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The MPEG-21 Multimedia Framework from the user's point of view

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Abstract. The MPEG group is providing the field of multimedia technologies with a set of sophisticated standards: MPEG-4, MPEG-7 and MPEG-21 to support the multimedia delivery & consumption chain from the content creation to its consumption in a secure environment. This paper shows features of MPEG standards from the user's point of view. It also discusses the MUFFINS project which has brought the MPEG-21 vision into life by realizing the first MPEG-21-based multimedia platform.

Ključne besede: MPEG standards, MPEG-4, MPEG-7, MPEG-21, MUFFINS project

Multimedijsko ogrodje standarda MPEG-21 z vidika uporabnikov

Povzetek. Skupina MPEG ponuja področju multimedijskih tehnologij niz sodobnih standardov: MPEG-4, MPEG-7 in MPEG-21 za podporo verigi ponudbe in povpraševanja po multimedijskih vsebinah od izdelave do uporabe vsebine, v varnem okolju in na varen način. Članek poskuša predstaviti lastnosti standardov MPEG z vidika uporabnika. Članek tudi na kratko predstavlja projekt MUFFINS, v okviru katerega je nastala prva multimedijska platforma na podlagi standarda MPEG-21.

Ključne besede: Standardi MPEG, MPEG-4, MPEG-7, MPEG-21, projekt MUFFINS

1 Introduction

Four years have passed since the Moving Picture Experts Group (MPEG) [1] started to work on a new standard – the MPEG-21 "Multimedia Framework". Though the work is far from being completed, the MPEG-21 standard has already significantly contributed to the development of the multimedia technologies. In 2001 a European Community project named MUFFINS [2] started in order to follow the development of the newly emerged MPEG-21 standard. Within the scope of the MUFFINS project, the first MPEG-21-based multimedia platform has been developed, showing the impact of the MPEG-21 standard on the multimedia technology development. It is important to note, that a standard is successful only if it is widely accepted. That means that its development needs to concentrate primarily on the possibilities of a widespread use. Therefore, this paper tries to describe the path that the development of the MPEG-21 standard has taken from the users' point of view. This includes also two other standards from the MPEG family – the MPEG-4 and the MPEG-7. The user tests performed during the MUFFINS project have given some insight into the users' opinion about the MPEG standards and the multimedia technologies. The project is discussed at the end of this paper.

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2 MPEG Standards - Creating an interoperable multimedia infrastructure

One of the most active groups in the field of multimedia is the MPEG – Moving Pictures Experts Group [1]. Two standards from this group, namely the MPEG-1 and MPEG-2, dominate the field of multimedia when it comes to the content representation (coding).

However, having become clear that the interoperability, from both the content producers' and consumers' point of view, is of the paramount importance for further development [3], the MPEG group started to work on another standard for content representation – the MPEG-4. Through features like the extended bitrate range, scalability, and error resilience the MPEG-4 supports many application areas. Moreover, the MPEG-4 has introduced two powerful concepts: audiovisual object representation [4][6], and "IPMP (Intellectual Property Management and Protection) hooks" – interfaces to digital rights management (DRM) systems [5][6].

As the multimedia market has been growing constantly, it has become apparent that more sophisticated mechanisms for content identification and

location are needed. Therefore the MPEG group has started to develop a new standard – the MPEG-7 to provide means for describing the content way beyond the traditional metadata. MPEG-7 provides a standardized metadata scheme, where the descriptive elements range from very low-level features (color, shape…) to high-level structural information about the content [3][4][7].

Although MPEG-4 and MPEG-7 form a powerful couple for representing and describing the multimedia content, a true end-to-end interoperability has still not been achieved. For that reason, the MPEG group has started to work on a new standard, i.e. the MPEG-21, which aims to define a truly interoperable framework through which a user is able to access and use the content in a transparent and secure way [3][8]. MPEG-21 does not favor any particular existing standard or technology as it is open for further development of multimedia technologies.

Two concepts, namely the Universal Multimedia Access (UMA) and the Universal Multimedia Experience (UME), play a very important role in the field of multimedia, especially when considering it from the user's point of view [9]. The idea behind the UMA is that any content should be available anytime and anywhere. The UME goes one step further. It points out that the user should have an equivalent, informative experience anytime and anywhere. Such high demands can be satisfied only by providing a high level of interoperability. As already noted, interoperability is the key feature of the MPEG standards; therefore the MPEG-4, MPEG-7, and especially the MPEG-21 standard, contribute considerably to the realization of the UMA and the UME concepts.

