DVB—The Family of International Standards for Digital Video Broadcasting

ULRICH H. REIMERS, FELLOW, IEEE

Invited Paper

This paper presents an overview of the fields of technology addressed by technical specifications created by the DVB Project (DVB). It serves as an introduction to the section of the special issue of the PROCEEDINGS OF THE IEEE *in which a number of very recent DVB technologies will be explained in detail. The overview starts with an explanation of the wide field of application which the members of the DVB Project decided to address over the years. It then discusses the base band processing required for DVB services and looks into the specifications provided for the broadcasting over cable, satellite, and terrestrial transmitters. The concept of broadcasting generic data is explained and the interaction channels supported by DVB will be introduced. Multimedia Home Platform (MHP) facilitates a horizontal market of receivers able to run software programs (applications in DVB terminology) in a well defined way. After a short introduction into the specifications addressing the delivery of broadcast-type content over broad-band IP networks, the concept of broadcasting to handheld devices is introduced. The paper closes with a description of the newest areas of development DVB has decided to tackle.*

Keywords—*Data broadcasting, digital TV, digital video broadcasting (DVB), multimedia home platform.*

I. INTRODUCTION

DVB—the abbreviation stands for digital video broadcasting and readers may be tempted to think that the technologies developed by the International DVB Project are broadcast related. This is right and wrong at the same time. Whereas in phase 1 of its existence DVB concentrated on the development of technical specifications relevant for the more traditional broadcasting of audio and video services over satellite, in cable networks and via terrestrial transmitters, in the later phases DVB addressed areas which lie outside of the classical broadcast world [1]. The history of the DVB Project and its mode of operation are described elsewhere in this issue [2]. Note that in DVB the word broadcasting is used very generically to describe the transport of media content from one point of origin to multiple receivers—irrespective of the physical network used for this transport. The specifications for carrying IP data on DVB networks, the solutions for interaction and return channels, the software environment called Multimedia Home Platform (MHP) and the specifications enabling point-to-multipoint distribution of all sorts of data to handheld devices belong to this group of solutions. Specifications developed by the DVB Technical Module are documents which—after approval by the Steering Board—are made publicly available in the form of "DVB Blue Books." In order for these documents to become international standards they are passed to the Joint Technical Committee (JTC) Broadcast jointly formed by the European Broadcasting Union, the European Telecommunications Standards Institute (ETSI) and the Comité Européen de Normalization Électrotechnique (CENELEC). These organizations then turn specifications into standards. In parallel DVB will in many cases deliver documents providing implementation guidelines accompanying the specifications.

Of the many fascinating areas of technology for which DVB has developed solutions the following will be described in specific papers of this issue: DVB-T—the solution for terrestrial broadcasting [3], DVB-H, a system delivering all sorts of content to battery-powered devices [4]; DVB-S2, the next generation satellite system [5]; DVB-IP, a solution for the carriage of broadcast content over broad-band IP networks [6] and the MHP [7].

II. FIELDS OF APPLICATION OF DVB TECHNOLOGIES

One of the most important rules of DVB is that the technical work is to be commercially driven by the requirements of the member organizations. In consequence, the fields of application of DVB technology developed significantly over time. So did the goals which DVB tried to achieve. The goals existing during the very first exploratory activities in 1991 and 1992 could be described by the following expectations.

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The author is with the Institut fuer Nachrichtentechnik (Institute for Communications Technology), Technische Universitaet Braunschweig (Braunschweig Technical University), Braunschweig D-38092, Germany (e-mail: u.reimers@tu-bs.de).

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1) Digital television will enable the transmission of very high-quality HDTV images, possibly even via terrestrial broadcasting networks.
2) DVB might enable the broadcasting of programs at standard-definition television (SDTV) quality using narrow-band channels, and it will enable an increase of the number of programs offered within existing transmission channel allocations.
3) DVB might be used to broadcast content to low-cost pocket TV receivers, equipped with built-in receiving antennas or short rod antennas guaranteeing stable reception for a number of television programs.
4) Television receivers in vehicles (trains, buses, or cars) might be served by DVB with broadcasts of a high quality, i.e., DVB might enable stable reception in moving vehicles even over difficult radio channels and at high speeds.
5) Moreover, as a data transmission technique, DVB will retain the typical characteristics of digital technology, such as the stability of the reception within a very clearly defined coverage area, the possibility of simple distribution over telecommunications networks as one service among many.

When the exploratory phase had ended it turned out that satellite broadcasters had been the first to understand the promises of DVB technology for their future businesses and therefore requested that DVB provide publicly available specifications for all components of the transmission chain from source coding of audio and video to the interfaces of a receiver in the home. An area that they did not want to be specified by a publicly available document were certain elements of conditional access systems. In the middle of the 1990s more and more DVB members representing various parts of the business chain in a multitude of countries around the globe had started to formulate their requirements, and the list of goals which DVB was to achieve could at that time be described by the following expectations.

