CSE 484 (Winter 2008)

Computer Security and Privacy

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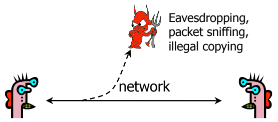
Thanks to Dan Boneh, Dieter Gollmann, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

http://slashdot.org/

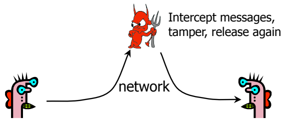
Confidentiality (Privacy)

- Confidentiality is concealment of information



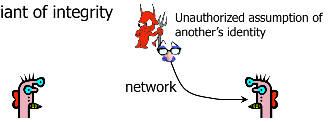
Integrity

- Integrity is prevention of unauthorized changes



Authenticity

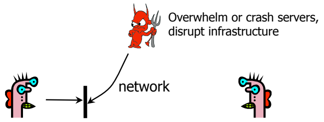
- Authenticity is identification and assurance of origin of information
- Variant of integrity



Unauthorized assumption of another's identity

Availability

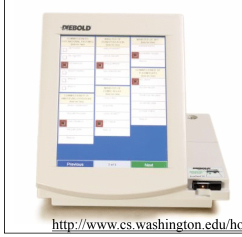
- Availability is ability to use information or resources desired

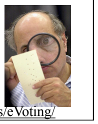


Overwhelm or crash servers, disrupt infrastructure

Case Study: Electronic Voting

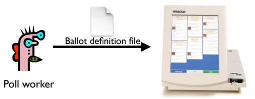
- Popular replacement to traditional paper ballots





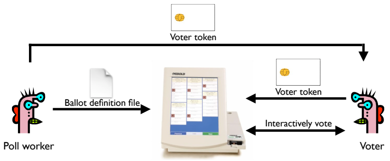
http://www.cs.washington.edu/homes/yoshi/papers/eVoting/

Pre-Election



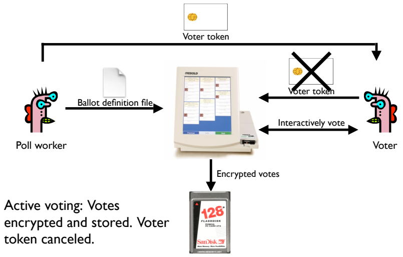
Pre-election: Poll workers load "ballot definition files" on voting machine.

Active Voting



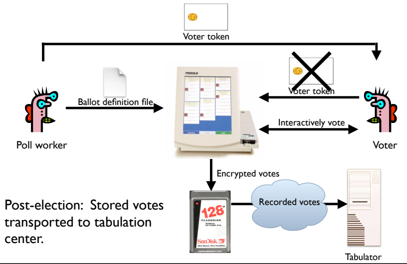
Active voting: Voters obtain single-use tokens from poll workers. Voters use tokens to active machines and vote.

Active Voting



Active voting: Votes encrypted and stored. Voter token canceled.

Post-Election



Post-election: Stored votes transported to tabulation center.

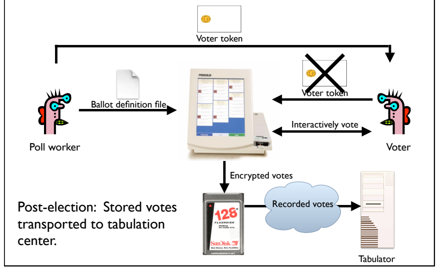
E-Voting Functionality (Simplified)

- Functionality goals:
  - Easy to use
  - People should be able to cast votes easily, in their own language or with headphones for accessibility
  - Election official should be able to efficiently tabulate votes
  - Election officials should be able to do a recount if necessary

E-Voting Security (Simplified)

- Confidentiality
  - Adversary should not be able to figure out how voters vote
- Integrity
  - Adversary should not be able to tamper with the election outcome
    - By changing votes
    - By denying voters the right to vote
  - Is it OK if an adversary can do the above, assuming you can catch him or her or them?
- Availability
  - Adversary should not be able to deny people the right to vote

Can You Spot Any Potential Issues?

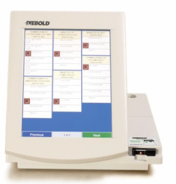


Post-election: Stored votes transported to tabulation center.

