The Interactive-Music Network

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Abstract:
This document explains the basic knowledge needed to understand the fundamental functionality of DRM systems. It includes intellectual property rights, general requirements on DRM solutions, basic concepts of DRM solutions, business models, individual technologies (e.g. content identification and description, rights management, encryption, watermarking and fingerprinting). This document aims to support people and organisations in selecting or developing suitable technology for their specific requirements on the protection of musical content.
Keyword List:
music, multimedia, infotainment, edutainment, music notation, standards, music libraries, music distribution, music protection, protection, watermarking, fingerprinting, accessibility, education, music archives, music publishing.

1. Introduction and Intellectual Property Rights

More than five centuries ago copying content was difficult as each manuscript had to be copied by hand. Yet, this was the only possibility to save manuscripts although human errors were introduced in each copy causing a content decay. Technological progress, especially the movable-type press and digital technology, changed this situation completely: Nowadays, creating and also copying content is easy and protection has become an important issue for digital data as digital data can be copied without any loss of information and it can be distributed immediately all over the world via the Internet. While physical materials benefit from physical barriers, unauthorized exploitation of digital content has never been easier before. As a result, huge efforts have been spend on the developments of mechanisms addressing infringement before digital rights management came into existence.

First, we will introduce related rights management terminology as given by Rosenblatt et al. [Rosenblatt2002], before going into technical details of rights management technology[1]:

- *rights holder:* a legal entity owning rights in intellectual property
- *user:* a legal entity that intends to make use of intellectual property rights
- *content owner:* see rights holder[2]
- *rights transaction:* a business process involving legally acquiring intellectual property[3]
- *agent:* a legal entity authorized by a rights holder to enter into a rights transaction on behalf of the rights holder
- *royalties:* a monetary compensation to a rights holder or his agent for the use of intellectual property rights
- *rights management:* a business process, which tracks intellectual property rights and related issues
- *digital rights management:* digital management of rights[4]

Rosenblatt et al. calls rights management systems existing before DRM "old rights management" (ORM), which mainly consists of different organizations that came into existence as an reaction of new technological menaces.

- *The American Society of Authors, Composers, and Publishers* (ASCAP) provides music licenses to users and royalties to members through a collective licensing system.
- *Broadcast Music International* (BMI) is a performing rights organization comparable to ASCAP.
- *Copy Clearance Center* (CCC) developed a licensing system.
- *The International Confederation of Societies of Authors and Composers* is a non-profit organization representing authors and composers.
- *Harry Fox Agency* (HFA) is the subsidiary of NMPA.
- *Motion Picture Association of America* (MPAA) and *Motion Picture Association* (MPA) are organizations related to the movie industries. MPAA was founded as a national trade association. Several years later MPA was formed to represent the audiovisual industry worldwide.
- *National Music Publishers Association* (NMPA) represents "mechanical" rights related to music such as reproduction and "synchronization rights".
- *Recording Industry Association of America* (RIAA) "fosters a business and legal climate that supports and promotes members' creativity and financial vitality". Together with the major record labels it started the "Secure Digital Music Initiative".
- *SESAC* (a French organisation) started as a licensing agency for classical music.

Some of the previously listed organizations influence the digital world. Yet, not all have or had the same influence on the legislative, which tries to balance the impact of new possibilities of digital media. For

[1] Further definitions can be found at [CEN/ISSS2003].
[2] A content owner may not own all rights to the content.
[3] It includes a simple process (buying an article) and complex processes (like buying a business or rights holder).
[4] According to Rosenblatt et al., rights management that uses digital technology and applies to IP in digital form.

example, certain possibilities related to digital media were and are still regulated by law in the so-called copyright. Camp [Camp2003] outlined the copyright system's legal, technological, and economic foundations with the aim to support the design of DRM systems. He identified several key functions[5], which should be considered in the requirements of a DRM system. Among these key functions identified by Camp are:

- protection of the author's reputation
- protection of the work's monetary value
- archiving of content
- ensuring of content integrity
- providing surety through persistence (due to analogue mass-production)
- facilitating personalization through filtering and annotation

Although copyright defines under which circumstances copying is legal and when copying is illegal, copyright infringements are ubiquitous and most people infringing IPRs are aware of their malpractice. One important issue that certainly negatively influences users is the fact that the original is still available and even untouched, which is in contrast to stealing of physical goods. Therefore several campaigns were launched addressing the topic “copying is stealing”. For example in 2003 MPAA launched an advertising campaign “copying is stealing” to sensitive public that IPR infringement by private people can be compared with stealing a CD from a record shop [MPAA2003].

As described in [MPAA2003] in the pre-digital age (before the 1980s) several legal disputes are known where copyright owners claimed copyright infringement offences:

- Ames Records allowed subscribers to hire records from it for a small rental charge.
- Amstrad supplied tape-to-tape recording equipment.
- Sony's video recorders were used for illegal copying.

Interestingly, neither Ames nor Amstrad nor Sony was liable for copyright infringement.

Nowadays, copying digital data is much easier and commercial oriented pirates as well as some consumers exploiting these new opportunities: Digital data can be copied without any loss of information and distributed fast world-wide via the Internet. Especially P2P file-sharing networks - the most popular one was probably Napster - enable users to share content. Although the US courts shut down Napster rights holders still claim that Napster's descendants cost them billions of dollars in revenues. As direct consequence rights holders are now targeting consumers, ISPs, operators and even founders of file sharing systems.

While the rights holders were quite successful against Napster actions against Grokster and StreamCast failed because the technology can be used for legitimate purposes, the service suppliers cannot control the use of the technology by the end user and the users' communication is entirely outside the control of the service suppliers.[6] Although Verizon RIAA won a court order forcing an Internet Service Provider to disclose the identity of individual consumers who traded music files, technologies like Freenet[7] allow users to share any kind of content without any risk of being identified by rights holders. Yet, the P2P user behaviours are changed and there seems to be a correlation with RIAA’s lawsuits against illegal music providers (January, 2004).

The technical endeavours of controlling the usage of content are summarized in the term digital rights management (DRM) and were first focused on security and encryption addressing the problem of unauthorized copying. But DRM evolved and now it covers various issues including:

[5] Interestingly the existing solutions analysed by Camp, which included copy protection as well as circumvention technologies, only partially fulfilled these requirements.
[6] Napster had a centralised architecture while its descendants are decentralised.
[7] Freenet can be summarized as a decentralized network of file-sharing nodes tied together with strong encryption and further technology, which allows anonymous users.

- the description of content
- the identification of content
- trading and exchanging content
- protection of content
- monitoring of content distribution and its usage
- tracking of content distribution

As emphasised by Iannella [Iannella2001], DRM is the “digital management of rights” and not the “management of digital rights”. Thus, it has become a very complex area addressing issues far beyond security and encryption.

1.1. Intellectual property rights

In this section we shortly summarize the topic Intellectual Property Rights (IPR) given in [MUSICAL1.2]. Yet, due to the numerous facets of this aspect this summary is a motivation for DRM and not a detailed description. For a detailed description of legal issues we suggest to consider adequate material like [Bechtold2002b]. Also, in [Rosenblatt2002] there is a chapter addressing the interweavement between law and technology: Rosenblatt et al. describe the basic types of intellectual property including:

- patents,
- trademarks,
- trade secrets, and
- copyright.

1.1.1. Intellectual property and copyright

As Intellectual Property (IP) is the basic for the following chapters, first the term “IP” has to be defined. IP is described in [MUSICAL1.2] as “creative ideas and expressions of the human mind that have commercial value and receive legal protection in the form of property rights.”, which include patents, trademarks, designs and copyright.
Hence, IPR's main purpose is to prevent others copying a person's original work. IPR lasts for a specific duration[8]. After this well-defined period of time the work enters public domain. “Copyright” is generally equivalent to “author's rights”. Although certain organisations like World Intellectual Property Organisation (WIPO) prefer the term “author's rights”, “copyright” is used within the area of DRM.

Cohen [Cohen2002] describes how copyright changed due to the appearance of online work: Initially copyright didn't control or access to or private use of an already purchased copy. Also copyright didn't interfere with fair use derivatives. Today content owners claim the right to control the access to and the use of content.

1.1.2. Music copyright

Music copyright is a negative right, which means it gives the composer the right to restrict others from certain activities including copying music. Third parties not acknowledging these restrictions are liable for copyright infringements. Copyright automatically arises upon the creation of content without any formal registration process. Thus, copyright is distinct from other subsequent copyrights.

1.1.3. Publishing rights and licensing

Copyright owners have the exclusive right to reproduce or make copies of their work. Furthermore, the copyright owner also has the exclusive right to perform publicly a copyrighted work, directly or indirectly through means of communication or transmissions.
While these two rights (recording and public performance rights) where clearly separated before the digital distribution of content via the Internet, today this is not so clear anymore. Hence service, providers

[8] E.g., the copyright for a new composition lasts for the lifetime of the composer and additional 70 years after his death.

are forced to obtain multiple licenses from different parties. This process can be very difficult as typically each right is connected with certain limitations
Rights can be negotiated either with the rights owner or with collection societies. Here a new level of complexity is introduced through technical developments.

1.1.4. Legislation

International agreements that protect artistic and literary works aim to harmonize legal definitions and terms of protection. In the Berne convention, which was signed by more than 1979 member states in 1979, such an international framework was determined. Yet, this framework has a degree of freedom to deviate from: As described in [Cohen2002] the copyright industries had secured an international commitment to additional legal protection for technological protection regimes in the 1996 WIPO Copyright Treaty, which leaves member states substantial flexibility in implementation.

The Digital Millennium Copyright Act of 1998 (DMCA, U.S.) forbids circumvention of access control technologies and also the manufacture and distribution of circumvention devices. Hence usage controls are protected indirectly. One side effect of the DCMA is shown in the SDMI-hack [Craver2001] where the content industry tried to stop Felten distributing his research knowledge [Felten2002].

In Europe the digital copyright directive was approved, which defines a range of devices that are to be prohibited. Yet, it leaves member states free to define what constitutes “adequate legal protection” against the act of circumvention. Member states may require preservation of exceptions (e.g. private non-commercial copying)

Furthermore there are other legal frameworks, e.g. the Uniform Computer Information Transactions Act (UCITA), which would validate consume “assent” to these restrictions and legitimise the accompanying technological controls as part and parcel of the agreement.

Another potential area of conflict is privacy as information are exchanged and stored. For example a customer exchanges information with a third trusted party, which stores this information.

1.2. Scenarios

DRM systems can be used in different scenarios. Although the main reasons for its application is the protection of IPR there might be some differences according to the individual scenario. These differences will reduce or increase the required DRM functionality.

- *Business-To-Business (B2B)* scenarios allow different assumptions, which are affected by the relationship between the business partners. Typically there is a certain level of trust between the partners otherwise they would not have a commercial relationship. Considering the computers hardware can be considered as administrated by a “well-selected” person and other persons are not able to modify the software installation on computers.

- *Business-To-Consumer (B2C)* scenarios are different to the B2B-scenario as there needn't or can’t be a certain level of trust between the partners[9]. But what is even more important is the fact that consumers have full control on their computers.

- *Consumer-To-Consumer (C2C)* scenarios are very interesting especially when considering social and legal aspects of DRM solutions. But these scenarios are not address in this document.

Of course, the previous examples are not comprehensive in depth as each scenario has specific requirements. Also there exist several hybrid forms not only due to the fact that content owners distribute content with the support of retailers. And this is indeed the main advantage of the Internet: its flexibility. Any business model can be selected for distributing content and adapted quickly. We will address

[9] Here trust is related to the actions of the consumer after purchasing a product or a digital item. There is no guarantee that a customer doesn’t infringe any right at all.

different business model in the next chapter. But concerning the security of content one must keep in mind the different assumptions on the possibilities of the involved parties.

1.3. Technology overview

The term DRM comprises different technologies, which were initially designed to enforce restrictions on content or to protect the interests of the content owners. Thus restrictions have to be expressed within a DRM system. This is traditionally done by rules, for example number of rendering[10], renderable periods, etc. Hence, rules are central in the design of a DRM system.

As different business models can be supported by DRM solutions, we try to shortly describe typical business models below. An extensive description of some of the following business models can be found in [Rosenblatt2002]:

- promotional content by limiting to a specific number of renderings.
- distributed retail by distributing content to retailers who sell it to customers (super distribution)
- Super distribution P2P-environments
- license per content
- license per collection of content
- license per rendering
- subscription
- selling rights

More information about business models in the music distribution sector is available at [MusicNetwork]. Obviously, choosing the right business model does not only depend on monetary criteria. Other issues include market and user analyses or improved products and services. These are criteria are reflected in Iannella's functional analyses [Iannella2001].

Depending on the functional issues different technologies are deployed. However we will limit the discussion in this document to functional aspects and technologies related to digital rights management. Therefore technologies, which have to be considered in a complete system, e.g. billing components or components tracking users behaviours, are not included in this document. Additionally we don't analyse the security of different technologies or implementations. Yet, one has to be aware that any DRM system is as strong as its weakest component. Hence, if a weak technology or a weak implementation is used the complete DRM solution suffers.

A short history of the development of DRM can be found in [MUSICAL1.2]. Additional information on DRM can be found in [CEN/ISSS2003].

1.4. Scope of the document

This document explains the basic knowledge needed to understand the fundamental functionality of DRM systems. After the some explanations of IPR within this introduction chapter the next chapters described the general requirements on a DRM solution. Then we introduce the basic concepts of DRM solutions. As the concepts always support business models these business models are explained afterwards. Having in mind the general aspects of DRM we present some specific individual technologies including content identification and description, rights management, encryption, watermarking and fingerprinting. This document aims to support people and organisations in selecting or developing suitable technology for their specific requirements on the protection of musical content. Short analyses of current solutions as well as standardization efforts give further information and support.

[10] As general DRM is independent of the distributed content we use the term “rendering” as a summary of all possible actions with content.

2. Needs and Requirements

Basically three different parties are involved in the distribution of digital data:

- content creators
- content providers
- consumers

These different parties have specific interest that might be mutually exclusive especially for business. For example a content provider might want to maximize his income and therefore might increase the prices of his offers or restrict possible usages. On the contrary a consumer might want to minimize the costs or maximize the usage of the bought goods. Although consumers a typically not involved in the decision process determining the used DRM solutions the consideration of their needs determines the success of a solution. Similarly content providers are also affected by the variety of their offers.

2.1. General questions relevant for content creators

Content creators contribute their work to content providers. Therefore they are first interested in the benefit of the distribution and the protection level of their content in the distribution solution. Benefit is not limited to monetary aspects but also includes visibility, sales promotion, customer relationship, etc. If these aspects are interesting for content creators the next hurdle will be the integration of content in the distribution system. This is exemplified in the following questions:

- Are multiple business models supported?
- Can the business model be chosen dynamically?
- How good is the protection of content?
- Can the usage of content be monitored?
- Does protection influence the content itself?
- Can content be integrated easily in the solution?
- Are modifications (e.g. format conversions) necessary?
- Which file formats are supported?

2.2. General questions relevant for consumers

Generally, consumers will accept a distribution solution if

- content fulfils their needs e.g. in terms of quality, diversity and variety
- costs (e.g. ease of use and value) are reasonable in comparison to the benefit

Here costs are not only the price for the product. Other factors like complexity of acquisition process (e.g. registration, payment or software installation) or usage limitations (e.g. due to a strong protection model) raise the costs and should be considered. Some users' attitudes are described below.

- What are the software requirements for the download?
- How complex is the registration process?
- What else is necessary for the download?
- How strong will restrictions influence the usage? (DRM = Digital Restriction Management)
- What kind of rendering software (audio and video players, image viewer...) must be used?
- What about the exchange of data with other devices? (ideally no limitations)

Of course some users are also concerned about privacy.

2.3. General questions relevant for content providers

On the one hand content providers need content. On the other hand customers have to buy this content. Therefore they depend both on content providers and on customers and they have to balance the needs of

content creators and customers in a reasonable way allowing a working business model. Content providers and customers, the content itself, and the chosen business model determine relevant needs. Yet, a content provider has to be aware what kinds of products have to be protected or managed digitally and how (how long, how strong, …) they have to be protected. And these aspects are indeed important as DRM is certainly a restriction of rights, which becomes easily contradictious to content providers' major aim in selling access. Also the content type lead to implications on and might even has some restrictions on usable technology.

