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MPEG-7

Overview of MPEG-7 Description Tools, Part 2

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MPEG-7,[1,2] which became ISO/IEC 15398 standard in Fall 2001, is the standard for describing multimedia content that provides the richest multimedia content description tools for applications ranging from content management, organization, navigation, and automated processing. The MPEG-7 standard defines a large library of core description tools, and a set of system tools provides the means for deploying the description in specific storage and transport environments. MPEG-7 addresses many different applications in many different environments, which means it needs to provide a flexible framework for describing multimedia data, including extensibility (using the Description Definition Language) and restrictibility (via the MPEG-7 Profiles under specification).

Part one of this article provided a comprehensive overview of MPEG-7's motivation, objectives, scope, and components. In this issue, I'll give more details on the MPEG-7 description tools, which comprise all of MPEG-7's predefined descriptors and description schemes. We can also define additional description tools for specific applications using the MPEG-7 Description Definition Language (DDL), an extension of the XML Schema.[3,4]

We can group these description tools in different classes according to their functionality (see Figure 1). These description tools are standardized by three of the six parts that make up the MPEG-7 standard:[5–10]

- Part 3 (Visual[6]) standardizes the descriptors related to visual features that apply to images and/or videos;
- Part 4 (Audio[7]) standardizes the description tools related to audio features, covering areas from speech to music; and

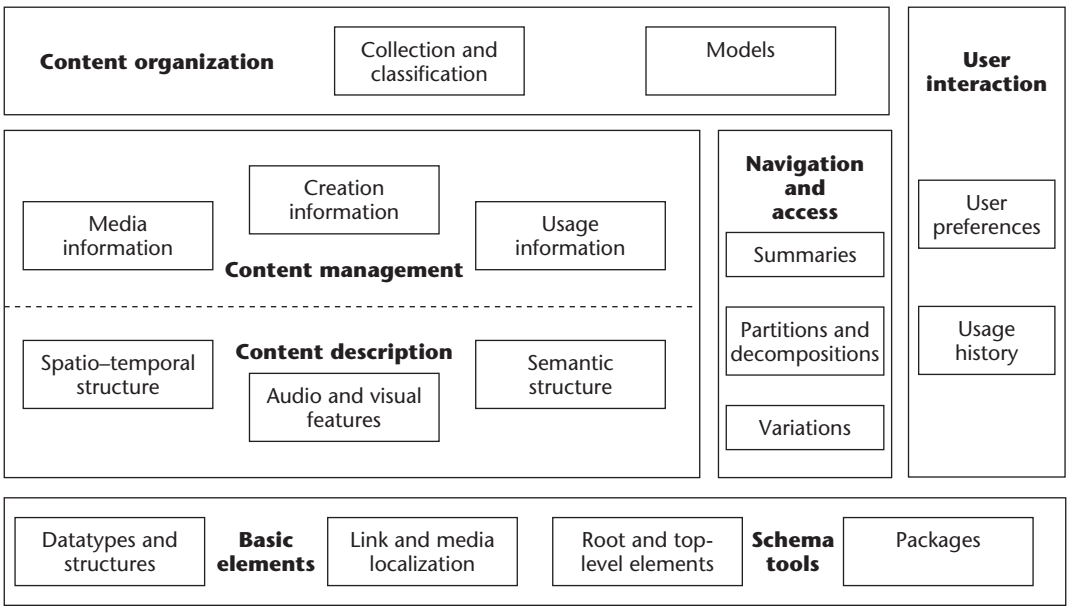

Figure 1. MPEG-7 description tools overview.

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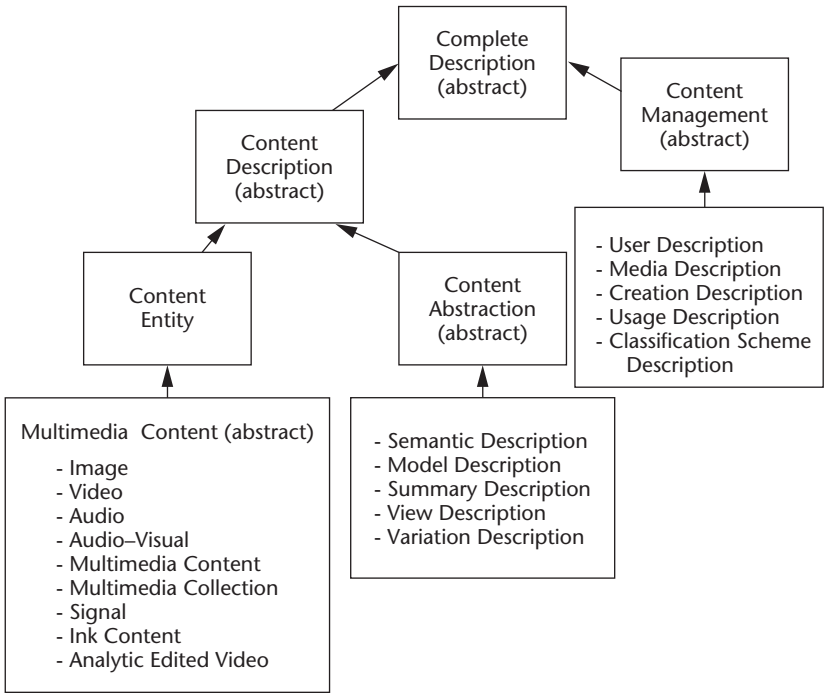

Figure 2. Type hierarchy for top-level elements.

