CS 201P - Computer Security, Notes

Fall, 2021

Please find below lecture slide notes associated with the lectures for CS 201P, Computer Security.

Notes:

- **Introduction:**
  - Introduction.
- **Physical Security:**
  - Locks and Keys.
  - Authentication Technologies.
  - Direct Attacks.
- **Operating Systems Security:**
  - OS Concepts.
  - SetUID.
  - Environment Variables.
  - Buffer Overflow Attacks.
  - OS Security.
- **Malware:**
  - Malware.
- **Network Security 1:**
  - Network models and ARP security.
  - TCP/IP Security.
- **Network Security 2:**
  - DNS security.
  - Wireless Networks.
  - Firewalls, Tunnels, and IDS.
- **Browser Security:**
  - Web Security.
- **Cryptography:**
  - Intro. to Cryptography.
  - Modes of Operation.
- **Application Security:**
  - Spam and Cybercrime.
  - Digital Rights Management.

Goodrich's Home Page.

Digital Rights Management

Introduction

- Digital Rights Management (DRM) is a term used for systems that restrict the use of digital media
- DRM defends against the illegal altering, sharing, copying, printing, viewing of digital media
- Copyright owners claim DRM is needed to prevent revenue lost from illegal distribution of their copyrighted material

DRM Content and Actions

- There are many capabilities covered by DRM

Digital Rights Management

Digital content:
- Videos
- Music
- Audio books
- Digital books
- Software
- Video games

Possible Actions and Restrictions:
- Play once
- Play k times
- Play for a set time period
- Play an unlimited amount
- Copy
- Burn to physical media
- Lend to a friend
- Sell
- Transfer to a different device

Early U.S. Copyright History

- US Constitution, Article 1, Section 8
  - “The Congress shall have the Power … To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries”
- Copyright Act of 1790
  - "the author and authors of any map, chart, book or books already printed within these United States, being a citizen or citizens thereof....shall have the sole right and liberty of printing, reprinting, publishing and vending such map, chart, book or books...."
  - Citizens could patent books, charts, or maps for a period of 14 years – Could renew for another 14 years if you were alive
  - Non-citizens and works form other countries not protected
  - Other laws followed to change the Act slightly

Copyright Act of 1976

- Could copyright literary works, musical works, dramatic works, choreographic works, graphical works, motion pictures, and sound recordings (architectural works added in 1990)
- Copyright holders had exclusive right to reproduce, create derivative works of the original, sell, lease, or rent copies to the public, perform publicly, display publicly
- Could hold copyright for 28 years with a possible 28 year extension
- Rights of copyright holders are limited slightly by sections 107 through section 118 – Often referred to as Fair Use

Fair Use Doctrine

- Various purposes for which reproducing a particular work is considered fair use
  - Criticism, comment, news reporting, teaching, scholarship and research
- Four factors are considered when determining if it is fair use [17 U.S.C. § 106]
  1. The purpose and character of the use, including whether such use is for commercial nature or is for nonprofit educational purposes;
  2. The nature of the copyrighted work;
  3. The amount and substantiality of the portion used in relation to the copyrighted work as a whole; and
  4. The effect of use upon the potential market for or value of the copyrighted work

Sony vs. Universal Studios

- In the 1970s, Sony invented Betamax, a video tape recording format similar to VHS
- Could be used to record copyrighted broadcasts
- At the same time, some movie studios created Discovision which was a large disk that would disintegrate after a few plays
- In 1976 Universal Studios and Disney sued Sony for all the lost profits and tried to ban the use of Video Tape Recorders (VTR)
- District Court for the Central District of California rejected the claim on the basis that noncommercial use of VTRs was considered fair use
- Court of Appeals for the Ninth Circuit reversed the ruling and held Sony liable for aiding in copyright infringement

Sony vs. Universal Studios (cont.)

