

CSci 5271
Introduction to Computer Security
Day 2: Intro to Software and OS Security

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Outline

Security risk and management
Some terminology
Logistics intermission
Example security failures
Software security engineering
Vulnerabilities in OS interaction

Security as an economic good

- Security is a good thing (for defenders)
- But, must trade off other things to get it
- Rational to not purchase all available
- In the big picture, always a compromise

Risk budgeting with ALE

- Annual loss expected = (loss amount) × (incidence)
- Net risk reduction = Δ ALE - (security cost)
- Like with a budget, spreadsheet may not match reality
- Like other cost-benefit analysis, can make trade-offs more explicit

Failure: Displacement activity

Security "syllogism" (after Doctorow):

1. We must do something
 2. This is something
 3. Therefore we must do this.
- Example: airport security
 - Example: external vs. internal threats

Failure: Risk compensation

- Some benefits of security are taken back by riskier behavior
- Example: H-Day in Sweden
- We'll return to human factors later

This class perspective

- We'll mostly ignore management issues
- For this class, maximize security at all costs

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"Trusted"

- In security, "trusted" is a bad word
- X is trusted: X can break your security
- "Untrusted" = might be evil
- Trusted Computing Base (TCB): minimize

"Trusted" vs. "trustworthy"

- Something you actually should trust is "trustworthy"
- Concise definition of security failure: something trusted is not trustworthy

"Privilege"

- Privilege is the power to take security-relevant actions
- Concise definition of security failure: the adversary gets privilege they shouldn't

3 privilege levels

1. Administrator/root/OS kernel
2. Regular user of system
3. Evil people on the Internet

3 privilege levels

1. Administrator/root/OS kernel
↑ Local exploit
2. Regular user of system
↑ Remote exploit
3. Evil people on the Internet

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Anyone still not registered?

- ☐ On waiting list, came first day ⇒ should have gotten permission number Wednesday afternoon
- ☐ Anyone else?

Exercise set 1

- ☐ Posted Friday afternoon, on website
- ☐ Due Thursday, September 26th
- ☐ Groups of 1-3

Moodle, group-forming

- ☐ Moodle page started
- ☐ Group-finding mechanism: forum

Finding project topics

- ☐ Pre-proposal due 9/18 (week from Wednesday)
- ☐ Don't skimp on topic: hard but important
- ☐ Conference papers linked from class site

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Classic buffer overflow

```
char buf[20];  
gets(buf);
```

- ❑ Vulnerability in `finger` daemon
- ❑ Morris worm brought down 1988 Internet (4.3BSD VAXes)

Buffer overflow classification

- ❑ Bug: stack buffer overflow
- ❑ Attack: return address overwrite
- ❑ Consequence: (binary) code injection

Read It Twice (WOOT'12)

- ❑ Smart TV (running Linux) only accepts signed apps on USB sticks
 1. Check signature on file
 2. Install file
- ❑ Malicious USB device replaces app between steps
- ❑ TV "rooted"/"jailbroken"

Confused deputy compiler

- ❑ Compiler writes to billing database
- ❑ Compiler can produce debug output to user-specified file
- ❑ Specify debug output to billing file, disrupt billing
- ❑ How to write policy preventing this?

Leaky intelligence analysts

- ❑ 1000s of analysts need to view 1000s of classified documents to do their job
- ❑ Can we prevent it if one wants to send them to the Washington Post?
- ❑ More than regular access control
- ❑ (Reality: many non-technical problems)

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Vulnerabilities are bugs

- Security bugs “just a special case” of bugs
- Like regular bugs, only obscure ones make it through testing
- Key difference:
 - Rare regular bug has limited impact
 - Attackers seek out vulnerability circumstances

Security and quality

- Security correlated with other software quality:
 - Developers understand code well
 - Interactions between modules controlled
 - Well tested

Security and other features

- Security would be much easier if systems were less complex
- But, very few users want that trade-off
- Risk compensation with development improvements

Contracts and checks

- Requirement: check X before doing Y
- What function’s responsibility is the check?
- Answer embodied in contracts, aka specifications, preconditions and postconditions

Defensive programming

- Analogy: defensive driving
- Don’t assume things are right, check
- Inbound: preconditions on arguments
- Outbound: error conditions
- Within reason: some things can’t be checked at some places

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Shell code injection

- ❑ Don't pass untrusted strings to a command shell
- ❑ In C: `system`, `popen`
- ❑ `system("cmd $arg1 $arg2")`
- ❑ Fix 1: avoid shell
- ❑ Fix 2: sanitize data (preferably whitelist)

Shell code injection example

- ❑ Benign: `system("cp $arg1 $arg2"), arg1 = "file1.txt"`
- ❑ Attack: `arg1 = "a b; echo Gotcha"`
- ❑ Command: `"cp a b; echo Gotcha file2.txt"`
- ❑ Not a complete solution: `blacklist `;`

Bad/missing error handling

- ❑ Under what circumstances could each system call fail?
- ❑ Careful about rolling back after an error in the middle of a complex operation
- ❑ Fail to drop privileges \Rightarrow run untrusted code anyway
- ❑ Update file when disk full \Rightarrow truncate

Race conditions

- ❑ Two actions in parallel; result depends on which happens first
- ❑ Usually attacker racing with you
 1. Write secret data to file
 2. Restrict read permissions on file
- ❑ Many other examples

Classic races: files in `/tmp`

- ❑ Temp filenames must already be unique
- ❑ But "unguessable" is a stronger requirement
- ❑ Unsafe design (`mktemp(3)`): function to return unused name
- ❑ Must use `O_EXCL` for real atomicity

TOCTTOU gaps

- Time-of-check (to) time-of-use races
 1. Check it's OK to write to file
 2. Write to file
- Attacker changes the file between steps 1 and 2
- Just get lucky, or use tricks to slow you down

TOCTTOU example

```
int safe_open_file(char *path) {
    int fd = -1;
    struct stat s;
    stat(path, &s);
    if (!S_ISREG(s.st_mode))
        error("only regular files allowed");
    else fd = open(path, O_RDONLY);
    return fd;
}
```

TOCTTOU example

```
int safe_open_file(char *path) {
    int fd = -1, res;
    struct stat s;
    res = stat(path, &s);
    if (res || !S_ISREG(s.st_mode))
        error("only regular files allowed");
    else fd = open(path, O_RDONLY);
    return fd;
}
```

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```

Changing file references

- With symbolic links
- With hard links
- With changing parent directories

Directory traversal with ..

- Program argument specifies file with directory files
- What about files/../../../../etc/passwd?

Environment variables

- Can influence behavior in unexpected ways
 - PATH
 - LD_LIBRARY_PATH
 - IFS
 - ...
- Also umask, resource limits, current directory

IFS and why it's a problem

- In Unix, splitting a command line into words is the shell's job
 - String → argv array
 - grep a b c VS. grep 'a b' c
- Choice of separator characters (default space, tab, newline) is configurable
- Exploit `system("/bin/uname")`

Next time

- Bugs particular to low-level (e.g., C) programs