- Part 5 (Multimedia Description Schemes [MDS][8]) standardizes the description tools related to features applying to audio, visual, and audio–visual content.

The last two parts of the standard, Conformance[11] and Extraction and Use of MPEG-7 Descriptions,[12] are still under development.

Schema tools and basic elements

To create MPEG-7 descriptions of any multimedia content, the first requirement is to build a wrapper for the description using the *Schema Tools*. The different description tools we can use for the description use generic *basic elements*, which are the MPEG-7 bricks that extend the ones provided by XML (built-in data types[13]).

Wrappers: Root and top-level elements

There are two different valid types of MPEG-7 descriptions: *description units* and *complete descriptions*. Each MPEG-7 description should start with the MPEG-7 root element (`<Mpeg7>`) including the description metadata header (`<DescriptionMetadata>`), which provides metadata about the description, and either a description unit (`<DescriptionUnit>`) or a complete description (`<Description>`). The description unit lets us create valid MPEG-7 descriptions containing any description tool instance as the component of the description. This lets us send only part of a whole description when an application sends a request for a specific component from a complete description. The complete description tag implies that the enclosed description's structure follows one of the MPEG-7 *top-level elements*, which are organized in three groups (see Figure 2):

- Content Management top-level elements describe management-related aspects of the content such as media, creation, and usage.
- Content Entity top-level elements describe multimedia entities such as image, video, audio, audio–visual, and multimedia content.
- Content Abstraction top-level elements describe abstractions of the content such as semantics, models, summaries, and variations.

These top-level elements are the starting points of any MPEG-7 complete description. Figure 3 presents a snapshot of an MPEG-7 description example.

Additionally, optional *relationships elements* let us describe the relationships among different top-level elements within the same MPEG-7 complete description.

Finally, *package tools* let us group description tools in any combination and rename them. These description tools are intended to let us customize description tools for predesigned applications (such as search engines).

Bricks: Basic elements

The basic elements are the generic entities that various description tools use as building blocks. They include Audio basic elements, Visual basic elements, basic numerical data types (such as numbers, matrices, and vectors), string data types (such as country, region, and currency codes following ISO standards), links and locators (such as time, media locators, and referencing description tools), and other basic description tools for people, places, textual annotations, controlled vocabularies, and so forth. Although MPEG-7 wasn't

Textual Annotation and Controlled Vocabularies Description Tools

Several Textual Annotation description tools provide different ways of creating textual annotation, from keyword- to linguistic-oriented annotation, having also a structured annotation based on the seven terms who, what action, what object, where, when, why, and how.

Controlled Vocabularies description tools let us have controlled terms for descriptors—that is, the descriptor values are selected from a controlled vocabulary or thesaurus. The description tool defining the controlled vocabularies is the Classification Scheme Description Scheme, which includes terms with associated multilingual labels and descriptions. We can group the terms in hierarchies or more complex relationships. Descriptors using classification schemes can be of Term Use type, which means that they can include controlled and not controlled terms, or of Controlled Term Use type, which means the term must be from a classification scheme. Classification schemes in MPEG-7 must be used as defined, without modification. Nevertheless, MPEG-7 lets us use other thesauri or controlled vocabularies to generate descriptions, after they are instantiated as an MPEG-7 classification scheme. The establishment of a registration authority for MPEG-7 classification schemes is currently in progress.

targeted at the standardization of description tools for supporting textual descriptions, some (see the "Textual Annotation and Controlled Vocabularies Description Tools" sidebar) were necessary to provide a complete set of description tools for audio–visual content.

Content Management top-level elements

The five top-level elements dealing with content management description are derived from the abstract Content Management Description Scheme. (In this article, we use abstract in the XML Schema sense, that is, abstract description tools are instantiated as description tools derived from them, and therefore, we need to have an `xsi:type` attribute to specialize the description tool instance [see Figure 3].) The content management description deals with information related to content, but the information is independent of what is in the content itself. It covers, among other things, classical archival and usage information.

```
<Mpeg7>
<DescritpionMetadata>...</DescriptionMetadata>
<Description xsi:type="ContentEntity">
<MultimediaContent xsi:type="VideoType">
  <Video id="video_example">
    <MediaInformation>...</MediaInformation>
    <TemporalDecomposition gap="false" overlap="false">
      <VideoSegment id="VS1">
        <MediaTime>
              <MediaTimePoint>
              T00:00:00</MediaTimePoint>
              <MediaDuration>PT2M</MediaDuration>
        </MediaTime>
        <VisualDescriptor xsi:type="GoFGoPColorType"
          aggregation="average">
              <ScalableColor numOfCoef="8"
                numOfBitplanesDicarded="0">
                <Coeff>1 2 3 4 5 6 7 8</Coeff>
              </ScalableColor>
        </VisualDescriptor>
        </VideoSegment>
        <VideoSegment id="VS2">
          <MediaTime>
              <MediaTimePoint>T00:02:00
                </MediaTimePoint>
              <MediaDuration>PT2M</MediaDuration>
        </MediaTime>
        <VisualDescriptor xsi:type="GoFGoPColorType"
            aggregation="average">
              <ScalableColor numOfCoef="8"
                numOfBitplanesDicarded="0">
                <Coeff>8 7 6 5 4 3 2 1</Coeff>
              </ScalableColor>
        </VisualDescriptor>
      </VideoSegment>
    </TemporalDecompostion>
  </Video>
</MultimediaContent>
</Description>
</Mpeg7>
```

Figure 3. Snapshot of an MPEG-7 description example.

