

# Malicious Code

## CS 236

### Computer Security

March 14, 2007

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## Outline

- Introduction
- Viruses
- Trojan horses
- Trap doors
- Logic bombs
- Worms
- Examples

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## Introduction

Clever programmers can get software to do their dirty work for them

Programs have several advantages for these purposes

- Speed
- Mutability
- Anonymity

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## Where Does Malicious Code Come From?

- Most typically, it's willingly (but unwittingly) imported into the system
  - Electronic mail (most common today)
  - Downloaded executables
    - Often automatically from web pages
  - Sometimes shrinkwrapped software
- Sometimes it breaks in
- Sometimes an insider intentionally introduces it

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## Is Malicious Code Really a Problem?

- Considering viruses only, by 1994 there were over 1,000,000 annual infections
  - One survey shows 10-fold increase in viruses since 1996
- In November 2003, 1 email in 93 scanned by particular survey contained a virus
- 2006 FBI report shows 65% of survey respondents had malicious code incidents
  - And viruses caused the most economic damage of all attacks to respondents

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## More Alarming Statistics

- In 1992, there were around 2000 unique viruses known
- Today, Symantec's databases of viruses includes 73,000+ entries
- Kaspersky Labs added 80,000 virus signatures to its database in 2006
- The numbers continue to grow

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## But Don't Get too Alarmed

- Most viruses are never found “in the wild”
- Most viruses die out quickly
- The Wild List<sup>1</sup> shows 792 active viruses worldwide
  - With another 2382 or so with only a single incident reported
  - Many on both lists are slight variants on a particular virus

<sup>1</sup>www.wildlist.org

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## How Much Do Viruses Cost?

- Group called mi2g estimated that MyDoom worm cost \$38.5 billion worldwide
  - Cleanup costs, lost productivity, etc.
- Many folks believe this (and other estimates) are bogus publicity stunts
  - Methodology lacking for real estimates
- Even if it's two or three orders of magnitude off, that's serious money

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## But Do I Really Have to Worry About Viruses?

- “After all, I run Linux/Mac OS/Solaris/BSD”
- “Aren't all viruses for Windows?”
- Mostly true in practice
  - Definitely not true in theory
  - First MacOSX virus discovered one month ago
    - OSX/Leap-A
- Anyone, at any time, can write and release a virus that can clobber your machine, regardless of what OS you run

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## Viruses

- “Self-replicating programs containing code that explicitly copies itself and that can ‘infect’ other programs by modifying them or their environment”
- Typically attached to some other program
  - When that program runs, the virus becomes active and infects others
- Not all malicious codes are viruses

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## How Do Viruses Work?

- When a program is run, it typically has the full privileges of its running user
- Including write privileges for some other programs
- A virus can use those privileges to replace those programs with infected versions

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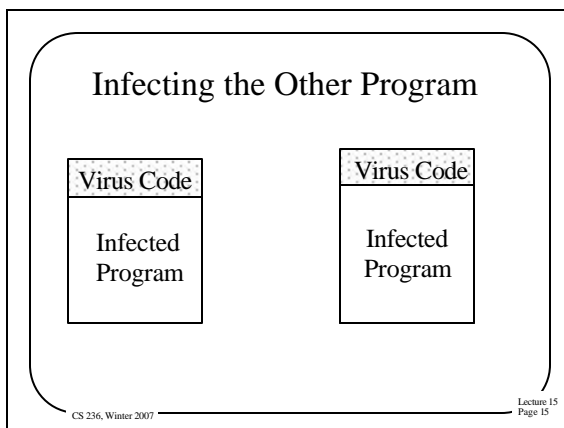
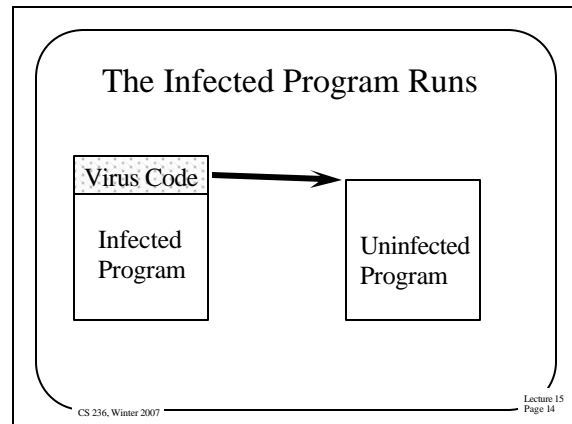
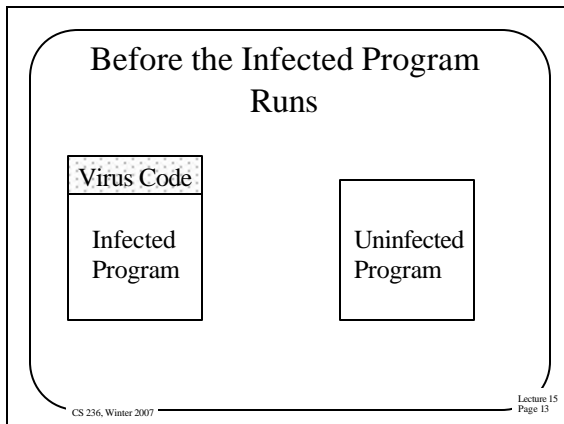
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## Typical Virus Actions

