MULTIMEDIA DELIVERY DEVICE for FIBER/COAXIAL HYBRID NETWORKS

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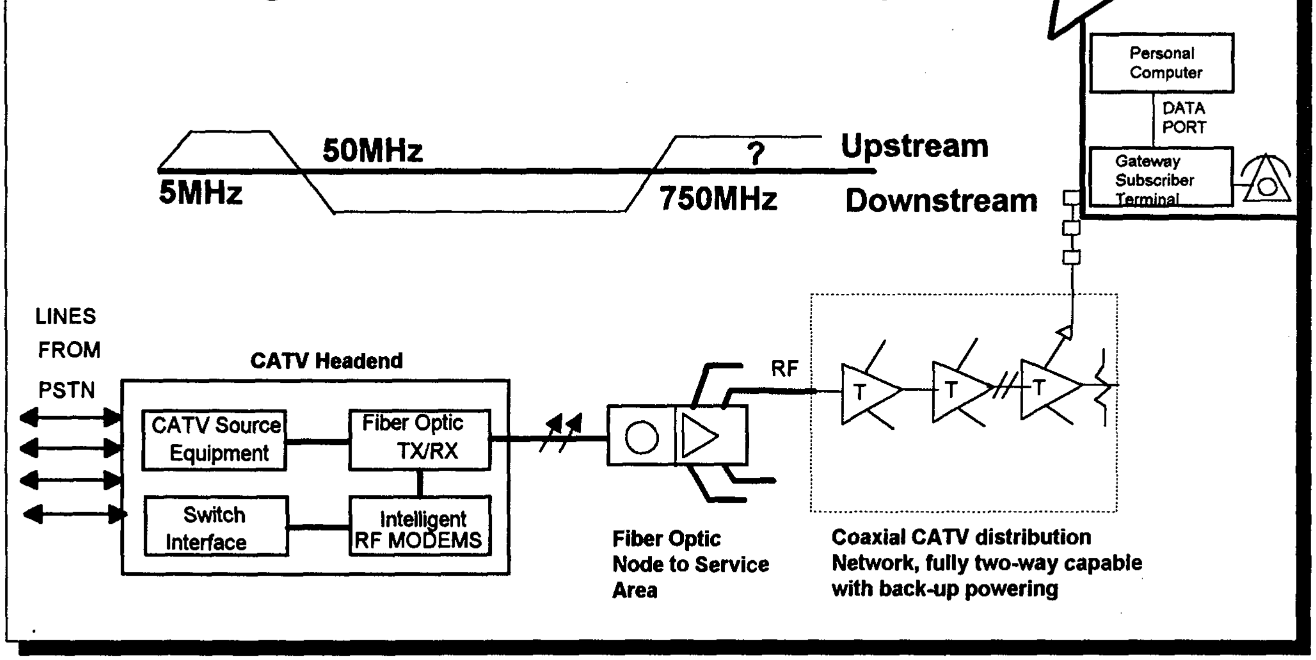
Abstract : *The fiber/coaxial network which is currently used for carrying entertainment video in mostly analog format is likely to carry other types of traffic in the near future. The types of traffic that will traverse the super highway fall in three broad categories, namely, (i) one way for traditional broadcast video delivery (ii) asymmetric two-way for video on demand services where minimum traffic exists for subscriber initiated controls and (iii) symmetric two-way services like voice, video-telephone, and computer network inter-connections. This paper focuses on the design aspects of a multimedia delivery device with symmetric delivery capacity of Nx64KBits/S for subscribers connected to the CATV network. The performance objectives for circuit switched and packet switched networks for both connection oriented and connectionless types are discussed with acceptable compromises required for a low-cost implementation of a Broadband Communication Gateway (BCG) system. This system provides Nx64KBit/S capability with appropriate interfaces for voice and data delivery and proper telephone network interfaces for universal switching by the Central Office (CO).*

1.0 Introduction : The Fiber/Coaxial hybrid network is emerging as a leading contender for the communication highway of the future. While high bandwidth services on an Asynchronous Transfer Mode (ATM) backbone are a distinct possibility, the upstream bandwidth of many CATV networks in existence today accommodates only modest services like telephony and data applications that use 64KBit/S, or multiples thereof on a full time basis. This paper describes a BCG system, including the architectural aspects of headend interfaces; internal architecture of the device; and application areas for voice telephony, symmetric data transport and Compact Disk Interactive (CD-i) interface for interactive entertainment. The paper concludes with the author's view of future enhancements of the gateway product for the highly competitive consumer market.

