Digital Video Broadcasting (DVB) the future of television

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Introduction

Digital Video Broadcasting (DVB) has become the synonym for digital television and for data broadcasting world-wide. DVB services have recently been introduced in Europe, in North- and South America, in Asia, Africa and Australia. This article aims at describing what DVB is all about and at introducing some of the technical background of a technology that makes possible the broadcasting of „datacontainers“ in which all kinds of digital data up to a datarate of 38 Mbit/s can be transmitted at bit-error rates in the order of 10^{-11}.

The development of standards for DVB, as well as the preparation for the introduction of services, is co-ordinated by the Project on Digital Video Broadcasting ("DVB Project"). Techniques for the transmission of DVB signals via satellite have been devised as well as a specification for retransmission of DVB signals via cable and (S)MATV networks. Among the more recent achievements are the standard for terrestrial transmission, for microwave distribution and for interactive services via PSTN/ISDN and via (coaxial) cable. A standard describing service information, a common scrambling system, and several other tasks have been finalised.

1. The DVB Project

The DVB Project was officially inaugurated in September 1993. It was preceded by what, at that time, was called the "European Launching Group for Digital Video Broadcasting". The project consists of a voluntary group of currently more than 200 organisations which have joined forces to make possible the development of standards for DVB, as well as the early introduction of DVB services. The partners have signed a Memorandum of Understanding which describes the goals of the project. The whole activity is neither funded nor controlled by political bodies but instead has developed its own objectives, policy and rules of procedure, based on the acknowledgement that today's broadcast and electronic media environment requires market-led approaches to new technical developments.

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The members of the DVB Project can be seen as representing four constituencies, namely the manufacturing industry, broadcasters and program providers, network and satellite operators and, last but not least, regulatory bodies, among them the European Commission. The Steering Board, chaired by Drs. Theo Peek (Philips, NL), receives regular reports from four modules and ad-hoc groups. The Commercial Module is responsible for formulating "user requirements" which - in contrast to many such requirements in other bodies - should be commercially orientated. A specific module deals with all issues related to Intellectual Property Rights (IPR). The "Promotions and Communications Module" is responsible for publicising the newsworthy achievements of the DVB Project and for the important relationship with numerous bodies in the world interested in introducing DVB. Finally, the Technical Module, chaired by the author, is the body which is concerned with technical development and with compiling the specifications. This Technical Module includes engineers from approximately 75 organisations. Currently nine subgroups are in charge of dealing with specific design tasks.

2. Scope of the Activities and Current Status

In the course of recent years the DVB Project has very successfully developed an impressive catalogue of specifications for Digital Video Broadcasting. As a matter of fact, the term "Digital Video Broadcasting" has even become too restricted, since DVB specifications can be used for broadcasting all kinds of data as well as sound accompanied by all kinds of auxiliary information. Some of the specifications aim at the installation of bi-directional communication channels, for example, using cable installations. To those readers interested in some introductory paper describing the DVB environment globally and/or in detail the following reading is recommended [1], [2], [3].

2.1 Baseband Processing

The transmission techniques developed by DVB are transparent with respect to the kind of data to be delivered to the customer. They are capable of making available bitstreams at (typically) 38 Mbit/s within one satellite or cable channel or at 24 Mbit/s within one terrestrial channel. On the other hand a digital video signal created in today’s TV studios comprises of 166 Mbit/s and thus can not possibly be carried via the existing media. Datarate reduction or „source coding“ therefore is a must for digital television.

One of the fundamental decisions which were taken during the early days of DVB was the selection of MPEG-2 for the source coding of audio and video and for the creation of programme elementary streams, transport streams etc. - the so-called systems level. Three international standards describe MPEG-2 systems, video and audio. Using MPEG-2 a video signal can be compressed to a datarate of for example 5 Mbit/s and still can be decompressed in the receiver to deliver a picture quality close to what analogue television offers today.

Figure 1 demonstrates the effects of data compression where each possible compressor is symbolised by a small funnel. For DVB the wanted quality levels range from SDTV (Standard Definition TeleVision) via EDTV (Enhanced Definition TeleVision) to HDTV (High Definition Television). SDTV means images which - in terms of technical quality - are roughly comparable to those of today's analogue television services. EDTV is equivalent to what the vision engineer in a modern studio may be able to see locally today. HDTV stands for a future generation of TV service with an image quality approaching that of today's cinema.

