SELECTABILITY OF CATV SERVICES

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PREPARED AT CABLESYSTEMS ENGINEERING

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CONTENTS

Contents - Continued

EXECUTIVE SUMMARY

Different types of services and systems have different needs and degrees of selectability. To determine how well a system meets the service needs, certain dimensions of selectability have been defined. The three major dimensions of selectability are content, timing, and billing. A high degree of selectability is appropriate for services which have high incremental costs and low penetration.

In evaluating possible delivery mechanisms, only systems which may have significant impact in CATV systems in the next ten years are considered. It is the opinion of the authors that fibre optics will not play a major role in CATV distribution systems in this time frame.

The present service offered on a CATV system is video programming. The service has a high penetration and services (channels) can be added or subtracted at a low incremental cost. The exception to this is the community channel which has a significant incremental cost. The present CATV network configuration provides an efficent, low cost means of providing many television channels. With any alternate delivery scheme, the "average subscriber" would pay more and get less service. Although the subscriber is presently restricted to choosing from among what is offered, he, in fact, has a large content choice. Timing selectability is low as the subscriber must meet the broadcast schedule. Timing flexibility is available with the use of a home video tape recorder. The billing system is flat rate and indicative of the CATV cost structure, which is fixed. Increased selectability for the presently offered service has marginal benefits and high costs.

For some future services, more selectability may be appropriate, especially for services which have high incremental costs such as PAY TV. When this selectability is reasonable, descramblers or descrambler/converters are the preferred delivery mechanism because they are flexible and upgradeable. Because they are used for the security of billing, it is imperative that both converters and descramblers be restricted in availability and controlled by CATV systems. Because converters are presently widespread, a significant change from the present situation must occur in order to offer better selectability. The immediate removal of converters from the marketplace is desirable if selectability is to be pursued.

Per program billing is feasible when two-way CATV systems exist if performed in conjunction with monitoring services using a low-cost listening area multiplex system. Again it is necessary to control the converter as it is an integral part of the monitoring system. Subscriber viewing patterns would be vastly changed if per program billing existed because a conscious dollar decision is involved. A complex rate structure would exist and the question of who controls the rates is a serious problem.

Many data services could be delivered on a CATV network. Data received by the subscriber should be in NTSC format for maximum compatibility so that captioning of programs, news flashes, still pictures, and data services can all be viewed with the same device and displayed on the subscriber's television set. Selectability of information services would initially be offered on a one-way cable system with low selectability.

As the system evolves, the subscriber could request data either via the telephone network pr a two-way cable system. Eventually a highly selectable and flexible service would be offered. Appropriate data base organization and software are essential for this final stage.

Return data consists of three types: monitoring services, polling services, and interactive services.

Although it is possible to use the telephone system for all of the incast data services, the loading generated by many of the services would necessitate installing additional dedicated lines. For continuous monitoring and heavily used polling services, the listening area multiplex system on the CATV system should be used as it is inexpensive and flexible. This method is not capable of truly interactive services, because it has a small message length limited to simple responses, but it is adequate for services foreseen in the near future.

When interactive services such as electronic shopping and computer terminal applications are introduced, the telephone system again is ideal as these could be piggybacked with low additional costs. Competitive with this, if two-way cable exists, is an interactive CATV system. When loading, usage and popularity increase such that in using the telephone system, a dedicated line is required, the packet incast or interrogation response system has a definite competitive advantage. A cable terminal could then be provided on a selectable basis to those desiring this added capacity at a cost of less than $100 per subscriber.

SCOPE

This study was conducted for the Department of Communications under contract #16ST - 36100 - 7 - 0750. Methods of offering various services with different degrees of selectability on a wired (cable) distribution network are examined. Only those technologies and systems foreseen in a ten year time horizon are considered. The technical feasibility of implementing services using various techniques is compared with emphasis given to the transmission system and terminal devices. Auxilliary devices have not been examined. No attempt at forecasting the marketing success of these services has been made. The evolution of cable communication services is studied and methods appropriate for different requirements are recommended.

NOTE: The opinions expressed in this report do not necessarily reflect those of Cablesystems Engineering, Canadian Cablesystems Limited or their management and are solely those of the authors.

SELECTABILITY DIMENSIONS

SELECTABILITY DIMENSIONS

Different types of services and systems have different needs and degrees of selectability. To determine how well a system meets the service needs, certain dimensions of selectability have been defined and will be used in this report. An objective evaluation of the system can then be undertaken.

Three basic categories must be dimensioned. The first is service selectability. The second dimension follows naturally from this - billing selectability. A selectable service would have to have an equally selectable billing scheme. Thirdly, the delivery mechanism must be dimensioned to determine if it meets the selectability requirements of the service and billing.

SERVICE SELECTABILITY

Service selectability can be divided into content selectability and timing selectability. These are dimensioned below:

A) Selectability of Content

1) Choose among what is offered.
   - Little input from subscribers concerning content.
   - Relatively long response time (i.e. many times the duration of a single program).
     (e.g. present broadcasting services where subscriber opinions are obtained from Nielsen ratings).
2) Suggest or have input about content of offering.
   - Significant visible input from subscribers concerning content but with no firm delivery commitment.
   - Reasonable response time (a few times the duration of a single program).
3) Demand desired content.
   - Subscriber chooses from a large library and the system is commited to delivering the desired content.
   - Good response time (equal to the duration of a single program).

Note: Subscribers cannot demand programs that are not in the library.

B) Selectability of Timing

1) Accept or reject a predetermined schedule
   - Little input from subscribers concerning timing
   - Long response time (many times the program duration).

(e.g. present broadcasting system where subscriber has input concerning program timing only through Nielsen ratings).

2) Suggest or have input concerning timing.

- Significant visible input from subscribers concerning timing.
- Reasonable response time (a few times the duration of a single program).

3) Demand a desired time slot.

- System is committed to delivering desired content in desired time slot.
- Good response time (equal to the duration of a single program).

BILLING SELECTABILITY

Billing for many services is based on a sometimes complex combination of various billing units. The possible billing units for CATV services are outlined below. Billing can be based on an element which is available, which is used, or which is requested. The latter two are considered more selectable than the first.

BILLING ELEMENT	BILLING UNIT
Duration	Available Used Requested
Program Content	Available Used Requested
# of Connections	Available Used
Point of Time	Available Used Requested
Viewership	Available Used Requested
Technical Quality	Available Used Requested
Channel	Available Used Requested
Service	Available Used Requested

DELIVERY MECHANISM

The possible delivery mechanisms to meet the service and billing selectability requirements are rated on the following parameters.

A) Capacity

- number of channels
- number of requests or interactions
- number of programs, etc.

B) Response Time

- Deterministic - request demand is met within a given time period.
- Probabilistic - request demand is met within an uncertain time period.
- Length of feedback time.

C) Reliability

- Probability of service success.

D) Security

- Percentage of "cheats" to a given service.

E) Flexibility

- Cost of changing service or billing.

F) Privacy

- Security of subscriber information.

G) Upgradableness

- Cost of improving delivery mechanism.

H) Cost

- Cost of delivery mechanism.

Possible services which will be dimensioned using the outlined criteria have been divided into four major areas. These are:

1) Video Programming

2) Broadcast Data

3) Incast Data

4) Other Video Services

VIDEO PROGRAMMING

VIDEO PROGRAMMING

INTRODUCTION

At present, video programming is the main service that is successfully carried on most CATV systems (FM penetration for Canadian Cablesystems Limited is less than ten percent of total subscribers). The subscriber is presented with enough programming choice (i.e. a large enough number of channels) that the service is considered acceptable.

The present video programming offering is very non-selectable. The potential subscriber either pays for and has access to many channels or he has access to none. This situation has evolved because of the high fixed cost of providing any type of service and the low incremental cost of increasing the quality of that service. For instance, all subscribers, even those with black and white receivers, are provided with colour signals. The incremental cost of providing colour service is negligible and perhaps the only alternative is to provide two systems, one for colour receivers and one for black and white receivers. This is, of course, horribly inefficient.

Various reasonable schemes for increasing the selectability of the video programming service are considered and their costs and possible ramifications are compared. If any change from the present broadcast all-or-nothing format is necessary to provide selectability, the possible evolution to the more selectable system is considered.

POTENTIAL SELECTABILITY LEVELS

Video programming services can be offered to subscribers with various levels of selectability. These are:

- standard CATV services
- groups of channels (CATV groupings)
- groups of channels (subscriber groupings)
- individual programs
- demanding a program
- voting for a program
- auctioning a program
- storage.

A detailed description of each service and implementation methods follows.

STANDARD CATV SERVICE

In standard CATV many television channels are multiplexed (usually frequency multiplexed) together and are made available to all subscribers. The subscriber pays a subscription to receive the multichannel service for a given time period. A "connect" charge is usually also paid. Excluding exceptional circumstances, the subscription fee is independent of actual system cost.

The subscriber has what can be considered a minimum level of selectability. He chooses from among the available programs and accepts or rejects the established schedule. Subscriber feedback concerning content and timing is received by broadcasters but it is slow and also is not visible to most subscribers.

CATV has evolved to this "all-or-nothing" service in Canada because of the economics of frequency multiplexing many (up to thirty-five) television channels on a single coaxial cable. The incremental cost of providing an additional channel on a CATV system in considered small so the subscriber's cost for receiving the extra channel is also small and has been considered negligible.

To provide more selectability on a system using the standard frequency multiplexing approach some or all channels would have to be made unavailable to subscribers. This would incur extra costs. The cost of alternate system approaches (e.g. the Rediffusion system)[1] are compared on the following page to the frequency multiplexed approach.

Frequency Multiplexed Coaxial System

This system has been outlined and can be considered to provide a minimum of selectability for broadcast programming. Low capital costs associated with this system make it attractive. Experience in the operation of eleven medium-to-large (approx. 10,000 - 100,000 subscribers) Canadian CATV systems has demonstrated that capital costs for a one-way, thirty-five channel, urban CATV system are as listed in Table 1.[2][3]

Table 1 - Capital Costs - F.D.M. System

Investment Per Km of system	- $6,000.00
Investment Per Subscriber	- $ 50.00

Assuming a density of 100 subscribers per kilometer, a total plant cost of $110 per subscriber is incurred.

Spatially Diverse Systems

In Great Britain, systems built by Rediffusion International Limited use separate twisted-pair cables to transmit each television channel into the home. The subscriber chooses among channels by using a manual selector switch. In North America this sytem is clearly uneconomical.[4]

A more economic approach for a multi-channel system uses a remote switch so that only one drop wire per subscriber is necessary.

Cost estimates for the complete switched system are not readily available for Canadian systems. However, some cost trends can be highlighted.

The switching exchange costs are approximately $75 per subscriber while the home control unit is $35. Total distribution cost (not including trunk) is close to $200 per subscriber for an "average" area.(4) This represents approximately double the broadcast coaxial approach and has thus been rejected in the past.

Selectability, however, is easy to add to the switched system at the remote switching centre. The selectability offered could be of a high level.

In Canada, the evolution to a switched system of the Rediffusion type can be considered impractical due to the presence of many coaxial broadcast systems. Therefore, it will not be considered further.

F.D.M. Coaxial (Remote Converter)

The high cost of the Rediffusion system can at least partly be attributed to the increased number of cables in the distribution area. If each subscriber tap-off device were considered a switching node, then additional cable costs would not be incurred. The multitap then, can be considered the "ideal" switching node in a switched system.

Again the evolution to this system seems difficult because many subscribers have purchased converters to receive additional channels and these would be rendered obsolete. Also selectability is no better than standard CATV if all channels were made available to all subscribers. Due to the outdoor placement of the converter, this system is more expensive than the present one. No advantage is gained by evolving toward this system.

Conclusion

For video programming service offering a low level of selectability, frequency multiplexing of many channels on one coaxial cable can be considered as ideal due to its low cost and its expandibility. See Table 2.

Table 2 - Standard CATV Service

	DELIVERY SYSTEM	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
1.	F.D.M. Coaxial	High 35 ch.	N/A*	99.9% (See Appendix 1)	2% Cheats	Good - Additional outlets	N/A	Two-way compatible
2.	S.D.M. (Rediffusion)	High 35 ch.	N/A*	>99.9% (Less active equipment)	2% (Estimate)	Poor - Additional outlets	N/A	Two-way compatible (extra trunk cable needed)
3.	F.D.M. Coaxial (Remote Converter)	High 35 ch.	N/A*	<99.9% (more active equipment)	2% (Estimate)	Poor - Additional outlets	N/A	Two-way compatible

* Subscriber response mechanism is not via cable.

GROUPS OF CHANNELS (CATV GROUPING)

This service provides restricted access to standard CATV services. Groups of channels (e.g. all Canadian channels, all American channels, local channels, etc.) are packaged by the CATV operator and subscribers only receive those packages that they want. The purpose is for the partial service subscriber to pay less than a full service subscriber (i.e. pay for what he wants).

If present television channel offerings are subdivided into groups then the necessary reduction in rates of partial system subscribers must be compensated by increased full service rates. Also all additional costs incurred in creating the channel groupings should be borne by full service subscribers. Present subscribers would either have their present channel offering reduced, or their subscription rate increased.

For new television services (e.g. movies, educational channels, channels with non-fiction television shows, etc.) channel groupings may be appropriate. The subscriber to the channel group pays for the cost not just of delivering the channel, but also perhaps in obtaining the channel (from non-broadcast sources). This seems appropriate if successful channel groupings can be obtained. Possible groups are an entertainment package including movies, concerts, theatre, and symphony, and a non-fiction package with children's educational programs, science and nature shows, political, social, and economic programs, etc.

The costs which must be borne by the subscriber to the restricted service can be divided into two parts. These are delivery costs which are dependent on the delivery technique and package costs which are dependent on channel content. Package costs are zero (or near zero) for standard CATV services (with the exception of community programming) but for alternate programming, it might become significant.

As package costs become significant with respect to delivery costs, selectability becomes more desirable.

As in standard CATV service the subscriber chooses from among what is offered and accepts or rejects a predetermined schedule. However, the subscriber chooses only from among those group(s) of channels to which he subscribes. He has little or no input into the channel groupings.

Billing is based on the channel groupings requested by the subscriber and the duration of the subscription. A "connect" charge is necessary to reduce changes in status (CATV cost is approximately $15).

Restricted access to the full broadcast service must be provided. The following restricting techniques can be used:

1) Traps
2) A/B Connection (dual cable)
3) Converters
4) Scramble - Descramble

No subscriber monitoring devices are necessary so a return transmission path is not needed.

Traps

Full service is provided to the subscriber's drop where traps are installed at the tap-off point so that some groups of channels are denied to partial service subscribers.

Costs are identical to the standard broadcast CATV system except for the addition of the cost of traps and their installation. Traps cost $7 and their initial installation cost is small compared with this (less than $1 per subscriber). No significant capital cost changes are foreseen in the next ten years.

The "trap" system is limited to twelve television channels unless a converter or dual cable is also used. Twelve channels cannot be considered adequate for the long term therefore the additional cost of a converter would have to be borne by many subscribers.[(5)]

Due to technical constraints (e.g. guardbands, envelope delay distortion) few traps can be cascaded so only limited channel groupings are available. The traps are also very inflexible and essentially cannot be updated.

A subscriber's status cannot be changed remotely so costs associated with changes in status are very high (about $15 per transaction).

Due to the outdoor placement of the traps, system security is good (similar to standard CATV).

