A Survey on MPEG-4 Standard and Digital Television Deployment

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Abstract: - MPEG-4 standard has been developed to support a wide range of multimedia applications. It provides users a new level of interaction with visual contents, including techniques to view, access and manipulate objects rather than pixels with great error robustness at a wide range of bitrates. The object-based representation paradigm make MPEG-4 a standard that may find application from low bitrate personal mobile communications to high quality studio production. One topic common to most applications is the need for supporting interactivity with different kind of data. A prime example is the introduction of Digital TV (DTV) instead of analog with obvious direct benefit such as improved quality and reliability.

DTV delivers interference and distortion free audio and video signals, while achieving much higher spectrum efficiency than analog television. Agreements for the DTV transition are being implemented with different emphasis in various countries, depending on network and station arrangements, government regulations, and market conditions. DTV increasingly impacts broadcasters, consumers and many related industries. The DTV systems that are now available worldwide, not only deliver crystal-clear picture, and high quality sound, but they also provide various innovative new services and programs, such as electronic program guide, personalized advertisements, control, IP encapsulation, data broadcasting various interactive services. High Definition (HD) programming requires installation of completely new production and distribution equipment and systems. This is a major capital investment for a broadcaster.

This work seeks to provide an overview of the influence of MPEG-4 standard on DTV from a perspective in Europe. The first part deals with some practical elements of the MPEG-4 standard. The focuses are on the set of technologies together with visual bitstream. The second part describes DTV development including Digital Video Broadcasting (DVB) activities and achievements as well as high definition system origination for DTV. Finally, the third part describes control and encoding for DTV including the corresponding services.

Key-Words: Coding, DTV, DVB, H.264/AVC, HDTV, MPEG-4 standard.

1 Introduction

The consumer electronics and telecommunication companies that recognized the possibilities of new technologies also recognized the benefits of standardizing them. Both these industries were well acquainted with the ins and outs of standardization. Video and audio compression standards were available or being developed in International Telecommunication Union (ITU). The Moving Picture Experts Group (MPEG) has set many widely used standards [1]. The group has expended its scope from basic coding technologies to technologies that support audio and video compression formats. According to its Terms of Reference, MPEG's area of work is the development of international standards of compression, decompression, processing and coded representation of moving pictures, audio and their combination, in order to satisfy a wide variety of applications [2].

While MPEG-1 and MPEG-2 standards follow a representation model, which has its roots in analogue television using the so-called frame-based model, MPEG-4, launched by MPEG in 1993, embodies a significant conceptual jump in audio-visual content representation – the object-based model. This model avoids the object-based model by recognizing that audio-visual content aims at reproducing a world that is made of elements called the objects. By adopting the object-based model, MPEG-4 starts a new generation of content representation standards, where the audio-visual scene can be built as a composition of independent objects with their own coding and features. The major advantages of the object-based approach are characterized by: Hybrid natural and synthetic coding, Content-based coding, and Universal access.

The power and advantages of the object-based representation paradigm, make MPEG-4 a standard that may find application from low bitrate personal mobile communications to high quality studio production. One topic common to most applications is the need for supporting interactivity with different kind of data. A prime example is the introduction of DTV instead of analog with obvious direct benefit such as improved quality and reliability. Once the content is in the digital domain, new functionalities can easily be added. The MPEG-4 standard provides key technologies that will enable such functionalities.

With the growth of the Internet, the interest in advanced interactivity with content provided by DTV is increasing. Coding and representation of not only frames of video, but also individual object in the scene (video objects) can open the door for completely new ways of television programming.

Content creation is turning into virtual production techniques as extensions to the chroma keying. By coding video objects instead of rectangular linear video frames, and allowing access to the video objects, the scene can be rendered with higher quality and with more flexibility. TV programs consisting of composite video objects, and supplementary graphic and audio can be transmitted directly to the viewer, with the additional advantage of allowing the user to control the programming in a more sophisticated way. In addition, depending on targeted viewers, local TV stations could inject regional advertisement video objects, better suited when international programs are broadcast.

