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MPEG-7 White Paper

Sonera MediaLab

www.medialab.sonera.fi
info@medialab.sonera.fi

October 13, 2003

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MPEG-7

1 Introduction

The value of information often depends on how easily it can be found, retrieved, accessed and managed. Current online audiovisual archives can be hard to search from outside the organizations that own them, because they all employ their own metadata schemes. Additionally, the amount of audiovisual information in databases, on the World Wide Web, in broadcast data streams etc., is growing. MPEG-7 helps in describing multimedia content in a standardized way and thus enables easier archiving, accessing, locating, navigating, searching, and managing of audiovisual information.

MPEG-7 is an ISO/IEC standard developed by Moving Pictures Experts Group (MPEG), a working group inside the International Organization for Standardization (ISO). MPEG has also developed the audio and video compression standards known as MPEG-1, MPEG-2 and MPEG-4. The MPEG-1 and MPEG-2 standards have enabled the production of widely adopted commercial products, such as Video CD and MP3 players, digital audio broadcasting devices, DVD players and recorders, and digital TV sets [1]. The MPEG-3 draft, which mainly concentrated on HDTV issues, existed some years ago, but it was later incorporated into the MPEG-2 standard. The MPEG-4 standard uses advanced compression algorithms and adds object oriented features to the MPEG family. It is targeted especially for low-bandwidth applications and devices, for example, mobile phones.

MPEG-7 became a standard in 2001. It is formally called *Multimedia Content Description Interface* and it aims at describing the content of multimedia data by attaching metadata to multimedia content. MPEG-7 specifies a standard set of description tools which can be used to describe various types of multimedia information. MPEG-7 does not replace earlier MPEG standards, as its objective is to provide additional functionality to other MPEG standards. Earlier MPEG standards make the content available, while MPEG-7 allows finding the content the user needs. The question of identifying and managing content is not just restricted to database retrieval applications such as digital libraries, but extended to areas like broadcast channel selection, multimedia editing, and multimedia directory services. [1]

The newest MPEG standard on the way, MPEG-21, provides a framework for different elements to build an infrastructure for the delivery and consumption of multimedia content to work together. MPEG-21 also includes various tools for making Digital Rights Management (DRM) more interoperable. Within the framework, other MPEG standards can be used where appropriate. The first parts of MPEG-21 became a standard in 2001 and 2003.

In this white paper, we take a look at the MPEG-7 standard. Its characteristics and main components are introduced in chapters 2 and 3. The following chapter presents MPEG-7 related forums and consortiums, and also some alternative metadata models. In chapter 5, we go through several MPEG-7 powered applications and prototypes to give an overview of an environment in which MPEG-7 is used today.

2 MPEG-7 Characteristics

MPEG-7 is a standard for describing the features of multimedia content so that users can search for, browse, and retrieve that content more efficiently and as effectively as they today use text based search engines. To create descriptions, MPEG-7 offers a comprehensive set of audiovisual metadata elements, and their structure and relationships. These are defined by the stan-

dard in the form of *Descriptors* and *Description Schemes* (see next chapter). MPEG-7 has the ability to describe the low-level features, semantics and structural aspects of any multimedia file. [1]

The MPEG-7 process chain includes feature extraction, the description itself, and the application utilizing the description. MPEG-7 concentrates on the description part. It does not standardize the extraction of audiovisual features. Nor does it specify the search engine or other application that can make use of the description. It is up to software vendors to gather the MPEG-7 described content into search indexes that can be used by their products. Typical query examples that MPEG-7 can enable include [1][2]:

- Audio: Search for songs by humming or whistling a tune or, using a music excerpt from an artist, get a list of the artist's records and video clips in which the artist sings or simply appears.
- Graphics: Draw a few lines on a screen and find a set of images containing similar graphics, logos, and ideograms.
- Image: Define objects, including color patches or textures and retrieve examples among which you select the interesting objects to compose your design.
- Video: Allow mobile phone access to video clips of goals scored in a soccer game, or automatically search and retrieve any unusual movements from surveillance video.