If partial service subscribers are to pay a reduced rate, then full service subscribers must pay for the installation, removal, and maintenance of all traps.

Traps are only cost competitive with other techniques (specifically scramble - descramble) if a large percentage of subscribers take full service.

The breakeven point for traps vs. descramblers is discussed in the descrambler section.

A/B Connection

Full twelve channel service is provided by two parallel distribution systems. A subscriber can connect to either or both systems.

Costs are only slightly less than double those of a standard CATV system.[6] The whole system except drops must be duplicated for all potential subscribers.

Two twelve channel groups and one twenty-four channel group can be offered. Converters are not needed in the near future with twenty-four channel capacity but in the medium term (five to ten years) at least one system would possibly need to have expanded channel capacity.

If single system subscribers were to pay for only the cost of a twelve channel system, then full service subscribers would have to pay double this amount plus the cost of the unused system which had to be built but is not used by the single service subscriber. For single system subscribers to pay less than in a standard system, then, two single service connections would be cheaper than one full service connection. This or any other billing system offering this selectability is absurd.

Converters

One full service system is built with access to non-standard channels available with the use of a converter.

Full service subscribers pay the cost of having additional channels on the system (about ten percent) plus the cost of a converter ($50).

Up to thirty-five channels are available with groupings of twelve basic channels plus twenty-three additional channels. If desired, limited channel converters could be used, but these would cost the same as a full service converter.

When a converter is available, other home units (e.g. descramblers or channel monitoring devices) can be provided more economically due to shared housings, power supplies, etc.

In Canada the converter is a ubiquotous device so it cannot be used as a means of providing selectability. Subscribers, in fact pay for the converter and not the additional channels that it provides.

Scramble - Descramble

Optional channels are scrambled at the head-end and descrambled in the subscriber's home. Various scramble - descramble techniques are available with costs dependent on the security of the system. A twenty dollar descrambler cost provides good cost vs security tradeoff. (See Appendix 2). When combined with a converter the descrambler cost could be reduced to ten dollars. In a medium or large system (greater than 1,000 subscribers) additional head-end costs can be neglected.

The descrambler-converter could use almost any group of channels and is easily updatable to include subscriber grouping, remote scrambling control, and even channel monitoring if two-way cable is available.

If scramble-descramble costs are compared with those of traps then for a $20 descrambler cost stand-alone descramblers are superior for less than twenty-five percent penetration. For descramblers combined with a converter the break-even penetration is forty percent.

At this penetration, thecost of selectability could be questioned as forty percent of subscribers do want the additional service. Selectability seems only valid if the package costs are very significant.

When this high breakeven penetration is combined with the flexibility and potential upgradableness of descramblers the trap alternative seems unwise for most situations.

Conclusion

Of the four possible grouping techniques, dual cable can be rejected due to its high cost, and converters due to their ubiquotousness.

Of the two remaining techniques, namely descramblers and traps, descramblers are most appropriate since they are flexible and upgradable. For many applications this level of selectability is appropriate as subscriber groupings of channels would offer greater content selectability at only a marginal increase in cost. Table 3 contains a summary of the dimensioned delivery techniques.

Table 3 - Groups of Channels (CATV Grouping)

DELIVERY SYSTEM	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
1. Traps	12 channels 35 channels with converter	N/A*	Good (99.9%)	Good (2% Estimate)	Poor - Few channel groupings	N/A	Poor
2. A/B Connection	24 channels 70 channels with converter	N/A*	Good (99.9%)	Good (2% Estimate)	Poor - Two channel groupings	N/A	Poor
3. Converter	35 channels	N/A*	Good (99.9%)	Unacceptable -Converter is ubiquotous	Poor - Two channel groupings	N/A	Good - Can add scrambler, channel monitor, etc.
4. Scramble-Descramble	12 channels 35 channels with converter	N/A*	Good (99.9%)	Medium (5% Estimate)	Good - Many channel groupings	N/A	N/A

* Subscriber response mechanism is not via cable.

GROUPS OF CHANNELS (SUBSCRIBER GROUPING)

Restricted CATV service is provided with the subscriber providing his own channel package. This system must be more flexible than with CATV grouping of channels due to the large number of possible channel combinations. Essentially this system is a subscription per channel.

The subscriber chooses from among the offered channels and accepts or rejects the scheduled times for certain shows on his choice of channels. The subscriber has total freedom in choosing channel groupings.

Billing is based on a per channel basis and is dependent on subscription duration. A connect change is also necessary to reduce transciency.

As can be seen in the previous table, the only technique for grouping of channels is Scramble-Descramble.

As with CATV groupings, the optional channels can comprise the entire offering or can be in addition to the basic service. No return capacity is necessary for this system. However, if the subscriber were given a great deal of freedom in changing groupings (i.e. eliminate the connect charge) then remote status changing or channel monitoring is necessary. This essentially provides individual program selectability.

INDIVIDUAL PROGRAMS

For individual program billing continuous channel monitoring and a means of restricting access to the full service are necessary. Various techniques of channel monitoring and their costs are described in Appendix 3. Since these do not relate directly to video programming, they will not be discussed further in this section.

With individual programs the subscriber chooses from among what is offered, but his choice is very flexible (i.e. on a per program basis). Timing of a program is not selectable. The subscriber is billed for what he watches and for the duration that he watches, not for what he requests or has available to him. Rates could vary with the program content and the point of time. However, if this were the case then some means of notifying the subscriber of the rate would be vital. This seems difficult to implement and might be resisted by subscribers.

As with subscriber groupings, the only reasonable delivery technique is scramble-descramble. The cost of providing this level of selectability is the descrambler cost ($10 when combined with a converter) plus the channel monitoring cost (approx. $35 if it were conducted using the "listening" area-multiplexed two-way technique described later in this report) plus the additional cost of providing a two-way CATV system (approx. $15) plus possible additional billing administration costs. It would seem that if individual programming monitoring were the only service to be carried on the two-way CATV system, the additional costs do not seem justified.

If the return system and a home terminal were in place, the cost of providing individual channel monitoring might be acceptable. As with any other video programming selectability technique, the package costs and delivery costs must be compared. If the package costs can be neglected, then selectability does not seem wise as subscribers do not pay for the actual cost of the service but pay an arbitrary rate that is independent of the CATV operator's costs.

See Table 4.

TABLE 4 INDIVIDUAL PROGRAMS

DELIVERY SYSTEM	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
FDM Coaxial Scramble-Descramble Monitor Channel	35 channels	Content - fast Timing - N/A*	Good (< 99.9%)	Medium	Good - any program	N/A	Content Selectibility already high. Timing selectibility upgraded with addition of home VTR.

* Subscriber response mechanism is not via cable.

DEMANDING A PROGRAM

Demanding a program gives the viewer selectability on the program content as well as the viewing time, providing maximum selectability. The subscriber is billed only for the programs he watches or requests.

A problem arises with offering such selectability on program content because it is assumed that a subscriber knows what he wants to watch. This is significantly different from the present situation where a subscriber casually monitors and watches a program and determines if he wishes to continue viewing it. Therefore in any request based service the service must be structured in order to aid the subscriber in making his selection. One alternative is to provide a catalogue, listing the available materials. This is probably not sufficient because the subscriber will have difficulty knowing how to use the catalogue and the program title will not necessarily have enough information to allow him to choose wisely. Program summaries need to be provided or previews displayed. The organization of such a catalogue and the question of how a selection is to be made are serious problems with this type of service.

The delivery system required to offer this level of selectability must contain the following items:

1) a substantial video library
2) an individual VTR for every person simultaneously watching different requested programs
3) a catalogue of available programs with program summaries.

4) a delivery means for requesting programs and monitoring this for billing purposes

5) a means of selecting and loading the tapes from the video library into the players

6) a means of notifying the subscriber of available time slots, of confirming requests, and of updating the library

7) a central processing function to control the billing, display the programs, and issue requests

8) a means of securely delivering the program to the person requesting it <u>OR</u>
monitoring others viewing the program <u>OR</u>
charging a flat rate for access to the request channel and securing delivery only to those paying that charge <u>OR</u>
combinations of the above.

On a real time basis, a cable system does not have the capacity to provide programs on request for the majority of viewing--30 channels offer only 30 different request to be viewed simultaneously. This is completely inadequate when compared to the number of TV viewers. Therefore, any programs on request would have to apply to a minority of viewers with a very specialized data base in order to provide a reasonable probability of requests getting viewed within a acceptable waiting time. Examples of these programs could be classical operas, plays and cultural events which appeal to a minority who may be willing to pay significant amounts for these programs. By dedicating one channel to this service, eight one hour events could be delivered between the maximum viewership hours of 4 and 12 p.m. Therefore, in one month about 250 different requests could be handled. For someone to take the service at least one request per month would be considered a minimum resulting in a capacity of about 250 subscribers per channel. Do 250 subscribers justify having one channel allocated to them? If spare capacity is available this could be quite appropriate. However, if there are alternate uses of the channel which serve more than 250 subscribers these uses should be considered a higher priority.

Billing for this service would probably have to be on a flat rate basis for all events shown on the channel with an additional charge per request.

Some cost estimates for this system are listed in Table 5.

Table 5 Demanding Programming Costs

Item	Cost ($)
Video library of 300 tapes ($25 per tape)	7,500
1 VTR	3,000
Catalogue for library - 250 copies	1,000
Requesting and monitoring over telephone system	NC
Descrambler - 250 ($16.00 per unit)	4,000
Channel displaying available times (time shared on information channel)	NC
TOTAL CAPITAL COST	15,500
OR $15,500/250	$62/sub.

Operating cost of ½ man from 4 - 12 = $6,000/yr

yearly operating cost of $25/sub.*

* Not including royalty, copywrite charges, etc.

An alternate approach to demanding programming is to use a home storage device. Instead of using the CATV system as a transmission medium and using a scarce resource (i.e. bandwidth), special tapes could be mailed to the subscriber. A larger tape library could be accessed (one library could serve a large area) and content selectability vastly increased. See Table 6.

With limited bandwidth, a CATV system does not seem suitable for programs on demand. Home storage devices will be discussed in a later section.

TABLE 6 DEMANDING A PRDGRAM

DELIVERY SYSTEM	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
1. CATV	250 hours per channel month (1 demand per subscriber per month)	Probabilistic (average > 24 hours)	Good	Good	Good	N/A	Poor Limited channel capacity.
2. Non CATV	Dependent on size of tape library	Probabilistic (average > 1 week)	Good	Good	Good	N/A	Good Increase size of tape library.

VOTING FOR A PROGRAM

Because of the capacity constraints of requesting a program, various schemes have been developed to compromise the selectability and still provide subscriber input. One of these schemes is voting for a program, where the most popular programs are the ones that are shown. The delivery requirements are similar to those for demanding a program except a more sophisticated software system which can record and total votes and prevent the same subscriber from voting twice is required.

Using this technique, selectability is only marginally increased over standard CATV service as the probability of one choosing a program and it being displayed on one of the 35 channels when desired is small in a system of any size. An additional problem is the impact this has on viewing patterns. Subscribers adopt a viewing pattern compatible with the broadcast schedules in order to view the programs they desire. In a voting scheme, since most of the time their requests will not be shown and the viewing schedule is uncertain, it is impossible for a subscriber to structure his day to watch his desired programs. This is a step backwards and is completely unsatisfactory.

AUCTIONING A TIME AND PROGRAM

A totally absurd scheme to compromise selectability and still provide subscriber input is auctioning. This is similar to voting except votes are 'weighted' according to a dollar amount bid. The programs which have the highest dollar amount bid are shown.

Again the uncertainty of scheduling as well as the implications of dollars controlling media exposure are serious disadvantages. This alternative is unacceptable.

STORAGE

Any previously discussed video programming service which is considered feasible has provided a low level of timing selectability. Greater selectability can be provided by a storage device such as a home video tape recorder (VTR). From the broadcast schedule, the subscriber can determine which programs he/she wishes to view. These are taped automatically by the VTR for later viewing at the subscriber's leisure.

The only additional equipment needed to improve the previous services and timing selectability is a home VTR. These presently retail in Canada in the $1600 range, but could be expected to decrease in cost to around $600 in future if purchased in large quantities.* The only charge to the subscriber is the initial capital cost or lease cost of the VTR. Therefore, no costs are incurred by subscribers not wanting greater selectability of timing. This seems ideal.

This service is very selectable with respect to timing although the subscriber chooses from the content that is offered. Any increase in content selectability has been shown to be very expensive.

Note that copywrite and royalty problems concerning video programming storage units are unsolved at the time of writing.

*Any other storage system (e.g. digital) would be prohibitively expensive.

DEMANDING PROGRAMMING WITH HOME STORAGE

To overcome the capacity problem on the requesting service is the householder could be provided with a storage device, such as a home VTR. On a delayed basis requests could be filled during the night to be available for viewing the next day. This delivery system requires the following components:

- video library
- catalogue mechanism and acknowledgement
- receiver, decoder, descrambler and VTR per household
- addressor
- VTR player per channel
- scrambler

In order to establish system capacity the following assumptions are made.

5 channels can be used for the service 24 hours per day.

30 more channels can be used from 1:00 a.m. to 7:00 a.m. - 6 hrs. per day.

Total available - 5 x 24 + 30 x 6 = 300 hrs.

On each trunk, 300 program hours per day are available in addition to normal broadcast T.V. Assuming that 80% of daily requests are repeats, of other people requests, means that $\frac{300}{.2}$ = 1,500 hours requested could be served per day. If 10,000 subscribers are fed off a trunk, 15% can make 1 request per day for specialized programs in addition to normal television. At first glance, the system appears to be acceptable.

An estimate of the costs for the system are shown in below.

video library - 2000 table at $25	=	50,000	
catalogue 10,000 copies	=	10,000	
requesting mechanism and acknowledgment - telco		NC	
receiver, decoder, descrambler VTR - 1,500 at 1600	=	2,400,000	(in future 600 each -$900,000)
addressor	=	1,000	
scrambler	=	1,000	
VTR player 40 at 3000		120,000	
		2,557,000	(in future - $1,057,000).

plus royalties and operating costs.

For 1500 subscribers this equates to a cost of $1704 per subscriber at present with a future predicted cost in the order of $710 per subscriber.

This service provides a high level of selectibility. The subscriber chooses from what is offered in the video library and has a much larger choice than in normal broadcasting. This service can be viewed as demanding a program. Since a home storage unit is used, the time of viewing is at the subscribers volition. Impulse requests cannot be handled since a lag of up to 24 hours is required to answer requests.

The billing could be made very selectable. Since the home VTR is addressed, security is present and subscribers could be billed for the request. Possibilities also exist to provide various scales and discounts depending on how many the subscribers requested the same program that night.

The largest constraint on this service rests in the delivery mechanism and the CATV system capacity. Using the listed assumptions, 15% of subscribers could make one request per day. This is probably quite adequate if not conservative, as the service is in addition to normal video programming. However, the assumption that 80% of all requests are repeats is quite tenuous. If a video library of only 100 events was available this is very possible. However, as the library size expands, the percentage of repeat requests is likely to decrease. The exact percentage is highly speculative as the selection process is difficult to imagine. It is apparent, though, that as the size of the library grows that the lag time would have to increase, perhaps considerably in order to provide the programs. Therefore, flexibility and upgradeability are poor. Similarly, if a high percentage of subscribers desire the service, the number of requests per subscriber that could be fulfilled would decrease. For example, for 100% penetration on a 10,000 subscriber trunk and if only 50% of the requests were repeats, only 2 requests per subscriber per month could be shown. The capacity of the service would be additionally reduced as conventional broadcast services extend their broadcast time to satisfy shift workers. Clearly this system has only limited application, even in conjunction with normal broadcast services.

