Malicious Software
Computer Security
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Outline

- Introduction
- Viruses
- Trojan horses
- Trap doors
- Logic bombs
- Worms
- Botnets
- Spyware
- Malware components

Introduction

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

Programs have several advantages for these purposes

- Speed
- Mutability
- Anonymity

speed - they can do things a while logt mm
mutability - code doesn't need to be traced oback to the person, anonymous as well

Where Does Malicious Code Come From?

- Most commonly, it's willingly (but unwittingly) imported into the system
  - Electronic mail
  - Downloaded executables
    - Often automatically from web pages
  - Sometimes shrink-wrapped software
- Sometimes it breaks in
- Sometimes an insider intentionally introduces it someone convinces you to download the software

Magnitude of the 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
- 2008 CSI report shows 50% of survey respondents had virus incidents
  - Plus 20% with bot incidents
- 2009 Trend Micro study shows 50% of infected machines still infected 300 days later

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

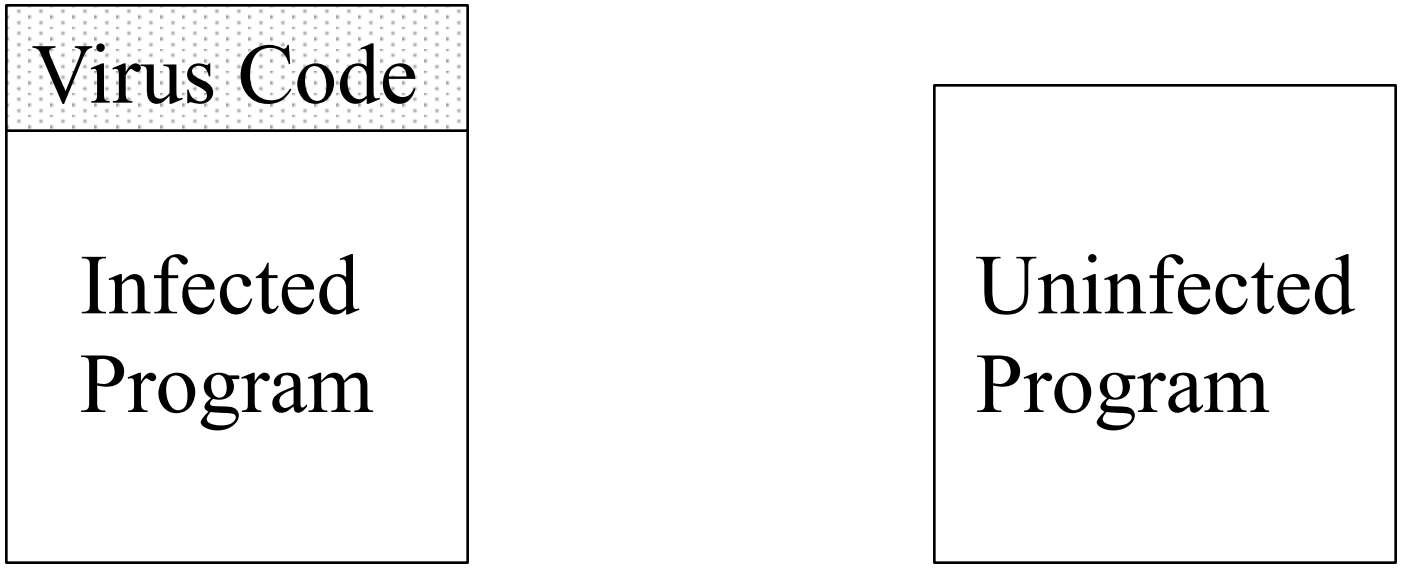
program that says "I've got malicious code in me, I am going ot cop malicious cold top p

How Do Viruses Work?