- In 1984, the Supreme Court had to decide on the issue – Is selling VTRs to the general public aid in copyright infringement of public broadcasts?
- The Supreme Court eventually ruled that "the sale of the VTR's to the general public does not constitute contributory infringement of copyrights"
  - Concluded that most copyright holders who license there work for public broadcast would not mind having their broadcasts recorded on to a Betamax tape by viewers
  - Betamax was ruled that it fell under the Fair Use clause
- Case often referred to by future copyright lawsuits including the Napster case

Digital Millennium Copyright Act (DMCA)

- Signed into law by President Clinton on October 28th, 1998
  - Illegal to circumvent anti-piracy measures built into software
  - Unlawful to create, sell, or distribute devices that illegally copy software
  - Legal to crack copyright protection to conduct encryption research, assess product interoperability, and test computer security systems
  - Provides exceptions to nonprofit libraries, archives, and educational institutions in some cases
  - ISPs are not held accountable for transmitting information resulting from their customers infringements
  - Service providers are required to remove material when found
- Congress passed the law with almost no opposition
  - Congress held the impression that it was merely a technical issue and not one of impact to public policy
  - Highly lobbied by the industry

Dmitry Skylarov and Ed Felten

- Dmitry Skylarov
  - Worked for Elcomsoft in Russia and created product that converts Adobe secure eBook to unprotected PDF (legal in Russia)
  - While in the US, Skylarov was arrested and placed in jail for DMCA violations
  - Eventually Elcomsoft was sued and Skylarov was released
- Professor Edward Felten of Princeton
  - In 2000, the Secure Digital Music Initiative (SDMI) invited researchers to try and break their watermark technology
  - Felten and his team were able to remove the watermarks and wrote a paper to be presented at a conference
  - SDMI and RIAA threatened to take legal action against Felten
  - Felten withdrew from conference but talked about the threats
  - Felten with help of the Electronic Frontier Foundation sued RIAA and SDMI
  - SDMI and RIAA withdrew their threat
  - Felten eventually presented the paper at a different conference

Copy Protection Methods

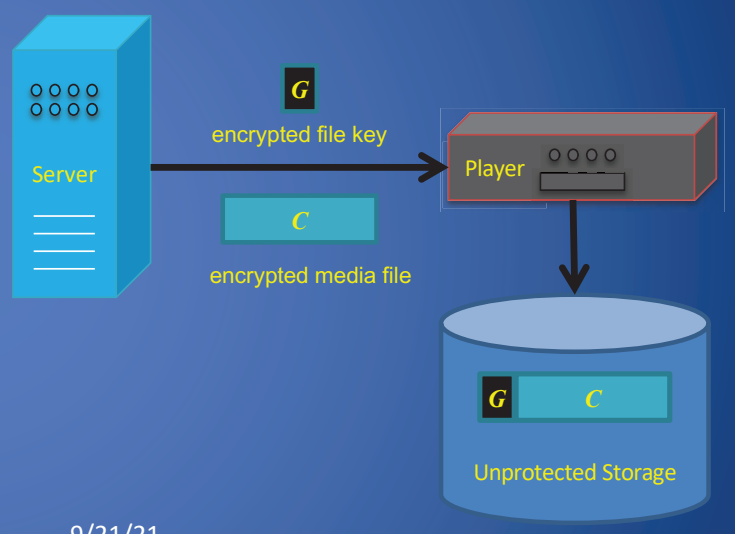
- Dongle
  - Pluggable hardware device that contains a secret value required to run the software
- Product key
  - Required to be entered by installation software
  - Online check for duplicate use
  - Hardware and OS fingerprinting to bind license to machine
- Phone activation
  - Human-to-human interaction servers as deterrent

The Analog Hole

- Every copy protection mechanism is open to the risk of the “analog hole”, that is, recording the content as it is being played

DRM Media File Example

- Step 1:
  - A media server sends to the player the media file encrypted with the file key and the file key encrypted with the player key



