e-Learning Media Format for Enhanced Consumption on Mobile Application

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Abstract. As the use of internet based learning has seen a significant increase over the last decade, the topic of new model, methods and tools to support e-Learning have been significant over the last ten years. In this paper, a multimedia application format (MAF) for e-Learning is proposed. The e-Learning MAF shall meet various requirements which enable users to facilitate search, evaluation, acquisition and use of e-Learning contents in ubiquitous environments. To meet these requirements, we design an ISO Base Media File Format file structure and associated MPEG-7 e-Learning metadata suit for e-Learning. In particular, MPEG-7 is used for e-Learning metadata so that it could allow users to consume e-Learning MAF contents with enhanced functionalities such as easy and fast navigation using content-based retrieval. To guarantee interoperability with other e-Learning formats, spaces that are able to contain the metadata of other formats are prepared. We implemented the proposed system on top of mobile device and showed the usability of the e-Learning MAF format and MPEG-7 e-Learning metadata. Furthermore, a prototype system to encode and decode e-Learning MAF is realized on top of mobile device.

Keywords: e-Learning, MAF, MPEG-7, e-Learning metadata

1 Introduction

As the use of the Internet keeps rising every year, digital multimedia contents also become abundant. In particular, to facilitate access to knowledge and to meet the needs of lifelong learning, on those digital environments, e-Learning has been a good alternative to conventional learning paradigms. As Learning environments become ubiquitous, e-Learning methods should also be changed toward being portable, flexible and adaptive.

In recent years, much research has been done on e-Learning tools and products with different pedagogical models and target audiences. Most of the researches concentrate on e-Learning metadata, content packaging and prototype system to manage e-Learning contents. For example, sharable content object reference model (SCORM) [1], [2], [3] was proposed in advanced distributed learning (ADL), which

is a collection of standards and description for managing learning objects, and making them portable from one learning management system to another. SCORM adopts metadata elements from different e-Learning standards groups. Known as IMS learning resource metadata, IEEE learning object metadata (LOM) developed by IEEE learning technology standard committee (LTSC) is both elaborate and general in character containing a broad range of elements [4]. CanCore was developed by a group of national and provincial educators and technology developers [5], [6]. CanCore is based on fully compatible with the IMS Learning Resource Metadata Information Model. Education network Australia (EdNA) Metadata standard [7] is conducted by EdNA Metadata Standard Working Group. The purpose of the EdNA Metadata is to support interoperability across all sectors of education and training in Australia in the area of online resource discovery and management. Gateway to Educational Materials (GEM) [8] has created a metadata element set based on Dublin Core [9] with the addition of education-specific elements.

However, several problems still remain challenging issues in many conventional e-Learning methods as follows.

1) Although e-Learning usually requires effective association and interaction of e-Learning resources and their metadata, there has been minimal research regarding the association and interaction.

2) e-Learning contents are typically composed of single media resource such as a single video, audio or text. If the e-Learning content needs to load multi-modal resources for effective learning, the multi-modal resources are hardly associated with the other resources. In particular, e-Learning contents with several multi-modal resources are often too big to be consumed in portable devices due to their limited storage or computational power.

3) Existing e-Learning contents have their own file formats and related metadata format dedicated to their specific applications. The absence of a standardized file format for containing media resources and e-Learning metadata often causes limited use of the e-Learning contents on different devices.

This paper presents an file structure for e-Learning. It could allow an e-Learning content to take both media resources and metadata. Also, it describes metadata set for e-Learing to allow users to consume e-Learning contents more efficient.

This paper is organized as follows. Section 2 describes about MAF which is matrix of e-Learning MAF. e-Learning scenarios and MPEG-7 e-Learning metadata and e-Learning MAF is presented in Section 3. Utility of e-Learning MAF is presented in Section 4. Conclusion is given in Section 5.