1) DVB will enable a multiplication of the number of television programs which can be broadcast in one transmission channel—irrespective of whether the transmission will be over satellite, on cable networks or via terrestrial transmitters.
2) DVB will support the broadcasting of radio programs and will enable data transmission for entertainment and business purposes.
3) DVB will make possible a flexible choice of image and audio quality, including the choice of HDTV.
4) For use in connection with pay services a secure scrambling method will be specified by DVB which will ensure that unauthorised access to such services is extremely difficult, if not impossible.
5) DVB standards for interaction channels between the viewer and the network operator or content provider will enable full interactive services to be introduced.
6) DVB will provide an open and interoperable software platform for enhanced services like enhanced broadcasting, interactive broadcasting or even full Internet access from a TV receiver.

Table 1
DVB Deliverables by Field of Application

Field of application	Number of standards	Number of guidelines
Source coding	0	3
Service information	1	2
TV-Anytime, Teletext, subtitling, VBI information, software download	5	0
Conditional access	1	2
Data broadcasting	1	1
Transmission to the home	12	2
Interaction channels	8	5
Multimedia Home Platform (MHP), Globally Executable MHP (GEM)	2	0
In-home networks, professional network interfaces, home terminal interfaces	10	3
DVB content over broadband IP	1	0
Digital satellite news gathering	2	1
Measurement guidelines	0	2
Miscellaneous	0	1
Total	43	22

7) DVB-T will offer the possibility to address receivers in all kinds of environments from the classical TV sets in the living room via portable devices in ones shirt pocket to TV receivers built into vehicles.
8) Furthermore, as a data transmission technique, DVB will incorporate typical characteristics for the utilization of digital technology, such as the stability of the reception within a clearly defined coverage area, the possibility of simple distribution over telecommunications networks, as one service among many others, and the possible integration into the world of personal computers.

In 2000 DVB reconsidered its goals and defined the vision for the following years as follows: "DVB's vision is to build a content environment that combines the stability and interoperability of the world of broadcast with the vigor, innovation, and multiplicity of services of the world of the Internet." Since that time various new technical solutions were developed upon request of the member organizations. In consequence the list of DVB deliverables reflect the zeitgeist to some extent. Table 1 lists these deliverables by field of application.

III. Baseband Processing

One of the fundamental decisions which was taken during the early days of DVB was the selection of MPEG-1/2 for the source coding of audio and video and for the creation of program elementary streams, transport streams, etc.—the so-called systems level. The international standard ISO 13 818 consists of multiple parts three of which describe MPEG-2 systems, video, and audio, respectively. All three are truly generic and can be considered too wide in scope for them to be applied to DVB directly. Therefore, [8] was created by the DVB Project. This "guidelines document" includes restrictions to the syntax and parameter values described by MPEG-2 as well as recommendations for preferred values for the use in DVB applications. The complexity of what has been achieved is nicely reflected by the fact that integrated receiver decoders (IRDs) are classified in five dimensions as follows.

- "25 Hz" or "30 Hz," depending on whether the nominal video frame rates based on 25 Hz or 30 000/1001 Hz (approximately 29.97 Hz) are supported. It is expected that 25-Hz IRDs will be used in those countries where the existing analog TV transmissions use 25-Hz frame rate and 30 Hz IRDs will be used in countries where the analog TV transmissions use 30 000/1 001 Hz frame rate. There are also likely to be "dual-standard" IRDs which have the capabilities of both 25- and 30-Hz IRDs.
- "SDTV" or "HDTV," depending on whether or not they are limited to decoding pictures of conventional TV resolution. The capabilities of an SDTV IRD are a subset of those of an HDTV IRD.
- "With digital interface" or "baseline," depending on whether or not they are intended for use with a digital bitstream storage device such as a digital VCR. The capabilities of a baseline IRD are a subset of those of an IRD with digital interface.
- MPEG-2 video or H.264/AVC video coding formats.
- Audio coding formats selected from a long list of options.

To give a complete definition of an IRD, all five dimensions need to be specified.

Over time a variety of sound formats were required by broadcasters in various countries in addition to the ones specified in MPEG-1/2 and therefore the optional use of both Dolby AC-3 and DTS coded audio is supported by this document. In the course of 2004 the use of even more efficient source coding technologies for audio and video became a requirement—for example by organizations planning to implement new HDTV services over satellite. In consequence, DVB added optional support of H.264/AVC for video content and optional support of MPEG-4 high-efficiency AAC audio.

The use of the MPEG-2 transport stream is the solution of choice for the more traditional broadcasting networks. But there are cases where DVB services are delivered over IP-based networks. For these [9] gives guidelines which are based on the use of RTP, a transport protocol for real-time applications as the systems layer. H.264/AVC is used for video coding and MPEG-4 high-efficiency AAC for audio.

In analog TV services teletext has been used for many years. Millions of TV receivers out in the field provide teletext decoding. Viewers are used to the convenience of obtaining information from teletext pages. Since for many years to come existing TV receivers will be used to display DVB services which for example have been received and decoded by a "black box" connecting the satellite LNB, the cable outlet or an aerial to the existing TV receiver, a mechanism needed to be provided which enables the delivery of "analog" teletext to the receiver via DVB. This mechanism is available and is known as DVB-TXT. Teletext pages are not the only data transported during the period of the vertical blanking interval (VBI) of analog television and DVB developed a generic means for the delivery of all VBI data, e.g., to enable the control of video recorders or the signaling of wide screen programs.

