this is the part where ravi writes the flag on the board

this slide is here so we don’t forget

announcements:

SQUARECTF we’re going hard see #squarectf in discord

https://2018.squarectf.com/

CYPHERCON

APRIL 11/12, 2019 MILWAUKEE

i’m getting a discount code for $-25, do not buy tickets yet

buy the digital badge it’s super cool

Format String Vulnerabilities

When output becomes input

Goal: Leak & Modify Stack

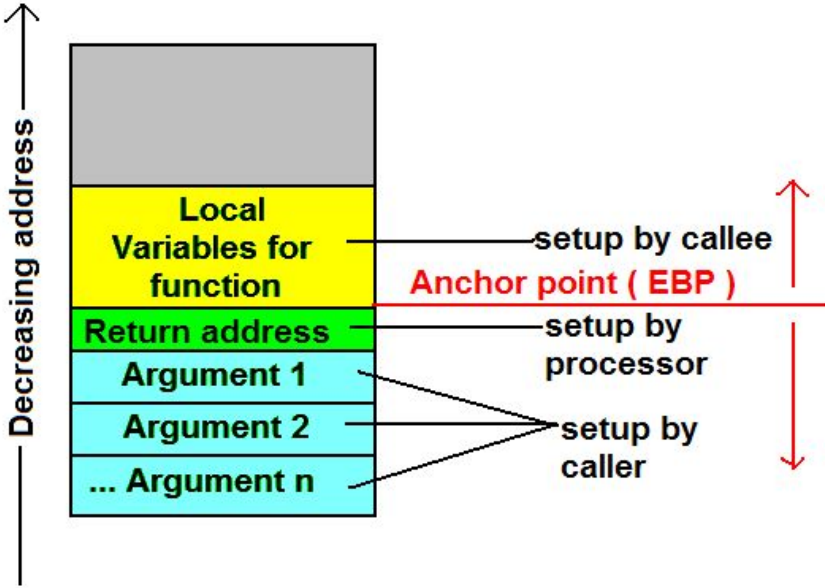
Leak & Modify

Leak: Local variables, arguments

Modify: Program execution (vars, or return addresses)

Review: The Stack

- Last in, first out
- Local variables
- Linkage



Printf’s Perspective

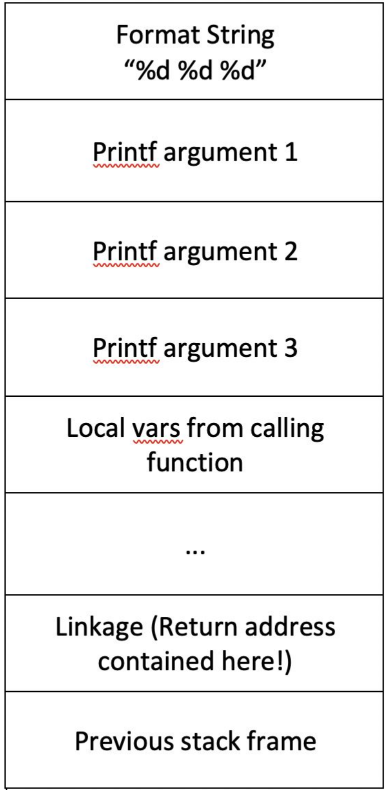
- Doesn’t know what arguments will be
- Expects a “format string” to tell it what to do

Example:

```
printf(“%d %d %d”, 1, 2, 3);

----

1 2 3
```



Format String
“%d %d %d”

Printf argument 1

Printf argument 2

Printf argument 3

Local vars from calling function

…

Linkage (Return address contained here!)

