THOMSON

COURSE TECHNOLOGY

Hands-On Ethical Hacking and Network Defense 2nd edition

Chapter 7
Programming for Security Professionals

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Objectives

- Explain basic programming concepts
- Write a simple C program
- Explain how Web pages are created with HTML
- Describe and create basic Perl programs
- Explain basic object-oriented programming concepts

Introduction to Computer Programming

- Computer programmers must understand the rules of programming languages
  - Programmers deal with syntax errors
- One minor mistake and the program will not run
  - Or worse, it will produce unpredictable results
- Being a good programmer takes time and patience

Computer Programming Fundamentals

- Fundamental concepts
  - Branching, Looping, and Testing (BLT)
  - Documentation
- Function
  - Mini program within a main program that carries out a task

Branching, Looping, and Testing (BLT)

- Branching
  - Takes you from one area of the program to another area
- Looping
  - Act of performing a task over and over
- Testing
  - Verifies some condition and returns true or false

A C Program

```
  GNU nano 1.3.12                    File: demo1.c

#include <stdio.h>

main()
{
printf("Hello World!");
}
```

- Filename ends in .c
- It's hard to read at first
- A single missing semicolon can ruin a program

Comments

```
  GNU nano 1.3.12                File: demo2.c

#include <stdio.h>      /* Standard libraries like printf       */

main()                  /* Every C program needs a main()       */
                        /* Processing starts with main()        */
{
printf("Hello World!\n\n");     /* Calls the function printf    */
                                /* \n is a newline character    */
}
```

- Comments make code easier to read

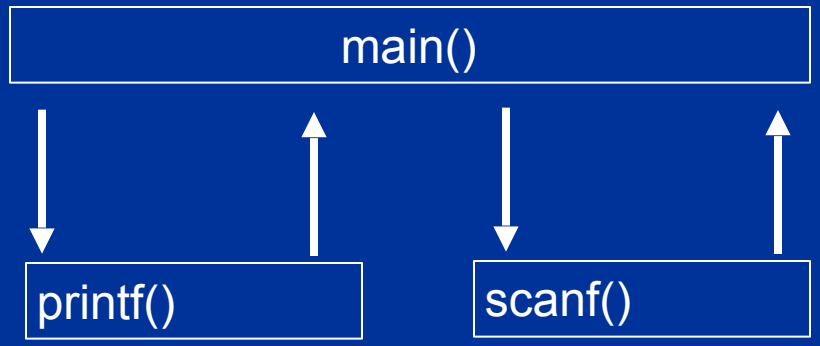
Branching and Testing

```
  GNU nano 1.3.12                    File: agedemo.c

#include <stdio.h>
main()
{
        int age;                          /* Declaring a variable          */
        printf("Enter your age: ");       /* Branching--Calling a function */
        scanf("%d", &age);
        if (age > 0)                      /* Testing the value of age      */
                printf("You are %d years old\n", age);
}
```

Diagram of branches

See links Ch 7b, 7c



Looping

```
  GNU nano 1.3.12                    File: loopdemo.c

#include <stdio.h>
main()

{
        int i;
        for (i=0; i<11; i++)    /* Looping: repeat ten times */
                printf("I will not hack in class\n");
}
```

Branching, Looping, and Testing (BLT)

- Algorithm
  - Defines steps for performing a task
  - Keep it as simple as possible
- Bug
  - An error that causes unpredictable results
- Pseudocode
  - English-like language used to create the structure of a program

Pseudocode For Shopping

- PurchaseIngredients Function
  - Call GetCar Function
  - Call DriveToStore Function
  - Purchase Bacon, Bread, Tomatoes, Lettuce, and Mayonnaise
- End PurchaseIngredients Function

Documentation

- Documenting your work is essential
  - Add comments to your programs
  - Comments should explain what you are doing
- Many programmers find it time consuming and tedious
- Helps others understand your work

