Tishk International University
Science Faculty
IT Department

Operating Systems

Lecture 5: Mass Storage and File System

3rd Grade - Fall Semester

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Lecture 5: Mass Storage and File System Agenda

1. Magnetic Disk Structure
2. Disk Partitioning and Formatting
3. How to Really Erase Mobile Data
4. Disk Scheduling
5. File and Directory Concept
6. Disk Allocation Methods
7. DataCenter Disk Technologies

- Magnetic Tape
- Hot-swappable Hard Disks
- RAID
- Storage Array Network

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1. Magnetic Disk Structure

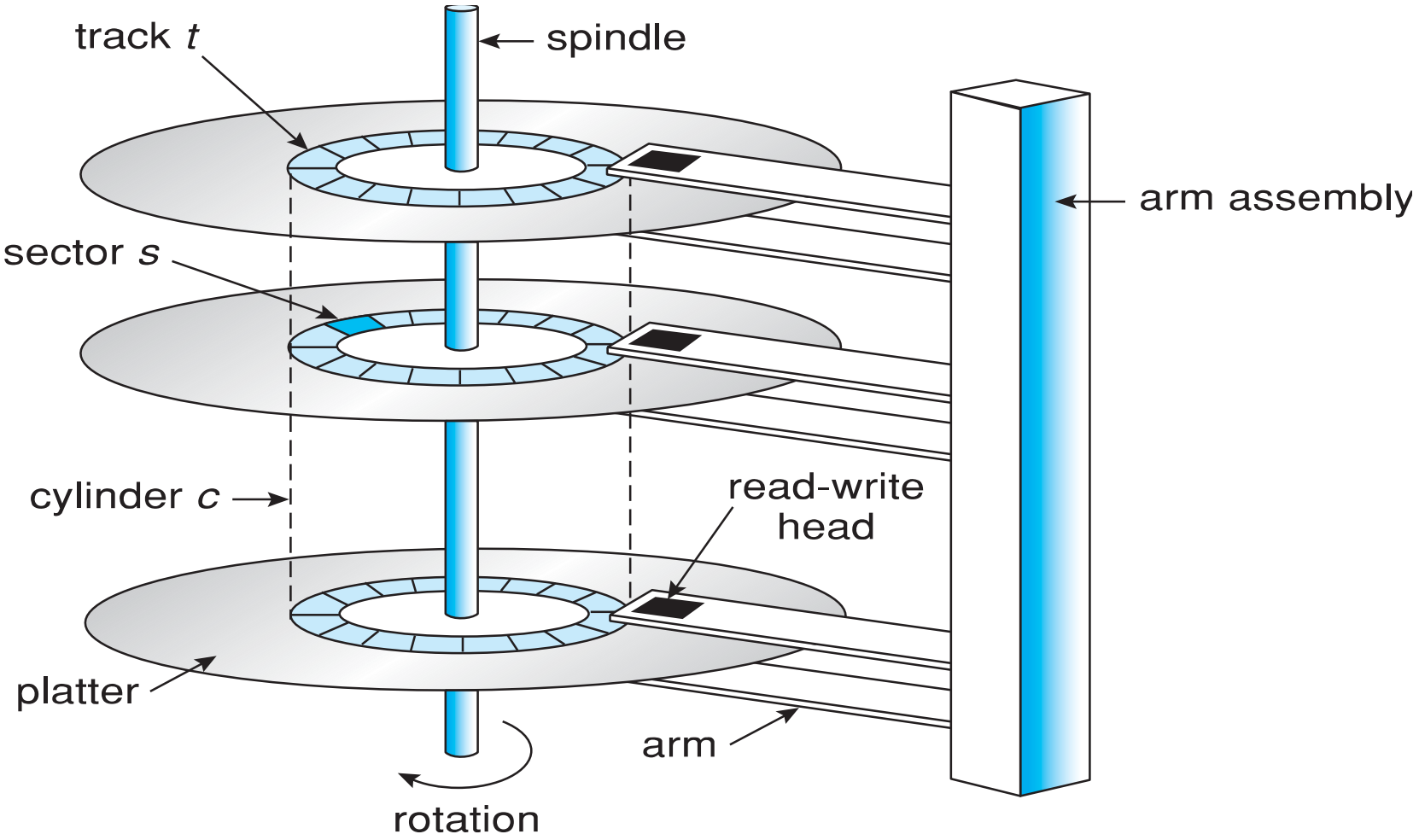
- **Magnetic Disks:** is a storage device that uses a magnetization process to write, rewrite and access data. It is covered with a **magnetic** coating and stores data in the form of tracks, spots and sectors
- Magnetic disk basic structure:
  - One or more ***platters*** in the form of disks covered with magnetic media. ***Hard disk*** platters are made of rigid metal and Each platter has two working ***surfaces.***
  - Each working surface is divided into a number of concentric rings called ***tracks.*** The collection of all tracks that are the same distance from the edge of the platter, is called a ***cylinder***.

Magnetic Disk Physical Structure

- Each track is further divided into ***sectors,*** traditionally containing 512 bytes of data each, although some modern disks occasionally use larger sector sizes.
- The data on a hard drive is read by read-write ***heads.*** The standard configuration (shown below) uses one head per surface, each on a separate ***arm***, and controlled by a common ***arm assembly*** which moves all heads simultaneously from one cylinder to another.
- The storage capacity of a traditional disk drive is equal to the number of heads (i.e. the number of working surfaces), times the number of tracks per surface, times the number of sectors per track, times the number of bytes per sector.

Hard Disk – Inside View (not required in Exam)

Moving-Head Disk Mechanism (not required in Exam)



Magnetic Disk Size Example

Western Digital 26400

Drive Parameters: 13328 cyl • 15 heads • 63 spt • 6448.6 MB

- 13328 cylinders
- 15 heads
- 63 sectors/track
- 512 B/sector
- Capacity =
  13328 x 15 x 63 x 512 =
  6,448,619,520 B