2 MAF

MPEG-A, or the ISO/IEC 23000 standard, is recently added to the well-known standards developed by moving picture experts group (MPEG). MPEG-A aims to facilitate the swift development of innovative, standards-based multimedia applications and services for interoperable and augmented use of extensively prevailed multimedia data such as MPEG-2, MPEG-4, MP3 and JPEG. To meet this goal, the MPEG-A standard specifies MAFs.

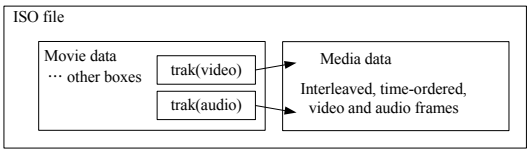

Fig. 1. Basic structure of ISO Base Media File Format

MAF offers selective borrowing current technologies not only MPEG standards, but also non-MPEG standards such as JPEG and JPEG2000. MAF presents a framework combining them into a single specification with relative metadata. A standard should specify the principle as little as possible while guaranteeing maximum interoperability. For this, MAF specifies how to combine metadata with media resources. MAF is derived from the ISO Base Media File Format [10]. The ISO Base Media File Format proffers an efficient, flexible and extendible method to combine media resources. The basic file structure of the ISO Base Media Format is object-oriented and can be decomposed into a continuous object named Box, and all media data subsist in Box.

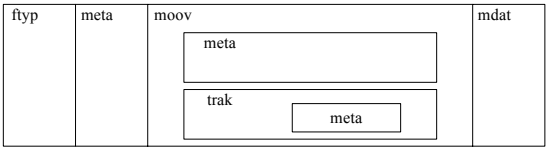

Fig. 2. Position of *meta*

Fig. 1 shows the basic structure of the ISO Base Media File Format. The ISO Base Media File Format separately stores actual media data and information about media data. As shown in Fig. 2, the ISO Base Media File Format has the object-oriented form. *mdat* holds the actual media data, and the information about media data is in *moov*. Each *trak* found in *moov* has information of individual media data respectably. ISO Base Media File Format allows *meta* to be contained by File, *moov*, or *trak*.

3 e-Learning MAF

3.1 e-Learning Scenarios

We first consider useful scenarios to discover requirements about e-Learning MAF. Suppose that there are two different users who consume e-Learning MAF on PC and any mobile device such as PDA or cellular phone. If users want to consume an e-

Learning MAF for their specific purpose, service providers could be expected to provide the best or desirable selection of many e-Learning contents for individual users. The PC users typically have better consuming condition than mobile users because network bandwidth and processing capability are limited. Users could start consuming a specific content after searching process. There should be a verifying process before consuming the content because a searching process recommends several contents about all queries the user requested. In the mobile environment, however, it is hard to verify all recommended contents because of network bandwidth and processing capability limitation such as computation power and memory size. Therefore, in the case of mobile application, a light weight e-Learning MAF just containing metadata about the content and reference identifiers of the media resources could be useful. It may help the mobile user choose desirable content without any time-consuming work to verify un-concerned contents because the embodied metadata could provide useful information about identifying content itself such as creator, lecturer, subject, abstract, etc.. The media resources required to consume the e-Learning MAF could be perfectly obtained by downloading or streaming them real-time. Consequently, the mobile user could consume the desirable e-Learning MAF entirely in spite of the limitations.

3.2 MPEG-7 e-Learning metadata

The importance of metadata for e-Learning is in terms of the Semantic Web. Based on e-Learning metadata, e-Learning repositories can offer effective search for e-Learning contents. Currently several widely used e-Learning metadata exist including CanCore, IMS Learning Resource Meta-data, IEEE LOM and GEM metadata. CanCore is educational metadata, and it is fully compatible with the IMS Learning Resource Metadata Information Model. CanCore has defined a sub-set of elements from IMS model for the purposes of the efficient and uniform description of digital educational resources. It is intended to facilitate effective interchange among learning objects. The IMS Global Learning Consortium developed IMS Learning Resource Meta-data, but it is being aligned with LOM. The schema had been superseded by the LOM. LOM, most widely used metadata for e-Learning, is defined by IEEE LTSC. LOM outlines the minimal set of attributes needed to allow learning objects (either digital or non-digital) to be managed, located and evaluated. It is based on DC metadata. GEM metadata is based on DC metadata with addition of education-specific elements. It consists of 8 GEM elements and 13 DC elements. We could intuitively understand the relation among e-Learning metadata through Fig. 3. Fig. 3 presents that DC metadata is the basic metadata for e-Learning because all metadata for e-Learning widely used are based on DC metadata. DC metadata is an international standard for cross-domain information resource description. The DC metadata have 15 descriptors that resulted from effort in interdisciplinary and international consensus building. It is intended to co-exist with metadata standards that offer other semantics. The 15 elements may appear in any order, and each element is optional and repeatable.