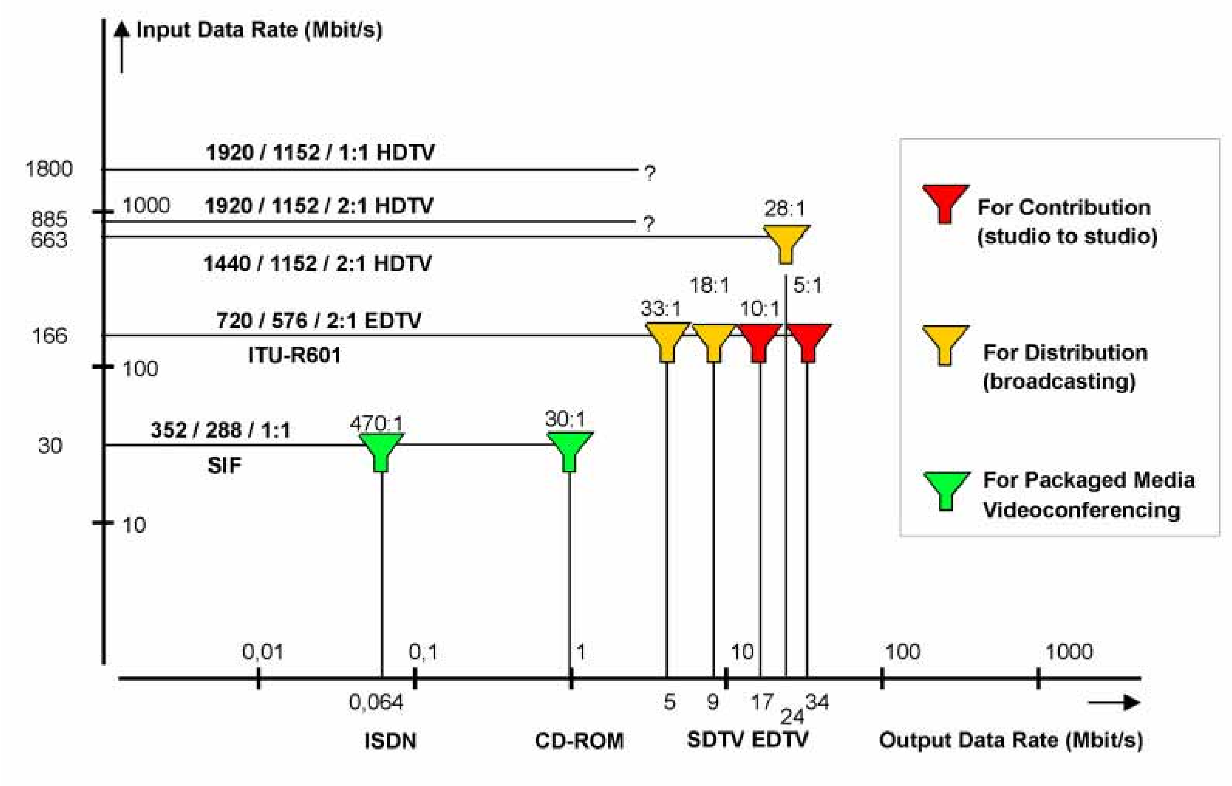

Figure 1: Reduction of the video datarate for DVB and other applications

In analogue 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 deriving information from Teletext pages. Since for many years to come the existing TV receiver concepts will be used to display DVB services which have been received and decoded by a "black box" (the so-called Integrated Receiver Decoder - IRD) connecting the satellite LNB (Low-Noise Block Converter), the cable outlet or the rooftop aerial to the existing receiver, a mechanism needs to be provided which enables the delivery of "analogue" Teletext to the receiver via DVB. This mechanism has been termed DVB-TXT.

In many countries it is customary to broadcast TV programmes with the original soundtrack and to provide a translation into the local language in the form of subtitles. It is also customary to add graphic elements to the transmitted images like, for example, station logos etc. A powerful mechanism was designed which allows the transmission of all kinds of subtitles and graphic elements as part of the DVB signals.