Furthermore a distribution solution must address various further aspect not only related to the DRM functionality. As DRM functionality is combined with other functionality the resulting systems address new fields. New issues are emerging relevant for the design and the usage of DRM and solutions. We give some examples below:

2.3.1. Legal framework

The distribution and protection system must be within the legal framework. For certain countries this can be done easily due to the homogeneous law system, e.g. in the United States. Yet, in Europe this is more difficult as national laws and copyright related issues differ. Content providers facing these challenges have to solve a huge juristic and administrative overhead before they are able to provider content. Furthermore these differences influence the structure of the distribution and protection solution. E.g. fair use might be treated differently within European countries, which influences the restrictions in a protection solution. The resulting additional efforts are sometimes not manageable. Therefore unique IPRs at least within Europe would improve the situation of content providers.

2.3.2. Customer relationship

The tracking systems of protection solutions can be used to improve the information available about customers and their habits. This kind of information can be used to improve external services to customers or to improve internal decision processes like the stock composition. Relevant information includes:

- further information about customers behaviour
- information about/from other customers (reviews, similar interests)
- protection of content
- monitoring of content distribution and its usage
- tracking of content distribution

It is important to use this information according to the privacy regulations of national laws, which might influence the amount and the kind of information that can be extracted.

2.3.3. Content related aspects

The tracking system also provides further functionality for identification and description of content, like

- content identification of previously unknown content
- creating a link of content to different kinds of content descriptions
- creating a link of content to additional information

2.3.4. Copy accuracy

The key functions' design considerations of the copyright system as identified by Camp [Camp2003] must be expanded beyond those given by law. Camp states that economic and technological factors must be included instead of recreating existing law in a digital network. His postulation is based on the nature of technology: Technology alters society as it diffuses through it. The result of this recognition leads to a 'larger technological, economic, and legal system', which he called *copy accuracy*. His copy-accuracy functions include:

- author monetary incentive
- reputation right
- attribution and integrity
- persistence and archiving
- access
- personal annotation

In his article Camp analysed the effects of three different systems and their 'adversaries' (DRM proponents and opponents) according to his copy-accuracy functions:

1. Adobe's eBook and Elcomsoft's Advanced eBook Processor
2. the CSS of DVD players and DeCSS
3. Giovanni (a system embedding labels by watermarking content) and free content

Camp concluded that during the creation of his article (in 2003) no system supported the set of the copy-accuracy functions. However Camp admitted that the set of design requirements was not trivial and that designing a DRM system satisfying these requirements would include secure storage, micro-credit, archiving, distributed caching, censorship-proof publishing, and reputation systems.

2.3.5. Payment

Credit card fees play an important role when the transaction volume is small, which is typically the case for paid download. This is clearly in contrast to online orders of physical goods where in addition to the costs of the goods additional costs for transportation play an important role. Therefore different micro payment systems have been developed reducing the fees for online transactions, which is important for digital contents.

As discussed in [Buente04] and [IWW03] consumers have different expectations on the payment systems including:

- The payment system should be well known and commonly used to avoid difficulties.
- Paying should be comfortable, e.g. difficult registrations should be avoided.
- Payment should be anonymous.

In [IWW02] different payment systems are distinguished, as shown in **Figure 1**:

- *Pre-Paid*: Pre-paid payment systems can be generally considered as not as customer friendly as other systems as they require a monetary transfer before receiving the content. Pre-paid methods can be hardware- or software-based.
- *Pay-Now*: Cash on delivery and debit are comfortable payment systems for consumers. Consumers only have to transmit their address and no credit-card information has to be exchanged. Further pay-now methods are based on mobile payments or payment per email.
- *Pay-Later*: These methods include credit card, invoice or billing systems.

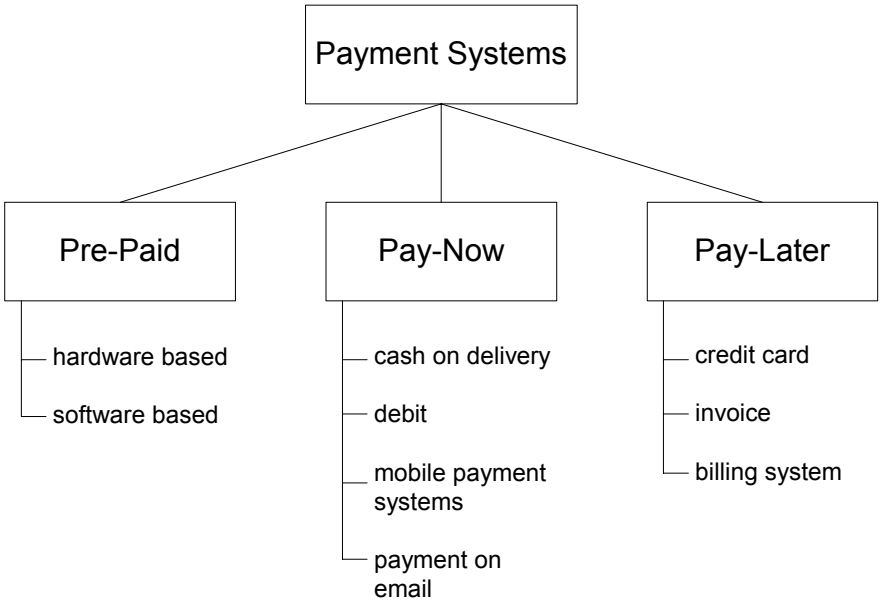


Figure 1: [IWW02] differs between pre-paid, pay-now and pay-later payment systems. The individual groups have specific (dis-) advantages for consumers or content providers. A cost efficient payment system is essential especially when relative cheap content is sold online. Otherwise the costs for the payment strongly distract costumers from any online purchase.

3. Technological Overview

Various technologies are necessary to establish a complete DRM system. In this chapter we shortly explain the individual components of a DRM system and their relationships.

3.1. Digital rights management systems

According to object oriented software design and development a system can be characterized by use cases (e.g. [Booch1986] and [Oestereich1998]), which describe functional aspects from a user's point of view. Another important issue is the modelling of entities within a system. Therefore we summarize the discussion of the functional and information architecture by Iannella [Iannella2001].

3.1.1. Functional aspects

As DRM systems are designed for managing[11]. Functional aspects of a DRM architecture can be grouped as follows (which is shown in **Errore. L'origine riferimento non è stata trovata.**):

- *IP asset creation and capture:* When content is created or captured rights are asserted. This includes rights validation, rights creation and rights workflow.

- *IP asset management:* Content is archived in an asset management system. Furthermore, meta data describing the content and the associated rights are stored. This meta data is needed for repository and trading functionality.

- *IP asset usage:* After trading the content the usage has to be managed, which includes permission management and tracking management? The permission management ensures that certain rights are honoured. The tracking management is needed e.g. to record usage if payment for each use is fixed.

[11] Thus the main purpose of DRM is tracking and controlling access to content based on the identity of the consumer

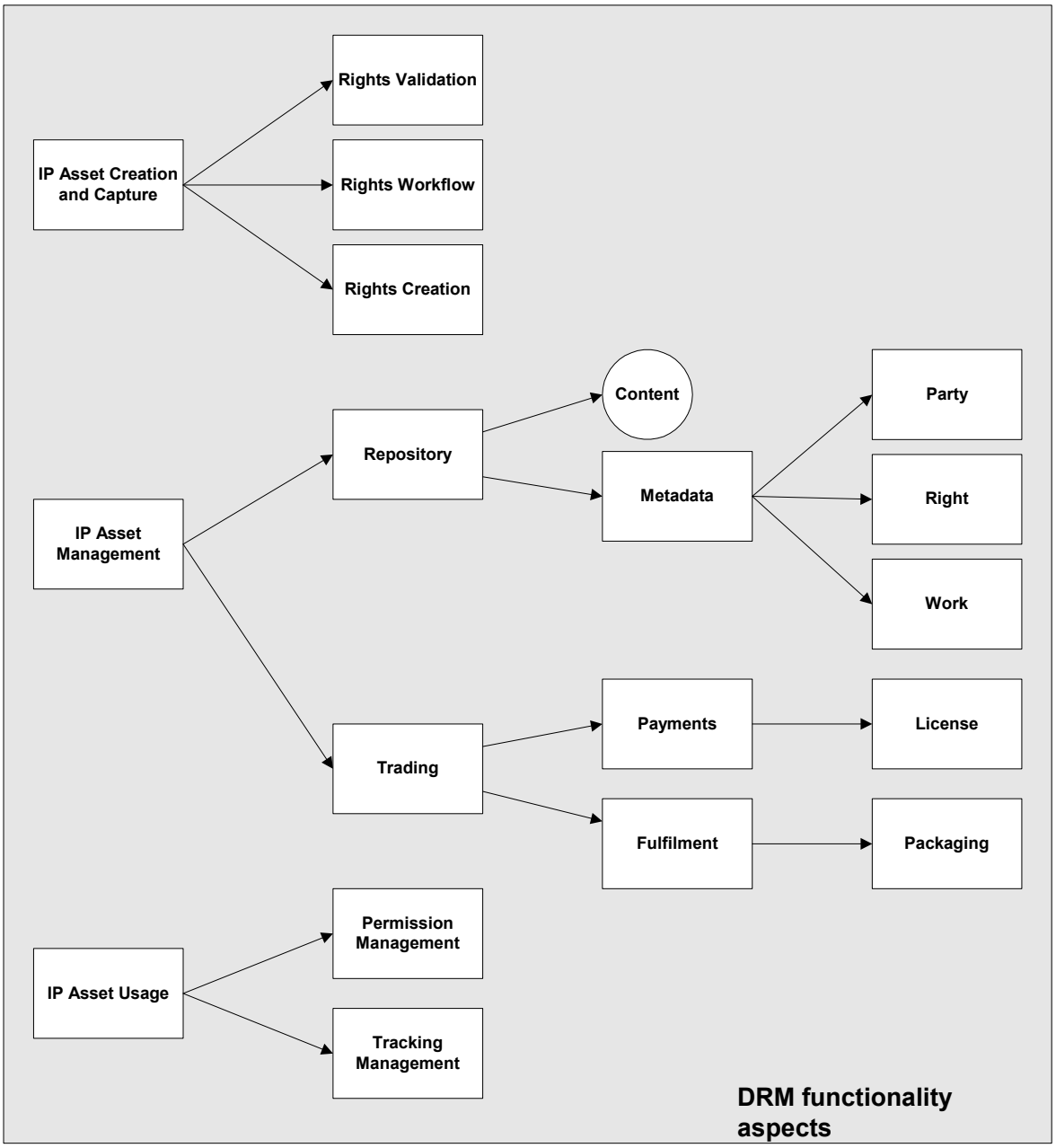


Figure 2: Functional aspects of a DRM system according to Iannella [Iannella2001]: IP asset creation and capture, IP asset management and IP asset usage are the core functionalities of each DRM system.

3.1.2. Information aspects

Information aspects of a system describe how entities are modelled within the system framework. Thus, relevant entities (and their relationships) have to be identified and modelled appropriately. Within a DRM system three identities occur:

- *Users* includes all possible types of users.
- *Content* is any type of content and its aggregations.
- *Rights* expresses the permissions, constraints, and obligations.

These are the core entities as identified in the <indecs> project, which are shown in Figure 3.

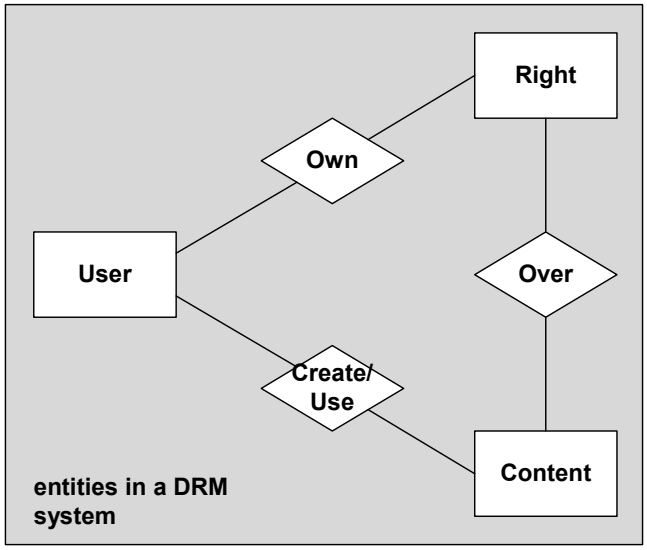


Figure 3: Entities in a DRM system according to Iannella [Iannella2001]: A DRM system manages content, users and the rights a user owns over content.

For identification of entities different standards are available, e.g.:

- URI [URI2396]
- DOI [DOI2003]
- ISTC [ISTC]

Detailed information on content identification is elaborated in chapter 5.

Users can be modelled by describing people and organizations. In vCard [vCard1996] and [vCard:1998] an independent electronic business card is defined for PDI. A vCard consists of one or more vCard objects, which are encoded in a data stream. Although this specification provides a clear-text encoding that is intended to be based on the syntax used by the MIME specification (cf. RFC 1521 [MIME1993]) it gives valuable information how to describe people. However for some DRM applications a role based modelling might be necessary.

The most important issues when modelling content is that content can be considered at various abstraction levels, it might be available in different representations and it can be a conglomerate of various different sources. E.g. a video can consist of still images, moving pictures, sounds and speech. Furthermore a work can exist in several expressions e.g. the original text or a resulting translation or a screenplay. Therefore the IFLA [IFLA1998] defined a model, which allows content to be identified at the work, expression, manifestation, and item layer (as shown in Figure 4) where for example manifestations of a book could include hard- or soft cover and item is a certain purchased item. The important issue concerning rights is that different rights holders can be recognized for each individual item.

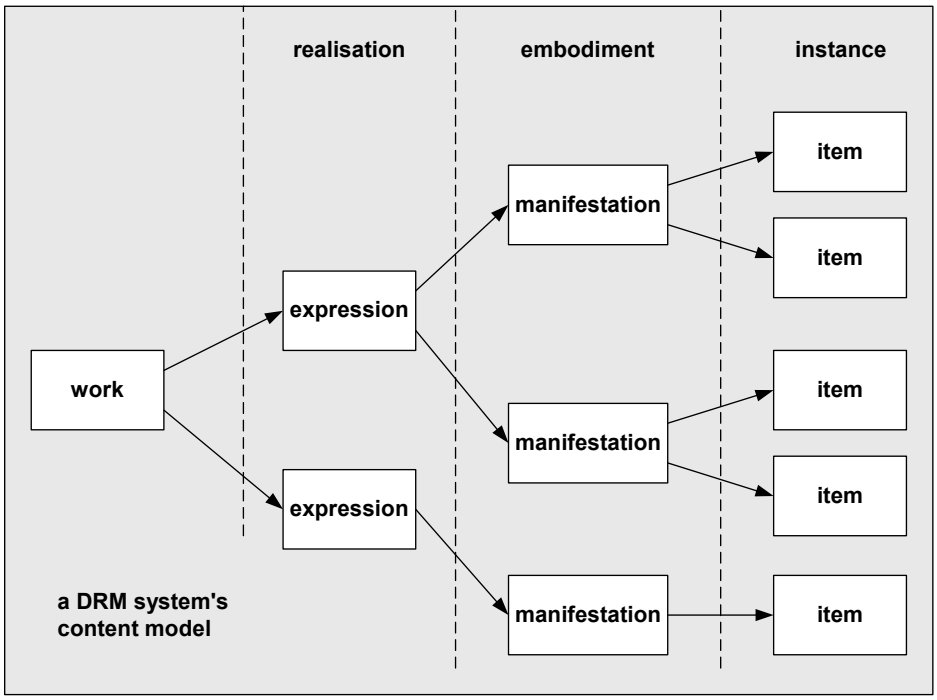


Figure 4: Example of a DRM system's content model as given by Iannella [Iannella2001]: A work can have different realizations (e.g. movie, book), different embodiment (e.g. hard or soft cover) and of course concrete instances (the individual item customers buy).

Similar to the user description, several standards exist for content description like:

- EDItEUR ONIX
- IMS Learning Resource Meta-data Information Model
- <indecs>

These models are shortly described in chapter 5.

3.2. Rights management

Typically access to content is related to usage permissions, which are expressed as rights. Digital rights management systems provide the functionality to manage rights digitally. Therefore rights have to be described as digital entities. The rights include information about allowable permissions, constraints, obligations, and other rights-related information like rights holders. They might even include information about rights transfer.