Figure 2-1 gives an example of the MPEG-7 chain. The description is obtained from the multimedia content via manual or semi-automatic extraction. Descriptions are saved in a storage system for later use. In a pull scenario, a set of descriptions matching the user's query are returned for browsing. In a push scenario, an intelligent agent filters descriptions and performs programmed actions (e.g. switches a broadcast channel or records the described stream).

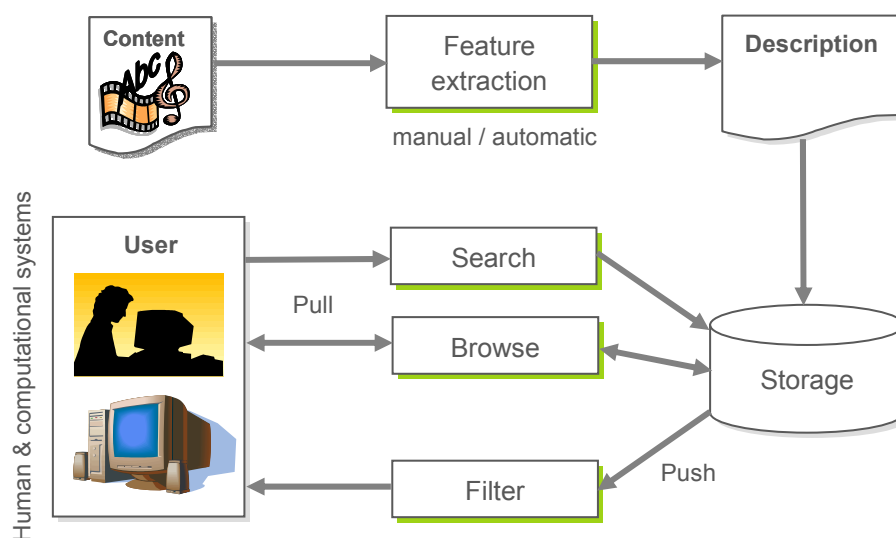


Figure 2-1. Example application using MPEG-7 ([1], edited).

The MPEG-7 description may be physically located with the associated audiovisual material, either in the same data stream or in the same storage system, but the descriptions could also be located somewhere else on the network. When the content and its descriptions are not co-located, a mechanism that links these two is needed. MPEG-7 can also be used independently of the other MPEG standards, for example, the description can be attached to an analog movie.

3 MPEG-7 Technical Overview

The main tools used to implement MPEG-7 descriptions are Descriptors (D), Description Schemes (DS), and Description Definition Language (DDL) [1]. The standard also defines a binary representation (BiM) for efficient transportation of the descriptions, and a reference software implementation. In this chapter these parts are introduced.

Figure 3-1 shows a relationship between the different elements (edited from [1]). The DDL allows the definition of Ds and DSs, providing the means for structuring the Ds into DSs. The DDL also allows the extension of particular DSs for specific applications. The Ds and DSs are instantiated as descriptions in XML format. A binary format can be used for the description for efficient delivery and storage.

