Streaming of governed content – Time for a standard

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***Abstract* - This paper presents ISO/IEC 23000-5 - Media Streaming Player, an ISO standard targeting the distribution of governed content in streaming mode. This standard is a major integration of MPEG technologies, ranging from MPEG-2 and MPEG-4 to MPEG-21 including a set of inter-device protocols developed by the Digital Media Project, now ISO/IEC 29116-1 - Media Streaming MAF Protocols. The paper also presents Chillout, adopted for the open source reference software of this standard. Chillout is written in Java and provides a set of libraries for developing applications conforming to the standard.**

I. INTRODUCTION

The industry of governed video streaming has been mostly a niche market so far, but the pre-requisites for a massive take up of so-called IPTV solutions and services are all in place. From the one hand, the growing number of terabytes of user generated content on the web and the new generation of video services on the Internet is attracting the interest of many operators to design and deploy solutions for distributing content in a way that respect the content rights holders. From the other, the limitations in the current proprietary Digital Rights Management (DRM) solutions felt by many operators and governments are pushing for the design and the development of new alternatives.

This paper presents an overview on ISO/IEC 23000-5 Media Streaming Player [4], an ISO standard under development in MPEG, scheduled to be approved in October 2007 targeting the distribution of governed content over streaming channels such as MPEG-2 Transport Stream or Real Time Protocol over Internet Protocol (RTP/IP).

Chapter II explains the motivations that led to the definition of this standard, while Chapter III presents the main features of it, and two walkthroughs showing the potentialities of the solution. The key technologies of the Media Streaming Player standard are briefly introduced in Chapter IV. Chapter V presents *Chillout*, the reference software of the Media Streaming Player standard which can be used to develop applications conforming to the standard and test their conformance as shown in Chapter VI. Finally, Chapter VII ends with conclusions.

II. WHY A MEDIA STREAMING STANDARD

Video streaming – in the form of MPEG-2 Transport Stream (TS) broadcasting – has been used for as many as 13 years in manifold instances: first on satellite, then on Cable TV, then on terrestrial networks, and eventually on IP networks. The governance of a service that has been widely deployed – pay TV – is based on two simple technology hooks in the MPEG-2 TS – Entitlement Management Messages (EMM) and Entitlement Control Messages (ECM) – but is otherwise proprietary.

This has a number of positive aspects for the service provider that can be summarised by a single word: customer ownership, but also some significant shortcomings, such as the need to design, have manufactured, deploy and maintain set top boxes, typically the second most significant expense for a pay TV operator next to content rights. This level of costs has so far prevented a broad deployment of successful and competing pay TV services in such "fragmented" markets as Europe.

For the end user the proprietary nature of the service also leads to significant constraints. The most severely felt one is probably the inability to subscribe to multiple pay TV services (of course, where there are) unless the end user is willing to stack set top boxes. A second constraint is the inability to buy the set top box with the features the end user wishes to have.

From the viewpoint of some public authorities there are concerns about an "information market" that is stifled by a few players with a very high entry threshold for any newcomer. Emblematic is in this respect the case of the Digital Terrestrial Television (DTT) deployed in the UK. Started with two competing pay TV operators, the UK DTT witnessed the forced merge of the two competing operators into one and eventually the closure of the DTT pay TV service. Today the UK government who had orchestrated the strategy has completely abandoned the idea of pay TV on the DTT where some 30 clear-text channels are broadcasted.

"Native" video streaming on the Internet Protocol (IP) as a "service" has a shorter track record but its use has been flourishing for some time. Most of that content has been streamed in clear-text, but there are significant examples of streaming of governed content, on the internet, however, the range of choices has been even wider than with broadcasting as the choice of technologies has extended not only to the protection layer but to the media layer as well.

We are also on the verge of a new generation of video services on the Internet. The desire of many telecommunication operators to expand the use of their network – that is getting more and more "broadband" – is prompting many of them to design and deploy IPTV services, i.e. the streaming of television services on network that are owned by the operator and employ the IP.

