Sunbeam Institute of Information Technology
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PreCAT

Module – Operating System Concepts

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Operating System – File Systems

- Way of organizing files on the disk is called as "File Systems".
- e.g. FAT (File Allocation Table), NTFS (New Technology File System), EXT2/3/4 (Extended 2/3/4), HFS (Hierarchical File System), ZFS, AFS, UFS, ...
- FAT limitation: Max file size = 4 GB.
- In general FS is logically divided into four parts:
  - Boot block or Boot sector
  - Super block or Volume control block
  - Inode list or Master file table
  - Data blocks
- There is only one FS in one disk partition. OS may support multiple FS e.g. Windows supports FAT, NTFS, and CDFS.
- FS is created when disk/partition is formatted. During formatting any old data is erased.
  - DOS/Windows 95 formatting utility: format.exe
  - Linux formatting utility: mkfs

Operating System – File types

- **From user perspective**
  - Document files
  - Compressed files
  - Media files
  - Executable files ...
- **From (UNIX) kernel perspective**
  - Regular files
  - Directory files
  - Link files (Windows shortcuts)
  - Pipe files
  - Socket files
  - Char device files
  - Block device files

- **In UNIX, devices are represented as files.**
  - Char device -- Byte by byte data transfer e.g. keyboard, mouse, ...
  - Block device -- Block by block data transfer e.g. storage device.

- **File IO System Calls**
  - open() - To open a file (called within fopen()).
  - close() - To close a file (called within fclose()).
  - read() - To read from file (called within fread(), fgetc(), fgets(), fscanf()).
  - write() - To write into file (called within fwrite(), fputc(), fputs(), fprintf()).
  - lseek() - To change current file position (called within fseek(), ftell()).

Operating System – File Allocation Mechanisms

- The file data blocks are allocated on the file system (data blocks region) on the disk.
- The data blocks can be allocated in various ways (depending on file system).
  - Contiguous allocation
  - Linked allocation
  - Indexed allocation
- The information about allocated blocks is maintained into inode (FCB) or Directory entry.
- **Contiguous Allocation**
  - Number of blocks required for the file are allocated contiguously.
  - inode of the file contains starting block address and number of data blocks.
  - Faster sequential and random access.
  - Number of blocks required for the file may not be available contiguously. This is called as "External Fragmentation".
  - To solve this problem, data blocks of the files can be shifted/moved so that max contiguous free space will be available. This is called as "defragmentation".

Operating System – File Allocation Mechanisms

- **Linked Allocation**
  - Each data block of the file contains data/contents and address of next data block of that file.
  - inode contains address of starting and ending data block.
  - No external fragmentation, faster sequential access.
  - Slower random access.
  - e.g. FAT

- **Free Space Management Mechanisms**
  - The free data blocks information is maintained in the super-block.
  - Super block use some data structures to maintain this information.

  Bit vector Linked list Grouping Counting

- **Indexed Allocation**
  - A special data block contain addresses of data blocks of the file. This block is called as "index block".
  - The address of index block is stored in the inode of the file.
  - No external fragmentation, faster random and sequential access.
  - File cannot grow beyond certain limit.

Operating System – Hard Disk Structure

- Time required to perform read/write operation on particular sector of the disk, is called as **"disk access time".**
- Disk access time includes two components = seek time and rotational latency.
- **“Seek time”** is time required to move head to desired cylinder (track).
- **“Rotational latency”** is time required to rotate the platters so that desired sector is reached to the head.
- When number of requests are pending for accessing disk cylinders, magnetic head is moved using certain algorithm. They are called as **"disk scheduling algorithms".**

Operating System – Disk Scheduling Algorithms

- **FCFS**
  - Requests are handled in the order in which they arrived.
- **SSTF - Shortest Seek Time First**
  - Request of nearest (to current position of magnetic head) cylinder is handled first.
- **SCAN or Elevator**
  - Magnetic head keep moving from 0 to max cylinder and in reverse order continuously serving cylinder requests.
- **C-SCAN**
  - Magnetic head keep moving from 0 to max cylinder serving the requests and then jump back to 0 directly.
- **LOOK**
  - Implementation policy of SCAN or C-SCAN.
  - If no requests pending magnetic head is stopped

Operating System – IO Management

- **Computer structure**
  - CPU: General purpose processor for program/OS execution
  - Memory: RAM
  - Storage: Disk
  - IO: Keyboard, Monitor
  - Connected by "bus".
  - Each IO device has a "dedicated" "internal" processing unit -- IO device controller.
- **Computer IO (Input Output)**
  - **Synchronous IO:** CPU is waiting for IO to complete.
    - Hardware technique used is called as Polling
  - **Asynchronous IO:** CPU is not waiting for IO to complete (doing some other task).
    - Hardware technique used is called as Interrupt
    - OS maintains a device status table to keep track of IO devices (busy/idle) and processes waiting for those IO devices.

