HDTV

Technological Insights to High-Definition Television

BITKOM

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1 Introduction

Large flat-screens have conquered private households during the past years. The majority of them are already well prepared for the reception in High Definition (HD) quality. In order to enjoy razor-sharp images to their full potential, the signal sources must deliver the required HD quality, no matter whether a TV program or a Blu-Ray Disc is concerned.

But how does the HD content travel from a broadcasting station to the receiver? This paper presents the optional digital transmission paths via terrestrial, cable, satellite, handheld or internet.

The digital transmission technologies provide interesting features for the consumer already, such as time-shifting television, video-on-demand, retrieval of key frames in the current program as well as growing interactivity in the future. However there are few programs that play the trump card of digital transmission technology - the high-resolution image.

2 What are the special Characteristics of HDTV?

High Definition Television - HDTV is a comprehensive term for a variety of television formats which present impressive, close to reality images to the consumers.

It is also an advancement of the current Standard Definition Television (SD-TV) with higher image resolution, image scanning and several image frequencies (Fig.2.1-2.3).

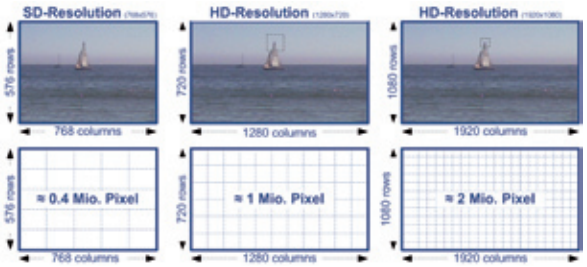

Fig.2.1: Image resolutions from SD-TV to HDTV

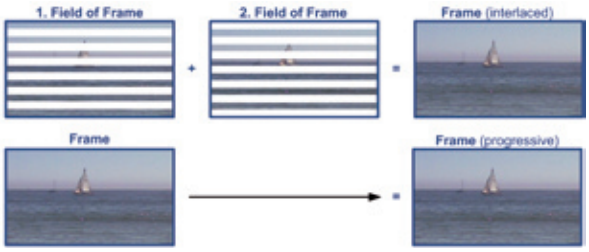

Fig.2.2: Image scanning interlaced (i) or progressive (p)

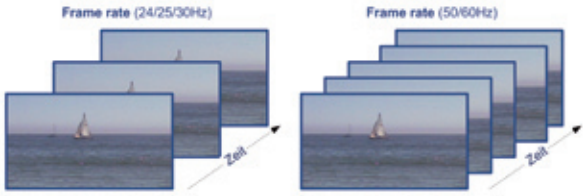

Fig. 2.3: Image frequencies in HD

With a two to fivefold higher resolution (about 2 million pixels) compared to the classical SD-TV, the consumer will enjoy the movies “sharper and more intensively” on 16:9 wide screens.

The HD formats are separated by specifications due to the number of lines (720 or 1080), progressive or interlaced (p or i) images and frequencies.

TV-Formats (Label)	Resolution (Columns x Rows)	Scanning (p or i)	Frequencies (Hz)	Committees (Standards)
720p/24	1280 x 720	progressive	24 Hz	SMPTE 296M & EBU Tech 3299
720p/25	1280 x 720	progressive	25 Hz	
720p/30	1280 x 720	progressive	30 Hz	
720p/50	1280 x 720	progressive	50 Hz	
720p/60	1280 x 720	progressive	60 Hz	
1080i/25	1920 x 1080	interlaced	25 Hz	SMPTE 274 & ITU-R BT.709
1080i/30	1920 x 1080	interlaced	30 Hz	
1080i/50	1920 x 1080	interlaced	50 Hz	
1080i/60	1920 x 1080	interlaced	60 Hz	
1080p/24	1920 x 1080	progressive	24 Hz	
1080p/25	1920 x 1080	progressive	25 Hz	
1080p/50	1920 x 1080	progressive	50 Hz	
1080p/60	1920 x 1080	progressive	60 Hz	

Tab. 2.1: Variety of HD formats

The variety of formats results among other factors from their original operational areas: film and television.

While 24Hz is used in film production, 50Hz or 60Hz is available for television. The representation in progressive frames (p) is new. Thus, the films appear completely flicker-free, although the data rate increases.