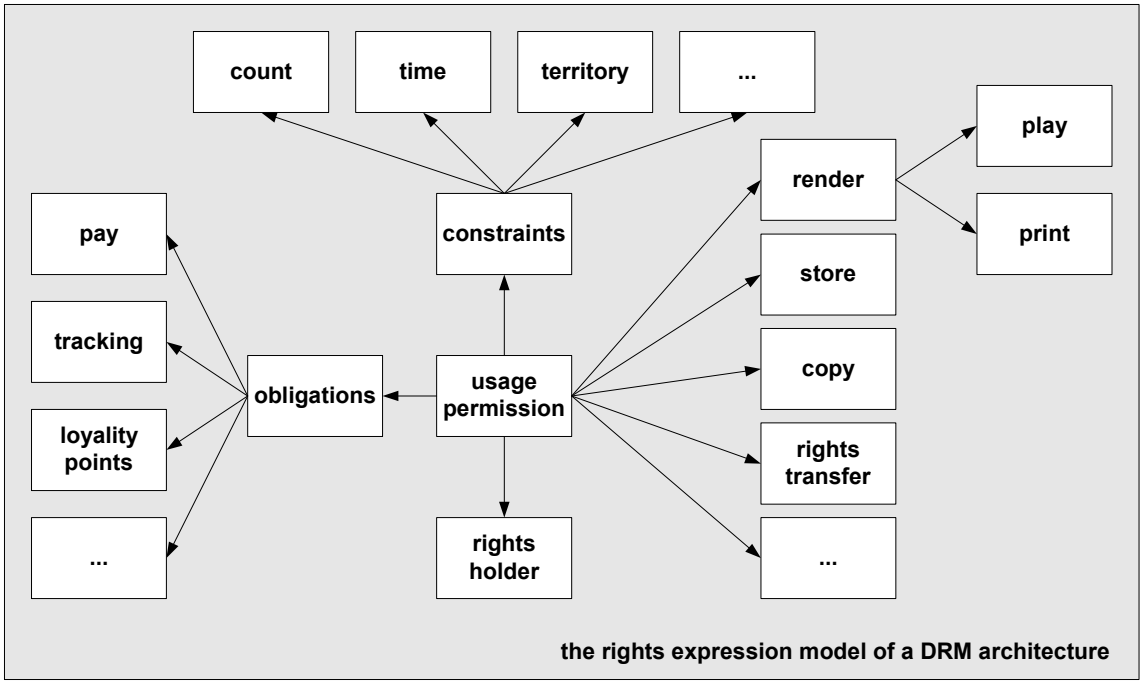


Figure 5: The rights expression model of a DRM architecture.

The rights expression model (as shown in Figure 5) can become quite complex for real world applications. Therefore different rights expression models[12] have been defined like the Open Digital Rights Language (ODRL) or the eXtensible Rights Management Language (XrML). Details about rights expression languages can be found below.

3.3. Protection technology

Whenever content with usage limitations is distributed via the Internet the content providers want to protect their content. Therefore different techniques have been developed to increase the content's security. These techniques limit the access to content as well as modification of content to ensure its integrity.

Considering protection technologies we can distinguish between:

- *active* protection, which impedes or stops illegal access
- *passive* protection, which is indirectly useable for protection of content

The following paragraphs are for introduction of the technical concepts. Details are presented below.

3.3.1. Active protection

Active protection prevents or impedes illegal access actively. This means access to content is not granted if the necessary permission is missing. Encrypting the content does this. For security reasons encryption is done with a key. As stated by Kerkhoff [Kerkhoff1883] the secrecy of the key and not of the algorithm is a necessary condition. However some existing DRM solutions keep their algorithms secret which endangers the security of the system as security holes might exists which are well-known only among attackers.

[12] These expression models are also called rights models. Their digital equivalents are called digital rights models and can be handled by digital devices.

Different encryption methods can be identified:

- **Symmetric encryption** schemes use the same key for encryption and decryption. There main advantage is their good performance. However key exchange is difficult.

- **Asymmetric encryption** schemes use different keys for encryption and decryption. For encrypting and decrypting a pair of keys is necessary. One of these keys is a so-called private key, which is only known to its owner. The public key is related to this private key and can be distributed freely. Data can be encrypted using the public key of an organization and decryption is only possible with the corresponding private key.[13] The main drawback of these schemes is their slow performance.

As symmetric encryption techniques suffer due to the key exchange typically keys are exchanged with asymmetric encryption schemes because of the smaller key length.

3.3.2. Passive protection

In contrast to active protection technology for passive protection do not actively protect content. A typical example for passive protection technology is watermarking: Watermarking techniques embed imperceptible qualifiers. These qualifiers do not directly protect content. But the qualifiers can be used e.g. to identify possible leaks in distribution chains. Fingerprinting or perceptual hashing techniques allow the identification of content without embedding an identifier.

3.4. Summary

A DRM system is a complex software solution for the digital management of rights. If used properly it allows content providers not only to manage their content efficiently. When combining DRM systems with other software solutions, e.g. CRM tools, the benefit of a DRM system drastically increases. Yet, privacy is an issue, which has to be taken seriously. A lot of personal data can be collected in DRM systems. Solutions have to consider national laws to prevent this personal data from any illegal use.

Analysing the possible impact and success of DRM systems is generally difficult. However successful future eCommerce will be based on DRM systems with high functionality. Factors, which influence their success, are related to the unsatisfied expectations and wishes of the customers. Privacy is only one of these issues. Other user requirements include private copies, possibilities to transfer content flexibly to other devices. And another important aspect is the interoperability of DRM systems.

As soon as the possibilities of DRM solutions will be widely recognized and accepted customers and content providers will strongly benefit from DRM systems. Considering the aspect stated by Andrew Odlyzko [Odlyzko2001] and others content, customer relationship and rights management system will merge to testify that content is not king: “content is queen and service is king”.

[13] On the contrary data can be encrypted with the private key and only the corresponding public can decrypt the data. A typical application for this scenario is authentication and integrity verification.

4. Different Business Models and Possible Technological Support

Distribution of content and business models are directly related. Yet, we do not intend to discuss and judge different business models. The objective of this chapter is to describe how DRM can support different business models. For further information we suggest the reader to consult [Rosenblatt2002].

4.1. License per content and license per collection of content (paid downloads)

This business model is the digital equivalent of the commerce of physical goods. In this case DRM approximates the rights model well known from the physical world. Rosenblatt et al. identified three different problems of this business model:

- the complexity of the purchase (e.g. registration and related identification processes)
- the complexity of the technologies' usage
- people are not used to render traditional content on computers (traditional "look & feel" is important)

While we agree on the first and the second problem, which can be addressed in the design of the solution, the third problem is already vanishing: People are used to download music from P2P-networks. Also digital audio players like Apple's iPod are common. This might also happen to eBooks.

Considering the complexity of purchase efficient micro payment mechanisms are vital for the future of commercial online content distribution.

4.2. Subscription based services

In current subscription models the user registers via username and password. He pays a regular fee for accessing content. This regularity makes a subscription model interesting for content providers, as it ensures a certain revenue stream over time. Only few companies have succeeded in establishing subscription based online services. Different reasons can be identified:

- the Internet is known for free information
- people appreciate the "look & feel" of physical products
- information is determined by its value, timeliness, and uniqueness (values depends on a dedicated group of customers who relies on some information and is willing to pay for it and its delivery under certain circumstances, e.g. time delay)

Interestingly the Internet provides a new service to the audience of music: some users regard the Internet as a huge jukebox, which provides all different kinds of music ever recorded. Thus subscription-based services provide new possibilities. Similarly streaming audio and web radio will replace the traditional DJ who guaranteed for a certain kind of quality. Also current discussions about levies are addressing similar issues known from subscription based business models. Not to forget subscription based services of cable television. Thus DRM has to support subscription based business models.

4.3. License per rendering (pay-per-view, pay-per-listen, …)

The sources for this business model stem from the physical world and are the typical model for live performances like theatres or concerts and also for cinemas and jukeboxes. Some cable-television providers have adopted this model, which is reflected in the term view-on-demand is equivalent to pay-per-view or pay-per-listen for audio-visual content.

The security of the delivered content strongly depends on the content itself. The protection level of time dependent content, e.g. a soccer match or latest news, is different from content whose value is more or less independent of time, e.g. a movie or a concert performance recording.

4.4. License for a specific number of rendering or for a specific time frame

In addition to the previously listed license per rendering extended models exist which allow a certain number of renderings or the rendering of content within a certain time frame. This strategy can also be applied to business documents to avoid rendering of information outside a validated time frame.

This business model is also applied to use content as promotional content. Consumers are allowed to render content for free within a certain time frame. The objective of this business model is to wake the customers' appetite for a certain product and after the free period the customer will by the content or the rights for rendering it. Interestingly the same idea is applied in a software copy protection mechanism called "Fade", which continuously removes functionality from illegal game copies after a certain period of time.

4.5. Distributed retail by distributing content to retailers (super distribution)

The content is distributed between more than two organisations either via peer-to-peer or via a multi tiered distribution. Problems arise due to certain degrees of freedom (e.g. the parties involved). In the super distribution scenario DRM is very important as the probability of loosing control over content increases drastically with the number numbers of parties involved in the distribution.

4.6. Super distribution in P2P environments

P2P environments are very demanding for protection technologies. Generally distribution via P2P networks is a super distribution on a certain kind of infrastructure. Yet, the parties participating in the distribution do not necessary have any information of each other.

4.7. Usage metering

Usage metering is well known from the physical world like gas or electricity. Yet, consumer tends to prefer a subscription-based model as monthly rates are more predictable. Nevertheless a trade-off has to be found between the customers' and the providers' risks. Furthermore this business provides an alternative to the subscription-based services as it implements the costs-by-cause principle and is more flexible than the license-per-rendering model.[14]

Internet service provider extended this model by providing a certain connection time or data transfer for free. Additional connection time or data transfer has to be paid for. Similarly, mobile phone service providers extended this model by providing a certain number of minutes for talking for free and selling additional minutes.

Another solution that is currently discussed is the usage of DRM systems in subscription-based services providing the possibilities to distribute fees adequately among right holders. A DRM solution can support this business model as it is capable of calculation of the metering. Additional information can be acquired, e.g. for marketing. Yet, privacy concerns have to be considered.

4.8. Selling rights

Instead of distributing the content the rights can be sold. Of course digital rights management also should address this business models as selling rights involves rights transactions among commercial organisations.

4.9. Summary

Successful DRM solutions support business models and not the other way round. It doesn't matter if the business models are adopted models from the physical world, new business models, or a combination of both. Naturally, the business models must be derived from the needs of the customers, which is a well known fact from the physical world. Yet, new technologies provide possibilities for further products and services.

[14] under the assumption that license-per-rendering are less convenient and more complex in handling

5. Content Identification, Content Description, and Content Management

Whenever data has to be accessed or retrieved two issues are important:

- content identification
- content description

These issues are independent of DRM. Therefore they are also described in [DE4.2.1] and [DE4.3.1]. As data have to be accessible by DRM solutions too, data and meta data have to be stored accordingly. Therefore different meta data standards have been defined to solve these issues. Indication of Quality: Before the Internet the quality of information could be judged easily e.g. simply by looking at it or by knowing its origin (including publishers).

5.1. Content Identification

Content identification should be accomplished with an open standardized mechanism. Several open standards have been created for this purpose in the digital world. But also existing content identification standards are well known in the physical world. We will explain some of both groups below.

As the data, which is exchanged via the Internet, should be readable on different systems, the "extended Markup Language" [XML] is used to describe the properties. This is not limited to identification but also includes other rights related information like the rights or the licenses.

5.1.1. ISBN

The International Standard Book Number (ISBN) is a unique machine-readable identification number, which marks any book unmistakably. This number is defined in ISO Standard 2108. and consists of ten digits. The ISBN is divided into four parts (group identifier, publisher prefix, title identifier, and check digit) of variable length, which must be separated clearly by hyphens or spaces:

ISBN 0 571 08989 5

or

ISBN 90-70002-34-5

The number of digits in the first three parts of the ISBN (group identifier, publisher prefix, title identifier) varies. The number of digits in the group number and in the publisher prefix is determined by the quantity of titles planned to be produced by the publisher or publisher group. Fewer digits represent publishers or publisher groups with large title outputs.

The length of the ISBN is being expanded to 13-digits. The plan is to complete the standard by January 1, 2005. Implementation of the 13-digit ISBN, however, will not be mandatory until January 1, 2007. On January 1, 2007 all ISBN agencies worldwide will distribute only 13-digit ISBNs.

Detailed information is available at [ISBN2003], [ISBN2003b], and [ISBN2003c].

5.1.2. ISSN

The International Standard Serial Number (ISSN) is an eight-digit number, which identifies periodical publications as such, including electronic serials. These are the Arabic numerals 0 to 9, except in the case of the last or check digit an upper case X can sometimes occur. Since ISSN are likely to be used in the same context as codes designed for other purposes, such as the International Book Number (ISBN) or local control numbers, a distinction must be preserved in the form of presentation when written or printed. An ISSN is, therefore, preceded by these letters, and appears as two groups of four digits, separated by a hyphen, for example:

ISSN 0317-8471

For more information we suggest visiting the homepage of [ISSN2003].

5.1.3. ISMN

The International Standard Music Number (ISMN) consists of the letter M followed by nine digits. The letters ISMN precedes the number. The ISMN is divided into four elements (distinguishing element, publisher identifier, item identifier, and check character), the second and third of which (publisher and item identifier) are of variable length. The check character is a single digit at the end of the ISMN that provides an automatic verification of the validity of the ISMN, for example:

ISMN M-3452-4680-5

More detailed information can be found at the national Canadian library [ISMN2003].

5.1.4. Uniform Resource Identifiers (URI)

According to RFC 2396 [URI2396] is "a Uniform Resource Identifier (URI) is a compact string of characters for identifying an abstract or physical resource." (cf. Wikipedia). This string indicates a name or an address and is often used to refer to an abstract or physical object. The URI syntax and semantics are derived from other WWW concepts. It was designed to meet the recommendations laid out in "Functional Recommendations for Internet Resource Locators" (RFC 1736 [IRL1736]) and "Functional Requirements for Uniform Resource Names" (RFC 1737 [URN1737]).

The abbreviation URI includes the following definitions:

- *Uniform* semantic interpretation is important when different mechanisms are used to access resources, which is important for a great flexibility in usage.
- *Resource* is a conceptual mapping to an entity or a set of entity.
- *Identifier* is a reference to a resource.

A URI can be a locator (Uniform Resource Locator - URL), a name (Uniform Resource Name - URN) or both. A typical example for a URI is the http address of the homepage of the Interactive MusicNetwork: http://www.interactivemusicnetwork.org.

One of the main design criteria was global transcribability. Therefore a strongly limited set of character is used. Considering the typical usage a URI is a string of characters must be typeable with a keyboard and must be easily remembered by people. Details about the syntax of an URI can be found in RFC 2396 [RFC2396].

5.1.5. Digital Object Identifiers (DOI)

The digital object identifier as developed by the International DOI Foundation [DOI2003]. It is an implementation of an URI and "is a system for persistent identification and interoperable exchange of intellectual property on digital networks". A handle system is used for resolution of the identifier (the so-called DOI directory), and the <indecs> framework for the resolution of the metadata description. The syntax of the DOI is specified by a NISO standard, (ANSI/NISO Z39.84). To overcome the main drawback of URLs, which are well known to everybody using the Internet, DOIs are mapped to URLs. This mapping can be changed dynamically.

The DOI consists of two parts: the prefix and the suffix. They haven't any length limitations and are separated by a forward slash. The prefix depends on a specific organization while the suffix identifies the entities.[15]

For example the DOI "10.1223/0810322188" can be resolved manually at http://dx.doi.org/ [DOI2003b]. It resolves to the document "Contemporary Musicians, Volume 10: Profiles of the People in Music" that

[15]Existing standard identifications can be incorporated into the suffix of DOI.

is published by Thomson Gale. Here the prefix "10.1223" identifies the publisher (Thomson Gales) and while the suffix "0810322188" corresponds to the ISBN (0-8103-2218-8). The direct advantage of the split between the prefix and the suffix is that there is a central registration of each document is not necessary. Besides the manual resolution "resolver plug-ins" for different web browsers are available at http://www.handle.net/resolver/ [DOI2003c].

5.1.6. ISO International Standard Textual Code (ISTC)

The ISO Project 21047 "is to develop an International Standard Text Code [ISTC] for the unique, international identification of individual textual works. The ISTC will provide a way for textual works to be uniquely distinguished from one another within computer applications and for the purposes of administering rights to such works." As ISTC is focused on textual work, we will not elaborate details.