DTV delivers interference and distortion free audio and video signals, while achieving much higher spectrum efficiency than traditional analog television. Also, DTV can seamlessly interface, with other communication systems, computer networks, and digital media, enabling data casting and multimedia interactive services. Digital and analog broadcasts are incompatible and new equipment is required both to transmit and receive the new services. For example, most broadcast stations have been required their existing analog transmissions during the transition period, while adding new digital services in accordance with the DTV standard. Arrangements for the DTV transition are being implemented with different emphasis in various countries, depending on network and station arrangements, government regulations, and market conditions.

Development of high definition and advanced television systems preceded in parallel in the United States, Japan, and Europe. For various technical, organizational, and political reasons, this has resulted in multiple sets of DTV standards applicable in different regions of world. There are three main DTV standard groups:

a) The Advanced Television Systems Committee (ATSC), a North America based DTV standards organization, which developed the ATSC terrestrial DTV series of standards.
b) The ISDB (Integrated Service Digital Broadcasting) standards represent a series of DTV standards developed by the Association of Radio Industries and Business (ARIB) as well as by Japan Cable Television Engineering Association (JCTEA).
c) The Digital Video Broadcasting (DVB) Project, a European based standards organization, developed the DVB series of DTV standards. They were standardized by the European Telecommunication Standard Institute (ETSI).

This work provides an overview of the influence of MPEG-4 standard on DTV. The first part deals with practical elements of the MPEG-4 standard. The focuses are on the set of technologies together with visual bitstream. The second part describes DTV development including DVB activities and achievements, as well as high definition system organization for DTV in Europe. Finally, the third part describes control and encoding for DTV, including corresponding services.

2 MPEG-4 Standard Overview

By adopting object based model, MPEG-4 starts a new generation of content representation standards, where scene can be built as a composition of independent objects with their own coding, features and behaviors. Multimedia developments on the Internet showed that users wonted the same interaction capabilities in the A/V world that they were used in terms of text and graphic. The object based coding architecture shows that the reproduced scene is a composition information of a number of audio and visual objects that have been independently coded and thus are independently accessible. The MPEG-4 architecture allows a full range of interactions, automatic or user driven from the simple local composition interaction to the remote interaction with the sending side requiring for an object to be sent to avoid wasting bandwidth and computational resources with low priority objects. Among the major advantages of object-based approach, the following characteristics should be noted: Hybrid natural and synthetic coding, Content-based interaction and reusing, Content-based coding, Universal access [3]. The power and advantages of the object-based representation paradigm make MPEG-4 a standard that may find application from low bitrate personal mobile communications to high quality studio production. This broad range of applications has associated with it a large set of requirements which has, with passage of time, made the MPEG-4 standard grow to become large and currently organized in 27 Parts. With the ability of MPEG-4, it became easer to acquire, produce and distribute A/V content.

2.1 A set of technologies

MPEG-4 standard seeks to provide a set of technologies in order to satisfy the needs of authors, service providers, as well as end users [4]. For example, MPEG-4 will enable the production of content with greater reusability and flexibility than possible with individual technologies. Also, better management and protection of element owner rights are provided with MPEG-4. For network service providers, this standard offers transparent information, interoperated and translated into the appropriate native signaling messages for each network. The help of relevant standard bodies is welcome. The foregoing excludes Quality of Service (QoS) considerations, for which MPEG-4 provides a generic QoS descriptor for different media. For end users, MPEG-4 enables functionalities potentially accessible on a single compact terminal and higher levels of interaction with content within the limits set by the author. Starting from the structure of the MPEG-4 standard, these goals are achieved by providing ways to support: coding, composition, multiplex and interaction.

Units of audio, visual or audio/visual content are called media objects (natural or synthetic in origin). The composition of these objects creates compound media objects that form A/V scene. Than, we have multiplexing and synchronizing the data associated with media objects for transport over network channels, providing a QoS appropriate for the nature of the specific media objects. By interaction, we mean interacting with the A/V scene at the receiver's end, or using a back channel at the transmitter's end.

Interactivity between the user and the encoder or the decoder takes place in different ways. The user may decide to interact at the encoding level, either in coding control to distribute the available bitrate between different video objects. To influence the multiplexing to change parameters such as the composition script at the encoder is also possible. In cases where no back channel is available, or when the compressed bitstream already exists, the user may interact with the decoder by acting on the compositor to change either the position of video object or its display order. The user can influence the decoding process at the terminal by requesting the processing of a portion of the bitstream only.