So which standard will assert itself?

The European Broadcasting Union (EBU) has tested compressed and uncompressed HDTV sequences by combining the relevant parameters (number of lines, image-scanning and image frequency).

The result is that for a good image quality the progressive representation is more advantageous than the representation by interlaced frames, and more definite than a higher number of lines.

Therefore, not only German, but also other European broadcasters have decided to broadcast in 720p/50.

However, the highest resolution possible would deliver the full format variation HD 1080p. This provides a more impressive image, wherein movements remain sharper. There are 1080p devices commercially available. Also the tools for the production are given. However, this format requires substantially more bandwidth for its broadcast.

And that is a challenge for broadcasters due to limited capacities of transmission paths - nevertheless, games consoles and blu-ray players deliver content in 1080p.

2.1. Components of HDTV Transmission

For the transmission of HDTV signals a high number of system modules work closely together (Fig.2.4).

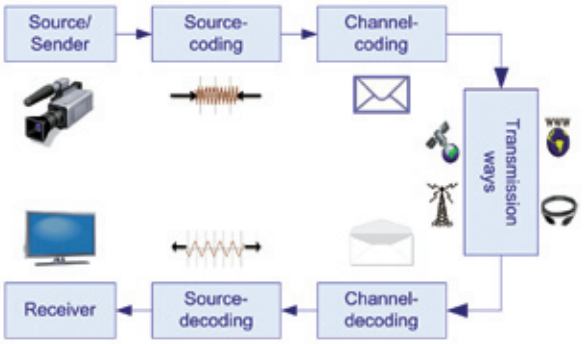

Fig. 2.4: Components of the HDTV transmission

Simplified description:

1. **Transmitter:** Film and TV studios as well as an increasing number of private users produce the HD-content with special equipment. By this, the foundation is laid for the whole transmission up until to the visual experience of the consumers.

2. **Source Coding:** The resolution-dependent large amount of data generated by the broadcasting station is supplied to a data reduction step. In the past the MPEG-2 video compression was used. A considerably higher data reduction is possible, e.g. with the new MPEG-4 AVC coding in particular for a HD channel. This reduces the required bandwidth by around 50% and thereby brings significant advantages. Following this, the formation of a transport stream takes place. The totality of all processes up to the transport stream is called source coding.

3. **Channel coding and modulation:** The signal is now adapted to the selected transmission method - satellite, cable, terrestrial or internet. Therefore a channel-specific error protection is added and the signal is modulated to the respective channel.

3. **Digital transmission paths**: Here the signal transmission takes place via satellite (DVB-S/S2), cable (DVB-C/C2), terrestrial (DVB-T/T2), handheld (DVB-H) or IP protocol (DVB-IPTV).

On the reception side, the HD content should be reproduced. Therefore the executed measures have to be inverted.

5. **Channel Decoding**: On the reception side the desired signal is selected and the error protection is removed.

6. **Source decoding**: Now the source decoding is carried out by a MPEG-2 or MPEG-4 decoder. The desired program is selected from the transport stream via demultiplexing, while the original video signal is regained by the MPEG-4- decoder.

7. **Receiver**: Finally a HD suitable receiver is used which can process the high-definition images. Besides flat-screens other devices can also be used, such as LCD or plasma television, several receivers like set-top boxes, personal computers and laptops:

   - Set-Top-Box (STB)
     The STB is a device by which a display is necessary for presenting the content.

   - Integrated Digital TV (iDTV)
     There are TV displays, where the digital receiver is already integrated.

   - PC/ Laptop/ PDA
     There is also the possibility to upgrade any PC, laptop, personal digital assistant (PDA) or a comparable device using a PC card or USB-Stick to digital television.

2.2 HD-Logos for Displays and Receiver

The European Information, Communication and CE Industry Technology Association (EICTA) has introduced special logos to mark devices suitable for HD:

Fig. 2.5: Logos for HD-ready devices

"HD-ready" for Displays

The logo describes the minimum requirements for a flat-screen, projector or integrated digital television for processing and displaying HD signals in a resolution of 720p or 1080i.

Resolution: The display must show at least 720 lines in a 16:9 format.

Video Inputs: The display accepts HD signals from the digital (DVI/HDMI incl. HDCP copy protection) or analogue interface.