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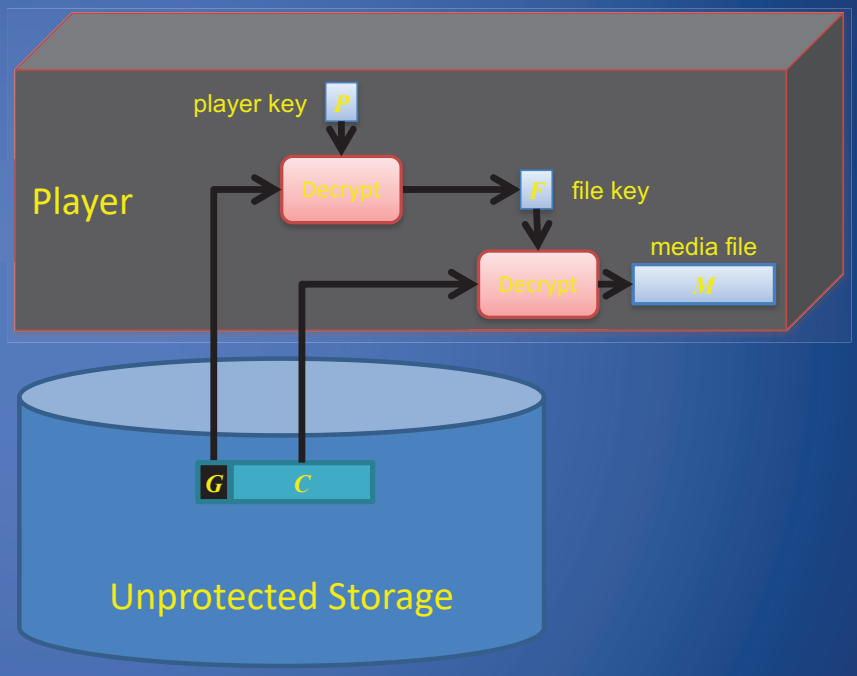
DRM Media File Example

- Step 2:
  - The player first decrypts the file key using the player key and then decrypts the media file with the file key.

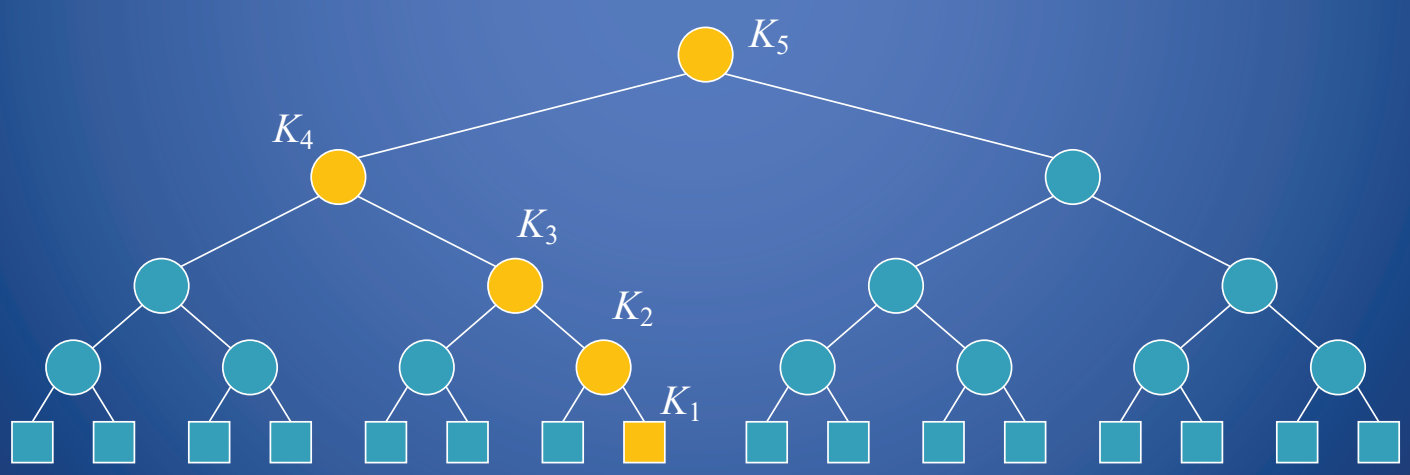


Traitors Tracing

- A controller distributes protected content to a collection of devices
- The devices share a common symmetric key with the controller
- Each content item is encrypted with the shared key and broadcast to all the devices
- Some devices (traitors) are cloned or used to illegally copy and distribute protected content
- Problems:
  - Identifying traitors
  - Revoking traitors