- *Media Description top-level element.* The Media Description top-level element describes the content using the Media Information Description Scheme, which encapsulates the different description tools for describing the multime-

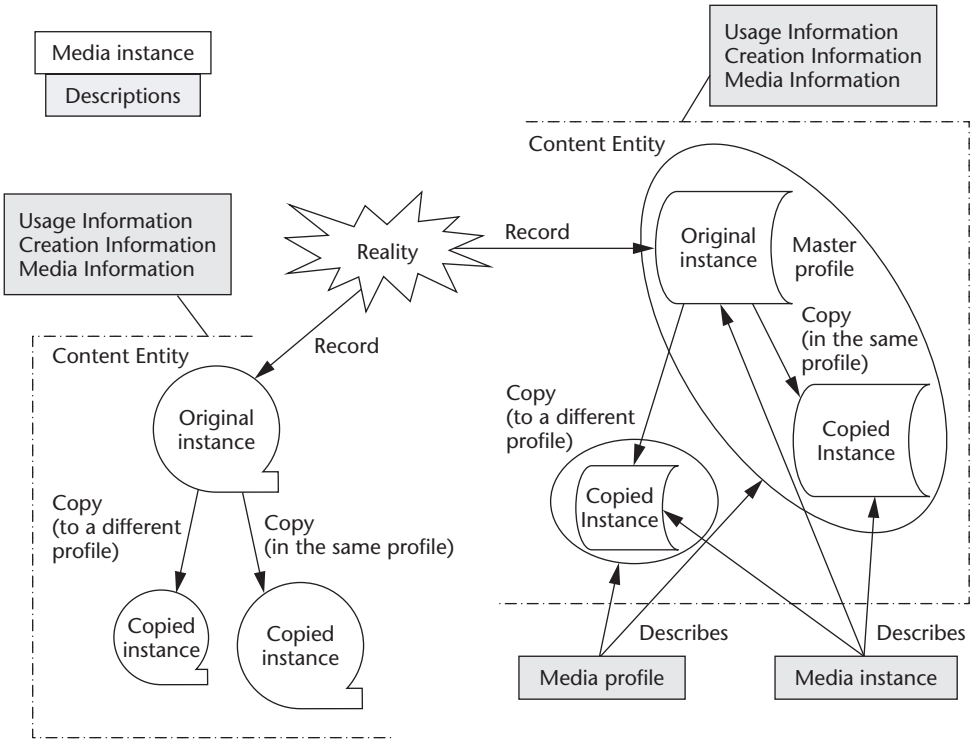

Figure 4. Relationships between the Content Management description tools and the content instances.

dia content's coding aspects. The Media Information Description Scheme is composed of an optional Media Identification Description Scheme for identifying the multimedia content independently of the different available instances, and one or more Media Profile Description Schemes for describing a profile of the multimedia content. A media profile refers to the parameters of each variation of the content that is produced from a content entity (such as a recording of a reality—such as a concert or sports event—or synthetic content generated by an authoring tool). The profile includes the description of the media format (file format and coding parameters) and transcoding hints and quality. For each profile, there's also a description of all the available instances with an identifier and a locator. Figure 4 depicts these concepts.

- *Creation Description top-level element*. The Creation Description top-level element describes the content using the Creation Information Description Scheme, which includes description tools for creation and production information (such as author, title, characters, and director), classification information (such as target audience, genre, and rating), and related materials.
- *Usage Description top-level element*. The Usage Description top-level element describes the content using the Usage Information Description Scheme, which provides the description tools for pointing to rights, usage information (such as availability and audience) and financial information (such as costs and prices).
- *Classification Scheme Description top-level element*. The Classification Scheme Description top-level element lets us describe a classification scheme (see the "Textual Annotation and Controlled Vocabularies Description Tools" sidebar) for a term-based descriptor used to describe the content.
- *User Description top-level element*. The User Description top-level element describes user-related information of the content making use of the Agent Description Scheme (for the user description), the User Preferences Description Scheme (for enabling effective and personalized access such as filtering, searching, and browsing preferences), and the Usage History Description Scheme (for logging user actions that might help refine user preferences).

Content Description top-level elements

The different top-level elements dealing with

content description are derived from the abstract Content Description Description Scheme. Content description deals with entities (Content Entity top-level elements) and abstractions (Content Abstraction top-level elements).