Operating System – IO Management

- **Interrupt Processing**
  - IO event is sensed by IO device controllers.
  - It will be conveyed to CPU as a special signal - Interrupt.
  - CPU pause current execution and execute interrupt handler.
  - "Interrupt handler" will get address of "ISR" (from IVT) and execute ISR.
  - When ISR is completed, execution resumes where it was paused.

- **Interrupt Controller**
  - Convey the interrupts from various peripherals to the CPU.
  - Also manage priority of the interrupt (when multiple interrupts arrives at same time).
  - e.g. 8085/86 (8259), Modern x86 processors (apic), ARM-7 (VIC), ARM-CM3 (NVIC), ...

Operating System – Hardware Abstraction Layer

- Most important feature of OS.
- It hides hardware details from end-user as well as from user programs.
- HAL Provides reusable code to interact with hardware.
- HAL layer of any OS is always arch dependent. Most of the code is written in assembly language.

Operating System – User Interfacing

- UI of OS is a program (Shell) that interface between End user and Kernel.
- **Shell** -- Command interpreter
  - End user --> Command --> Shell --> Kernel
- **User interfacing (Shell)**
  - Graphical User Interface (GUI)
  - Command Line Interface (CLI)

- **Windows**
  - GUI shell: explorer.exe
  - CLI shell: cmd.exe, powershell.exe
- **DOS**
  - CLI shell: command.com
- **Unix/Linux**
  - CLI shell: bsh, "bash", ksh, csh, zsh, ...
  - GUI shell/standards
    - GNOME: GNU Network Object Model Environment (e.g. Ubuntu, Redhat, CentOS, ...)
    - KDE: Kommon Desktop Environment (e.g. Kubuntu, SuSE, ...)
    - FCE: XForms Common Environment (e.g. Raspberry Pi, ...

Operating System – Networking

- Networking feature enable computers (processes) to communicate with each other.
- Even though important (nowadays), networking is optional feature of OS.
- For networking computers are connected to each other in LAN, MAN or WAN.
- Computers are connected with different topologies e.g. bus, star, ring, mesh, ...
- Networking feature internally use "sockets" IPC mechanism.
- Socket is communication end-point.

Operating System – Security and Protection

- **Security is securing system from "external" threats** e.g. virus, trojans, worms, hacking, etc.
  - Security is optional feature and is not implemented in many OS.
  - Security is usually provided by "Anti-virus" application.
  - Windows 10+ comes with Windows Defender, which is handling security aspects.
- **Protection is protecting system (programs & files) from internal threats/elements**.
  - **Dual mode protection:** CPU can differentiate whether code belongs to OS or user application.
  - **IO protection:** Only OS should be able to perform IO operations. User programs should use system calls to perform IO. This is feasible when IO instructions are privileged instructions (they can only be executed in kernel mode).
  - **Memory protection:** One process should not access memory of another process directly, so that one process cannot disturb execution of another process. This is implemented using MMU.'
  - **CPU protection:** If a process goes in infinite loop, the whole system should not hang. This is done using Timer hardware.

Operating System – Booting

- Process from computer power on to OS startup.

