Multiple Virtual Storage (MVS)

Lesson 2: MVS Environnent Concepts

Lesson Objectives

- In this lesson, you will learn the following:
  - The manner in which data and commands are processed in general
  - The various MVS characteristics in detail

Note: We will be covering the basic characteristics of Mainframe OS in depth. Before that, let us check how data processing is done.

2.1: Data Processing
Data Processing Concepts

- For executing Business applications, we can have:
  - On-Line Mode / Foreground Mode:
    - It provides an interactive mode for the end user to execute the application programs.

  - Batch Mode / Background Mode:
    - It provides a non-interactive mode for executing the programs.
    - Programs are normally submitted as batch job for execution.
    - Instructions to execute are maintained in a separate command file.

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Data Processing:
Data Processing Concepts:
Online environment:
End user performs business functions. These application programs work interactively with End user. Execution is done in foreground mode, that is normally using the terminal devices for taking the input or displaying the output. Any transactions made are immediately updated in database to reflect the changes. It is typically used for transaction processing, queries, and master updates functions.

Batch Environment:
Some application programs are executed in background mode in which the business functions are periodically executed automatically. These functions are triggered by end user "as and when" required. The Operations department is responsible for monitoring the execution. A command file is created to execute these functions. This command file may consist of multiple programs / system utilities to execute the job. It is typically used for bulk transaction processing, report printing, periodic processing (for example: invoice generation, payroll calculation).

2.2: Command Processing

Command Processing Concepts

- Command Issue Mode:
  - How a user (programmer / end-user) interacts with the computer
  - For example: To edit a program, to execute a program:
    - On-line Mode: Using Terminal
    - Batch Mode: Using Punched Cards, JCL

- Command Execution Mode:
  - Foreground: Terminal is locked while the command is being executed.
  - Background: Terminal is free while the command is being executed.

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2.3: Basic Characteristics of Mainframe O/S
Characteristics

- The Mainframe O/S performs the following tasks:
  - Batch Processing
  - Multiprogramming
  - Multiprocessing
  - Time sharing
  - Virtual Storage
  - Spooling

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2.3: Basic Characteristics of Mainframe O/S
Concept of Batch Processing

- On a Mainframe, batch processing is the normal way of using the computer system and has been for decades.
- Work is processed in units called jobs.
- Job is an execution of one or more programs in pre-defined sequence.
- JCL supplies specifications of a job such as programs to be executed, their sequence, where those are stored, what files are used, and where the output is to be held.
- Application programs are executed in background mode

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Batch Processing:
When batch processing is used, work is processed in units called "jobs". A job may cause one or more programs to be executed in sequence. The system collectively processes batch jobs. The operating system is responsible for scheduling the jobs according to priority and the resources they require.

How are jobs executed in batch mode:
> When a user submits a job to the system, that job is added to a list of other jobs, perhaps submitted by other users, that are waiting to be executed.
> As the processor becomes available, the job scheduler of the O/S selects the next job to be executed from this list .
> The job scheduler can make decisions about the order in which jobs should be executed.
> Jobs with higher priority can be given preference over jobs with lower priority.

How are jobs executed in batch mode:

5. Priority of a job is specified in the JCL command file that supplies specifications of a job such as programs to be executed, their sequence, where those are stored, what files are used, where the output is to be held, and so on.
6. Once the execution is done, the output is held in the output queue or printed directly.

Example:

A large company would use batch processing to automate their payrolls where in it would find the list of employees, calculate their monthly salary (with tax deductions) and print the corresponding payslips. Batch processing is useful for this purpose since these procedures are repeated for every employee each month.

2.3: Basic Characteristics of Mainframe O/S
Concept of Multiprogramming

- Single user cannot keep CPU and I/O devices busy at all times.

- The program has CPU based and Non-CPU based instructions.

- CPU is kept waiting during the non-CPU based instructions execution.
  - For example: I/O operations (Disk, Terminal, Printer)

- This results in wastage of CPU time - a precious resource.

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Multiprogramming:
While executing a program, some processing instructions – like reading data from disk – take much longer time than others.
As a result, most programs are idle, thus waiting a large percentage of the time for the completion of I/O operations. This also leads to wastage of CPU time.
So, how can we go about making efficient CPU utilization?

Multiprogramming means OS allows one or more programs to execute concurrently. Most programs spend most of their time waiting for I/O operations to complete.
So while one program waits for an I/O operation, the CPU can execute instructions for another program.
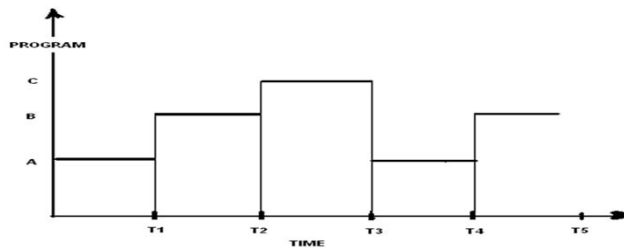CPU executes only one program at any given moment of time.

Note: CPU performs concurrent execution of program and not simultaneous execution.

The above slide shows a diagrammatic representation of Multiprogramming. When one program goes for I/O, the O/S takes up second program for execution, and when that goes for I/O, then O/S starts executing another program.

Program doing I/O, goes in "wait" state. After I/O is over, it gets into "ready" state for execution.

The O/S keeps track of which programs are in "ready" state and which programs are in "wait" state.

Note: At any moment, the CPU is executing only one program. It is the concurrent execution of multiple programs.

2.3: Basic Characteristics of Mainframe O/S
Why Multiprogramming?

- Multiprogramming organizes program execution so that CPU always has one job to execute.

- Multiprogramming simply reclaims the CPU during idle periods to let other programs execute.

