A System for Universal Access to Multimedia Content based on the MPEG-7 Standard

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Abstract

Future mobile communications will bring a terminal diversity that until today has never happened. This paper describes a universal access system able to deliver multimedia content that is tailored for each type of terminal. The system is composed by three applications: a content analyzer application, a content customization engine and a multi-characteristics terminal simulator. The system uses MPEG-7 as the content description standard and a user context description format developed for the purpose of this system while waiting for the availability of the MPEG-21 solution under development.

I. INTRODUCTION

The exploding variety of multimedia information is nowadays a reality since everyone has a camera, a scanner or another device that almost instantly generates multimedia content. Most often the content author wishes to share its masterpiece with everyone, but the variety of terminals and networks may be a problem if he/she wants everyone to see his/her work with the best possible quality.

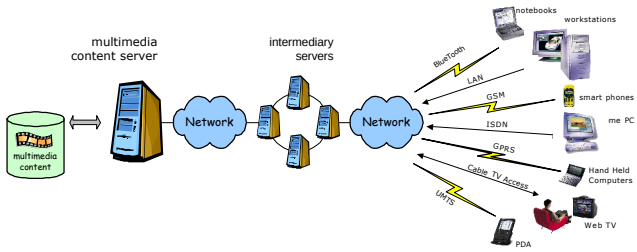

Fig. 1 – Mobile information services chain.

This scenario describes today's situation of accessing multimedia content from any terminal as illustrated in *Fig. 1*. Typically, when a terminal accesses content to which it was not designed for, the user experience is very poor. The scenario described misses a bridging element between all the components involved, which should take into account their characteristics and assure an efficient and consistent inter-working. In other words, an efficient way to "access any information from any terminal", allowing the delivery of any content (or an adaptation of it) to the user should be provided.

The access to multimedia information by any terminal through any network is a new concept referred in this paper as Universal Multimedia Access (UMA). The objective of UMA technology is to make available different presentations of the same information, more or less complex, e.g., in terms of media types, suiting different terminals, networks and user preferences. In UMA applications, it would be desirable (to avoid the extraction on-the-fly) to have available descriptions of the parts that have to be matched/bridged - the user environment characteristics, and the content characteristics - in order to more easily and efficiently customize the desired content:

- Content description: information on the content features, which are instrumental to perform an efficient customization of that content.
- User environment/context description: information on the user conditions which are useful to make available an adequate customized variation of the pretended content.

This paper describes a universal multimedia access system [1] capable of delivering multimedia content to heterogeneous terminals and access conditions based on the emerging MPEG-7 standard.

A. Multimedia Content Description

Content descriptions are intended to facilitate the access to the pretended content (finding, filtering or accessing). The content descriptions, which may help universal access systems, focus on the content structure and encoding characteristics: encoding parameters, regions of interest, object's relevance, video transcoding and video summarization hints.

MPEG-7 [2] is a new standard developed by MPEG [3], which concerns multimedia content description at very different levels: it offers a wide range of description tools that consider both low-level features such as color and pitch as well as high-level features such as the name of some characters in a scene. MPEG-7 provides a set of description tools intended to characterize the audiovisual content in terms of the type of features listed above. The standard separates the descriptions from the content but provides linking mechanisms between the content and the descriptions since there may exist more than one description for the same content; these links must work in both directions.

The types of description tools specified by the MPEG-7 standard are:

- **Descriptors (D):** represent a feature, and define the syntax and semantics of the feature representation.
- **Description Schemes (DS):** specify the structure and semantics of the relationships between their components, which may be both Descriptors, and Description Schemes.

- **Description Definition Language (DDL):** allows the creation of new Description Schemes, as well as the extension of existing Description Schemes.
- **Systems tools:** support the multiplexing of descriptions, synchronization of descriptions with the associated content, binary representation for efficient storage and transmission, management and protection of intellectual property, etc.

B. User Environment Description

An overview of the current candidate solutions for user environment description [4] showed that there was no global framework able of describing the user environment/context characteristics. The authors presented this overview to the MPEG standardization group, which decided to address the problem. Therefore, Part 7 of the MPEG-21 standard [5], called Digital Item Adaptation [6], was created to address among others the user environment/context description problem. A diversity of elements characterizing the user environment may enter in the equation that rules the content adaptation/delivery strategy. MPEG-21 DIA considers four dimensions, which have been proposed to MPEG by the authors: (1) user preferences; (2) terminal characteristics; (3) network characteristics; (4) natural environment.

The user environment description offers UMA applications a great advantage because without too much effort UMA applications have access to information about the usage context that otherwise could not be known or could be very difficult to obtain. The user environment description gives UMA its real dimension in terms of content customization: the user environment is understood as the set of characteristics that influence and/or condition the user's access to content.

II. A UNIVERSAL MULTIMEDIA ACCESS SYSTEM

The content customization can be implemented in three different places: 1) at the content server, 2) at a proxy server, and 3) at the user terminal. The system here presented implements the customization engine at the content server and at a proxy server. *Fig. 2* illustrates the UMA System and its major elements.

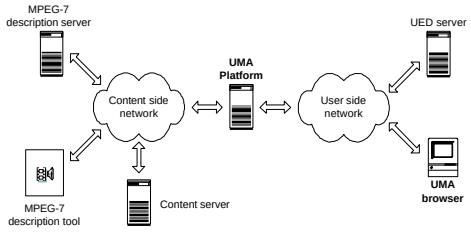

Fig. 2 – Major elements of a UMA System.

