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# Systems Security

## COMSM1500

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# Buffer overflow

Continued…

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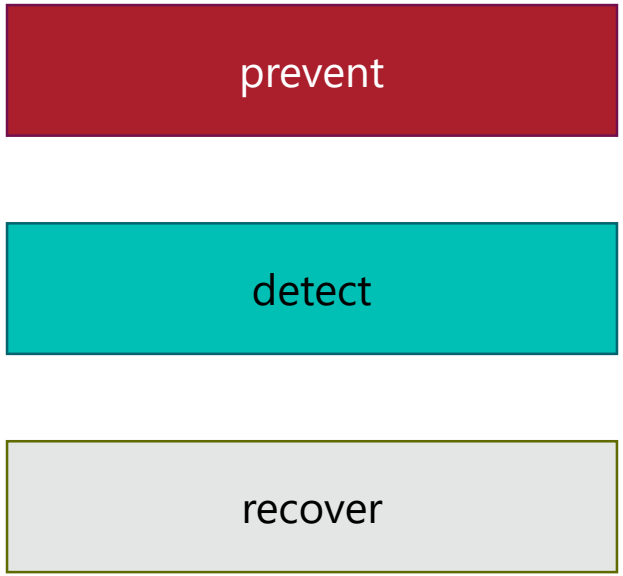
# countermeasures



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# Detecting

## Buffer overflow

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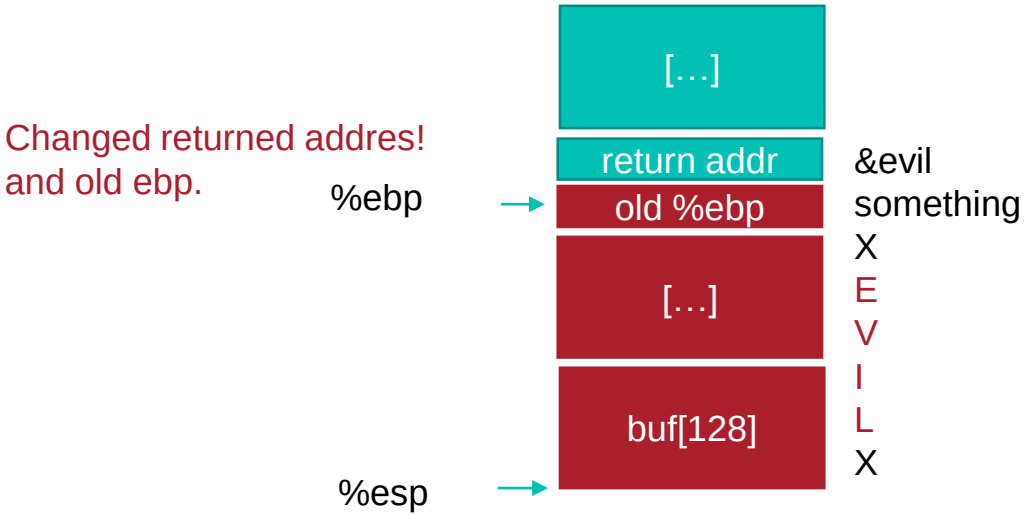
# Example

```
int read_get(void) {
  char buf[128];
  int i;
  gets(buf);
  i = atoi(buf);
  return I;
}

int main() {
  x = read_get();
  printf("%s", x);
}
```



# Buffer overflow exploit

- Gaining control over the instruction pointer
  - i.e. changing return address
  - control what will be executed
- Make that pointer points to malicious code
  - embedding code (e.g. shell code last time)
  - jumping to unexpected part of code (i.e. open door)
- Gain control over stack pointer
  - i.e. control data

# Stack canaries

- Let attacker overwrite stack

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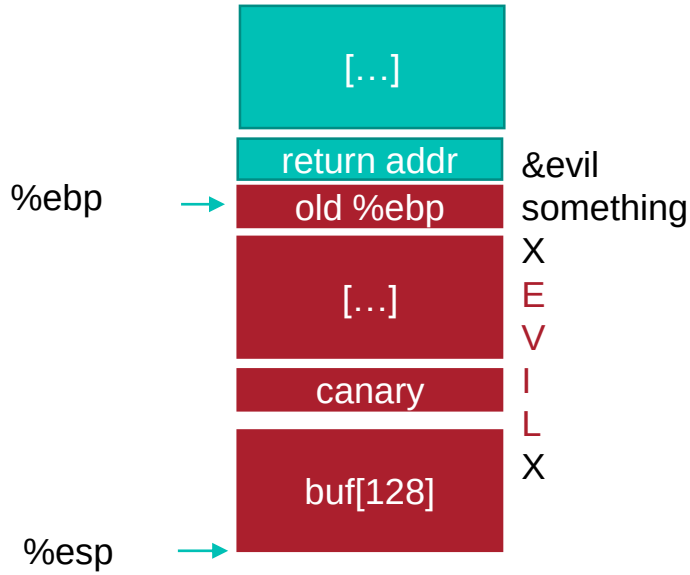
- Let attacker overwrite stack
- Before return
  - Check the value of the canary
  - If it changed something bad happened
  - Compiler support



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# Problem?

