2 Digital Video Broadcasting Technology

2.1 Introduction

Television (**TV**) has undergone a lot of important milestones throughout the years of its evolution starting with a primitive mechanical television (1884) through electronic analog (black and white, color) televisions to digital television (in standard and high definition resolutions). Digital television provides a new way of video distribution and broadcasting. It is a new media that offers a lot of innovations with a new operation model. The advent of digital television significantly contributes to a convergence of computers, television and Internet. Benefits for customers are noticeable: a treat from a picture in high definition resolutions, audio in **CD** (*Compact Disc*) quality, hundreds of TV channels and plumbless access to a wide range of new services. These digital technologies allow various companies, operators, providers and distributors to offer a variety of useful and profitable services such as a high data rate Internet access, offline as well as online games, video on demand, video and audio (songs) streaming, electronic newspapers and others.

+ Digital television utilizes a big advantage it offers a high speed data transmission enabling it to provide a rich multimedia content. In comparison to analog television one analog TV channel can carry a group of digital TV channels including radio and data channels. How is it possible? Thanks to digital video compression techniques and modulations.

In order to allow digital television come into being cooperation among a several companies was required. Some of the best-known companies are: the *European Telecommunications Standards Institute* (**ETSI**), *Digital Video Broadcasting* (**DVB**) consortium (project), the *Advanced Television Systems Committee* (**ATSC**) and other.

Digital video broadcasting project originated in years 1991 to 1993 and grouped about 80 members. Currently, about 300 organizations and companies form this project (consortium) in more than 30 countries. Project member portfolio covers electronic device producers, network operators, broadcasters, software companies and regulatory bodies [18].

2.2 DVB Services

From the end user point of view every new technology is interesting when it offers a lot of new more quality services in comparison with existing technologies. DVB technology is not more the passive medium. It enhances an analog TV technology by a picture quality, data services and interactivity.

The DVB technology provides three basic (core) services:

- video broadcasting (television in standard or high definition resolutions),
- audio broadcasting,
- data broadcasting.

However, except a TV program distribution the DVB technology also allows to distribute to users varied data services. These services can be divided into two groups: interactive and pseudo-interactive. In case of pseudo-interactive (or one-way interactive) services data for such services are transmitted via transmission channels along with TV channels and after decoding they are stored in a memory of the end user device (set-top-box). The user has options to select and browse information in a memory. In case of interactive (fully or two way interactive) services a return channel is used by the user to choose and control data services provided by operator. The return channel is realized by a separate transmission medium.

Among classic pseudo-interactive services we can include:

- electronic news (news agencies, text and graphical information),
- webcasting (data service providing information from selected Internet sites; usually public interest information),
- weather forecasts,
- information from reservation systems (hotels, time-tables, city public transport, etc.) without options of an active access,
- information from betting systems,
- software and games distribution,
- exchange information systems (stock, commodity and option exchanges, financial inter-bank markets, etc.),
- auction systems,
- advertisement information,
- distance learning and trainings.

The interactive services cover:

- Internet access,
- interactive distance learning,
- electronic business, interactive advertisements,
- reservation systems with active access (control),
- video-services (video on demand, video rental services),
- games,
- electronic banking,
- betting, quizzes, contests, voting.

2.3 DVB Standards

DVB represents a set of open standards maintained by DVB Project (consortium) covering broadcasting of digital video or in general digital TV.

These standards are published by a *Joint Technical Committee* (**JTC**) of standardization organizations ETSI, **CENELEC** (*European Committee for Electrotechnical Standardization*) and **EBU** (*European Broadcasting Union*). Therefore, they are internationally accepted. DVB was first adopted in Europe (United Kingdom).

Currently, except Europe DVB is also used in Australia, Asian, African and American countries. In addition to DVB, there are other standards for digital television, such as **ATSC** (*Advanced Television Systems Committee*) employed e.g. in Canada, US or Mexico or **ISDB** (*Integrated Services Digital Broadcasting*) implemented in Japan [18].

