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MODERN TV STANDARDS

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Explanatory Notes

Definition

Interesting

Note

Example

Summary

Advantage

Disadvantage

ANNOTATION

This module provides short overview of analog and digital TV concepts. At present, the evolution trends in the area of TV broadcasting are focused on new integration of the broadcasting and IP ICT infrastructures. The main intention of this learning module is to provide an overview of the Digital Video Broadcasting (DVB) standards, as well as Hybrid Broadcast Broadband Television (HbbTV) standards.

OBJECTIVES

Main objective of this course is to acquire basic knowledge in the area of digital television and digital video broadcasting systems (DVB TV), concept of the Hybrid Broadcast Broadband Television (HbbTV), but mainly the knowledge in the field of the DVB TV and HbbTV standards.

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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 televisions to digital television. Origins of the mechanical television can be found when a Nipkow disc was invented and patented. This mechanical disc was spinning and via small holes the images were scanned and on the other end displayed on a small screen. There were also commercial home TV sets (Octagon, Baird models) but this primitive television was only interested for “curious” customers.

The electronic television was able to evolve when a *cathode-ray tube* (**CRT**) was developed [1]. It utilizes an electron beam that creates image on a fluorescent surface of screen (line by line). First electronic television was analog and black and white and in the 1950s color television started to appear. A significant boom in a television production happened after Second World War in the United States when number of households with TV sets dramatically increased. For analog (or analogue) television three encoding systems have been developed – NTSC, PAL and SECAM. European countries adopted PAL/SECAM systems. Broadcasters have been distributing the analog television via a set of channels within very high and ultra-high frequency bands - one television channel per one carrier (channel) frequency.

In 1980s it was possible to broadcast analog video with digital audio signals but a conversion from analog to digital television required efficient coding algorithms and high performance processors. With invention of MPEG compression algorithms in the beginning of the 1990s digital television gained an open highway for its realization and standardization. Currently, digital television is broadcasted via cable, air and satellite in standard and high definition resolutions. Rapid progress in information and communication technologies changed ordinary TV sets to smart TVs which are equipped by the broadband connection. This capability brings end users a lot of other applications as well as access to IPTV services [2].

Actual efforts are focused on a development of hybrid digital television. In 2009 **HbbTV** (*Hybrid Broadcast Broadband TV*) consortium came into being with the main objective to combine broadcast, broadband and IPTV services to deliver entertainment to users via their end devices (TVs, set-top-boxes).

Fig. 1 - Evolution of TV sets

2 Analog and digital TV, concept and comparison

Analog television (**ATV**) transmits an analog signal whose amplitude values vary over a continuous interval. This signal carries the audio signal (sound), video signal (information about picture brightness and color) and synchronization information (horizontal, vertical). The audio signal is modulated using frequency modulation and the video signal is transmitted using amplitude modulation both on one channel frequency, i.e. one TV station occupies entire capacity of one channel frequency.

Analog nature of transmitted signal causes that analog television typically provides lower quality of picture. The analog signal is a subject of interferences and noises during transmission (physical principles of signal propagation, reflections, weather) resulting in ghosts and snow (noise, graininess) in final picture. With increasing a distance between user's antenna and transmitter the analog signal lowers its intensity and it cannot be completely regenerated.

Digital television (**DTV**) transmits digital signal. Because source video and audio signals are analog signals they have to be digitized at first, i.e. converted to streams of 0s and 1s. As is mentioned in following section digitized signals have to be compressed and then combined to form a transport signal (stream) that is adjusted for broadcasting finally.

DTV signals are protected by error correction codes which enable to regenerate original signal and eliminate noise and interferences [1]. Therefore users can watch TV channels (picture and sound) in same quality how they were broadcasted (no ghosts). This technology provides users with picture in standard (SD) as well as *high definition* (**HD**) resolutions and sound in **CD** (*Compact Disc*) quality. Digital television can use capacity of one frequency channel more effectively. Compression (and multiplexing) algorithms allow operators to insert more TV (as well as radio) stations within the same capacity previously occupied by one analog TV station. Digital television offers a lot of innovations with a new operation model which significantly contributes to a convergence of computers, television and Internet. Benefits for customers are noticeable hundreds of TV channels and access to a wide range of new services.

DTV and ATV can use the same medium for broadcasting (cable, air, and satellite). They share the same frequency band but not the same frequencies at the same time. DTV is not backward compatible with ATV. Users have to buy a new digital *set-top-box* (**STB**) [3]. Fig 2 shows how picture quality behaves based on signal strength. Simply said, digital picture is either in perfect quality or there is no picture. There is long interval when digital picture remains in perfect quality whereas analog TV picture is gradually becoming more grainy and/or with ghosts.

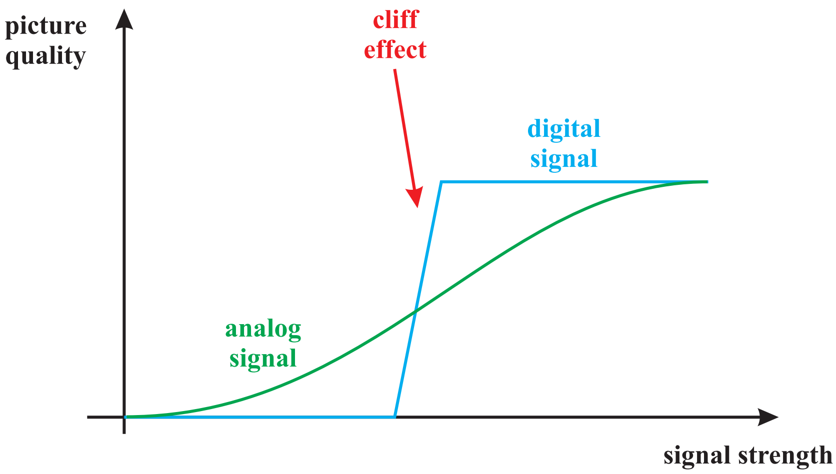

Fig. 2 - Digital television – how picture quality depends on signal strength

3 MPEG standards overview and basic specifications

As was already mentioned digital television broadcasts digital signal but multimedia content i.e. video and audio signals come from their sources as analog signals and they have to be converted into a digital form (analog-to-digital converter).

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 systems (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 techniques. Using a compression the original rate can be decreased (based on quality and resolutions) to several Mbps.