Previous stack frame

Format String Examples

```
printf(“Hello World!”);

printf(“This is a newline: \n”);

printf(“This is an integer argument: %d”, 5);

printf(“This is an integer in hex: %x”, 5);

printf(“This is a character arg: %c”, ‘a’);

printf(“This is a string arg: %s”, “This is a string”);
```

Format String Syntax

%d: Print the next thing on the stack as an integer

%x: Print the next thing on the stack as hex

%c: Print the next thing on the stack as an ASCII character

%s: Print the next thing as a string

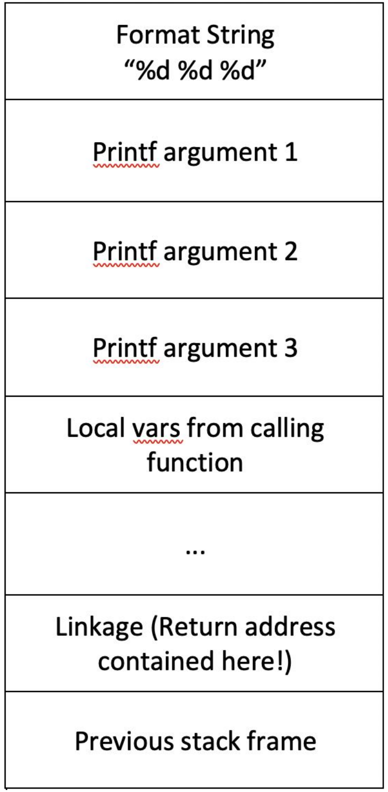
(Note: for %s the string's starting address must be passed, not the entire string)

Exploit

- What’s an argument? What is just on the stack?
- Same format string, different call, very different output:

```
printf (“%d %d %d”, 1);
```

```
1 [1st local var] [2nd local var]
```



Format String
“%d %d %d”

Printf argument 1

Printf argument 2

Printf argument 3

Local vars from calling function

…

Linkage (Return address contained here!)

Previous stack frame

Typical Exploit

1. Find a call to printf using user input as format string
2. Create malicious format string to leak or modify data
3. Profit?

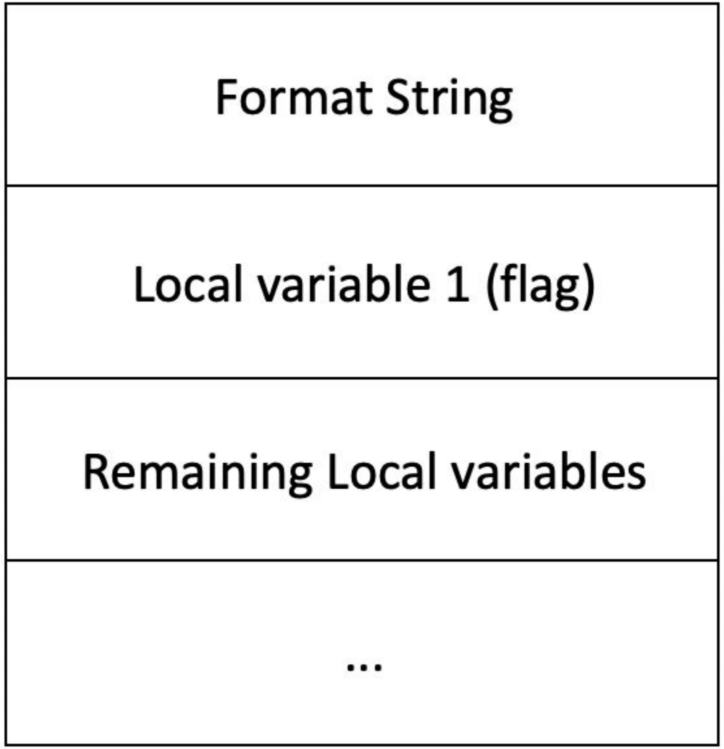
sigpwny.com
Challenge 1:
Leak a stack variable

Challenge 1

Vulnerable call:

```
printf(input_buffer);
```

%x gives us what looks like an address... Possibly a string?



Format String

Local variable 1 (flag)

Remaining Local variables

...