Bugs

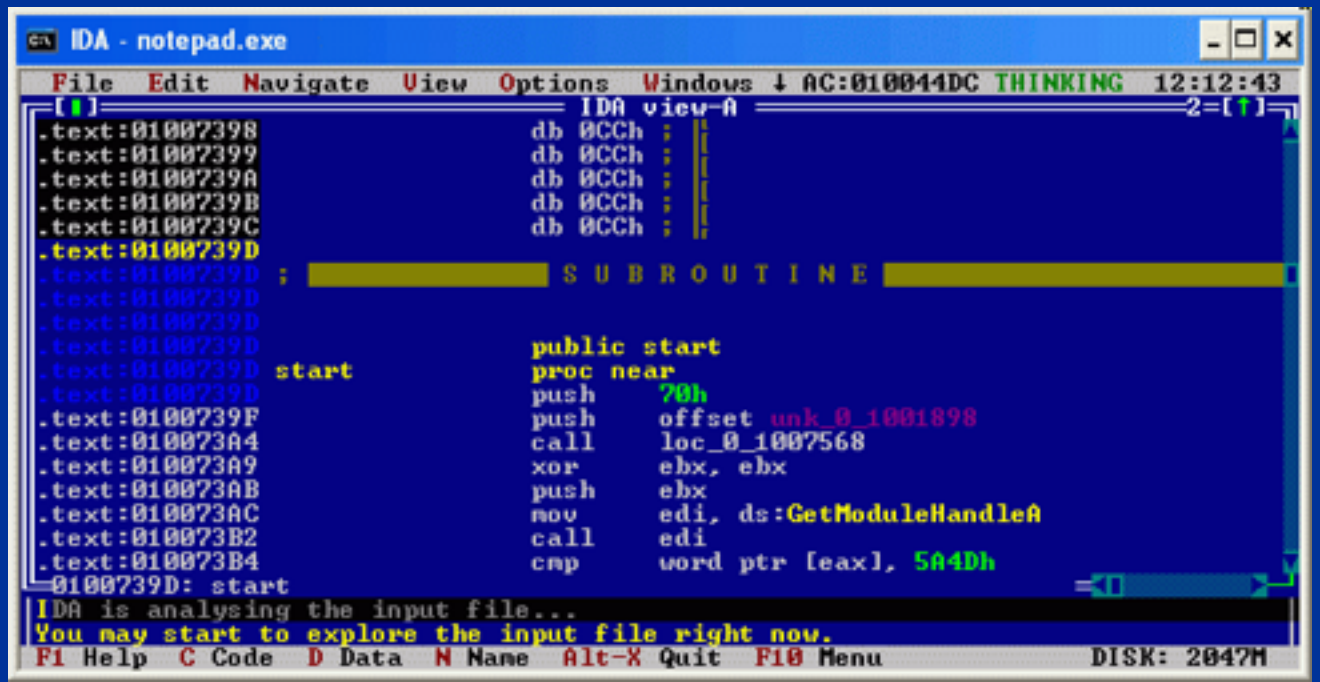
- Industry standard
  - 20 to 30 bugs for every 1000 lines of code (link Ch 7f)
    - Textbook claims a much smaller number without a source
- Windows 2000 contains almost 50 million lines
  - And fewer than 60,000 bugs (about 1 per 1000 lines)
  - See link Ch 7e for comments in the leaked Win 2000 source code
- Linux has 0.17 bugs per 1000 lines of code
  - (Link Ch 7f)

Learning the C Language

- Developed by Dennis Ritchie at Bell Laboratories in 1972
- Powerful and concise language
- UNIX was first written in assembly language and later rewritten in C
- C++ is an enhancement of the C language
- C is powerful but dangerous
  - Bugs can crash computers, and it's easy to leave security holes in the code

Assembly Language

- The binary language hard-wired into the processor is **machine language**
- Assembly Language uses a combination of hexadecimal numbers and expressions
  - Very powerful but hard to use (Link Ch 7g)



Compiling C in Ubuntu Linux

- Compiler
  - Converts a text-based program (source code) into executable or binary code
- To prepare Ubuntu Linux for C programming, use this command:

  sudo apt-get install build-essential
- Then you compile a file named "program.c" with this command:

  gcc program.c –o program

Anatomy of a C Program

- The first computer program a C student learns "Hello, World!"

```
  GNU nano 1.3.12                    File: demo1.c

#include <stdio.h>

main()
{
printf("Hello World!");
}
```

Comments

- Use /* and */ to comment large portions of text
- Use // for one-line comments

```
  GNU nano 1.3.12                    File: agedemo.c

#include <stdio.h>
main()
{
        int age;                        /* Declaring a variable          */
        printf("Enter your age: ");     /* Branching--Calling a function */
        scanf("%d", &age);
        if (age > 0)                    /* Testing the value of age      */
                printf("You are %d years old\n", age);
}
```

Include

- #include statement
  - Loads libraries that hold the commands and functions used in your program

```
#include <stdio.h>

main()
{
printf("Hello World!");
}
```

Functions

```
#include <stdio.h>

main()
{
printf("Hello World!");
}
```

- A Function Name is always followed by parentheses ( )
- Curly Braces { } shows where a function begins and ends
- main() function
  - Every C program requires a main() function
  - main() is where processing starts