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At the same time more and more user generated content is being fed to social web sites and streamed by the tens of millions every day. Currently this is done in an "ungoverned" fashion but there is more and more awareness (see e.g. [1]) that governed streaming is beneficial to all the parties involved.

In short, so far, the industry of governed video streaming has been mostly a niche market, but now the industry is going to have an exponential explosion. For this to happen it is necessary to add one more technology to the industry toolkit: interoperable governance.

Since 2000 the Moving Picture Experts Group (MPEG) has been working on a comprehensive suite of standards called ISO/IEC 21000 – Multimedia Framework (a.k.a. MPEG-21). This contains a set of key technologies such as

1) A data structure capable of hosting diverse data types accompanying a "resource" audio, video, image, text etc. (Digital Item Declaration or DID [8])
2) An identification system of content (Digital Identification or DII [9])
3) A set of technologies usable to protect content (Intellectual Property Management and Protection or IPMP [10])
4) A language to express rights associated to a resource (Rights Expression Language or REL [11][12][13])
5) A file format for storing Digital Items and resources (File Format [14])
6) A technology to transmit Digital Items in streaming mode (Digital Item Streaming or DIS [15])

and other related technologies.

The Digital Media Project [2] was established in December 2003 as an international non-profit group seeking to achieve three goals: improving the ultimate user's experience, better monetizing the value chain for middle-men, and protecting the needs and rights of content creators and digital publishers, producers and studios, by addressing issues of improved delivery of digital media. DMP has recently approved version 3.0 of its specification, called Interoperable DRM Platform (IDP) [3]. As the name implies, the IDP is a platform, i.e. a middleware (that one would probably better call the "digital media operating system") on top of which almost countless types of digital media value chains can be set up and operated. IDP-3.0 is broadly based on the MPEG-21 standard with the addition of a few necessary technologies not available from the MPEG-21 standards.

In July 2006 a group of DMP members submitted a proposal to MPEG to standardise a Media Streaming Multimedia Application Format (MS MAF) based on DMP IDP specification. In October 2006 the MS MAF has been balloted as a Committee Draft. At the time of writing the MS MAF is expected to become a Final Draft International Standard in October 2007.

III. THE SOLUTION

A. *What is a MAF*

MPEG's Multimedia Application Formats (MAF) provides the framework for integration of elements from several MPEG standards into a single specification that is suitable for specific but widely usable applications. Typically, MAFs specify how to combine metadata with timed media information for a presentation in a well-defined format that facilitates interchange, management, editing, and presentation of the media. The presentation may be 'local' to the system or may be accessible via a network or other stream delivery mechanism. Several Multimedia Application Formats have already joined the ISO/IEC 23000 (MPEG-A) set of standards, while many are undergoing the process of standardisation.

MAF specifications integrate elements from different MPEG standards into a single specification that is useful for specific but very widely used applications. Examples are delivering music, pictures or home videos. MAF specifications may use elements from MPEG-1, MPEG-2, MPEG-4, MPEG-7 and MPEG-21.

B. *MS MAF Reference model*

Figure 1 depicts a general Media Streaming MAF systems overview. As [4] is not an end-to-end specification but a "streaming format" and associated protocols leading to a Media Streaming Player specification, only the relationships with other devices that are directly functional to the performance of the Media Streaming Player (MSP) are considered. For example, the Media Streaming Player MAF does not provide the specification for a device registration protocol.

In Figure 1 the data flowing through the dotted block are specified in [4]. Any device in the reference diagram is called a *Media Streaming Device* (MSD). An MSD can be any of the following devices

1) *Media Streaming Player*, i.e., a device capable of consuming content for human use.
2) *Content Provider Device*, i.e., a device capable of interacting with a Media Streaming Player to provide Media Streaming Content.
3) *License Provider Device*, i.e., a device capable of interacting with a Media Streaming Player to provide Licenses upon request.

