

# License Management Scheme for Learning Resources Delivery in P2P Networks

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***Abstract:** P2P network is generally considered to be a threat to rights management in E-learning area. In this paper, we describe a solution by presenting a license management scheme that considers integrating a rights management into E-learning platform in P2P network. Resource owners can specify restrictions on who can use their resources and which part of resources under what specific constraints. Each peer can autonomously specify authorization constraints for learning object and the enforcement is performed directly by the node through the peers. We express the protection chain of learning resource distribution in 3 digital licenses: Offer License, Consumer License and Peer License. In addition to the right expression, we demonstrate an effective way of license management implementation and present a novel means to embed license processing engine (LPE) dealing with licenses to each peer, from which the load of license server can be reduced.*

**Keyword:** License Management, P2P, Learning Resource Delivery, Digital Rights Management

## 1 Introduction

Digital Rights Management (DRM) technology is basically an aggregation for security technologies to protect the interests of the content owners so that they may maintain persistent ownership and control of their content. DRM specifies digital license, including all the usage rights information of qualified recipients on specified contents and allowing the user access to them. With the increasingly demand of learning resources protection in E-learning area, there have been strategies of integrating DRM and flexible commercial model into applications, management, exchange and trade of web-based learning content by describing rights in license services. Such traditional DRM technology in E-learning resource application depends on two-Tier or N-Tier Client/Server architectures network. However, the emergence of P2P technology presents new challenges to DRM because it allows users to search and download E-learning resources located anywhere in P2P network.

Peer-to-peer systems and applications are distributed systems without any centralized control or hierarchical organization, where the software running at each node is equivalent in functionality. It makes illegal usage more convenient over learning resource

delivery platform through the P2P application system such as Napster, Gnutella, and KaZaA<sup>[1][2]</sup>. Since every user is a learning resources owner as well as a distributor and a consumer, it is hard to classify property rights to different roles clearly.

Our scheme starts from the protection chain of learning resource delivery. There are typically three roles in the protection chain: Learning Resource (LR) creator gives a grant to publish the origins of contents and admits different LR distributors to distribute the packaged content to the peer consumers in P2P channel through digital content protection chain. For one thing, roles and granted rights are classified by recording important information <subject, rights, resources, conditions> in digital license which is based on rights expression languages (MPEG-21 REL) in XML format and is encrypted and stored in license database. For another thing, delegation control is a mechanism used in P2P distribution scenarios to control in condition as supporting the delegation of rights. It means that a license issuer declare that a licensee can delegate the rights to which a grant or grantGroup conveys.

License management scheme considers learning object when the enforcement is performed directly by the node through the peers. For example, an instructor in one peer would give a piece of courseware to college students, but he has to prevent students from viewing the tests part. With our license scheme, resource owners in learning resource Provide Layer can specify restrictions on who can use their resources and which part of resources under specific constraints, while peer consumers also can deliver and delegate rights to other peers in P2P network layer.

In addition, we proceed to describe a license processing engine (LPE) in order to enforce different usage rights on different parts of learning resources. LPE embedded in each peer supports generation, storage, interpreting, validation; editing, revocation and export of all the licenses. In this way, it can reduce the heavy load of license sever.

The rest of this paper is structured as follows: Section 2 compares our license management to related work. In Section 3, we express the protection chain of learning resource delivery in 3 digital licenses: Offer License, Consumer License and Peer License. Then we describe representations of the above digital licenses with MPEG-21 Rights Expression Language (REL). Section 4 describes the system structure of license management scheme and analyzes how it works. Then

it presents implementation of license management that produces a novel means for embedded licenses processing engine dealing with licenses to each peer. We demonstrate the effectiveness of our approach using prototype implementation and finally summarize our contributions and future work in Section 5.