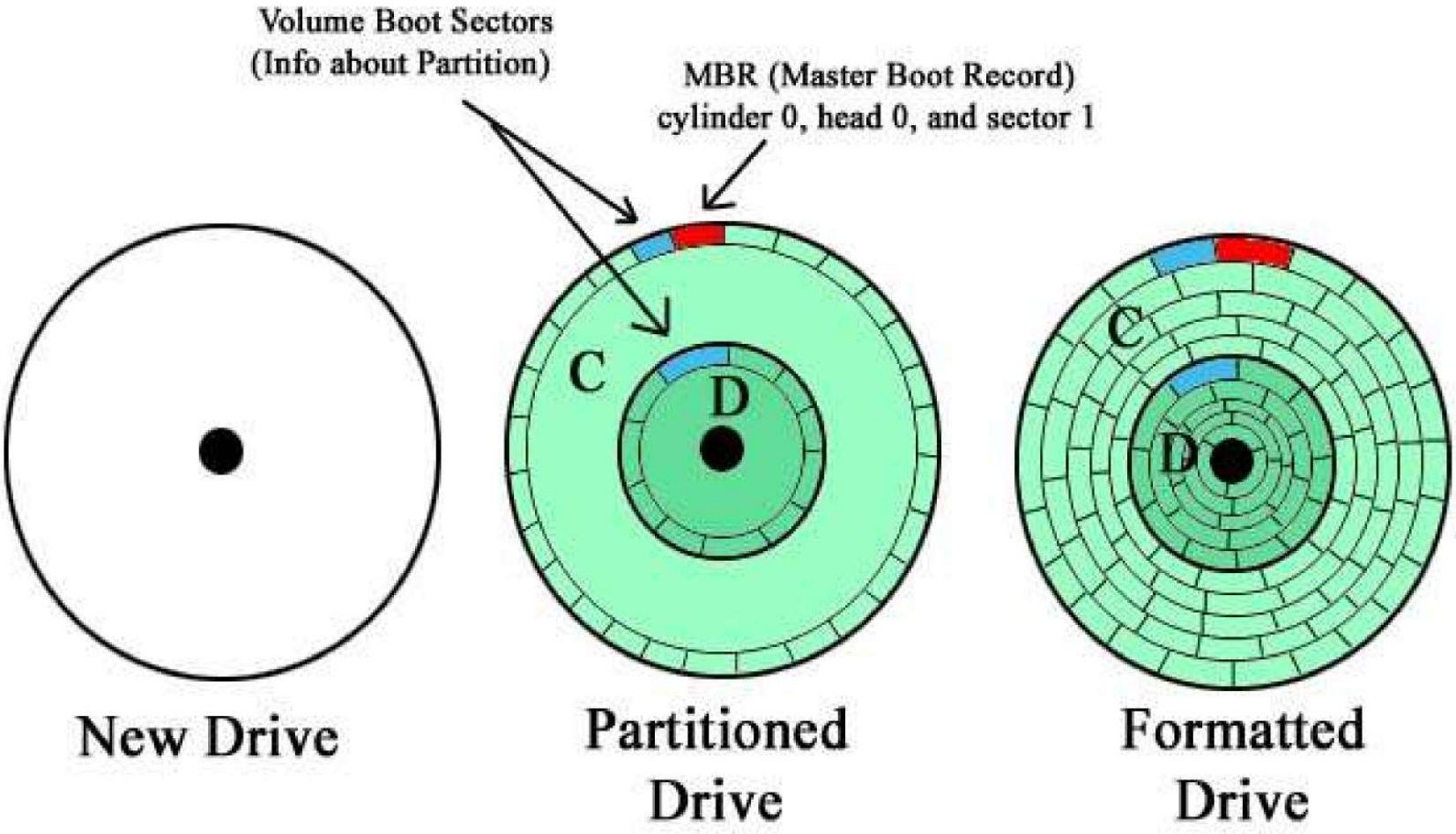
Disk Logical Structure

- Disk drives are addressed as large 1-dimensional arrays of **logical blocks**, where the logical block is the smallest unit of transfer
- The 1-dimensional array of logical blocks is mapped into the sectors of the disk sequentially
  - Sector 0 is the first sector of the first track on the outermost cylinder.

2. Disk Partitioning and Formatting

- **Disk partitioning** is the act of dividing a hard disk drive (HDD) into multiple logical storage units referred to as ***partitions***, to treat one physical disk drive as if it were multiple disks, so that a different file system can be used on each partition.
- **Disk Formatting** **w**hich involves setting up a file system for initial use. No operating system, can work with a hard drive that hasn't been formatted.
- **Note:** When formatting in Windows, data may or may not actually be erased after formatting the drive. Depending on the type of format, it's very possible the data is still there, hidden from Windows and other operating systems but still accessible in certain situations.