An ISTC must be allocated by the IST registration agencies. It consists of a 16 hexadecimal[16] digit identifier. The four elements represent the registration agency element; the year element; the work element and a check digit. An example is: 0A9 2002 12B4A105 6

5.2. Content description

Within a DRM system the identification of content is more important than the description of content. However functionalities are merging and therefore we will also shortly address the issue of content description. According to Iannella [Iannella2001] content description should be based on the most appropriate metadata standard for each genre. However, any overlap with other metadata systems might result in difficulties in the implementation due to redundant information.

5.2.1. EDItEUR ONIX

The "Online Information Exchange" [ONIX] is targeting at books and was developed by EDItEUR [EDItEUR]. "ONIX for Books" includes three record types that are represented in XML. These record types are the Product record, the Main Series record, and the Subseries record. ONIX is mainly addressing the needs of publishers and online vendors.

The following Product record example is taken from [ONIXb]. One can clearly see that the content description is mixed with other information like the price:

```
<Product>
    <RecordReference>1234567890</RecordReference>
    <NotificationType>03</NotificationType>
    <ProductIdentifier>
        <ProductIDType>02</ProductIDType>
        <IDValue>0816016356</IDValue>
    </ProductIdentifier>
    <ProductForm>BB</ProductForm>
    <Title>
        <TitleType>01</TitleType>
        <TitleText textcase = "02">British English, A to Zed</TitleText>
    </Title>
    <Contributor>
        <SequenceNumber>1</SequenceNumber>
        <ContributorRole>A01</ContributorRole>
        <PersonNameInverted>Schur, Norman W</PersonNameInverted>
        <BiographicalNote>A Harvard graduate in Latin and Italian literature, Norman
        Schur attended the University of Rome and the Sorbonne before returning to the
        United States to study law at Harvard and Columbia Law Schools. Now retired
        from legal practise, Mr Schur is a fluent speaker and writer of both British and
        American English</BiographicalNote>
    </Contributor>
    <EditionTypeCode>REV</EditionTypeCode>
    <EditionNumber>3</EditionNumber>
```

[16] numerals 0-9 and letters A-F

```
<Language>
    <LanguageRole>01</LanguageRole>
    <LanguageCode>eng</LanguageCode>
</Language>
<NumberOfPages>493</NumberOfPages>
<BASICMainSubject>REF008000</BASICMainSubject>
<AudienceCode>01</AudienceCode>
<OtherText>
    <TextTypeCode>01</TextTypeCode>
    <Text>BRITISH ENGLISH, A TO ZED is the thoroughly updated, revised, and
    expanded third edition of Norman Schur's highly acclaimed transatlantic dictionary
    for English speakers. First published as BRITISH SELF-TAUGHT and then as
    ENGLISH ENGLISH, this collection of Briticisms for Americans, and Americanisms
    for the British, is a scholarly yet witty lexicon, combining definitions with
    commentary on the most frequently used and some lesser known words and
    phrases. Highly readable, it's a snip of a book, and one that sorts out – through
    comments in American – the "Queen's English" – confounding as it may
    seem.</Text>
</OtherText>
<OtherText>
    <TextTypeCode>08</TextTypeCode>
    <Text>Norman Schur is without doubt the outstanding authority on the similarities
    and differences between British and American English. BRITISH ENGLISH, A TO
    ZED attests not only to his expertise, but also to his undiminished powers to inform,
    amuse and entertain. – Laurence Urdang, Editor, VERBATIM, The Language
    Quarterly, Spring 1988 </Text>
</OtherText>
<Imprint>
    <ImprintName>Facts on File Publications</ImprintName>
</Imprint>
<Publisher>
    <PublishingRole>01</PublishingRole>
    <PublisherName>Facts on File Inc</PublisherName>
</Publisher>
<PublicationDate>1987</PublicationDate>
<Measure>
    <MeasureTypeCode>01</MeasureTypeCode>
    <Measurement>9.25</Measurement>
    <MeasureUnitCode>in</MeasureUnitCode>
</Measure>
<Measure>
    <MeasureTypeCode>02</MeasureTypeCode>
    <Measurement>6.25</Measurement>
    <MeasureUnitCode>in</MeasureUnitCode>
</Measure>
<Measure>
    <MeasureTypeCode>03</MeasureTypeCode>
    <Measurement>1.2</Measurement>
    <MeasureUnitCode>in</MeasureUnitCode>
</Measure>
<SupplyDetail>
    <SupplierSAN>1234567</SupplierSAN>
    <AvailabilityCode>IP</AvailabilityCode>
    <Price>
        <PriceTypeCode>01</PriceTypeCode>
        <PriceAmount>35.00</PriceAmount>
    </Price>
</SupplyDetail>
</Product>
```

Besides price information copyright information like a "download copyright notice", a "copyright owner", or territorial rights can be included. It has to be mentioned that several online book traders (including Amazon) use this metadata standard.

5.2.2. IMS Learning Resource Meta-data Information Model

Learning materials are address by IMS [IMS], which identifies a subset of IEEE's Learning Object Meta-data (LOM) meta-data elements as LOM defines a very large amount of elements. Yet, allows the

extension to the LOM standard for certain purposes. Meta-data are also defined in XML to ease data exchange. Examples for IMS can be found at http://www.imsproject.org/metadata/.

5.2.3. DCMI

The "*Dublin Core Meta Data Initiative*" is also addressing the issue of interoperable online metadata standards. It consists of a simple and a qualified level. Simple Dublin comprises fifteen elements, describing content (description, type, source …), intellectual property (creator, rights …), and instantiations (format …). Additional elements are included in Qualified Dublin Core (e.g. audience). The Dublin Core metadata describes one version of a resource (one-to-one principle). Also a client should be able to ignore any qualifier and use the values as if the were unqualified (dumb-down principle). Its goals include the "simplicity of creation and maintenance", "commonly understood semantics", "international scope", and "extensibility".

5.2.4. <indecs>

The "interoperability of data in eCommerce systems" [indecs] initiative was set up by international rights owners and resulted in a non-for-profit company. Its aim is to encourage metadata initiatives based on <indecs>. Its design is based on five axioms:

- "Metadata is critical": Electronic trading strongly depends on the identification and description of content.
- "Stuff is complex": An audiovisual content may contain numerous pieces of different intellectual property.
- "Metadata is modular": Metadata can be considered as individual modules, which are connected in a certain way individually for each content.
- "Transactions need automation": This is vital to reduce administrative overhead in the distribution of digital content.
- "Everything is a view": Entities can be described and identified differently.

The <indecs> model "elaborates a logical and semantic framework for describing *entities,* their *attributes* and, where appropriate, *values* of each. Entities, attributes and values are referred to as types of metadata *elements*." Three different views can be distinguished: percepts ("perceived by senses"), concepts ("conceived by mind"), and relations ("connections between multiple views"). Percepts are further subdivided in animate or inanimate (being or thing). Relations are subdivided in dynamic or static (event or situation). This general view is complemented by the commercial view, which is generally concerned how things are made (make, used by, do …). The legal view (make, used by, own …) finalised the view concept.

The above description explains <indecs>'s basic capabilities. It is used e.g. by [DOI] and [MUZE]. <indecs2> is a follow-on project creating a rights data dictionary.

5.2.5. EBU PMC Project P/Meta

The European Broadcasting Union is also addressing the problem of meta data exchange standards. Yet it is addressing the business-to-business media and meta data exchange. It identified several tasks (see [EBUPMeta]):

1. To establish understanding between EBU members of the media-related data interchange requirements of media commissioner/publishers (broadcasters), suppliers (producers) and consumers, using the BBC Standard Media Exchange Framework (SMEF) as the core information architecture.
2. To validate and extend the SMEF model as appropriate against members' requirements in terms of data and process, noting local synonyms (or translations), to create an "E-SMEF". This would extend the thinking to the development of a commercial process framework for exchange of media between EBU members.

3. Using E-SMEF, to apply emerging SMPTE metadata standards to the production and broadcast or distribution process, and study the feasibility of creating and adopting common exchange formats for essence and metadata.
4. To establish understanding of the use of unique identifiers in metadata e.g. the SMPTE UMID, as a crucial linkage tool between unwrapped data (metadata) and wrapped or embedded metadata in media files or streams, and develop protocols for their management between members.
5. As an aid to commercial and system interoperability between members, and in co-operation with standards bodies in related industries such as music and print publishing, to collate all relevant unique identifier schemes and map them against each other. This could be in collaboration with the EU INDECS project and the DOI Foundation, and extend to cover their data models too.

Their final draft is available at their web site.

5.2.6. SMEF

The "*Standard Media Exchange Format*" [SMEF] was defined by the BBC [BBC] for media asset management. It goes beyond the business areas and also addresses the delivery to the home. Its data model (SMEF_DM) is considered as a integration key information system that will evolve over time to cover more of BBC's business. SMEF-DM is available at BBC's website.

5.2.7. MPEG-4

MPEG-4 defines a stream management framework. This framework includes a coded representation of metadata for the "description, identification and logical dependencies of the elementary streams" [MPEG4]. Thus the object descriptor protocol addresses the fact that content may have different sources. MPEG-4 includes this object content information as well as intellectual property management and protection.

5.2.8. MPEG-7

"MPEG-7, formally named "*Multimedia Content Description Interface*", is a standard for describing the multimedia content data that supports some degree of interpretation of the information's meaning, which can be passed onto, or accessed by, a device or a computer code." [MPEG7]

5.2.9. Others

Several other meta data standards exist. For a more extensive description of meta data standards we suggest further literature like the "Meta Data Reference Guide" [MDRG]. Interestingly for CDs users maintain several metadata databases. These communities collect information about music and make it publicly available. One of these community support meta data databases is MusicBrainz [MusicBrainz].

Also the Open Archives Initiative (OAI) "develops and promotes interoperability standards that aim to facilitate the efficient dissemination of content." [OAI]. OAI developed the "OAI Protocol for Metadata Harvesting" [OAIPMH], which defines a mechanism for harvesting XML-formatted metadata from repositories. The Sheet Music Consortium [SMC] uses this OAI protocol for metadata harvesting with the aim of building an open collection of digitized sheet music.

6. Rights Management

As DRM is the digital management of rights they have to be represented in a digital format to be digital manageable. These digital representation must consider several aspects as also described in [Rosenblatt2002]:

- content rights transactions: traditional business models
- components of rights models: types of rights and their attributes
- fundamental rights: render rights (print, view, play), transport rights (copy, move,. loan), derivative work rights (extract, edit, embed)
- rights attributes (considerations, extends, types of users)

A general problem of DRM systems is the fact that they do not (yet) qualitatively distinguish between the different kind of usages. For example copying for personal purpose and copying for friends or even unknown persons is the represented as the same action within a DRM system. This is what Rosenblatt et al. expressed as “they [digital rights models] don’t do a great job of modelling the actual uses of content.” Maybe this is one of the necessary improvements of DRM systems in the future.

Licenses can have a strongly varying complexity reflecting everything from simple to complex rights situations. Therefore the language used for the description of rights should be able to model even very complex situations, which can appear easily when dealing with digital content (e.g. audio-visual material).

6.1. Rights description languages

Not only meta data description are stored in the XML format. Several rights description languages are based on XML too. An overview of different XML based rights description languages can be found at [CoverPages]. In this section we will shortly describe properties of some rights description languages.

6.1.1. DPRL

The “Digital Property Rights Language” [DPRL] was developed by Mark Stefik at Xerox Palo Alto. Xerox patented DPRL and a separate business unit attempted to commercialise it. This business unit became the separate company ContentGuard [ContentGuard]. ContentGuard modified DPRL and renamed it in XrML (cf. below). Besides supporting eCommerce DPRL main focus is to support the specification access and usage right or controls.

"DPRL is used to specify fees, terms and conditions governing the use of digital content. DPRL is extremely flexible and supports multiple business models and rights protection policies, giving publishers the flexibility they need for their current and future businesses. DPRL supports multiple pricing models: subscription-based, outright purchase, purchase of individual rights (view, print, copy, edit, etc.), metered usage, time-based usage, and membership pricing. DPRL defines syntax for specifying rights for a digital document. Rights such as 'play,' 'print,' 'copy,' 'edit,' etc. can be grouped into named 'rights groups'."

"The design goals for DPRL are: (1) To describe rights, fees, and conditions appropriate for the commerce models that are important to publishers and consumers in digital publishing. (2) To provide standard terms for usage rights specifications that have useful, concise and easily understandable meanings. (3) To provide operational definitions of specifications for vendors of trusted systems that distribute or render digital works, so that the compliance of systems can be tested and evaluated. (4) To provide a basis of extensibility to new language features in a manner that does not unduly compromise the other goals."

The following example was taken from [DPRL98]. The XML-based description is also readable for humans with bigger effort (depending on the file size). This requires some assumptions on the system, which interprets the rights, as the licensing information must not be modified. Therefore a “trusted” system is assumed, which handles the right information and the related content accordingly. The XML

documents describe works and related rights issues like *owner* or *rights-groups*. The rights are defined on the content and the operation like *play*, *copy*, or *loan*.

```
<work>
    <description>
        <title>Moby Dog</title>
        <author>John Beagle</author>
    </description>
    <owner>Murphy-Books-ID12345-zxcvoiuyr</owner>
    <rights-group>
        <rights-group-name>Consumer</rights-group-name>
        <rights-list>
            <copy>
                <next-copy-rights>
                    <delete>Distributor</delete>
                    <access>
                        <security-class>3</security-class>
                    </access>
                    <fee>
                        <per-use>10</per-use>
                        <to>Account-ID-678-qwerqeruyt</to>
                    </fee>
                </next-copy-rights>
            </copy>
            <play>
                <fee>
                    <metered>
                        <rate>0.05</rate>
                        <per>1:0:0</per>
                        <to>Account-ID-678-qwerqeruyt</to>
                    </metered>
                </fee>
            </play>
            <delete></delete>
            <transfer>
            </transfer>
            <loan>
                <next-copy-rights>
                    <delete>Distributor</delete>
                    <remaining-rights>Distributor</remaining-rights>
                    <access>
                        <security-class>3</security-class>
                    </access>
                </next-copy-rights>
            </loan>
        </rights-list>
    </rights-group>
    <rights-group>
        <rights-group-name>Distributor</rights-group-name>
        <rights-list>
          :
          :
         </rights-list>
    </rights-group>
</work>
```

A tutorial on DPRL is available at [DPRL].

6.1.2. XrML

The “eXtensible Rights Management Language” [XrML] was derived from DPRL. Obviously the description of rights and licenses with XML is expressed in its name. Similarly to DPRL a XML document describes a work and related rights. XrML 2.0 is extensible to address specific needs and can include other elements like resource-level metadata standards (e.g. ONIX or RDF). Rights expressions are authenticated (XML Signature) and protected (XML Encryption). Its flexibility is an advantage as it supports different business models. The following paragraph summarizes some aspects from the XrML Specification [XRMLSpec] freely available at [XrML] (see also [XrMLFAQ]).

A XrML document contains a license. This license contains a set of grants. These grants convey (respectively contains information about) certain principal rights to certain resources under certain conditions. The rights specify a class of actions that are allowed to be performed on the associated resource. These actions include rendering, transportation, and derivative work but also file (backup, verify, directory, …) or software management (install, uninstall). Conditions can be attached to the rights including access limitations, time limitations, transaction limitations, and territory limitations. Furthermore XrML is also able to address issues of watermarking and tracking. A simple example taken from [XrMLSpec] show how the license files for printing a specific book might look like.

```
<license>
        <grant>
                <keyHolder>
                        <info>
                                <dsig:KeyValue>
                                        <dsig:RSAKeyValue>
                                                <dsig:Modulus>Fa7wo6NYf...</dsig:Modulus>
                                                <dsig:Exponent>AQABAA==</dsig:Exponent>
                                        </dsig:RSAKeyValue>
                                </dsig:KeyValue>
                        </info>
                </keyHolder>
                <cx:print/>
                <cx:digitalWork>
                <cx:locator>
                        <nonSecureIndirect URI="http://www.contentguard.com/sampleBook.spd"/>
                </cx:locator>
                </cx:digitalWork>
        </grant>
</license>
```

XrML is used in several commercially available products including Microsoft's Unified solution, which is based on XrML. But more important are two other facts: First, MPEG-21's Right Expression Language (REL) is based on XrML. Regarding MPEG-21, XrML had to beat two further competitors: the Open Digital Rights Language ODRL and Real Networks' extensible Media Commerce Language (XMCL). ContentGuard also submitted the eXtensible rights Markup Language Version 2.0 to the the Right Language TC [OASISRLTC] of OASIS [OASIS].

