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

User Authentication

Cryptography as a Security Tool

Improving Password Security
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 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
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 read-only 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, ...

Disclaimer

- Parts of the lecture slides contain original work of Abraham Silberschatz, Peter B. Galvin, Greg Gagne, Andrew S. Tanenbaum, and Gary Nutt. The slides are intended for the sole purpose of instruction of operating systems at the University of Rochester. All copyrighted materials belong to their original owner(s).