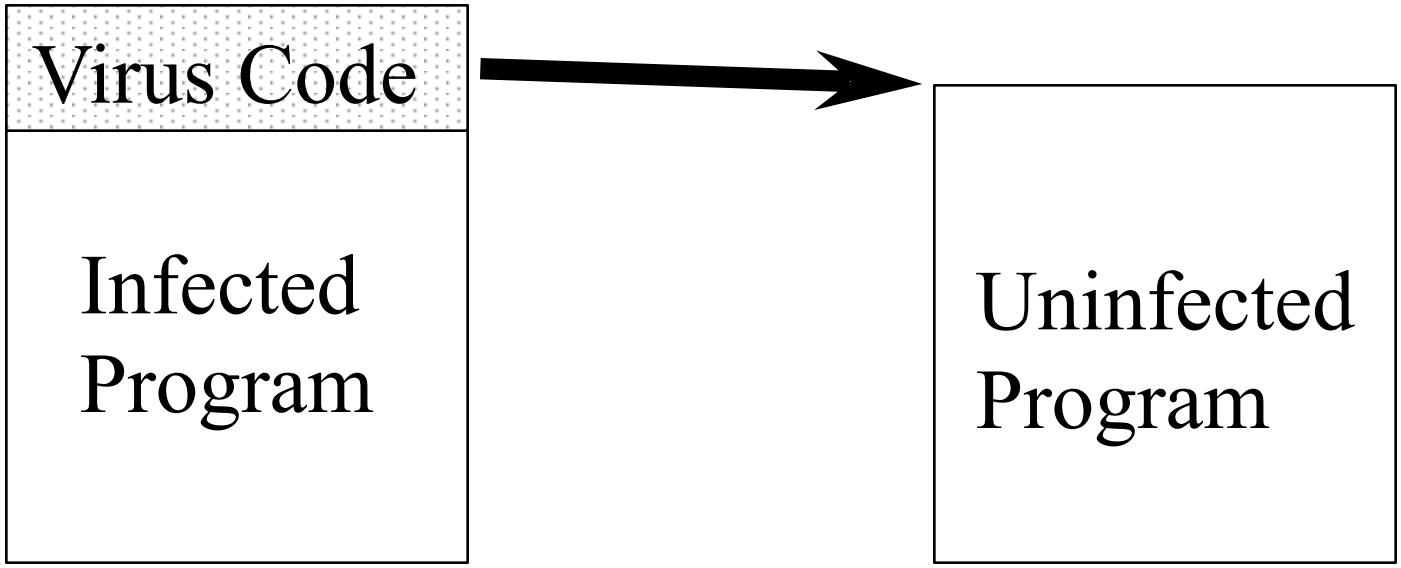
- When a program is run, it typically has the full privileges of its running user
- Including write privileges for some other programs
- A virus can use those privileges to replace those programs with infected versions

