The ENTHRONE 2 Metadata Management Tool (MATool) (WISE 2008 MATool Demonstration)

Artur Lugmayr
NAMU Lab., Tampere University of Technology, Finland
http://namu.cs.tut.fi, lartur@acm.org

Abstract

There are many metadata standards, and many more are to emerge – and many more metadata systems have to deal with. To cope with the challenge of the management of metadata generated and various sources, in many arbitrary formats, and for different purposes, a metadata management solution is required. This research work describes the MATool, as metadata management tool developed within the IST IP ENTHRONE 2. The tool provides metadata aggregation, metadata collection, and metadata conversion capabilities in the context of end-to-end Quality of Service (QoS) *integrated management system for audio-visual services. The live demonstrator of the MATool were available at WISE 2008.*

1. Introduction

Today's Internet does not provide a sufficient mechanism for the delivery of bandwidth hungry audio-visual services to the consumer. Despite existing and emerging technologies, promising a certain level of *Quality of Service (QoS)*, there are either rather less seen in practice or they do not provide sufficient mechanisms to solve the problems related to it. IPV6 promises minimal QoS levels, however, can mostly be found in test-beds or research laboratories rather than in practice. The RTP protocol provides mechanisms for QoS, but does not solve the network problems, emerging from a lack of bandwidth. Within the scope of this research work, the metadata management solution of the IST ENTHRONE 2 is presented.

ENTHRONE 2 is an IST integrated project under the Framework Program 6, and provides a technical solution for end-to-end QoS [6] based on MPEG-21 technology. The goal of the project is the development of the *ENTHRONE Integrated Management Supervisor (EIMS)* for QoS for audio-visual applications based on MPEG-21. Within the scope of this research work, the MATool responsible for metadata management and its demonstrators are presented. Fig. 1 illustrates the MATool within the context of ENTHRONE 2 as interface between different system components.

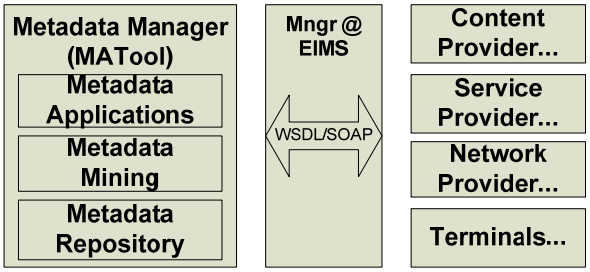

Figure 1. System overview

A few of the challenges ENTHRONE 2 is facing in relation to metadata management are:

- conversion of metadata into a system wide uniform format (MPEG-21 DID);
- distribution of valid metadata to system components;
- collection of contextual information coming from network, terminal, and service/content provider;
- re-pursuing and aggregation of metadata from different sources;
- automating metadata handling, processing, and QoS data handling;
- preservation of integrity of QoS metadata throughout the life-cycle;
- provision of common metadata interfaces between system components;
- provision of facilities to collaboratively work on metadata within an European wide project.

2. Related Works

The key-standard used within ENTHRONE 2 is MPEG-21. MPEG-21 is a multimedia framework, based on a metadata structure called *Digital Item (DI)* acting as unit for encapsulation of essence and

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metadata. MPEG-21 *Digital Item Adaptation (DIA)* provides a toolset (called AQoS) for the adaptation of content to available resources and device capabilities. The MATool is responsible for the management of MPEG-21 DIs within the ENTHRONE 2 EIMS solution.

Currently there exists much research work for providing QoS, however, rather less systems provide *true QoS* throughout the value-chain. The IST project ENTHRONE 1 resulted in new management architectures for providing QoS [7] (see also [1, 8, 13]). Other works relating to QoS management can be found in [2, 17]. Besides metadata standards, such as MPEG-7, MPEG-21, TV-Anytime, and MXF, a description of metadata in digital interactive TV can be found in [4, 10] and [9]. Further readings about metadata management are [3, 5, 11, 16].

3. Metadata in ENTHRONE 2

Within the context of ENTHRONE 2, we can distinguish between different metadata categories. These are shown in Figure 2.

