Protecting the Client

Protecting the Client

- Clients of networked applications
- Smart cards
- DRM

Network Clients

- Thus far, we've focused on servers—network apps and privileged 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 the user 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

"Watering Hole" Attacks

- Hack a web site that you think your targets will visit
- ☞ Or—buy an ad through an ad broker; have this ad serve up malware
  - ☞ This has happend to major news sites, including the *New York Times* and *Forbes*
- Plant malware there
- Wait. . .

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, and hence are at risk from browser security flaws
- Example: the Eudora mailer suffered from an Internet Explorer flaw (`http://email.about.com/cs/eudoratips/qt/et122001.htm`)
- Mozilla provides a rendering engine for use by other applications
- iOS has one for use by apps
- 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 via a *watering hole attack*—you can compromise their machine
- Client software is often updated *less* frequently
- Rarely run on dedicated machines

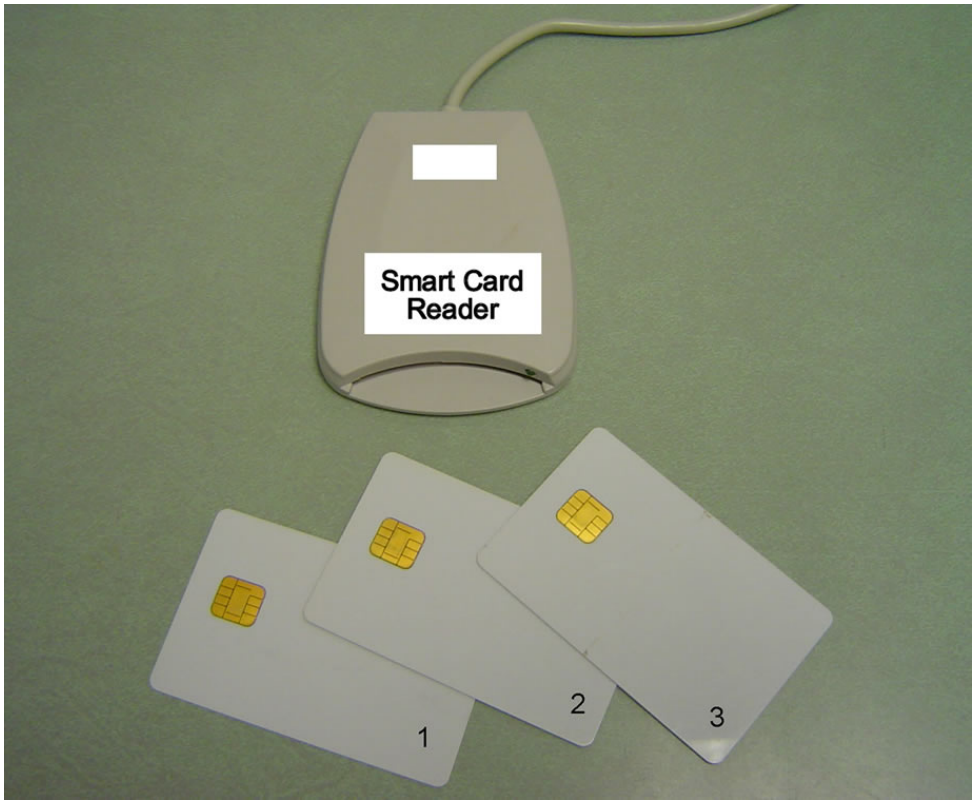
The Enemy Has Your Device

- 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
- Note: not the same as RFID-based cards

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.)
- Resistant to counterfeiting (credit cards, especially in Europe and starting to be deployed in the US)
- “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?
- Note: most smart cards don't have a privileged mode and a protected kernel. (What about multi-use smart cards?)
- 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

From Chipworks.com's Web Site

"Chipworks' Circuit Analysis Reports provide full reverse engineering information of all or selected circuitry on a particular die—complete with detailed schematics to reveal the operation of a competitor's device. . .

"Report Contents:

- "Package and die overview including a package x-ray.
- "Annotated die photograph identifying the major functional blocks.
- "Complete set of hierarchical schematics to capture the operation of the device.
- "Top-level schematic overview to capture the entire function of the circuit.
- "Schematics for each analyzed block."

