

# 1 Overview of Digital TV

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The tremendous potential of digital television is attracting interest from telecommunications providers, computer manufacturers, network providers, consumer electronic companies, and broadcasters around the world. Pay Per View, high speed Internet access, video on demand, cable telephony, and e-commerce represent a portion of the new money spinning ventures in which industry firms are investing increasing amounts of dollars and resources. This chapter acts as a foundation block for the technology discussions that follow in later chapters. Here, we introduce the basic concepts and benefits of digital television. Then we introduce the various international standard bodies that are involved in establishing sets of technical specifications for implementing digital TV systems throughout the world. Finally, this chapter provides you with some detailed information about how the components of the digital broadcasting environment work together.

## TERMINOLOGY . . . . .

Before entering a detailed discussion about digital television systems, it is important that you understand a number of industry-specific terms. Here's a short list of the most important ones.

**Head-end** • An industry term that is used to describe a TV operator's main operations center.

**Set-top box** • A set-top box may be defined as a consumer electronics device used to decode and tune digital signals and convert them to a format that is understood by your television.

**MHz** • MHz is an abbreviation for megahertz. One MHz represents a million cycles per second. The speed of a processor in a digital set-top box (defined below) is measured in MHz.

**Bandwidth** • If you have ever waited for a page to download into your PC on a Saturday evening, then you're already familiar with the concept of bandwidth. Think of bandwidth as a pipe that carries information. The less bandwidth you have, the longer the time it will take to download a Web page onto your PC.

**Return path** • Many of the digital TV services on offer require some form of interaction between the subscriber and either the program provider or the network operator. This interaction may consist of transmitting a couple of user commands but can be as extensive as the communications required by a telecommunications link to the Internet. The term "return path" is used to describe the physical channel that facilitates this two-way interaction.

**Protocol** • A protocol is a formal description of the messages that need to be exchanged and the rules that need to be followed for two or more systems to exchange information.

**Network service provider** • Many of the cable, microwave multipoint distribution services (MMDS), terrestrial, satellite, and broadcasting companies are beginning to move into the telecommunications sector to offer a variety of services that have not been associated with their traditional TV-based offerings. Consequently, in this book we sometimes refer to this group of companies as service providers or network service providers. A network service provider will not only manage the network infrastructure, but will also control the various services that run over its high-speed networks.

## WHAT IS DIGITAL TELEVISION? . . . . .

Digital television, commonly known as digital TV, is a completely new way of broadcasting and is the future of television. It is a medium that requires new thinking and new revenue-generating business models. Digital TV is the successor to analog TV and eventually all broadcasting will be done in this way.

Around the globe, cable, satellite, and wireless operators are moving to a digital environment. Affiliates of the four major networks in the United States—ABC, NBC, CBS, and Fox were slated to begin digital broadcasts by November 1999. By 2006, the Federal Communications Commission (FCC) in the U.S. has mandated that no more analog television signals be broadcast. In Europe, the digital TV train is also rolling out of the station, with broadcasters in France, Ireland, Spain, Germany, Holland, and the U.K. planned to launch digital technologies in 1999. Most industry analysts are predicting that the transition to digital TV will be an evolution rather than a revolution, changing the way of life for hundreds of millions of families around the world.

Companies are acknowledging that the convergence between personal computers, TV sets, and the Internet has already begun and are positioning themselves to maximize revenue from this new computing paradigm.

For consumers, the digital age will improve their viewing experience through cinema-quality pictures, CD-quality sound, hundreds of new channels, the power to switch camera angles, and improved access to a range of exciting new entertainment services. Digital TV also gives subscribers the opportunity to enjoy more programming through cinema-style wide screen TVs. Gone are the days of choosing between a small range of channels. Television will become more fun and powerful to use, yet at the same time simpler and friendlier.

For the broadcaster, a move to a digital environment decreases the bandwidth utilization per channel, facilitates the offering of Internet applications to their subscribers, and opens a new era of business opportunities.

The new digital technologies will allow cable companies, satellite providers, and wireless broadcasters to offer a variety of powerful revenue-generating services, including:

- Internet access at blazing speeds;
- multi-user network games;
- video on demand;
- streaming video and audio;
- home banking services;
- e-commerce applications;
- PC software upgrades;
- Broadcasting rich multimedia content; and
- electronic newspapers.

Digital television also opens up a new world of opportunities for companies who want to develop content and applications for the new paradigm. This includes the creative communities within the television and film industry, Internet content providers, and software development houses, as well as new companies that will be created around this new industry.

To fully understand digital TV, we need to look at its origin and how various compression and transmission technologies were used to revolutionize the television experience. For the past 50 years, broadcasters have been using analog signals as a means of transmitting TV to the mass market. During this period, we experienced the transition from the black-and-white sets to color TV sets. The migration required viewers to purchase new TV sets and broadcasters had to acquire new transmitters, posts and production equipment.

The switch from black-and-white to color had palpable benefits for everyone. Today, the industry is going through a profound and amazing transition: migrating from conventional TV to a new era of digital technology. Television operators are upgrading their existing networks and deploying advanced digital platforms to open a new world of opportunities for consumers, content providers, and entrepreneurs.

First, digital TV offers high speed data transfer rates, which make the delivery of rich multimedia content a reality. Second, many cable, terrestrial, and satellite companies are establishing themselves as Internet service providers, which will enable TV viewers to browse the Internet on their TV sets.

Finally, the new medium will allow viewers from the comfort of their homes to use a simple remote control to electronically purchase goods and services offered by various content providers. Digital TV uses the same language as computers—a long stream of binary digits, each of which is either 0 or 1. With digital television, the signal is compressed and only the updated data is transmitted. As a result, it is possible to squeeze six or eight channels into a frequency range that was previously occupied by only one analog TV channel.

The digital TV cycle begins by recording a particular event or program with digital equipment and is relayed to a redistribution center. In most cases, the redistribu-

tion center will be a cable, satellite, MMDS, or terrestrial operator. From here, the operators use specific transmission techniques to broadcast the new digital signal to subscribers on their network.