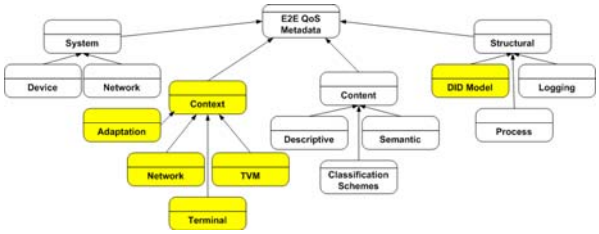

Figure 2. Metadata types

System metadata relates to metadata generated on system level, thus metadata which is mostly in proprietary formats – many times not based on XML (e.g. device capabilities, network parameters such as jitter). E2E QoS metadata relates to XML schema based metadata. Except for the description of content sources (TVMs), contextual metadata is based on the MPEG-21 format (e.g. UEDs for describing the usage environment). Content metadata directly relates to content assets and describes semantic, structure, and classification schemes (e.g. in TV-Anytime). Structural metadata defines the actual model for metadata handling, such as the MPEG-21 based DID model used within the scope of the project. However, structural metadata also can be used for advanced applications, such as logging or billing systems.

To emphasize collaborative working inside ENTHRONE 2, and keep different versions of metadata up-to-date, a project internal metadata management platform has been created. The system is based on a Trac Wiki tool, and embeds a SVN version tracking system. A screenshot is shown in Figure 3.

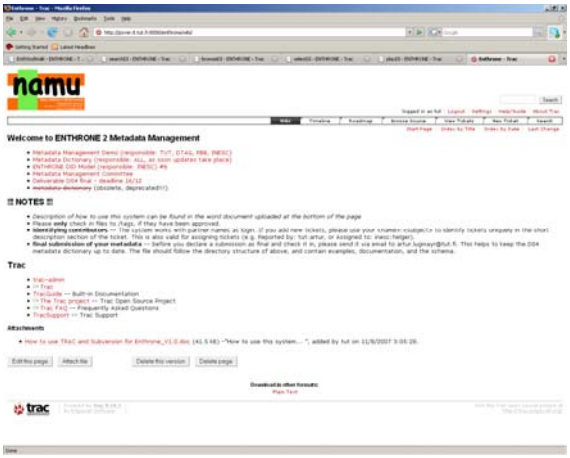

Figure 3. Wiki/Trac and SVN based online collaborative platform for metadata management

4. MATool Implementation

The basic MATool architecture is based on a typical web-based architecture, consisting of front-end, business-logic, and back-end database system (see Figure 4).

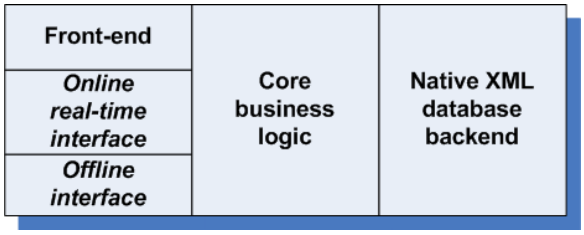

Figure 4. Basic MATool architecture

For ENTHRONE 2 two modifications were essential:

- **front-end:** the front-end is compromised of an *online real-time interface*, and *offline interface*. The online real-time interface is used for real-time critical tasks, such as the collection of contextual metadata. The offline interface is a HTML front-end offering web-based access to services, such as metadata conversion (e.g. MXF to TV-Anytime);
- **back-end:** fully native XML database backend, to guarantee a full metadata oriented workflow, without any data conversion to relational database models.

4.1. Functionalities

The MATool provides a set of functionalities for different metadata tasks. To proof the concept in a practical scenario, the different functionalities have been validated by the implementation of a software demonstrator.

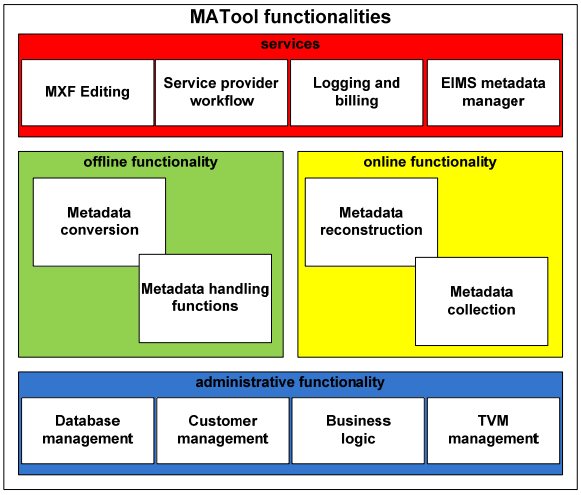

Figure 5. MATool functionalities

Within the scope of the EIMS, the MATool provides the following main functionalities (see Figure 5):