HD-Formats: The display shows images in 720p (1280x720, 50/60Hz progressive) or 1080i (1920x1080, 50/60Hz interlaced).

In addition, quality marked receivers with the „TV HD" logo are necessary for the reception of television programs in HD,.

"HDTV" for Receiver

This "HDTV" logo was designed for HD suitable receivers (set top boxes, hard disk recorders or flat-screens with integrated tuner) which receive HD signals over a digital transmission path according to the technical details of the „ HD ready „ logos (720p, 1080i) and can be transferred via a compatible interface to an „HD ready" display.

Reception: A receiver must be able to process a HD signal via a digital transmission path in a suitable manner.

HD-Formats: The devices support 720p (1280x720, 50/60Hz progressive) or 1080i (1920x1080, 50/60Hz interlaced).

"HD-ready 1080p" for Displays

This logo distinguishes displays which can also present 1080p signals, e.g. by a blu-ray player or game console, in addition to 720p and 1080i.

"HDTV 1080p" for Receiver

Devices with this logo fulfil the specifications of the above mentioned "HD ready 1080p".

'Full HD 1080'

The logo has not been specified by EICTA and can thus be used in varying constellations. In general it should indicate that a display can show the highest possible resolution of 1920x1080 pixels.

Consumers can recognize whether a device fulfils minimum standards and is compatible with other HD devices using these logos. Hence, this logo initiative satisfies the consumer's need for safety and represents an important contribution to the successful take-up of of HDTV.

2.3 Organizations involved

A variety of system modules are involved in the transmission of HDTV signals (Fig.2.4). Accordingly, differing organizations are involved in the development of specifications. Two of these organizations are „MPEG" for the module sources coding and „DVB" - for the module of transmission paths.

Moving Pictures Experts Group MPEG

MPEG is a working group of the Organizations ISO and IEC, engaged in the standardization of **video compression** among other things. Resulting from this collaboration there are now a variety of standards, which make possible increasingly more efficient compression:

MPEG-2 is a standard for the data compression of video signals. It is also used in the digital television DVB of the first generation.

MPEG-4 is advancement with a very high data compression rate and thus is also interesting for HDTV. The compression ratio is around 50% higher than with the MPEG-2 standard.

Digital Video Broadcasting Project

DVB is an originally European initiative for the development and **standardization of the transmission arrangements for digital television**. Meanwhile it is a worldwide project with over 250 members from research, industry, broadcasters, service providers, network operators, associations, institutions and regulators with its headquarter in Geneva. The standards developed by DVB are the norms for digital television in Europe today.

Notation	Standard	Details
DVB S	EN300 421	Framing structure, channel coding and modulation for satellite services
DVB S2	EN 302 307	2nd Generation for broadcasting and other satellite applications
DVB C	EN 300 429	Framing structure, channel coding and modulation for cable systems
DVB C2	TM 68	2nd Generation for DVB-C
DVB T	EN 300 744	Framing structure, channel coding and modulation for digital terrestrial television
DVB T2	A 122	2nd Generation digital terrestrial television broadcasting system
DVB H	EN 302 304	Transmission system for handheld terminals
DVB IPTV	TS 102 034	Transmission of MPEG-2 TS based DVB Servides over IP-networks

Tab. 2.2: Standards of the DVB-family (www.dvb.org)

The release of the Standards specifications is the responsibility of European or global Standardization Institutes.

In connection with DVB the following organizations play a role (Tab2.3).

Organisations	Names
ITU	International Telecommunication Union
ISO	International Organisation for Standardisation
IEC	International Electrotechnical Commission
ETSI	EU Telecommunications Standards Institute
EBU	Eropean Broadcasting Union
CENELEC	Comité Européen de Normalisation Electrotechnique

Tab. 2.3: Selected standardization institutes

The International Telecommunications Union (ITU) aims to harmonize the standards for digital television. The development of these standards is implemented by the European Standardization Organization for Telecommunications (ETSI).

3 How does the HD-Content reach the Receiver?

The classical SD-TV television has three alternative transmission arrangements to transfer the "content" of a broadcasting station onto the viewers´ screens:

Terrestrial, Cable and Satellite.