- 1). Find uninfected writable programs
- 2). Modify those programs
- 3). Perform normal actions of infected program
- 4). Do whatever other damage is desired

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- ### Macro and Attachment Viruses
- Modern data files often contain executables
    - Macros
    - Email attachments
    - Ability to run arbitrary executables from many applications, embedded in data
  - Easily the most popular form of new viruses
    - Requires less sophistication to get right
  - Most widespread viruses today use attachments
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- ### Virus Toolkits
- Helpful hackers have written toolkits that make it easy to create viruses
  - A typical smart high school student can easily create a virus given a toolkit
  - Generally easy to detect viruses generated by toolkits
    - But we may see “smarter” toolkits
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- ### How To Find Viruses
- Basic precautions
  - Looking for changes in file sizes
  - Scan for signatures of viruses
  - TSR monitoring
  - Multi-level generic detection
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## Precautions to Avoid Viruses

- Don't import untrusted programs
  - But who can you trust?
- Viruses have been found in commercial shrink-wrap software
- The hackers who released Back Orifice were embarrassed to find a virus on their CD release
- Trusting someone means not just trusting their honesty, but also their caution

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## Other Precautionary Measures

- Scan incoming programs for viruses
  - Some viruses are designed to hide
- Limit the targets viruses can reach
- Monitor updates to executables carefully
  - Requires a broad definition of “executable”

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## Containment

- Run suspect programs in an encapsulated environment
  - Limiting their forms of access to prevent virus spread
- Requires versatile security model and strong protection guarantees

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## Viruses and File Sizes

- Typically, a virus tries to hide
- So it doesn't disable the infected program
- Instead, extra code is added
- But if it's added naively, the size of the file grows
- Virus detectors can look for this growth

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## Problems With Size Checking for Virus Detection

- Requires keeping carefully protected records of valid file sizes
- Won't work for files whose sizes typically change
  - E.g., Word files with possibly infected macros
- Clever viruses find ways around it
  - E.g., cavity viruses that fit themselves into “holes” in programs

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## Signature Scanning

- If a virus lives in code, it must leave some traces
- In early and unsophisticated viruses, these traces were essentially characteristic code patterns
- Find the virus by looking for the signature

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## How To Scan For Signatures

- Create a database of known virus signatures
- Read every file in the system and look for matches in its contents
- Also check every newly imported file
- Also scan boot sectors and other interesting places

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## Weaknesses of Scanning for Signatures

- What if the virus changes its signature?
- What if the virus takes active measures to prevent you from finding the signature?
- You can only scan for known virus signatures

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## Polymorphic Viruses

- A polymorphic virus produces varying but operational copies of itself
- Essentially avoiding having a signature
- Sometimes only a few possibilities
  - E.g., Whale virus has 32 forms
- But sometimes a lot
  - Recent Storm worm had more than 54,000 formats

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## Stealth Viruses

- A virus that tries actively to hide all signs of its presence
- Typically a resident virus
- For example, it traps calls to read infected files
  - And disinfects them before returning the bytes
  - E.g., the Brain virus

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## Combating Stealth Viruses

- Stealth viruses can hide what's in the files
- But may be unable to hide that they're in memory
- Also, if you reboot carefully from a clean source, the stealth virus can't get a foothold

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## TSR Monitoring

- TSR - Terminate-and-Stay-Resident
  - Essentially a daemon process
- A virus detector that runs in the background
- Automatically scans (and possibly takes other actions) continuously

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## Other TSR Monitor Actions

- Signature scanning can't find new viruses
- Watching system activity for suspicious actions possibly can
- A TSR monitor can run intrusion detection systems or other code to catch new viruses

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## Multi-Level Generic Detection

