Abstract

Some basic concepts about electronic programme guides and what Philips is doing in the area are explained, followed by a more detailed explanation of some key components needed in such a system. By way of example, some aspects of the Philips system are highlighted, both on the receiver and the transmitter side. Special attention is given to the constraining character of the digital video broadcast environment; some challenging problems for the design of an electronic programme guide in such environments are explained, and solutions are sketched.

Keywords: digital television, electronic programme guides, user interface, service information.

1. Introduction

1.1. The Electronic Programme Guide

One of the terms that is heard most often in scenarios for future television systems is 'Electronic Programme Guide' (EPG). An EPG, as perceived by the user, is a tool for browsing through information about the television channels and programmes that are available. In its simplest form, it is merely a digital version of the programme listings one can find in daily newspapers; a more advanced version might combine such textual information with audiovisual information, and also provide a means to control different functions of the TV set or related products, for instance by allowing for automatic VCR programming.

When the research on EPGs started at Philips Research in Eindhoven, there were some more or less sophisticated EPG applications already deployed in analog television systems, with varying degrees of success. However, there is more reason to look closely at EPG applications in digital video systems, since
these systems provide both the necessity for and the feasibility of a mass deployment.

The *necessity* is caused by

- the expected number of channels in these systems. It is possible to have several times as many channels on the same cable if those channels are digitally compressed. If the user is to have any possibility to browse through the content of a few hundred channels, an on-screen programme guide will be more or less necessary. The large number of channels also makes it more necessary for the individual channels to advertise themselves to the user, for instance through the EPG;

- the increased flexibility in a digital system. In a digital TV system, there is not a one-to-one relationship between physical channels and television channels. For example, one physical channel could contain six television channels one day, and five the next. The EPG is expected to shield the user from this complexity by providing an intuitive user interface for selecting channels;

- the need to make the new digital video systems more attractive than the existing analog ones. In the end, the consumer will have to pay for the introduction of the new technology, and consumers will not want to pay more for less functionality.

The *feasibility* relies on

- the fact that digital video systems are inherently well suited for the combination of the television signals with ancillary data, such as could be used by the EPG;

- the fact that the deployment of digital video systems, at least in the near future, will rely on set-top boxes to convert the digital signal back to analog. Since these set-top boxes are a totally new product, no backwards compatibility problems have to be dealt with; since they are necessary to anyone who wants to decode the signal at all, they provide a convenient vehicle for the introduction of totally new services, such as EPGs;

- the large bandwidth provided by digital video systems.

Taken together, these points clearly indicate that the EPG has an important role to play in digital video systems.

### 1.2. The service information

All the information that is provided by an EPG to the user has to be transported over some communication channel. Traditionally, the information is
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given to the producer of a (printed) programme guide weeks in advance of the programmes themselves, and is then printed and distributed via mail or shops. As was pointed out above, digital television systems provide an excellent means for distributing this information in electronic form to the user: the presence of a high-bandwidth digital link.

Typically, digital television systems will contain programming from more than one programme provider. In order for the EPG to be able to present the information on the different programmes in a consistent way, it is desirable to standardize as far as possible the format of the information. This has been done before in other television systems (D2MAC, teletext). The standardized format is optimized for describing so-called services (typically, television channels), and is therefore referred to as service information. For digital television systems world-wide, the Digital Video Broadcast project (see below) has been the biggest contributor to a standardized format for service information.

1.3. A system viewpoint

One of the central issues of the deployment of an EPG system is that the EPG itself is not located in any one system component, such as the multiplexer or the set-top box. It is a distributed entity, which relies as much on a graphics chip in the receiver as on a database system at the transmitter site. In order to be successful in the deployment of an EPG system, it is imperative that this be taken into account from the start. This is very different from the situation in a 'traditional' Philips business such as the production of television sets.

As an example, take an EPG feature such as 'preview'. To be able to provide the user with a preview of a movie that is scheduled for the next day, the entire broadcast chain gets involved:

• encoders, stream pumps and multiplexers to inject the clip itself;
• data bases, service information compilation software and probably also conditional access software at the head-end to link the clip in the correct (pre-arranged) manner to an event definition, and
• the EPG software in the receiver which must recognize the presence of a clip and set its demultiplexer parameters accordingly, based on actions from the user, as perceived by the user interface software.

1.4. Philips and EPGs

Philips has a history of EPG research which reaches back more than five years. In the last one and a half years, the development of the EPG has gone from research to finished product. This product is part of the product
2. Overview of system components

2.1. The MPEG-2 transport stream

Almost all digital video broadcast systems deployed or under deployment today conform to the standards developed by the so-called Motion Pictures Expert Group (MPEG\(^1\)) with respect to video source coding and multiplex scheme. Of interest for this paper is mainly the multiplex scheme, or more precisely the MPEG-2 Transport Stream. The transport stream is a packet-based time multiplex that allows for the combination of video, audio and data streams into a single bitstream,\(^2\) which can then be transmitted over a single physical channel. This, together with the large bandwidth provided by most systems for digital video, provides the technical background for the definition of an EPG: along with the 'normal' television programmes, in compressed digital form, it is now also possible to transmit large amounts of ancillary information about the television programmes.