Future DVB services will consist of a wide variety of programmes carried via a large number of transmission channels. In order for the IRD to be able to tune to such channels and in order for the DVB customer to be able to navigate the profusion of programmes, powerful navigational aids need to be provided as part of the DVB streams. "Service Information" constitutes such a set of aids (DVB-SI). A set of guidelines describing how the SI should or could be used increases the value of the SI. SI codes indicating services by different broadcasters are listed in a separate European Telecommunications Report (ETR).

2.2 Transmission

Technical specifications for the transmission of the baseband signals, as described in paragraph 2.1, via all sorts of broadcast delivery channels have been among the principal deliverables of the DVB Project.

The first specification which could be finalised was that for the satellite delivery of DVB signals entitled DVB-S. In this document, for the first time, different tools for „channel coding“ were described which later on became important for all other delivery media as well.

The term „channel coding“ is used to describe the algorithms used for adaptation of the source signal to the transmission medium. In the world of DVB it includes the FEC (Forward Error Correction) and the modulation as well as all kinds of format conversion and filtering. Key to the success of the DVB transmission specifications is the concept of the QEF-(Quasi-Error-Free-) transmission of digital signals. QEF implies that practically no errors occur in the end-to-end relationship between transmitter and receiver. In reality, QEF means that less than 1 bit in 10^{11} bits transmitted over the channel may be erroneous. This very strict requirement is a result of the fact that the baseband signals are extremely vulnerable due to the fact that they have been subject to datarate reduction. One erroneous bit - affecting the most critical part of the baseband signal - therefore may cause a very considerable deterioration of the image or sound quality over a relatively long period of time. If on the other hand the bit error rate is reduced to 10^{-11}, in each individual DVB program of SDTV quality one erroneous bit will occur only every 5 hours.

In order to achieve such a high level of protection of the transmitted signal against the adverse effects occurring in real transmission channels affected by noise, multipath signals, echoes, interference and non-linearity DVB has defined a „concatenated coding“ of the baseband signals. Two FEC systems (Reed-Solomon coding as the „outer“ FEC and punctured convolutional coding as the „inner“ FEC) are used in concatenation within the channel encoder on the transmitter side. In between the two systems the signals are interleaved. This means that consecutive bits leaving the outer FEC circuitry are spread over a certain period of time before the resulting bitstream is then protected by the inner FEC. If this interleaving is then revoked within the IRD bursts of errors that may have occurred during transmission will be turned into single errors spread over the datastream which can be easily corrected by the outer FEC.

The DVB-S specification has enabled the start of DVB services via satellite in all parts of the world. Using this specification a datarate of typically 38 Mbit/s can be accommodated within a satellite channel of 33 MHz bandwidth transmitted down to earth by a so-called transponder. A typical satellite uses 18 such transponders and thus may deliver 684 Mbit/s to a small (60 cm diameter) satellite dish (**Figure 2**).

