TECHNICAL ASPECTS OF TWO-WAY CATV SYSTEMS IN GERMANY

Rolf M. Schnee
HEINRICH-HERTZ-INSTITUT BERLIN (WEST)

Franz K. Kraus
HEINRICH-HERTZ-INSTITUT BERLIN (WEST)

ABSTRACT

In the near future pilot projects for two-way cable television are to be introduced in the Federal Republic of Germany. In preparation for these, investigations are being carried out, using a laboratory system, of a variety of services and of the technology necessary to accommodate large numbers of subscribers. The system described in this paper was conceived on the basis of these investigations.

1.0 Introduction

In the Federal Republic of Germany there are cable television networks in existence in Nuremberg, Hamburg and Düsseldorf, which belong to the Federal Ministry of Posts and Telecommunications. None of these is a two-way system. They were set up primarily to serve areas lying in the shadow of high eminences, where normal reception would be poor. There are legal stipulations that preclude the operation of two-way systems.

However, the Commission for the Development of the Telecommunication System (KtK), set up by the German Federal Government in 1974, recommended in its concluding report that a number of CATV pilot projects be introduced, in order to test telecommunications services and alternative ways of organizing their administration.

A decision is due to be taken during the next few months on whether several large-scale pilot two-way television networks are to be set up in the Federal Republic of Germany. These would then offer a variety of interactive services to a large number of subscribers.

In preparation for these pilot field projects a two-way cable television laboratory project is being set up at the Heinrich-Hertz-Institute, financed by the Federal Ministry of Science and Technology.

This latter project is based on the recognition that prior laboratory work is necessary to

- evolve new telecommunications services and develop known ones further, and
- examine the technical and theoretical problems of the necessary technical system.

The interactive CATV systems known today mainly offer only very limited interactive services to a restricted group of subscribers. Very often a return channel foreign to the system is employed, with all the resulting disadvantages. The limitations with regard to the bandwidth demand, the complexity of the services, the number of simultaneously active subscribers, the privacy of the message, etc. were removed to a significant extent in the laboratory system design, enabling a large number of complex telecommunications services to be offered to a large number of subscribers.

The CATV system thus specified undoubtedly exceeds the scope of the pilot field projects to be undertaken in the near future, in respect of the telecommunications services, the frequency of use and the complexity assumed here. However, precisely as a result of this apparent exaggeration, fundamental problems are recognized and solved.

2.0 The Demands on the Technical System

To determine the traffic volume certain assumptions were made:

- the planned CATV system would serve 10,000 subscribers, who could all use the system interactively;
- a maximum of 1,000 subscribers would be interactive simultaneously.

Type of Service	Expected Number of Simultaneous Users	Examples, Remarks
TV/Teletext	Number not Restricted	Programmes for Unlimited Distribution
Pay TV	Number not Technically Restricted	Programmes for Limited Distribution
Simple Services	100	Mailbox, Billing etc.
Games and Information Services	700	Inter-Subscriber Games, Subscriber-Computer Games Information about Transport, Culture, Medicine etc. in some case with additional Audio and Video Information
Complex Services	200	Computer Access, CAI, supplied with Audio und Video Information Services with Flexible Structure of Man-Machine Dialogue

Fig. 1 Different Types of Telecommunications Services

The evaluation of the assumed traffic volume with the given spectrum of services produced the following further parameters:

- in the downstream direction, in addition to the television distribution programmes, approx. 200 to 300 individual television channels,
- up to 1,000 smallband digital channels with bit rates of 9.6 kbit/s,
- approx. 90 speech channels in downstream and upstream directions, and
- approx. 20 television channels in the upstream direction are required;
- the central facility must be capable of dealing with a maximum of 60 interactions per second;
- up to 15,000 still pictures must be available for random access.

In addition to the traffic volume, a further important parameter is the service quality. Essential factors here are

- the reaction time of the system during a dialogue, which must not exceed 3 seconds,
- a high degree of message privacy with interactive services,
- the user language,
- the construction of the home terminal, with regard both to anthropotechnical design and high-quality presentation of information.