2.0. System Architecture of BCG

The BCG system architecture consists of the CATV network Distribution System, headend telephone network (PSTN) to CATV distribution bridge, and the gateway transceiver device at the subscriber's home. Figure1 illustrates the system architecture of the BCG and a frequency plan model for a full service network in which the symmetric services use the conventional CATV return band from 5 to 40MHz for upstream communications. The system is designed to be frequency agile to approximately 800MHz. The BCG functions over the CATV Fiber to the service area topology where the node splits will serve from 500 to 2000 subscribers. The bandwidth efficiency of the BCG allows 400 to 500 full-time 64KBits/S circuits to function in the available upstream bandwidth of a conventional CATV system.

Figure. 1. Network Overview and Frequency Plan

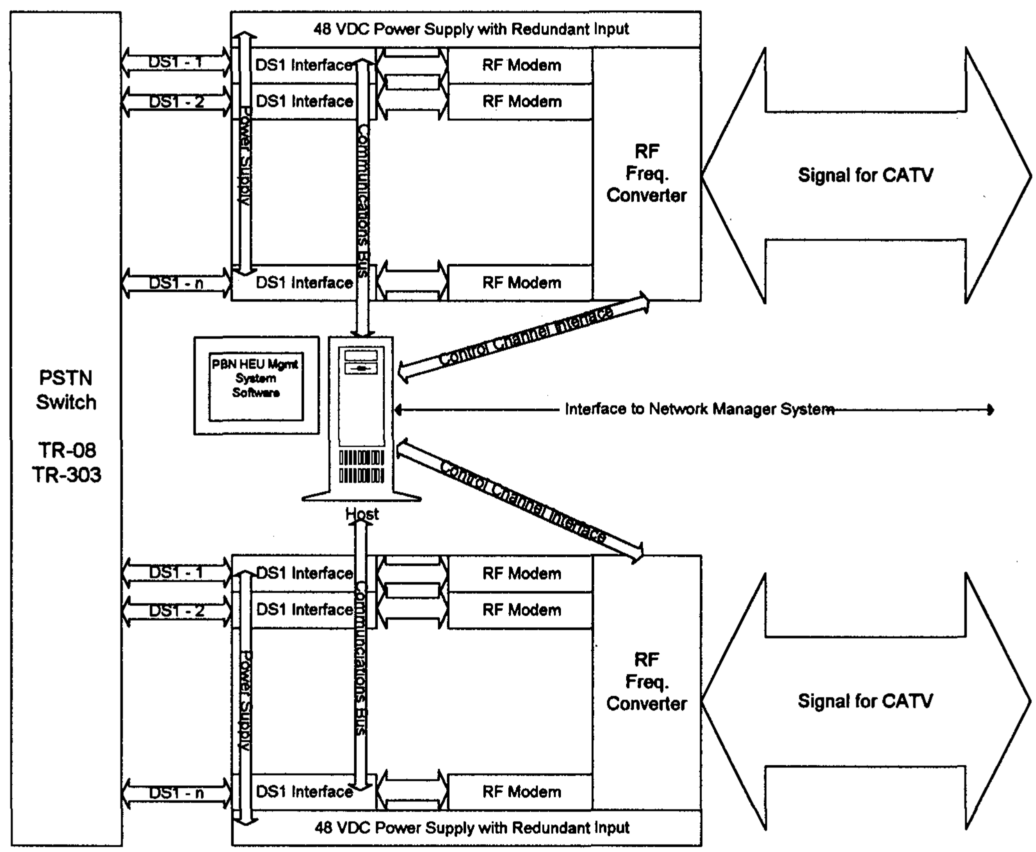


2.1. Bridging PSTN and CATV at the Headend

Modern telephone systems use a Time Division Multiplex (TDM) structure for transmission and switching. The protocols and switching methods have evolved into well established standards and require compatibility for seamless interconnects. The CATV distribution system uses an equally mature frequency division multiplexing for the backbone of its distribution system, and it is unlikely to change in the near future. For transporting TDM structure efficiently on a CATV network, the issue of differential distances of subscribers encountered in CATV distribution has to be resolved. Figure. 2 illustrates the PSTN to CATV distribution interface system used in the Philips BCG product family.

