OS Components, System Calls, Interrupt

ECE595, Aug 23

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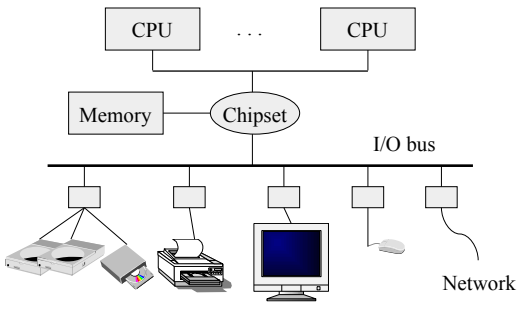
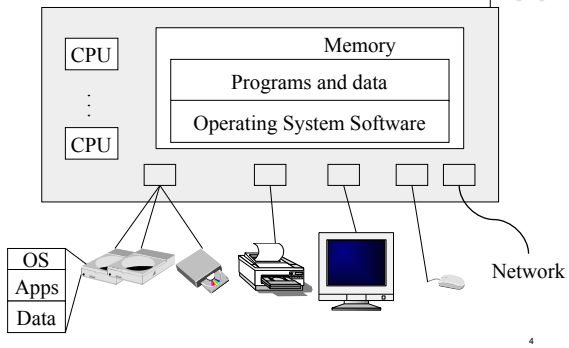
Reminder

- Find a lab partner and email ece595@ecn by September 2

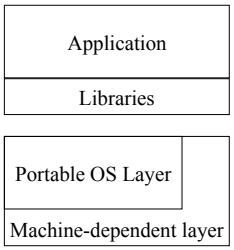
[lec1] A Typical Computer from a Hardware Point of View



A Typical Computer System: adding software

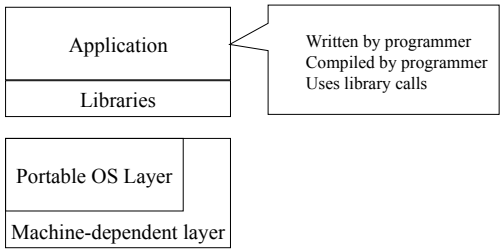


Typical OS Structure



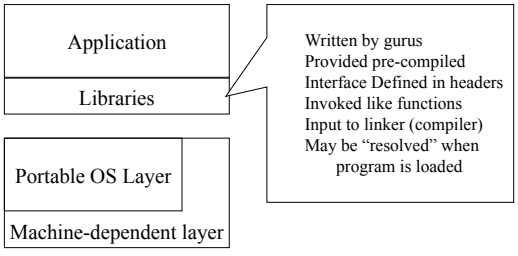
5

Typical Unix OS Structure



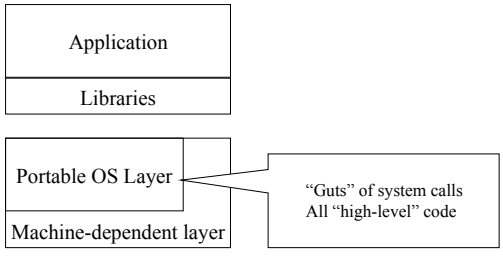
6

Typical Unix OS Structure



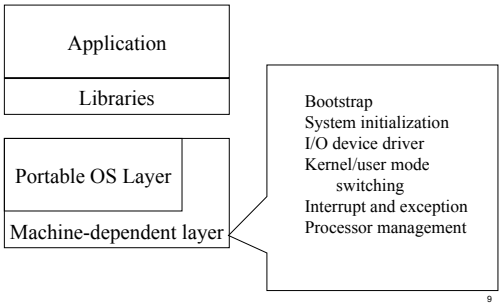
7

Typical Unix OS Structure



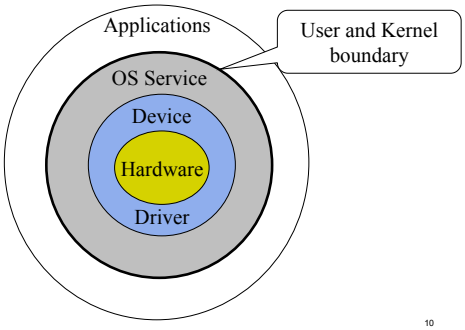
8

Typical Unix OS Structure



9

Another Look: UNIX "Onion"