3.0 The Technical System

Fig. 2 shows the structure of the interactive CATV system, divided into subsystems.

3.1 The Computer System

The tasks of the computer system can be divided into two areas:

a) the offering and carrying out of the services (service-specific tasks),

b) the monitoring and control of the system (system-specific tasks).

The particular problem of this computer system consists in coping with the high number of simultaneously interactive subscribers (1,000). In the worst case approx. 60 interactions must be dealt with per second. In all, the subscribers have access to approx. 300 services with a total programme size of approx. 25 MB.

From these figures it follows that with a solution involving minicomputers that have per processor a maximum memory capacity of apprx. 2 MB it is never possible to keep all the programmes resident in the memory at once, and therefore very efficient task management is especially necessary.

The hardware concept (fig. 3) provides for a multi-processor system, in which the individual processors are connected via a bus. In addition, the most important processors are connected via a shared memory. Several processors can be connected to the bus, so that an extension of the hardware is no problem.

The terminal processor receives all the interactions coming from the subscribers via the digital transmission system and processes the subscriber-specific information. The service computer deals with the content of the interaction and conveys the information direct to the subscriber via the digital transmission system. If, during a dialogue, information in the form of still pictures, moving-picture sequences or audio is necessary, the task of providing it is passed to the controller. This latter computer controls and administers the storage-system equipment.

3.2 The Transmission Network

On account of the high number of individual broadband channels required for dealing with the individual services, the total area served is divided into approx. 10 sub-areas. Each sub-area is supplied with the individual programmes via its own cable, which transmits 30 broadband channels arranged as adjacent channels. For the individual programmes the connection of the sub-areas to the central facility is star-shape, while on a second cable the approx. 12 general distribution programmes are transmitted via a tree network to the whole area served. For a transition period, in which it will not yet be possible to assume that subscribers have television sets capable of receiving adjacent channels, the unlimited distribution programmes will not be transmitted in adjacent channels.

The network is divided into the active levels A and B, and the passive levels C, D and E (fig. 4). On the A level, the programmes for several sub-areas are normally transmitted. One cable carries the unlimited distribution programmes; one cable - a separate one for each sub-area - transmits the individual programmes; a further cable transmits for each of several sub-areas the 5 broadband upstream channels which are lined up in blocks, each with one interjacent channel that is not used. The 5 broadband upstream channels provided for each sub-area consist of 4 video channels and a broadband channel carrying the signals of the digital transmission system for the transmission of data and speech.

In its basic structure the two-way network is a tree network, since the distribution of programmes continues to be an important task. However, a pure tree network has a very unfavourable effect on the transmission of individual interactive programmes, since it provides no guarantee either of privacy when information is directed to a particular subscriber or of freedom from interference when information is transmitted to the central facility.

In order to avoid these disadvantages, groups of subscribers are connected in star-shape via the E level to a so-called forefield installation (German "Vorfeldeinrichtung VFE"), which is linked to the D level. In the forefield installation video- and data-switching is carried out, controlled by the central facility, so that each subscriber only receives the information intended for him. For the video signals this switching is performed as follows: the signals in the channel assigned to a particular subscriber are transferred, by means of a converter controlled from the central facility, from the 30-channel cable to a channel in the 12-channel cable not occupied in the distribution direction, and are transmitted to the subscriber on this channel (fig. 5). In the upstream direction the forefield installation guarantees that the data or speech signals are assigned in sequence to the digital transmission channels and that broadband channels are assigned for video transmission to the central facility. Through these functions overlapping of signals is avoided and interference from the subscriber area, e.g. as a result of defects in subscribers' sets, is kept out of the upstream network.

