Case Study: Access control
Case Studies in Access Control

- Joint software development
- Mail
Joint Software Development

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Joint Software Development
Situations

- Small team on a single machine
- Medium-to-large team on a LAN
- Large, distributed team, spread among several organizations
Roles

- Developer (i.e., can commit changes)
- Tester
- Code reviewer
Permissions

- We want the technical mechanisms to reflect the organizational roles

- The real challenge: mapping the organizational structure to OS primitives

- Why?
Why Enforce Access Controls?

- Protect software from outsiders reading/stealing it
- Protect against unauthorized changes
  ⇒ That can include internal rivalries
- Know who made certain changes?
Assume you just have user/group/other permissions, with no ACLs. How would you set things up?

- Put all developers in a certain group
- Make files and directories group readable/writable
- Decision to turn off “other” read access is site-dependent
ACL Setup

- Could add each developer individually

- Bad idea — if a developer leaves or joins the group, many ACLs must be updated

- Still want to use groups; vary group membership instead

- Advantage: can have multiple sets of group permissions — why?
Reviewer/Tester Access

- Reviewers and testers need read access
- They do not need write access
- No good, built-in solution on classic Unix
- With ACLs, one group can have r/w permissions; another can have r permissions
Medium-Size Group

- No longer on single machine with simple file permissions
- More need for change-tracking
- More formal organizational structure
Basic Structure

- Basic permission structure should be the same
- Again: use group permissions as the fundamental permission unit
- Limits of non-ACL systems become more critical
Version Control Systems

- For medium-size projects, use of a version control system (i.e., CVS, Subversion, Mercurial, RCS, etc.) is mandatory

- (Why?)

- What are the permission implications of a version control system?
Why use a VCS?

- Auditability — who made which change?
- When was a given change made?
- Can you roll back to a known-clean version of the codebase?
- What patches have been applied to which versions of the system?
All of those features are important just for manageability

Security needs are strictly greater — we have to deal with active malfeasance as well as ordinary bugs and failures
Structure of a VCS

Repository Master copy; records all changes, versions, etc.

Working copies Zero or more working copies. Developers *check out* a version from the repository, make changes, and *commit* the changes.
Here are the Unix client commands for RCS, CVS, Mercurial, and Subversion. What are the security implications?

```bash
$ ls -l /usr/bin/ci /usr/bin/cvs /usr/pkg/bin/hg /usr/pkg/bin/svn
-r-xr-xr-x 1 root wheel /usr/bin/ci
-r-xr-xr-x 1 root wheel /usr/bin/cvs
-rwrxr-xr-x 1 root wheel /usr/pkg/bin/hg
-rwrxr-xr-x 1 root wheel /usr/pkg/bin/svn
```
They’re Not SetUID!

- They execute with the permissions of the invoker
- They could try to do access control, but it’s meaningless — anyone else could write code to do the same things
- The permission structure of the repository is what’s important
The Repository

■ Essential feature: developers must have write permission on the directories

■ File permissions are irrelevant; old files can be renamed and unlinked instead of being overwritten

■ (Potential for annoyance if new directories are created with the wrong permission — must set umask properly)

■ But — what prevents a developer with write permission on the repository from doing nasty things?

■ Nothing...
Large Organization

- Use client/server model for repository access
- Most users (including developers) have no direct access to the VCS repository
- Either build access control into VCS server or layer on top of underlying OS permissions
- But — must restrict what commands can be executed on repository by developers
If you rely on OS permissions, *something* has to have root privileges, to let the repository part of the process run as that user.

If the VCS itself has a root component, is it trustable?

If you use, say, ssh, is the command restriction mechanism trustable?

If you rely on VCS permissions, you need to implement a reliable authentication and ACL mechanism.

