浙江大学计算机学院
数字媒体与网络技术

Digital Asset Management
数字媒体资源管理

4. Digital Rights Management

任课老师：张宏鑫
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Digital Rights Management Revisit

- DRM and movie industry: DVD CSS
- DRM and music industry:
  - audio CD: from sony BMG
  - internet music: iTunes store
- E-Books: Adobe Acrobat, M$ Reader, Kindle

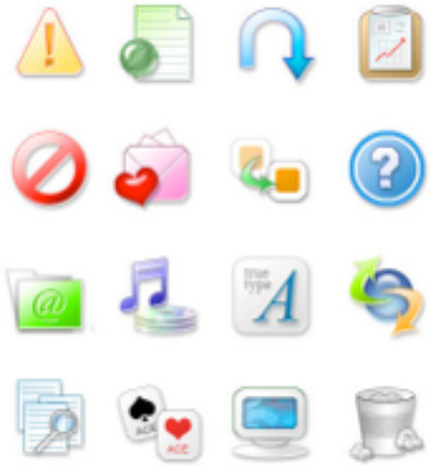
- permission
- restriction
- obligation

Rights

own

over

- rights holder
- end customer



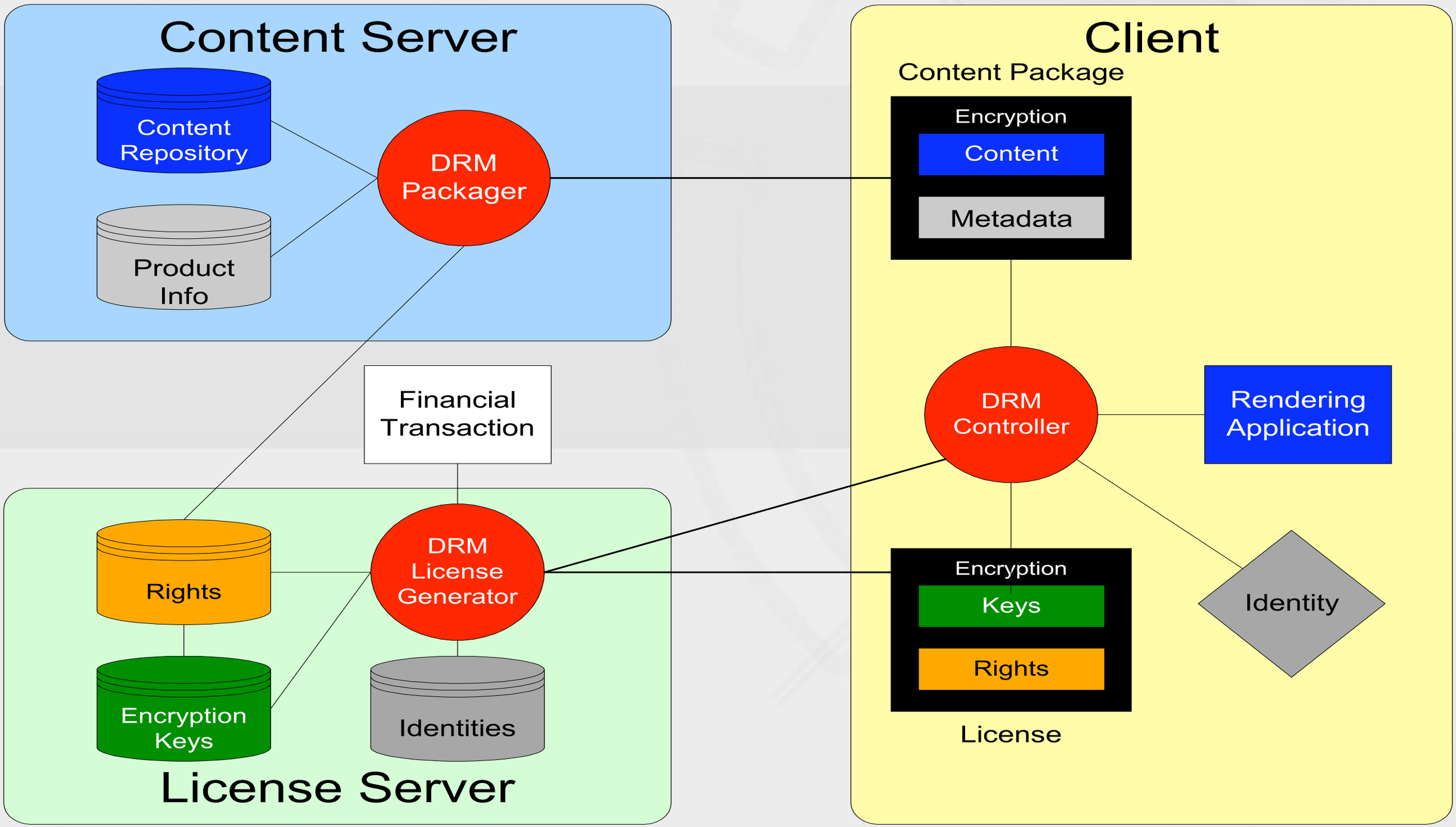
create/use

User

Content

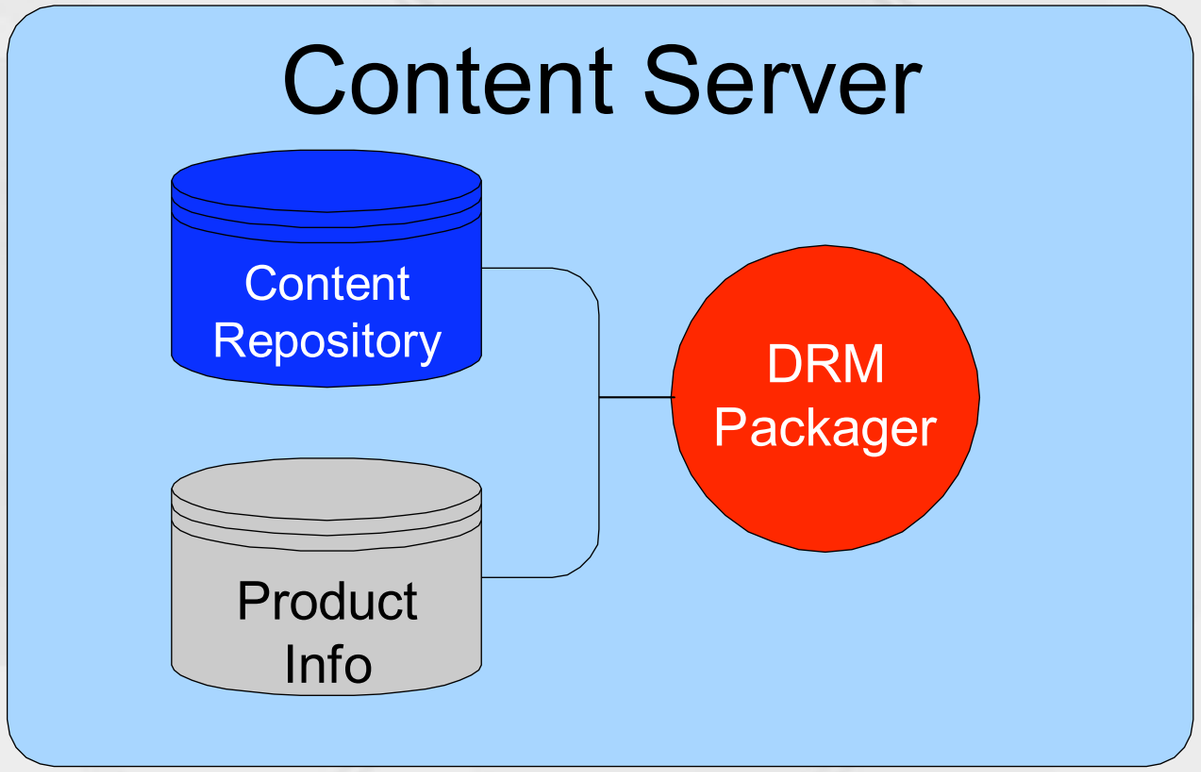
DRM basic Model

DRM Reference Architecture



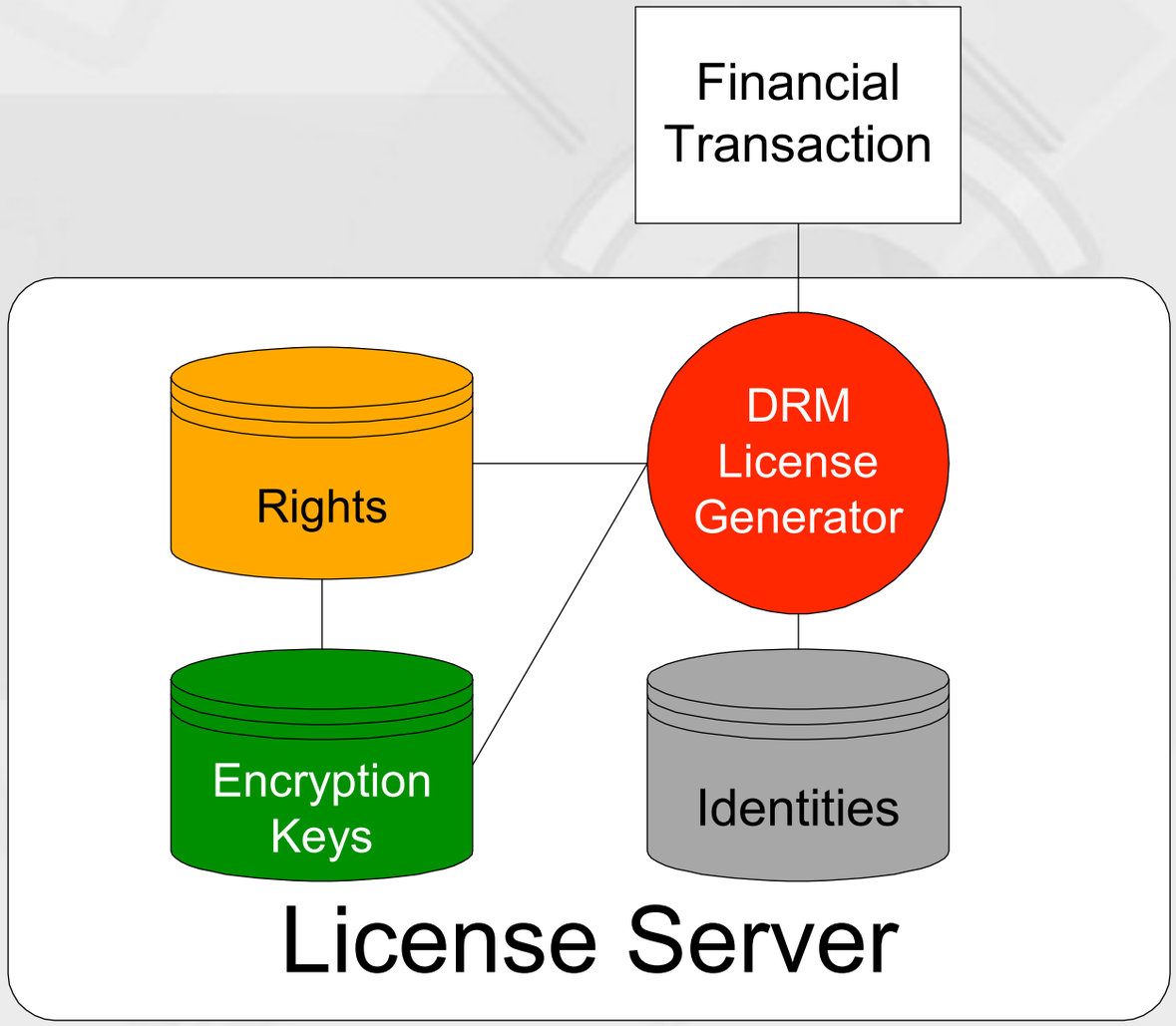
Content Server

- Content Repository
  - –Content Management system
  - –Digital Asset Management system
  - –File server
- Product Info
  - **–Rights**
  - –Product metadata
- DRM Packager
  - –Packages content with metadata
  - **–Encrypts**



