Segurança de Sistemas e dados (MSI 2019/2020)

Aula 10

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Slides Adaptados do Prof. Manuel Eduardo Correia

Digital Rights Management

Digital Rights Management

- DRM is a good example of limitations of doing security in software
- We'll discuss
  - What is DRM?
  - A PDF document protection system
  - **DRM for streaming media**
  - **DRM in P2P application**
  - DRM within an enterprise

➔Iris

What is DRM?

- "Remote control" problem
  - Distribute digital content
  - Retain some control on its use, **after delivery**
- **Digital book** example
  - Digital book sold online could have huge market
  - But might only sell 1 copy!
  - Trivial to make perfect digital copies
  - A fundamental change from pre-digital era
- Similar comments for digital music, video, etc.
  - EME (Encrypted Media Extensions) for example is the standard that allows DRM in HTML5 video that is used by Netflix.
    - https://en.wikipedia.org/wiki/Encrypted_Media_Extensions
    - https://en.wikipedia.org/wiki/Widevine

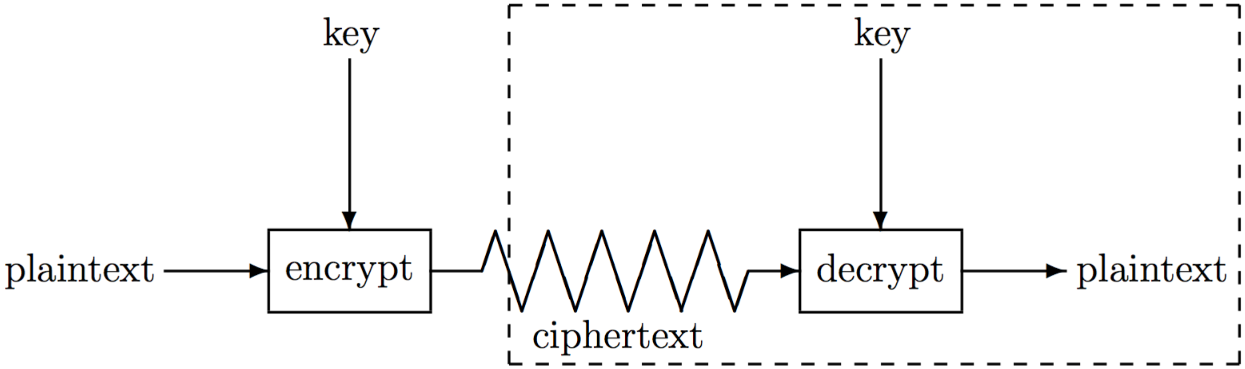
Persistent Protection

- "Persistent protection" is the fundamental problem in DRM
  - How to enforce restrictions on use of content **after** delivery?
- Examples of such restrictions
  - No copying
  - Limited number of reads/plays
  - Time limits
  - No forwarding, etc.

What Can be Done?

- The honor system?
  - Example: Stephen King's, *The Plant*
- Give up?
  - Internet sales? Regulatory compliance? etc.
- Lame software-based DRM?
  - The standard DRM system today
- Better software-based DRM?
  - MediaSnap's goal
- Tamper-resistant hardware?
  - Closed systems: Game Cube, etc.
  - Open systems: TCG/NGSCB for PCs
  - Intel SGX ➔ André Brandão's MSc Work

Is Crypto the Answer?



- Attacker's goal is to recover the **key**
- In standard crypto scenario, attacker has
  - Ciphertext, some plaintext, side-channel info, etc.
- In DRM scenario, attacker has
  - Everything in the box (at least)
- Crypto was not designed for this problem!

Is Crypto the Answer?

- But crypto is necessary
  - To securely deliver the bits
  - To prevent trivial attacks
- Then attacker will not try to directly attack crypto
- Attacker will try to find keys in software
  - DRM is "hide and seek" with keys in software!

Current State of DRM

- At best, **security by obscurity**
  - A derogatory term in security
- Secret designs
  - In violation of **Kerckhoffs Principle**
- Over-reliance on crypto
  - "Whoever thinks his problem can be solved using cryptography, doesn't understand his problem and doesn't understand cryptography." — Attributed by Roger Needham and Butler Lampson to each other

DRM Limitations

- The **analog hole**
  - When content is rendered, it can be captured in analog form
  - DRM **cannot** prevent such an attack
- **Human nature** matters
  - Absolute DRM security is impossible
  - Want something that “works” in practice
  - What works depends on context
- DRM is not strictly a technical problem!

