New Services over CATV Network

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Abstract

Traditional CATV networks are growing into two-way, multimedia networks. In recent years cable providers are trying to offer multiple services over a single network. Internet access, high speed data transfer, video on demand and games are some of the applications driving this trend. The problem of delivering new services over CATV networks is characterised by certain infrastructure investments, and the possibilities of upgrading existing CATV networks were analysed. The article describes development of techniques and technologies applied in modern two-way interactive CATV systems.

1. Introduction

The main function of traditional CATV networks - distribution of TV and radio programs - has rapidly changed in a last few years. Modern cable infrastructure should be designed to deliver a variety of new communication services and to support both current and future applications.

In the recent years CATV network topologies have been changed, and beside the usual tree and branch structure the star and ring topology was introduced. Nowadays, the broadband cable networks use the Hybrid Fiber Coaxial (HFC) technology. The optical nodes of the CATV systems come closer to the subscriber's outlet. The ring topology gives higher reliability and usually is used in the optical network. From the optical node and in the house network, the star topology is preferred.

The expansion of digital techniques in audio – Digital Audio Broadcasting (DAB) and television broadcasting – Digital Video Broadcasting (DVB), in case of terrestrial and satellite broadcasting has great influence on CATV systems. The DVB specifications can be used for broadcasting video and audio signals, as well as all kinds of data. One of the strengths of DVB technology lies in the fact that it enables the point-to-multipoint transmission of very large amounts of data at high data rates, with good protection against all kinds of transmission errors. Many of the services possible in the DVB transmission will require some form of interaction between the user and either the program provider or the network operator. Some of the specifications require bi-directional communication channels, using for example CATV installations.

Using cable systems infrastructure to deliver digital two-way services requires the solution of a technical problem of upstream transmission, and is thus critical for digital cable systems.

Another technical problem that arises in designing CATV bi-directional systems is the need that the network resources should be efficiently shared between users while providing a quality of service that is appropriate for their applications. Upgraded CATV network will offer economic benefits both to cable operators and to cable consumers.

2. Internet Access

The technology is rapidly changing as manufacturers of communication systems develop new products for cable communication. Most people today use a dial-up modem for the Internet access, which is not only slow, but forces them to break their data connection every time they want to make a regular phone call, if they don't have extra phone lines. These connections have relatively narrow bandwidth capability and offer maximum speeds of 56 kb/s for a regular dial-up modem, and ISDN connection with 64 to 128 kb/s. Cable offers a much higher bandwidth and allows data to be transferred at several tens of Mb/s. It could be a powerful alternative to telephone lines. The idea of using the cable TV infrastructure to provide the home with broadband access to the Internet has just got a tremendous boost. The technology involved in delivering new communication services over cable networks extends from only television signal transmission, to offering telephone services and computer network connection in our homes to the wide area networks to which cable systems ultimately connect. Providing new communication services on cable requires consideration of these technologies and particularly of how cable systems will interconnect with other systems.

The most important research topics are the design of powerful modems for use in CATV networks and the design of smart access techniques to create a broadband multi accessible duplex communications channel. The use of cable modems in CATV networks allows introduction of high speed Internet services to the home without using regular telephone lines. High-speed cable modems are the basis of packet-based services for data, voice, and video services in the future, using CATV network infrastructure. Smart access techniques have to be used because of the special point-to-multipoint connections available in CATV-networks. Cable modems will deliver data to the users hundreds of times faster than existing dial-up phone modems, but unfortunately, high costs and unsuitable cable plants are responsible for relatively slow introduction of new services into CATV systems.

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3. Upgrade of CATV Network

Most of today's cable plants are suitable for one-way communication, from the headend to the subscriber. CATV networks are originally designed to broadcast time division multiplexed analogue television and radio signals in the frequency band from 47–862 MHz.

Cable networks are built to support a large number of TV channels, usually more than fifty and possible up to nearly hundred of channels. For downstream transmission this means that cable has the potential of carrying tremendous capacity of data. Many of new interactive services require transmission from the subscriber to the headend as well, with bandwidth requirements for such upstream transmission varying tremendously depending on the service. Internet applications have requirements, from low-bandwidth e-mail to high-bandwidth video sent from a home-based Web server.

The frequency range between 5 and 30 MHz is allocated for upstream transmission of analog and digital signals. For more efficient introduction of new interactive services in CATV networks, the return channel for upstream transmission will have extended bandwidth from 5 to 55 MHz or even 5 to 65 MHz. In these cases the downstream frequency band starts at 73 MHz or 86 MHz respectively. Upstream traffic (from the subscriber) and downstream traffic (to the subscriber) share the same coaxial cables.