The transport stream is a continuous bitstream divided into fixed-length packets. Each packet consists of a four-byte header, an optional so-called adaptation field, and payload. One of the fields in the header is the Packet IDentifier, or PID, which is a thirteen-bit field used to identify the bitstream ('elementary stream') a packet belongs to. The PID is thus a sort of logical channel number. All packets that have the same value in their PID field carry data of only one elementary stream, for instance one stream of bits from a digital video encoder.

\(^1\) MPEG's formal name is ISO/IEC JTC1 SC29 WG11, indicating that it is a working group which is part of a joint undertaking by the International Standardization Organization and the International Electrotechnical Commission.

\(^2\) The system allows for multiprogramming, i.e. the combination of several television programmes (logical channels) into one bitstream (physical channel).
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Philips has played a very active role in MPEG, and currently holds the chairmanship of the Systems sub-group.

2.2. The Digital Video Broadcasting environment

2.2.1. The Digital Video Broadcast project

The MPEG-2 standard has a very wide scope: it targets a large set of application areas and consequently provides a large amount of flexibility. Each application will have to choose the 'tools' it wants to use from the variety provided by the MPEG-2 standard. Different groups and organizations are doing just that, among others the Digital Video Broadcast project. This project is a Europe-based cooperation between some 150 companies and institutions, the goal of which is to coordinate and facilitate the introduction of digital video, primarily in broadcast systems (satellite, cable and terrestrial). The project has been very successful so far in coming to agreement on selecting a subset of the MPEG-2 standard as well as filling in the parts that are outside the scope of MPEG. Currently, the project's set of standards is being adopted by other standardization and specification bodies, such as the Digital Audio-Video Council (DAVIC).

However, the Digital Video Broadcast project has also deliberately refrained from standardizing what is better left to the market, such as the specification of an electronic programme guide. This has many reasons, for example:

- each broadcaster or service provider might want to provide a different EPG in an attempt to communicate a specific 'look and feel' to his customer;
- manufacturers of decoders will want to be able to provide decoders with different capabilities, as a means of distancing themselves from the competition and in order to provide the end customer with a choice between low-end and high-end products;
- specifying the behaviour of an EPG at an early stage in the development of digital video broadcasting would freeze the technology at this stage and hamper the introduction of new ideas.

What has been done, though, is the specification of a number of data structures that can be used by the EPG, called Service Information. This is the subject of the next section.

2.2.2. The Digital Video Broadcasting service information

Within the Digital Video Broadcasting project, a sub-group with the quaint name of 'DVB/V2 SI' has been working on the subject of service information,
i.e. ancillary information about the radio and television services provided in a
digital video broadcast system. The work has resulted in a specification for
data structures used to transmit (mostly textual) information about the ser-
vices described, as well as physical parameters such as modulation schemes
and carrier frequencies. The work of the Service Information group was
founded on a set of 'commercial requirements', which state that the service
information should support the following:

• delivery system and marketing independence;
• transmission on different media; easy transitions between media (e.g. satel-
lite to cable);
• implementations with or without conditional access; multiple conditional
access systems;
• independence of presentation system; possibility for both simple and sophis-
ticated presentation;
• multiple languages; signalling of countries where reception is intended; par-ental rating features;
• easy implementation and use;
• automatic and dynamic receiver configuration;
• compatibility with the MPEG-2 standard;
• simple re-multiplexing;
• low mandatory processor load; low transmission overhead; fast acquisition.

These requirements have been largely fulfilled. The resulting specification
has been handed in to the European Telecommunications Standards Institute
(ETSI) and is currently on its way to becoming a European technical standard.

The service information is, roughly speaking, intended for two purposes in
the receiver. Firstly, it contains information to the user on such things as
names, content and schedules of services and events offered to the user. Sec-
ondly, it contains information intended for the receiver software on such things
as carrier frequencies and modulation schemes, intended for use by various
automatic set-up mechanisms.