Content Entity top-level element

The Content Entity top-level element describes multimedia content by instantiating one or several description schemes derived from the abstract Multimedia Content Description Scheme. As Table 1 shows, these derived description schemes use different description tools:

- *Still Region Description Scheme*. The Still Region Description Scheme extends the Segment Description Scheme for the description of an image or a 2D spatial region, not necessarily connected in space, because there are description tools for defining the regions and their connectivity. We can incorporate any Visual description tool (see the "Visual Description Tools" sidebar) into the Still Region Description Scheme-based description.

- *Video Segment Description Scheme*. The Video Segment Description Scheme extends the Segment Description Scheme for the description of a video or groups of frames, not necessarily connected in space or time, because there are description tools for defining regions, intervals, and their connectivity. We can incorporate any Visual description tool (see the "Visual Description Tools" sidebar) into the Video Segment Description Scheme-based description.

- *Audio Segment Description Scheme*. The Audio Segment Description Scheme extends the Segment Description Scheme for the description of an audio or groups of audio samples, not necessarily connected in time, because there are description tools for defining intervals and their connectivity. We can incorporate any Audio description tool (see the "Audio Description Tools" sidebar, next page) into the Audio Segment Description Scheme-based description.

- *Audio–Visual Segment Description Scheme*. The Audio–Visual Segment Description Scheme extends the Segment Description Scheme for the description of an audio–visual content or segments of it, which corresponds to the audio and video content in the same tempo-

Table 1. Multimedia content derived description tools and their components.

Content Description Type	Description Scheme
Image	Still Region
Video	Video Segment
Audio	Audio Segment
Audio–visual	Audio–Visual Segment
Multimedia	Multimedia Segment
Multimedia Collection	Collection or Structured Collection
Signal	Still Region, Video Segment, or Audio Segment
Ink Content	Ink Content
Analytic Edited Video	Analytic Edited Video

Visual Description Tools

ISO/IEC 15938-3, MPEG-7 Visual, standardizes the description tools we use to describe video and image content. The Visual descriptors (there are no Visual Description Schemes) are based on visual features that let us measure similarity in images or videos. Therefore, we can use the MPEG-7 Visual Descriptors to search and filter images and videos based on several visual features like color, texture, object shape, object motion, and camera motion.

We can classify the MPEG-7 Visual Descriptors into generic and high-level (application-specific) description tools. The generic Visual descriptors let us describe color, texture, shape, and motion features. The high-level descriptors provide description tools for face-recognition applications.

The generic Visual descriptors are grouped as follows:

- *Basic Elements* (used by the other Visual descriptors): grid layout, time series, 2D–3D multiple view, spatial 2D coordinates, and temporal interpolation.

- *Color Descriptors*: Color Space, Color Quantization, Scalable Color, Dominant Color, Color Layout, Color Structure, and Group-of-Frames/Group-of-Pictures Color.

- *Texture Descriptors*: Homogeneous Texture, Non-Homogeneous Texture (Edge histogram), and Texture Browsing.

- *Shape Descriptors*: Region-Based, Contour-Based, and 3D Shape.

- *Motion Descriptors* (for video): Motion Activity, Camera Motion, Parametric Motion, and Motion Trajectory.

- *Location Descriptors*: Region Locator and Spatio–Temporal Locator.

Audio Description Tools

ISO/IEC 15938-3, MPEG-7 Audio, standardizes the description tools for describing audio content. Most Audio description tools are based on audio features that let us measure similarity in sounds (such as music and speech). Therefore, we can use these MPEG-7 Audio descriptors and description schemes to search and filter audio content based on several audio features like spectrum, harmony, timbre, and melody. Other Audio description tools let us describe spoken content and create a classification of sounds.

We can classify the MPEG-7 Audio description tools into generic and high-level description tools. The generic Audio description tools include a group of low-level descriptors for audio features, named the MPEG-7 Audio Framework (see Figure A), that let us describe an audio signal's spectral, parametric, and temporal features. The high-level group provides description tools for sound recognition and indexing, spoken content, and query-by-humming applications, among other things.

We can group the high-level audio description tools by the functionality they support as follows:

- *Robust audio matching*, supported by the Audio Signature Description Scheme, which describes spectral flatness of sounds;
- *Timbre matching* (identification, search and filtering), supported by the Harmonic Instrument Timbre and the Percussive Instrument Timbre Descriptors;
- *Melodic search*, supported by the Melody Contour Description Scheme (efficient melody description) and the Melody Sequence Description Scheme (complete melody description);
- *Sound recognition and indexing*, supported by the Sound Model Description Scheme, the Sound Classification Model Description Scheme, the Sound Model State Path Descriptor, and the Sound Model State Histogram Descriptor; and
- *Spoken content*, supported by the Spoken Content Lattice Description Scheme and the Spoken Content Header Descriptor.

