Operating System and Security

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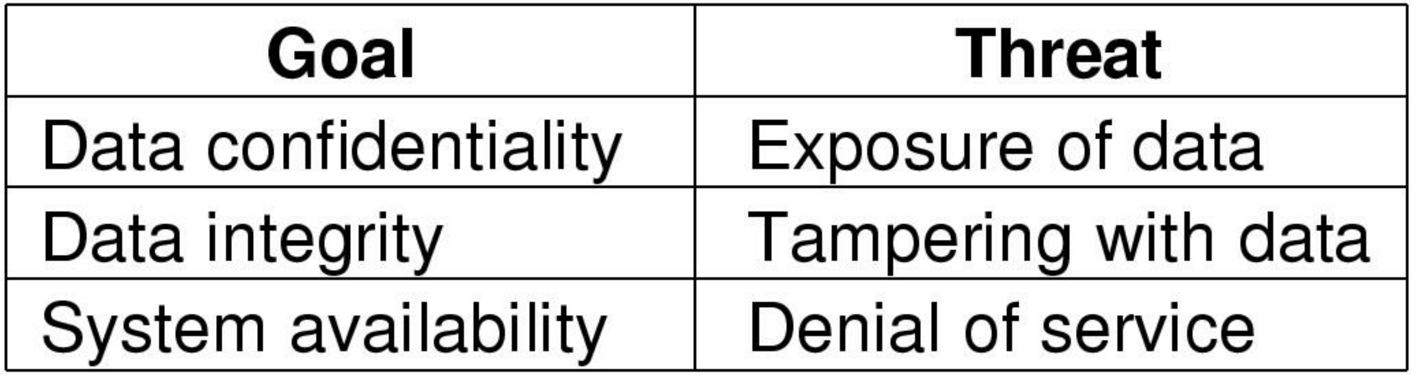
From: http://www.syslog.com/~jwilson/pics-i-like/kurios119.jpg

What is Security

- C.I.A



Goal	Threat
Data confidentiality	Exposure of data
Data integrity	Tampering with data
System availability	Denial of service

- Preventing unauthorized users from executing undesirable actions, such as
  - Stealing your data (C)
  - Giving you fake data/Tampering your data (I)
  - Preventing you from doing your work (A)

Securing what?

- Securing the OS from users
    - OS-level mechanisms
- Securing one user from another
    - Access control, isolation
- Securing users from OS!
    - Yes, sometimes the OS is not trusted by the user.
    - E.g. in a cloud users may not trust the cloud platform's OS.

Security mechanisms in OS and hardware

- CPU Execution privileges (“Who can access?”)
  - Part of CPU state
  - x86 privilege rings (0,1,2,3) in EFLAGS
  - VTx provides root and non-root modes
- Memory protection (“What can be accessed?”)
  - Protection bits in segment descriptors
  - Protection bits in page-table registers
  - Virtual Memory (naming)
- File system privileges (“What can be accessed?”)
  - User accounts
  - Access permissions

Common Motivations of Intruders

1. Peeping Tom
   - Casual prying by nontechnical users
2. Insider threat
   - Disgruntled insiders, programmer's backdoor
3. Extortion
   - Make money
4. Espionage/Intelligence gathering
   - Commercial or military or government
5. Hacktivism
   - Political or social motivation
6. Sometimes motivations may overlap
   - Was Snowden incident 2? 4? 5? All?