In many countries it is customary to broadcast TV programs with the original soundtrack and to provide a translation into the local language in the form of subtitles. Another practice is to add graphic elements to the transmitted images—for example, station logos, etc. A powerful mechanism is described by the relevant DVB specification which allows the transmission of all kinds of subtitles and graphic elements as part of the DVB signals.

DVB services typically consist of a wide variety of programs carried via a large number of transmission channels. In order for the receiver to be able to tune to such channels and in order for the DVB customer to be able to navigate the profusion of programs, powerful navigational aids need to be provided as part of the DVB streams. The service information (SI) described in [10] constitutes this set of aids, entitled DVB-SI.

The specification for the carriage and signaling of TV-Anytime information in DVB transport streams is among the most recent achievements. This document defines how personal digital recorders (PDR) can be supported using TV-Anytime phase 1 specifications on DVB transport streams. The TV-Anytime process for recording content is "search, select, acquire." Metadata is searched for the content the viewer wishes to record, the viewer selects the correct content and the PDR then records it. A number of interrelated technologies are defined that can be used to enable various PDR applications.

IV. Transmission on Cable, Satellite, and Terrestrially

A look at Table 1 reveals that 12 specifications exist which describe technologies supporting the transmission of content to the home. These cover the full list of transmission media. Satellite broadcasters may use DVB-S [11] and DVB-S2 [12]. Both technologies are described in [5] in this issue. For use in cable networks DVB-C was developed [13]. The terrestrial transmission system DVB-T is specified in [14] and its most recent companion system for the broadcasting to battery-powered handheld devices (DVB-H) is specified in [15]. In two papers in this issue the features of DVB-T and the experience gained with its implementation are described [3] and DVB-H is introduced [4], respectively.

In addition, solutions have been provided for the distribution of DVB content in (satellite) master antenna TV [(S)MATV] installations, via multipoint video distribution systems (MVDS) and on microwave multipoint distribution systems (MMDS) operating in a number of frequency ranges up to 60 GHz.

The encoder processing in DVB-C, DVB-S, and DVB-T is based on the same fundamental concept. The three systems differ in the form of modulation used. Fig. 1 shows the block diagram of the encoder for DVB-T. The shaded blocks are used in DVB-C and DVB-S as well as in DVB-T. Note that the DVB-S specification was developed as early as 1993. At that time, the encoder processing selected was

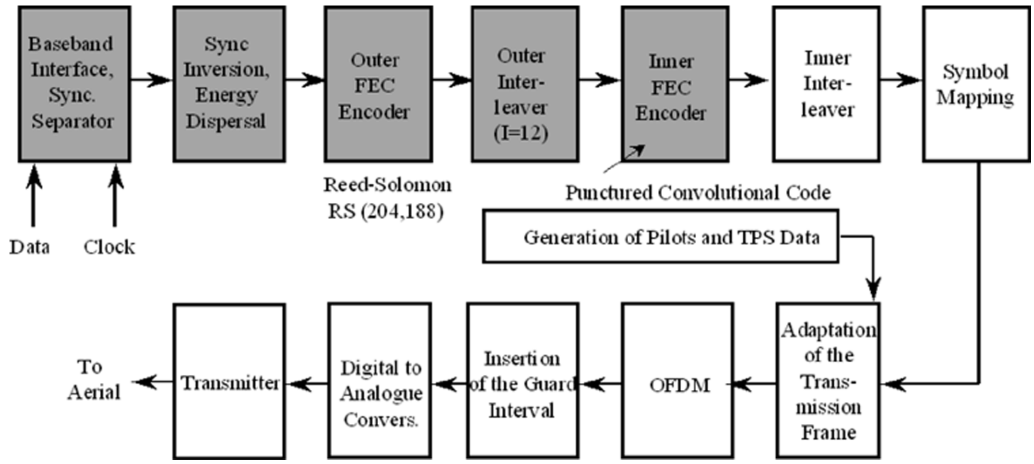

Fig. 1. Block diagram of the encoder for DVB-T. Shaded blocks are used in DVB-C and DVB-S as well.

seen as very advanced and long discussions were held about the economical viability of the implementation in the consumer receiver of, for example, a Viterbi decoder. The forward error correction (FEC) is based on the concatenation of an outer block code [Reed–Solomon (RS 204 188)] and an inner (punctured) convolutional code. In between both FEC encoders a convolutional interleaver is placed. For DVB-C the modulation chosen is QAM (with 16, 32, 64, 128, or 256 points in the constellation diagram). DVB-S uses QPSK or BPSK and for DVB-T orthogonal frequency division multiplexing (OFDM) was selected where each individual carrier can be modulated with QPSK, 16 QAM, or 64 QAM.

DVB-H employs additional FEC encoding for enhanced robustness which is required since the DVB-H terminals are supposed to be handheld terminals with small built-in antennas. This additional FEC encoding takes place before the baseband signals enter the encoder which is exactly the DVB-T encoder shown in Fig. 1 [4].

DVB-S2 is a system which was defined only in 2003. The FEC scheme of DVB-S2 therefore differs significantly from the one shown in Fig. 1 [5]. DVB-S2 again uses a concatenation of FEC schemes but here a low density parity check code (LDPC) was chosen and concatenated with a Bose–Chaudhury–Hocquenghem (BCH) code. In 1993 it would have been unthinkable to choose LDPC because its live decoding would have been seen as far too complex to be introduced in a consumer product.