10

Roadmap

- OS components
- System calls
- Lab 1
- Interrupt (connecting back to ece437)

11

Operating System components

- Process management
- Main-memory management
- Secondary-storage management
- File management
- I/O system management
- Networking
- Command-interpreter system

12

Process management

- A *process* is a program in execution
  - Process is *active*, program is *passive*
  - A process needs resources to accomplish its task:
    - CPU time
    - Memory
    - Files
    - I/O devices

13

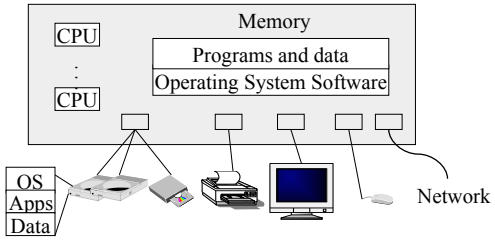
Process management

- The OS is responsible for:
  - Process creation and deletion
  - Process suspension and resumption
  - Provision of mechanisms for:
    - Process communication
    - Process synchronization (e.g. parallel computing)
      - E.g.10 processes together adding up 10 billion numbers
      - Lab2
    - Deadlock detection and handling

14

Main-memory management

- Memory: a *volatile* storage device
  - shared by the CPU and I/O devices
  - shared by processes



15

Main-memory management

- The OS is responsible for:
  - Allocate and free memory space as needed
    - Keep track of which parts of memory are currently being used and by whom
  - Protection
    - How to do it fast?
  - Support larger address space than physical memory
    - malloc(2G) on a 1G machine?

16

Secondary-storage management

- Main memory (*primary storage*) is volatile and small → OS needs a *secondary storage* to back up main memory
- Most modern systems use disks as the principle on-line storage medium
- The OS is responsible for:
  - Allocating/freeing disk storage
  - Disk scheduling
    - FIFO can be horrible
    - How does the elevator move?

17

File management

- *A file* is a logical entity
  - It is a collection of related information defined by its creator.
- The OS is responsible for:
  - File creation and deletion
  - Directory creation and deletion
  - Mapping files onto secondary storage
  - Support of primitives for manipulating files and directories (e.g. ls, ls -l)
  - Sharing and protection

18

Operating System components

- Process management
- Main-memory management
- Secondary-storage management
- File management
- I/O system management
- Networking
- Command-interpreter system

19

I/O subsystem management

- I/O devices of many flavors
  - Storage devices: drives, tapes
  - Transmission devices: NIC, modems
  - Human-interface devices: screen, keyboard, mouse
- I/O subsystem hides peculiarities of I/O devices
- I/O subsystem consists of:
  - A uniform device-driver interface (wrapper)
  - Drivers for specific hardware devices
  - Buffering / spooling / caching (access locality)

20

Networking (distributed systems)

- A *distributed system*:
  - A collection of machines that do not share memory or a clock
  - Connected through a network to provide user access to various system resources
  - Examples: Internet, WWW, banking, peer-to-peer, cloud, …
  - Allows computation speed-up, increased data availability, enhanced reliability, low latency, …
- The OS is responsible for
  - Communication between processes
  - Reliability – reliable protocols on unreliable Internet

21

Command-interpreter system

- Interface between user and OS
- Many commands are given to the OS by control statements which deal with:
  - process creation and management (a.out, kill –9)
  - secondary-storage management (partition disk)
  - file system
    - access (ls, cat)
    - protection (chmod 700 *, umask 077)
  - networking (telnet, ssh)
  - monioring (ps, top, vmstat, netstat)

22

Command-interpreter system (cont.)

- The program that reads and interprets control statements is called the *command-line interpreter* (or the *shell* in UNIX)
- What is the shell program's structure like?
- Two prevalent approaches to the interface
  - moused-based windows-and-menus (Mac, Windows)
  - command line (UNIX)

23

Roadmap for ECE595 lectures (labs)

Introduction to OS components
Individual components
- Process management
- Memory management
- File management
- Secondary-storage management

- (Device management)
- (shell)
- (Networking)

Hardware support for OS interspersed (before relevant topics)

24

Common Themes in our journey

- Functionality, performance, tradeoff if applicable
- Software vs. hardware vs. hybrid solutions

25

Roadmap

- OS components
- System calls
- Lab 1
- Interrupt

26

[lec1] What is an OS?