6.1.3. ODRL

The "*Open Digital Rights Language*" [ODRL] also allows the expression of terms and conditions related to the usage of digital content. It is also independent of the content type. ODRL is also extensible. In contrast to XrML ODRL is an open free standard.

The ODRL rights information considers several core entities, including assets, rights, parties offers and agreements. Assets include any type of content that can be uniquely identified. The rights modelling considers permission, constraints, requirements, and conditions. Parties include rights holder, end users, and roles.

The ODRL specification was submitted to W3C. Before, XMCL (RealNetworks) was merged into ODRL. ODRL is the officially accepted standards rights expression language of the Open Mobile Alliance (OMA), which is again shows its role as competitor to XrML and Microsoft.

6.1.4. XMCL

RealNetworks submitted the "eXtensible Media Commerce Language" to MPEG-21 as a competitor to XrML. But shortly before the MPEG-21 meeting took place RealNetworks dropped XMCL. XMCL was merged with ODRL.

6.1.5. MPEG-21

Although MPEG-7 is more focused on meta data description but contains IPMP (Intellectual Property Management and Protection) meta data, MPEG-4 was the beginning the integration of DRM related functionality. In MPEG-4 interfaces (“hooks”) are defined. Based on MPEG-4, MPEG-21 models digital items and the interactions of users with these items (Digital Items Declaration, Digital Item Identification and Description, Content Handling and Usage, IPMP, Terminals and Networks, Content Representation, and Event Reporting). It introduces a Rights Data Dictionary and a Rights Expression Language (XrML). A detailed introduction can be found at [MPEG21].

6.2. Rights processing

Expressing the rights is only the first step. Ideally the rights are processed automatically whenever content is created, derived, or exchange. This cannot be achieved yet as different terminology – especially when dealing with multinational content – and even different legal foundations complicate an automation process. Thus a rights ontology or thesaurus is inevitable.

7. Encryption

Whenever data are transmitted over an insecure channel, which indeed is the Internet, the only possible protection mechanism is encryption. But attacks are not limited to the encryption algorithm itself. Also attacks are possible against keys or protocols. In this chapter we will address some general aspects of encryption to allow a basic understanding of distribution systems' requirements. Further details on encryption can be found at [Menezes96], [Schneier96], or [Wobst00]. Several brief introductions are available, e.g. in [Wobst03].

7.1. Cryptography

Cryptography is the art of encryption and is several thousand years old. Encryption transforms the content which are known an encryption algorithm or a cipher. Retransformation of the original message (or plain text) from the encrypted form (or cipher text) is known as decryption. To prevent others from reading the cipher text the method could kept secret or the algorithm uses a secret to determine the transformation. Kerckhoff [Kerckhoff1883] already formulated in 1883 that security by obscurity is not possible: Keeping the encryption method secret doesn't increase the security of the method. The security of an algorithm therefore must not be based on its secrecy but on the usage of a key.

Different methods exist:

- **symmetric** encryption methods
- **asymmetric** encryption methods

7.2. Symmetric encryption methods

Whenever data is exchanged communication partners agree on a common key for the encryption of the data as shown in figure Figure 6. As the same key is used for encryption and decryption by symmetric encryption methods (see also Table 1) everybody who has access to the key can decrypt encrypted data.

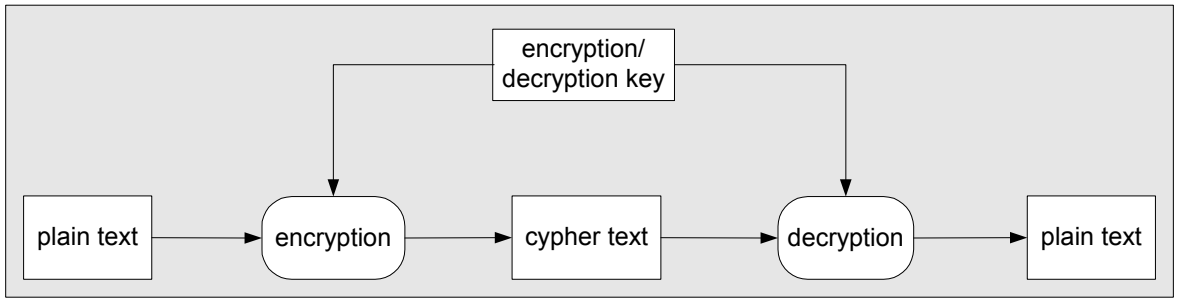


Figure 6: Symmetric encryption methods use the same key for encryption and decryption. The key determines the transformation for the plain text to the cipher text. Thus everybody who has knowledge about the secret key can decrypt cipher texts. Thus, everybody who has knowledge about the key can decrypt cipher texts, which have been encrypted with this key.

The *substitution algorithm* is probably the most famous symmetric encryption method: By using a table every character is replaced by another one. However, statistical attacks considering the distribution of digits in natural text can be used to attack this simple method.

A similar method is based on the *Vignere method*: Instead of using a fixed table a password determines the mapping. Each letter determines a certain "distance". With this defined mapping the password values are added to the initial certain "distance" data. The recipient can use the same key to decrypt the received data.

One severe attack is the knowledge of the encrypted and the decrypted data, that allows the calculation of the mapping and therefore the decryption of other encrypted messages. But also statistical attacks can be applied. Of course the security of this system depends on the length of the password or key. If the key has

the same length as the message maximum security is achieved. In this case the key is also called a one-time pad.

There are two main types of symmetric encryption algorithms that differ in the size of the data the cipher works on[17]:

- **Block ciphers** process a number of bits simultaneously.
- **Stream ciphers** process a single bit a time.

7.2.1. Block ciphers

Modern methods partition the message into blocks of a certain size. For each of these blocks a secret message with the same size is generated. To minimize the potential success of attacks the transformation from the message to the secret message considers the plain text and the key. Typically this transformation is repeated with a different key[18]. Typical block based algorithms are DES, 3DES, IDEA, AES, Blowfish, Twofish and RC6.

- **DES** was originally developed by IBM, modified by NASA and NIST and adopted as a federal standard. DES is a block cipher with the block size of 64 bits. The length of the key is also 64 bits, but as eight bits are used for parity the effective key length is 56 bits. Encryption: The plaintext block is split in two bitstrings with the lengths of 32 bits. One encryption process consists of 16 rounds. In each round a encryption function F is applied to one half with a certain independent round key of 48 bits length. For each round the independent round key is generated from the 56 bit original key. The result is XOR with the other half. The two halves are swapped and the process is repeated. In the last round there is no swap. Decryption is similar to the encryption process. However, the input subkey are applied in reverse order.

- **3DES**: Nowadays a simple DES encryption is no longer secure. Thus 1999 NIST defined 3DES, which consecutively applies three stages of DES. The effective key length of 3DES is 168 bits.

- **AES** replaced DES in 2001 and is a modified Rijndael encryption algorithm (with fixed block size). AES has a symmetric structure and can also be used on smart cards. Several rounds operate on the blocks. Each round includes:

  - **ByteSub:** Individual bytes are transformed with a high non linear function.
  - **ShiftRow:** Rows are shifted over four different offsets.
  - **MixColumn:** Bytes in columns are linearly combined.
  - **Round key addition** makes round function key dependent.

  As this new standard has been specified most systems would likely switch to that standard soon.

- **IDEA** is a block cipher for a block size of 64 bits and was developed at the ETH-Zurich in 1992. Its key length is 128 bit. The algorithm is base on mixing operations from different algebraic groups (XOR, addition modulo 2^{16} and multiplication modulo $2^{16}+1$). The same algorithm is applied for encryption and decryption. The mixing operations operate on 16bit subblocks, which was due to the fact that the operations should be also efficient on 16bit processors. It is faster than DES and considered as more secure.

- **Blowfish** was designed by Bruce Schneier with the aim to have a not patented encryption algorithm. It can handle a variable key length and its block size is 64 bits. The first part of the

[17] Yet this distinction is somewhat hazy as block ciphers can be used as stream ciphers and vice versa

[18] Different keys are used in different rounds. Therefore the keys are also called “roundkeys” and are generated from the general key

algorithm expansions the input key length by creating several subkeys. In the second part of the algorithm the data is encrypted by using a 16-round Feistel network[19].

- **Twofish** is a 128 bits block cipher. It accepts key lengths up to 256 bits. Twofish originated from an attempt to improve Blowfish. As Blowfish it is also not patented. It was a finalist in NIST's call for the AES algorithm.

- **RC6** was also among the finalists in NIST's call. It is a rather simple algorithms and the knowledge gained from RC5's analyses work incorporated. However, its performance is weaker than the Rijndael algorithm on certain hardware, e.g. including 8 bit and 16 bit processors. The algorithm is patented by RSA Security Inc.

7.2.2. Stream ciphers

Stream based encryption methods create a pseudo random bitstream by using a secret key. This bitstream is combined with the plain text with an XOR operation to create the secret message. The recipient repeats the same opertations to recover the plain text. One of the most important issues of this methods is the randomness of the bitstream. This method is used e.g. by A5 or RC4, which is used by the SSL-protocol. Block based methods can be also used as a stream based method.

- **RC4** was developed in 1987 by Ronald Rivest and was initially kept secret. It was designed for bulk encryption and is faster than most other symmetric functions such as DES. RC4 uses a variable length key that is used to generate a pseudo-random stream. This pseudo-random stream is XOR-ed with the plaintext.

name	*type*	*key length*	*speed*	*security*	*application*	*comments*
One-Time Pad	stream	plain text length	high	perfect	exceptions	the only proofable secure algorithm
DES	block	56 bit	HW: high SW: low	special HW attacks	common	key length is weak point
3DES	block	112 bit	HW: high SW: low	no attack known	common	-
IDEA	block	128 bit	Faster than DES	very high	common	Patented
RC5	block	variable	SW: high	Practically secure	some products	US patent, improved: RC5a
RC6	block	variable	SW: high	no attack known	some products	improved version of RC5
Blowfish	block	variable	SW: high	no attack known	common, e.g. Open Source	Free
Twofish	block	variable	HW/SW: fast	more secure than Blowfish	-	Free
AES (Rijndael)	block	128-256 bit	HW/SW: very fast	Theoretical weaknesses	common	DES's successor

Table 1: Symmetric encryption algorithms

[19] A Feistel network is key dependent mapping from an input string to its permutated output string.

7.3. Asymmetric encryption methods

The general problem of the symmetric schemes is the exchange of secret keys. As the secret keys has to remain secret transmission of keys in plain text is not possible. This problem is addressed by public-key or asymmetric encryption methods.

Asymmetric encryption methods use two keys (as shown in Table 2):

1. The public key is for the encryption of data. This key can be distributed freely.
2. The private key is used for the decryption of the data.

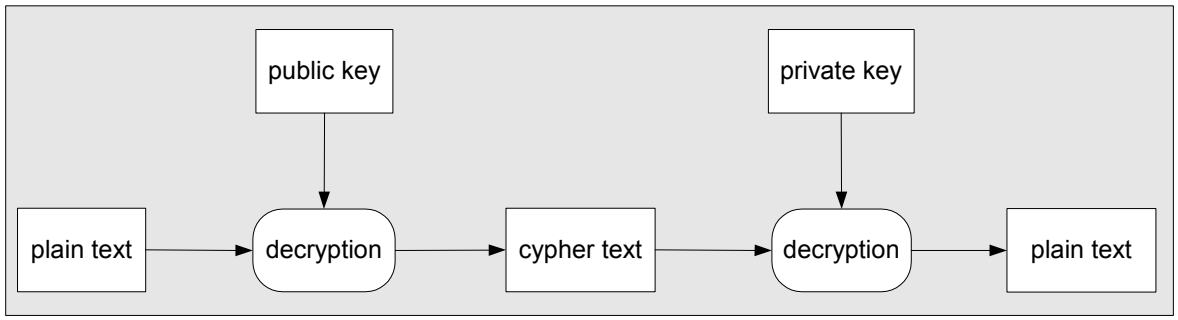


Figure 7: In contrast to the symmetric encryption algorithm the asymmetric encryption methods use different keys for encryption and decryption. The public key can be accessed by everybody interested in encrypting a message for a certain receiver. The private key is kept secret.

Thus, no keys have to be exchanged. One can even think of a "telephone book" that publishes the emails addresses and the corresponding public keys. However, public key encryption is computation expensive.

The existing solutions for the asymmetric methods are based on the computation of mathematical calculations which are extremely difficult for very large numbers.

- **ElGamal**
- **RSA**
- **Elliptic Curve Ciphers** (ECC) probably will replace RSA in the future.

name	*key length*	*speed*	*security*	*application*	*comments*
RSA	mainly 1024 or 2048 bit	very low	till now: secure	most important method	based on factorisation
ElGamal	mainly 1024 or 2048 bit	very low	till now: secure	Broadly used	based on discrete logarithm
Diffie-Hellmann	none	very low	till now: secure	broadly used (IPsec, SSH)	like ElGamal but only for interactions

Table 2: Asymmetric encryption algorithms

7.4. Key length

Generally longer key lengths provide higher security. But this is not necessarily the case as this property is influenced by several issues including the design of ciphers or the suitability of keys. Especially the comparison of different ciphers based on the comparison of the key lengths is meaning less. One example is public key algorithms' key length: They require much longer key lengths than symmetric algorithms.

7.5. Cryptoanalysis

Cryptoanalysis deals with the analysis of cryptographical methods. For example, the "brute force" attack is a straight forward attack that calculates and verifies all possible keys. Of course this can be very time-

consuming but for certain encryption algorithms hardware was developed to speed up this task and even distributed calculations that use a huge amount of computers connected via the Internet are performed. A method can be considered as secure when the most effective attack is the "brute force" attack. However, cryptoanalysis is not limited to the decryption of the secret message: collecting any kind of information which can be collected about the secret message.

7.6. Dangers and attacks

The security of all asymmetric encryption methods depends on the complexity of the computation of mathematical problems. Therefore a "tricky" calculation or quantum computers might endanger the security of all asymmetric encryption methods in the future.
Besides this potential risk modern encryption algorithms don't have any potential security leaks that can be exploited. Therefore attackers exploit other leaks like the above mentioned randomness of a PRN generator. Other possible leaks are cryptographical protocols, chosen keys, short pass phrases, ... Besides these attacks even more sophisticated attacks are applicable like the power consumption or the time delay of cryptographic coprocessors.

7.7. One-way encryption

Encryption with one-way algorithms[20] cannot be reversed. Typical applications are scenarios, where the plain text must not be recovered and include the storage of passwords. One of those one-way hash algorithms is the secure hashing algorithm (SHA) that creates a 160 bit hash value. As these one-way encryption functions typically base their calculations on a password they can be used to sign data with a digital signature.

7.8. Applications in DRM systems

Encryption technologies are primarily used to secure the communication between different parties and the storage at the parties' storage media. While this makes generally sense in business environments, concerns has to be raised to the encrypted storage of content at the consumers' side. As consumers access the encrypted data an unencrypted version must be temporarily available in the memory of the computer. Consumers capable of handling debugging software are able to access this decrypted content as long as "trusted solutions" are not available (cf. below).

Besides the secure communication and storage of content encryption technology is used for further applications:

- verifying content based on digests
- verifying identities based on certificates
- verifying identities and content based on signatures

[20] These algorithms are also known as one-way hash algorithms.

8. Watermarking

Besides the active protection technologies like the encryption described in the previous chapter passive protection technologies provide further possibilities. They address the identification of content or the identification of content owners. Thus they do not prevent copying per-se. However, these mechanisms can be used for the detection of IPR infringements as shown in the latest movie piracy case: Caridi distributed several Oscar screeners - among them were „The Last Samurai“, „Shattered Glass”, and „In America“ – illegally, which were further distributed on the Internet in illegal file-sharing networks. This chapter describes digital watermarking techniques, which are techniques that actually mark content.

8.1. General principle

Digital Watermarking embed data in digital media either perceptibly or imperceptibly. As perceptible watermarking techniques influence the quality as well as they have limited robustness we will limit this discussion on imperceptible watermarking techniques.[21] Imperceptible digital watermarking methods and steganographical methods embed information in a carrier. This carrier can be abstracted as an information carrier. Therefore theories well-known in communications engineering can be applied to this type of communication. In contrast to steganography, whose most important requirement is the undiscovered communication, information about the communication can be available with watermark techniques. This knowledge leads to increased requirements on the robustness and the security of the communication respective of the embedded message.

