things programs on portal shouldn't do

read other user's files

modify OS's memory

read other user's data in memory

hang the entire system

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privileged instructions

can't let any program run some instructions

example: talk to I/O device

allows machines to be shared between users (e.g. lab servers)

processor has two modes:

- kernel mode — privileged instructions work
- user mode — privileged instructions cause exception instead

only *trusted* OS code runs in kernel mode

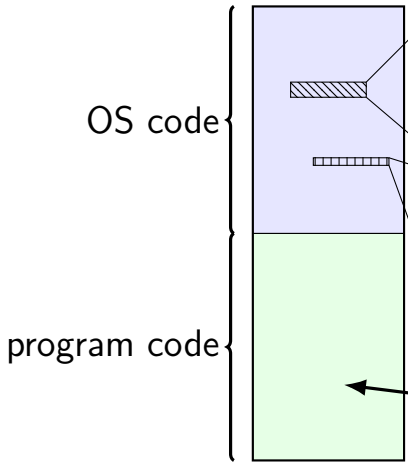
kernel mode

extra one-bit register: “are we in kernel mode”

processor switches to kernel mode to run OS

OS switches processor back to use mode when running normal code

calling the OS?




```
void readFromDiskInto(int diskLocation, char *dest) {
    ...
    runPrivilegedInstruction(...);
    ...
}
```

```
void readFileSafely(const char *name, char *dest) {
    if (canCurrentProgramCanAccessFile(name)) {
        readFromDiskInto(lookupFile(name), dest)
    }
}
```

how do we let this code call `readFromSafely` in kernel mode but not `readFromDisk`?

controlled entry to kernel mode

OS specifies where to start executing code in kernel mode

- typically set at boot
- requires privileged instructions to change

OS makes sure the code it says to start is "safe"

- (hopefully)
- example: checks whether current program is allowed to read file before reading it

Linux x86-64 system calls

special instruction: `syscall`

runs OS specified code in kernel mode

Linux syscall calling convention

before `syscall`:

`%rax` — system call number

`%rdi`, `%rsi`, `%rdx`, `%r10`, `%r8`, `%r9` — args

after `syscall`:

`%rax` — return value

on error: `%rax` contains -1 times “error number”

almost the same as normal function calls

Linux x86-64 hello world

```
.globl _start
.data
hello_str: .asciz "Hello, World!\n"
.text
_start:
  movq $1, %rax # 1 = "write"
  movq $1, %rdi # file descriptor 1 = stdout
  movq $hello_str, %rsi
  movq $15, %rdx # 15 = strlen("Hello, World!\n")
  syscall

  movq $60, %rax # 60 = exit
  movq $0, %rdi
  syscall
```

approx. system call handler

```
sys_call_table:
    .quad handle_read_syscall
    .quad handle_write_syscall
    // ...

handle_syscall:
    ... // save old PC, etc.
    pushq %rcx // save registers
    pushq %rdi
    ...
    call *sys_call_table(,%rax,8)
    ...
    popq %rdi
    popq %rcx
    return_from_exception
```

Linux system call examples

`mmap`, `brk` — allocate memory

`fork` — create new process

`execve` — run a program in the current process

`_exit` — terminate a process

`open`, `read`, `write` — access files

`socket`, `accept`, `getpeername` — socket-related

system call wrappers

can't write C code to generate syscall instruction

solution: call "wrapper" function written in assembly

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backup slides