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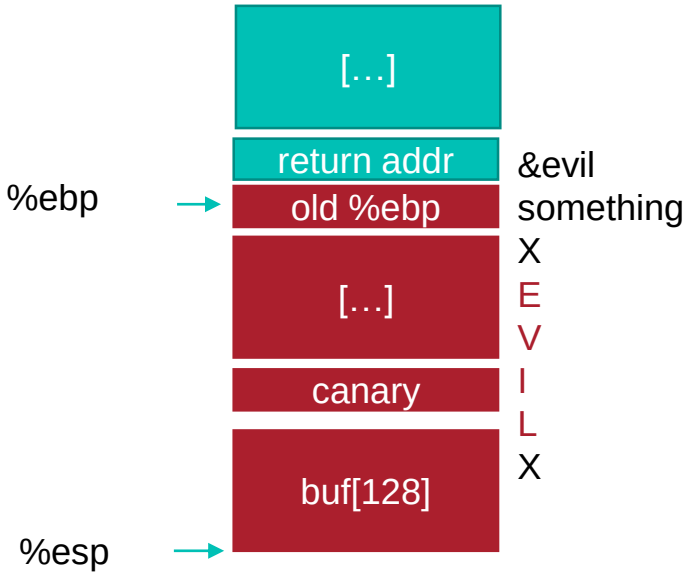
# Stack canaries

- Let attacker overwrite stack
- Before return
- Careful about canary value
  - if deterministic can be guessed and avoided



# Stack canaries

- Let attacker overwrite stack
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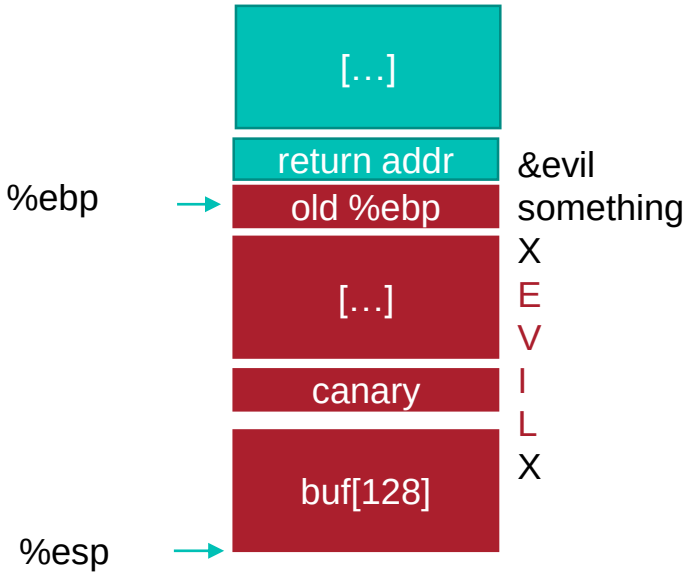
- Use some special characters
  - e.g. \0, EOF etc…
  - remember last week
  - would only work for some input functions



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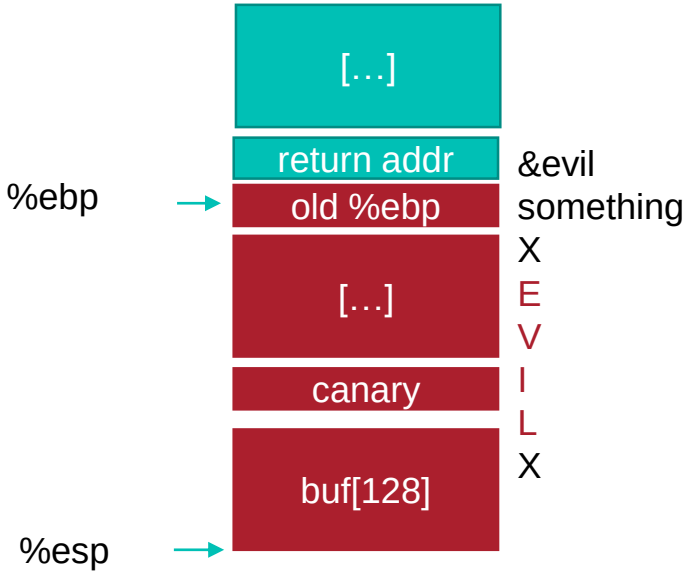
  - would only work for some input functions
- Use some random value
  - careful with entropy



# When do canaries fail?

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- When attacker overwrite function pointers
  - int *ptr = … ;
  - char buf[128];
  - gets(buff);
  - ptr(…);

# When do canaries fail?

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- Can attacker guess the randomness?
  - Source of randomness is a research topics on its own!