The application scenario determines the content of the watermark. For the protection of intellectual property typically information about the rights holder is embedded. Although information about the content itself or a link to this meta data can be embedded, which supports the identification of content. Other scenarios embed information relevant for authentication[22] or even information related to marketing and PR.[23]

8.2. Characteristics and requirements

The general principle of watermarking methods can be compared with the symmetrical encryption. Both methods require the same key for encoding and decoding the information. A watermarking system consists of two sub-systems: the watermark writer (encoder) and the watermark reader (decoder).

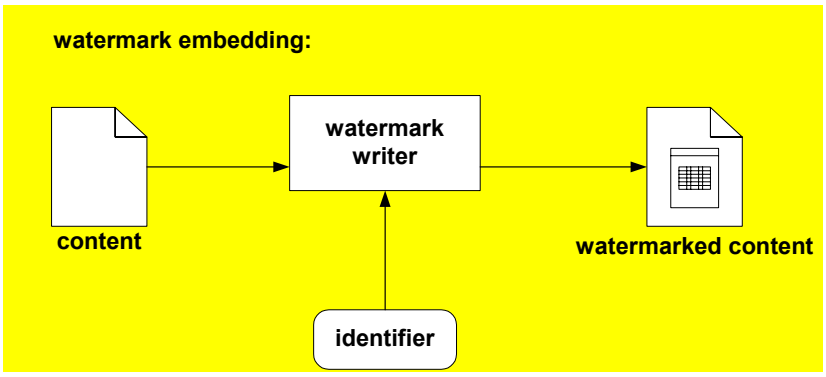


Figure 8: During the watermarking embedding process the watermarking message is interwoven with the original content. Thus, the resulting content differs from the original one.

The embedding process is shown in Figure 8. Important for the watermarking techniques is the fact that watermark message (the identifier) is embedded in the content. This is the message, which is read during

[21] More or less a perceptible watermark in music scores already exists: the copyright information.
[22] Typically a soft-hash or perceptual hash value is embedded, which is another term for fingerprinting.
[23] A watermark in an image or audio can be used to start a plug-in in a web browser for automatic linking the content to a certain website.

the retrieval process as shown in . This has severe implications to the protection scenario as content that is already distributed has to be considered carefully.

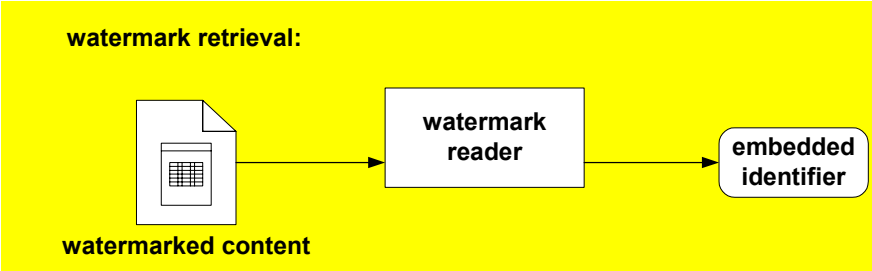


Figure 9: During the retrieval process the embedded watermark message is restored.

The retrieval processes (as shown in Figure 9) differ in the detection itself and the number of input parameters. Blind[24] detection schemes require only the marked content and the detection key for the detection. In contrast to the blind detection schemes the non-blind[25] methods require in addition to the previous parameters the original and sometimes the embedded watermark message. Semi-blind methods require in addition to the blind detection schemes parameter the watermark message.

Non-blind methods are practically only interested for a very limited number of application scenarios due to the necessary input of the original. In the typical application scenarios – like broadcast monitoring or the automatic identification of the copyright owner – the original is either not known or not immediately accessible.

As already described before, watermarking techniques have additional requirements on the robustness and security. General requirements on a watermarking technique are:

- The *quality* can be considered as the most important criteria. In general the embedding of a message in content should not affect the perceived quality of the content. As perceived quality always depends on the media type watermarking techniques have to be developed or adapted to individual media types.

- The *robustness* is defined by the types and numbers of operations (and their parameters) applied to the watermarked content, which can be survived by the watermark message. From a watermark developer's and user's view these processing operations are called attacks. Depending on the intention of the operations they can be distinguished between intentional and unintentional attacks. Although an attacker has numerous attack operations available, their combination and their parameters can not be chosen arbitrarily as the result also has to fulfill a certain quality requirement. The operations a watermarking scheme should be robust against are defined by the individual application scenario. For the identification of content and protection of IPR robustness can be considered as the second most important criteria.

- The *capacity* is the amount of information, which can be embedded in the content. It is the third most important criteria. Due to the mutual dependencies between quality, robustness and capacity, a certain quality level is defined (according to the application scenario) and the robustness is chosen dependent on the deserved quality. Capacity is finally defined by quality and robustness.

[24] Blind watermarking schemes are also called "public" watermarking schemes.
[25] These are also called "private" watermarking schemes.

- The *complexity* of an algorithm is important for certain application scenarios where real time embedding or detection is important.

- The *security* of a watermarking scheme does not only depend on the robustness but also on other issues like the message embedded. Also its implementation and integration into the overall system cannot be neglected.

We do not go into details of the individual technologies. General information on watermarking techniques can be found in [Katzenbeisser]. Cox et al. [Cox2002] provide a detailed technical inside on watermarking schemes for images. A application oriented introduction and detailed information about requirements and application scenarios can be found in [Arnold2003].

8.3. Limitations

Although watermarking schemes have some obvious advantages for certain application scenarios as they can embed arbitrary information direct in content. Also they can survive processing and media conversion, which makes them very suitable for embedding meta data information. But compression techniques can be regarded as competitors as they eliminate imperceptible information thus future developments might have strong effects on the embedded content.

For the usage together within IPR protection scenarios they have some drawbacks. For example the robustness of watermarking schemes might not be sufficient and an attacker can be able to remove – or maybe copy – a watermark message. However, he cannot be 100% secure about the success of his attack. Additionally content has to be watermarked before retrieving a watermark message is possible. Whenever data is already distributed, which is the case for all current media types, a redistribution of watermarked data is necessary. Surely this can be done if new media formats like SACD or DVD-Audio are established.

As watermarking methods always have to respect the perceived quality the have to be developed or adapted for each individual media type. Yet for some media types (e.g. text or music scores) a watermark embedding is difficult.

Currently objective tests and performance analysis of existing watermarking techniques available are only addressing a limited scope. These benchmarking suites like [stirmark] or [Certimark] do not fully consider practical requirements. Here standardized application scenarios defining requirements would be advantageous. Another limitation is the missing standardisation of the embedded information, which can be solved easily.

8.4. Applications in DRM systems

Although watermarking techniques must be developed for individual media types a broad range of watermarking algorithms are available for various media types including, audio, images, video, geometry data, text, music scores, etc. Several requirements can be addressed by integrating watermarking techniques into DRM solutions (see also [Rosenblatt2002]):

- *Source identification* can be achieved by imperceptible watermarking techniques, which do not affect the perceived quality. The information embedded links to the content owner or to a rights owner.

- *Tracking and tracing* by embedding so-called transaction watermarks, which is information about people involved in transactions, might allow the detection of leaks within the distribution chain.

- *Meta data* labelling is probably the most interesting application of watermarking. The watermark message stores a link to a database containing meta data information.

From a security point of view we consider applications involving encrypted watermarks and encrypted files with watermarks critically if they are used for access control in end user devices. Yet, Rosenblatt et

al. concludes “a scheme that incorporated both encryption and watermarking is not foolproof, but (all else being equal) it’s the best DRM scheme available” [Rosenblatt2002].

9. Fingerprinting

In contrast to watermarking techniques, which modify content, fingerprinting techniques can identify content without prior modifications. Thus they have an inherent advantage if used in application scenarios where content is already distributed without a watermark but an identification of the content is necessary. In this chapter we explain shortly the idea and application of fingerprinting technologies.

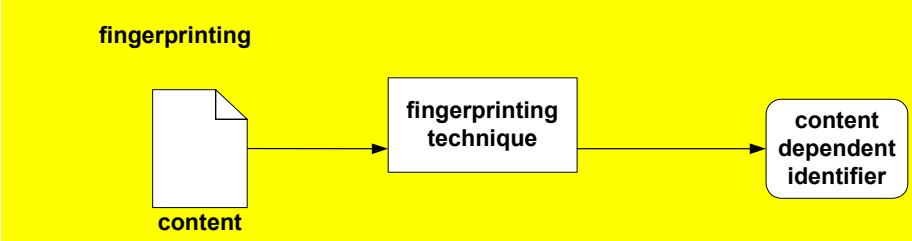


Figure 10: The fingerprinting method calculates the content dependent identifier directly from the original content. Thus the content has not to be modified.

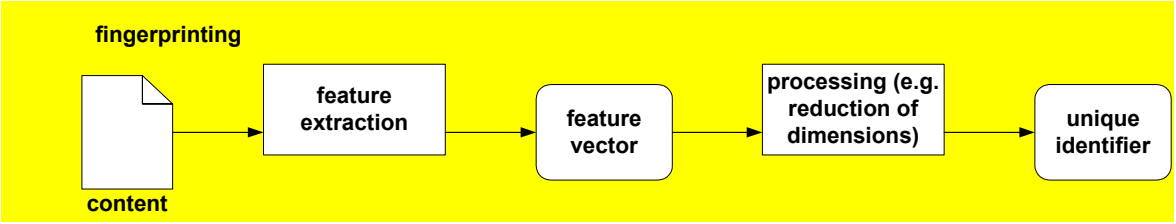
9.1. General principle

Fingerprinting techniques calculate a content dependent identifier as shown in Figure 10. This content dependent fingerprint can be compared with a human fingerprint: It is a unique identifier for renderings and the original content cannot be created from the identifier. Thus these techniques are also related to the cryptographical hashing functions. But cryptographical hashing functions have the important property that closes input values to not result in close hash values. For fingerprinting techniques the opposite requirement must hold. Therefore they are also called perceptual or soft hashing functions.[26] Perceptual hash reflects the fact that perceptual similar content should result in a similar hash value.

Due to these properties fingerprinting solutions are very suitable for automatic play list generation, broadcast monitoring. But other applications can be thought of e.g. tracking the content flow or even restricting the content flow (e.g. in corporate networks). Due to these characteristics fingerprinting techniques attract increased attention recently.

9.2. Characteristics and requirements

Fingerprinting techniques are related to content based retrieval (CBR). CBR methods also create a content dependent signature directly from the content, which also depends on the perception of content. This signature is also compared to pre-calculated and stored content signatures. Figure shows the principle steps necessary for the calculation of a unique identifier. First, features are extracted from the content. These extracted features typically have very high dimensions and are processed further resulting in unique identifiers.



The feature extraction process itself can be quite close to the human perception and extract features which are directly perceived by humans, like the frequency distribution for audio. On the contrary features which do not directly depend on the human perceptions can also be used, as long as they allow the discrimination of content. A typical example is the sign of the difference between neighbouring energy bands as proposed by [Philips].

[26] Sometimes even the term “passive watermarking” is used, which we consider as bad as no mark is embedded. l

If the complete information is used, the dimensionality of the feature vector would be very high. Therefore the dimensionality is reduced by removing redundant information. During this processing step further improvements, e.g. error resilience, can be achieved. The resulting feature vector should fulfil the previous listed requirements for fingerprints. A good feature vector has a increased robustness against noise resulting from the content acquisition (e.g. recording).

In addition to the feature vector a suitable distance measure is necessary. This is also related to CBR methods, where similarity has an important role. As typically a huge amount of data has to be identified, the scalability is important. This influences the features' choice, the distance measure as well as the retrieving architecture. Typical distance measures used are the Euclidean or related distance measures or distance measures based on correlation. The retrieving architecture also strongly influences the complexity and the scalability of the fingerprinting technique. Efficient spatial access structures were developed like indices or application oriented approach like the ones used for DNA information processing. A final hypothesis test calculates the probability of the correct identification of the content.

As the sole purpose of fingerprinting techniques is the identification of content, a good performance in discriminating a huge a mount of data and corresponding fingerprints is crucial. Similarly to watermarking techniques requirements can be identified:

- The *robustness* can be defined by the types and numbers of operations and their parameters applied the content, which does not effect the retrieval of the content. Typical operations depend on the application scenario where the fingerprinting method will be integrated in. For example when a system should be able to recover the song from a radio transmission that is recorded via a mobile phone the fingerprinting system should be capable of the reduced frequency band available due to the mobile phone. Also small audio extracts somewhere within the song must not result in misidentification as humans will rather realize in the middle or at the end of the song that is worth being remembered or purchased. Finally a noisy background will probably be the general recording place e.g. in a car, bar, club, or café.

- The *scalability* is an important criterion. For general data, e.g. audio millions of different types of content exist. Some of them are even available in different editions, e.g. studio or live performance recordings. Ideally a system is capable of handling all available works in a reasonable amount of time, where "reasonable" is again defined by the application scenario.

- The *complexity* of an algorithm is important for certain application scenarios where real time identification is important.

9.3. Limitations and comparison to watermarking

Different limitations have to be considered when integration fingerprinting technology. As already mentioned, fingerprinting techniques do not modify the content but calculate an identifier directly from the content itself. This is an obvious advantage when content is already available in an non-marked version. Yet, this is also a drawback in comparison to watermarking schemes. Personalisation is not possible. This has an influence e.g. an the tracking. Although content can be tracked, tracking users is not possible as content is generally not unique for individual users.

Instead of being marked content must be registered. That means that only content can be identified if its fingerprint was previously calculated and stored in a database.

Another limitation of these fingerprinting techniques have to consider when using fingerprinting controlling the data transfer networking infrastructure: encrypted content or scrambled content can not be identified. Identification is only possible with content that is accessible as it is intended for rendering.

A comparison between the different properties of watermarking and fingerprinting is shown in Table 3.

	Watermarking	Fingerprinting
Development	Has to be developed for individual media types	
Availability	Audio, video	Various media types
Alteration	Content alteration	Not necessary but registration
Registration	Not necessary (cf. alteration)	Prior to identification
Attacks	Vulnerable	Limited vulnerability (perceptual features)
Capacity	Varying on content (minimum requirement should be 64bit for creating a link)	Indirectly in the content and the method's ability to discriminate content
Infrastructure	Depending on application	Needed

Table 3: principle characteristics of watermarking and fingerprinting schemes

9.4. Applications in DRM systems

Besides the above listed applications of fingerprinting systems in automatic play list generation, broad cast monitoring, content tracking and content flow limitations another application is very interesting for fingerprinting techniques: royalties distribution. Content can be monitored in peer-to-peer networks with the help of fingerprinting techniques. This information can be combined with other information available e.g. meta data within the peer-to-peer networks used by humans for content identification. Keeping in mind the future revenue stream new possibilities can be created when new technologies are considered as discussed in chapter 11.

10. DRM Technologies

In this chapter we describe the principle components of DRM systems. This general principle is more or less underlying each implementation of a DRM system. The typical parties involved are the content owner who distributes content, the customer or the consumer who purchases content, and a clearing house that manages licenses. For simplicity we assume that the content owner is also the content distributor, which is not generally the case. If this is not the case, the relationship between the content distributor and the content owner will influence the DRM architecture as content can be exchanged between these two parties at different security levels.

10.1. General aspects

Sellers of traditional goods benefit from online shops as they accessible without any time constraint. Product information as well as purchase related information can be made available. But not only traditional goods can be sold on the internet. Especially content providers of digital content have a general interest in and strongly benefit from online distribution. Several advantages can be identified including:

- availability: 24 hours a day and 7 days a week
- reduced costs: not only complete collections are sold
- try before buy: customers can have a pre-listening/preview
- customer relationship: direct contact to customers like personalized offers, increased feedback possibilities, ...
- reduction of shipping costs
- only a small storage space is need: data fits on a hard disk and must be stored only ones

Due to the fact that the content itself is valuable content providers deserve a secure distribution. Therefore content is encrypted before distribution. Distribution can be done in various ways among them is download or email transmission. For rendering content a licences is needed which can be stored locally or on a remote server. Also the customer is not limited to certain devices. As mobile phones become more and more multi-media devices potential customers might also want to access data via mobile phones. This is a general problem today. Customers don't want to be restricted by protection solutions. As most available distribution platforms strongly restrict customers (e.g. content can be rendered only on one certain device) in the customers' view DRM is the acronym for "digital restriction management".

When analysing the security of a system, different assumptions have to be made as described in [Arnold2003]. These assumptions include the knowledge of the attacker. However, this is quite difficult to estimate as software patches ("hackz" or "crackz") can be often downloaded from the Internet. This allows even users with almost no knowledge to circumvent certain protection mechanisms. Furthermore the applied security solutions can be secure while the runtime system isn't secure at all. This allows potential hackers to successfully attack the runtime system while not interfering with the applied security solutions. Thus, a secure system is vital for the security of content. Therefore the hardware industry is targeting at secure devices[27].

