Managing multimedia content and delivering services across multiple client platforms using XML

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Abstract

This paper describes a modular platform based on the XML technology, aiming at enabling users to transparently access and consume multimedia content through distinct access devices, including digital television Set Top Boxes (STBs), Personal Digital Assistants (PDAs), mobile phones, PCs and ISDN card phones, using distinct network connections. The platform is based on the XML technology, used both as an intermediate format to represent the content facilitating the transcoding operations and as an object-based model for the management of media assets and devices. Regarding this last aspect, the MPEG-21 standard is used as a framework to supervise the transactions of multimedia content packages (*digital items*), in particular from the outside world into the CONTESSA platform, promoting the interoperability between systems and technologies while exchanging information. A general overview of the architecture and functionality of the platform is given, going then into more detail in aspects related with content management, support for adaptation and user requirements and validation procedures.

1. Introduction

The CONTESSA project [1], IST-2000-28567 *Content Transformation Engine Supporting Universal Access*, is a European research project partially funded under the IST programme. The objective of CONTESSA is to develop a modular platform to enable dynamic transcoding of multimedia content to distinct access devices, including digital television STBs, mobile terminals such as PDAs and 2G+ phones, PCs and ISDN card phones, through distinct access networks, thus facilitating and promoting a wider and easier access to information. For Service providers, the CONTESSA platform will enlarge the range of reached audience and will demonstrate the benefits of using transparent ways of managing and publishing multimedia content for multiple client platforms. For the consumer, it will demonstrate the ability to access same databases and seamlessly retrieve the information in the most adequate format, regardless of the characteristics of the terminal equipment or network connections. The technology convergence within networks and services, anticipates the transport and delivery of content across heterogeneous networks and its consumption in a multiplicity of receivers. The variety of client devices with distinct capabilities to receive, process, store and display digital content, means that in most cases it is either necessary to maintain multiple copies of the content or to restrict the access to content to only certain types of equipment. CONTESSA, operating seamlessly between content repositories and consumers, provides the means to overcome this problem. In this paper we give a generic description of the concept and objectives of the project and concentrate on the aspects related to content management, support for adaptation and validation tasks. Related to description, identification and transfer of content across distinct contexts, a brief introduction of the MPEG-7 and MPEG-21 standards will be done.

2. Technology approach

CONTESSA is a component based software platform comprising distinct tools that interoperate based on the XML data model. It provides transcoding services applied directly on raw data through a two-stage transformation process (raw data-to-XML-to target device format). Although introducing an extra level of processing, the use of XML as an intermediate format provides flexibility and extensibility because it isolates the source content format from the target device format. For the collection and management of content, the platform incorporates a tool – *Content Collection Engine* - to allow distributed access to content providers' sources for content extraction, performing the dynamic and periodic update of the CONTESSA data repository. The data exchange and control mechanisms are based on the XML data model and distributed technologies such as CORBA. It presents an open, modular architecture, providing total independence from specific data models used in the content repositories. This is accomplished by defining an open publishing format and providing a correspondent open API to transfer content into CONTESSA. In addition, it allows the efficient encapsulation and identification of different versions of the same content to suit the different requirements of distinct client devices. As explained in section 3, this publishing format follows the open specification currently being standardised in MPEG-21.