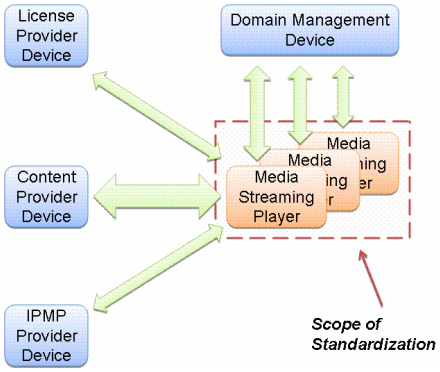

Figure 1. Reference diagram for Media Streaming applications.

4) *IPMP Tool Provider Device*, i.e., a device capable of interacting with a Media Streaming Player to provide IPMP Tools, the modules implementing protection algorithms on the resources.
5) *Domain Management Device*, i.e., a device capable of managing various functions needed for a proper functioning of a domain, e.g. create a domain, renew the domain membership, delete a domain, add a device to a domain, remove a device from a domain.

To exchange data with other devices a Media Streaming Player employs several types of Media Streaming Protocols. The following walkthrough explains the role of the technologies specified by ISO/IEC 23000-5.

A Media Streaming Player obtains streaming content from a Content Provider Device using a Content Access Protocol. In order to use that content, a Media Streaming Player obtains a license from a License Provider Device using a License Access Protocol. Further, to process the content, a Media Streaming Player may obtain the appropriate IPMP Tools from an IPMP Tool Provider Device using an IPMP Tool Access Protocol.

A user may have a plurality of Media Streaming Players and may want to use the content on all of them. In order to do that, he/she needs to have a domain created using a Domain Management Device and then obtain a domain-wide license. All interactions between Media Streaming Players and the Domain Management Device can be implemented by a set of protocols. Finally, Media Streaming Players may create, depending on the license, a file that contains licenses, IPMP Tools, resources, etc. and possibly transfer the file to other Media Streaming Players for use in the domain.

In short, the Media Streaming Player standard:

1) specifies how to use specific MPEG technologies
2) references the data formats exchanged between an MSD and a Media Streaming Player
3) references the transport protocols used to move data between an MSD and a Media Streaming Player
4) references the domain protocols used to exchange the data between an MSD and a Media Streaming Player.

C. *Some walkthroughs*

IPTV: In this scenario a Content Provider Device streams resources and Digital Items on an IP network with a guaranteed Quality of Service (QoS) using the Real Time Protocol (RTP) over User Datagram Protocol (UDP). The Digital Items streamed contain, in addition to other service-related metadata, the IPMP Tools that are needed to play the resources and the corresponding licenses. Additionally, an MSP may access a separate License Provider Device to obtain additional licenses. A subscriber to the IPTV service can play content received depending on subscription terms and, if the license permits it, the Media Streaming Player can create a file out of that content and store it for later play. If the MSP is part of a domain, it can request and obtain a further license to copy and/or move the file and have it used by the MSPs of the domain.

Digital Broadcasting without return channel: In this scenario, the Content Provider Device streams resources and Digital Items on a radio channel (in the terrestrial or satellite bands) using the MPEG-2 Transport Stream. The Digital Items streamed contain, in addition to other service-related metadata, the IPMP Tools that are needed to play the resources and the corresponding licenses. A subscriber to the TV service can play content received depending on subscription terms and different services may have different licenses. If the license for a particular content permits it, the Media Streaming Player can create a file out of that content and store it. If the subscriber has its MSPs part of a domain and the subscription/license allows so, the MSP can create and store a file with that content and copy and/or move to and have the file used by the MSPs of the domain.

IV. KEY TECHNOLOGIES OF THE MEDIA STREAMING MAF

This section provides a few details on key technologies at the foundation of the Media Streaming MAF standard.

A. *MPEG-2 and MPEG-4 IPMP-X, MPEG-21 IPMP Components*

The protection information in the Media Streaming MAF is expressed as a profile of, and extensions to the MPEG-21 IPMP Components standard [11].