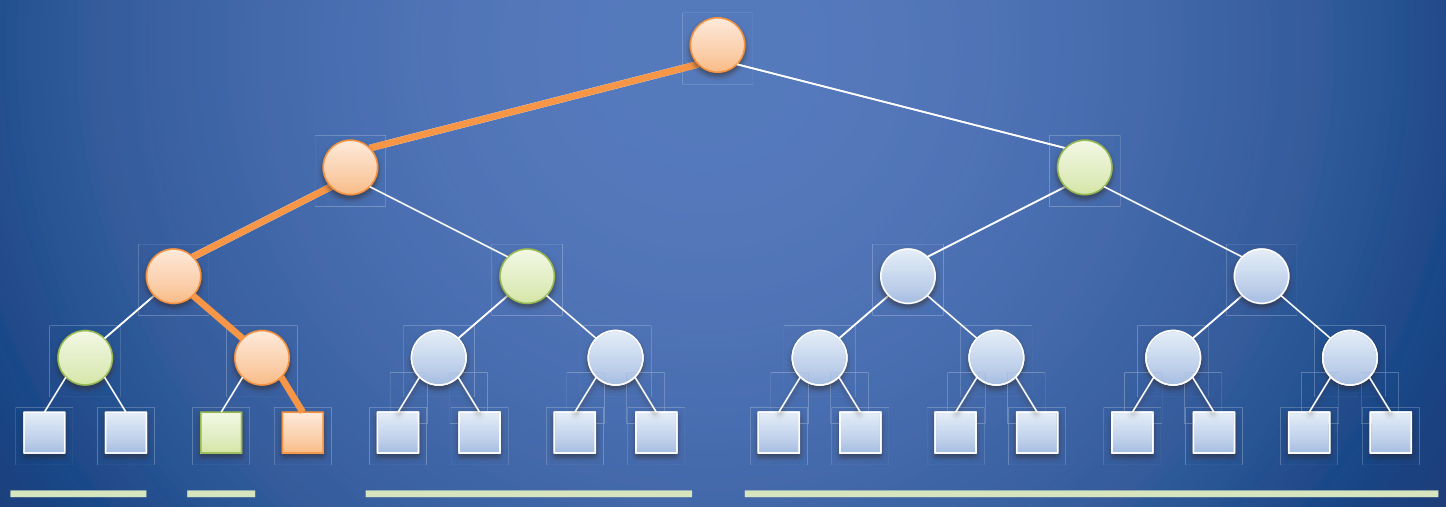
Logical Key Hierarchy

- Balanced binary tree of symmetric encryption keys
- Devices associated with leaves, each holding the keys on the path to the root
- Content encrypted with the key of a node v can be decrypted by all the devices in the subtree of v



