Enhancing the Access to Networked Multimedia Content

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Abstract. This paper presents the approach towards UMA used in the Integrated Management Supervisor (IMS) of the ENTHRONE IST project. The IMS enables the distribution of multimedia content with end-to-end QoS guarantees over heterogeneous networks to heterogeneous client devices. At its core is the adoption of open standards such as MPEG-21 and Web Services.

1 Introduction

Nowadays, consumers can access multimedia content using terminals with a wide range of capabilities. Furthermore, the ubiquity of networks, also with very different characteristics, allow consumers to access multimedia content from almost anywhere and make networked access to multimedia content increasingly popular .

This paper describes the Integrated Management Supervisor (IMS), a software system developed in the context of the ENTHRONE IST project [1]. ENTHRONE tries to address the challenges posed by the distribution of multimedia content over networks in an environment with such diversity. Our focus is on two aspects that we consider essential to cope with this diversity. First, on a service oriented architecture that facilitates the interoperation between the different components of the system and that makes it easy to deploy in a wide range of scenarios. Second, on content adaptation mechanisms that are able to understand and use information about the context of usage, including network characteristics and conditions, terminal capabilities, user preferences and possibly environmental conditions.

2 IMS Architecture

The main goal of the ENTHRONE project is to "provide a solution for the access to multimedia content with end-to-end quality of service." In order to ensure end-to-end quality of service each component along the delivery path must provide a QoS-based service. ENTHRONE's tenet is that the integrated management of these components allows a better use of the available resources, making it possible to achieve the best quality giving the existing constraints.

The IMS is the system the ENTHRONE project designed and developed to achieve such an integrated management. It comprises different types of subsystems to interface with the different types of components found along the content delivery chain. Figure 1 illustrates the high-level architecture of the IMS. The kernel of the IMS is the IMS-Dispatcher. This is the subsystem responsible for taking global, system-wide decisions. Connecting the IMS-Dispatcher and the non-IMS subsystems are other IMS subsystems more service-specific. The IMS Network Manager (IMS-NM) is the subsystem responsible for the aspects related to the management of the network service. The IMS Terminal Device Manager (IMS-TDM) is the subsystem responsible for the management of terminals. Among other tasks, it is responsible for monitoring the perceived quality and for collecting information concerning the terminal capabilities. The IMS Content Manager (IMS-CM) is the subsystem responsible for the management of multimedia metadata and resources.

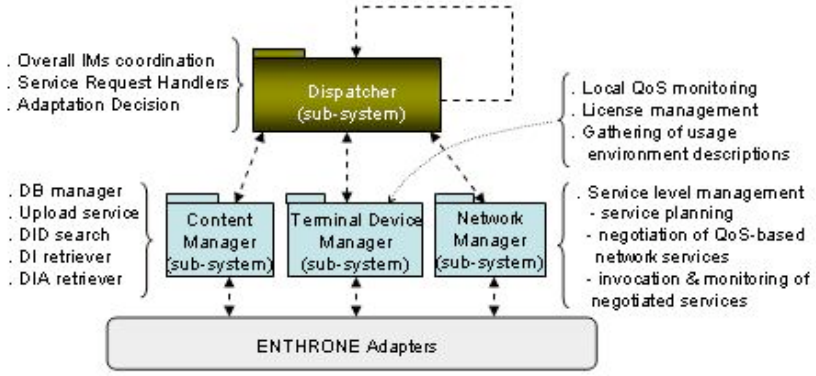

Fig. 1 – High-level IMS architecture.

In order to simplify the deployment of the IMS on the Internet, each of the IMS subsystems was developed as providing a service to other subsystems, leading to a service-oriented architecture. In the current implementation of the IMS, many of the services provided by the IMS subsystems are implemented as Web Services, facilitating their interoperation.

3 Adaptation Decision Support

The use of common and standard data and metadata formats, and of content adaptation decision capabilities were identified as essential for the IMS to meet its challenges. Among the available emerging standards for content representation, MPEG-21 [2]-[6] can be considered as one of the most advanced, complete and flexible. Because MPEG-21 also supports content adaptation decision, it was chosen as the metadata format in ENTHRONE.

MPEG-21 DIA [3] specifies a set of tools to assist the adaptation of Digital Items. These tools can be used to describe transmission and consumption environment constraints, as well as Quality of Service. In particular, the tool referred to as "Adapta-

tionQoS" (AQoS), allows describing the relationship between QoS constraints (e.g., on network bandwidth or a terminal's computational capabilities), feasible adaptation operations satisfying those constraints and the quality that can be expected when applying those adaptation operations. It provides the means to formulate a quality-based adaptation strategy under constrained environments. The tool "Usage Environment Description" (UED) allows the description of the environment in which the content is to be consumed, notably the capabilities of the terminal, the characteristics of the network and information regarding the user and surrounding natural environment. The tool "Universal Constraints Description" (UCD) can be used to express optimization constraints.