## INTERNATIONAL STANDARD BODIES AND AGREEMENTS . . . . .

Making digital television a reality requires the cooperation of a variety of industries and companies, along with the development of many new standards. A wide variety of international organizations have contributed to the standardization of digital TV over the past couple of years. Most standards organizations create formal standards by using specific processes: organizing ideas, discussing the approach, developing draft standards, voting on all or certain aspects of the standards, and then formally releasing the completed standard to the general public. Some of the best-known international organizations that contribute to standardizing of digital television include:

- the European Telecommunications Standards Institute (ETSI);
- Digital Video Broadcasting (DVB);
- the Advanced Television Systems Committee (ATSC);
- the Digital Audio Visual Council (DAVIC);
- the European Cable Communications Association (ECCA);
- CableLabs;
- the W3 consortium; and
- the Federal Communications Commission (FCC).

Their contribution to the standardization process is explained and detailed in the following sections.

### **European Telecommunications Standards Institute (ETSI)**

ETSI is a nonprofit organization whose mission is to determine and produce a wide range of telecommunication standards. It is an open forum that unites approximately 647 members from countries all over the globe, representing administrations, service providers, manufacturers, and end-users. Any European organization proving an interest in promoting European telecommunications standards has the right to represent that interest in ETSI and thus to directly influence the standards-making process. ETSI consists of a General Assembly, a Board, a Technical Organization, and a Secretariat. The Technical Organization produces and approves technical standards. It encom-

passes ETSI projects, technical committees, and special committees. More than 3,500 experts are at present working for ETSI in over 200 groups. (Additional information about ETSI is available from their web site at <http://www.etsi.org/>).

## Digital Video Broadcasting (DVB)

The DVB project was conceived in 1991 and was formally inaugurated in 1993 with approximately 80 members. Today, the DVB project has made huge advancements and boasts a membership of over 230 organizations in more than 30 countries worldwide.

Members of the group include electronic manufacturers, network operators, broadcasters, software companies, and various regulatory bodies.

The DVB project has been a big success and has generated various standards for delivering digital TV to people throughout Europe, Asia, Australia, and North America.

The work of the DVB project has resulted in a comprehensive list of technical and nontechnical documents that describe solutions for implementing digital television in a variety of different environments.

The international standards and solutions developed by DVB over the past few years can be classified and summarized as follows:

1. DVB-S—An international standard for transmitting digital television using satellites.
2. DVB-C—An international standard for transmitting digital television using digital cable systems.
3. DVB-T—An international standard for transmitting digital television in a terrestrial environment.
4. DVB-MC/S—An international standard for transmitting digital television using microwave multipoint video distribution systems.
5. DVB-SI—An international standard that defines the data structures that accompany a digital television signal.
6. DVB-CA—An international standard that defines digital television security standards.
7. DVB-CI—An international standard that defines a common interface to the digital TV security system.
8. DVB-I—An international standard for deploying interactive TV.
9. DVB-Data—An international standard designed to allow operators to deliver software downloads and high speed data services to their customers.
10. Interfaces—An international standard that defines digital TV interfaces to high speed backbone networks.



**Figure 1.1**  
DVB Logo

Copies of these standards are available for download on ETSI's web site.

DVB-compliant digital equipment is widely available and is easily identified by the DVB logo illustrated in Figure 1.1. The DVB has had its greatest success in Europe, however the standard has implementations in North and South America, Africa, Asia, and Australia. For additional information about DVB, visit their web site at <http://www.dvb.org/>.

### **Advanced Television Systems Committee (ATSC)**

The ATSC committee was formed to establish a set of technical standards for broadcasting standard and High Definition Television (HDTV). Pictures based on this standard can have 3 to 5 times the sharpness of today's analog broadcasts.

The committee is composed of 136 member organizations, standard bodies, IT corporations, educational institutions, and electronic manufacturers. It has been formally adopted in the United States, where an aggressive implementation of digital TV has already begun. In addition to the U.S., Canada, South Korea, Taiwan, and Argentina have also adopted the ATSC digital TV standard for terrestrial broadcasts. A sample of the ATSC standards are outlined in Table 1.1.

**Table 1.1** ATSC Standard Documents

<b>Document Number</b>	<b>Standard Description</b>	<b>Brief Overview</b>	<b>Web Address of Detailed Document</b>
A/52	ATSC Digital Audio Compression	Specifies coded representation of audio information and the decoding process, as well as information on the encoding process	<a href="http://www.atsc.org/Standards/A52/">www.atsc.org/Standards/A52/</a>
A/53	ATSC Digital Television Standard	Specifications and characteristics for an advanced TV (ATV) system	<a href="http://www.atsc.org/Standards/A53/">www.atsc.org/Standards/A53/</a>
A/54	ATSC Guide	Description of ATV system	<a href="http://www.atsc.org/Standards/A54/">www.atsc.org/Standards/A54/</a>
A/64	Transmission measurement and compliance for digital television	Description of measurement and ATSC compliance system	<a href="http://www.atsc.org/Standards/A64/">www.atsc.org/Standards/A64/</a>

This table only displays a snapshot of the ATSC standards. To review the complete listings of ATSC standards, we recommend you visit the ATSC Web page at [http://www.atsc.org/Standards/stan\\_rps.html](http://www.atsc.org/Standards/stan_rps.html) for a more detailed listing.

For the latest information and updates about ATSC, visit their web site at <http://www.atsc.org/>.

## Digital Audio Visual Council (DAVIC)

The organization was formed in 1994 with the aim of defining standards for the end-to-end transfer of digital audio, video, and Internet-based content.

DAVIC is a nonprofit standards organization currently located in Switzerland. The organization currently has a membership of over 180 companies from 25 countries around the globe, representing companies and individuals from all sectors of the audio-visual industry. DAVIC members meet on a regular basis to define specifications and use their web site ([www.davic.org](http://www.davic.org)) to collaborate and implement various international projects.

