An MPEG-21 Web Peer for the consumption of Digital Items

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Abstract: MPEG-21 enables content consumers to access and interoperate with a large variety of multimedia resources and their descriptions in a flexible manner. Considering the great heterogeneity that presently exists across the entire multimedia content chain and the growing importance of open standards to facilitate the interoperations across environments, applications and formats, an MPEG-21 Peer was developed to process and present complex multimedia content, represented as MPEG-21 Digital Items. The novelty of the work essentially relies on the adoption of a Web Services architecture, based on a single Digital Items processing core available for all types of terminal devices.

Keywords: multimedia consumption; MPEG-21; Digital Items; MPEG-21 Peer; Web Services.

1. Introduction

With the advent of the WWW and the proliferation in the mass market of a diversity of multimedia-enabled end-user devices, consumers increasingly expect to be able to access any kind of content anywhere and at any time regardless of the capabilities of their terminals. To this reality adds the large volumes of multimedia content available on-line, presenting a multiplicity of formats and the ever growing acceptance of the network-centric paradigm from the general public. An access to content that meets user expectations and demands must take into account all the different aspects of this heterogeneous scenario. Nowadays, one of the reasons for the popularity of networks is the information accessibility that they offer: the consumers now can reach the multimedia contents from almost anywhere. This is a challenge for the recent standards, technologies and business models.

A thorough characterization of both the content as well as of the context of usage is therefore needed to enable the selection and delivery of the content in the most adequate conditions given the current context of usage. MPEG-21 aims to provide a solution that satisfies these needs, thus improving the multimedia experience of the users. However, dealing with all this issues implies that the solution is also complex. Applications implementing MPEG-21 are required, including for the transparent presentation of richer information to the end user. Due to the complexity of this standard, it is difficult to implement all MPEG-21 specifications in a single application, and therefore the integration of several tools, each implementing a specific functionality (e.g. adaptation, license processing, or streaming of the content, etc.) in the MPEG-21 framework, is necessary. MPEG-21 does not specify the technologies to be used and the manner of integrating the tools when developing MPEG-21 applications. This allows great flexibility for implementers.

This paper describes an MPEG-21 application named Distributed DI (DDI) Browser that implements a view on the presentation and consumption of meta-information and multimedia content defined according to the MPEG-21 standard, that aims at providing a friendly and intuitive interface to end-users. The goal is to achieve interoperability and also to enable the usage, visualization, and interaction with the multimedia contents on different types of terminals. This application was partially developed within the framework of the ENTHRONE Integrated Project[1], a research project co-funded by the European Commission under FP6.

The remainder of this paper is structured as follows: an introduction to MPEG-21, particularly to the parts 2 and 10 of the standard, is made in the next section; then a brief state of the art survey of the MPEG-21 applications is presented; after that, the implemented DDI Browser is described; in a separate section the integration of the results in the ENTHRONE project is discussed, and finally the future work and some conclusions are presented.

2. MPEG-21

MPEG-21 aims at describing how the various elements of the multimedia content delivery chain fit together to create an interoperable multimedia framework where content is conveyed as Digital Items (DI) (ISO/IEC N6388, 2004).

This standard is currently composed of 17[2] parts: 1 - Vision, Technologies and Strategy; 2 - Digital Item Declaration (DID); 3 - Digital Item Identification and Description (DII); 4 - Intellectual Property Management and Protection

[1] ENTHRONE IST-038463, "*End-to-End QoS through Integrated Management of Content, Networks and Terminals*"

[2] Although the numbering of these 17 parts arrives to number 18, there are in reality only 17 parts as number 13 is not used.

Components (IPMP Components); 5 - Rights Expression Language (REL); 6 - Rights Data Dictionary (RDD); 7 - Digital Item Adaptation (DIA); 8 - Reference Software; 9 - File Format (FF); 10 - Digital Item Processing (DIP); 11 - Evaluation Tools for Persistent Association; 12 - Test Bed for MPEG-21 Resource Delivery; 13 - unassigned; 14 – Conformance testing; 15 - Event Reporting (ER); 16 - Binary format; 17 - Fragment Identification for MPEG Media Types; 18 – Digital Item Streaming.