Potential Adversaries

- Voters
- Election officials
- Employees of voting machine manufacturer
  - Software/hardware engineers
  - Maintenance people
- Other engineers
  - Makers of hardware
  - Makers of underlying software or add-on components
  - Makers of compiler
- …
- Or any combination of the above

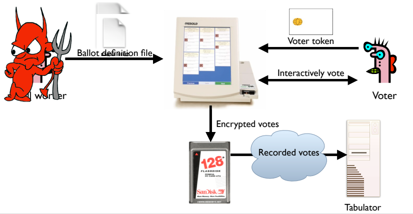
What Software is Running?



Problem: An adversary (e.g., a poll worker, software developer, or company representative) able to control the software or the underlying hardware could do whatever he or she wanted.

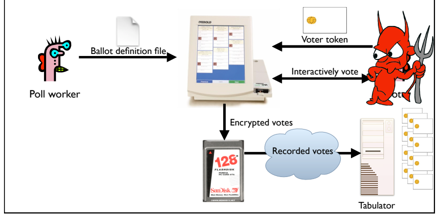
Problem: Ballot definition files are not authenticated.

Example attack: A malicious poll worker could modify ballot definition files so that votes cast for "Mickey Mouse" are recorded for "Donald Duck."



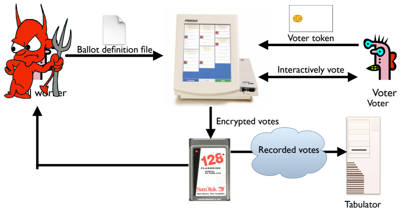
Problem: Smartcards can perform cryptographic operations. But there is no authentication from voter token to terminal.

Example attack: A regular voter could make his or her own voter token and vote multiple times.



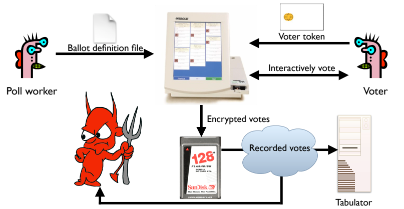
Problem: Encryption key ("F2654hD4") hard-coded into the software since (at least) 1998. Votes stored in the order cast.

Example attack: A poll worker could determine how voters vote.



Problem: When votes transmitted to tabulator over the Internet or a dialup connection, they are decrypted first; the cleartext results are sent the the tabulator.

Example attack: A sophisticated outsider could determine how votes vote.



Whole-System is Critical

- Securing a system involves a whole-system view
  - Cryptography
  - Implementation
  - People
  - Physical security
  - Everything in between
- This is because "security is only as strong as the weakest link," and security can fail in many places
  - No reason to attack the strongest part of a system if you can walk right around it.

Analyzing the Security of a System

- First thing: Summarize the system as clearly and concisely as possible
  - Critical step. If you can't summarize the system clearly and concisely, how can you analyze it's security?
- Next steps:
  - Identify the assets: What do you wish to protect?
  - Identify the adversaries and threats
  - Identify vulnerabilities: Weaknesses in the system
  - Calculate the risks
  - Evaluate controls / mitigation strategies, and iterate

Assets

- Need to know what you are protecting!
  - Hardware: Laptops, servers, routers, PDAs, phones, ...
  - Software: Applications, operating systems, database systems, source code, object code, ...
  - Data and information: Data for running and planning your business, design documents, data about your customers, data about your identity
  - Reputation, brand name
  - Responsiveness
- Assets should have an associated value (e.g., cost to replace hardware, cost to reputation, how important to business operation)

Adversaries

- National governments
- Terrorists
- Thieves
- Business competitors
- Your supplier
- Your consumer
- New York Times
- Your family members (parents, children)
- Your friends
- Your ex-friends
- ...

Threats

- Threats are actions by adversaries who try to exploit vulnerabilities to damage assets
  - Spoofing identities: Attacker pretends to be someone else
  - Tampering with data: Change outcome of election
  - Denial of service: Attacker makes voting machines unavailable on election day
  - Elevation of privilege: Regular voter becomes admin
- Specific threats depend on environmental conditions, enforcement mechanisms, etc
  - You must have a clear, simple, accurate understanding of how the system works!