## 2 Related work

Kwok and Liu describe a license management scheme for Consumer-to-Consumer music sharing<sup>[3]</sup>. It introduces a framework for rights management for interconnected peers. Licenses are described with a XrML to process the specified usage rights. However, in this case the exchanging peers are consumers of music instead of the education domain. The standard package of learning resources is much more complex than music because learning resources including file formats such as text, audio and video format are usually stored in one package.

Guofei Gu. et al first propose a novel Public License Infrastructure (PLI) that uses cryptographic threshold secret sharing schemes to provide decentralized public license services for the Digital Rights Management (DRM)<sup>[4]</sup>. This distributed PLI replaces the centralized license server in a conventional DRM system. This DRM system is especially useful for small content providers such as peers in a P2P network who cannot afford the conventional server/client based DRM system and traditional distribution channels.

In E-learning Technology Standards, a proposed liaison<sup>[8]</sup> is formed between the Learning Technologies Sub-committee (LTSC) of the IEEE and MPEG, specifically in order to support the LTSC in selecting a rights language for the delivery of teaching and learning. Meanwhile, ISO/IEC JTC1 SC36 WG4 makes great efforts on how to define a Rights element in Learning Object Metadata while WG6 has defined a profile of MPEG-21 REL. However, our research concerns more about application in P2P network rather than standards in a wide and general range.

## 3 License expression in protection chain

### 3.1 Protection chain

In P2P network system, there are generally three roles in the protection chain: Learning Resource Creator, Learning Resource Distributor and Peer Consumer. Learning Resource Creator is an author of a resource or software tools aggregating different digital contents to be content packages. It is also the original owner of LR. The responsibility of distributor is mainly about the exchange of learning resource: manage trade via an e-Commerce exchange. The peer consumer is no longer the end of value chain, because all the peer users that connected in P2P network can share certain learning resources together, the delivering of resources

will not stop until the rights constraints specify the end of rights or licenses are expired. To draw a conclusion, every peer in value chain can be a learning resources owner as well as a distributor and a consumer.

Our license management scheme considers integrating a rights management into a Peer-to-Peer Learning Resource Delivery. Offer License, Consumer License and Peer License are key elements. Offer License is used to express downstream rights which means to distribute rights to next role by means of license distribution and learning resource dissemination, while upstream rights in Consumer License focus on rights requested from low to higher role which are used to be an authorization request. A parallel stream rights expressed by Peer License produced between peer users when rights are shared and transferred from one to another.

### 3.2 License structure

Usage rights information in licenses is stored in digital form based on rights expression languages. The most relevant ones are MPEG-21 REL<sup>[6]</sup> and OMA(Open Mobile Alliance) ODRL(Open Digital Rights Language). MPEG-21 REL is extended from XrML, while ODRL was proposed by R.Ianella from IPR Systems. In this paper, we adopt MPEG-21 REL to our scheme and extend it into E-Learning field.

A license contains the following parts: 1) Grant or grantGroup. Each grant conveys to an identified party the right to use a resource subject under certain conditions. A complete grant consists of at least 3 fragments: Principal fragments containing UID and KpubUser(or X509 information); Resource fragments containing ResourceID and ResourceUrl; Rights fragments specifying a right from database. 2) The license issuer. Typically, the issuer digitally signs the license using KpriIssuer, signifying that the issuer does indeed bestow the grants that the license contains. In addition, the issuer may provide additional information about the issuance of the license. 3) Miscellaneous additional administrative information.

Delegation control is an extended mechanism used in P2P network distribution scenarios to control the delegation of rights. It is defined in MPEG-21 REL. A license issuer can specify that the licensee can delegate the rights that a grant or grantGroup conveys.

As we can see in figure 1, a course Creator issues a license to Student A that grants him the right to play (view) the video case study from virtual classroom and to delegate that right. 1) The delegationControl element in Student A's license specifies a depth constraint of 100. The Usage-grant in Consumer License matches one of the Offer-grants in Offer License (for a student, viewing the test is forbidden). Then the publisher signs Student A's license using the issuer element, indicating that the publisher authorizes the usage grants it contains. 2) Peer Student A delegates his grant to peer Student B. As described above, the license that Student A issues to Student B must contain a delegationControl element that is compatible with the delegationControl

element in his license. Specifically, the depth of constraint for Student B's license must lower than

Student A's license.