- **metadata aggregation (EIMS Metadata Aggregation Manager):** aggregation and enrichment of metadata from different metadata sources, verified by the offline interface based service provider workflow demonstrator;
- **metadata collection (EIMS Metadata Collection Manager):** collection of contextual metadata and providing the metadata to different components of the EIMS, verified by the online real-time interface for the collection of contextual information demonstrator;
- **metadata conversion (EIMS Metadata Conversion Manager):** conversion of metadata between different metadata formats, verified by the offline interface MXF2TVA converter.

4.2. Software Architecture

From the software configuration side, the MATool is based on the following software:

- **front-end:** Appache HTTP Server Vers. 2.0.59 in combination with a SOAP/WSDL interface for providing an offline/online interface;
- **core business logic:** MATool Java based middleware running on Apache Tomcat 6.0;
- **native XML database backend:** Tamino XML Server 4.4.1 including its Java based access APIs.

Figure 6 shows the class diagram of the DID related classes, which are used in the service provide workflow described in the demonstrator section of this work.

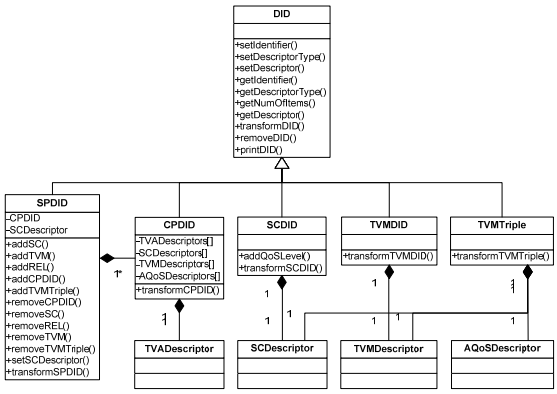

Figure 6. Service provider DID (SPDID) classes

4.3. Database Design

The database in its current version supports the following metadata schemas:

- TV-Anytime as standardized by the TV-Anytime Forum [15];
- MPEG-21 DID, MPEG-7, and MPEG-21 DIA as standardized by MPEG [12];
- MXF DMS.1 as standardized by SMPTE [14];
- TVMRF metadata schemas as developed within ENTHRONE 2 to describe the functionalities and capabilities of TVMs;

The XML native database is capable of storing any type of XML based metadata. However, the database functions are adopted for the use in an MPEG-21 environment and process MPEG-21 DIDs. For querying the database, Tamino provides an API to use either XPath or XQuery for querying the database (see Table 1 for examples). The MATool implements own adapters, which are especially suited for processing MPEG-21 DID functions, such as retrieve DID, upload DID, or remove DID.

Table 1. XQuery example for querying DIDs with specific identifiers

```
declare namespace
  tf='http://…/tamino/TaminoFunction'
declare namespace
```

```
  didl='urn:mpeg:mpeg21:2002:02-DIDL-NS'
declare namespace
  dii = 'urn:mpeg:mpeg21:2002:01-DII-NS'
declare namespace
  tvmid='eims:tvmIdentification:01'

for $q in input()/didl:DIDL
where starts-with
   ($q/didl:Container/didl:Descriptor/
    didl:Statement/dii:Identifier/identifier
return $q
```

The database model is based on one collection, which is capable of storing all the DIDs produced by the demonstrators of ENTHRONE 2. For identifying specific DIDs inside the database the MPEG-21 DII mechanism is used. The MPEG-21 DII syntax is: `enthrone:did:category:sub-category`.

The category is used to identify the instantiation source or type of this DID used within the ENTHRONE 2 context (e.g. metadata source such as content provider). The sub-category tag is a categorization of above. One example is the identifier enthrone:did:rbb:1, which identifies a DID coming from the content provider RBB, identified with the sub-category 1.

4.4. Interfaces

The MATool is compromised by an online real-time interface, and by an offline interface. The different interface functionalities are presented in Table 2.