## European Cable Communications Association (ECCA)

ECCA is the European Association of cable operators. The main goal of the Association is to foster cooperation between operators, and to promote their interests

at a European level. ECCA gathers European cable operators, consisting of more than 40 million subscribers. The first informal cooperation between European cable operators started in 1949. As these informal meetings became more frequent, a formal structure for European cooperation was required and on September 2, 1955, the Alliance Internationale de la Distribution par câble (AID) was set up by representatives of Switzerland, Belgium, and The Netherlands. In 1993, AID was renamed the European Cable Communications Association, thus stressing the communication role of its members as well as its European goals.

ECCA now has 29 members in 17 countries. It also has 5 associate members in central and eastern Europe. ECCA has considerably contributed to European policies related to cable on the regulatory as well as on the technical standards field.

On the regulatory, ECCA has done a lot of work on areas such as digital TV, copyright, must-carry, and open-access issues. In addition to these projects, ECCA members have also compiled the following technical specifications.

## Eurobox

On initiative of the ECCA organization, a common specification for cable set-top boxes following DVB standards was agreed upon by a large number of cable operators in Europe (the Eurobox platform).

The Eurobox platform was set up in 1997, and has more than 5.5 million subscribers. A more detailed description of the Eurobox is available in Chapter 5 of this book.

## Euromodem

A collective resolution to develop a global standard for high speed cable modems was signed at the ECCA Cable Forum in November 1998. The standard fully complies with European standards and with several DVB specifications. The ECCA group has considered two different types of modems: class A and class B. Class A modems are capable of transmitting data at very high speeds in a downstream direction (maximum of 50.8 Mbits/sec) and 3 Mbits/sec in the upstream direction. They are capable of accessing the Internet at high speeds and support a number of security technologies. Class B is the second type of modem considered by the group. It extends the functionality of class A devices through the support of time critical services such as video conferencing and telephony. At the time of going to press, a number of electronic manufacturing companies were invited to submit plans to manufacture modems compliant with the Euromodem standard.

## Cable telephony

On the basis of the full liberalization of the telecommunications sector in Europe, cable companies, satellite providers, and terrestrial broadcasters in different countries are planning to become competitors to the local telephony companies. Therefore, their networks are being or have been upgraded to broadband telecommunications networks, which are able to provide all kinds of services from telephony and local Internet access to high speed broadband connections. ECCA is also actively working in this area. For additional information about ECCA, visit their web site at <http://www.ecca.be/>.

## CableLabs

Cable Television Laboratories, Incorporated (CableLabs), was originally established in May 1988 as a research and development consortium of cable television system operators. To qualify as a member of CableLabs, a company needs to be a cable television system operator. CableLabs currently represents more than 85 percent of the cable subscribers in the United States, 70 percent of the subscribers in Canada, and 10 percent of the subscribers in Mexico. CableLabs plans, funds, and implements a number of research and projects that help cable companies take advantage of future opportunities in the areas of digital TV, telephony, and high speed Internet. For additional information about CableLabs, visit their web site at <http://www.cablelabs.com/>.

## W3 Consortium (W3C)

The W3 Consortium (W3C) was originally founded in 1994 to lead the World Wide Web to its full potential by developing common protocols that promote its evolution and ensure its interoperability. The organization is an international consortium, jointly hosted by the Massachusetts Institute of Technology in the U.S; an organization in Europe called the Institut National de Recherche en Informatique et en Automatique, and Keio University in Japan.

The consortium provides a range of services, including: a repository of information about the World Wide Web for developers and users; reference code implementations to embody and promote standards; and various prototype and sample applications to demonstrate use of new technology. For detailed information about the W3C, visit their web site at <http://www.w3c.org/>.

## Federal Communications Commission (FCC)

The Federal Communications Commission (FCC) is an independent United States government agency, directly responsible to Congress. The FCC was established by the

Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite, and cable. The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions. There are six operating bureaus. The bureaus are: Mass Media, Cable Services, Common Carrier, Compliance and Information, Wireless Telecommunications, and International. These bureaus are responsible for developing and implementing regulatory programs, processing applications for licenses or other filings, analyzing complaints, conducting investigations, and taking part in FCC hearings.

The Cable Services Bureau was established in 1993 to administer the cable Television Consumer Protection and Competition Act of 1992. The Bureau enforces regulations designed to ensure that cable rates are reasonable under the law. It is also responsible for regulations concerning "must carry," retransmission consent, customer services, technical standards, home wiring, consumer electronics, equipment compatibility, indecency, leased access, and program access provisions. The Bureau also analyzes trends and developments in the industry to assess the effectiveness of the cable regulations. For additional information about the FCC, visit their web site at <http://www.fcc.gov/>.