Of all the DVB solutions for the transmission of content to the home, DVB-T has received by far the most attention. Its excellent performance has led to its adoption in large parts of the world. In 2005 DVB-T is in use in Australia, France, Germany, Italy, The Netherlands, Singapore, Spain, Sweden, Taiwan, United Kingdom, and several other countries. It seems safe to say that eventually DVB-T will be in operation in the whole of Africa, in Australia, in total Europe, and the largest part of Asia. Only Canada, Japan, Mexico, South Korea, and the United States have opted for other solutions so far. The situation in the People's Republic of China and Latin America is still unclear.

A wide variety of DVB-T terminals are in use today. In addition to TV receivers with built-in DVB-T front-ends set-top-boxes with or without hard disc are marketed. DVB-T PCI cards and USB boxes for stationary personal computers as well as PMCIA modules for laptops are available. Portable integrated TV receivers with LCD displays and built-in rechargeable batteries are sold in countries like Germany where DVB-T is used to provide "television anywhere." Among the most fascinating DVB-T receivers are those for cars which are either available factory assembled or as after market products. DaimlerChrysler for example offers DVB-T receivers factory assembled for the Mercedes-Benz S-Class for the German market. The quality of the receivers in conjunction with the antenna system integrated into the car is such that even at the very highest driving speeds perfect DVB-T reception is achieved.

V. Data Broadcasting

The transport layer used by the DVB broadcast systems is the MPEG-2 transport stream to which adaptations have been developed which enable the transmission not only of audio and video but also of any other digitally coded information. To denote this, the picture of the data container (Fig. 2) is often used. The data container can be seen as a visual representation of the multiplex. Depending on the usable data rate of the broadcast channel, the size of the container varies. The blocks identified as program specific information (PSI) and service information (SI) are important for the housekeeping inside the data container.

Data services can be either program related or totally independent of any other service in the multiplex. Examples of program related data services are teletext or other applications, giving additional information about the current program. In addition to these kind of services, there are those that are not linked to a specific program and thus form an independent part of the multiplex. Possible areas of use are software download, MHP applications, information services, or EPGs. In Europe, DVB data broadcasting is used to offer fast Internet access services for example via satellite. Users of these

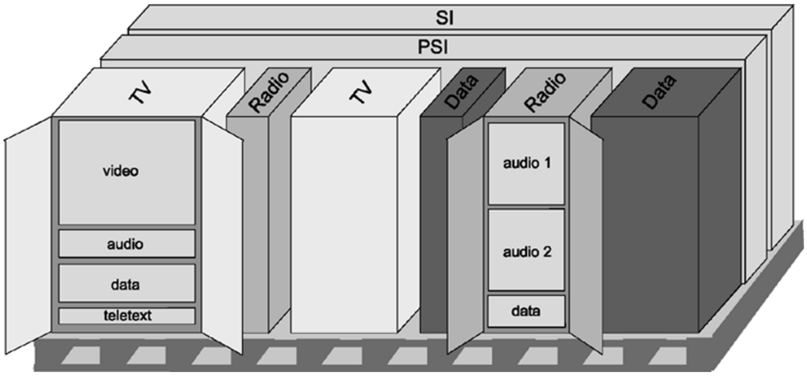

Fig. 2. Components inside the DVB data container.

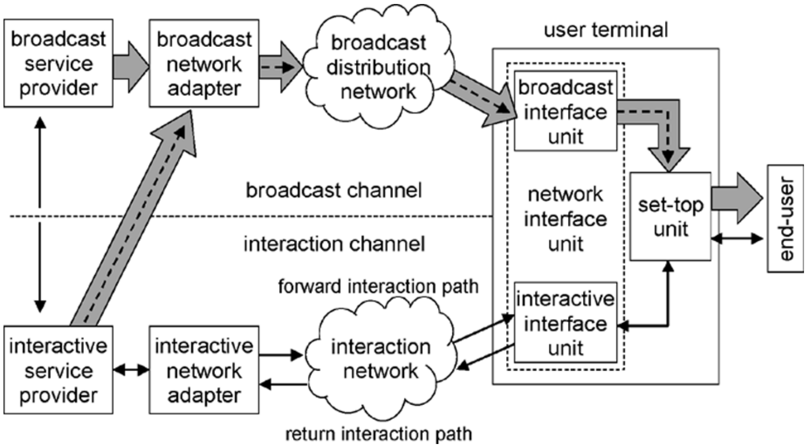

Fig. 3. Generic system reference model used by DVB for interactive services.

services connect their computers to the Internet via standard telephone modems but in addition install a satellite receiver card into their PCs which then provides an additional broadband downstream via which the Internet service provider delivers Web content requested on the modem connection.

Irrespective of the kind of service the digital data represents, it can be inserted into the MPEG-2 transport stream (TS). But depending on the needs of the application (e.g., exact timing of presentation, synchronization with other services), additional provisions have to be made in order to ensure a correct transmission and to guarantee that the receiver understands the transmitted service. In consequence, four ways of transmission were defined by DVB in [15]: data piping, data streaming, the use of a data or object carousel, and multiprotocol encapsulation.