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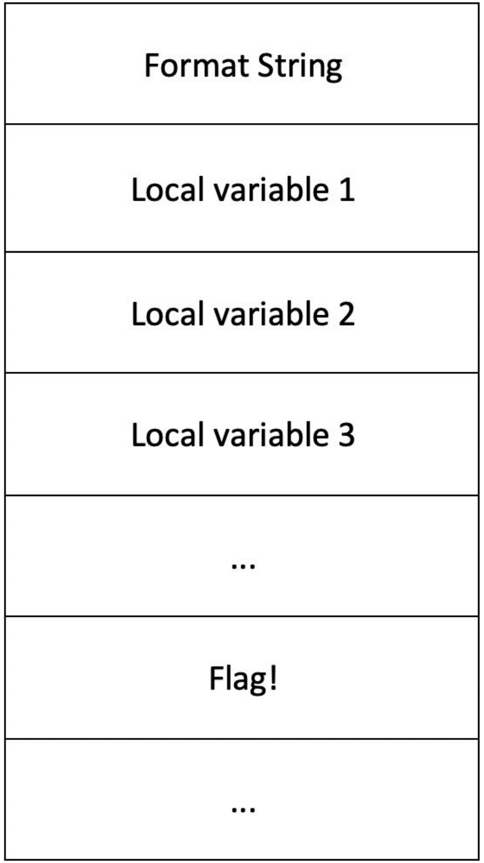
Challenge 2:

Leak a variable far down the stack

Challenge 2

Vulnerable call:
`printf(input_buffer);`

The flag is further down the stack... Use multiple format specifiers to see more?



Format String

Local variable 1

Local variable 2

Local variable 3

...

Flag!

...

What if the buffer is too small?

%(number)$x will print the “number”-th argument.

Example:

```
    printf(“%3$s”, “arg 1”, “arg 2”, “arg 3”);
```

Will print “arg 3,” since “arg 3” is the 3rd argument.

What if the buffer is too small?

%(number)$x will print the “number”-th **thing on the stack.**

Example:

```
    printf(“%4$x”, 0x1, 0x2, 0x3);
```

Will print whatever was pushed on the stack prior to printf.

sigpwny.com

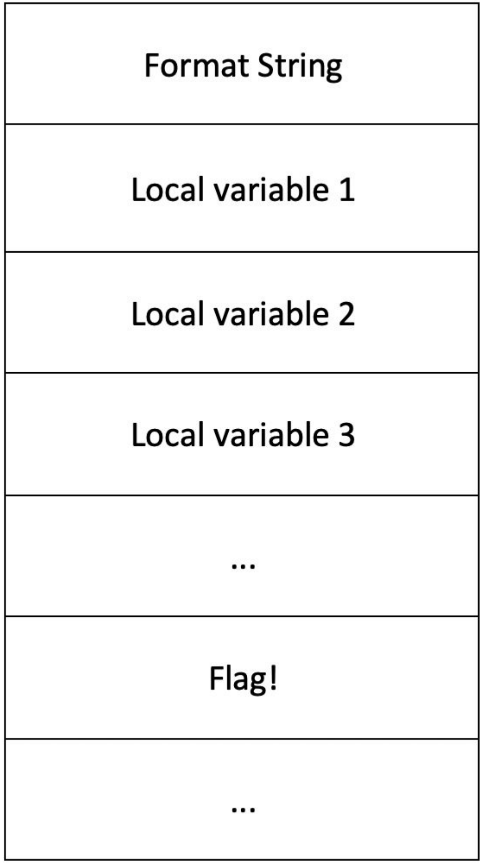
Challenge 3:
Leak a variable with a small format string

Challenge 3

The variable we want is at an offset of 11 from the format string.

If we could do %x 11 times, we would get the flag.

How can we effectively do %x more times using only 6 characters?



Format String

Local variable 1

Local variable 2

Local variable 3

...

Flag!

...

Modifying Contents

%n: Writes the number of characters output to an address passed on the stack.

Example:

```
    int x;

    printf(“12345%n”, &x);
```

Stores ‘5’ in x, since 5 characters were written.

Modifying Contents

%n can be used to overwrite any address on the stack with new information!

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Challenge 4:
Modify a variable

Challenge 4

- dont_modify_me’s address is on the stack and can be viewed using %6$x
- Using %n instead of %x will overwrite dont_modify_me’s value with the number of bytes written