In this paper we provide only a brief description of the main concepts of MPEG-21, notably those that were essential for the development of the work here described. We assume that the reader is familiar with MPEG-21. If it is not the case, he should refer to (ISO/IEC N6388, 2004), (Bormans, 2003) or (Burnett, 2005).

The application presented here - DDI Browser - has currently implemented part 2 and part 10.

2.1. Digital Items and Users

The MPEG-21 standard defines two essential concepts: Digital Item (DI) and User. A DI is defined as:

> *"a structured digital object with a standard representation, identification and meta-data within the MPEG-21 framework. This entity is also the fundamental unit of distribution and transaction within this framework"* (ISO/IEC N6388, 2004).

Digital Items combine multimedia resources, other digital objects and related metadata. It also encompasses the description of the relations among all these elements. Examples of DIs are: multimedia presentations, music albums, collections of e-learning objects, TV program guides, video playlists, digital libraries, etc.

Any entity that interacts with Digital Items within the MPEG-21 multimedia framework is a User (ISO/IEC N6388, 2004).

Due to the relevance for the prototype presented in this paper, we will briefly introduce the parts 2 and 10 of MPEG-21, respectively Digital Item Declaration (DID) and Digital Item Processing (DIP).

2.2. Digital Item Declaration

Part 2 of the standard specifies the Digital Item Declaration Language (DIDL). This language is used to generate the Digital Item Declaration (DID), typically an XML document, which describes the structure of the DI. This part defines several elements to be used for describing the structure and composition of a DI. Below we present some of these elements:

- *DIDL*: is the root element of a DID.

- *Container*: groups more *Items* and/or sub-*Containers*.
- *Item*: contains *Components* and/or sub-*Items*. Item represents "the lowest level of granularity transacted by Users within the MPEG-21 framework" (ISO/IEC FDIS 21000-2, 2005).
- *Component*: binds *Resources* to a set of descriptions that contain control or structural information about the resource but do not contain information describing the content inside.
- *Descriptor*: associates information with the enclosing element (*Item*, *Container*, *Component*, *Choice*, *Descriptor*, *Selection*, etc.).
- *Choice*: describes a set of *Selections* that can affect some conditioned elements such as: *Items*, *Descriptors*, *Component*, etc.
- *Condition*: specifies the enclosing element as being optional and links it to the *Selection*(s) that affect its inclusion.
- *Selections*: describes a specific decision that affects one or more conditioned elements in Digital Item.

The DID model enables the support of a static User – Digital Item interaction. The Users have the possibility to limitedly configure parts of the DID using the *Choice*/*Selection* mechanism (ISO/IEC FDIS 21000-2, 2005).

2.3. Digital Item Processing

Digital Item Processing (DIP) intends to cover all aspects of processing a static Digital Item from the User perspective, by enabling the Users to specify a selection of preferred procedures to apply to the Digital Item when consuming it. DIP provides the means for a dynamic User – Digital Items interaction.

DIP specifies a set of basic operations (Digital Item Basic Operations - DIBOs) such as Digital Item downloading, rights management, printing or playing media resources. Also, it defines the mechanism of using extended operations (Digital Item eXtended Operations - DIXOs) ensuring the addition of User specified functionality to a DID.

The DIP operations are called in methods defined in Digital Items. These methods are named Digital Item Methods (DIMs) and can be regarded as a "menu" of User interaction possibilities with the Digital Item (ISO/IEC FDIS 21000-10, 2005).

3. MPEG-21 Applications

MPEG-21 introduced the term Peer to characterize a "device or application that compliantly processes a Digital Item" (ISO/IEC N6388, 2004). Such processing includes the creation and presentation/rendering of DIs.

MPEG-21 Peers for visualizing and interacting with DIs are still scarce. In the existing implementations, solutions have been found for ensuring accessibility, flexibility and performance of the Peers on specific terminal devices (e.g., only PC, or only PDA, or mobile phones).

The research group Multimedia Lab pertaining to Ghent University (Belgium) has developed a generic MPEG-21 terminal for the processing of DIs and the contained DIMs (Keukelaere, 2003). This is an online terminal (available at http://multimedialab.elis.ugent.be/demo.asp#dip) which communicates with a streaming server, through SOAP messages, for dynamically configuring the video streams referenced by DIs.

