DMLRid – An XML-Based Proof-of-Concept Mobile DRM Framework for Sharing Learning Contents among Mobile Networks

Vladan Nincic, Maiga Chang, and Fuhua Lin

***Abstract*—This paper proposes a framework that helps in closing the gap that exists between the mobile learning environment and students' everyday use of mobile devices. This new framework for Digital Rights Management in systems for mobile learning enhances the ability to define, manage, and share the licensed learning multimedia content among different mobile networks. The major strength of the proposed framework is to position the role of the university in the m-learning value chain as a policy setter, not an implementer. The new framework introduces a new approach that while the university may have a Web portal page for mobile learning material, it should not host or provide the complete delivery service. Instead, the university should let the content providers handle that role. Recognizing the fact that a single licensing authority is not obtainable in the near future, we proposed a new object repository for storing the information needed by a specific university – Digital Mobile Learning Rights Depository (dMLRiD) consisting of two databases, Rights and Data Depository with appropriate standard interfaces. This framework allows for a possibility that multiple University Data Depositories for mobile learning may exist, our proposed framework is flexible enough to allow different implementations.**

***Index Terms*—Digital rights management, mobile learning; XML, multimedia, proof of concept, content provider.**

I. Introduction

Our research project looks into the technical part of an m-learning system that deals with the content rights management. The project does not aims to create a new Digital Rights Management (DRM) or a mobile learning system, or to build a new REL, rather its goal is to better define the issues that surround the delivery mechanisms for different devices in mobile learning. Two main issues that we explore are the context of different copyright needs and delivery across the mobile networks, to offer the same experience to all students and actors in mobile learning. Once we are able to deliver appropriate content for each device and simultaneously prevent the abuse of copyrighted works, we will be able to establish a fully modern mobile learning environment. Defining the term framework, Pree (2000) comments that we need to explore the building blocks that will predefine the overall architecture of the system, while to produce the final application would mean to "adjust building blocks to specific needs by overriding some methods in subclasses [1]."

Our proposed framework is related directly to mobile content delivery, as Markiewicz and de Lucena (2001) argue that the frameworks are "application generators that are directly related to a specific domain, i.e., a family of related problems [2]."

In looking at our mobile learning content delivery framework that includes DRM handling, we can notice that some elements require more flexibility. The constant development of new multimedia formats, and codecs, alongside with the new types of content and devices, create a changeable environment for each element related to the content handling, such as data storage, packagers, interfaces and license generators. In that sense, the proposed framework will indicate its hot spots, which will be the points of its flexibility. As Riehle (2000) explains, "[h]ot spots are abstract classes or methods that must be implemented. Frameworks are not executable. To generate an executable, one must instantiate the framework by implementing application specific code for each hot spot [3]."

A. DRM Architecture

In exploring the digital content delivery, we need to consider the ways to secure that the rights of the content authors, owners and other members of the delivery chain are respected. From that perspective, "Digital Rights Management refers to controlling and managing rights to digital intellectual property [4]."

To represent the intellectual and usage rights, a DRM solution needs to describe the rights using a defined set of rules - Digital Right Expression Languages (DREL). DRELs deal with the description of the rights and are of utter importance for interoperability activities. For example, Iannella (2001) shows one possible description model [5]. Usage permissions are defined by the set of attributes and related to the content via Constrains, Obligations and Right Holders.

By defining the attributes, we allow for creation of a framework that will represent any model of usage, with the idea to offer a flexible solution. Any new set of services or an application should belong to one of those attributes, which makes possible to define an appropriate framework.

B. DRM Interoperability Initiatives

The list of specifications with applicability to this area is

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extensive, as there are many activities in the industry and academia. Among others, there are: IEEE Digital Rights Expression Language, XrML, ODRL, Creative Commons, Europe4DRM, and Business associations, groups, like OMA, Marlin, Coral [6].

Open Digital Rights Language (ODRL) represents another initiative, aimed at development and promotion of an open standard for rights expressions [7]. This initiative is working on the ODRL v2.0 [8], and its parts will be included within the new OMA DRM 2.0 – mobile DRM.

