Digital Rights Management

and other protection mechanisms for author rights

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Myself

- Background in Coding Theory (University of Bergen)
- Current research interest
  - application of coding theory to digital watermarking
  - other areas of information security
- Lecturer at University of Surrey (40 min. South of London)
- CV available if you know of an open post near Sea and Mountains.

1. Introduction
   - Copyright Protection

2. Digital Rights Management
   - Typical DRM Solutions
   - Controversies
   - DRM-Security
   - Trusted Computing
   - Flexible solutions

3. Fingerprinting and Watermarking
   - Watermarking
   - Digital Fingerprinting
   - Deterring versus Prevention

4. Conclusions

The problem

- Creation is Expensive
- Copying is Cheap

Example

Logarithm Tables in ages past needed protection.

- Every figure computed manually (hoards of people)
- Reproduction (printing) relatively cheap
- ... leading to copyright piracy

- Today, computation is cheap
  - Logarithm Tables do not require protection

The digital problem

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- Amateur equipment is highly advanced
  - Perfect CD copies on your home PC

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- Amateur equipment is highly advanced
  - Perfect CD copies on your home PC
- Cheaper and better quality for anyone
  - It always was possible...

Different Scenarios

- Large-scale and small-scale
  - Bob gave a copy to his best friend Polly
  - Oscar put the file on his web server
    - … downloaded by 1 345 823 arbitrary users
- Professional (profit-makers) versus careless amateurs
  - 242 643 rogue CD-s sold on a street markets in Calcutta
    - … criminals make millions …
  - Charlie(12) gave free copies to his 101 232 'friends' at facebook

Objective

Prevention versus Detection

- Prevent infringements
    - ... violations become impossible
- Detect and trace infringements
    - Prosecute violators – for penalties or for compensation
    - Deter potential violators
        - ... nobody is willing to risk a violation

Solutions

- Digital Rights Management (DRM)
  - Prevent copying
  - Limit copying and viewing
- Forensics and Investigation
  - Trace violators for prosecution
- Digital Fingerprinting – forensic aid

Possible Penalties

- Criminal justice: gaol and fines
- Civil law suit: compensation
- Revoke (disable) player
- Terminate subscription
- Penalty fees

Proprietary Solutions

- System requires a secret key in the player
    - Inaccessable for the user
    - Only trusted producers can make approved players
- Open standards would be impossible
    - ... no secret key
- Three main 'players'
    - Apple (i-tunes)
    - Microsoft
    - OMA – Open Mobile Alliance

The main players

- Apple and Microsoft are independent
  - Promote products of a single manufacturer
- Open Mobile Alliance (OMA)
  - Syndicate of 400 proprietary businesses
  - ... do not confuse it with an open standard
  - Licencing and approval from a syndicate
- How many partners can keep a secret?
  - The DVD-encryption was broken because one partner made a bug

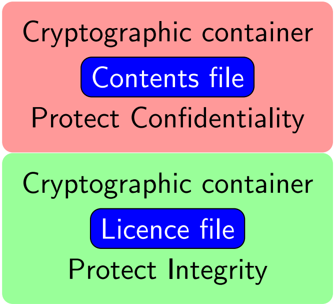
Function

- Prevent creation of working copies
- For example
  - Copies used only with original medium (computer games)
  - Copies play only on players belonging to licencee
  - Maximum of n copies can be made (e.g. *one* backup copy)
  - Viewing possible – printing impossible (e-libraries)

Traditional Fair Use

- Copies for personal use were traditionally legal
- Use copies with any player
  - traditional players are open technology (once patents expire)
  - once DRM contents is bought, you are locked to one brand
    - is your car player compatible with the one in your living room?
    - what if the manufacturer goes out of business?
- Do you treat all infringements the same?
  - A 10-year old schoolboy sharing files with a class mate
  - Organised crime selling bootleg copies *en masse*
- Traditional DRM cannot distinguish