Most existing e-Learning metadata concentrate on effective and efficient search for contents. Although existing e-Learning metadata are enough to describe content itself efficiently search, there should be additional information to meet the users'

requirement about content-based retrieval. Because existing metadata for e-Learning could not support content-based retrieval, we define MPEG-7 e-Learning metadata which can describe not only information about content itself for efficient searching and acquisition but also semantic description for content-based retrieval. Proposed MPEG-7 e-Learning metadata is based on DC metadata for effective and efficient searching and acquisition of the e-Leaning content like existing e-Learning metadata. Moreover, it also describes semantic information about the content for content-based retrieval. MPEG-7 e-Learning metadata is described by MPEG-7 MDS [11]. The MPEG-7 MDS is used to describe and annotate multimedia data. Because MPEG-7 is a standard for describing the multimedia content data that supports some degree of interpretation of the information meaning, which can be easily accessed by a device or a computer. MPEG-7 is not aimed at any one application in particular. The elements that MPEG-7 standardizes support as broad a range of applications as possible. MPEG-7 is a more systematic and well-structured description than other metadata for e-Learning. Only MPEG-7 could describe not only temporal segment structure but also hierarchical decomposition of multimedia contents. It has some advantages about accessing the elements and navigating them.

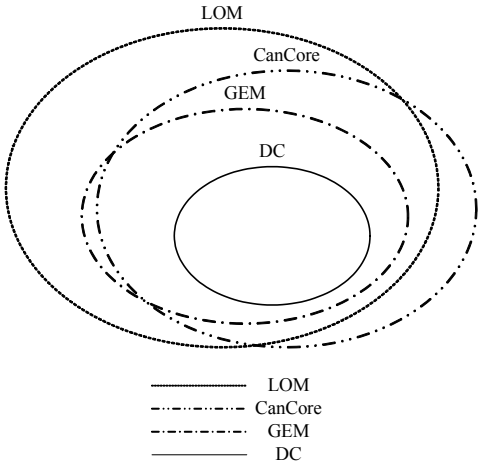

Fig. 3. Usage scenarios of e-Learning MAF

Because MPEG-7 e-Learning metadata is based on DC metadata, there should be relation between them. As shown in Table 1, MPEG-7 could describe all DC metadata elements. In addition to DC metadata, MPEG-7 e-Learning metadata specifies semantic information about the content. Users could consume the e-Learning content more efficiently by using the semantic information which enables users to access and navigate specific theme or sub-content in the e-Learning content.

Table 2 illustrates the organization of the proposed MPEG-7 e-Learning metadata for collection-level description. The collection-level description describes e-Learning content collection which contains not only multiple media resources but also plural

contents on it. In the proposed MPEG-7 e-Learning metadata, collection-level description is represented by *Creation & production*, *Media description*, *Usage description* and *Content collection*.

