

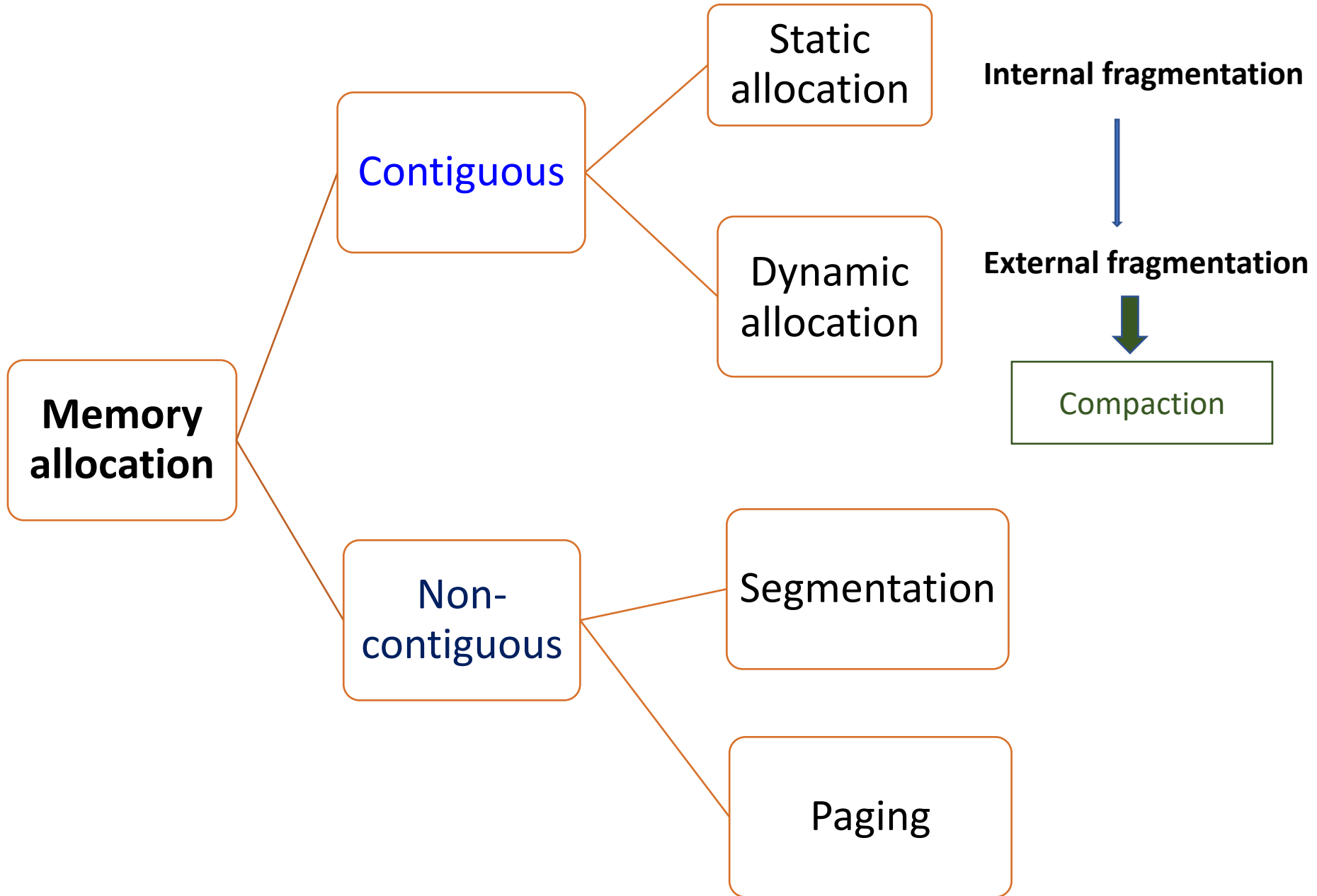
# **Operating Systems Concepts**

Review II

# Content

- Main Memory
- Virtual Memory
- Mass-Storage Systems
- File System
- I/O Systems
- Protection and Security
- Virtual Machines and Distributed Systems