Klugenfurt University (Austria) brought a considerable contribution to the MPEG-21 DIA standardization but they also developed various MPEG-21 applications, among which the most relevant for the purposes of this paper is the DIConsumer used for the consumption of DIs created with another Klugenfurt tool named DIBuilder. These two applications are available at http://mpeg-21.itec.uni-klu.ac.at/cocoon/mpeg21/mpeg21Demo.xml.

Wollongong University (Australia) is an example of another institution that has interest in implementing MPEG-21 applications. One of their projects consists of an MPEG-21 Peer for mobile devices (S. Lauf, 2005) based on an efficient and flexible architecture which encompasses a sufficient range of MPEG-21 technologies to realize the consumption, authoring and transmission of DIs.

Enikos (http://www.enikos.com/) is an Australian company focused exclusively on MPEG-21 technology. The two commercial products of this company are DICreator and DIBrowser. DICreator is a tool that permits to easily create, edit and view DIDs. DIBrowser is an application capable of browsing any local or remote DID, presenting its internal structure as a tree. Enikos also released a new product: the MPEG-21 DIP Desktop Peer which is a demo application implementing DIP functionality.

Adactus (http://www.adactus.no/) is a software company (from Norway) offering solutions for delivery and presentation of adapted multimedia for mobile terminals. **mobilize** is the base product of Adactus and consists in a cross-platform system for content delivery that makes use of MPEG-21 technology: DIA (for adaptation), ER (for reporting the content usage and consumption), and REL (for protecting the content carried in DIs).

Among all the existing MPEG-21 Peers, none is fully portable to many or all types of devices. The DDI Browser Peer intends to solve the portability problem and proposes a modality of processing and visualizing complex DIs on majority of terminal devices.

4. Distributed DI BROWSER

The MPEG-21 standard does not specify how a terminal application should present DIs to Users. Hence, multiple applications, implementing different views, may be developed. The adequacy of an application is usage scenario specific. Due to current familiarization of Users with the World Wide Web and to the explosion of Web applications, it was decided that DDI Browser would be Web oriented. A modular and incremental design approach was adopted, supporting initially a restricted set of MPEG-21 functionality (DID and DIP) to which new ones can be added. This approach is suited to the evolving nature of the MPEG-21 standards.

4.1. Application functionality

The functionalities implemented for this MPEG-21 Web Peer are: downloading DIs stored in a remote repository; validating the respective DIs against the normative DID schema; processing DIs "by pieces" for ensuring an adequate consumption on many devices (including thin devices); navigating the contents of remote DIs in a Web page style; presenting the assets within DIs; processing the User preferences and selections for accessing the restricted contents from a DI; and executing DIMs methods for dynamic interaction User-Digital Item (currently, DIP functionality works only on PC version).

4.2. Web Services based architecture

A client-server architecture was adopted and Web Services concepts were applied for increasing the interoperability and portability to heterogeneous terminal devices. This architecture delegates on the server the responsibility of DIs processing, leaving the client with the content presentation. The main advantage of using this distributed architecture is the possibility of browsing complex Digital Items also on devices such as PDAs and mobile phones, as it moves all the processing heavy tasks to the server side.

Possible configurations of the architecture of the DDI Browser are illustrated in figure 1. The DDI Browser is composed by two main sub-systems: the client - generically called Graphic DI (GDI) Renderer and the server - INESC DI Processing (IDIP) Server. The application functionality is based on the mentioned server application. Note there can be different client sub-systems, employing different technologies and targeting diverse scenarios or applications. As a clear separation was done between GUI generation and processing, through the definition of a Web Services interface, it is possible to use the same processing module with different GDI Renderers to suit the requirements of various terminal devices. One possible form of implementing the GDI Renderers module is as a Web application. This is precisely the proposed implementation that is called the Web DI Browser (WDI Browser). Furthermore, GDI Renderer may be developed either as Applet or as plugin to generic Web browsers. Other possible implementations of the GDI

Renderer module could be, for example, a custom Java client application installed on the User terminal, using the services of the IDIP Server module installed at the server side via the Web Services API.