Redundant information represents (for example) information that can be predicted and it is not necessary to transmit it because the receiver (decoder) is able to add it. Compression techniques also rely on limitations related to human perception of acoustical and visual information. Audio signals contain some information that is not heard by human ears and can be removed. Video signal contains a lot of information that is repeating in consecutive frames and based on this principle suitable algorithms can decrease an amount of data transferred from the transmitter to the receiver.

For compression of digital stills the JPEG format was developed that is using discrete cosine transform. In case of moving pictures the *Moving Pictures Experts Group* (**MPEG**) was formed with a task to develop efficient compression techniques for a work with video clips in computers and their transport between computers or other devices.

DVB technology adopted MPEG compression standards [2].

The first standard defined by this group was MPEG-1. This standard provides medium quality video at low constant bit rates up to 1.5 Mbps for interactive systems with video storage on CD-ROMs. It also became very popular for video clips distribution over Internet. However, MPEG-1 was not capable to replace analog television. Based on MPEG-1 principle the new MPEG-2 standard was developed. MPEG-2 definition was influenced by a need for encoding standard television and its distribution via terrestrial, cable and satellite systems.

MPEG-2 standard is optimized for broadcasting and also for higher bit rates (2 Mbps and more) based on final video quality and resolution. It is also suitable for movie storage on e.g. DVDs. MPEG-2 standard is compatible with MPEG-1, i.e. MPEG-2 decoder can decode all MPEG-1 encoded elementary streams [2].

MPEG-4 standard published in 1998 offers coding of audio-visual objects.

It contains more complex algorithms which allow this standard to provide users with video at same quality but lower bit rates than MPEG-2. MPEG-4 supports wide range of bit rates and can be used for low bit rate Internet (IP) TV as well as high definition resolutions TV distribution. ITU standardized this standard as H.264.

The MPEG-2 standard (just as MPEG-1) defines three main parts:

- MPEG-2 system (part 1) that specifies how final MPEG-2 stream is produced,
- MPEG-2 video (part 2) that specifies how elementary video streams are encoded,
- MPEG-2 audio (part 3) that specifies how elementary audio streams are encoded.

MPEG-2 video coder takes uncompressed video frames and encodes them whereby fixed sized frames are converted (compressed) to frames (access units, Fig. 3) of variable size. Their size depends on original picture complexity and a type of each frame whether it is an I, P or B frame [2]:

- 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 but provide lowest compression rates.
- P (Predicted) picture is coded in reference to a proceeding (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 that's why they are coded by bidirectional interpolation. The B pictures provide the highest compression rates.

The MPEG video coder produces sequences of I, P, B pictures forming them in *groups of pictures* (**GOP**). Each GOP starts with an I picture followed by P and/or B pictures (Fig. 4). Presence and number of P and B pictures in one GOP influence the final compression rate, coding delay, ability to edit it and propagation of errors.

The MPEG-1 audio part defines three audio layers: the Layer I (most used on Philips' digital audio cassettes), Layer II (more effective coder for fixed bit rates from 32 to 192 kbps pre channel), Layer III (popular as MP3 format). The MPEG-2 enhances these audio coders by coding of more than two audio channels (up to 5.1 multichannel) as well as by other audio coders (MPEG-2 AAC).

With new *ultra high definition* resolutions (**UHD**, 4K as 3840x2160 and 8K as 7680x4320) new demand for efficient video codecs appeared. H.264/MPEG-4 AVC codec was enhanced to support these resolutions and new video compression standard was developed and standardized in 2013 as H.265/MPEG-H called as *High*

Efficiency Video Coding (**HEVC**) standard. In comparison with its predecessor HEVC should double compression rate at the same level of video quality.

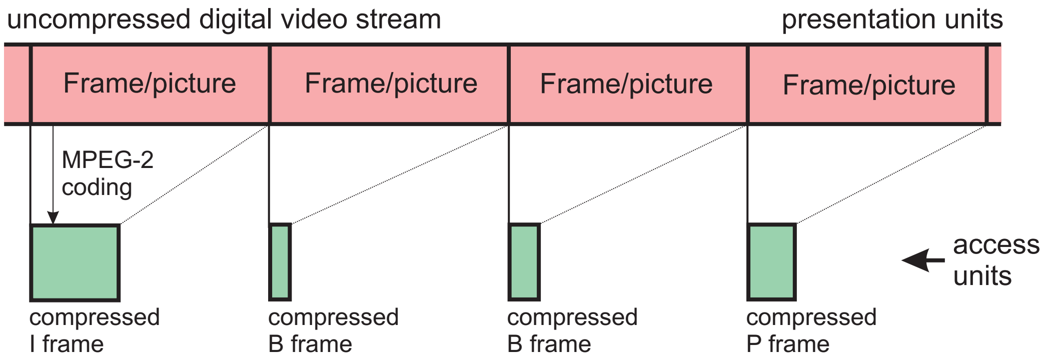

Fig. 3 - Coding by MPEG-2 coder

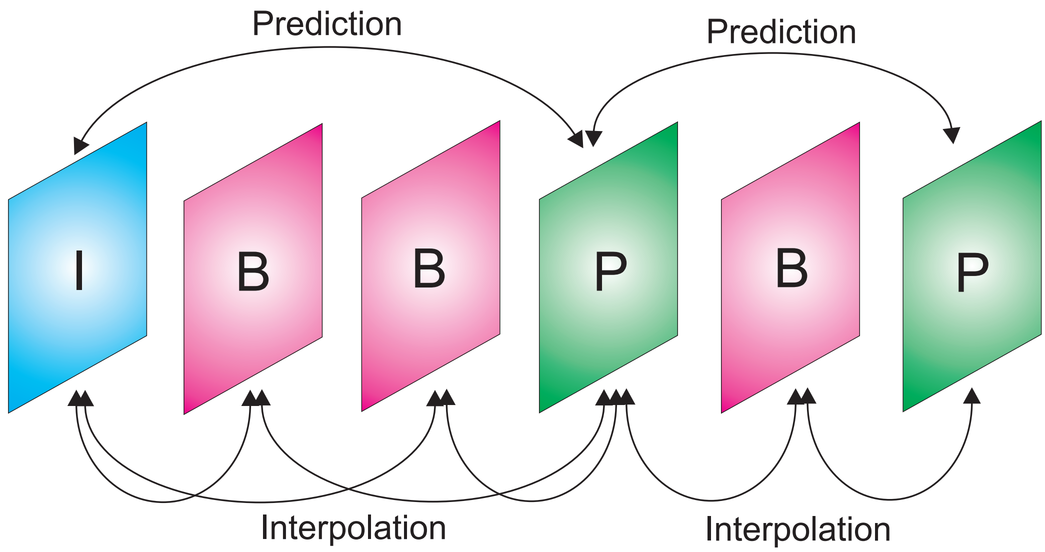

Fig. 4 - Group of picture for MPEG video encoder

4 Digital television broadcast standards

During evolution of digital television a several broadcasting standards have been developed and deployed in the world (Fig. 5). Most of these standards adopted the MPEG multiplexing principle (MPEG-TS, MPEG transport stream) and MPEG-2 video codec. However, difference lies in that how they process a transport stream behind the MPEG multiplexer and as well as in video and audio formats they use before encoding. We can distinguish following digital television broadcasting standards [4]:

- *Digital Video Broadcasting* (**DVB**) - DVB represents a set of open standards maintained by DVB Project (consortium) covering broadcasting of digital TV and published by a Joint Technical Committee (JTC) of standardization organizations ETSI, **CENELEC** (*European Committee for Electrotechnical Standardization*) and **EBU** (*European Broadcasting Union*). It uses **OFDM** (*Orthogonal Frequency-Division Multiplexing*) modulation. DVB was first adopted in Europe and later implemented in Asia, Africa and Australia.

- *Advanced Television System Committee* (**ATSC**) – ATSC standards have been applied in North America and South Korea and allow broadcasting digital television via cable, air and satellite in SD and HD quality. Dolby Digital AC-3 is used for audio coding and MPEG-2 or ITU-T H.264 (MPEG-4) for video coding. Transport streams are modulated by **8VSB** (*eight-level vestigial sideband*) terrestrially and by 16VSB or 256-QAM over cable. Instead of ATSC satellite TV broadcasting, the U.S. and Canada uses either DVB-S or proprietary systems to deliver digital TV via satellite.

- *Integrated Services Digital Broadcasting* (**ISDB**) – ISDB standards adopted in Japan, Philippines, Sri Lanka and countries in South America also offer cable, terrestrial and satellite as well as mobile digital television and digital radio. They all are also based on MPEG-2 or MPEG-4 standards. Depending on transmission media they use PSK (satellite) or COFDM with PSK/QAM (terrestrial) modulation.

- *Digital Terrestrial Multimedia Broadcasting* (**DTMB**) – DTMB is a merger of various Chinese multimedia standards with objective to provide digital TV to fixed and mobile users in China, Hong Kong and Macau. Standard applies enhanced methods for synchronization, error correction and transmission (modified OFDM).

- *Digital Multimedia Broadcasting* (**DMB**) – DMB technology represents a digital radio transmission system that allows broadcasting multimedia content (TV, radio, data) to mobile devices. It was developed in South Korea.

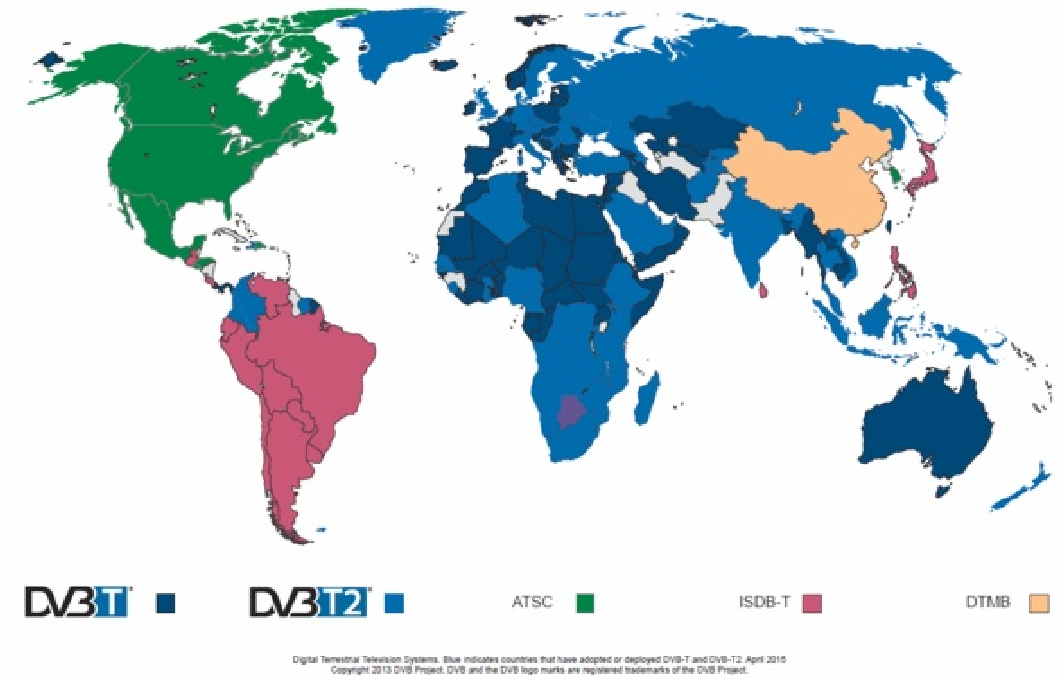

Fig. 5 - Deployment of digital television standards in the world

5 DVB standards

DVB is set of standards covering not only video/audio compressing but all functions relating to 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. As was already mentioned, MPEG-2 systems layer (part 1) 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.

E=m·c²

In general, the MPEG-2 systems layer performs multiplexing, packetization, timing and synchronization, conditional access.

Fig. 6 shows a block diagram illustrating all main operations that have to be done at a DVB transmitter side to broadcast a digital content to users [5]. At first all programmes have to be encoded and multiplexed along with information such as time stamps, tables and other supporting data (e.g. teletext). 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 via the transmission medium.