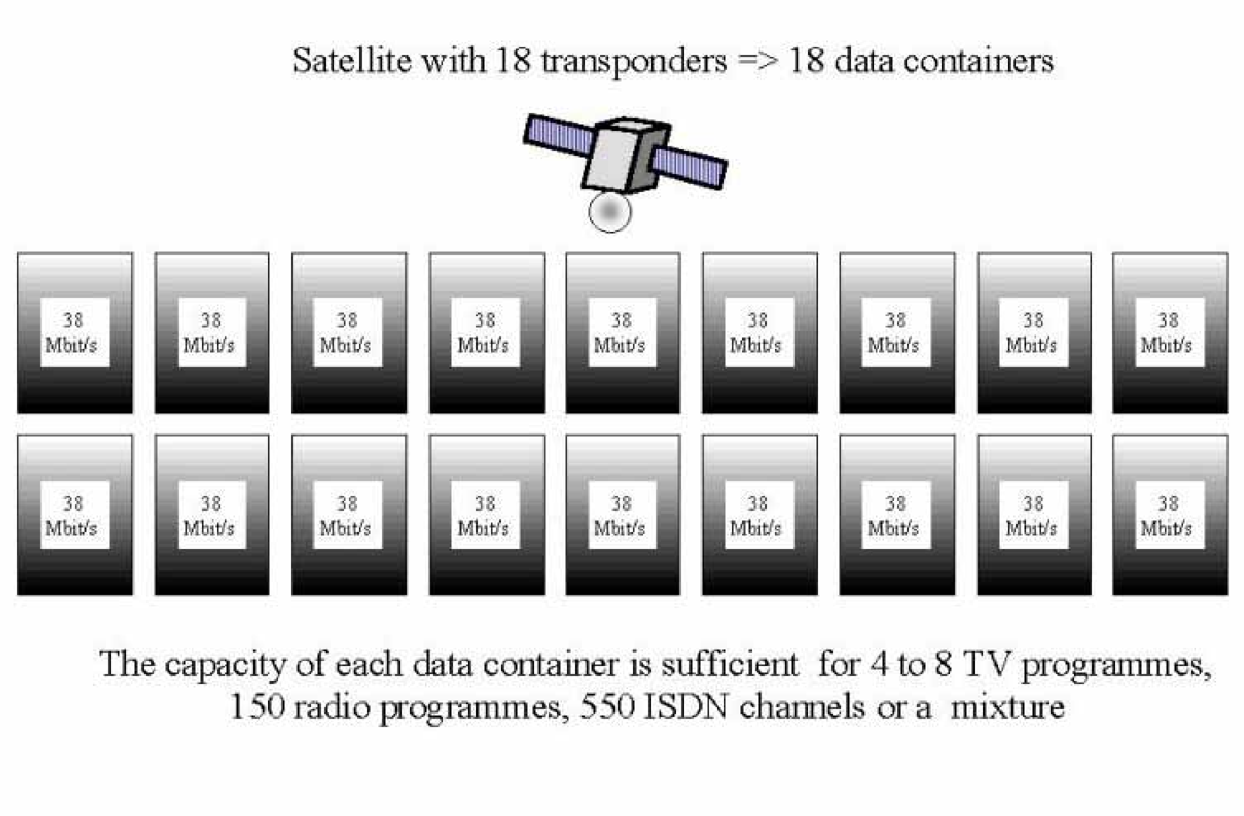

Figure 2: Transmission of DVB signals via satellite

Another specification describes channel coding and modulation for DVB signal delivery on cable [CATV] systems (DVB-C). This document forms the basis of a third one, in which the use of (Satellite) Master Antenna TV ([S]MATV) installations for DVB is described (DVB-CS).

The use of terrestrial transmission for DVB is currently (spring 1997) being prepared in several European countries - most actively in the United Kingdom. The specification relevant to this application was finalised in early 1996 and became a European Telecommunications Standard in the spring of 1997.

If Microwaves are used for the delivery of DVB signals, two specifications can be chosen for the Multichannel Microwave Distribution System (MMDS), depending on the frequency range applied. The first describes MMDS for use at 10 GHz and above (DVB-

MS). This transmission system is based on the use of the DVB-S technology. The second is applicable to MMDS transmission at frequencies below 10 GHz. This standard is based on DVB-C technology and therefore has been termed DVB-MC.

2.3 Conditional Access

In many cases DVB-based services will either be of the „pay“ type or will at least include some elements which are not meant to be freely available to the public at large. The term „Conditional Access“ is frequently used to describe systems that facilitate the control of the access to programmes, services etc. Conditional Access (CA) systems consist of several blocks, among others, the mechanism to scramble the programme or service, the „Subscriber Management System (SMS)“, in which all customer data are stored, and the „Subscriber Authorisation System (SAS)“ that encrypts and delivers those code words which enable the descrambler to make the programme legible.

It was one of the strategic decisions made by the DVB Project that neither SMS nor SAS should be standardised. The only part of a CA system which was developed jointly by members of DVB is the „Common Scrambling Algorithm“, a powerful tool to make secure scrambling of Transport Streams or Programme Elementary Streams possible. Due to the special nature of this system it is not disclosed to the public in detail. The specification can be obtained from a „custodian“.

All other parts of CA systems for DVB are offered in the form of several competitive, commercial products which are marketed by DVB members.

In order for an Integrated Receiver Decoder to be able to descramble programmes which have been broadcast in parallel, using different CA systems, a „Common Interface for Conditional Access and other Digital Video Broadcasting Decoder Applications“ can be incorporated into the IRD. Through the insertion of a PCM/CIA module into that interface, different CA systems can be addressed sequentially by the IRD. The term „MultiCrypt“ is used to describe the simultaneous operation of several CA systems.

