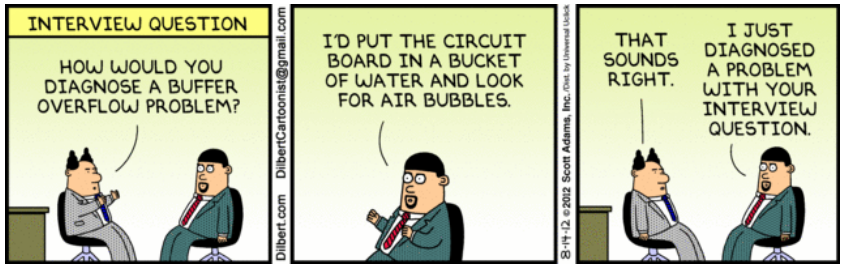
Buffer overflows (a security interlude)

Address space layout

the stack discipline

+ C's lack of bounds-checking

HUGE PROBLEM



String Library Code

C standard libray function **`gets()`**

```
/* Get string from stdin */
char* gets(char* dest) {
    int c = getchar();
    char* p = dest;
    while (c != EOF && c != '\n') {
        *p++ = c;
        c = getchar();
    }
    *p = '\0';
    return dest;
}
```

pointer to start of an array

same as:

```
*p = c;
p = p + 1;
```

What could go wrong in this code?

Same problem in many functions:

`strcpy`: Copies string of arbitrary length

`scanf`, **`fscanf`**, **`sscanf`**, when given **`%s`** conversion specification

Vulnerable Buffer Code

```
/* Echo Line */
void echo() {
    char buf[4];  /* Way too small! */
    gets(buf);
    puts(buf);
}
```

```
int main() {
  printf("Type a string:");
  echo();
  return 0;
}
```

```
$ ./bufdemo
Type a string:1234567
1234567
```

```
$ ./bufdemo
Type a string:12345678
Segmentation Fault
```

```
$ ./bufdemo
Type a string:123456789ABC
Segmentation Fault
```


Buffer Overflow Disassembly

echo code

```
00000000004006cf <echo>:
 4006cf:  48 83 ec 18           sub    $0x24,%rsp
 4006d3:  48 89 e7              mov    %rsp,%rdi
 4006d6:  e8 a5 ff ff ff        callq  400680 <gets>
 4006db:  48 89 e7              mov    %rsp,%rdi
 4006de:  e8 3d fe ff ff        callq  400520 <puts@plt>
 4006e3:  48 83 c4 18           add    $0x24,%rsp
 4006e7:  c3                    retq
```

caller code

```
4006e8:   48 83 ec 08          sub    $0x8,%rsp
 4006ec:  b8 00 00 00 00       mov    $0x0,%eax
 4006f1:  e8 d9 ff ff ff       callq  4006cf <echo>
 4006f6:  48 83 c4 08          add    $0x8,%rsp
 4006fa:  c3                   retq
```

Buffer Overflow Stack Example

Before call to gets

Stack frame for `call_echo`

00	00	00	00	Return Address
00	40	06	f6	
20 bytes unused				
[3]	[2]	[1]	[0]	buf ⟵ %rsp

```
void echo() {
    char buf[4];
    gets(buf);
    . . .
}
```

```
echo:
  subq  $24, %rsp
  movq  %rsp, %rdi
  call  gets
  . . .
```

call_echo:

```
  . . .
4006f1:  callq  4006cf <echo>
4006f6:  add    $0x8,%rsp
  . . .
```


Buffer Overflow Stack Example #3

After call to gets

Stack frame for `call_echo`

00	00	00	00	Return Address
00	40	06	**00**	
33	32	31	30	
39	38	37	36	
35	34	33	32	
31	30	39	38	
37	36	35	34	
33	32	31	30	buf ⟵ %rsp

```
void echo()
{
    char buf[4];
    gets(buf);
    . . .
}
```

```
echo:
  subq  $24, %rsp
  movq  %rsp, %rdi
  call  gets
  . . .
```

call_echo:

```
  . . .
4006f1:  callq  4006cf <echo>
4006f6:  add    $0x8,%rsp
  . . .
```

```
unix> ./bufdemo-nsp
Type a string: 012345678901234567890123
012345678901234567890123
```

Overflowed buffer, corrupted return pointer, but program seems to work!

Buffer Overflow Stack Example #3 Explained

After call to gets

Stack frame for `call_echo`

00	00	00	00	Return Address
00	40	06	**00**	
33	32	31	30	
39	38	37	36	
35	34	33	32	
31	30	39	38	
37	36	35	34	
33	32	31	30	buf ⟵ %rsp

Some other place in .text

```
  . . .
400600:  mov    %rsp,%rbp
400603:  mov    %rax,%rdx
400606:  shr    $0x3f,%rdx
40060a:  add    %rdx,%rax
40060d:  sar    %rax
400610:  jne    400614
400612:  pop    %rbp
400613:  retq
```

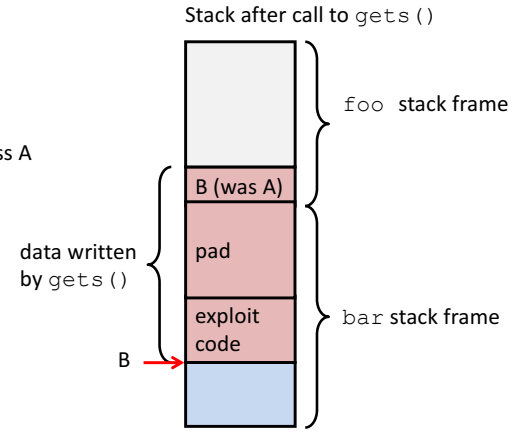
"Returns" to unrelated code
Lots of things happen, without modifying critical state
Eventually executes `retq` back to `main`

Malicious Use of Buffer Overflow

```
void foo(){
  bar();
  ...
}
```

return address A

```
int bar() {
  char buf[64];
  gets(buf);
  ...
  return ...;
}
```



Input string contains byte representation of executable code
Overwrite return address A with address of buffer (need to know B)
When `bar()` executes `ret`, will jump to exploit code (instead of A)