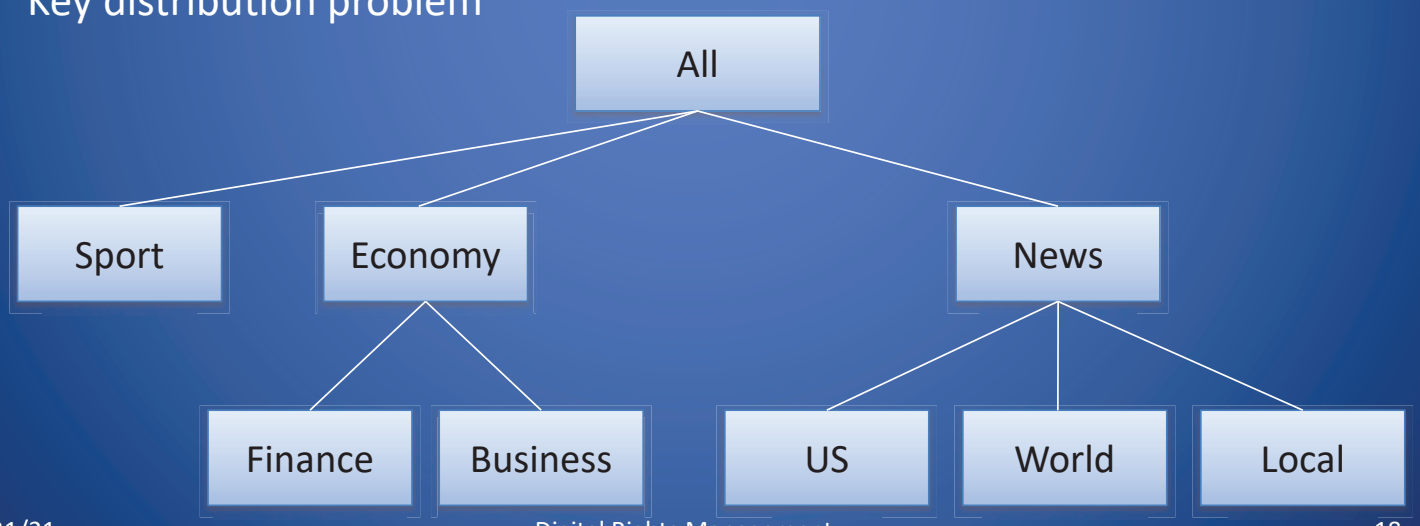
Revocation of a Device

- If a device needs to be revoked, the keys known to this device must be changed and the new keys must be distributed
- The distribution of new keys can be done with a logarithmic number of encrypted broadcast messages



Encrypted Broadcasts

- Content hierarchy with various subscription packages
- Each content item is encrypted with a single symmetric key before broadcasting
- Subscriber authorized to view item must have the key to decrypt the item
- Single key per node allows computation of keys of descendant nodes
- Key distribution problem



CD/DVD Protection

- Most CD/DVDs are protected so they cannot be copied
- CDs are not indestructible and backups are required
- Legal to make backups of CDs you own in most countries – Not legal to sell
- Most protection technologies encrypt the files using a key that is added to the disc as a digital signature
- Almost every encryption technique has been cracked

CD/DVD Protection

- Technically, it is impossible to completely prevent users from copying media they purchase
  - Bit-by-bit copy of software
  - Recording of music using microphones
  - Recording of movies using cameras
  - Scanning of text media
- Given enough time and resources, any media can be copied
- Most companies realize they cannot stop “professionals” from duplicating but they try to stop the casual user from copying