/ See Table 7.

TABLE 7 STORAGE (WITH VARIOUS CONTENT SELECTIBILITY TECHNIQUES)

	DELIVERY SYSTEM	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
1.	Standard CATV FDM Coaxial Home VTR	35 channels (with converter)	Content - N/A* Timing - Fast	Good+	Content - Good Timing - Poor[x] (home VTR is ubiquotous)	Flexible timing inflexible content	N/A	2 way compatible
2.	Channel Groups (CATV Grouping) Home VTR	35 channels (with convertor - descrambler)	Content - N/A* Timing - Fast	Good+	Content - Good Timing - Poor[x]	Flexible timing inflexible content	N/A	2 way compatible
3.	Channel Groups (Subscriber Grouping) Home VTR	35 channels (with convertor descrambler)	Content - Med. → slow Timing - Fast	Good+	Content - Good Timing - Poor[x]	Good - any broadcast program - any time	N/A	2 way compatible
4.	Individual Program Home VTR Monitor channel	35 channels (with convertor descrambler	Content - Fast Timing - Fast	Good+	Content - Good Timing - Poor[x]	Good - any program - any time	N/A	Content & timing selectibility high - no upgrading necessary
5.	Demanding Program Home VTR	300 hours per day	Content - 24 hr. Timing - Fast	Good+	Content - Good Timing - Poor[x]	Good - any library program - everytime	N/A	Not foreseen as necessary

* Subscriber response mechanism is not via cable.

\+ Home VTR is high maintenance item.

x For timing selectability, poor security is acceptable.

SUMMARY

The standard CATV system in Canada has evolved to offer an inexpensive service with a low level of selectability. Higher levels of selectability for the present services could be offered but the delivery cost to provide this becomes very significant (much greater than the package cost). These higher selectability levels thus seem inappropriate for broadcast video programming.

Increased selectability of video programming on a CATV system can only be considered likely if a selectable service is offered in addition to the non-selectable basic package. Various selectability levels are considered possible.

If high incremental cost programming is made available before a two-way CATV system is available, the selectable programming will be offered in channel group(s) with CATV grouping. Traps or descramblers seem most appropriate with the choice depending on service popularity.

If a two-way CATV system is available then selectability of content and billing can be made on an individual program basis. Channel monitoring via CATV and scrambling would be used.

The only way of increasing content selectability is by demanding content. Demanding video programming content on a CATV system, except for very specialized applications seems almost prohibitively expensive, and the selectability level is in fact restricted by a small program library. The alternate non-cable delivery technique with a home VTR seems best.

The best way of providing timing selectability is with a home VTR. This can be used for the CATV system or for tapes obtained from a central program library. Security is not a concern and the subscriber who wants timing selectability pays for the necessary hardware.

A summary of video programming services and their selectabilities is in Table

TABLE 8 - VIDEO PROGRAMMING SELECTABILITY

SYSTEM	SERVICE SELECTABILITY						BILLING SELECTABILITY
	CONTENT			TIMING			
	CHOOSE	SUGGEST	DEMAND	CHOOSE	SUGGEST	DEMAND	
1. Standard CATV	Low			Low			Service Available, Duration Available
2. Channel Groups (CATV Grouping)	Med.			Low			Service Available, Duration Available
3. Channel Groups (Subscriber Grouping)	Med.-High			Low			Service Available, Duration Available
4. Individual Program	High			Low			Service Used, Duration Used
5. Demand Program			High			High	Program Demanded, Service Available
6. Voting For Program		High*			High*		Program Requested (if made available) Program
7. Auctioning a Program		High*			High*		Program "Sold", Program Used
8. Storage (With systems 1-4)		Low to High				High	Service Available, Duration Available, Hardware Cost
9. Demand Program (Use Storage)			High			High	Program Demanded, Service Available

*NOTE: This system might be unfair to some subscribers (i.e. for some, selectability might be low).

BROADCAST DATA

BROADCAST DATA

INTRODUCTION

Broadcast data is foreseen as a growing part of cable services, augmenting the current audio and video entertainment programs. Some limited forms of broadcast data are currently offered by many CATV operators by using character generators for bulletin board information. Developments have also been carried out in many countries to provide a link between the home television set and computer data bases so home users can gain access to a large quantity of data in a matter of seconds.

A list of frequently mentioned data services is prepared and their general requirements briefly described. Though the list may not be comprehensive, it is believed that the services are quite representative and those that are not mentioned would generally fall into the same category as of one of those mentioned.

The choice of data delivery systems will be discussed and the associated system and terminal costs analyzed. Those systems that appear either too costly or too limited in capacity will be quickly discarded from further discussion. Furthermore, attempts will be made to determine the feasibility of amalgamating all the mentioned services to use a common delivery system with the objective of minimizing the total system cost.

Services will be described in greater detail to determine the best selectability and billing scheme.

POTENTIAL SERVICES

A list of potential data services that could be provided through cable is shown in Table 9. Those services shown are often mentioned in other studies. For example, electronic banking may be fitted in the same category as information retrieval (request).

Table 9 - Potential Broadcast Data Services

Services	Purpose	Interaction	Addressing
Electronic Mail	Information	Yes	Yes
Shopping	Information	Yes	Yes
Education	Information	Yes	Yes
Computer Terminal	Information	Yes	Yes
Information Retrieval (Capture)	Information	No	No
Information Retrieval (Request)	Information	Yes	Yes
Captioning (Program Related)	Information	No	No
Meter Reading	Controlling Data	Yes	Yes
Load Shedding	Controlling Data	No	No
Control Functions	Controlling Data	No	Yes

Video frame grabbing may be necessary for both shopping and education. Since video frame grabbing is described in section it will not be further discussed in this section.

Services shown in this Table can be broadly divided into two types, i.e. information data and controlling data. Each may require interaction and addressing capabilities. Conceivably, both types of data can use the same encoding and decoding scheme. Hence a similar decoding device may be shared.

Controlling functions can be typified by

a) Load shedding, which is basically broadcast/capture in nature, and does not require any high sophistication of electronic circuitry. Since it is a remote on/off controlling function, a simple low cost tone modulation scheme may be used to minimize the terminal cost. The receiver can therefore be a stand alone unit operating on a CW carrier transmitted through cable. When the carrier is present, the load is switched off and when absent switched on. In this way, the load will be on in the case of a break along the transmission medium.

b) Remote connect/disconnect, which may be used for pay services, different frame grabbing services, etc., will be addressed but may not necessarily require any response. Addressing capability which requires higher sophistication is already built into the requested/addressed information decoder. This means that the same decoder may be shared by this type of controlling function.

c) Meter reading is again an addressable service but it also needs return capability for feeding back the read data. Similar to b), the addressable information decoder may be used to provide this service.

Information services can be further subdivided into two types, one being strictly broadcast and capture, the other one being request and addressed. CATV systems may not be the sole provider of broadcast/capture digital information services. Broadcasters may decide to transmit Teletext data similar to those in the U.K. to provide news flashes, captioning, and other similar kinds of services that do not require interaction. Hence, users who are not or could not be CATV subscribers could still be able to receive some kind of non-interactive information service via over-the-air broadcast (VHF/UHF or even satellite). Though it is feasible, it is very unlikely that a dedicated television channel will be used within the next ten years to broadcast information data except during the station sign-off period.

CATV systems can provide one or more dedicated channel(s) for information data services. They could be provided both in broadcast/capture and request/address mode. Requests could be made through a key-pad either via telephone line or a return signal through the return trunk of a CATV system. Furthermore, it is also feasible for CATV systems to insert encoded broadcast data onto every broadcast TV channel. Using six lines per field yields about 18 pages of data per television channel per second. However, interfacing hardware including the computer would cost roughly $8,500 per channel. The interfacing hardware includes a modulator/demodulator ($5,000) and a television line inserter ($3,500). Therefore, it is envisaged that should broadcast data be offered on cable, the most likely route would be to use dedicated channels.

It might appear that a common decoder should be used to receive broadcast data from broadcast TV stations (broadcast/capture) and broadcast data from dedicated data channels (with addressing capability), so the terminal cost at the user's home could be minimized. The following section analyzes some possible conditions.

Conditions for Service Utilization

So far, three types of data services have been identified.

a) Broadcast Information. Broadcast/capture information is basically provided by broadcast TV stations and is multiplexed with video during vertical blanking. Up to six lines per field can be transmitted.

b) CATV Information. Request/address or broadcast/capture is provided over cable systems by transmitting data on dedicated channels(s) and can provide 600 pages of text per second.

c) Controlling. Controlling data may or may not be addressed can be piggybacked onto a), b) or both, or transmitted separately using a different transmission scheme.

Depending on the priority of the types of data services, various home terminal receivers are foreseen. There are three basic home receivers. The first receiver is strictly for load shedding, the second is a sophisticated fixed frequency receiver for request/addressed or broadcast/capture services, and the third receiver is a tunable version of the second which can also be used for captioning of video programming.

Costs for each type of receiver are listed in Table . Large quantities for each receiver are assumed.

Table 10 Home Receiver Costs

Receiver Type	Cost ($)
Load shedding Receiver (Rx.1)	$ 20
Dedicated Data Channel Receiver (Rx.2)	$50 to 200
Tunable Data Receiver (Rx. 3)	$80 to 230

The possible use of each receiver is shown in Table 11.

Table Home Terminal Receiver Version

Desired Service	Receiver
Controlling	Rx. 1*
Broadcast Information	Rx. 3
CATV Information	Rx. 2
Controlling and Broadcast Information	
(coincidentally used)	Rx. 1 & Rx. 3
(not coincidentally used)	N/A
Controlling and CATV Information	
(coincidentally used)	Rx. 2
(not coincidentally used)	N/A
Broadcast and CATV Information	
(coincidentally used)	Rx. 2 & Rx. 3
(not coincidentally used)	Rx. 3
(coincidentally used and Controlling)	Rx. 2 & Rx. 3
(not coincidentally used and Controlling)	Rx. 1 & Rx. 3

*Note: Rx. 1 can be used for Load Shedding only.

DATA DELIVERY SYSTEMS

Information/data services of various kinds are being offered to many CATV subscribers by sending out textual information in analogue video form through one or more dedicated television channels. A video display of textual information is provided by character generators ranging from a self-contained single channel type limited to a few pages of memory to a fully computer controlled multi-channel unit which can have a few hundred pages of storage capacity and accept input data from various wire services. Each character generator can sometimes be time shared by two or more different services. For example, it can display manpower information during office hours and community message or want ads after office hours.

These services are generally well accepted by CATV subscribers as useful. However, there are many shortfalls in this method of providing such a service. To name a few:

a) Inefficient use of frequency spectrum. Each character generator occupying a full television channel is used to provide generally static information.

b) Excessive waiting time. Generally, each character generator has an active memory file of up to 16 pages. Each page is usually displayed for about 10 - 15 seconds. In other words, an average access time for these 16 pages of information is about two minutes.

c) Limited information capacity. There is a tradeoff between acceptable access time and information displaying capacity.

c) User storage is virtually non-existant. Should a user decide to record a page of information, (e.g. job opportunity), he must have quick eyes and good memory or wait for the page to show up during the next cycle.

There are at least two methods to improve the effectiveness and efficiency of existing data services through analogue video.

One method is similar to the existing system in that pages of text are delivered in analogue video frames. Instead of displaying a page for 12 to 15 seconds, 30 different frames can be transmitted every second for the NTSC standard. Hence efficiency of frequency used is increased by more than two orders of magnitude. However, in order to enable the user to choose the desired page among those rapidly flipping through, a digital code must be attached to each page both for identification and retrieval. Secondly, closed-captioning which is program related could not be done with this delivery scheme. Thirdly, there is a need for a frame storage device at each users terminal and though such a unit is commercial available, the cost is very prohibitive ($2,000).

Eventually, an electro-mechanical frame storer could be available in quantities at the $100 to $200 range.

Another method is to encode the data in digital form for transmission. At the receiving end, data is retrieved, decoded, and a character generator used to generate the video signal suitable for displaying on a television screen. By transmitting data digitally, roughly 600 pages of textual information can be transmitted every second in the same video channel, which improves the efficiency by another order of magnitude.

There are a few digital home information data system developed in several countries. Examples are Teletext and Viewdata in the United Kingdom, and Antiope in France.

Teletext and Antiope both utilize a television channel for data transmission. While Teletext uses only two unused scanning lines during the vertical blanking period, Antiope can be expanded to use every horizontal scanning line of a television channel for transmission. For both systems data is transmitted digitally and it has been designed around a television composite signal by using the active portion of a horizontal scanning line with the remaining portion, comprising of horizontal sychronizing pulse, colour burst etc. unchanged.

One of the main advantages of designing a data transmission system around a television signal is that if the data is an augmenting part of the television program (e.g. deaf-captioning), the text can be multiplexed onto the television signal during the vertical blanking and transmitted as part of the video signal. To a normal viewer, the data lines would not be visible. Some viewers may use a special decoder to retrieve the data which can be mixed with the video image to become an integral part of the picture.

Viewdata was developed by the U.K. Post Office which also operates the telephone system in the U.K.. The system is designed around the telephone network whereby a user can request any one of the 60,000 pages offered by dialing the Viewdata centre. Information is transmitted to and from the user through the same telephone line coupling through a modem. It takes about two seconds to receive the text which can be viewed on the television screen through a Teletext decoder. At the present time, up to 200 telephone lines can be simultaneously interfaced with a Viewdata centre computer. Design is being made to accommodate up to 600 telephone lines.

A CATV system could be used to provide Viewdata service. However, to implement such a service in the U.K. through cable would cost between 1,000 million and 5,000 million, a very substantial investment. Presumably, one main reason for such a high cost is that CATV is much less popular in the U.K. than in Canada where national penetration is over 50% and, for metropolitan areas, it ranges from 70% to over 90%.

There is an advantage for sending Viewdata over the telephone in that security can be fairly well maintained. However, with the limited number of telephone lines available for dial up, during peak load there may be a severe telephone traffic congestion which would annoy many users. In particular, some lines may be tied up for many minutes by heavy users taking an educational course, doing a catelogue shopping, etc. CATV systems can offer a relatively stable interactive service. Furthermore, since most data could be transmitted in a broadcast mode, there would be a minimal amount of interactive requirement.

It is quite apparent that data can be most efficiently delivered in cable by digital transmission. The following is an attempt to describe the system requirements which is envisaged to be most suitable for broadcast data.

a) A similar encoding and decoding scheme should be used for all broadcast information data services in order to ensure minimum total system and terminal costs. The obvious choice is a digital encoding system designed around the framework of an NTSC video signal. Available systems such as Teletext and Antiope could be modified and adopted as a suitable standard.

b) Digital data should be able to be transmitted and received through either a dedicated video channel or multiplexed onto a video signal to form a composite signal.

c) Decoding device should have a provision for addressable features by using a user identification code.

d) Decoding devices should have provisional attachment terminals for other peripheral equipment such as printers, frame storers, VTR's, and controlling switch devices. However, for controlling functions, a separate unit with built-in RF circuitry and decoder may be advantageous.

e) Since not all the data services are of textual form, packet transmission would be desirable so that different types of services could be multiplexed onto the same transmission channel.