## BUILDING BLOCKS OF A DIGITAL TV SYSTEM . . . . .

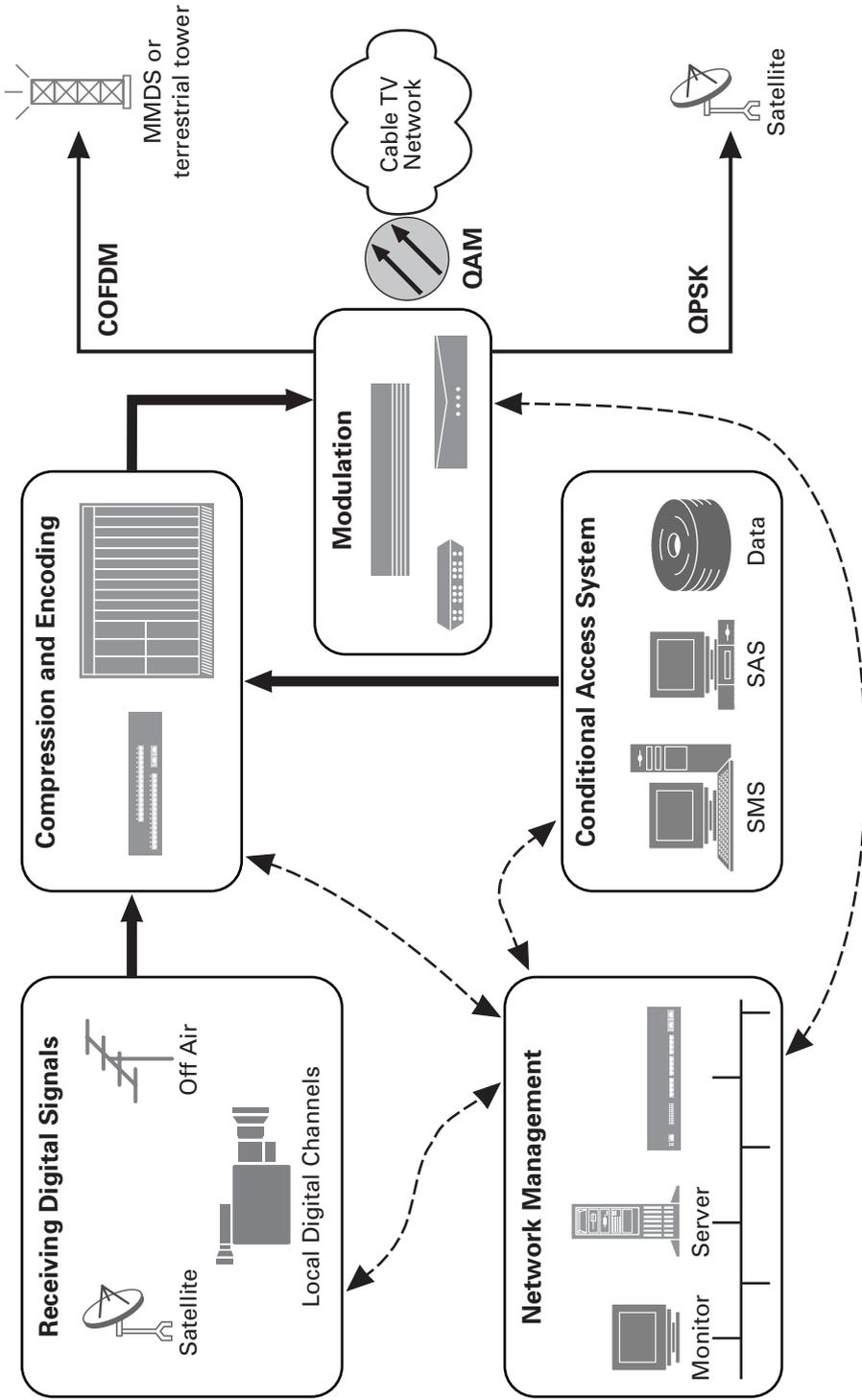
A TV operator normally receives content from a variety of sources, including local video, cable, and satellite channels. The content needs to be prepared for transmission to the customer's home by passing the signal through a digital broadcasting system. The diagram in Figure 1.2 depicts the basic building blocks of a digital broadcasting system.

Note that the components shown in this diagram are logical units and do not necessarily correspond to the number of physical devices that are deployed in a total end-to-end digital solution. The role of each component shown in Figure 1.2 is briefly outlined in the following categories.

### Compression and Encoding

Central to a digital video-broadcasting network is the compression system, whose job is to deliver high quality video and audio to consumers using a small amount of network bandwidth. The main goal of any compression system is to minimize the storage capacity of information. This is particularly useful for service providers who want to "squeeze" many digital channels into a digital stream.

A compression system consists of *encoders* and *multiplexers*. Encoders are devices used to digitize, compress, and scramble a range of audio, video, and data channels. Digital encoders allow TV operators to broadcast several high quality video



**Figure 1.2**  
Simplified block diagram depicting the basic building blocks of a digital broadcasting system

programs over the same bandwidth that was formerly used to broadcast just one analog video program.

Once the signal is encoded and compressed, an MPEG-2 stream is transmitted to the multiplexer (MPEG-2 is an acronym for Moving Pictures Experts Group). This group has defined a range of compression standards and file formats, including the MPEG-2 video animation system. MPEG-2 is generally accepted in 190 countries worldwide as the standard for digital video compression. There are two major MPEG standards available on the market today: MPEG-1 and MPEG-2.

The MPEG-1 file format is normally used by interactive TV developers to create TV “stills” and has a quality level slightly less than conventional video cassette recorders. The MPEG-2 file format is used in a digital broadcasting environment and features CD-quality audio complemented with a high screen resolution. Once the signal has been compressed into MPEG-2 format, the multiplexer combines the outputs from the various encoders together with the security and program information and data into a single digital stream.

## Modulation

Once the digital signal has been processed by the multiplexer, it is now time to amalgamate the video, audio, and data with the carrier signal in a process called *modulation*. The unmodulated digital signal outputted from the multiplexer has only two possible states, either a “zero” or a “one.” By passing the signal through a modulation process, a number of states are added, which increases the data transfer rate. The modulation technique used by TV operators will depend on the geography of the franchise area and the overall network architecture.

The three major types of digital modulation are Quadrature Amplitude Modulation, Quadrature Phase Shift Keying, and Coded Orthogonal Frequency Division Multiplexing.

### Quadrature Amplitude Modulation (QAM)

QAM is a relatively simple technique for carrying digital information from the TV operator’s broadcast center to the customer. This form of modulation modifies the amplitude and phase of a signal to transmit the MPEG-2 transport stream. QAM is the preferred modulation scheme for cable companies because it can achieve transfer rates up to 40 Mbits/sec.

## Quadrature Phase Shift Keying (QPSK)

QPSK is more immune than QAM to electromagnetic noise and is normally used in a satellite environment or on the return path for a cable television network. QPSK works on the principle of shifting the digital signal so that it is out of phase with the incoming signal. QPSK will improve the robustness of a network, however, this modulation scheme is only capable of transmitting data at 10 Mbits/sec.