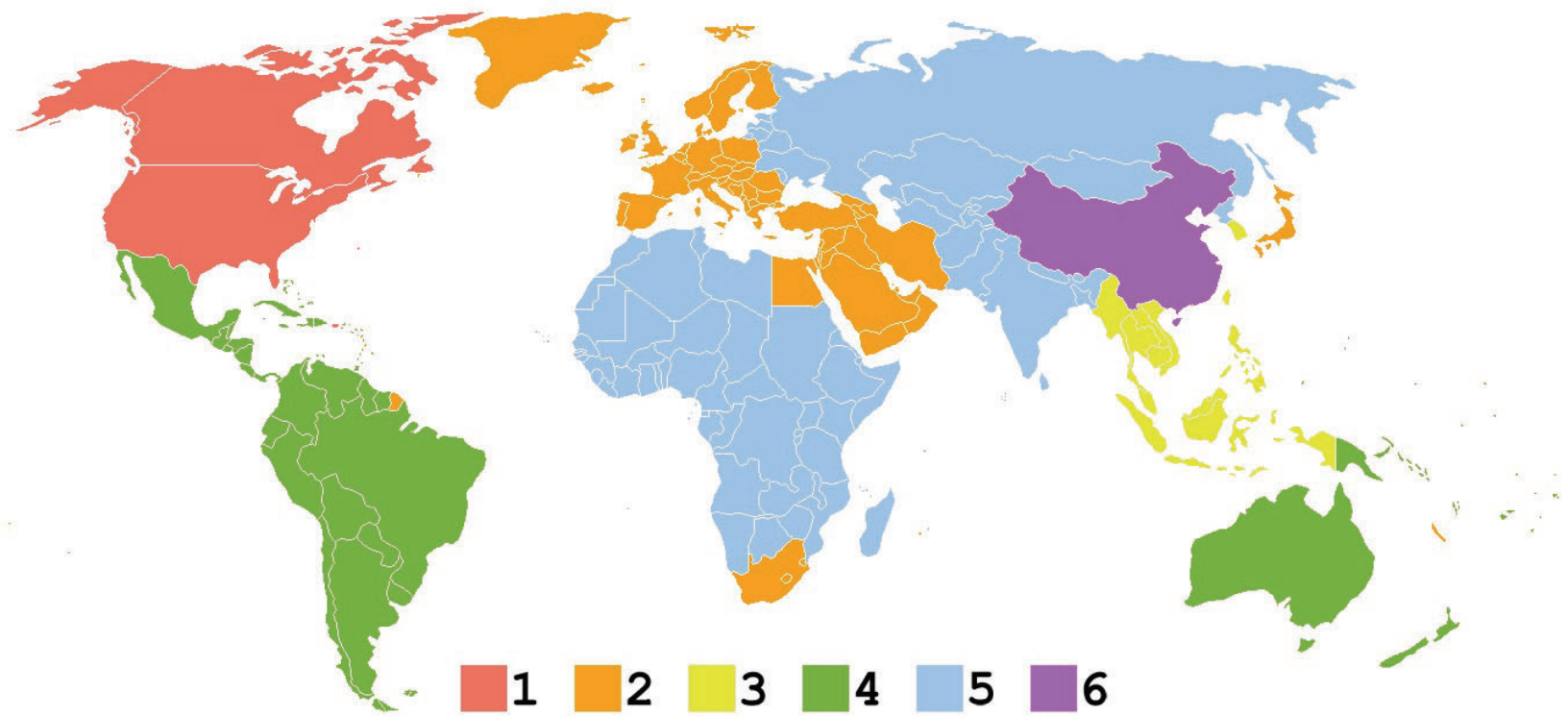
SafeDisc V1 and V2

- Copy protection created by MacroVision
- Games starting in 1999 were protected
- Based on having read errors on the original disc
  - CD burners had to be able to copy the errors exactly as is
- Version 2Has bad sectors like version 1 but also has “weak” sectors
  - Weak sectors often become bad sectors when copying
  - Uniform bit-patterns are hard to write for many CD writers – Some people allege hardware manufacturers may have done this on purpose to aid CD copy protection
- Easy to break
  - 1:1 CD-Copy using several CD copy programs
  - SafeDisc Patches: Generic SafeDisc Patch, Daemon Tools
  - Executable UnWrappers: unSafeDisc, DumPlayerx

DVD copy protection

- Traditional recording media (e.g., audio tape, VHS tape) for audio and video are analog and used different standards NTSC, PAL, SECAM ...
- Piracy is not too big of a concern because quality degrades with each copy generation.
- With digital recording and high-resolution video, DVD copy protection was a big issue to the movie industry.
- In fact, it took about 2 years after the invention of DVD to put DVD movies on the shelf. Part of it is due to the development of a reasonable copy protection scheme.