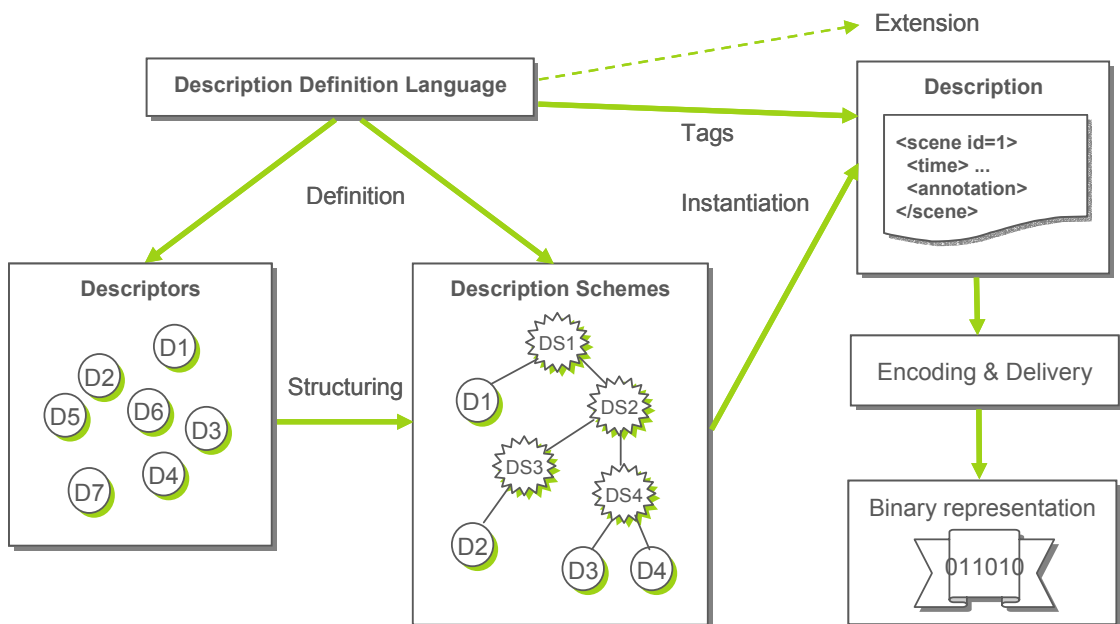


Figure 3-1. MPEG-7 main elements.

3.1 Descriptors and Description Schemes

A Descriptor defines the syntax and semantics of each feature. For example, for the color feature, the color histogram or the text of the title is the descriptor. The director of a multimedia document or a texture in a single picture is also an example of a descriptor [3].

A Description Scheme specifies the structure and semantics of the relationships between its components which may be both Descriptors and Description Schemes.

For example, the *ImageText* DS describes a spatial region of an image or a video frame that corresponds to text or captions [4]. The *ImageText* DS can describe the textual characters, language, font size, and font style, in addition to the other properties of the parent DS.

Figure 3-2 displays an image with one scene text and two superimposed texts in French. When we use the *ImageText* DS shown in Figure 3-3 for this image, we get the MPEG-7 description listed in Figure 3-4.



Figure 3-2. Sample image with texts [4].

```

<!-- ##### -->
<!-- Definition of ImageText DS -->
<!-- ##### -->
<complexType name="ImageTextType">
    <complexContent>
        <extension base="mpeg7:StillRegionType">
            <sequence>
                <element name="Text" type="mpeg7:TextualType" minOccurs="0"/>
            </sequence>
            <attribute name="textType" use="optional">
                <simpleType>
                    <restriction base="string">
                        <enumeration value="superimposed"/>
                        <enumeration value="scene"/>
                    </restriction>
                </simpleType>
            </attribute>
            <attribute name="fontSize" type="positiveInteger" use="optional"/>
            <attribute name="fontType" type="string" use="optional"/>
        </extension>
    </complexContent>
</complexType>

```

Figure 3-3. Definition of ImageText Description Scheme [4].

```

<ImageText id="ImageText1" textType="scene">
    <RegionLocator>...</RegionLocator>
    <Text xml:lang="fr">Cherie, je suis la</Text>
</ImageText>
<!-- Image Text 2 -->
<ImageText id="ImageText2" textType="superimposed"
    fontSize="40" fontType="Arial">
    <RegionLocator>...</RegionLocator>
    <Text xml:lang="fr">
        En direct du state DE-KUIP Rotterdam Jean-Francois DEVELEY</Text>
</ImageText>
<!-- Image Text 3 -->
<ImageText id="ImageText3" textType="superimposed"
    fontSize="30" fontType="Times New Roman">
    <RegionLocator>...</RegionLocator>
    <Text xml:lang="fr">
        Nous allons assister a un match fantastique</Text>
</ImageText>

```

Figure 3-4. Excerpt of MPEG-7 description for image in Fig. 3-2 [4].

3.2 Description Definition Language

Description Definition Language (DDL) is a language which allows the creation of new MPEG-7 Description Schemes and Descriptors. It also allows the extension and modification of existing Description Schemes [3]. A DDL schema (a DDL file) specifies the constraints that a valid MPEG-7 description should respect. It is encoded in XML that defines document structure and embeds it directly within the document through the use of markups. XML is similar to HTML, but with user definable tags. The definition of valid document structure is expressed in a grammar known as DTD (Document Type Definition).