change up an executable due to write privilege

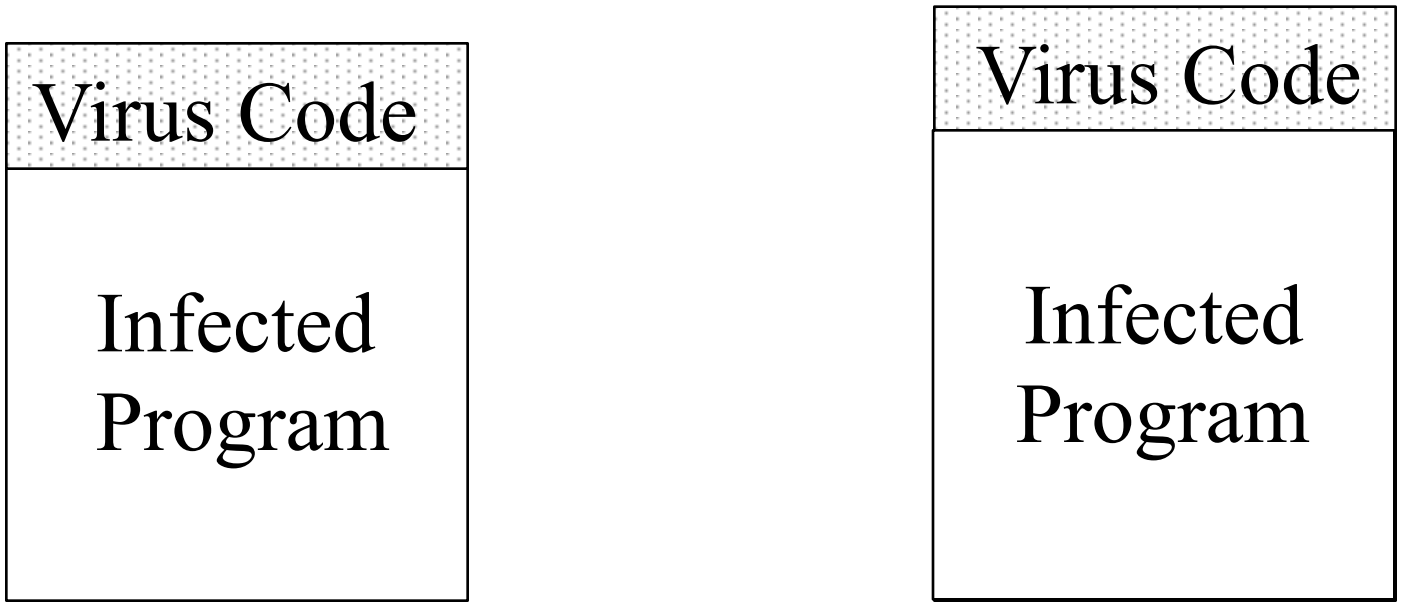
Before the Infected Program Runs



The Infected Program Runs



Infecting the Other Program



Macro and Attachment Viruses

- Modern data files often contain executables
  - Macros
  - Email attachments email attacheen t
- Many formats allow embedded commands to download of arbitrary executables
- Popular form of viruses
  - Requires less sophistication to get right

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 toolkits are getting smarter

How To Find Viruses

- Basic precautions
- Looking for changes in file sizes
- Scan for signatures of viruses
- Multi-level generic detection

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

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"

Containment

a program can execute only when its ldd

- Run suspect programs in an encapsulated environment
  - Limiting their forms of access to prevent virus spread
- Requires versatile security model and strong protection guarantees
  - No use to run in tightly confined mode if user allows it to get out

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 look for this growth
- Won't work for files whose sizes typically change
- Clever viruses find ways around it
  - E.g., cavity viruses that fit themselves into "holes" in programs

Signature Scanning

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

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
- Can use same approach for other kinds of malware

other kinds of malware - they also have

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

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
  - Storm worm had more than 54,000 forms

even time toi pkaklllied

Polymorphism By Hand

- Malware writers have become professional and security-aware
- They know when their malware has been identified
  - And they know the signature used
  - Smart ones subscribe to all major anti-virus programs
- They change the malware to remove that signature and re-release it

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

residence voirp

Combating Stealth Viruses

- Stealth viruses can hide what's in the files
- But may be unable to hide that they're in memory
- Careful reboot from clean source won't allow stealth virus to get a foothold
- Concerns that malware can hide in other places, like peripheral memory

Other Detection Methods

- Checksum comparison
- Intelligent checksum analysis
  - For files that might legitimately change
- Intrusion detection methods
  - E.g., look for attack invariants instead of signatures
- Identify and handle "clusters" of similar malware

certain files like word docs are no suppos

Preventing Virus Infections

- Run a virus detection program
  - Almost all serious organizations do this
  - 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 had this problem a few years ago
- Make sure users are careful about what they run
- Also make sure users are careful about what they attach to computers