# When do canaries fail?

- When attacker overwrite function pointers
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- malloc and free (heap)
  - char *p, *q;
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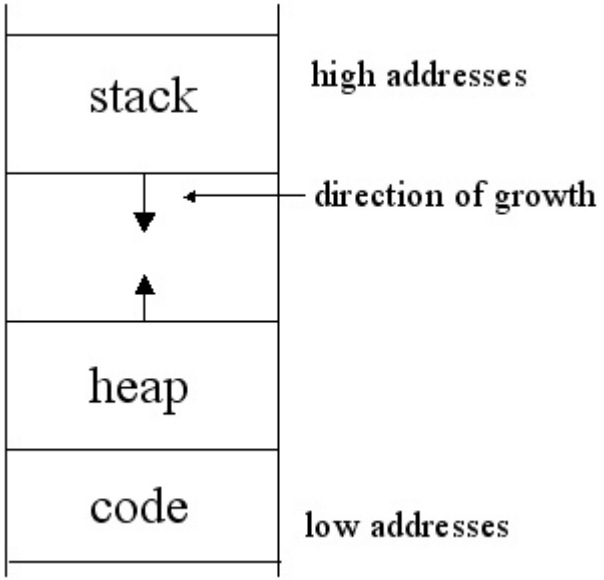

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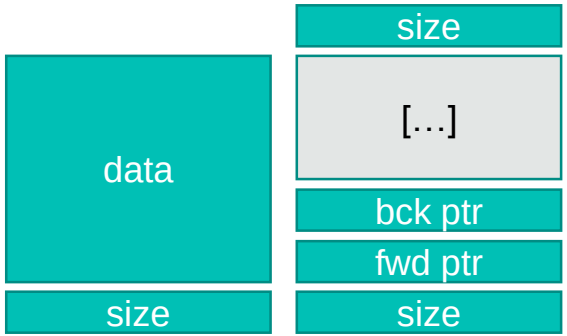


pointer and size for book keeping

# When do canaries fail?

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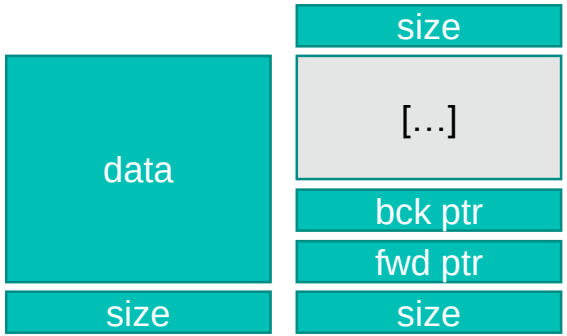


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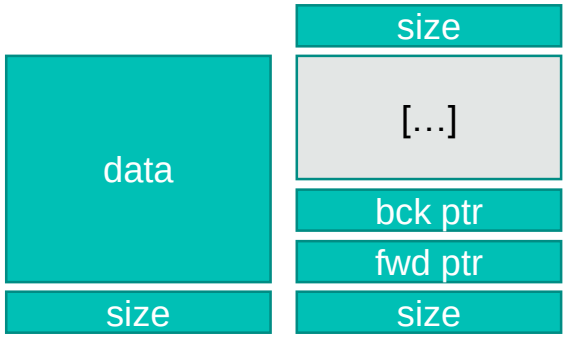


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# When do canaries fail?

Homework/exam question: Describe the canary technique to protect from buffer overflow exploits and discuss its limitation.

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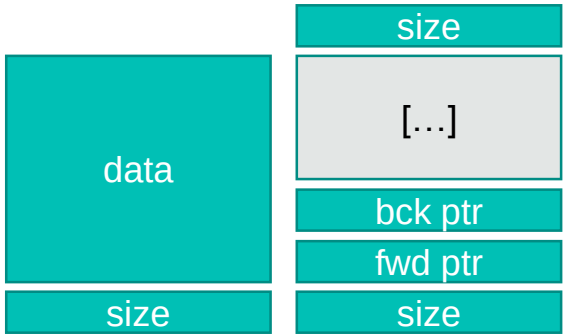


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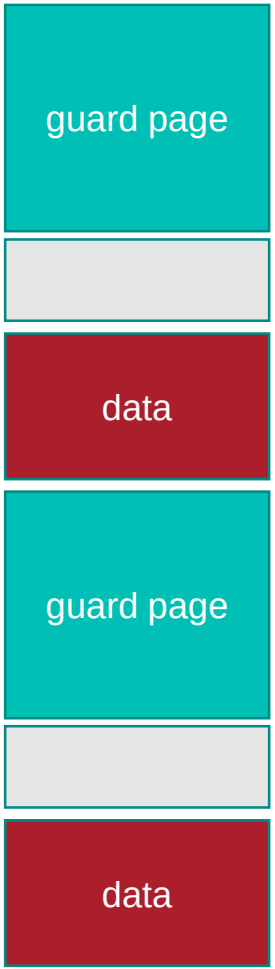
# Electric Fence

- Use guard page
  - Page with memory protection so that if touched, create a fault



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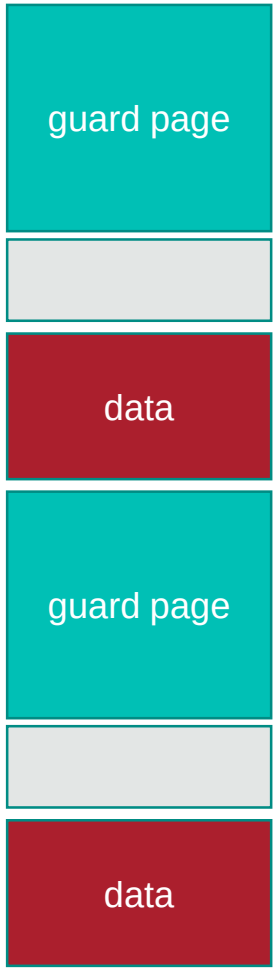
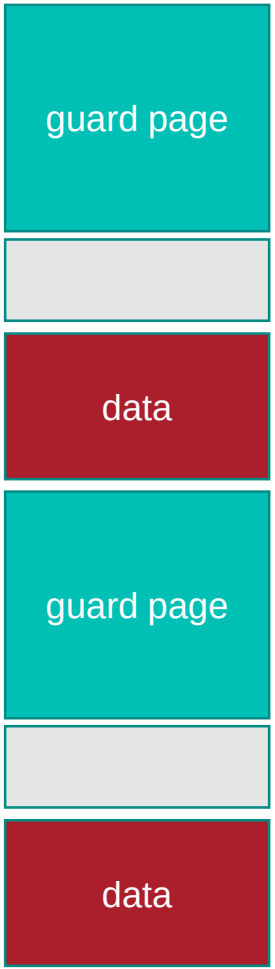