3.3 The Digital Transmission System

The digital transmission system organizes the transmission of digital information between the central facility and the subscriber terminals. There are three types of connection:

1) data dialogue connections

Data must be transmitted from the computer to a subscriber at a relatively high bit rate. Subsequent to this there is a pause of up to 60 s, as the subscriber processes the information. The subsequent subscriber's reply is relatively short and should in turn be transmitted at a high bit rate. The digital transmission system only allocates these connections involving a channel of high bit rate when they are needed.

2) remote control connections

The transmission of control commands and measured data requires a connection of short duration, in which only a few bits are transmitted.

3) speech connections

For the transmission of speech (in DPCM) about 90 channels with a bandwidth of 8 kHz are required. Channels with a transmission capacity of 64 kbit/s are available.

3.3.1 Organization of the Time Division Multiplex Transmission

The initiative for transmission comes exclusively from the control unit in the central facility.

Time is divided into so-called time slides. Within such a time slide the central facility transmits a downstream block consisting of an address section and a data section.

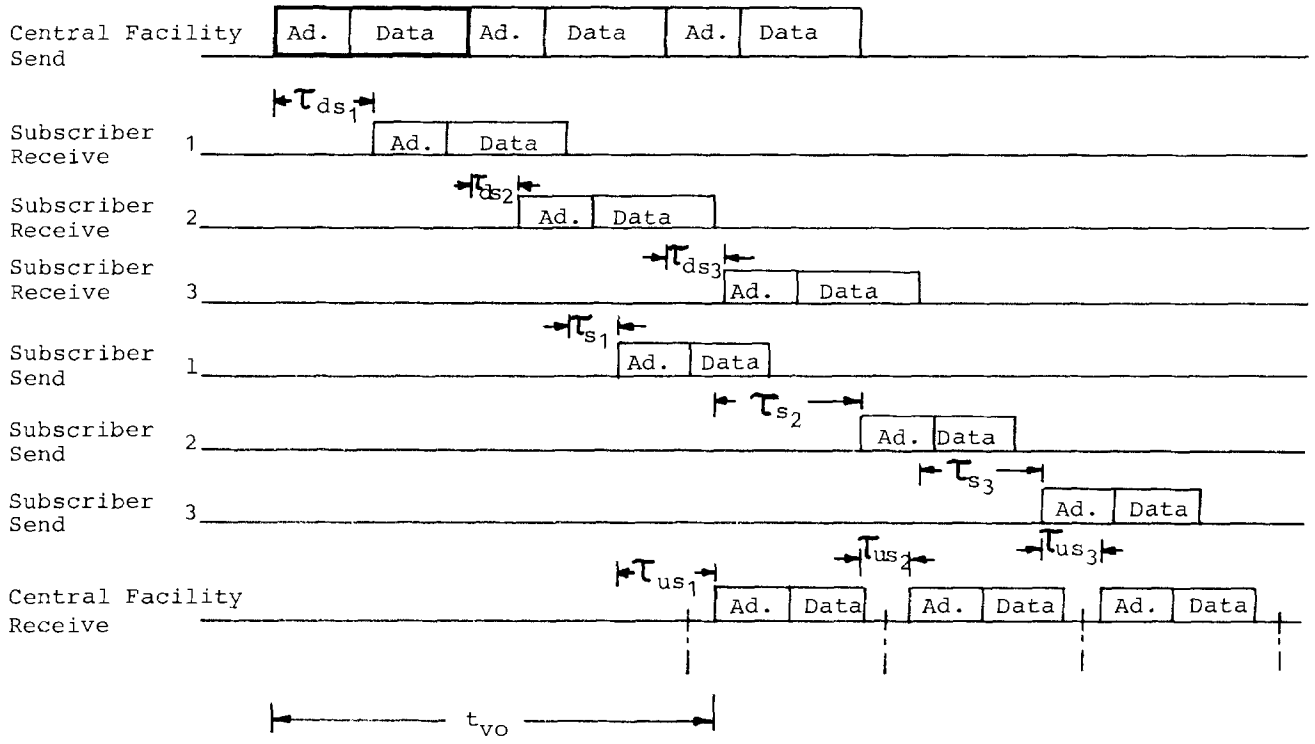

Fig. 6 Transmission Procedure

The address section contains the address of the subscriber for whom the information in the data section is intended. The subscriber recognizes his address and selects the information which follows it from the bit stream in the downstream network. The reception of a block is interpreted by the subscriber not only as a "reception of information" but also as a request to transmit. He can therefore send a data block to the central facility directly after receiving a block, during a time span corresponding to a time slide.

