Wang Communications Inc.,
One Industrial Avenue, Lowell,
Massachusetts 01851, USA. tel: (617) 459 5000 ext 4175
Mr. Courtney S. Wang.

Zeta Laboratories Inc.,
3265 Scott Blvd., Santa Clara,
California 95051, USA. tel: (408) 727 6001
Mr. Charles Frank, Director of Marketing.

TELETEXT SYSTEM SOURCES:

Cabledata,
3200 Arden Way, Sacramento,
California 95825, USA. tel: (916) 485 2911
Mr. Ray Matteson, VP Marketing.

EEG Enterprises, Inc.,
1 Rome Street, Farmingdale,
New York 11735, USA. tel: (516) 293 7472
Mr. Edward A. Murphy, President.

The Games Network,
PO Box 36E19, Los Angeles,
California 90036, USA. tel: (213) 932 1950
Mr. Barry Mengdal.

Jerrold Division, General Instruments of Canada Limited,
87 Wingold Avenue, Toronto,
Ontario M6B 1P8, Canada. tel: (613) 789 7831
Mr. Edgar D. Ebenbach, VP Marketing.

NABU Manufacturing Corporation,
2421 Lancaster Road, Ottawa,
Ontario K1B 4L5, Canada. tel: (613) 221 7000
Mr. Rich MacIntosh, VP CCI Marketing.

Norpak Limited,
10 Hearst Way, Kanata,
Ontario K2L 2P4, Canada. tel: (613) 592 4164
Anne McKuage.

Time Video Information Services Inc.,
Time & Life Bldg., Rockefeller Center, New York,
New York 10020, USA. tel: (212) 484 1992
Mr. Larry T. Pfister, Vice President.

Tocom Inc.,
PO Box 47066, Dallas,
Texas 75247, USA. tel: (214) 438 7691
Mr. Wayne Churchman.

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