Selectability

Information data delivered using request/address can be made very selectable. The user may choose a service from among those offered and be billed accordingly. Rate structures may be based on the number of requests, amount of information, amount of computer time used, or even the availability of the information, in which case, the user may be billed for the direct cost of obtaining the requested information.

Information data through broadcast/capture is much less selectable. The user either subscribes or does not subscribe and he could only be charged on a flat rate basis whether he uses the services or not. Conceivably, the monthly flat rate charge would be based primarily upon the decoder cost.

Controlling data services, depending on the functional requirement could be made quite selectable. Though a stand-alone receiver decoding unit could be made at a relatively low cost, the installation cost, which may include an array of power line switching relays and other necessary hardware adding on to the labour cost, could be quite expensive. Since the true nature of a controlling function is so far not quite clear, it is rather difficult to speculate how these services should be provided except that the data could be broadcast on a separate channel or it may share with the channel(s) designated for request/address type information data.

Cost Estimates for Broadcast Data

A data transmission system for a typical CATV system would comprise of a satellite computer with medium storage capacity (less than 10 Mbyte or about 15,000 32 x 20 line pages) located a convenient site in the system, preferably where all the return trunks converge (i.e. the hub). This satellite computer may be linked to a central computer with high storage capacity which would be used as a master data bank for non-popular special inforamtion. Should a user request such a piece of information, the satellite computer could make the same request to the central computer to run the search and send back the correct information to the user through the satellite computer. Cost estimates for the service are shown in Table 12.

Table 12- Cost Estimates For Broadcast Data

Item	Cost ($)
Central computer with 10 front end data processors	300,000
Satellite computer with video interfacing unit	35 to 100,000
Modulator	2,500
Decoders (Information data)	100 (50 future)
Vertical blanking broadcast/capture	100 (50 future)
Dedicated channel request/address	200 (100 future)
Decoder (Controlling data)	
Stand-alone non-NTSC compatible	20

See Table 13.

TABLE 13 - BROADCAST DATA DELIVERY SYSTEM

SERVICES	CAPACITY	RESPONSE TIME	RELIABILITY	SECURITY	FLEXIBILITY	PRIVACY	UPGRADABLENESS
Broadcast/capture in vertical blanking	low	average 6 s.	good	N/A	poor	N/A	N/A
Dedicated channel broadcast/capture	high	average 6 s.	good	N/A	poor	N/A	good
Dedicated channel request/address	high	average 6 s.	good	good	good	good	N/A
Stand-alone controlling data	low	fast	good	good	fair	N/A	fair

Summary

Broadcast data can be divided into two major types namely information data and controlling data. Information data can be subdivided into broadcast/capture and request/address. While broadcast/capture information data could be provided by either broadcast television stations or cable systems, request/address is assumed to be provided by cable systems only. Likewise, controlling data would be provided by cable systems.

Digital transmission is found to be most efficient and suitable for broadcast data. An encoding system designed around the framework of an NTSC video signal with packet transmission, and addressable capability would be most desirable. Though all broadcast data can be transmitted sharing the same format, a separate decoder with built-in receiver may be necessary for handling the controlling data due to its non-interruptable requirement if captioning is desired. Hence the encoding system for this data may be somewhat different from information data. A less complex scheme may be used so the terminal hardware may be produced for much less cost.

INCAST DATA

INCAST DATA

INTRODUCTION

In order to determine the requirements for return signaling, various services were analyzed. A representative sample of services requiring return signaling follows. Although the list is not exhaustive, it contains the return services most often quoted. Those that have not been mentioned would probably have characteristics similar to one of those that are analyzed.

These services which require return signaling are:

Service	Billing
- Electronic Mail	Transaction or message length
- Shopping	Transaction
- Alarms	Flat rate
- Opinion polling	Flat rate
- Education	Flat rate
- TV Games	Transaction
- Computer terminal	Message length or transaction
- Meter reading	Flat rate
- TV channel monitoring	Flat rate
- Request for broadcast	Transaction
- Financial Services	Transaction

Viewing these services in the selectability framework, service selectability for content or time is either not applicable or implicit. Billing selectability, however, is a meaningful way of grouping. It is easily apparent that return signaling services may require incremental investments in plant and terminal devices which can be easily apportioned to those using the services. It is also necessary to apportion the bandwidth and usage costs to the subscriber. This can be done on a flat rate basis or for some services distributed according to usage by monitoring transactions.

Descriptions of these services and the characterization as to their deliver requirements follow.

CHARACTERIZING INCAST DATA SERVICES

Alarm Service

Alarm services involve the monitoring of smoke sensors and alarm equipment and transmitting its status to a central location. In case of an emergency or malfunction, the appropriate agency has to be notified.

For fire alarms a system malfunction could result in significant property loss and liability, and for medical alert this malfunction could result in death. For services of this critical a nature, the system's condition should be monitored in the order of seconds. Those delivery mechanisms that may provide confirmation in the order of minutes or hours are unsatifactory.

Each monitoring cycle need only be of a short duration with 1 bit providing the status of each alarm.

Response time, however, is critical. From the time of an alarm until appropriate notification occurs only seconds should elapse with a desired response time in the order of ten seconds.[7]

Opinion Polling

Opinion polling is a service that could be undertaken with local origination productions to provide audience involvement in the program or to provide marketing research information about various advertisements, political stands or various other topics.

As a general rule most opinion polls could be phrased in a multiple choice manner with either a yes, no, or an A,B,C response. The incast message, therefore, from each subscriber need only be of a duration of 2 bits to provide these types of responses.

For most of these applications, it would be desirable to display the results of the questions to those participating so they have feedback and can compare their feelings with their peers. Indeed, without this feedback, it is doubtful that the subscribers would be motivated enough to respond. It is therefore evident that a reasonable response time of 1 minute is desirable to tally all opinions and display the results.

With a 1 minute response time, no more than 60 x 24 = 1,440 requests per day can be monitored.

Electronic Mail

Electronic mail as an incasting service could only be used in conjunction with a broadcast - addressed service. An introductory system could satisfy an existing communications need which is presently at least partially satisfied (i.e. local correspondence). Both the telephone and mail networks handle this traffic at present.

Twenty-two percent of present mail volume is correspondence and thirty-five percent of mail volume is local.(8) Most mail correspondence may be non-local as much local correspondence is carried on the telephone network but, in any case, a large local correspondence volume does exist.

Local correspondence could be considered a "trial" service as it does not need the security of business transactions which will be discussed later. The correspondence service would be used to increase subscriber confidence in the system as a prelude to "transactions" which account for forty percent of mail volume.(8) Also non-local correspondence and transactions could be added with the addition of long distance data trunking.

The analysis below of the two existing networks which provide correspondence services will help to characterize this service.

Postal Service
- (Transactions and Correspondence only)
- Response time - 1 to 7 days
- Duration - 1 to 5 pages average
- No. of Messages - 1 per day average
- Receipt - at convenience of receiver
- Billing - minimum flat rate per message sent
  - if weight greater than minimum, billing is dependent on weight and destination
  - no subscription fee.

Telephone Service
- Response time - 60 seconds at initiation, instantaneous afterwards
- Duration - 1 to 10 minutes
- No. of Messages - 10 per day
- Receipt - at convenience of sender and consent of receiver
- Billing - subscription per month (in Canada)
  - for non-local calls, rate dependent on message length (time), destination, and time of day
  - installation fee.

The major "defect" in the present postal system is the response time which necessitates little or no interaction. Also messages which must be answered relatively quickly (in the order of hours) are not suitable for this system.

Telephone service has a high degree of interaction and thus a faster response time but receipt of message is dependent on the coincidental availability of both the sender and receiver.

For non-interactive correspondence, a one hour response time would be adequate (i.e. a message is available to the receiver within one hour of transmission). Single messages would vary in duration from about 500 - 20,000 message bits. About one message per day would likely be the average traffic with businesses exceeding this amount considerably.

Each message would have a header containing both the sender and receiver addresses.

Billing could be based on subscription, number of messages sent, duration of message, time of day, or any combination of these.

Security would be necessary, although the incast message would be secure by nature. (see Appendix 4).

Security in the downstream direction is more critical and is discussed in the Broadcast - addressed services discussion.

Shopping

Electronic shopping can be performed in two basic ways. One is to perform a search through a list or catalogue of items and manually record information such as price, appearance, etc. The alternative is to request information about a certain item (or group of items) and have the desired information automatically displayed.

The first system is a "response interactive" system in which the subscriber responds to an index or standard list and cannot initiate an interaction. This service requires a simple home terminal with the capacity to transmit the desired page number and to receive the broadcast message. For many comodities, a frame-grabbing device in the home would be necessary to inform the subscriber about the product. For others, such as groceries, a display of commodity name and price would be sufficient.

Required response time would be in the order of ten seconds with each request consisting of a page number of some three digits (twelve bits). The number of requests would be in the order of one hundred per day.

Security for this system would not have to be important as no transactions would take place.

Subscribers could be billed for a subscription to the service or, for a requested page of information or a combination of the two. Billing rates for requests could be dependent on time of day to eliminate peak loading on the forward transmission channel.

The alternative system would carry much more incast traffic as the subscriber would have to initiate an interaction. The commodity name would be transmitted and the subscriber would receive information about that commodity. Searching and sorting would be automatically performed by a central computer.

Sorting could be made selective (e.g. instead of sorting for all ketchup prices, only prices of 0.5Kg ketchup bottles would be transmitted to the subscriber).

Incast channel traffic would be small messages containing commodity type and other relevant information (approximately 200 bits). A ten second response time is desirable.

Financial Services

Financial services requires an identical transmission medium to that required by the final phase of shopping or Teletext. (i.e. a high degree of interaction (subscriber initiated and security).

These services would require a real time connection between the CATV central computer and the financial institutions central computer. Many large financial institutions presently have centralized data processing from their branches. This service would extend the terminal to each home.

No frame-grabbing is necessary for any financial transaction but hard copy would be desirable.

Computer Terminal

A computer terminal is a specialized service. The cable is acting as a communication path for this device. Although this application is very general, a maximum data rate of 110 bits per second is adequate. Computer traffic is very bursty, with the average data rate being considerably less than this--probably less than 5 bits per second.[9] Usually, the computer terminal is idle waiting for the operator to type in a message. Incast transmission could be with full or half duplex. Because of the difficulty in detecting program errors, full duplex or a positive acknowledgement with parity is recommended. This results in more loading on the forward path.

Education

Education requirements in the incast direction could depend on the format of the broadcast stream. Two basic types are visualized.

The first type involves home classrooms with lessons simultaneously being transmitted to many locations. For public schools, this would mean dedicating eight broadcast channels during the day. Incast data requirements would be used to monitor the progress and understanding of students. This could be handled similarly to the "opinion polling" or TV games service with a fast response time.

Alternatively education could be offered by computer aided instruction. For this method the home computer terminal has identical requirements.

Meter Reading

Meter reading could be implemented in various ways and have different requirements depending on the type of meter reading desired.

At one extreme for single rate metering it is only necessary to read the meters once a month (a billing period) to determine the consumption since the previous reading. This would involve transmitting a message of about 9 bits if binary encoding is used or 12 bits if BCD encoding is used to detect the added consumption per meter per month. This transmission could be commanded from the hub and therefore a receiver and control logic in the home is needed.

For time of day metering, readings would have to be taken at the beginning and end of each rate step to determine the consumption while that billing rate was in effect. Depending on the number of rate steps, this would probably involve at least two readings and perhaps up to twenty-four if this was done on an hourly basis. As the period between readings decreases the additional consumption decreases and the message length required to transmit the information would be thought to decrease. However, to avoid significant rounding errors, it is probably necessary to maintain the same significance as the monthly flat rate system and transmit 9 to 12 bits.

Although it is more inefficient in transmission capacity, a different approach could be used to minimize the home terminal cost. The previous approach required a receiver and control logic in the home terminal. This could be eliminated if one were to dedicate a single bit to monitor the least significant digit of each meter and transmit its condition continually to a central office. By monitoring the condition of the least significant digit in the meter the head-end could count revolutions in the dial and determine the total usage remotely and independently of the meter. This system would be satisfactory for either flat rate or time of day billing. It would have to be monitored sufficiently often such that under maximum consumption a count would not be skipped between readings. For a monthly flat rate meter, reading 1 scan per hour is probably sufficient. For time of day billing however, 1 scan per minute is probably more appropriate.

TV Channel Monitoring

TV channel monitoring involves monitoring the channel which is viewed by the subscriber for pay per view pay television, Nielson rating or various marketing survey applications. Assuming that up to 30 channels are offered 5 bits are needed to encode the channel being viewed. If for marketing research applications commercials need to be monitored, it is necessary to repeat a scan every 10 to 15 seconds to provide at least 2 samples during a 30 second commercial. For Nielson ratings or per view pay television, however, it is only necessary to monitor every 5 to 15 minutes for the same certainty.

Requests for Broadcasts

The delivery requirements for requests for broadcast naturally depend on the nature of the request. If a movie is to be chosen from a specific video library or if a page of information is to be chosen, they could all be requested by transmitting back simply an item number. The message length required to request a specific item therefore is dependent on the number of items in a central library. For example, 14 bits are quite sufficient to address up to more than 16,000 different items. Since the subscriber is making a request, it is desirable to have a confirmation. In the case of the short service time article, such as frame grabbing, a fast response time probably in the order of 10 seconds is required. The usage of the service will determine the number of requests in a day, for services of the information retrieval, and video library nature. Probably around 150 requests per day can be assumed.

It is important to realize that this is a very elementary requesting scheme. More sophisticated schemes where movie titles or specific pieces of information are addressed by name would need a much greater message length and faster data rate and require some type of alphanumeric keyboard. These then become very similar to their requirements to the faster and longer message of a shopping or banking service.

Characterization Summary

The data incast services that were characterized appear to fall into three general groupings. These are the faster, longer and bursty type services such as electronic mail, shopping, banking, education, and home computer terminals. Also, there are the continuous short monitoring services such as alarms, page requests, Nielson rating and monitoring of the channels which were watched. There are also polling services such as meter reading; opinion polling, and TV games. A summary of the delivery requirements and their categories is shown in Table 14.

Table 14 - Delivery Requirements of Incast Data Services

	Response Time	Message Length	Number of Scans/Request Per Day	Maximum Information Transfer Rate	Classification of Service
Electronic Mail	1 hr.	50-20,000 bits		110 bits/s	bursty
Alarms	10 s	1 bit/alarm	8,640	slow	continuous monitoring
Opinion Polling	60 s	2	1,440	slow	polling
Shopping - Search	10 s	12 bits	100	slow	continuous monitoring
- Request	10 s	200 bits	20	110 bits/s	bursty
T.V. Games	10 s	2 bits	8,640	slow	polling
Education - Polling	10 s	2 bits	8,640	slow	polling
- Computer aided instruction				110 bits/s	bursty
Computer Terminal	Average data rate 5 bits/s			110 bits/s	bursty
Meter Reading - Monthly		9-12bits/meter	1/month	slow	polling
- Time of Day		9-12bits/meter	2-24	slow	polling
- Accumulating Monthly		1 bit	24	slow	polling
- Accumulating Time of Day		1 bit	3,600	slow	polling
T.V. Channel Monitoring		5 bits	288-8,640	slow	continuous monitoring
Requests for Broadcast - Simple	10 s	16	150	slow	continuous monitoring
- Complex	10s	200	150	110 bits/s	bursty
Financial Services	See Shopping				bursty

INCAST TRANSMISSION METHODS

With these delivery requirements in mind alternative transmission methods can be examined to determine suitability. A review of two-way cable television technology and home terminals is included in Appendix 5. When considering this problem, questions immediately arise. Is it necessary to install a cable return path? Will the already in existence telephone system be adequate for these services? What is the comparative cost involved in both cases?

