Keys and Passwords
Handling Long-Term Keys

- Where do cryptographic keys come from?
- How should they be handled?
- What are the risks?
- As always, there are tradeoffs
Public/Private Keys

• Who generates the private key for a certificate?
• The server may have better random number generators
• Only the client needs the key
• (Does the corporation need a copy of the key?)
• If the server generates the key, how does it get to the client securely?
• (How does the public key get to the CA securely?)
Secret Keys

- Who generates secret keys?
- The problem is harder — both parties need to know them
- Again, how are they communicated securely?
Communication Options

- Channel authenticated by other means
- Public-key protected channel
- Hard-wired contact
- Out-of-band communications
- Note: process matters!
Out-of-Band Communications

- Telephone
- SMS text message
- Postal mail
What are the Enemy’s Powers?

- Steal letters from a mailbox?
- Fake CallerID with an Asterisk PBX?
- Planting malware on the phone?
- Burglary, bribery, blackmail?
Tamper Resistance

- Keys are safer in tamper-resistant containers — they can’t be stolen
- See “the three Bs” above
- Note well: tamper-\textit{resistant}, not tamper-\textit{proof}
- The availability of tamper-resistant hardware changes the tradeoffs
Online vs. Offline

- Does the key generator need to be online?
- A CA can be offline, and accept public keys via, say, CD
- That may be riskier than having it generate the private key — what if there’s a buffer overflow in the read routine?
- (But the CA has to read other things, like username)
- For secret keys, the server can’t be offline; rather, some copy of the key has to be online, to use it
No Perfect Answers!

- There are always tradeoffs
- The right answer in one situation may be the wrong answer in another
- Must evaluate the risks and the benefits of each alternative
- Caution: assume that the enemy’s powers will grow
Putting it All Together

- Let’s look at some relatively simple privileged programs
- How do they combine the different mechanisms we’ve seen?
- What are the threats? The defenses?
The “Passwd” Command

- Permits users to change their own passwords
- In other words, controls system access
- Very security-sensitive!
- How does it work?
Necessary Files

- `/etc/passwd` — must be world-readable, for historical reasons
  - Maps numeric UID to/from username

- Historical format:
  ```
root:8.KxUJ8mGHCwq:0:0:Root:/root:/bin/sh
  ```

- Fields: username, hashed password, numeric uid, numeric gid, name, home directory, shell
- Numeric uid/gid is what is stored for files
- Password is two bytes of salt, 11 bytes of “encryption” output
- Encoded in base 64 format: A-Za-z0-9./
Password Refresher

- Stored in irreversibly hashed form
- Classic scheme used encryption algorithm in odd way
- Use “salt” to prevent the same password from hashing to the same value on different machines, or for different users
- Salt makes dictionary of precomputed hashed passwords much more expensive
Storing the Hashed Password

- Better not make it world-readable
- Store in a *shadow password* file
- That file can be read-protected
File Permissions

$ ls -l /etc/passwd /etc/shadow
-rw-r--r-- 1 root  root  671  Oct  3 10:42 /etc/passwd
-r-------- 1 root  root  312  Oct  3 10:42 /etc/shadow
Must Be Owned by Root!

- Ownership of that file is equivalent to root permissions
- Anyone who can rewrite it can give themselves root permissions
- Cannot use lesser permissions
- Note: adding a line to that file (often with a text editor) is the first step in adding a user login to the system
Implications of the Numeric UID/GUID

- Assigning a UID to a username grants access to that UID’s files
- In other words, anyone with write permission on `/etc/passwd` has access to all files on the system
- Consequence: even if we changed the kernel so that root didn’t have direct access to all files, this mechanism provides indirect access to all files
- Conclusion: Cannot give root control over UID assignment on secure systems
What Else Shouldn’t Root Be Able to Change?

- The user’s password!
- Attack: change the user’s password to something you know
- Windows XP does not give Administrator either of these powers
The Passwd Command

- Clearly, must be setUID to root
- Must be carefully written...
Authenticating the User

- Passwd program has real UID
- Demand old password — why?
- Guard against someone doing permanent damage with minimal access
- Root can change other user’s passwords
Where Does the Salt Come From?

- Passwd command generates random number
- Need this be true-random?
- No — “probably different” will suffice.
- Seed ordinary pseudo-random number generator with time and PID
Restricting Access

- Suppose only a few people were allowed to change their own passwords
- Take away other-execute permission; put those people in the same group as “passwd”
Front Ends

- What about the help desk, for forgotten passwords?
- Have a setUID root front end that invokes passwd
- Validate: make sure they can only change certain users’ passwords
- Log it! (Much more later in the semester on logging)
Making a Temporary Copy

• Must copy password file to temporary location and back to change a password

• Watch out for race condition attacks!