The following gives a brief overview of the service information tables and
their use:

• the Network Information Table is intended for the transmission of informa-
tion that can help the receiver setting up frequency tables for the different
channels available on a certain network;

3 Note that this represents a 'bootstrap' problem. Before the information about physical para-
meters can be decoded, at least one digital channel must be acquired.
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- the Bouquet Association Table is intended to provide information about a group of services that are marketed as a single entity, a so-called bouquet. The goal of describing the services in a separate table is to make it possible for receivers to implement a bouquet-oriented user interface. In such a user interface, services would be arranged in two levels, where the top level would be a list of bouquets and the next level all services of each bouquet;
- the Service Description Table is intended to provide information about the services that are transmitted in the current Transport Stream or in other Transport Streams. A service, here, is often more or less equivalent to today's television programmes, but could also be a data service, such as a home shopping channel;
- the Event Information Table is intended to provide information about the events of the various services. An event is a labelled time chunk of a service, such as 'The 5 o'clock news';
- the Running Status Table is intended for providing a mechanism for quick and overhead-efficient transmission of warning messages when an event begins;
- The Time and Date Table is intended to provide the receiver with the current date and time automatically.

Philips has been one of the most active partners in the standardization of service information.

The service information working group has worked very well as a forum where content providers can give input on their functional needs and have them tested against technical feasibility by equipment manufacturers.

2.3. The typical Digital Video Broadcasting receiver

The DVB receiver, in the short term, will most often take the form of a set-top box that converts the digital signal back to an analog one. The latter can then be fed to a normal TV set. Although there has been no standardization of how to build a set-top box, it is to be expected that there will be considerable similarities between boxes of different brands, for the simple reason that the required functionality in combination with the high price pressure leaves little freedom to experiment. Typically, a digital video broadcasting set-top box is an extremely constrained platform. The most serious constraints are the very limited
- memory, both RAM and ROM;
- processing power; and
- graphics capabilities.
These constraints make the design of an attractive and powerful EPG on the platform a very challenging undertaking. This is true especially with regard to the graphical user interface, which has to provide convenient access to a very large amount of (mostly textual) information using very limited resources.

3. The Philips EPG

3.1. Implementation on the transmitter side

The service information (SI) will typically have to be compiled from a variety of different sources: databases (internal and external), material extracted from other transmissions, and manual input. It is preferable to compile this information into some intermediate database which is tuned to the requirements of the service information. The reason for doing this is to let the subsequent steps of the process be independent of the format in which the material is provided. The result of the compilation is a database containing information about bouquets and services, as well as pre-scheduled events of those services, in a common format. Let us call the mechanism that performs this first step in the process the 'precompiler'.

The information output by the precompilation step is largely static and network-independent. It now needs to be combined with

- information about conditional access, especially pay-per-view events;
- network parameters, such as grouping of services, frequencies, modulation etc;
- identity numbers for services and events; and
- various pieces of private information, such as pointers to audiovisual material for the EPG.

The second step, then, is the service information compiler. This unit takes the precompiled service and event descriptions and combines them with the information listed above. Besides this quasi-static information, the SI section compiler also adds dynamic information such as the running status of events and services. It also makes decisions based on dynamic information provided to it. An example of the latter is when an event starts, and thus becomes the 'current' event. The result is a complete set of sections that describe the services and events of some multiplex or set of multiplexes.

The last step for the generation of service information streams is something we will call a service information stream injector. This unit takes the compiled sections according to some transmission scheme and feeds them to the multiplexer/transmitter. Having the injector as a (logically) separate entity
allows us to separate two asynchronous procedures: the compilation procedure (which is performed on part or all of the sections when a configuration change has occurred) and the insertion of the complete sections into the stream. The latter process is driven by the need to repeat each section within a prescribed interval. The service information injector makes sure this is done while obeying bit-rate constraints that are imposed on it from the multiplexer control software.

Figure 1 gives an overview of the different steps of the SI compilation and insertion. Note that the symbols that resemble computers do not necessarily have to represent physically separate pieces of equipment.

3.2. Implementation on the receiver side

3.2.1. Overview

The implementation of the EPG in the receiver has the following main aspects:

- the retrieval and storage of service information;
- relating that information to other information, particularly related to conditional access;
- presenting the information to the user and letting the user interact with it.

Each of these aspects will be treated separately below.
3.2.2. Service information retrieval

The retrieval and storage of service information in the EPG implementation should be able to provide fast access to any part of the information and always keep the information up to date, while making minimal use of memory and processor power. In a system where the information is repeated in the broadcast stream in a cyclic manner (i.e., retransmitted at regular intervals), these requirements are contradictory. As an example, consider a piece of information which is repeated in the transmission every twenty seconds. If the information is not stored, accessing that piece of information will take ten seconds on the average, which may be unacceptable. Storing the information, however, consumes much memory (since it is not clear which piece of information the user will request next) and is also in conflict with the requirement to keep the information up to date.

Another problem encountered in the design of the service information retrieval process is that not all the information is available on each physical channel. The user, not being aware of the existence of a division between physical and logical channels, should not be confronted with this constraint.

The solution for both these problems lies in a combination of

• caching techniques borrowed from the computer world;
• careful scheduling of information in the broadcast stream; and
• a design of the user interface which hides the problems from the user.