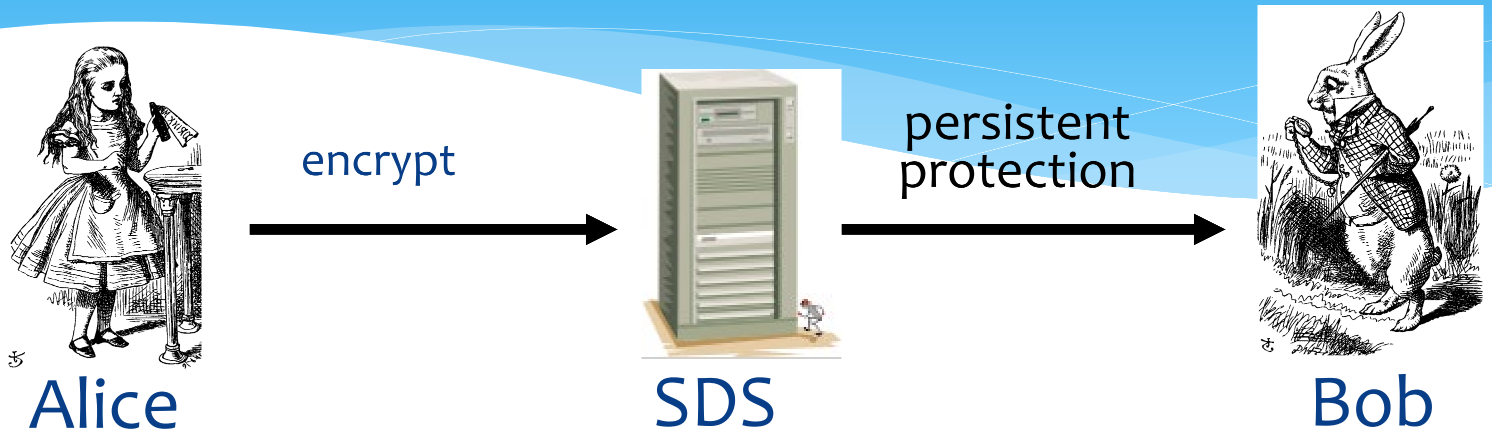
Software-based DRM

- Strong software-based DRM is impossible
- Why?
  - We can’t really hide a secret in software
  - We cannot prevent SRE
  - User with full admin privilege can eventually break any anti-SRE protection
- Bottom line: **The** killer attack on software-based DRM is SRE

DRM for PDF Documents

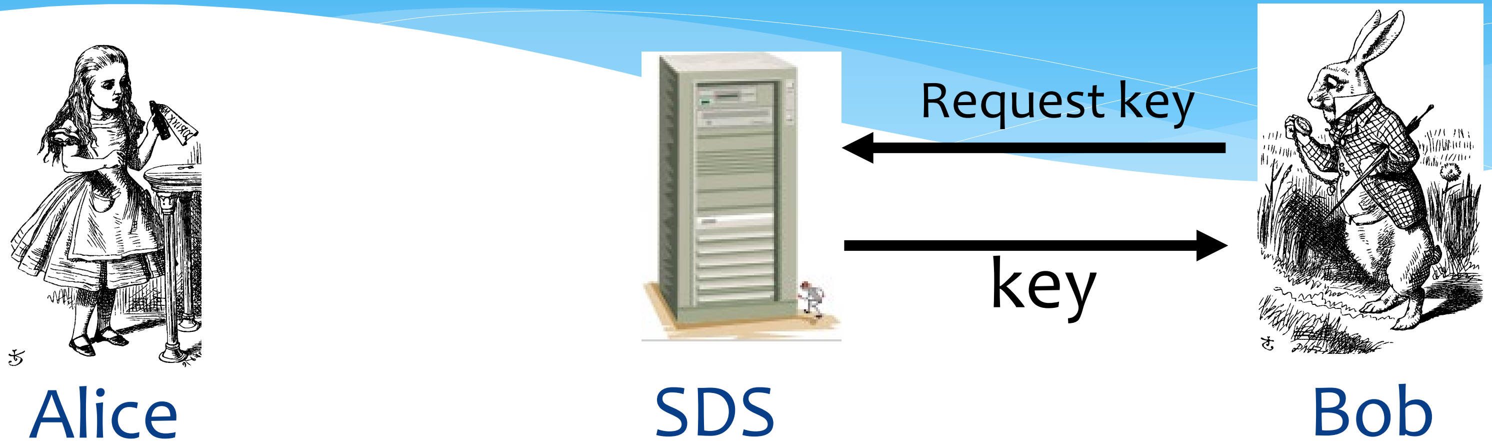
- Based on design of MediaSnap, Inc., a small Silicon Valley startup company
- Developed a DRM system
  - Designed to protect PDF documents
- Two parts to the system
  - Server — Secure Document Server (SDS)
  - Client — PDF Reader “plugin” software