Another way of providing the viewer with access to programmes which have been processed by different CA systems is termed „SimulCrypt“. In this case commercial negotiations between different programme providers have led to a contract which enables the viewer to use the one specific CA system built into his IRD to watch all of the programmes, irrespective of the fact that these programmes were scrambled under the control of one of several CA systems. A basic contract to enable SimulCrypt is described by a „Code of Conduct“. The specification describing how the interaction of CA system components needs to be performed in order for SimulCrypt to become practical is a very recent result of the DVB work.

It is one of the goals of the DVB Project to help create European „Anti-Piracy Legislation“, which should make provisions for strict penalising of so-called "pirates" for the breach of CA systems. A proposal for such legislation was created and forwarded to all relevant European regulatory bodies.

If scrambled programmes received via satellite and terrestrial transmission are to be fed into cable networks it may in certain cases be advisable for the operator of that cable to change the CA system in order for all the programmes in his network to be under the control of only one CA system. The process of changing the CA system at a cable head end is called „Transcontrol“ and is supported by the DVB Project.

2.4 Interactive Services

Many of the services possible in the DVB world will require some form of interaction between, for example, the user and either the programme provider or the network operator. This interaction may consist of the transmission of just a few commands but may also be extensive and may thus resemble communication via the Internet.

In DVB the tools for enabling interaction have been generally split into two sets. One is network-independent and can be regarded as a protocol stack which approximately extends via ISO/OSI layers two to three. An important part of this stack was derived from the Digital Storage Media Command Control (DSM-CC) protocols created by MPEG. A separate document was created as a "guideline" in order for users to be able to understand and use this somewhat complicated stack.

The second group of DVB specifications relates to the lower layers (approximately one to two) of the ISO/OSI model and therefore specifies the network-dependent tools for interactivity. So far (spring 1997) two specifications have been created. The first describes ways to use Public Switched Telephone Networks (PSTN) and Integrated Services Digital Networks (ISDN) as physical networks for interaction. The second deals with a comprehensive solution for the use of CATV networks for the same purpose. In the near future additional specifications will be designed which connect (S)MATV systems to the outside world of interactivity and which can be used for the interaction channels accompanying terrestrial DVB.

2.5 Miscellaneous

One of the strengths of DVB technology lies in the fact that it enables the point-to-multipoint transmission of very large amounts of data at high data rates while very securely protecting them against all kinds of transmission errors. These data may be audio and/or video but in many applications the data will be files or other forms of generic information. In order to enable the transmission of such kind of data, including the possibility of repeat transmissions of the same data at regular or irregular time intervals, a specification for data broadcasting has recently been developed. This specification is intended as a preferable implementation of such a data broadcasting scheme. Other (proprietary) implementations may coexist. The specification knows four „application areas“ depicted in **Figures 3 and 4** (Data Piping, Data Streaming, Multiprotocol Encapsulation, Data Carrousel).