The first task of a CATV operator that wishes to offer interactive services is to upgrade its cable plant to handle bi-directional information flow. With modest modifications of the backbone equipment in the cable system, the network will be able to support two way traffic, as shown in **Figure 1.**

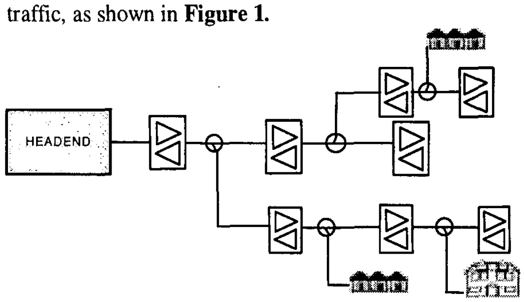

Figure 1. Two way CATV network

The operators have to add return amplifiers and band-splitting filters (diplexers) in the CATV network to separate the upstream and downstream signals, and amplify each direction separately in the right frequency range, install controllers at the headend, and special units at the end-subscribers to separate the upstream from downstream traffic. Typical equipment at the subscriber premises is shown on **Figure 2.**

Downstream transmission from the headend is a typical broadcast. The same signal is sent to all users in the network. The upstream transmission is, in contrast, inherently personalcast. Each subscriber is placing a different signal onto the network. These different signals must share the same part of transmission spectrum and different access methods are needed to arbitrate which signal is actually carried. Access methods can be Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Carrier Sense Multiple Access (CSMA), etc. Which method is appropriate depends on the expected application. Upstream transmission presents a technical challenge, because multiple noise sources invariably accompany the multiple signal sources.

In the reverse direction it is more difficult to keep appropriate carrier-noise ratio than in the forward direction, because of the phenomena called noise funnelling. The effect of noise funnelling (noise accumulation) originates in return path of the CATV network because the network operates as a system with several inputs and one output. The sum of input noise and the noise arise from each return path appears at the network output. Reducing the number of noise sources funnelling into a single upstream channel can solve the noise ingress problem. Careful plant engineering is often required for the upstream signal to arrive to the headend in recognisable form.

Digital data signals are distributed on radio frequency (RF) carrier signals in a cable network. Cable modems convert digital information into a modulated RF signal and also RF signals from a cable network back to digital information. These conversions are performed by cable modem at subscriber premises, and by headend equipment handling multiple subscribers.

By providing Internet access over the CATV network it is necessary to determine what kind of network technology to use to connect the customer to the Internet. A single TV channel with the bandwidth of 7 MHz (VHF band) or 8 MHz (UHF band) can support multiple data streams or multiple subscribers using shared Local Area Network protocols (LAN). This technology allows transmission of digital data over one or more TV channels of a CATV network. The broadband LAN is built on two TV channels, one transmitting data from the headend to subscribers (downstream), and the other transmitting data from subscribers to the headend (upstream). At the headend, a frequency translator connects the two channels into a channel pair. One or more channel pairs can be allocated to LAN service.

Using a standard analogue TV channel bandwidth for data transfer allows the use of the same equipment as is used for analogue cable TV transmission in the headend and in a cable plant. For fast access to the Internet, the CATV headend should be connected to an Internet service provider by a high-speed link. An IP router can be installed at the CATV headend and connected by a dedicated telecommunications line to the Internet service provider. Data received from the Internet provider can be passed through a Fast Ethernet switch to a downstream modulator.

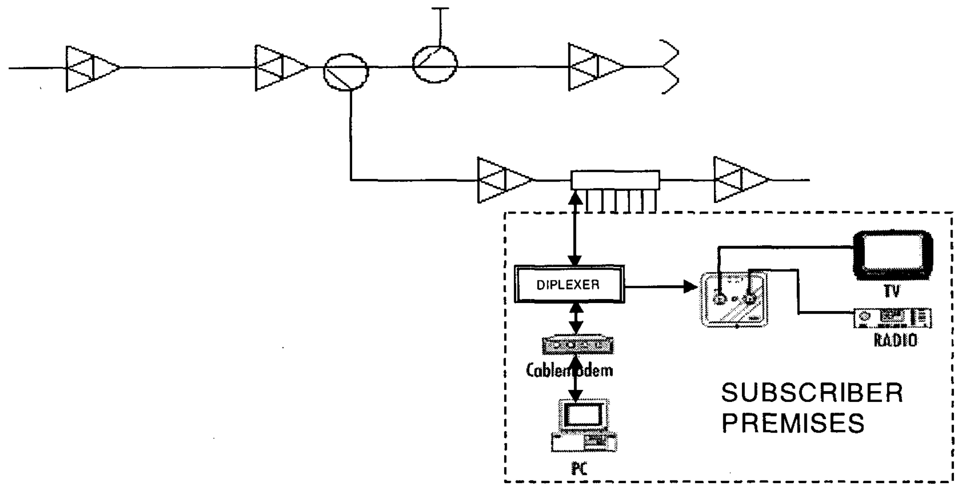

Figure 2. Equipment at the end-subscriber premises

Different modulation techniques can be used to optimise data speed, which is transmitted usually with 6 MHz bandwidth within a TV channel. The most of the cable modem manufacturers use Quadrature Amplitude Modulation (QAM) in forward direction with feasible speeds for 64-QAM up to ~36 Mbps, and Quaternary Phase Shift Keying (QPSK) in reverse direction with speeds up to ~10 Mbps. The QAM has excellent spectral effectiveness and is relatively robust, and the QPSK is a good compromise between the spectral effectiveness and the reliability of data transmission through a noisy medium. The various solutions impose different equipment costs, achieve different coding efficiencies, and have different sensitivities to noise and distortion in the cable network.