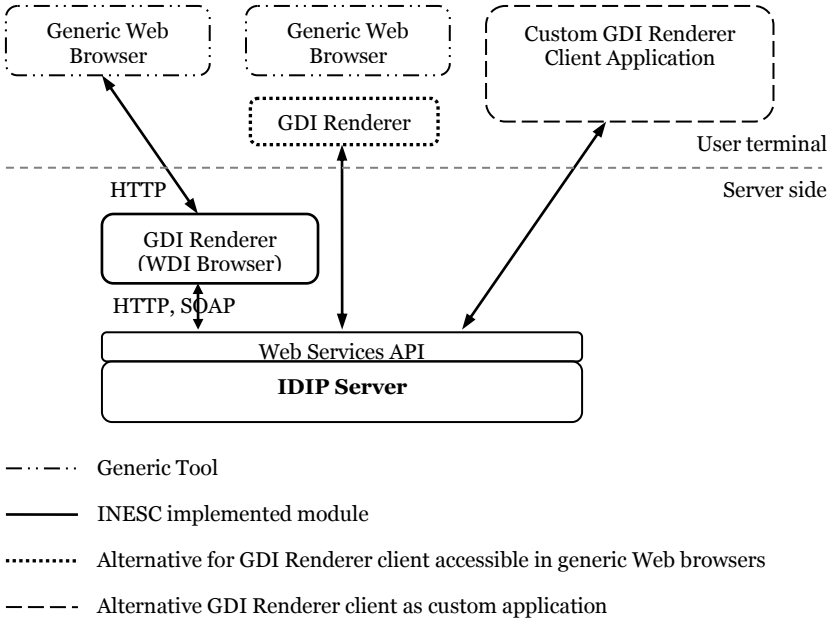

Figure 1 Mixed solutions for a GDI Renderer client

The messages exchanged between the client and server sub-systems are based on normative DID representations (which are XML), each including the DIDL element that is requested to be visualized at User terminal at a determined moment. Given the implementation of GDI Renderer in the form of a Web application (WDI Browser), the end-users can access the DDI Browser system using a common Web browser (e.g. IE, IE Mobile, Firefox Mozilla, Netscape, Opera, etc.).

Web Services Server

The IDIP Server application is the central unit of the implemented MPEG-21 Web Peer. Its main role is to provide MPEG-21 specific processing and to control the navigation and all the interactions with DIs. The IDIP Server is structured on modules (of Java classes). This modularity allows easy integration with other external modules adding new functionalities. The top module represents the Web Services API and the technology used to develop it was Sun Java Web Service Developer Pack 2.0 (JWSDP 2.0).

On the server side a caching mechanism for the elements previously processed and visualized was implemented. The caching and management of the previous states of browsing in DIs assure that end-users can navigate backward in any moment. Also, the IDIP Server stores and processes the User's preferences regarding the access/visualization of the conditioned elements in the DIs.

Web Client

The implemented client – WDI Browser – is a Web application (developed with PHP5) which uses different XSL templates for generating HTML presentations of the information (metadata and media resources) contained in DIs that are accessible to a User on a common Web browser installed on his terminal device. The WDI Browser has a modular structure and permits to add support for different types of terminals with little or no additional effort and reusing the processing modules at the server side. Implementations and tests so far have enabled the use of the DDI Browser through its WDI version on PCs (in Windows and Unix environments), PDAs (in Windows Mobile) and mobile phones (in Symbian). The WDI Browser can be installed on the same Web server as the IDIP Server module or on a separate Web server.

The DIP functionality was added as an applet application to the client side and is based on the MPEG-21 DIP reference software (ISO/IEC FCD 21000-8, 2007).