Historically, the oldest transmission path is terrestrial broadcasting, i.e. the wireless radiation of content via terrestrial radio masts standing on the ground. Later on, broadcasting via cable and via satellite systems have attained and gained great significance due to the extensive program variety achievable. Also a most recent addition is the **Internet**.

Basically the HD-content can be transmitted now using all available paths. Therefore the DVB project has introduced the **Digital Video Broadcasting System (DVB)** in Europe.

This consists of a series of compatible standards for the transmission via satellite, broadband cable, terrestrial broadcasters, mobile devices and IP-based broadband networks:

Satellite	DVB-S/ DVB-S2,
Cable	DVB-C/ DVB-C2,
Terrestrial	DVB-T / DVB-T2,
Handheld (Mobile)	DVB-H und
Internet Protocol	DVB-IPTV.

The task of the DVB system is the transmission of data frequencies - economically and with the highest quality - from the broadcasting station to the receiver. The principle is shown in fig. 3.1.

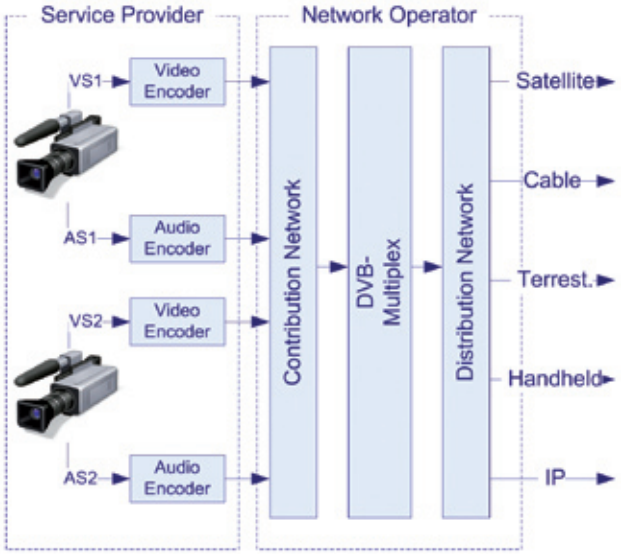

Fig. 3.1: Alternative digital transmission ways

For all DVB standards a „container" is used which transfers television signals and additional data in a transport stream simultaneously.

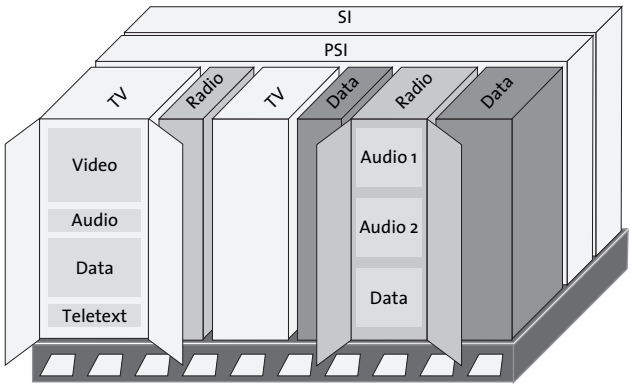

Fig. 3.2: Data in the DVB-data container (www.dvb.org)

This allows several programs to share a channel.
The program is usually based on data rates of 2-8 Mbps or up to 27 Mbps for HDTV. It is important to note that the bit rate is variable according to the content.

3.1 Digital Satellite TV

The standard published in 1993 Digital Video Broadcasting Satellite (DVB-S) describes the transmission of television and radio programs via satellite.

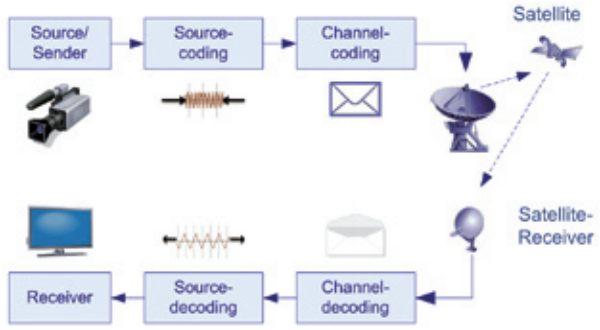

Fig. 3.3: Transmission of HDTV via Satellite

As opposed to other transmission methods, reception is possible even in remote areas with DVB-S. There are antennas which enable the reception on the move in airplanes, ships or buses by use of automatic tracking.