An XML schema can be seen as an extended DTD, because it goes beyond the current functionalities of a DTD and allows more precise data type definitions. The MPEG-7 DDL uses the W3C XML Schema Language as a base language and adds MPEG-7-specific mechanisms, such as array and matrix data types, on top of it.

A DDL parser is used to check the validity of the description with these rules. The parser is first initialized with a schema (a DDL file) and it can then parse a description to report any errors.

Currently there are only a couple of MPEG-7 specific schema parsers available, but XML Schema parsers (for example XSV, XMLSpy, Xerces) can be used to validate the description schemes or descriptions if specific MPEG-7 features are not used or they are first removed.

3.3 Binary Format for MPEG-7

MPEG-7 textual descriptions (XML files) tend to become large and thus inefficient. That is why MPEG-7 defines a binary format, BiM, that enables the streaming and compression of the descriptions. Actually, BiM can be used to compress any XML document. The document structure is highly compressed, 98 % on average [1].

3.4 Parts of the Standard

The MPEG-7 standard consists of eight parts (for more information, see the Additional Resources section). The architecture of the standard, the syntax of the binary format and several tools are defined in part 1 (Systems). Description Definition Language is the subject of part 2. Schemes are defined in the following parts. Part 3 (Visual) provides standard descriptors and description schemes that are purely visual. Part 4 (Audio) provides standard descriptors and description schemes that are purely audio. Part 5 (Multimedia Description Schemes) provides descriptors and description schemes that are neither visual nor audio. Part 6 documents the included reference software called eXperimentation Model, or XM for short. The next part provides guidelines and procedures for testing the conformance of MPEG-7 implementations. The last part deals with the extraction and use of MPEG-7 descriptions. According to the MPEG work plan [5], an addition to part 7, Conformance extensions, will be published in 2004. Additionally, a new part, Schema definition, is under construction.

4 MPEG-7 Related Forums and Consortiums

Moving Pictures Experts Group (MPEG) is the working group in charge of the development of MPEG standards, but there also exist forums and consortiums that promote the use of MPEG and have an influence on MPEG development.

The **MPEG Industry Forum** (MPEGIF) – earlier called MPEG-4 Industry Forum – is a not-for-profit organization promoting the MPEG standards and serving information on MPEG technology, products and services. The forum also carries out different tests and organizes exhibitions and events. The forum changed its name, because it now addresses MPEG-7 and MPEG-21 issues as well, but MPEG-4 still remains the focus area. There are currently 100 member companies including companies such as Apple, Hitachi, IBM, Microsoft, Nokia, RealNetworks, and Sony.

The **MPEG-7 Consortium** (MP7C) provides information on MPEG-7 standardization, and guidance and examples on how to use the MPEG-7 technologies. The consortium's mission is to transfer MPEG-7 technology into the marketplace by promoting product interoperability and to support a seamless and easy-to-use metadata content standard to industries.

The **World Wide Web Consortium** (W3C) develops Web specifications, guidelines, software, and tools. W3C standards called recommendations and other technical reports are freely available to all. W3C is hosted by three organizations on three locations: in the United States, Europe and in Japan. Several countries have also established local W3C Offices to promote the W3C recommendations and give guidance. One of the technologies W3C develops is XML Schema that is the base language for MPEG-7 DDL.

MPEG-7 is not the only player in the field of audiovisual metadata. There also exist other metadata initiatives. Application developers should be at least aware of them if their customer's system uses them, for example. The list of initiatives includes, but is not limited to, the following:

- Dublin Core provides 15 elements for describing the core information properties, such as *Description*, *Creator* and *Date*, and it is mostly used with Web pages or other Web objects [6].
- SMPTE Metadata, from the Society of Motion Pictures and Television Engineers, consists of a huge directory of elements and it is particularly targeted for the domain of program making in the broadcast environment [7].
- EBU P/Meta focuses on business-to-business exchanges of program material [8].
- TV-Anytime metadata concentrates on business-to-consumer features and services [9].
- <indecs> and <indecs>rdd metadata models concentrate on intellectual property issues [10] [11].

Of course, it would be best, if only one metadata standard were supported by all players. We still have many standards and recommendations. That is why the MPEG Liaisons division deals with organizing collaboration between MPEG and related activities in other standardization bodies and tries to achieve a consensus on metadata issues.

