Lec 5: Trusting Trust

CS492E: Introduction to Software Security

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Why Binary?

Binary vs. Source Code

Given both binary and source code of a program, which one do you need to analyze if you want to know the program is ***safe*** to run?

1. Source code
2. Binary code

Source Code is Not Always Available

- Malware
- Commercial software
- Etc.

What about open-sourced programs?

Fun Fact

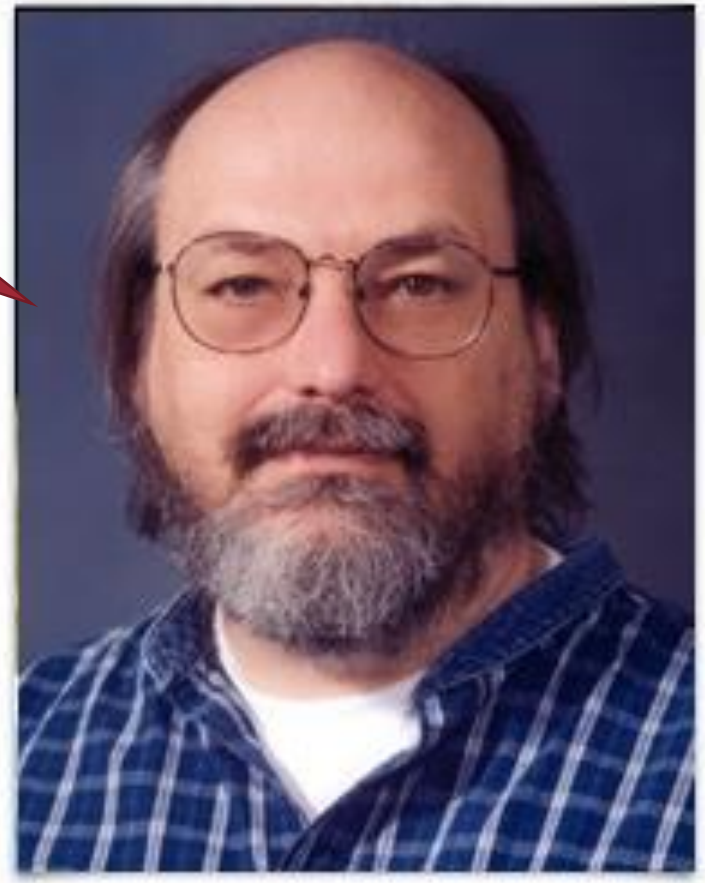
Security experts often analyze binaries even though they possess source code.

Why?

Key Question

You are given the entire source code of an app, can you find all possible vulnerabilities in the app by analyzing its source code?