**Main Memory**



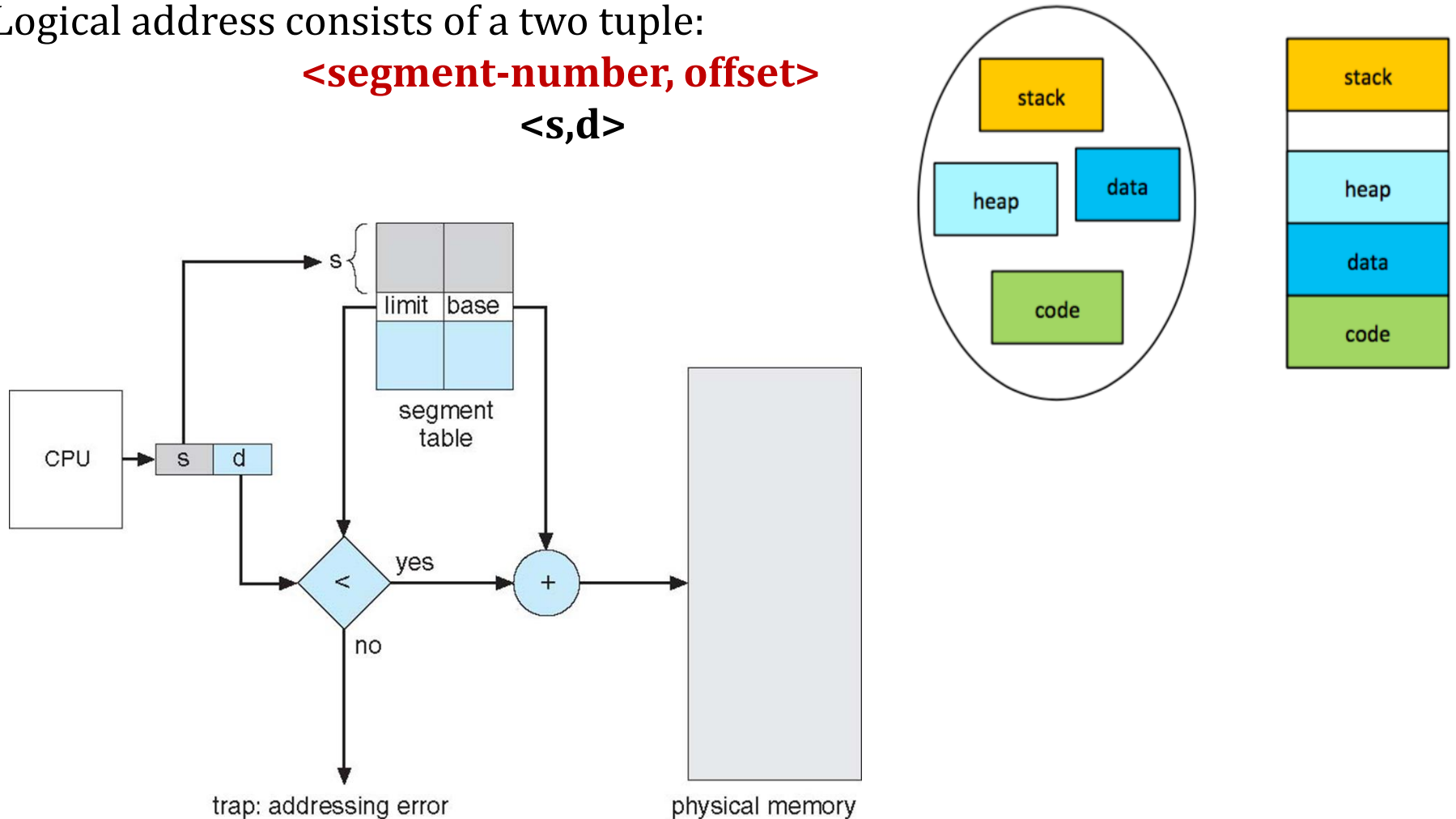
# SEGMENTATION

Divide virtual address space into separate logical segments

Logical address consists of a two tuple:

**<segment-number, offset>**

**<s,d>**



# PAGING

Address generated by CPU is divided into:

**<page-number, offset>**

Divide **physical memory** into fixed-sized blocks called **frames**

Divide **logical memory** into blocks of same size called **pages**

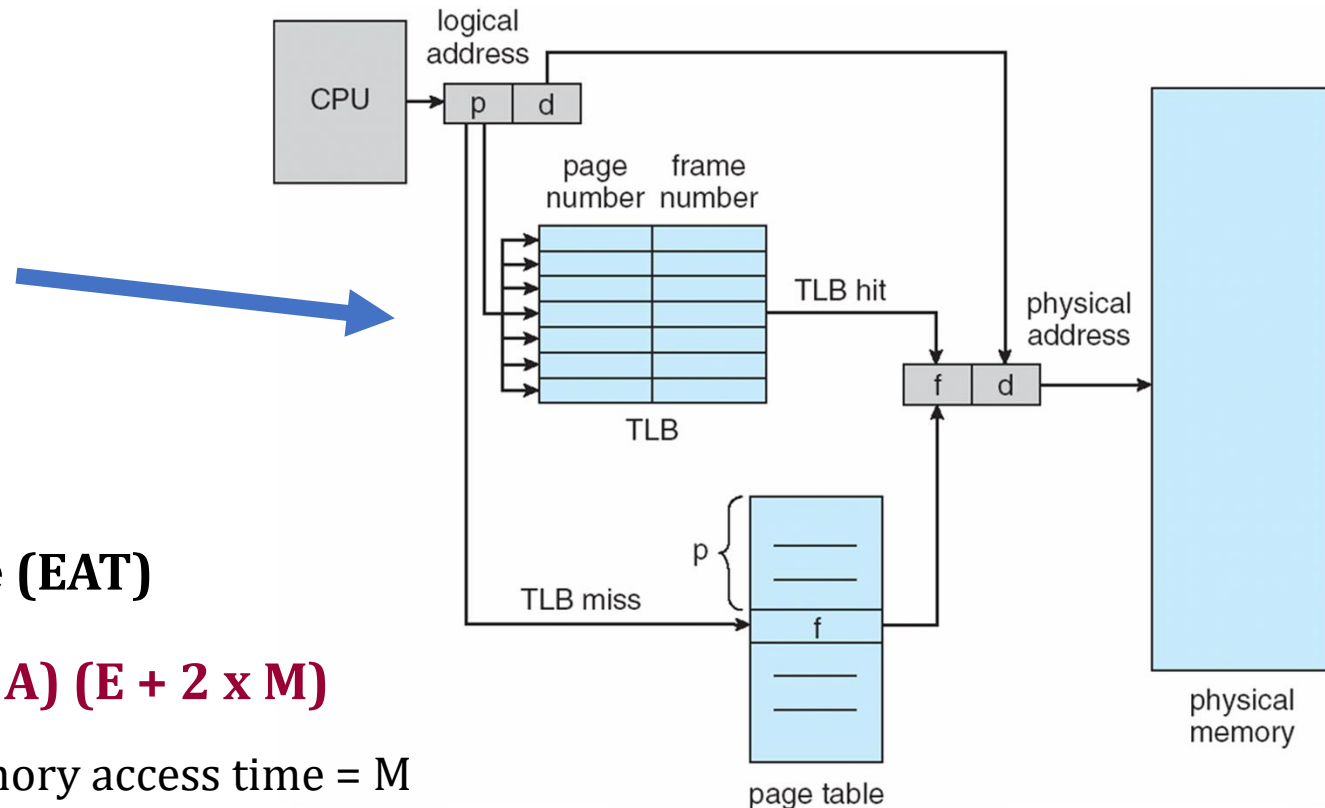
**Translation Lookaside Buffer (TLB)**

**Effective Access Time (EAT)**

$$EAT = A (E + M) + (1 - A) (E + 2 \times M)$$

TLB access time = E, Memory access time = M

TLB hit ratio = A and  $1 - A$  = TLB miss ratio



## **Structure of the Page Table**

```
graph LR; A[Structure of the Page Table] --- B[Hierarchical Paging]; A --- C[Hashed Page Tables]; A --- D[Inverted Page Tables];
```