Table 1. Relation between Dublin Core metadata and MPEG-7

DC element	Definition of DC element	MPEG-7 MDS
Title	A name given to the resource	CreationInformation/Creation/Title
Creator	An entity primarily responsible for making the content of the resource.	CreationInformation/Creation/Creator[Role /Name=”creator”]/Agent/Name
Subject	A topic of the content of the resource.	CreationInformation/Classification/Subject
Description	An account of the content of the resource.	CreationInformation/Creation/Abstraction
Publisher	An entity responsible for making the resource available.	CreationInformation/Creation/Creator[Role /Name=”Publisher”]/Agent/Name
Contributor	An entity responsible for making contributions to the content of the resource.	CreationInformation/Creation/Creator[Role /Name=”Contributor”]/Agent/Name
Date	A date of an event in the lifecycle of the resource.	CreationInformation/Creation/CreationCoordinates/Date
Type	The nature or genre of the content of the resource.	CreationInformation/Classification/Genre
Format	The physical or digital manifestation of the resource.	MediaInformation/MediaProfile/MediaFormat/FileFormat
Identifier	An unambiguous reference to the resource within a given context.	MediaInformation/MediaProfile/MediaInstance/MediaLocator/MediaUri
Source	A reference to a resource from which the present resource is derived.	UsageInformation/Availability/Dissemination/Source
Language	A language of the intellectual content of the resource.	CreationInformation/Classification/Language CreationInformation/Classification/Caption Language
Relation	A reference to a related resource.	CreationInformation/RelatedMaterial/MediaLocator/MediaUri
Coverage	The extent or scope of the content of the resource.	UsageInformation/Availability/Availability Period CreationInformation/Classification /Target/Market CreationInformation/Classification /Target/Age CreationInformation/Classification /Target/Region
Rights	Information about rights held in and over the resource.	CreationInforamtion/Creation/CopyrightString UsageInformation/Right/RightID

Table 3 shows the organization of the MPEG-7 e-Learning metadata for item-level description. The item-level description describes information about one e-Learning resource that belongs to one or more collections. As the item-level description can describe collections in one e-Learning resource, it enables users to access and navigate collections more efficient. Therefore, we propose the item-level description which consists of *structure description*, *navigation and access description*, *creation and production description*, *media description* and *usage description*. The *structure*

description has hierarchical structures which specify the resources in terms of spatio-temporal segments. The *navigation and access description* is the specification of summaries, partitions and decompositions, and variation of the multimedia content for facilitating browsing and retrieval.

Table 2. Organization of collection-level MPEF-7 e-Learning metadata

Collection-level description		Mapping to MPEG-7 MDS
Main descriptor	Required metadata	
Content collection description	Creation description	Collection/CreationInformation
	Content reference	Collection/ContentCollection/ContentRef
	Collection of contents	Collection/ContentCollection/ContentCollection
Creation & production description	Title	CreationInformation/Creation/Title
	Creator	CreationInformation/Creation/Creator[Role/Name=”creator”]/Agent/Name
	Description	CreationInformation/Creation/Abstraction
	Publisher	CreationInformation/Creation/Creator[Role/Name=”Publisher”]/Agent/Name
	Contributor	CreationInformation/Creation/Creator[Role/Name=”Contributor”]/Agent/Name
	Date	CreationInformation/Creation/CreationCoordinates/Date
	Rights	CreationInforamtion/Creation/CopyrightString
	Subject	CreationInformation/Classification/Subject
	Tpye	CreationInformation/Classification/Genre
	Language	CreationInformation/Classification/Language CreationInformation/Classification/CaptionLanguage
	Relation	CreationInformation/RelatedMaterial/MediaLocator/MediaUri
	Coverage	CreationInformation/Classification/Target/Market CreationInformation/Classification/Target/Age CreationInformation/Classification/Target/Region
Media description	Format	MediaInformation/MediaProfile/MediaFormat/FileFormat
	Identifier	MediaInformation/MediaProfile/MediaInstance/MediaLocator/MediaUri
Usage description	Source	UsageInformation/Availability/Dissemination/Source
	Coverage	UsageInformation/Availability/AvailabilityPeriod
	Rights	UsageInformation/Right/RightID