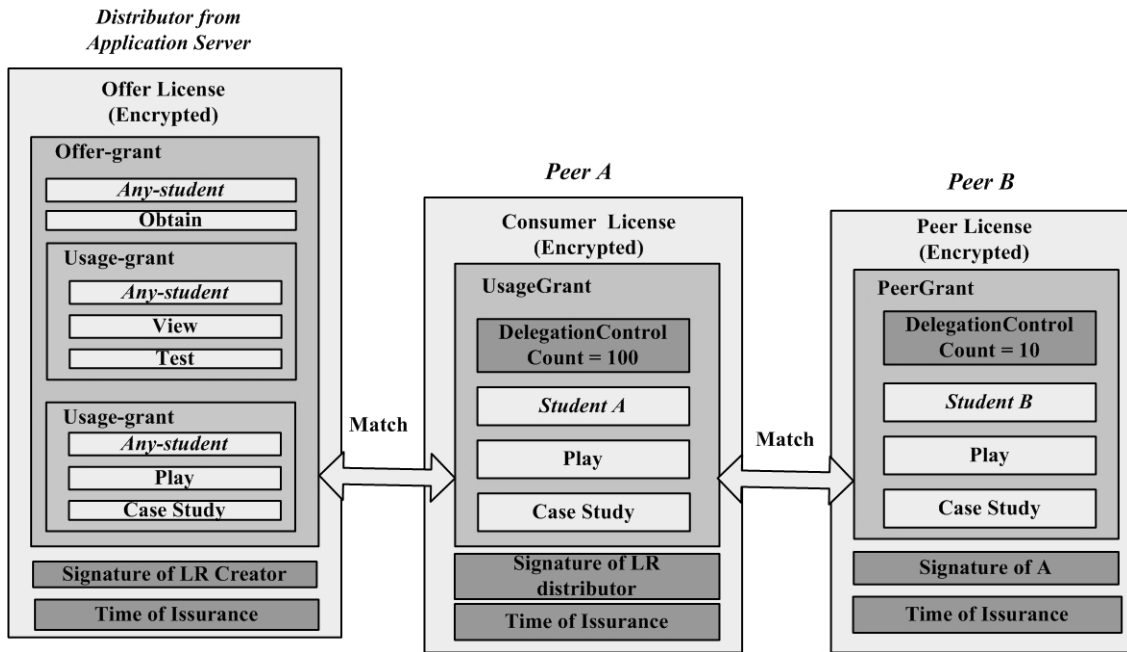


Figure 1 License Structure

Student A reduces the depth constraint to 10 and Peer B may reduce it further (such as setting it to zero, so that Student N can not delegate the grant to other peers). Student A signs Student B's license using the issuer

element, indicating that he authorizes the grants it contains. Following example in Table 1 shows the XML-based license in peer A and B.