# Electric Fence

- Use guard page
  - Page with memory protection so that if touched, create a fault
- Fault immediate
- No extra code check
- What may be the problem?



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- Very memory inefficient
- Work only across pages
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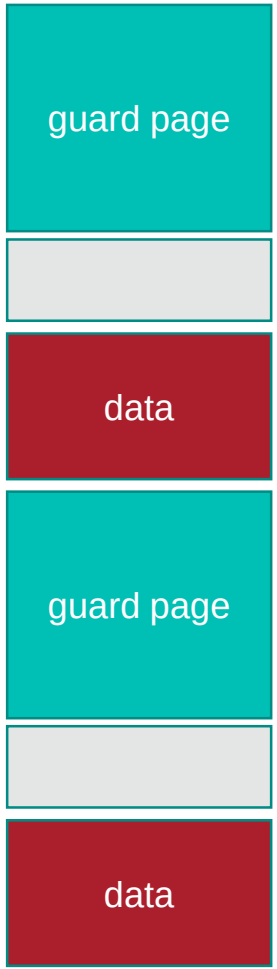

# Electric Fence

Homework/exam question: Describe the page guard technique to protect from buffer overflow exploits.

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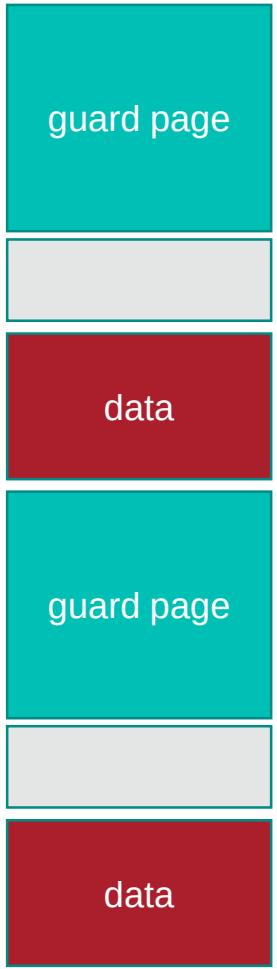

# Bounds checking

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Requires compiler support: issue with legacy libraries

# Bounds checking

Homework/exam question:
Describe bound checking techniques to protect from buffer overflow vulnerabilities.

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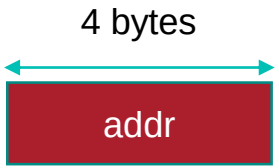
# Fat address

- 32 bits address

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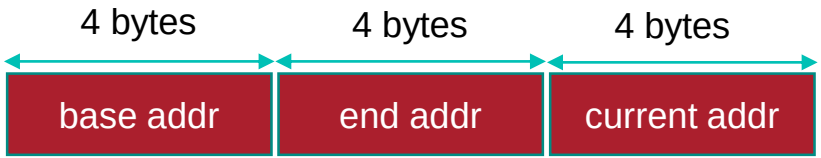

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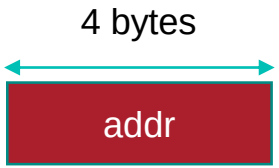


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int *ptr = malloc(8);
While(1) {
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   ptr++;
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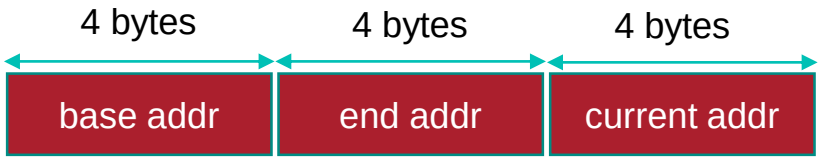
- fat address



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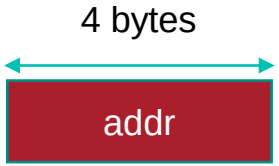


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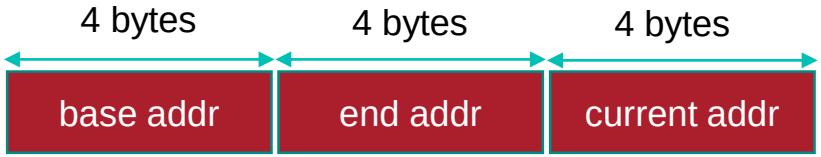


Need to instrument code
i.e. compiler support

Problem with external library
Non-atomic

# Fat address

Homework/exam question:
Describe fat addresses techniques to protect from buffer overflow vulnerabilities.