The Data Object



Cryptographic container

Contents file

Protect Confidentiality

Cryptographic container

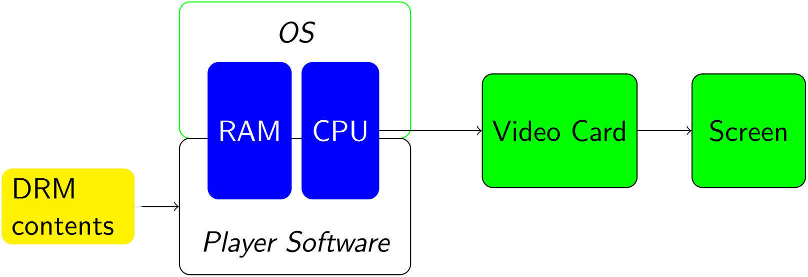
Licence file

Protect Integrity

- Contents and Licence may be separate
- Only trusted readers can decrypt contents
- Only trusted software update/create the licence

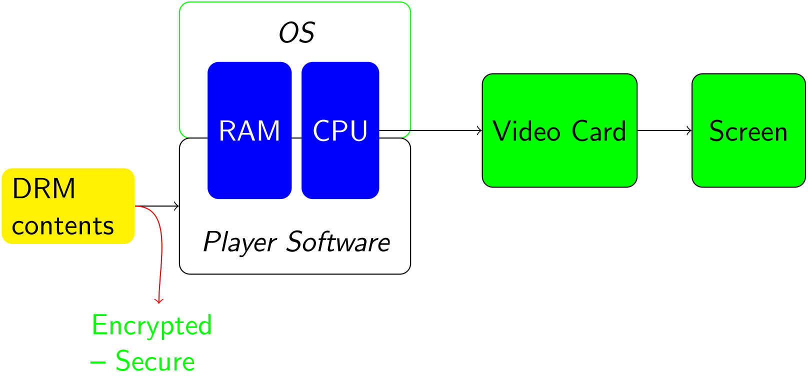
Software Player Architecture

Components



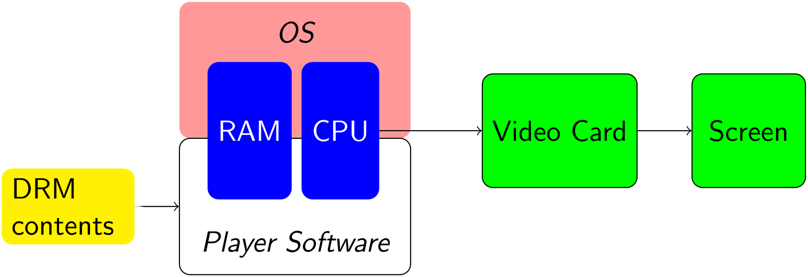
Software Player Architecture

The protection



Software Player Architecture

The problem



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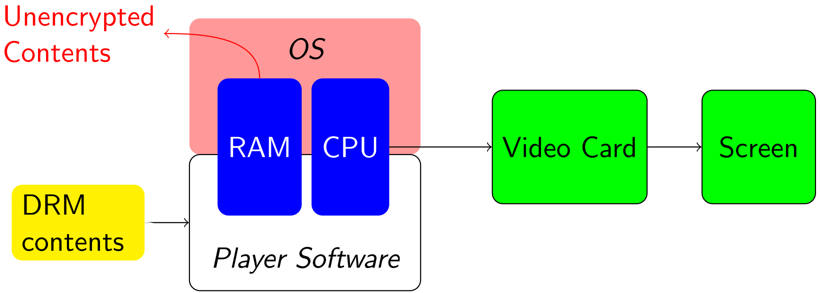