Market Aspects

The first digital satellite TV transmission began in 1994 in Thailand and South Africa. Since then DVB-S has become a very popular system with over 100 million receivers worldwide.

After more then ten years the DVB project has moved on to an "updated version": **DVB-S2**.

The core element is a toolbox of modern technologies for source and channel coding as well as modulation. This opens the door to a number of commercially lucrative services, also to HDTV for instance.

Technical Details

The satellite transmission is a radio communication whereby the satellite works as a combination of a mirror and an amplifier:

1. The compressed signals are provided with an error protection and then sent in the uplink-direction by the Earth station.

2. The satellite filters and amplifies the distance-attenuated and atmospherically disturbed signals, then retransmits them in the downlink direction back to Earth.
   In this context the signals are distributed on individual signal amplifiers - Transponders. Each has a specific frequency band, assigned to a range between 27MHz and 36MHz.

3. Then the reversal of the signal processing previously executed by the broadcasting station takes place at the receiver.

The number of digital programs to be transferred depends on the bit rate achievable by the channel coding and modulation. Due to the transmission circumstance by satellite, a net bit rate of about 30Mbit/s is achieved at 27MHz transponder bandwidth and 40Mbit/s at 36MHz transponder bandwidth. Under the given circumstances one can transfer up to 10 MPEG-2 transport streams, alternatively also compressed HDTV signals.

According to the desired quality requirement this number decreases or increases.

Next Step DVB-S2

DVB-S2 is an advancement of the DVB-S standards. It is characterized by higher transmission efficiency under invariant reception conditions. This has laid the foundation for HDTV.

In conjunction with compression techniques such as MPEG-4 AVC 20 to 25 television channels can be transmitted in standard-definition or 5 to 6 in high-definition quality on a 36-MHz transponder.

DVB-S2 allows the transmission of two independent transport streams on a transponder, e.g. the parallel transmission of a TV program in HDTV resolution and another in the normal SD standard.

If the availability of HD-content further increases, it could become necessary to build up additional satellite capacities.

More than 1.000 television and radio programs can be received nowadays with a single satellite system. In addition, it is also possible to retrieve internet content and other multimedia services with the satellite receiver.

3.2 Digital Cable Television

The standard published in 1994 **Digital Video Broadcasting Cable (DVB-C)** describes the transmission of television and radio programs via a cable network.

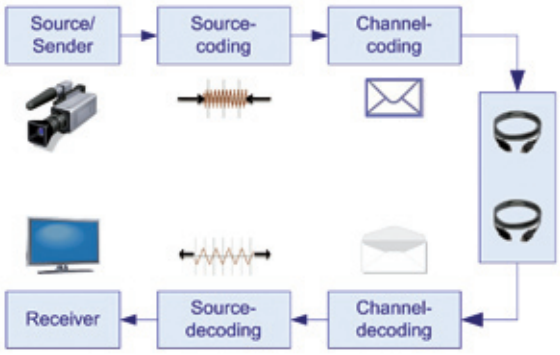

Fig. 3.4: Transmission of HDTV per Cable

The cable systems have a shield against external interferences and can hence transmit in a relatively high and constant quality. Therefore they do not need an elaborate error protection and can transmit data with a higher bit rate. This allows the transmission of HDTV.

Technical Details

For DVB-C the quadrature-amplitude modulation (QAM) was chosen as a standard modulation technology, taking these constraints into account. This technology offers the best adaptation of the signal to the existing cable TV channel.

Besides, a selection between different variants (16-QAM up to 256-QAM) is possible. In the cable TV channel a net bit rate of 38 Mbit/s is available, which corresponds approximately with the value of the satellite channel. Thereby it is quite easily possible to feed satellite channels into the cable system.

In the meantime, some cable operators have already begun to „upgrade“ their networks by a 256-QAM modulation and thus offer transmission rates of 50 Mbit/s. This is aimed at satisfying the growing consumer demand for a broader interactive and personalized service portfolio.

Thus, for example, parallel to TV radio signals can also be transmitted. These require a comparatively low bandwidth. Also interactive services and applications are possible.

The use of DVB-C currently spans from cable systems of major CATV networks (cable television) through to smaller SMATV (satellite master antenna TV).