DVB standards cover all aspects related to broadcasting and processing of digital video and audio at a physical and data link layer of a communication model. In details, these standards define modulations and forward error coding, multiplexing of several services into one transport stream, interfaces, etc. A lot of these aspects closely relate to transmission media used for broadcasting (terrestrial, satellite or cable). Some of standards that can be found within DVB are as follows [19]:

- DVB-S – broadcasting digital TV via satellite (S)
- DVB-S2 (satellite 2nd generation) – broadcasting high definition TV via satellite
- DVB-SH – broadcasting IP based media to handhelds (mobile, PDA) via satellite
- DVB-T – broadcasting digital TV via terrestrial (T) environment
- DVB-T2 (terrestrial 2nd generation) – broadcasting high definition TV via terrestrial
- DVB-C – broadcasting digital TV via cable (C) systems
- DVB-RCS/RCT/RCC – return (interaction) channel via satellite/terrestrial/cable
- DVB-H – broadcasting digital TV to handhelds (H) via terrestrial
- DVB-MC/MS – broadcasting digital TV via microwave systems
- DVB-Data – transmission of high speed data services
- DVB-SI – defines a *service information* (**SI**), i.e. data structures (so called metadata)

- DVB-CSA – defines a *common scrambling algorithm* (**CSA**)
- DVB-CI – defines a *common interface* (**CI**) between a removable conditional access module and receiver
- DVB-NIP – defines *Network Independent Protocol*s (**NIP**) to support interactive services
- DVB-MHP – definition of a java-based *Multimedia Home Platform* (**MHP**) for development of end user applications

There are also other DVB standards not mentioned in the list above covering a subtitling, measurement, multiplexing, 3D-TV, IPTV, source coding, etc. but most of them are out of scope of this chapter.

2.4 DVB System

DVB-S, DVB-T and DVB-C are best known as well as most used technologies for accessing the digital content. As was already mentioned, those standards define the physical and data link layer of an entire distribution system. All multimedia content is grouped and transmitted through MPEG *transport stream*s (**TS**).

If we talk about the multimedia content namely its video and audio content it is good to realize that source video and audio signals are analog signals and they have to be converted into a digital form (analog-to-digital converter) to utilize benefits of a digitization. However, the analog video signal that needs a bandwidth of 5 MHz in case of a standard European 625-line TV signal with 720 pixels per line amounts to 414,720 (576 x 720) pixels per picture (frame). After digitization a black and white video signal (with 25 pictures per second) would require a rate of about 83 Mbps (or about 250 Mbps for color video). Those bit rates are too high and almost inapplicable in real communications (e.g. over satellite). Fortunately, video signals as well as audio signals contain a lot of redundant information that can be removed via suitable compression technique.

Using the compression the original rate can be decreased (based on quality and resolutions) to several Mbit/s. For this purpose the *Moving Pictures Experts Group* (**MPEG**) was formed with a task to develop efficient compression techniques for a work with moving clips in computers and their transport between computers or other devices. DVB technology adopted an MPEG-2 compression standard [20]. It supports several video qualities and resolutions as well as it provides high flexibility.

As was already said above DVB is set of standards covering not only video/audio compressing but all functions of an entire DVB system for digital video delivery to end users or other providers. Such DVB system has to multiplex all input streams (video, audio, data signals) into one final transport stream and send it via given transmission medium in a proper form. Next parts of this chapter will deal more with this stream processing.