3 MPEG-4 from the user's point of view

MPEG-4 brings many benefits from the user's point of view. Some of them (like error resilience, scalability, hybrid coding of synthetic and natural data…) are probably not very apparent to the user, therefore only two major ones will be presented: the ability to interact with the content and interactivity of different DRM systems.

3.1 Interacting with the content

Ability to interact with the content comes from the MPEG-4 characteristic which allows decomposition of an audio-visual (AV) scene into primitive audiovisual objects (e.g. background image, music, human figure...). These objects are then coded into separate bit stream segments [4][6].

On the user's terminal (Figure 1), audiovisual objects are composed back into the audiovisual scene according to the composition rules (scene description information) set by the content producer. Besides that, the content producer also defines how will user events affect the scene composition. This way a user may interact with the content (moving, hiding, swapping… the AV objects that compose the AV scene).

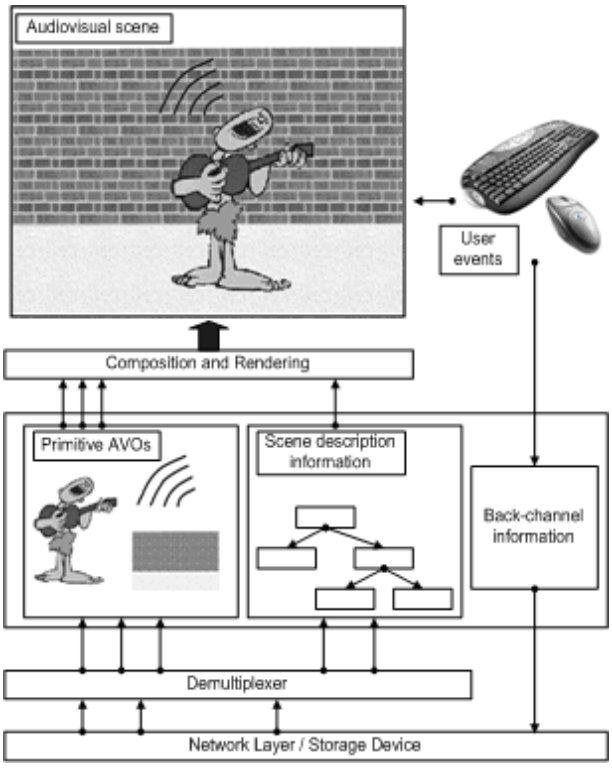

Figure 1. Audiovisual terminal

3.2 The IPMP hooks

In the past the DRM systems, which were used on users' terminals, were in most cases proprietary. Thus the user could only use (play) those pieces of content whose protection was supported by the on-terminal DRM system. Such solution seriously impedes the idea of full-scale interoperability.

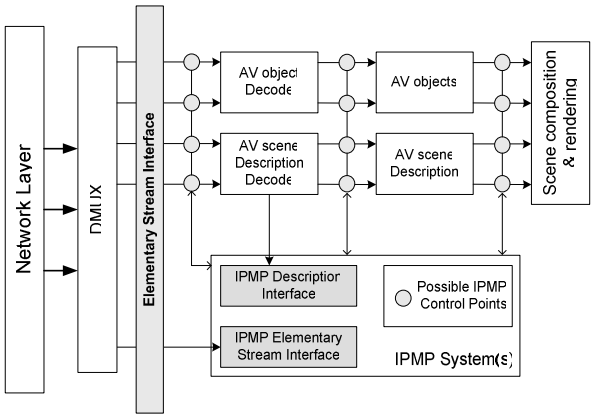

Figure 2. IPMP hooks

Therefore the MPEG-4 has introduced the so called "IPMP hooks" [5][6], which represent interfaces to (different) DRM systems. For the user this means that his terminal can use (play) a wide range of the protected content, which uses different protection mechanisms, just by plugging in the right IPMP system.
The IPMP hooks provide two interfaces: an interface to the IPMP elementary stream and an interface to the IPMP description stream. The IPMP system is also allowed to access different control points in the terminal architecture (Figure 2).