## Coded Orthogonal Frequency Division Multiplexing (COFDM)

COFDM operates extremely well in heavily built-up areas where digital transmissions become distorted by obstacles such as buildings, bridges, and hills. COFDM is different to QAM because it uses multiple signal carriers to transfer information from one node on the network to another. At the moment, COFDM may be implemented with either 2,000 (2K) or 8,000 (8K) carrier signals. European terrestrial and MMDS operators mainly use the COFDM modulation scheme. In contrast, COFDM has not been deployed in the United States because the ATSC (Advanced Television Systems Committee) has defined a digital terrestrial system that meets the needs of a less-rugged geographical terrain.

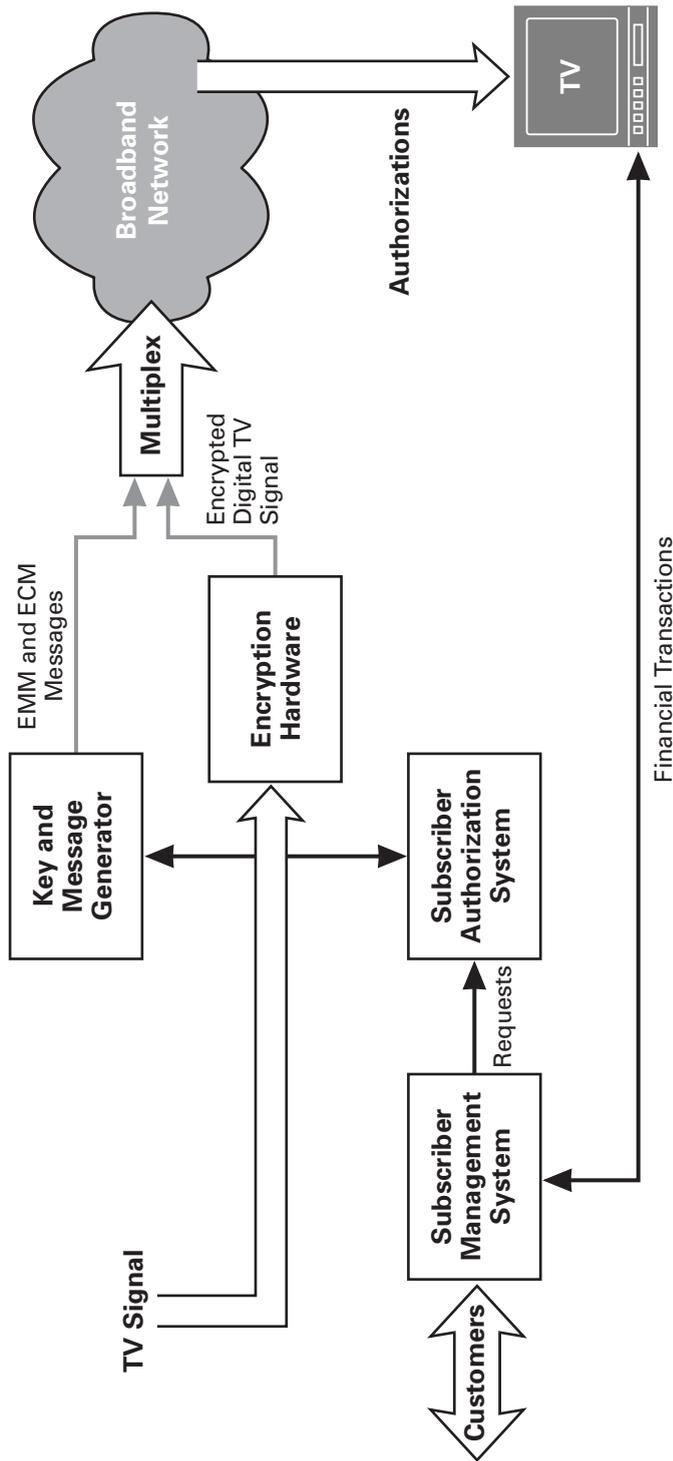
## Conditional Access System

Broadcast and TV operators are now interacting with their viewers on many levels, offering them a greater program choice than ever before. Additionally, the deployment of a security system or conditional access (CA), as it is commonly called, provides them with unprecedented control over what they watch and when. A CA system is best described as a virtual gateway that allows viewers to access a new world of digital services.

The main goal of any CA system is to control subscribers' access to digital TV pay services and secure the operators revenue streams. Consequently, only customers that have a valid contract with the network operator can access a particular service. Using today's CA systems, network operators are able to directly target programming, advertisements, and promotions to subscribers by geographical area, market segment, or according to personal preferences. The CA system is therefore a vital aspect of the digital TV business. In technical terms, the key elements of the CA system are illustrated in Figure 1.3.

Restricting access to a particular service is accomplished by using a technique called cryptography. It protects the digital service by transforming the signal into an unreadable format. The transformation process is known as "encryption" in a digital environment and "scrambling" in an analog domain. Once the signal is encrypted, it can only be decrypted by means of a digital set-top box. Decryption is the process

# Building Blocks of a Digital TV System



**Figure 1.3**  
Basic principle of an end-to-end conditional access system

used to convert the message back to its original format. This is carried out using a decryption key. A key is best described as a secret value, consisting of a random string of bits, which is used by a computer in conjunction with mathematical formulas called algorithms to encrypt and decrypt information.

The box incorporates the necessary hardware and software subsystems to receive and decrypt the signal. These components are comprised of a de-encryption chip, a secure processor, and some appropriate hardware drivers. The de-encryption chip is responsible for holding the algorithm section of the CA. The secure processor can either be soldered onto the set-top box's printed circuit board or else attached to a smart card. Smart cards are plastic cards that look like credit cards. This processor contains the necessary keys needed to decrypt the various services. Chapter 11 discusses the cryptography aspects of smart card security in more detail.

