Midterm Study Guide

Sunday, October 22, 2017 6:58 PM

CS363 Information Assurance and Security
-- Midterm Exam Study Guide

(I reserve the right to interpret if a question is covered by this guide. Still, only about 90% of questions are covered by this guide.)

Overview:
1. CIA.
   - Can rephrase it.
   - Can give application examples.

Buffer overflow:
1. Can explain what it is, the cause of it, how to implement it
2. Know stack-based, heap-based, and in other segments
3. Can identify buffer overflow in the source code

Shellcoding:
1. Can explain how to use shellcode to exploit buffer overflow attacks
2. Know the process to write shellcode

Format string:
1. Know how to use format string to exploit buffer overflow attacks
2. Can identify format string security issues in the source code

Countermeasures:
1. Know defenses and countermeasures: canary, shadow stack, non-executable bit, ISR, ASR
2. Can use defenses and countermeasures to analyze scenarios.

Overview:

1) CIA

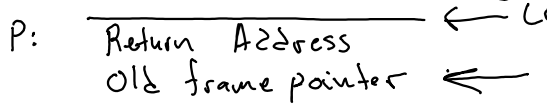
Confidentiality
Integrity
Availability

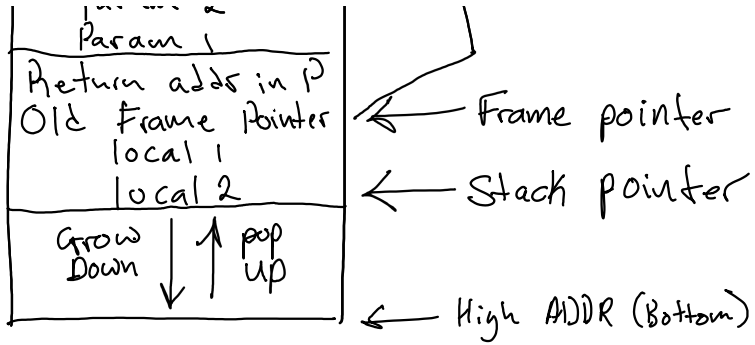
Buffer Overflow:

1) Definition: an interface under which more input can be placed into a buffer or data holding area than the capacity allocated, overwriting other information. Attackers exploit such a condition to crash a system or to insert specially crafted code that allows them to gain control of the system.

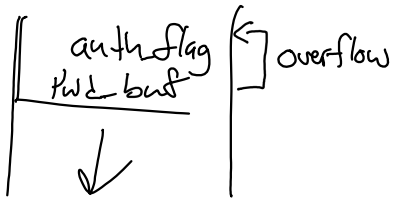
2) Stack Buffer Overflows: occurs when the targeted buffer is located on the stack, usually as a local variable in a function's stack frame. AKA Stack smashing

Stack frame: P calling Q (Pop-up, grow Down)



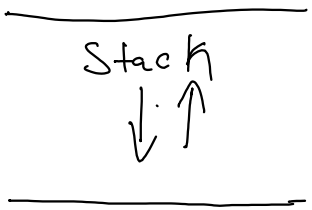



```
int check_authentication (char * password) {
  int auth_flag = 0;
  char password_buffer[16]; // 17+ chars = buf overflow
  strcpy (password_buffer, password);
  if (strcmp (password_buffer, "brillig") == 0)
    auth_flag = 1;
  if (strcmp (password_buffer, "outgrabe") == 0)
    auth_flag = 1;
  return auth_flag;
}
```



Stack Buffer Overflow used to crash system or execute code / inject ADDR

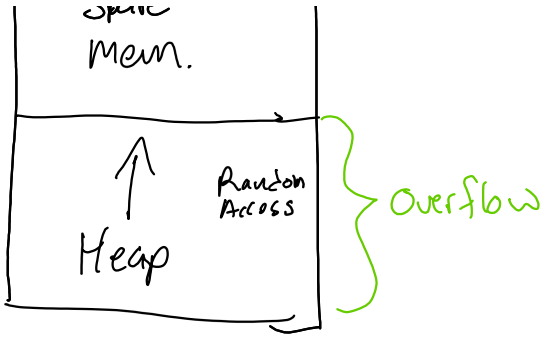
Heap Overflow: Overflow on heap ... Duh.