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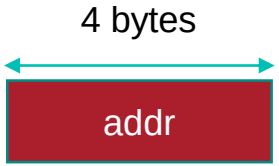


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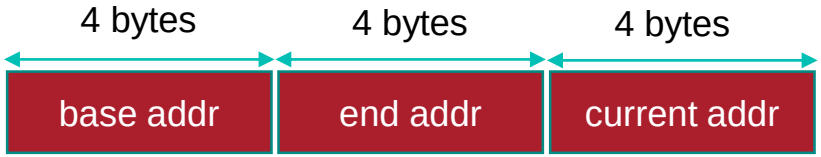


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# Worms

… and a bit of history

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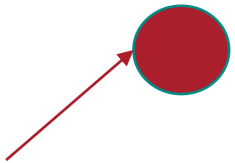

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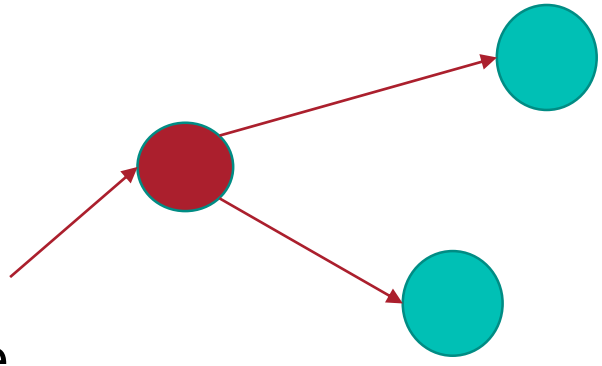
- Send payload to compromise other machines



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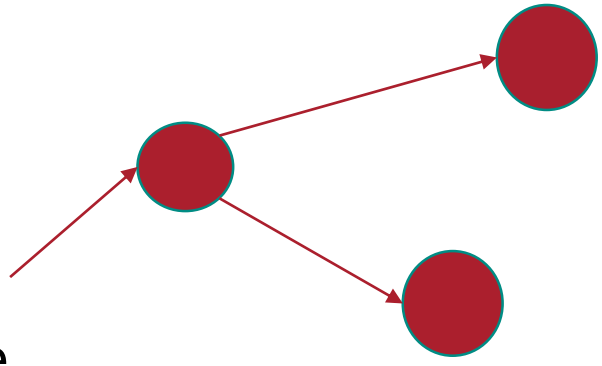

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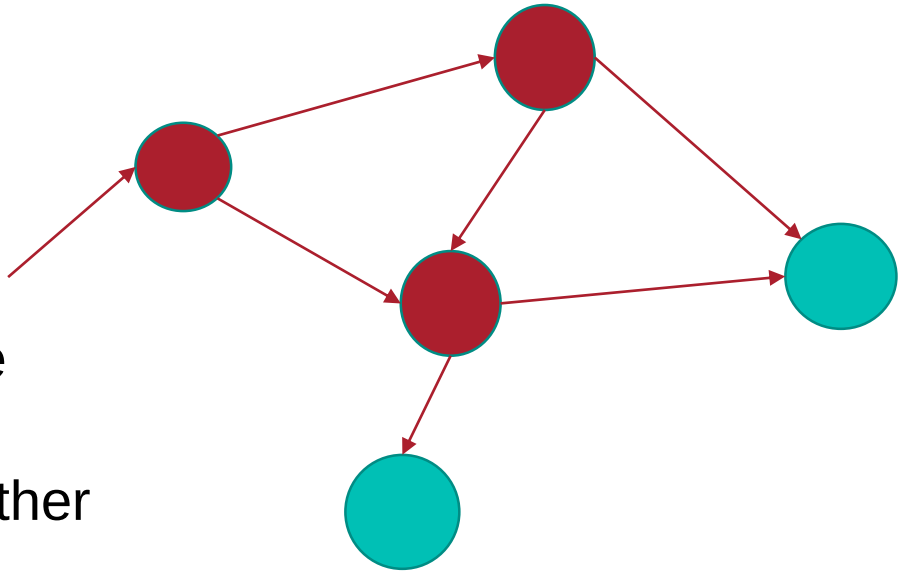
- Repeat



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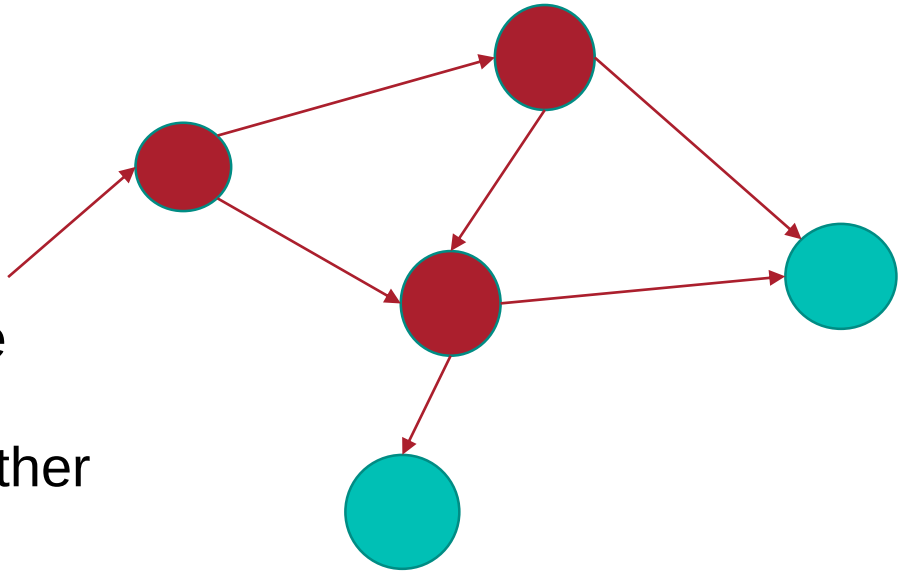
- Stated purpose “mapping” the internet