The cable network is shared by all subscribers connected to it. This makes cable plant, considered as a communication system, fundamentally different from a telephone network that dedicates a twisted pair line between the central office and each subscriber. The system that allows multiple users to access a cable network requires a solution for allocating network resources. Such an access scheme can introduce complexity into cable communication systems. Sharing access among multiple users also gives rise to privacy and security problems. One user connected to a cable network can potentially receive transmissions intended for another, or make transmissions pretending to be another user. Designing a digital cable system requires the applications and services that the network might support to be established. Therefore security aspects will play an important role. Privacy of users has to be guaranteed and the possibility of illegal access has to be avoided. Careful traffic control should be performed on a CATV system to maximise data speeds even if new subscribers are added to the system. Cable data networks can be custom tailored and subdivided within each part of the network to meet customer demands, to provide faster service for each individual subscriber. To expand capacity of the data network, multiple TV channels can be allocated for data transfer.

For the past few years there is a battle between Europe and North America over underlying standards for cable modems and interactive set-top boxes. Several different standards for cable modems are causing confusion on the European market.

4. Cable Modem Standards

Two international standards have emerged for cable modem products that could be used in Europe. The cable modem standard developed in USA is DOCSIS (Data Over Cable Service Interface Specification) which is in widespread use today in America, and the DVB/DAVIC (Digital Video Broadcasting Project/Digital Audio Visual Council) developed for set-top-boxes and cable modems in Europe, which is a DVB-based standard, concentrated on digital audio-visual applications and services of broadcast and interactive type.

Both standards are built to deliver high speed data services over the cable, but real differences between DOCSIS and DVB appear when we consider future business models of integrated data, telephony and video services in a full service network. DOCSIS is designed to deliver high speed data to the subscribers PC, and is not best suited for services such as enhanced TV.

DVB/DAVIC offers conception of integration of DVB video and data broadcasts with return channel capability that can operate in and out of band for both set-top-boxes and cable modems.

European cable operators want to offer a wider portfolio of broadband services, not just high speed Internet. Althow the DOCSIS modems are the current available standard of choice, these modems are not prefered for use in Europe.

A large number of manufacturers are putting investment into DVB cable modem solutions both for the end user and for the interactive network adapters in the cable headend. It is important that everything is interoperable and they want to integrate it to the rest of DVB broadcast solutions and to the headend equipment. A final EuroModem product specification was ready in May 1999. By June 11, 1999, interested vendors submitted a detailed description of their plans and capability to produce or supply DVB/DAVIC cable modems and headend equipment that complies with the EuroModem specification. DVB/DAVIC cable modems meet the preference of European operators for a standard that better fits their set-top architectures. Some European cable operators already started with DVB transmission, the others will start soon, and the solution with DVB/DAVIC would have many advantages over a separate cable modem system. It is a integrated solution and has lot of benefits in terms of ingress, billing and network management.

DOCSIS modems, supported by more than 25 vendors, are making it possible for cable companies to enter the data communications market now. The operators choose the cheapest and easyest system to implement. New services with high-speed Internet connection allow them to make money without worryng about the content. That way they can also reach new customers. A lot of cable operators could go that way, because it is the fact that DOCSIS modems are more developed at the moment, and they are available.

The current cable modem confusion is bigger since 1998, when several DOCSIS vendors attempted to counter DVB EuroModem with the introduction of a "EuroDOCSIS" specification that incorporated some features desired by European customers, such as an 8 MHz bandwidth downstream transmission format.

European cable operators have to consider how the technical properties of DVB/DAVIC benefit the future purpose of CATV system and if immediate implementation of high speed Internet is the most important parameter. A broader offering of new services in cable network in a near future can be another important parameter for the decision. There is also a desire to support Euro products, rather than importing solutions from American suppliers.

5. Conclusion

Although cable networks have been designed primarily to deliver a broadcast television service, modern CATV networks have the potential to provide a powerful communication medium that could support a variety of applications. Cable television network can be sucessfuly integrated with computer data network to offer new services to the subscribers. High-speed cable modems are the basis of packet-based services for data, voice, and video services in the future, using upgraded CATV network infrastructure. Digital and analogue signals will work in the same advanced telecommunications networks to deliver telephony, data, video and all other high speed data services to residential, educational, business, public, and government customers, regardless of the selected cable modem standard.

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