10.1.1. DRM architecture

The general architecture of a DRM system is shown in Figure 11. Primary technology components can be identified (according to):

- *Packagers*[28] collect license information, meta data and the requested content in encrypted files. These secure files are called packages, containers, etc.
- *Controllers*[29] realise local rights management systems at the client side and are responsible for authentication of the device or the user, decryption of the content, provision of access to the content and sometimes for financial transactions.

[27] These secure devices are also called trusted devices reflecting the assumption that trusts in the security of the systems can be provided.
[28] or content servers

- *License servers* or clearing houses are run by third trusted parties and create and distribute licenses that grant access to the requested content via the local rights management system and can also contain access conditions.

As described by Rosenblatt et al. a broader definition of DRM encompasses everything that can be done to define, manage, and track rights to digital content. Thus further elements are included in this definition:

- *Business rights* (or contract rights) are typically associated with some content in certain scenarios. E.g. the right to use a certain audio sequence in a commercial spot might be granted while processing of the audio sequence is prohibited.
- *Access tracking* or tracking of operations on content provides valuable information for content providers even if the do not charge for access to the content. This information also helps to improve business models or relationships to customers.
- *Rights licensing* is an important issue especially when content can be modified and is redistributed. However technical solutions are strongly limited, e.g. when the modification is translation.

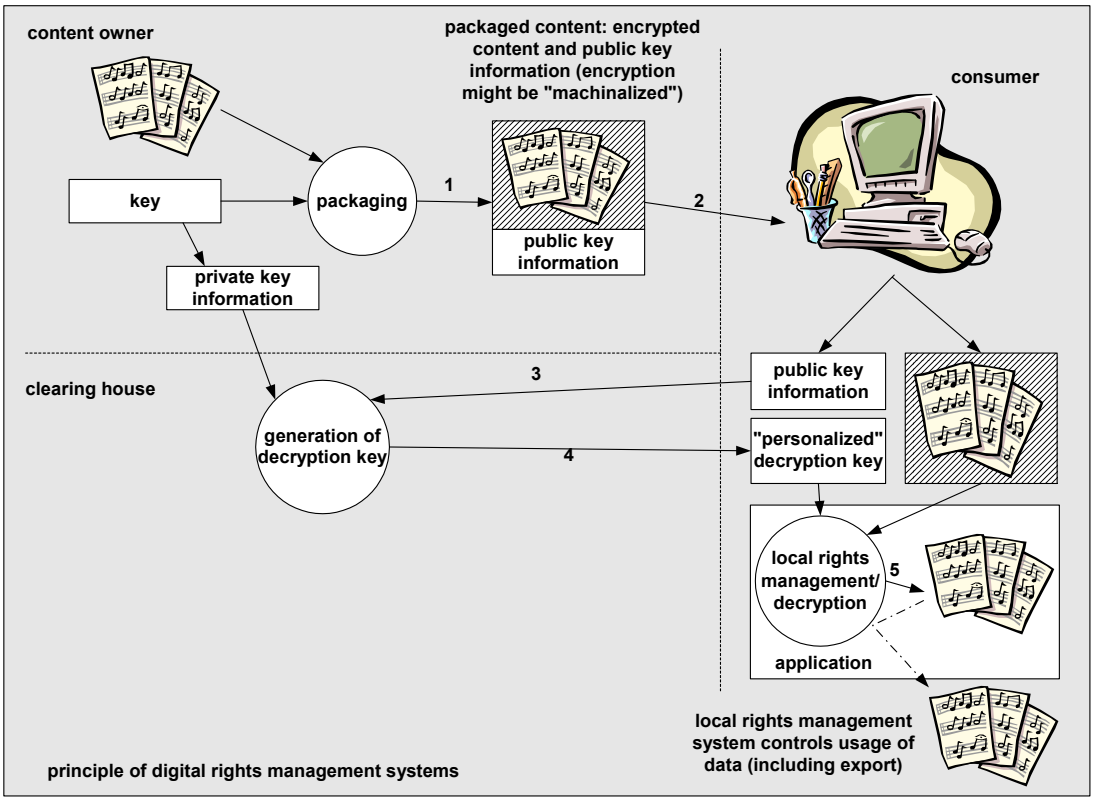


Figure 11: This figure illustrated the principle architecture of a DRM system. The important aspect is that content is always encrypted outside of the DRM environment. Whenever an application wants to access information, the local rights management system is called to decrypt the content and it also influences the functionality of the application. Thus a user cannot access any data outside the DRM system.

10.1.2. Content owner

Whenever content is distributed this content is encrypted using the methods described in chapter 7 and the encrypted content is transmitted to the customer with public information about the encryption key. This process is called “packaging” and is step “1” in the figure. However, this is just a very minimalist view on the package and the packaging. Typically rights information is also included in the package to permit or to restrict certain types of operations, certain operations intervals, or the amount of operations as well

[29] or DRM controllers

additional product information (metadata). This rights information is stored in the license. Possible rights description languages are described in chapter 6.

Content is stored in a repository. Either the repository is built within the DRM solution or it is part of a CMS system. If a CMS stores the content and the packaging system is not able in managing arbitrary file types the storage format of the content must be chosen according to the capabilities of the packaging respective the DRM system.

Again, it is also necessary to protect the content distribution system. Typical attacks might come from the Internet. These attacks can be faced by a well configured firewall. Yet, attacks from users with physical access to the content distribution system are also possible. Thus, trust in the people working at the content distributor's side is also necessary.

After packaging, content is distributed to the consumers. This can be done using different transmission channels. The Internet via download is probably the most common channel. But also a transmission via email, floppy disk, or CD is possible. The transmission processes is indicated in step "2".

10.1.3. Consumer

Whenever the consumer receives the content it is initially useless for him as it is encrypted. Thus, he needs the decryption keys. Of course it is possible to distribute the keys directly to the customer. Yet, this would reduce the security of the system drastically. Therefore a local rights management component is responsible of this task. This component requests they keys from the clearing house (step "3"), which is a third trusted party. To increase the security this local rights management component is unique and can be identified. Thus personalised keys are send to the local rights management component (step "4"), which makes them only useable for one certain local rights management component.

After receiving the decryption key the content is decrypted. For security reasons neither the decryption key nor the decrypted content[30] must be stored locally. Therefore a strong connection between the local rights management component and the application rendering the content is necessary, as content exchange is not only possible via files but also through other channels, like the clipboard or via screenshots.

We'd like to stress that the previous described functionality is not restricted to a personal computer. It can also be deployed in other devices. But certain – e.g. mobile – consumer devices will result in certain requirements on the complexity of the involved algorithms as there computational power is weaker and the usability of devices is directly correlated to the execution speed of certain operations.

One important aspect – not only when dealing with mobile devices – is the problem if the DRM solution should also be functional in an offline environment. This requirement increases security threats considerably.

10.1.4. Clearing house

The clearing house enables the consumer to render the content. The minimalist version transmits "personified" decryption keys to consumers. A more sophisticate version considers licensing issues: The valid content usage period or the amount of rendering. The clearing house is also able to initiate financial transaction, e.g. when pay-per-use is demanded in the license.

10.1.5. Rendering applications

As described above, a strong connection between the local rights management is necessary. In [Rosenblatt2002] different rendering applications are distinguished: standalone, plug-in, and java rendering applications.

- *Standalone* rendering applications allow a maximum control of the content. Yet, this advantage has to be paid with several drawbacks: First, the software has to be distributed to the consumers. Second, the

[30] Local storage of the decrypted content depends on the business model. Some business models might allow this. Some might only allow local storage with poor quality (e.g. strongly compressed audio files).

consumer has to install the proprietary software on his hardware. Generally, users prefer ready-to-use solutions. They don't want to be bothered with technical details.

- *Plug-in* rendering applications are common solutions, which integrate themselves into existing software. As a direct consequence the functionality of the "hosting" software is augmented. In the case of DRM plug-ins it is able to render a increased number of files types. Of course, the plug-in has to modify the "hosting" software's behavior to control data exchange and to avoid any content leakage.

Unfortunately these solutions have to be developed for each hardware platform. From a content distributor's point of view *Java* combines the advantages of standalone and plug-in applications and additionally throws away the hardware dependency as Java programs are not run directly on the microprocessor but are executed on a simulated processor, which is called the Java Virtual Machine (JVM). DRM solutions implemented in Java can be run on every processor for which a JVM exists.[31] Today this is the case for most web browsers. Although [Rosenblatt2002] et al. raise the problem of incompatibilities, we think that an efficient platform independent DRM solution implemented in Java is possible.[32]

10.1.6. Security issues

Above we already addressed relevant security issues. But as the main purpose of a DRM solution is the protection of content respectively its license conform usage we further investigate this problem within this section. Security is always related to certain assumptions. For example, the above described assumption of the technical skills of an attacker. But other security issues are directly related to the user and the involved hardware and software platforms.

Digital rights management systems for general content distribution scenarios require the identification of the user. E.g. this is very important for secret information exchanged within a company. Similarly a identification of a customer is important in the music distribution scenario as consumers can be seen as business partner. For the business transaction a credit card number might be sufficient. But if the content's usage is limited to the person who purchased information about the person rendering is necessary. This information may be a simple email address, a user ID, a password, or other personal information. In other application scenarios biometric identification systems are used. E.g. one can think of personalized mobile devices with biometric sensors: a "lost" mobile device is useless for its "finder". Yet, simple biometric solutions – and these are all current the solutions which can be integrated into mass products for monetary reasons – can be easily fooled. Other solutions exist, like the "typewriting style" are considered by music distribution solution providers [MUSICRYPT]. For identification other possibilities include digital certificates (created by a third trusted party) or smart cards.

Besides user identification device identification plays an important role. This can be done e.g. by a unique identification number or by the Media Access Control (MAC) address[33]. The advantage of using the MAC address instead of the IP address is the fact that IP addresses can be dynamic addresses and also an IP addresses can correspond to multiple users.

But device identification is not sufficient at all. One aspect that is generally neglected is the device integrity. The device integrity includes hardware as well as software integrity, which is very difficult. First, hardware and software are under total control of a user.[34] But even if the customer is trustworthy, "external influences" like Trojan horses might violate the device's integrity.

The problem of the device integrity is addressed by the "trusted computing" activities like the "Trusted Computing Group" [TCG], "Trusted Computing Platform Alliance" [TCPA], or "Next Generation Secure

[31] Of course the processing power must be sufficient.
[32] The incompatibilities between Microsoft's Java version and Sun's Java version were mainly due to a "misinterpretation" of the Java specification.
[33] The MAC address is a unique value associated with a network adapter and are also known as hardware addresses or physical addresses.
[34] At least this is the case nowadays. This might change in the future if the "trusted computing" initiatives succeed. Yet consumers have to pay for this technology and they do not only benefit from it.

Computing Base" [NGSCB]. This is typically assumed as a precondition, e.g. in [DPRL98]: "DPRL assumes a trusted environment, and part of Xerox's licensing activity centers around toolkits that enable construction of that environment.'Trust' simply means that the agents performing users' actions on an object must honour the rights specification for that object --- the agent must charge the user if that is specified, or prevent the action if the appropriate right code is not present. Trusted implementations can obviously range from individual trusted rendering tools all the way to a fully trusted network environment." Yet, this is difficult to achieve, especially whenever the hardware and software cannot be fully controlled, which is the usually the case whenever a consumer owns a device.

The "trusted computing" idea, which is supported by the most hardware and software players, aims to a standard for a "more secure" PC. Although this goal is very important in commercial scenarios (e.g. document security, information assurance …) such a standard is ambivalent for consumers [TCFAQ]. The danger is that control of individual hardware is transferred from the hardware owner to other parties like the software vendor implemented the operating system or the content industry in general. While this is interesting for content distributors, consumers might neglect this standard as from there point of view the system is less trustworthy and what is even more important: somebody has to pay for the additional components. The resulting trusted devices will not allow access to decrypted data, e.g. through debugging software, will not start modified software, and they will also control the input and output devices.

10.2. Integrating DRM systems with existing systems

Although DRM systems can be used as stand-alone solutions it is more fruitful to combine DRM systems with other systems to maximize their common benefit. As DRM systems manage content access they can be used whenever content is involved. Thus DRM systems address the complete content "life cycle" and related tools or systems, including:

- Content Creation Tools
- Content Management Systems (CMS)
- Customer Relationship Management (CRM)
- Web publishing systems
- Access Control
- …

In companies typical a certain workflow process was established. As modifications of an existing workflow process is very expensive or maybe not possible, deploying DRM systems mustn't result in any change. This is even more important when techniques or solutions are applied for the protection of content. The protection level of some protection technology is time depending – it might depend on the time and effort attackers spent in breaking it. If some content requires the highest protection level, the involved protection technology must be updated regularly. Therefore changes of the workflow process are not bearable. But DRM systems must not only fit in the workflow process but should also support it.

10.2.1. Content creation and management

In business application scenarios dealing with content creation and management DRM technology can be integrated in the content creation tools and the content management system. The main motivation for this is that content is always stored together with meta data. This meta data may include contract rights or licensing rights.

As an alternative, rights meta data can be created by a manual input. Yet, manual input is expensive as well as error-prone. Thus a DRM system allows the automation of meta data creation and improves its consistency even if compound works are created. For example an audio visual presentation might contain several individual images, video sequences, songs and speech, which have their individual rights. Content creation and authoring software involving a DRM system can automatically deal with these rights issues and also solve problems when extracts of such a kind of audio visual sequence are created.

Besides the storage of rights in a DRM system fingerprinting and watermarking technologies can link media to the corresponding set of rights. Thus even a link between the rights and the rights is possible

when a media break happened. These Content Management Systems (CMS) integration issues are addressed in [Rosenblatt2003a] and [Rosenblatt2003b].

10.2.2. Web publishing and customer relationship management

Deployment of DRM solutions in consumer related areas typically involves the sales of digital content. This has to be done via an online catalogue or portal. DRM solutions provide the necessary technologies to achieve different business models that better suit the wishes of customers. These business models may include subscription based services, free time-limited trials, or pay-per-rendering and can be chosen independently for different customers.

Further improvements are possible when DRM technologies are integrated with Customer Relationship Management systems. Therefore the offers can be chosen exactly matching the customers' behaviour. E.g. whenever a customer purchases a rendering right for a certain content, free time-limited trial rights can be created for related content. Also the prices for products can be adapted to the usage allowing a subtle change between pay-per-rendering and subscription based services. [Rosenblatt2003a] and [Rosenblatt2003b] also address these distribution issues.

10.2.3. Access control

Access Control is a desired criterion for content providers and content owners. Yet, this is not a desired criterion for customers as they generally do not accept any restrictions on content they purchased. Also, access control might also interfere with privacy as discussed in [Cohen2002] and considered in [EUDirective]. Thus we don't go further into details of this issue.

Another aspect of access control is from a company's point of view that wants to keep confidential material within the company. Thus Enterprise Content Management (ECM) can be regarded as an application which very strongly demands efficient rights management systems. Thus [NGSCB] and [TCG] lay the necessary foundation for a secure environment within business applications.[35] As the computers involved in this area are under the control of one administrator the security assumptions within this scenario are different from the previous scenario. Also DRM systems do not interfere with privacy in this scenario. But DRM systems might interfere with other laws as access to information can be limited to a certain time-interval.

[35] Other possible consequences, e.g. software monopoles, have to be considered carefully and a thorough observation is necessary to avoid negative effects to economy.

11. Outlook

Return on investment (ROI) or return on capital employed (ROCE) plays an important role for non-profit as well as for commercial organisations. Both judge solutions' and technologies' benefit according to their ROI. ROI is even more important if venture capital is involved or a company is listed in the stock-market.
One problem of general security solutions is to measure this return on investment. Costs for new technology can be measured accurately but what about the saved amount of money? The problem return on security invest (ROSI) is currently highly debated. Some information on ROSI can be found at [ROSI2003]. This situation is even compared with the problem of selling fire sprinklers at the end of the 19th century: "[Parmalee] realized that he could never succeed in obtaining contracts from the mill owners ... unless he could ensure for them a reasonable return upon their outlay," [ROSI2003b]. In [ROSI2003c] some guidelines are given including "How to do it", ROSI a spreadsheet for the ROSI Model and a references on contemporary research.

