Modela-TV: Service Personalization and Business Model Management for Mobile TV

ABSTRACT

This paper presents Modela-TV, a research project which investigates how free-to-air file download services can be the basis of new business models in mobile multimedia content delivery networks. Hereby, we present the proposed system architecture, together with implementation guidelines for the main technologies involved. A novel method for the personalization of broadcast file download services is introduced. This represents one of the main outcomes of the project, as personalization is considered a key feature in mobile TV services.

Categories and Subject Descriptors

D.2.6 [**Software Engineering**]: Programming Environments - *Interactive environments.* E.5 [**Files**]: *Optimization, organization/structure*. H.3.3 [**Information Search and Retrieval**]: *Information filtering*.

General Terms

Design, Performance, Management

Keywords

Mobile TV, Service Prototype, Personalization, Filecasting, Content management, Service Guide.

1. INTRODUCTION

Current Mobile TV revenue streams are primarily based on billing customers, either for content and transmission, as in the case of On Demand Streaming Services deployed by 3G Mobile Network Operators, or for access to a bouquet of premium TV channels, as in the case of Mobile Broadcast Services. In the traditional (non-mobile) television business, main revenue streams are generated by advertisement on free-to-air services, but also by premium and pay-per-view based business models. Enabling such a scenario in the Mobile TV landscape is regarded as a key factor to boost the penetration of mobile TV services. Current revenue streams are too weak to meet the expectations of all the agents in the value chain. A prove of this fact is that most of the current incomes of mobile streaming services are held by content providers.

On the other hand, the availability of content for download on the internet has shifted user habits and expectations on media services. Regardless of legal implications, users regard content as easily available and affordable (if not free). In a mobile scenario, this implies that users expect receiving content of their personal interest during the short time they are connected to the service.

For these reasons, the project "Service Personalization and Business Model Management for Mobile TV (Modela-TV)" proposes a Mobile TV service which allows service operators to use different business models (free-to-air, pay, premium…) simultaneously when offering content to mobile users. The service takes into account user expectations with regards to content availability and cost. The aim of the project is to develop a business model management platform for mobile multimedia delivery services through which, a) service operators can enable several revenue streams simultaneously and b) users can access personalized content at an affordable cost.

2. TECHNOLOGIES

The Modela-TV platform manages several technologies but relies mainly on two: On one hand, FLUTE (*File Delivery over Unidirectional Transport*), a protocol for the reliable (and scalable) distribution of files over IP multicast networks, which can be deployed over any mobile broadcast/multicast system based on IP (such as MBMS, DVB-H, Wi-Fi or WiMAX). On the other hand, the platform also manages a DRM (*Digital Rights Management*) subsystem in order to protect the intellectual property of the content to be delivered. These systems provide an adequate technical framework to deal with the commercialization of protected content. New ways of delivering content are introduced, which are meant to adapt the usage of the broadcast network in order to match the expectations of the users.

2.1 FLUTE

FLUTE (*File Delivery over Unidirectional Transport*) [1] is a protocol for the unidirectional delivery of files over the Internet, which is particularly suited to multicast networks. The protocol uses ALC (*Asynchronous Layered Coding*) and LCT (*Layered Coding Transport*) for a reliable and scalable transport of the multicast files. Furthermore, LCT implements a Forward Error Correction block to accomplish reliable multicast.

A FLUTE session consists of a set of logically grouped ALC/LCT channels associated with a single source sending FLUTE packets. Each FLUTE session is uniquely identified by the source IP address and the Transport Session Identifier (TSI). An ALC/LCT channel is defined by the combination of a sender and an address associated with the channel by the sender. A receiver joins the channel to start receiving the data packets sent by the source, and leaves it when it wants to stop receiving data packets of a specific channel (e.g. for congestion control) or when it wants to close the session. Previously, receivers must know the multicast addresses of the channels using out-of-band mechanisms such as SDP (Session Description Protocol).

