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Intro to Operating Systems Spring 2000

Protection and Security

Questions answered in these notes:

- How can the system authenticate a user?
- How are access rights specified?
- What are common security problems?

Reading for topic: Chapter 19 & 20

Motivation

Protection more important as computer systems develop

- Multiple users have access to same resources
- Computers connected to network
- Increasing importance of electronic commerce

Goals

- Prevent accidental misuse
  - Example: Mistakenly overwrite command interpreter & no one can log in
  - Relatively easy to solve by making likelihood small
- Malicious abuse
  - Example: Break the password for accounting system & transfers $3 billion
  - Hard to completely eliminate

Components of Protection Mechanism

Authentication

- Make sure system knows which user is doing what action

Authorization determination

- Determine what the user is and is not allowed to do
- Separate policy and mechanisms

Access enforcement

- Make sure there are no loopholes in the system

Slightest flaw in any areas ruin entire protection mechanism

Authentication

Authentication most often performed with *passwords*

- Secret piece of information used to establish the identity of a user
- Should not be stored in readable form
  - One-way transformations should be used
- Passwords should be relatively long and obscure
  - Short passwords are easy to crack
  - Long passwords are easily forgotten and usually written down
- Disadvantage: Relatively weak form of protection

Another form of identification: *key*

- Does not have to be kept secret
- Should not be forgeable or able to be copied
- If stolen, the owner is aware
- Disadvantage: Key must be cheap to make, yet hard to duplicate

Authorization Determination

Access rights represented with *access matrix*

One domain (e.g., user or process) per one row

One resource per column

Each entry indicates the privileges of that domain on that object

	File A	Printer1	TTY 3	...
Domain 1	R	W	RW	
Domain 2	---	W	---	
Domain 3	RW	W	---	
Domain 4	RWX	---	---	
Domain 5	---	---	---	

Additional considerations

- Can process change from one domain to another?
- Can access rights of entry be changed?
- Can rights be copied from one domain to another?

Representation of Access Matrix

Full access matrix is sparsely populated

- Information condensed in two forms: Access lists and capabilities

Access Lists

- For each resource, indicate users that can perform operations
  - Column of access matrix
- Most general: each object has list of <user, privilege> pairs

Disadvantage

- Tedious to have separate entry for every user
  - Optimization: Group users into classes
  - UNIX Example: Three classes: self, group, everyone else

Advantages

- Access lists are simple and used in almost all file systems
- Revocation is trivial

Representation of Access Matrix

Capabilities

- With each user, indicate resources that may be accessed
  - Row of access matrix
- Store a list of <object, privilege> pairs with each user

Implementation: Naming

- Secure pointer
- Cannot even name objects not in your capability list
- Policy for sharing capabilities

Examples

- Page tables
- Unlisted phone numbers?

Advantages

- More secure; default is cannot access object

Revocation of Access Rights

Potentially difficulty: Capabilities distributed throughout system

Re-acquisition

- Periodically delete all capabilities
- Must reacquire capability to access again

Back-pointers

- Each object has pointers back to all capabilities
- Follow pointers back to remove capability

Indirection

- Capability does not point to object, but to entry in global table
- Delete entry in table

Keys: Unique, un-modifiable bit pattern

- Associate value of master key with local key
- Change master key value

Access Enforcement

Security kernel responsibilities

- Protecting identification and authorization information
- Enforcing access controls

Requirements

- Must run in protected mode
- As small and simple as possible

Paradox

1. More powerful protection mechanism -->
2. Larger and more complex security kernel -->
3. More likely to have implementation bugs

Levels of protection

- Most systems let entire OS run in all-powerful mode

  Such systems are not very secure

Common Security Problems

Abuse of valid privileges

- Privileges are not fine grained enough
- Example: Super-user can do **anything**

Listener

- Eavesdrop on terminal wire or local network to steal information
- Set Ethernet card to promiscuous mode

Denial of Service or Spoiler

- Consume all resources and make system crash or unusable
- Example: Grab all file space or create many processes

More Security Problems

Leverage Covert Channels

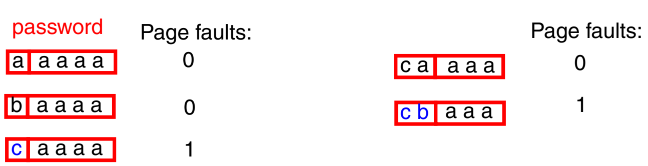
- Information that leaks outside of normal interface
- Example: Tenex page-fault caper

  System checked password only until no match

  Cracked passwords by placing input string across page boundaries

  Measured time for password check

  Solution: System touches entire password



- Impossible to confine all information (e.g., power consumption)

More Security Problems

Imposter or Trojan Horse

- Program that misuses its environment
- Many examples

  Program looks like login process, remembers passwords

  Editor that reads unauthorized files

  ATMs

  Fake deposit slips

Trap Door

- Designer leaves hole in software to leverage later
- Example

  Login makes user a super-user regardless of password file

  Problem: Inspection of source code reveals trap door

  Change compiler to insert special code when compiling login!

  Compiler code also show trap door, so have special compiler for compiler

  Simple compiler only distributed in binary!

More Security Problems

Virus

- Fragment of code embedded in legitimate code
- Problem for personal computers
- Spread by copying infected programs over network or floppy disk

Worm

- Process that is capable of spreading itself from machine to machine
- Example: Disabled thousands of computers in Fall of 1988
- Sendmail attack
  - Leverage debug command left enabled to execute code as super-user
- Fingerd attack
  - Give long name to fingerd to overflow buffer and modify stack
- Rsh
  - Crack passwords of local users by guessing common ones
  - Look for .rhost files for access to more machines

Regaining Security

May be impossible to secure system once penetrated

- Not all possible to tell that security violation occurred
  - Villain can remove all traces from log files
- Hooks could have been left around for the imposter to regain control
- Cannot restore system from backup tapes
  - Attack could have occurred earlier than suspected

Only solution

- Remove all files from disk and reinstall all software