4.3. Object Model

During the processing of DIs it is necessary to manipulate MPEG-21 information in a manner that ensures easy access to its elements and an efficient processing, contributing to the overall performance of the DDI Browser. Therefore, a corresponding object representation for the XML elements defined in the MPEG-21 specifications was created. The mapping of the MPEG-21 elements into Java object instantiations and vice-versa was made with a specific tool (Apache XMLBeans available at http://xmlbeans.apache.org/) that needs of a set of rules – normatively defined in XML schema files – in order to reflect the relationships between the elements. For practical reasons, at runtime, the original XML content (DID) of a DI is stored in the object model and is used as an alternative in some particular situations (e.g., looking for some specific attribute that is not defined in MPEG-21 nor in the normative schemas and as a consequence does not have any representation in the object model). So far, the Object Model module includes the implementations for the following MPEG-21 parts: 2 -Digital Item Declaration, 3 - Digital Item Identification and 10 - Digital Item Processing.

The Object Model is rather more specific to MPEG-21 processing than to the DDI Browser. Hence, the created Object Model can also be used or integrated in other MPEG-21 applications.

4.4. Processing and presentation

The DIs are processed and visualized in a progressive manner. The processing of DIs consists in preparing them for browsing/consumption. The navigation in DIs is made from the top DIDL element to the bottom nodes. At each step of the navigation, only a single element is processed and displayed to the end-user; the respective element is a *Container* or an *Item*. There is no limit regarding the depth of the hierarchic level corresponding to a sub-*Item* or sub-*Container* element. This allows the consumption of large and complex DIs on thin-devices.

The presentation is also made in a "step by step" style. To each element (*Item*/*Container*) processed at a certain moment is associated a Web page. The hierarchical relationships between the elements are defined by hyperlinks. This Web philosophy was easily adopted due to the similarity between the tree structure of the DID representation and the manner of navigation in websites.

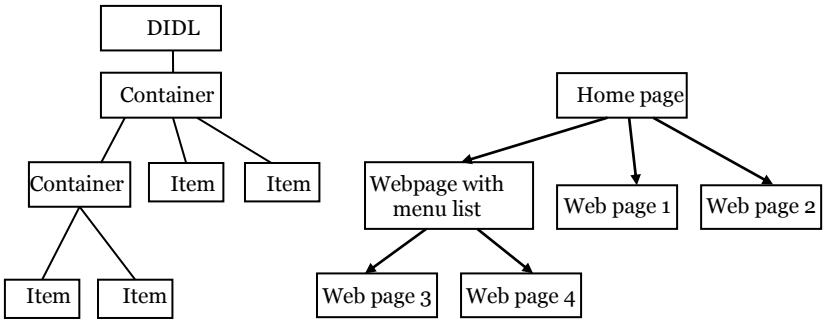

Figure 2 Similarity between a DID representation (on the left) and a website (on the right)

An element of type *Item* may contain information that is not made available to the User unless he performs some selections. During navigation, when *Choice* elements are present in an *Item*, the User is asked to express his preferences (selections) related to the conditioned parts of the content. For example, a selection may be set for choosing the appropriate video file format to be played on the User's terminal device.

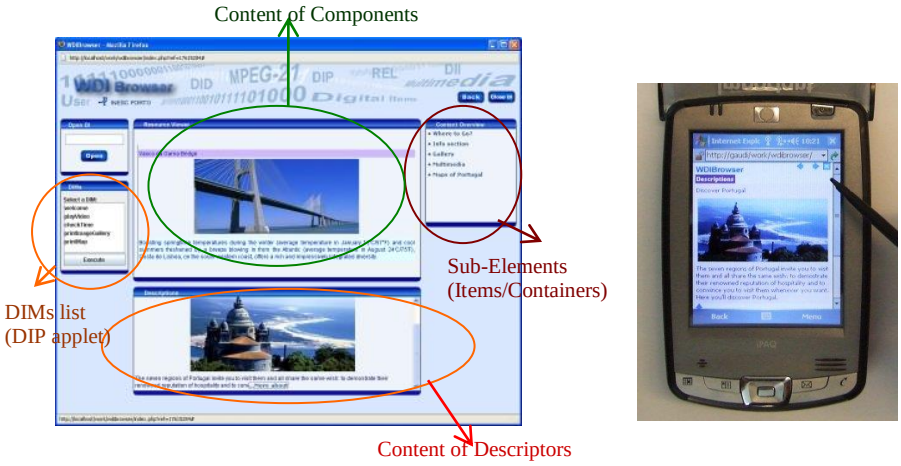

Figure 3 WDI Browser layouts (PC - on the left, and PDA - on the right)