User Authentication

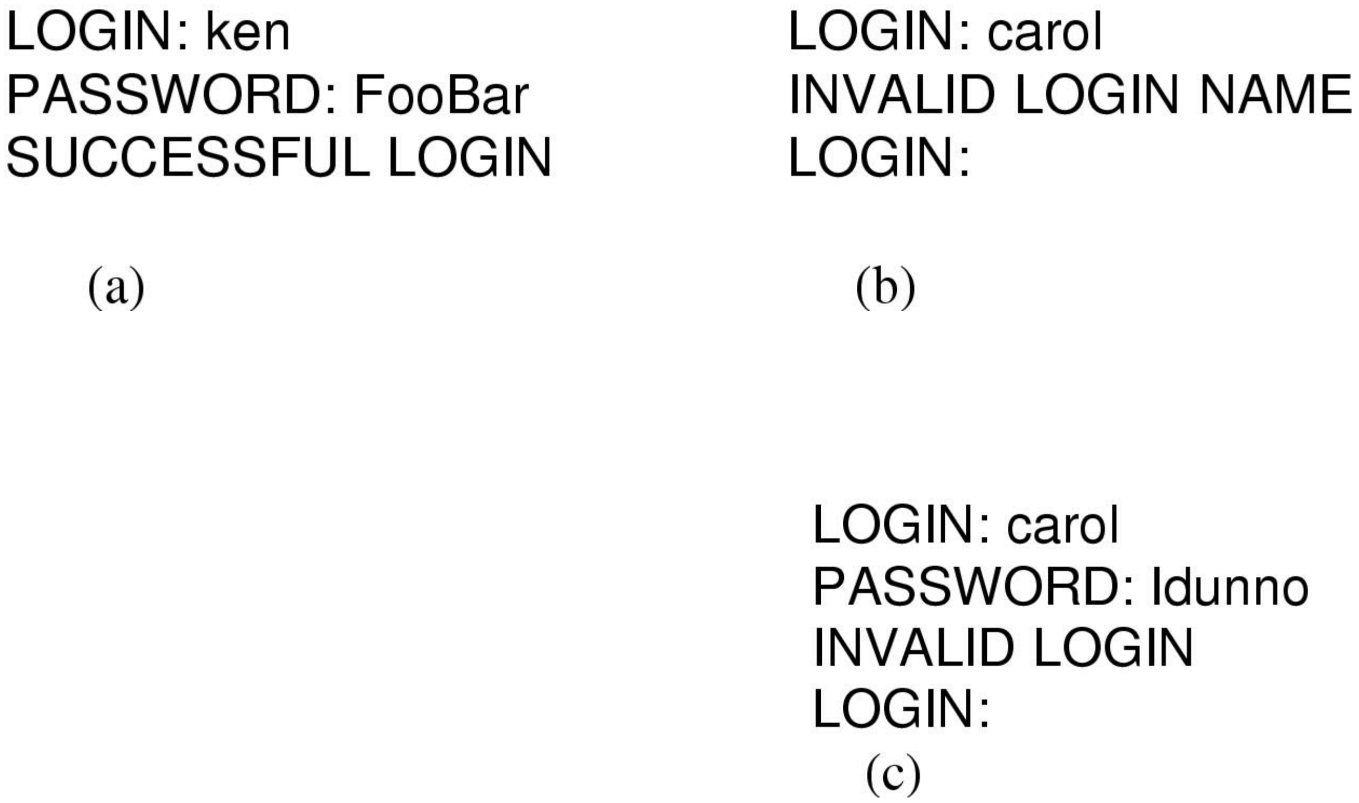
- Verifying that you are who you claim you are.

- File permissions and user’s rights are set according to user’s identity, which is established by authentication.

- Basic Principles. Authentication must identify:
  - Something the user knows
  - Something the user has
  - Something the user is

- This is done before user can use the system

Something the user knows: Passwords



```
LOGIN: ken
PASSWORD: FooBar
SUCCESSFUL LOGIN
```

(a)

```
LOGIN: carol
INVALID LOGIN NAME
LOGIN:
```

(b)

```
LOGIN: carol
PASSWORD: Idunno
INVALID LOGIN
LOGIN:
```

(c)