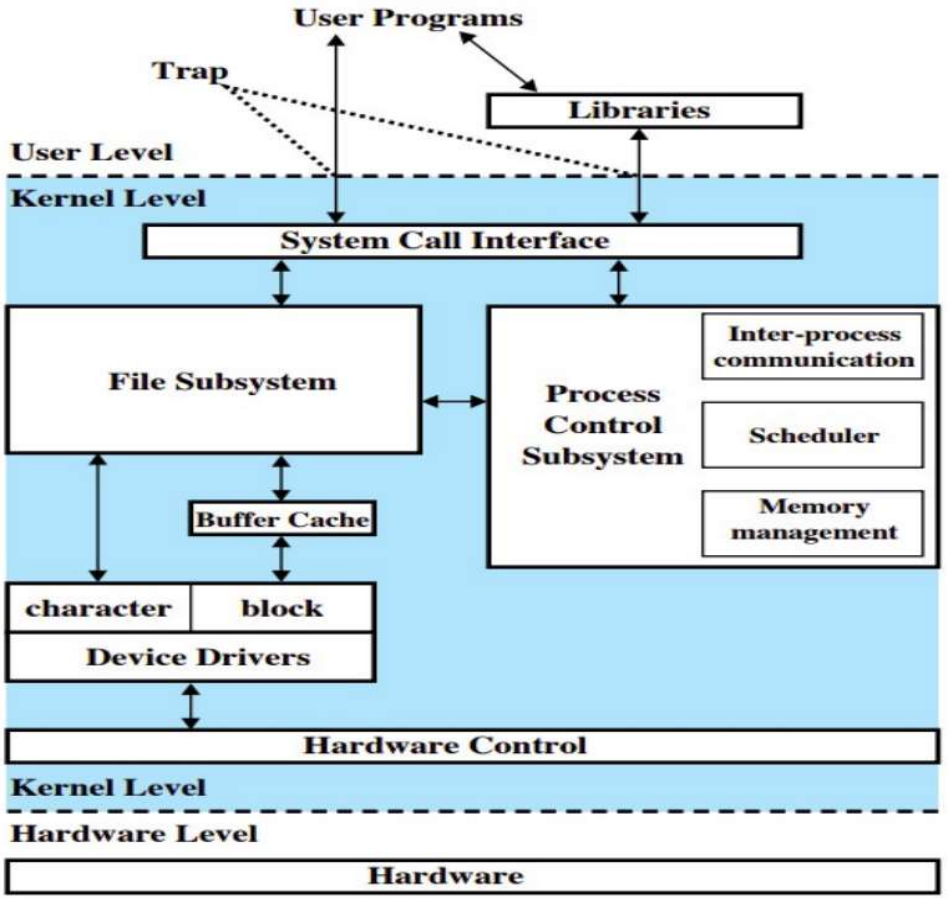
- **Booting steps**
  - Computer power on.
  - Load firmware (BIOS or EFI) programs from base ROM into RAM.
  - Run POST/BIST (from firmware).
  - Run Bootstrap loader (from firmware) to find bootable device.
  - Bootstrap loader loads bootloader program from bootable device.
  - Bootloader program shows multiple options to end user and user select one of them.
  - Bootloader program run corresponding bootstrap program.
  - Bootstrap program load OS kernel into main memory and OS boot

Operating System – Booting

- **Bootstrap program**
  - Bootstrap program can load OS kernel into RAM and start its execution.
  - Bootstrap program is different for each OS each version.
  - Bootstrap is located in first sector (512 bytes) of a disk/partition.
- **Bootloader program**
  - Bootloader program can be configured to show multiple boot options to end user.
  - Depending on user selection, it runs Bootstrap program of corresponding OS.
  - There are many important bootloader programs.
    - ntldr, bootmgr, LiLo, GrUB, Bootcamp, uBoot
- **Bootable device**
  - Storage device (disk, pen drive, CD/DVD, etc.) whose boot block contains bootstrap program, is said to be Bootable device.
- **Bootstrap loader**
  - The set of programs fixed in Base ROM (Motherboard) is called as "Firmware".
    - BIOS (Basic Input Output System) -- Firmware developed for PC by IBM + MS.
    - EFI (Extensible Firmware Interface) -- Firmware developed for PC by Intel + HP.
    - Bootstrap loader is a program from Base ROM. It find the bootable device as per "boot device priority" in the BIOS setup.
    - Once bootable device is found, it starts its bootloader.

Operating System – UNIX Operating System

- UNIX: UNICS – Uniplexed Information & Computing Services/System.
- UNIX was developed at AT&T Bell Labs in US, in the decade of 1970's by Ken Thompson, Denies Ritchie and team.
- It was first run on a machine DEC-PDP-7 (Digital Equipment Corporation – Programmable Data Processing-7).
- UNIX is the first multi-user, multi-programming & multi-tasking operating system.
- UNIX was specially designed for developers by developers - System architecture
- Design of UNIX is followed by all modern OS's like Windows, Linux, MAC OS X, Android etc



Thank you!

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