For various reasons, manufacturers of DVB receivers wish to be able to update the software included in products which are already in the homes. The DVB specification for system software update (SSU) provides the tools to do this. The specification includes two profiles. The “simple profile” describes the signaling of either a proprietary data transfer format or a standardized DVB data carousel. The second profile defines the update notification table (UNT), which provides a standard mechanism for carrying additional data, e.g., update scheduling information, extensive selection, and targeting information or filtering descriptors. Both the simple profile and the UNT-based profile are described in one single document [17].

VI. Interaction Channels

Interactive services may require varying levels of interaction between the user and the service provider or the network operator. The most basic form of interactivity called ‘local interactivity’ can be achieved within the user terminal. For local interactivity, data belonging to certain interactive services is transmitted and stored in the terminal. That terminal can react to the inputs of the user for instance via the standard remote control without requiring further exchange of data across the network.

The requirement of providing an interaction channel across the transmission network was established by the desire to enable the user to respond in some way to the interactive service and by the necessity of the service provider or network operator to listen and possibly react to that response. The user’s response may take the form of some simple commands, like voting in a game show or for purchasing goods advertised in a shopping program. On the other hand, interactive services are conceivable which require that the user is able to have full Internet access at the receiver. Fig. 3 shows the generic system reference model which DVB uses for the definition of technologies for interactive services.

Table 2
Set of Specifications for Interaction Channels in DVB

	DVB acronym	Standard	Implementation guidelines
Network-independent protocols for interactive services	DVB-NIP	ETS 300 802	TR 101 194
Interaction channels			
• PSTN/ISDN	DVB-RCP	ETS 300 801	
• DECT	DVB-RCD	EN 301 193	
• GSM	DVB-RCG	EN 301 195	
• GPRS	DVB-RCGPRS	ES 202 218	
• CATV	DVB-RCC	ETS 300 800, ES 200 800	TR 101 196
• LMDS	DVB-RCL	EN 301 199	TR 101 205
• Satellite	DVB-RCS	EN 301 790	TR 101 790
• SMATV	DVB-RCCS		TR 101 201
• Terrestrial	DVB-RCT	EN 301 958	

Adding interactivity to the DVB infrastructure requires the system to be extended by components providing communication means between the end user and the provider of the interactive service. The interactive service provider can be related to the broadcast service provider or even be the same organization. In any case, it can make use of the high bit-rate DVB broadcast channels in delivering information to the user of the interactive service at typical rates of up to 20 Mb/s per channel in terrestrial broadcast networks, and up to 38 Mb/s per channel in broadcast networks via satellite or cable. The transmission capacity of the interaction channel depends largely on the type of network that is used. It may range from a few kilobits per second if a simple telephone modem is used to more than 10 Mb/s via an interaction channel in cable networks. The set of DVB specifications for interactive services describes solutions for a variety of possible interaction channels. Table 2 lists the DVB specifications of these interaction channels in addition to the specification of the network independent protocols which are to be used in each of them.

VII. The Multimedia Home Platform

In an era of convergence in media and networks, the DVB member organizations were convinced that the specification of a transport platform alone was not sufficient for the next generation of broadcast related services and for interoperable user terminals. Based on the experience in the Internet world, the demand grew for true multimedia services offered to TV users. With the Internet people are used to the fact that various platforms and user terminals render services differently and provide varying functionality although all main functions are based on widely accepted and deployed standards—one example would be browsers. Such behavior

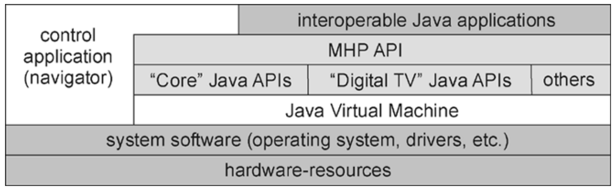

Fig. 4. Basic MHP architecture.

is not acceptable for TV-based services where viewers expect a consistent look, feel, and behavior of "applications." The word application stands for something, which would be called a software "program" in the PC world. Since the word program is used for TV content in the world of broadcasting a new term needed to be defined: application. Therefore, the DVB consortium set itself the goal of specifying a technical solution for the user terminal enabling the reception and presentation of applications in an environment that is independent of specific equipment vendors, application authors, and broadcast service providers. The result of the development was the MHP, which is specified in [18] and described in detail in this issue [7].

One way of looking at MHP is depicted in Fig. 4. The basic architecture of MHP starts from hardware resources and system software which a manufacturer will chose according to his own product specifications. On top of the system software MHP operates a Java virtual machine (VM) which provides various application programming interfaces some of which are based on elements of PersonalJava whereas others were developed to accommodate specific requirements of digital TV. The total set of APIs creates the MHP API on which interoperable applications which are broadcast to the MHP terminal can be executed.

MHP is a very complex system whose complete description is beyond the scope of this paper. Suffice to say that the standard includes many more aspects than those shown in Fig. 4. Among these aspects are transport protocols for both the broadcast and the interaction channel. There are formats of static and dynamic content that may be part of a MHP application. MHP uses a lifecycle model which defines the various states in the life of an application downloaded to the receiver. There are the signaling protocols including an application information table which informs the receiver about the available applications. A sound security framework is defined since applications running on a receiver could potentially do much harm to the device. A graphics reference model exists by which a consistent look and feel of applications running on receivers manufactured by a variety of companies can be guaranteed, etc.