All of these services require slow data rates making the telephone system for the return path quite acceptable. Indeed some infrequent requests can be handled by verbal orders over the telephone. Expanding to digital services by using the tone encoder on push button telephones is possible for many services. For faster digital services a 110 bit per second modem is required. It is apparent that the present telephone system is quite capable of providing a signal path for these services.

Services such as alarms and TV channel monitoring which require an almost continuous transmission path necessitate the installation of additional dedicated lines. Most other services, at least initially could be piggybacked on the present telephone system. As usage grows, again additional dedicated lines may need to be installed to ensure telephone availability to other members in the household, and for other services. When the frequency of use increases significantly, it is appropriate to consider cable.

An example of this is meter reading. For monthly meter reading, the telephone system obviously has a competitive advantage if a two-way cable system is not in place, as it already has the transmission medium and the addressing means, and system loading is minimal. However, if time of day metering develops cable may be a more appropriate alternative as the frequency of requests and system loading has increased significantly. An alternative could be to install a local memory in conjunction with the telephone system to accumulate and store the billings and transmit it less frequently. This still needs to be compared to cable as it is not obvious which method should be preferred.

RETURN SIGNALING TECHNIQUES ON CABLE

There are basically two different philosophies for two-way systems. The vast majority of all home terminals and systems are of the interrogate response type. Examples of this type are the RCA, EIE, Telcin, Hughes-Theta Com, Tocom, Communicom, Vicom and Qube home terminals and various other designs that did not develop past the prototype stage. A central computer individually polls each home terminal to see if it has a message and check its status. The home terminal responds confirming its address, sending its status, and giving any message present. The system is sequentially polled checking the status of individual terminals. Terminals for this type of system presently cost in the $165 to $300 range, although in the future they could potentially sell for $75.

Another two-way system philosophy is the listening, area multiplex system developed by Co-axial Scientific.[10] In this delivery scheme communities are divided into service areas of the distribution amplifiers. Within these areas an F.D.M. technique is used to assign each subscriber home terminal a different frequency. The home terminal continuously transmits only a status and message word. The control computer interrogates the entire distribution area at once by closing a code operated switch located in the return signal path at the distribution amplifier. A receiver at the central location merely listens to the home terminals in that area to determine their status. The central computer then proceeds to the next area where the same frequencies can be re-used and continues in this manner sequentially through the other distribution areas in the system.

The home terminal for this system, because it does not need the receiver and decoding logic of the interrogation response units, would presently cost in the $60 range and could be expected in future quantities to be in the $20 range.

A brief description of the various development efforts is in Appendix 5.

Another potential transmission method which has not as yet been developed for cable is Packet Broadcasting. Packet broadcasting is a technique ( ) where data is sent from one point to another by broadcasting over a communication channel which is shared by a large number of nodes. The system was developed in the late 1960's in Hawaii and has been called the "ALOHA system". This system has been in operation at the University of Hawaii since 1970.[12]

The packet system is capable of originating requests and does not need to be polled as in an interrogation response system. Instead, when a message is ready to be sent, the home terminal transmits the packet and waits for a positive acknowledgement. If this is not received within a certain period, it transmits the message again until it is acknowledged.

Packet broadcasting is especially useful and efficient for "bursty" types of communication. (i.e. the average data rate is significantly less than the maximum date rate). Almost all interactive data communications systems can be categorized as being "bursty". This "burstiness" of data traffic has also been used to create efficient communications trunk networks which use packet switching (e.g. DATA PAC).

Packet broadcasting is a more uncontrolled form of data communications which essentially takes advantage of the same efficiencies. A potential packet broadcasting home terminal is similar to any completely interactive home terminal (i.e. it contains a keyboard, memory, both a transmitter and receiver, and a display capability).

The packetized portion of the terminal which is software controlled by the microprocessor is essentially free. The HF modulator transmission time is controlled by the microprocessor. A packetized terminal is then equivalent in cost to a Vu-Facts receiver plus an interactive home transmitter, and could be expected to cost presently around $200 decreasing to $100 in quantity and potentially $75 in the future.

Packet broadcasting is not evitable for alarm services where regular monitoring is required but is suitable for interactive services where communication is bursty. An average data rate of five bits per second [9] for any active terminal can be conservatively assumed.

An analysis of various packet broadcasting transmission methods to incast the home terminal information is contained in Appendix 6.

COST OF PROVIDING TWO-WAY CABLE

Regardless of the transmission method, two-way cable has common requirements. Because of the configuration of present systems ingress and noise collects in the cable system drops and distribution area accumulating, as in a funnel, towards the central hub. Ingress imposes by far the most critical requirement. Early two-way tests were plagued by unreliability resulting from ingress. [13] It is therefore our opinion, and to some extent generally believed, that the ingress must be stopped from accumulating in a CATV plant by blocking it at various locations. The most appropriate location appears to be at the bridger. Co-axial Scientific, Hughes, Qube and Tocom all use switches at the bridger of somewhat different formats. As an alternative, digital systems could have regenerators at this location. For the purposes of this study, similar costs are assumed regardless of whatever method is employed. The following is an estimate of the costs of providing a system with two-way communications.

It is assumed that a 525 mile, two-way compatible system is being updated. The system has 325 trunk bridger amplifiers and 1800 line extenders. Average density is 110 subscribers per mile.

For each trunk bridger amplifier the following is required.

- 5 - 30MHz return trunk amplifier	$100
- 5 - 30MHz return bridger amplifier	100
- equalizers	8
- bridger filter, blocking device and housing	350
- two trunk filters	40
	$578

For 325 amplifiers the cost is $578 x 325 - $187,850

For each line extender

- return amplifer	$ 50
- filters	20
	$ 70

For 1800 amplifiers the cost is 70 x 1800 = $126,000

Standby Power - one for every two trunk stations (allocate ½ cost to return and ½ to forward).

$1200 each x ½ x $\frac{325}{2}$ = $97,500

Therefore, the total cost of the two-way system is

$187,800
126,000
97,500

$411,350 for 525 miles of plant

= $783 per mile

- or 110 subs per mile - $7.12 per sub

= if 20% return penetration - 22 return subs per mile

the cost per return sub = $35.60

To this must be added the head-end and terminal costs which are dependent on the transmission scheme. The transmission methods can now be evaluated to determine which ones are appropriate for the different classifications of requirements.

TRANSMISSION METHOD EVALUATION

Continuous Short Monitoring Services

Continuous short monitoring and their requirements are listed in Table 14. Alarm services are representative of the requirements. Continuously and at short intervals (about 10 seconds) the status of the alarm needs to be checked for operation and condition. The applicability of the different transmission systems in analyzed.

If the listening, area multiplex system is used, transmission overhead on the system in minimized as the terminals do not have to be addressed. Handshaking does not occur because the terminals are identified by area and frequency. Inexpensive home terminals without receivers and decoding logic can therefore be used.

Hub costs for using this system are shown in Table 15.

Table 15 Hub Costs for Listening System

Item	Cost($)
- receiver (500 channels - for a large system)	$100,000
- code operated switch addressor	5,000
- central computer with perepherals	30,000
- standby processor	10,000
- software	10,000
- miscellaneous equipment	5,000
TOTAL	$160,000

A subscriber terminal costing $60 in small quantities is required, with moderate quantityprice estimates of $35.00.

Therefore, the cost per subscriber for the area multiplex listening system is $\frac{\$160,000}{N}$ + 35 where N is the number of subscribers.

Alternatively, an interrogation response system can be used. Generally, due to the short message in comparison to the address length, most of the traffic consists of transmitting addresses. This results in an inefficient use of the communication path. Costs of this system are as follows:

- Central Data system - $30,000 per 2,000 terminals
- Home terminal - $150.

Therefore, the cost per subscriber for the interrogation response system is $\frac{30,000}{2,000} + 150 = \$165$.

Now we can examine the point of indifference from a cost point of view between these two systems.

$$\frac{160,000}{N} + 35 = \frac{30,000}{2,000} + 150$$

$$\therefore N = 1230$$

Therefore, if more than 1230 terminals are required the area multiplex system is preferred. The point of indifference is actually much lower as for this size of a system a smaller less expensive receiver could be used.

At the 100,000 subscriber capacity of the area multiplex system subscriber costs drop to 36.60 per subscriber, significantly lower than the almost constant $165 cost of the interrogation response system.

A packet system could also provide this service. However, since its costs are similar to the interrogation response home terminal, area multiplexing is preferred. Also a packet system without a receiver could provide monitoring services by randomly transmitting the status. This would involve every terminal transmitting its address and message such that it would be received every 10 seconds. This would necessitate a 15 bit address (to allow for 32,000 terminals), and a packet length select bit to indicate either a short packet length for monitoring or longer for upgradeability, and a 16 bit message. Therefore, every 10 seconds 32 bits of throughput from each terminal is required or 3.2 bits per second. As can be seen from the various packet schemes enumerated in Appendix 6 this would have a significant loading on the system. Also as the home terminal is considerably more complicated than the area multiplexing system and therefore more costly, the listening system is preferred.

With 14 message bits, fourteen independent conditions can be monitored or if the conditions are mutually exclusive up to 16,384 states determined. This is ample for monitoring and ideal in transmission efficiency as addresses are not transmitted. Therefore, for services of this type, the low cost area multiplex listening system is preferred and has adequate capacity.

Bursty Message Services

Electronic mail, shopping and computer terminals are typical of services of this type. For their requirements the area multiplex listening system is unsuitable as it has a fixed short word length and is non interactive having no data receiver.

A polled, interrogation response unit could be used to provide these functions. Because it is necessary to poll terminals to determine if they have a message, a considerable amount of time is consumed needlessly as most terminals will have no message. Additionally if many messages occur with long transmissions the polling rate is necessarily slowed down resulting in a slower response time. A technical description of interrogation response implementation is in Appendix 7.

A packet system is ideal for this type of service. Since it does not need to be polled, but can initiate messages if and only if it is required. This is very efficient for this type of service. Projected costs for a suitable terminal are in the order of $150. A technical description of various packet implementations for these services are listed in Appendix 6 .

Polling Services

Services which are suited for polling are those such as meter reading, opinion polling and TV games where the time for monitoring the home terminal can be acceptably controlled from the hub or data communications centre. The interrogation response terminal is ideally suited for these services as communication need only occur when conditions need to be monitored. This results in efficient use of the system. Because the packet system has a receiver it also can operate in the interrogation response mode.

An alternate approach using the packet system, for services such as meter readings, is to automatically transmit the meter readings at predetermined intervals. This eliminates the need to interrogate the unit. This is beneficial in that the receiver portion can be tuned to a video channel for captioning or subtitle purposes.

Depending on the evolution of services, it may be desirable to consider the capabilities of the area multiplex listening system as this terminal could easily be the first to evolve.

Capabilities of the Area Multiplex System

Although the 'listening' system cannot be interrogated and is therefore not ideal for applications such as meter reading and opinion polling, individual message bits can be dedicated for this purpose. Since these are transmitted continuously and only used occasionally, the system is inefficient. However, due to the lower cost of the home terminal and the likely evolution of two-way, this is an alternative. To illustrate its flexibility the following assignment scheme is listed for the 14 bit message.

TV Select	1 Bit	Interactive Response
TV Channel Monitoring	5 Bits	
Pay Scrambler	1 Bit	Response/Request
TV On - TV Off	1 Bit	(1024 Alternatives)
Meter Reading	3 Bits	
Alarms	3 Bits	Alarms

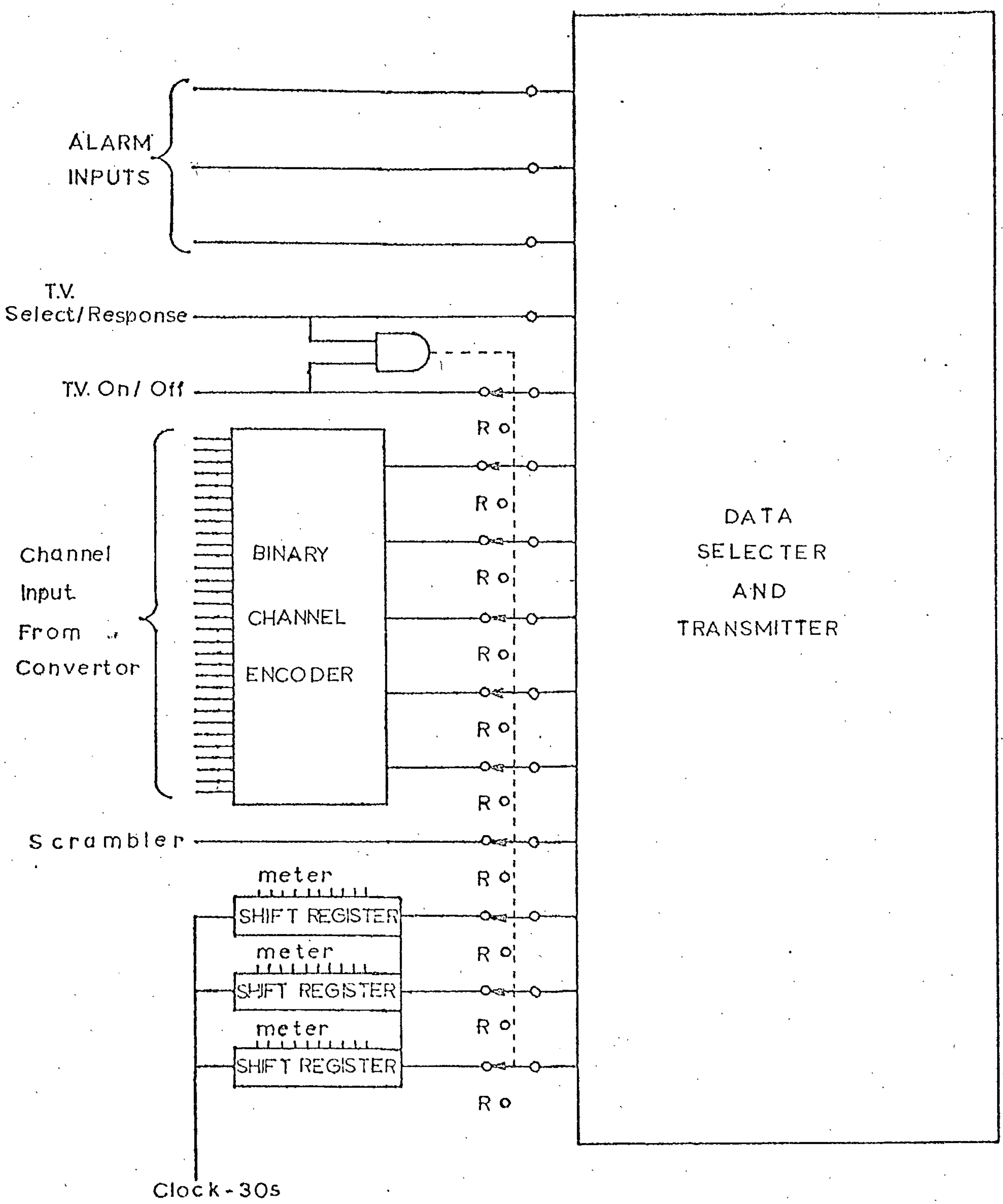
When the control switch is in the TV select position, the home terminal inputs monitor the TV channel, scrambler, 3 utility meters and TV condition.