5 MPEG-7 Applications

In this chapter we will introduce in brief some potential application areas and real world applications for MPEG-7. Basically, all application domains making use of multimedia can benefit from MPEG-7. The list below shows some application areas and examples that MPEG-7 is capable of boosting [1].

- Broadcast media selection: media selection for radio and TV channels
- Digital libraries: image catalogue, musical dictionary, video and radio archives
- E-commerce: personalized advertising, on-line catalogues
- Home entertainment: systems for the management of personal multimedia collections
- Journalism: searching speeches of a certain person using his name, voice or face
- Multimedia editing: personalized electronic news services
- Shopping: searching clothes that one likes
- Surveillance: traffic control

5.1 IBM MPEG-7 Annotation Tool

The Annotation Tool assists in annotating MPEG-1 video sequences with MPEG-7 metadata. Shots in the video sequence can be annotated with static scene descriptions, key object descriptions, event descriptions, and other lexicon sets. The annotated descriptions are associated with each video shot and stored as MPEG-7 descriptions in an XML file. Annotation Tools is a stand-alone Windows application and it can be freely downloaded from IBM alphaWorks [12].

We quickly tested the application with an MPEG advertisement video where five dentists are sitting in a meeting room and an interviewer asks them about the product being advertised. The software first automatically performed shot detection on the video and divided it into seven shots. It also divided the shots in key frames. We annotated one shot by selecting appropriate event, scene and key objects from the list, and by entering keywords "five dentists". An excerpt of the MPEG-7 description the application created is shown in Fig. 5-1.

```
<?xml version="1.0" encoding="iso-8859-1" ?>
<Mpeg7 xmlns="urn:mpeg:mpeg7:schema:2001"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
  xsi:schemaLocation="urn:mpeg:mpeg7:schema:2001 Mpeg7-2001.xsd">
  <Description xsi:type="ContentEntityType">
  <MultimediaContent xsi:type="VideoType">
  <Video>
  <TemporalDecomposition>
  <VideoSegment>
  <MediaTime>
  <MediaTimePoint>T00:00:00:28028F30000</MediaTimePoint>
  </MediaTime>
  </VideoSegment>
  </TemporalDecomposition>
  <VideoSegment>
  <TextAnnotation type="scene" relevance="1" confidence="1">
  <FreeTextAnnotation>Indoors</FreeTextAnnotation>
  <FreeTextAnnotation>Meeting_Room</FreeTextAnnotation>
  <FreeTextAnnotation>Person (w/frontal_face)</FreeTextAnnotation>
  <FreeTextAnnotation>Person_Speaking</FreeTextAnnotation>
  <FreeTextAnnotation>five dentists</FreeTextAnnotation>
  </TextAnnotation>
  </VideoSegment>
  </Video>
  </MultimediaContent>
  </Description>
</Mpeg7>
```

Figure 5-1. An example description created by the IBM MPEG-7 Annotation Tool.

5.2 Ricoh MPEG-7 MovieTool

MovieTool is another Windows application for describing video contents. The description is saved as an MPEG-7 file. Among other things, MovieTool does the following [13]:

- Provides visual clues to aid the user in creating the structure of a video.
- Visually shows the relationships between the structure and the MPEG-7 description.
- Presents candidate tags to help the user choose appropriate MPEG-7 tags.
- Checks the validity of the MPEG-7 descriptions in accordance with the MPEG-7 schema.

The documentation lists some limitations for MovieTool: it supports MPEG-1 only, the BiM format is not supported, and non-ASCII character encoding within the MPEG-7 file is limited to Shift-JIS Japanese. Additionally, MovieTool does not provide video search functions based on MPEG-7 files.

5.3 Canon MPEG-7 Spoken Content Transcription Service

Canon Research Centre has developed a spoken content transcription service. Their application is used via a Web interface where the user can upload an audio file and the service creates and returns an XML file conforming to the MPEG-7 *SpokenContent* description scheme. Currently Canon's engine can only recognize phonemes (no words) and it can only process WAV files of limited size [14].

When the service was tested with a 20 kB audio sample where an English speaking male speaks, the service produced a description that lists all the phonemes in the sample and also a rather strange looking table describing the order of the phonemes. It was out of the scope of our test to see whether the application interpreted the sample correctly.