Table 3. Organization of item-level MPEF-7 e-Learning metadata

Item-level description		Mapping to MPEG-7 MDS
Main descriptor	Required metadata	
Structure description	Temporal video segment	VideoSegment/TemporalDecomposition/VideoSegment/MediaTime
	Temporal audio segment	AudioSegment/TemporalDecomposition/AudioSegment/MediaTime
Navigation and access description	Theme-based summary	Summary/HierarchicalSummary/SummarySegmentGroup/SummarySegment
	Theme list	Summary/HierarchicalSummary/SummaryThemeList
Creation & production description	Title	CreationInformation/Creation/Title
	Creator	CreationInformation/Creation/Creator[Role/Name=”creator”]/Agent/Name
	Description	CreationInformation/Creation/Abstraction
	Publisher	CreationInformation/Creation/Creator[Role/Name=”Publisher”]/Agent/Name
	Contributor	CreationInformation/Creation/Creator[Role/Name=”Contributor”]/Agent/Name
	Date	CreationInformation/Creation/CreationCoordinates/Date
	Rights	CreationInforamtion/Creation/CopyrightString
	Subject	CreationInformation/Classification/Subject
	Tpye	CreationInformation/Classification/Genre
	Language	CreationInformation/Classification/Language CreationInformation/Classification/CaptionLanguage
	Relation	CreationInformation/RelatedMaterial/MediaLocator/MediaUri
	Coverage	CreationInformation/Classification/Target/Market CreationInformation/Classification/Target/Age CreationInformation/Classification/Target/Region
Media description	Format	MediaInformation/MediaProfile/MediaFormat/FileFormat
	Identifier	MediaInformation/MediaProfile/MediaInstance/MediaLocator/MediaUri
Usage description	Source	UsageInformation/Availability/Dissemination/Source
	Coverage	UsageInformation/Availability/AvailabilityPeriod
	Rights	UsageInformation/Right/RightID

The e-Learning contents are sequential media. According to the passing of time, the e-Learning content is divided into several sub-contents. The item-level description describes information about groups and segments. As the item-level description can describe collections in one e-Learning resource, it enables users to access and navigate collections more efficient.

As shown in figure 4, an e-Learning content is built from temporal segments of the media data. The temporal segments are grouped into a group, so the e-Learning content is organized into several groups.

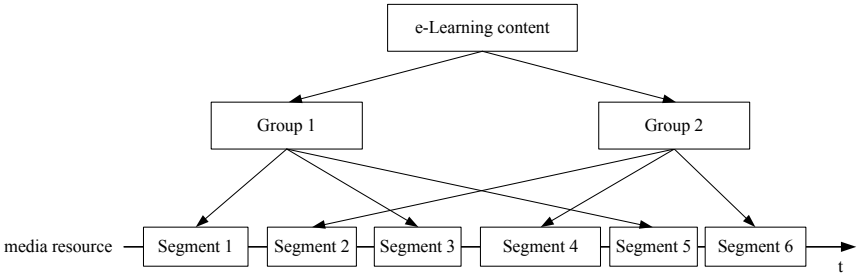

Fig. 4. Hierarchical structure of e-Learning content

3.3 e-Learning MAF

Fig. 5 illustrates the structure of e-Learning MAF. Because the unified framework converts media resource files such as avi, mp3, JPEG into a unified e-Leaning file, e-Learning resource management systems could control the e-Learning files more efficiently. Information about media resources such as video, audio, image and text required by e-Learning content resides at *trak* in *moov*, and actual media resource data is in *mdat*. e-Learning metadata could allow users to consume e-Learning contents with enhanced functionalities such as easy and fast navigation using content-based retrieval. Proposed MPEG-7 e-Learning metadata locates at *meta* in *moov*, and additional spaces for contain existing e-Leaning metadata could locate in additional *trak*. Because of the additional space, proposed e-Learning MAF guarantees interoperability with other metadata for e-Learning. If a user has LOM metadata decoder, the user could consume LOM metadata which is located in *trak*.

Scene description information should present how the various objects are located in space and time. Because it is impossible to refer to the information from particular media elementary streams directly, object descriptors should identify each object and separate the scene description from encoded objects. This allows changing media data without any amendment of the scene description.