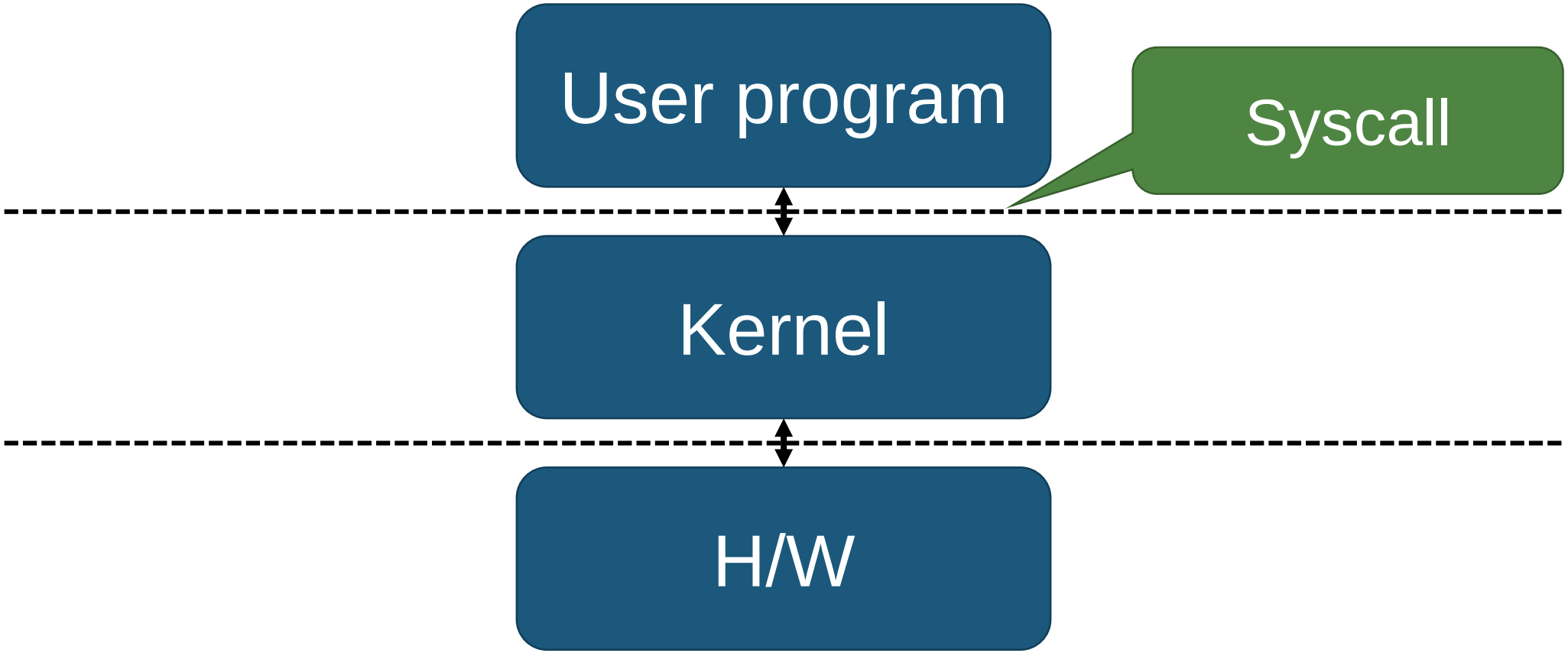
The answer is NO!



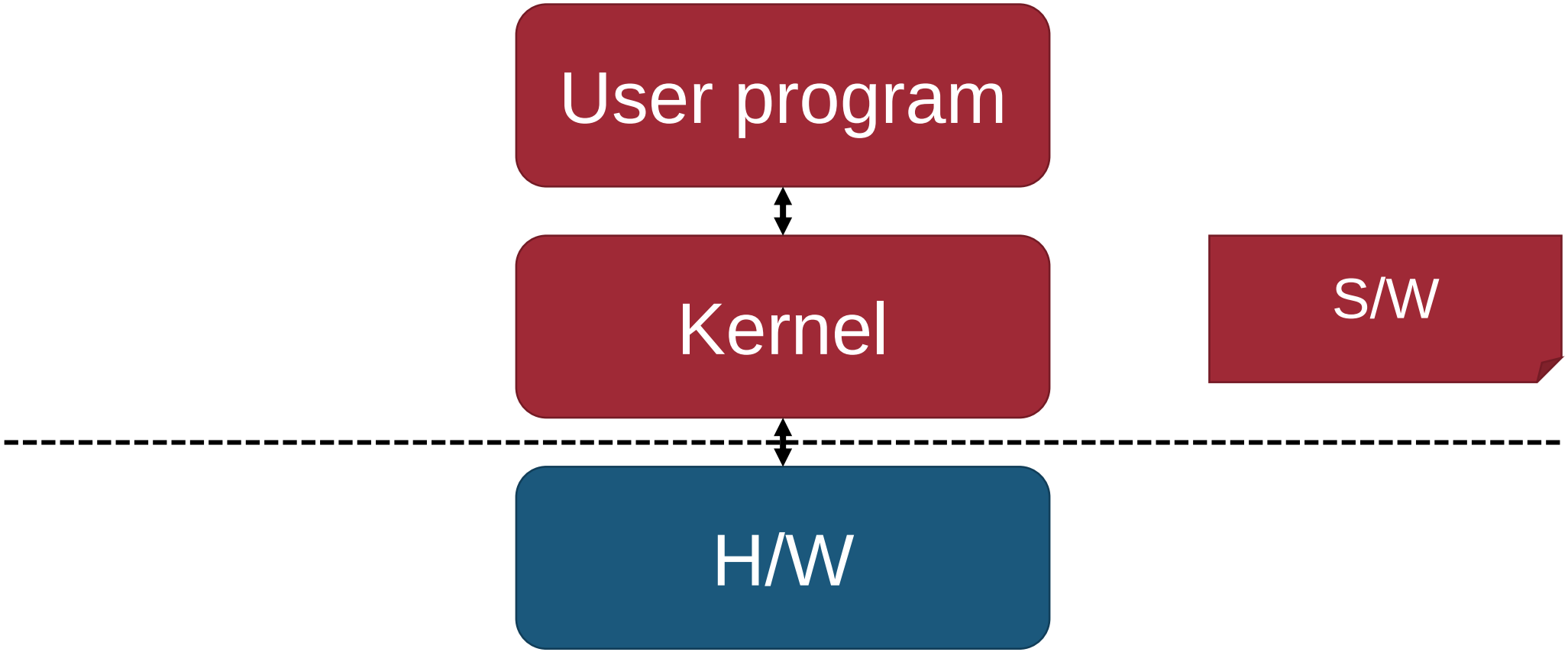
Ken Thompson
Reflections on Trusting Trust
CACM 1984