C. Differentiation of Planned Research from Existing Literature

There are two main differences between this research and majority of the initiatives by the industry or academy, described in this literature review. The first difference is a way our research deals with the specific new issue of collaboration in the mobile learning environment that is yet not considered by the other initiatives. Our focus is on the interoperability and ability to share multimedia files horizontally, between the members of a same class or a team within the class. Current social trends of social networking (Facebook, Twitter, YouTube and other) have made the collaboration and sharing a regular process in everyday life. Our research will propose a new framework that will help in closing the gap that exists between the mobile learning environment and students' everyday use of mobile devices.

The second important difference between this research and other mentioned initiatives lies in the fact that our research is looking at the university as the focal point of the content delivery for mobile learning. Students of a university have their devices registered on different mobile networks, just like other people in the same geographical area. There are several reasons why modern mobile learning tools and learning mechanisms that include collaboration do not work for all students.

1) Unless they all register in the same mobile network, they will not have the same access rights to the content.
2) They may have different delivery behavior defined in the networks.
3) They are not able to share the content or send it to each other, while keeping the content protected from outside usage (which may be important if a student group is working on a project that should not be shared with outsiders).

This research is proposing a way to define the rights outside of the networks, which would enable all those sharing mechanisms needed for a modern mobile learning environment. Furthermore, the framework defined in this research will have the flexibility to be open for any implementation of the future service models.

II. Methodology

The main goal of the project is to develop a new framework for delivery of the DRM-protected content in an m-learning environment. To achieve this, it was required to perform a detailed analysis of the DRM interoperability, fully define the elements of a framework and needed use cases. In addition, it was required to choose the software tools to identify the solution and to present the new DRM framework that would offer an additional level of interoperability for a mobile learning environment.

The following contents give a detailed analysis of the research design that has resulted in building a Proof-of-Concept (PoC) logical demo to support the results of the research. UML sequence diagrams are used to show the communication between the explored elements of the proposed framework.

A. Design

The research solution is supported by the PoC demo tests done within a simulated environment that demonstrates the logical call flow of the messages exchanged between the hot spots of our proposed framework. The PoC demo environment does not attempt to recreate a fully functional mobile content delivery system, as that is out of scope of this research. Instead, it contains logical units, with the purpose of providing the PoC type of demonstration with the simulated instead of "real world" content. The PoC results allow us to construct the new framework by using the standard software framework definition elements. As our intention is to make the framework very flexible, the architecture will not presume the use of any programming languages. Instead, it is given as a set of block architecture and UML diagrams, with the interfaces and objects defined using the XML schemes as the leads only in helping in the development of a physical solution.

A basic diagram for the use of a DRM system in a mobile learning Use Case with multiple devices, assuming they are using different DRM systems is shown on Fig. 1. The Multi-DRM Environment box in Fig. 1 illustrates the focus of this project.

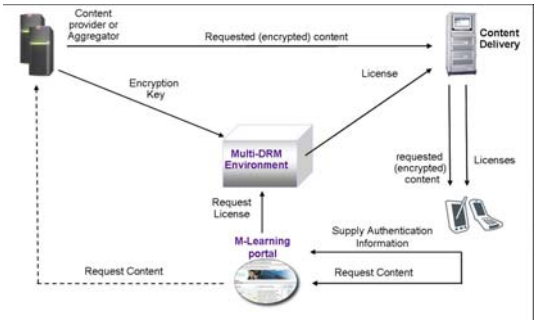

Fig. 1. Basic mobile learning use case with the DRM architecture

The presented environment has to be defined by using the standard mechanisms – architecture, element description, call flows and UML diagrams, with the objects defined using the XML code. The different nature of the devices used in m-learning causes that the DRM environment needs to be more flexible than a typical mobile Content Delivery environment, usually employing only mobile phone communication elements, as the integration with other device types is done further back in an operator's infrastructure (mainly using the operator's billing and authentication systems).