The switching interface to the PSTN complies with industry standard TR-08 and TR-303 requirements. Each subscriber is assigned a dedicated time slot from the switch; thereby no concentration is provided in the cable transportation system. The RF MODEMS provide necessary RF transportation for CATV interfaces. The MODEMS are intelligent to handle the differential distances encountered in a CATV distribution architecture and work together with the subscriber premise device to handle burst traffic in the upstream path. Bandwidth efficiency is realized using multilevel modulation techniques that are appropriate for a CATV environment; frequency agility provides flexibility and capability to avoid "trouble spots" in frequency associated with typical return systems. Hot insertion of electronics and redundant power supply functions can be provided to reduce down-time. A Management System provides network monitoring primarily at DS1s and configuration control of the DS0s. Many of the control functions are performed using an out-of-band channel without interfering with the operation of telephony channels. The system controller is based on an industry standard open platform with Graphical User Interface (GUI) making multi-vendor, multi-application management possible from a single management console. The RF signals from the MODEM and control channel connect to the CATV system for distribution through fiber optic transmitters and receivers.

Figure 2. PSTN to CATV Distribution Interface



2.2 Subscriber Terminal Unit

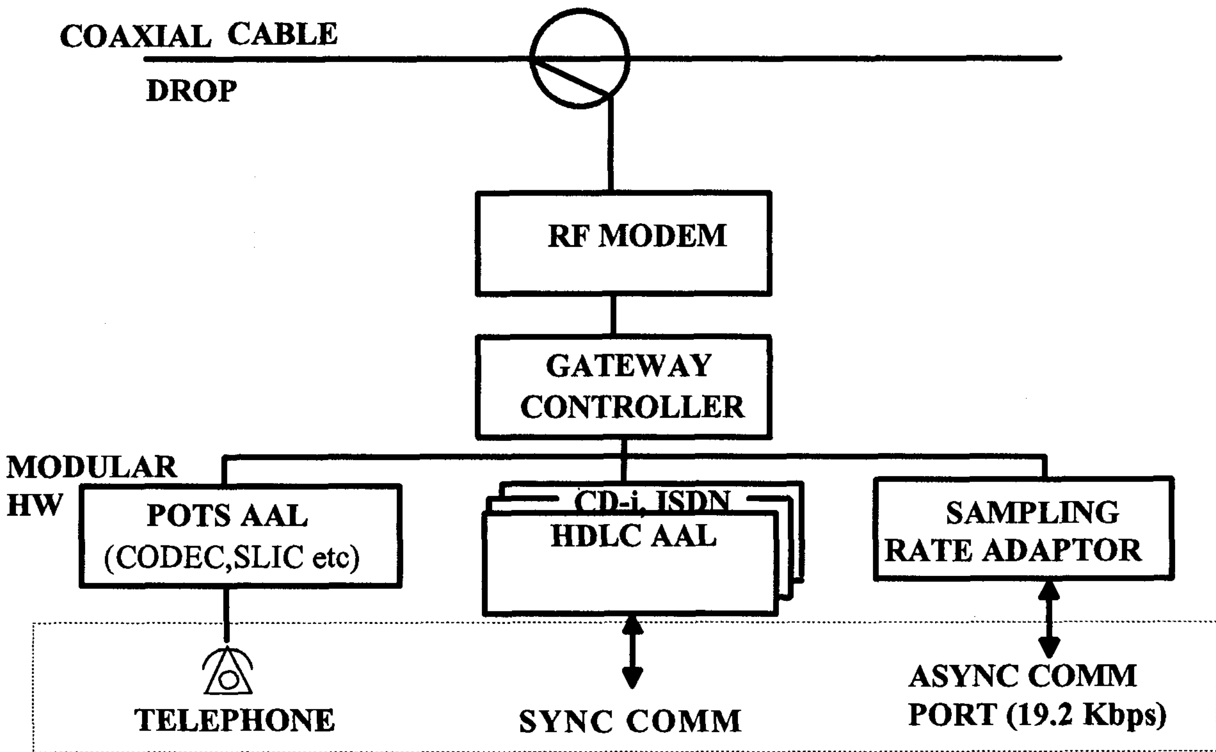
The internal architecture of the BCG subscriber terminal unit (SU) is shown in figure 3. The SU provides the physical and electrical connection between broadband distribution network and subscriber baseband connections. It provides Modulation and Demodulation, Analog to Digital and Digital to Analog conversions, Data Port protocol and rate adaptation for transmission and reception over the broadband CATV medium.