(a) A successful login

(b) Login rejected after name entered

(c) Login rejected after name and password typed

Storing passwords

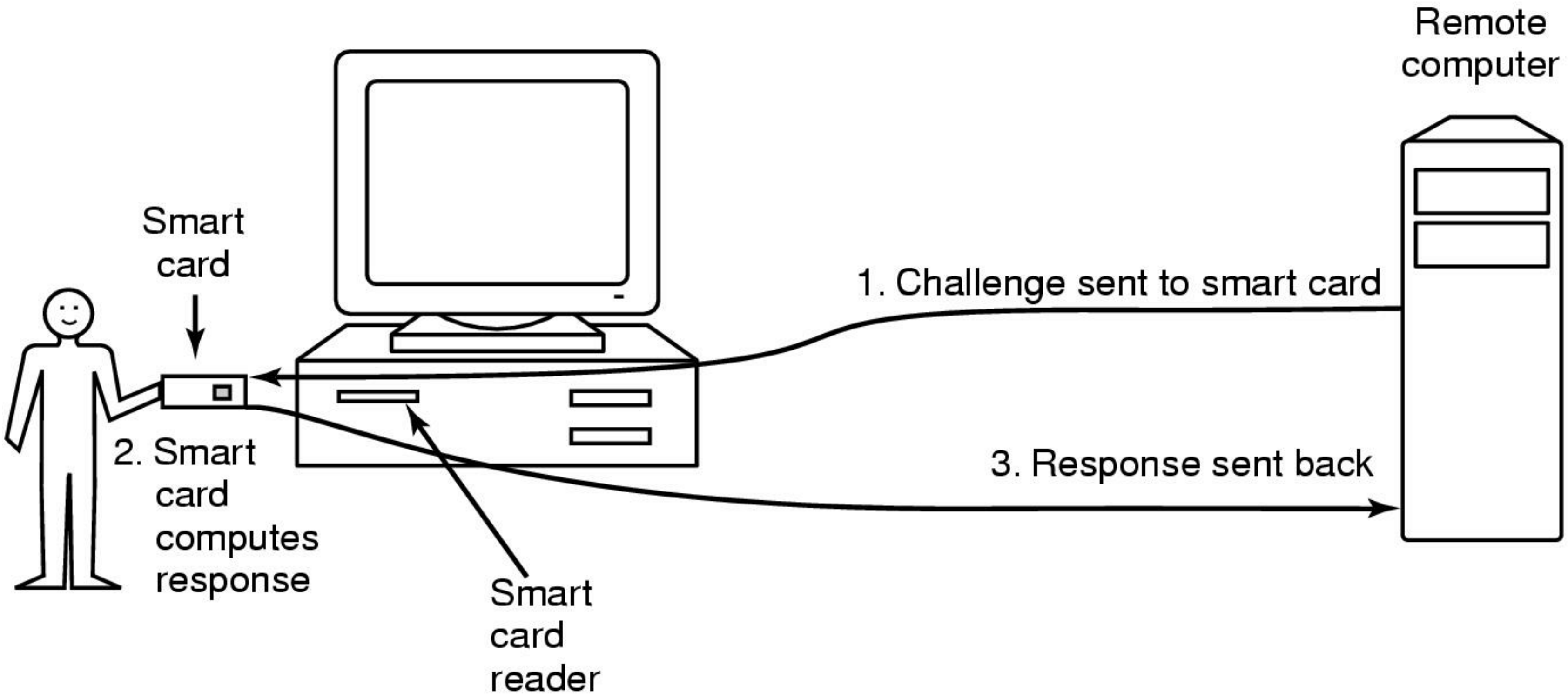
- Originally stored in plaintext in a “secure” file.
    - Secure only as long as root account is not compromised
    - Also, users may not want sysadmins to know their passwords, which usually contain private data.

- Now these are hashed using one-way functions
    - Given password input x
        - easy to evaluate $y = f(x)$
    - But given y
        - computationally infeasible (or at least non-trivial) to compute $x = f^{-1}(y)$

Challenge-Response Authentication

- Forgot password?
- Ask user something that no one else would know.
  - Poor choices: Mother’s maiden name, where you were born, first girlfriend/boyfriend, pet’s name, high school, childhood street etc.
  - All easily guessed
  - Not sure why websites still do this
- Ask user to compute something
  - “What is the fifth smallest prime number?”
  - Assuming the question can’t be understood by a program.
- Attack: Beg customer service to help a poor user who forgot password