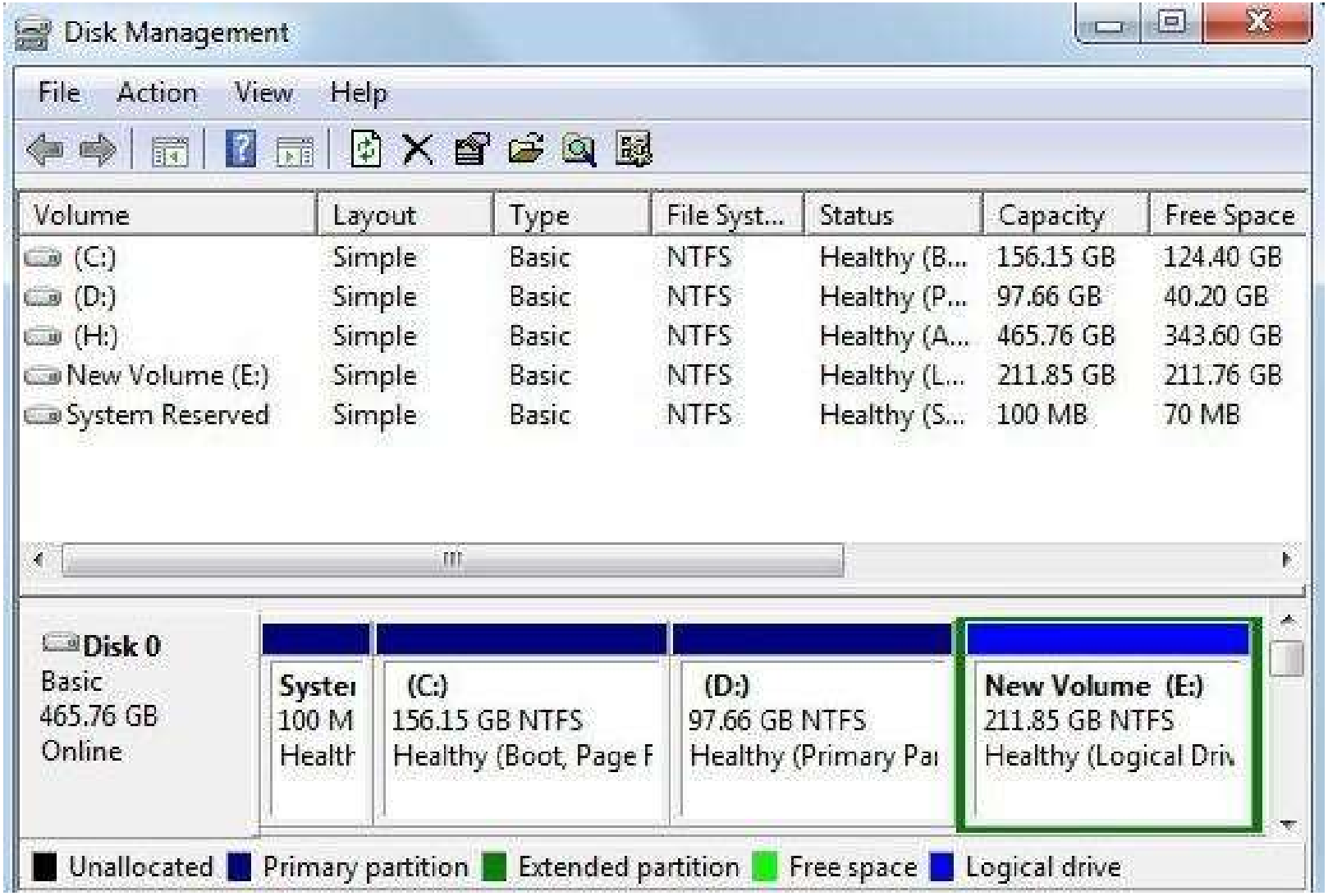
Disk Partitioning and Formatting



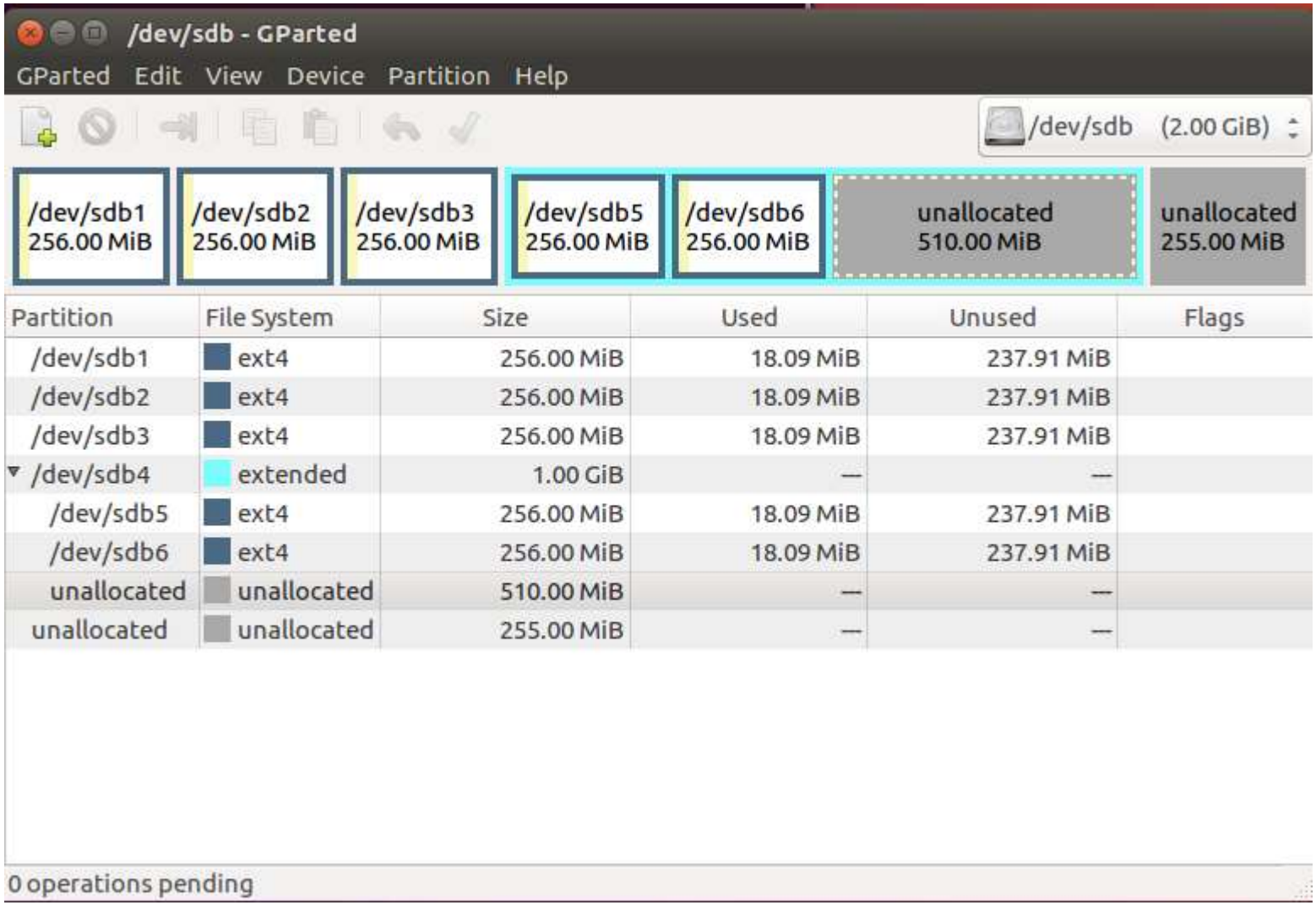
Types of Partitions

- **1. Primary Partition** is a partition that is needed to store and boot an operating system, though applications and user data can reside there as well.
- There can be up to a **maximum of four primary partitions on a single hard disk in MBR partition table**, with only **one of them set as active** (see “Active partition”).
- **2. Active partition** is a primary partition that has an operating system installed on it. It is used for booting your machine.
- **3. Extended Partition**: It is the partition which can be further subdivided into a number of logical partitions, and cannot be directly formatted with a file system. An extended partition can contain up to 24 logical partitions.
- **4. Logical Partition** is created within an extended partition. A logical partition is a way to extend the initial limitation of four partitions. Logical partitions are used for storing data mainly.