MPEG-21 IPMP Components allows associating rights and protection information to a Digital Item or parts of it. For instance, parts of a Digital Item could be governed by means of a license only, or governed by a license and protected by means of IPMP Tools (modules performing cryptographic functions such as encryption, watermarking key management, etc.). The Media Streaming extensions to [11] defined in [4] and in the XML IPMP Messages specification [6] allow delegating an MPEG-2 or an MPEG-2 IPMP-X system that could be part of a Media Streaming Player to enforce the protection on the media resources based on the protection information specified in the Digital Item. It is therefore possible to initialise an IPMP Tool with decryption keys and any other relevant information specified in the Digital Item.

Furthermore, the specification allows aggregating IPMP Tools in *Tool Packs*: modules incorporating a number of IPMP Tools with a *Tool Agent*, an additional module instantiating, initialising, authenticating, and supervising any operation performed by IPMP Tools. By means of this feature, the Media Streaming Player is relieved by the burden of managing IPMP Tools, and Content Providers do not need to disclose the details of how the content they distribute is protected.

B. *IPMP XML Messages*

In order to allow a Device to host a number of non normative IPMP Tools, the Media Streaming Player employs the message-based interface defined in ISO/IEC 23001-3 [6]. This specification defines a set of messages which are employed in a Media Streaming Player for three purposes:

1) to enable a Media Streaming Player to instantiate, initialize, authenticate and manage IPMP Tools throughout their lifecycle in an standard way
2) to enable IPMP Tools to exchange information between them or with the Media Streaming Player in an interoperable way
3) to enable an IPMP Tool to receive IPMP information from a Media Streaming Device through the Digital Item streamed to the Media Streaming Player on which the IPMP Tool is instantiated

C. *MPEG-21 Rights Expression Language*

The vast area of application domains covered by the rights expression capabilities of a Media Streaming Player enable the distribution and management of governed content in multiple application areas.

The Media Streaming MAF supports three MPEG-21 REL Profiles, the Mobile And optical Media (MAM) Profile [12], which was designed to express licenses in MPEG-21 REL targeting the mobile domain, the Dissemination And Capture (DAC) Profile [13], which was designed to express REL licenses equivalent to TV Anytime RMPI [16] licenses which are used in the broadcasting domain, and the Open Release Content (ORC) Profile [14], still undergoing the process of standardisation, allows expressing equivalent Creative Commons [17] licenses in MPEG-21 REL.

The vast area of application domains covered by the rights expression capabilities of a Media Streaming Player enable the distribution and management of governed content from multiple application areas.

D. *MPEG-21 Digital Item Streaming*

Digital Item Streaming (DIS) enables the description of how a Digital Item and possibly binary content part of it (such as audio and visual resources) can be fragmented and inserted (bound) into one of several transport streams. Moreover, this standard provides an abstraction layer between a stored Digital Item and its representation in a specific channel. This enables different bitstreams to be created from a single DI to provide different views/subsets of the DI, different renderings of the content, and different bitstream formats. As a result, different parts of a DI can be sent over separate channels.

By means of this technology it is possible to stream any type of information included or referenced by a Digital Item with a high degree of flexibility. For instance, it is possible to utilise DIS for transmitting resources and associated metadata or IPMP information such as decryption keys. The Media Streaming Player is then capable of re-constructing the original Digital Item with the information received from the streaming channels in real time and processing it as more appropriate: for instance displaying metadata in sync with a video to the user, or forwarding decryption keys to an IPMP Tool to be used in a specific time frame to decrypt a protected resource.

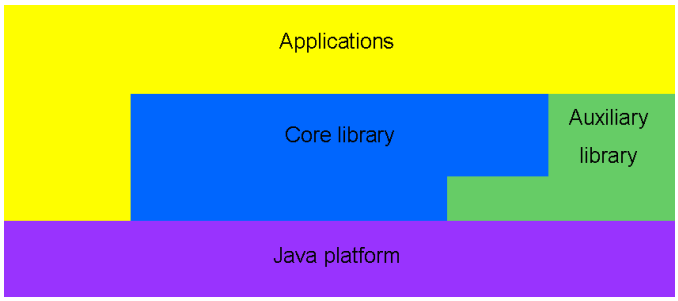

Figure 2. The Chillout software structure.