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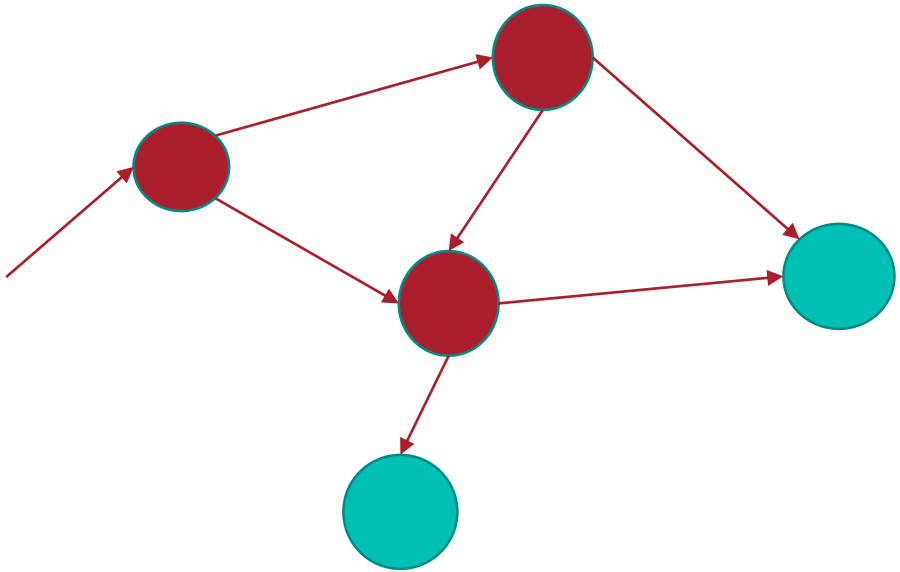
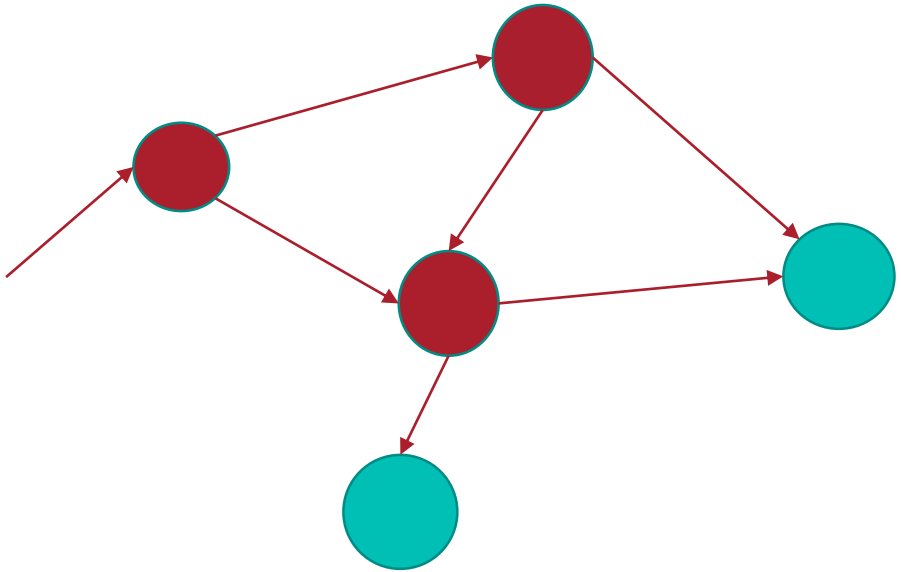
- Worm could test if a copy was already there by asking



# Morris Worm 1988

- Worm could test if a copy was already there by asking
  - Countermeasure?