Trusting Trust

Trust Boundary



Trust Boundary



Software Security = Distrusting S/W

- You cannot trust code that you did not totally create yourself
- No amount of source-level verification or scrutiny will protect you from using untrusted code!

Stage 1: Self-Reproducing Program (a.k.a. Quine)

```
char s[ ] = {
        '\t',
        '0',
        '\n',
        '}',
        ';',
        '\n',
        '\n',
        '/',
        '*',
        '\n',
        (213 lines deleted)
        0
};
```

```
/*
 * The string s is a
 * representation of the body
 * of this program from '0'
 * to the end.
 */

main( )
{
        int i;

        printf("char\ts[ ] = {\n");
        for(i=0; s[i]; i++)
                printf("\t%d, \n", s[i]);
        printf("%s", s);
}
```

Stage 2: C Compiler in C

```
...
c = next( );
if(c != '\\')
        return(c);
c = next( );
if(c == '\\')
        return('\\');
if(c == 'n')
        return('\n');
...
```

```
...
c = next( );
if(c != '\\')
        return(c);
c = next( );
if(c == '\\')
        return('\\');
if(c == 'n')
        return('\n');
if(c == 'v')
        return('\v');
...
```

```
...
c = next( );
if(c != '\\')
        return(c);
c = next( );
if(c == '\\')
        return('\\');
if(c == 'n')
        return('\ n');
if(c == 'v')
        return(11);
...
```

Stage 3: Trojan Horse

```
void compile(char *s)
{
  // ...
}
```

```
void compile(char *s)
{
  if(match(s, “login pattern”)) {
    compile(“login backdoor”);
    return;
  }
  // ...
}
```

Stage 3: Trojan Horse (2)

