Protecting the Client

- Clients of networked applications
- Smart cards
- DRM

Network Clients

- Thus far, we've focused on servers — network apps and privilege programs
- Do clients have the same risks?
- Yes — in some ways, more. . .

Clients at Less Risk

- You can send arbitrary text to a web server
- To attack a web browser, you have to lure them to the infected server
- But — email can be sent to anyone — and it can contain links to web servers
- Other apps are harder to attack

Email and the Web

- Most mailers do not do their own HTML processing (at least not for full HTML)
- They have some way of invoking the standard browser's rendering engine
- Example: the Eudora mailer suffered from an Internet Explorer flaw (`http://email.about.com/cs/eudoratips/qt/et122001.htm`)
- Mozilla provides the *Gecko* rendering engine
- Active content — Java, Javascript, ActiveX, Flash, and the like — make life *much* harder (but we'll cover that later in the semester)

Other Applications

- *Any* program, including network clients, can have security flaws
- Buffer overflows and the like abound
- If someone using the application connects to your server — or if you can trick someone into connecting to your server — you can compromise their machine
- Client software is often updated *less* frequently
- Rarely run on dedicated machines

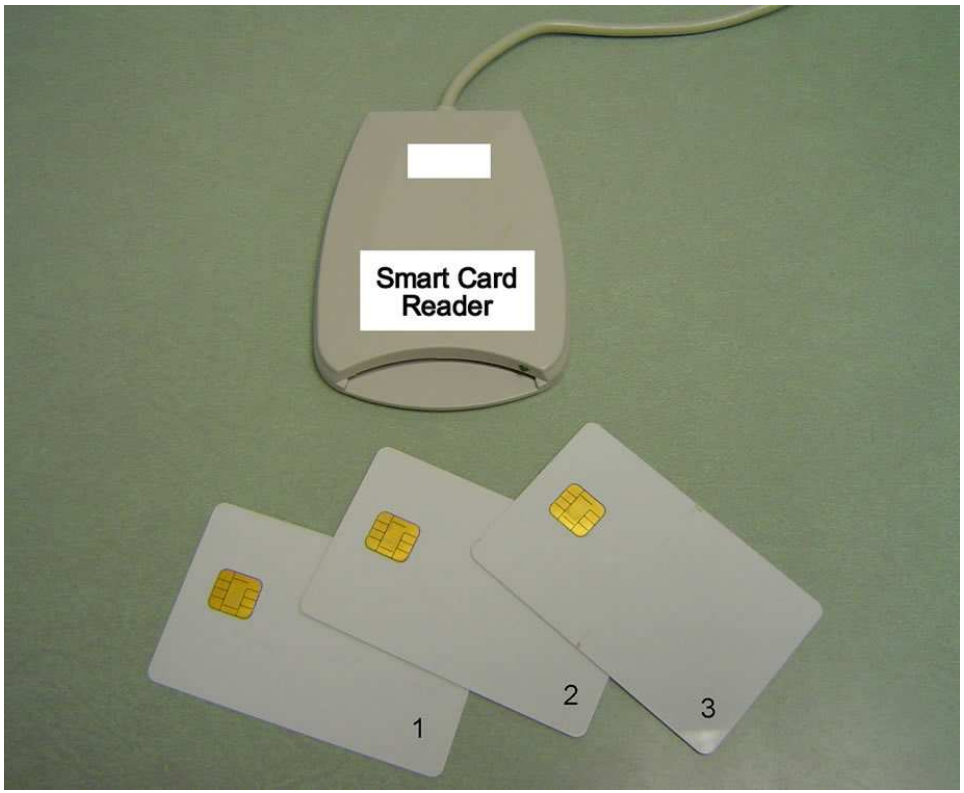
The Enemy Has Your Device

- Normally, you own your machine
- What if the enemy owns it?
- What if your enemy is *supposed* to own it?
- Who'd do that? Lots of people. . .

Smart Cards

- Often in credit card form factor
- Contains small CPU and non-volatile storage (some contain an RSA accelerator chip)
- Used for many purposes

Reader and Smart Cards



These cards use contacts for power and I/O. Other types use inductive coupling or radio.

Uses of Smart Cards

- Money or equivalent (transit fares, parking meters, vending machines, etc.)
- Counterfeit resistance (credit cards, especially in Europe)
- “Something you have” for authentication
- Pay TV or satellite/cable box

The Enemy's Goals

- In stored value systems, the attacker wants to add more money to the card
- Alternatively, the attacker wants to extract the secret, to permit counterfeiting of more cards
- If an authentication token is locked by a PIN, the attacker wants to discover or replace the PIN

Attack Techniques

- Software
- Physical

Software Attacks on Smart Cards

- The card is running software and talking to the outside world
- Can you launch a buffer overflow attack?
- Is that software vulnerable to the usual attacks?
- In principle, any attack that works against other systems can work here

Physical Attacks

- An attacker can manipulate the physical environment
- An attacker can monitor the physical behavior
- An attacker can try to reverse-engineer the chip

Differential Power Analysis

- When a transistor switches on, it allows current flow
- The power difference between “on” and “off” can be measured
- Measure the instanteous power consumption of the smart card
- Repeat this for a moderately large number of operations
- Statistical analysis will reveal the value of the cryptographic key at different points