Once a basic architecture of an environment is given by block diagrams of the elements, to understand better communication between the elements, the UML Sequence diagrams are required. As blocks are considered as single

communication points, communication between the blocks depicts an environment from a functional point of view.

This project is focused on the details of the server-side only, as the intention of the proposed framework is to offer the deeper level of interoperability, assuming that the devices have a multitude of media codecs and associated DRM clients are already present in the handset platform.

B. DRM Architecture

A Basic UML sequence diagram represents the behavior of all of the relevant elements within a framework. The complexity of a UML sequence diagram allows us to define the communication between the units (or objects) without specifying their internal structure. A UML sequence diagram can represent well the architecture of an application or a framework. For that reason, this project uses the white hot spots to provide as much flexibility as possible for the future development, as well as use the UML sequence diagrams to represent the elements of the framework and relations among them.

One of the most important Use Cases for this analysis is the case of Superdistribution of the mobile content, a feature enabled by DRM. This functionality enables collaboration, by allowing the students to exchange copyrighted material among them. In addition, as the content is protected, it cannot be used without a proper license. Students who receive the protected content and have a compliant device would be able to acquire a license, enabling the content use on their own devices.

Based on the previous discussion, a generic look at the DRM elements is demonstrated in Fig. 2. As it can be seen, we can identify four main actors in the process: Consumer, Content Distributor, Service Provider and Content Licensor.

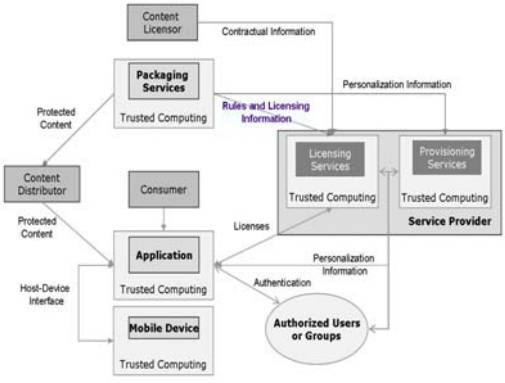

Fig. 2. DRM elements architecture

Many current DRM solutions support Superdistribution (including PacketVideo, Microsoft Playready DRM, OMA v1 Separate Delivery and OMA v2 DRM, among others). For the purpose of this research, we look at the case of superdistribution involving multiple mobile networks, which is of key importance for mobile learning environment, as mentioned earlier. The supporting PoC use the case of superdistribution as a test of the proposed multi-network capable DRM framework.

C. Mobile Learning Use Cases

As today's students have accounts in different mobile networks, we have to take into account the need to support multiple delivery paths to an end device. In other words, it is important to consider not only the differences among the end devices but also the different infrastructures of different networks. That includes different formats, rights definitions, content handling, DRM rules and license format (for example, while one operator may support a Creative Commons license, others may not).

Understanding that the mobile learning deals with the multitude devices in the context where students use different mobile operators, there is a need to define an interoperable solution that would enable students to participate in m-learning environments within a network they already use with their mobile devices, instead of a learning institution forcing that choice on the students.

As mentioned earlier, in a situation where a University wants to enable m-learning to include the collaboration and content sharing while maintaining the content copyrights, it has to assure equal treatment of any mobile network in the area. In addition, it needs to assure that the mobile networks allow file sharing with the different networks, while maintaining the copyrights. Today, that is not the case, as there is no way to transfer the copyrighted content across the mobile networks anywhere in the world.

With that in mind, we explore two m-learning use cases, which represent the main issues within the context of the mobile learning and mobile content delivery of copyrighted materials:

1) A student downloads a learning unit that he/she wants to share with colleagues from the same learning group. In most cases, students will be using different mobile networks, making the content sharing or superdistribution impossible (under the assumption that even the originating network supports the superdistribution, which is not always the case). If an inter-carrier gateway is used, which consists of Right management and Rights translating elements, we can get the rights properly translated and content delivered onto the other network to end users.
2) When a student wants to move to another mobile network, the question arises about what will happen with the already acquired multimedia content. Again, we have to look into another new element, an online vault or digital locker that would contain the rights information for all the users. If that locker were unified across Canada, for example, the move from one to another network would not affect the ability of students to have access to their previously acquired content.