Something the user has: Authentication Using a Physical Object



– magnetic stripe cards, chip cards: stored value cards, smart cards

Something the user is: The user’s body

- Biometrics:
  - voice
  - face
  - fingerprint
  - iris scan
  - typing style

- These have both false-positives and false-negatives
- Susceptible to spoofing attacks

Countermeasures against authentication attacks

- Limiting times when someone can log in
  - “Sorry: You can’t log in at 2am”
- Limited number of login tries
  - “Too many invalid logins. Your account is now LOCKED.”
- Two-factor authentication
  - Password + Automatic callback/SMS at number prespecified
- Logging: Tracking all logins and locations of login
  - “Your last login: from Timbuktu yesterday.”
- Ask user to recognize text in a figure
  - CAPTCHA = Completely Automated Public Turing test to tell Computers and Humans Apart
- Honeypot accounts: Simple login name/password as a trap
  - security personnel notified when attacker bites
  - Only if you want to track/catch the intruder (sometimes don’t care)

Common Attacks and Countermeasures

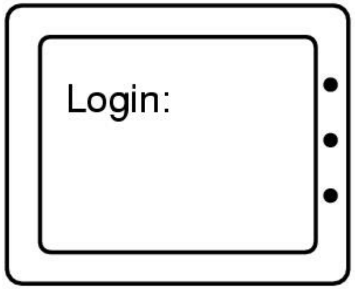
Trojan Horses

- Malicious email attachments
  - CM: Don’t open. Open in a VM. Use a cloud-based reader.
- Malicious websites that exploit browser vulnerabilities
  - Visit and get hacked
  - CM: Turn off Flash plugins, Javascript. Affects usability.
- “Free” program made available to unsuspecting user
  - Actually contains code to do harm
  - CM: Run in VM. Don’t download.
- Place altered version of utility program on victim's computer
  - Trick user into running that program
  - CM: Administrator must strictly control file permissions

Virus and Worm

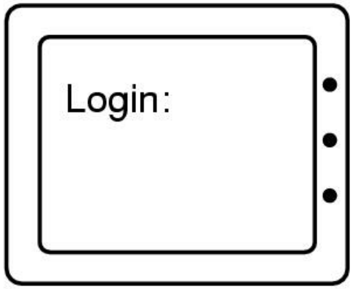
- Virus
  - program that can reproduce itself by attaching its code to another program
  - requires human intervention to spread to another machine
- Worms
  - spread across machines
  - automatically, or with human assistance

Login Spoofing
“I’m sure I entered the right password. What happened?”



(a)

Correct login Screen



(b)

Phony login Screen

Countermeasures:

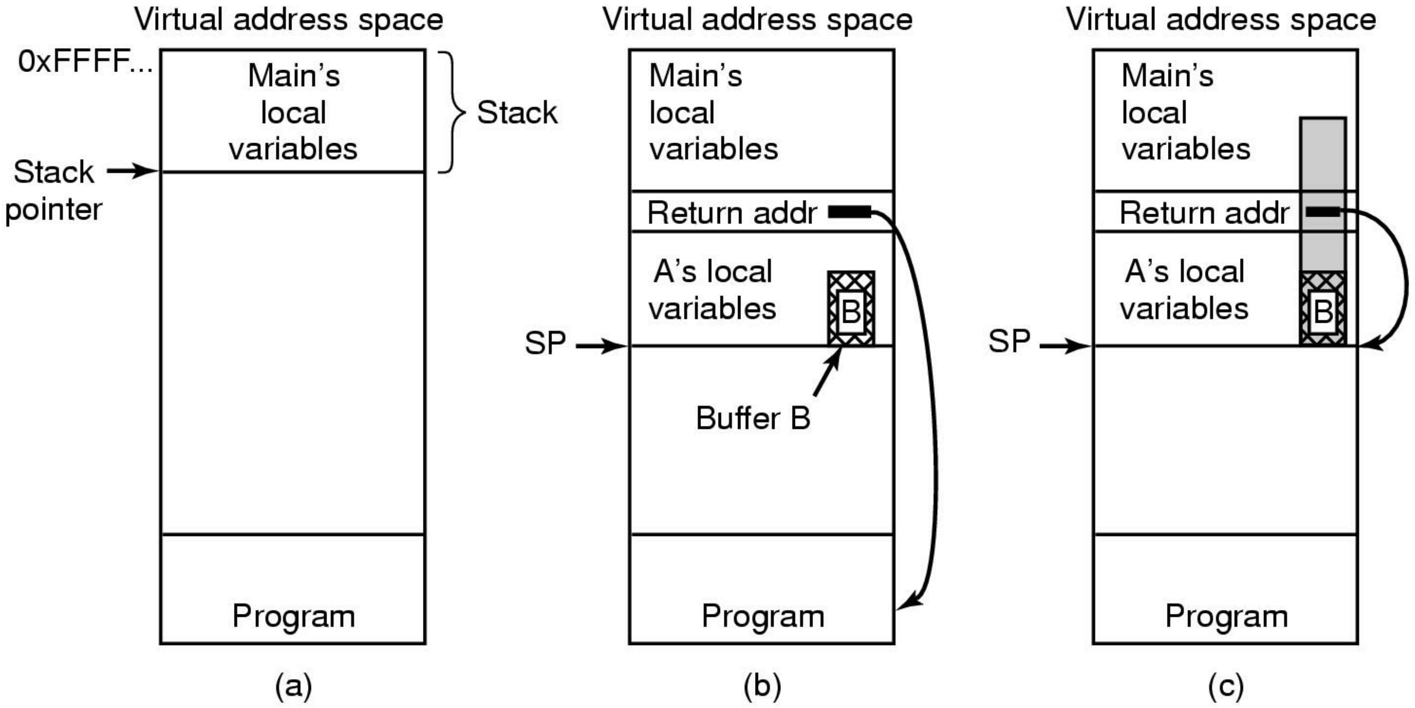
- Cautious user can intentionally enter a fake password the first (few) time(s).
- Use “Trusted Path”
  - A sequence of user actions that is guaranteed to give control to the OS.
  - E.g. pressing Ctrl-Alt-Del could guarantee that legitimate login (or logout) screen will show up.

Logic Bombs

- Company programmer writes a program with potential to do harm
- OK as long as he/she enters password daily
- If programmer fired, no password and bomb “explodes”
- CM: Log all activity
  - Easy to detect and correlate.

- Don’t try this at work!
  - Your employer may be smarter than you give them credit for.

Buffer Overflow



- (a) Situation when main program is running
- (b) After function *A* called
- (c) Buffer overflow shown in gray

Memory reuse — Dumpster Diving

- Request memory, disk space, tapes
- Don’t write. Just read and interpret existing data.
- May find passwords, ssh keys, emails, personal information, browsing history, etc.
- CM:
  - Scrub memory/storage before allocating to user.
  - Encrypt data. Throw away the key once done.
  - Disadvantage: Takes more time.

Logging

- Logs: A time-wise record of system activity.
  - Events always appended. “Never” erased.
- Logs must be analyzed often to detect suspect activity
- What to log?
  - Too much logging
    - takes up storage
    - slows down normal operations.
    - Slows down analysis.
  - Too little logging and you miss critical events.
- Privacy risk
  - Can break laws.
  - Or violate user’s perception of privacy. (sometimes

Other ways to gain access

- Trying privileged system calls to see what happens

- Doing specified DO NOTs
    - “Only authorized personnel beyond this point”

- Convince a system programmer to add a backdoor

Design Principles for Security

- Default should be no access
- Check for current authority
- Give each process least privilege possible
- Protection mechanism should be
  - simple
  - uniform
  - in lowest layers of system
- Scheme should be simple and psychologically acceptable
  - If its too hard, users will get around it.
  - Like using post-it notes on the monitor.