Pg 369 for Struct "chunk"

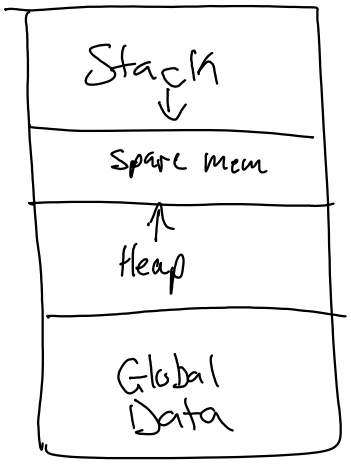
```
int main (int argc, char * argv[])
{
  chunk_t *next;

  setbuf (stdin, NULL);
  next = ...
```




```
next -> process = show len;
Printf ("Enter value: ");
gets (next -> inp);
next -> process (next -> inp);
printf ("buffers done\n");
}
```

Global Data Overflow: buffers located in the program's static/global data area




```
/* Global Static Data -> Struct chunk */
int main (int argc, char *argv[])
{
   setbuf (stdin, NULL);
   chunk.process = showlen;
   printf ("Enter value: ");
   gets (chunk.inp);
   chunk.process (chunk.inp);
   printf ("buffers done\n");
}
```

3) Common Buffer Overflow weak points in Source Code:

- gets (char *str) → read line from standard input into str
- sprintf (char *str, char *format, ...) → create str according to supplied format and vars
- strcat (char * dest, char *src) → append contents of string src to string dest

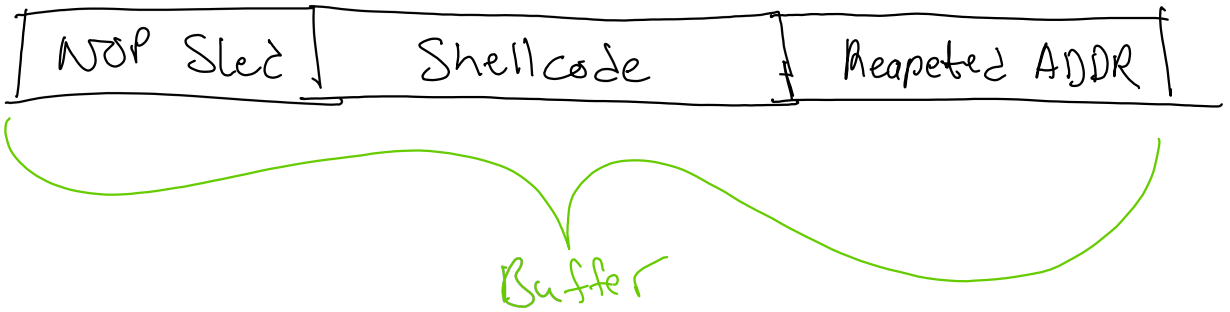
strcpy(char *dest, char *src) → copy contents of string src to src dest

vsprintf(char *str, char *fmt, va_list ap) → create str according to supplied format and vars.

Shell Coding:

1) Shell code → used to transfer execution to code supplied by the attacker. → Assembly

NOP Sled → code placed near end of buffer and padded with NOP instructions



NOP Sled:

```
memset(buffer, 0x90, 60); //Build NOP sled (60 bytes)
```

Shell code:

```
char shellcode[]=
  "\x31\xc0\x31\xdb\x31\xc9\x99\...";
```

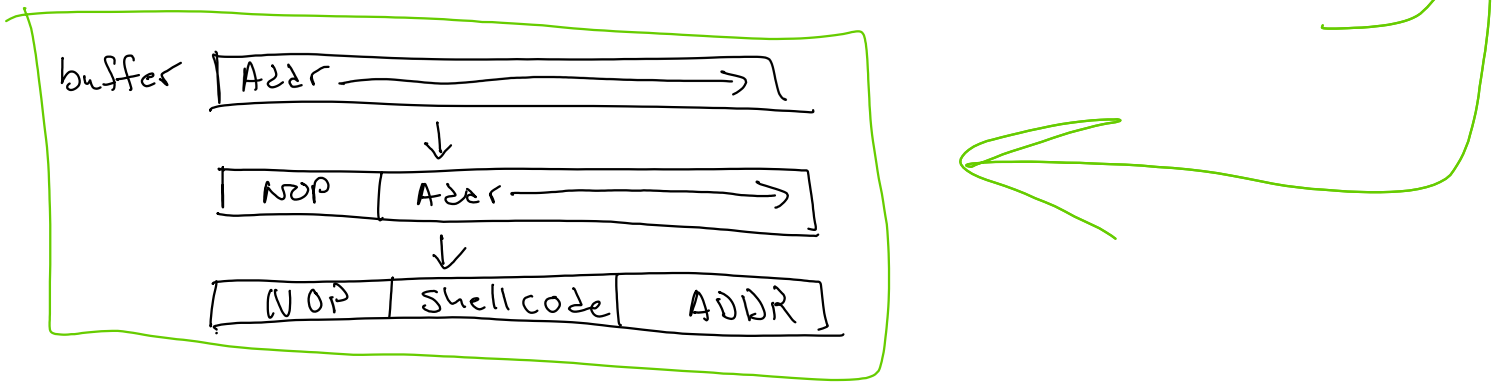
↓

```
memcpy(buffer+60, Shellcode, sizeof(Shellcode)-1);
```