Protecting a Document



- Alice creates PDF document
- Document encrypted and sent to SDS
- SDS applies desired "persistent protection"
- Document sent to Bob

Accessing a Document

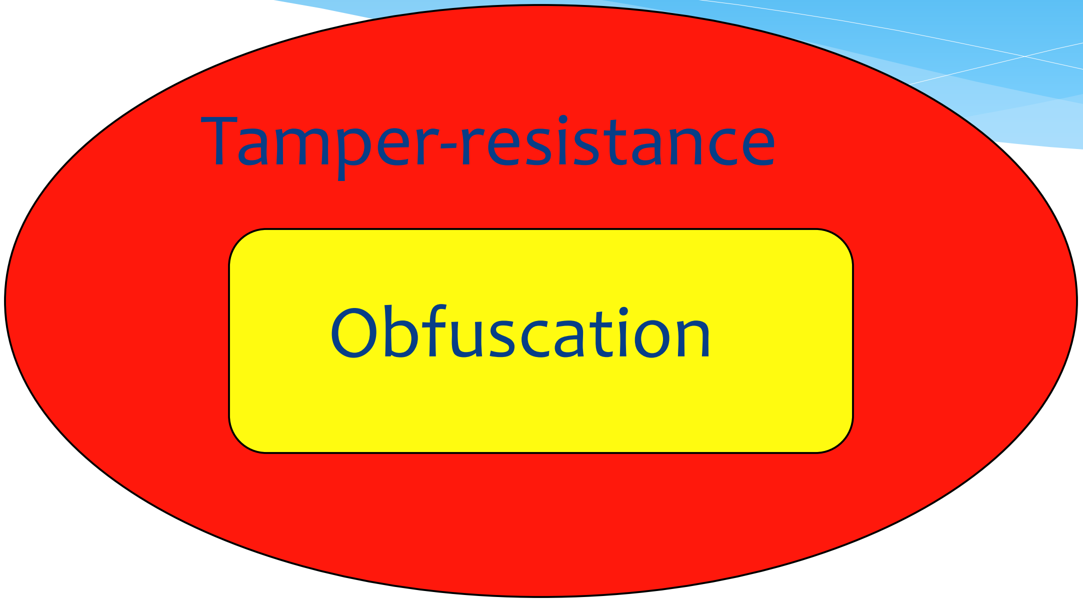


- Bob authenticates to SDS
- Bob requests key from SDS
- Bob can then access document, but only thru special DRM software

Security Issues

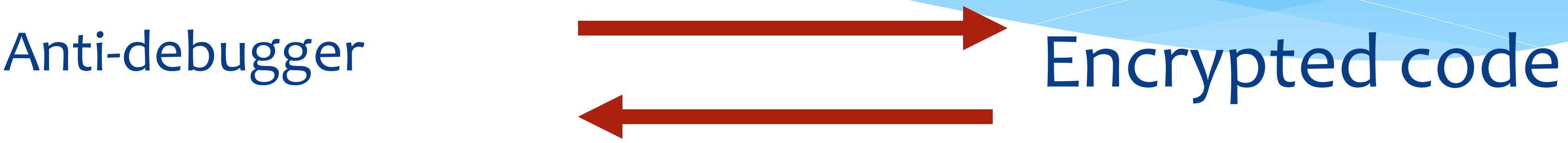
- Server side (SDS)
  - Protect keys, authentication data, etc.
  - Apply persistent protection
- Client side (PDF plugin)
  - Protect keys, authenticate user, etc.
  - Enforce persistent protection
- Remaining discussion concerns **client**

Security Overview



- A tamper-resistant outer layer
- Software obfuscation applied within

Tamper-Resistance



Anti-debugger

Encrypted code

- ❑ Encrypted code will prevent static analysis of PDF plugin software
- ❑ Anti-debugging to prevent dynamic analysis of PDF plugin software
- ❑ These two designed to protect each other
- ❑ But the persistent attacker will get thru!