There are two kinds of FLUTE sessions, File Delivery Sessions and File Carousels. The latter consists of a cyclical transmission of all files to be transmitted on a seamlessly endless loop and it is the one normally used, since cyclical transmission provides a reliable mechanism to receive files correctly. Furthermore, sessions can be static or dynamic, depending on whether the contents of the session change during its lifetime.

One of the fundamental components of FLUTE is the File Delivery Table (FDT), which provides a means to describe various attributes associated with the files that are included within the session, for example the file *Content-Location* (URL or URI of the item) or its numeric identifier TOI (Transport Object Identifier), used by the ALC/LCT client to filter the packets corresponding to the wanted files. The FDT is delivered as FDT Instances, which are XML fragments providing descriptions of one or several files over ALC/LCT with TOI = 0. Obviously the receiver needs parsing the FDT Instance that describes a file before it can start the download.

DVB IPDC (IP Datacast) [2] defines file grouping in FLUTE as a mechanism to download together files that have some kind of dependency at application level. This grouping is performed by means of the elements *Group* contained in the *file* element of the FDT Instance that describes a file. For each *file* element, one or several elements of type *Group* may be defined. The FLUTE clients that start downloading a file with a given *Group* element must start download all files with the same *Group* tag. Thus, file grouping enables an efficient caching of files.

2.2 DRM

The term DRM (*Digital Right Management*) refers to a series of technologies which enable the consumption of licensed digital content in a controlled environment. OMA DRM 2.0 [3] is an open standard which provides such a technological framework by defining appropriate content formats, protocols and Rights Expression semantics. The OMA BCAST Service and Content Protection [4] uses OMA DRM 2.0 and introduces a series of adaptations [5] in order to support the delivery of licensed content over broadcast networks under a variety of business models. According to these specifications, the usage of DRM in Modela-TV is explained below.

The DRM 2.0 standard is based in a four layer key hierarchy model (four security levels). The first one is the registration where, either through ROAP (*Right Object Acquisition Protocol*) or by off-line mechanisms, authorized receivers are provided with a set of *keys* which allow them to access certain Right Objects (ROs), in conformance with the usage rights expressed by the content owner. Modela-TV adopts the *Subscriber Group Addressing* feature defined in [5], which allows to defining the exact group of broadcast receivers that will be able to access the protected content. *Subscriber Group Addressing* consists of encrypting ROs with UGKs (*Unique Group Keys*). Thus, in the registration phase, all authorized receivers in a *Subscriber Group* are provided with the same UGK which will allow them to decrypt a series of ROs.

Furthermore, in Modela-TV the content is encrypted with CEKs (*Content Encryption Keys*) and encapsulated in *dcf* (*DRM Content Format*) files [3], which contains the Rights Objects associated to the content item (in addition to the encrypted content itself). The ROs contain the CEK and the access rights expressed by the content provider (e.g. preview or advertisement placement). Therefore, upon reception of a *dcf* file, a receiver will use its keys (i.e. a set of UGK) to decrypt the ROs within the *dcf* file. If a RO is decrypted, the receiver will use the CEK to decrypt the content and display it to the user, according to the rules expressed in the RO.

2.3 ESG

The Electronic Service Guide (ESG) is a file download service used to provide users and terminals with a description of the services available on an IP platform (similar to Electronic Program Guides of Digital TV Services).

Modela-TV adopts the usage of OMA BCAST ESG standard [6] as follows: the *Access* fragments of the ESG are used to provide the FLUTE session information for File Download services (referencing a FLUTE SDP fragment). Each file of the carousel is associated with a *Content* fragment which provides descriptive information such as parental rating, textual descriptions or TV-Anytime [7] genre descriptions. This descriptive data can be used to implement personalization features in the service. In this context, the TV-Anytime data model is of special interest, since it supports very accurate genre descriptions of the content of the files that are transmitted. TV-Anytime may also include profile and history data, thus providing information about the user preferences.