- Resource manager
  - Manage shared resources (CPU, mem, I/O, networking)
- Extended (abstract) machine

27

Dual-Mode Operation (ECE437)

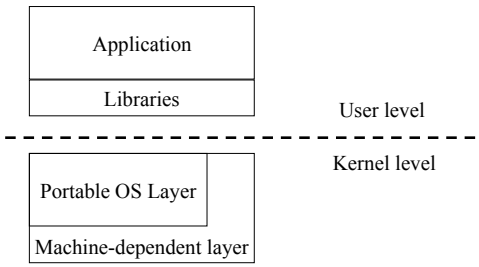
- OS manages shared resources
- OS protects programs from other programs

➔ OS needs to be “privileged”

- Dual-mode operation of hardware
  - Kernel mode – can run *privileged* instructions
  - User mode – can only run *non-privileged* instructions

28

Typical Unix OS Structure



29

Dual-Mode Operation

- OS manages shared resources
- OS protects programs from other programs

➔ OS needs to be privileged

- If OS manages shared resources, how does a user program request for accessing shared resources (e.g. hard drive)?

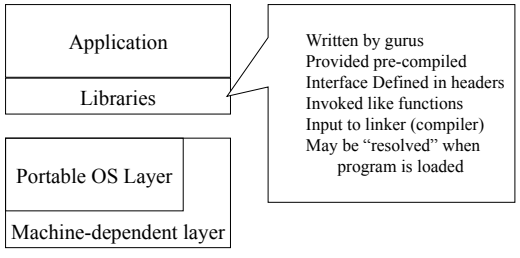
30

System calls

- Interface between a *process* and the operating system kernel
  - Kernel manages shared resources & exports interface
  - Process requests for access to shared resources
- Generally available as assembly-language instructions
- Directly invoked in many languages (C, C++, Perl)
  - Who is helping out here?

31

Typical Unix OS Structure



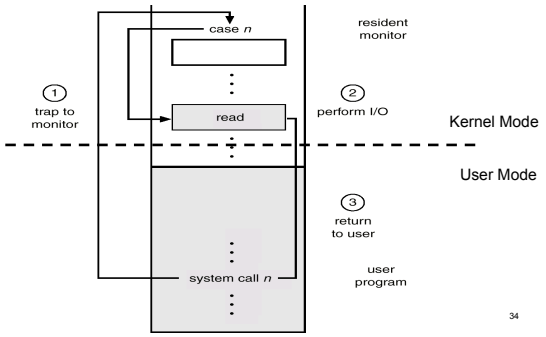
32

Example

- Given the I/O instructions are privileged, how does the user program perform I/O?
  - open()
  - read()
  - write()
  - close()

33

Use of a system call to perform I/O



34

System calls

- Categories
  - Process management
  - Memory management
  - File management
  - Device management
  - Networking

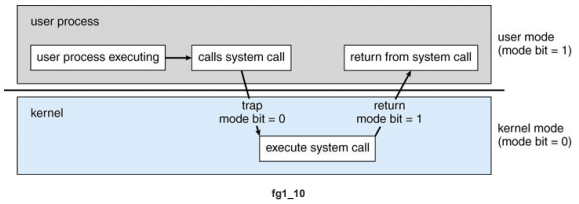
35

System calls in Linux (man syscalls)

- SYSCALLS(2) Linux Programmerâs Manual SYSCALLS(2)
- NAME
- none - list of all system calls
- SYNOPSIS
- Linux 2.4 system calls.
- DESCRIPTION
- The system call is the fundamental interface between an application and
- the Linux kernel. As of Linux 2.4.17, there are 1100 system calls
- listed in /usr/src/linux/include/asm-*/unistd.h. This man page lists
- those that are common to most platforms (providing hyperlinks if you
- read this with a browser).
- _llseek(2), _newselect(2), _sysctl(2), accept(2), access(2), acct(2),
- adjtimex(2), afs_syscall, alarm(2), bdflush(2), bind(2), break, brk(2),
- cacheflush(2), capget(2), capset(2), chdir(2), chmod(2), chown(2),
- chown32, chroot(2), clone(2), close(2), connect(2), creat(2), cre-
- ate_module(2), delete_module(2), dup(2), dup2(2), execve(2), exit(2),
- fchdir(2), fchmod(2), fchown(2), fchown32, fcntl(2), fcntl64, fdata-
- .....