Repeated ADDR:

```
ret = (unsigned int) &i - offset; // set return Addr
```

```
for (i=0; i < 160, i+=4)  // fill buffer w/ return addr
    *((unsigned int *)(buffer + i)) = ret;
```



2) Shellcode = a string of assembly instructs for the OS

Process of writing SC:
1) determine software attking
2) determine OS software resides on
3) determine CPU architecture (what assembly must I use)
4) compose desired command in corresponding assembly

↓

90 90 eb 1a ← x86 machine code

↓

"\x90\x90\xeb\x1a" ← x86 shellcode

format String overflow:

printf(text); ← NO! BAD! Vulnerable!

printf("%s", text); ← YES! CORRECT WAY!

B assin a strin with formattin ta) the bar wa

will try to evaluate the tag.

perl -e 'print "%08x."x40' ← this will print ADDRS (stack) if bad printf used

don't forget, little endian (backwards addr)

bytes 0x25, 0x30, 0x38, 0x78, and 0x2e repeats

Stack ADDR ?!

Printf "\x25\x30\x38\x78\x2e\n" -> %80x.

%s can read strings from mem addresses

%n can overwrite mem address

if %s leave off the 'x0' and read @ offset

write.

target ADDR

perl -e 'print "AAAA" + "\x?\x?" + "BBBB" + "%x\n"x127 + "%n" ~ 'x08'

padding to ID target ADDR offset

ADDR offset

write to ADDR @ offset

exploit-exercises.com

Some practice

Counter measures:

Canary:

```
foo ()
{
  ...
  static int canary = rand();
```

not in heap or stack

```
int mySecret;
mySecret = canary
...
if(mySecret != canary){alert(0);}   <-- if canary finds "poison" error out
exit(0);
}
```

Cannot protect against format string attack (Arb. ADDR => Arb. Value)

Shadow Stack:

Separate stack to hold (copies) return addresses for comparison

no protection for other data

W⊕X / DEP:

Make all writable memory as non-Executable
<> MS DEP (Data Execution Prevention)
Blocks all code inject exploits

Hardware Support: AMD "NX" bit, Intel "XD" bit (post 2004 CPU)

Widely deployed: Windows (since xp sp2), Linux (via PaX patches), OpenBSD, OS X (since 10.5)

Problems:

We can do return-to-libc <-- lib functions loaded before

Overwrite return address w/ address of libc function
- Setup fake return address and arguments
- ret will "call" libc function

No Injected Code

Defense Summary
- No Defense Method against all attks

ISR → Instruction Set Randomization

Randomizes ls locations

Can't protect against libc attack unless the libc funct adders are also Randomized (ASR → Address spaces Randomization)

ASR

Randomize memory addresses

Attacks to ASR
Address Guessing for libc (probe for ADDR)
probe for offset
libc Attack

Better ASR:

64-bit arch. (larger mem space)
↳ increase Randomness
Randomization Frequency (Rand. inside → vars)

Granularity
- permute stack vars
- permute code & lib fnctions
- permute static data

combine w/ other approaches. (ISR + ASR)

GDB:

1) compile so can use gdb on code
↳ gcc [other flags] -g <source code> -o <output file>

2) GDB commands

Break Point:	break <source>:<line> or break <function name>
Continue/Step:	continue step
print code:	list
print assembly:	disassemble <func>
Run Code:	run
show content in a register:	info register <register>
show content in all gen. purpose reg:	info register

examine memory: x <addr>

: i - instruction
example: x/2i $eip

3) Registers

General Purpose:

Temp variables:
- EAX → Accumulator
- ECX → counter
- EDX → Data
- EBX → Base

Pointers & Indexes:
- ESP → Stack Pointer
- EBP → Base Pointer
- ESI → Source Index
- EDI → Destination Index

EIP → Instruction Pointer

EFLAGS: bit flags
↳ for comparisons and memory segmentation