To achieve the highest audio quality within the full range of bitrates and at the same time to provide extra functionalities, the MPEG-4 Audio standard includes some types of coding techniques like [5]: Parametric coding, Linear predictive coding, Time/frequency coding, Synthetic natural hybrid coding, Text-to-speech integration, Scalable coding.

2.2 MPEG-4 visual bitstream

The MPEG-4 visual standard is developed to provide users a new level of interaction with visual contents. It provides technologies to view, access and manipulate objects rather than pixels, with great error robustness at a large range of bitrates. The MPEG-4 natural video standard consists of collection of tools that support wide range of multimedia applications. MPEG-4 also provides a mode for overlapped motion compensation. An MPEG-4 visual bitstream provides a hierarchical description of a visual scene as shown in Fig. 1. The hierarchical levels that describe the scene most directly are: Video Session (VS), Video Object (VO), Video Object Layer (VOL), Video Object Plane (VOP), Group of VOPs (GoV).

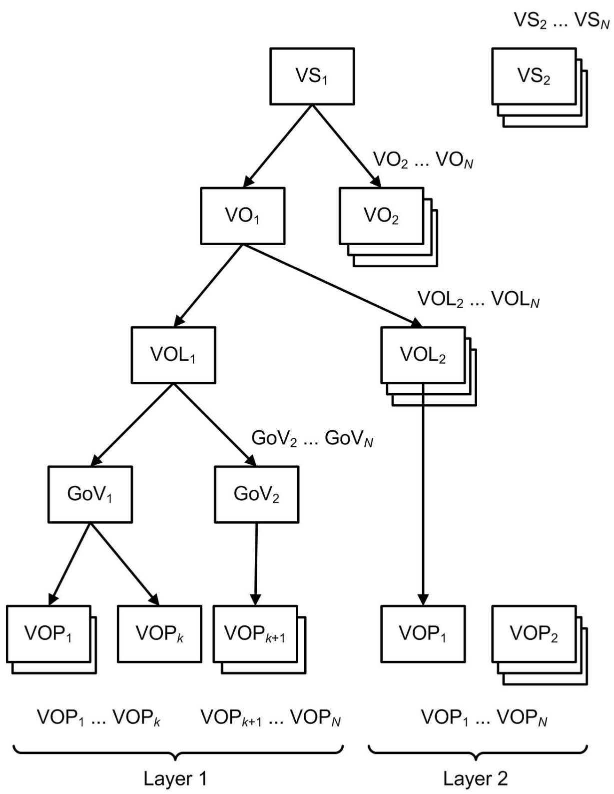

Fig. 1. MPEG-4 video bitstream logical structure.

VS represents the complete MPEG-4 scene which may contain any 2-D or 3-D natural or synthetic objects and their enhancement layers. VO corresponds to a particular 2-D object in the scene. This can be a rectangular frame, or it can be an arbitrarily shaped object corresponding to an object or background of the scene.

The VOL provides support for scalable coding. A video object can be encoded using spatial or temporal scalability, going from worse to fine resolution. Each video object can be encoded in scalable (multi-layer) or non-scalable (single-layer) form, depending on application, represented by the VOL. Depending on available bandwidth, computational power, and user preferences the desired resolution can be made available by the decoder.

The GoV assort together video object planes. GoVs can provide points in the bitstream where VOPs are encoded independently from each other, and can provide random access points into the bitstream.

A VOP is a time sample of a VO. VOPs can be encoded independently of each other, or dependent on each other by using motion compensation. A VOP can be used in different ways. In the most common way the VOP contains the encoded video data of a time sample of video object. In that case it contains motion parameters, share information and texture coding. These are encoded using macro blocks, containing a section of the luminance component and the spatially subsampled chrominance components.

The general block diagram of MPEG-4 encoding and decoding based on the notation of video objects is shown in Fig. 2. For reasons of efficiency and backward compatibility, VOs are coded via their corresponding VOPs.