MHP is a solution addressing what is called a "horizontal market." This term implies that a customer can buy a receiver, which is MHP compliant and use it to run all the MHP applications currently on air—irrespective of where these applications originate. Considering the enormous complexity of the MHP specification it becomes clear that such interoperability was difficult to achieve. The key tools to achieve interoperability in practice are the MHP standard itself, the MHP test suite and the related self-certification program. The latter two were developed by DVB and its member companies. Implementers of MHP compliant devices can get the test suite from a custodian, test their implementation and certify to the custodian if and when they will be able to guarantee interoperability. They then will be granted the right to use the MHP logo on their device.

Not surprisingly, the development of the MHP was carried out with those countries and broadcasting organizations in mind which use the complete DVB line-up of technologies and standards. The MHP therefore relies, for example, on the DVB broadcast channel protocol stack. When the specification was finished and, very importantly, when it could be demonstrated to the world in 2002 that DVB had created an open standard and had solved the many surrounding problems related to intellectual property, testing, self-certification, etc., organizations which were not part of the original activities showed an interest in adopting MHP. The problem is that the DVB protocol stack is not being used in its entirety in countries such as the United States. Instead, transport layer protocols had been developed and successfully put in use in Japan and in the United States, which are not DVB compliant. The adoption of the MHP in these parts of the world therefore required modifications of the original version of MHP.

The DVB Project created an activity aimed at the joint development of a specification now known as the Globally Executable MHP (GEM) upon the request of organizations, who offer services not fully in line with the DVB system but are interested in the use of the MHP in their networks [19]. This document in conjunction with the MHP specification itself creates a complete software platform which can be incorporated in, for example, cable networks in the United States (OCAP) or in terrestrial broadcasting networks in the United States (ACAP) and in the broadcast networks in Japan (ARIB Std B-23). Where required, GEM defines functional equivalents to what the DVB stack includes and therefore "glues" the MHP into non-DVB systems.

In 2005 DVB started to develop what is called a "storage media target" of the MHP and GEM upon request of the developers of one of the potential DVD successor systems.

VIII. DVB Over IP-Based Networks

Broadband access networks based on IP have become available in many parts of the world. DSL and interactive cable are on offer today. WiMAX networks promise to deliver broad-band services even to remote homes. Fiber to the home and VDSL is expected to be deployed in some geographical areas over the next few years. Elsewhere fiber connections will move steadily closer to the home. DSL is becoming an n Mb/s access technology where n $(1 < n < 25)$ depending on the length of the local loop. Overall, broad-band connections are expected to deliver steady improvement in available capacity to consumers. It is this area which DVB addresses with specifications providing DVB-services over IP-based networks. DVB developed an architecture of an open IP infrastructure upon request from network operators, manufacturers, and a number of broadcasters wishing to offer their content to customers that they can not reach via classical broadcast networks.

The first deliverable of DVB in this field is the specification which describes the transport of MPEG-2 based DVB services over IP-based networks [20]. This specification and its features are described in detail in [6] in this issue. Whereas MPEG-2 based DVB services are readily available for instance on cable networks, the geographical reach of which can be extended using broad-band IP networks, it is clear that neither the MPEG-2 transport stream as a transport platform nor the traditional methods of audio and video coding are ideally suited to these networks. In consequence a specification is being developed in 2005 in which the stack of protocols typical for broad-band IP networks and the most recent audio and video coding schemes as described in Section III of this paper are connected to form an open platform for the delivery of DVB services. As in the existing specification a major effort is going into an open and nonproprietary solution for service discovery and service selection. Both specifications promise that the customer can buy a DVB-compliant terminal device from any manufacturer to connect to his/her broad-band IP network and receive the services offered via a service guide based on the service discovery and service selection mechanism.

With the advent of home servers and multiple terminals used in one apartment or house, home networking is becoming more and more important. In order for home networks to be interoperable DVB defined an IEEE1394 home network segment and an Ethernet home network segment. Work on the creation of a wireless home network segment is expected to be finalised in 2005.

IX. DVB-Handheld

In many countries, the decision to select DVB-T for terrestrial television was based on some very specific features of the DVB-T standard which enable its use outside the typical living room environment, among them the possibility to also receive broadcast services with portable devices and even in cars and trains traveling at high speed. In consequence, the benefits of such a terrestrial broadcast system attracted the interest of the mobile communications industry. In particular, the ability to reach mobile terminals via a wireless point-to-multipoint link, in connection with a wide geographical coverage and high transmission capacity are features which sparked the interest of this industry.

DVB responded to the industry interest by specifying a new transmission standard: digital video broadcasting—transmission system for handheld terminals (DVB-H). DVB-H is the latest development within the set of DVB transmission standards. Work on the technical specification started in autumn 2002 and was finalized in February 2004. The DVB-H set of standards was published by the European Telecommunications Standards Institute (ETSI) in November 2004 [21]. DVB-H is described in detail in [4] in this issue. Since 2003 field tests with DVB-H are under way in many parts of the world, including the United States.