Features provided by the SU are:

1. BORSCHT Functions,
2. Packet-oriented protocol supporting Nx64Kbs channels,
3. Battery Backed Power Supply option,
4. Adaptive ranging for differential distance management on CATV medium,
5. Plug and Play - No setup requirement,
6. Data port for multimedia applications, and
7. Modular structure to accept various interface adaptation devices.

The microprocessor and the MODEM are capable of handling payloads at data rates in

Figure 3. BCG Subscriber Terminal Unit Architecture



Nx64KBits/S format up to a maximum of 2.048Mbits/S. The size of the payload for an application delivered to the Application Adaptation Layer (AAL) devices by the gateway controller is variable in 64KBits/S steps to a maximum of 1.536 MBits/S for ANSI requirements and 2.048MBits/S for CCITT requirements. Different AALs provide the necessary interface for different applications. For example, the POTS AAL is a CODEC for a voice application and the sampling AAL can be a CCITT V110 rate adapter for a simple serial port interface at 19.2KBits/S asynchronous port. The following sections discuss the AALs, specifically in their connectivity and isochronous voice application, a packet switched AAL using High Level Data Link Controller (HDLC) for connection oriented and connectionless services, and a rate sampled 19.2KBits/s interface for personal computers.

3.0 AAL for Voice Application

A typical CODEC for voice applications samples an analog line at 8KHz and provides 8 bits of data per sample after companding using standard companding methods like A-law or μ-law. So in the downstream direction the CODEC payload is delivered directly to the CODEC. In the upstream direction, several bytes are collected over a period of time from the CODEC and burst-out in the proper upstream time slot. The burst packet transmission in the upstream direction is used to conserve bandwidth and reduce hardware requirements at the headend. However, the data collection introduces some time delay for transmission of the packet; therefore, the packet size for a connection oriented delay sensitive service should be kept minimal to reduce the impairment due to talker and listener echoes. For POTS applications, a Subscriber Line Interface Circuit (SLIC) is necessary to do the BORSCHT functions; however, for a computer multimedia application, a CODEC with sufficient drive to activate a low power headset is adequate.

3.1 AAL for Synchronous Data Port

For data communication, some networks use packet-switched technology, in which blocks of data called packets are switched from a source to a destination. Source and destination can be terminals, computers, printers, or other types of data communication devices. In a packet -switched technology, it is possible to share the same distribution and transmission facilities in connection-oriented (where call-setup is required before data exchange) or connectionless (no logical connection is setup prior to data exchange) modes. Synchronous protocols based on HDLC and other protocols like X.25, LAPB, LAPD etc. that evolved from HDLC provide standards for call setup and data exchange methods from the data stream provided by the gateway controller. A typical AAL provides an ISDN-B service extracting two bearer channels (2B) at 64KBits/S each and one data channel (D) at 16KBits/S derived from three 64KBits/S time-slots provided by the gateway controller. The ISDN-B service provides a low-cost high-performance connectivity solution to residential cable customers for high-speed links computer links or video conferencing applications. Similarly, a higher speed service like H0 (384 KBits/S) and H11 (1.536 MBits/S) can be provided by using the proper AALs from the gateway controller.