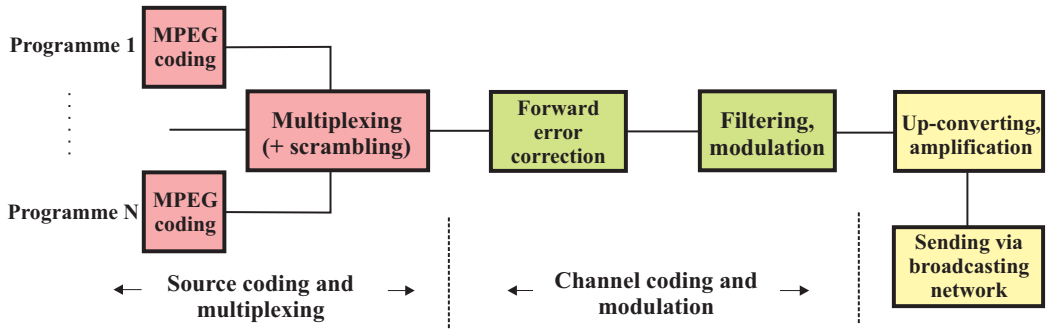
2.5 DVB System - MPEG-2 systems layer

MPEG-2 systems layer defines how various elementary streams representing one or multiple programmes are multiplexed together. The elementary streams can carry video, audio, data, and other information. This multiplexing process creates a single (multi-programme transport) data stream that can be stored or transmitted via a physical medium. In general, the MPEG-2 systems layer performs more functions:

- multiplexing,
- packetization,
- timing and synchronization,
- conditional access.

First two functions are described below the characterization of other two can be found in [22]. In this chapter we use a term “programme”. It has a lot of meanings but we will think of it as a single broadcasting service or channel.

Figure below shows a block diagram illustrating all main operations that have to be done at a transmitter side to broadcast a digital content to users [20]. At first all programmes have to be encoded and multiplexed. The resulting transport stream is equipped by error protecting codes and modulated to a carrier. At a last phase the signal is amplified and sent to the transmission medium.



Main operations performed at transmitter side

2.6 DVB System - Elementary streams

The elementary streams can carry the MPEG-2 compressed video and audio, data, timing and system information, conditional access information and other programme related data. They represent components of the programme.

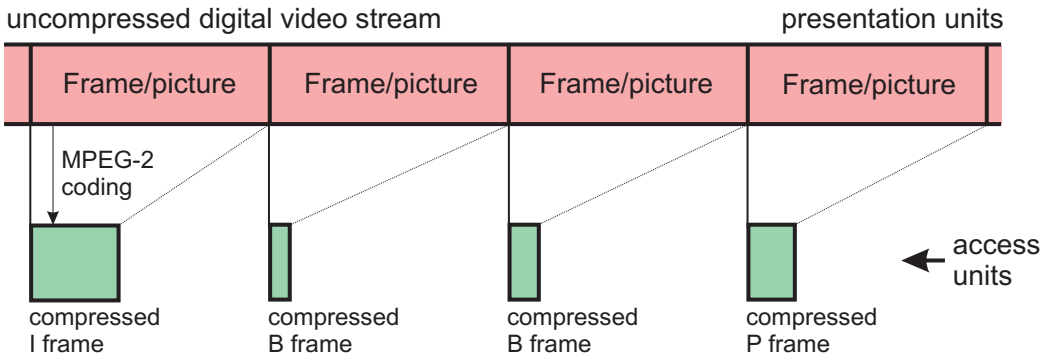
The simplest type of a programme is a radio service that consists of a single elementary audio stream. On the other hand a classical television service consists of three elementary streams: one stream carries coded video, second stream carries coded stereo audio and third contains teletext.

However, there is no problem to offer a television service containing one stream with video in the standard definition, one stream with high definition video, a several audio streams in different languages and even more streams for teletext in different languages [21].

Let's consider an uncompressed digital video stream that consists of a sequence of frames. Each frame (e.g. 830 kB for 625 lines) representing an uncompressed video picture is called a presentation unit. MPEG-2 coder encodes and compresses every presentation unit making an access unit. The access units as can be seen in Figure below are not of the same size. Their size depends on original picture complexity and a type of each frame whether it is an I, P or B frame [20]:

- I (Intra) frames/pictures are coded in similar way like JPEG pictures without any reference to other video pictures. They contain all information needed to reconstruct original pictures.
- P (Predicted) picture is coded in reference to a preceding (I or P) picture. This picture only carries information about a change (motion) between preceding and actual picture.
- B (Bi-directional) picture is similar to the P picture but it is also coded in reference to a picture which follows.

An output of the MPEG-2 coder is a sequence of the access units and this sequence constitutes the elementary video stream. In the similar way an uncompressed audio stream of audio presentation units is encoded by the MPEG coder to a sequence of audio access units forming so the audio elementary stream.



Principle of video sequence coding