All of this is possible — but is it *secure*?
Mailers

Issues
Accepting Mail
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However... Local Access or Client/Server?
Client/Server
Bug Containment
Local Mail Storage
Central Mail
Directory
Dangers of User-Writable
Mailbox Directories
Defending Against These Attacks
Delivering Mail to a Program
Privileged Programs
Privileged Mail
Readers
Many More Subtleties
Why is it Hard?
Mailers

- Issue of interest: local mail delivery and retrieval

- Surprisingly enough, network email doesn’t add (too much) security complexity
Issues

- Email *must* be reliable
- Users must be able to send email to any other users
- The system should reliably identify the sender of each message
- All emails should be logged
- Locking is often necessary to prevent race conditions when reading and writing a mailbox
- Authentication
Accepting Mail

■ Must accept mail from users

■ Copy it, either to protected spool directory for network delivery or directly to recipient’s mailbox
Spool Directory

- If the mailer is setuid, it can copy the email to a protected directory with no trouble.
- If the directory is world-writable but not world-readable, you don’t even need setuid — add a random component to the filenames to prevent overwriting.
- (Homework submission script does this)
- File owner is automatically set correctly, for use in generating `From:` line.
However...

- Cannot securely write metadata for such directories — others could overwrite the metadata file
- Cannot prevent users from overwriting their own pending email
- Listing the mail queue still requires privilege
Local Access or Client/Server?

- For client/server, issues are similar to VCS: authentication, root programs, restricting actions, etc.
- For local access, must confront permission issues.
- This is complicated by the many different versions of Unix over the years.
Since Client/Server:

- Standardized, (relatively) simple access protocols, POP and IMAP
- For ISP or large enterprise, neither need nor want general shell-type access to mail server
- Large system mailers have their own authentication database
- Does not rely on OS permissions
- But — a mail server bug exposes the entire mail repository
- Also — how do users change their passwords?
Separate programs into two sections:

- Small, simple section that does authentication and changes uid (must run as root)
- Large section that runs as that user

Major advantage: security holes in large section don’t matter, since it has no special privileges

Much more on program structure later in the semester
Local Mail Storage

- Where is mail stored? Central mailbox directory or user’s home directory?

- Note that mail delivery program must be able to (a) create, and (b) write to mailboxes

- If mailbox is in the user’s directory, mail delivery program must have root permissions
Central Mail Directory

- We can put all mailboxes in, say, /var/mail
- What are the permissions on it?
- If it’s writable by group mail, delivery daemon can create new mailboxes
- Make mailboxes writable by group mail, and owned by the recipient?
- Permits non-root delivery — but how do new mailboxes get created and owned by the user?
## Dangers of User-Writable Mailbox Directories

<table>
<thead>
<tr>
<th>Dangers</th>
<th>Example Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permission escalation</td>
<td><code>ln -s /etc/passwd /var/mail/me</code></td>
</tr>
<tr>
<td>Vandalism</td>
<td><code>rm /var/mail/you</code></td>
</tr>
<tr>
<td>Denial of service</td>
<td><code>touch /var/mail/does-not-exist-yet</code></td>
</tr>
</tbody>
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Defending Against These Attacks

Delivering Mail to a Program

Privileged Programs

Privileged Mail Readers

Many More Subtleties

Why is it Hard?
Defending Against These Attacks

**Escalation** Check mailbox permissions and ownership before writing (note: watch for race conditions)

**Vandalism** Set “sticky bit” on directory

**DoS** Remove (or change ownership of) mailboxes with wrong ownership

Note well: most of these are trickier than they seem
Delivering Mail to a Program

- Most mail systems permit delivery of email to a program
- Must execute that program as the appropriate user
- (Who is the “appropriate” user? Note that on Solaris, you may (depending on system configuration) be able to give away files)
- Implies the need for root privileges by the local delivery program
Privileged Programs

- What must be privileged?

- What privileges?

- Local delivery needs some privileges, frequently root

- Delivery to a program always requires root

- The mail reader?
Privileged Mail Readers

- The System V mail reader was setgid to group mail
- Could delete empty mailboxes
- More importantly, could create lock files by linking in the mailbox directory
- But — note the danger if the mailer was buggy
  “You don’t give privileges to a whale” (about 21K lines of code...)

Many More Subtleties

Why is it Hard?
Many More Subtleties

- Writing a mailer is *hard*
- I’ve barely scratched the surface of the design decisions, even the permission-related ones
- Complicated by varying system semantics
Why is it Hard?

- Mailers cross protection boundaries
- That is, they copy data from one permission context to another
- Both can be arbitrary userids
- Simply importing data to a userid is a lot easier
- In addition, a lot of functionality is needed
- Not surprisingly, mailers have a very poor security record