5.4 Singingfish Multimedia Search

Singingfish (a subsidiary of Thomson) has developed a streaming media search engine [15], one of the few search engines that currently utilizes MPEG-7. It uses MPEG-7 Multimedia Description Schemes to model the metadata characteristics of Internet streaming media [16]. By "Internet streaming media" Singingfish means any multimedia data type where playback begins before the download completes. This includes not only streaming via protocols such as RTSP, but also HTTP file transfers at bit rates sufficient to keep pace with the playback. Currently, Singingfish's database contains links to Microsoft Windows Media Formats, Apple QuickTime, MP3, and RealNetworks's RealVideo, RealAudio and RealFlash formats. They also have plans to add support for Macromedia Flash and ActiveSky. Singingfish has cataloged and indexed more than 50 million streams and downloadable MP3s on the Web, with 200 000 to 300 000 files added weekly. Additionally, business partners, such as MSNBC.com, provide an XML feed of streaming media news content to Singingfish using the MPEG-7 format [17]. Because Web streams come and go, the searchable collection includes about 10 million files.

To collect metadata Singingfish extracts data from the media file and the referring Web page(s). They then use multimedia description schemes from the MPEG-7 standard to model these media items and their relationships. For example, they utilize the following description schemes and sub-schemes:

- *StreamingAV* is used as a top-level entity for Internet-accessible streaming multimedia content
- *Segment* and *SegmentDecomposition* allow to model hierarchical playlist formats such as M3U/PLS, SMIL, and ASX

- *MediaInformation* contains descriptions that are specific to the storage media. These include URL link to stream, bit rate, media format, duration, MIME type, media type, etc
- *CreationMetainformation* binds together creation and classification information such as title, author, artist, album, record label, language, category, and genre
- *RelatedMaterial* is used to hold information about web page(s) that contain links to streaming media. This data can be used to increase the quality of the search and for automated classification
- *UsageMetaInformation* is used to capture the copyright and content owner
- *AudioSegment* holds spoken text extracted via speech recognition tools, closed caption decoding, or transcripts provided by the content producer
- *SequentialSummary* is used to represent multiple key frames extracted from a single Internet streaming video

The media database is available via a full-text search interface at singingfish.com, but Singingfish also licenses its customizable search to Web portals, search and directory sites, broadband service providers, entertainment networks, and other destination sites. For example, Windows-Media.com and RealNetworks RealOne Player use Singingfish to power their media searches. Singingfish also provides the content for Inktomi Media Search that is available as an add-on to Inktomi's Web Search customers.

5.5 Query by Humming – Melody Search Engine

Musicline's MPEG-7 powered search engine allows finding music by humming [18]. It is used via a microphone attached to the computer. The search engine extracts the melody from the user's singing or from the instrument the user is playing and compares the result with a database. The melody theme that is found most similar is presented in the first place of a ranked list as an answer to the user. Currently the database contains 3 000 melodies. The system does not work with whistling and does not recognize speech or lyrics.

5.6 MERL MPEG-7 Projects

MERL (Mitsubishi Electric Research Laboratories) has run several research projects where they have utilized MPEG-7 and developed the following prototypes [19]:

- MPEG-7 Music Player project deals with automatic music categorization. Currently users can put up to 2 000 songs on a single portable playback device and will have access to up to 10 000 songs in the near future. The problem with these devices is that they lack knowledge about the content and therefore offer no way for the user to navigate the enormous amount of information. The application developed in this project tries to address these problems by offering a query-by-example feature that lists songs that are similar in style and mood to the current song.
- MPEG-7 Sound Recognition project has developed a system that identifies sound events as diverse as speech, singing, environmental noises, animal sounds, musical instruments and music genres. Uses for this technology include remote audio monitoring, media archive searching and automatic music monitoring for broadcast facilities.
- MPEG-7 Video Browsing and Summarization project has developed a personal video recorder application that provides the user with the content he wants when he wants it by storing a large volume of content recorded from a broadcast and then providing effective navigation of the stored content using summarization and indexing.

Mitsubishi's target MPEG-7 applications in the future include consumer electronics like personal video recorders, video browsing for DVD players, and remote access of video.