Obfuscation

- Obfuscation can be used for
  - Key management
  - Authentication
  - Caching (keys and authentication info)
  - Encryption and “scrambling”
  - Key parts (data and/or code)
  - Multiple keys/key parts
- Obfuscation can only slow the attacker
- The persistent attacker still wins!

Other Security Features

- Code tamper checking (hashing)
  - To validate all code executing on system
- Anti-screen capture
  - To prevent obvious attack on digital documents
- Watermarking
  - In theory, can trace stolen content
  - In practice, of limited value
- Metamorphism (or individualization)
  - For BOBE-resistance

Security Not Implemented

- More general code obfuscation
- Code “fragilization”
  - Code that hash checks itself
  - Tampering should cause code to break
- OS cannot be trusted
  - How to protect against “bad” OS?
  - Not an easy problem!

DRM for Streaming Media

- Stream digital content over Internet
  - Usually audio or video
  - Viewed in real time
- Want to charge money for the content
- Can we protect content from capture?
  - So content can't be redistributed
  - We want to make money!

Attacks on Streaming Media

- Spoof the stream between endpoints
- Man in the middle
- Replay and/or redistribute data
- **Capture the plaintext**
  - This is the threat we are concerned with
  - Must prevent malicious software from capturing plaintext stream at client end

Design Features

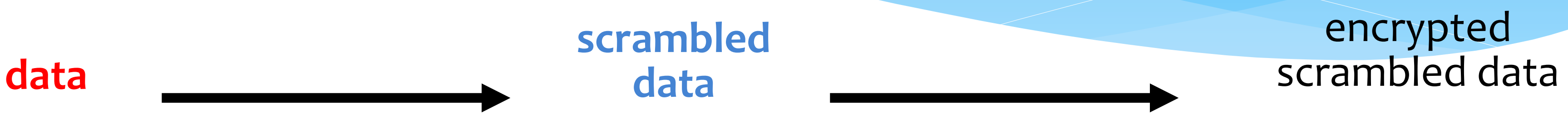
- Scrambling algorithms
  - Encryption-like algorithms
  - Many distinct algorithms available
  - A strong form of metamorphism!
- Negotiation of scrambling algorithm
  - Server and client must both know the algorithm
- Decryption at receiver end
  - To remove the strong encryption
- De-scrambling in device driver
  - De-scramble just prior to rendering

Scrambling Algorithms

- Server has a large set of scrambling algorithms
  - Suppose N of these numbered 1 thru N
- Each client has a subset of algorithms
  - For example: LIST = {12,45,2,37,23,31}
- The LIST is stored on client, encrypted with server's key: $E(\text{LIST},K_{\text{server}})$

