Avoiding exploitation

Other defensive strategies

Until C is memory safe, what can we do?

Make the bug harder to exploit

- Examine necessary steps for exploitation, make one or more of them difficult, or impossible

Avoid the bug entirely

- Secure coding practices
- Advanced code review and testing
  - E.g., program analysis, penetrating testing (fuzzing)

Strategies are **complementary**: Try to **avoid bugs**, *but* **add protection** if some slip through the cracks

Avoiding exploitation

Recall the steps of a stack smashing attack:

- Putting attacker code into the memory (no zeroes)
- Getting `%eip` to point to (and run) attacker code
- Finding the return address (guess the raw addr)

How can we make these attack steps more difficult?

- **Best case**: Complicate exploitation by changing the the **libraries**, **compiler** and/or **operating system**
  - Then we don’t have to change the application code
  - *Fix is in the architectural design, not the code*

Detecting overflows with canaries

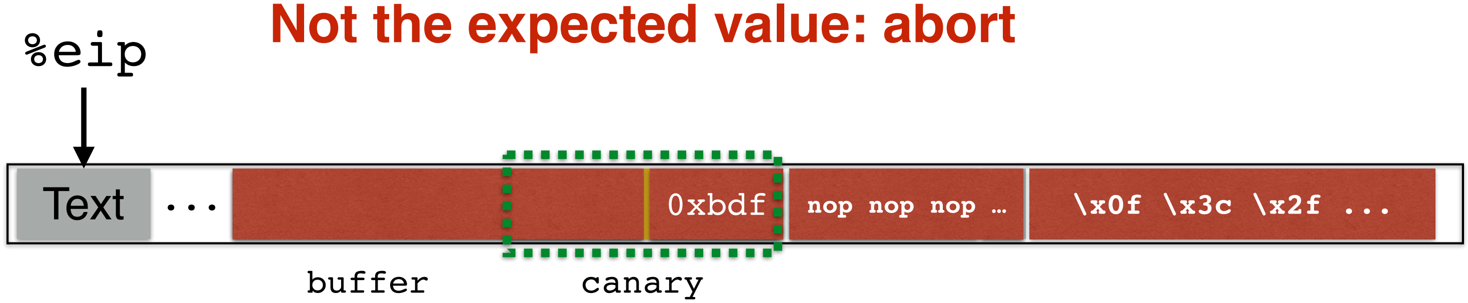
19th century coal mine integrity

- Is the mine safe?
- Dunno; bring in a canary
- If it dies, abort!

We can do the same for stack integrity

Detecting overflows with canaries

Not the expected value: abort



What value should the canary have?

Canary values

From StackGuard [Wagle & Cowan]

1. Terminator canaries (CR, LF, NUL (i.e., 0), -1)
   - Leverages the fact that scanf etc. don't allow these
2. Random canaries
   - Write a new random value @ each process start
   - Save the real value somewhere in memory
   - Must write-protect the stored value
3. Random XOR canaries
   - Same as random canaries
   - But store canary XOR some control info, instead

Recall our challenges

- Putting code into the memory (no zeroes)
    - **Defense**: Make this detectable with **canaries**