How To Deal With Virus Infections

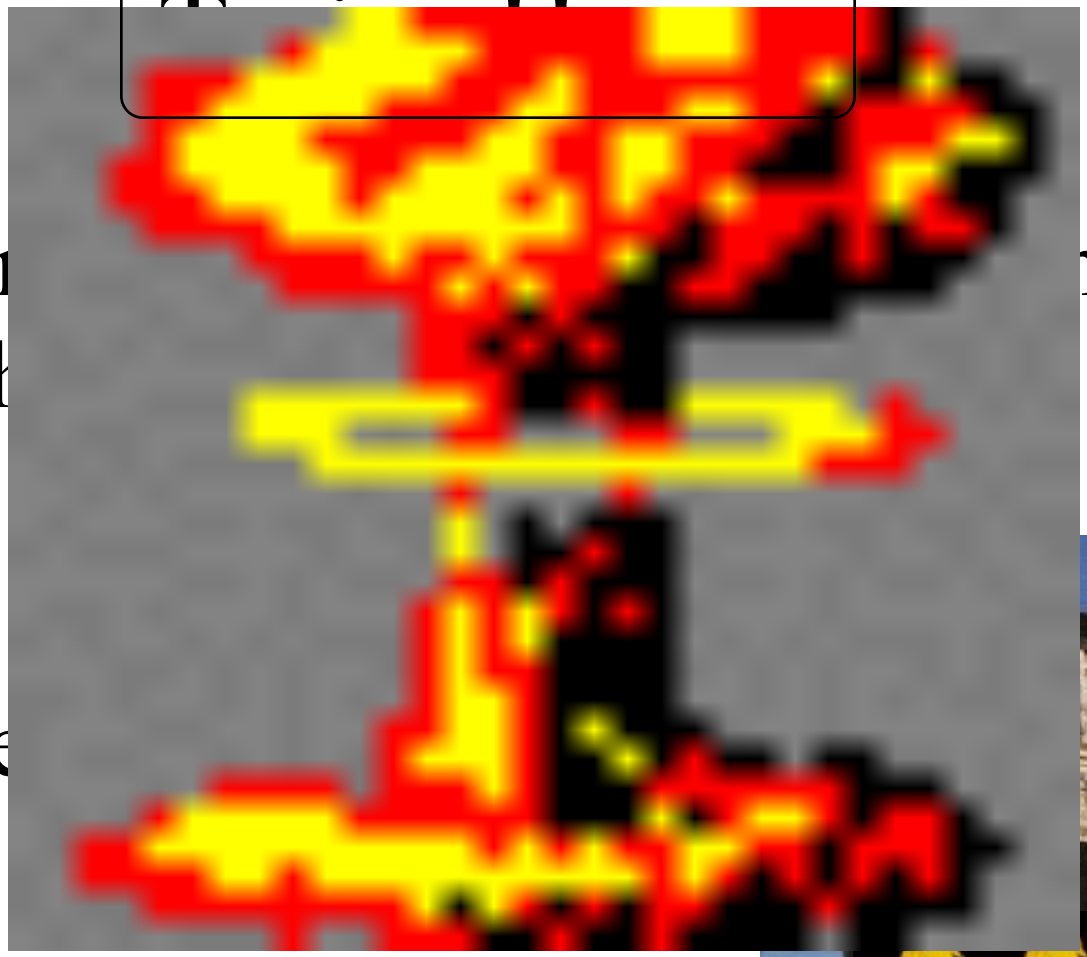
- Reboot from a clean, write-protected medium
  - Vital that the medium really is clean
  - Necessary, but not sufficient
- If backups are available and clean, replace infected files with clean backup copies
  - Another good reason to keep backups
- Proof-of-concept code showed infection of firmware in peripherals . . .

Even if you rebooot from clean OS, you stil need to make sure your OS is nor corrupted

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

- Seemi ntains code th
  - When Greeks slaughte



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 a common location host program
- Downloaded applets are also popular
- Frequently found in email attachments
- Bogus security products also popular
- Flash drives are a hardware vector

Recent Trends in Trojan Horses

- GozNym Trojan stealing money from infected customers' bank accounts
- AceDeceiver Trojan targets iOS devices
- USBThief Trojan targets non-Internet connected devices
- Marcher Trojan pretends to be an Adobe Flash installer
- Triada Trojan can alter SMS messages sent from Android devices (e.g., to redirect payments)
- Xbot Trojan steals bank account info

Trapdoors

- Also known as back doors
- 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

Trapdoors and Other Malware

- Malware that has taken over a machine often inserts a trapdoor
- To allow the attacker to get back in
  - If the normal entry point is closed
- Infected machine should be handled carefully to remove such trapdoors
  - Otherwise, attacker comes right back

Logic Bombs

- Like trapdoors, typically in a legitimate program
- Code that "explodes" under certain conditions
- Often inserted by program authors
- Previously used by primarily by disgruntled employees to get revenge
  - Former TSA employee got two years in prison for planting one in 2009
- Beginning to be used by nation state cyber attacks
  - South Korean banks and media companies hit with major logic bomb in March 2013

Extortionware and Ransomware

- Attacker breaks in and does something to system
  - Demands money to undo it
  - "Break-in" often via social engineering
    - E.g., claiming it will cure another infection
- Encrypting vital data is common
  - US hospitals a popular recent target
  - Some incidents also encrypted backups
- Unlike logic bombs, not timed or triggered

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

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

How Did the Internet Worm Work?

- The worm attacked vulnerabilities in Unix 4 BSD variants
- These vulnerabilities allowed improper execution of remote processes
- Which allowed the worm to get a foothold on a system
  - And then to spread

The Worm's Actions

- Find an uninfected system and infect that one
- Here's where it ran into trouble:
  - It re-infected already infected systems
  - Each infection was a new process
  - Caused systems to wedge
- Did not take intentional malicious actions against infected nodes

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
- Why didn't firewalls stop it?
  - They weren't invented yet

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

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

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

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

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

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

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
- Didn't turn on periodically

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

Stuxnet

- Scary worm that popped up in 2010
- Targeted at SCADA systems
  - Particularly, Iranian nuclear enrichment facilities
- Altered industrial processes
- Very specifically targeted

we don't know how to get in there, if we build dsusze

Where Did Stuxnet Come From?