**Hierarchical Paging**

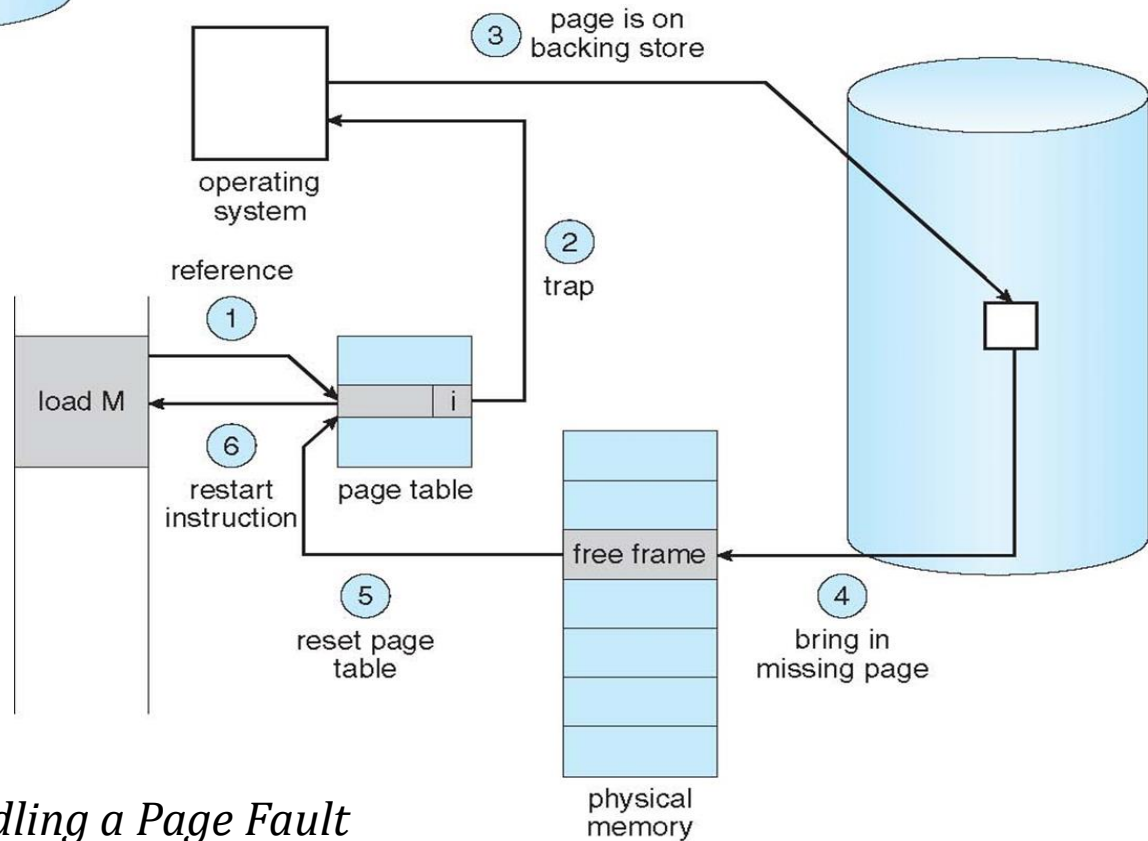
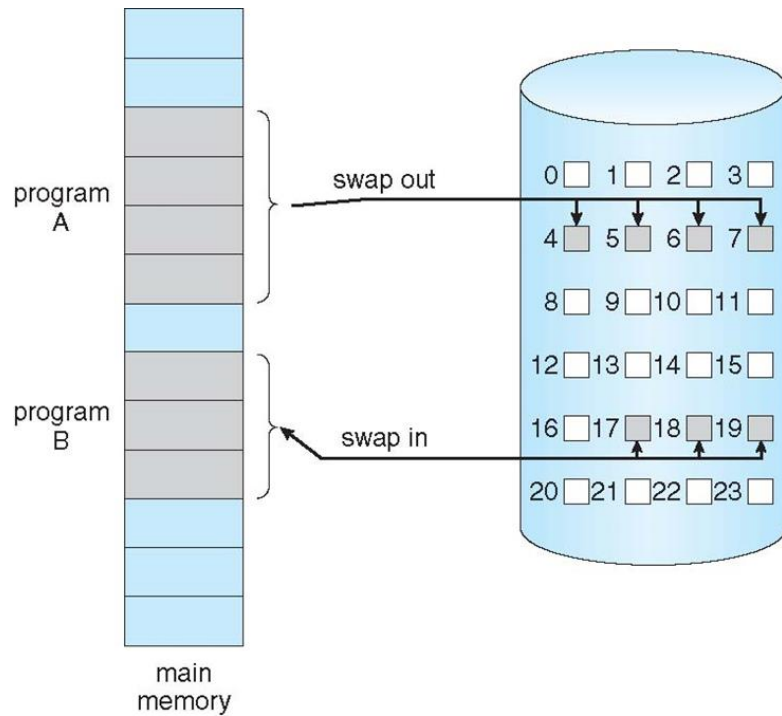
**Hashed Page Tables**