Functions

- Functions can call other functions
  - Parameters or arguments are optional
- \n represents a line feed

```
  GNU nano 1.3.12                    File: agedemo.c

#include <stdio.h>
main()
{
        int age;                        /* Declaring a variable          */
        printf("Enter your age: ");     /* Branching--Calling a function */
        scanf("%d", &age);
        if (age > 0)                    /* Testing the value of age      */
                printf("You are %d years old\n", age);
}
```

Declaring Variables

- A variable represents a numeric or string value
- You must declare a variable before using it

```
  GNU nano 1.3.12                    File: agedemo.c

#include <stdio.h>
main()
{
        int age;                        /* Declaring a variable          */
        printf("Enter your age: ");     /* Branching--Calling a function */
        scanf("%d", &age);
        if (age > 0)                    /* Testing the value of age      */
                printf("You are %d years old\n", age);
}
```

Variable Types in C

Table 7-3 Variable types in C

Variable Type	Description
int	Use this variable type for an integer (positive or negative number).
float	This variable type is for a real number that includes a decimal point, such as 1.299999.
double	Use this variable type for a double-precision floating point.
char	This variable type holds the value of a single letter.
string	This variable type holds the value of multiple characters or words.

Mathematical Operators

- The i++ in the example below adds one to the variable i

```
  GNU nano 1.3.12                    File: loopdemo.c

#include <stdio.h>
main()

{
        int i;
        for (i=0; i<11; i++)    /* Looping: repeat ten times */
                printf("I will not hack in class\n");
}
```

Mathematical Operators

Table 7-5 Mathematical operators in C

Operator	Description
+ (unary)	Doesn't change the value of the number. Unary operators use a single argument; binary operators use two arguments. Example: +(2).
- (unary)	Returns the negative value of a single number.
++ (unary)	Increments the unary value by 1. For example, if a is equal to 5, the ++a command changes the value to 6.
-- (unary)	Decrements the unary value by 1. For example, if a is equal to 5, the --a command changes the value to 4.
+ (binary)	Addition. For example, a + b.
- (binary)	Subtraction. For example, a - b.
* (binary)	Multiplication. For example, a * b.
/ (binary)	Division. For example, a / b.
% (binary)	Modulus. For example, 10 % 3 is equal to 1 because 10 divided by 3 leaves a remainder of 1.

Logical Operators

- The i<11 in the example below compares the variable i to 11

```
  GNU nano 1.3.12                    File: loopdemo.c

#include <stdio.h>
main()

{
        int i;
        for (i=0; i<11; i++)    /* Looping: repeat ten times */
                printf("I will not hack in class\n");
}
```

Logical Operators

Table 7-6 Logical operators in C

Operator	Description
==	Used to compare the equality of two variables. In a == b, for example, the condition is true if variable a is equal to variable b.
!=	Not equal. The exclamation mark negates the equal sign. For example, the statement `if a != b` is read as "if a is not equal to b."
>	Greater than.
<	Less than.
>=	Greater than or equal to.
<=	Less than or equal to.
&&	The AND operator; evaluated as true if both sides of the operator are equal. For example, `if (( a > 5) && (b > 5)) printf ("Hello, world!");` prints only if both a and b are greater than 5.
||	The OR operator; evaluated as true if either side of the operator is equal.
!	The NOT operator; the statement `a != 5`, for example, means that variable a is not equal to the number 5.