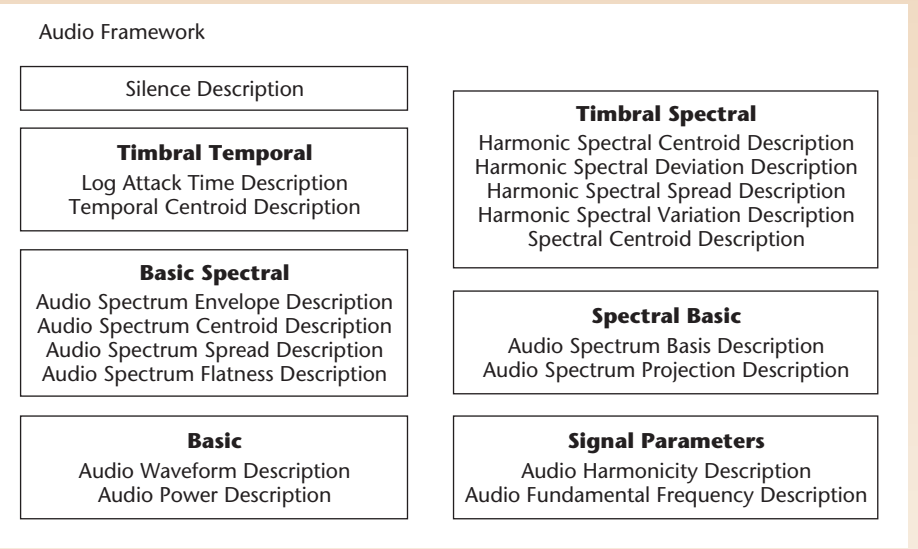

Figure A. Overview of the MPEG-7 Audio Framework.

ral intervals. The segments don't need to be connected in space and/or time, because there are description tools for defining spatio–temporal segments and their connectivity. We can incorporate Visual and Audio description tools into the Audio–Visual Segment Description Scheme through the Audio Segment Description Scheme and Video Segment Description Scheme that can appear within the description's decomposition level.

- *Multimedia Segment Description Scheme*. The Multimedia Segment Description Scheme extends the Segment Description Scheme for the description of a multimedia content or segments of it, including audio, video, and possible other media. It uses the Media Source Decomposition Description Scheme that describes the media source decomposition in one or more segments, including their segmentation criteria, their spatio–temporal segmentation relationships (gap and overlap), and the resulting segments using Segment Description Schemes or references.
- *Collection Description Scheme*. The Collection Description Scheme comprises different description tools that we use to describe collections derived from the abstract Collection Description Scheme. These derived description tools are Content Collection Description Scheme (for collections of multimedia content), Segment Collection Description Scheme (for collections of segments), Descriptor Col-

lection Description Scheme (for collections of descriptors), Concept Collection Description Scheme (for collections of semantic concepts, like objects and events), and Mixed Collection Description Scheme (for collections including any of these components).

- *Structured Collection Description Scheme*. The Structured Collection Description Scheme lets us describe relationships among collections and models. The relationships can indicate various relations among the items, such as the similarity of collections in terms of features or the overlapping of semantic meaning. Besides a Graph Description Scheme for describing relationships, it includes description tools for describing the collections, models, and clusters.

- *Ink Content Description Scheme*. The Ink Content Description Scheme extends the Segment Description Scheme for the description of a segment of ink data, not necessarily connected in space or time, as there are description tools for defining spatio–temporal segments and their connectivity. We can incorporate any Visual description tool (see the "Visual Description Tools" sidebar) and description tools specific to ink data (such as ink media and creation and handwriting recognition) into the Ink Segment Description Scheme based description.

- *Analytic Edited Video Description Scheme*. The Analytic Edited Video Description Scheme extends the Video Segment Description Scheme for the description of an edited video segment (such as shots and transitions) from an analytic point of view—that is, the description is made (either automatically, with supervision, or manually) after the edition of the video. The Analytic Edited Video Description Scheme adds, among others, description tools for the spatio–temporal decomposition from the viewpoint of video editing (shots and transitions), and editing-level location and reliability.

Most of these description tools are derived from the abstract Segment Description Scheme. This description scheme includes description tools that let us annotate the different spatio–temporal segments that can compose a multimedia content, instead of the content as a whole. These description tools include, among others, the Media Information, Creation Information, Usage Information, Text Annotation, and Semantic Description Schemes.

Content Abstraction top-level elements

Content abstraction deals with the description of secondary content representations that are created from or are related to the multimedia content. Semantics depicted in the content, summaries of a video, or a model of audio–visual features are abstractions of multimedia content. The different top-level elements dealing with content abstraction are derived from the abstract Content Abstraction Description Scheme:

- *Semantic Description top-level element*. The Semantic Description top-level element uses the Semantic or Concept Collection Description Schemes. The Semantic Description Scheme lets us describe reality or fiction (narrative world) depicted by, represented by, or related to the multimedia content. The Semantic Description Scheme includes specialized semantic description tools (derived from the Semantic Base Description Scheme) for describing objects (Object Description Scheme), events (Event Description Scheme), agents (Agent Object Description Scheme), concepts (Concept Description Scheme), and their relationships. Figure 5 (next page) illustrates a conceptual description using these description tools.

- *Model Description top-level element*. The Model Description top-level element uses the different description tools available for describing models. These description tools are derived from the abstract Model Description Scheme and let us describe different specialized model types—for example, probabilistic, analytic, and classification models.