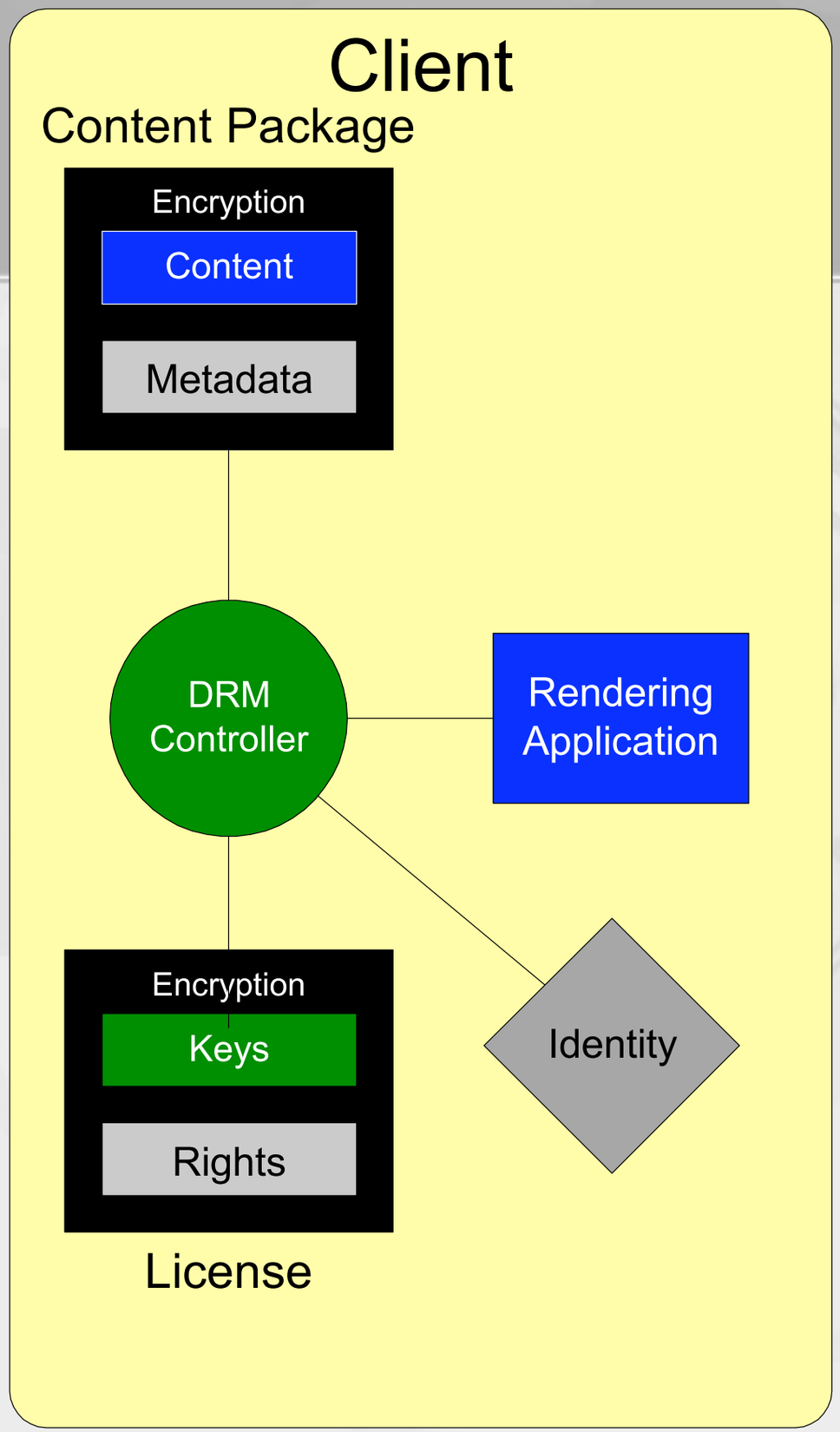
License Server

- Encryption key repository
- User identity database
  - –Usernames
  - –Machine IDs
- DRM License Generator



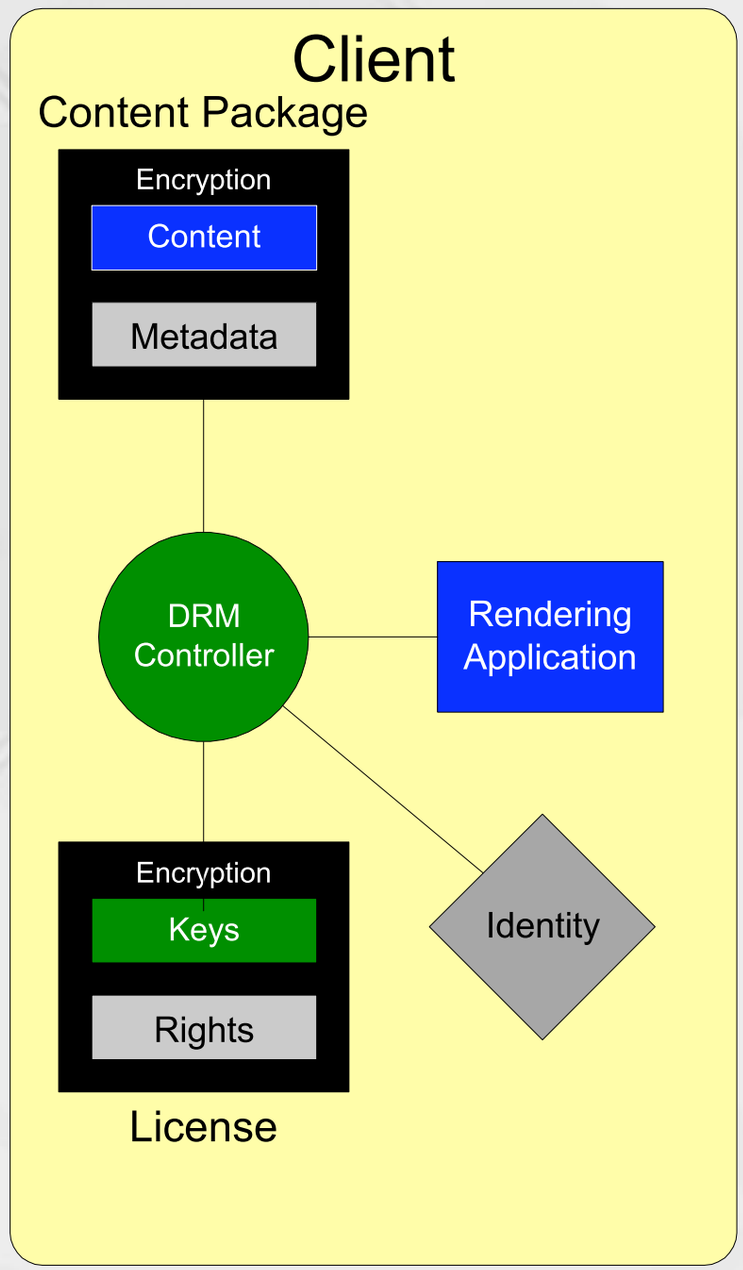
Client

- DRM Controller
  - –Nerve center of process
- Rendering application
- Content packages
- Licenses
- Identity



Processes - User Initiation

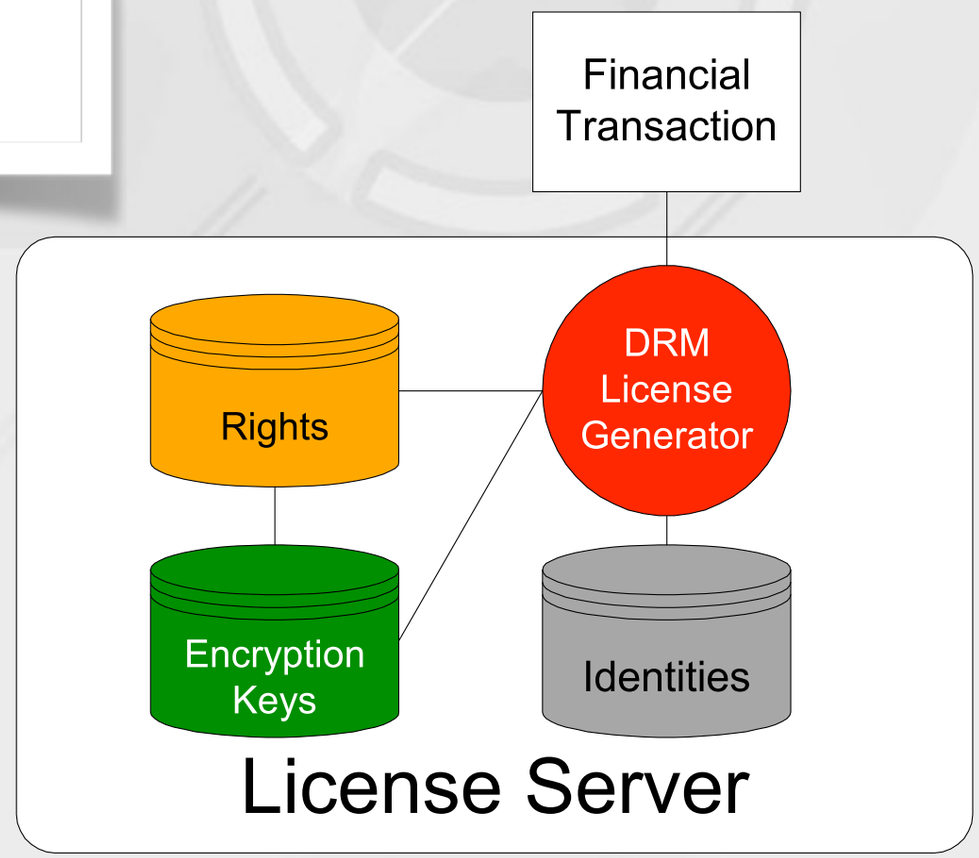
- User obtains content package
- User requests operation
  - –view, play
- DRM controller collects info
  - –Content
  - –Identity
  - –Requested rights
- DRM controller:
  - –license generator