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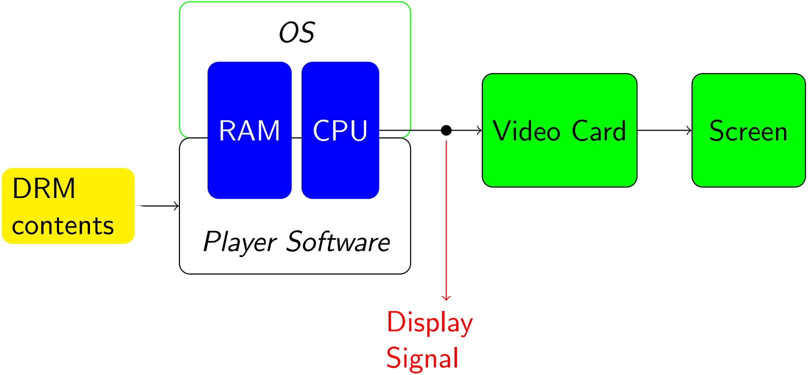

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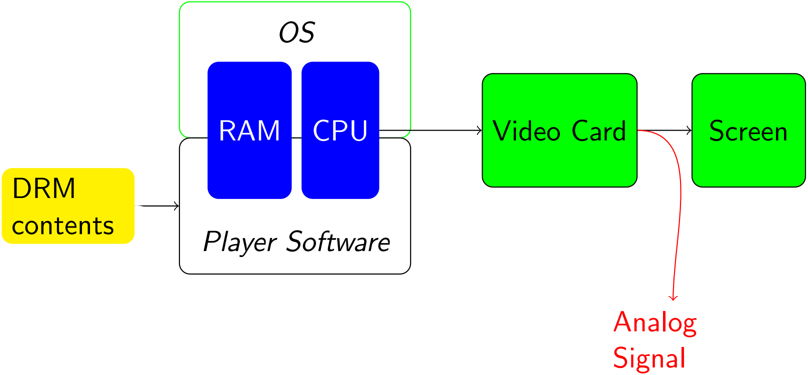

Software Player Architecture

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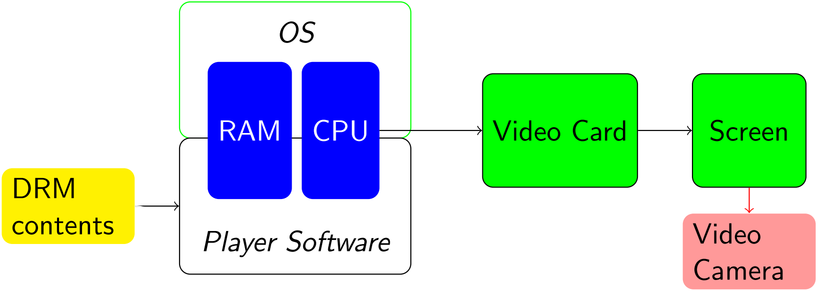
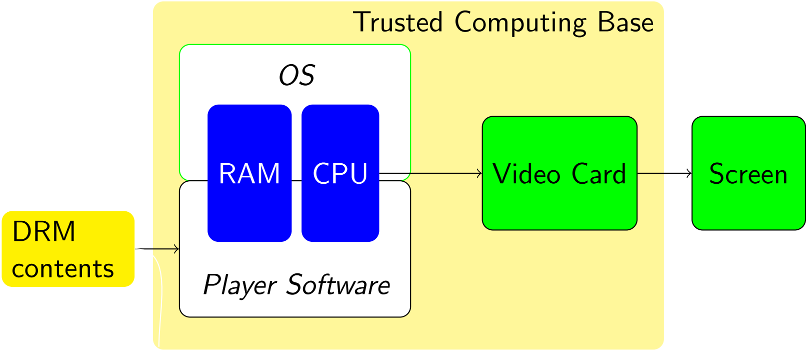


Software Player Architecture

The solution



Analog leaks

- No protection against analog leaks
  - e.g. refilming with a separate camera
- Inferior quality
  - thus it might not be a problem
- Analog leaks possible at various stages
  1. Tapping the screen feed
  2. Re-filming
- At increasing level of quality loss
- How many do you have to protect?
  - and included in the trusted computing base?

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  - User control is limited
- So who is the rightful owner? Data provider or user?
- Can the user trust the data provider?