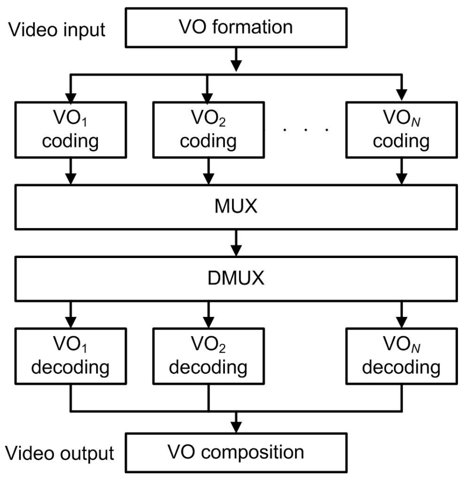

Fig. 2. Block scheme of MPEG-4 based on the video objects notation.

3 DVB Activities and Achievements

In the existing applications digital video initially provides similar functionalities as analog one. The content is represented in digital form, with some direct benefits such as improved quality and reliability. Nevertheless, the content remains the same to the user. However, once the content is in digital domain, new functionalities can easily be added. This will allow the user to view, access, and manipulate the content in completely new ways. The MPEG-4 standard provides key technologies for such functionalities.

In DTV, the video frames are represented and transmitted as digital data. Once a video is digitized, it can be treated like any other multimedia data. A digital video signal requires a large storage spaces and high bandwidth for transmission. Hence DTV signals are compressed, then modulated and broadcasted through terrestrial, cable, or satellite networks.

DTV has two main formats: standard definition (SD) and high definition (HD). SDTV provides a resolution almost two- times compared to analog TV quality. The HDTV provides a resolution almost four-times compared to analog TV. The waking principles of the SDTV and HDTV standards are the same. Some of the features that have been incorporated in the various HDTV standards are:

- Higher spatial and temporal resolution,
- Higher aspect ratio,
- Multichannel high quality surround sound,
- Reduced artifacts.

The DTV system adopted by the ITU-R has tree main subsystems: Source coding and compression, Service multiplex and transport, R/F transmission. A generic digital terrestrial television broadcasting model is shown in Fig. 3.

The source coding and compression subsystem employs bitrate reduction methods to compress the video, audio, and ancillary digital data. It can be noted that ancillary data generally refers to the control data, conditional access control data, as well as data associated with the program.

The service multiplex and transport subsystem divides the digital data stream into packets of information. Each packet is labeled properly so that it can be identified uniquely. The video, audio, and ancillary data packets are multiplexed to generate a single data stream.

The R/F transmission subsystem performs the channel coding and modulation. The channel coder takes the input data stream which has been compressed and adds the additional information so that the receiver is able to reconstruct the data even in the presence of bit error due to channel noise. The compressed bitstream is received and decoded at the receiver side.

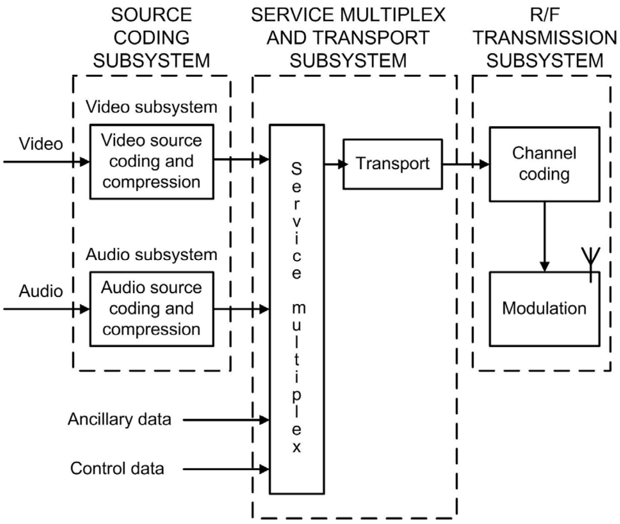

Fig. 3. Generic digital terrestrial TV broadcasting model.

DVB Project as the focal point of the development of DTV for many countries worldwide was founded in 1993. This Project was preceded by the European Launching Group (ELG) with the following rules which were incorporated in the DVB Project Status [7]:

- Each DVB member has to pay its own cost and a moderated annual fee to support some DVB activities.
- Member organizations from Committees outside of Europe are welcomed.
- DVB operates on the basis of four constituencies bringing together content owners and broadcasters, network operators, hardware and software manufacturers and regulators.
- Technical systems will only be developed by the DVB Technical Module if and when commercial requirements of such systems have been provided by the DVB Commercial Module and approved by the DVB Steering Board.
- Every two years the strategy of DVB is to be revisited in order to be able to accommodate the changing nature of the world of electronic media.

