CS6570 Secure Systems Engineering

Lab 1

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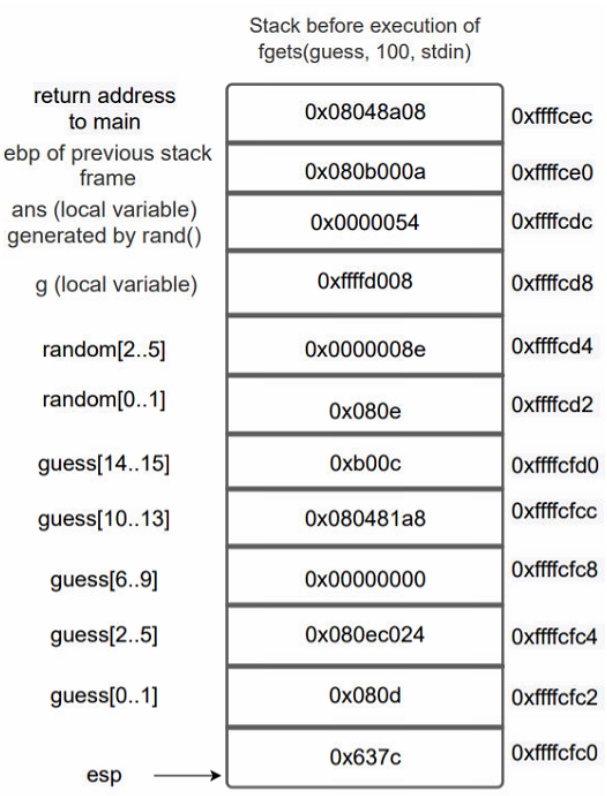
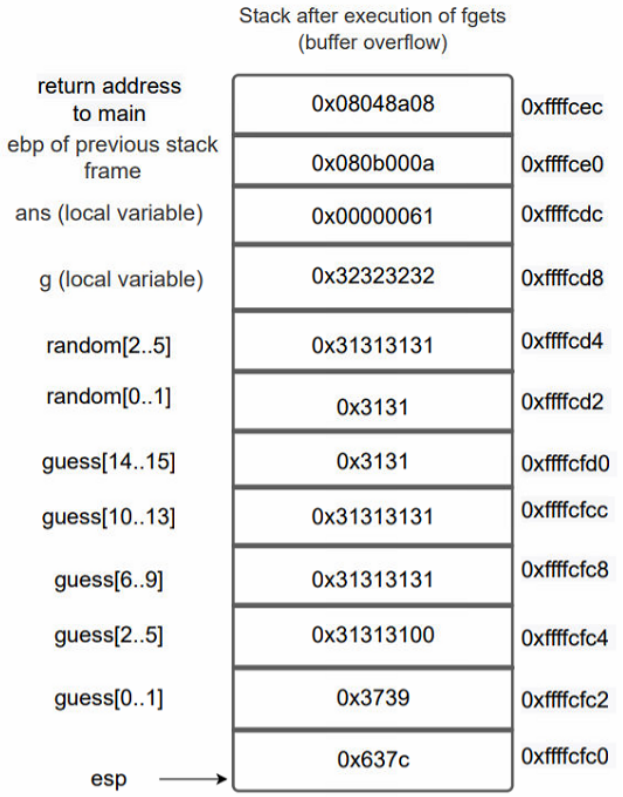
Q1. Draw the different snapshots of the content of the stackframe along with different values of registers like ebp, esp etc for each step of the attack.