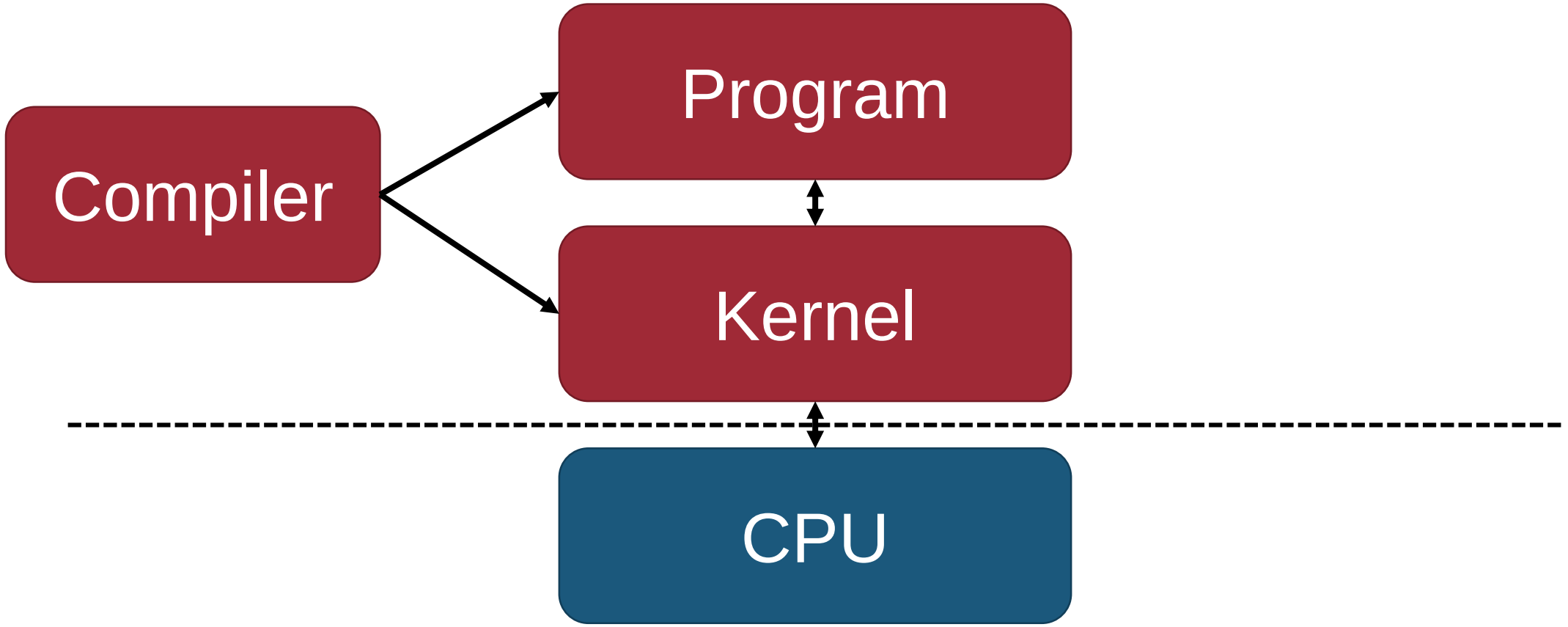
```
void compile(char *s)
{
  // ...
}
```

```
void compile(char *s)
{
  if(match(s, “login pattern”)) {
    compile(“login backdoor”);
    return;
  }
  if(match(s, “compiler pattern”)) {
    compile(“insert the backdoor”);
    return;
  }
  // ...
}
```

Self-Replicating Backdoor

This technique applies to ***any*** program-handling program such as an assembler, a loader, or hardware microcode, etc.

To What Extend Should We Trust?



What You See Is Not What You Execute*

```
#include <stdio.h>
int main (void)
{
  printf( “hi\n” );
}
```

```
01010101010111111010
10101010101010010001
00100100011111111010
11111010010101001010
00101101000101101000
01010010010100101111
11101010100000010100
10110000010000010111
```