36

Transition from user to kernel mode



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Roadmap

- OS components
- System calls
- Lab 1
- Interrupt

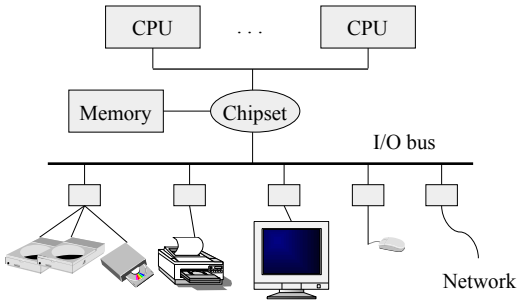
38

Lab 1 (week 2)

- DLXOS setup
- Trap (drop into the kernel) implementation
  - Used in later projects
  - Adding a new system call (getpid)

39

[lec1] A Typical Computer from a Hardware Point of View



40

Concurrency & Unexpected Events

- How do human handle unexpected events?
  - Assume
    - mail delivered to my mailbox continously
    - I have a secretary
  - Do I have mail now? (need to be processed quickly)
- Poll vs. interrupt
- Which one is more efficient?
  - Assume 1 interrupt more costly than 1 poll
  - If I have one mail per day?
  - If I have lots of mail per delivery?

41

Interrupt (ECE437)

- A mechanism for
  - coordination between concurrently operating units of a computer system (e.g. CPU and I/O devices)
  - for responding to specific conditions within a computer
- Results in transfer of flow of control (to interrupt handler in the OS), forced by hardware

42

Two types of Interrupts

- *Hardware interrupts*
  - timers
  - I/O devices: keyboards, NICs, etc.
- *Software interrupts* (aka. *trap, exception*)
  - an error (floating point exception)
  - a *system call* requesting OS for special services (e.g. I/O)

43

Handling interrupts (ECE437)

- Incoming interrupts are disabled (at this and lower priority levels) while the interrupt is being processed to prevent a lost interrupt
- Interrupt architecture must save the address of the interrupted instruction
- Interrupt transfers control to the interrupt service routine
  - generally, through the interrupt vector, which contains the addresses of all the service routines
- If interrupt routine modifies process state (register values)
  - save the current state of the CPU (registers and the program counter) on the system stack
  - restore the state before returning
- Interrupts are re-enabled affter servicing current interrupt
- Resume the interrupted instruction

44

X86 Interrupt and Exceptions (1)

Vector #	Mnemonic	Description	Type
0	#DE	Divide error (by zero)	Fault
1	#DB	Debug	Fault/trap
2		Non-Maskable interrupt	Interrupt
3	#BP	Breakpoint	Trap
4	#OF	Overflow	Trap
5	#BR	BOUND range exceeded	Trap
6	#UD	Invalid opcode	Fault
7	#NM	Device not available	Fault
8	#DF	Double fault	Abort
9		Coprocessor segment overrun	Fault
10	#TS	Invalid TSS	

X86 Interrupt and Exceptions (2)

Vector #	Mnemonic	Description	Type
11	#NP	Segment not present	Fault
12	#SS	Stack-segment fault	Fault
13	#GP	General protection	Fault
14	#PF	Page fault	Fault
15		Reserved	Fault
16	#MF	Floating-point error (math fault)	Fault
17	#AC	Alignment check	Fault
18	#MC	Machine check	Abort
19-31		Reserved	
32-255		User defined	Interrupt

Vector 128 is for system calls

[lec1] What is an OS?

- Resource manager
  - Manage shared resources (I/O, CPU, mem, networking)
- Extended (abstract) machine

"Modern OSes are interrupt driven"

- "An OS is a giant interrupt handler!" (Def 3)
  - Timer interrupt → Context switches in multiprogramming
  - (unexpected) I/O interrupts
  - System calls (traps) to switch from user to supervisor mode
- At the lowest level an OS is just a bunch of interrupt service routings
  - Each routine simply returns to whatever was executing before it was interrupted
    - A user process
    - An OS process
    - Another interrupt routine
  - Else infinite wait loop

Questions?

- We will dive in process management next week
- Reading assignment: OSC Chapters 1-2

49