If this single procedure in each time slide is carried out with alternating subscribers and periodically repeated after n time slides for the individual subscriber, several subscribers are allocated to a channel in time multiplex.The time slides must be allocated in a specific order to the individual simultaneous connections.

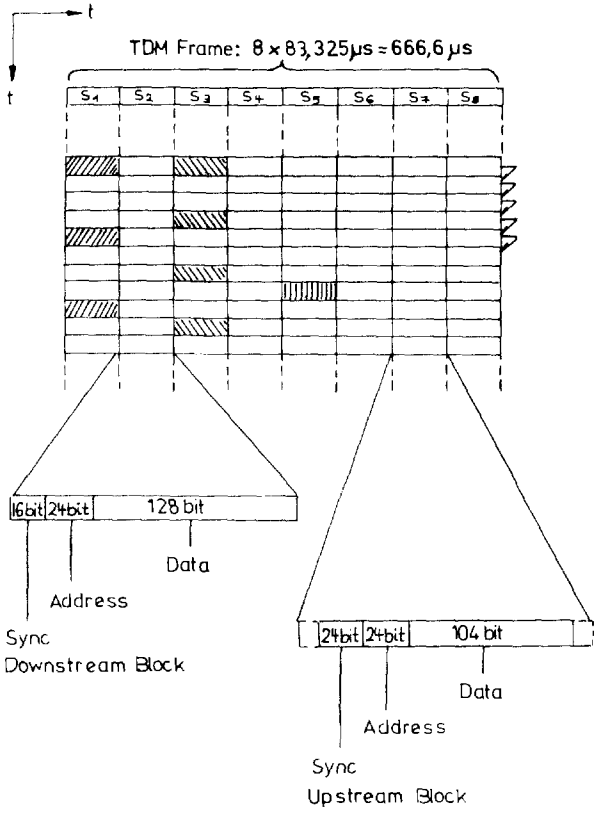

Fig. 7 Frame of the TDM System

In the upstream direction the system displays the same frame organization. The blocks have the same bit rate as those of the downstream network, but are about 16 bit shorter, so as to equalize the delay times varying from subscriber to subscriber in the cable network. (In the subscriber unit, in addition, the possibility exists of equalizing the delay times in steps of 8 bits.)

3.3.2 Setting Up a Connection

In order to recognize the connection requirements of the subscriber, the digital transmission system sends out free calls at regular intervals, which request the subscriber desiring a connection to send a block containing his address and his connection requirement. The number of free calls is much larger than the number of connection requirements. If overloading occurs despite this, none of the subscribers receives a reply. They repeat the connection requirement after a random number of free calls.

3.4 The Head End

The head end constists of cable-transmission and cable-receiving units. In a cable-transmission unit the 12 distribution programmes, consisting of off-air programmes and pay TV, are brought together in non-adjacent channels and transmitted via the network described above.

In seperate cable-transmission units for each sub-area, 30 channels are available for the transmission of the individual programmes and the digital transmission system. To assimilate the range of the 30-channel system to the 12-channel system, the individual video signals are transmitted in a synchronous mode, and the picture carriers are related in certain phases.

In the cable-receiving units the signals transmitted to the central facility from the sub-areas in groups of 5 channels for each sub-area are received and demodulated.