Sony XCP – as an example

- November 2005, Sony BMG recalled 2.1M CD-s [1]
  - they were too controversial
- Proprietary player required to play the CD on a PC
- Rootkit-type technology
  - modified the OS kernel
  - concealed itself
- Data supplier (partly) controls the customer PC

Does it work?

- Some solutions seem to keep providers happy
  - ... i-tunes have survived a long time
- Manufacturers seem not to believe in security
  - ... they require legal protection of the quasi-secure technology
- Security technology tends to be broken
  - ... organised criminals can generally get through
  - ... normaly people are prevented

Graceful Infringement Reactions

Katzenbeisser, Kursawe and Talstra (Philips) [2]

- Copying is not prevented
- Legal contents accompanied by a blacklist
- Player enforces penalties based on blacklist
- Pro: penalties can be tuned to severity of offence

The Player's Role

1. Playing
   - Any contents can be played
   - Contents played is watermarked
   - ... marked with the ID of the player
2. Enforcement
   - Whenever legal contents is aquired, a blacklist is supplied
   - Check for own ID in the blacklist
   - Enforce penalties based on violations listed

Contents Provider's Role

- Monitor the Internet (and other publication channels)
- Update blacklists
- Publish blacklists with authorised contents

Advantages

- Privacy
  - The monitor cannot identify the source
  - Only source player recognises its own identity
- Graceful reactions to different offences
  - Minor contents leaks deserve minor reactions
  - Large-scale distribution requires large-scale reactions

Digital Watermarking

Definition

Digital Watermarking refers to any technique to

- hide (modulate) a message in a host file
  - e.g. image, sound file
- preserving the use and value of the host file

How is it done?

- Redundancy of the host
    - small changes are imperceptible
- Say a 24-bit RGB pixmap image
    - change the *least significant bit* of each pixel/each component
    - Colour depth 24-bit → 21-bit
        - Who can tell the difference
    - Three bits per pixel to represent the hidden message

Robust Watermarking

Definition

Robust Watermarking refers to any watermarking technique where

- an attacker can neither destroy nor change the embedded watermark
- with non-negligible probability
- without also destroying the host file so beyond practical use

- Scenario-dependent definitions
  - 'Beyond practical use'
  - 'non-negligible probability'

Copyright applications

- Watermarks can contain
  - copyright notices – proof of ownership
  - ‘fingerprint’ – identifying the authorised user
    - ... to allow tracing of violators
  - DRM information – licencing information
    - Preventing contents and DRM information from being distributed separately

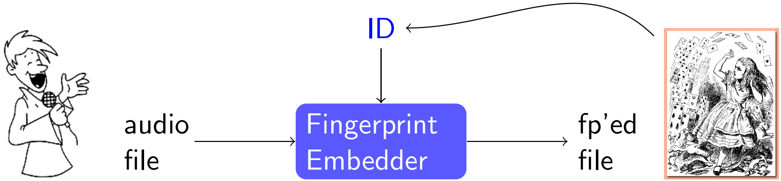
The threats

- A copyright violator attempts to disable the watermark
  - Remove all copyright-protection information
  - Change or add false proof of ownership
  - Change DRM information (e.g. rewind counters)
  - Change fingerprint (e.g. framing an innocent user)
- Robust Watermarking is appropriate

Is robust watermarking feasible?

- Well ... maybe
- Continuous improvements appear in the literature
- Especially for images
  - Robust against jpeg compression
  - Robust against printing and scanning
  - Robust against additive noise
  - Robust against rotation and cropping
- Hard to resist all attacks simultaneously
- Local geometric distortions is hard (Stirmark attack)
- Less research on Audio Watermarking (to date)

Digital Fingerprinting



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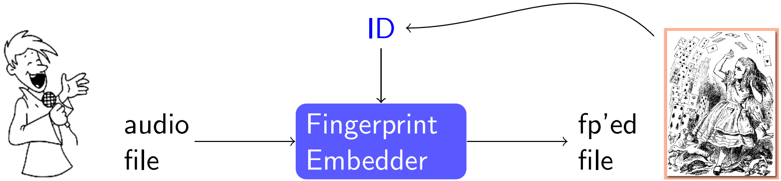