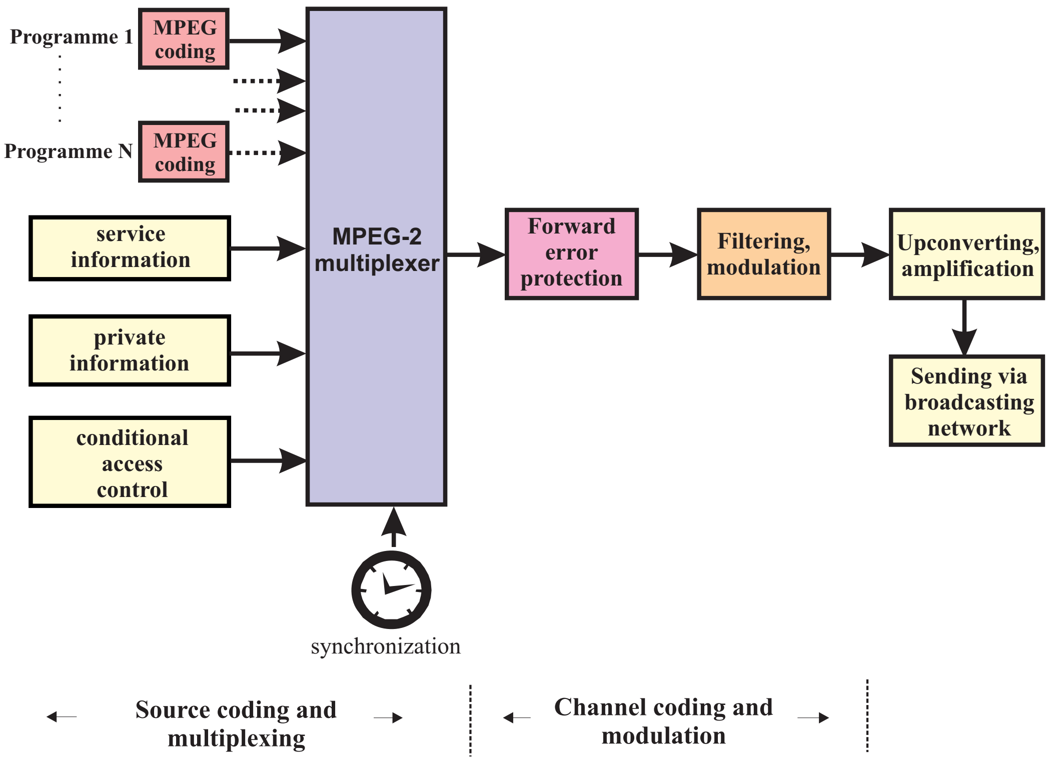

Fig. 6 - Block diagram of DVB transmitter

DVB standards [6] cover broadcasting TV via cable (DVB-C, DVB-C2), satellite (DVB-S, DVB-S2, DVB-S2X, DVB-SH) and terrestrial transmissions (DVB-T, DVB-T2, DVB-H), return channel (DVB-RCS/RCT/RCC), microwave broadcasting (DVB-MC/MS), transmission of high speed data services (DVB-Data). They also define service information (DVB-SI), common scrambling algorithm (DVB-CSA), common interface (DVB-CI), network independent protocols, java-based multimedia home platform (DVB-MHP) as well as a subtitling, measurement, multiplexing, 3D-TV, IPTV, source coding, etc.

Next subsections deal with actual DVB standards defining methods and algorithms at data link and physical layer of the communication model for TV broadcasting to fixed and mobile end user devices. They use the same multiplexing process to produce DVB transport stream but differ in a way how this stream is adjusted for broadcasting via given medium.

5.1 Digital video broadcasting - terrestrial

The DVB-T service was firstly implemented in United Kingdom in 1998. So far, DVB-T was deployed in more than 70 countries and the same number of countries decided for DVB-T2 which is able to broadcast standard, high, ultra-high definition and mobile TV and radio.

DVB-T/T2 services are aired terrestrially within the *ultra-high frequency* (**UHF**) band covering frequencies in a range from 300 MHz to 3 GHz [1]. They share the same band with analog TV therefore its deployment is dependent on releasing of frequencies occupied by analog television channels. An 8 MHz channel carrying single analog TV channel can carry within DVB-T several digital TV and radio channels with other information.

DVB-T technology can reuse the same infrastructure used by analog terrestrial television (the existing broadcasters and transmitters).

At the receiving side users have to buy a new end receiver that can be in the form of a standalone device (set-to-box) or as an integrated receiver decoder (IRD) in TV set.

Table 1 compares DVB-T with DVB-T2 [7].

New error correction codes: **LDPC** (*Low Density Parity Check*) combined with **BCH** (*Bose-Chaudhuri-Hocquengham*) enable DVB-T2 to transmit a very resistive signal. Both are based on **OFDM** (*orthogonal frequency division multiplex*) modulation with a large number of subcarriers (frequencies) which is very robust in a multipath propagation environment and both use bit, time and frequency interleaving. In general, DVB-T2 is very flexible because it offers a lot of modes.

OFDM places guard intervals between OFDM symbols what with a low symbol rate enable it to eliminate intersymbol interference. This principle also offers operators a possibility to create so called a single frequency network where transmitters broadcast a signal on the same frequency. DVB-T standards can incorporate a hierarchical modulation which is able to combine two separate transport streams for two different types of receivers into one DVB stream.

Table 1 Comparison of DVB-T and DVB-T2 standards

Parameters	**DVB-T**	**DVB-T2**
FEC	Convolutional & Reed Solomon Coding - 1/2, 2/3, 3/4, 5/6, 7/8	LDPC + BCH 1/2, 3/5, 2/3, 3/4, 4/5, 5/6
Modulations	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, 256QAM
Guard Interval	1/4, 1/8, 1/16, 1/32	1/4, 19/128, 1/8, 19/256, 1/16, 1/32, 1/128
Number of subcarriers	2k, 8k	1k, 2k, 4k, 8k, 16k, 32k
Bandwidth	6, 7, 8 MHz	1.7, 5, 6, 7, 8, 10 MHz
Typical data rate	24 Mbit/s	40 Mbit/s
Max. data rate (20 dB C/N)	31.7 Mbit/s (using 8 MHz)	45.5 Mbit/s (using 8 MHz)
Required C/N ratio (24 Mbit/s)	16.7 dB	10.8 dB

5.2 Digital video broadcasting - satellite

A natural ability of satellites to distribute signals to large areas of the Earth surface has been utilized for broadcasting of analog television and radio for decades. This ability mainly relates to geostationary satellites that are placed in a geostationary orbit i.e. in distance about 36000 km (over the equator).

Each geostationary satellite appears for Earth user fixed in the sky so there is no need for an antenna tracking system.

On the other hand satellite transmissions suffer from error prone satellite links therefore every signal before transmitting has to be adapted for such difficult propagation conditions.

A communication payload of satellites consists of transponders. Their function is to receive, restore, amplify, process, re-modulate and send signal back to Earth. Currently, the conventional geostationary satellite contains about 20 to 30 transponders and a single transponder can most often have a bandwidth ranging from 26 to 72 MHz (e.g. 36 MHz on the ASTRA 3A satellite). In satellite analog television a single transponder took care of one TV channel.