**Inverted Page Tables**

# Virtual Memory



# Demand Paging



*Steps in Handling a Page Fault*

# **Demand Paging**

```
graph LR; DP[Demand Paging] --- PRA[Page-replacement algorithms]; DP --- AF[Allocation of Frames]; PRA --- FIFO[- First-In-First-Out (FIFO) Algorithm]; PRA --- Optimal[- Optimal Algorithm]; PRA --- LRU[- Least Recently Used (LRU) Algorithm]; PRA --- SC[- Second-Chance (Clock) Page-Replacement Algorithm]; PRA --- ESCA[- Enhanced Second-Chance Algorithm]; PRA --- CA[- Counting Algorithms]; AF --- FN[- Fixed number]; FN --- EA[▪ Equal allocation]; FN --- PA[▪ Proportional allocation]; AF --- PB[- Priority based];
```

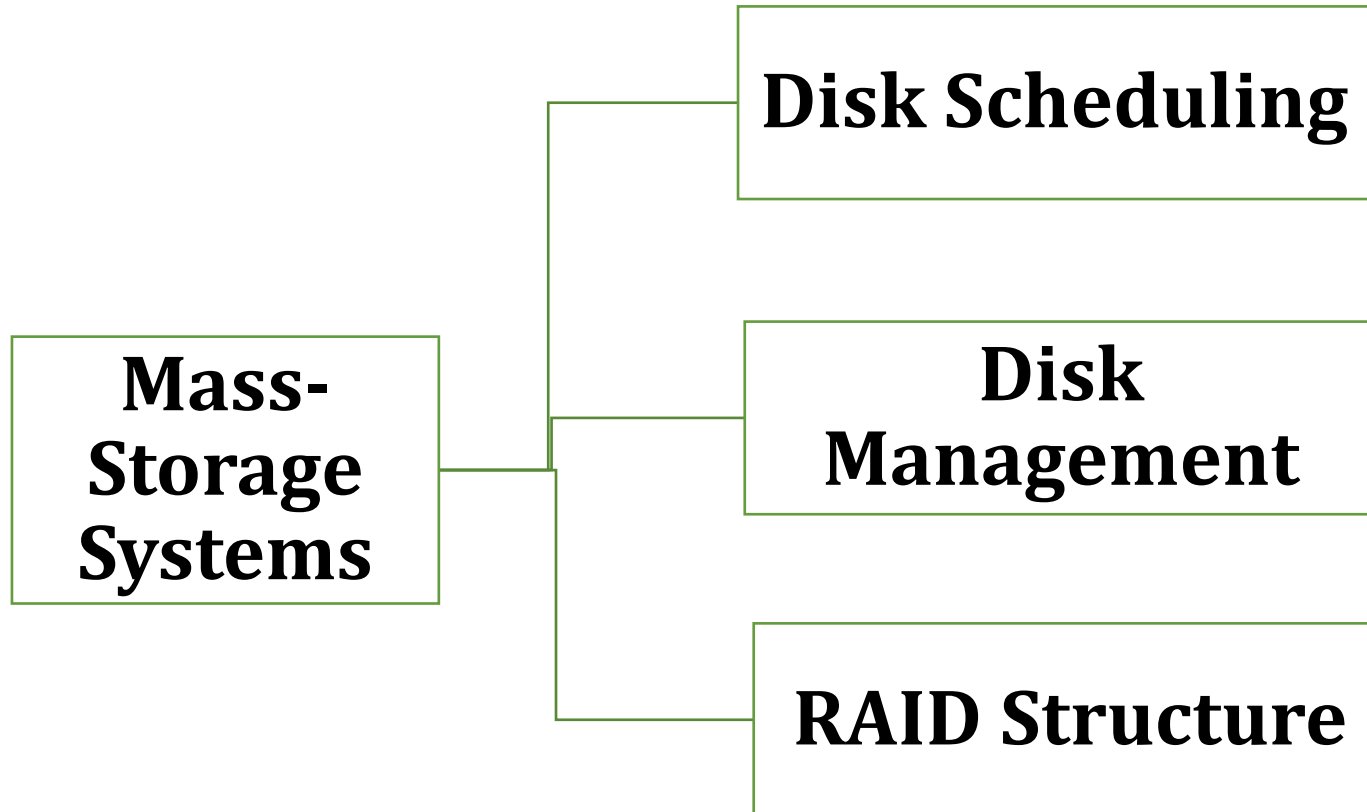
## Page-replacement algorithms

- First-In-First-Out (FIFO) Algorithm
- Optimal Algorithm
- Least Recently Used (LRU) Algorithm
- Second-Chance (Clock) Page-Replacement Algorithm
- Enhanced Second-Chance Algorithm
- Counting Algorithms