When the switch is in the response mode the TV select features of a converter are disabled preventing the channel from being changed. If the TV set is on, the interactive mode is used while if the TV set is off, the terminal automatically switches to the TV select mode to monitor the meters.

Since the meter reading mode does not operate continuously, each meter has to be sequentially cycled into their respective bit at a clock rate greater than the scan time (about 30 seconds is appropriate). This requires a shift register to input the serial information. A block diagram of the encoding network is shown in Figure 1.

Using this assignment scheme, the terminal can monitor 3 alarms, the channel being watched, a pay scrambler, and three different meters as well as provide response or request services for 1024 items.

It is therefore evident that depending on the evolution of services, because of the cost advantage, the listening area multiplex system probably will initially be used to provide the 'polling' services.



R - denotes response
from keyboard

Fig. 1 Listening Terminal Encoding Network

SUMMARY

Although it is possible to use the telephone system for all of the incast data services, the loading generated by many of the services would necessitate installing additional dedicated lines. Alarm monitoring and TV channel monitoring are examples. For these continuous monitoring services the listening, area multiplex system over cable should be used as it is inexpensive and flexible. This method is not capable of truly interactive services, because it has a small message length limited to simple responses, but it is adequate for services foreseen in the near future.

When interactive services such as electronic shopping and computer terminal applications are introduced, the telephone system again is ideal as these could be piggybacked with low additional cost. Competitive with this, if two-way cable exists, is an interactive CATV system. When loading, usage and popularity increase such that in using the telephone system, a dedicated line is required, the packet incast or interrogation response system has a definite competitive advantage. A cable terminal could then be provided on a selectable basis to those desiring this added capacity at a cost of less than $100 per subscriber.

OTHER VIDEO SERVICES

OTHER VIDEO SERVICES

Other video services can be provided on cable which fall into none of the previous categories. One is incast video services.

Two possible types of incast video services are foreseen for CATV systems. The first service would consist of local origination programming to be incast to the hub where it can be processed for simultaneous broadcast. The expected traffic for this service is light and programs would tend to originate from only a few locations (e.g. public buildings, arenas, etc.) The second service is a video monitoring service that would incast a video frame to be received at the hub for retransmission to the appropriate location. Some example services are traffic monitoring at major intersections and a remote video surveillance system to provide security (similar to slow-scan television).

Another video service required in the future is frame grabbing. This is also discussed in this section.

COMMUNITY PROGRAMMING

Due to the expected light channel loading of live community programming on the incast system, it seems unwise to dedicate 6MHz of bandwidth to this service on the entire system. A dedicated cable to link the transmission origination point to the trunk or, perhaps, the head-end or hub would not use bandwidth on the CATV distribution system. Fortunately most local programming would originate at only a few selected points so this approach is feasible (a minimum of redundant cabling is incurred).

Selectability does not pertain to the incast portion of community programming but does pertain to the broadcast portion. As has been mentioned, significant costs are incurred by the CATV operator in producing community programming. The techniques for obtaining selectability for the broadcast portion are outlined in the section on broadcast video services.

VIDEO MONITORING

Due to the high cost of security services to monitor closed circuit television (CCTV) systems on site, an alternate system bringing the CCTV pictures from various locations to a central monitoring point could reduce the amount of labour necessary to provide security and thus potentially reduce costs. In addition, smaller commercial establishments which desire continuous service, but cannot afford the necessary labour rates could be monitored at a small incremental cost.

Some security services are provided in a similar fashion by using slow scan television over a narrow-band communications link. The system is shown in Figure 2. Note that a scan converter is necessary at each transmission site and that a single 4KHz communication line is used from each camera site to the receiving site. There are, then, few economies of scale to be realized using this system.

The CATV approach is shown in Figure 3. An addressable switch is substituted for the scan converter and a 6MHz communication line is time-shared. The 6MHz line can be shared among several security companies, traffic monitoring, and other desired services. Economies of scale are realized as the transmission site hardware is reduced (no scan converter). The 6MHz channel is only available if the CATV system is return-feed compatible. Otherwise it is very expensive. (See section on Return Costs.)

Selectability is provided at the hub of the CATV system and is software controlled. Only the information desired by each party is

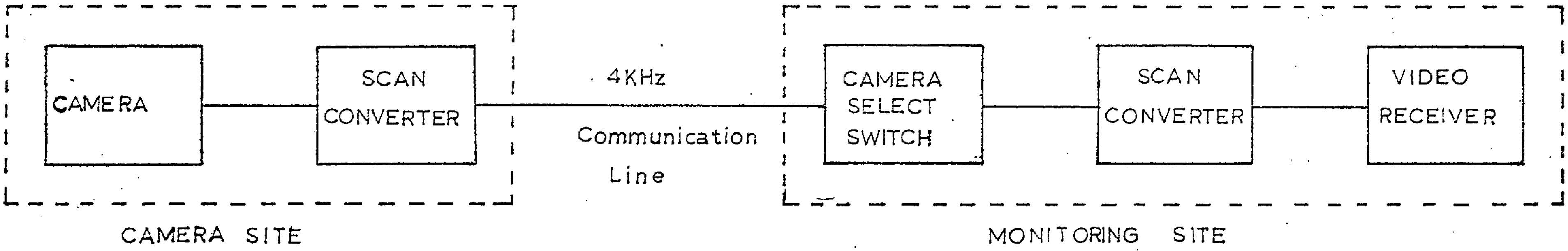


Figure 2 Narrowband Video Monitoring

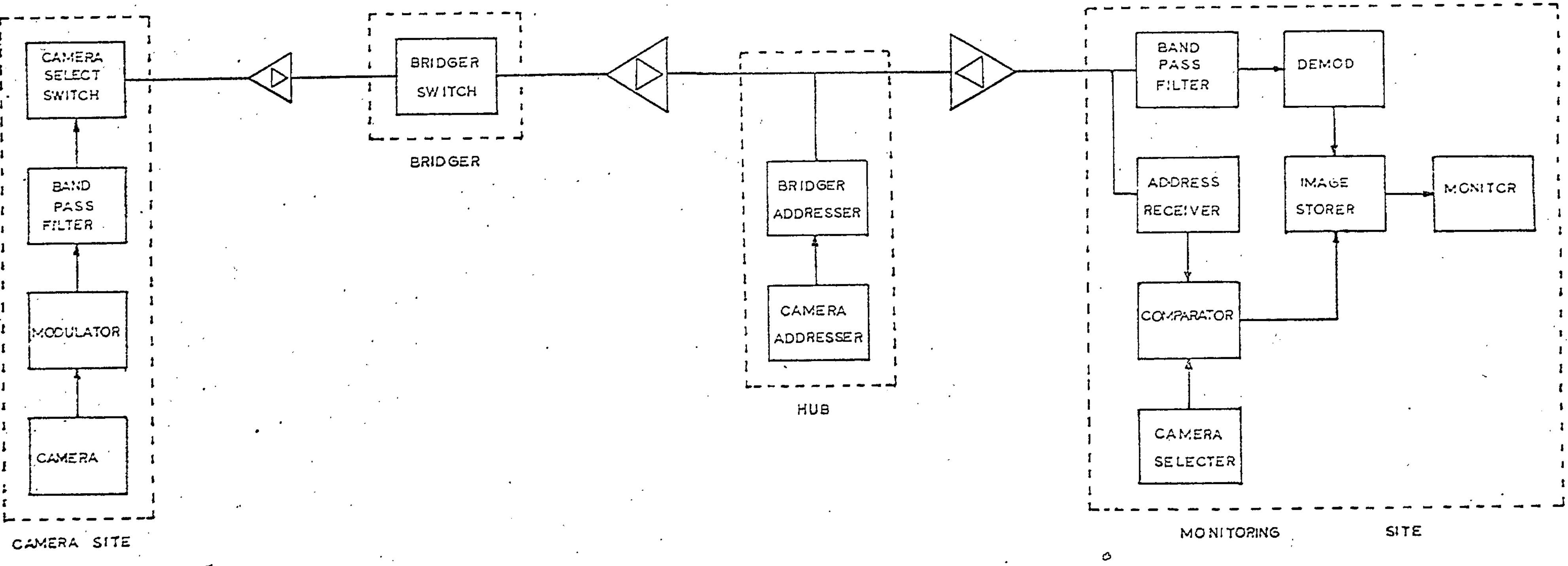


Figure 3 CATV Video Monitoring

received by that party as security is important. Either a scrambled signal broadcast on the CATV system or a dedicated cable from the hub to the monitoring point can be used to provide security and selectability. As previously mentioned, the incast system is secure due to system configuration as well as to the time-sharing of the channel.

Present and future costs for the transmission site are listed below.

TX SITE COSTS (EXCLUDING CAMERA)

	Present Cost ($)	Future Cost ($)(Quantity)
Modulator	700	100
BPF	150	50
Addressable Switch	150	50

The "future" costs are based on inexpensive present items which are commercially available (e.g. video game modulator).

STILL PICTURE DISPLAY

Several services such as electronic shopping and electronic mail require a frame grabber to display a picture. For compatability with a television receiver, NTSC format must be used. The resolution provided in this delivery method is adequate for these services.

A frame grabber is basically a video storage device which is capable of storing one frame of 525 line NTSC standard video. By repetitively scanning the same frame at the rate of roughly 30 times a second, a video display of effectively a still picture can be achieved. During transmission, a continuous string of up to 30 different frames may be transmitted in every second. It would be virtually impossible for a viewer to see what is coming through without providing automatic circuitry to capture the frame the viewer selected.

A frame can be treated just like a page of information. It can be easily numbered and digitally encoded similar to broadcast data. By transmitting the video frames with limited lines of information data, the same broadcast data decoder may be used to identify the correct frame and activate the frame grabber. At the same time, it could also be used to display the textual information associated with the frame. Synchronizing pulses needed for the video signal could be locally generated or use the incoming signal as a reference.

The current cost of a frame storer is roughly $2,000. An electromechanical field storage device for consumer use has been made by a company in Japan but is not yet available in North America.

Conceivably, such a frame storer could be made available for less than $200 in large quantities.

For many services a hard copy display of the video frame is desirable. An NTSC compatible hard copy device could provide hard copy for both still pictures and data from the character generator.

EVOLUTION

EVOLUTION

The selectability presently offered to CATV subscribers is poor-billing for the service is flat rate, all or nothing, and content is chosen from among what is offered. The subscriber has the choice of purchasing or leasing a converter to increase his channel offering from 12 to up to 30 channels.

To evolve from the present system to one offering more selectability with the same program offering is difficult. Much additional hardware would be needed. The average subscriber would have to pay more to cover the cost. For channel selectability, this would involve scrambling channels and providing those wanting access to the channels with descramblers. While selectability of billing is increased, those choosing less than full service will experience a decrease in selectability of content. To provide more than a few levels of selectability (2 or 3), it is necessary to incorporate the descrambler with the convertor. This poses serious problems as converters are universally available and often owned by the householder. Interfacing with various converter designs is difficult, especially since this would mean modifying subscriber owned hardware. The security is also decreased considerably as the subscriber unit, which he justifiably has access to and can tamper with, is an important block necessary for providing billing security. This is unacceptable.

An evolution to a per program system increases billing selectability with no decrease in content selectability. For increased selectability this seems ideal. A per program system can be implemented for low cost by monitoring the converter channel if a two-way CATV network already exists but does not justify the cost of that network. Per program billing will therefore have to wait for the introduction of the two-way monitoring services.

Modifications to and security of subscriber owned converters are again a problem. The cable company could provide a converter/descrambler but this would render the subscriber converter obsolete. This seems socially irresponsible. If the sale of converters were to cease immediately and converters only leased by cable operators by the time two-way services evolved, the converter problem would be minimized.

While the level of selectability presently offered is poor, it is appropriate for the costs involved. Delivery costs are basically fixed and do not vary significantly by adding or subtracting channels, and the program package cost is low or free. The present CATV system is a cost effective delivery mechanism for providing present services. To increase his timing selectability, the subscriber has the option of purchasing a home V.T.R. This effectively increases content selectability as well. The subscriber ownership of the V.T.R. is not undesirable.

In the near term, Pay TV is a video programming service providing increased selectabilty. The package cost of this service is significant so increased delivery costs to provide billing selectability can be justified. Scramble-descramble is the preferred technique as it offers flexibility and upgradeability to include other programming.

As was mentioned, a two-way CATV system is required to provide selectability or a per program basis. When the two-way listening area multiplex system is installed for various monitoring service (e.g. alarms) per program video may then reasonably become available if considered desirable. It is imperative for these services, that the CATV system maintain control of the home terminal. Any monitoring service is inherently non selectable and would be billed on a subscription basis. Of course, choosing among the various monitoring services is at the subscriber's discretion.

For data transmission to the subscriber, the NTSC format is recommended due to its versatility in providing frame grabbing and captioning as well as interactive data services. A non interactive broadcast/capture information data service could be offered using this receiver. Selectability of this service is similar to standard CATV (subscription) but could evolve to a higher level. The listening area multiplex system or the telephone network could be used to provide a simple level of requesting. Billing selectability could then be increased.

In order to evolve past this simple request system, a versatile data base organization and sophisticated software must be used. To maintain compatibility this must be taken into account when designing the simple request system.

For interactive services, a sophisticated microprocessor controlled home terminal is needed. The exact protocol of this system is uncertain. Any interactive service, being software controlled, is highly selectable by nature. The original listening area multiplex system, would still remain viable for monitoring services.

A block diagram of a sophisticated home terminal is shown in Figure 4.