Fault Injection

- Certain stresses can cause erroneous computations
- It's practical to use heat or radiation to confuse a CPU or memory
- It has been demonstrated, theoretically and practically, that this can be used to break security
- Other techniques: controlling power

Reverse Engineering

- With suitable tools, it's possible to reverse-engineer a CPU and read the memory
- Techniques include microtomes, scanning electron microscopes, and the like
- Separate set of physical-layer defenses

Chipworks.com's Self-Descrption

"Chipworks provides microprobing, a type of reverse engineering, as part of our complete portfolio of patent and competitive intelligence services. Microprobing is an analytical technique used to achieve electrical contact with, or access to, a point in the active circuitry of a die using a special piece of equipment called a "microprobing station". Microprobing lets us selectively inject probes into a device's internal nodes and measure real time waveforms, currents and voltages which is critical for identifying specific functions that occur under specific conditions."

Protecting Chips

- Use of “non-metallic links” for device programming
- Ghost logic — fake logic elements to complicate the analysis
- False heat dissipation
- Extra metal layers

Satellite and Premium Cable TV

- *Very* sophisticated enemies
- General attack
  - Sell counterfeit descrambler boxes
  - Buy legitimate access card
  - Extract key from card
  - Distribute keys over the Internet

Where is the Value?

- Is the value on the card or in some database?
- If the value is in the card, must take precautions against counterfeiting
- If the value is in the database, the card is a just a pointer; security features in the card protect against theft, not value loss

MTA Metrocard

Primarily an online system; central database has authoritative card value. Some offline use for buses. No protection against theft.

Washington, D.C., Farecard

Note that the card itself knows its value. No protection against theft or counterfeiting.

The CU ID Card

- The mag stripe and bar code are primarily database indices
- (The mag stripe actually contains more data)
- If the card is reissued, a new database index is assigned
- New ID cards contain RFID chips; I haven't analyzed them yet. . .

Mag Stripe Cards

- Two or three tracks; standardized format
- CUID has social security number plus other fields:

```
track 1: error: e5
track 2: <211871371012940>
track 3: error: e5
```

- My Amtrak card:

```
track 1: <AGR^STEVEN^BELLOVIN^PLUS>
track 2: <20070228=5081653010>
track 3: error: e5
```

Digital Rights Management

- Allow publisher to control use of content
- Prevent arbitrary redistribution of copyrighted materials
- Change sales terms from *physical purchase* to *license*

General Approaches

- Restrict consumer's ability to use the material
- Trace usage (often via "watermarking")

Restricting Use

- Preferred approach of content providers
- Used by most (legitimate) vendors of digital music and films
- Many different types, implementing many different policies

Apple's iTunes

- "personal, noncommercial use"
- "five Apple-authorized devices at any time"
- "shall not be entitled to burn Video Products"
- "burn an audio playlist up to seven times"
- (`http://www.apple.com/support/itunes/legal/terms.html`)

Microsoft's Media DRM

- Media files are encrypted, and contain pointer to license source
- User obtains license from clearing house
- License includes terms and conditions as well as decryption key
- "Licenses can have different rights, such as start times and dates, duration, and counted operations."
- "may allow the consumer to `...` copy the file to a portable device"
- "Licenses, however, are not transferable."
- (`http://www.microsoft.com/windows/windowsmedia/howto/articles/drmarchitecture.aspx`)

How Does It Work?

- Operating system mediates access to files
- Operating system enforces rules imposed by the content provider
- Ordinary OS protection mechanisms isolate the unprotected content from the user
- Or do they?

The User Versus the OS

- If you own the computer, you're the administrator; you have root privileges
- The vendors' challenge: protecting content against the superuser
- Several different approaches

Approaches

- Obscurity — make it hard to find the plaintext
- Obfuscation — confuse the code to make reverse-engineering harder
- End-to-end crypto — do decryption on the sound card or video card. (But what abou the “analog hole”?)
- Trusted hardware
- Automatic upgrades

Automatic Upgrades

- Apple does this to the iPhone
- Microsoft will sometimes update your software without telling you
- DVR vendor took away “skip 30 seconds” button
- Upgrades or downgrades?

Trusted Hardware

- Ultimately, all software-only schemes are futile
- You can always trace the code, patch modules, etc
- But — other software can attempt to detect such “attacks”, and disable playback
- See above
- The *only* reliable solution is trusted hardware
- Manage the keys and the decryption outside of the OS
- As needed, use tamper-resistance techniques for such hardware

Watermarking

- Tag files with owner and/or licensee information
- Tags should should be invisible in normal use of the file
- Tags should resist detection and deletion
- Used for iTunes' unlocked music files
- In practice, this has proved to be extremely difficult to accomplish

Defeating Watermarking

- Pictures: scaling, clipping, color balance, rotation, geometric distortion, printing/scanning
- Sound: Fourier transforms
- Thus far, the attackers are winning

Legal Issues

- The law in the US and other countries outlaws “circumvention technology”
- Lawsuits and threats of lawsuits have blocked some work
- A lot of other stuff is out there, including both academic research and practical tools (i.e., dcss)
- Crucial philosophical issue: do DRM schemes give content owners more power than copyright law would?

Current State of Affairs

- Technical measures are good enough that they're not the weak point
- CD/DVD ripping plus redistribution is easier than cracking DRM schemes
- That said, many DRM schemes have been cracked
- Two-fold attack by content owners: technical measures and lawsuits