- Virus detection software that is specialized to handle both known and new viruses
- Using a combination of methods
- Both continuously and on command

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## Generic Detection Tools

- Checksum comparison
- Intelligent checksum analysis
  - For files that might legitimately change
- Intrusion detection methods
  - More sophisticated than intelligent checksum analysis
  - Possibly very high overhead

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## Preventing Virus Infections

- Run a virus detection program
  - 97% of all FBI reporting companies do
  - And many still get clobbered
- Keep its signature database up to date
  - Modern virus scanners do this by default
- Disable program features that run executables without users asking
  - Quicktime recently had this problem
- Make sure users are very careful about what they run

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## How To Deal With Virus Infections

- Reboot from a clean, write-protected floppy or from a clean CD ROM
  - Important to ensure that the medium really is clean
  - Necessary, but not sufficient
- If backups are available and clean, replace infected files with clean backup copies
  - Another good reason to keep backups
- Recent proof-of-concept showed infection of firmware in peripherals . . .

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## Disinfecting Programs

- Some virus utilities try to disinfect infected programs
  - Allowing you to avoid going to backup
- Potentially hazardous, since they may get it wrong
  - Some viruses destroy information needed to restore programs properly

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- Seemingly harmless
- When activated, the Greeks are slaughtered



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## Basic Trojan Horses

- A program you pick up somewhere that is supposed to do something useful
- And perhaps it does
  - But it also does something less benign
- Games are common locations for Trojan Horses
- Downloaded applets are also popular locations
- Frequently found in email attachments

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## Trojan Horse Login Programs

- Probably the original Trojan horse
- Spoof the login or authentication screen of a machine or service
- Capture attempts to access that service
- Then read the user IDs and the passwords

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## Trapdoors

- A secret entry point into an otherwise legitimate program
- Typically inserted by the writer of the program
- Most often found in login programs or programs that use the network
- But also found in system utilities

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## Logic Bombs

- Like trapdoors, typically in a legitimate program
- A piece of code that, under certain conditions, “explodes”
- Also like trapdoors, typically inserted by program authors
- Often used by disgruntled employees to get revenge
  - In 2002, Paine Webber employee caused \$3 million in damage to the company this way

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## Worms

- Programs that seek to move from system to system
  - Making use of various vulnerabilities
- Other performs other malicious behavior
- The Internet worm used to be the most famous example
  - Blaster, Slammer, Witty are other worms
- Can spread very, very rapidly

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### The Internet Worm

- Created by a graduate student at Cornell in 1988
- Released (perhaps accidentally) on the Internet Nov. 2, 1988
- Spread rapidly throughout the network
  - 6000 machines infected

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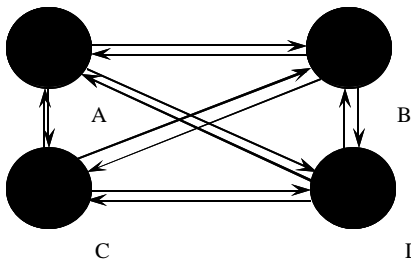
### The Effects of the Worm

- Essentially, affected systems ended up with large and increasing numbers of processes devoted to the worm
- Eventually all processes in the process table used up
- Rebooting didn't help, since other infected sites would immediately re-infect the rebooted machine

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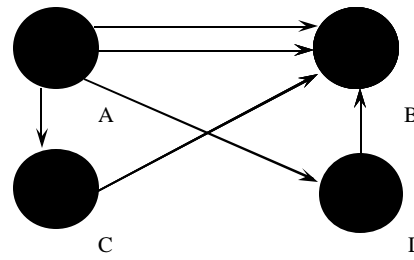
### A Visual Picture of the Infection



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### And What If Someone Reboots?



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### How Did the Internet Worm Work?

- The worm attacked network security vulnerabilities in one class of OS
  - Unix 4 BSD variants
- These vulnerabilities allowed improper execution of remote processes
- Which allowed the worm to get a foothold on a system

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### The Worm's Actions on Infecting a System

- Find an uninfected system and infect that one
- Using the same vulnerabilities
- Here's where it ran into trouble:
  - It re-infected already infected systems
  - Each infection was a new process

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## The Worm's Breaking Methods

- `rsh` - if the remote host is on the trusted hosts lists, simply `rsh`'ing could work
- `fingerd` - exploit a bug in the `fingerd` program to overwrite a buffer in a useful way
- `sendmail` - invoke a debugging option in `sendmail` and issue commands

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## What Didn't the Worm Do?