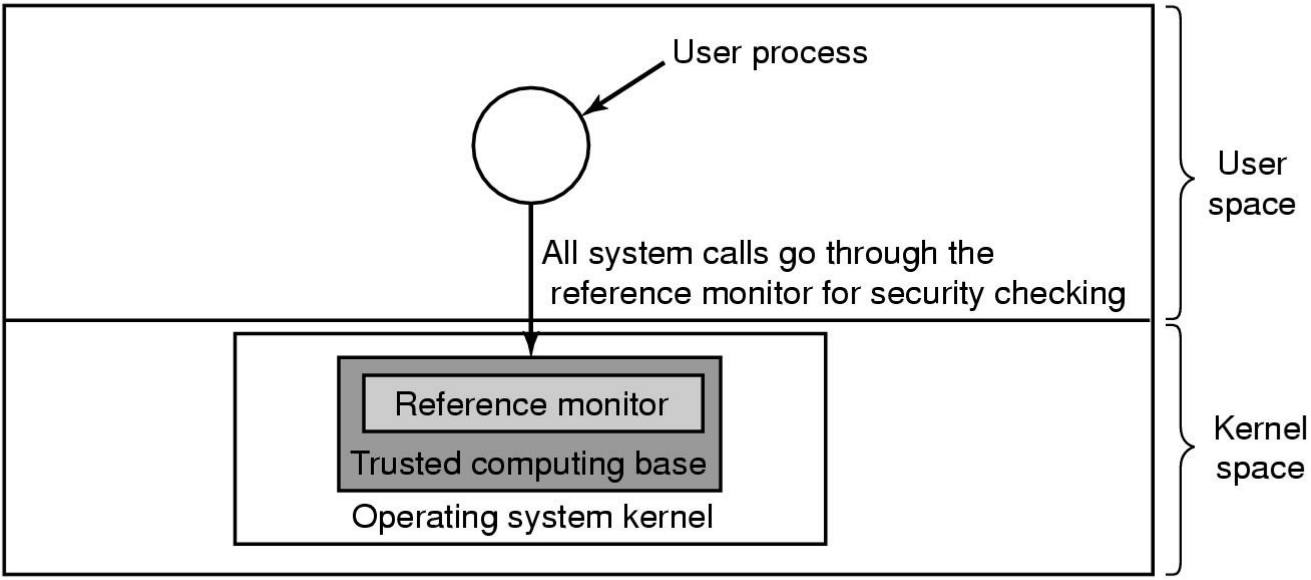
Sandboxes

- Run dowloaded code/browser in a VM or a “Jail”.
- Isolate trojans/viruses, worms
- Effectiveness of isolation only as effective as the security of the Sandbox.
- VM Escapes and Jail-breaks are possible.
    - Usually due to implementation bugs in the hypervisor or runtime

Access control

- Discretionary access control (DAC)
  - “John can access X. Alice can do Y.”
  - Commodity systems
- Mandatory access control (MAC)
  - Military/spy systems
  - More later
- Role-based access control (RBAC)
  - “CEO can do X. Software Engineer can do Y. Secretary can do Z”.
  - Enterprise systems
- Administrative Role-based Access Control
  - “Dean can allow department chair to do X. Dept chair can allow secretary to do Y”