The *Schedule* fragments that reference a *Content* fragment contain the element *ContentLocation*, equal to the attribute *Content-Location* of the FDT Instance of the file, thus completing the access information required by the FLUTE client to fetch the file from the carousel. Furthermore, *Schedule* fragments may content instances of the element *DistributionWindow* to inform receivers of the time frames when each file is available in the carousel, in order to reduce battery consumption.

The *Access* fragments contain a *KeyManagementSystem* element which indicates that the DRM profile is used. The *RightsIssuerURI* attribute provides receivers with information to obtain rights associated to the content item. *Purchase Channel* fragments provide a relationship between the URIs and URLs of RIs, so that receivers can contact RIs if the user wants to acquire new rights.

3. ARCHITECTURE

The figure 1 shows the general architecture of the system, showing the most relevant technologies involved in the project.

The *Business Model Manager* is the main entity of the architecture and the interface between the platform and the operator. It manages the content ingestion and the Digital Rights associated to each media item. Through the *Business Model Manager*, the operator establishes the relationships of the content items with each Subscriber Group. This way, the management of the subscriber data base, the repository of content and the associated metadata (user profiling, purchase information and content description) are also in control of the operator through the user interface of the *Business Model Manager*. According to the setup provided by the operator, the *DRM subsystem* encrypts the content items and produces the *DRM Content Format* (dcf) files which are then aggregated to the free-to-air broadcast by the

Filecast Server. The latter also delivers the metadata (content descriptions, purchase information, etc.) to users in the service area by aggregating the ESG of the service.