Processes - License Generation

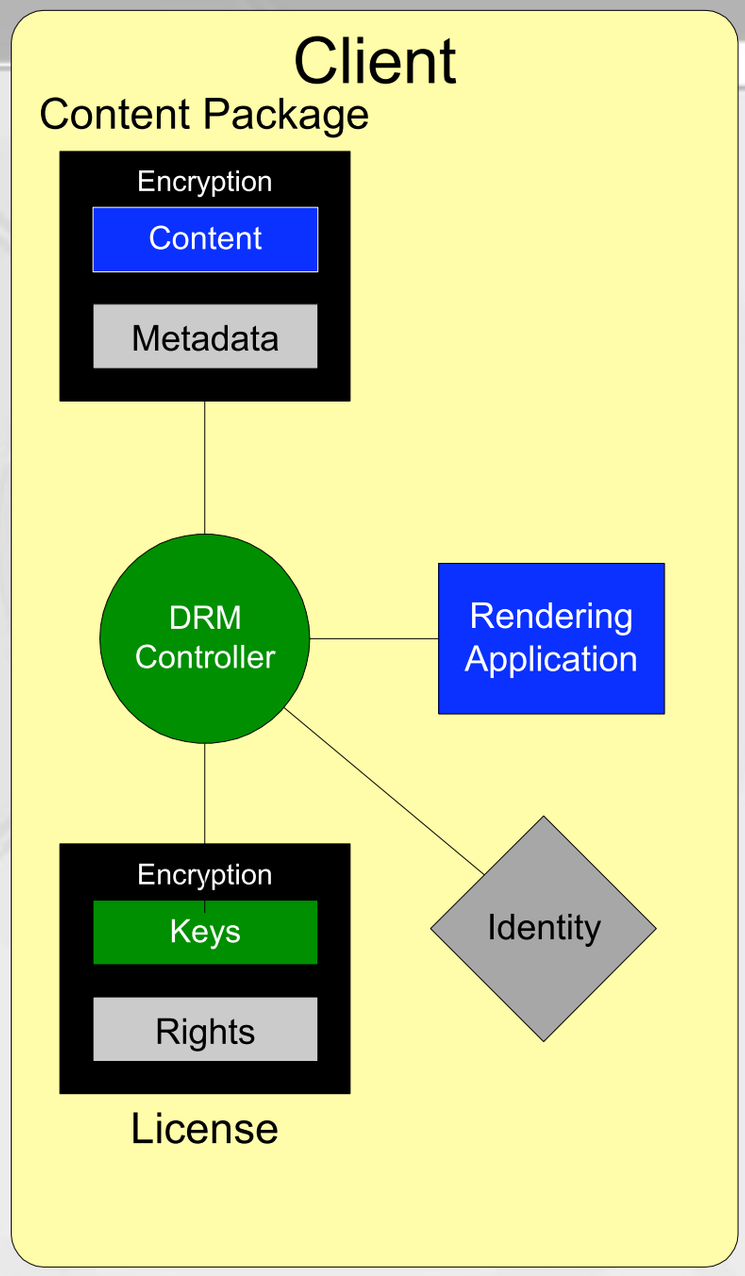
DRM License Generator…

- Checks content & identity
- Obtains keys from key repository
- Creates & sends license to client
- Generates financial transaction, where necessary



Processes - User Completion

- DRM Controller…
  - Receives license
  - Extracts keys from license
  - Decrypts content
  - Generates financial transaction, where necessary
  - Hands content to rendering application
- Rendering application plays content



- 守护数字文档,数字版权管理:一个商业难题 [新华网 2006年7月7日]
  - 在国内某著名兵工厂的一次老总级别会议后,一份电子版的会议纪 要被秘密地发送到了几个有权限的重要人物手中,三个小时之后, 这份文件将会自动销毁.
- 一个商业难题
- 新销售体系
- 待填补的市场

Thus, we see ...

- DRM can help ensure companies, corporations, and other entities who share similar business that:
  - Rights are tracked at ingestion
  - Access is controlled during production processes
  - Protection for the content extends throughout product life-cycles

Thus, we see ...

- Additionally, DRM can integrate persistent content protection with content management to ensure:
  - Proper business practices
  - Implementation of new business models
  - Compliance with regulatory requirements in industries such as financial services, healthcare, and government

- 首批广播影视数字版权管理标准完成起草
  - http://news.cctv.com/china/20081108/105830.shtml
  - http://space.tv.cctv.com/video/VIDE1226188087000110

Previous Technologies

- PKI – Public Key Infrastructure
- PGP – Pretty Good Privacy
- S/MIME
- Access Control Systems
- Smart Cards
- Biometrics

How are these technologies different to DRM?

- Only protect the data in transit
  - E.g. over the Internet or on CD
- Once the data is opened, it can be:
  - edited
  - copied
  - printed
  - saved as an unprotected file

And then

- Redistributed to anyone else in an unprotected format.

Rely on TRUST once the content is delivered

Protecting Digital Intellectual Property

- Preventing Copying with Encryption
  - 加密
- Preventing Copying with Watermarking
  - 水印

Preventing Copying With Encryption (加密)

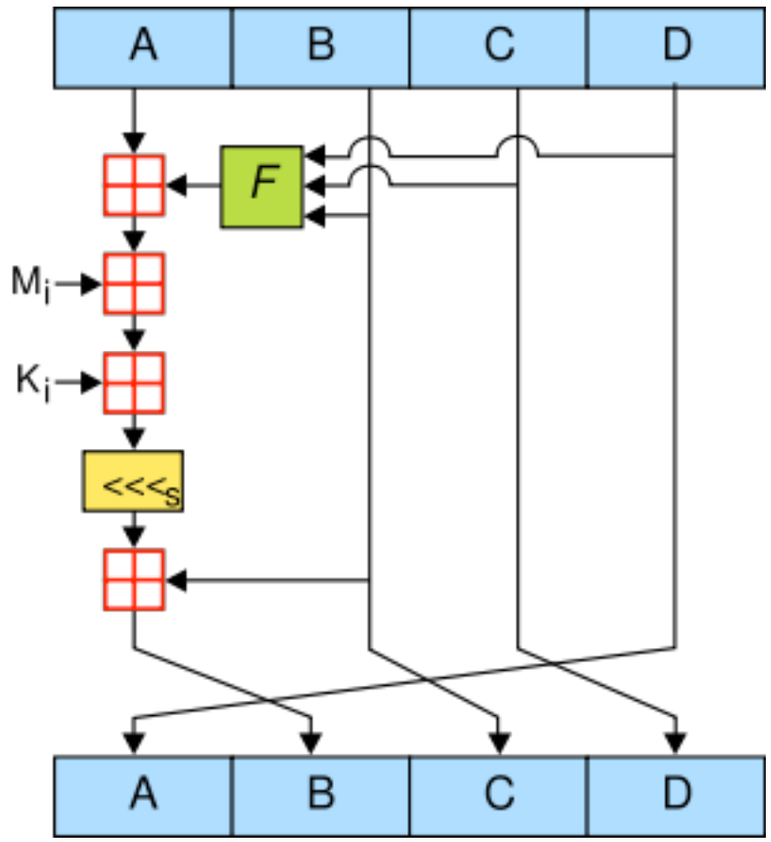
- Encryption is the scrambling of a message
  - Simple one is Caesar encryption
  - To decrypt (decode) message, you need one or more *Keys*
  - Also need an encryption *algorithm*, that specifies how to apply the key to the message to produce the scrambled message
- Symmetric key crypto: same key used for encrypt/decrypt
- Public key (we'll talk about the details later…):
  - Keys come in matched pairs: one encrypts, other decrypts
  - Given one key, you cannot deduce the other

Encryption

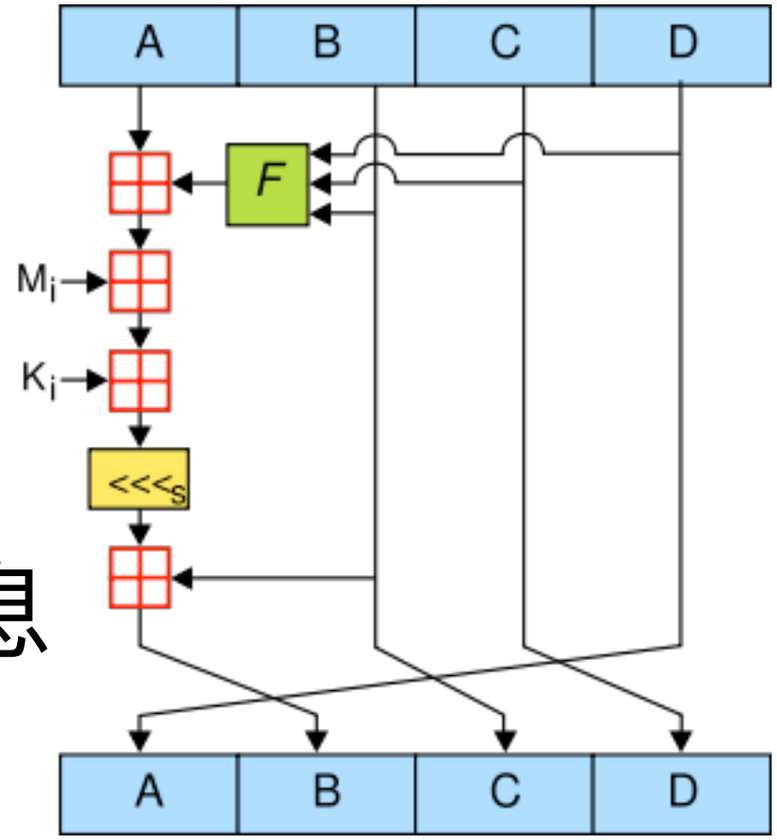
- RSA
- DES
- MD5

MD5
(Message Digest Algorithm version 5)

- MD5 is widely used in the open source world
- Enough for data sharing
- But not so safe



