3 RESOURCE MANAGEMENT

An operating system is a **resource manager**. The system's CPU, memory space, file-storage space, and I/O devices are among the resources that the operating system must manage.

PROCESS MANAGEMENT

- A process is a **program in execution**. It is a unit of work within the system. Program is a ***passive entity;*** the process is an ***active entity***.
- Process needs resources to accomplish its task
  - CPU, memory, I/O, files
  - Initialization data
- Process termination requires reclaim of any reusable resources
- Single-threaded process has one **program counter** specifying location of next instruction to execute
- Process executes instructions sequentially, one at a time, until completion
- Multi-threaded process has one program counter per thread
- Typically system has many processes, some users, some operating systems running concurrently on one or more CPUs
- Concurrency by multiplexing the CPUs among the processes/threads

Process Management Activities

The operating system is responsible for the following activities in connection with process management:

- Creating and deleting both user and system processes
- Suspending and resuming processes
- Providing mechanisms for process synchronization
- Providing mechanisms for process communication
- Providing mechanisms for deadlock handling

A process is the unit of work in a system. A system consists of a collection of processes, some of which are operating-system processes (those that execute system code) and the rest of which are user processes (those that execute user code). All these processes can potentially execute concurrently — by multiplexing on a single CPU core — or in parallel across multiple CPU cores.

MEMORY MANAGEMENT

- To execute a program all (or part) of the instructions must be in memory
- All (or part) of the data that is needed by the program must be in memory
- Memory management determines what is in memory and when
  - Optimizing CPU utilization and computer response to users
- Memory management activities
  - Keeping track of which parts of memory are currently being used and by whom
  - Deciding which processes (or parts thereof) and data to move into and out of memory
  - Allocating and deallocating memory space as needed

Background

- Program must be brought (from disk) into memory and placed within a process for it to be run
- Main memory and registers are only storage CPU can access directly
- Memory unit only sees a stream of:
  - addresses + read requests, or
  - address + data and write requests
- Register access is done in one CPU clock (or less)
- Main memory can take many cycles, causing a **stall**
- **Cache** sits between main memory and CPU registers
- Protection of memory required to ensure correct operation

Main memory is a large array of bytes, ranging in size from hundreds of thousands to billions. Each byte has its own address. Main memory is a repository of quickly accessible data shared by the CPU and I/O devices. The CPU reads instructions from main memory during the instruction-fetch cycle and both reads and writes data from main memory during the data-fetch cycle (on a von Neumann architecture).

FILE-SYSTEM MANAGEMENT

File management is one of the most visible components of an operating system. Computers can store information on several different types of physical media. Secondary storage is the most common, but tertiary storage is also possible.

A file is a collection of related information defined by its creator. Commonly, files represent programs (both source and object forms) and data. Data files may be numeric, alphabetic, alphanumeric, or binary.

- OS provides uniform, logical view of information storage
  - Abstracts physical properties to logical storage unit - **file**
  - Each medium is controlled by device (i.e., disk drive, tape drive)
    - Varying properties include access speed, capacity, data-transfer rate, access method (sequential or random)

- File-System management
  - Files usually organized into directories
  - Access control on most systems to determine who can access what
  - OS activities include
    - Creating and deleting files and directories
    - Primitives to manipulate files and directories
    - Mapping files onto secondary storage
    - Backup files onto stable (non-volatile) storage media

File Concept

- Contiguous logical address space
- Types:
  - Data
    - Numeric
    - Character
    - Binary
  - Program
- Contents defined by file's creator
  - Many types
    - **text file,**
    - **source file,**
    - **executable file**

File Attributes

- **Name** – only information kept in human-readable form
- **Identifier** – unique tag (number) identifies file within file system
- **Type** – needed for systems that support different types
- **Location** – pointer to file location on device
- **Size** – current file size
- **Protection** – controls who can do reading, writing, executing

- **Time, date, and user identification** – data for protection, security, and usage monitoring
- Information about files are kept in the directory structure, which is maintained on the disk
- Many variations, including extended file attributes such as file checksum
- Information kept in the directory structure

File Operations

- **Create**
- **Write –** at **write pointer** location
- **Read –** at **read pointer** location
- **Reposition within file - seek**
- **Delete**
- **Truncate**
- **Open (F_i)** – search the directory structure on disk for entry F_i, and move the content of entry to memory
- **Close (F_i)** – move the content of entry F_i in memory to directory structure on disk

File Types – Name, Extension

file type	usual extension	function
executable	exe, com, bin or none	ready-to-run machine-language program
object	obj, o	compiled, machine language, not linked
source code	c, cc, java, pas, asm, a	source code in various languages
batch	bat, sh	commands to the command interpreter
text	txt, doc	textual data, documents
word processor	wp, tex, rtf, doc	various word-processor formats
library	lib, a, so, dll	libraries of routines for programmers
print or view	ps, pdf, jpg	ASCII or binary file in a format for printing or viewing
archive	arc, zip, tar	related files grouped into one file, sometimes com-pressed, for archiving or storage
multimedia	mpeg, mov, rm, mp3, avi	binary file containing audio or A/V information