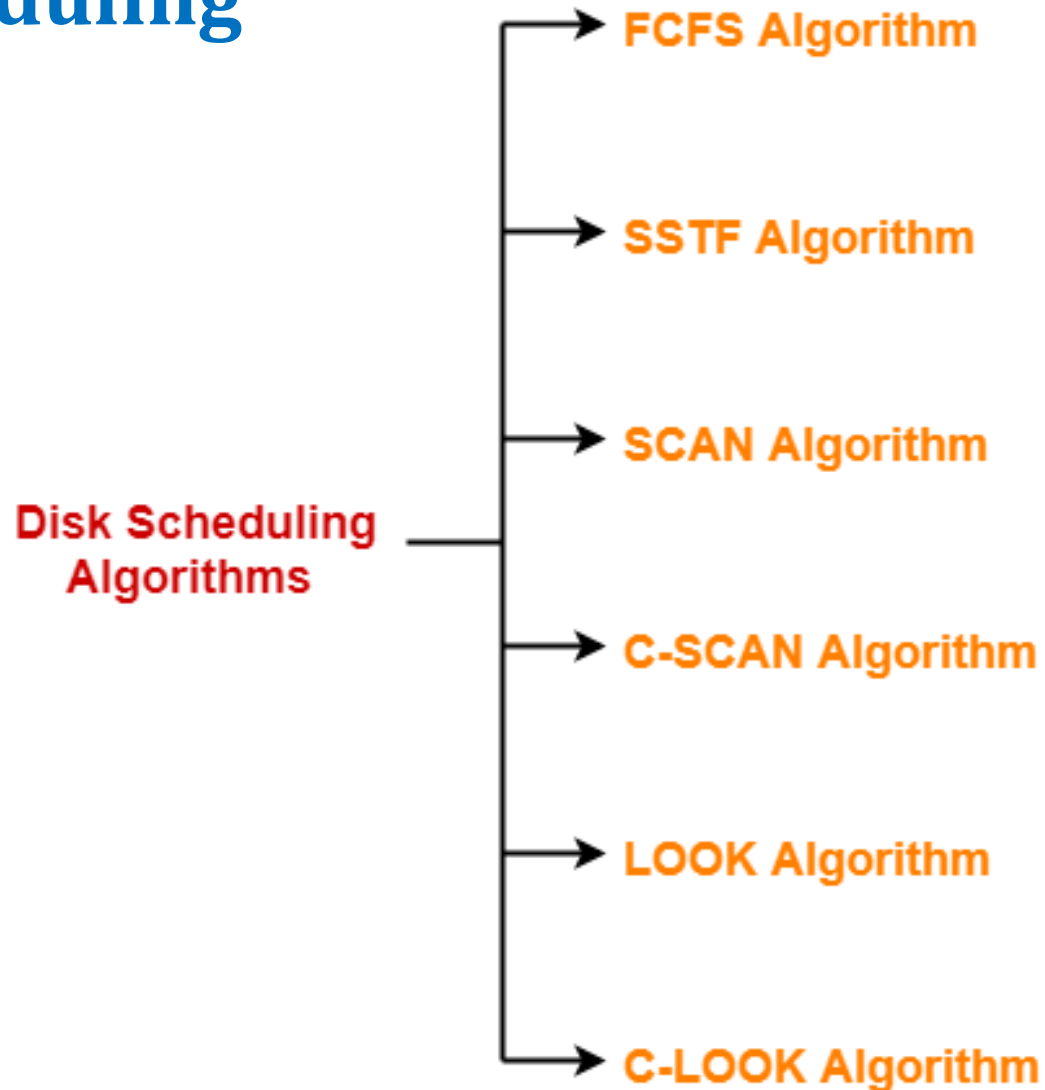
## Allocation of Frames

- Fixed number
  - Equal allocation
  - Proportional allocation
- Priority based

# Mass-Storage Systems



# Disk Scheduling



# Disk Management

- **Low-level formatting**, or **physical formatting** — create sectors on a blank platter
  - Each sector can hold header information, plus data, plus error correction code (**ECC**)
  - Usually 512 bytes of data but can be selectable
- **Partition** organize disk in one or more groups of cylinders
- **Logical formatting** write file system data structures
- **Boot block** initializes system
  - The bootstrap is stored in ROM
  - **Bootstrap loader** program stored in boot blocks of boot partition

# RAID

- **Mirroring** is writing data to two or more hard drive disks (HDDs) at the same time.
- **Striping** breaks data into “chunks” that are written in succession to different disks.
- **Level 0** - striping across disks, no mirroring.
- **Level 1** – mirroring + striping
- **Level 2** - mirroring + striping + ECC parity & parity disks
- **Level 3** - mirroring + striping (bit/byte) + ECC & 1 parity disk
- **Level 4** - mirroring + striping + block level ECC & 1 parity disk
- **Level 5** – mirroring + striping + block level distributed ECC parity
- **Level 6** - mirroring + striping + block level Dual parity

# **File System**



## **File System Interface**

*The user level (more visible) of the file system.*

- Access methods
- Directory Structure
- Protection
- File-System Mounting
- File Sharing

## **File System Implementation**

*The OS level (less visible) of the file system.*

- Allocation and Free Space Management
- Directory Implementation

# I/O Systems

I/O Hardware

Layered I/O structure

Application I/O Interface

Kernel I/O Subsystem

STREAMS

Performance

**Protection and Security**

- **PROTECTION** refers to a mechanism for controlling the access of programs, processes, or users to the resources defined by a computer system.
  - *PRINCIPLE OF LEAST PRIVILEGE*
  - ACCESS CONTROL → *ACCESS MATRIX*
- **SECURITY** is the practice of the confidentiality, integrity, and availability of data.
  - Cryptography as a Security Tool
  - User Authentication
  - Implementing Security Defenses

# **Virtual Machines & Distributed Systems**

- **VIRTUAL MACHINES** - a software program that emulates a hardware system
  - Implementation of virtual machines
  - Benefits
- **DISTRIBUTED SYSTEMS** - computing environment in which various components are spread across multiple computers on a network.
- It make a convenient medium to share resources, speed up computation, and improve data availability and reliability.
  - Reasons of DS
  - Network-based OS
    - Network operating system
    - Distributed operating system

# The end

GOOD LUCK!