Table 2. MATool interfaces in online/offline mode

ONLINE WSDL INTERFACE
status uploadCPDID(DID) uploads a DI coming from the content provider
DID downloadCPDID(ID) downloads a MPEG-21 DI with a certain identifier
status registerTVM (TVM) registers a new TVM
status unregisterTVM(ID) unregisters a TVM
TVM[] queryAllTVMs() queries all available TVMs
TVM queryTVM(ID) queries for a TVM
DID buildSPDID(CPDID, TVMID, AQoSID, RELID) builds a full DI at service provider side
status uploadUED(UED) uploads a UED
UED downloadUED(ID) downloads an UED
UED[] downloadAllUEDs() dowlowads all UEDs
Initialize(serviced) initialization of the MATool for the scope of a session
uploadAQoS(AQoS) uploads an AQoS descriptor
uploadADTEDecission(decision) uploads an adaptation decision

OFFLINE WSDL INTERFACE
uploadCPDID(CPDID) uploads a content provider DID
downloadCPDID(id) downloads a content provider DID
downloadSPDID(id) downloads a service provider DID
buildSPDID(cpdid id, spdid id, tvm id, service classes) builds a service provider DID from TVM information, service classes, AQoS (contained in the TVM information), and content provider DID
transformMXF2TVA(MXF, TVA) transforms MXF metadata to TV-Anytime metadata
registerTVM(TVMRF) registers a TVM content source
unregisterTVM(id) unregisters a TVM content source

5. MATool – Metadata Demonstrators

As stated earlier, MATool functionalities have been validated with demonstrators. Within the scope of this section, three demonstrators are presented. The MATool web-front end is presented in Figure 7.

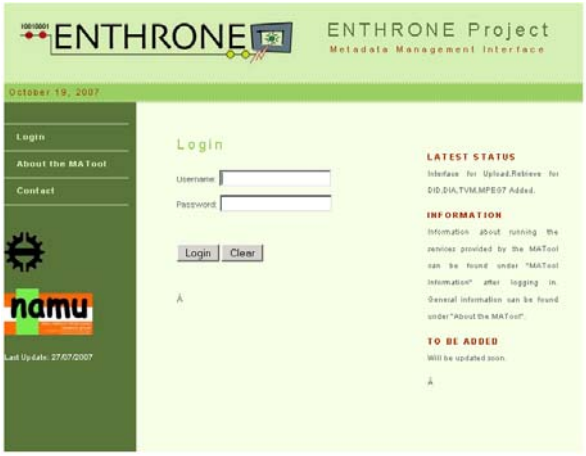

Figure 7. MATool front-end

5.1. Metadata Aggregation (Service Provider Workflow)

The idea behind this demonstrator is to simulate the workflow steps of a service provider. The service provider should be able to retrieve content metadata from a content provider and build complete content packages for the consumer. These content packages should contain additional information such as content source server, and adaptation parameters. Metadata aggregation in this context is not real-time critical, and therefore does not impact QoS metrics directly.

The content provider provides its content described in metadata including its semantic annotations. These

content descriptions in form of MPEG-21 DIDs are forwarded to the service provider. The MPEG-21 DIDs provided by the content provider are called *Content Provider DIDs (CPDIDs)*. Semantic annotations of content are based on the TV-Anytime standard and include parameters such as e.g. title, genre, and synopsis.

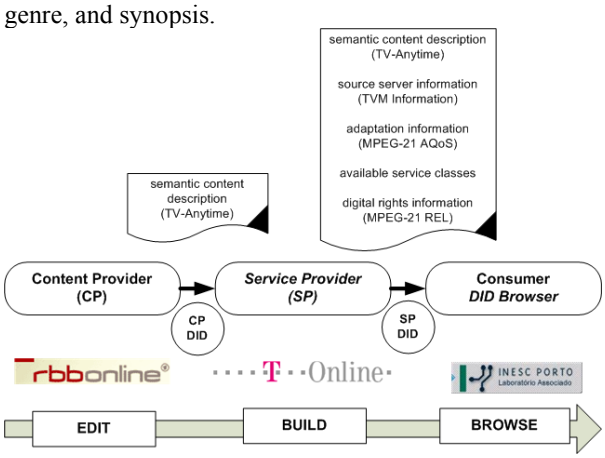

Figure 8. Service provider workflow

The service provider adds information concerning the content source, thus e.g. streaming server, available service classes, and content adaptation parameters. The content provider DID is enriched towards a *Service Provider DID (SPDID)*. The service provider DID is forwarded to the consumer, which can make selections of the variations of the different content variations with his browser system.