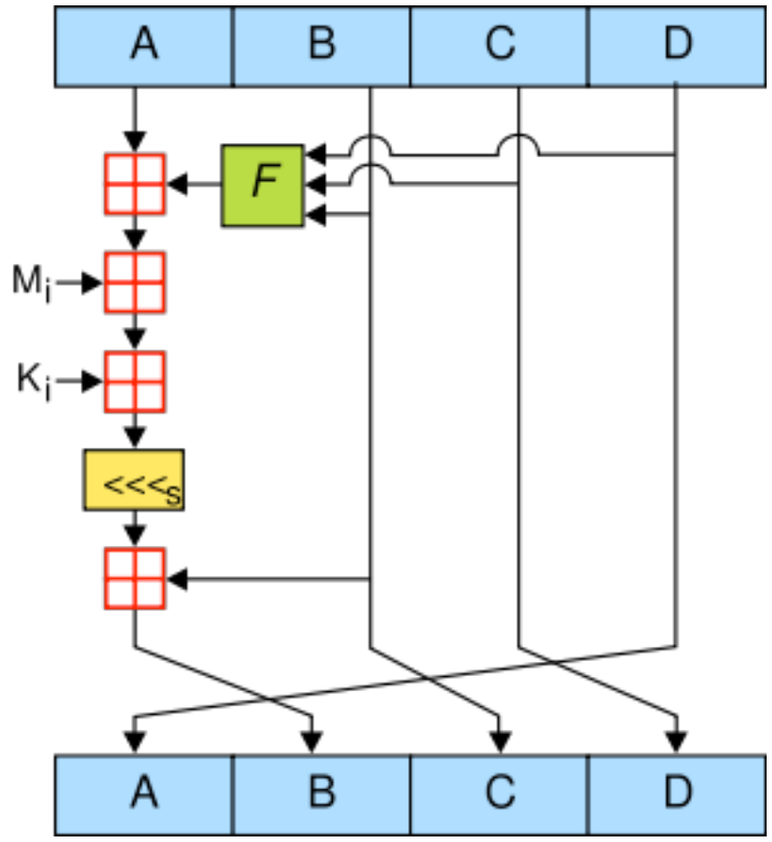
MD5 算法



- 输入： 以512位分组来处理的信息
  - 每一分组又被划分为16个32位子分组
  - 对信息进行填充，使其位长对512求余的结果等于448
  - N*64+56个字节

- 输出： 四个32位分组，构成128位散列

MD5算法



- Chaining Variable
  - A=0x01234567， B=0x89abcdef，C=0xfedcba98， D=0x76543210
- 循环运算
  - A到a， B到b， C到c， D到d
  - 主循环有四轮
    - 一轮进行16次操作
    - 每次操作对a、b、c和d中的其中三个作一

MD5 算法

- 基本函数
  - F(X,Y,Z) =(X&Y)|((~X)&Z)
  - G(X,Y,Z) =(X&Z)|(Y&(~Z))
  - H(X,Y,Z) =X^Y^Z
  - I(X,Y,Z)=Y^(X|(~Z))
  - & 表示“与”，|表示“或”，
    ~表示“非”，^表示“异或”

- 基本操作
  - FF(a, b, c, d, Mj, s, ti)
    a = b + ((a + F(b, c, d) + Mj + ti) << s)
  - GG(a, b, c, d, Mj, s, ti)
    a = b + ((a + G(b, c, d) + Mj + ti) << s)
  - HH(a, b, c, d, Mj, s, ti)
    a = b + ((a + H(b, c, d) + Mj + ti) << s)
  - II(a, b, c, d, Mj, s, ti)
    a = b + ((a + I(b, c, d) + Mj + ti) << s)
  - Mj表示消息的第j个子分组（从0到15）

MD5算法

- 在第i步中，ti是4294967296*abs(sin(i))的整数部分，i的单位是弧度。

- 完成上述64步操作之后，将A、B、C、D分别加上a、b、c、d。然后用下一分组数据继续运行算法

- 最后的输出是A、B、C和D的级联。

- 例：（可试用python中的md5实现：hashlib）

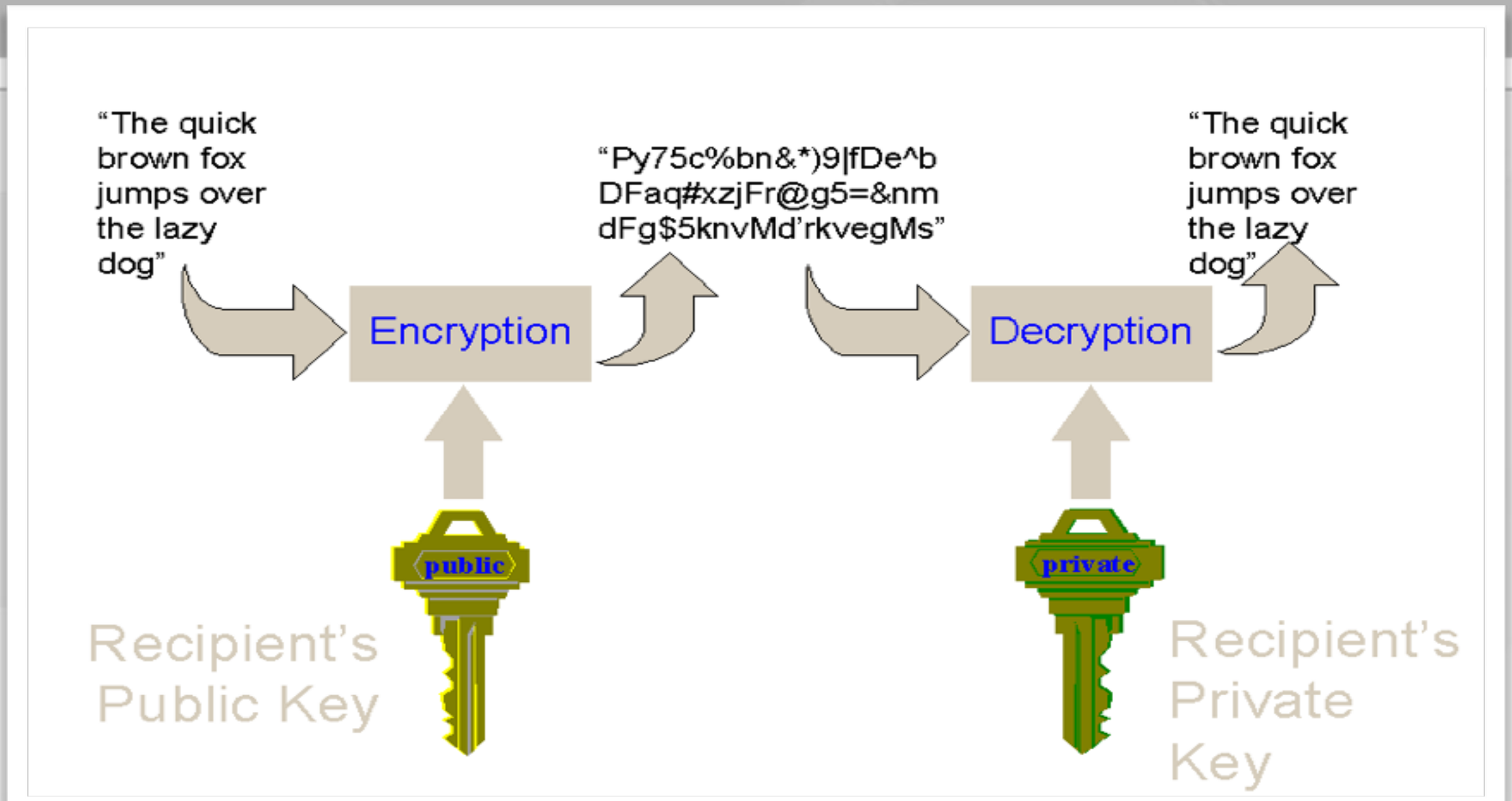
  - MD5 ("") = d41d8cd98f00b204e9800998ecf8427e

  - MD5 ("abc") = 900150983cd24fb0d6963f7d28e17f72

开源密码体系的崩溃

- 山东大学的王小云教授
  - [Crypto 2004], 利用hash碰撞原理， 攻破MD5、HAVAL-128、 MD4和RIPEMD算法
  - 2005年8月, 给出攻击SHA－1的算法

Basic Idea of Cryptography



Think of encryption key as sealing an envelope, and decryption key as unsealing it.

How do you “break” encryption?

- Usual assumptions of cryptography…
  - Adversary knows details of algorithm (not in WWII!)
  - Adversary may know something about nature of messages (why would this help?)
  - Adversary *doesn’t know decryption key(s)*
- Hard: exploit mathematical weakness in the algorithm
- Hard: guess key by (educated) trial and error
- Usually easier: attack some weaker part of the system
  - Usually, trick system into revealing a key
  - Chain is only as strong as weakest link!

DVD Content Scrambling System (CSS)

- To each **licensed DVD player** corresponds a **decryption key**:
  - P1, P2, …, Pn
- Each disc is encrypted under its own key, call it D
  - n copies of D are stored on the disc; each copy encrypted with one player's P
  - Player finds a D that it can decrypt, then uses D to play disc

- DVD player is a trusted client
  - It's not supposed to ever reveal any D, or its own P
  - What happens if either of these occur?
  - Why can't you convert DVD to another format?
  - Why can't you make direct copies of a DVD onto another disc (copying the D keys along with the content?)

Early DeCSS timeline...

- Sep ’99, DeCSS released as open-source Linux DVD player
- Dec ’99, DVDCCA sues 500 individuals in California for hosting DeCSS, alleging trade-secret violations
- Jan ’00, MPAA sues 2600.com in New York under DMCA’s copyright protection circumvention laws
- Jan ’00, DVD Source Code Distribution Contest
- Jan ’00 Jon Johansen arrested in Norway, later released
- Aug 00 MPAA wins DMCA suit in NYC

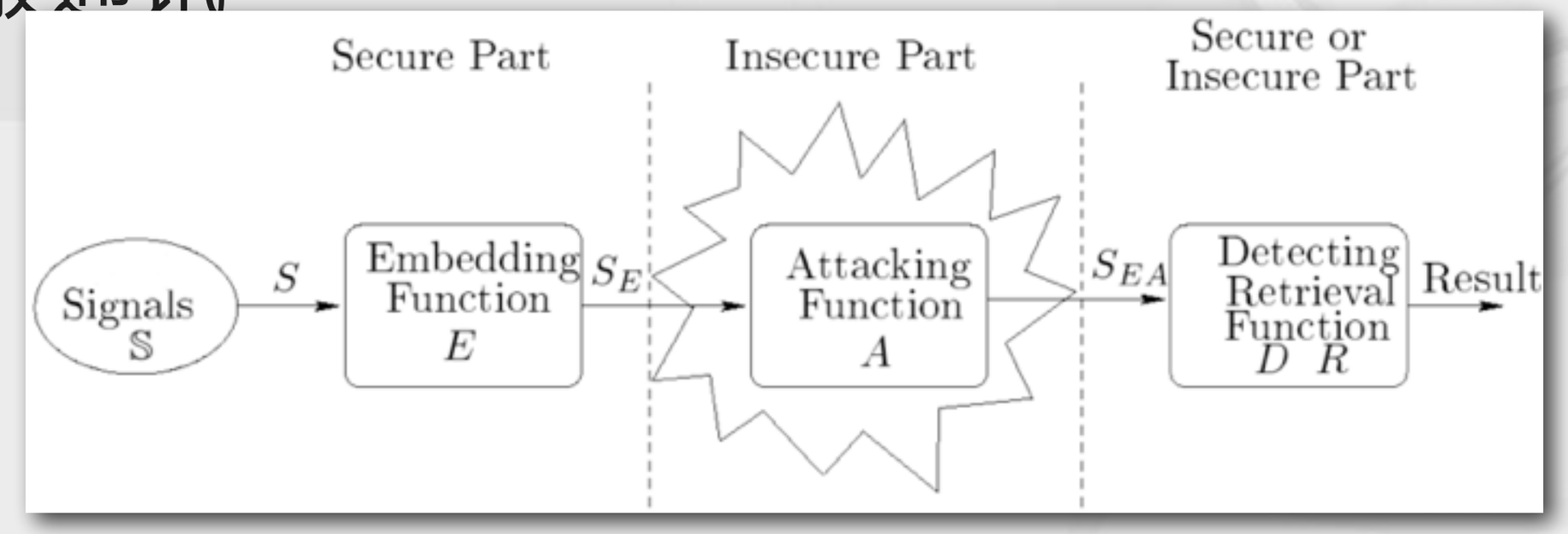
How Was CSS cracked?