A given subscriber may decrypt and access the digital signal only if the subscriber has purchased the relevant entitlement. As an example, the entitlement may be provided in the form of an electronic smart card that is plugged into the set-top box. Alternatively, in a pay-per-view scenario, the entitlement may be delivered electronically by entitlement management messages (EMMs) and entitlement control messages (ECMs) within the broadcast stream. An EMM is used to carry authorization details and are subscriber-specific. Consequently, the number of EMMs that need to be sent over the broadband network is proportional to the number of set-tops on the network. In addition to sending EMMs to specific customers, operators can also broadcast EMMs to groups of subscribers in different geographical areas. ECMs, on the other hand, carry program- and service-specific information, including control words that are used by the smart card to decrypt the relevant program. However, if a subscriber is not entitled to watch the program, then a signal is sent to the set-top box to indicate that this program has not been authorized for de-encryption. ECMs and EMMs are generated and broadcasted at the TV operations center using specialized hardware devices. They are then transmitted to the viewer's smart card. The card will check access rights and descramble the requested digital services. It is possible to change the value of an ECM every 10 seconds in order to maximize security on a digital network. A typical smart card is capable of storing up to a hundred entitlement messages, which means that each subscriber on the network is capable of ordering 100 pay-TV events at any one time.

In addition to encrypting digital services, the CA also interfaces with the following subsystems:

### Subscriber Management System (SMS)

To exploit the commercial potential of digital broadcasting, TV operators need to interface their technical systems with a subscriber management system (SMS). The SMS provides the support required to accurately manage the digital TV business model. It handles the customer database and sends requests to the subscriber autho-

ization system (SAS)—the technical management part of the CA system. Functions typically provided by an SMS software application system include:

- register, modify, and cancel subscriber records;
- targeted marketing campaigns;
- inventory management of set-tops and smart cards;
- customer experience tracking;
- cross-selling of services;
- interfacing with banks and credit card companies;
- fault management;
- multilingual and multicurrency capability;
- bill preparation and formatting;
- presentation of bills in electronic formats; and
- accounting and auditing facilities.

Many of the software solutions currently available in the marketplace are capable of supporting the increasing variety of interactive services offered to subscribers. The main goal of any SMS system is to ensure that subscribers view exactly what they pay for.

### Subscriber Authorization System (SAS)

The main task of the SAS is to translate the requests coming from the SMS into EMMs. These authorization messages are then sent via the digital multiplex to the smart card, which is located in the set-top box. They are sent to customers on a regular interval (for example, every month) to renew subscription rights on the smart card. In the case of Pay Per View (PPV) applications, the SAS sends a certain amount of electronic tokens to the smart card that will allow customers to purchase a variety of PPV events. The SAS contains database(s) that are capable of storing the following items of information:

- pay TV product information,
- data to support the electronic TV guide,
- identification numbers of smart cards,
- customer profiles, and
- scheduling data.

Additionally, SAS security can be enhanced by periodically changing the authorization keys broadcasted to the subscriber base. Some well-known CA systems include:

- CryptoWorks from Philips,
- Viaccess from France Telecom,
- Nagra from NagraVision,
- MediaGuard from Canal+ Technologies,
- VideoGuard from NDS,
- DigiCipher from General Instruments, and
- Iredeto from MindPort.

## Network Transmission Technologies

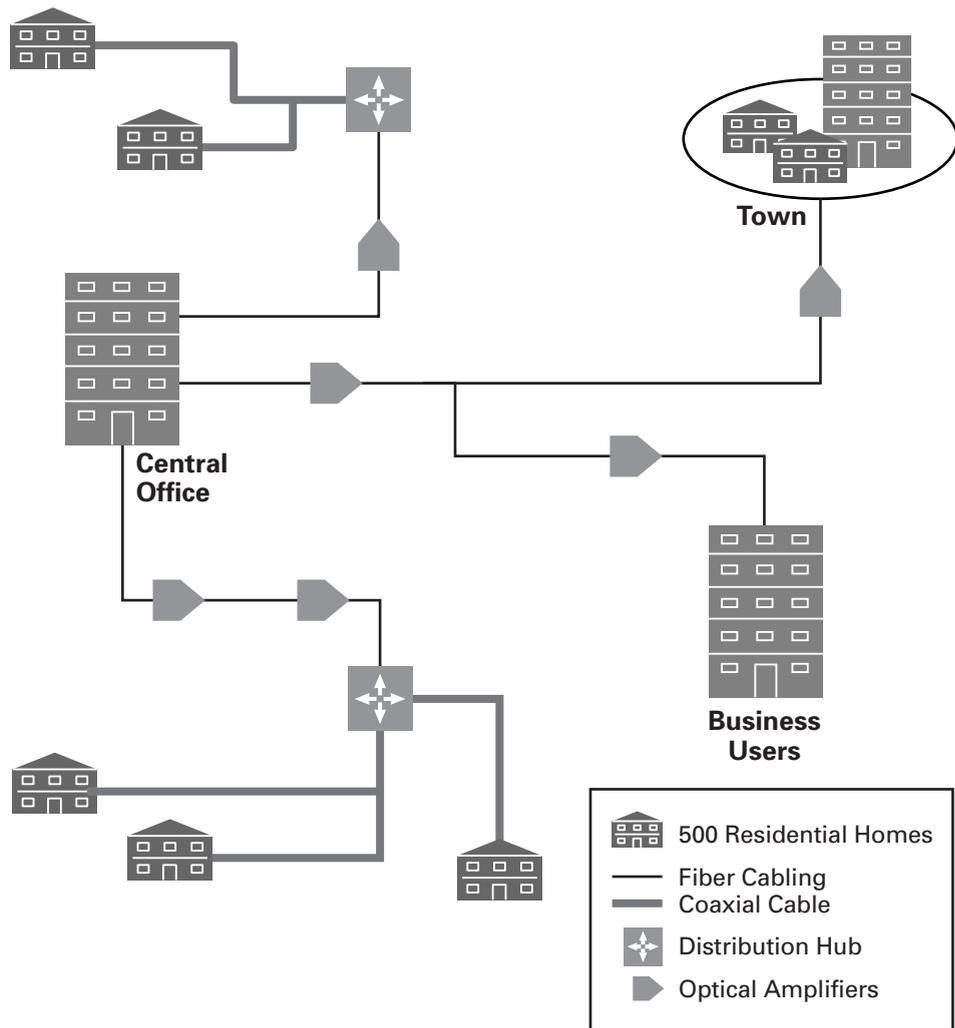
Several different technologies have been deployed to bring broadband entertainment services from a central point to customers on a digital TV network. The different distribution systems (or mix of systems) adopted to broadcast digital TV services in countries around the world has largely been a function of each market's unique characteristics, including elements such as topography, population density, existing broadcast infrastructure, as well as social and cultural factors.