MPEG-4 standardized the scene description which supports complete freedom in modifying itself through scene update. Binary format for scenes (BIFS) [12], scene description language for MPEG-4, offers dynamic scene behavior and user interaction. Because BIFS makes it possible to not only synchronize among media resources but

also represent interaction between users and e-Learning contents, e-Learning MAF employs BIFS to render media resources. BIFS is a binary format so there should be a compiler to translate the scene from text to binary.

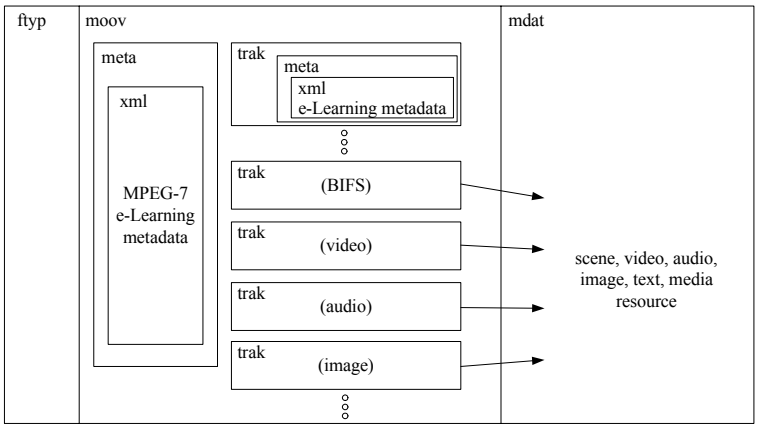

Fig. 5. Structure of e-Learning MAF

4 Experiments

In this paper, we presented a unified file structure for e-Learning. It allows an e-Learning content to contain both media resources and metadata in one file. Also, the paper describes metadata for e-Learning to enables users to consume e-Learning contents efficiently.

To verify the effectiveness and efficiency of the e-Learning MAF, we implement encoding and decoding system for e-Learning MAF. Especially, the decoding system is realized on top of the mobile device. Fig. 6 illustrates the encoding and decoding system. During encoding process, information about media resources is held by *trak* respectively. MPEG-7 e-Learning metadata is described in MPEG-7 MDS after extracting metadata from multimedia resources. The MPEG-7 e-Learning metadata contains information about the media sources, content itself and content semantic information. Additional e-Learning metadata also could exist in e-Learning MAF at prepared space. Scene Descriptor describes time information about when the specific resources are to be rendered and information about interaction with users.

The e-Learning MAF generated by the encoder could be consumed by the decoder. ISO base atom parser extracts media data, MPEG-7 e-Learning metadata and rendering data. It also could extract existing e-Learning metadata when e-Learning MAF contains it. After extracting MPEG-7 e-Learning metadata, MPEG-7 parser analyzes the metadata. When users request content-based retrieval, the analyzed

information is employed. The extracted media resources are rendered by BIFS decoder through e-Learning MAF player.