Server-side Scrambling

- On server side



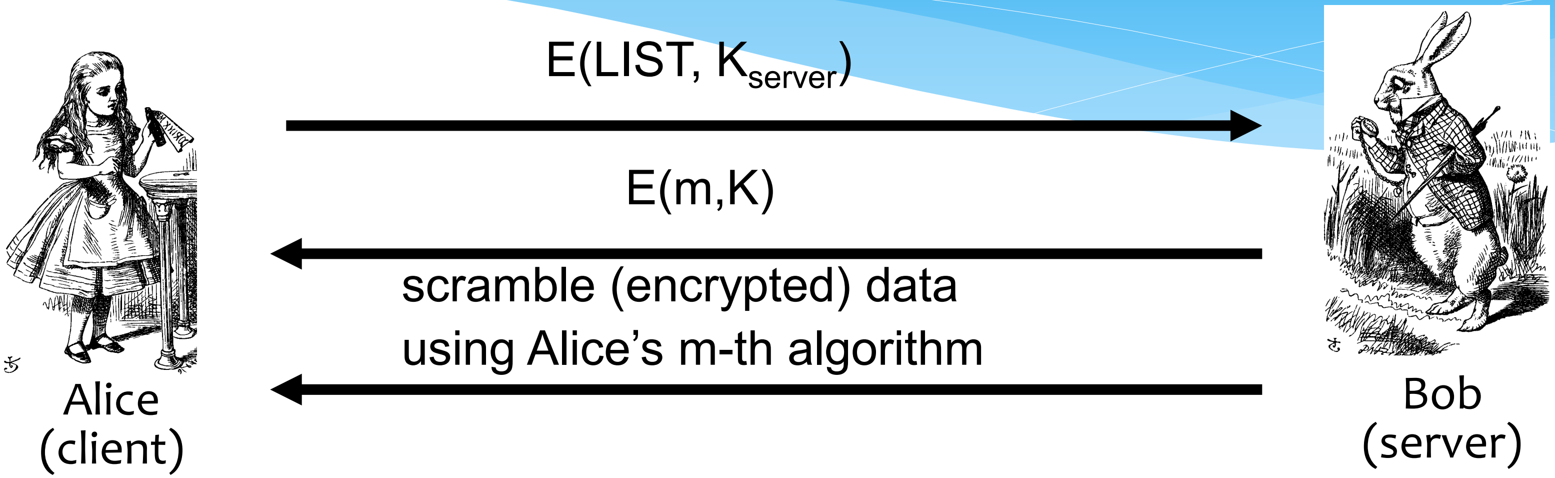
data

scrambled data

encrypted scrambled data

- □ Server must scramble data with an algorithm the client supports
- □ Client must send server list of algorithms it supports
- □ Server must securely communicate algorithm choice to client

Select Scrambling Algorithm



E(LIST, K_{server})

E(m,K)

scramble (encrypted) data
using Alice’s m-th algorithm

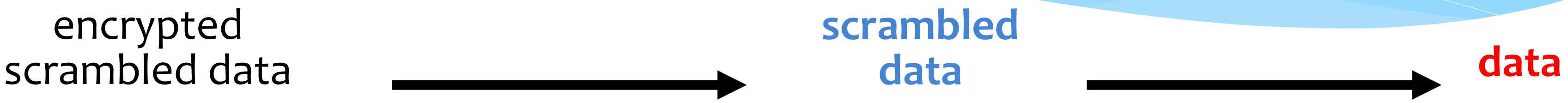
Alice
(client)

Bob
(server)

- The key K is a session key
- The LIST is unreadable by client

Client-side De-scrambling

- On client side



encrypted scrambled data

scrambled data

data

- Try to keep plaintext away from potential attacker
- "Proprietary" device driver
  - Scrambling algorithms "baked in"
  - Able to de-scramble at last moment

Why Scrambling?

- **Metamorphism** deeply embedded in system
- If a scrambling algorithm is known to be broken, server will not choose it
- If client has too many broken algorithms, server can force software upgrade
- Proprietary algorithm harder for SRE
- We cannot trust crypto strength of proprietary algorithms, so we also encrypt

Why Metamorphism?