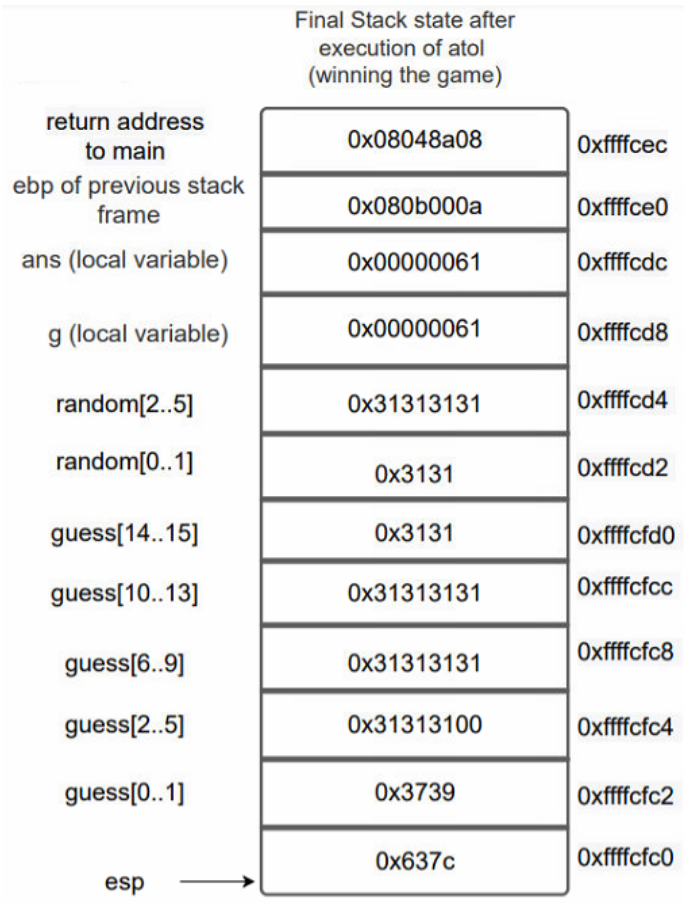
Stack state before making a function call to `do_stuff`

```
Reading symbols from ./vegas1...done.
(gdb) b 61
Breakpoint 1 at 0x8048a03: file vegas1.c, line 61.
(gdb) r
Starting program: /home/nptel/assignments/vegas1
Welcome to my guessing game!


Breakpoint 1, main (argc=1, argv=0xffffd0e4) at vegas1.c:61
61                      res = do_stuff();
(gdb) x/16x $esp
0xffffcff0:     0x080eb00c      0x0000008e      0x00000000      0x000003e9
0xffffd000:     0x080eb070      0xffffd020      0x00000000      0x08048c51
0xffffd010:     0x080eb00c      0x0000008e      0x00000000      0x08048c51
0xffffd020:     0x00000001      0xffffd0e4      0xffffd0ec      0xffffd044
```







Q2. List all the bugs/vulnerabilities present in the program.

There are two major bugs in the program:

1. `fgets(guess, 100, stdin)` in `do_stuff` function.
2. `fgets(winner, 360, stdin)` in `win` function.

The above are vulnerabilities because of the incorrect/careless usage of the otherwise safe `fgets` function. The maximum limit on the number of characters to read (second argument in `fgets`) in each case is larger than the actual size of the buffers `guess` (16 bytes) and `winner` (100 bytes). This can potentially cause a buffer overflow.

Q3. If there are vulnerabilities, then which of them can be exploited to subvert execution?

Both of the above-mentioned vulnerabilities may be exploited to subvert execution. We can easily give a large input string and modify the memory location where the return address is stored. We can also modify values stored inside some crucial local variables to alter the way the program usually behaves.

Q4. As an attacker, how can you create an exploit that cheats to 'win' the game? Use one of the vulnerabilities that you found.

To 'win' the game, we have to pass the condition `if(g == ans)`. All we have to do is make `g` equal to `ans`. It is not possible for us to accurately 'guess' what the random number stored in `g` is. Instead what we can do is take advantage of the vulnerability in the `do_stuff` function in the form of `fgets`.

Based on the organization of variables in the stack (as shown in Q1), we can change the contents of the memory location `ans` by overflowing the `guess` buffer. We have to store values inside `guess` and `ans` such that `atol(guess) == ans`. We chose to store the value `97` in both locations.

`atol` function converts the initial portion of the character array (till the null termination) to long type and returns that number.
If `guess = {'9', '7', '\0', ....}`, then `g = atol(guess) = 97`

From the diagram shown in Q1, the variable `ans` is located at an offset of 26 bytes from base address of buffer `guess`. So, we can fill the first few bytes of `guess` with `'9', '7', '\0'` and fill the remaining 23 characters with any random hexadecimal values. The next 4 bytes (size of the long variable `ans`) should then be filled with `'a', '\0', '\0', '\0'` (following the little-endian system) so that `g == ans` is satisfied. Note that the ASCII value of `'a'` is 97, and the same will be stored in `ans` variable.

One possible exploit string is `"97\0111111111111111111112222a\0\0\0"`, where `\0` is the null termination character.