Peer A's license	Peer B's license
<pre> &lt;!-- Peer A's license --&gt; &lt;license&gt;   &lt;grant&gt;     &lt;delegationControl&gt;       &lt;depthConstraint&gt;         &lt;count&gt;100&lt;/count&gt;       &lt;/depthConstraint&gt;     &lt;/delegationControl&gt;     &lt;keyHolder licensePartId = "Student A"&gt;       &lt;info&gt;X.509 Information&lt;/info&gt;     &lt;/keyHolder&gt;     &lt;mx:play/&gt;     &lt;digitalResource licensePartId="Case Study: Computer Network"&gt;       &lt;nonSecureIndirect URI="..." &gt;     &lt;/digitalResource&gt;   &lt;/grant&gt;   &lt;issuer&gt;     &lt;dsig:Signature&gt; SignedInfo of distributor&lt;/dsig:Signature&gt;     &lt;details&gt;       &lt;timeOfIssue&gt;2005-11-19T00:30:00&lt;/timeOfIssue&gt;     &lt;/details&gt;   &lt;/issuer&gt; &lt;/license&gt; </pre>	<pre> &lt;!-- Peer B's license --&gt; &lt;license&gt;   &lt;grant&gt;     &lt;delegationControl&gt;       &lt;depthConstraint&gt;         &lt;count&gt;10&lt;/count&gt;       &lt;/depthConstraint&gt;     &lt;/delegationControl&gt;     &lt;keyHolder licensePartId = "Student B"&gt;       &lt;info&gt;X.509 Information&lt;/info&gt;     &lt;/keyHolder&gt;     &lt;mx:play/&gt;     &lt;digitalResource licensePartId="Case Study: Computer Network"&gt;       &lt;SecureIndirect URI="..." &gt;     &lt;/digitalResource&gt;   &lt;/grant&gt;   &lt;issuer&gt;     &lt;dsig:Signature&gt; SignedInfo of Peer A&lt;/dsig:Signature&gt;     &lt;details&gt;       &lt;timeOfIssue&gt;2005-11-20T00:30:00&lt;/timeOfIssue&gt;     &lt;/details&gt;   &lt;/issuer&gt; &lt;/license&gt; </pre>

Table 1 XML-based License

## 4 System Structure

### 4.1 License Management Scheme

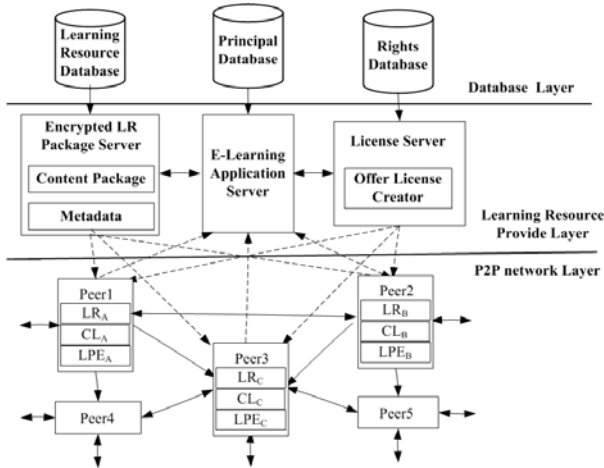
Figure 2 shows the system model of the proposed scheme. There are LR provider layer and P2P network layer.

*License server:* license server is used to generate offer license, consumer license and deliver a consumer license to the client<sup>[7]</sup>. It is the license key and the key ID in the media file that generates a key, and then specifies the rights from rights databases.

*Encrypted LR package server:* We generally utilize Learning Object Metadata (LOM)<sup>[8]</sup> and Content Package (CP) to describe video/audio driven courseware or live lecture in traditional classroom. The learning resources packages are encrypted and stored in streaming media sever or broadcasted live where scripting commands are embedded.

*E-Learning application sever:* It is built for the platform of registry, publish, exchange and management of LR to other E-learning platform in P2P network. In the process of Registry, the LR creator or publisher on application server collect the <principals, rights, resource> information so that license server can create offer license and use KpriCreator to sign it.

*License processing engine(LPE):* In traditional DRM, LPE can typically operate as an additional module in a web server or application server. In P2P network, LPE performs two main functions. First, it can reduce the load of license server. Second, it is a peer level special program in order to deal with license package. It consists of a set of components that offer the functionality necessary for license management such as generation, interpreting, storage, editing and revocation of license.