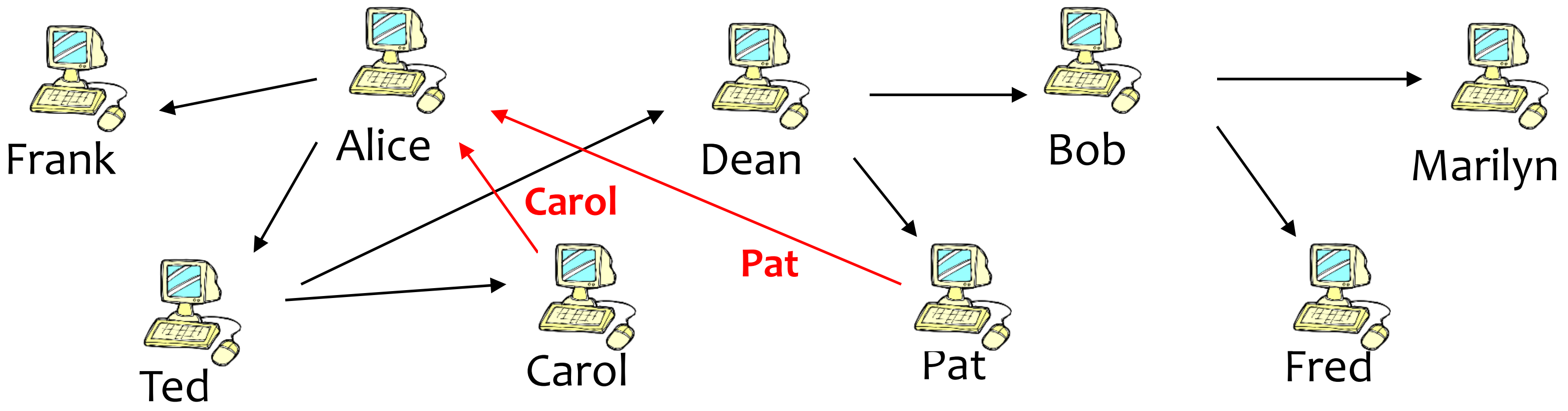
- The most serious threat is **SRE**
- Attacker does not need to reverse engineer any standard crypto algorithm
  - Attacker only needs to find the key
- Reverse engineering a scrambling algorithm may be difficult
- This is just **security by obscurity**
- But appears to help with BOBE-resistance

DRM for a P2P Application

- Today, much digital content is delivered via peer-to-peer (P2P) networks
    - P2P networks contain lots of pirated music
- Is it possible to get people to pay for digital content on such P2P networks?
- How can this possibly work?
- A peer offering service (POS) is one idea

P2P File Sharing: Query

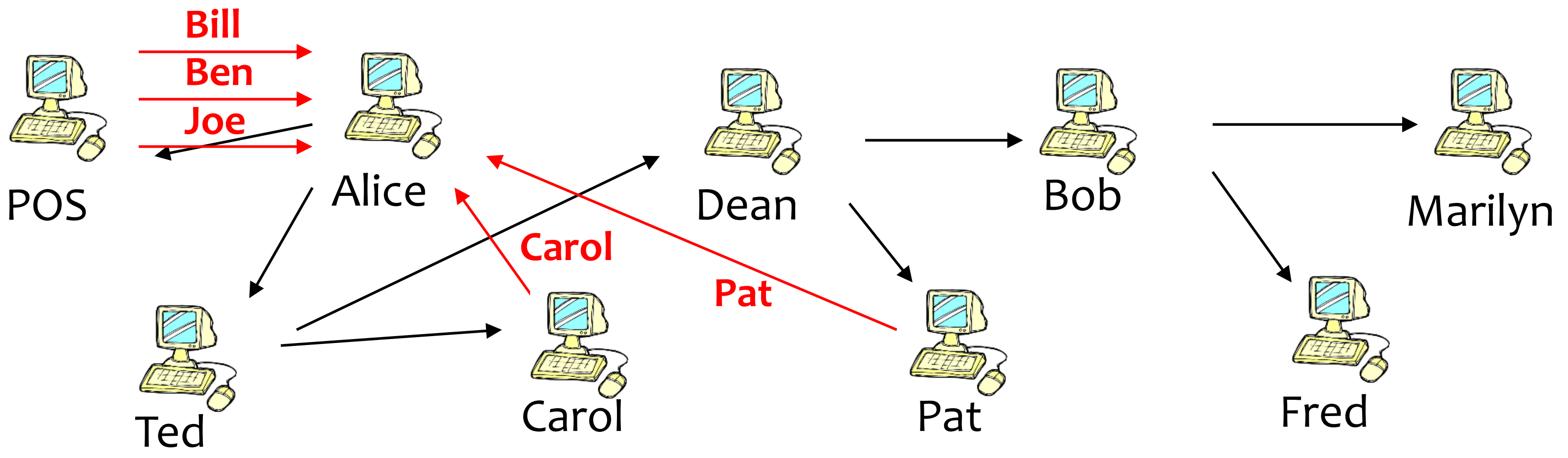
- Suppose Alice requests "Hey Jude"
- **Black** arrows: query flooding
- **Red** arrows: positive responses



□ Alice can select from: **Carol**, **Pat**

P2P File Sharing with POS

- Suppose Alice requests "Hey Jude"
- **Black** arrow: query
- **Red** arrow: positive response



- ❑ Alice selects from: **Bill**, **Ben**, **Carol**, **Joe**, **Pat**
- ❑ **Bill**, **Ben**, and **Joe** have legal content!