Demonstration: Buffer Overflow

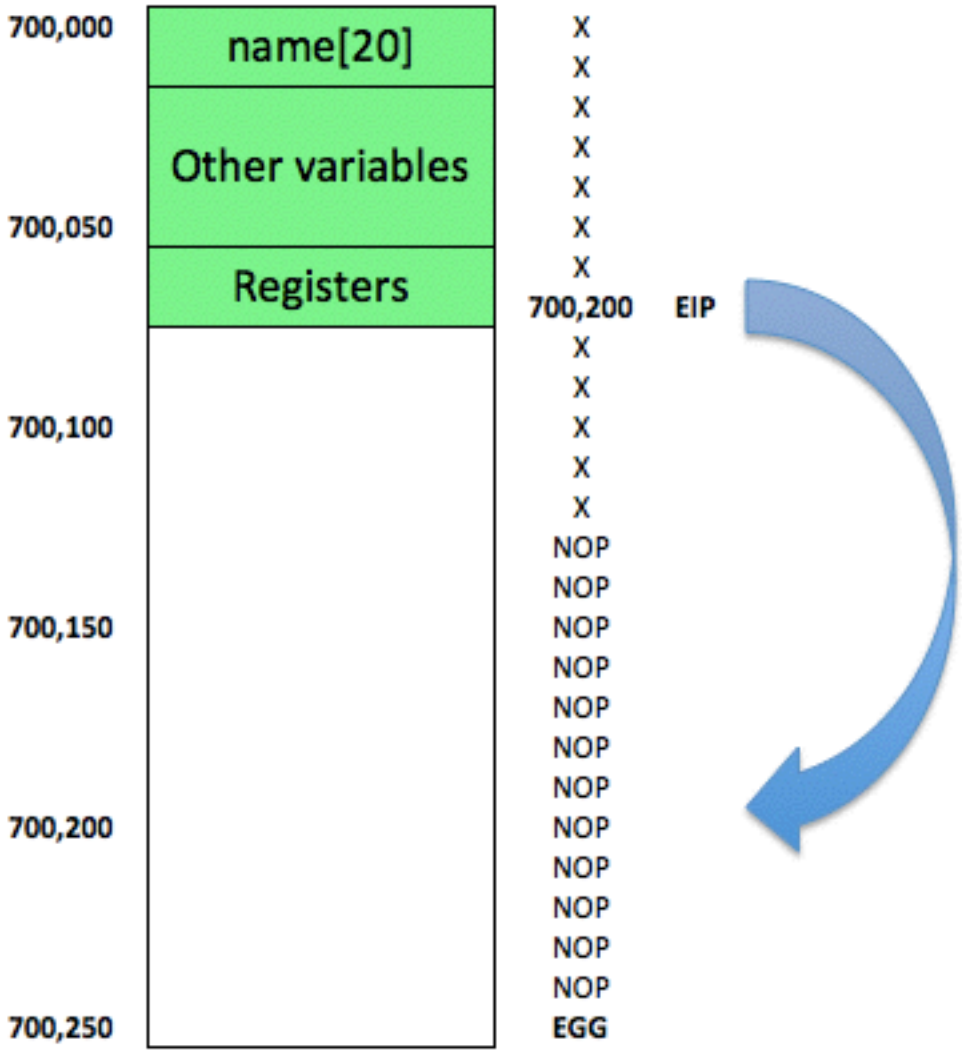
```
#include <stdio.h>

main()
{
char name[10];
printf("What is your name?");
scanf("%s",name);
printf("Hi, %s\n\n",name);
}
```

