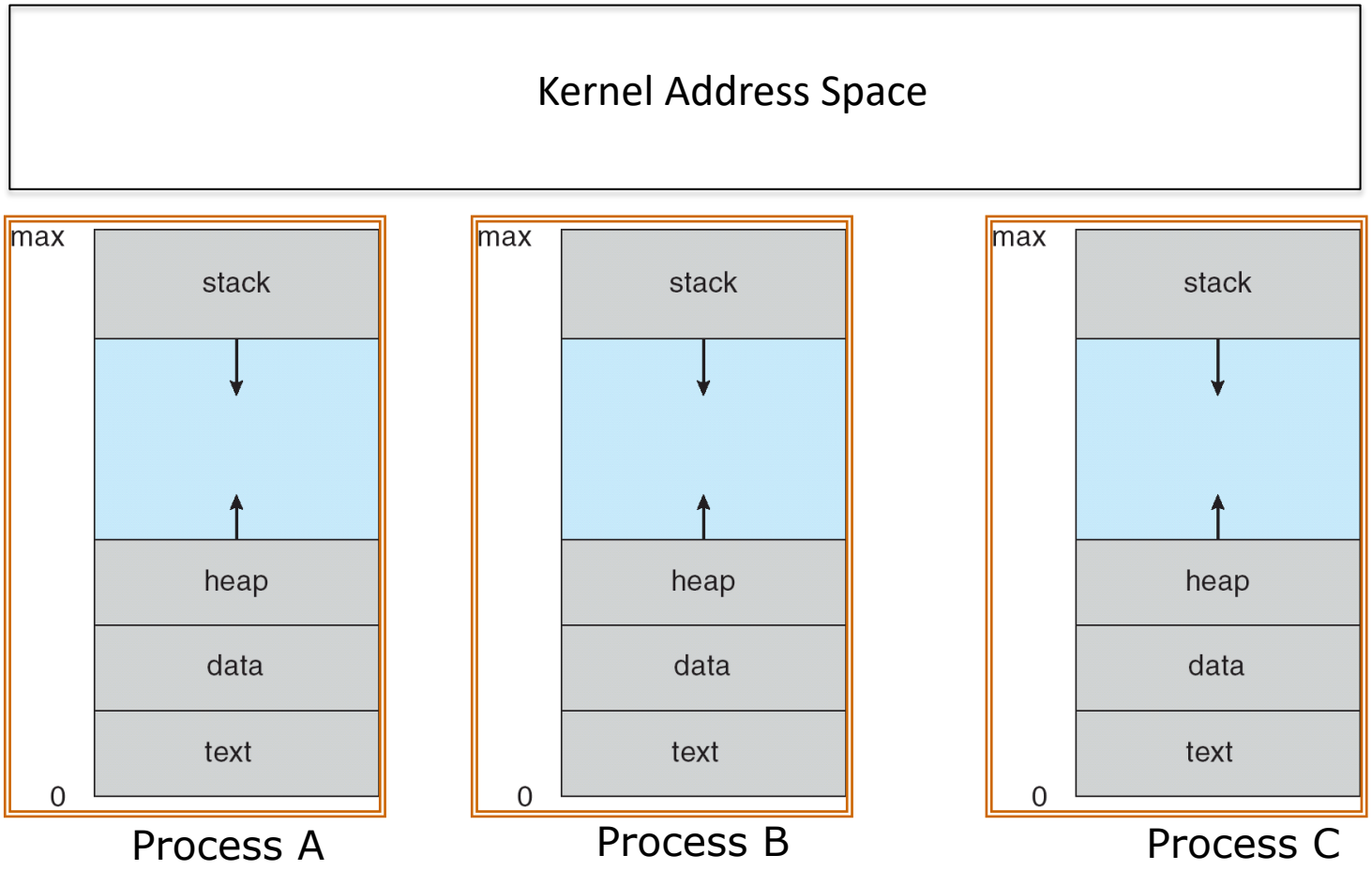
System Calls

COMS W4118

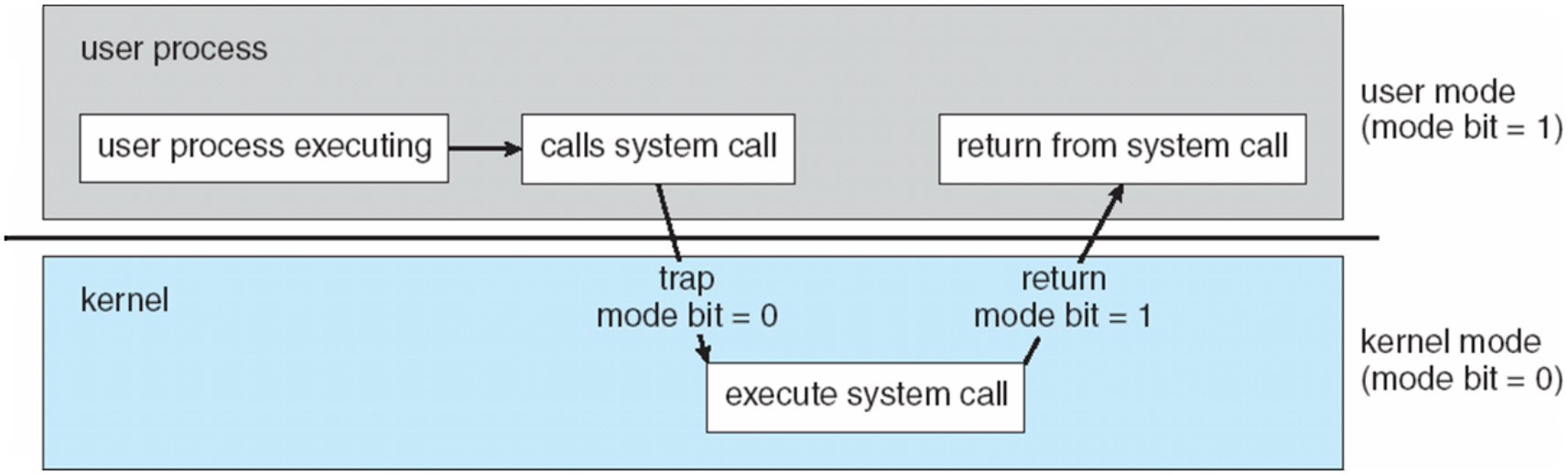
References: Operating Systems Concepts (9e), Linux Kernel Development, previous W4118s

Address Space Overview



System calls

- User process normally runs in unprivileged **user mode**
  - Cannot perform privileged operations
- User process issues **system call** to enter **kernel mode**
  - Privilege elevated, but only for predefined functions