5. Integration with ENTHRONE

ENTHRONE, *End-to-End QoS through Integrated Management of Content, Networks and Terminals*, is an Integrated IST Project of EU Framework Program 6. It aims to provide an integrated management solution for the transparent access to multimedia resources while ensuring QoS and efficient usage of the resources, based on MPEG-21 cross-layer media adaptation. ENTHRONE proposes the development of MPEG-21 User terminals for a wide range of heterogeneous devices with different capabilities, where the service requests are initiated, received and consumed. The ENTHRONE architecture comprises different subsystems, among which the EIMS (Enthrone Integrated Management Supervisor) plays a central role in the provisioning of multimedia services adapted to User terminal devices. It provides its functionality based on the MPEG-21 specifications and on Web Services technologies (Andrade, 2006). From the viewpoint of the end-user, the EIMS implements functionality that enables Users to search and browse multimedia contents represented as MPEG-21 Digital Items and to consume selected media resources transparently adapted to the characteristics of his/her environment. The EIMS is a distributed system composed of several modules. The EIMS-TDM (Terminal Device Manager) is the module responsible for the management of terminals. In figure 4, the actors interacting with the ENTHRONE system are: Content Provider (CP), Service-Provider admin (SP-admin), Service-Provider Front-End (SP-FE), Network Provider (NP) and Perceived QoS probes.

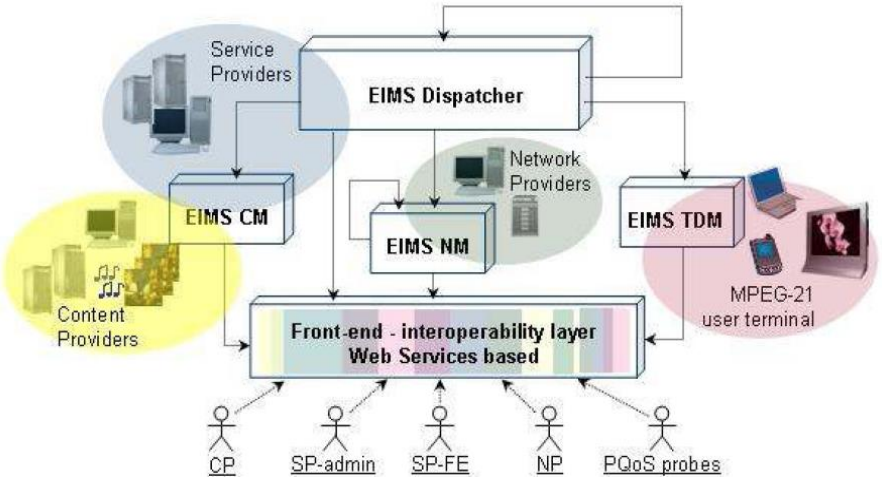

Figure 4 EIMS high-level architecture

Currently, efforts have been initiated for integrating the DDI Browser with the terminal component of the ENTHRONE project: the DI Browser will interact with the EIMS-TDM module to pass User's requests and selections to the EIMS and to receive back replies and accordingly present the results to the end-user.

6. Future work

Future work on the described MPEG-21 Web Peer is related with: improving the DIP implementation to be capable of working with many types of terminal devices, increasing its usability by adding new Web interfaces (e.g. for mobile phones). Aspects such as: browsing the local DIs stored on User's device, searching for DIs in (Web) repositories, managing and controlling the sessions of Users, etc., are also being considered. The search for DI operation will take into account the User preferences, the terminal capabilities and networks characteristics, in conformance with the requirements defined in ENTHRONE.

7. Conclusions

The DDI Browser has the capacity of browsing simple and large MPEG-21 DIs and it can be applied in various domains of activity in which the use of multimedia content is essential.

The distributed architecture based on Web Services permits to maintain the same processing core for many types of terminal devices and this increases the system's portability.

Due to the modular structures of its client and server components and to the Web Services architecture, this MPEG-21 Web Peer is flexible and interoperable, allowing easy integration of other external modules or tools.

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