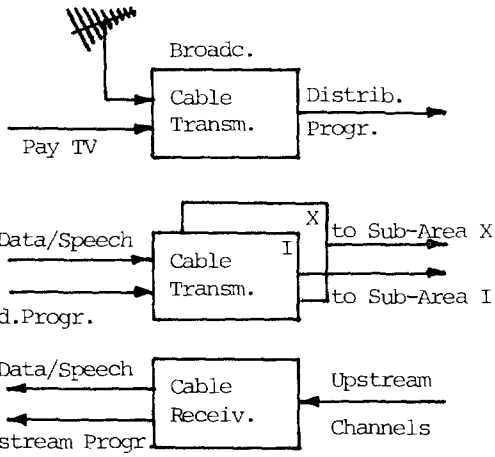

Fig. 8 Head End

3.5 The Storage System for Audiovisual Information

The storage system makes the audiovisual information, consisting of still pictures, moving-picture sequences and audio, available for the services.

During peak hours simultaneous access to approx. 200 different still pictures, approx. 50 moving-picture sequences and approx. 90 audio sequences is to be expected. At such times all the services offered will be used, on average, by at least one subscriber. Since it is intended that during a service access to the video or audio information should take less than 3 secs., all the audiovisual information must be available to many subscribers for random access.

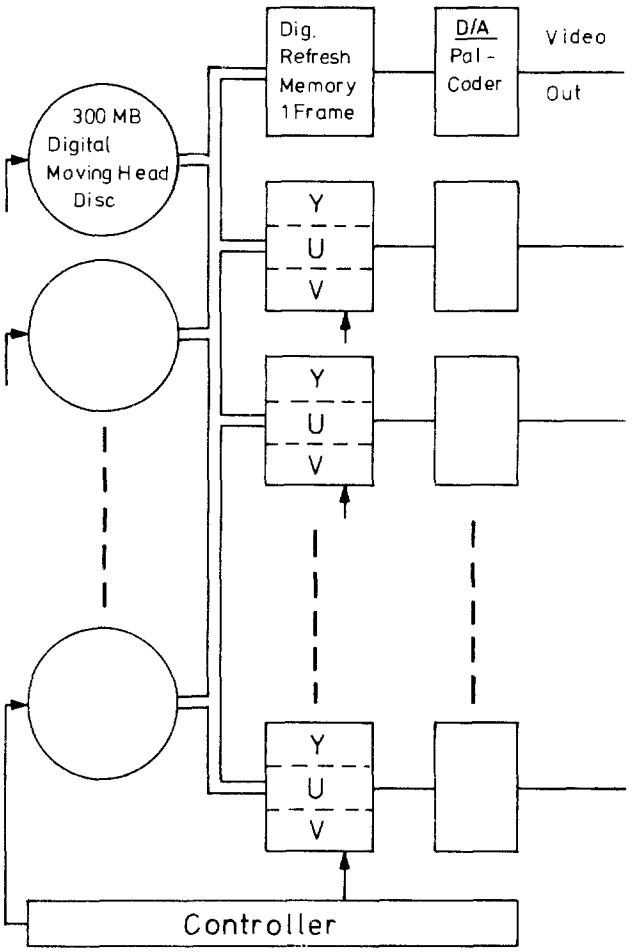

Fig. 9 Storage Unit for Still-Pictures

The still pictures are recorded, with separate luminance and chrominance signals, in digital form on moving head discs. When a still picture is to be transmitted to a subscriber, the video information is selected from the moving head disc concerned, under the influence of a controller, and buffered in a digital refresh memory, which is then selected cyclically. This signal is converted back into analogue form, PAL-coded and transmitted to the cable-transmission unit. If subscribers have refresh memories, only an addressed single frame is transmitted to them, which leads to a lower number of refresh memories, PAL-coders and modulators in the central facility, and to a reduction in the transmission capacity required in the network.

Audio or speech signals are recorded with a band width of 8 kHz in digital form (DPCM) on moving head discs. The storage organization resembles to a considerable degree that of the still pictures. The speech signals are read at a bit rate of 64 kbit/s from the buffers and are transmitted to the subscribers in time-division multiplex together with data via the digital transmission system.