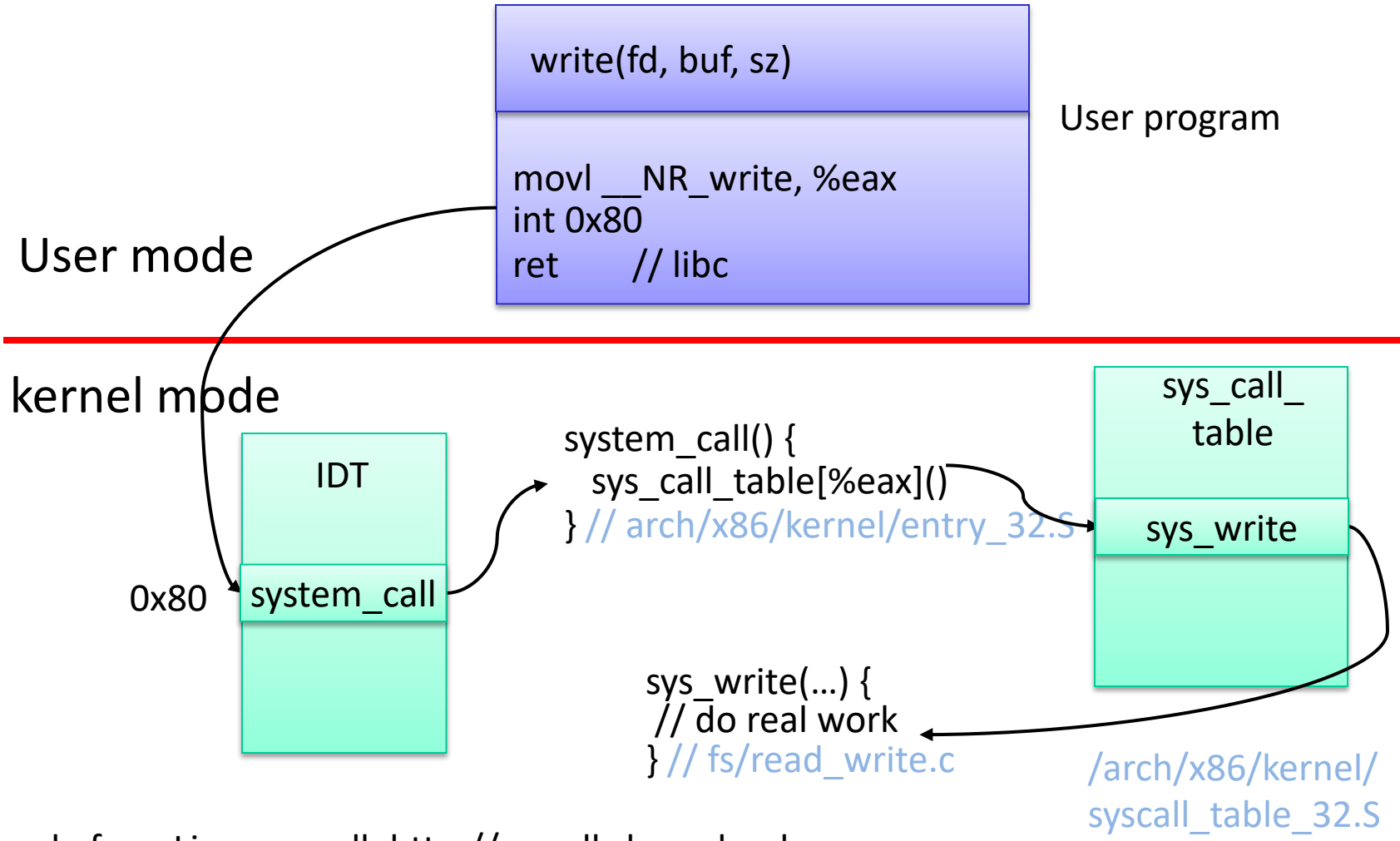


Three kinds of interrupts

- Hardware interrupts
  - Ex) network packet, timer, key press, mouse click
- Exceptions
  - Ex) dividing by zero
- Software interrupts
  - Ex) int 0x80

```
while (1) {
    if (interrupt or exception) {
        n = interrupt/exception type
        call interrupt handler n
    }
    fetch next instruction
    if (instruction == int n)
        call interrupt handler n
    else
        run instruction
}
```

Linux System Call Dispatch



To see code for a Linux syscall: http://syscalls.kernelgrok.com

Linux System Call Parameter Passing

- Syscalls with fewer than 6 parameters passed in registers
  - %eax (syscall number), %ebx, %ecx, %esi, %edi, %ebp
- If 6 or more arguments
  - Pass pointer to block structure containing argument list
- Maximum size of argument is register size
  - Larger arguments passed as pointers
- Use special routines to fetch pointer arguments
  - get_user(), put_user(), copy_to_user(), copy_from_user
  - Include/asm/uaccess.S
  - These functions can block. Why?
  - Why use these functions?
- OS must validate system call parameters

Tracing system calls in Linux

- Use the "strace" command (man strace for info)
- Linux has a powerful mechanism for tracing system call execution for a compiled application
- Output is printed for each system call as it is executed, including parameters and return codes
- ptrace() system call is used to implement strace
  - Also used by debuggers (breakpoint, singlestep, etc)
- Use the "ltrace" command to trace dynamically loaded library calls

System Call Tracing Demo

- pwd
- ltrace pwd
  - Library calls
  - setlocale, getcwd, puts: makes sense
- strace pwd
  - System calls
  - execve, open, fstat, mmap, brk: what are these?
  - getcwd, write

Interesting System Calls

- brk, sbrk: increase size of program data
  - void* sbrk(int bytes)
  - Accessed through malloc
- mmap
  - Another way to allocate memory
  - Maps a file into a process's address space
  - Or just grab memory with MAP_ANONYMOUS
  - MAP_PRIVATE or MAP_SHARED