3.2 AAL for Interactive Services

The proliferation of interactive devices such as the CD-i system provides an additional application for two-way capacity on CATV systems. Many of the current interactive systems are based on some form of CD-ROM storage. The CD can be readily replaced by a communications channel, effectively placing the CD drive at some remote location. A CD retrieves data at about 1.4 MBits/S, nearly filling one T1 channel. Applications can then be run transparently. There is no difference to the user between local CD applications and remote, server based, applications. Of course, the whole point of this is to provide a truly interactive system. Getting the commands from the user back to the server with a minimum delay is critical to the interactivity of the system. The return delay needs to be limited to just a few milliseconds. In fact, the system we are describing adds just a couple of milliseconds of delay to the return data. The user will not be able to perceive the difference between a local application and an application running on a server miles away.

As in all interactive applications on broadband networks, the return capacity is a critical resource. In the networked CD-i application, using the basic BCG technology, we are not making very effective use of the return capacity. Certainly we do not need 64KBits/S of return capacity to be able to control the interactive applications. By using smaller packets, we can accommodate more users in a given amount of return bandwidth. As the packets get smaller, however, the transmission system gets less efficient. We can add users, but the overall data capacity of the return channel is reduced. For example, if we can support 24 users at 64KBits/S, we can possibly support 36 users at 32 KBits/S by sending smaller packets. We can also share the bandwidth by sending packets less frequently. This adds delay to the system and so we need to use this option carefully. By using both of these techniques, we can comfortably support 64 users in a single 1.5 MHz return channel. Each user is allocated 16KBits/S, with the system adding about 3 msec of delay due to the return channel protocol.

3.3 AAL for Asynchronous Data Port

Today, most homes that are equipped with personal computers use telephone MODEMS to communicate to bulletin board services and other data exchanges via the serial ports. These serial ports usually handle about 19.2KBaud and in some cases are capable of going as high as 115KBaud . It is desirable to offer these services using a CATV system with the connectivity of the telephone network without compromising the telephone voice connection. Also, a direct digital port eliminates the need for traditional voice MODEMS, thus reducing the cost of the service provided by the CATV versus the twisted-pair telephone network. There are many rate sampling methods like CCITT V.110 that provide standards for transporting data up to 19.2KBits/S through asynchronous lines onto a 64KBits/S synchronous highway. Direct rate sampling with start bit timing corrections are available from some component vendors like Mitel to provide low-cost methods of rate sampling for asynchronous lines. The modest 19.2KBits/S data rate compares favourably with available telephone MODEMS that have to resort to data compression to achieve higher speeds and occupy the telephone line. Most personal computers can work at these speeds with the standard serial ports and some may require upgrades to communication boards even at these modest rates. Higher data rates can be achieved by providing more time slots and custom or parallel printer port drivers on the PC.

4.0 Conclusion

The world is undergoing some of the most revolutionary changes in interactive communications since the advent of telephones. The fiber/coaxial hybrid network is in place for the "last mile" to integrate the communication needs of new services like multimedia. This paper gave an overview of Nx64KBits/S transport on a CATV network with full PSTN connectivity. The service can be extended to higher data rates to provide multimedia services like video conferencing, interactive games, and high-speed ISDN networks. Many of these services can be provided today on the CATV network for a typical home user if commercial justification and usefulness can be demonstrated. The BCG starts with a telephone MODEM sized device that simultaneously transports 64KBits/S voice and 64KBits/S data for a full two-way symmetric service. The product line will be extended to offer more services like interactive video and work-at-home applications, while simultaneously transporting voice. The product will migrate to the side of the house to provide lifeline telephone service and ISDN connectivity when regulations permit commercial success of such a network.

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