2.1 Platform Architecture

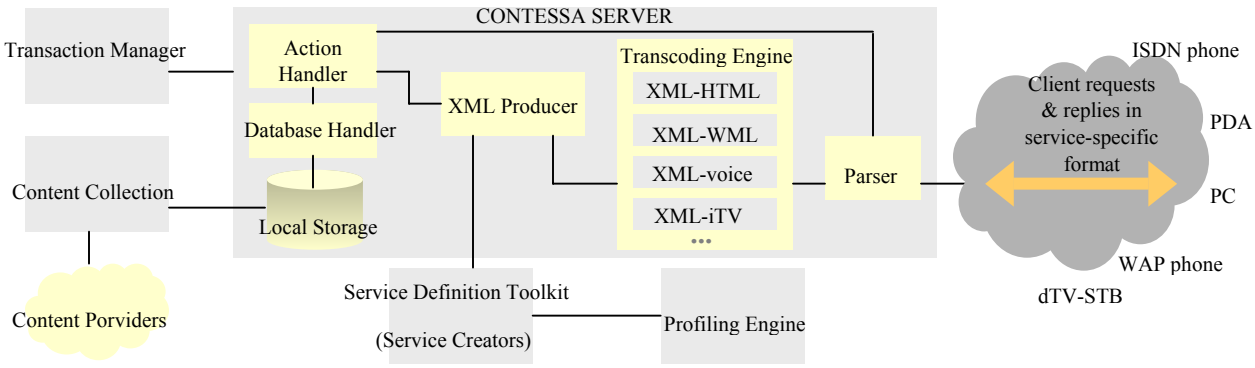

Figure 1. Architecture of the CONTESSA platform

Figure 1 shows the architecture of CONTESSA. It comprises the following main components:

- *XML Producer*, (XMLP) – generates an XML document with the execution results, using XML schemas specific to the service, previously generated by the Service Creator using the SDT;
- The *Transformation Engine*, (TE), is the tool that converts the service execution results to the client specific format. To achieve that, it applies different XSLT style sheets on the input XML document.
- *Service Definition Toolkit*, (SDT), enables the service provider to design new services for the end-users or modify existing ones. It automatically generates XML schemas and XSL files (with the formatting rules) appropriate to each service on each client device;
- *Profiling Engine*, (PE) - caters for the personalisation of services provided by the CONTESSA platform, defining a set of rules (XSL files), depending on the user's preferences;
- *Content Collector*, (CC) - acts as an independent application that performs the collection of data from various external content repositories in an automated way, thus ensuring that the database's update is as fast and flawless as possible and that the access to content is easy and flexible.

3. Management of content

Within the content production industry, it is very common the use of both proprietary and standardised systems for the representation of essence (multimedia content) and associated metadata as well as for content management systems. This problem of diversity is also found in the way different content suppliers represent, storage and manage their content and promote the association between the metadata and the essence. Management of all these types of information, systems and rules across different contexts or environments is not effective without a standardised, open method. The XML object data model can be used as the underlying technology to handle data produced by these distinct data models and in fact it is increasingly being used for the development of standards in these domains.

3.1 The role of standards

Recently, intensive work has been undertaken to standardise and unify methods for the representation of metadata and for the management of content. Regarding metadata, groups and organisations around the world have already issued specifications, both generic as well targeting specific segments. The most relevant standardisation groups working in this domain are the MPEG-7 of ISO/IEC, EBU with the P/Meta specification, SMPTE and the Dublin Core Forum. Regarding the management of digital assets, the MPEG-21 specification addresses all aspects concerned with the delivery and consumption of multimedia content in heterogeneous environments. Successful implementation of open specifications is crucial for the dissemination of information and to prove the feasibility of adapting proprietary formats to any of these standards. This is one particular aspect contemplated by CONTESSA through the provision of plug-ins attached to the CONTESSA platform and by defining and providing specific open APIs.

3.1.1 The MPEG-7 specification

MPEG-7, "Multimedia Content Description Interface" [2], is a metadata standard based on XML Schema to describe multimedia content in terms of its different level features: catalogue information (title, creator, access rights, etc.), semantic (descriptive information about objects and events) and structural (colour of an image or texture, the timbre of a recorded instrument, etc.). The essence may include still pictures, graphics, 3D models, audio, speech, video, and composition information about how these elements are combined in a multimedia presentation. MPEG-7 descriptions do not depend on the way the described essence is coded or stored but the standard can exploit different characteristics of the representation or encoding formats, allowing different levels of granularity. Unlike most content description systems, MPEG-7 allows to describe low-level features and to break down segments of content into smaller units. For example, if an audio-visual scene is encoded using an object-based algorithm, it is possible to assign descriptions to individual objects within the scene and to their spatial-temporal relationships. MPEG-7 information can be delivered independently or together with the essence it describes and it can be represented either in textual or binary format or even in mixture of the two depending on the application.