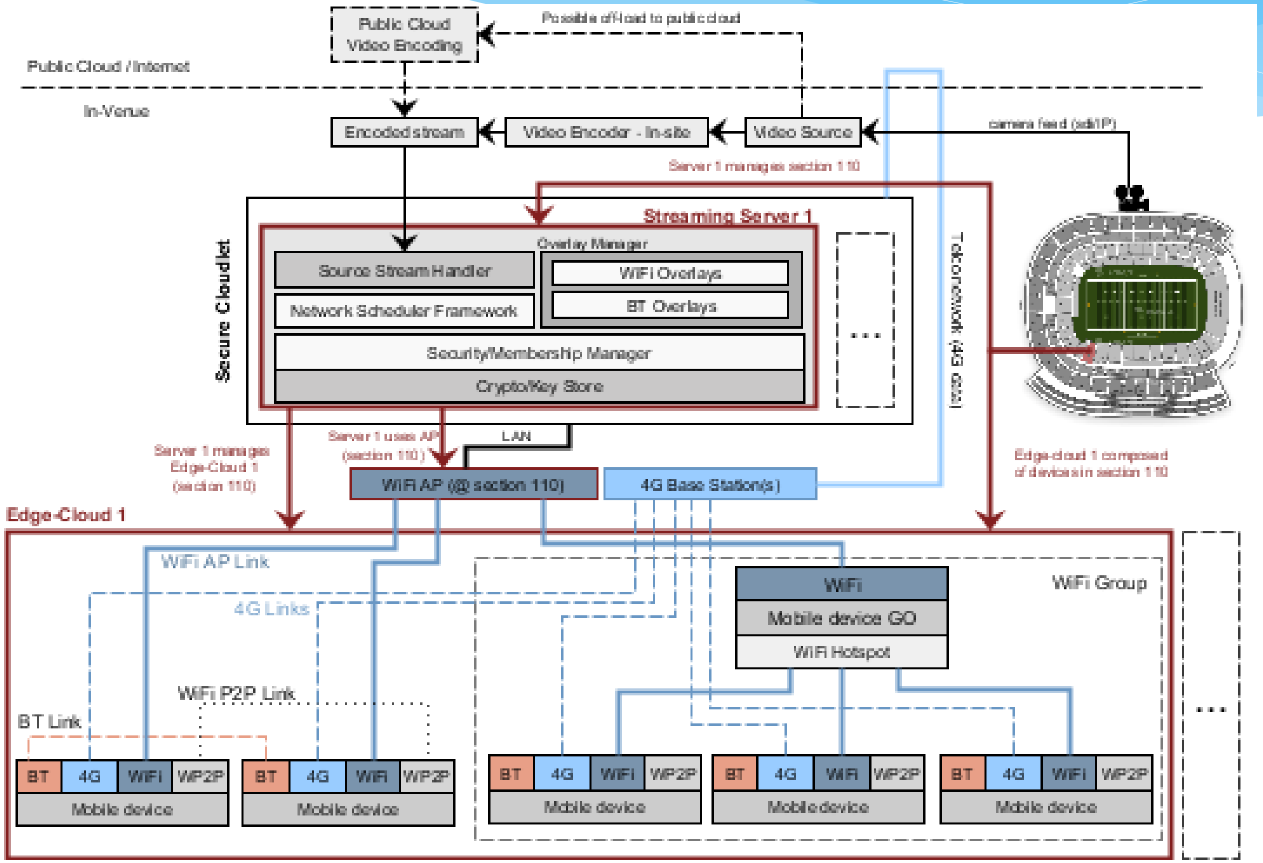
POS

- Bill, Ben and Joe must appear normal to Alice
- If “victim” (Alice) clicks POS response
  - DRM protected (legal) content downloaded
  - **Then** small payment required to play
- Alice can choose not to pay
  - But then she must download again
  - Is it worth the hassle to avoid paying small fee?
  - POS content can also offer extras