4 MPEG-7 from the user's point of view

As mentioned above, the multimedia search and retrieval has become a very active research field because of the increasing amount of audio-visual (AV) data being available. This context has led to the development of efficient processing tools that are able to support the identification and retrieval of AV documents. The MPEG-7 standard, also known as "Multimedia Content Description Interface", aims at providing standardized core technologies allowing description of the multimedia content in multimedia environments. This is a challenging task given by a broad spectrum of requirements and targeted multimedia applications, and a great number of audio-visual features of importance in such context. In order to achieve this complex goal, MPEG-7 standardizes [7]:

- Datatypes that are description elements not specific to the multimedia domain that corresponds to reusable basic types or structures employed by multiple Descriptors and Description Schemes.
- Descriptors (D) to represent Features.
- Description Schemes (DS) to specify the structure and semantics of relationships between their components, which may be both Ds and DSs.
- A Description Definition Language (DDL) to allow the creation of new DSs and, possibly, Ds and to allow extension and modification of existing DSs.
- Systems tools to support multiplexing of descriptions or description and content, synchronization issues, transmission mechanisms, file format, etc.

Figure 3 presents an overview of the multimedia description schemes. At the lower level basic elements can be found. They deal with schema tools (root element, top-level element and packages), basic datatypes, mathematical structures, linking and media localization tools as well as basic DSs, which are found as elementary components of more complex DSs.
Based on this lower level, content description & management elements can be defined. These tools describe the content of a single multimedia document from several viewpoints. Currently five viewpoints are defined: Creation & Production, Media, Usage, Structural aspects and Semantic aspects. The first three description tools address primarily information related to the management of the content (content management) whereas the two last ones are mainly devoted to the description of perceivable information (content description). The following table (Table 1) defines more precisely the functionality of each set of description tools:

Set of description tools	***Functionality***
Media	Description of the storage media: typical features include the storage format, the encoding of the multimedia content, the identification of the media. Note that several instances of storage media for the same multimedia content can be described.
Creation & Production	Meta information describing the creation and production of the content: typical features include title, creator, classification, purpose of the creation, etc. This information is most of the time author generated since it cannot be extracted from the content.
Usage	Meta information related to the usage of the content: typical features involve rights holders, access right, publication, and financial information. This information may very likely be subject to change during the lifetime of the multimedia content.
Structural aspects	Description of the multimedia content from the viewpoint of its structure: the description is structured around segments that represent physical spatial, temporal or spatio-temporal components of the multimedia content. Each segment may be described by signal-based features (color, texture, shape, motion, and audio features) and some elementary semantic information.
Semantic aspects	Description of the multimedia content from the viewpoint of its semantic and conceptual notions. It relies on the notions of objects, events, abstract notions and their relationship.

Table 1: List of Tools for Content Description and Management

It should be mentioned that MPEG-7 also introduces tools supporting improved user interaction with multimedia content. The description schemes can be used to describe personal preferences and usage patterns of users, enabling automatic discovery selection and

recommendation or recording of the multimedia content. Such tools and services will help reduce the information overload that users may be faced with in the near future.

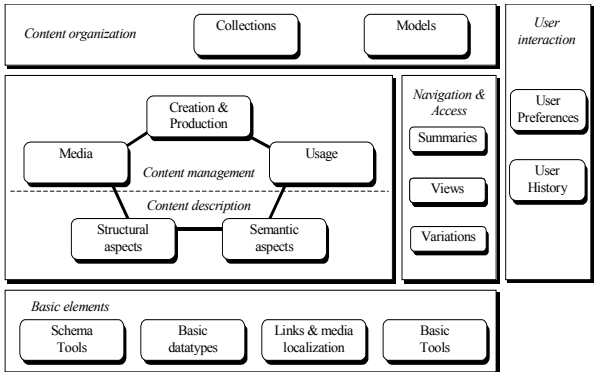

Figure 3: Overview of the MDSs

5 MPEG-21 from the user's point of view

MPEG-21 seeks to create a big picture of multimedia standards. It aims to guarantee interoperability by focusing on how elements of a multimedia application infrastructure should relate, integrate, and interact. The aim of MPEG-21 is to define a multimedia framework to enable transparent and augmented use of multimedia resources across a wide range of networks and devices used by different communities [10].

From the user's point of view, the MPEG-21 Multimedia Framework supports powerful content-based search mechanisms, augments content location and identification procedures, improves content delivery mechanisms, and supports interoperability and transparence between different DRM systems.

The MPEG-21 vision puts into effect ideas of the UMA and UME concepts, as it aims to support the content creation, delivery & consumption chain while following three basic ideas: Full-scale interoperability, transparency from the user's point of view, and the IPMP.

The MPEG-21 standard is based on two fundamental concepts, explained in following subsections:

- The MPEG-21 Digital Item (DI) concept,
- The MPEG-21 User concept.

The first one defines the object (What) of the MPEG-21 Multimedia Framework, while the later defines the subject (Who) of the MPEG-21 Multimedia Framework [8].