For moving pictures there is as yet no practicable equipment for random and multi-user access for a programme quantity of approx. 200 hours. The moving-picture storage is organized in such a way that when a service involving moving pictures is requested, the desired video information is made available in the form of video cassettes, by means of manual or automatic loading of cassette-players. The video sequence is controlled by the services programme.

3.6 The Home Terminal

The home terminal can be extended in steps. The simplest version for interactive services consists of a TV set, a refresh memory for alpha-numerical information and a simple numeric keyboard with a few special keys. With this, selection can be made from among a great many interactive programmes, especially those constructed according to the so-called menu technique.

In its most complex form the home terminal comprises an alpha-numeric keyboard, a refresh memory for alpha-numerical information, graphic and video still pictures, a printer and a microprocessor, which enables a part of the programme or programme sections to be processed directly by the subscriber's equipment. As a result of this decentralization a reduction of the load on the central facility and, above all, a shortening of the reaction times is envisaged.

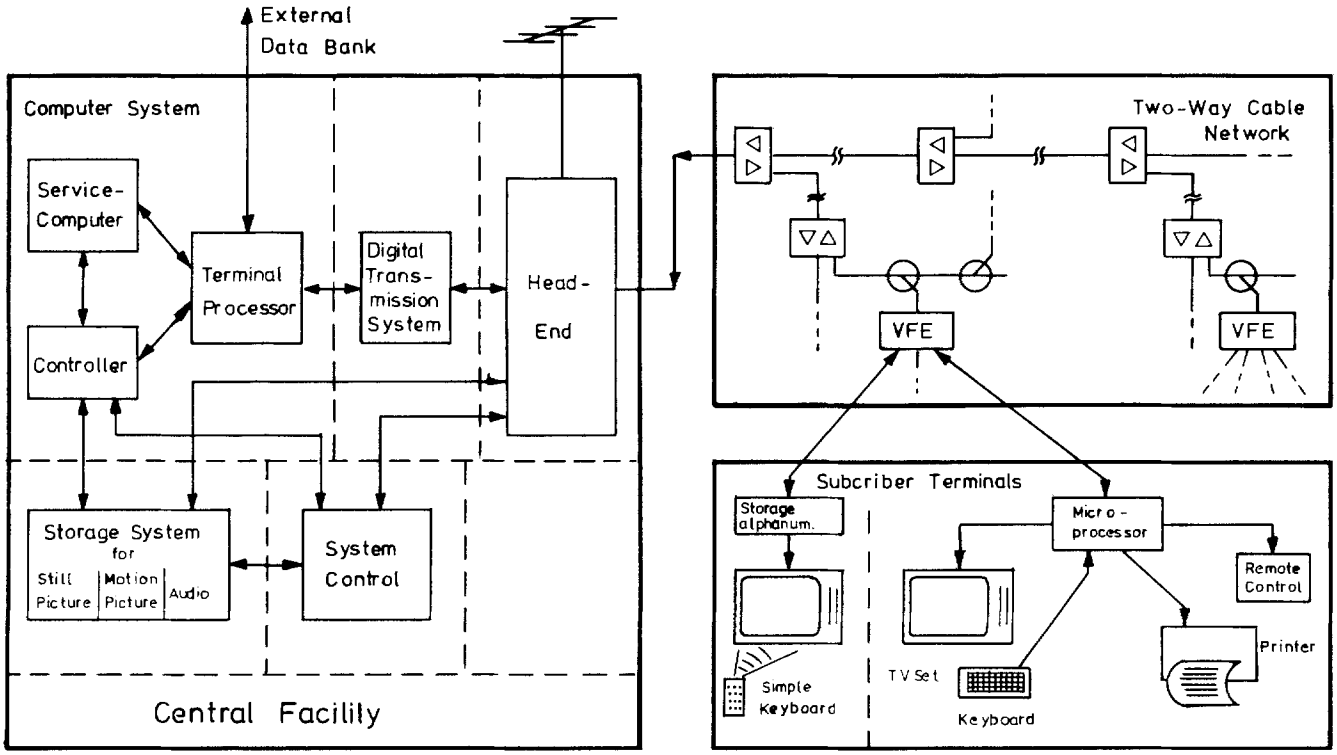

Fig. 2 Interactive C A T V System

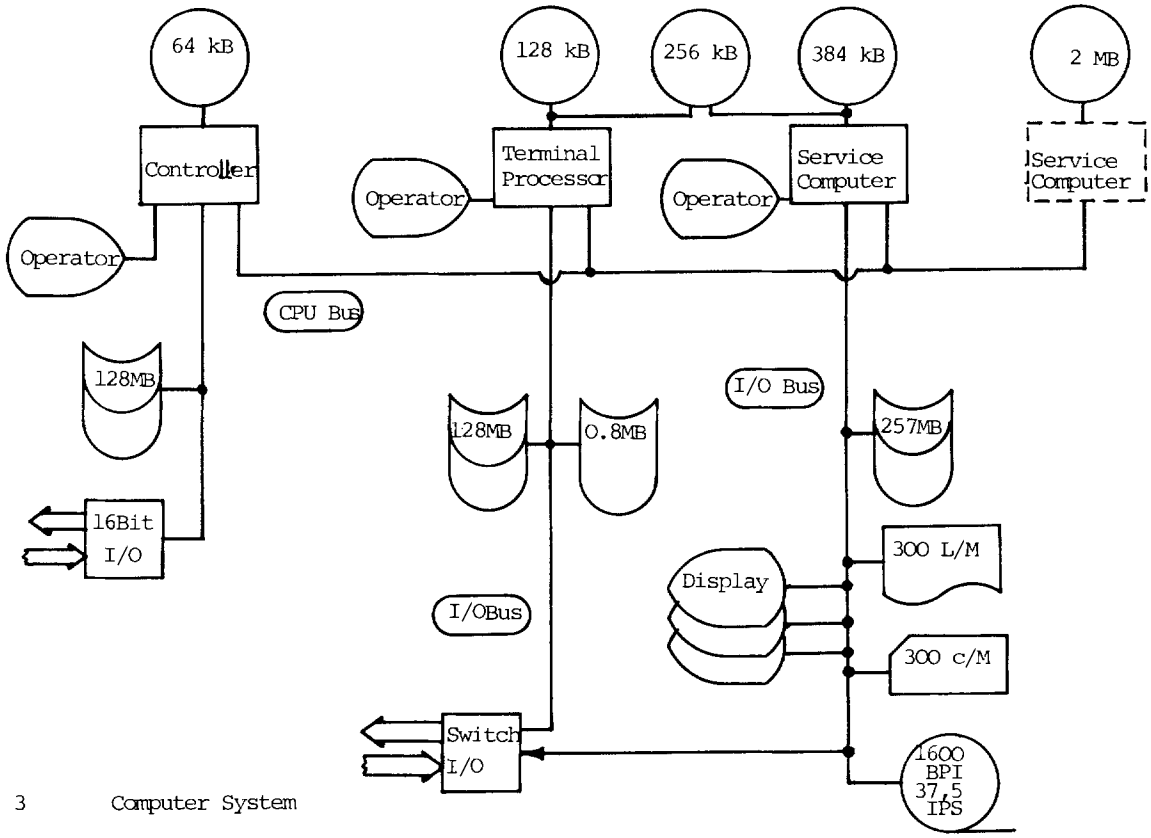

Fig. 3 Computer System

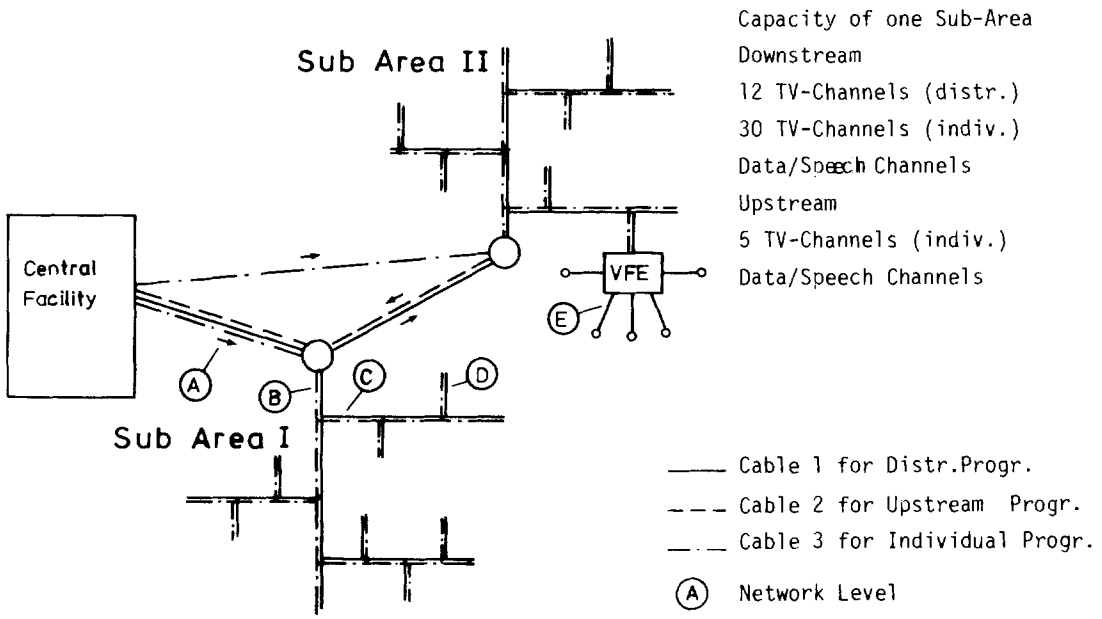

Fig. 4 Schematic Representation of the Cable Network

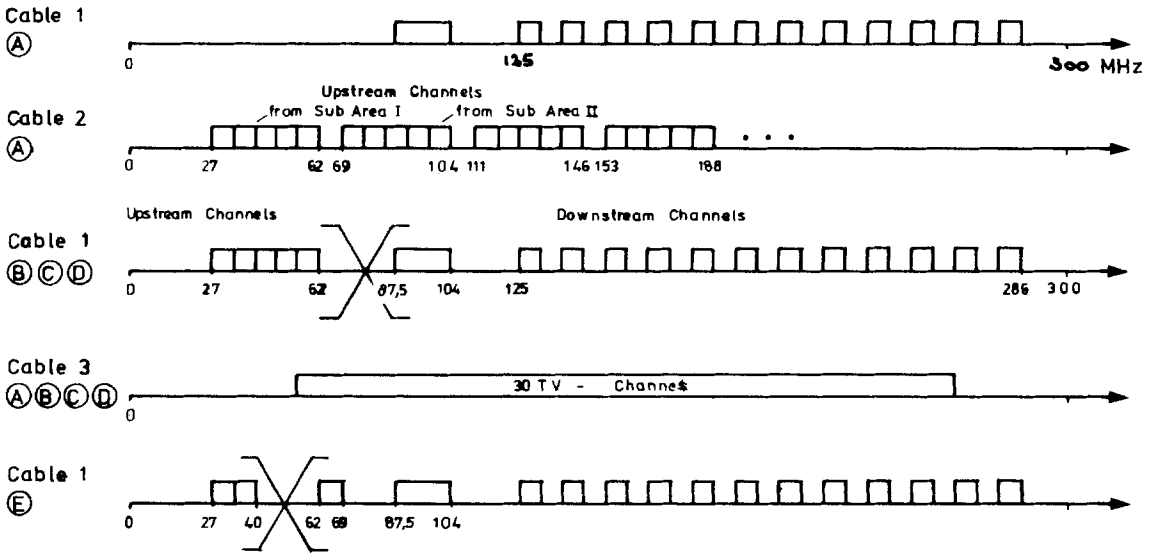

Fig. 5 Frequency Allocation