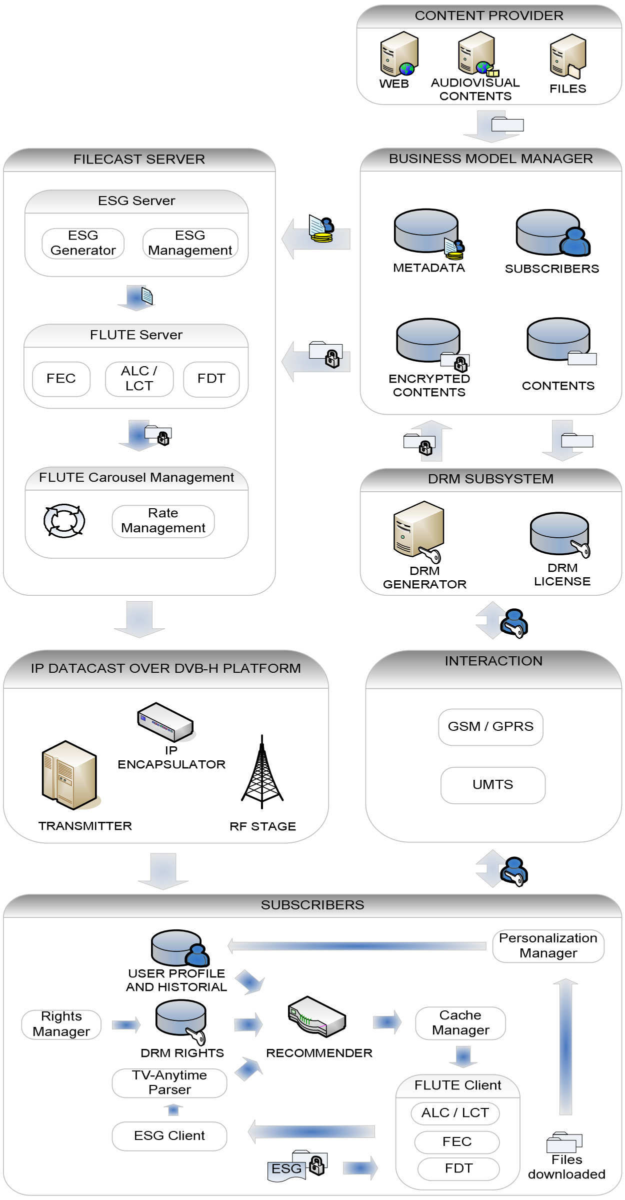

Figure 1. Modela-TV general architecture

The *Filecast Server* is, as explained, the *entity* that deals with the delivery of the content through the mobile broadcast network. The *Filecast Server* queries the *Business Model Manager* to obtain the *TV-Anytime* markup and the purchase information associated to each content item and aggregates this information in the generated ESG. The ESG is broadcasted and then received by the client application to discover which content items are available and their characteristics. Furthermore, the *Filecast Server* also manages the distribution of the content associated to each service by managing the configuration of the FLUTE carousel sessions and the definition of the associated File Distribution Tables. The software supports the definition of File Groups which, as described in the FLUTE section, can be used to accelerate the acquisition of a compilation of content items.

In the current version, the *Filecast Server* provides a constant bit rate IP flow to the encapsulator. In order to minimize the Average Download Time, all files are transmitted at full rate and the long term bit rate associated to each file is controlled by setting its cycle time. As explained in [8], with this configuration, a minimum of the Average Download Time in the service area occurs when the long term bit rate of each file is proportional to the file size, Si and to an estimation of the probability of access in the service area, Pi. The File Carousel Manager is responsible for scheduling the transmission of files and in order to set the file cycle, the platform provides the File Carousel Manager with these values to maximize the QoS (Quality of Service).

In the case of study, the content is delivered by means of a *DVB-H distribution platform*. Moreover, the *Filecast Server* aggregates the FLUTE sessions which correspond to the content delivery services and their Service Guide as a set of IP multicast streams that are encapsulated into an MPEG Transport Stream. The latter is broadcasted by the DVB-H air interface. The IP Encapsulator sets the configuration of the MPE encapsulation (time slicing and MPE-FEC parameters) and aggregates the metadata tables (PSI/SI) which are necessary to extract the IP data from the MPEG-TS by the receivers.

The client application provides *subscribers* with a user interface which discovers and lists all the content available through the service. Once the terminal tunes the DVB-H receiver to the frequency that transports the services, the client application receives the Service Guide and presents a list of the available content for download. When the user selects a content item, this is downloaded to the terminal as a background service. The client application also allows entering user preferences and downloading content accordingly. In order to do this, the client application interprets the content descriptions provided through the ESG and selects the media items which better suite the user preferences.

If *interaction* is required (e.g. in order to obtain digital rights), an interactive channel like GPRS or UMTS can be used.

4. PERSONALIZATION

Personalization is one of the most important design aspects of mobile multimedia services, so it represents one of the main goals of the project. This provides many advantages to the user, for instance the automatic discovery of interesting content, saving time when looking for new content. The perception of the service adapting to the user preferences and needs encourages a positive experience, most significantly when accessed from personal devices such as mobile phones.

Personalization is also a great asset for content distributors. An efficient and functional application favors the consumption of content, thus increasing the market share of mobile content production. Since users receive content according to their preferences, content distributors can rely on the platform delivering the content only to their target audience and advertisers can improve the impact of their campaigns.

In Modela-TV, personalization is achieved by means of a recommender on top of the DVB-H middleware that interacts with the ESG client and the cache manager of the Filecast client.

For each content item in the carousel, the recommender compares the TV-Anytime descriptions of the content with the preferences of the user in a semantic space, in order to derive an estimation of the local probability of access of that content item. This value is signaled to the cache manager which is responsible for pre-fetching and storing in cache memory the files with best value for the user, according to the implemented caching policy.