5.1 The MPEG-21 DI concept

Digital Item (DI) presents a fundamental unit for distribution and transaction within the MPEG-21 framework. Part 2 (Digital Item Declaration) of the MPEG-21 standard is dedicated to provide powerful, flexible, and unambiguous DI definition model [8].

Part 3 (Digital Item Identification) of the MPEG-21 standard specifies how a Digital Item can be identified. This includes: how to uniquely identify Digital Items and parts thereof (including resources), how to uniquely identify description schemes, how to use identifiers to link Digital Items with the related information and how to identify different types of Digital Items [8].

Figure 4 shows an example of a DI, in this case representing a music collection, comprised of audio sources and their fingerprints, lyrics, band snapshots, presentation movie, and link to the on-line music store.

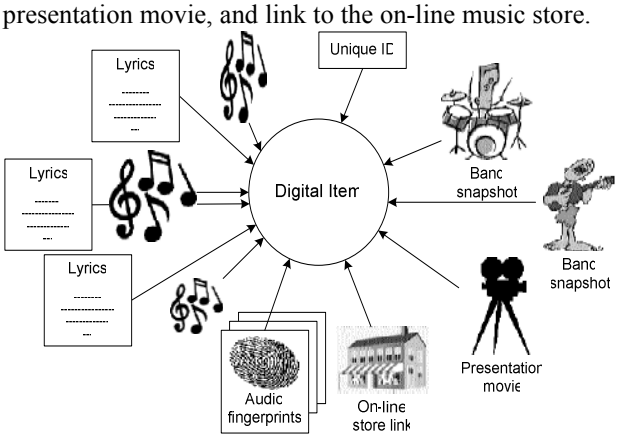

Figure 4. Example Digital Item

5.2 The MPEG-21 User concept

Fast development of the users' terminal hardware and software equipment, followed by the introduction of peer-to-peer networking, has caused the change in the users' role in the multimedia market. Users have evolved from passive content consumers into actors with a much more powerful and active role. They can be content creators, providers and consumers at the same time and on the same terminal.

MPEG-21 is aware of the changes in the users' role, therefore it makes no distinction between a "content provider" and a "consumer" — both are MPEG-21 users. However, a user may assume specific or even unique rights and responsibilities according to the interaction with other users within MPEG-21-based environment [8].

An MPEG-21 user is any entity that interacts in the MPEG-21 environment or makes use of a Digital Item. The MPEG-21 primarily focuses on two very important areas of the user interaction with DIs:

- Intellectual Property Management & Protection (IPMP)
- and Digital Item Adaptation (DIA)

Parts 4 (IPMP), 5 (Rights Expression Language) and 6 (Rights Data Dictionary) of MPEG-21 standard deal with the DRM within the MPEG-21 framework and provide interoperable and flexible IPMP architecture.

Part 7 (Digital Item Adaptation) of MPEG-21 standard is dedicated to provide a transparent access to the DI-s. As the DI-s can be accessed through different types of networks, it is essential to adapt the DI to the network parameters.

6 MUFFINS – the first MPEG-21-based multimedia platform

Successfulness of a certain standard can be measured by its real-life scenario usage. Only those standards that are widely accepted and used can be rated as successful. For that reason, the development of a standard must be well planned, and the progress must be evaluated at multiple check points. The MUFFINS project has been started to follow and contribute to the development of the MPEG-21 standard. The project aimed to prove the MPEG-21 concepts, and to show the power of the MPEG-21-based multimedia platform.

6.1 The MUFFINS vision

The vision of the MUFFINS project and its overall structure is illustrated in Figure 5. On the left side of the figure, the multimedia content can be found, ranging from common AV items to the state-of-the-art formats. On the right side consuming devices can be seen, including cell-phones, set-top boxes, personal computers, media players… The aim of the MUFFINS vision is to help the consumer devices on the right to find any media item on the left and then to access and consume it. The delivery of the media items may require mediation of servers, gateways, transcoders…