- Idea =>
- P must appear somewhere in the decryption code of a trusted player
  - –Hardware players difficult to reverse-engineer/probe
  - –Software players maybe easier? …turns out yes!
  - –Later analysis revealed weaknesses in CSS…it probably could have been broken *without* first recovering a key

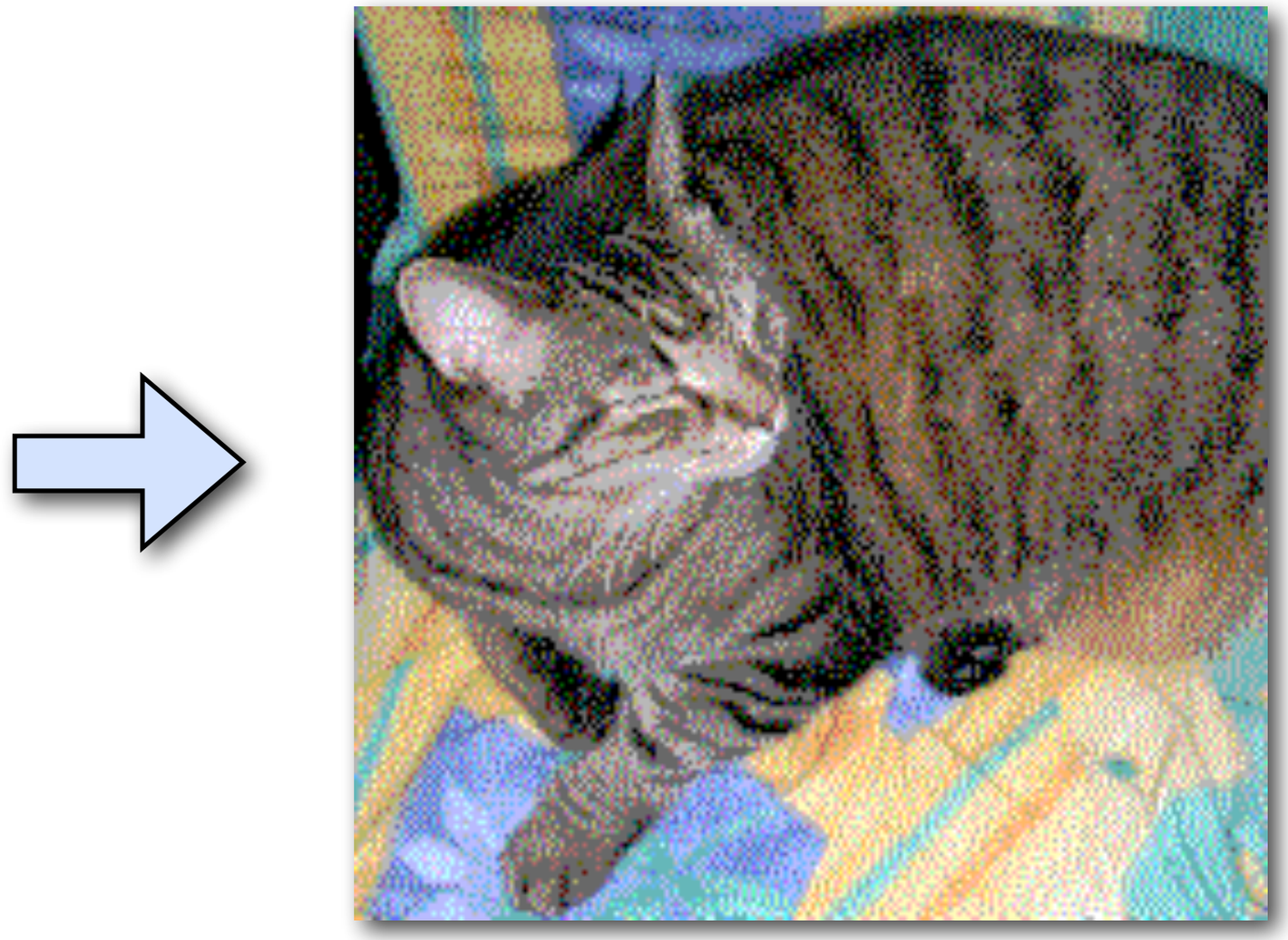
- Original goal of CSS: even if one P is compromised, others are still sound
- Flaw: weakness in the algorithm allowed *all* P's to be compromised once a single P was found
  - –Why wasn't this flaw discovered *before* the algorithm went into production players?

Preventing Copying With Watermarking (水印)

- digital art
- 票据防伪
- 数据隐藏
- 隐蔽通讯



Stenography



1. removing all but the last 2 bits of each color component
2. X 85

About homework-03

Digital Watermark

- Invisible ink on multimedia data
  - image
  - video
  - music
  - graphics

Digital Watermark

- Image

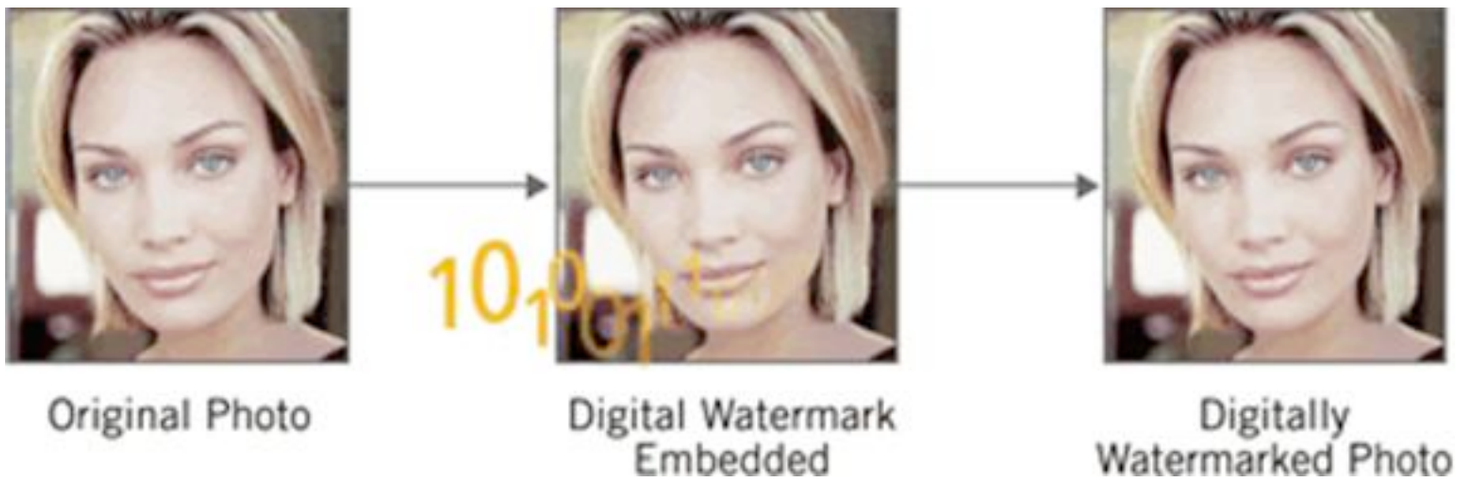
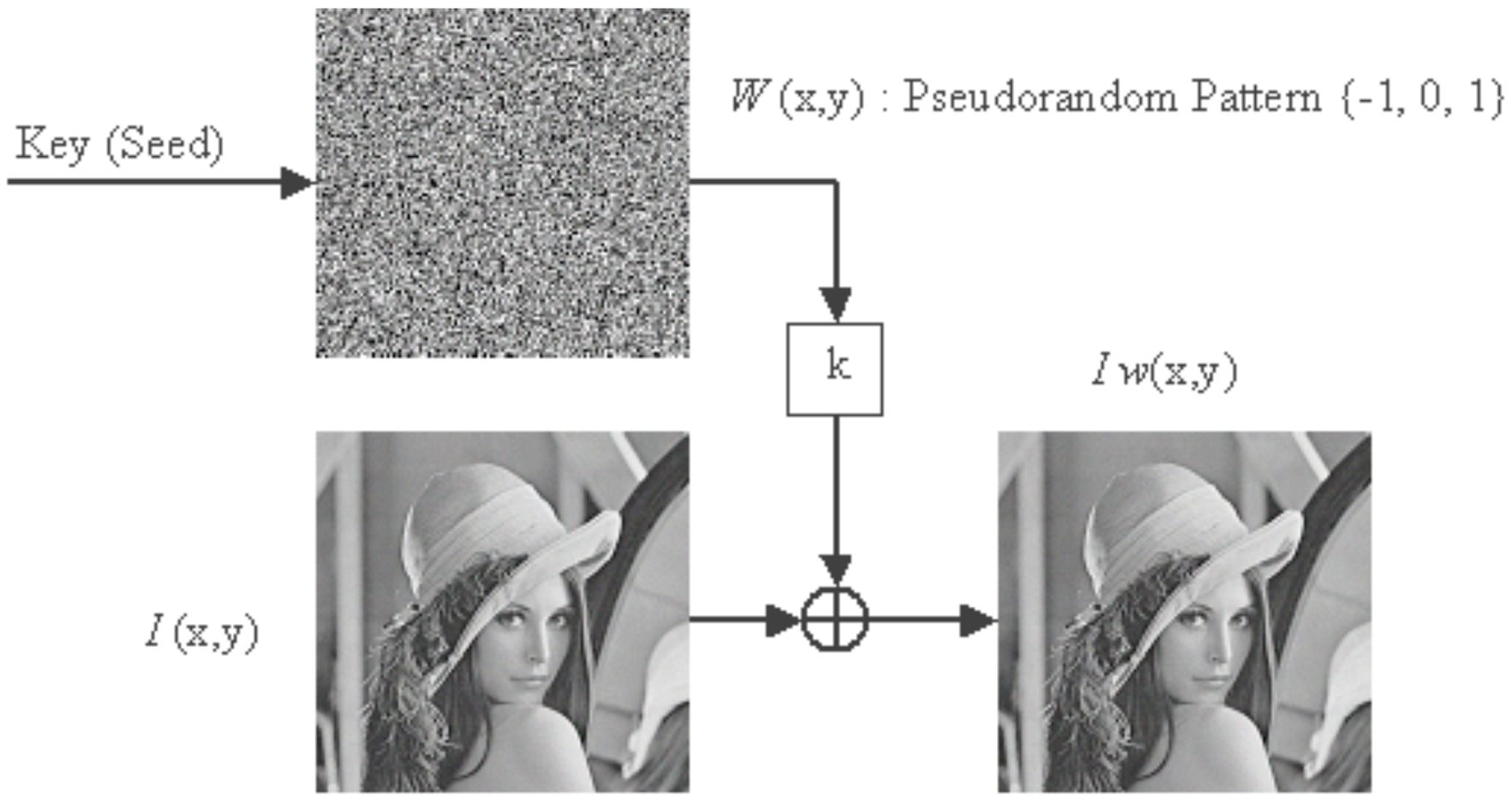