• Actual solution: put temporary file in /etc instead of /tmp; avoid whole problem

• Secondary benefit: use temporary file as lock file, and as recovery location in case of crash
Update in Place

- Password changes could overwrite the file in place
- Doesn’t work for use add/delete or name change
- Still need locking
Passwords on the Command Line?

- Bad idea — `ps` shows it
- Bad idea — may be in shell history file
  
  ```
  $ history 12
  12 date
  13 man setuid
  14 ls -l `tty`
  ```
- Your terminal isn’t readable by others:
  
  ```
  $ ls -l `tty`
  crw--w---- 1 smb tty 136, 5 Oct 26 14:24 /dev/pts/5
  ```
Changing Your Name

• Chsh is like passwd, but it lets you change other fields
• Ordinary users can change shell and human-readable name; root can change other fields
• Much more dangerous than passwd
Input Filtering

- What if user supplies new shell or name with embedded colons?
  Embedded newlines? Both?
- Could create fake entries!
- Must filter for such things
Features Used

- Access control
- Locking/race prevention
- Authentication
- Privilege (setUID)
- Filtering
Security Analysis: Internet Thermostats

- I recently decided to investigate Internet thermostats
- Control and monitor my house temperature remotely
- Are there security risks?
One Popular Brand

- Thermostats have built-in web servers
- Simplest mode: direct connection to thermostat
- Alternate mode: thermostat and user connect to company’s web site; company can generate alert emails
What’s at Risk?

• Turning off someone’s heat in the middle of winter?
• Turning on the heat in the summer?
• Run heat and air conditioning simultaneously?
Local Management

![Thermostat Hallway Status Control - Microsoft Internet Explorer](image)

<table>
<thead>
<tr>
<th>NT20e Status</th>
<th>Thermostat Hallway Status</th>
<th>Hallway Status</th>
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<tbody>
<tr>
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<td>Sunday, May 20, 2007 7:04:59 AM</td>
</tr>
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<td></td>
<td>Zone Temperature</td>
<td>70.4°F</td>
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<td></td>
<td>Local</td>
<td>70.4°F</td>
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<tr>
<td></td>
<td>Override</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cool Setting</td>
<td>78.0°F</td>
</tr>
<tr>
<td></td>
<td>Heat Setting</td>
<td>68.0°F</td>
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<tr>
<td></td>
<td>Hold Mode</td>
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<tr>
<td></td>
<td><strong>Schedule Settings</strong></td>
<td></td>
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<tr>
<td></td>
<td>Day Class / Period</td>
<td>In / Mom</td>
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<tr>
<td></td>
<td>Cool</td>
<td>78.0°F</td>
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<td></td>
<td>Heat</td>
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<td></td>
<td>HVAC Mode</td>
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<td>Fan State</td>
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<td>Low Temperature</td>
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<tr>
<td></td>
<td>High Temperature</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>Filter change</td>
<td>OK</td>
</tr>
</tbody>
</table>
Local Problems

• No https — people can eavesdrop

• Uses “Basic Authentication”:
  “The most serious flaw in Basic authentication is that it results in the essentially cleartext transmission of the user’s password over the physical network. . . .
  “Because Basic authentication involves the cleartext transmission of passwords it SHOULD NOT be used (without enhancements) to protect sensitive or valuable information.”

• No read-only mode
Remote Management
Remote Problems

- Https — but only to the server
- Unencrypted traffic from the server to the thermostats
- (The words “security” and “encryption” are not mentioned in the API manual...)
- Passwords are sent in the clear across the Internet
- Passwords are stored in bulk on the server
Privacy Issues

- Energy consumption patterns
- Al Gore’s thermostat setting? Japanese office thermostat settings?
- Vacation schedules (burglary risk?)
Defenses

- Can’t touch thermostat software
- Add layering — access controls on top of built-in controls
- Use crypto tunnels
- Filter setting change requests
Last-Ditch Defenses

- Add a low-limit heat switch in parallel
- Add a high-limit heat switch in series
- These are hardware devices, not software
- Protect against bugs
- What if they fail?
- Independent failure modes; protect against each other
How to Analyze This?

- Hard to know all the threats
- Approach: see what is made available, and ask who might want it
- Reason by analogy and effect
- Check the “gold standard” (Au): Authentication, Authorization, Audit