File Structure

- None - sequence of words, bytes
- Simple record structure
  - Lines
  - Fixed length
  - Variable length
- Complex Structures
  - Formatted document
  - Relocatable load file
- Can simulate last two with first method by inserting appropriate control characters
- Who decides:
  - Operating system
  - Program

MASS-STORAGE MANAGEMENT

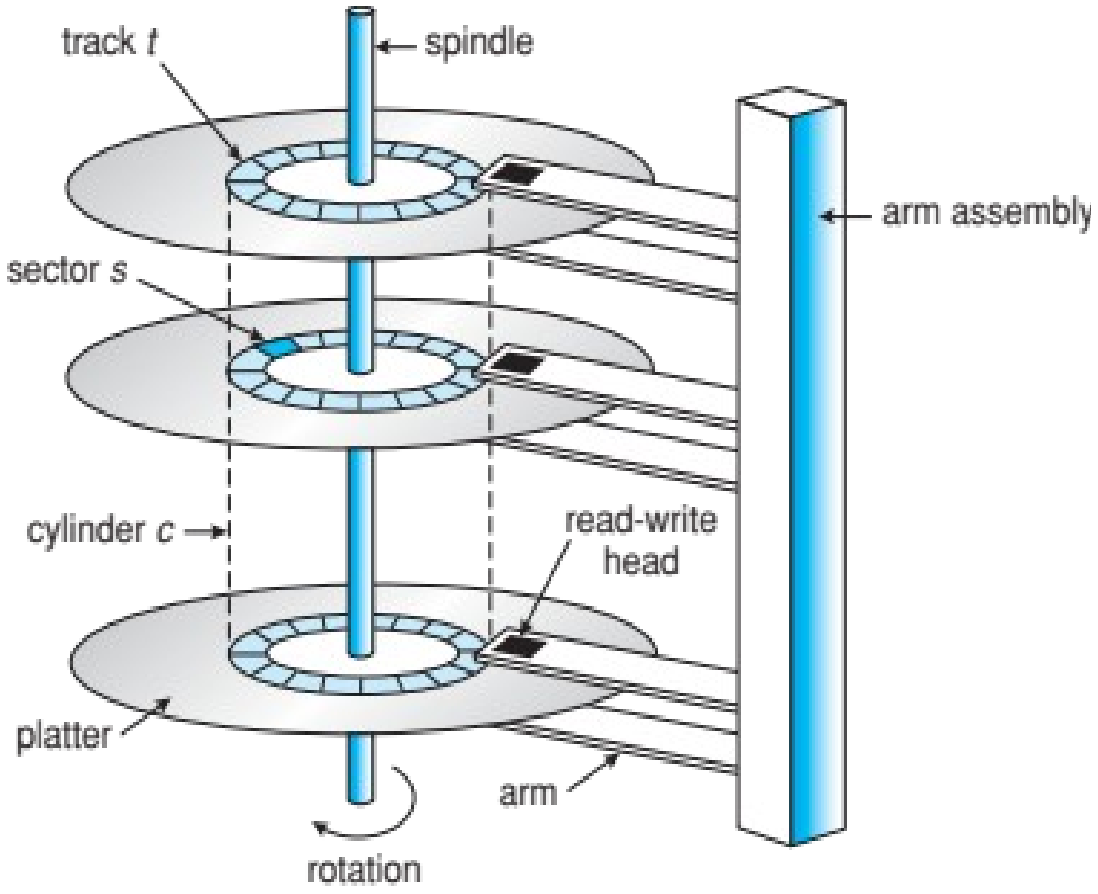
- Usually disks used to store data that does not fit in main memory or data that must be kept for a “long” period of time
- Proper management is of central importance
- Entire speed of computer operation hinges on disk subsystem and its algorithms
- OS activities
  - Mounting and unmounting
  - Free-space management
  - Storage allocation
  - Disk scheduling
  - Partitioning
  - Protection

Overview of Mass Storage Structure

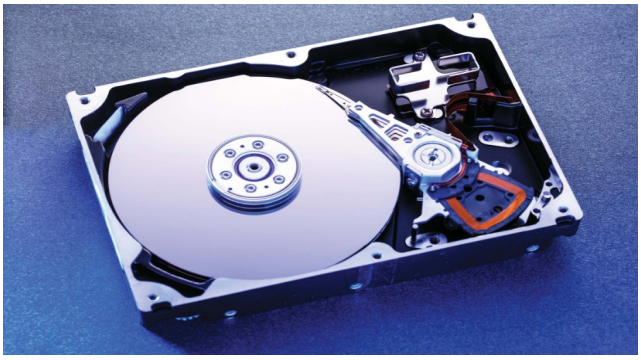
- Bulk of secondary storage for modern computers is **hard disk drives** (**HDDs**) and **nonvolatile memory** (**NVM**) devices
- **HDDs** spin platters of magnetically-coated material under moving read-write heads
  - Drives rotate at 60 to 250 times per second
  - **Transfer rate** is rate at which data flow between drive and computer
  - **Positioning time** (**random-access time**) is time to move disk arm to desired cylinder (**seek time**) and time for desired sector to rotate under the disk head (**rotational latency**)