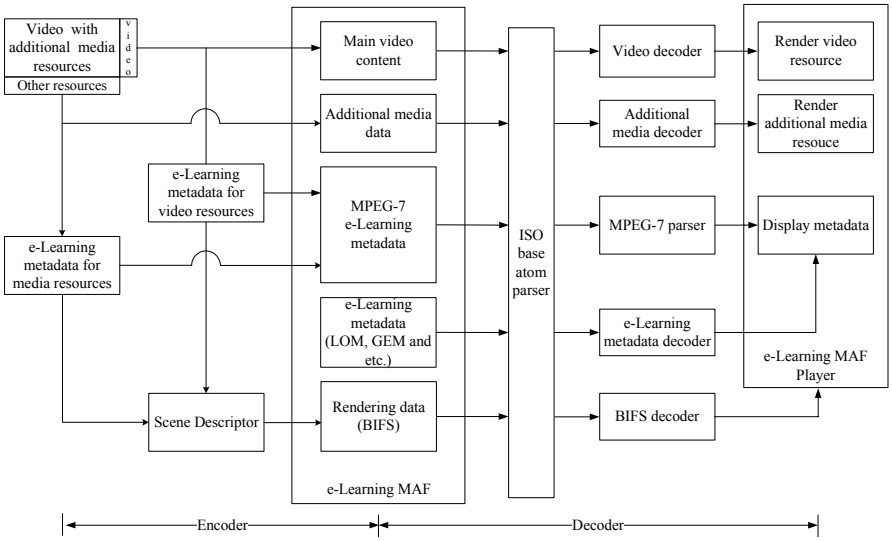

Fig. 6. Encoding and decoding system for e-Learning MAF

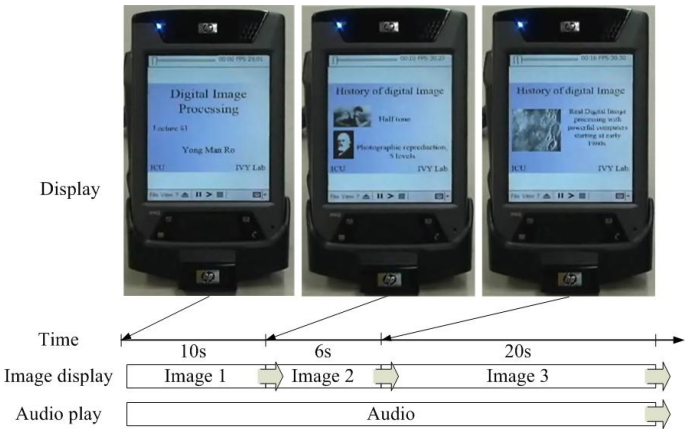

Fig. 7. Decoding system for e-Learning MAF

An e-Learning MAF file was created by MP4Box offered by GPAC. The e-Learning MAF file consists of one MP3 file, several JPEG images and MPEG-7 e-Learning metadata. Because BIFS is a binary format, XMT-A format is used to

describe scene description. During the playing of a audio resource, image 1 is displayed for 10 seconds, and image 2 is displayed for next 6 seconds and image 3 is displayed for next 20 seconds. *meta* was generated at *trak*-level, and e-Learning metadata which was packed by *xml* occupies *meta*. The e-Learning MAF file created by encoding system was consumed through modified Osmo4 player in mobile environment. As shown is Fig. 7, the player renders MP3 and JPEG images as desired time. MPEG-7 e-Learning metadata could support not only efficient searching and acquisition of e-Learning content but also content-based retrieval. Fig. 8 shows enhanced functionalities such as sequential access and theme-level access using MPEG-7 e-Learning metadata. Sequential access enables users to navigate and consume specific sub-content in e-Learning content, and users also could navigate and consume specific theme that users want to consume. Whenever users consume the e-Learning MAF, users could make effective use of those sequential access and theme-level access.

a) Sequential Access b) Theme-level Access

Fig. 8. Content-based retrieval based on MPEG-7 e-Learning metadata

5 Conclusion

In this paper, we have proposed a framework of MAF for e-Learning and defined MPEG-7 e-Learning metadata based on DC metadata and MPEG-7 MDS. The proposed e-Learning MAF facilitates the flexible augmented use of e-Learning contents in ubiquitous environments. Moreover, it guarantees interoperability with existing e-Learning metadata, such as LOM, CanCore and GEM by providing additional spaces to contain them. Proposed MPEG-7 e-Learning metadata locates at

meta in *moov*, and additional spaces for contain existing e-Leaning metadata could locate in the additional spaces independently. Because of the additional space, proposed e-Learning MAF guarantees interoperability with other metadata for e-Learning. With MPEG-7 e-Learning metadata, users could search and acquire e-Learning contents more efficiently and effectively, it also enables users to consume the contents with content-based retrieval which could be described by MPEG-7 MDS. Because MPEG-7 is more a systematic and well-structured description than any other metadata for e-Learning, there are some advantages about accessing the elements and decoding them by describing MPEG-7 e-Learning metadata in MPEG-7. The prototype system to encode and decode e-Learning MAF is realized on top of the mobile device. Further studies on objective verification about the utility of MPEG-7 e-Learning metadata are needed.

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