POS Conclusions

- A very clever idea!
- Piggybacking on existing P2P networks
- Weak DRM works very well here
  - Pirated content already exists
  - DRM only needs to be more hassle to break than the hassle of clicking and waiting
- Current state of POS?
  - Very little interest from the music industry
  - Considerable interest from the “adult” industry

Iris


Public Cloud
Video Encoding
Possible off-load to public cloud
Public Cloud / Internet
In-Venue
Encoded stream
Video Encoder - In-site
Video Source
camera feed (sdi/IP)
Server 1 manages section 110
Streaming Server 1
Secure Cloudlet
Overlay Manager
Source Stream Handler
WiFi Overlays
Network Scheduler Framework
BT Overlays
Security/Membership Manager
Crypto/Key Store
. . .
Telco network (4G data)
Server 1 manages
Edge-Cloud 1
(section 110)
Server 1 uses AP
(section 110)
LAN
WiFi AP (@ section 110)
4G Base Station(s)
Edge-cloud 1 composed
of devices in section 110
Edge-Cloud 1
WiFi AP Link
4G Links
WiFi P2P Link
BT Link
WiFi Group
WiFi
Mobile device GO
WiFi Hotspot
BT
4G
WiFi
WP2P
Mobile device
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DRM in the Enterprise

- Why enterpise DRM?
- Health Insurance Portability and Accountability Act (HIPAA)
  - Medical records must be protected
  - Fines of up to $10,000 “per incident”
  - GDPR in effect on 25th May 2018 – Even heavier fines.
- Sarbanes-Oxley Act (SOA)
  - Must preserve documents of interest to SEC
- DRM-like protections needed by corporations for **regulatory compliance**

What’s Different in Enterprise DRM?

- Technically, similar to e-commerce
- But motivation for DRM is different
  - Regulatory compliance
  - To satisfy a legal requirement
  - Not to make money — to avoid losing money!
- Human dimension is completely different
  - Legal threats are far more plausible

Enterprise DRM

- Moderate DRM security is sufficient
- **Policy management issues**
  - Easy to set policies for groups, roles, etc.
  - Yet policies must be flexible
- **Authentication issues**
  - Must interface with existing system
  - Must prevent network authentication spoofing (authenticate the authentication server)
- Enterprise DRM is a solvable problem!

DRM Failures

- Many examples of DRM failures
  - One system defeated by a felt-tip pen
    - http://www.berkeleydailyplanet.com/issue/2002-05-31/article/12308?headline=Sony-s-CD-protection-method-foiled-with-a-felt-tip-pen&status=301
  - One defeated my holding down shift key
  - Secure Digital Music Initiative (SDMI) completely broken before it was finished
  - Adobe eBooks
  - Microsoft MS-DRM (version 2)
  - Many, many others!

DRM Conclusions

- DRM nicely illustrates **limitations of doing security in software**
- Software in a hostile environment is extremely vulnerable to attack
- Protection options are very limited
- Attacker has enormous advantage
- Tamper-resistant hardware and a trusted OS can make a difference
  - We'll discuss this more later: TCG/NGSCB

Secure Software Development

Penetrate and Patch

- Usual approach to software development
  - Develop product as quickly as possible
  - Release it without adequate testing
  - Patch the code as flaws are discovered
- In security, this is "penetrate and patch"
  - A **bad** approach to software development
  - A **horrible** approach to secure software!

Why Penetrate and Patch?

- First to market advantage
  - First to market likely to become market leader
  - Market leader has huge advantage in software
  - Users find it safer to "follow the leader"
  - Boss won't complain if your system has a flaw, as long as everybody else has the same flaw
  - User can ask more people for support, etc.
- Sometimes called "network economics"

Why Penetrate and Patch?

- Secure software development is hard
  - Costly and time consuming development
  - Costly and time consuming testing
  - Easier to let customers do the work!
- No serious economic disincentive
  - Even if software flaw causes major losses, the software vendor is not liable
  - Is any other product sold this way?
  - Would it matter if vendors were legally liable?

Penetrate and Patch Fallacy

- **Fallacy:** If you keep patching software, eventually it will be secure
- Why is this a fallacy?
  - Empirical evidence to the contrary
  - Patches often add new flaws
  - Software is a moving target due to new versions, features, changing environment, new uses, etc.