Part One

Backgrounds of MPEG-2 Systems
Introduction

What MPEG is, the efforts that MPEG initially undertook, what MPEG-2 Systems is and how it is used by applications.

MPEG, which stands for the Moving Picture Experts Group, is the name of a group of audiovisual coding experts operating in ISO/IEC, see Note 1.1. The MPEG group is responsible for a series of well-known international standards, used for coding of audiovisual information in a digital compressed format, such as MPEG-2 video, AVC, MP3 audio and AAC. MPEG was established in 1988 and had its first meeting in May 1988 in Ottawa, Canada. The first two standards produced by MPEG were MPEG-1 and MPEG-2, published as ISO/IEC 11172 [1–6] and ISO/IEC 13818 [7–18], respectively.

Typically, each MPEG standard contains specifications for compression of audio, for compression of video and for transport and synchronization of compressed audio and video. These specifications are usually referred to as MPEG audio, MPEG video and MPEG systems, respectively, and documented in different parts of MPEG standards. For the parts contained in the MPEG-1 and MPEG-2 standards, see Note 1.1.

From the start, the objective of MPEG was to develop standards for the compression of digital video and audio. The MPEG-1 work item ‘Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s’ expressed a focus on Compact Disc and its bitrate. However, when it became clear that the developed technology was suitable for usage by many applications at a wide range of bitrates, the objective for MPEG-2 was broadened to ‘Generic coding of moving pictures and associated audio’. As a consequence of this broadening the MPEG-3 work item on HDTV at high bitrates was dropped: MPEG-3 never happened.

The MPEG-1 standard is successfully used in Video CD, in MP3 audio devices and for coding audio in digital TV broadcast. The MPEG-2 standard is almost universally used in digital cable TV, digital satellite TV, terrestrial digital TV broadcast, DVD, Blu-ray Disc, digital camcorders and other families of products.

\(^1\)Many digital TV broadcast systems combine MPEG-1 audio with MPEG-2 video and systems.
\(^2\)Blu-ray and Blu-ray Disc are trademarks of the Blu-ray Disc Association.
The focus of this book is on MPEG-2, in particular on MPEG-2 systems. Several of the basic concepts in MPEG-2 systems were developed first for MPEG-1 systems, and therefore MPEG-1 systems also will be addressed to some extent in this book. To understand MPEG-2 systems, some basic knowledge of MPEG video and audio is needed. The audio and video parts of MPEG standards define the format of compressed audio and video streams and how to decode such MPEG audio and video streams back into uncompressed audio and video.

In the audiovisual applications addressed by MPEG-1 and MPEG-2, the MPEG audio and video streams are not transported in parallel, but instead are transported in a single stream that contains both MPEG audio and MPEG video data. Such a stream is called an MPEG-1 or MPEG-2 system stream. The format of system streams as well as the rules and conditions on their construction are specified in the MPEG-1 and MPEG-2 system specifications [2,8].

The MPEG-1 and MPEG-2 systems features include packetization of audio and video streams, their signalling, synchronization of audio and video and requirements for the decoding of audio and video from an MPEG system stream, while ensuring a high quality of service. So

### Note 1.1 The MPEG Committee and Some of Its Standards

MPEG is a Working Group within a Sub-Committee of a Joint Technical Committee on Information Technology of ISO and IEC; more particularly, MPEG is referred to as ISO/IEC/JTC1/SC29/WG11, that is, WG 11 within SC 29 of JTC 1 of ISO and IEC. The ISO is the International Standardization Organization (see www.iso.org/). The IEC is the International Electrotechnical Commission (see http://www.iec.ch/). The first two standards produced by MPEG were MPEG-1 (1992) and MPEG-2 (1994), published as ISO/IEC 11172 and ISO/IEC 13818; each containing several parts:

<table>
<thead>
<tr>
<th>ISO/IEC 11172-1</th>
<th>MPEG-1 systems</th>
<th>ISO/IEC 13818-1</th>
<th>MPEG-2 systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO/IEC 11172-2</td>
<td>MPEG-1 video</td>
<td>ISO/IEC 13818-2</td>
<td>MPEG-2 video</td>
</tr>
<tr>
<td>ISO/IEC 11172-3</td>
<td>MPEG-1 audio</td>
<td>ISO/IEC 13818-3</td>
<td>MPEG-2 audio</td>
</tr>
<tr>
<td>ISO/IEC 11172-4</td>
<td>MPEG-1 compliance</td>
<td>ISO/IEC 13818-4</td>
<td>MPEG-2 compliance</td>
</tr>
<tr>
<td>ISO/IEC 11172-5</td>
<td>MPEG-1 software simulation</td>
<td>ISO/IEC 13818-5</td>
<td>MPEG-2 software simulation</td>
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</table>

Various other 13818 parts, amongst others:

| ISO/IEC 13818-9 | MPEG-2 real-time interface for system decoders |

Initially, MPEG was part of ISO/IEC JTC1/SC2/WG8, the same working group that was developing the JPEG standard; but in 1990, when the subgroups became too large, both MPEG and JPEG were promoted to Working Group level under SC29: JPEG became WG1, while MPEG became WG11.
as to accurately define synchronization of audio and video, the system specifications include a model of audio and video decoding. MPEG does not specify how to perform audio, video and systems encoding; instead only the format of the MPEG audio, video and system streams at the output of the encoders is specified, thereby leaving to the market how to encode audio, video and systems in a most efficient and cost-effective manner (see Figure 1.1).

MPEG-2 systems provide an application independent interchange format, optimized for the target applications, so that mapping to practical transport layers can be made conveniently. For example, the MPEG-2 system specification defines for broadcast applications a transport format that is suitable for transport over terrestrial, satellite, cable and IP networks and that can also be used by recording devices. This approach allows producing and managing content independently of the delivery network to the consumer. Thereby MPEG-2 systems became the basis of an infrastructure to produce, store, exchange and transport audiovisual content.