The block diagram of the DVB project structure is shown in Fig. 4.

The commercial working group i.e., Commercial Module of DVB Project is responsible for the definition of commercial requirements for the new systems from the viewpoint of the users. These requirements form the basis of work within the Technical Module. After completion of the technical specification work, the Commercial Module verifies these specifications for the new systems and passes them on the Steering Board for final decision. DVB does not standardize its own work, but passes its specifications to the European Telecommunications Standards Institute (ETSI) for integration into the regular standardization world. The DVB Project decided that in order for the technological solution used to find a wide international basis, DTV should be based on the MPEG standard. This decision leads to an intensive cooperation between many European organization and MPEG. For many years, the DVB Project developed specifications addressing the technology of broadcast networks in order to transport digitized audio and video to TV receivers, set-top boxes, and high fidelity audio receivers. Later, specifications for interactive channels were added. The completion of the specification for data broadcasting opened up DVB networks for the transmission multimedia content. An example is encapsulation IP based services in DVB data stream.

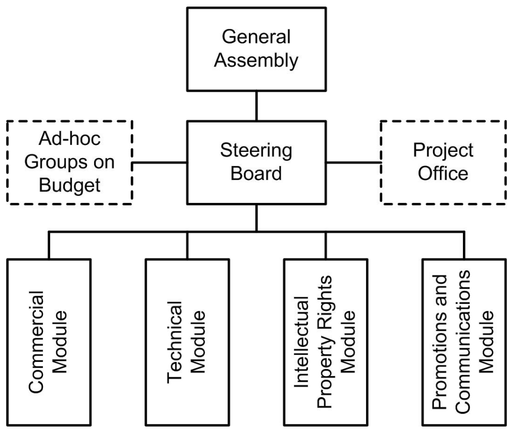

Fig. 4. DVB project structure.

The advent of the Multimedia Home Platform (MHP) was great because with MHP software applications can be run on all sorts of terminal devices. The ongoing development of the MHP is one of the key activities of the new DVB. Namely, MHP can now be embedded in non-DVB digital broadcasting environments. Another area of DVB is the development of specifications for the transport of "DVB content" over fixed and mobile telecommunications networks. Finally, in order to describe technical activities and achievements within the Technical Module of the DVB Project, let us list a few of its ad-hoc groups:

- Advanced A/V Content Formats, for the transport of DVB content over IP-based networks;
- Convergence of Broadcast and Mobile Services, defining the technologies

necessary to construct hybrid networks with a broadcast and a cooperating mobile telecommunications branch;

- Content Protection Technology, including copy management and rights management,
- DVB-H, for the transmission of high-rate data streams to battery-powered personal communications devices.

After more than 15 years of work, the DVB Project is still extremely active in developing new solutions for the dynamic world of the electronic media.

4 Relevant Production Systems for DTV in Europe

HDTV programming requires installation of completely new production, and distribution equipment and systems. This is a major capital investment for a broadcaster. The age of consumer-acceptable HDTV receivers, with flat panel displays, has arrived and consequently HDTV is implemented.

A number of national HD Forums have been established in Italy, United Kingdom, Germany, France, Spain, Portugal, and Nordic countries. The European Broadcasting Union (EBU) established European HDTV Forum with a focus on coordination with respect to interoperability questions. The EBU has specified in EBU Tech. 3299 [8] four HDTV production systems (Table 1) relevant for DTV in Europe.

Table 1. HDTV production systems.

System	Horizontal samples	Active lines	Scan	Frame rate
S1	1280	720	Progressive	50 Hz
S2	1920	1080	Interlaced	25 Hz
S3	1920	1080	Progressive	25 Hz
S4	1920	1080	Progressive	50 Hz

HDTV in Europe is a natural evaluation of television. Pay-TV operators first introduce HDTV services to the market and large public broadcasters to the end of the decade. Important factors include the penetration and availability of HDTV displays, receiver devices and sufficient broadcasts.