# Morris Worm 1988

- Worm could test if a copy was already there by asking
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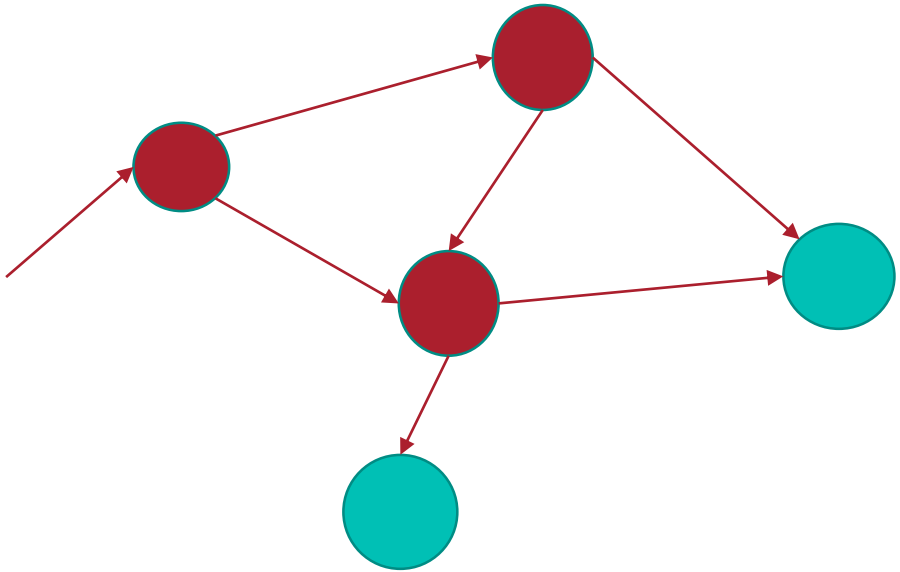
  - Simply say yes



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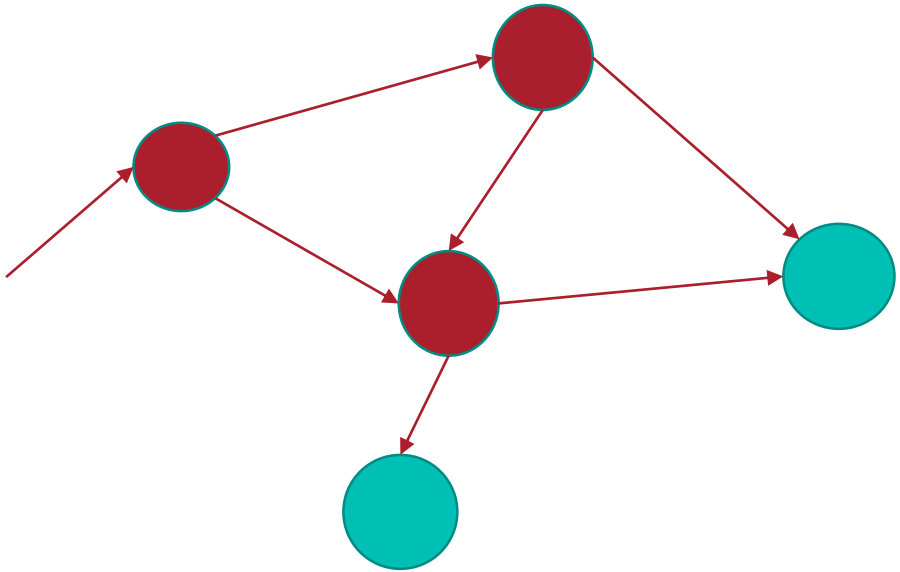

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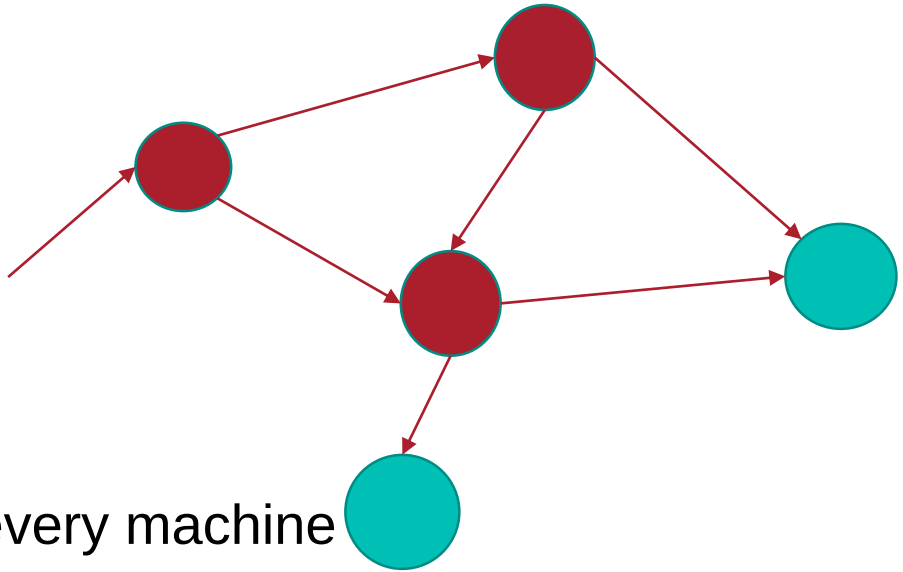
- Machine running to a crawl