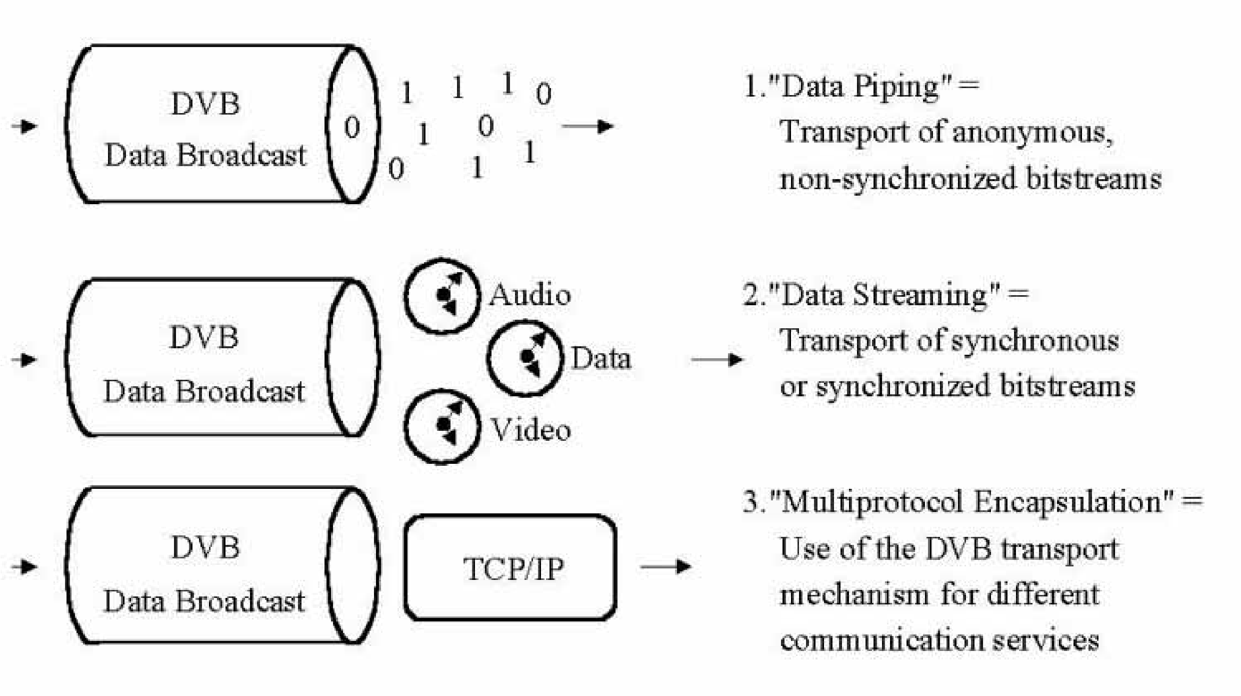

Figure 3: Application areas for DVB data broadcasting (1)

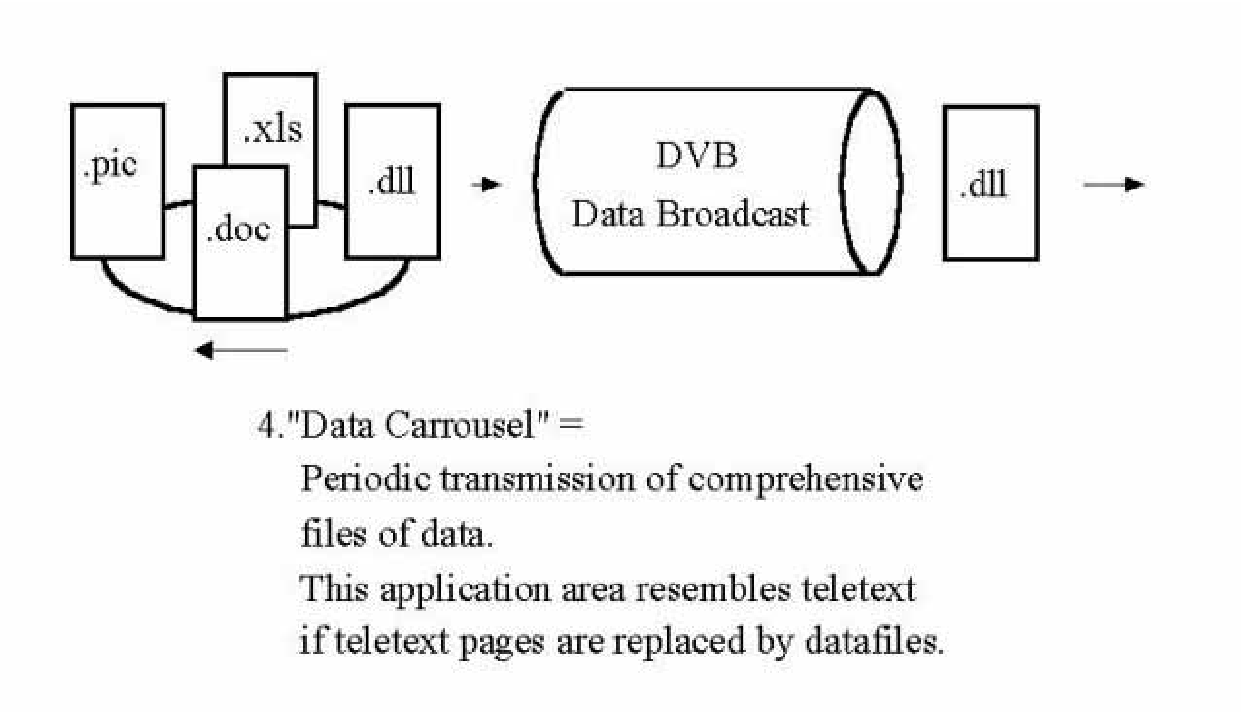

Figure 4: Application areas for DVB data broadcasting (2)

At the request of some broadcasters the DVB Project is currently considering the possible future designing of a set of specifications for Digital Satellite News Gathering (D-SNG). This set will most probably consist of some of the documents mentioned above plus some new tools, for instance, for enabling bi-directional communication between the personnel operating the D-SNG uplink and those operating the downlink.