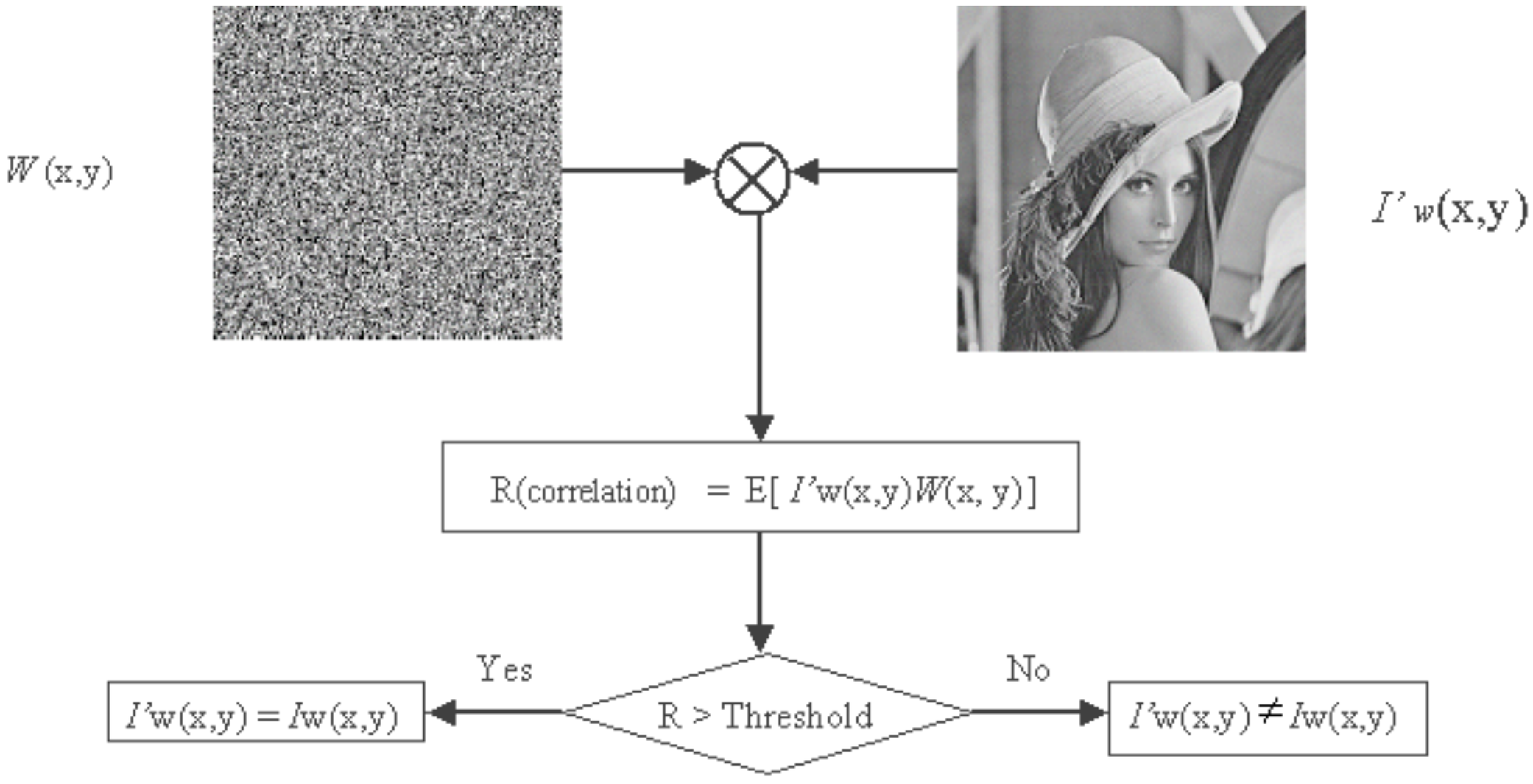
Image watermarking



$$I_w(x,y) = I(x,y) + k * W(x,y)$$

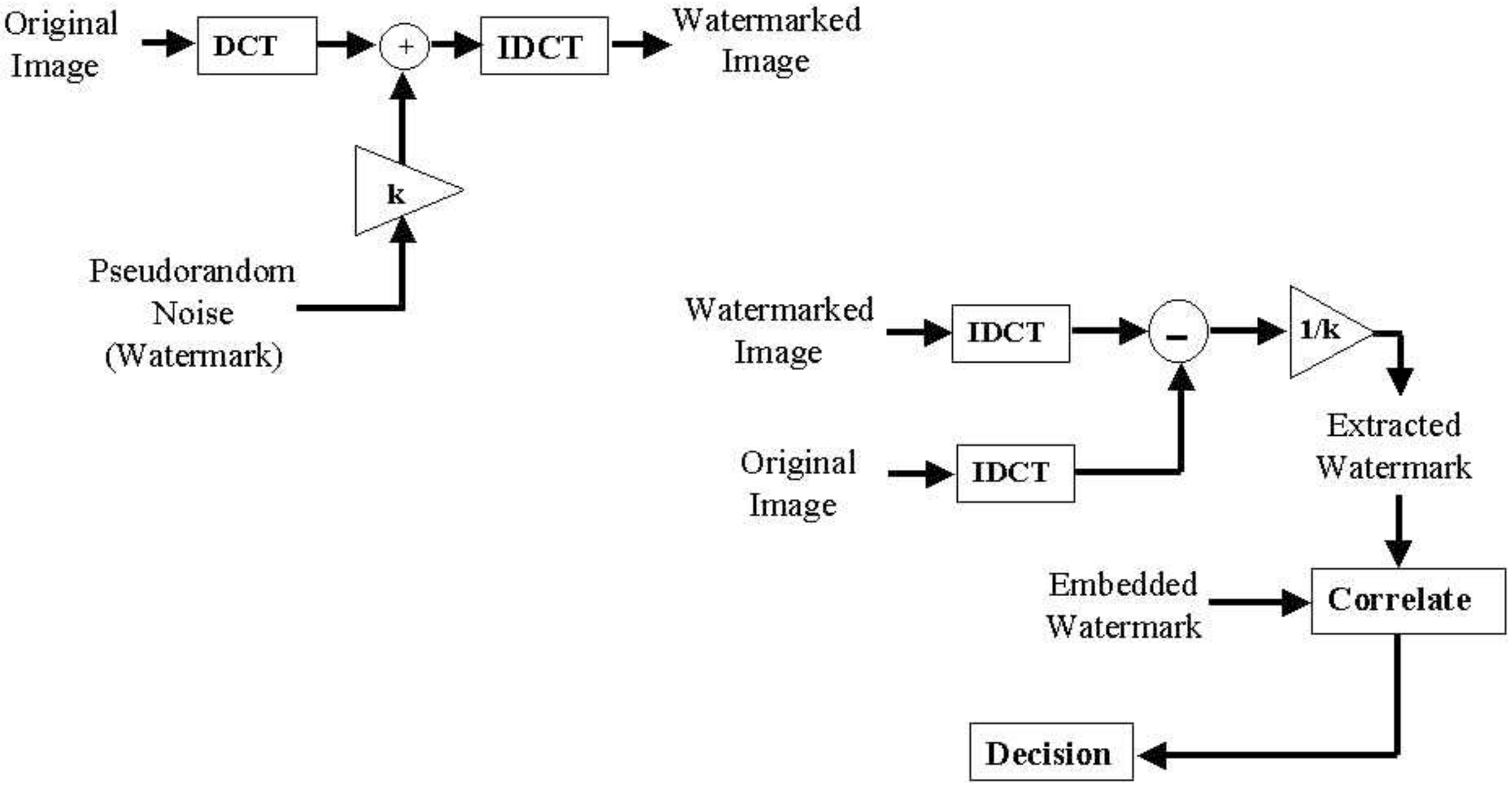
Embedding

Image watermarking



Detecting

DCT based algorithm



REF: http://scien.stanford.edu/pages/labsite/2001/ee368/projects2001/dropbox/project06/

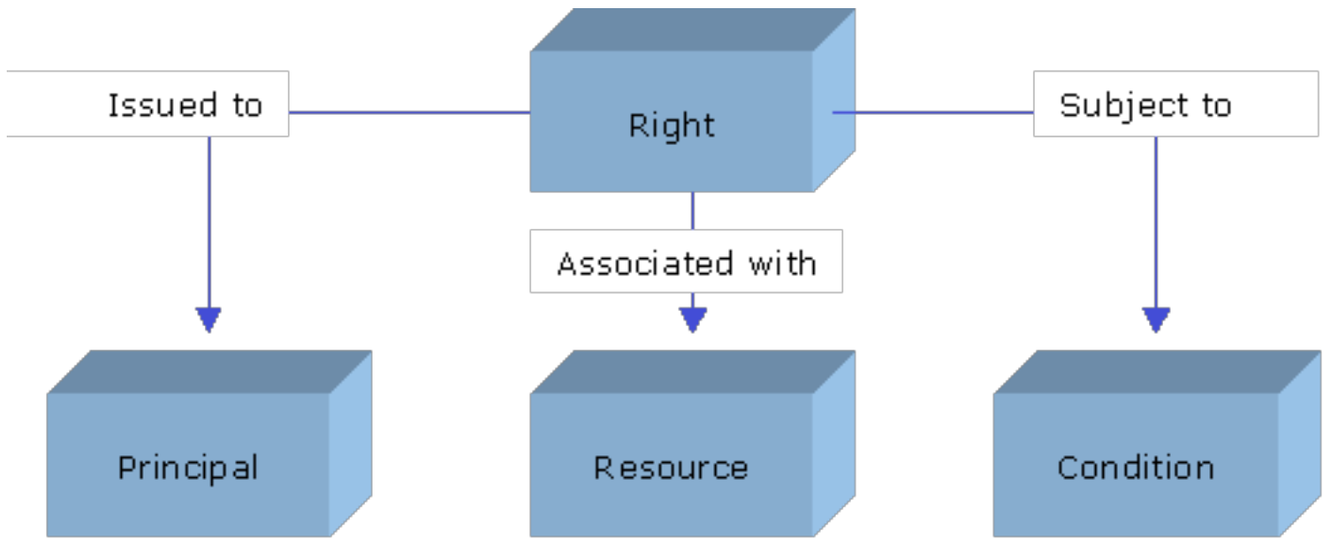
Digital Watermark

Music: mp3stego

http://www.petitcolas.net/fabien/steganography/mp3stego/index.html

Digital Rights Management
– Rights Expression Language (REL)

