Software Security

Overflows, overruns and (some) confusions

Today's Lecture:

- Malware Taxonomy
- Characters and Numbers
- Canonical Representations
- Memory Management
- Race Conditions
- Defences

Introduction:

Bad software is everywhere:

- NASA mars Lander ($165 million) – Conversion of units
- Ariane-5 rocket ($500 million) – Integer overflow
- National Cancer Institute (8 patients die) – Drug Dosage Miscalculation

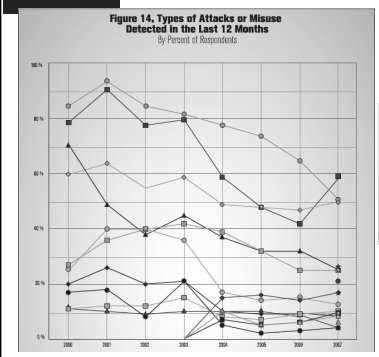
- Search for "*software horror stories*" or "*worst software bugs*" in Google

Why is that?:

Complexity:

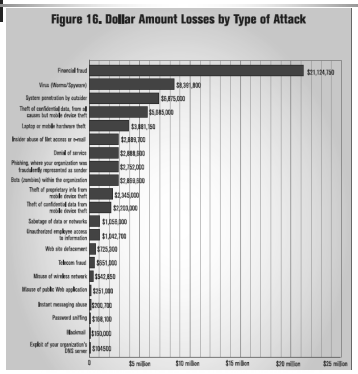
System	Lines of Code:
Netscape	– 17,000,000
Windows	– 40,000,000
Space Shuttle	– 10,000,000
Boeing 777	– 7,000,000

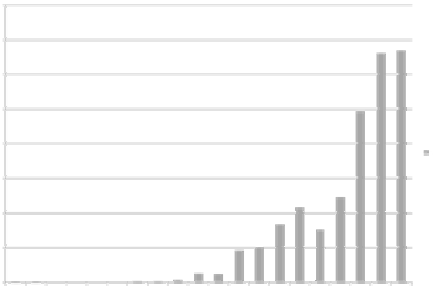
Estimated 5 bugs/1000 loc



TYPE OF ATTACK	2007	TYPE OF ATTACK	2007
Insider abuse of Net access	59%	Financial fraud	12%
Virus	52%	Password sniffing**	10%
Laptop / mobile device theft	50%	Web site defacement*	10%
Phishing where your organization was fraudulently represented as sender**	28%	Misuse of public Web application*	9%
Instant messaging misuse**	25%	Theft of proprietary information (intellectual property)	9%
Denial of service	25%	Exploit of the organization's DNS server**	5%
Unauthorized access to information	25%	Telecom fraud	5%
Bots within the organization**	21%	Sabotage	4%
Theft of customer / employee data**	17%		
Misuse of wireless network*	17%		
System penetration	13%		

*Added in 2006 survey
**Added in 2007 survey





Malware Taxonomy:

- Malware

  Software that has malicious purpose

Types of malware: Viruses
Worms
Trojan Horse
Backdoors
Mobile Code
Adware

Malware Taxonomy:

- Viruses
  - self-replicating program with malicious intent
  - attaches themselves to executables
  - usually must be executed to propagate

First virus developed in 1982, called *Elk Cloner* for Apple DOS.

First PC Virus called (c)Brain in 1986

Malware Taxonomy:

- Worms
  - malicious programs that use the internet to spread
  - also self-replicates
  - does not need human intervention to duplicate
  - can spread uncontrollably in a very brief period of time
  - usually uses a software exploit or via e-mail

Examples: Morris Worm, CodeRed, SQL Slammer

Malware Taxonomy:

- Trojan Horses
  - seemingly innocent application that contains malicious code
  - usually useful programs that have unnoticeable but harmful side effects

Example: pretending a file is innocent, possible due to Windows hiding extensions.