DVB-C2

Since 2007 the specifications of DVB-C2 have been in development and will probably be finalized by the beginning of 2009. New services such as video-on-demand (VOD) and multichannel HDTV will be available then.

In this context the MPEG-4 AVC coding will be used -this requires a lower transmission bandwidth.

3.3 Digital Terrestrial Television

The standard published in 1997 - **Digital Video Broadcasting Terrestrial (DVB-T)** - describes the transmission of television programs via electromagnetic waves and their reception by a roof or indoor antenna.

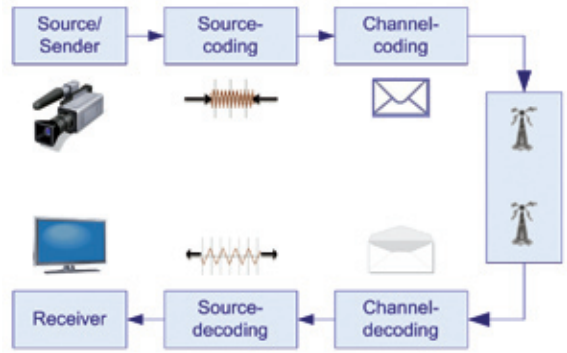

Fig. 3.5: Transmission of HDTV via Terrestrial

A DVB-T network can provide various services such as HDTV and multichannel SD-TV over set-top boxes, portable receivers or built-in PC boards.

In the age of the mobile society the stationary, portable or mobile reception with wireless devices in high quality is an important sales argument. With this, digital television and data services can be received by small mini-receivers on vacation, in a cafe or in the garden with the appropriate antennas.

Basically the radio transmission is also possible over DVB-T in a wonderful quality.

Another incentive for the consumer is the free of charge use of additional program offerings and technically possible data services, such as the fast downloading of movies in HD and music in CD quality. Therefore, DVB-T fulfils all requirements for a variety of new multimedia applications for at home and outdoors.

Market-Aspects

Since the introduction of DVB-T, more than 60 million receivers have been sold worldwide. The sources of this success are in addition to the added value of digital technology, a jointly coordinated approach by the broadcasters, network operators and device industry to building a consistent attractive program. The upgrading of networks and low-priced devices also contributed to this success.

As presented in Tab. 3.1, DVB-T has established itself in the UK, France, Germany, Spain and Italy successfully.

Country	Population (Mill.)	DVB-T Services Launch	Receivers Sold (Mill.)
UK	60	1998 (2002 Freeview)	27
France	64	2005	8 (includes rentals)
Germany	82	2002	8
Spain	45	2000	8
Italy	59	2004	6,5
Australia	21	2001	6,5
Taiwan	30	2005	2,5

Tab. 3.1: Successful DVB-T markets (www.dvb.org)

DVB-T is experiencing growing popularity. An excellent example is France, where within a period of two years following its introduction, more than eight million DVB-T receivers were sold without subsidies.

Internationally, in addition, new services are starting almost monthly. Mobile operators already offer mobile phones for example with an integrated DVB-T receiver. With this, customers can use the advantage of the excellent mobile TV reception of DVB-T networks.

Technical Details

As with all DVB standards, the signal is also compressed first in DVB-T, and then transmitted via the „container principle“. This allows the simultaneous transmission of

television signals, audio signals and additional data by a combined MPEG transport stream.

The digital terrestrial television (DVB-T) enables the transmission of about 18 to 24 television programs as well as other data on a usual channel (6 - 8MHz bandwidth) over the conventional house or indoor antenna.

With DVB-T the intensity of error protection can be varied. Through this flexibility it is possible to select the number of broadcast programs and the kind of reception, depending on whether mobile, portable or stationary should be received.

Next Step DVB-T2

In June 2008, the specification was finished for the second generation of digital terrestrial broadcasting standard **DVB-T2**. This advancement provides an increase in the available data rate per channel of about 50% - without investing in more powerful broadcasting station and also without reducing the state-of the art reception quality.

A large number of innovations have been included in the DVB-T2 specification. For instance the possibility of transmitting HDTV programs simultaneously to recipients with a roof antenna and SD-TV programs to portable and mobile receivers.