- It didn't attempt to intentionally damage a system
- It didn't attempt to divulge sensitive information (e.g., passwords)
- It didn't try hard to become root
  - And didn't exploit root access if it got superuser access

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## Stopping the Worm

- In essence, required rebooting all infected systems
  - And not bringing them back on the network until the worm was cleared out
  - Though some sites stayed connected
- Also, the flaws it exploited had to be patched

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## Effects of the Worm

- Around 6000 machines were infected and required substantial disinfecting activities
- Many, many more machines were brought down or pulled off the net
  - Due to uncertainty about scope and effects of the worm

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## How Much Did the Worm Cost?

- Hard to quantify
  - Typical for costs of computer attacks
- Estimates as high as \$98 million
  - Probably overstated, but certainly millions in down time, sysadmin and security expert time, and costs of disconnections

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## What Did the Worm Teach Us?

- The existence of some particular vulnerabilities
- The costs of interconnection
- The dangers of being trusting
- Denial of service is easy
- Security of hosts is key
- Logging is important
- We obviously didn't learn enough

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## MyDoom

- Virus, worm, trapdoor, or Trojan Horse?
- Some of each, really
- Very wide spread
  - Proportionally smaller than Internet worm, but bigger total numbers
- Arrived in email posing in various guises

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## How MyDoom Works

- Usually arrives in email
- Contains an attachment with an executable (Trojan Horse)
- When attachment is opened, it alters registry entries and creates a file in a Kazaa directory (virus)
- Also tries to spread via email (worm)
- Opens a port on your machine (trapdoor)
- Also launches DDoS attack (in some variants)

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## Why Did MyDoom “Succeed”?

- Not especially sophisticated
- Didn't introduce any new methods
- Didn't exploit any new vulnerabilities
- People still open “interesting” attachments
- Very aggressive
  - Went out to everyone
  - Can also spread via file sharing networks

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## Santy Worm

- Exploited a vulnerability in phpBB software (2004)
- Cleverly used Google queries to automatically find systems to infect
- Infected 30,000-40,000
- Demonstrated innovation in finding infectable sites

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## Code Red

- A malicious worm that attacked Windows machines
- Basically used vulnerability in Microsoft IIS servers
- Became very widely spread and caused a lot of trouble

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## How Code Red Worked

- Attempted to connect to TCP port 80 (a web server port) on randomly chosen host
- If successful, sent HTTP GET request designed to cause a buffer overflow
- If successful, defaced all web pages requested from web server

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## More Code Red Actions

- Periodically, infected hosts tried to find other machines to compromise
- Triggered a DDoS attack on a fixed IP address at a particular time
- Actions repeated monthly
- Possible for Code Red to infect a machine multiple times simultaneously

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## Code Red Stupidity

- Bad method used to choose another random host
  - Same random number generator seed to create list of hosts to probe
- DDoS attack on a particular fixed IP address
  - Merely changing the target's IP address made the attack ineffective

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## Code Red II

- Used smarter random selection of targets
- Didn't try to reinfect infected machines
- Adds a Trojan Horse version of Internet Explorer to machine
  - Unless other patches in place, will reinfect machine after reboot on login
- Also, left a backdoor on some machines
- Doesn't deface web pages or launch DDoS

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## A Major Difference

- Code Red periodically turns on and tries to infect again
- Code Red II worked intensively for 24-48 hours after infection
  - Then stopped
- Eventually, Code Red II infected all infectable machines
  - Some are still infected, but they've stopped trying to spread it

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## Impact of Code Red and Code Red II

- Code Red infected over 250,000 machines
- In combination, estimated infections of over 750,000 machines
- Code Red II is essentially dead
  - Except for periodic reintroductions of it
- But Code Red is still out there

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## A Bad Secondary Effect of Code Red

- Generates lots of network traffic
- U. of Michigan study found 40 billion attempts to infect 8 fake "machines" per month
  - Each attempt was a packet
  - So that's ~1 billion packets per day just for those eight addresses
- "The new Internet locust!"

<sup>1</sup> Farnham Jahanian, talk at DARPA FTN meeting, Jan 18, 2002

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## Worm, Virus, or Trojan Horse?

- Terms often used interchangeably
- Trojan horse formally refers to a program containing evil code
  - Only run when user executes it
  - Effect isn't necessarily infection
- Viruses seek to infect other programs
- Worms seek to move from machine to machine

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## Virus Hoaxes

- Virus hoaxes are at least as common as real viruses
- Generally arrive in email
- Usually demand instant action, on pain of something really terrible
- It's wise to check with a reliable source before taking action on such email messages
  - Or forwarding them

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