5 Master Control and Encoding for Digital Television

Master control areas contain the equipment for control and monitoring of the on-air program, whether from a network release center, a station group central casting location, or a local station [9]. In a DTV, the master control output is usually fed to compression equipment for distribution or emission. The system architecture for these functions varies considerably for different networks and stations. It also depends on the number of program outputs and whether services are in SD or HD. Fig. 5 shows how a master control and encoding system may be configured for a local DTV broadcast station.

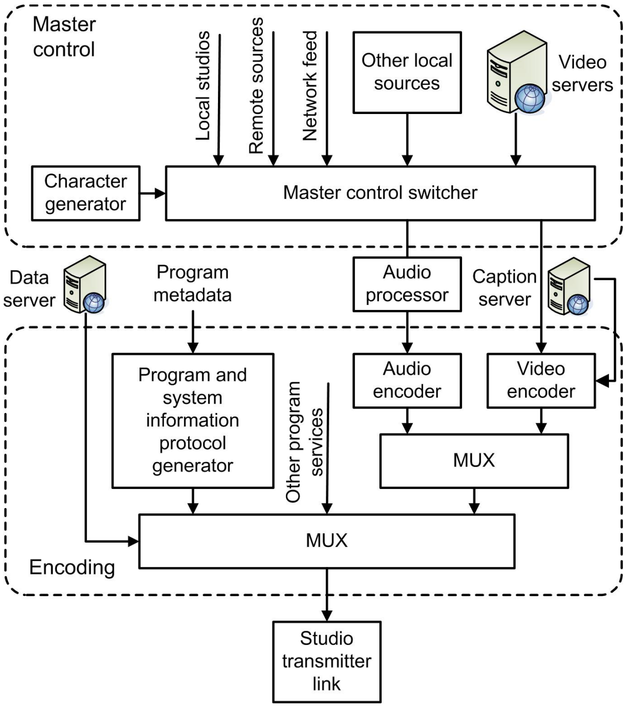

Fig. 5. Master control and encoding for DTV.

It shows various local, remote and network sources feeding i.e. sending signals to a baseband master control switcher which may be either SD or HD. The switcher is used to select the program source to be transmitted. The video and audio outputs from this switcher feed the encoders and multiplexer (MUX). The MUX output goes to the transmitter. Audio processing is implemented by some broadcasters. Arrangements for a network master control may be similar. In that case, the master control switcher output will feed the encoders for the network or group distribution, and than will go to satellite uplink rather than a terrestrial transmitter. For multiple SD programs or one SD and one HD, there may be a separate master control area for each service. Alternatively, one master control position may be configured to control two or more switchers from the same control plane. Usually, this arrangement will apply when a station operates several DTV program services for multicasting.

Each encoder produces a data stream which is combined into a single program stream in a MUX. The output of this MUX is then combined, in a second MUX, with other data packets to produce the final transport stream that is fed to the transmitter. Depending on design, the MUX may be separate devices or may be in a single box integrated with video encoder. As for the audio encoder they may be combined in the integrated unit, or may be a stand-alone device. It is common for a station to locate the encoding and multiplexing equipment at the studio central and send the single transport stream over the studio transmitter link to the transmitter.

When stations multicast two or more program services in a single output bitstream on their DTV channel, there will be multiple video and audio feeds. This is the broadcasting form for the signal being sent from master control to multiple audio and video encoders. These other program services are all combined to the final MUX, as indicated in the figure. In general, increasing the number of programs in one MUX results in lower picture quality and more visible artifacts, but this depends on the format of the video carried and the program content. When multiple programs are carried, statistical multiplexing may be used. This can improve the quality of each service considerably. Statistical multiplexing allocates available bandwidth to each program on an as-required basis rather than using a fixed bitrate for each one. The statistical nature of video means that peak bandwidth requirements for multiple programs rarely coincide.

The vast majority of terrestrial DTV services worldwide currently use MPEG-2 video encoding, but in some circumstances advanced codecs such as MPEG-4 Part 10/H.264 are beginning to be introduced. H.264 will probably be used exclusively for HDTV broadcasting in Europe.

MPEG-4 Part 10/H.264 standard [10] has the same basic functional elements as previous standards (MPEG-1, MPEG-2, MPEG-4 part 2, H.261, and H.263), i.e., transform for reduction of spatial correlation, quantization for bitrate control, motion compensated prediction for reduction of temporal correlation, and entropy encoding for reduction of statistical correlation. However, to fulfill better coding performance, the important changes in H.264/AVC occur in the details of each functional element by including intra-picture prediction, a new 4x4 integer transform, multiple reference pictures, variable block sizes and a quarter pel precision for motion compensation, a deblocking filter, and improved entropy coding [11,12].