Types of Partitions Windows Example

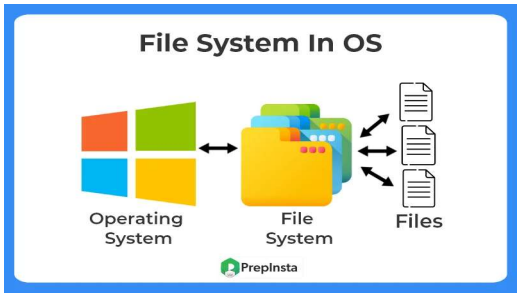


Types of Partitions –Linux Example



Types Of File System Formats

- **NTFS** – NTFS, short for Windows **NT** **F**ile **S**ystem, is a propitiatory file system created by Microsoft for its Windows line of operating system.
- **HFS+** –is a file system created by Apple for use with hard disks on Mac operating system.
- **FAT / FAT 16 / FAT 32 –** FAT, short for File Allocation Table, is the most compatible format for storing data, and it has been used in hard drives, USB flash drives, and memory cards.
- **exFAT –**is a propitiatory file system created by Microsoft for flash drives in situations where NTFS is not feasible due to its data structure overhead or file size is bigger than 4GB.
- NOTE: FAT32 is compatible with almost all operating system and devices, but it supports file size of 4GB only.



3. How to Really Erase Mobile Data

- **Problem**: When selling an old phone, the standard procedure is to restore the device to factory settings, wiping it clean of any personal data. This creates a new-phone feel for the new owner and offers protection for the original owner. However, a security firm has determined returning Android devices to factory settings doesn't actually wipe them clean.

How to Really Erase Mobile Data

- **Solution** Procedures to *really* erase mobile data by encrypting it *before* attempting the reset. For Android:

1. Plug in your phone to charge.
2. Open the Settings Icon on your Android device
3. Select Security within the Settings list
4. Select Encrypt Phone and wait about an hour.
5. When the process is complete, restore to factory settings.

4. Disk Scheduling

- The operating system is responsible for using hardware efficiently — for the disk drives, this means having a fast access time and disk bandwidth
- **Disk Bandwidth** is the total number of bytes transferred, divided by the total time between the first request for service and the completion of the last transfer
- When multiple requests are to be processed there is also some inherent delay in waiting for other requests to be processed.
- For this purpose there are different Disk Scheduling Algorithms (shown in the next slide):

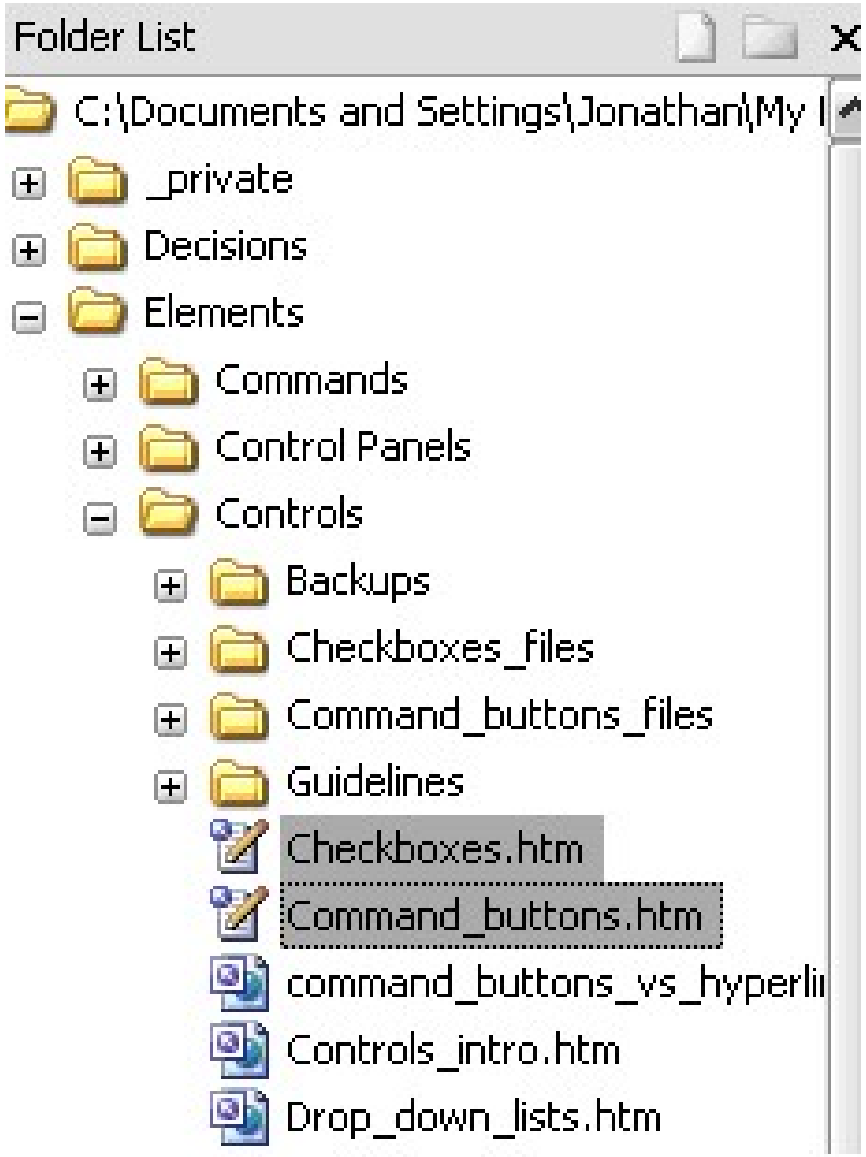
Basic Disk Scheduling Algorithms

- **FCFS** (First Come, First Served) perform operations in order requested
- **SSTF** (Shortest Seek Time First) after a request, go to the closest request in the work queue, regardless of direction.
- **SCAN** go from the outside to the inside servicing requests and then back from the outside to the inside servicing requests.
- **LOOK** like SCAN but stops moving inwards (or outwards) when no more requests in that direction exist.

5. File and Directory Concept

- A **file** is an object on a **computer** that stores data, information, settings, or commands used with a **computer** program.
- A **directory or folder** is a location for storing files on the computer.
- **Directories** are found as a **tree** and are stored the same as any other file in the system, except
  - there is a bit that identifies them as directories, and
  - they have some special structure that the OS understands.
- Files may be accessed using either:
  - absolute pathnames (relative to the root of the tree) or
  - relative pathnames (relative to the current directory.)