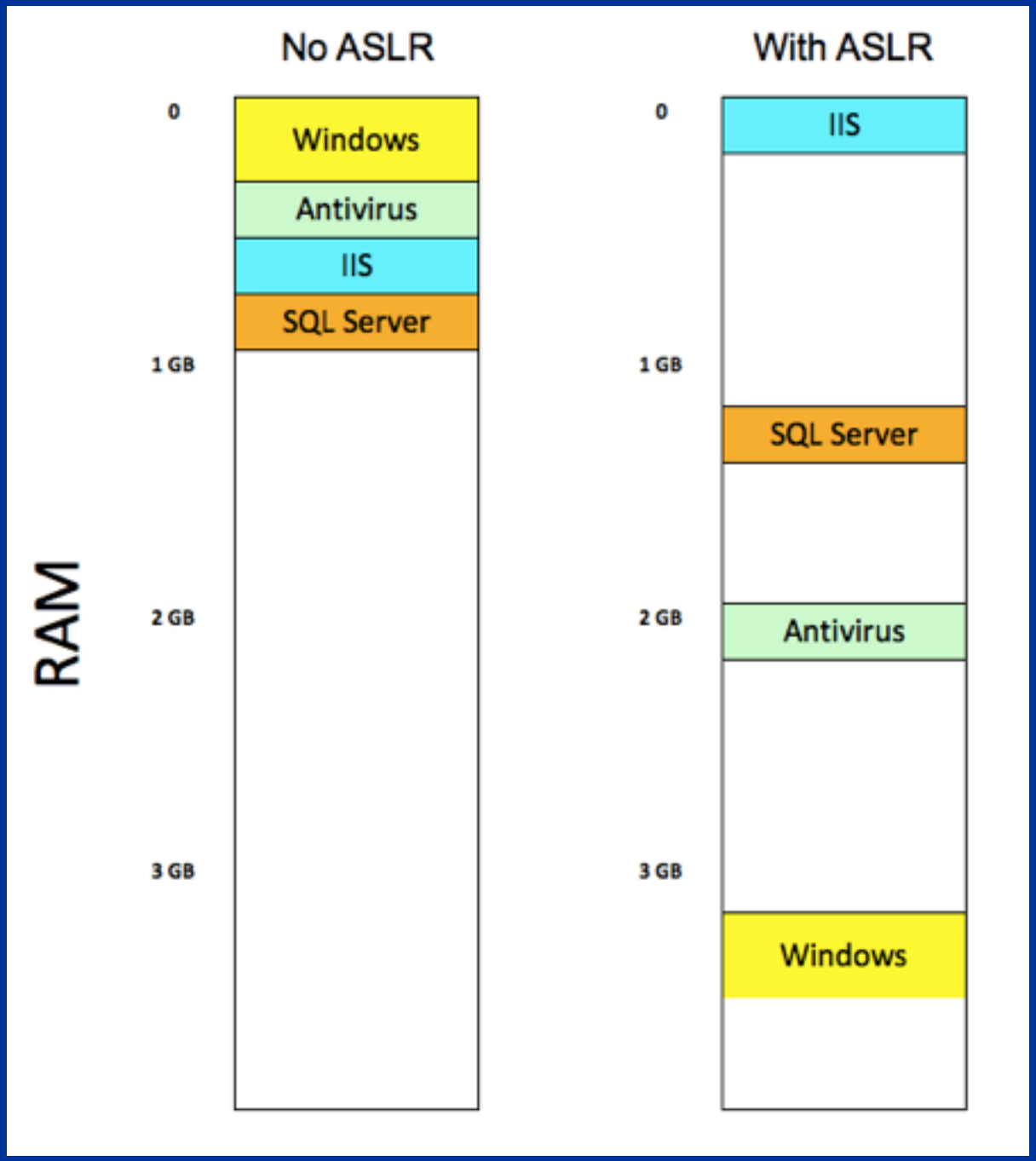
```
yourname@S214-01u:~$ ./hello2.exe
What is your name?12345678901234567890
Hi, 12345678901234567890

*** stack smashing detected ***: ./hello2.exe terminated
Aborted (core dumped)
```

