Security

CS 256/456

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Security vs. Protection

- Protection
  - Mechanism to control (restrict/provide) access to resources by programs, processes, or users
  - A means to specify the control policy
- Security
  - Authentication of system users to ensure legitimacy
  - Prevent malicious or accidental unauthorized destruction or alteration of data, introduction of inconsistency

The Security Environment

Security goals:
- Authentication
- Data confidentiality
- Data integrity
- System availability

Threats of intruders or adversaries:
- Identity hijacking
- Exposing data
- Tampering with data
- Denial of service attacks

We focus on OS-related security issues

Login Spoofing

- Login spoofing
  - A program running by the attacker displays a login screen (like the real one)
  - After a legitimate user types in username and password, it records those, kills itself, and a real login screen is shown
  - The user thinks she typed in a wrong password and tries again, which works
- Countermeasure?
  - Start each login session with a non-user-catchable key combination "Ctrl-Alt-Delete"

Leaking Unnecessary Information

LOGIN: ken
PASSWORD: FooBar
SUCCESSFUL LOGIN

(a)

LOGIN: carol
INVALID LOGIN NAME
LOGIN:

(b)

LOGIN: carol
PASSWORD: Idunno
INVALID LOGIN
LOGIN:

(c)

User authentication:
(a) A successful login
(b) Login rejected after name entered
(c) Login rejected after name and password typed

Cryptography as a Security Tool

- Encryption – constrain set of possible receivers
  - Symmetric (secret key) vs. asymmetric (public key)
- Authentication – constrain set of possible senders
  - Hash or message digest (one-way function, secret key) vs. digital signature (public key)
- Key distribution

User Authentication

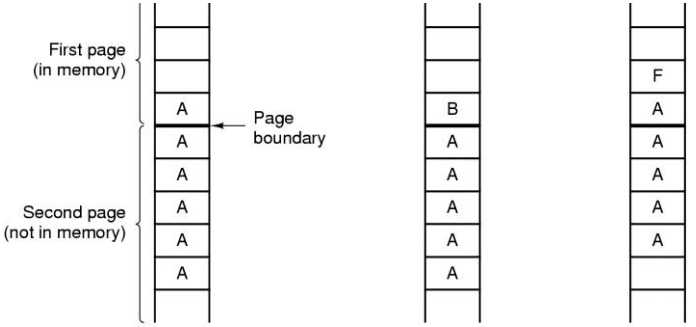
- UNIX user passwords are mapped using a one-way function "e()"; and then stored in a globally readable file "/etc/passwd"
  - Bobbie, e(Dog)
  - Tony, e(6%%TaeFF)
  - … …
- Attack:
  - used a precomputed common password list
- Countermeasure?
  - salt
  - Bobbie, 4238, e(Dog4238)
  - Tony, 2918, e(6%%TaeFF2918)

Improving Password Security

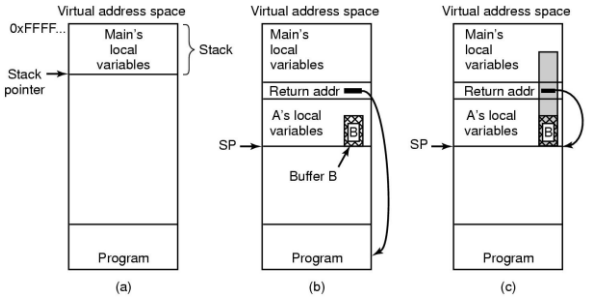
- One-time passwords
  - Challenge-response authentication
- Authentication using a physical object (e.g., ATM card)
- Authentication using biometrics

The TENEX Password Problem

- Files are accessed with passwords. At each access, the password is checked byte-by-byte and an error is returned as soon as a byte is mismatched.