Protecting Chips

- Use of “non-metallic links” for device programming
- Program in sensitive data; don’t hardwire it.
- 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

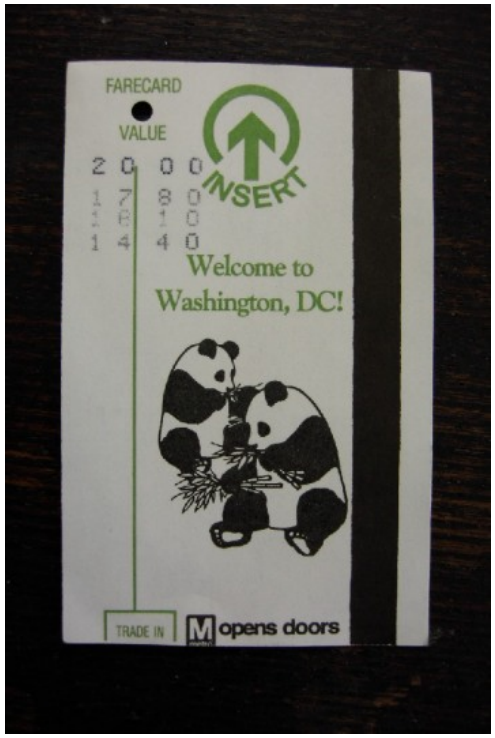
Where is the Value?

- 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 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 for pay-as-you-go Metrocards; database update for monthly cards.

Washington, D.C., Farecard



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

The CU ID Card

- The RFID chip and mag stripe are primarily database indices
- (Older cards had a bar code, too, but the mag stripe held more data. Both had social security numbers.)
- If the card is reissued, a new database index is assigned

Mag Stripe Cards

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

```
track 1: error: e5
track 2: <2118713710312940>
track 3: error: e5
```

- My Amtrak card:

```
track 1: <AGR^STEVEN^BELLOVIN^PLUS>
track 2: <20150228=5081658710>
track 3: error: e5
```

(Note the expiration date on track 2)

Mass Transit Fare Cards Broken

- Dutch researchers cracked their public transit system's RFID cards, both cryptographic and non-cryptographic
- MIT students cracked the MBTA's (Boston) systems: mag stripe and cryptographic RFID
- Many other transit systems vulnerable
- Why? Bad crypto, underestimating the enemy, simple mistakes of the type we've discussed here

RFID Chips in Passports

- New passports contain an RFID chip with data and digitized picture (ICAO standard)
- This data is, of course, digitally signed
- But—not all countries have signing certificates for all other countries
- Permits the creation of passports with forged RFID chips
- Solution: creation of a PKI, where each certificate lists the countries for which it can sign passports. But—is this PKI trustable?
- Who is the enemy? Smugglers? Terrorists? Foreign intelligence agencies? All of the above?

Apple iPhone Encryption

- All content is encrypted with one of a set of randomly-generated AES keys
- These keys are themselves protected: either encrypted with a key derived from a random UID that is stored in a secure, on-chip area, or encrypted with a key derived from the UID and the PIN
- Hardware-enforced maximum guess rate of 80 ms/try

The FBI versus the iOS 8

- Assume custom software, either provided by Apple or via an FBI jail-break of the phone
- Try all possible PINs:

4 digits	800 seconds
6 digits	22 hours
6 lower-case letters or digits	5.5 years
6 letters or digits	144 years
8 arbitrary characters	253,678 centuries

☞ These numbers assume *random* PINs. Is that assumption valid? Almost certainly not:
`https://freedom-to-tinker.com/blog/jbonneau/guessing-passwords-with-apples-full-device-encryption/`

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 films and books; formerly used by music vendors
- 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 or ring tone 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://goo.gl/CEMLu`)

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

- Many carriers and vendors do that to mobile phones
- 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—but is it *good enough*?
- 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 in theory, but many consumers buy watermarked music

Economics vs. Algorithms

- "Amateurs worry about algorithms; pros worry about economics"
- What does it *cost* the attacker to break the DRM or watermarking?
- If the cost is high enough and the price for legitimate purchase is low enough, most people won't bother to break the DRM
- Is that good enough, given how rapidly files can spread? Apple thinks so, and has persuaded content owners of that

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
- Security need not be perfect, merely good enough
- 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

Conclusions

- Many situations require that some crucial device be in enemy hands
- True security in such cases is almost impossible
- More than in most situations, this shows the role of economics: the attack has to be cost-effective
- This is usually the best approach: make the security *good enough*