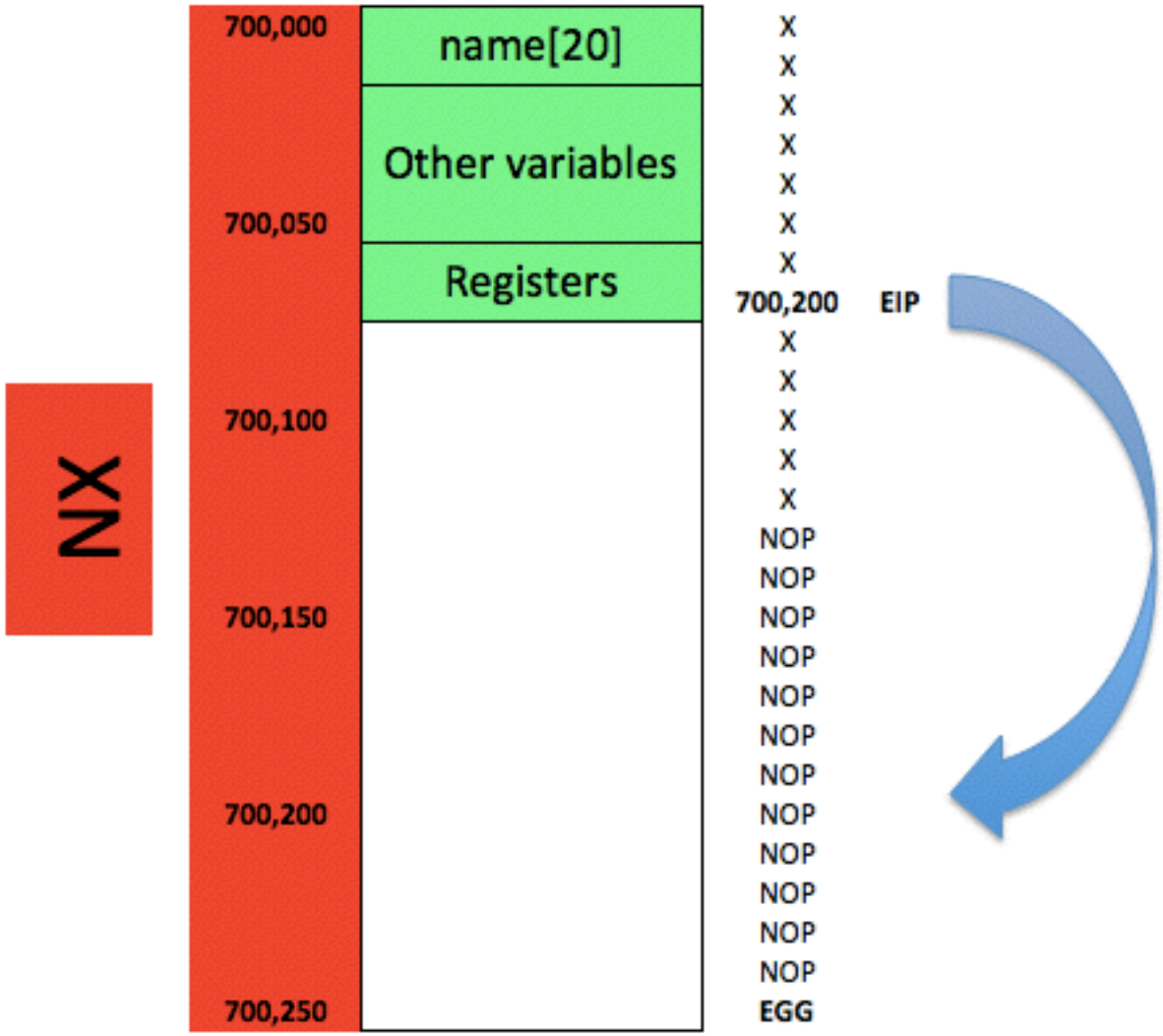
Buffer Overflow



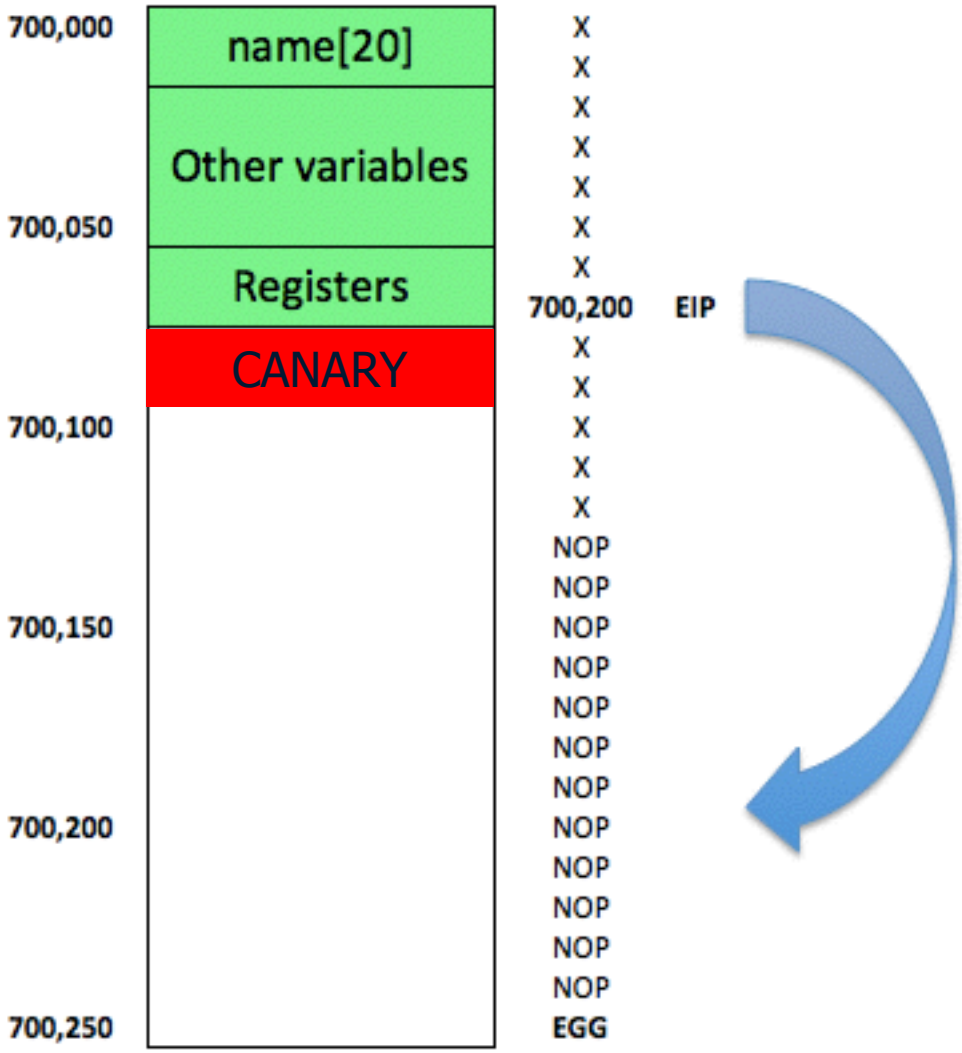
Buffer Overflow Defenses


No ASLR
With ASLR
RAM
0
1 GB
2 GB
3 GB
Windows
Antivirus
IIS
SQL Server
0
1 GB
2 GB
3 GB
IIS
SQL Server
Antivirus
Windows