Tree-Structured Directories



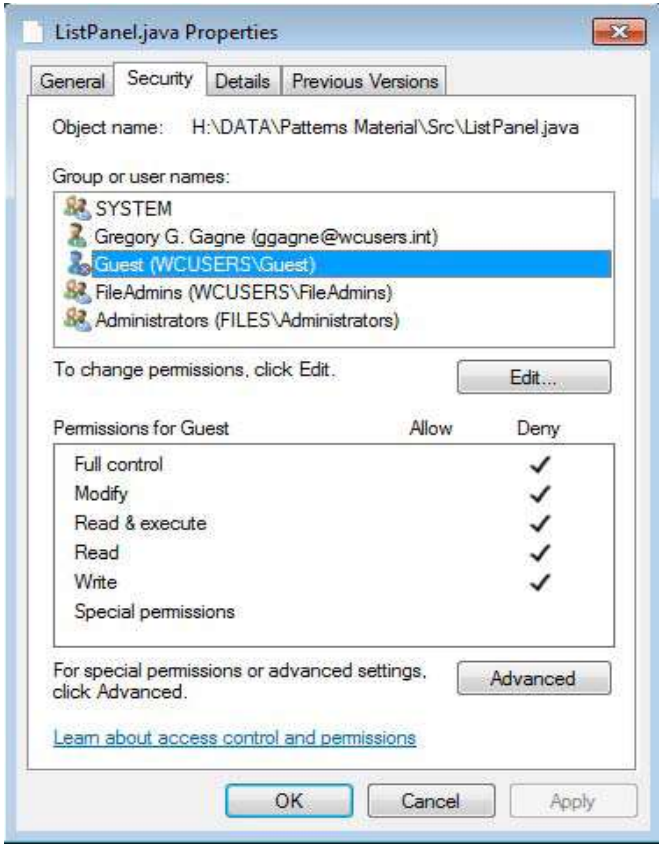
File Attributes

- **Name** –
- **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**
- **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.

File Attributes Example on Mac

File Access Control (not required in the exam)

- Windows uses simple GUI.



- UNIX uses a set of 9 access control bits, for read, Write and Execution.

```
-rw-rw-r--   1 pbg  staff    31200  Sep 3 08:30   intro.ps
drwx------   5 pbg  staff      512  Jul 8 09.33   private/
drwxrwxr-x   2 pbg  staff      512  Jul 8 09:35   doc/
drwxrwx---   2 jwg  student    512  Aug 3 14:13   student-proj/
-rw-r--r--   1 pbg  staff     9423  Feb 24 2012   program.c
-rwxr-xr-x   1 pbg  staff    20471  Feb 24 2012   program
drwx--x--x   4 tag  faculty    512  Jul 31 10:31  lib/
drwx------   3 pbg  staff     1024  Aug 29 06:52  mail/
drwxrwxrwx   3 pbg  staff      512  Jul 8 09:35   test/
```

File Operations

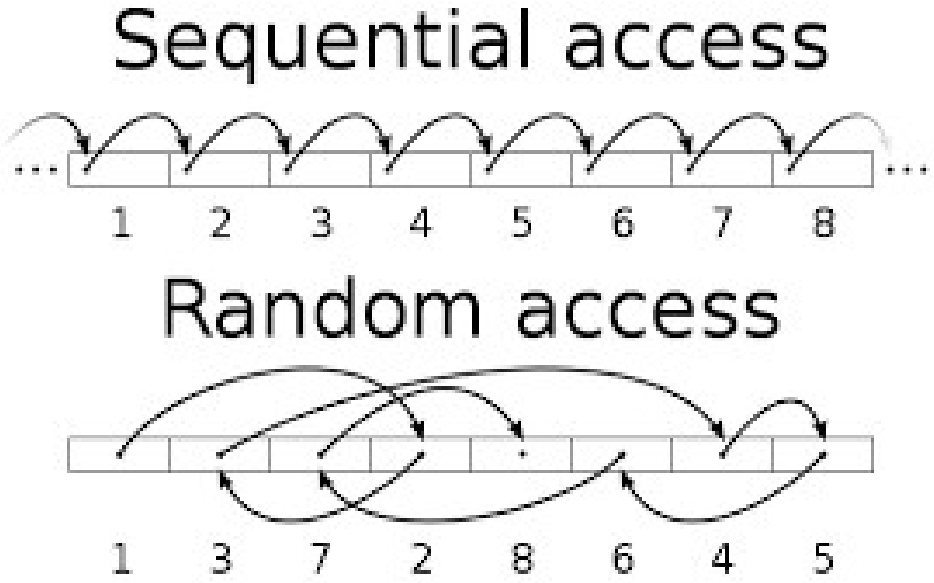
- **Create**
- **Write –** at **write pointer** location
- **Read –** at **read pointer** location
- **Reposition within file - seek**
- **Delete**
- **Truncate – cut part of the file**
- ***Open(F_i)*** – search the directory structure on disk for entry F_i, and move the content of entry to memory
-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

File Types and Extensions

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 compressed, for archiving or storage
multimedia	mpeg, mov, rm, mp3, avi	binary file containing audio or A/V information

File Access Methods

- **Sequential Access:** Information in the file is processed in order, one record after the other (similar to old cassette operation).
- **Direct Access Random Access) –** allow program to Jump to any record and read that record directly.

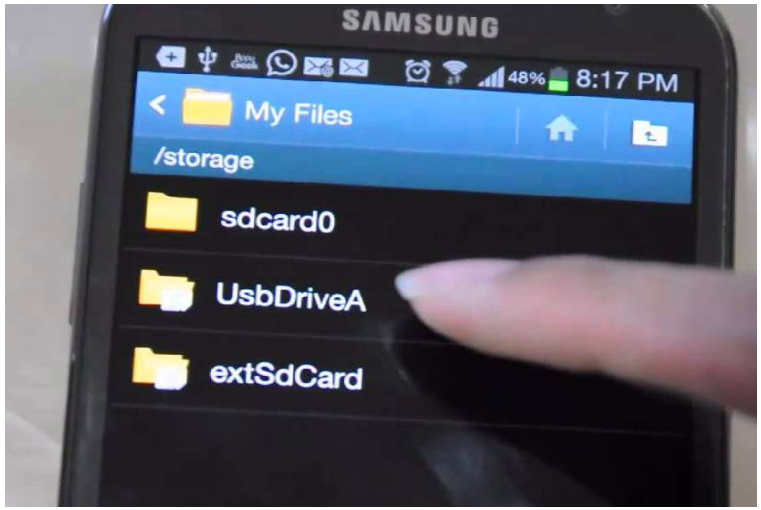


Directory Operations

1. Search for a file
2. Create a file - add to the directory
3. Delete a file - erase from the directory
4. List a directory - possibly ordered in different ways.
5. Rename a file - may change sorting order

File-System Mounting

- **Mounting file systems** is to combine multiple file systems into one large tree structure.
- Most devices will automatically mount an SD card or USB Flash after the card is inserted. If that was not the case, a **mount command** is used to mount it.
- Once a file system is mounted onto a mount point (directory) , any further references to that directory actually refer to the root of the mounted file system.