CP = Content Package (standardized learning resource package)

CL = Consumer License

Figure 2 License Management Scheme in P2P network

### 4.2 Sample

At initiate status, Peer 1 to 3 is purchasing and downloading learning resources in the form of encrypted Content Package (CP1, 2, 3) from server. They are permitted to “play” that is specified in Offer

License. The maximum number of delegation control in Consumer License is n. If the average rate of the count in delegation control to the next peer is 1/k, at the second status, trusted peer 4 and 5 separately send request to Peer1-3 to share CP1-3 and then get “play” right from peer license, delegation control of count with n/k times. At the same time, Peer1-3 who are trusting each other share the resources. In the end status, the Dcount is reduced to zero in peers. That means the delegation activity is over. (Suppose none of the licenses is expired)

S=0	CP	CL	D <sub>count</sub>
Peer1	CP <sub>1</sub>	CL <sub>A</sub>	n
Peer2	CP <sub>2</sub>	CL <sub>B</sub>	n
Peer3	CP <sub>3</sub>	CL <sub>C</sub>	n

Table 2 Initiate Status

S=1	CP	CL	PL	D <sub>count</sub>
Peer1	CP <sub>1</sub> ,CP <sub>2</sub> ,CP <sub>3</sub>	CL <sub>A</sub>	PL <sub>B</sub> ,PL <sub>C</sub>	$\frac{(k-4)n}{k}, \frac{n}{k}, \frac{n}{k}$
Peer2	CP <sub>2</sub> ,CP <sub>1</sub> ,CP <sub>3</sub>	CL <sub>B</sub>	PL <sub>A</sub> ,PL <sub>C</sub>	$\frac{(k-4)n}{k}, \frac{n}{k}, \frac{n}{k}$
Peer3	CP <sub>3</sub> ,CP <sub>1</sub> ,CP <sub>2</sub>	CL <sub>C</sub>	PL <sub>A</sub> ,PL <sub>C</sub>	$\frac{n}{k}, \frac{n}{k}$
Peer4	CP <sub>1</sub> ,CP <sub>3</sub>	0	PL <sub>A</sub> ,PL <sub>C</sub>	$\frac{n}{k}, \frac{n}{k}$
Peer5	CP <sub>3</sub> ,CP <sub>2</sub>	0	PL <sub>C</sub> ,PL <sub>B</sub>	$\frac{n}{k}, \frac{n}{k}$

Table 3 Second Status

S=N	CP	CL	PL	D <sub>count</sub>
Peer1	CP <sub>1</sub> ,CP <sub>2</sub> ,CP <sub>3</sub>	CL <sub>A</sub>	PL <sub>B</sub> ,PL <sub>C</sub>	0,0,0
Peer2	CP <sub>2</sub> ,CP <sub>1</sub> ,CP <sub>3</sub>	CL <sub>B</sub>	PL <sub>A</sub> ,PL <sub>C</sub>	0,0,0
Peer3	CP <sub>3</sub> ,CP <sub>1</sub> ,CP <sub>2</sub>	CL <sub>C</sub>	PL <sub>A</sub> ,PL <sub>C</sub>	0,0,0
...				
Peer N	CP <sub>3</sub> ,CP <sub>1</sub> ,CP <sub>2</sub>	0	PL <sub>A</sub> ,PL <sub>B</sub> ,PL <sub>C</sub>	0,0,0

Table 4 The End Status

CP = Content Package

CL = Consumer License

PL = Peer License

D<sub>count</sub> = Delegation control of count in CL&PL

### 4.3 Implementation of License Processing Engine

In the current approach, DRM is enforced by client side application and hardware based authorization. The client side application is installed on the client terminal and is responsible for P2P network communication. license packages and encrypted content packages are stored in a tamper-resistant environment. LPE interface communicate with OS safe kernel which provides necessary functions to trusted platform, from basic cryptographic functions to platform and program attestation, and to sealed storage for sensitive data. In this part, we mainly discuss the implementation of license generation, interpretation, validation, revocation and storage. Although the trust management of system is of vital importance, we address it for future extension.

