CSci 4271W
Development of Secure Software Systems
Day 10: Unix Access Control

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Outline

Configurability

- Basic idea: let one mechanism (implementation) support a variety of security policies
- I.e., make security a system configuration
- Classic example for today: OS access control
- Flexible mechanism to support different policies
- Trade-off: an incorrect configuration can lead to insecurity

Confidentiality and integrity

- Access control directly serves two security goals:
- Confidentiality, opposite of information disclosure
- Integrity, opposite of tampering
- By prohibiting read and write operations respectively

Access control policy

- Decision-making aspect of OS
- Should subject S (user or process) be allowed to access object (e.g., file) O?
- Complex, since admininstrator must specify what should happen

Access control matrix

	grades.txt	/dev/hda	/usr/bin/bcvi
Alice	r	rw	rx
Bob	rw	-	rx
Carol	r	-	rx

Slicing the matrix

- $O(nm)$ matrix impractical to store, much less administer
- Columns: access control list (ACL)
  - Convenient to store with object
  - E.g., Unix file permissions
- Rows: capabilities
  - Convenient to store by subject
  - E.g., Unix file descriptors

Groups/roles

- Simplify by factoring out commonality
- Before: users have permissions
- After: users have roles, roles have permissions
- Simple example: Unix groups
- Complex versions called role-based access control (RBAC)

Outline

One namespace

- All files can be accessed via *absolute pathnames* made of directory components separated by slashes
- I.e., everything is a descendant of a root directory named /

Filesystems and mounting

- There may be multiple filesystems, like disk partitions or removable devices
- One filesystem is the root filesystem that includes the root directory
- Other filesystems are mounted in place of a directory
  - E.g., `/media/smccaman/mp3player/podcast.mp3`

Special files and devices

- Some hardware devices (disks, serial ports) also look like files
  - Usually kept under `/dev`
- Some special data sources look like devices
  - `/dev/null`, `/dev/zero`, `/dev/urandom`
- Some OS data also available via `/proc` and `sys` filesystems
  - E.g., `/proc/self/maps`

Current directory, relative paths

- At a given moment, each process has a current working directory
  - Changed by `cd` shell command, `chdir` system call
- Pathnames that do not start with / are interpreted *relative* to the current directory

Inodes

- Most information about a file is a structure called an inode
- Includes size, owner, permissions, and a unique inode number
- Inodes exist independently of pathnames

Directory entries and links

- A directory is a list of directory entries, each mapping from a name to an inode
- These mappings are also called links
- "Deleting a file" is really removing a directory entry
  - The system call `unlink`

Entries . and ..

- Every directory contains entries named . and ..
- . links back to the directory itself
- .. links back to the *parent* directory, or itself for the root

(Hard) links

- Multiple directory entries can link to the same inode
- These are called hard links
- Only allowed within one filesystem, and not for directories

Symbolic links

- Symbolic links are a different linking method
- A symbolic link is an inode that contains a pathname
- Most system calls follow symbolic as well as hard links to operate on they point to

Outline

Midterm-related resources

- Two solution set PDFs from old exams are now posted
- Bring your questions (including lab and pset-related) to office hours or Piazza

Midterm-related advice

- Pencil or erasable pen would be good writing implements (unless you don't make mistakes)
- You can bring any paper, but distilling the most useful information will save you time
- Several previous exams had questions related to terminology: this can benefit from targeted studying

Outline

UIDs and GIDs

- To kernel, users and groups are just numeric identifiers
- Names are a user-space nicety
  - E.g., `/etc/passwd` mapping
- Historically 16-bit, now 32
- User 0 is the special superuser `root`
  - Exempt from all access control checks

File mode bits

- Core permissions are 9 bits, three groups of three
- Read, write, execute for user, group, other
- `ls` format: `rwx r-x r--`
- Octal format: 0754

Interpretation of mode bits

- File also has one user and group ID
- Choose one set of bits
  - If users match, use user bits
  - If subject is in the group, use group bits
  - Otherwise, use other bits
- Note no fallback, so can stop yourself or have negative groups

Directory mode bits

- Same bits, slightly different interpretation
- Read: list contents (e.g., `ls`)
- Write: add or delete files
- Execute: traverse
- X but not R means: have to know the names

Other permission rules

- Only file owner or root can change permissions
- Only root can change file owner
  - Former System V behavior: "give away `chown`"
- Setuid/gid bits cleared on `chown`
  - Set owner first, then enable setuid

Non-checks

- File permissions on `stat`
- File permissions on link, unlink, rename
- File permissions on read, write
- Parent directory permissions generally
  - Except traversal
  - I.e., permissions not automatically recursive

Outline

Octal digits represent access

- 7 = rwx
- 6 = rw
- 5 = rx
- 4 = r
- 0 = no access

Setting: files related to this class

- Student and course staff materials
- Imagine everything is in Unix files on CSE Labs
  - Versus reality of a mixture of Unix with web-based systems like Canvas

Users and groups

- Users: smccaman (instructor), wang8330 (TA), stude003 (student)
- Groups: csci4271staff (instructor and TAs), csci4271students, csci4271all (staff and students)

What I want from you

- Brainstorm sets of octal permissions bits that could be used
- For each permission bits set, give user, owner, and file/directory contents/use that would be sensible

Outline

Process UIDs and `setuid(2)`

- UID is inherited by child processes, and an unprivileged process can't change it
- But there are syscalls root can use to change the UID, starting with `setuid`
- E.g., login program, SSH server

Setuid programs, different UIDs

- If 04000 "setuid" bit set, newly exec'd process will take UID of its file owner
  - Other side conditions, like process not traced
- Specifically the *effective UID* is changed, while the *real UID* is unchanged
  - Shows who called you, allows switching back

More different UIDs

- Two mechanisms for temporary switching:
  - Swap real UID and effective UID (BSD)
  - Remember *saved UID*, allow switching to it (System V)
- Modern systems support both mechanisms at the same time

Setgid, games

- Setgid bit 02000 mostly analogous to setuid
- But note no supergroup, so UID 0 is still special
- Classic application: setgid `games` for managing high-score files

Special case: `/tmp`

- We'd like to allow anyone to make files in `/tmp`
- So, everyone should have write permission
- But don't want Alice deleting Bob's files
- Solution: "sticky bit" 01000

Special case: group inheritance

- When using group to manage permissions, want a whole tree to have a single group
- When 02000 bit set, newly created entries with have the parent's group
  - (Historic BSD behavior)
- Also, directories will themselves inherit 02000

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