Data Execution Prevention



Detecting stack smashing with a canary value



Understanding HTML Basics

- HTML is a language used to create Web pages
- HTML files are text files
- Security professionals often need to examine Web pages
  - Be able to recognize when something looks suspicious

Creating a Web Page Using HTML

- Create HTML Web page in Notepad
- View HTML Web page in a Web browser
- HTML does not use branching, looping, or testing
- HTML is a static formatting language
  - Rather than a programming language
- < and > symbols denote HTML tags
  - Each tag has a matching closing tag
  - <HTML> and </HTML>

Table 7-7 HTML formatting tags

Opening Tag	Closing Tag	Description
<H1>	</H1>	Formats text as a level 1 heading. (Level 1 is the largest font size, and level 6 is the smallest.)
<H2>, <H3>, <H4>, <H5>, and <H6>	</H2>, </H3>, </H4>, </H5>, and </H6>	Formats text as a level 2, 3, 4, 5, or 6 heading.
<P>	</P>	Used to mark the beginning and end of a paragraph.
 	</BR>	Used to insert a carriage return.
<B>	</B>	Formats enclosed text in bold.
<I>	</I>	Formats enclosed text in italics.

```
<!-- This HTML web page has many tags -->
<HTML>
<HEAD>
        <TITLE> HTML For Security Testers </TITLE>
</HEAD>
<BODY>

<H2>Security Tester Web Site </H2>

<P><B>There are many good Web sites to visit for security testers. For vulnerabilities click</B>
<A HREF="HTTP://www.cve.mitre.org"><FONT COLOR="red">here!</FONT></A>
</P>
<BR><FONT SIZE="-1">Copyright 2005 Security Testers, Incorporated. </FONT></BR>

</BODY>

</HTML>
```

Figure 7-4 HTML source code

Security Tester Web Site

There are many good Web sites to visit for security testers. For vulnerabilities click here!

Copyright 2005 Security Testers, Incorporated.

Figure 7-5 An HTML Web page

Understanding Practical Extraction and Report Language (Perl)

- PERL
  - Powerful scripting language
  - Used to write scripts and programs for security professionals

Background on Perl

- Developed by Larry Wall in 1987
- Can run on almost any platform
  - *NIX-base OSs already have Perl installed
- Perl syntax is similar to C
- Hackers use Perl to write malware
- Security professionals use Perl to perform repetitive tasks and conduct security monitoring

```
# This is my first Perl script program
# I should always have documentation in my scripts-- no matter
# how easy I think the script is to understand!

print "Hello security testers!\n\n";
```

Figure 7-9 Creating the first.pl Perl script

Understanding the Basics of Perl

- perl –h command
  - Gives you a list of parameters used with perl

```
yourname@S214-01u:~$ perl -h

Usage: perl [switches] [--] [programfile] [arguments]
  -0[octal]       specify record separator (\0, if no arg
  -a              autosplit mode with -n or -p (splits $_
  -C[number/list] enables the listed Unicode features
  -c              check syntax only (runs BEGIN and CHECK
  -d[:debugger]   run program under debugger
  -D[number/list] set debugging flags (argument is a bit
  -e program      one line of program (several -e's allow
  -f              don't do $sitelib/sitecustomize.pl at s
```

Table 7-9 Using printf to format output

Formatting Character	Description	Input	Output
%c	Character	`printf '%c', "d"`	d
%s	String	`printf '%s', "This is fun!"`	This is fun!
%d	Signed integer in decimal	`printf '%+d %d', 1, 1`	+1 1
%u	Unsigned integer in decimal	`printf '%u', 2`	2
%o	Unsigned integer in octal	`printf '%o', 8`	10
%x	Unsigned integer in hexadecimal	`printf '%x', 10`	a
%e	Floating point in scientific notation	`printf '%e', 10;`	1.000000e+001 (OS dependent)
%f	Floating point in fixed decimal notation	`printf '%f', 1;`	1.000000