Market-Aspects

It is expected that DVB-T2 will be introduced in the UK within the next years first. For an introduction in Germany there are no detailed plans at present. After initial tests, a broad introduction could be expected in a few years time at the earliest.

Considering the technical-economic restrictions and particularly the consumer's interests, every country should think about the right point in time for an introduction. A country that is beginning with the digital transition is certainly well advised to consider DVB-T2 right from the start.

A different situation is given in countries in which DVB-T has already been introduced. A quick change over would be difficult there, because in particular new receivers would become necessary in the households.

3.4 DVB-H Broadcasting to Handhelds

The standard published in 2004 **Digital Video Broadcasting Handheld (DVB-H)** describes a system for the transmission of television programs on battery-operated mobile devices such as cell phones, PDAs, etc. DVB-H uses the same terrestrial communication technique as DVB-T and is based on it.

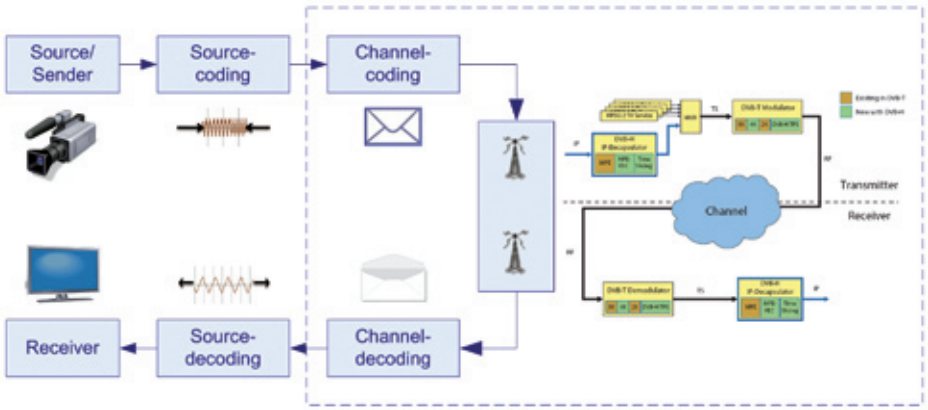

Fig. 3.6: Transmission via DVB-H (www.dvb.org)

Market-Aspects

For some time, there has been a growing interest in receiving films on small mobile devices whilst on the move. Colloquially this is called“mobile TV“.

The technology is meanwhile so far developed that appropriate power-saving devices are presently available at market-acceptable prices.

Fig. 3.7: Preferred operational areas from DVB-H / T

DVB-H is already in use in many countries like Italy, Finland, Switzerland, Austria and the Netherlands. At the same time tests are taking place in other countries. The EU commission has recently recommended DVB-H as a standard for mobile phone TV.

Technical Details

DVB-H is an extension of the DVB-T standard with an improved error protection, an integrated method to reduce the power consumption and a more efficient compression with the source coding procedure MPEG-4 AVC. The data rates and resolutions can be adapted according to the capacity of the channel network and the requirements of the end devices.

Normally 15 to 25 television programs can be transmitted via a television channel to the mobile device.

For the sake of completeness it should be noted that some mobile providers also offer the reception of TV programs in their portfolio within their UMTS offensive. However, with the increasing number of 3G users this offer represents a very heavy load for the network and can so quickly reach to the technical and operational limits.

Next Steps

Through the IP capability of DVB-H interactive services could be introduced to the medium additionally to traditional broadcasting services like television. This in turn increases the demand for bandwidth and changes the requirements of the transmission channels.

3.5 Digital Video Broadcasting Internet Protocol DVB-IPTV

DVB-IPTV is a collective term for a series of specifications (TS 102 034, 102 539, 102 824) for the transmission of television programs via an **Internet Protocol based Broadband Network (IPTV)** in a quality up to HDTV.

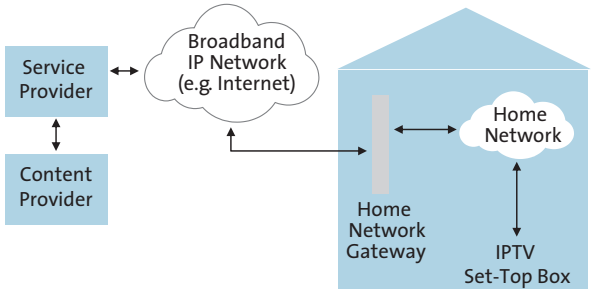

Fig. 3.8: Transmission via DVB-IPTV (www.dvb.org)

The most important advantage of IPTV is the possibility of offering interactive services through a feedback channel, in addition to television in SD and HD quality.