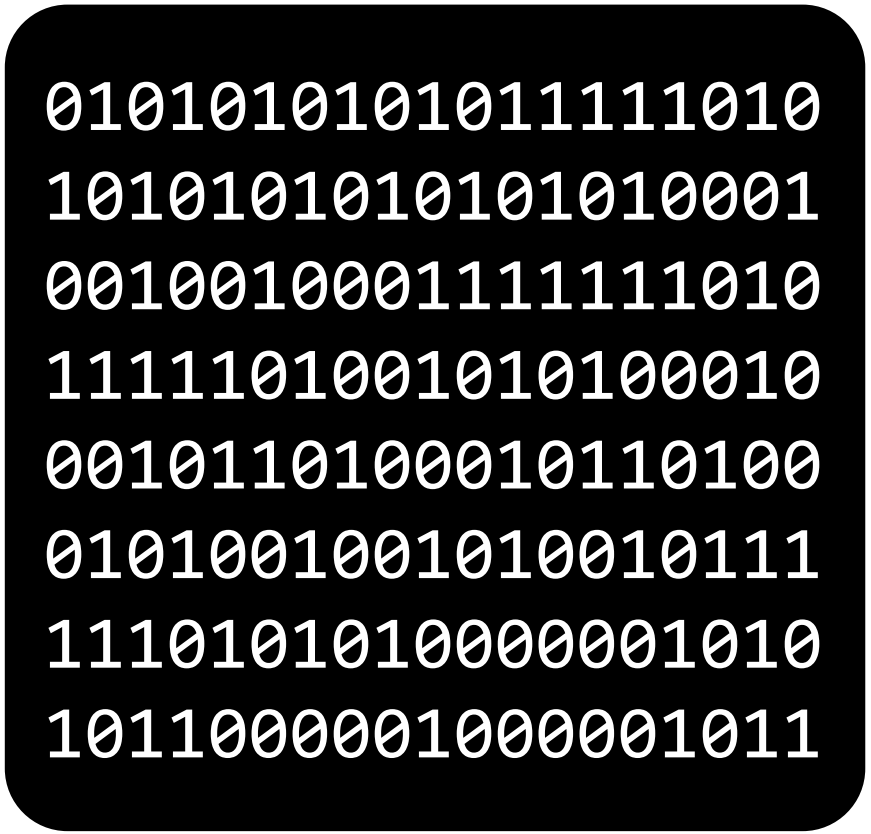
Source Code

Binary Code

* 2007 Gogul Balakrishnan, PhD Thesis

Binary Code Analysis is Essential

This is what we execute



Binary Code

Reverse Engineering

Semantics

```
01010101010111111010
10101010101010010001
00100100011111111010
11111010010101000010
00101101000101101000
01010010010100101111
11101010100000010100
10110000010000010111
```

Reverse Engineering

Read and analyze binaries and understand their semantics

Example Kernel Vulnerability

```
groups_per_flex = 1 << sbi->s_log_groups_per_flex;
if (groups_per_flex == 0) return 1;
flex_group_count = … / groups_per_flex;
```

When overflow?

Example Kernel Vulnerability

36?