As DRM is belongs to the category of security mechanism the same problems arise here. Yet, additional return on investment factors can be identified:

- cost saving resulting from electronic stock
- cost saving resulting from traditional content delivery (including packaging or redelivery)
- flexibility and scalability of the online solution (business model can be changed or adopted easily)
- improved services to customers (e.g. availability, transmission speed, …)
- improved customer relationship management
- improved monitoring capabilities
- improved brand loyalty

Again, some returns are difficult to measure. But it should be clear that the benefit of a modern distribution and DRM solution is far beyond the return by protection of content after the point of purchase.

11.1. The future solution

In the previous chapter we described those general principles of DRM systems. Again we'd like to emphasize that DRM systems integration within other solutions like content management systems will increase the benefit most. Aspects that cannot be neglected in the design and decision process include the business models and the workflow process.

Currently there is a change in the hardware and software industry. Their tendency is going into the direction of "trusted computers" or "trusted devices". Independently how long it takes to achieve these ambitious goals, which has some advantages and also some drawbacks, customers have to accept these solutions and also to pay for them. This development towards "trusted devices" is highly debated, as it seems to endanger the right for "free speech" and free information exchange. Future solutions of trusted computers might allow the customers a more flexible key management away from hardware keys stored in machines but with keys stored in smart cards. This will also be influenced by other standardisation activities like DMP, OMA, CRF or the recently announced collaboration of Philips and Sony. A common accepted solution cannot be seen yet.

Additional to the strict DRM activities different alternatives have been proposed:

- *Light Wight Digital Rights Management* [LWDRM] cooperates with consumers. It distinguishes between locally bound and signed content in which user certificates are enclosed. As these user certificates link the content to users, users are expected to be very reluctant in distributing this personalised content.

- *Creative Commons* uses "private rights to create public goods" [CC]. It main intention is that others can use others' work only for non-commercial use. This license model is related to GNU GPL [GPL] and EFF Open Audio License [EFFOAL].
- *Fisher's license model* is based on a low-rate subscription. Fisher showed in detail how such a model could work [Fisher2004a, Fisher2004b].
- *German Academic Publishers* [GAP] is developing a new model for the design and administration of electronic publications. It is especially interested in the scientist's need for "Open Access"

So what the future might bring is hard to say as the history already told us that not the best solution must succeed in the long run[36]. Nevertheless GartnerG2 and the Berkman Center for Internet & Society [Berkman2003] presented "five possible scenarios for copyright law applicable to digital media in the United States". These scenarios predicted losses and gains for consumer values and costs and revenues for content owners, artists, technology CE vendors, and Internet service providers:

1. *The no-change scenario* is based on the assumption that DCMA is enforced irregularly results in a gain for technology providers, Internet service providers, and the consumer values. „This scenario is the least likely to play out, as the entertainment industries are not likely to sit still and see their business models slowly destroyed. Media companies have already attempted to address piracy via legal, regulatory and technology solutions. They will continue to pursue solutions to what they perceive as an attack on their traditional business models. However, it is likely that the no-change scenario will prevail in the immediate future as efforts so far have yielded minimal results and piracy is still widespread." [Berkman2003]

2. *The taking property rights seriously scenario* is based on the assumption that content owners and providers strongly succeed in protection their IPRs. As a result the gains for content owners and artists will increase together with increased cost on the overhead with violation prosecution. Technology and Internet service providers will gain marginally and the consumers will be the losers. "This scenario certainly plays to the interests of those in the media industry and copyright holders who would seek to maintain existing business models based on complete control of the content. However, it is probably the one scenario that best illustrates the chasm separating content owners/media companies from large segments of the consumer population. It is also the scenario that, if realized, would most emphatically underscore the regional differences in intellectual property laws and enforcement. " [Berkman2003]

3. *The effective technology defence scenario* assumptions are that content will be distributed physically and digitally. Content is copy protected while still meeting consumers' needs. It also includes the assumption that copy-protection is an ongoing cycle, which is indeed the case. "This scenario can be described as "technology rescues the content industries from wanton copyright piracy." However, the technological challenges are compounded by the numbers of increasingly tech-savvy consumers around the world. There is very little margin for error and the transition to universal copy protection must be relatively quick. Otherwise, media companies and artists may find that large numbers of consumers are seeking digital content from sources other than traditional music labels, movie studios and publishers." [Berkman2003]

4. *The compulsory license scenario* assumes that the current copyright system is replaced bye a system in which the creators and producers of content are compensated by the government in proportion to the "consumption" frequency. "While this scenario has its own risks—giving a government entity significant discretionary power and assuring the virtual annihilation of the physical retail market—the potential for reducing litigation, lowering the costs of enforcement and eliminating the incentive for an ongoing encryption "arms race" make it very attractive." [Berkman2003]

[36] One example is the success of VHS against Betamax or Video 2000 although VHS was inferior against its competitors.

5. *The utility model scenario* considers digital content as a public utility. Regulations are enforced by a federal regulatory body. Concerning the estimated effects this scenario is most interesting. "Of all five scenarios presented here, this one countenances major legal, business and consumer behaviour changes. From a technology perspective, it is less complicated than might be considered. At least one technology provider currently has an offering that could track content distribution to the end user in much the same way power companies use meter-reading systems. However, music and movie producers and their businesses—not to mention conventional retail distribution entities—will be violently opposed. Music and movie producers would see their revenue models altered greatly, with the costs associated with distributing content and usage eliminated." [Berkman2003]

Thus the "utility model scenario" might be the best solution to the current problem of the content owner. But before such a final solution is publicly accepted and established, content providers have to find their individual solutions.

1. Appendix: Standardization activities

In addition to the previously mentioned standardization activities on content identification and rights management several other organizations or standards exist. A more detailed list can be found in [NIST500-241], [EICTA] or in [CEN/ISSS2003].

1.1.1. CEN/ISSS

The European Committee for Standardization (*Comite Europeen de Normalisation*) [CEN/ISSS] develops European technical standards. CEN/ISSS set up a group to examine the standardization aspects of technologies for DRM (CEN/ISSS DRM Group) in October 2001. The final report is available at [CEN/ISSS2003].

1.1.2. CRF

The *Content Reference Forum* [CRF] is a recently formed standards group of technology and content-related companies. It‘s aim is to develop a universal way to distribute digital content across various media and geographies (“a dynamic marketplace where participants can promote, sell and legitimately share content; consumers can get the right content for their location, platform and preferences; and the underlying commercial agreements and rights surrounding the content are respected”). “Founding and current member companies of the Content Reference Forum are ARM, Ltd., ContentGuard Inc., Macrovision Corporation, Microsoft Corporation, Nippon Telegraph and Telephone Corporation, Universal Music Group and VeriSign, Inc.”

1.1.3. DMP

The *Digital Media Project* [DMP] was launched by Leonardo Chiariglione. Its aims are published in the Digital Media Manifest (DMM): “The Digital Media Manifesto identifies the need for coordinated policy and technical actions needed to achieve this fuller realisation of Digital Media. The policy actions include reviewing the Digital Media standardisation process. The technical actions require, as explicit critical success factors, the development of specifications for interoperable Digital Rights Management (DRM) platforms technically open to value-chain players and for interoperable end-user devices, and the development of recommended practices for end-to-end conformance assessment.”

1.1.4. IETF

The *Internet Engineering Task Force* [IETF] has a specialized DRM group. This Internet Digital Rights Management Group (IDRM) that was concluded. Besides IDRM other groups deals or dealt with DRM related aspects. Among these groups are Group Domain of Interpretation rekey protocol (GDOI) and Multimedia Internet KEYing (MIKEY) within the Multicast Security (MSEC) working group. Also the working group Intellectual Property Rights (IPR) is dealing with a DRM related activity.

1.1.5. IFPI

IFPI represents the international recording industry and is closely related to RIAA. As it fights piracy it is in favour of DRM technologies (cfg. [IFPI]).

1.1.6. ISMA

The *Internet Streaming Media Alliance* [ISMA] wants to accelerate the adoption of open standards for streaming media types over the Internet. These standards are also addressing protection issues. Therefore it released a content protection specification for peer review, which is based on open standards and technology. It is build upon the general ISMA version 1.0 specification.

1.1.7. MPEG

The *Motion Picture Expert Group* [MPEG] is an ISO/IEC working group for standards developments of coded representations of digital audio and video. Several specifications are directly or indirectly addressing the area of DRM, like MPEG-4 IPMP (intellectual property management and protection), MPEG-7 (content description) or MPEG-21 (multimedia framework).

1.1.8. OMA

The Open Mobile Alliance [OMA] is "to facilitate global user adoption of mobile data services by specifying market driven mobile service enablers that ensure service interoperability across devices, geographies, service providers, operators, and networks, while allowing businesses to compete through innovation and differentiation".

1.1.9. RIAA

The *Recording Industry Association of America* [RIAA] also is strongly involved in anti-piracy activities. Four specific categories of piracy are addressed: pirate recordings, counterfeit recordings, bootleg recordings and online piracy. Thus DRM is also related to RIAA.

1.1.10. SDMI

The *Secure Digital Music Initiative* [SDMI] is a forum with the aim to develop an open technology for the protection of digital music. Due to several reasons SDMI can be considered as a failure. A very interesting cause for the reasons was the public challenge on the protection system and the strong limitations and restrictions not only on the achieved results but also on the information about the deployed technology. This shows once more, that security cannot be achieved by obscurity.

1.1.11. W3C

The *World Wide Web Consortium* [W3C] held a workshop on DRM. Yet it seems that its activities slowed down. Additionally W3C is addressing related areas like within the Resource Description Framework (RDF).

1.1.12. WIPO

The *World Intellectual Property Organization* [WIPO] "is an international organization dedicated to promoting the use and protection of works of the human spirit. These works - intellectual property - are expanding the bounds of science and technology and enriching the world of the arts."

1.1.13. recent standardization activities

Philips and *Sony* bought Intertrust at the end of 2002. At the same time they announced that this deal would enable further possibilities for secure content distribution. In December 2003 Philips Electronics announced it was six months away from launching a system against illegal copying that will allow consumers to play digital video and music on any digital media player. It seems that this solution will respect users' requirements on open systems as well as the electronic industry's requirement on an interoperable and independent system. Considering Philip's and Sony's impact due to their common development on the CD their current activity seems to be very promising.

2. Vendor list

The following list was taken from [DCITA] (with some minor modifications) collects several vendors of DRM related technologies.

Vendor Name	Country	URL	Product Name	Description	Formats	Copyright Protection	Watermarking	Interoperability
Adobe	• USA • Australian Office	http://www.adobe.com/products/contentserver/main.html	• Adobe Content Server • eBook Reader	eBook exchange, packaging and protection system. Requires eCommerce connection	Acrobat	Yes, encrypted One time URL or PDF Merchant PC specific key	Use other Windows based technologies	Open: Supports OEBF and ONIX
Aladdin Knowledge Systems	USA	http://www.ealaddin.com	Privilege Rights Manager plus HASP or eTOKEN hardware devices	Copyright protection for distributiion of software	Software applications	Privelege	–	N/A
Alchemdia	USA	http://www.alchemedia.com now: http://www.finjan.com/products/mirage.cfm	Mirage 3.1	MirageTM Enterprise 3.1 – Mirage provides Secure Display, Secure Printing and Secure Auditing! It offers control information as it is being used	Documents	Mirage	–	–
Digimarc	USA	http://www.digimarc.com	Digimarc MarcSpider® image tracking Digimarc MediaBridge™ Print to Web Watermarking Solutions	Digimarc ImageBridge watermarking enables images to carry embedded information such as image copyright notices, licensing requirements, usage restrictions, contact information and a link to a specific web page	• Gif • Jpeg • Photoshop • video	–	Digimarc MediaBridge™ Print to Web Watermarking Solutions	Market leader in watermarking
Digital Rights Exchange	• Perth • WA	http://www.dr-ex.com.au	DR-Ex Content Owner	DR-EX handles the entire DRM process for the sale of music in digital format including: • Encryption and packaging • Hosting and distribution • License control • Transaction processing • Royalty and profit distribution	Windows Media Player	Through Microsoft WMP technology	–	Microsoft based

Vendor Name	Country	URL	Product Name	Description	Formats	Copyright Protection	Watermarking	Interoperability
eMeta Corp	• USA • UK	http://www.emeta.com	eRights	eRights is a complete information commerce enterprise software solution for online content providers. It provides user authentication and access control, and drives successful strategies for the sale of content by providing the flexibility to experiment and implement extensive business and sales models	–	X	–	Little known
IBM	• USA • Australian Office	http://www-3.ibm.com/software/data/emms/features/	EMMS (Electronic Media Management System)	EMMS is a software suite of seven components that interact to provide content owners, businesses, retailers and consumers with a unique set of solutions for their digital distribution needs. These components can be purchased and integrated together to create a new EMMS value network, or purchased individually and integrated with an existing EMMS value network	–	X	Available	Supports Open standards when established
IPR Systems	Sydney, NSW	http://www.iprsystems.com	Digital Book Xchange	Provides complete bookshop and eCommerce system using Adobe Acrobat	Acrobat, Learning Objects	Currently uses Acrobat PDf Merchant but can support Content Server and Microsoft Reader	Included	Open: • Java • XML • Supports • ODRL • OEBF • ONIX
Liquid Audio	USA	http://www.liquidaudio.com	LiquidAudio SP3	Proprietary digital Music distribution and copyright protection system	–	X	–	Proprietary

Vendor Name	Country	URL	Product Name	Description	Formats	Copyright Protection	Watermarking	Interoperability
MacroVision	USA	http://www.macrovision.com	• MacroSAFE • FLEXlm • SafeAudio • SafeDisc • SafeCast	Macrovision made its name in VCR copy protection systems and now provides products for digital content	• Video • Audio • Software	X	–	Proprietary
MarkAny	Korea	http://www.markany.com/eng/default.htm	• Esigniaȼ • Video MAIM 2.0 – • MarkAny Image Watermarking • DOCUMENT SAFER MAO 2.0 • MarkAny Audio Watermarking	–	• Video • Audio,	X	–	Little known
MediaSec Technologies	• Germany • USA	http://www.mediasec.com	• MediaSign™ Authentication/ Authenticity • MediaLabel™ Content Labeling • MediaCrypt™ Smart Encryption	Content and multimedia security using digital watermarking, digital labeling, self-authentication, and smart encryption technologies	–	X	–	Little known
Microsoft	• USA • Australian Office	http://www.microsoft.com/reader/info/sdk.asp and http://www.microsoft.com/reader/info/das.asp	• Microsoft eBook Reader • Digital Asset Server	–	Digital Books	Yes. XrML based Key and Licence Server	Use other Micorosft .net Technologies	Uses XrML and OEBF
Microsoft		http://www.microsoft.com/windows/windowsmedia/drm.asp	Windows Media Rights Manager SDK Windows Media Format SDK	–	• Music • Video	Microsoft Multimedia Player	MMP	Emerging
OverDrive	USA	http://www.overdrive.com/serv_overview.asp	Overdrive System and Service	Provides complete bookshop and eCommerce system based around Microsoft Digital Asset Server (DRM) and Microsoft Reader services and Adobe Content Server	Digital Books	Uses Adobe and/or Microsoft	Provided	Uses XrML and OEBF

Vendor Name	Country	URL	Product Name	Description	Formats	Copyright Protection	Watermarking	Interoperability
Real Networks	• USA • Australian Office	http://www.realnetworks.com	• Helix Universal Server • Helix media Gateway • Helix Producer	Open, comprehensive platform of digital media products and applications for any format, operating system or device	Stream and cache all major media types – including: • RealAudio/ RealVideo • Apple's QuickTime • MPEG-2 • MPEG-4 • Windows Media	Helix Universal Server	Helix Universal Server	Widely supported player
Rightsmarket	Canada	http://www.rightsmarket.com	• RightsPublish • RightsVault	General (digital content publishers) (RightsPublish) and B2B (RightsVault)	–	X	X	Proprietary
Rumble Group	Sydney, NSW	http://www.rumblegroup.com	RNI Enterprise	Digital Asset Management Service with rights management within the architecture	Video, Audio and Images	Uses Intertrust	–	X
SealedMedia	• UK • USA	http://www.sealedmedia.com	SealedMedia Digital Rights Management Solution	Copyright Protection technology using special SealedMedia plug-ins	• PDF • Word • Excel • PowerPoint • HTML • GIF • JPEG • MP3 • QuickTime	–	–	X
Verance	USA	http://www.verance.com	Verrance Audio and Watermarking ConfirMedia monitoring service	Broadcast Detectable video and audio watermarking	–	X	–	–

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