- **Head crash** results from disk head making contact with the disk surface -- That's bad
- Disks can be removable

Moving-head Disk Mechanism



Hard Disk Drives



- Platters range from .85" to 14" (historically)
  - Commonly 3.5", 2.5", and 1.8"
- Range from 30GB to 3TB per drive
- Performance
  - Transfer Rate – theoretical – 6 Gb/sec
  - Effective Transfer Rate – real – 1Gb/sec
  - Seek time from 3ms to 12ms – 9ms common for desktop drives
  - Average seek time measured or calculated based on 1/3 of tracks
  - Latency based on spindle speed
  - 1 / (RPM / 60) = 60 / RPM
  - Average latency = ½ latency

Nonvolatile Memory Devices

- If disk-drive like, then called **solid-state disks** (**SSDs**)
- Other forms include **USB drives** (thumb drive, flash drive), DRAM disk replacements, surface-mounted on motherboards, and main storage in devices like smartphones
- Can be more reliable than HDDs
- More expensive per MB
- Maybe have shorter life span – need careful management
- Less capacity
- But much faster
- Busses can be too slow -> connect directly to PCI for example
- No moving parts, so no seek time or rotational latency

- Have characteristics that present challenges
- Read and written in “page” increments (think sector) but can’t overwrite in place
- Must first be erased, and erases happen in larger ”block” increments
- Can only be erased a limited number of times before worn out – ~ 100,000
- Life span measured in **drive writes per day** (**DWPD**)
- A 1TB NAND drive with rating of 5DWPD is expected to have 5TB per day written within warrantee period without failing

Volatile Memory

- DRAM frequently used as mass-storage device
  - Not technically secondary storage because volatile, but can have file systems, be used like very fast secondary storage
- **RAM drives** (with many names, including RAM disks) present as raw block devices, commonly file system formatted
- Computers have buffering, caching via RAM, so why RAM drives?
  - Caches / buffers allocated / managed by programmer, operating system, hardware
  - RAM drives under user control
  - Found in all major operating systems
    - Linux /dev/ram, macOS diskutil to create them, Linux /tmp of file system type tmpfs
- Used as high speed temporary storage
  - Programs could share bulk date, quickly, by reading/writing to RAM drive

CACHE MANAGEMENT

- Important principle, performed at many levels in a computer (in hardware, operating system, software)
- Information in use copied from slower to faster storage temporarily
- Faster storage (cache) checked first to determine if information is there
  - If it is, information used directly from the cache (fast)
  - If not, data copied to cache and used there
- Cache smaller than storage being cached
  - Cache management important design problem
  - Cache size and replacement policy

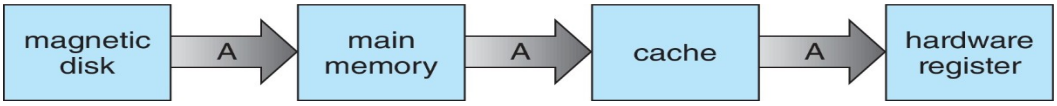
Characteristics of Various Types of Storage

Level	1	2	3	4	5
Name	registers	cache	main memory	solid-state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25-0.5	0.5-25	80-250	25,000-50,000	5,000,000
Bandwidth (MB/sec)	20,000-100,000	5,000-10,000	1,000-5,000	500	20-150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape

Movement between levels of storage hierarchy can be explicit or implicit

Migration of data "A" from Disk to Register

- Multitasking environments must be careful to use most recent value, no matter where it is stored in the storage hierarchy



- Multiprocessor environment must provide **cache coherency** in hardware such that all CPUs have the most recent value in their cache
- Distributed environment situation even more complex
- Several copies of a datum can exist

I/O SYSTEM MANAGEMENT

- One purpose of OS is to hide peculiarities of hardware devices from the user
- I/O subsystem responsible for
  - Memory management of I/O including buffering (storing data temporarily while it is being transferred), caching (storing parts of data in faster storage for performance), spooling (the overlapping of output of one job with input of other jobs)
  - General device-driver interface
  - Drivers for specific hardware devices

NOTE:

Read Chapter 1 from the reference book, Operating System Concepts 10th edition, to learn more about this lesson.

Hi I'm Flashee!

You have reached the end of the lesson. Be sure to answer the corresponding **activity of this lesson** on the activities folder of our class materials in the file server.