6 Summary

Former MPEG standards – MPEG-1, MPEG-2, and MPEG-4 – focus on the compression and transportation of audiovisual content. MPEG-7 is the first MPEG standard to focus not on compression, but rather on metadata, or descriptions, for the content. MPEG-7 is based on XML metadata, and defines a core set of Descriptors (D) for audio, video and graphics using the Description Definition Language (DDL) supported by a group of Description Schemes (DS). MPEG-7 was designed to describe media content including, but not limited to, MPEG encoded content. With the help of MPEG-7, users can search, browse, and retrieve media content efficiently. The standard does not specify how to extract the metadata, nor the application utilizing the metadata.

In addition to MPEG-7, there also exist other metadata initiatives. Dublin Core is used mainly on Web pages. SMPTE Metadata, EBU P/Meta and TV-Anytime target the broadcast environment. MPEG Liaisons division organizes collaboration with other standardization bodies to achieve consensus in the future.

MPEG-7 is currently used in such applications as video annotation and browsing, Internet audio/video search and spoken content transcription. For example, IBM, Ricoh, Canon, Thomson and Mitsubishi have already developed their own MPEG-7 applications. Microsoft and RealNetworks – the biggest Internet streaming technology providers and members of the MPEG Industry Forum – have not yet announced a product that supports MPEG-7 or a competitive technology. The query for "MPEG-7" on microsoft.com only returned several research slides and a reference to the MPEG FAQ. The same query on RealNetworks' web site did not return any documents at all. Similarly, the same query did not return any hits on the web sites of the following randomly chosen MPEG Industry Forum member companies: AOL Time Warner, Apple, Intel, Motorola, Sony, Nokia.

MPEG-7 is a quite complex standard. Only time will tell if it will succeed. Traditionally, application developers have only allocated resources for a new technology if there has been a sound commercial justification for it and the same goes for MPEG-7. So, in the end, the success of the standard will depend on its users; if the users feel that they can't handle the growing amount of audiovisual content, software vendors and manufacturers will respond with MPEG-7 applications. It is also possible that in the near future MPEG-7 may spawn a new industry of companies producing, owning and selling metadata.

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Additional Resources

Initiatives, Forums and Associations

MP7C	www.mp7c.org
MPEG	www.chiariqlione.org/mpeg/
MPEGIF	www.mpegif.org
W3C	www.w3.org

The MPEG-7 Standard

The MPEG-7 standard ISO/IEC 15938 can be obtained from ISO, where it is divided into eight parts as shown below.

- ISO/IEC 15938-1: Multimedia content description interface – Part 1: Systems
- ISO/IEC 15938-2: Multimedia content description interface – Part 2: Description definition language
- ISO/IEC 15938-3: Multimedia content description interface – Part 3: Visual
- ISO/IEC 15938-4: Multimedia content description interface – Part 4: Audio
- ISO/IEC 15938-5: Multimedia content description interface – Part 5: Multimedia description schemes
- ISO/IEC 15938-6: Multimedia content description interface – Part 6: Reference software
- ISO/IEC 15938-7: Multimedia content description interface – Part 7: Conformance testing
- ISO/IEC 15938-8: Multimedia content description interface – Part 8: Extraction and use of MPEG-7 descriptions

Parts 6 and 7 are also publicly available from:

http://isotc.iso.ch/livelink/livelink/fetch/2000/2489/Ittf_Home/PubliclyAvailableStandards.htm

Definitions, acronyms and abbreviations

ASX	Windows Media Player playlist (file extension)
BiM	Binary Format for MPEG-7
DVD	Digital Versatile Disc
EBU	European Broadcasting Union
HDTV	High-Definition Television
HTTP	Hypertext Transfer Protocol
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
M3U	Playlist for multiple MP3 files
MPEG	Moving Picture Experts Group
MPEG-7	ISO/IEC 15938: Multimedia Content Description Interface
MP3	MPEG-1 Audio Layer-3 (audio coding)
PLS	Playlist file
RTSP	Real Time Streaming Protocol
SMIL	Synchronized Multimedia Integration Language
SMPTE	Society of Motion Picture and Television Engineers
XML	Extensible Markup Language