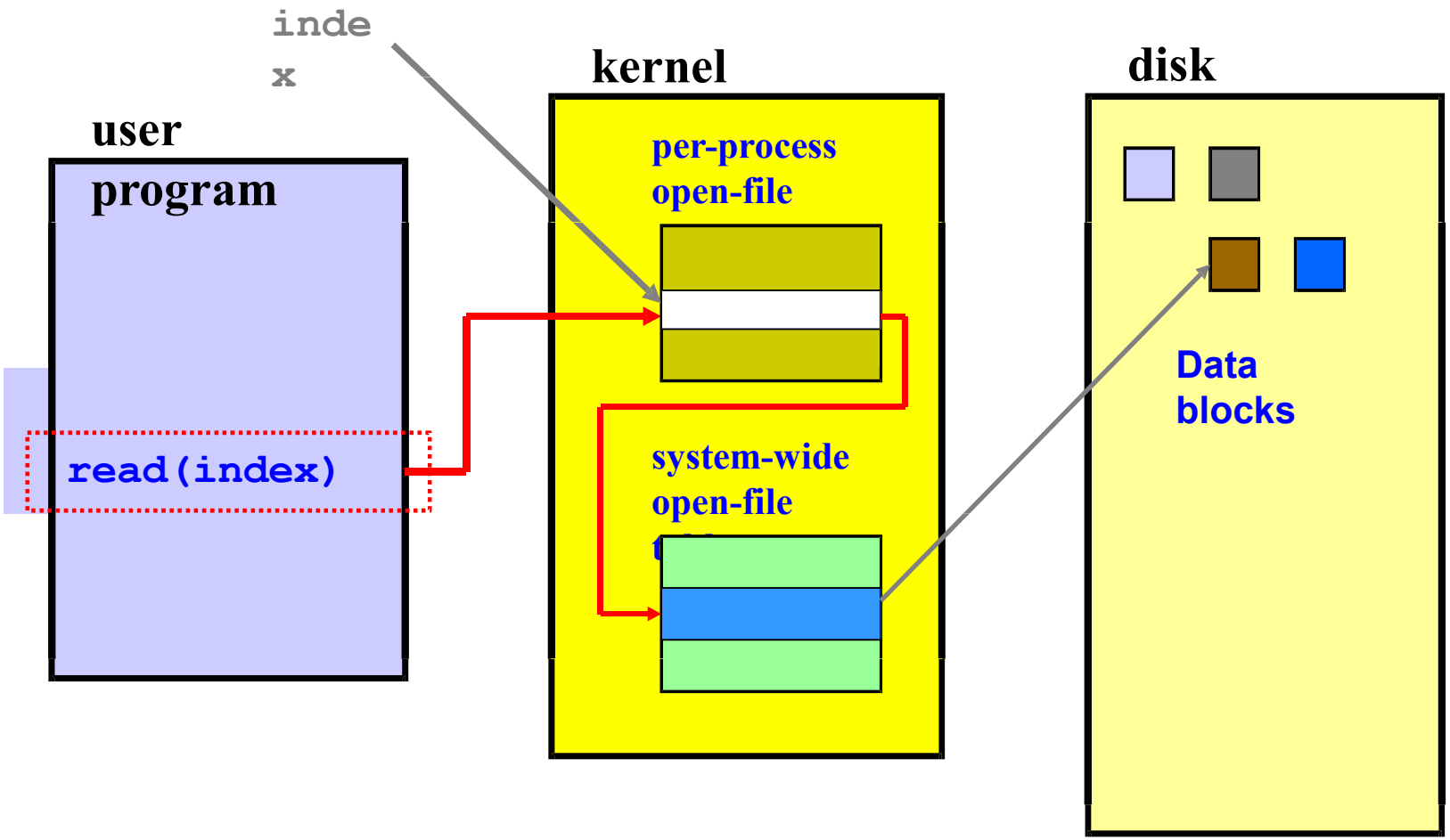
File Control Block

- The ***File Control Block, FCB,*** (per file) containing file details like ownership, size, permissions, dates, etc.
- Regarding File System, there are also two main data structures stored in memory:
  - ***A system-wide open file table***, containing a copy of the FCB for every currently open file in the system.
  - ***A per-process open file table,*** containing a pointer to the system open file table.

File Opening and Reading Description

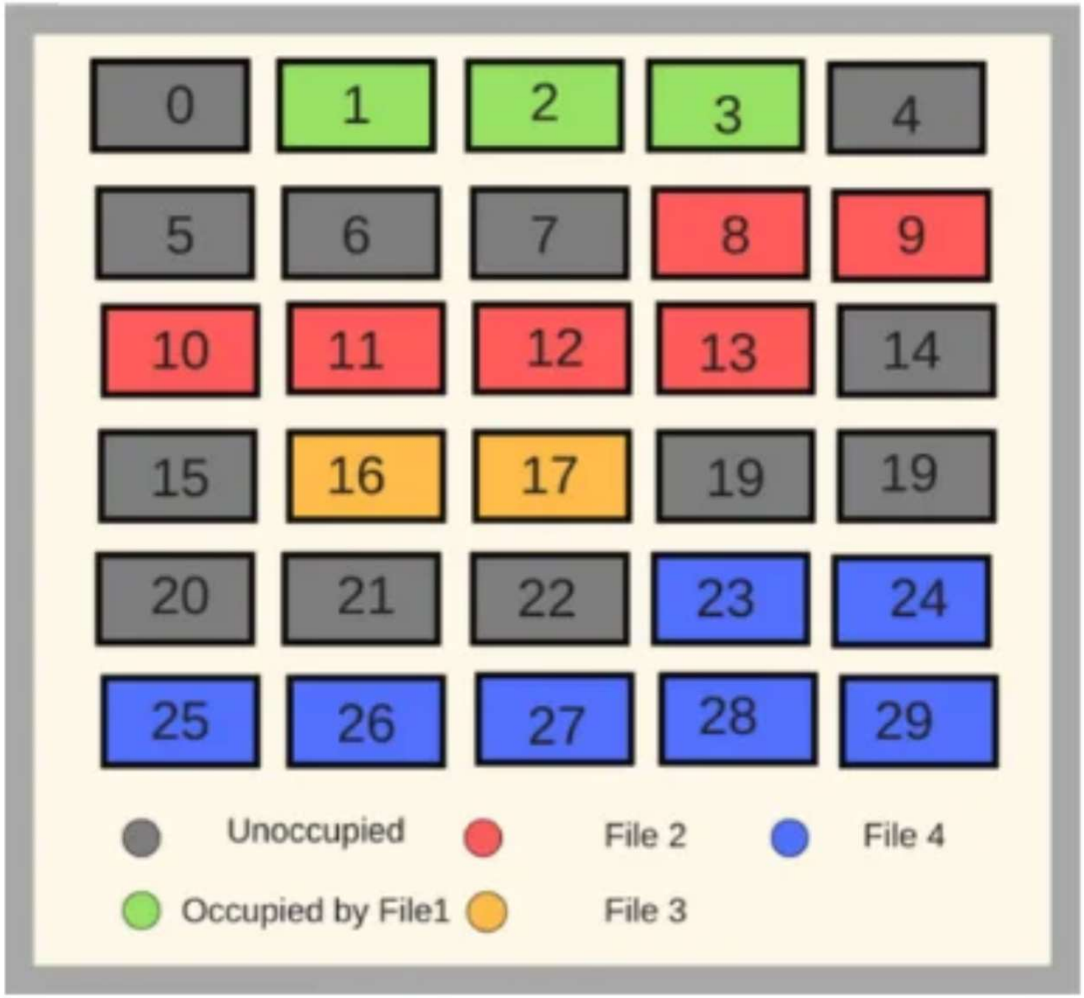
- When a new file is created, a new FCB is allocated and filled out with important information regarding the new file.
- When a file is accessed during a program, the open( ) system call gets the FCB information from disk, and stores it in the system-wide open file table.
- An entry is added to the per-process open file table referencing the system-wide table, and an index into the per-process table is returned by the open( ) system call. **Linux** refers to this index as a ***file descriptor***, and **Windows** refers to it as a ***file handle***.
- When a file is closed, the per-process table entry is freed, and the counter in the system-wide table is decremented