Metadata for DRM



- MPEG-21: REL
  - A digital item
    - is a structured digital object with a standard representation, identification and metadata
  - User
    - is any entity that interacts in the MPEG-21 environment or makes use of digital items

Rights model

- Render rights
  - –View, Print, Play or Execute
- Transport rights
  - –Copy, Move, Loan
- Derivative work rights
  - –Edit, Embed, Extract
- Utility rights
  - –Backup, Caching, Data integrity

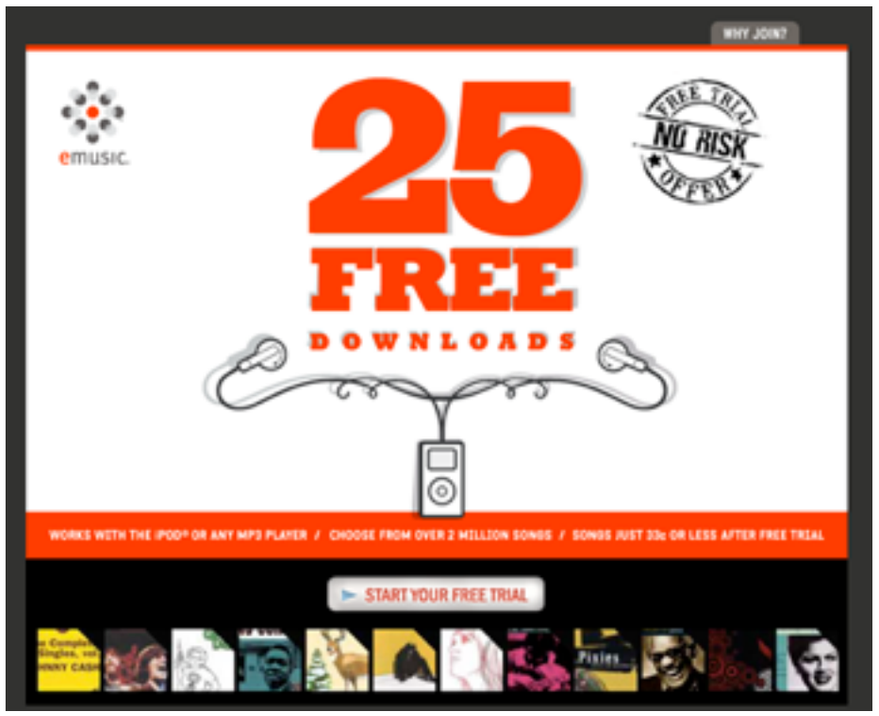
DRM technologies and associated devices

Name	Used in	Date to use	Description
Fairplay	ipod, iphone, itunes	2003+	The purchased music files are encoded as AAC, then encrypted with an additional format that renders the file exclusively compatible with iTunes and the iPod
3-play	Microsoft Zune	2006+	Music files that are received wirelessly from other Zune devices can be played only a maximum of three times on the device.
Janus WMA DRM	All PlaysForSure Devices	2004+	Janus is the codename for portable version of Windows Media DRM for portable devices.
OMA DRM	Implemented in over 550 phone models	2004+	A DRM system invented by the Open Mobile Alliance to control copying of cell phone ring tones

DRM opposition

digital rights management
= digital restrictions management ?

DRM-free



- Apple began selling "DRM-Free" music through their iTunes store in April of 2007
- the DRM-Free iTunes files were still embedded with each user's account information

Digital Rights Expression Languages

- Rights may be managed using digital rights expression languages.
- DRELs specify the permissions given to
  - users, distributors and repositories
  - and the conditions and obligations that have to be satisfied for these permissions to be exercised.

Rights Expression Language (REL)

- A standard way to express and interpret rights specification for interoperability.
- Comprehensive, generic, precise and extensible.

- eXtensible rights Markup Language (**XrML**).
  - XrML 2.0 : MPEG REL
- Open Digital Rights Language (**ODRL**).
  - ODRL 1.1 : OMA (Open Mobile Alliance) REL

General description of RELs

- A rights expression language (REL) is a type of policy authorization language.
  - Focus is on expressing rights granted by one party to another.
  - Issuance and delegation rights for other grants are core concepts.
    - Can be used to model lending, loans, transfers of rights.

- REL design goals:
  - Provide a flexible, extensible mechanism for expressing authorizations.
  - Enable interoperability across various policy evaluation systems.
  - Make it easy for policy authors (e.g. content owners) to express their desired policies.

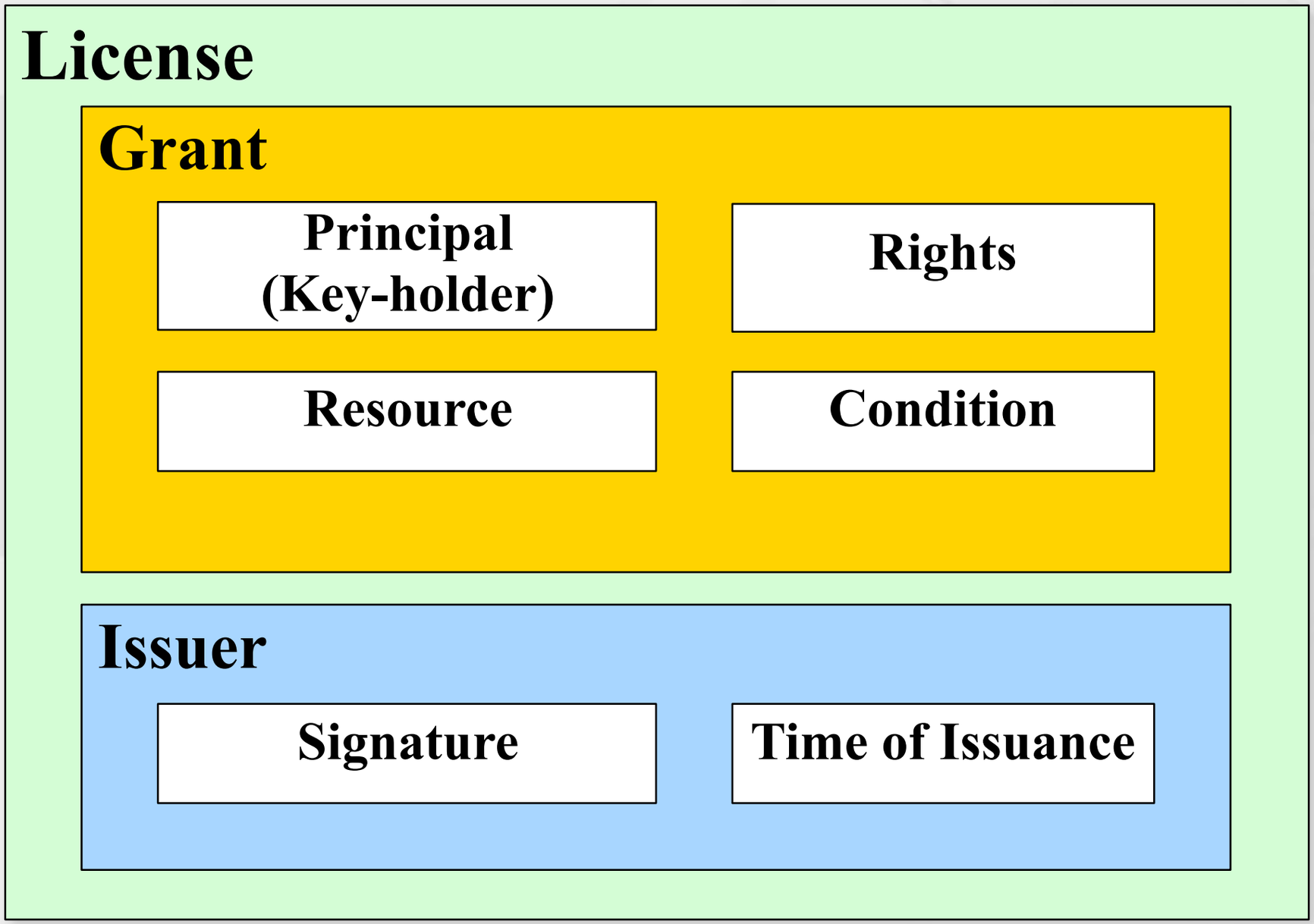
An example REL: XrML 2.X

- XrML, the *XML Rights Management Language*, is a standard currently under development

XrML introduction

- The only REL in working DRM systems.
- Specification language:
  - Programmers specify high-level rights in a license file.
  - An XrML interpreter parses the license file.
  - REL SDK for building an XrML interpreter.
- Data model:
  - License, grant, principal, right, resource and condition

XrML license



XrML 2.X

- In the RM context, XrML 2.X allows content owners a systematic way to express their intent for distribution and consumption.
- Like other policy languages, XrML 2.X **licenses** (statements) declare authorizations, but cannot enforce compliance.
  - Systems that consume XrML 2.X licenses must be trusted by the license issuer to properly enforce the grants specified within the license.
- Licenses are digitally signed by the issuer to protect their integrity.
- Licenses may be embedded within content or move independently.

Semantic of a Grant

- Every XrML 2.X grant has the following form:
  - Issuer authorizes principal to exercise a right with respect to a resource subject to conditions.
  - A license is a collection of one or more grants made by the same issuer.

- Grants may be **chained** together:
  - Bill's RM system trusts Tom and his delegates.
  - Tom delegates the right to license printing to John.
  - John issues a license: "Bill has the right to print the book."
  - Therefore Bill can print the book.