Telecommunications networks will play an important role in connecting, for example, the playout centre of a broadcaster and the satellite uplink station in another city. Different types of networks (PDH, SDH) will be used for this purpose. The DVB Project has designed two interfaces which will be used to connect the world of DVB signals to PDH and SDH networks, respectively.

If terrestrial broadcast networks are to be laid out in the form of Single Frequency Networks (SFN), in which all the transmitters need to emit bitstreams exactly identical to each other at precisely defined instances of time, the feeding of these transmitters requires special care. A specification was drafted which describes a "megaframe" structure that serves the purpose of enabling the feeding of SFN.

DVB systems are new technology for equipment manufacturers, broadcasters and network providers. The testing and evaluation of such systems therefore require some form of guidelines. The "DVB Measurement Guidelines" were developed to distinguish meaningful from useless measurements and to help understand how measuring should be carried out.

Instead of specifying the architecture of the hardware needed in professional DVB installations and in the Integrated Receiver Decoders (IRD) or some form of operational software, for instance, the Application Programming Interface (API) of such units, the DVB Project, after lengthy discussions, decided at the request of the manufacturers that it would restrict its activities to specifying external interfaces only. Interfaces for the IRD have been specified. Interfaces for the use in cable head ends, satellite uplink stations and similar professional installations exist as well.

In order for the IRD to be able to interoperate with future types of storage media (DVD, DVC, D-VHS etc.) certain conditions must be met by the DVB data streams. These conditions relate, for example, to the maximum bit rate that may be used for the transmission of programmes, which in its turn is defined by the recording capabilities of the respective storage medium. These conditions were identified and included in the relevant DVB documentation.

3. Conclusion

A surprisingly large group of organisations in Europe has recently announced the start of DVB transmissions via satellite and on cable. New organisations are being founded in order to facilitate the start of services soon. But outside Europe DVB has also become very popular. Currently services based on the DVB developments are being initiated in many parts of the world, among others in Japan, Hong Kong, Thailand, Indonesia, Australia, South Africa, Canada and the U.S. It thus seems likely that endeavours originating in Europe - for the first time in decades - may help to unite the world of consumer electronics.

The work of the DVB Project has resulted in a comprehensive list of technical and non-technical documents describing solutions required by the market players in order for them to be able to make the best use of the new technology of broadcasting digital signals. These documents are the result of the co-operative efforts of many individuals who spent thousands of hours designing new solutions to new problems.

Many organisations have provided important contributions to the work of the project in that they have either made available some results of their work to DVB (MPEG, DAVIC) or in that they have co-operated with DVB in transforming specifications into standards and norms (ETSI, CENELEC).

Both the extremely valuable contributions by the many individuals and the co-operation by the organisations involved are highly appreciated.

The work of the DVB Project has reached a high level of maturity, but it has not ended yet. Numerous design activities are still ongoing. Among these activities is the compilation of a document which describes ways to broadcast High Definition TeleVision (HDTV) using the DVB solutions. Thus DVB is preparing the medium-term to long-term future of television just as it has, over the last few years, provided solutions for the immediate future of our business.

4. References

[1]: Reimers, Ulrich (ed.): Digitale Fernsehtechnik - Datenkompression und Übertragung für DVB. 2nd Edition. Berlin, Heidelberg, New York: Springer-Verlag , 1997.

[2]: Reimers, Ulrich: A Guideline for the Use of DVB Specifications and Standards, DVB-Document TM 1694, rev.1, September 1996.

[3]: Wood, D.; Satellites, science and success - The DVB story. EBU Technical Review No. 266 - Winter 1995. Pages 4 to 11.

Topical information on the DVB Project and its work can be found at
http://www.dvb.org/.