File Reading Diagram (not required in the exam)

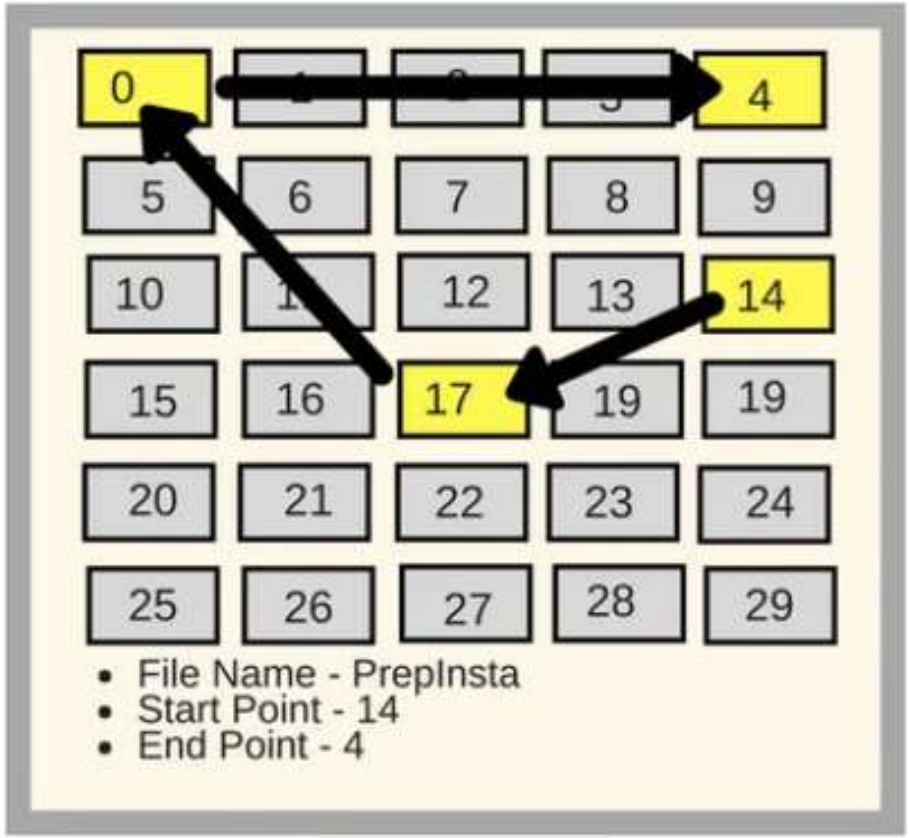


6. Disk Allocation Methods

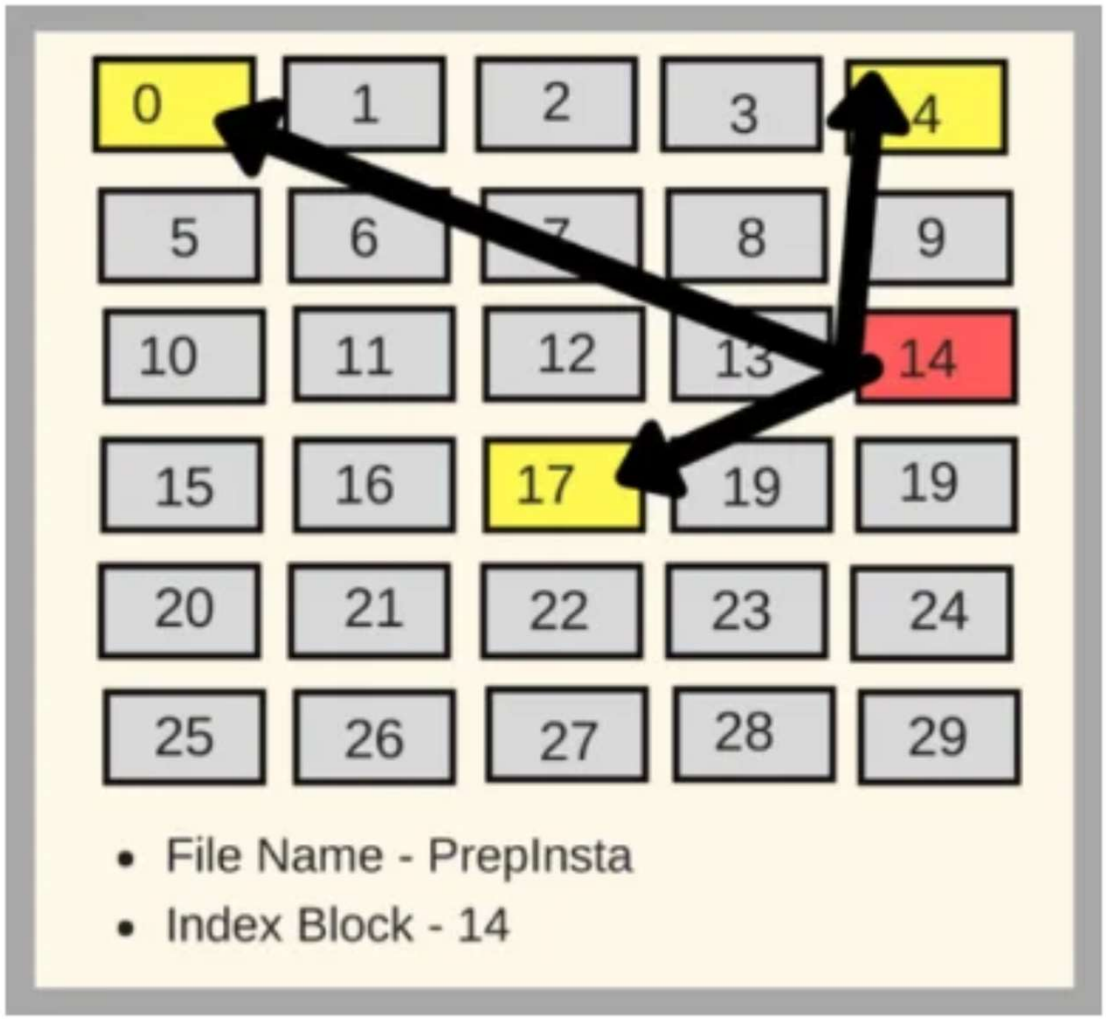
6.1 Contiguous Allocation : requires that all blocks of a file be kept together contiguously.