Understanding the BLT of Perl

- Some syntax rules
  - Keyword “sub” is used in front of function names
  - Variables begin with the $ character
  - Comment lines begin with the # character
  - The & character is used when calling a function

Branching in Perl

`&speak;`

- Calls the subroutine

`sub speak`

- Defines the subroutine

```
# Perl program demonstrating branching

$word = "Hack";
&speak;

$word = "Or";
&speak;

$word = "Die!";
&speak;

sub speak {
   print"$word\n";
}
```

For Loop in Perl

- For loop

```
# Prepares a shell script that does a ping sweep

for ($a = 1; $a <100; $a++)
{
        print "ping 192.168.1.$a -w1\n";
}
```

Testing Conditions in Perl

```
# Leet test
print "How smart are you (1-10): ";
open (INFO, "-");
$IQ = <INFO>;
if ($IQ > 7) {
   print "1337!\n";
   }
else {
   print "1u53r!\n";
   }
```

Understanding Object-Oriented Programming Concepts

- New programming paradigm
- There are several languages that support object-oriented programming
  - C++
  - C#
  - Java
  - Perl 6.0
  - Object Cobol

Components of Object-Oriented Programming

- Classes
  - Structures that hold pieces of data and functions
- The :: symbol
  - Used to separate the name of a class from a member function
  - Example:
    - `Employee::GetEmp()`

Example of a Class in C++

```
class Employee
{
public:
    char firstname[25];
    char lastname[25];
    char PlaceOfBirth[30];
    [code continues]
};
void GetEmp()
{
    // Perform tasks to get employee info
    [program code goes here]
}
```

Ruby Example

```
require 'msf/core'
require 'zlib'

class Metasploit3 < Msf::Exploit::Remote
        Rank = GreatRanking # aslr+dep bypass, js heap spray, rop, stack bof

        include Msf::Exploit::FILEFORMAT

        def initialize(info = {})
                super(update_info(info,
                        'Name'           => 'Adobe CoolType SING Table "uniqueName" Stack Buffer Overflow',
                        'Description'    => %q{
                                        This module exploits a vulnerability in the Smart INdependent Glyplets
(SING) table
                                handling within versions 8.2.4 and 9.3.4 of Adobe Reader. Prior versions are
                                assumed to be vulnerable as well.
                        },
                        'License'        => MSF_LICENSE,
                        'Author'         =>
                                [
                                        'Unknown',     # 0day found in the wild
                                        '@sn0wfl0w',   # initial analysis
                                        '@vicheck',    # initial analysis
                                        'jduck'        # Metasploit module
```

- Metasploit is written in Ruby
- See link Ch 7u

LOLCODE

```
HAI 1.2
CAN HAS STDIO?
I HAS A VAR
IM IN YR LOOP
   UP VAR!!1
   VISIBLE VAR
   IZ VAR BIGGER THAN 10? KTHX
IM OUTTA YR LOOP
KTHXBYE
```

Links Ch 7x, Ch 7y

lolcode.codeschool.com/levels/1/challenges/1

SIGN IN

Can Haz
LOLCODE
by Code School

1

LERN HOW 2 LOLCODE

O HAI! YR KITTEH, TELL ME BOUT DEMZ. 2 TELL ME UR KITTEH'S NAYM, U TYPE:

```
VISIBLE "<KITTEH NAYM GOEZ HERE>"
```

REMEMBR 2 PUT YR KITTEH'S NAYM IN QUOTES.

JUS GIMMEH ANSWER

Yr Input

SUBMIT CODE

Yr Output

Brainfuck

Character	Meaning
`>`	increment the data pointer (to point to the next cell to the right).
`<`	decrement the data pointer (to point to the next cell to the left).
`+`	increment (increase by one) the byte at the data pointer.
`-`	decrement (decrease by one) the byte at the data pointer.
`.`	output the byte at the data pointer.
`,`	accept one byte of input, storing its value in the byte at the data pointer.
`[`	if the byte at the data pointer is zero, then instead of moving the instruction pointer forward to the next command, jump it *forward* to the command after the *matching* `]` command.
`]`	if the byte at the data pointer is nonzero, then instead of moving the instruction pointer forward to the next command, jump it *back* to the command after the *matching* `[` command.

Link Ch 7z

"Hello, World!" in Brainfuck

```
++++++++++[>+++++++>++++++++++>+++>+
<<<<-]>++.>+.+++++++..+++.>++.<<+++++++++++++++.>.+++.------.---
----.>+.>.
```