# Computer Security

## Software vulnerabilities. Buffer overflows.

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# Simple (classic) buffer overflow

Aleph One, Smashing the stack for fun and profit, Phrack magazine 7(49)

Overflow *any* stack-placed buffer accepting unchecked input

unsafe functions: `strcpy`, `strcat`, `scanf` with `%s`
- `gets`: deleted from C standard in 2011
- safe alternatives introduced for some

Danger not limited to unsafe input
- also careless overflow of index in (local) array

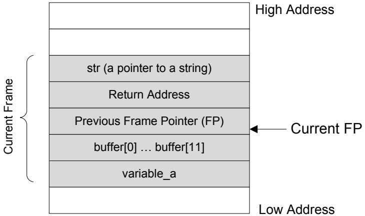
Reason: low abstraction level of C
- no objects carrying size info (that could be checked)
- can create arbitrary pointer values using pointer arithmetic
- $\Rightarrow$ checks are responsibility of user, not of runtime system

# Simple example (in your lab)

```
void func (char *str) {
  char buffer[12];
  int  variable_a;
  strcpy (buffer, str);
}

Int main() {
  char *str = “I am greater than 12 bytes”;
  func (str);
}
```

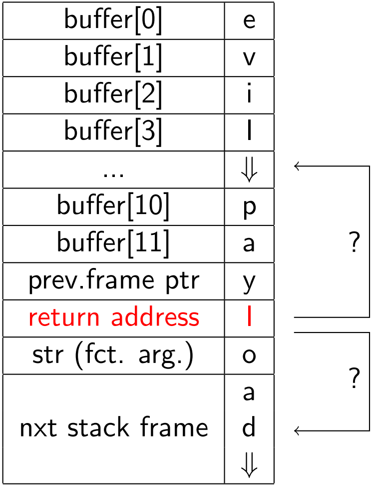
(a) A code example




(b) Active Stack Frame in func()

http://www.cis.syr.edu/~wedu/seed/Labs_12.04/Software/Buffer_Overflow/Buffer_Overflow.pdf

# What happens on overflow



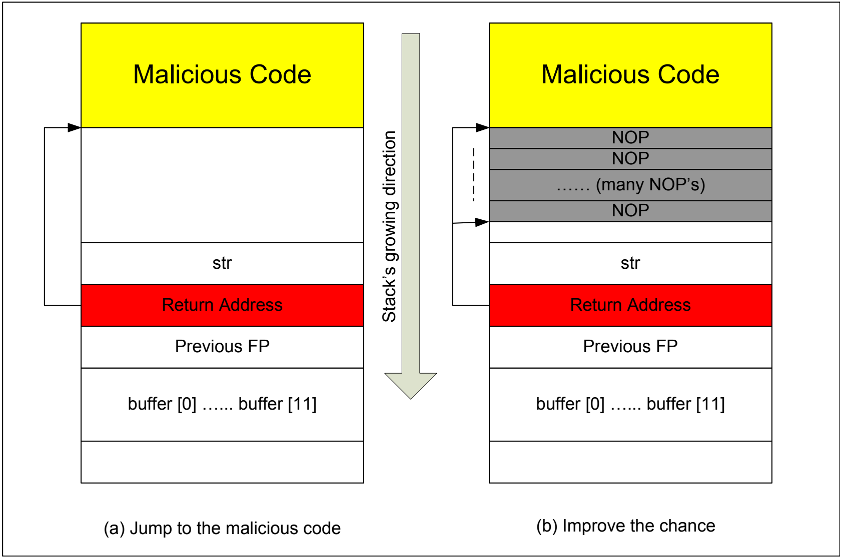

return address slot overwritten

on function return, execution jumps wherever that points to

For *successful* exploit, must know:
1) position of return address slot *relative* to buffer start:
i.e., buffer size and stack layout (calling convention)

2) *absolute* memory address of buffer (to fill in proper payload address)

# Exploit: improving chances




http://www.cis.syr.edu/~wedu/seed/Labs_12.04/Software/Buffer_Overflow/Buffer_Overflow.pdf

# Steps to successful exploit

Let's revisit exploit assumptions:

- can determine *where* to inject payload (*address*)
- can *overwrite* return address
- tampering is *not detected*
- can *execute* payload code

# How to protect?

Option: make it difficult to find attack point (address)

Attacker must know *what address* to jump to:

Address Space Layout Randomization

What flexibility does the attacker code have?
Is attack still realistic? For 32-bit vs. 64-bit ?

# How to protect?

Option: detect change

check if RET address altered *before* function return

Two basic ideas:

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Option: detect change
  check if RET address altered *before* function return

Two basic ideas:
Check return address itself $\Rightarrow$ need copy of correct value
Check bytes next to (before) ret address $\Rightarrow$ canaries
    terminator canary: 0, CR, LF, EOF
    random canary (don't know $\Rightarrow$ can't put back)
    random XOR canary (must also know control value)

Who/how/when implements these checks?

# How to protect?

Option: hamper execution

Attacker must execute injected code:
Non-executable stack / write XOR execute

# Advanced attacks: return-into-libc

If you can't execute code on stack, try something else

Typical attack is to call `exec` or some other library function
⇒ instead of *executing code* (`call exec`), put address (and parameters) of libc function on stack, in place of normal ret address

Which protections are effective?

Can chain attacks – put multiple library addresses on stack

Generalize: return-oriented programming

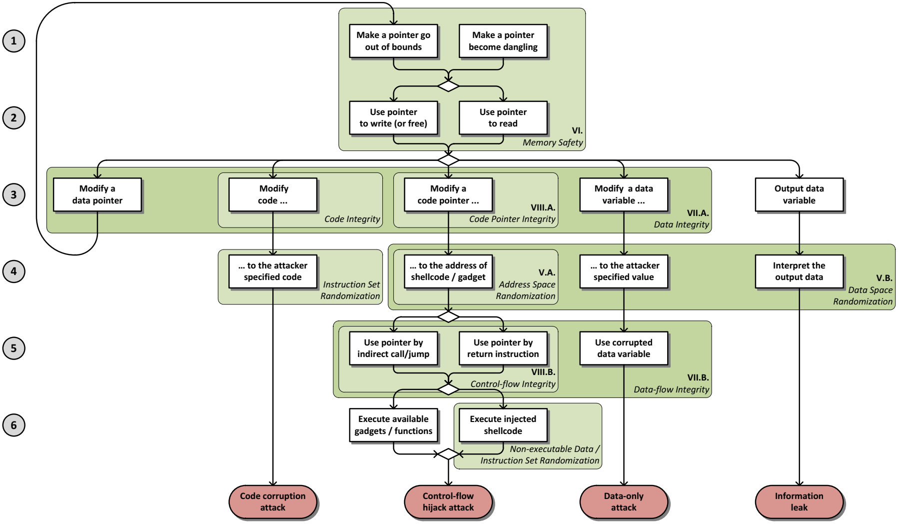
# Overwriting a pointer

Function pointers (denote code)
- pointers from `longjmp`
- pointers to user functions
- pointers to library functions (PLT: procedure linkage table)

or usual pointers to data

Attacks might be in two steps:
- a buffer overflow overwrites a pointer (to desired address)
- in later code, this is used to overwrite critical area
  - ret address, PLT, etc.

# Software security: memory vulnerabilities




Szekeres, Payer, Wei, Song. SoK: Eternal War in Memory, IEEE S&P 2013