6.2 Link Allocation: in which files can be stored as linked lists, with the expense of the storage space consumed by each link.



6.3 Indexed Allocation: combines all of the indexes for accessing each file into a common block (for that file).



7. DataCenter Disk Technologies
7.1 Magnetic Tape

- A **magnetic tape:** is a sequential storage medium used for **data collection, backup and archiving**.

7.2 Hot-swappable Hard Disks

- Hard drives can be removable, and some are even ***hot-swappable***, meaning they can be removed while the computer is running, and a new hard drive inserted in their place.

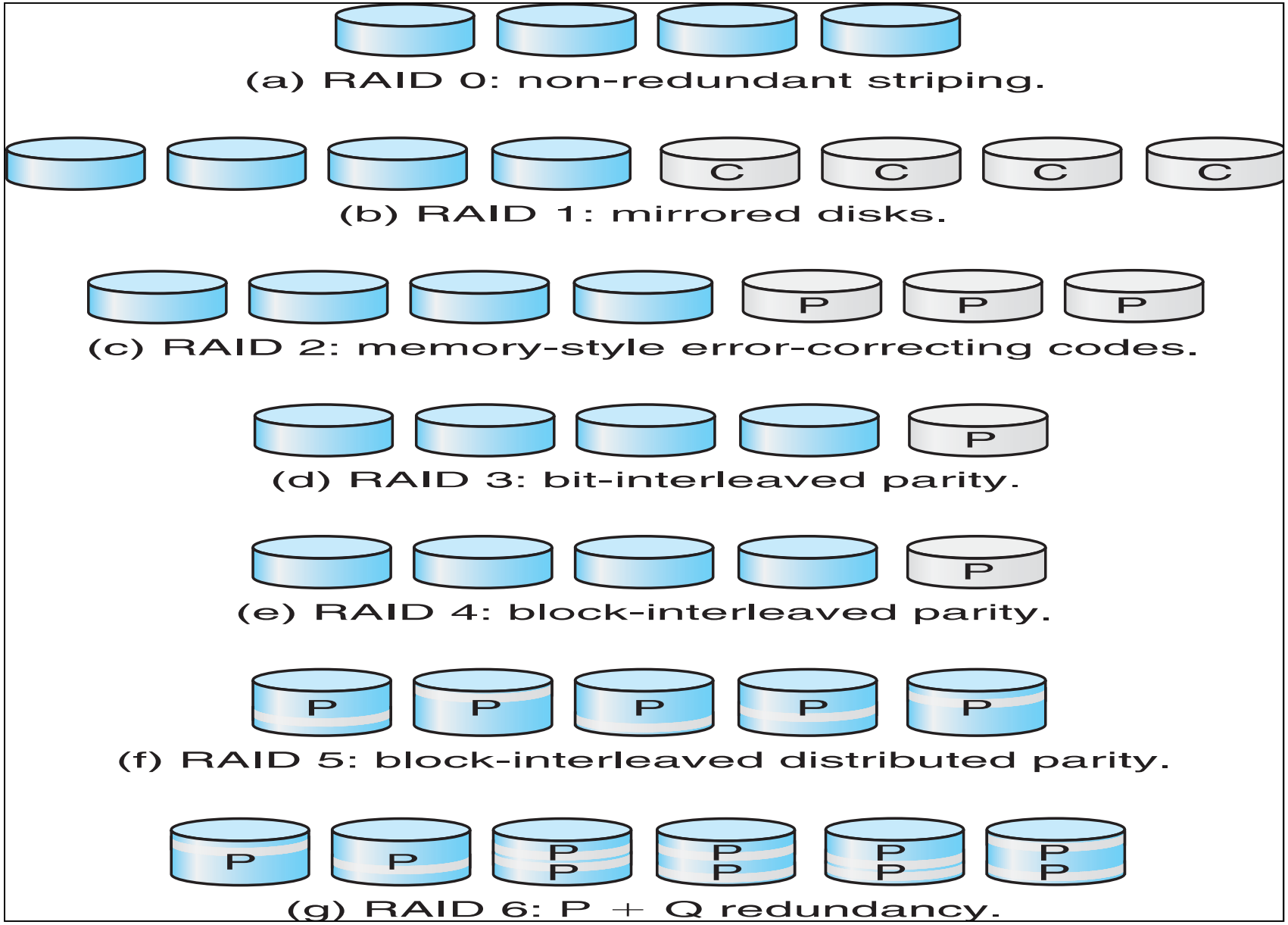
7.3 RAID

RAID, **Redundant Array of Independent Disks** is a data storage virtualization technology that combines multiple physical disk drives components into one or more logical units for the purposes of:

(1)data redundancy, and

(2)performance improvement

RAID Levels (not required in Exam)



7.4 Storage Array Network

- A ***Storage-Area Network, SAN,*** connects computers and storage devices in a network, using storage protocols instead of network protocols.