Applying the DVB technology a single 36 MHz satellite transponder can carry a number of TV channels (4 – 20, depending on resolution, video coding and bit rates) or radio channels (150).

Currently, the satellite systems provide DVB services all over the world. DVB-S standard came in 90s and uses MPEG-2 for video coding. In DVB-S transmitter a transport stream is equipped by an outer Reed Solomon code (with a coding rate 188/204), interleaved (resistance to block errors) and encoded by an inner convolutional code (with a coding rate from 1/2 to 7/8). Afterwards, the encoded transport stream is modulated by **QPSK** (*Quaternary Phase Shift Keying*) modulation [1].

DVB-S2 (*DVB – satellite 2nd generation*) is based on DVB-S but integrates new features and algorithms [8]. It relies on the same FEC codes as DVB-T2 (LDPC+BCH). QPSK and 8-PSK modulations are used for TV broadcasting, 16-APSK and 32-**APSK** (*Amplitude and Phase Shift Keying*) modulations for professional applications (interactive services, news gathering). In order to allow backwards compatibility with DVB-S it also can use the hierarchical modulation.

DVB-S2 also allows adaptively changing the coding and modulation (ACM) parameters to adapt signal to actual transmission conditions (frame by frame) for each particular user (interactive and point-to-point services). DVB-S2 increases the transmission efficiency by 30% (compared with DVB-S).

DVB-S2X (standardized in 2014) extends DVB-S2 specification by additional framing, coding and modulation options to increase the spectral efficiency, better support for UHD TV and future broadband interactive networks.

5.3 Digital video broadcasting - cable

First standard for digital TV distribution over the coaxial cable (DVB-C) was published in 1994 and slowly started to replace analog cable TV worldwide [1], [2]. It has found application in various networks such as larger *community antenna/access TV* networks (**CATV**), smaller *satellite master antenna TV* systems (**SMATV**, Fig. 7) as well as *hybrid fiber coax* networks (**HFC**). This standard utilizes Reed Solomon codes to encode a transport stream which carries MPEG-2 or MPEG-4 coded video among others and which afterwards is modulated by *quadrature amplitude modulation* (**QAM**).

In order for cable operators to stay competitive with other satellite and terrestrial TV operators, to use available bandwidth more efficiently and to provide more TV channels and new services to users DVB-C2 standard [9] was defined (2008).

Besides SD and HD TV broadcasting this standard can also provide users with innovative interactive (IP) services (e.g. video on demand). As with DVB-T2, DVB-C2 also implements LDPC + BCH for FEC functions as well as the OFDM modulation with modulation schemes 16- to 4096-QAM to achieve 30% increase in transmission (spectrum) efficiency.

For example, when 4096-QAM modulation is used on 8 MHz bandwidth bitrates up to 83.1 Mbit/s can be achieved.

DVB-C2 signal can be adapted (optimized) for various network conditions and requirements because it supports a lot of modes and options. It is expected that both standards (DVB-C and DVB-C2) will coexist for many years.

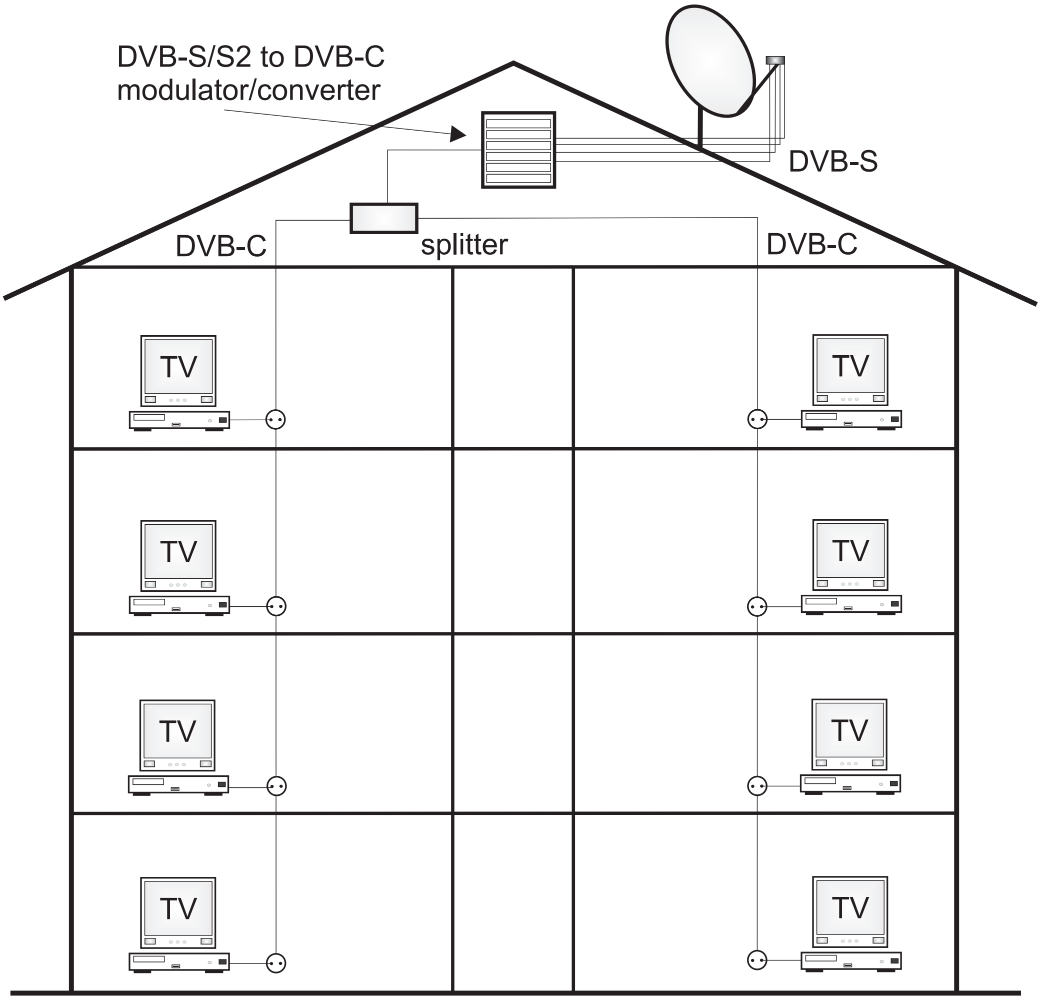

Fig. 7 - Example of DVB-S to DVB-C SMATV application

5.4 Digital video broadcasting for handhelds

DVB-T standard as a proven technology for delivery of television to fixed devices can also broadcast to mobile devices but such transmissions are not efficient because it doesn't consider limited battery life and difficult reception conditions.