According to the application design criteria, only files for which the user has access rights are stored in cache. This process is accomplished due to the correlation between the Subscribers Groups and the values of the *Group* elements that are included in the FDT. As explained, the UGKs are used to encrypt Right Objects that target a group of users, whereas all files with common *Group* tags are fetched by the FLUTE client after a single download instruction. So, if a user decides to download a file, the application will first verify that it has access to it. If negative, it will prompt the user to acquire access rights (using the *Purchase Channel* information included in the Service Guide). If positive, the FLUTE client will start downloading that file and all the files with the same *Group* tag, which will be stored in cache.

This way, the access time of any other file for which the user has associated rights will be faster, since all content items associated to the user's category of subscriber are cached automatically by the FLUTE client. If the size of the set of files for which the user has associated rights is bigger than the size of the cache memory, then the caching replacement policy will determine which files remain in cache, using the information provided by the recommender to assess the value of each media item for the user.

As described in [9], caching replacement policies in broadcast scenarios are different of the caching policies used in internet web browsing. In a broadcast scenario, the cache management algorithm must store in cache the objects with higher ratio between the probability of access and the object transmission rate, since the value of storing an object in cache is inversely proportional to its rate. This is due to the fact that, if an object has a long transmission cycle, then the access time of that file is drastically reduced in the event of a cache hit. Thus, for each incoming file, the cache replacement policy computes its *PIX* (*Probability Inverse Transmission Rate*) ratio, compares it to the files stored in cache and discards the file with lower *PIX*. In order to implement *PIX* based cache replacement policies, an estimation of the local probability of access is needed and, in our case, this is provided by the recommender.

5. CONCLUSIONS AND FUTURE WORK

Modela-TV provides with a platform for the deployment of personalized multimedia content delivery services in mobile multicast networks. The design of the system architecture of Modela-TV has taken into account the expectations of users with regards to personalization, download speed and content availability, without compromising the interests of content license holders. Furthermore, service operators are provided with means to monetize the content through a variety of revenue streams at a very affordable cost, compared to current mobile multimedia content delivery services.

Modela-TV also proposes a new method for the personalization of multicast file download services, based on the use of FLUTE groups and content descriptions to optimize the usage of the cache memory allocated for the service.

A prototype of the platform has been implemented and it has been tested in a test laboratory assembled at the Institute of Telecommunications and Multimedia Applications (iTEAM) of the Polytechnic University of Valencia (UPV), as illustrates the figure 2.

Figure 2. Modela-TV Application

Beside the laboratory tests, the service is going to be tested by means of a pilot transmitter that is going to be installed in the University Campus. The Radio Frequency Planning of the test transmitter has been performed with iTEAM´s planning tool, guaranteeing coverage in all the University Campus. The pilot will host field trials and end user trials.

6. REFERENCES

[1] Paila, T., Luby, M., Lehtonen, R., Roca V., Walsh, R.: File Delivery over Unidirectional Transport. RFC 3926 (2004)

[2] ETSI, TS 102 472 v1.2.1: Digital Video Broadcasting (DVB); IP Datacast over DVB-H, Content Delivery Protocols" (2006)

[3] Open Mobile Alliance: Digital Rights Management V2.0. (2008)

[4] Open Mobile Alliance: Service and Content Protection for Mobile Broadcast Services V.1.1 (2008)

[5] Open Mobile Alliance: DRM V2.0 Extensions for Broadcast Support (2008)

[6] Open Mobile Alliance: Service Guide for Mobile Broadcast Services, Candidate Version 1.0 (2008)

[7] ETSI, TS 102 822-3-1 v1.4.1: Broadcast and On-line Services: Search, select and rightful use of content on personal storage systems ("TV-Anytime") (2007)

[8] Zhiqi, G., Songyu, Y., Wenjun, Z.: Using object multiplex technique in data broadcast on digital CATV channel. IEEE Transactions on Broadcasting June 2004

[9] S. Acharya, R. Alonso, M. Franklin, S. Zdonik Broadcast Disks: Data Management for Asymmetric Communication Environments ACM SIGMOD Conference, San Jose, CA, 1995