- *Summary Description top-level element*. The Summary Description top-level element uses the Summarization Description Scheme, which lets us describe a set of summaries to enable rapid browsing, navigation, visualization, and sonification of multimedia content. Each summary is specified using the Summary Description Scheme, which lets us describe either hierarchical or sequential summaries.

- *View Description top-level element*. The View Description top-level element uses different

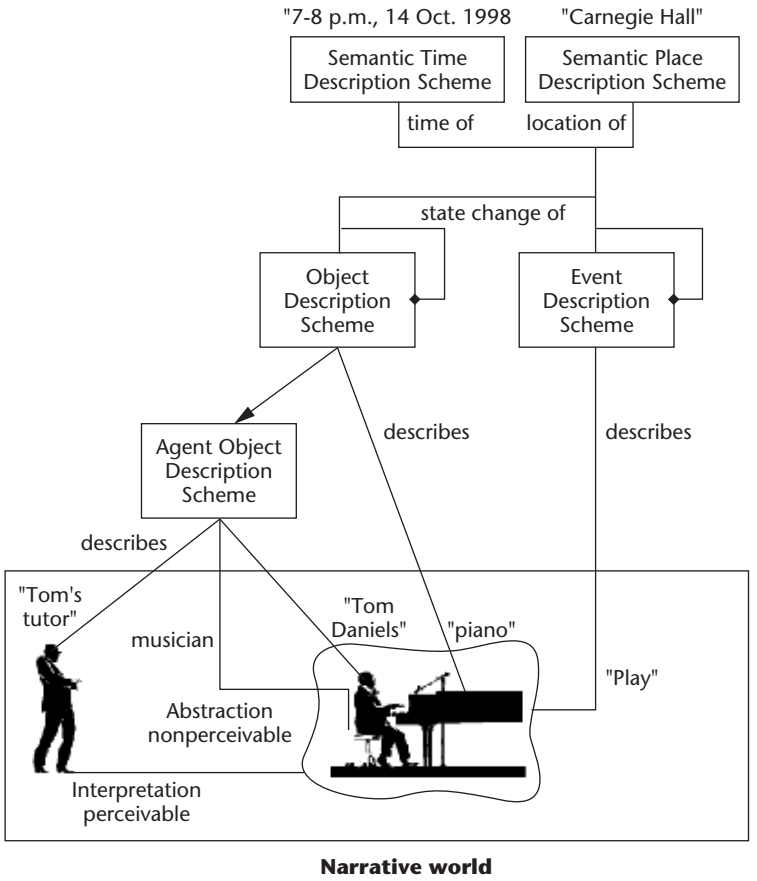

Figure 5. Example of conceptual aspects description.

Table 2. Features associated to the main spatio–temporal region description tools.

Feature	Video Segment	Still Region	Moving Region	Audio Segment
Time (MDS)	x		x	x
Shape (Visual)		x	x	
Color (Visual)	x	x	x	
Texture (Visual)		x		
Motion (Visual)	x		x	
Camera motion (Visual)	x			
Audio features (Audio)			x	x

description tools for the description of content views—that is, a space and frequency partition of a multimedia content (signal). The abstract View Description Scheme is used to describe the Source and Target View image, video, or audio signal (including their locations), and it's specialized in the different description tools for describing the specified types of views (space, frequency, resolution, space resolution and space frequency). We use the View Set Description Scheme to describe a set of views, indicating completeness and redundancy in the coverage of the space and/or frequency planes as well as the types of views in the set.

We use the abstract View Decomposition Description Scheme as the base to describe a decomposition of a multimedia content (signal) into views. Specific description tools for the description of view decompositions are the View Set, Space Tree, Frequency Tree, Space Frequency Graph, Video View Graph, and Multiresolution Pyramid Description Schemes.

- *Variation Description top-level element*. The Variation Description top-level element uses the two description tools for the description of content variations, including summarization, modality translation, reductions (such as the number of colors, spatial size, temporal duration, compression, and frame rate reduction), and so on. The Variation Description Scheme includes description tools, among others, for the description of the source, the type of variation, and the source's fidelity. We use the Variation Set Description Scheme to describe a set of variations (using the Variation Description Scheme) of a source.

Describing multimedia assets

The first and main use of MPEG-7 will be describing individual multimedia assets, creating MPEG-7 documents that user queries[14] or filtering agents[15] will access. Nevertheless, as I've already described, the possibility exists of using the MPEG-7 description tools to describe collections of multimedia assets and to annotate user preferences and usage history that applications running on the devices accessing the content (such as set-top boxes) will use.