How Studios Split our Planet



DVD Region Code Symbol

A region code byte is recorded on a disc

DRM Architecture

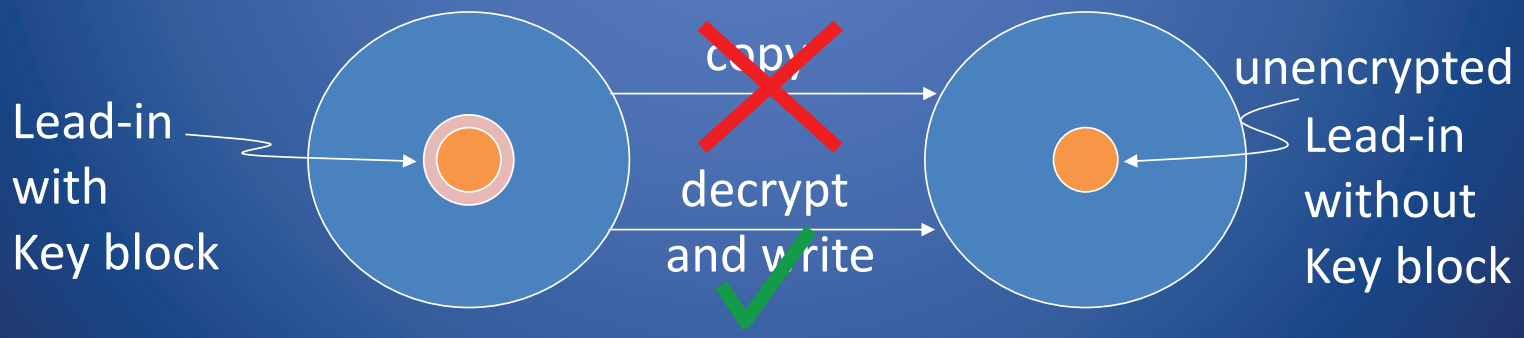
- Proposed by the Copy Protection Technical Working Group for DVD (CPTWG), IBM, Intel, Matsushita, Toshiba.
- Idea:
  - Alice sells Bob a video, in order for Alice to prevent Bob from re-disseminating the video to others, Alice tries to make sure that Bob only accesses the video data on a trusted (or compliant) device

Trusted Devices

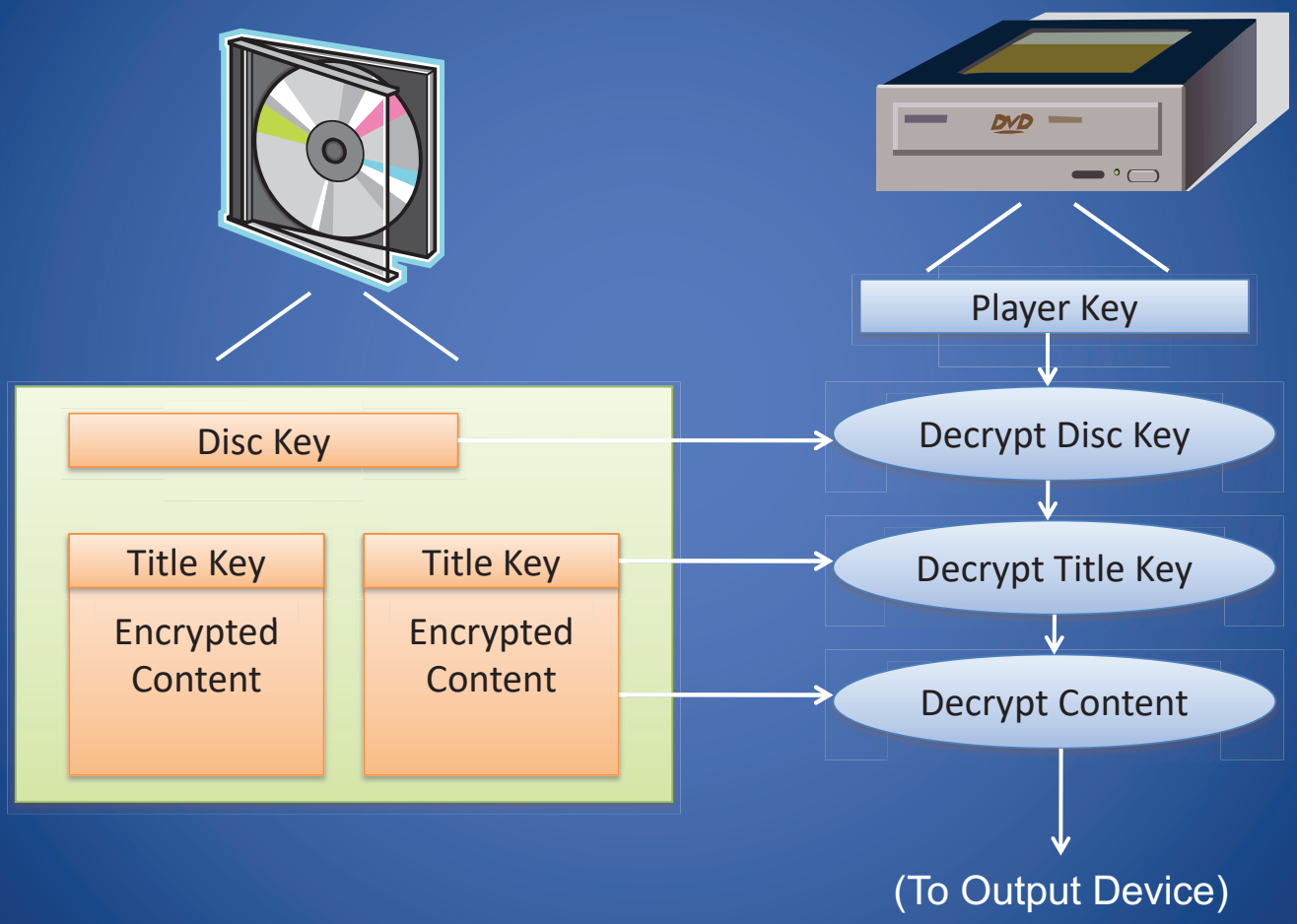
- A trusted device is manufactured by a trusted manufacturer.
- A manufacturer is trusted if it has joined the Copy Control Association (CCA)
- A trusted device is given a (secret) player key
- The trusted manufacturer has to sign an agreement with CCA, basically barring it from making devices that could undermine the copy protection mechanism.
- Since 2000, manufacturers must produce DVD ROM drivers compliant with=RPC 2 (Region Playback Control)