That's why DVB-H was defined and published in 2004 to deliver digital television to handheld devices (mobile phones and PDAs). This standard is based on DVB-T and can share the same multiplex with it. DVB-H also supports data transmissions to handhelds thanks to multiprotocol encapsulation in MPEG-2 streams. Frequency bands assigned to DVB-H broadcasting are VHF, UHF and L (1.452-1.492 GHz). To save power in handhelds this standard uses Time Slicing. DVB-H services are transmitted in bursts and handhelds can go into sleep mode between bursts of selected service (Fig. 8).

In 2013 ETSI published new standard for **DVB-NGH** (*DVB Next Generation Handheld*) which updates and replaces DVB-H [10].

In order to deliver digital video, audio and data to handhelds DVB also defined another standard DVB-SH that represents a hybrid satellite/terrestrial system working in S band (around 2.2 GHz). DVB-SH relies on satellites providing coverage of large areas and terrestrial gap fillers covering places without signal from satellites. Satellites can use OFDM or time division multiplex for signal broadcasting. Powerful 3GPP2 Turbocode is used for FEC. Higher layer for DVB-SH (protocols, signaling, etc.) is defined by DVB-IPDC standard.

Trials and deployments of DVB standards for handhelds started from 2007 in many countries (e.g. Finland, India, Italy, US, China, South Africa) but this technology didn't succeed because of few devices available, lack of business model and new technologies such as 4G/LTE which already offers needed capacity for this kind of service.

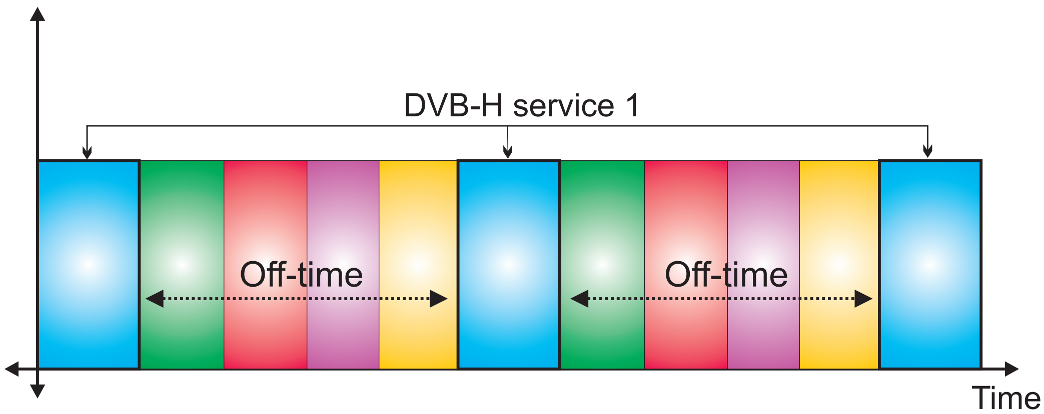

Fig. 8 - Time slicing principle

5.5 Digital video broadcasting - multimedia home platform

To provide users with interactive digital television the DVB project defined and published DVB-MHP standard [11]. Services such as games, voting, shopping and other information services are transferred (broadcasted) in DVB stream together with video and audio streams. This standard defines open software system (middleware) which enables applications developed in Java to be executed on vendor independent TV terminal. For specific group of services (voting, e-mail, shopping, etc.) this platform expect from TV terminal to be equipped by return channel which can be realized by a phone line, broadband channel (DSL) or e.g. DVB-RTC.

DVB-MHP was deployed in some countries in Europe (Italy, Belgium, Poland) as well as in Korea, Australia.

Currently, big TV producers offer smart TVs equipped by broadband interface and own platform for installation and execution of web based applications (developed in HTML), e.g. Samsung's TV have Smart Hub. Alternative solution to DVB-MHP is HbbTV which is also delivering applications to users in the DVB stream.

6 HbbTV (Hybrid Broadcast Broadband TV)

Hybrid broadcast broadband TV (**HbbTV**) is a global initiative focused on the harmonization of broadcast and broadband services and on the proposal of technical specifications how to deliver these services and applications to end users through connected TVs, set-top boxes and multiscreen devices.

The Technical Specification (TS) has been produced by *Joint Technical Committee* (**JTC**), Broadcast of the *European Broadcasting Union* (**EBU**), *Comité Européen de Normalisation ELECtrotechnique* (**CENELEC**) and the *European Telecommunications Standards Institute* (**ETSI**).

Fig. 9 depicts the HbbTV overall system architecture with a hybrid terminal [12]. The description of the HbbTV system architecture is introduced in [12] and more details can be found in [12], [13], [14], [15].

The functionalities of the hybrid terminal create conditions for its connection to both segments of the hybrid network (broadcast and broadband). In this way the hybrid terminal can receive standard broadcast A/V content, application data and application signaling information. In addition the hybrid terminal can be connected to the Internet via a broadband interface. This allows bi-directional communication with the application provider. Over this interface the terminal can receive the different types of multimedia content (e.g. A/V content streaming on demand), downloading A/V content, etc. The broadband interface can also create connection of additional screens (like smartphone, tablet, etc.) to the same local network as the hybrid terminal (Fig. 9).