*License generation:* Offer license was issued by LR creator such as a university, after the license server validates the certificate of the LR distributor who can specify the rights correlated to the different learning resource. For instance, a video material can be played or copied while a text material can be view or print. Then License Server creates the offer license using the Document Object Model (DOM) as follows: 1) the

principal element in offer license is a predetermined role that will use this resource. The consumer is presented in a type of role such as “any-student”, “any-teacher”. 2) The rights attached to the learning resources are usually aggregated in learning resource package. When the learning resource package information from LR package server is processed, the rights element and resource element can be easily conformed. To generate a consumer license is different from offer license. After the payment has been performed, a consumer in one peer makes an application for agreements of the learning resources. The consumer selects a set of available conditions including delegationControl and sends the authorization request. License Server receives the request, verifies and validates it and uses the license key seed and the key ID to generate a key pair. 1) User ID is stored in Principal Database while Resource ID and Resource Info (URI) are recorded in resource database. License server chooses UID, ResourceID, and ResourceInfo as instance data to use for resolving issuing and consumer license. 3) An authentication module ciphers the license data for the consumer and the temper-resistant platform in client stores the generated license ciphered by KpubConsumer. When a peer sends a query message to all its neighbors, target LR package on one of his neighbors is reached. LPE on target peer A accepts the signal and verifies the identity of peer B through verifying center. At the same time, the basic information is stored in local database of peer A. The LPE interpret the consumer license of A and check the delegationControl element to say if its value is more than zero. If the result is true, after authentication, the consumer B acquires the peer license including the <principal, rights, resources, condition> in a XML document. Authentication module ciphers the license data for peer B. The temper-resistant platform in client stores the generated license ciphered by KpubPeer.

*License interpretation:* After the license is decrypted and loaded into the LPE, the license interpreter module receives licenses. The implementation is based on Xquery<sup>[10]</sup> that allows us to create queries dynamically and execute these queries against the REL License Files, obtaining an XML document with the conditions associated to the original matching grants. If the value of conditions is out of the conditions given by original matching grants, the peer will have no usage rights on the resources. What’s more, if the value of delegationControl element is equal to zero, the activity of delegation will be terminated.

*License validation and revocation:* LPE interface supports validating license signature, license status checking and authenticate proceeding. The activity of checking license signature is to verify the digital signatures of different licenses to ensure its integrity and authenticity. The license status checker inspects a revocation lists to find if identified license is legally revoked. It is also used to prevent duplication.

*License storage:* Offer license is encrypted and stored in a license database in license server and

license database interface works for saving and searching licenses, using the unique IDs of the databases to reference peer information. The consumer and peer license are encrypted and stored in each peer with license ID where tamper-resistant cryptographic hardware module is permanently embedded in a computer, such as a trusted platform module that can provide secure storage for keys and other sensitive information to licenses, and it can perform cryptographic operations.

We describe a simple license processing management flow in Figure 3. It shows how a peer B request rights from Peer A with LPE that check consumer license in A and create peer license if B is a legal peer.