III. Proof-of-Concept Framework

We look into two examples of different possible solutions for the use cases, i.e. inter-carrier gateway and online vault - unified Digital Locker.

A. Inter-Carrier Gateway

The "inter-carrier gateway" uses the similar approach that is already in use for SMS service across the world. An additional network element deals with the rights and licenses for a specific content and translates information from one to another operator.

This inter-carrier gateway will be used every time there is

content going from one to another mobile network, without any DRM concerns. The copyrighted content would need to be handled with another additional element, making this use case not ideal for a mobile learning usage.

B. Online Vault - Unified Digital Locker

The online vault is responsible for managing the users owned media library for authorized PCs and mobile devices. Each operator is responsible for delivering the media from the online vault to the users' authorized mobile device and/or a PC in their proprietary formats. This solution integrates with each operator storefront for validation (using the unified academic authentication front-end).

As we can see, this use case is better suited for the case of mobile learning which we have defined previously as the research focus. The online vault can be considered as a key interoperability factor that enables universities to assure equal treatment of all students. In addition, by making it more flexible, we can prepare the mobile learning environment to react to new trends, such as previously mentioned collaboration and file sharing among predefined group.

C. Proof-of-Concept Framework - dMLRid

Considering the chosen use case of online vault, this project makes certain assumptions. Instead of having a single licensing authority, we propose a Data Depository object (element), storing information needed by a specific university. While that allows for a possibility that the multiple University Data Depositories for mobile learning may exist, our proposed framework is flexible enough to allow different implementations.

As a result, we have a desired architecture of our PoC environment that focuses on the dMLRiD element of the framework, which functionality depicts properly the innovation of our proposed framework. Fig. 3 illustrates the dMLRiD in the context of communication, making the requirements for the needed environment even more prominent.

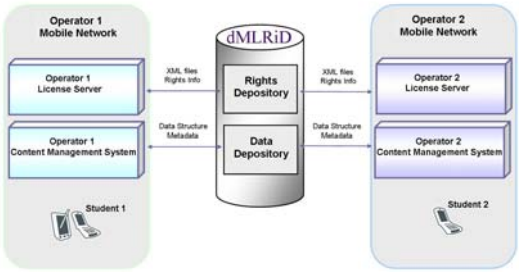

Fig. 3. Proof-of-concept architecture

The main element of the PoC is the Digital M-Learning Rights Depository (dMLRiD) that consists of two databases – DataDepository and the RightsDepository (or RightsLocker). The PoC demonstrates the functionality of the dMLRiD, which is given by its architecture based on the set of standards (Dublin Core Metadata, Learning Objects Metadata, ODRL, OMA, and Creative Commons).

D. Test Case

During the PoC, a prototype interoperable DRM environment database is built, with scripts to simulate interfaces within the needed call flows. The applications are tested to evaluate their functionality in a Linux CMS Server and Windows environment. Each test case is based on the Use Case analysis and the results (XML files, SQL commands, DB structure and the license example) are documented.

For Use Cases, we analyzed the typical mobile learning case, in which students collaborating within a class, exchanging the learning object. The students could be using the same or different mobile networks. It is important to understand that from the functional perspective our proposed framework does not differentiate those two cases (the same or a different network). This is one of the main advantages of our approach, to make just another layer in the logical structure of the framework, allowing us to focus on the main environment functionality – to enable the transfer of DRM protected files between the students within the mobile learning context.

Fig. 4 illustrates the specific architecture of our Use Case.