Media Streaming MAF Protocols

The Media Streaming MAF Protocol standard [5] specifies a set of protocols to be used in conjunction with a Media Streaming Player in applications where governed audio and video information is streamed to an end-user device. This standard is divided in two sections: Access Protocols, specifying the messages exchanged between MSDs when communicating with the purpose of obtaining from another device content items, licenses and IPMP Tool Bodies (the code of the algorithms implementing an IPMP Tool) and Domain Management Protocols, specifying the messages exchanged between MSDs in order to create a domain of devices or users and manage the users/devices membership.

V. IMPLEMENTING THE STANDARD

Chillout [25] is the name of the DMP IDP and MPEG Media Streaming MAF Reference Software which consists of a set of Java libraries implementing DRM functions and Java applications built on top of the *Chillout* libraries. *Chillout* is being developed by a growing international community and is released as Open Source Software under the Mozilla Public License 1.1 [18].

The *Chillout* software is based on the Java platform and is divided in a number of libraries as shown in Figure 2. The high level description of each layer is given below:

Java Platform Layer: this layer provides the Java running environment on which MSDs depend on. It comprises of the Java Virtual machine, plus a number of add-ons provided by third parties, such as the Apache Tomcat servlet container [19] to power web applications, the Apache Axis [20] SOAP implementation, providing web-service capability, the EJBCA [21] providing a Certificate Authority for authentication and authorization, the Java Media Framework [22] for rendering media resources[1], etc.

Core library: library of classes implementing the core functionalities as specified in [4]. The Chillout Core Library can be employed to generate any XML structure conformant to this specification, and conversely to extract any information contained within. A set of classes part of this library have been generated automatically by an Open Source software tool called Java Architecture for XML Binding (JAXB) [23] by taking in input the schemas. Additionally, this library provides

[1] The Java Media Framework will soon be replaced by GStreamer [24]

the methods to generate and parse an MPEG-21 File Format conformant to this specification.

Auxiliary library: library of classes encapsulating the functionalities that every MSD must have when operating in a real environment, such as digital signature calculation, secure storage of information, license validation, tools for instantiating and make IPMP Tools operational, several implementations of IPMP Tools etc.

Applications: a set of applications showing how to use the Core and Auxiliary libraries and customizable for specific needs. This category includes all the MSDs presented so far, plus a number of applications not part of the Media Streaming Player Standard but specified in [3] that can be used to generate governed and protected content, provide content and resources identifiers, digital certificates to applications, etc.

The Media Streaming Player can be implemented using *Chillout*, which provides the means to generate and to handle the information reaching Media Streaming Players (e.g. a set-top box), and to perform the protocols between a Media Streaming Player and a Content Provider Device, a License Provider Device, a DRM Tool Provider Device and a Domain Management Device. It can also generate Media Streaming Player-conformant content and information in general, thus leaving application developers to concentrate on the business logic of the applications running on top of Chillout without the need to understand the details of the standard.

VI. CONFORMANCE TESTING

The purpose of the ISO/IEC 23000-5 conformance is to enable a user to test that an implementation of a Media Streaming Player conforms to this standard. Therefore the following (non-exhaustive list of) test suites are provided:

1) Digital Items with/without IPMP Information Descriptors/IPMP information, with/without licenses, and with/without IPMP Tools
2) Licenses granting a number of rights (e.g. mx:play, m1x:governedCopy) to a MSP under a number of conditions typical of the DAC profile and granting the right to play and distribute content within a domain
3) IPMP Tools (examples of)

In order to allow MSD developers to test their implementation for conformance, the following example implementations of MSDs based on the reference software are provided:

1) Media Streaming Player
2) Content Provider Device
3) License Provider Device
4) IPMP Tool Provider Device
5) Domain Management Device

VII. CONCLUSIONS

In this paper, a new ISO standard for the streaming of governed content was presented. The Media Streaming Player standard has the potentials to become what the industry and the users are expecting for the next generation of content distribution over streaming channels. In any case, the standard is open to future needs, and can evolve beyond the current scope, as soon as more requirements will become evident.

ACKNOWLEDGMENT

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