Malware Taxonomy:

- Backdoors
  - Malware that creates covert access for attacker
  - Used for connecting, spying, collecting data etc…
  - Can be embedded in normal programs
  - Sometimes planted by rogue software developers

Example: Windows encryption software, BT HomeHub

Malware Taxonomy:

- Mobile Code
  - A class of benign programs that are mobile, executed on a large number of systems, not explicitly installed by end-user
  - Usually for purpose of interactive content

  e.g. ActiveX, Java applets
  - Can be misused by rogue developers
  - Exploit user's inability to distinguish between good and rogue sites

Malware Taxonomy:

- Adware
  - Program forcing unsolicited advertising on end users
  - Very popular
  - Usually bundled with free software, funded by the advertising
  - Gathers statistics about internet usage
  - Information used to display targeted information

Malware Taxonomy:

- Sticky Software
  - Software implementing methods that prevent its deletion (e.g. no uninstall program)

Future of Malware:
  - Bios, Firmware, Sub-OS, etc…
  - Polymorphic and Metamorphic Viruses

Characters and Numbers:

- Many software flaws due to broken abstractions

Characters:
  - Different ways of representing characters exist
  - If input validation does not exist or not complete - > trouble!

Example: *MS IIS vulnerability*

  {IPaddress}/scripts/..%c0%af../winnt/system32/

  %c0%af in UTF-8 encoding = /

  thus -> C:\winnt\system32\

Characters and Numbers:

Integer overflows:
  - when arithmetic operation attempts to create an integer larger than can be represented in available memory

e.g. Ariane-5:
  - 64 bit floating point number converted to 16-bit signed integer
  - Number larger than 32,767 thus conversion failed
  - Rocket exploded

Characters and Numbers:

Array overflows:
  - Computing array indices uses integer arithmetic
  - If no check exists, memory outside of allocated space gets accessed.
  - upper and lower bounds of arrays should be checked
  - some languages deal with this issue better than others (e.g. C vs. Java)

Canonical Representations:

- Alternative names for various parts of systems

e.g. DNS, relative file paths

- Translation of names to their correct representations can be done in more than one way
- If not kept in mind, problems can arise

e.g. case sensitivity of files pwd vs. Pwd

Lesson – never trust your inputs

Memory Management:

- In C and C++ programmer performs memory management
- Flexible, fast but dangerous
  - Buffer Overruns
  - Stack Overruns
  - Heap Overruns
  - Type Confusion

Memory Management:

Buffer overrun:

- When program is executed, memory sections (buffers) are allocated to variables
- If such value exceeds size of buffer, an overflow occurs
- adjacent memory locations are overwritten

Memory Management:

Stack overrun:

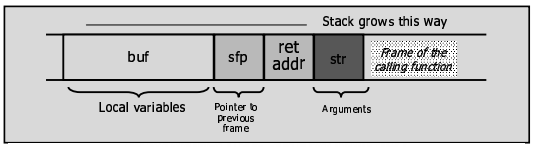
- Suppose Web server contains this function

```
void func(char *str) {
    char buf[126];
    strcpy(buf,str);
}
```

Allocate local buffer (126 bytes reserved on stack)

Copy argument into local buffer

- When this function is invoked, a new frame with local variables is pushed onto the stack



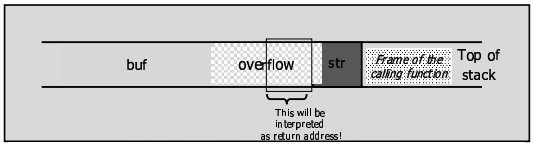
Memory Management:

- In case str is overstuffed
- Memory pointed to by str is copied onto stack…

```
void func(char *str) {
    char buf[126];
    strcpy(buf,str);
}
```

strcpy does NOT check whether the string at *str contains fewer than 126 characters

- If a string longer than 126 bytes is copied into buffer, it will overwrite adjacent stack locations



Memory Management:

Heap overrun:

- Occurs on the heap
- Heap – memory area dynamically allocated by application
- contains for example pointers to (temporary) files and functions
- attacker redirects pointer from tmp file to target file using a buffer overrun, e.g. to a password file and overwrites it with his own data

Memory Management:

Type Confusion:

- manipulation of pointer structure so that two pointers, one with a wrong class tag, point to the same objects
- thus object can be manipulated by parties that have access to the 'wrong' type.

- Java and .NET attempt to prevent this

Race Conditions:

- Occurs when multiple computations access shared data in a way that their results depend on the sequence of access.

- Known in security literature as TOCTTOU
- Traditional issues of concurrency

Defences:

- *Hardware* – specialised hardware
- *Type Safety* – type safe languages
- *Safer Functions* – using safer coding practices

Prevention

- *Code Inspection* – Fuzzing, Valgrind, etc…
- *Testing*

Detection

- *Least Privilege*

Mitigation

Summary:

- Malware Taxonomy
- Overflows
- Defences