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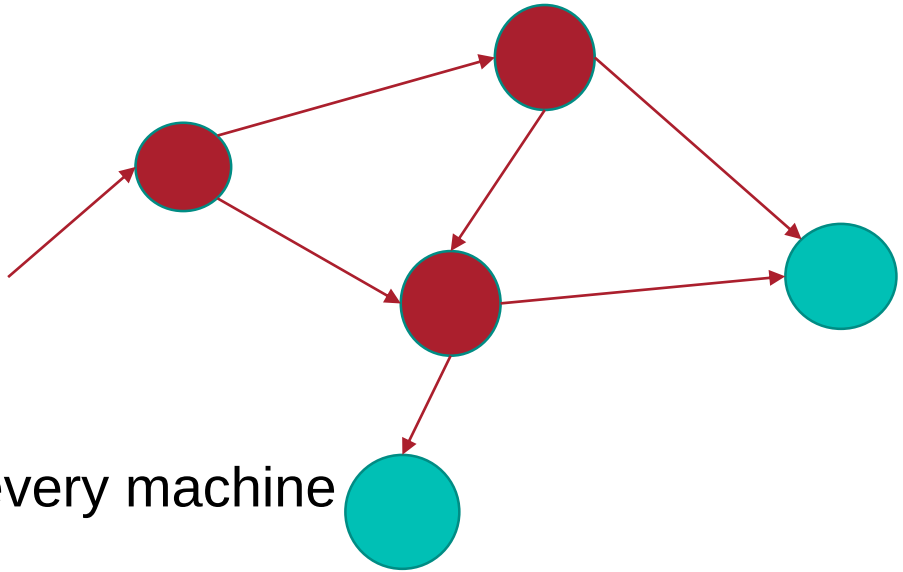
- Take down a machine to clean it
- Get infected again instantly



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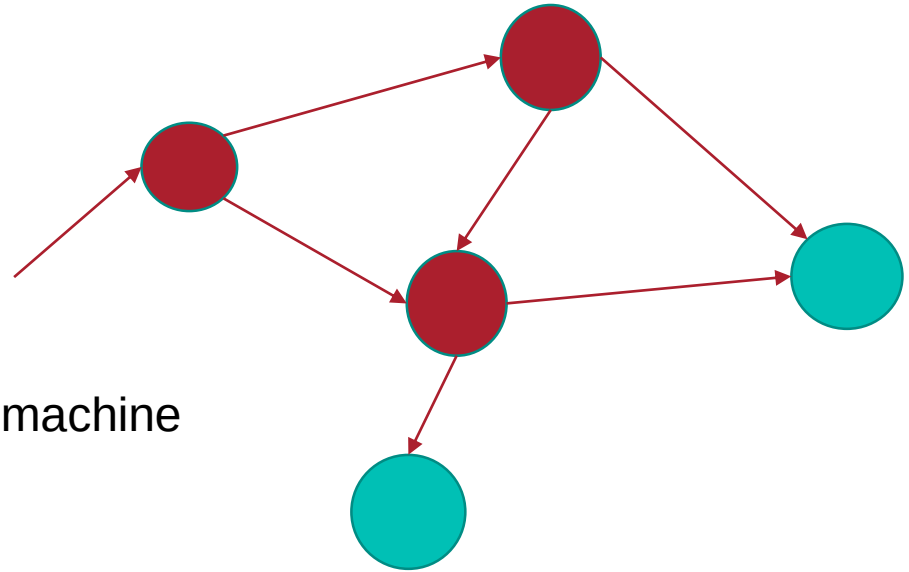

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  - Countermeasure?
  - Simply say yes
  - Copy anyway 1/7 time
- Results thousands process on every machine
- Machine running to a crawl
- Take down a machine to clean it
- Get reinfected instantly
- Required a coordinated effort to “clean” the internet
- Largest denial of service attack

# Blaster

- 2003 – Affect Windows 2000/XP Machines
- Exploit buffer overflow vulnerability on Remote Procedure Call
  - Get a shell with “admin” privilege
  - To download payload via ftp
  - And install it

# Blaster

- 2003 – Affect Windows 2000/XP Machines
- Exploit buffer overflow vulnerability on Remote Procedure Call
- Aim to remain undetected
  - No more thousands processes
  - Check existence of a mutex (“BILLY”)
- Infect other random machine on the network
- Variant A – start a thread to DDOS Microsoft update

# Blaster

- 2003 – Affect Windows 2000/XP Machines
- Exploit buffer overflow vulnerability on Remote Procedure Call
- Aim to remain undetected
- Infect other random machine on the network
- Variant A – start a thread to DDOS Microsoft update
- Contains two messages
  - I just want to say LOVE YOU SAN!!
  - billy gates why do you make this possible ? Stop making money and fix your software!!

# Blaster

- 2003 – Affect Windows 2000/XP Machines
- Exploit buffer overflow vulnerability on Remote Procedure Call
- Aim to remain undetected
- Infect other random machine on the network
- Variant A – start a thread to DDOS Microsoft update
- Later variant caused system to reboot every 60 seconds

# Other buffer overflow example

- Twilight Hack (Wii)
  - Buffer Overflow on Legend of Zelda: Twilight Princess
  - When reading save files
  - Used to install pirated games

# Buffer overflow in 2019? (just one of many)

## CVE-2019-10164 Detail

MODIFIED

This vulnerability has been modified since it was last analyzed by the NVD. It is awaiting reanalysis which may result in further changes to the information provided.

## Current Description

PostgreSQL versions 10.x before 10.9 and versions 11.x before 11.4 are vulnerable to a stack-based buffer overflow. Any authenticated user can overflow a stack-based buffer by changing the user's own password to a purpose-crafted value. This often suffices to execute arbitrary code as the PostgreSQL operating system account.

# Buffer overflow in 2019? (just one of many)

Homework/exam question:
Buffer overflow attacks have been known for decade. Yet they occur. Discuss.

## CVE-2019-10164 Detail

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University of BRISTOL

# Thank you

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