3.1.2 The MPEG-21 specification

Multimedia technology has evolved into a complex infrastructure of services and devices, where different players in the content value chain can access information from almost anywhere at anytime provided with ubiquitous terminals and networks. However, co-operation between them is not easily achieved as each sector has its own rules, procedures, interests and forms of using this infrastructure. MPEG-21 [3-6]

addresses the aspects of identifying, describing, managing and protecting the content in the multimedia content delivery chain from its creation to the consumption. MPEG-21 will provide several tools to manage how digital objects such as audio, video or multimedia files, are encoded, secured, archived, searched, transmitted, and consumed. MPEG-21 defines the concept of a Digital Item (DI), as a structured and hierarchical digital object containing several multimedia objects (such as several sound recordings, video clips, images, etc.) and metadata. To enable the declaration of the parts that make up each DI, MPEG-21 is developing an XML-based language called the Digital Item Declaration Language (DIDL).

3.2 The CONTESSA Content Collection Model

To handle the variety of items that may be transferred into it, CONTESSA specifies an open interface via the Content Collection Module. It comprises tables to describe the essence and a common format for the storage of binary data. In practice, a common format that each content supplier must use to publish the contents they want to transfer inside CONTESSA. Each item being published to CONTESSA may consist of a number of resources of different media types and their descriptions. For instance, a video clip may have associated to it an MPEG-2 video file, one or more Real Video files with different bit rates, JPEG files with representative images of the video clip and an MPEG-7 file with detailed descriptions. The different versions of the same content can be used dynamically according to the client device that has requested the information. As explained above, MPEG-21 defines the concept of a DI and specifies the DIDL as a standardised method for declaring the structure of the DI and to enable its transfer. The proposed data model isolates the essence from their declarations, storing the former as an MPEG-21 DI and the later in the form of tables. It is a relational model, using a repository of DIs with the respective DI Declarations (DID) pointed by the entries in the tables of that model. This model is shown in figure 2.

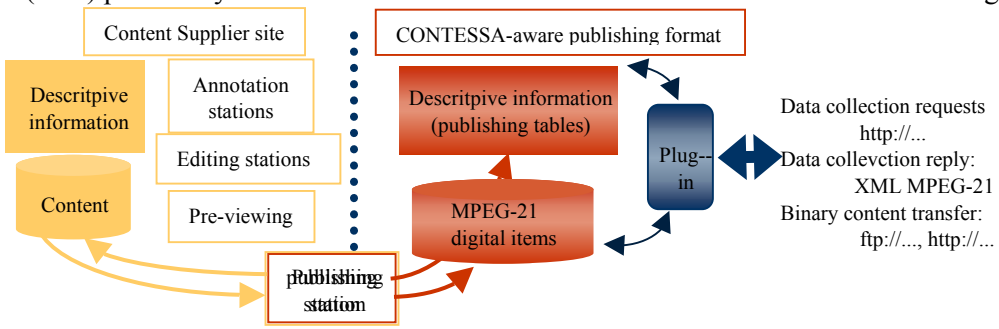

Figure 2. Data model for the CONTESSA-aware publishing format

In response to a request, the plug-in filters the publishing tables and uses that information to fetch from the repository the DID(s) to be returned. Inside the DID, standard MPEG-21 mechanisms are in place to either convey resources embedded directly in the DID or to provide the Content Collector information on the location of the resources to be fetched as well as the transfer protocol to be used.

4. Services and user validation

4.1 Requirements Elicitation

Requirement analysis is the foundation of a user-centred approach. It provides precise descriptions of the content, functionality and quality demanded by prospective users thus decisively contributing to creating products that appeal and meet user needs.