Sample XrML 2.X License

```
<?xml version="1.0" encoding="UTF-8" ?>
 <license>
 <grant>
  <keyHolder>  …  </keyHolder>
  <mx:play />
  <mx:diReference>
  <mx:identifier>
       urn:mpeg:example:2002:twotonshoe:album
   </mx:identifier>
   </mx:diReference>
 </grant>
 <issuer> … </issuer>
</license>
```

XrML authorization model

- Input
  - Principal
  - Right
  - Resource
  - Time interval
  - Licenses
  - Designated “root grants” (implicitly trusted)

- Output
  - “No”
  - “Yes,” unconditionally
  - “Maybe,” if a set of conditions are also met

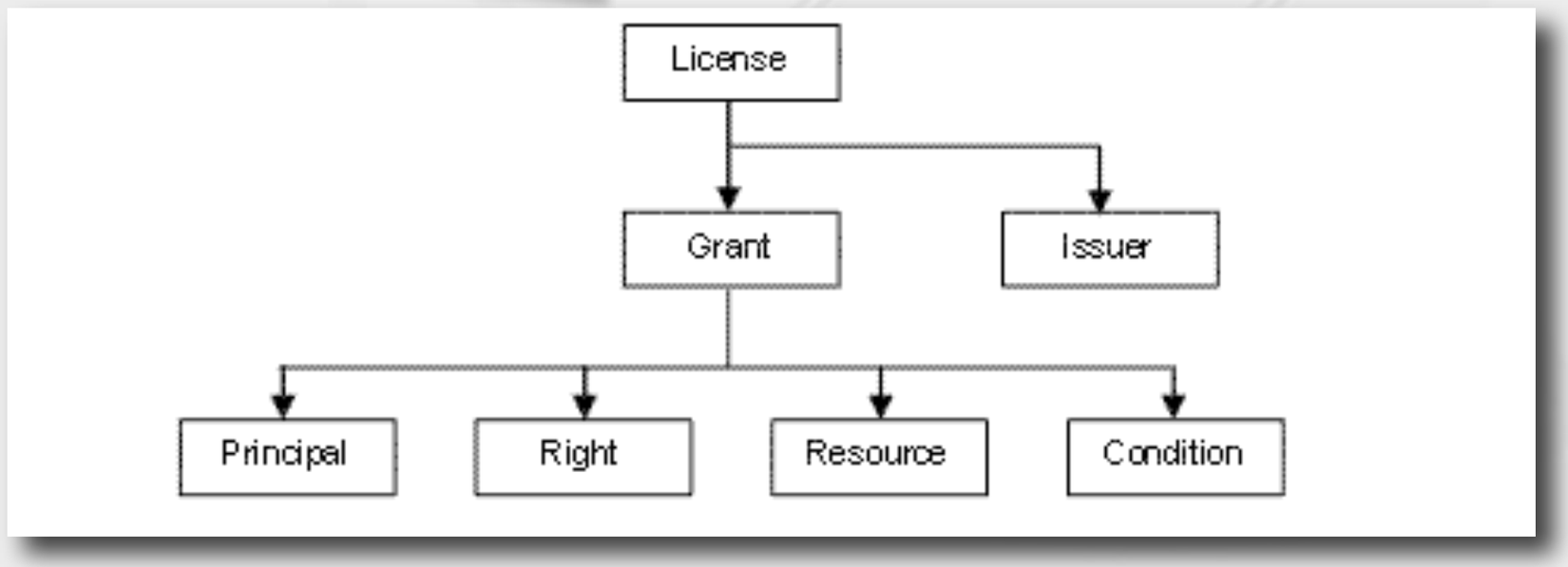
XrML Key Language Features

- Mechanisms for enhanced expressivity
  - Patterns, variables and quantifiers
  - Grouping grants
  - Delegation
- Meta-rights
  - Issue
  - Obtain
  - Revocation
  - PossessProperty
- Linking conditions
  - PrerequisiteRight

MPEG-21 REL

- Derived from XrML
- 3 Components:
  - –Kernel set
  - –Standard extension
  - –multimedia extension

structure of a simple license



XrML 2.X and Multiple Authorities

- XrML 2.X offers a new level of expressiveness
  - –Enables representation of a wider range of scenarios.
- Example scenario: evaluating authorizations from multiple authorities for a resource.
  - –Today, RM systems operate using a “closed-world assumption.”
    - Any action not explicitly authorized by the content owner is prohibited.
  - –Copyright doesn’t work like this.
    - Copyright is a liability-based system.
    - Some actions are permitted by law even if they are not explicitly authorized by the copyright holder.
  - –How might we use XrML 2.X to represent authorizations as well as limitations built into the law?

XrML 2.X and Multiple Authorities (cont'd)

- Content creators are given exclusive rights by law; these rights are then licensed to consumers.
- Limitations on the exclusive rights contained in a copyright can be thought of as independent grants of licenses by Congress to the consumer.
  - "Congress says every library has the right to make an archival copy of a work" (17 U.S.C. 108).
  - Variables allow us to write licenses that apply to (potentially undefined) sets of content and users.
  - Congressional grants can be conditioned on possession of a licensed copy of the work.
- RM systems would need to recognize both the content owner as well as Congress as authorities for a given work.

Evaluating Policy Expressions

- RM systems attach policy expressions to content and then project that policy along with the content into a remote system.
  - Policy creators need to have confidence that the receiving system will faithfully implement the defined policies.
- For years in security research, we've built protocols that depend on trusted computing bases (TCBs) at their core.
  - The TCB must behave as expected, because it's the part of the system which you have to implicitly trust.

Attestable TCBs

- For RM systems, having a TCB locally is not sufficient to ensure very high levels of trust
  - We need to be able to prove the existence & reliance on a TCB to a remote party.
  - “Attestation”
- A content author is only going to allow content & policy to flow to TCBs (and, recursively, applications) he believes are going to behave properly.
  - “Behave” == implement policy as defined
- Content consumers are only going to let code they understand run their systems.

Trust is Central to Attestable TCBs

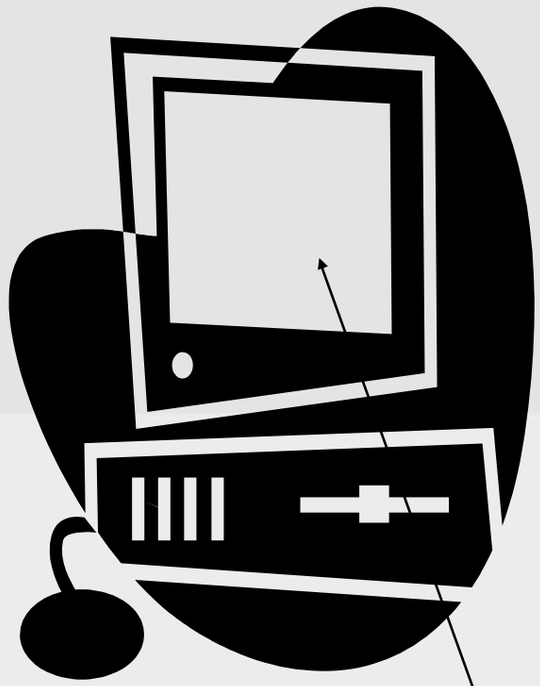
- Four elements that must be present in order to trust a TCB
  - I know who / what the it is, and that it is not an imposter
  - I know its state – it has been properly initialized
  - I know that it cannot be tampered with
  - I know that my communication with it is private and tamper-proof

Building Attestable TCBs

- There are two separate industry initiatives today trying to build attestable TCBs on evolutions of PC hardware and software.
  - TCPA – Trusted Computing Platform Alliance
  - Microsoft's Next-generation Secure Computing Base (NGSCB)
- TCPA is specifying changes to the PC hardware that can make attestations.
  - Goal is to be able to sign statements about the entire software stack running on top of the PC, from the moment power is turned on forward
- NGSCB has a somewhat different focus.
  - Goal is to create a separate, parallel execution environment inside PCs that is rigidly controlled by the user, and make attestations about only that code.
  - Additionally, provide sealed storage, curtained memory and secure I/O with the user.

NGSCB – How It Works

- Subdivide the execution environment by adding a new mode flag to the CPU.



Trusted Input

Trusted Output

User

App

Kernel

OS

Standard

Trusted

NCA

NCA

Nexus

Pub/Pri Keys

SSC

Attestation in NGSCB

- Attestation is a recursive process
  - The SSC (security chip) always knows the unspoofable identity of the running nexus.
  - Assuming it does, the SSC can then attest to (make signed statements about) the identity of the nexus.
    - SSC has a digital signature key pair, plus some certificates for that key pair.
  - The nexus in turn can attest to the identity of nexus computing applications (NCAs)
- If you accept the certificates & digital signature key pair as belonging to an uncorrupted SSC, then you can trust the statements the SSC makes about the running nexus.

Attestation and RM Systems

- Why would RM system builders be interested in the attestation feature?
  - Attestation allows a host machine to query what software is running on a remote machine before sending it content.
- Examples:
  - In an enterprise RM environment, servers could be configured to only release classified documents to non-portable machines.
  - Before sending personal information to a server, a client could demand proof that the server is running a software stack certified to comply with privacy-protecting principles.
  - In a consumer RM environment, content could be licensed such that it could freely migrate among all devices within a single “household”.
- Operation of the PC is never blocked; the hardware simply will not lie about the software running on top of it.
  - Servers can choose not to talk to clients they don’t like.

Summary

- Two security technologies:
  - Rights expression languages (RELs)
  - Attestable TCBs
- These technologies provide a number of new security features for computing platforms, including advances in secret storage and policy expression, evaluation and projection.
- RM systems built on today's platforms are useful for a wide variety of solutions; the features provided by RELs and attestable TCBs will further expand that set.

Agenda

- Overview
- Introduction of DRM (Sony & DRM)
- Protecting Digital Intellectual Property
- Rights Expression Language (REL)
- Case Study – Existing DRM systems

浙江大学计算机学院
数字媒体与网络技术

Case Studies

InterTrust

- Original DRM vendor (with IBM)
  - –May have coined the term
  - –Originally called Electronic Publishing Resources
  - –First implementations in hardware
  - –Major patent portfolio
- New technology: Rights|System
  - –Framework for multiple devices
    - Rights|Desktop for PCs
    - Rights|TV for settop boxes
    - Rights|PDA for handheld devices
    - Rights|Phone for Symbian mobile phones
  - –Public encryption algorithms

IBM EMMS

- Developed in IBM labs over period of 8 years
- Cross-device, like InterTrust
- Integration with IBM server components
  - –WebSphere
  - –DB2
  - –Service Provider Delivery Environment (SPDE)

Microsoft

- 1st generation: Windows Media Player
- 2nd generation: Digital Asset Server
  - –Server for Microsoft Reader E-Books
  - –Uses subset of XrML
- 3rd generation: “Unified DRM” (RMS)
  - –One DRM for all devices & platforms
  - –Open API for rendering app developers
  - –XrML based

MacroVision (1985-)

- Copy protection technique for VHS tapes
- Inserts special signals into the vertical blanking interval of NTSC protocol
  - –affects automatic gain control in most VCRs, but is ignored by most televisions
  - –difficult to remove from the original signal
- Makes subsequent recordings shake and have periods of bright and dark frames

Apple's FairPlay Technology

- DRM for iTunes
  - playing, recording, and sharing of files
- Moves beyond "protection only"
  - allows media to be shared among devices
  - allows others to listen to (but not copy) music
  - allows music to be burned to an audio CD, which loses the DRM protection

How FairPlay Works

- iTunes uses encrypted MP4 audio files
- Acquire decryption key by trying to play song
  - player generates a unique ID
  - sends this ID to the iTunes server
  - if there are less than N authorizations in your account, the server responds with decryption key
- The decryption key itself is encrypted so cannot be given to another machine

Discussion

- Is FairPlay too lenient, too stringent, or just about right?
- What is your experience with this DRM?
- What happens if Apple decides to stop supporting FairPlay?