MPEG-2 and MPEG-4 Part 2 are brifely compared with MPEG-4 Part 10/H.264 in Table 2.

Table 2. Comparison of MPEG-2, MPEG-4 Part 2 and MPEG-4 Part 10/H.264 standards.

Standard / Properties	MPEG-2	MPEG-4 Part 2	H.264 MPEG-4 Part 10
Block size	8x8	16x16, 16x8, 8x8	16x16, 16x8, 8x16, 8x8, 8x4, 4x8, 4x4
Macroblock size	16x16, 16x8	16x16	16x16
Intra-prediction	No	Transform domain	Spatial domain
Quantization	Scalar	Vector	Scalar
Reference picture	1	1	Multiple
Prediction mode	Forward/ backward	Forward/ backward	Forward/ backward, forward/ forward, backward/ backward
Weighted prediction	No	No	Yes
Deblocking filter	No	No	Yes
Picture types	I, P, B	I, P, B	I, P, B, SI, SP
Error robustnes	Data partitioning, FEC for high priority transmission	Sync., data partitioning, header extension, rev. VLCs	Data partitioning, flexible macroblock ordering, redudant slice
Encoder complexity	Medium	Medium	High
Backward compatibility	Yes	Yes	No
Transmission rate	2-15 Mb/s	64 kb/s-2 Mb/s	64 kb/s -150 Mb/s

Currently, the commercial H.264 codecs are widely developed by several companies for replacing/ complementing existing products. Besides HDTV broadcasting, H.264 can be applied to consumer equipment such as digital cameras, cell phones, video over IP networks, and digital storage systems.

6 DTV Services

Digital satellite and digital cable services using DVB-S and DVB-C have been available with SDTV programming for a number of years. European commercial and public service broadcasters are well advanced with DTV services. Bitrates are chosen depending on economic considerations, the degree to which high-quality flat panel displays are in the public hands acceptable quality and the availability of statistical multiplexing.

DVB multiplex combines several data streams together to a fixed bitrate MPEG transport stream. This makes it possible to transfer several programs simultaneously over the same transport channel, together with various services. Statistical MUX allocates to each service the required bandwidth for its real-time needs, so that programs with complex scenes receive more bandwidth than services with less complex ones [13]. This bandwidth sharing technique produces the best video quality at the lowest possible aggregate bandwidth.

DVB transmission used MPEG transport stream and statistical multiplexing to allow several multimedia streams of different data rates to be transmitted. This may involve several SDTV programs or one HDTV, possibly with a single SDTV companion channel over one 6 to 8 MHz – wide channel. DVB-S2 has been developed for digital satellite transport. DVB-T is under continuous development in Europe. However, there are large differences in the time schedule from country to country with the most developed digital broadcasting being in the United Kingdom, where DVB-T, DVB-C and DVB-S were well established. For example, DVB-T began in France in 2005. Other countries have also begun digital terrestrial and satellite broadcasting.

Regular HDTV services in Europe were first broadcast via satellite utilizing DVB-S2 and H.264 compression. The newer DVB standards DVB-S2 and DVB-T2 have the capacity to carry several HDTV channels in one multiplex. Even the original DVB standards can carry more HDTV channels in a multiplex if the most advanced MPEG-4 compressions are used.

There are two approaches used to combine digital services into multiplex: Constant Bit Rate (CBR) and Variable Bit Rate (VBR) encoding. Usually, the picture changes rapidly and on overage one MPEG compressed television video stream needs some fixed bitrate [14]. Therefore, it makes sense to allocate higher bitrate to the service when there is a need for it and to decrease bitrate when there is no need to transfer big amounts of data. The total MUX capacity is still constant. It is dynamically shared between all services according to their current needs. Based on the rate-distortion theory, to achieve equal video quality for all programs, the channel bandwidth should be distributed unevenly among the programs in proportion to the information content, i.e., complexity of each of the video service. Thus, the objective of statistical multiplexing is to dynamically distribute the available channel bandwidth among the video programs in order to maximize the overall picture quality of the multi-program video coding system.