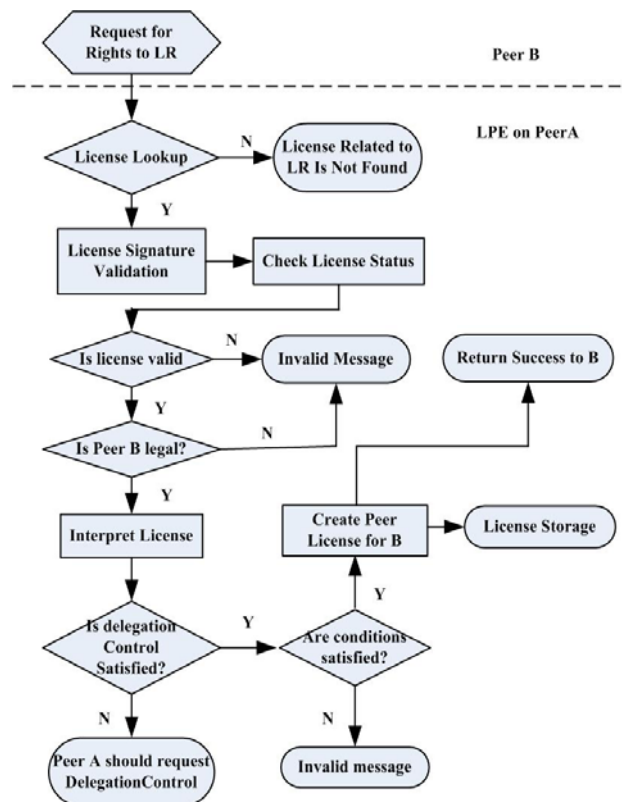


Figure 3 license processing management flow

Overall, license processing engine consists of important modules that make license management flexible and efficient. Consumer and Peer licenses are no longer totally stored in license server since peer licenses could be stored in client where safe kernel and trusted reference mode work for protection. This also solves the problem of building up heavy-loaded centralized license server.

## 5 Summary

We have proposed a license management scheme to consider integrating a rights management into E-learning platform in P2P network. Our approach defines 3 licenses expressed by MPEG-21 REL in the protection chain of learning resources accompanied by

the scheme. The delegation control is used as a key element for learning resource delivery in P2P network through the peers. For the system structure, we show a sample that concerns license management among the several peers. Moreover, implementation of license management focuses on license generation, interpretation, validation, revocation and storage of licenses in different peers. Therefore, license processing engine embedded in each peer enhance the license processing ability.

To make it more reliable, we should define safe kernel, trusted platform, and protocols among LPE. Privacy-enhancing license transport protocol should be presented as well. In addition, we still need binding rights objects to learning objects metadata although we store the content package and license separately.

## 6 Reference

- [1]. D.Milojicic, et al., "*Peer-to-Peer Computing*". tech.report HPL-2002-57R1, HP Labs, 2002.
- [2]. Behrooz Khorshadi, Xin Liu, Dipak Ghosal "Determining the Peer Resource Contributions in a P2P Contract", Proceedings of the 2005 Second International Workshop on Hot Topics in Peer-to-Peer Systems.2005.
- [3]. S.H.Kwok and S.M.Lui, "A License Management Model to Support B2C and C2C Music Sharing", International Journal of Information Technology & Decision Making, 1 (3), 541-558, 2002.
- [4]. Guofei Gu, Bin B. Zhu, et.la, "PLI: A New Framework to Protect Digital Content for P2P Networks". ACNS, pp.206-216, 2003.
- [5]. R.Sandhu, X.Zhang, "Peer-to-Peer Access Control Architecture Using Trusted Computing Technology", Proc.10th ACM Symposium on Access Control Models and Technologies, ACM Press, pp. 147-158, 2005.
- [6]. T. DeMartini, X. Wang, and B. Wragg. "Study of Text of ISO/IEC FCD 21000-5 Rights Expression Language", ISO/IEC JTC 1/SC 29/WG 11/N5599, March 2003.
- [7]. Zongkai Yang, Qingtang Liu, Kun Yan, Wanting Deng, Jing Jin, Integration of Digital Rights Management into Learning Content Management System, Proceedings of the International Conference on Information Technology: Coding and Computing, Volume 1, pp.465-469, 2005.
- [8]. IEEE Learning Technology Standards Committee (LTSC), "Draft 6.4 of the Learning Object Metadata (LOM)" available at: <http://ltsc.ieee.org/wg12/index.html>, 2002.ISO.
- [9]. S. Guth, B. Simon, and U. Zdun. "A Contract and Rights Management Framework Design for Interacting Brokers". Proc. of the 36th Hawaii International Conference on System Sciences, January 2003.
- [10]. Chu, C-C, Su, X., Prabhu, B.S., Gadh, R., Kurup, S.Sridhar,G.,Sridhar,V. "Mobile DRM for Multimedia Content Commerce in P2P Networks", CCNC 2006 Workshop on Digital Rights Management Impact on Consumer Communications. Las Vegas, Nevada, USA.