The most popular of these technologies are detailed in the following subsections.

### Digital Via Hybrid Fiber-Coax (HFC)

Hybrid fiber-coax (HFC) technology refers to any network configuration of fiber-optic and coaxial cable that may be used to redistribute a variety of broadband entertainment services. These broadband services include telephony, interactive multimedia, high speed Internet access, video-on-demand, and distance learning. The types of services provided to consumers will vary between cable companies.

Many of the major cable television companies in the United States, Europe, Latin America, and Southeast Asia are already using it. Networks built using HFC technology have many characteristics that make it ideal for handling the next generation of communication services. First and foremost, HFC networks can simultaneously transmit broadband analog and digital services. This is extremely important for network operators who are rolling out digital TV to their subscribers on a phased basis. Additionally, HFC meets the expandable capacity and reliability requirements of a new digital TV system. HFC's expandable capacity allows network operators to add services incrementally without major changes to the overall plant infrastructure. HFC is essentially a "pay as you go" architecture that matches infrastructure investment with new revenue streams, operational savings, and reliability enhancements. The HFC network architecture is comprised of fiber transmitters, optical nodes, fiber and coaxial cables, and distribution hubs. An end-to-end HFC network is illustrated in Figure 1.4.



**Figure 1.4**  
End-to-end HFC Network

From the diagram we can see that the signal is transmitted from the central office in a star-like fashion to the fiber nodes using fiber-optic feeders. The fiber node, in turn, distributes the signals over coaxial cable, RF amplifiers, and taps throughout the customer serving area. In conclusion, HFC is the lowest-cost alternative available in terms of cost-per-home-passed. This fact, combined with the other advantages already discussed, ensures that HFC will remain the primary technology for distributing advanced broadband services in a cabled environment.

## Digital via Wireless Cable

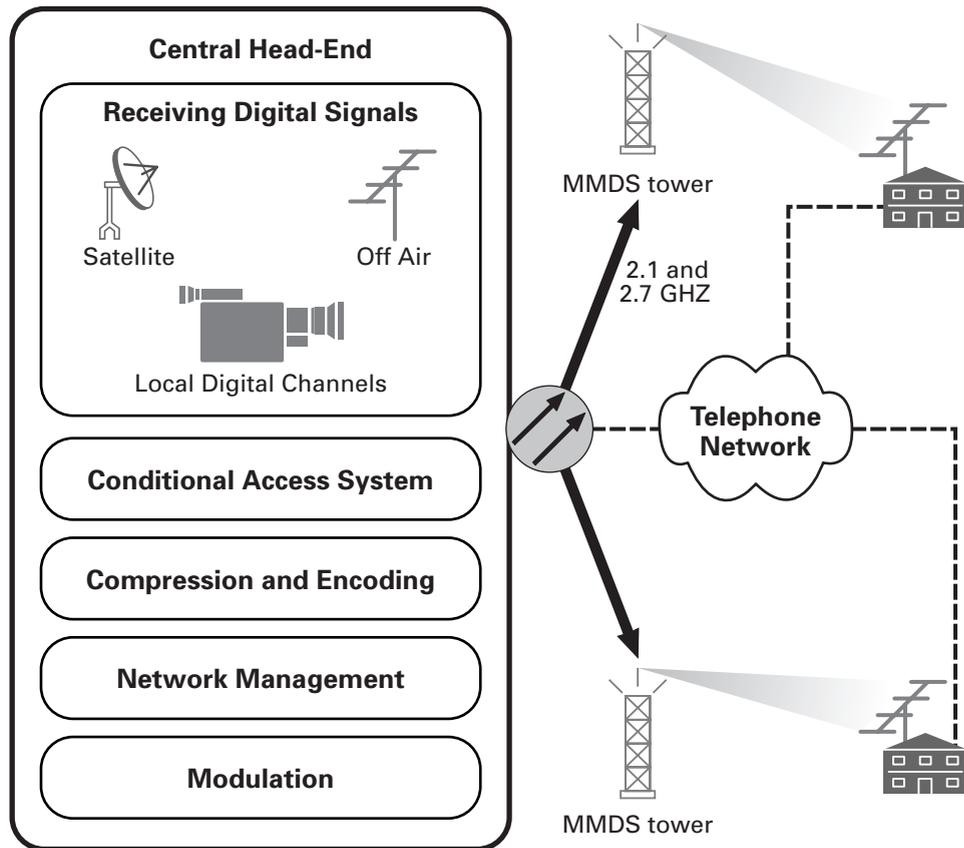
Wireless cable is a relatively new service used to broadcast TV signals at microwave frequencies from a central point or head-end to small antennas located on the subscriber's roof. It is enabled through the use of two distribution technologies: multi-channel multipoint distribution system (MMDS) and local multipoint distribution system (LMDS).

### MMDS

Analog-based MMDS began in the mid-1970s with the allocation of two channels for sending business data. The service, however, became very popular for TV subscriber programming and applications were made to allocate part of the ITFS (Instructional Television Fixed Service) band to wireless cable TV. Once the regulations had been amended, it became possible for a wireless cable system to offer up to thirty-one 6 MHz channels in the 2.5 to 2.7 GHz band. During this timeframe, the system was used by nonprofit organizations to broadcast educational and religious programs. In 1983, the FCC allocated frequencies in both of these spectrums, providing 200 MHz bandwidth for licensed network providers. The basic components of an end-to-end digital MMDS system is shown in Figure 1.5.