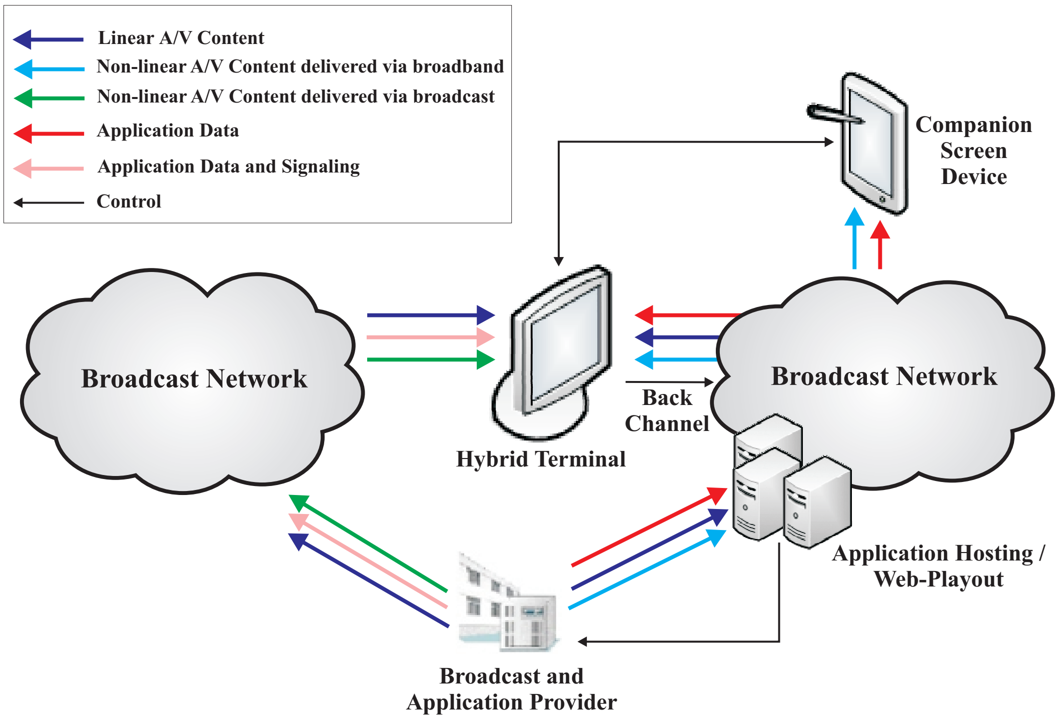

Fig. 9 - HbbTV overall system architecture

6.1 HbbTV Standards

The HbbTV *Technical Specifications* (**TS**) are developing by industry leaders to improve the video user experience for end users (consumers) by enabling innovative, interactive services over integrated broadcast and broadband networks. The elements of existing specifications from other standards including **OIPF** (*Open IPTV forum*), **CEA** (*Consumer Electronics Association*), DVB a **W3C** (*World Wide Web Consortium*) have been used in the process of the development of HbbTV TS.

ETSI TS 102 796 V1.1.1

This Technical Specification „ETSI TS 102 796 V1.1.1“ was published by Standardization Institution ETSI in July 2010.

This standardization document defines a platform for signaling, transport, and presentation of enhanced and interactive applications designed for running on hybrid terminals (DVB broadcast connection and broadband connection to the internet) [13].

The main uses of the broadcast connection are the following:

- Transmission of standard TV, radio and data services.
- Signaling of broadcast-related applications.
- Transport of broadcast-related applications and associated data.
- Synchronization of applications and TV/radio/data services.

The main uses of the broadband connection are the following:

- Carriage of On Demand content.
- Transport of broadcast-related and broadcast-independent applications and associated data.
- Exchange of information between applications and application servers.
- Discovery of broadcast-independent applications.

Applications are presented by an HTML/JavaScript browser.

Detailed description of the Technical Specification „ETSI TS 102 796 V1.1.1“ is introduced in [13].

ETSI TS 102 796 V1.2.1

The latest version 1.5 of the HbbTV specification was published by Standardization Institution ETSI in as Technical Specification „ETSI TS 102 796 V1.2.1“ in November 2012 [14].

Key additions to the HbbTV1.5 standard included:

- Access to pay-tv services with multiple DRM support using Common Encryption
- Support for HTTP adaptive streaming (based on MPEG-DASH) to dynamically optimize the picture quality/bandwidth trade-off, extending to linear content delivery (thematic and event channels, etc.)
- Access to the DVB EIT schedule table from the HbbTV application to build an enhanced 7-day Electronic Program Guide (EPG).

Detail description of the Technical Specification „ETSI TS 102 796 V1.2.1“ are introduced in [14].

ETSI TS 102 796 V1.3.1

In the end of 2012 the work on the HbbTV 2.0 was started. The requirements of the major HbbTV specification have been collected. The HbbTV 2.0 specification has been published by the HbbTV association in March 2015.

The version 2.0 of the HbbTV specification was published as Technical Specification „ETSI TS 102 796 V1.3.1“ in October 2015 [12].

Some technologies have been updated and some new features specified within this ETSI TS 102 796 V1.3.1.

Technologies updated include the following:

- The basic web standards have been updated from the HTML4, CSS2, DOM2 generation to the HTML5, CSS3, DOM3 generation.
- The profile of MPEG DASH has been updated to be based on the 2nd edition of ISO/IEC 23009-1 and includes additional features including ones added in that edition.
- An updated version of CI Plus including the possibility of a hybrid terminal using a DRM system in a CICAM instead of or in addition to one integrated into the terminal; the possibility to use the CICAM Auxiliary File System (ETSI TS 103 205, clause 9) allowing the Host to retrieve data/resources from the CICAM.

New features include support for the following:

- Video encoded in HEVC delivered via broadband.
- Delivering and presenting subtitles associated with ISOBMFF content.
- An application on the hybrid terminal launching an application on a Companion Screen Device and vice-versa.
- Communication between applications on a hybrid terminal and applications on a Companion Screen Device or a second hybrid terminal.

- Insertion of adverts into on-demand content.
- Delivering A/V content via the broadcast (not in real-time) for later presentation.
- Synchronization within a hybrid terminal between content delivered via broadband and other content delivered either via broadcast or broadband.
- Synchronization between content presented on a hybrid terminal and applications or content presented on a Companion Screen Device or a second hybrid terminal.
- Caching of DSM-CC object carousels.
- Launching of an application resident on the CICAM.

The present document defines a platform for signaling, transport and presentation of enhanced and interactive applications designed for running on hybrid terminals that include both a DVB compliant broadcast connection and a broadband connection to the internet.

The main uses of the broadcast connection are the following:

- Transmission of standard TV, radio and data services.
- Signaling of broadcast-related applications.
- Transport of broadcast-related applications and associated data.
- Transport of On Demand content for Push-services.
- Synchronization of applications and TV/radio/data services.

The main uses of the broadband connection are the following:

- Carriage of both On Demand and Live content.
- Transport of broadcast-related and broadcast-independent applications and associated data.
- Exchange of information between applications and application servers.
- Starting applications on a Companion Screen Device.
- Communicating with applications on a Companion Screen Device or a second hybrid terminal.
- Synchronizing media and applications between a hybrid terminal and a Companion Screen Device or a second hybrid terminal.

Applications are presented by an HTML/JavaScript browser.

Detail description of the Technical Specification „ETSI TS 102 796 V1.3.1“ is introduced in [12].

The transfer of existing standards of DVB, EBU, OIPF, CEA, W3C, CI+, ISO, **IEC** (*International Electrotechnical Commission*) to the actual Technical Specification ETSI TS 102 796 V1.3.1, declared as HbbTV 2.0 specification, is illustrated on Fig. 10.