3.1 Adaptation Decision Engine (ADE)

The ADE is the module of the IMS-Dispatcher that takes DI adaptation decisions in order to provide the best quality given usage environment constraints (on the terminal, networks and encoders) and user preferences. It can be invoked both before and during content streaming. The latter can happen in case the measured perceived QoS falls below a preconfigured value. In both cases it determines the set of service parameters that provide the best quality, given the above mentioned constraints. Figure 2 illustrates the structure of the ADE.

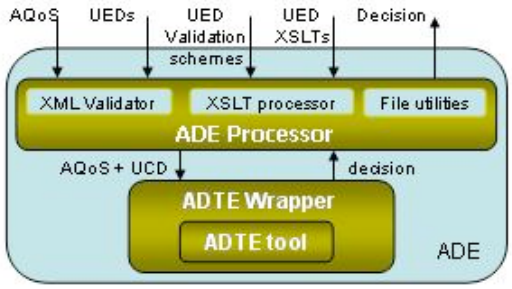

Fig 2 – The ADE functional architecture

The ADE takes as inputs DIA descriptions (UEDs and AQoS). In a first stage, the ADE processor module transforms UEDs into UCDs. This way, the capabilities of terminals and the user preferences, the characteristics of available adaptation engines and the capacity of the network are transformed into constraints, which are fed along with AQoS metadata into the Adaptation Decision Taking Engine (ADTE). The ADTE is the module of the ADE that performs the actual decision taking and is based on open software submitted to the official MPEG software repository and available at [7]. The ADE output is a set of "name-value" pairs selected among the AQoS descriptors originally provided. This output is used to configure different resources, including the encoding parameters of the streamer. In the current implementation, this configuration is done using different Web Services and associated SOAP messages.

The use of XSLT endows the ADE of great flexibility, decoupling the ADE from other components. For example, it is possible to seamlessly replace the ADTE and/or accept different UEDs or use different transformations of UEDs into UCDs.

3.2 AQoSDescriptionGenerator component

DIA AQoS metadata is essential for the operation of the ADE. The AQoSDescriptionGenerator is the component developed in ENTHRONE to generate AQoS descriptions. It is used as a Web Service, delivering its output through SOAP messages. As referred above, AQoS provides a mean to relate different codec operation points, constraints and operators' values to achieve a given perceived quality. The example in Fig 3 illustrates a possible AQoS description.

```
<DIA>
  <DescriptionMetadata>
    <ClassificationSchemeAlias alias="AQoS"
            href="urn:mpeg:mpeg21:2003:01-DIA-AdaptationQoSCS-NS"/>
  </DescriptionMetadata>
  <Description xsi:type="AdaptationQoSType">
          <Module xsi:type="UtilityFunctionType">
      <Constraint iOPinRef="BANDWIDTH">
                  <Vector>100000   500000   1000000</Vector>
      <Utility iOPinRef="PSNR">
                  <Vector>28   34   38</Vector>
      </Utility>
    </Module>
    <IOPin semantics=":AQoS:1.1.1" id="BANDWIDTH"/>
    <IOPin semantics=":AQoS:1.2.1" id="PSNR"/>
  </Description>
</DIA>
```

Fig 3 AQoS description example, created by the AQoSDescritpionGenerator

Accurate quality estimates require that the perceptual quality of A/V signals is assessed for each set of encoding parameters. However as this would lead to a huge effort, in ENTHRONE we have adopted an approach where AQoS metadata is generated per classes of DIs. Genre, codec class and bitrate are used to differentiate between classes. Classification schemes for codec type, genre and AQoS are used to provide a system wide common definition of identifiers Table 1 summarizes some of the most relevant input parameters, which are based on the MPEG-7 MediaFormatType [8].

Type	Name	Example	Description
String	CodecClassifier	urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:3.1.2	Unique classifier for specific codec types, i.e. MPEG-4 Visual Simple Profile @ Level 1
String	GenreClassifier	urn:enthrone:cs:2005:GenreQuality:3.1.	Quality related genre classifier, i.e. Football
String	qualityMeasure	urn:mpeg:mpeg21:2003:01-DIA-AdaptationQoSCS-NS:1.2.1	Classifier that identifies the measure for the perceptual quality, i.e. PSNR for assessing the video quality
Int	Bitrate	64	Netto bitrate of the streams in kbit/s
String	BitrateRange	32-1500	Netto bitrate of the streams in kbit/s
String	imageSize	320x240	Picture size in pixels

Table 1 Some of the most relevant input parameters to the AQoSDescriptionGenerator

4 Concluding remarks

This paper describes the concepts and functionality of ENTHRONE and in particular its IMS subsystem and content adaptation support. Major strengths of the described system rely on its extended coverage and use of MPEG-21 tools and its ability to support QoS- and context-aware universal access to multimedia content. Nonetheless, full use of the MPEG-21 potentialities is still far from being achieved. Support for more elaborated forms of content adaptation is envisaged. It is, in particular, possible to develop adaptation mechanisms based on scalable encoders and on the use of binary descriptions of the bit-stream. The later can be used to perform less demanding adaptation operations, which can be done by general-purpose engines in a distributed fashion, without the need to know the intricacies of the encoding algorithm. Another aspect that can be explored is to augment the adaptation decision performance of the IMS is the use of high-level semantic information concerning the perceived quality of experience of the user.

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