Elicitation of user requirements can be achieved through the use of informal methods such as observation, interview, document analysis, focus group analysis, checklists or questionnaire. They can be applied in parallel to complement each other to yield more effective results. In CONTESSA, interviews and questionnaires where used in order to aid the user-organizations in compiling their requirements. One important aspect of this task was the identification of services to be implemented in the prototype. The services *Electronic Programming Guide (EPG), Sports News* and *Weather* were chosen based on their present popularity in Europe, on the possibility of making them available on a variety of client platforms and because they are expected to contain multimedia information, thus requiring tailoring to the capabilities of the devices and context in which they are used. For each user partner of CONTESSA, a description of the organizational and technological context in which these services are currently provided and the anticipated changes due to the introduction of similar services on new platforms was produced. Also a detailed account of the workflow for each service, the platforms/devices chosen and the different categories of users involved, including the end users of the service itself.

4.2 Applications

The three services that are going to be implemented and presented with the developed prototypes will fully exploit and demonstrate the potentialities of the CONTESSA system. They will be presented in two or more different devices, will include personalisation and use information from external entities. They will also allow testing the functionality of the CC module in cataloguing and describing different versions of the same content and dynamically selecting the appropriate one for the particular device.

The *Weather* service will be offered through mobile devices and ISDN phones. Personalisation will be based on the "area" parameter. The end-user will be able to select the areas of her/his interest. A synopsis of the weather forecast will be displayed in the initial personalised page, along with links to detailed forecasts. The *Weather* service will encompass information about "Entertainment Spots" like cinemas and theatres, including mainly location information and a short description of the related event. End-users will thus be able to organise their leisure based on the weather and the entertainment spots.

The *Sportnews* service will be offered through WAP-enabled phones, ISDN phones and Digital TV. Personalisation will be based on the "favourite team" parameter. Optionally, titles and abstracts of the articles related to the favourite team will be presented in the initial personalised page, along with links to the entire articles. Apart from information about local events, consumers will also be able to access information about international football events.

The *EPG* service will be offered through Digital TV, Web and WAP-enabled phones. Personalisation will be based on the "airing preference" parameter (news, athletic events, TV games, etc.). The airing's title, along with a short description can be displayed in the initial personalised page. From this page the end-user may access more detailed information.

4.3 User validation procedures

User validation is the assessment of the quality of use of a product or a service for specific users who want to achieve their goals in their environment. While verification tests if the product is free of bugs, validation tests if the product meets the requirements of its intended users. For the CONTESSA platform

and the services provided through it, two types of users have been identified: *technology users* and *consumers*. The former are the User organisations participating in the CONTESSA consortium that will use and directly interact with the developed technology to create and provide services to the consumers (e.g. information about news, traffic, weather, music download, etc.). The later are the end-users who will consume and interact only with the services created by the former using CONTESSA. Service Creators and Content Suppliers are technology users, since the focus of CONTESSA is to enhance and facilitate content management and production for service providers.

Service Creators interact with the CONTESSA platform using the tool "Service Definition Toolkit". The tasks that will be performed and that will be under validation are: *to define, list, view, modify/update or delete services and categories of services; to search the consumers' profiling database and view profiles.*

Content Suppliers will use the CONTESSA module "Content Collector". They are responsible for providing content to the CONTESSA database. Their basic tasks include the following: *to register and un-register; to create, list, view, modify/update or delete sources; to assign sources to Service Creators and service categories; to manually publish content into CONTESSA.*

The user validation plan has been divided in three phases, tightly coupled to the mock-up demo created at the beginning of the project and to the two prototypes that will be developed.

Phase 1: Collection of user feedback to the concept, demonstration and mock-up. Since this phase occurred at an early design stage and because it addressed an innovative system, we have chosen to rely on *heuristic evaluation* (expert usability inspection method) coupled with some form of exploratory user study, such as coaching, interviews and user feedback.