In order to provide a generally useful interchange format, the MPEG-2 system stream format is designed so that all practical transport requirements of target applications are met. Not only MPEG audio and MPEG video streams can be carried, but also other content, such as subtitling and metadata, as well as audio or video formats defined by other standardization bodies. Moreover, when new audio and video formats evolve, MPEG-2 systems can be extended with support for these new formats, provided that a market requirement for such carriage is identified.

The MPEG committee typically only specifies carriage over MPEG-2 systems of MPEG defined streams. Support for non-MPEG defined streams, such as audio, video and subtitling...
standards evolving outside of MPEG, is usually beyond the scope of MPEG, and left to other standardization bodies or to applications. A list of important application standardization bodies is provided in Note 1.2.

The typical process for applications to adopt MPEG audio and video standards and the role of MPEG-2 systems therein is depicted in Figure 1.2. When new audio and video standards

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**Note 1.2 Some Application Standardization Bodies**

**DVB** is an industry-led consortium designing open interoperable standards for the global delivery of digital media services, operating from Europe. ‘DVB’ stands for Digital Video Broadcasting (see www.dvb.org/).

**ATSC** is an international organization developing standards for digital television, operating from the United States. ‘ATSC’ stands for Advanced Television Systems Committee (see www.atsc.org/).

**ARIB** is the Association of Radio Industries and Businesses, operating from Japan. ARIB aims at establishing technical standards for radio systems in the field of telecommunications and broadcasting (see http://www.arib.or.jp/english/).

**DVD Forum** is the international organization that defines formats for DVD (Digital Versatile Disc) products and technologies (see www.dvdforum.org/).

**BDA** is the Blu-ray Disc Association, dedicated to developing and promoting the Blu-ray Disc Format (see www.blu-raydisc.com/).

**OIPF** is the Open IPTV Forum with the objective to enable and to accelerate the creation of a mass market for IPTV by defining and publishing specifications for end-to-end IPTV services (see www.oipf.tv/).

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![Diagram of Typical process for adoption of MPEG standards](image-url)
evolve in MPEG, then the MPEG-2 system standard is extended to specify carriage of the new audio or video compressed data within an MPEG system stream. Note that MPEG may also specify how to contain the new audio or video compressed data in an ISO (mp4) file and that other bodies may specify carriage over non-MPEG defined transport means; for example, IETF may specify transport over IP.

Next, an application standardization body can adopt the MPEG-2 systems extension and define guidelines for its usage within the applications governed by that application standardization body. For example, DVB may specify constraints for the use of the MPEG-2 systems extension within DVB compliant applications.

While MPEG audio and MPEG video specifications are usually succeeded by next generation audio and video compression standards, this is different for MPEG-2 systems. As long as MPEG-2 systems and the associated infrastructure are considered suitable for the applications they serve, support for new generation audio and video compression standards will be incorporated by upgrading the MPEG-2 system specification with support for these new standards. One argument here is that often new features can only be introduced in an evolutionary way, without changing the transport format. Another argument is that investing in a totally new infrastructure is usually considerably more expensive than upgrading an existing infrastructure. As a consequence, it is expected that MPEG-2 systems will remain widely used for the foreseeable future, even as video and audio standards evolve.

1.1 The Scope of This Book

This book describes the MPEG-2 system specification as developed in the early 1990s and has evolved since then into the fourth edition of the MPEG-2 systems standard. While MPEG-2 systems will continue to evolve further, this book describes the MPEG-2 system functionality as of October 2013. Also relevant background information is provided. The discussion of MPEG-2 system functionality requires knowledge of various fundamental issues, such as timing, and of supported content formats. Therefore also some basic information on video and audio coding is provided, including their evolution. Also other content formats supported in MPEG-2 systems are described, as far as needed to understand MPEG-2 systems.

Normative requirements that MPEG-2 system decoders and streams have to meet are specified in the MPEG-2 system specification. While MPEG-2 system functionality is described in this book, including clarification of requirements that apply, this book does in no way define normative MPEG-2 system requirements. In other words, this book may be used to improve the understanding of MPEG-2 systems, but not as a guideline for designing encoder and decoder implementations. Furthermore it should be taken into account that the list of requirements discussed in this book is not necessarily exhaustive.

1.2 Some Definitions

Throughout this book, data rates are expressed in units of kb/s and Mb/s, indicating \(1000\ (10^3)\) bits per second and \(1\ 000\ 000\ (10^6)\) bits per second, respectively. However, when the size of digital memory is expressed in units of KB and MB, then units of \(1024\ (2^{10})\) bytes or \(1\ 048\ 576\ (2^{20})\) bytes, respectively, are indicated in this book. These notations are commonly used in practice and therefore also in this book. Nevertheless, its usage may create confusion, for example when a data rate is mathematically related to a memory size.
References

1. ISO/IEC (1998) Information technology – Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s. ISO/IEC 11172. The MPEG-1 standard is published in five parts; see [2], [3], [4], [5] and [6].


7. ISO/IEC (2013) MPEG-2 standard, published in 10 parts; see [8], [9], [10], [11], [12], [13], [14], [16], [17] and [18].


15. ISO/IEC (2007) MPEG-2 Part 8 has been withdrawn.


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3 MPEG-1 part 5 is not a standard, but a technical report that provides a software implementation of the first three parts of the MPEG-1 standard. The source code is not publicly available.

4 Approximately every 5 years the next version of the MPEG-2 System standard is published, as discussed in Chapter 8 of this book.