An MMDS system consists of a head-end that receives signals from satellites, fiber optic cable, off-the-air TV stations, and local programming. At the head-end, the signals are mixed with commercials and other inserts, scrambled, converted to the 2.1 and 2.7 GHz frequency range, and sent to microwave towers. The signals are then rebroadcast from low-powered base stations within a 35-mile diameter of the subscriber's home. Signals are received with home rooftop antennas, which are 18 to 36 inches wide. The receiving antenna should have a clear line of site to the transmitting antenna. A down converter, usually a part of the antenna, converts the microwave signals into standard cable channel frequencies. From the antenna, the signal travels to a set-top box where it is decrypted and from there the signal passes into the television. If the subscriber requires interactivity, then the digital set-top box is also connected to the public telephone network.

Today, there are systems in use all around the U.S. and in many other countries, including Australia, South Africa, South America, Ireland, and Canada. Currently, MMDS is an analog service providing about 20 channels of programming to subscribers. Digital MMDS increases the number of channels to between 130 and 180. Digital MMDS also reduces the line-of-sight restrictions by providing a more efficient signal that will require less signal strength at the set-top box. Digital signals will need about 100 times less signal strength than analog signals, which translates to a substantial increase in the range of service area. Where an analog signal degrades with distance, the digital signal will remain constant and perfect as long as it can be received. In addition to more channels, digital MMDS customers will also be able to receive a variety of Internet, telephony, and interactive TV-based services. MMDS is presently using a standard phone line for the return path, but trials are under way to utilize a portion of the wireless bandwidth for return capabilities.



**Figure 1.5**  
End-to-end digital MMDS solution

In Ireland for example, MMDS operators are currently very active in testing and delivering a diversity of advanced digital TV and Internet services using MMDS network transmission techniques to customers across the island. The services on offer to customers include:

- high speed access to the Internet;
- private data networks for companies on the island;
- broadcast video and Pay Per View television;
- Plain Old Telephone Service (POTS); and
- fractional and full leased lines

Future services discussed by Irish operators include video conferencing and delivering multimedia training courses to remote parts of the country using advanced MMDS digital technologies. MMDS operators across the world are adopting similar approaches to their Irish counterparts and are poised to take advantage of the exciting new digital MMDS broadcasting revolution, allowing the delivery of a variety of services to their customer bases.

### LMDS

LMDS uses microwave frequencies in the 28 GHz frequency range to send and receive broadband signals, which are suitable for the transmission of video, voice, and multimedia data. Digital LMDS has been commercially deployed and is used to deliver video programming from local and cable channels. Additionally, it is also capable of delivering a plethora of Internet- and telephony-based services to consumers. The system architecture for LMDS is very similar to the MMDS system. The reception and processing of programming and other head-end functions are the same. The signals are then rebroadcasted from low-powered base stations in a 4–6 mile radius of the subscriber's home. Signals are then received using six square-inch antennas, which can be mounted either inside or outside the home. As with the MMDS, the signal travels to the set-top box, decrypted, and formatted for display on the customer's television. In addition to a high video and audio quality, other benefits of LMDS include its bandwidth range of 1 GHz and the availability of a return channel for interactive TV services.

## Digital via Terrestrial

Commercially launched in the U.K. in November 1998, terrestrial communications, or DTT as it is commonly called, can also be used to broadcast a range of digital services.

Elements of a terrestrial communications network include:

1. **Transmission medium**—Services are normally provided via the ultra high frequency band (UHF). The frequencies in this band range from 300 MHz up to 3 GHz. Standard 8 MHz channels are used and shared with analog transmissions.
2. **Modulation scheme**—DTT uses the COFDM modulation scheme. The main purpose of COFDM is to make the terrestrial signal immune to multipath reflections. In other words, the signal needs to be robust enough to traverse geographical areas that include mountains, trees, and large buildings.
3. **Transmission infrastructure**—Uses an existing network of broadcast stations and transmitters.
4. **Customer's premises equipment**—With a modern aerial, there should be no need to replace it to receive the DTT service. If the aerial is a very old one, the viewer would certainly benefit from updating. Additionally, DTT

necessitates the purchase of a new digital set-top box to receive and decode the digital signal.

### Digital via Direct Broadcast Satellite (DBS)

Digital television is also available through direct broadcast satellite (DBS), which can provide higher bandwidth than terrestrial, MMDS, or cable transmission.

Direct Broadcast Satellite (DBS) is a service whereby you receive subscription television from a single high-powered satellite. This satellite is typically located about 22,000 miles above the surface of the earth. At the moment, when you subscribe to an analog service you receive a state-of-the-art mini-dish that is maintained and owned by the local distributor, along with a decoder for your television set that unscrambles the signals received from the satellite. This year, consumers will be able to receive digital satellite service by installing a new and smaller digital satellite dish and buying a new digital satellite set-top box. Digital via DBS brings consumers more channels to choose from, new features, and new services.

### Network Management

As you can see the broadcasting center is made up of many complex components. As these components handle more and more services, network problems must be quickly detected and resolved. To maximize system uptime and monitor the services delivered to customers, a network monitoring and control system is installed at the broadcasting center. The main goal of such a system is to minimize service interruptions to digital TV customers. Features of a typical head-end control system include:

- monitoring the availability of devices,
- gathering statistics,
- reporting alarms and problems to support personnel, and
- remote diagnostics.

The systems available at present are vendor-specific and will run on either Windows NT or UNIX platforms.

## SUMMARY . . . . .

Digital television brings about many challenges, but with those challenges come a lot of opportunities. Advances in technology over the past few years have meant that the

possibility of delivering digital television services to billions of people around the globe has moved from the realms of fantasy into reality.

Digital TV offers a potential mechanism through which every home, school, business, and community center in the world could be included in the information society.

It opens up a new world of opportunity for companies to develop and utilize their existing network infrastructures. This includes broadcasters; cable and satellite companies; the creative community in television and film; Internet content providers; web site producers; and new, innovative companies that will form around the future of digital TV. The broadcast of digital TV and multimedia data works well because of the agreements and partnerships forged by a number of organizations around the world. A complete digital broadcasting system is comprised of a number of building blocks including the compression, encoding, and modulation-system, a CA system for security purposes; network transmission media to deliver the digital services; and, finally, a network management system to detect and resolve problems.