CSS: Content Scrambling System

- In most cases, a DVD (video disk) is protected by the CSS scheme. Intuitively, the video content is encrypted using a *disc key*, *k*.
- In the lead-in area of a CSS-protected DVD, the disk's key *k* is encrypted about 400 times, each using a different player key.
- A DVD player with the ith player key will read the ith entry of the key block. This entry is then decrypted using the player key k_i to obtain the disk key *k*.
- The video content is then decrypted on-the-fly while the movie is played.
- Using a normal DVD writer the copy will not have the key block and disk will not be playable
- if someone decrypts a video, with special tools (HW or SW), it is possible make pirated copies with the lead-in key block or without CSS (i.e., decrypted).



Viewing a DVD



CSS Keys

- Authentication Key
  - Used for mutual authentication
- Session/Bus Key
  - negotiated during authentication
  - encrypt title and disk keys before sending them over the unprotected bus
  - Prevent eavesdropping
- Player Key
  - Licensed by the "DVD Copy Control Association" to the manufacturer of a DVD player
  - Stored within the player
  - Authenticates the player
  - Used to decrypt disk key.
- Disk Key
  - Used to decrypt the title key
- Title Key
  - This key is XORed with a per-sector key to encrypt the data within a sector
- Sector Key
  - Each sector has a 128-byte plain-text header
  - Bytes 80 - 84 of each sector's header contain an additional key used to encode the data within the sector

DeCSS

- Created in 1999 by Jon Johansen
- Decrypts CSS and allows for copying files to hard drive
- At the time, little information known about CSS algorithm
- DeCSS came with the source code that showed how easy it was to crack CSS
- Technique used for creating open source DVD players that could run on Linux
- First in a long line of DVD decrypting programs
- Johansen was sued by the DVD-CCA but case was dropped
  - Mass pirating occurred far before DeCSS was published
  - DVD writers are unable to write to the region that CSS writes
  - Most DVD copies done using special equipment that copy bit by bit

Advanced Access Content System

- New standard for DRM that allows for limited sharing and copying of next generation DVDs
  - Developed by Microsoft, Sony, Disney, IBM, Matsushita, and Warner Brothers
  - Used in Blu-Ray
- Method
  - Based on broadcast encryption
  - Revocation of traitors