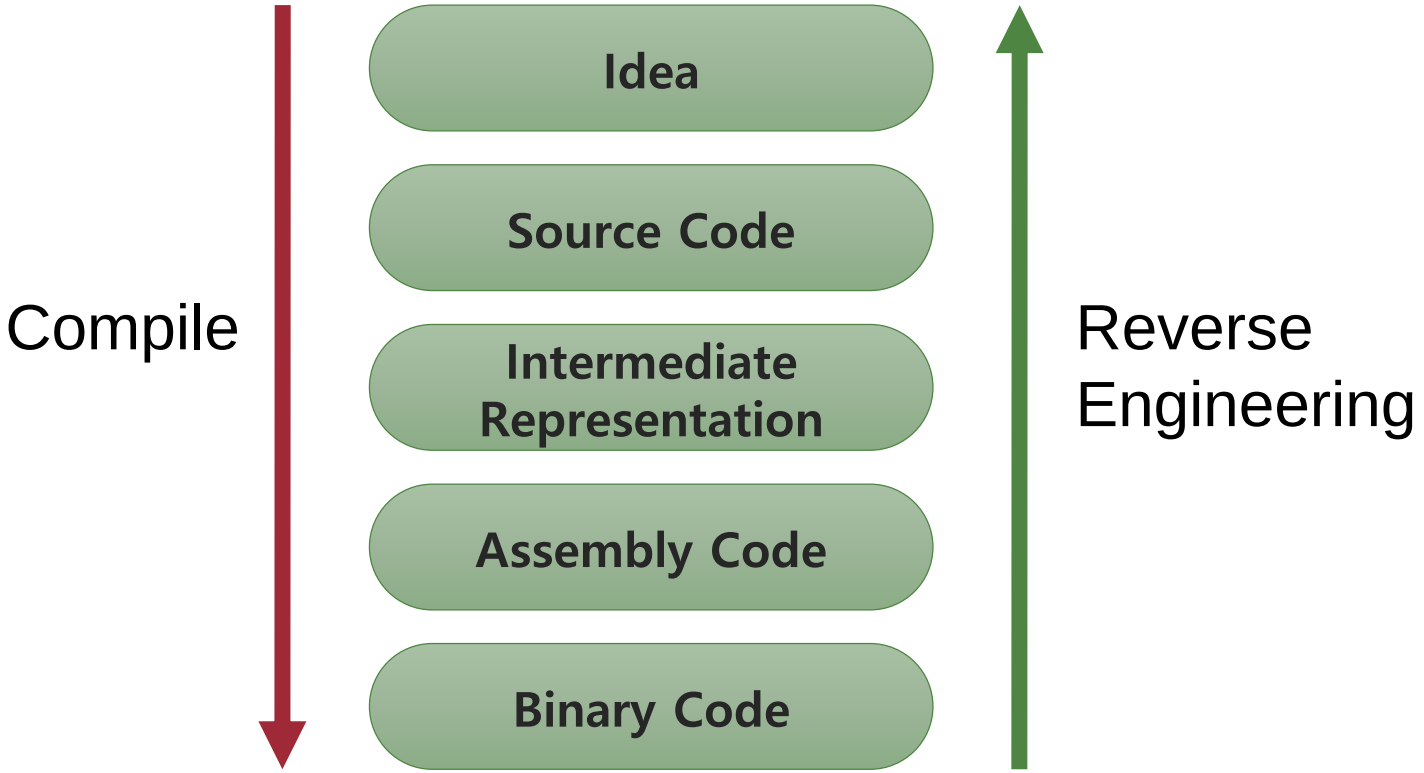
```
groups_per_flex = 1 << sbi->s_log_groups_per_flex;
if (groups_per_flex == 0) return 1;
flex_group_count = … / groups_per_flex;
```

On x86, 1 << 36 is equivalent to 1 << 4 = 16

On PPC, 1 << 36 is 0

Binary Analysis
= Software Security

Binary Analysis is Difficult



Why Difficult?

- Requires manual effort

- There's no ***program abstraction*** in binary code

```
4C 8B 47 08          mov         r8,qword ptr [rdi+8]
BA 02 00 00 00       mov         edx,2
48 8B 4F 20          mov         rcx,qword ptr [rdi+20h]
45 0F B7 08          movzx       r9d,word ptr [r8]
E8 54 16 00 00       call        00000001400026BC
48 8B 74 24 38       mov         rsi,qword ptr [rsp+38h]
8B C3                mov         eax,ebx
48 8B 5C 24 30       mov         rbx,qword ptr [rsp+30h]
48 83 C4 20          add         rsp,20h
5F                   pop         rdi
C3                   ret
48 8B C4             mov         rax,rsp
48 89 58 08          mov         qword ptr [rax+8],rbx
48 89 68 10          mov         qword ptr [rax+10h],rbp
48 89 70 18          mov         qword ptr [rax+18h],rsi
48 89 78 20          mov         qword ptr [rax+20h],rdi
41 54                push        r12
41 56                push        r14
41 57                push        r15
48 83 EC 40          sub         rsp,40h
48 8B 9C 24 90 00    mov         rbx,qword ptr [rsp+0000000000000090h]
```

Types?
Functions?
Variables?
…

Conclusion

- Binary analysis is necessary for software security.
- Binary analysis is difficult, but we will learn how to do it throughout this course.
- More advanced topics for binary analysis and software security
  - ***IS561***: Binary Code Analysis and Secure Software Systems

Questions?