3.2.3. Interfacing with the conditional access system

Most digital television broadcast systems in the near future will rely heavily on the use of conditional access features, since a considerable portion of the programming will be pay-TV, i.e., only available to users who have paid to watch in one form or another. Even programmes that are intended for free-of-charge watching should be available only under certain conditions, because of copyright and copy protection reasons, and will therefore often be scrambled.

For the EPG designer, it is necessary to separate the different kinds of paying schemes. Typically, the following schemes are used:

• subscription: the user pays to watch a certain service during some (long) period of time, such as a month;
• pay-per-view: the user pays for an entitlement to watch a certain event of a certain service in advance;
• impulse pay-per-view: the user has not obtained entitlement to watch an event in advance, but pays for all events that he or she watches.
The first two schemes are very similar from the point of view of the EPG; the user is either allowed to watch or not. In the latter case, the EPG must signal the sad news to the user in some appropriate manner. For impulse pay-per-view, the EPG has to let the user decide if he wants to watch the event or not, and also provide an interface to mechanisms that prevent excessive spending, watching by unauthorized people, etc.

All these points are, in fact, just examples of a broader problem. Besides providing the user interface to the channel selection process (which relies on the service information) the EPG must also provide an interface to the conditional access system (which relies on private data structures). It would be unacceptable to have two different user interfaces in the same box. However, there are several system design problems that are a direct result of this, mainly related to keeping the two sets of information structures consistent.

The implementation of the Philips EPG provides a solution to these problems, in particular for the Philips-owned conditional access system, CryptoWorks™.

3.2.4. User interface

The EPG user interface can be looked at from the different viewpoints of functionality and representation. Here, we will outline these issues and discuss the interaction with the user interface.

In determining which functionality the EPG should support, it is necessary to understand that the EPG has two users. The programme provider uses the EPG to market a range of products, the programmes. The consumer uses the EPG to find information about the programmes. The two users have different goals; the design must take both goals into account.

Concerning the consumer (or the end user), the first question is: ‘Which functions does the end user want?’. The answer to this question depends on a number of parameters, such as the end user’s age, sex, cultural and social background, and so on. However, early research as well as studies of other implementations yield a few basic functions, such as:

- schedules for each channel;
- an overview of all material being transmitted now (and soon);
- an overview of events sorted by category of content; and
- more detailed information about each event.

In addition to these basic functions, the following ones are very interesting:

- previews and appetizers;
- search operations;

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- on-line help;
- personalization:
  - parental control of access to channels;
  - favourite channel list: only interesting channels are included in the 'channel ring';
- reminders and automatic recording;
- selection of soundtracks in different languages;
- selection of subtitles in different languages;
- near video-on-demand.\(^4\)

In addition to the functions listed above (which, incidentally, are all supported to some degree by the Philips EPG), there are functions associated with conditional access. Also, the functional needs of the programme provider have been taken care of, for instance by providing a mechanism for advertising within the framework of the EPG.

The representation of the functionality to the user has to take into account a number of factors. Some of the most important ones are associated with:

- the limited possibilities of the user interface in a TV setting, caused by:
  - the low screen resolution;
  - limitations of the input device (remote control);
  - the large viewing distance;
  - the limited amount of (graphics) memory and processor power available to the EPG;
- the fact that a user who wants to watch TV should not be bothered by a tedious or complicated selection procedure; and
- the peculiarities of the system for service information, including the large latencies in retrieving information.

Corporate Design has designed a user interface for the Philips EPG which provides a simple and attractive search environment in spite of these difficulties.

4. Conclusions

This paper describes the implementation of an electronic programme guide in a digital video broadcast system, making use of the service information

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\(^4\) Near video-on-demand is a broadcasting method where the same event (for instance a movie) is broadcast on separate channels at short intervals. For instance, a two-hour movie could be broadcast on eight separate channels, starting once every fifteen minutes. The EPG should provide an intuitive user interface for this type of broadcasting scheme.
standardized in the Digital Video Broadcast project. For the most part, deploying such an EPG service is straightforward and relies on concepts that are well tested and understood. However, there are a few aspects that are complicated and need careful design:

- the design of the user interface, including:
  - a well-defined functionality,
  - a logical way of interacting with the user interface in order to gain access to the desired functions,
  - an attractive and clear representation which must be realized within the limitations of the set-top box hardware, and
  - a clear understanding of the user interface requirements in different cultures;
- a solution of how to deal with the broadcast distribution model without introducing excessive delays or memory requirements; and
- the definition of the EPG system, including issues such as:
  - defining clear interfaces over which information from external data bases can be converted into the service information format,
  - general software architecture at uplinks and cable head-ends,
  - linking the service information to various private data structures, especially those of the conditional access system.

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