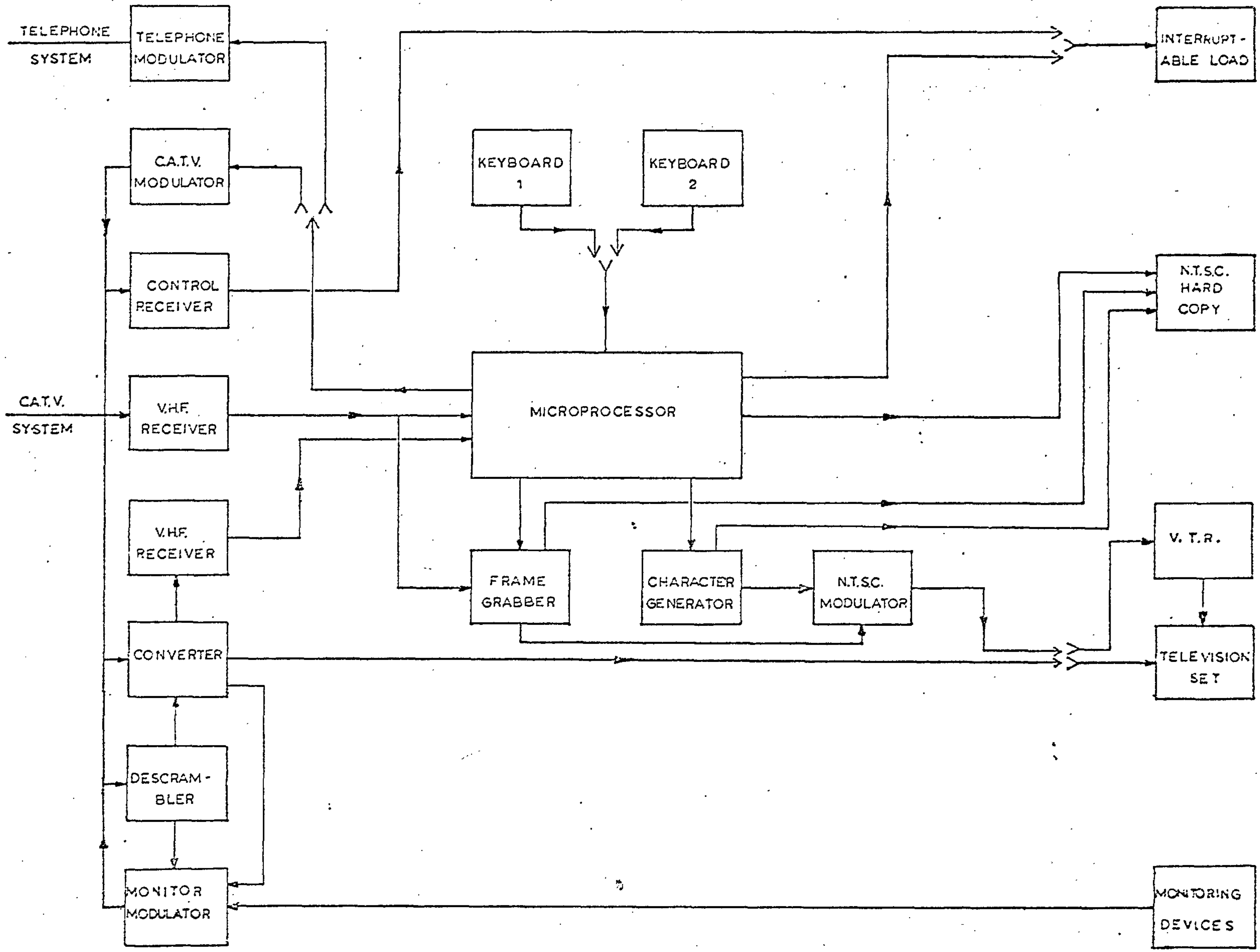


Figure 4 Home Terminal

APPENDIX 1

CATV SYSTEM RELIABILITY

CATV SYSTEM RELIABILITY

The carriage of many services (e.g. fire alarms) on a telecommunications network requires a high degree of reliability from that network. To be considered a possible telecommunications network for these services, a CATV system must demonstrate this high degree of reliability.

CATV networks are configured so that long routes of both passive and active devices are cascaded so that any single failure in the cascade will destroy the communications loop to at least some subscribers. With non-redundant-trunking and due to the cascading system configuration, a CATV network has in the past been considered relatively unreliable.

Subscriber complaints over standard CATV service have supported this contention and most CATV subscribers consider reliability of high importance.[A] However, it must be remembered that the telecommunications network for standard CATV services also includes the television or FM broadcaster and the VHF or UHF transmission path which occasionally is very long (approx. 150km). These two systems which are partially uncontrollable by the CATV operator add to the unreliable image of a CATV system but are, in fact, not applicable when considering various new services.

Major outages (those affecting more than five hundred subscribers) have been recorded in various CATV systems. Other outages can be considered statistically insignificant. A one hundred percent plant equivalent outage time is computed monthly.[15]

A thirty-two month average from September of 1975 up to and including April of 1978 for various CATV systems is shown in Table 15.

TABLE 15 CATV SYSTEM OUTAGES AND RELIABILITES

System	Outage Time (Min.)	Reliability (%)
Jarmain Cable TV (Branftord)	1573	99.88
Cornwall Cablevision	1056	99.92
Grand River Cable TV	1829	99.86
Hamilton Coaxial	831	99.94
Kingston Cable TV	1205	99.91
London Cable TV	1052	99.92
Jarmain Cable TV (Newmarket)	866	99.93
Pine Ridge Cable TV	1972	99.85

An "average" reliability of 99.9% has been experienced. This has been in systems with little or no standby power and with no protection from active equipment failure. It is felt that the addition of standby power and a "0dB gain" bypass switch in case of a trunk amplifier failure should significantly decrease outage time if the system is designed with sufficient "fade margin" to remain operable with the "0dB gain" switch in the bypass mode.

The demonstrated reliability of these systems (i.e. 99.9%) can be considered adequate for most potential telecommunications services. In fact, standard CATV subscribers demand a high degree of reliability for their service as they use the service a large percentage of the time (approx. four hours per day). This would account for the impression that CATV systems are unreliable.

In summary, a standard CATV network can be considered to have adequate reliability for most potential services. With system improvements such as the "0dB gain" bypass switch and the addition of standby power, this reliability will improve in the future.

APPENDIX 2

SCRAMBLERS AND SECURITY

SCRAMBLERS AND SECURITY

The question of scrambling and security is really two different issues. One is actually scrambling effectiveness and the other is cheatability. Various scrambling schemes have been developed for pay television. These vary in cost and methods. Descriptions of these follow.

Oak Scrambling System

This system scrambles by modulating the transmitted signal with a 15.75KHz sine wave phase locked to the horizontal frequency. The horizontal sync. pulse is suppressed confusing the sync. circuits of the television receiver. The descrambling signal is amplitude modulated on the aural carrier. The descrambler is basically an AGC amplifier whose gain is controlled by the 15.75KHz signal on the descrambling carrier. This returns the video to its normal format. The descrambler costs around $25. Scrambling effectiveness is acceptable. Depending on the video information lock-up can occur for a small percentage of the time - especially in modern TV sets with sophisticated sync. processing circuitry. As the scheme is relatively simple it could be cheated by someone with a technical background with ease. The scrambling method does tend to degrade the picture quality as it is dependent on the signal to noise ratio at the aural carrier. This noise is centered around the horizontal line frequency and shows a characteristic low frequency noise appearance. Residual scrambling still remains after descrambling of typically .5dB.[16] The aural signal is not affected by this scrambling method.

Jerrold S.D.S.-D.S.T. Scrambling System

This system scrambles by inverting the whole video format - sync. down - white up. This causes the television to lose synchronization. If it does synchronize to the video information the picture is still inverted. To descramble the system, the carrier is phase locked and delayed by 180° and added back in. Tags in the vertical interval are used to automatically control when the descrambling is operating and provide a reference for the sync pulse level. The scrambling method is very effective - much more so than the OAK as both the sync is removed and the video is inverted. The descrambler unit for this system costs in the range of $50. The technique however is easy to circumvent. This can be achieved by reversing the detector diodes in a television and using a manual gain control on the AGC. Also certain TV sets, G.E. in particular, if they are overloaded, display a decipherable picture. The audio is not affected using the scrambling method.( )

Jerrold Starpack, Magnavox, Sylvania, and Blonder Tongue Systems

These scrambling systems all use the same basic principal. Both the horizontal and vertical sync. is suppressed by up to 6dB. This suppresses the sync. into the video portion of the signal causing the TV picture to be scrambled. Occasionally the television locks to the video information in such a manner that the picture is perceptable. The scrambling effectiveness is good; slightly better than OAK, but not as effective as the Jerrold S.D.S. technique. To allow descrambling a carrier in the F.M. band is modulated with descrambling information. The descrambler tunes to this carrier and attenuates the video signal by 6dB when appropriate to restore the correct levels. This descrambler costs in the $15 to $25 range. The system is difficult to defeat as not all the information is present in the video channels. In order to defeat the scrambling, someone would need to have a costly spectrum analyzer to recognize and determine the frequency of the descrambling carrier as well as the technical ability to construct a receiver decoder. The audio signal is not affected by this technique.(18)

Test or Promo Scrambling System

This scrambling system transmits an interfering carrier in the channel passband at precisely 2.257MHz above the video carrier at the same level as the video carrier. This signal is modulated by two low frequency A.M. signals. This scrambles the video and the second harmonic generated in the TV mixer scrambles the audio signal. This is a very effective scrambling mechanism and renders the signal unwatchable. To descramble the picture a high Q trap removes the interfering carrier. Costs for this 'descramber' are in the $10 range. This scrambling system is not especially secure as a trap can be easily manufactured or purchased to remove the interference. Also, if no lower adjacent channel is present, by off-tuning the TV set so that the interfering signal falls in the lower sound trap a watchable black and white signal can be seen. This system also has some technical problems as the interfering carrier can cause a colour beat in the upper adjacent channel on some TV sets. Also the high Q trap used to remove the scrambling removes some video information, decreasing the video resolution.(19)

Pay TV Corp

This scrambling system was developed for over-the-air Pay TV, although it could be adequate for cable. This scrambling system is by far the most secure form from cheating as it requires information in the video vertical interval, in the home terminal memory, and in a monthly program card to generate the descrambling code. This scrambling system basically inverts different blocks of video lines in the picture. Because only some of the lines in the picture are inverted it cannot be easily circumvented. However the scrambling effectiveness is considerably reduced as a large portion of the video lines are normal. Effectiveness could be improved by combining this method with one of the sync. suppression methods. The descrambler costs in excess of $100. [20]

Conclusion

Table 16 compares these scrambling systems. Although other methods are possible these provide a good range to illustrate the security - cost tradeoff. The high cost required in the extremely secure terminals is excessive and cannot be sustained by the service. Instead for only a marginal decrease in security a low cost system with difficult cheatability and good effectiveness can be obtained. This is primarily the Jerrold Starpack, Magnavox etc. system. For any scrambling system it is important that cable companies have sole access to descramblers and that it is illegal for anyone else to produce, sell, or own a descrambling unit. For this to happen, the descrambling unit must be sufficiently unique that it has no other purposes. The sync. suppression scheme appears to meet this requirement.

Table 16- Scrambling Systems

Scrambling System	Scrambling Effectiveness	Scrambling Cheatability	Cost	Video Improvement
Oak	acceptable	medium	$25	somewhat
Jerrold S.D.S.-D.S.T.	excellent	easy	$50	not noticeable
Jerrold Starpack, Magnavox, Sylvania, Blonder Tongue	good	difficult	$15 to $25	not noticeable
Test, Promo	excellent	easy	$10	somewhat
Pay T.V. Corp	poor	extremely difficult	$100	not noticeable

APPENDIX 3

TECHNIQUES & COSTS OF CHANNEL MONITORING

TECHNIQUES & COSTS OF CHANNEL MONITORING

There are four basic techniques of channel monitoring. These are:

- In real time monitoring, the channel over two-way cable.
- Monitoring in a local memory and at longer intervals (1 week, etc.) reading the memory over phone lines or cable.
- Mailing out program cards which enable a home terminal when inserted and punched. These are then returned for billing purposes.
- Coin operated descramblers like vending machines where coins enable the descrambler for certain periods of time.

Table 17 summarizes the advantages and disadvantages of these monitoring techniques. The listening return cable approach is definitly superior for moderate to dense penetrations as it is very flexible, low in cost and ideally suited for the application. For very low penetrations some of the other technique could be preferred although none of these are up-gradeable or desirable for larger penetrations.

METHOD	COST	FLEXIBILITY	CHEATABILITY	OPERATING COST	RELIABILITY
Real time Cable	See Incast Data < $60/sub	high	secure	low	good
Local Memory and Phone	> $100/sub	high	secure	low	good
Coin Operated System	$70	low	open to cheating	very high collection cost	poor
Program punch cards and tickets	> $100/sub	low	open to cheating	medium	poor

TABLE 17 TECHNIQUE & COSTS OF CHANNEL MONITORING

APPENDIX 4

INCAST SECURITY

INCAST SECURITY

The basic broadcast configuration of a CATV system can be reversed to form not a multipoint-to-multipoint broadcast system but a multipoint-to-single-point incast system. This type of system has an inherent degree of security. The only possible way of tapping an incast signal is to monitor the system trunk between the subscriber and the forward broadcast point (hub) or a distribution line or drop "adjacent" to the subscriber's home.

Adequate incast signal level for reception is received at nearby subscriber's terminals (tap to tap isolation is approximately 26dB) but an HF receiver and decoding logic is necessary to receive an intelligible signal. This HF receiver would not comprise any part of a home terminal so special hardware would have to be built for monitoring. Also a potential monitor would have no access to the frequency of a home terminal in a COS system or the home terminal address in a packet system. There is safety in numbers due to the large number of carriers in the COS system and due to the large number of broadcasts in a packet system.

It can then be said that there is a minimum of security risk in the incast channel compared with the broadcast channel where, by definition, many subscribers can receive a broadcast signal. Efforts to improve security should be concentrated on the broadcast portion of the system.

If any needs exist for a highly secure incast channel then appropriate scrambling - descrambling techniques can be used. The need for this high degree of security is not seen as being necessary for normal household traffic (including transactions). Some business traffic might require high security and would pay for the scrambling service.

APPENDIX 5

REVIEW OF TWO-WAY TECHNOLOGY AND HOME TERMINALS

REVIEW OF TWO-WAY TECHNOLOGY AND HOME TERMINALS

EIE, RCA, TELCIN SYSTEM

The EIE, RCA and Telcin System are basically various developments of the same system originally tested in Orlando Florida. The system was originally structured for information from the computer being transmitted at a 42Kbit/s rate in the FM band, requiring a 200KHz bandwidth, and the upstream information from the home terminal transmitting back to the computer at a 675 Kbit/s rate in the 10 to 30MHz band with a 2MHz bandwidth. The clock rates were chosen in this manner because the system transmits less information from the computer to the remote terminal than does the remote terminal to the computer, specifically 32 bits and 28 bits respectively.

The most recent development of this system manufactured under the Telcin name has a slightly modified structure. A data rate of 40Kbit/s in both directions is used, requiring a 200KHz bandwidth. Two 16 bit data words, a subscriber address and a command word, are transmitted from the computer system, and three 16 bit data words are transmitted from the remote unit: a subscriber address, a data word and a command structure. This system is able to interrogate up to 1,000 homes approximately every 10 seconds. By allocating additional 200KHz increments of bandwidth in both the upstream and downstream path additional numbers of such terminals can be serviced.[21][22]

HUGHES, THETA COM SYSTEM

The Hughes subscriber response system was originally tested in El Segundo California 1972. Digital data is transmitted downstream and upstream at a rate of 1 Mbit/s. A downstream word of 22 bits is transmitted and an upstream message of 17 bits is sent from the home terminal to the central computer. A total basic interrogation response time of less than 2.4 seconds results for 50,000 subscribers.

More recently Hughes has developed from this system a facilities management system with operational interactive sub-systems for security, energy conservation, life safety, communication and maintenance and mechanical control.[23][24][25]

CO-AXIAL SCIENTIFIC SYSTEM

The Co-Axial Scientific two-way communication system was originally tested in Columbus Ohio in 1973. Since that time it has been used to provide per view pay television services to local residents. More recent installations include a National Science Foundation project in Rockford, Illinois and an alarm system under construction in Syracuse, New York.