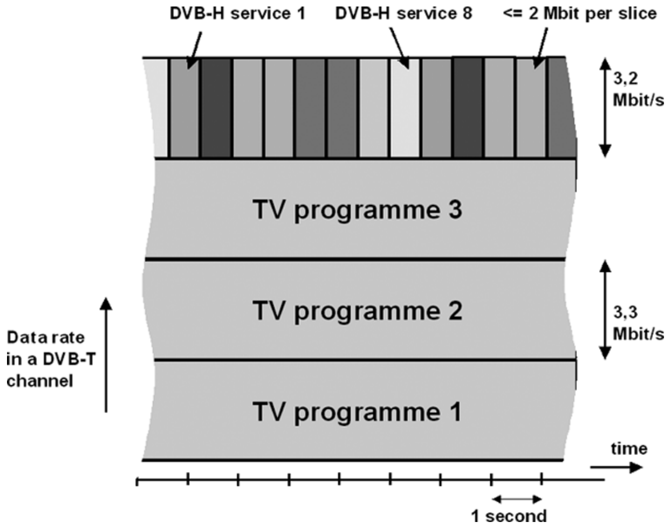

Fig. 5. Possible split of the capacity of one DVB-T channel between three TV programs and an additional eight DVB-H services.

The DVB-H technology is a spin-off of the DVB-T standard. It is to a large extent compatible with DVB-T but takes into account the specific properties of typical terminals, which are expected to be small, lightweight, portable, and—very importantly—battery-powered. DVB-H can offer a downstream channel at high data rate which can be used stand-alone or as an enhancement of mobile telecommunications networks which a typical handheld terminal is able to access anyway. DVB-H thus creates a bridge between the classical broadcast systems and the world of cellular radio networks. The broadband, high capacity downstream channel provided by DVB-H features a total data rate of several megabit per second and may be used for audio and video streaming applications, file downloads, and for many other kinds of services. The system thereby introduces new ways of distributing services to handheld terminals, offering greatly extended possibilities for content providers and network operators.

Among the various requirements which need to be fulfilled by a broadcast service addressing handheld terminals the following are of special relevance: due to the fact that handheld terminals operate from batteries with a very limited capacity, the DVB-H front-end needs to consume as little power as possible. The need to operate with small, possibly built-in antennas calls for a very robust transmission signal. The reception needs to be possible at very high speed of travel.

Fig. 5 shows the time slicing feature of DVB-H by way of an example. Time slicing enables significant power savings in the receiver relative to the power consumption of a DVB-T receiver. What is shown is the data flow in a DVB-T channel as a function of time. The parameters used to set up this channel are typical for the use of DVB-T in Germany where a DVB-T channel delivers some 13.2 Mb/s. In Fig. 5 it is assumed that about three quarters of the DVB-T data rate is allocated to three TV programs. The remaining 3.2 Mb/s are used for DVB-H services. In contrast to the TV programs which require a continuous flow of data the DVB-H capacity is divided into 8 individual services each occupying what is

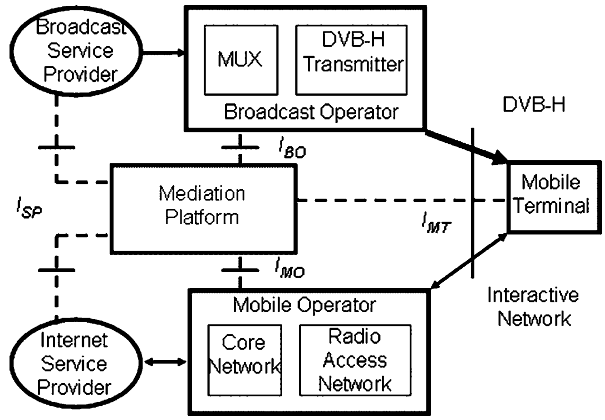

Fig. 6. Architecture of the IP datacast system.

called a time-slice in the DVB-H terminology. The service data rate available for each of the 8 services is easily calculated as $3.2\ \text{Mb}/8 = 0.4\ \text{Mb/s}$. During each time slice 2 Mb are transported to the receiver which in consequence means that the duration of the time slice is $2/3.2 = 0.625$ s. A receiver tuned to service no. 1 can go into power save mode for the period of time during which services no. 2 to 7 are being transmitted. In the example shown this is equivalent to 4.375 s. Taking into account a certain wake-up time required to turn the receiver on again (for example 0.2 s) the ratio of the power consumption of the time slice receiver and that of a receiver turned on continuously can be calculated as $(0.2\ \text{s} + 0.625\ \text{s})/(8 * 0.625\ \text{s}) = 0.17$.

The term IP datacast is used by DVB for a system under development which integrates DVB-H in a hybrid network structure consisting of both a mobile communications network such as GPRS or UMTS and an additional DVB-H downstream. The architecture of the complete system is shown in Fig. 6.

The IP datacast system is highly complex due to the wide range of functionalities that have to be addressed in order to support for example the following usage model. The owner of an IP datacast mobile terminal switches on the device. Immediately, this device identifies the available services via an electronic services guide (ESG). The user orders one of the available services via a secure transaction with the service provider who decides whether a part of the DVB-H downstream will be allocated to provide the service or whether the service will be made available via the interactive network only. In order to take this decision a popularity measure of the requested service will be created which allows optimized allocation of the DVB-H capacity in view of the number of active users in a given coverage area. Audio and video as well other data are transported to the mobile terminal using standardized media formats and transport protocols. Content protection is provided such that only those users who have paid for the service have access to it. A negotiated level of quality of service is guaranteed. If the user moves then the handover both in the interactive network as well as in the DVB-H network are managed seamlessly. The IP datacast specification will provide solutions for all the issues mentioned. It will be forwarded to one of the standardization organizations in the third quarter of 2005.