When describing a multimedia asset, there are two main options. One is to describe it as a whole—that is, without describing parts of it. This option implies that the multimedia asset will have no structural decomposition, and therefore, it will be composed by a Content Management description and/or a Content Abstraction description. These descriptions may be wrapped by a Multimedia Content description, but without the full potential of a description organized by the content's spatio–temporal structure. Spatio–temporal structured descrip-

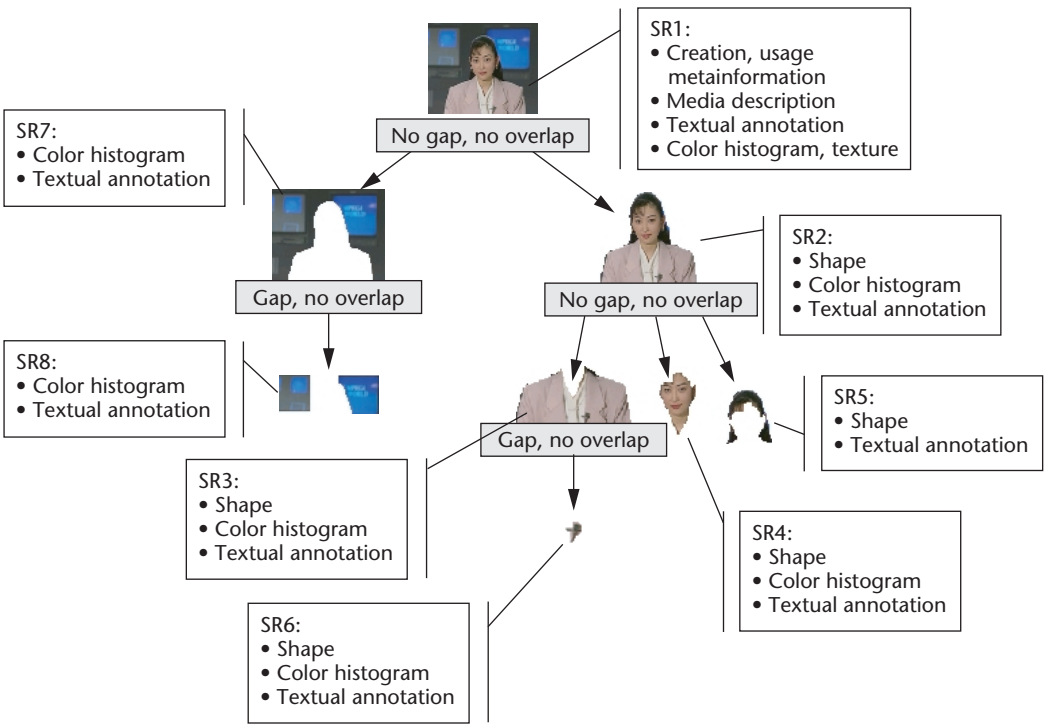

Figure 6. Examples of image description with Still Regions.

tions are one of MPEG-7's main, innovative, and powerful features. It provides the functionalities for describing content at different levels of detail based on a spatial and temporal segmentation.

Table 2 lists the main description tools for describing spatio–temporal regions, together with the main audio–visual features (see the "Visual Description Tools" and "Audio Description Tools" sidebars), that we can include in each description. Besides this feature, we can attach content management and semantic descriptions to each region in the decomposition.

Figure 6 depicts an example of decomposition- and region-based description. We can annotate the whole image with a Still Region covering the whole image, including a Content Management description, a Textual description, and Visual descriptions applied to the whole frame. After spatial segmentation at different levels, we can describe the different regions using different description tools (from the ones allowed with the Still Region Description Scheme), depending on the nature of the region. We can use Segment Relationship description tools to describe relationships among the different regions.

In the case of video and audio assets, MPEG-7 provides description tools for describing static spatial regions as well as temporal regions (segments) and moving regions (in the case of video, of course). Figure 7 shows a snapshot of a video with

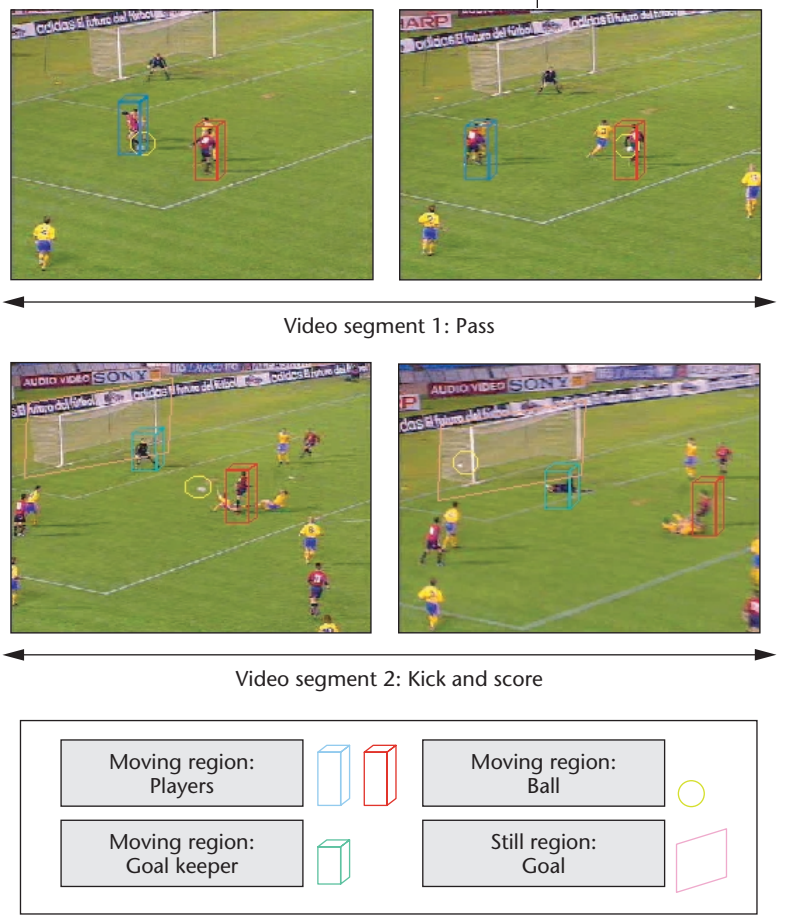

Figure 7. Example of video segments and regions.