Reference Monitor and Trusted Computing Base

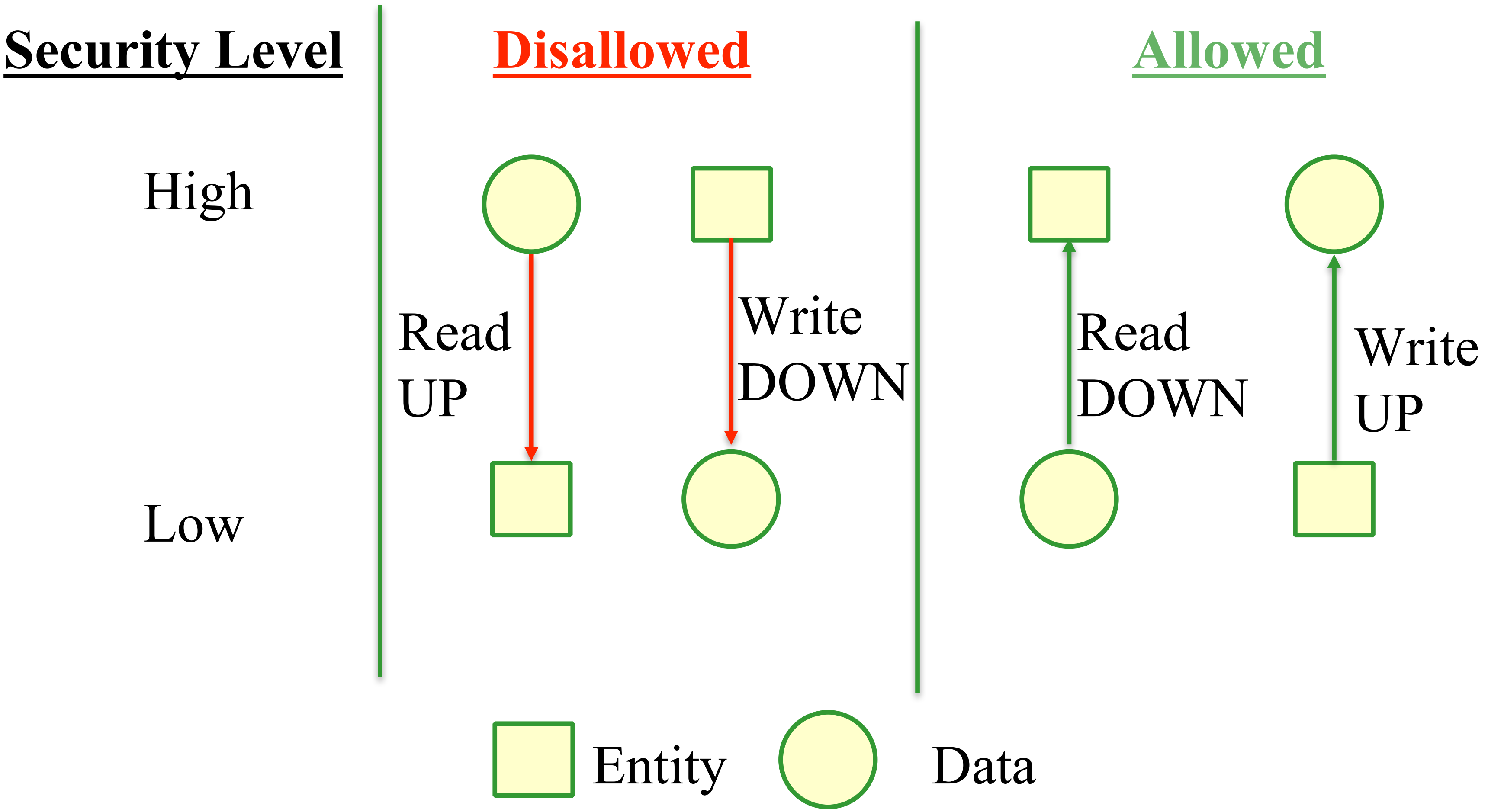


- A reference monitor, enforces access control/capabilities.
    - also called “security kernel”
- Its “trusted” because it MUST work correctly to ensure rest of the system is secure.
- Usually small, so it can be verified easily.
- Verification: either manual or automated. Hard either way.

Multi-level Security

- Also called Mandatory Access Control (MAC)
  - As opposed to Discretionary Access Control (DAC) in commodity systems.
- Data objects are classified at different levels
  - Top secret, secret, confidential, unclassified etc
  - Sometimes additional compartments: Crypto, Subs, NoForn
- People (and computers) have clearances
- Informally: To see a data object, you must have clearance for that level and for that compartment.

MLS: No Read UP, No Write DOWN



Security Level

Disallowed

Allowed

High

Low

Read UP

Write DOWN

Read DOWN

Write UP

□ Entity ○ Data

No Read UP: Lower classification level should not read data from higher-level.

No Write DOWN: Higher level should not write data to lower level.

MLS Pump

- In practice, to get things done, upper-level must at least acknowledge the receipt of data from lower level.
  - But acks create a backdoor for covert channels (surreptitious communication)

- An MLS Pump
  - Allows acks from higher to lower levels,
  - but at such a low data rate that covert channels become impractical.