X. Prospects of the Future Developments in DVB

The world is becoming a "connected planet." Networking and access to content is becoming ubiquitous. In most developed nations, the impact of the Internet, mobile communications, and digital broadcasting is having a powerful and direct influence on people's lives—both at work and at home. However, some of the indirect effects are also creating new opportunities and greater demands for further innovation as one perceives profound changes in the structure of certain industries, the business models under which they operate and the expectations of consumers in how they wish to use digital media. DVB responds to, and embraces, this new thinking. The consequence of ubiquitous access to media content means that the current mechanisms of binding rights to devices (smart cards, storage devices) will need to be replaced by mechanisms that bind content rights to the individual—the concept of the authorized domain which is one of the fundamental elements underlying the work of DVB on content management and copy protection captures that thinking. Peer-to-peer technology will also enable personal content to be created and distributed in a way that may need to utilize DVB specifications. Related technologies that may become important include "presence"—the convergence between mobile and static use of networks to understand a person's current location, availability, and preferred method of communication at that moment, e.g., a mobile phone or a DVB-H terminal.

In the area of media content storage consumers will soon face the problem of the "infinite attic." They can store data and media to their heart's content, but can find nothing when they need to retrieve it. They will need content management tools and techniques that label items as they store them and search for multimedia data. Content recognition, fingerprinting, classification, and intelligent management of distributed (networked) stored content become important. Portable video players are now emerging where content is delivered or updated via fixed or mobile IP networks. More and more examples will emerge of these kinds of requirements over the coming years. DVB decided to be ready to respond to the market opportunities where its competence and its members' resources can be applied successfully.

The vision for DVB, over the next phase of its development, is to be an enabling forum for precompetitive standards setting in the "connected world" of networked digital media and applications. Broadcasting is about the creation, management, storage, delivery, and consumption of valuable content. Initially, DVB concentrated on broadcast delivery, then on the development of interactivity-capability in receivers (MHP). The focus is now moving to the content itself—content protection and copy management, portable content formats and TV anytime/anywhere. This should include the contribution side, including professional services, as well as the consumer-focused distribution side. If valuable content is to be made readily accessible over a range of networks, it will need to be provided in a descriptive and protective package that can interact with diverse discovery, payment, and delivery systems.

XI. Conclusion

Over more than 14 years, DVB developed a significant number of technical solutions to commercial, scientific, and engineering problems. Over time the list of requirements developed significantly and therefore the activities of DVB reflect the changes in the industry since the early 1990s. The first DVB solutions can be considered fundamental enablers of digital broadcasting. The work ongoing in 2005 is much more devoted to finding solutions for ubiquitous access to content wherever it may be and on whatever network it may be available.

The success of DVB is the success of literally hundreds of companies and organizations and of hundreds of people working in the commercial, legal, technical, and PR departments of these companies. A meeting of the DVB technical module (TM) is typically attended by some 90 engineers. The meetings of the 11 *ad hoc* groups of the TM which are active in early 2005 bring together some 200 people. Therefore, it is certainly fair to say that DVB is an example of a truly international organization in which an elite of people works very hard to foster the progress of our industry.

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Ulrich H. Reimers (Fellow, IEEE) studied communication engineering at Technische Universitaet Braunschweig (Braunschweig Technical University), Braunschweig, Germany. Following research at the University's Institut fuer Nachrichtentechnik (Institute for Communications Technology) he joined BTS Broadcast Television Systems in Darmstadt. Between 1989 and 1993 he was Technical Director of Norddeutscher Rundfunk (NDR) in Hamburg—one of the major broadcasters in Germany. Since 1993 he has been a Professor at Technische Universitaet Braunschweig and Managing Director of the Institut fuer Nachrichtentechnik (Institute for Communications Technology). Prof. Reimers is chairman of the Technical Module within the DVB Project and a board member of Deutsche TV-Plattform (the German institution coordinating the interests of all organizations involved in TV). He is the author of more than 100 publications—among others, of various textbooks on DVB.

Prof. Reimers was awarded the Montreux Achievement Gold Medal in 1995 for his contributions to the development of the DVB technology. In 1998 he received the IBC John Tucker Award and was made an Honorary Fellow of the Royal Television Society of the United Kingdom. In July 1999 he received the J. J. Thomson Medal of the Institution of Electrical Engineers (IEE). In June 2000 he was awarded the 1st Class Cross of Merit of the Lower Saxony (Germany) Order of Merit. In October 2000 he was awarded a Diploma of Honor of the National Association of TV and Radio Broadcasters (HAT) of Russia. In June 2001 he was the recipient of the Leibniz Ring and of the IEEE Masaru Ibuka Consumer Electronics Award. In September 2002 he received the IEEE Consumer Electronics Engineering Excellence Award 2002. In May 2004 he was awarded the Richard-Theile-Medaille of FKTG in Germany.