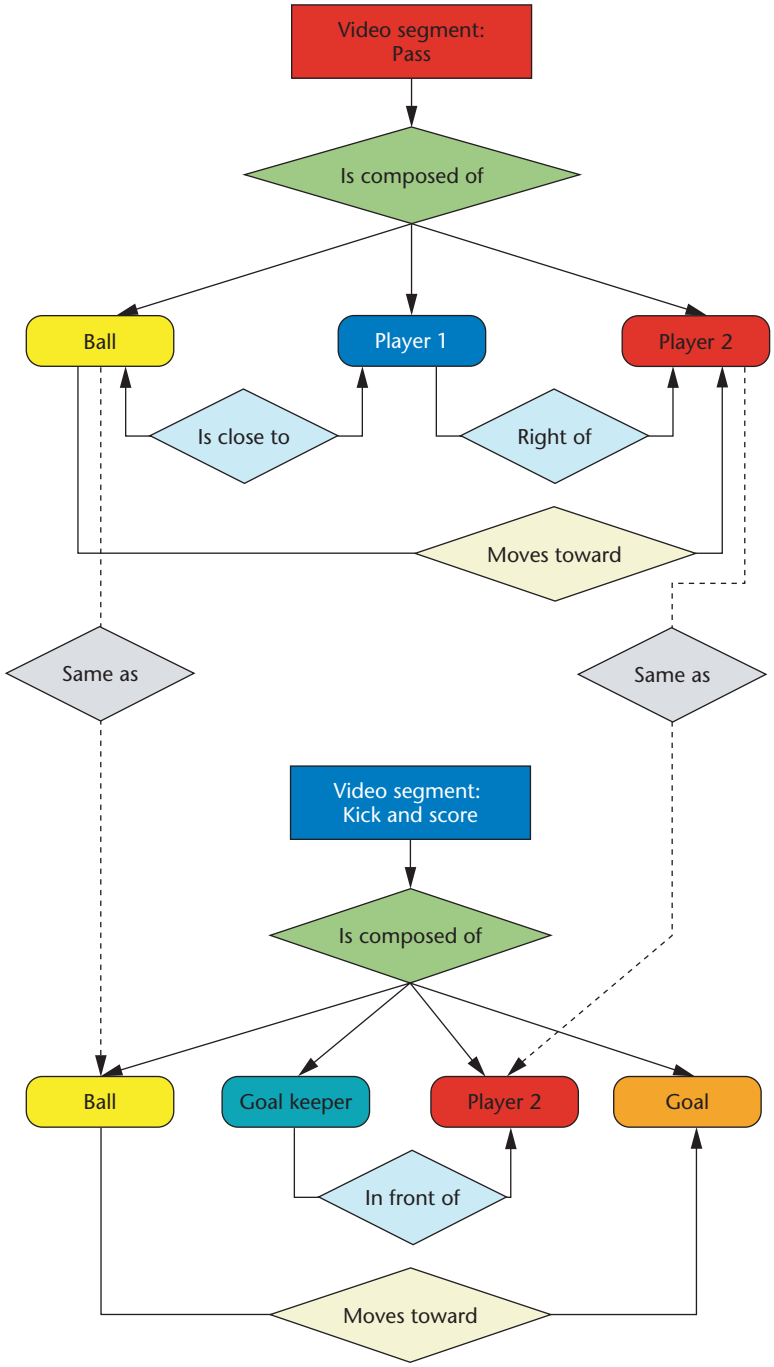

Figure 8. Example of a Segment Relationship Graph for the image in Figure 7.

two temporal segments, each of them with several regions (still and moving). To describe the composition and positional relationship of regions within the same segment and the (identity) relationship of a same region from one segment to another, we can use the Segment Relationship Graph description tool (see Figure 8).

Further reading and resources

For more information about MPEG-7, visit the MPEG homepage (http://mpeg.tilab.com/) and the MPEG-7 Alliance Web site (http://www.mpeg-industry.com). These Web pages contain links to a wealth of information about MPEG-7, many publicly available MPEG documents, several lists of Frequently Asked Questions, and links to other MPEG-7 Web pages. Complete MPEG-7 schemas and description examples are available at the MPEG-7 Schema page (http://pmedia.i2.ibm.com:8000/mpeg7/schema). You can validate MPEG-7 descriptions using the NIST MPEG-7 Validation Service (http://m7itb.nist.gov/M7Validation.html). **MM**

Acknowledgments

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