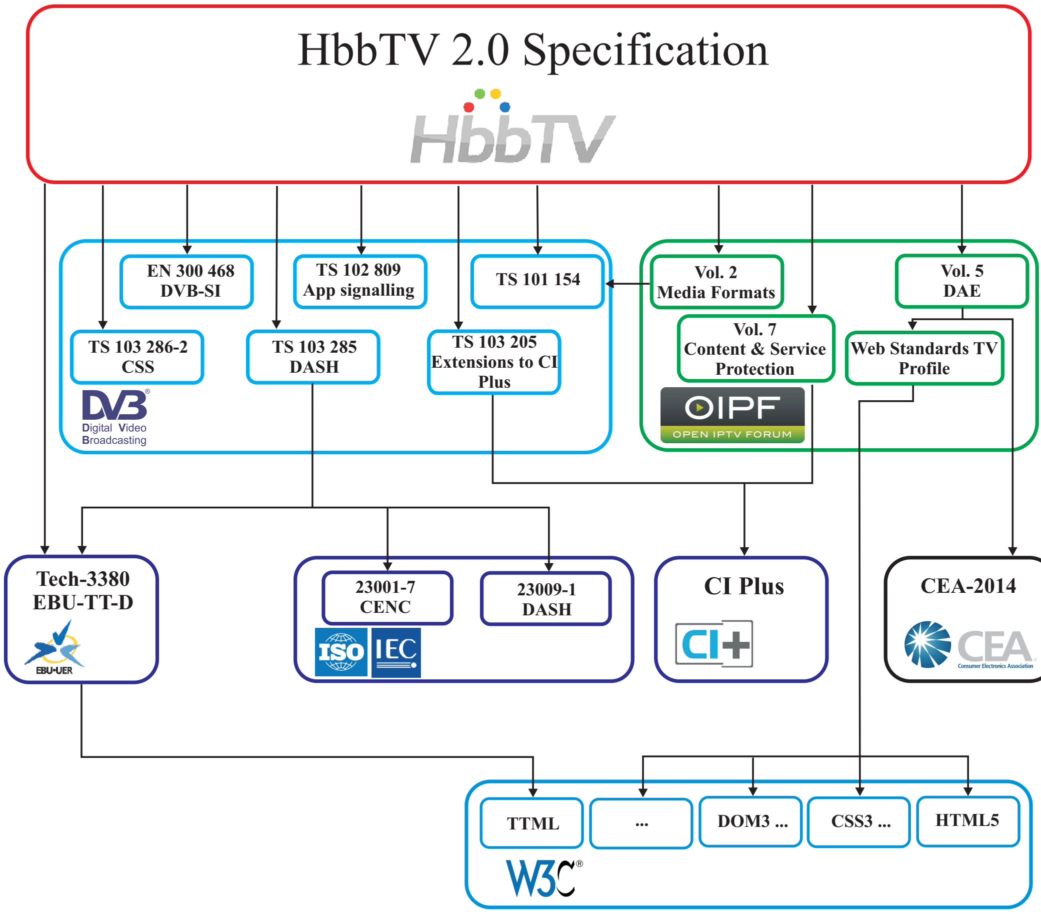

Fig. 10 - Transfer of existing standards of DVB, EBU, OIPF, CEA, W3C, CI+, ISO, IEC to the actual Technical Specification ETSI TS 102 796 V1.3.1

The penetration of the HbbTV in the Europe and over the world is illustrated on Fig. 11.

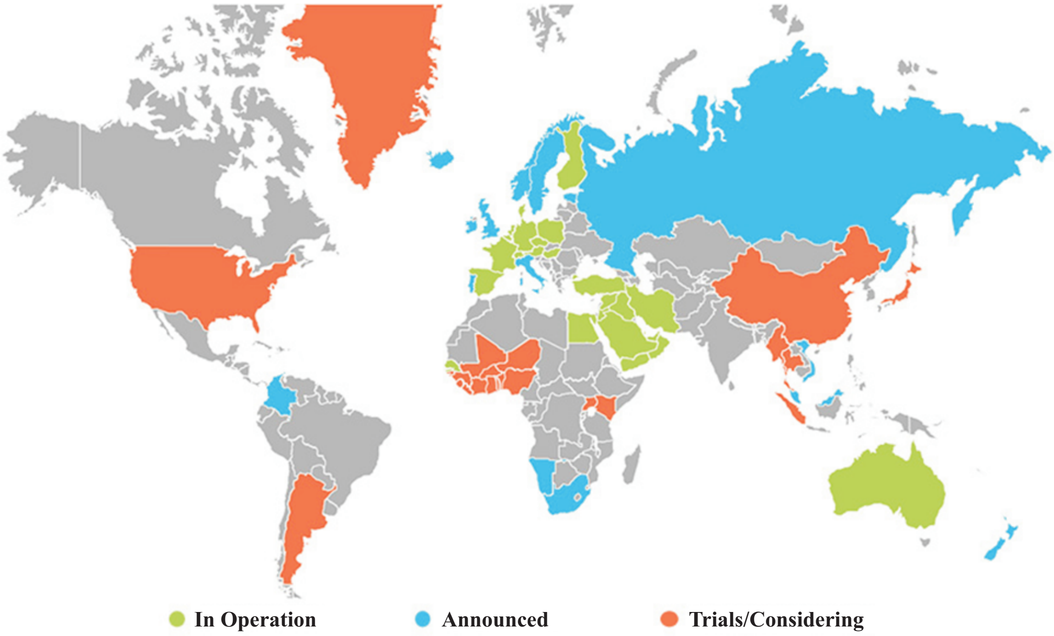

Fig. 11 - Penetration of the HbbTV over the world

6.2 HbbTV Services

The list of HbbTV services which are delivered through HbbTV infrastructure is introduced below.

- Enhanced teletext,
- Catch-up services and video-on-demand (VOD),
- Electronic program guides (EPG),
- Interactive advertising,
- Live Streaming,
- PVR – personal video recording,
- Web portals,
- Personalization,
- Voting and games,
- Social networking,
- Other multimedia applications.

The description of HbbTV services is introduced in Learning module LM12: New generation of multimedia services-applications“, [16].

7 Annex: Modern TV Standards - Internet Protocol Television

Topic Internet Protocol Television - IPTV is elaborated and provided to students and teachers within the separate Learning module LM 19 A: Modern TV Standards - Internet Protocol Television.