ID

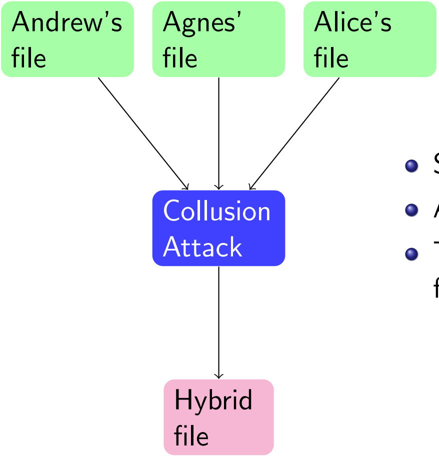
audio file

Fingerprint Embedder

fp'ed file

- Each copy sold contains the ID of the buyer
- If Charlie shows up with Alice's copy,
    - Alice can be prosecuted

Collusion Attacks



- Several copies ⇒ Extra information
- Averaging, cut-and-paste, etc.
- The hybrid carries no clean fingerprint

Collusion-Secure Codes

- Layered model
  - Coding layer: map user ID → codeword (fingerprint)
  - Embedding layer: hide fingerprint in copy
- Collusion-secure codes for the coding layer
  - Assume an abstract model
  - Robust against collusion attacks
- Embedding layer:
  - E.g. watermarking
  - Robust against other attacks (as other watermarking applications)
- Limitted by the state of the art in watermarking

Traitor Tracing in Broadcast Encryption

- Content is encrypted
  - subscribers have decoder boxes with a key
- Traitor Tracing protects the key
  - allows tracing of illegal decoder boxes

How it works

- Master key: matrix $K = [k_{i,j}]$ of keys
- User key: sequence $(k_{c_j,j} : j = 1 \dots n)$
    - one key per column of K
    - $(c_j : j = 1 \dots n)$ is a codeword from a collusion-secure code
- Session key: $\kappa = \kappa_1 + \kappa_2 + \dots + \kappa_n$
- Distribute an enabling block
    - $K_S = [E_{k_{i,j}}(\kappa_j)]_{i,j}$
    - κ can be calculated from K_S
        - if and only if one key per column of K is known
- Only known application where collusion-secure codes provably work.

The advantages of fingerprinting

- Fingerprinting is one component of the graceful reaction system of Katzenbeisser *et al*
- Technology applies only *after* the fact
- Irrelevant to innocent users
    - protects privacy and 'fair use'

The NDS Operational Security Unit

Len Withall [3]

- NDS distributes (among other things) Sky TV
- Operational Security Unit est. 1996
- Before ... decoder cards cracked within months
- The unit investigated piracy
    - tracing and prosecuting pirates
- Reputation that Sky cards are not worth cracking
- Sky P1 card remained secure for $4\frac{1}{2}$ year

Who needs protection?

- Big money at stake …
  - but how much?
  - and whose money?
- 85% of music recordings do not make money [RIAA]
  - proliferation of recordings means marketing
  - … increased revenue from live performance
- Loss estimates tend to assume that the alternative to an illegal copy is a legal copy paid for
  - Unlikely – it might mean fewer legal copies as well

The different solutions

- Prevention
- Forensics – detection and prosecution
- Fingerprinting – technological support for forensics
- Economic solutions
    - Maybe revenue could be ensured in different ways
    - ... research publications are now increasingly funded by the authors (or their sponsors)

Conclusion

- No perfect solution
  - Hard to prevent violations
  - and also protect fair use
- Security implies platform-dependence
- Fingerprinting allows fair use
  - ... but sufficient security is still an open question
- Forensic investigation has proved effective
- No authoritative study of socio-economic implications
  - ... and economic alternatives
- Maybe technology is the wrong way forward?

References

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