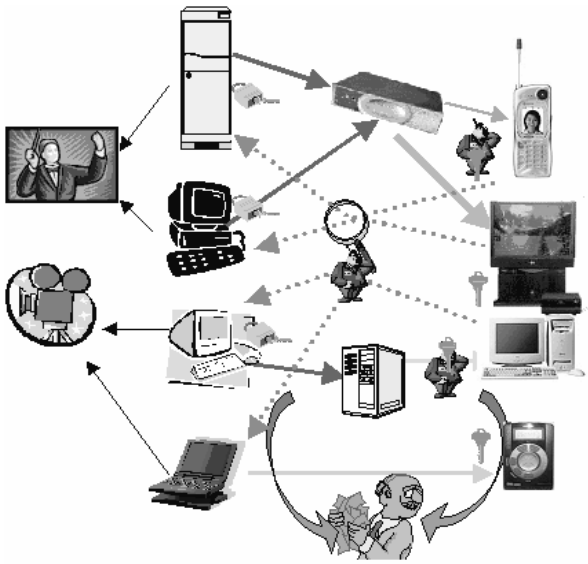

Figure 5. The MUFFINS vision

Crucial elements in this framework are security and protection tools, symbolized by keys and locks... "Agents" are those pieces of technology that facilitate the entire process by assisting search engines and protection tools, and by customizing content for an individual use [11].

6.2 The MUFFINS architecture

By being a short-termed project, the MUFFINS project is unable to realize the whole MUFFINS vision. Instead it is concentrated on proving the basic MPEG-21 concepts and building a multimedia platform for a real-life scenario, which based on predefined use cases [12].

In order to carry out the given tasks, the MUFFINS project has come up with an architecture which utilizes some common content delivery mechanisms, supports the MPEG-21 IPMP mechanisms, provides a content-based search mechanism (audio content search based on the MPEG-7 audio fingerprints [4] [7]), allows DI adaptation, and is open to agent-based technologies. The front end of the MUFFINS architecture is a web-based service – MUFFINS Online Store (MOS), providing content authoring tool for content providers, content search & delivery mechanisms for the content consumers, and enforcing the DRM mechanisms.

6.3 The MUFFINS user testing

One of the most important aspects in any architecture implementation evaluation is the impact on potential end-users.

The user testing within the scope of the MUFFINS project is comprised of a MUFFINS architecture demonstrator and a questionnaire [13]. Based on the questionnaire, the examinees' knowledge in the field of multimedia and their satisfaction with the MUFFINS real-life scenario implementation are assessed.

A thorough analysis of user test results is presented in [13], therefore this paper presents only the most interesting results.

Figure 6 shows how often do examinees encounter MPEG standards in their everyday life ("1" stands for "never", "7" stands for "all the time"). Results show that most of the potential end-users know very little about new standards like MPEG-7 and MPEG-21.

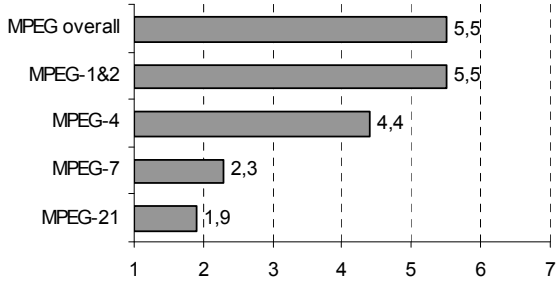

Figure 6. Frequency at which examinees encounter MPEG standards

Figure 7 shows what the examinees find attractive ("1" stands for "unattractive", "7" stands for "very attractive"). The most interesting part of the MUFFINS real-life scenario is the part showing possibilities and

power of the advanced forms of searching for multimedia content. It can altogether be concluded that the examinees find the MUFFINS architecture quite attractive.

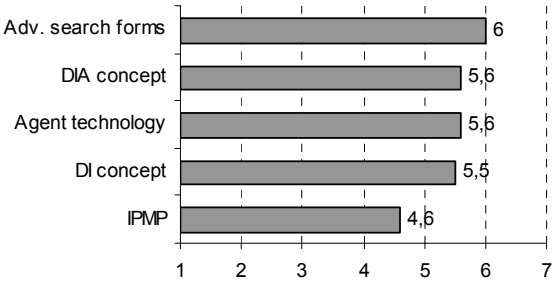

Figure 7. Areas found attractive by the examinees

7 Conclusion

In the search of the true end-to-end interoperability the MPEG group has developed three sophisticated standards, namely the MPEG-4, MPEG-7, and MPEG-21 composing a powerful, secure, and interoperable multimedia framework. In any system based on these three standards users can play an active role in the multimedia market as they are offered powerful tools and mechanisms for creating, distributing, and consuming the content.

It is important to emphasize the role of DRM in the MPEG standards. The ability to provide an open, interoperable and at the same time secure multimedia framework, which shields both content owners and content consumers and enforces the content usage restrictions, has a great impact on business models of telecommunication and digital media companies.

The results of the MUFFINS project have proved that the path laid down for the MPEG-21 standard is the right one. However, the MUFFINS user testing has revealed that most of the potential MPEG-21 users are still unaware of the development in the field of multimedia.

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