

# 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.



## 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

- What has changed in recent years?
- Digital copies are perfect
  - Analogue copies (music cassettes, photocopies) are imperfect
- 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
  - Inaccessible 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 licensee
  - 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

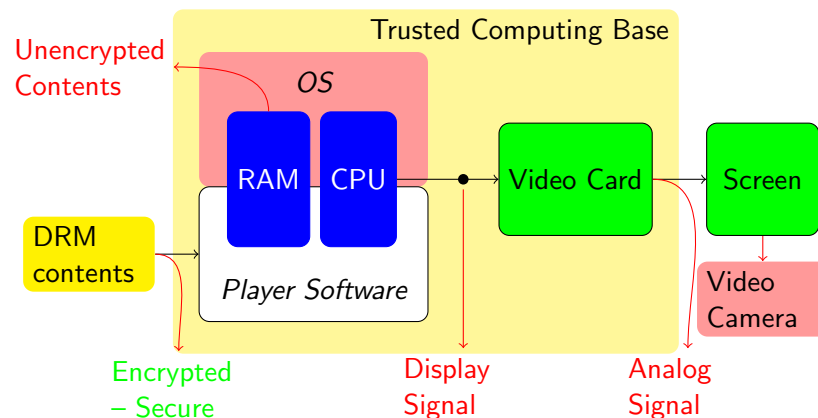
Protect Integrity

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



## Software Player Architecture

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?



## Who owns the computer?

- Trusted computing is the principle that
  - software or data providers can **trust** the system
- The *user* is **not trusted**
- Hence, software/data providers take partial control
  - User control is limited
- So who is the rightful owner? Data provider or user?
- Can the user trust the data provider?



## 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



## 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



## 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



## 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



## 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'



## 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

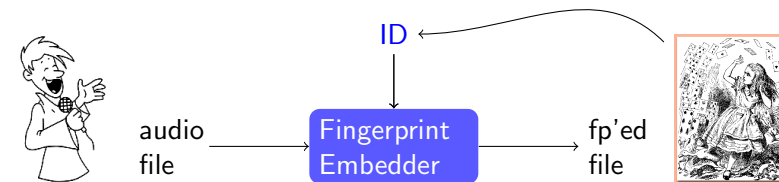


## Is robust watermarking feasible?

- 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)



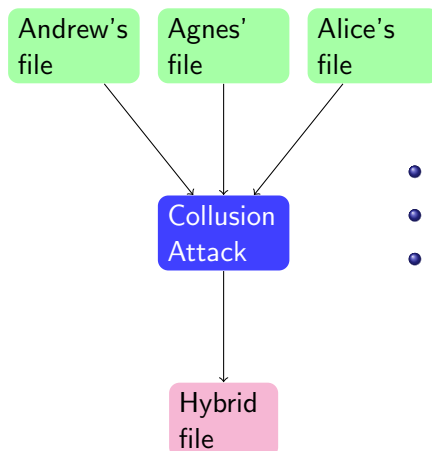
## Digital Fingerprinting



- 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  $\Rightarrow$  Extra information
- Averaging, cut-and-paste, etc.
- The hybrid carries no clean fingerprint



## Collusion-Secure Codes

- Layered model
  - Coding layer: map user ID  $\rightarrow$  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)
- Limited 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
  - $K_S = [E_{k_{i,j}}(\kappa_j)]_{i,j}$
  - $\kappa$  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



## 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?



## 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)



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