Threats

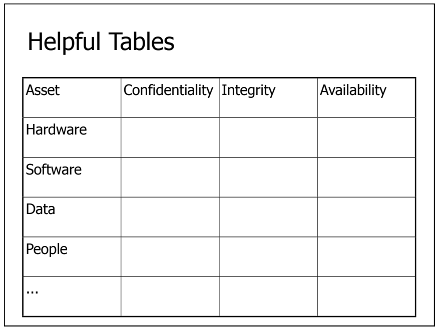
- Several ways to classify threats
  - By damage done to the assets
    - Confidentiality, Integrity, Availability
  - By the source of attacks
    - (Type of) insider
    - (Type of) outsider
    - Local attacker
    - Remote attacker
    - Attacker resources
  - By the actions
    - Interception
    - Interruption
    - Modification
    - Fabrication

Vulnerabilities

- Weaknesses of a system that could be exploited to cause damage
  - Accounts with system privileges where the default password has not been changed (Diebold: 1111)
  - Programs with unnecessary privileges
  - Programs with known flaws
  - Known problems with cryptography
  - Weak firewall configurations that allow access to vulnerable services
  - ...
- Sources for vulnerability updates: CERT, SANS, Bugtraq, the news(?)

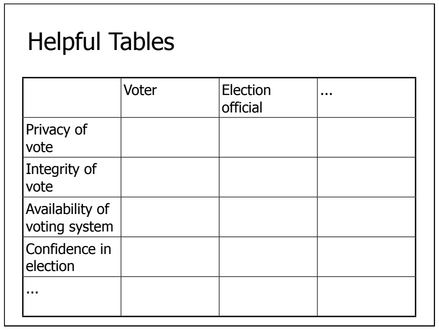
Risks Analyses: Lots of Options

- Quantitative risk analysis
  - Example: $\overset{\text{Risk Exposure}}{\boxed{\text{Risk}}} = \overset{\text{Risk Impact}}{\boxed{\text{Asset}}} \times \overset{\text{Probability}}{\boxed{\text{Threat} \times \text{Vulnerability}}}$
  - Monetary value to assets
  - Threats and vulnerabilities are probabilities
  - (Yes: Difficult to assign these costs and probabilities)
- Qualitative risk analysis
  - Assets: Critical, very important, important, not important
  - Vulnerabilities: Has to be fixed soon, should be fixed, fix if convenient
  - Threats: Very likely, likely, unlikely, very unlikely



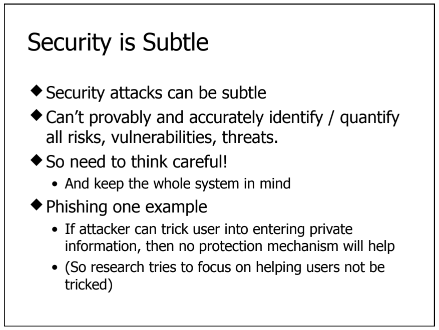
Helpful Tables

Asset	Confidentiality	Integrity	Availability
Hardware			
Software			
Data			
People			
...			



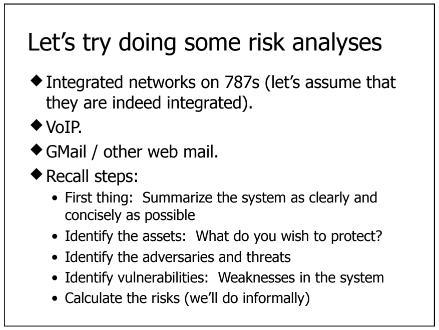
Helpful Tables

	Voter	Election official	...
Privacy of vote			
Integrity of vote			
Availability of voting system			
Confidence in election			
...			



Security is Subtle

- Security attacks can be subtle
- Can't provably and accurately identify / quantify all risks, vulnerabilities, threats.
- So need to think careful!
  - And keep the whole system in mind
- Phishing one example
  - If attacker can trick user into entering private information, then no protection mechanism will help
  - (So research tries to focus on helping users not be tricked)



Let's try doing some risk analyses

- Integrated networks on 787s (let's assume that they are indeed integrated).
- VoIP.
- GMail / other web mail.
- Recall steps:
  - First thing: Summarize the system as clearly and concisely as possible
  - Identify the assets: What do you wish to protect?
  - Identify the adversaries and threats
  - Identify vulnerabilities: Weaknesses in the system
  - Calculate the risks (we'll do informally)