In this context it is obvious to think about the Internet in the form of a high-speed DSL network as a transmission arrangements, because there the IP protocol is already applied anyway.

In principle IPTV can be transmitted over terrestrial, cable, satellite as well as over a mobile network. In practice

however there is misunderstanding and confusion exists between IPTV and Internet-TV.

Basically IPTV and Internet TV are two completely different systems with different business and market models.

Internet-Television or Web-TV

With the Internet TV any user can take the television programs made available by a broadcasting station „to view when and where you want - anywhere and anytime". Free TV offers are possible as well as Pay TV programs.

With Internet TV „television from the Internet" is what is meant. Content producers can be simply anyone. The range of quality can therefore reach from simple video clips up to sophisticated television productions.

An important point is that the provider does not guarantee the quality of service (QoS), because they do not control the connection of the users and having to share the available bandwidth with all other data sources.

IPTV

With IPTV one program package offered by a provider is available to a registered user's area with a defined quality (QoS).

This package can contain standard definition television as well as film archives (Video-on-demand), Free TV as well as Pay TV and even HDTV is possible

This offer is supplemented by additional interactive functionalities like video recorder in the network or locally (Personal Video Recorder) with time-shifted reproduction possibility as well as ergonomic program guides (Electronic programs Guide).

To be able to receive this program package, one must be customer of the provider.

Market-Aspects

In several EU countries there are already appropriate services today, with a growing number of participants. As the broadband networks become much faster, HDTV transmissions are also possible like this, and „Triple Play" belongs practically to the basic configuration. With it an intensive competition of the new IPTV providers stands out currently in particular with the cable network operators.

In the international vocabulary the term „IPTV" is used more and more for both variants: for television in closed networks (managed networks) as well as for TV and video from the open internet (open networks). This takes into consideration the fact that also the networks of the open internet become increasingly faster.

4 Outlook

As evident from the preceding sections, the different „digital arrangements“ are already today able to transmit the „High Definition amounts of data“ quickly and with integrity. In addition, the advancement of the 2nd DVB generation supports this objective.

But whilst we in Europe are still just discussing HD-TV, the next HD-TV generation has already announced itself in the USA and Asia!

4.1 UHDTV & 3D-HDTV

The new trends are **Ultra High Definition Television (UHDTV)** and **three-dimensional HDTV (3D-HDTV)**.

In Japan, the first results of the next generation HDTV - the UHDTV also known as „Super Hi-vision“ of research institutes and the Consumer Electronics industry have already been presented.

UHDVT is a digital video format which has a 16-fold higher image resolution (7680 fk in 4320) with 33 million pixels than HDTV with 2 million pixels. Further details are listed Tab 4.1.

Parameter	UHD-TV	HD-TV
Definition (Pixel)	7680 x 4320 (33 Mio. Pixel)	1920 x 1080 (2 Mio. Pixel)
Aspect Ratio	16:09	16:09
Bit resolution	10 to 12	8 to 10
Frame rate (Hz)	50, 60	24, 25, 30, 50, 60
Data rate (compressed)	72 Gbit/s	max. 2,49 Gbit/s
Standards	SMPTE 2036-1 ITU-R BT.1769	SMPTE 274M ITU-R BT.709

Tab. 4.1: Selected UHDTV parameters

The first prototypes of the components of a complete production chain already exist and the next are already being developed:

- Studio camera with „4 fk 8“ megapixel in CMOS technology; there is already an image sensor with 33 million pixels.
- System with a storage capacity for 18-minute recording time.
- UHD video projector as a display with 8 million pixels.
- Real-time MPEG-4 AVC codec which has been realized with parallel processors.

Another look at the television of tomorrow is the development in the area of 3D-HDTV. This is used, for example, in the USA for the live broadcastings of the NBA Playoffs.

The viewing experience increases the interest of the basketball fans and has been developed itself at the same time for the NBA as well as for the service providers as a lucrative opportunity.


FEATURE

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