- Stuxnet was very sophisticated
  - Speculated to be from unfriendly nation state(s)
  - New York Times claims White House officials confirmed it (no official confirmation, though)
- Research suggests SCADA attacks do not need much sophistication, though
  - Non-expert NSS Labs researcher easily broke into Siemans systems
- Duqu worm might be Stuxnet descendent
  - Appears to be stealing certificates

Worm, Virus, or Trojan Horse?

- Terms often used interchangeably
- Trojan horse formally refers to a seemingly good program that contains 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
- Don't obsess about classifications

Botnets

- A collection of compromised machines
- Under control of a single person
- Organized using distributed system techniques
- Used to perform various forms of attacks
  - Usually those requiring lots of power

What Are Botnets Used For?

- Spam (90% of all email is spam)
- Distributed denial of service attacks
- Hosting of pirated content
- Hosting of phishing sites
- Harvesting of valuable data
  - From the infected machines
- Much of their time spent on spreading

Botnet Software

- Each bot runs some special software
  - Often built from a toolkit
- Used to control that machine
- Generally allows downloading of new attack code
  - And upgrades of control software
- Incorporates some communication method
  - To deliver commands to the bots

Botnet Communications

- Originally very unsophisticated
  - All bots connected to an IRC channel
  - Commands issued into the channel
- Most sophisticated ones use peer technologies
  - Similar to some file sharing systems
  - Peers, superpeers, resiliency mechanisms
  - Conficker's botnet uses peer techniques
- Stronger botnet security becoming common
  - Passwords and encryption of traffic

Botnet Spreading

- Originally via worms and direct break-in attempts
- Then through phishing and Trojan Horses
  - Increasing trend to rely on user mistakes
- Conficker uses multiple vectors
  - Buffer overflow, through peer networks, password guessing
- Regardless of details, almost always automated

Characterizing Botnets

- Most commonly based on size
  - Estimates for Conficker over 5 million
  - Zeus-based botnets got 3.6 million machines in US alone
  - Trend Micro estimates 100 million machines are members of botnets
- Controlling software also important
- Other characteristics less examined

Why Are Botnets Hard to Handle?

- Scale
- Anonymity
- Legal and international issues
- Fundamentally, if a node is known to be a bot, what then?
  - How are we to handle huge numbers of infected nodes?

Approaches to Handling Botnets

- Clean up the nodes
  - Can't force people to do it
- Interfere with botnet operations
  - Difficult and possibly illegal
  - But some recent successes
- Shun bot nodes
  - But much of their activity is legitimate
  - And no good techniques for doing so

Spyware

- Software installed on a computer that is meant to gather information
- On activities of computer's owner
- Reported back to owner of spyware
- Probably violating privacy of the machine's owner
- Stealthy behavior critical for spyware
- Usually designed to be hard to remove

What Is Done With Spyware?

- Gathering of sensitive data
  - Passwords, credit card numbers, etc.
- Observations of normal user activities
  - Allowing targeted advertising
  - And possibly more nefarious activities

Where Does Spyware Come From?

- Usually installed by computer owner
  - Generally unintentionally
  - Certainly without knowledge of the full impact
  - Via vulnerability or deception
- Can be part of payload of worms
  - Or installed on botnet nodes

Malware Components

- Malware is becoming sufficiently sophisticated that it has generic components
- Two examples:
  - Droppers
  - Rootkits

Droppers

- Very simple piece of code
- Runs on new victim's machine
- Fetches more complex piece of malware from somewhere else
- Can fetch many different payloads
- Small, simple, hard to detect

Rootkits

- Software designed to maintain illicit access to a computer
- Installed after attacker has gained very privileged access on the system
- Goal is to ensure continued privileged access
  - By hiding presence of malware
  - By defending against removal

Use of Rootkits

- Often installed by worms or viruses
  - E.g., the Pandex botnet
  - But Sony installed rootkits on people's machines via music CDs
- Generally replaces system components with compromised versions
  - OS components
  - Libraries
  - Drivers

Ongoing Rootkit Behavior

- Generally offer trapdoors to their owners
- Usually try hard to conceal themselves
  - And their other nefarious activities
  - Conceal files, registry entries, network connections, etc.
- Also try to make it hard to remove them
- Sometimes removes others' rootkits
  - Another trick of the Pandex botnet