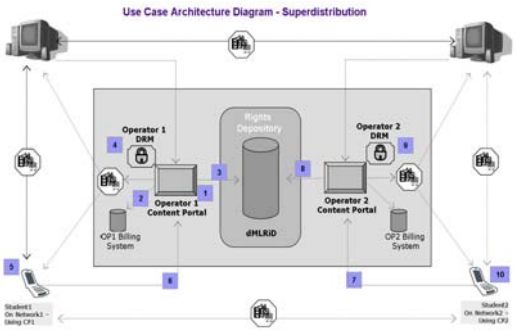

Fig. 4. Proof-of-concept architecture

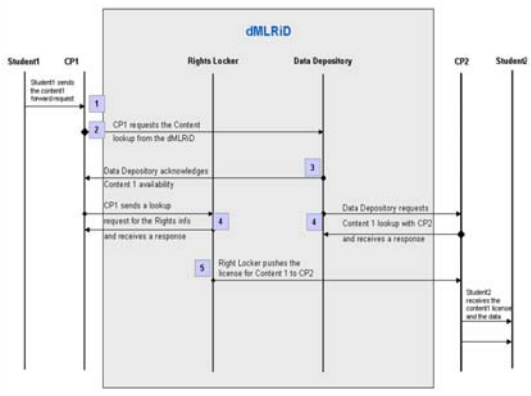

Fig. 5. Call flow

The major problem with the Use Case that Fig. 4 shows is that the licenses differ for different DRM systems that mobile providers deploy. A process of translation of licenses may be difficult to be approved by the operators, especially in the case where an external content hosting is used. In order to translate the licenses, a translator is needed, with the integrated communication with all of the networks.

The supporting POC uses the case of Superdistribution as a test for the proposed multi-network capable DRM framework. We wanted to provide a solution that will enable the transfer of the content not only vertically (University-student), but also horizontally (student-student), by creating an environment able to communicate with both the multiple networks and multiple DRM systems.

Based on this problem analysis, we defined our Test Case.

The scope of this research projects limits the ability for PoC to utilize the full Use Case or to explore the complete functional test case(s), in this paper, we use the superdistribution with the translation as the test case. Our goal is, then, to show the communication between the objects, and not to deliver the content to any end destination, as the actual enhancements of this new proposed framework is described by the communication flow.

We assume further that there is an external translation service and only deal with the process of superdistribution if the Content Provider (CP) 2 contains the needed content. In that case, we needed a mechanism to handle the content information and communicate with the CP1 and CP2, in order to make this content superdistribution possible. Fig. 5 shows the possible call flow.

In order to use the content superdistribution, both students need to be registered in the RightsDepository (dMLRiD) system. RightsLocker will contain the profiles for the whole class – in our case, just two students. Student 1 acquires or creates a DRM-protected content (Content1) that she/he wants to share with a colleague student from the same class. Student 1 does not need to know which network is student 2 on. Assuming that the content is not in the DataDepository, the license is translated into the rights and the appropriate end then into the proper license for the Student 2 to be able to use the content. Translation is assumed to be done by an external system, i.e. XAL– needed approval from a CP, and the test case does not deal with that part. It is assumed that the CP 1 gives permission to the Forward right for Student 1 for a specific Content 1. Depository acknowledges the content availability in the network 2 (DB Lookup) and pushes the rights (translated into the license by Translators) to CP2 (over an external translation element, hence the test is to push the content rights info).

IV. Discussions and Future Works

This research offers a new framework as a possible solution for the issues of interoperability and collaboration in mobile learning including use of the copyright-protected content. The major strength of the proposed framework is to position the role of the University in the m-learning value chain as a policy setter, not implementer.

The new framework introduces a critical new approach that while the University may have a Web portal page for m-learning material, it should not host or provide the complete delivery service. Instead, the University should let the content providers handle that role.

The next step would be to prepare the content to be assimilated in the processes of each mobile operator for delivery in their mobile network. One possible process would be to apply for the access to a mobile operator's service platforms, with appropriate interfaces information exchanged. Upon getting the access, AU would work with a content aggregator in order to register the content with the mobile operator, to enable its delivery across the mobile network.

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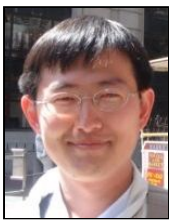

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