Buffer Overflow



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

Countermeasures:

- boundary checks, non-executable stack/data segment, …

Information Leaking Through Side Channels

- Side channels
  - performance observations
  - program execution signals (e.g., cache usage, memory bus usage)
- Side channel attack on hyper-threading processors [Percival 2005]
  - OpenSSH running DES encryption on one hyper-thread
  - attacker running on the other hyper-thread
  - attacker and OpenSSH share hardware cache, so attacker can monitor its own cache miss pattern to infer the execution of OpenSSH (and its DES encryption key)

Denial-of-Service Attack

- Attacker attempts to consume all available resources at the host so no resources are left to serve legitimate users
  - attacks often come from network and they are distributed
- TCP flooding:
  - attackers establish many bogus TCP connections
  - host allocates buffer space for each connection
  - host memory being exhausted eventually
- Countermeasure?
  - discard flooded requests: throw out good and bad ones
  - trace back to source of floods
    - attack requests with spoofed identities
    - sources are most likely an innocent, compromised machines
  - delayed processing/resource allocation
    - stateless TCP [Shieh et al., NSDI2005]

Viruses and Worms

- Virus
  - fragment of code embedded in a legitimate program
  - Designed to self-replicate/infect other programs
- Worms
  - A process that uses the spawn mechanism to use system resources
  - Can reproduce themselves across networks to shut down systems

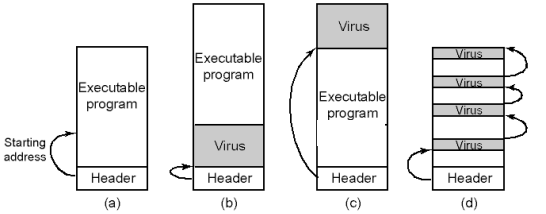
The Morris Worm [1988]

- Three methods of infection
  - rsh from trusted machine
  - Buffer overflow attack in finger
  - Bug in sendmail
- Once a machine was infected, used password cracking for further proliferation
- If a copy of the worm already existed, 1 in 7 exited
  - Downfall since it brought the Internet down

Virus

- Virus (fragment of code embedded in a legitimate program)
  - program can reproduce itself
    - e.g., when invoked, traverse the file system and attach it to randomly selected executables
  - additionally, do harm
    - steal your data
    - temporarily crash the system
    - permanently damage data or hardware
    - denial of service by using all available system resources
- "Good" virus
  - quickly spreading virus
  - difficult to detect
  - hard to get rid of

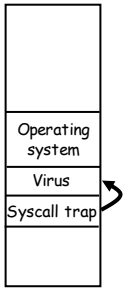
Infecting An Executable (Trojan Horses)



(a) An executable program
(b) With a virus at the front
(c) With the virus at the end
(d) With a virus spread over free space within program

Memory Resident Viruses

- Virus resides in memory; intercepting system calls
- Where in memory to put the virus?
  - known unused memory in OS kernel
  - make the OS believe the memory that virus uses is "legitimately used"
- How to load virus there in the first place?
  - boot sector viruses
  - device driver viruses



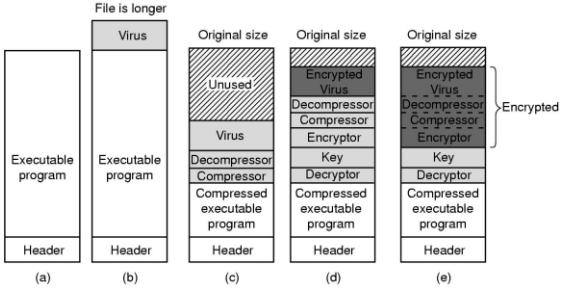
How Viruses Spread

- Try to infect programs on
  - networks: exploiting buffer overflow errors in network server daemons
  - floppy drives
- Attach to innocent looking email
  - when it runs, use mailing list to replicate

Antivirus Techniques

- Size checkers
  - keep a record on the size of disk files and scan them periodically for any size changes
  - apply on readonly executables.
- Signature scanning
  - maintain a database of patterns of common viruses
  - scan disk files for these patterns

Anti-Antivirus Techniques



(a) A program
(b) Infected program
(c) Compressed infected program
(d) Encrypted virus
(e) Compressed virus with encrypted compression code

More Antivirus Techniques

- Integrity checkers
  - similar to size checkers, but this time we compute a checksum for file and store them somewhere; we periodically check all files to see whether the checksum still matches
- Behavioral checkers (memory-resident anti-virus program)
  - intercept system calls and detect suspicious activities: overwriting executables, …

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