- Getting %eip to point to (and run) attacker code

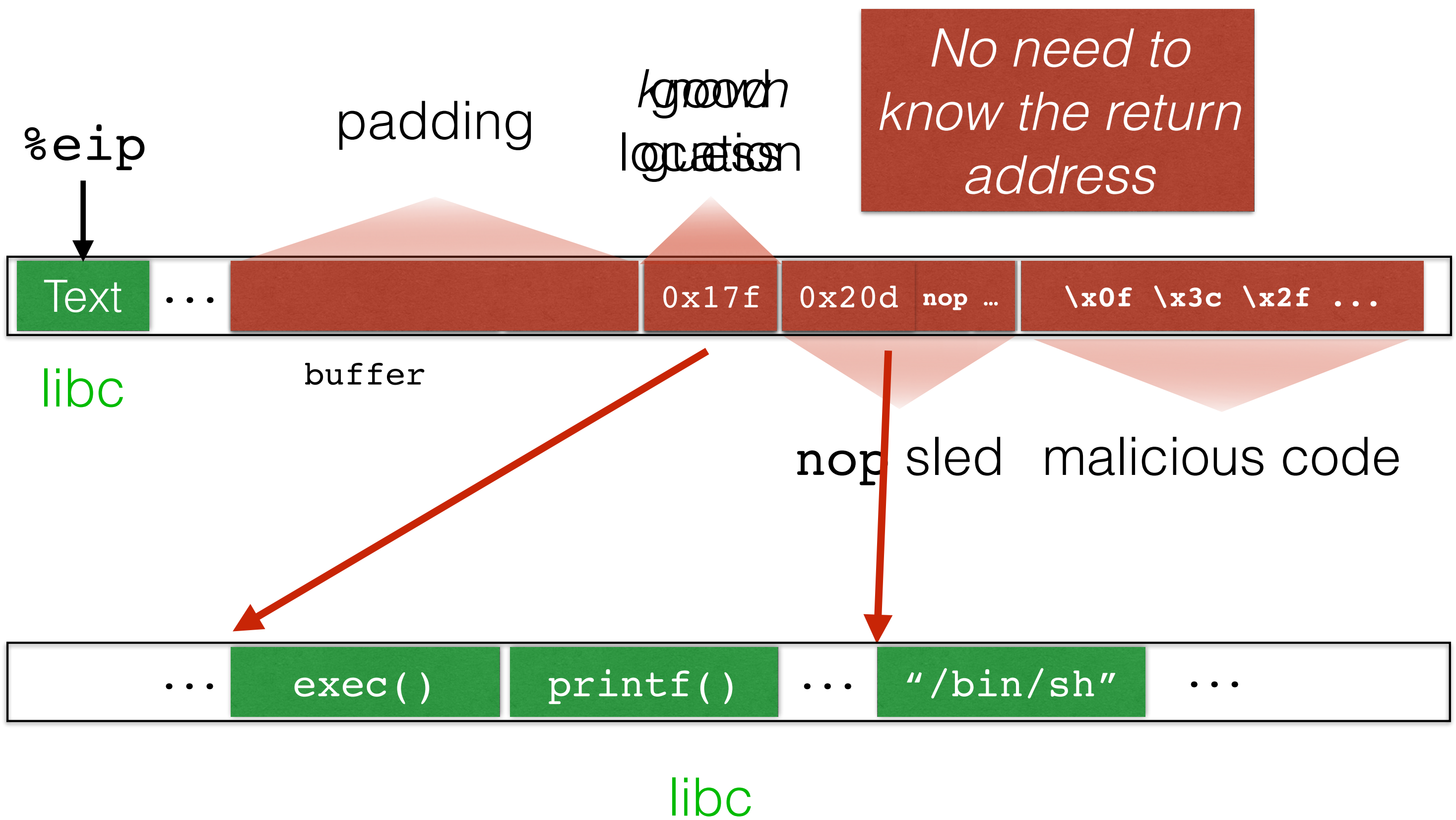
- Finding the return address (guess the raw addr)

Recall our challenges

- Putting code into the memory (no zeroes)
  - **Defense**: Make this detectable with **canaries**
- Getting %eip to point to (and run) attacker code
  - **Defense**: **Make stack (and heap) non-executable**
- Finding the [obscured] raw addr)

So: even if canaries could be bypassed, no code loaded by the attacker can be executed (will panic)

Return-to-libc



Recall our challenges

- Putting code into the memory (no zeroes)
  - Defense: Make this detectable with canaries

- Getting %eip to point to (and run) attacker code
  - Defense: Make stack (and heap) non-executable
  - **Defense**: **Use Address-space Layout Randomization**

Randomly place standard libraries and other elements in memory, making them harder to guess

- Finding t addr)