Service classes represent an abstraction of classes of service offered to the consumer, or requested by the consumer. In the current implementation the service classes are named gold for highest quality, silver for medium quality, and bronze for low quality.

The workflow (see Figure 9) can be divided into the following logical consecutive steps:

- **edit**: adding semantic programme information (e.g. title, genre, synopsis) and creation of the CP-DID;
- **build**: enriching of semantic information with service provider specific data (e.g. streaming source, adaptation parameters, and service classes) to build the SP-DID;
- **browse**: browsing of the variety of different SP-DIDs and selection of content.

5.2. Context Metadata Collection

The idea behind this demonstrator is the collection of contextual metadata of ENTHRONE 2 system components. Metadata coming from terminal, content provider, service provider, network provider, and system components is collected, and provided to different other EIMS sub-components. This includes metadata from content sources, thus TVMs, adaptation metadata, terminal metadata (UEDs), UCDs, AQoS metadata, and other DIDs.

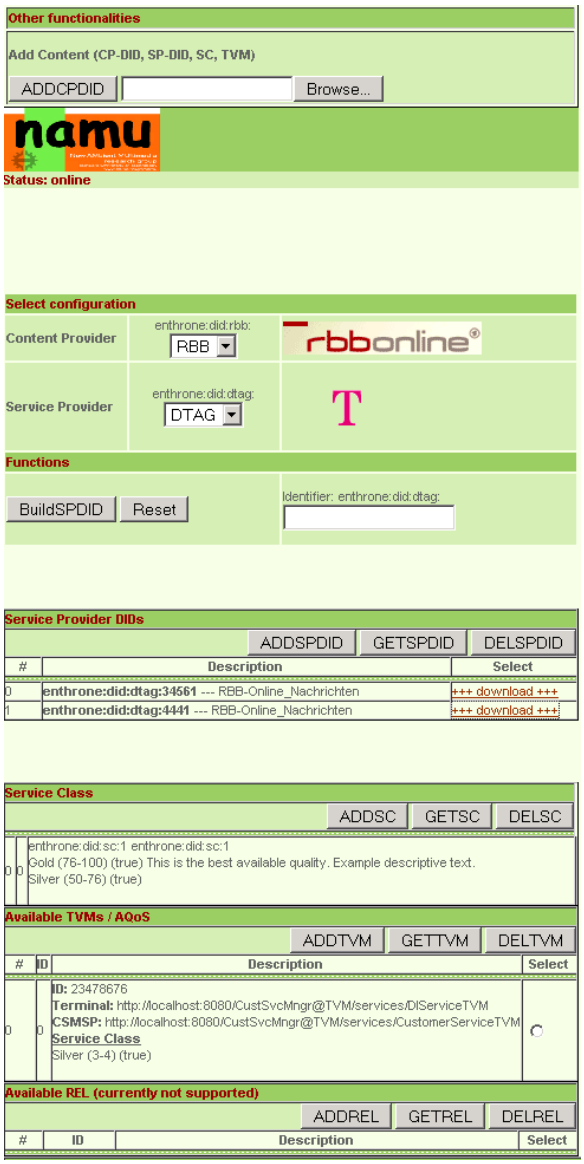

Figure 9. Web based service provider workflow interface for building SPDIDs (metadata aggregation)

The collection of contextual metadata is time-critical, and has impact on the QoS metrics. However, the time consuming functionalities, such as adaptation of content are performed outside the MATool. The

MATool only provides these components with the relevant data.

5.3. Metadata Conversion (MXF to TV-Anytime to MPEG-21)

This demonstrator devotes to the conversion between MXF and MPEG-21 metadata. This demonstrator is currently under development, and compromises two functional steps:

1. conversion of MXF metadata to TV-Anytime;
2. encapsulation of TV-Anytime metadata into a MPEG-21 DID.

6. Discussion

Metadata management is a critical task, also as its real-time constrains are. Especially in an end-to-end QoS system, which is purely based on MPEG-21, only a fine-tuned metadata solution can solve issues concerning data concurrency, interoperability, and provide a value-chain spanning solution. From the described demonstrators, currently the metadata aggregation and metadata collection are implemented. However, the metadata conversion component (MXF2TVA2MPEG21) is currently still under development.

Future work is focusing on the finalization of the conversion component, as well as on the development of a billing system. The idea behind the billing system is to provide service providers the capability to invoice consumers according the different adaptation steps that have been performed.

Acknowledgements

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