Phase 2: Development of CONTESSA prototypes in iterations with test-evaluation-improvement. The initial prototype will be tested under laboratory conditions involving the User organisations of CONTESSA, the *technology users*, which will select individuals, content and applications from their own organisations. The validation will include a test of the functional user requirements defined previously (User Requirements Definition) and will take into account the technology partners' evaluation plans. It will provide feedback to the development team in terms of user problems with the user interface and errors found, and will suggest improvements and eventually inclusion of further functionality. For validating the initial prototype the *focus group validation method* was selected. Focus groups in particular bring together a cross-section of stakeholders in a discussion group format. This method is useful for requirements elicitation and can help to identify issues that need to be tackled

Phase 3: The third phase will be performed with the final prototype and will involve also the *consumers*. In this phase groups of consumers will have the opportunity to evaluate the system and comment on the interfaces and the type of applications that have been implemented. A set of operational guidelines for each type of user will be created to help understanding the provided functionality. For this phase the method selected was *questionnaires*, which are useful in the middle and final phase of the design. The system is tested with real users who give their opinions on what they like or dislike, what problems they encounter with navigation, menus etc. User feedback also helps determining system's technical shortcomings during its implementation, saving valuable time and money for designers and engineers.

An important issue in user validation is the selection of both the assessment criteria and the methods to measure them. The former have been identified by the users' organizations and have subsequently lead, within the user validation framework, to the selection of appropriate measuring methods. This is illustrated in the next table.

Assessment criteria	Measurement method
Productivity and Performance * time/cost to design a new service * time/cost to redesign an existing service * number of platforms served	Measurement (in seconds, minutes, hours, etc.) of execution times and errors encountered, in a real-world environment: - individual tasks' execution times; - calculation of the "time to perform all tasks"; - measurement of errors and of the time needed for error recovery The criterion is met if there is a 50% reduction comparing to the present workflow. Counting - the criterion is met if at least 3 different platforms are counted.
Learnability	SUMI questionnaire provided as an Annex to the User Validation Report.
Conformance to ISO 9241	Comparative results and detection of shortcomings and weaknesses using the IsoMetrics inventory, used for testing conformance of interactive software systems with ISO 9241 / 10. It can be used for formative (IsoMetricsL - long version) and summative (IsoMetricsS - short version) evaluation.
Integration with existing software	Calculation of the time needed to integrate the CONTESSA system with existing software. The criterion is met if the time required is 6-8 months for Flash and 2-4 months for DR.

5. Final remarks

The set of tools being developed by CONTESSA will allow increased, easier, efficient and secure access to multimedia content across distinct environments or contexts. It will make possible for end-users to consume multimedia information in a transparent way, independently of the client device or network connections. The architecture of the platform is innovative in the sense that it is modular and expandable, using XML as an intermediate stage. Also because it provides extremely powerful interfaces for the technology users, allowing an easy and flexible definition of services and management of content. The data model proposed for exchanging and managing content adopting the MPEG-21 framework has the major benefit of promoting interoperability among different systems and therefore the possibility of using content from one context to a different one. Using the MPEG-21 framework to identify packages of content enables the use of a variety of content representation and metadata models. It provides greater flexibility for the use and adaptation of multimedia content to the different requirements of different client devices. For example it enables the efficient packaging and identification of different versions (in quality for instance) of the same image or video and the selection and retrieval of the most adequate for the client device that requested the content. It also allows the use of MPEG-7 search engines to perform searches and retrieval of content or the direct access to content to customers equipped with MPEG-21 enabled devices. The development of the project has followed since the beginning a user-centred approach employing dedicated methods for the elicitation of user requirements. An early involvement of users in

the design phase is essential to the objective of meeting the user needs and expectations, as well and throughout the development phases. A careful and detailed user validation plan has been produced, having already given important feedback to the development team during its first stage of implementation. It is now entering its second phase, with the testing at the users' organisation premises, of the first prototype working in real-world conditions. It is expected to obtain valuable feedback from this user validation phase, which will impact the development of the second prototype.

6. References

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