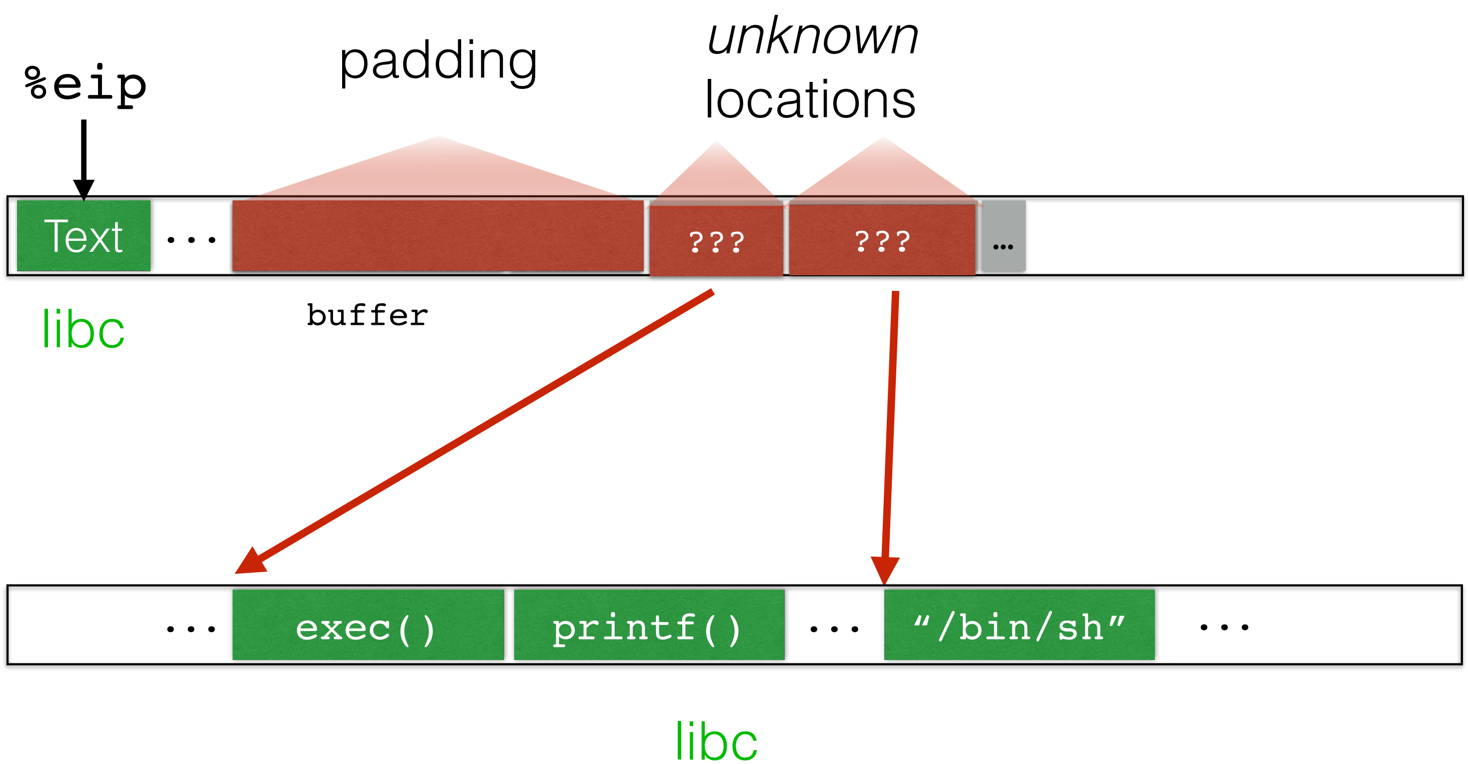
Recall our challenges

- Putting code into the memory (no zeroes)
  - Defense: Make this detectable with canaries

- Getting %eip to point to (and run) attacker code
  - Defense: Make stack (and heap) non-executable
  - Defense: Use Address Space Layout Randomization

- Finding the return address (guess the raw addr)
  - **Defense**: **Use Address-space Layout Randomization**

Return-to-libc, thwarted



ASLR today

- **Available on modern operating systems**
  - Available on Linux in 2004, and adoption on other systems came slowly afterwards; **most by 2011**
- Caveats:
  - **Only shifts the offset** of memory areas
    - Not locations within those areas
  - **May not apply to program code**, just libraries
  - **Need sufficient randomness**, or can brute force
    - 32-bit systems typically offer 16 bits = 65536 possible starting positions; sometimes 20 bits. Shacham demonstrated a brute force attack could defeat such randomness in 216 seconds (on 2004 hardware)
    - **64-bit systems more promising**, e.g., 40 bits possible