The continuously operating home terminal sends back a 16 bit data word with 14 message bits at a 2Kbit/s rate. Return channels have a 20KHz bandwidth including guardbands allowing 50 channels per 1MHz. Because of the slow data rate a scanning receiver would take 20ms to monitor each home terminal. The effective data thup't however can be greatly increased because of the F.D.M. nature of this system by using parallel receivers at the central location. If 10MHz is assigned to the return signals 100,000 terminals can be monitored in less than six seconds. (26)

QUBE SYSTEM

The Qube system was developed by Warner Communications and Pioneer and was first installed in Columbus in the spring of 1977. As of this report technical data has not been made public. It is conceptually an interrogation response type system. It is believed to have 256Kbit/s data rate in each direction with a 24 bit message. The downstream carrier is in channel A and the upstream carrier is at 25MHz. Both occupy a 4MHz bandwidth.[27]

VICOM

The Vicom two-way system began operation in the Telecable system in Overland Park, Kansas in 1971 under the name Queset. The downstream signal is a 6MHz bandwidth frequency shift keyed carrier between 112 and 114MHz with a 1Mbit/s data rate. The upstream carrier operates at 8MHz using phase shift modulation also at a 1Mbit/s data rate.[28]

COMMUNICOM

The Communicom two-way system was developed by Jerrold and General Instrument Corporation and was marketed in 1973. The basic system had a 10,000 subscriber capacity being expandable to 65,000 subscribers. The downstream carrier was assigned the 108 to 112MHz band at a 1Mbit/s rate with a 39 bit word. Upstream transmission was also a 39 bit word at a 1Mbit/s rate in a 4MHz bandwidth between 5 and 30MHz. Response time was designed for 2 seconds.[29]

TOCOM

The Tocom system was developed in 1972 and has been installed in various small communities in the United States, the most famous installation being in the Woodlands in Texas. Here it has provided security services for residents. It has gone through three evolutions in learning about two-way cable technology. The present system allocates 1,024 subscribers per two-way channel. With 60 available channels, capacity for more than 60,000 subscribers exist. [30]

APPENDIX 6

PACKET BROADCASTING

Appendix 6 Packet Broadcasting

There are many possible system configurations which can be used as packet broadcasting systems (or packet incasting systems for a CATV network). The technical capabilities (basically throughput) and costs of each system vary.

These system configurations are shown and their throughputs calculated.

Packet Broadcast System 1 (See Fig. 5)

Home Terminal	- Receive slot
	- Transmit at 9.6 KBit/s
	- Word Length 384 Bit
	- Positive Acknowledgement (POSACK) Receiver
Bridger	- Single channel BPF
H.E.	- Single channel Receiver per Branch at 9.6 KBit
	- POSAK Transmitter (could be message)
	- Slot Transmitter

1 Bit = .104ms at 9.6KBit/s.

∴ jitter = 1.56 Bits

$$\text{Min. slot length} = \frac{384 + 1.56}{9.6 \times 10^3} = 40.2 \text{ ms.}$$

Max. Throughput = .368 x 9.6KBit/s (See Fig. 6)
= 3.5 KBit/s
or 7 Bits/household for 500 households.

N.B. Jitter, ingress, thermal noise, etc. will reduce maximum throughput. For 80 KHz BW/channel and 75 Bridgers per trunk, 6MHz is used.

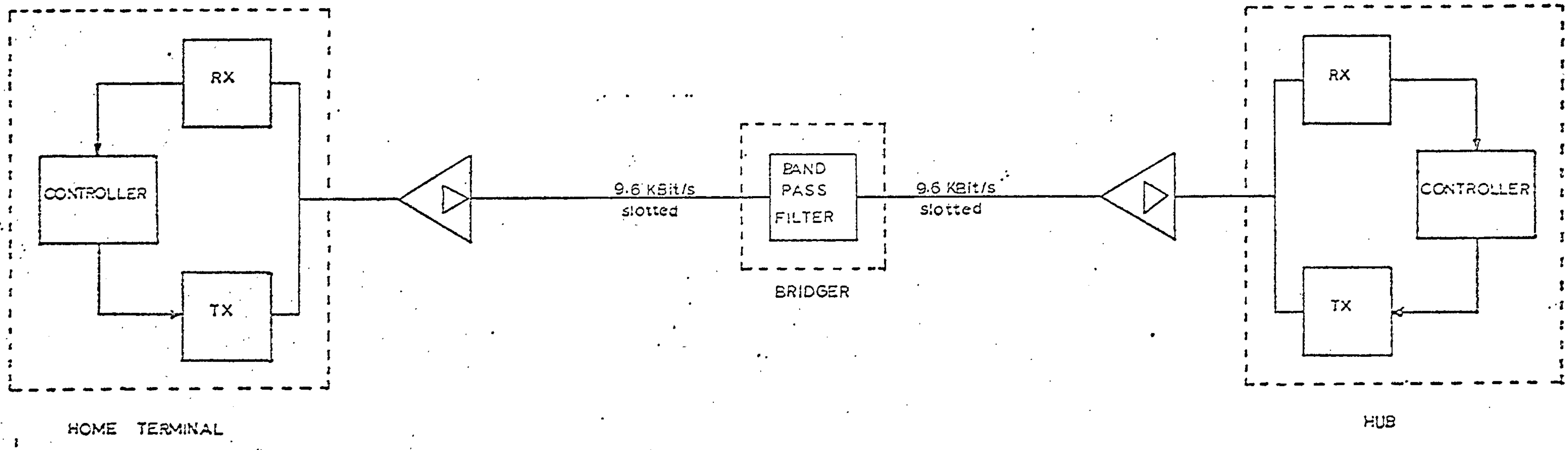


Figure 5 Packet Broadcast System

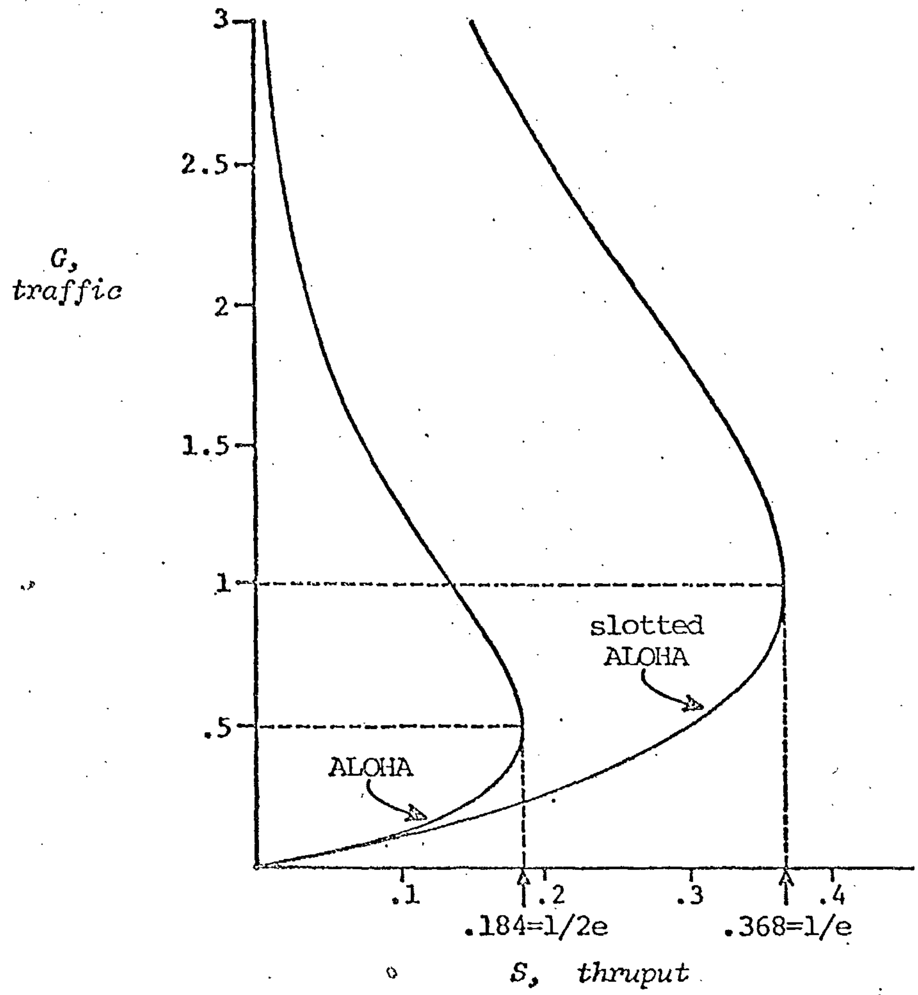


Figure 6 (9)

TRAFFIC VS THRUPUT FOR AN ALOHA CHANNEL AND A SLOTTED ALOHA CHANNEL

Packet Broadcast System 2 (See Fig. 7)

Home Terminal - Transmit 64 KBit/s
- Word length 384 Bits
- POSACK Receiver

Bridger - Receive 64 KBit/s
- Transmit 64 KBit/s

H.E. - Multichannel Receiver at 64 KBit/s
- POSACK Transmitter

∴ Jitter = N.A.

Max. Throughput

(Terminal - Bridger & Bridger - H.E.) = .184 x 64 KBit/s (See Fig.)
= 11.776 KBit/s or 23.6 Bit/s per household for 500 households.

For 150 KHz BW/channel and 75 Bridgers per trunk, 11.25 MHZ is used.

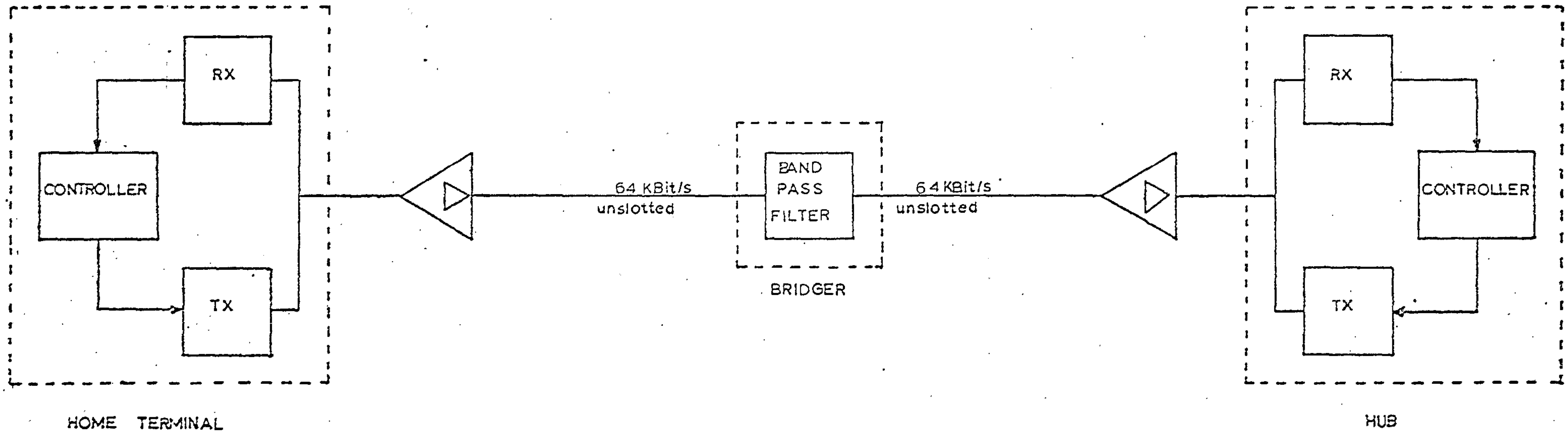


Figure 7 Packet Broadcast

<u>Packet Broadcast System 3</u> (See Fig. 8).

Home Terminal	- Transmit at 3 MBit/s
	- word length 384 Bit
	- POSACK Receiver
Bridger	- Receive at 3 MBit/s
	- Transmit at 3 MBit/s
H.E.	- Single Receiver at 3 MBit/s
	- POSACK Transmitter
Jitter	= N.A.

Max. Throughput
(Terminal - Bridger) = Trivial

Max. Throughput = .184 x 3 MBit/s (See Fig. 6)
(Bridger - H.E.) = 552 KBit/s
or 5.52 Bit/s per household for 100,000 households
(200 Bridgers)

For one 3 MBit/s channel, about 12 MHz B/W is needed.

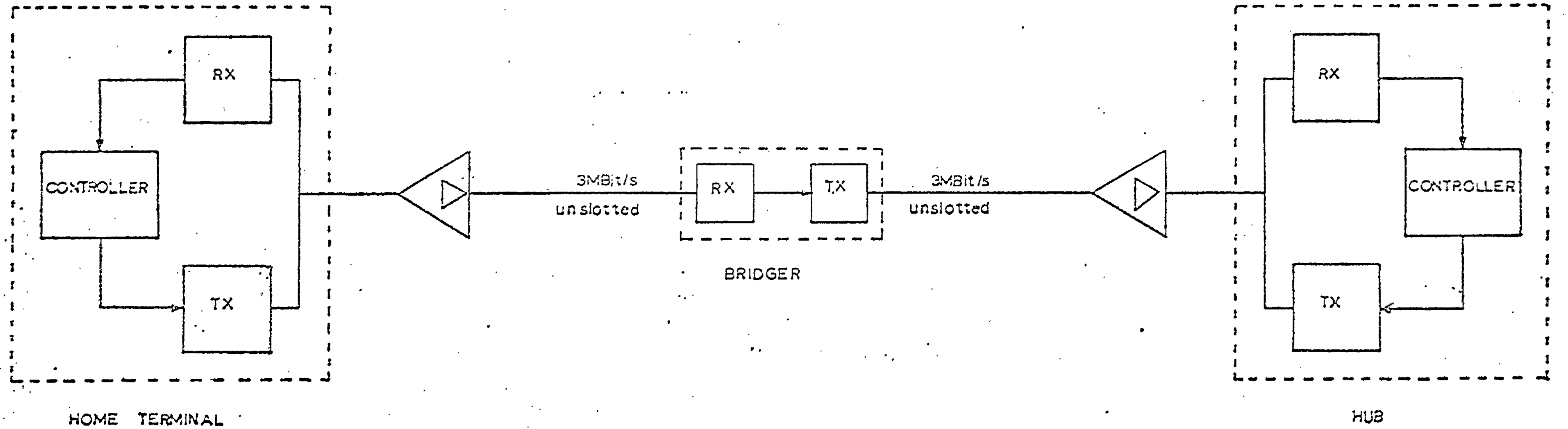


Figure 8 Packet Broadcasting System 3

APPENDIX 7

INTERROGATION RESPONSE IMPLEMENTATION

INTERROGATION RESPONSE IMPLEMENTATIONS

If a 9.6K bits/s data rate is used in the system, the following capacity exists.

- Use a different return frequency for each group of 500 households.
- Each household has a 15 bit address which is transmitted and confirmed and a 1 bit short/long packet indicator.
- Therefore addressing consumes $16 \times 2 \times 500 \times \frac{1}{9000} = 1.665$
- In a 10 second interval 80,064 bits of throughput can occur in the 8.34 second time left for information after addressing.
- For 500 households, this is 16 bits/sec. per household average throughput.

Using this scheme, a large throughput exists but a poor response time of 10/s occurs. To improve this the following system is suggested.

- A 64K bits/s data rate in both direction.
- Use a different frequency for each group of 500 households.
- Each household has a 15 bit address which is transmitted and confirmed and a 1 bit short/long packet indicator.
- Therefore addressing consumes $16 \times 2 \times 500 \times \frac{1}{64000} = .25$ sec.
- Therefore in 1 second 48,000 bits of throughput can occur.
- For 500 households, this is 96 bits/sec per household average throughput.

This system has an adequate response time of less than 1 second and a high throughput and is capable of providing almost all services.

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