The function of each element in the UMA System is:

- Content server: this element acts as the content source.
- MPEG-7 description tool: this element is used to analyze the multimedia content available at the content server and generate an MPEG-7 description that will be saved locally or posted into an MPEG-7 description server.
- MPEG-7 description server: this element stores the MPEG-7 descriptions received from the MPEG-7 description tool. In this database, one MPEG-7 description exists per each piece of content. This element provides the UMA Platform with the MPEG-7 description for the pretended piece of content.
- UED server: this element stores the user environment description (UED) received from the UMA browser. This element provides the UMA Platform with the UED for the pretended user. It implements the same functionality as a WAP UAProf server [7].
- UMA Platform: this element corresponds to the application implementing the content customization engine (*UMA Engine*) required to provide the best experience to the user for the content he/she asked. It will act as a content customization server.
- UMA browser: this element includes a Web browser used to access content and allows the user to manage his/her environment description.

The content server, the MPEG-7 description server and the UED server are mere Web servers (Apache Web server), which implement the HTTP POST command allowing other applications to store content in the server. The UMA browser, the UMA Platform and the MPEG-7 description tool were implemented for this system.

A. MPEG-7 Description Tool

The MPEG-7 description tool consists in a content analyzer that scans the image and video content, and builds an MPEG-7 description that will be used later by the UMA Platform. The generated descriptions can be saved locally or posted (through an HTTP command POST) to an MPEG-7 description server. This tool creates MPEG-7 descriptions based on the *MediaInformationDS* and on the *ColorTemperatureD* [8].

B. UMA Platform

As mentioned before, the UMA Platform implements the content customization engine plus the required modules to interface with a network. Several modules compose the UMA Platform as can be seen in the architecture presented in *Fig. 3*. The modules are:

- Network Interface Manager: the Network Interface Manager is responsible for the network communications between the UMA Engine, and the other UMA System elements. It is also responsible for retrieving the descriptions (content and user environment). When the processing of a request is complete, this module updates the caching tables with the customized new content and descriptions. The caching tables are useful to enable the re-use of previous adaptations.
- User Request Processor: this module must transform any user environment description (e.g. WAP UAProf or MPEG-21 DIA) to the internal UED format so that the customization decision algorithms may process it. The

Table 3 – User environment tested scenarios.

User envir. characterist.	Pocket PC 1	Pocket PC 2	WAP device 1	WAP device 2
Terminal	Compaq IPAQ	UMA browser	UMA browser	Siemens ME45
Width	240	240	176	66
Height	320	320	144	101
Color Domain	Color	Gray	Color	Gray
Bits per pixel	16	8	8	1
Bit rate	64 kbit/s	64 kbit/s	64 kbit/s	24 kbit/s

Several types of images and video with the corresponding MPEG-7 descriptions were used for testing the overall system. Three images categories were defined in order to evaluate the performance of the system under different conditions, Table 1. Three video categories were also defined, ranging from CIF resolution coded at 1 Mbit/s to QCIF resolutions coded at 256 kbit/s, Table 2.

On the user side, seven context descriptions were used to simulate WAP terminals (*Fig. 6*) and Pocket PCs (*Fig. 6*), with different characteristics and different network connections, see Table 3 (in some cases the UMA browser was used to simulate certain conditions).

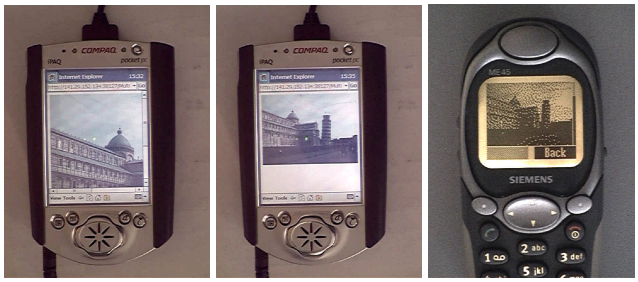

Fig. 6 – Examples: (a) image not customized to the Pocket PC display resolution (only part of the image is seen); (b) image customized to the Pocket PC display resolution; (c) image customized for a black and white WAP terminal.

The UMA System was tested under different access conditions: a WAP terminal with a GPRS connection, a Pocket PC terminal with a UMTS connection and the UMA browser with a LAN connection. The diversity of test scenarios in which the UMA System was tested confirmed that the adaptation processes are the main cause of the server load, since in any situation the time consumed by content processing was always rather high. More precisely, the uncompressed domain content processing is a major responsible for the poor adaptation performance. Therefore, content processing algorithm optimizations are essential to improve the performance and adaptation in the compressed domain is a must.

When the content source had a high resolution and the terminal limited capabilities, the server CPU was rapidly used up for a long period (several milliseconds) by the content processing. In order to improve these situations, where a big gap exists between the available and the adapted content characteristics exists, strategic content variations with lower quality may be made available in order to ease the customization efforts. This process allowed the UMA Platform to jump from one image category to another image category that has the content with characteristics closer to the terminal capabilities.

The tests with the Pocket PC, WAP terminal and UMA browser (desktop PC) showed that the same content could be delivered to different terminals after adaptation, thus reducing the maintenance and storage costs of having one content variation for each terminal type.

IV. CONCLUSIONS

The tests performed with the UMA system developed allow to conclude that in order to achieve a good customization performance it is vital that previous adaptations can be re-used. Also the diversity of content characteristics that were used to test the system confirmed that the adaptation processes are the main cause of the server load. When the content source had a very high resolution and the terminal limited capabilities, the server resources were rapidly consumed. Therefore, adaptation algorithms optimization is essential as well as processing in the compressed domain. The system also showed that costs may be reduced thanks to the adaptation on the fly and reduction of storage space.

The presented system studied the problem of universal access to multimedia content: the key factors of a good universal access system concern the user environment description, the content description, the decision rules and the adaptation algorithms. UMA technology will not have an answer from one single research area; the answer will come from all these research topics since they are all interdependent.

V. REFERENCES

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