7 Future Steps for DTV Services Deployment

DVB-T represents the most widely deployed solution for digital terrestrial television, with the flexibility and ability to deliver a whole range of services. It will continue to be a promising system with consumers benefit. For almost all European countries the D-day for analogue switch-off is approaching in the next couple of years. This transition will create a new great opportunity for the introduction of new technologies.

DVB Project is now actively working on DVB-T2, bringing with it efficiencies of 30-50% in its use of spectrum compared to DVB-T. Standardization issues are almost completed. Vendors are already working on the design of DVB-T2 equipment. In parallel, further work will be required within the DVB Project and elsewhere on the creation of implementation guidelines, validation testing, etc. Products that implement the DVB-T2 standard are not likely to become widely available until the second part of 2010. Whilst prices will fall over time, in line with past experiences for DVB technologies, they can be expected to be relatively high initially. This means that DVB-T2 should not, in the short to medium term, be considered for the launch of free-to-air multichannel standard definition services targeted at migrating from analogue to digital. DVB-T is ideal for these purposes [15].

The technical work on DVB-S2 has been completed and the work group within DVB is in stand by mode. It is expected that DVB-S2 will not replace DVB-S in the short or even the medium term, but makes possible the delivery of services that could never have been delivered using DVB-S.

The DVB-C specification was developed in 1994. It provides a toolbox of QAM modulation schemes from 16-QAM to 256-QAM for television and radio broadcasting services, as well as for data transmission. At the moment, this standard is deployed worldwide in cable systems ranging from the larger CATV networks down to smaller systems. Responding to increased consumer demand for a broader range of DTV services, many cable operators have already upgraded their networks, deploying 256-QAM modulation (thus achieving 50 Mbit/s payload per cable channel) and increasing the frequency range used for downstream transmission up to its maximum of 862 MHz. Many cable operators currently offer a rich analogue TV package alongside several hundreds of digital TV channels and an increasing amount of new, and more sophisticated (interactive and personalised) services. Demand for more and more advanced services however is constantly growing, and cable operators are seeking ways to offer products like HDTV and VoD on a commercial scale within a relatively short timeframe, together with the required accompanying interactive services. Hybrid Fibre Coax (HFC) networks are therefore being optimised providing enhanced performance and thus allowing even higher modulation schemes than DVB-C is offering today. The DVB-C2 specification is currently in the drafting process.

The DVB-H standard is fully specified and published. Some additional work is ongoing within the DVB Project revising the DVB-IPDC (IP Datacast) systems layers following extensive implementation experience. As with all elements of DVB-H, once finalized, the work is standardized as quickly as possible to facilitate implementers.

DVB has also published a specification for Satellite services for Handhelds (DVB-SH), introducing the option of using satellites operating in the S-band below 3GHz as part of the mobile TV chain. DVB-SH is also designed to utilize the DVB-IPDC systems layer specifications and thus complements the DVB-H specification. DVB-SH seeks to exploit opportunities in the higher frequency S-band, where there is less congestion than in UHF. Work is continuing within the DVB Project's Technical Module on items such as the development of a set of implementation guidelines and the validation of the interfaces with DVB-IPDC.

8 Conclusions

MPEG-4 standard has been developed to support a wide range of multimedia applications. It provides users a new level of interaction with visual contents including technologies to view, access and manipulate objects rather than pixels with great error robustness at a large range of bitrates. Application areas range from DTV and streaming video to mobile multimedia. Digital video provides similar functionalities as analog one. Namely, the content is represented in digital form with obvious direct benefits such as improved quality and reliability. Also, the content remains the same to the user.

Spatial and temporal scalability are also supported in MPEG-4. Scalability is implemented in terms of layers of information, where the minimum needed to decode is the base layer. Any additional enhancement layer will improve the resulting image quality either in temporal on in spatial resolution.

DTV increasingly impact broadcasters, consumers and many related industries. The DTV systems that are now available around the world not only deliver crystal-clear pictures and high quality sound, but they also provide various innovative new services and programs, such as electronic program guide, personalized advertisements, control, data broadcasting, various interactive services. DTV also provides a seamless interface with communication systems, computer networks, and digital media.

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