- Multi-programming results in better and efficient CPU utilization.

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2.3: Basic Characteristics of Mainframe O/S
Multiprogramming Overheads

- **Multiprogramming Overheads:**
  - Program Queue Management
  - Program Status Management
  - Context Switching during Changeover
  - Multiple programs must be in main memory
  - Management of Common Resource Sharing (e.g. Printer)
  - It is critical to determine optimum level of Multiprogramming to maintain certain service level.

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2.3: Basic Characteristics of Mainframe O/S

Relevance of Multiprogramming:

- Multi-programming is applicable even for single user system
- Multi-programming is a must for multi-user system

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2.4: Multiprocessing

Concept of Multiprocessing

- There are multiple CPUs (processors) in one machine.

- During Multiprocessing, these CPUs work together under a single operating system.

- Each CPU executes a separate program.

- O/S assigns programs to each CPU.

- Essentially CPU is treated as an allocable device!!!!!

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2.3: Basic Characteristics of Mainframe O/S
Concept of Time Sharing

- Batch processing was the only way to use mainframe in early days.
  - Batch job processing is called background processing.

- As terminals became more common, users needed a more direct way to use the computer system.

- In Time Sharing system, each user has access to the system through a terminal. The user enters commands that are processed immediately.
  - Online processing: It lets users interact directly with the computer. Time sharing is called foreground processing.

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Time sharing:
Time sharing is a logical extension in which CPU switches jobs so frequently that users can interact with each job while it is running, thus creating interactive computing.
In timesharing:
> Response time should be < 1 second.
> Each user has at least one program executing in memory ⇨ process
> If several jobs ready to run at the same time ⇨ CPU scheduling
> If processes don't fit in memory, then swapping moves them in and out to run.
> Virtual memory allows execution of processes not completely in memory.
On-line communication between the user and the system is provided. When the operating system finishes the execution of one command, it seeks the next "control statement" not from a card reader, but rather from the user's keyboard.
This involves the CPU allocating individual time slices to a number of users on the computer system. As the number of users increase, the response time for each terminal declines. The speed of the CPU compared to that of the VDU and terminal is so much faster that it gives the user the impression that s/he is the sole user of the system.

2.3: Basic Characteristics of Mainframe O/S
Concept of Time Sharing (Contd…)

- Remember, time sharing involves the following:
  - Resource Sharing
  - Time Slice
  - Multiple Users compete for computer resources at the same time
  - At any given point in time, only one user can have control of the resources
  - Think about what should be the basis of priority and sharing?

- Time Sharing typically refers to sharing of resources in an interactive processing mode.

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Time Sharing:
Time Slice:
Each user is given control of resources for a pre-defined period, that is a time slice. The control is passed on to the next in the queue user at the end of time slice (even if first user's work is incomplete). If the user requires I/O before the time slice is over, then the control is handed over to the next user (since CPU cannot do anything until I/O is complete).
One can decide on the time sharing priority based on usage of one or more algorithm:
　　　　First come first served?
　　　　Priority based?
　　　　Whosoever can grab it - Law of Jungle?
　　　　Equal - Democratically?
　　　　Need based?
Usually the combination of 2 and 4 is used, that is all are equal but some are more equal!!!!!

Priority:
Each user / function is assigned a priority level.
The higher priority users are serviced first in a round robin fashion.
Only if the higher priority users are in "wait" state for I/O completion, then the users in lower priority are serviced.

2.3: Basic Characteristics of Mainframe O/S
Concept of Virtual Storage

- Virtual Storage is a technique that lets a large amount of main storage (memory) be simulated by a processor that actually has a smaller amount of real storage installed.
  - For example: A processor that has 4 MB of real storage might use virtual storage to simulate 8 MB of main storage.
  - To do this, the computer uses disk storage as an extension of real storage.
  - From the user's point of view, virtual storage appears to be real storage.

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2.3: Basic Characteristics of Mainframe O/S
Basics of Virtual Storage

- Why Virtual Storage?
  - It enables execution of program larger than main memory size.

- What is Virtual Storage?
  - It is a technique to simulate large amount of main storage.

- How is Virtual Storage implemented?
  - (Refer note pages)

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Virtual Storage:
Basics of Virtual Storage:
Why Virtual Storage?
It is required to enable execution of programs which are larger than the main memory size.
What is Virtual Storage?
It is a technique to simulate large amount of main storage.
In reality, main storage is much less.
For example: Real main storage is 16MB but virtual storage is 2GB.
How is Virtual Storage implemented?
Program executable code is generated assuming virtual storage size.
At any given moment, only part of the program is loaded in main memory, that is only the current program instruction and the data it accesses needs to be in real storage (memory). Other instructions and data can be placed temporarily on disk and recalled into main storage when needed.
Address translation mechanism is used to map virtual address to actual address. Operating systems with virtual storage, transfer the instructions and data between real storage and disk, as and when they are needed.
It is feasible because only the instruction currently being executed and the corresponding data need to be in the main storage.

2.3: Basic Characteristics of Mainframe O/S
Advantages and Overheads

- Advantages of Virtual Storage:
  - Main memory can be shared by multiple programs.
  - It enables effective use of the limited main storage.

- Overheads of Virtual Storage:
  - Address mapping
  - Keeping track of what is in memory and what is not
  - Data / Instructions need to be "brought in" main memory as and when required
  - "Remove" from main memory what is not currently required (to make room for instructions of other program)
  - Memory Management

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Virtual Storage:
Advantages and Overheads:
Memory Management:
Problem: Anything that is to be executed must be in memory (Memory limitation).
Solution: (1) Place task in real memory; (2) Place task in virtual memory

Real Memory implementation:
Code and data are in real memory.
Size of code and data is limited by size of installed memory
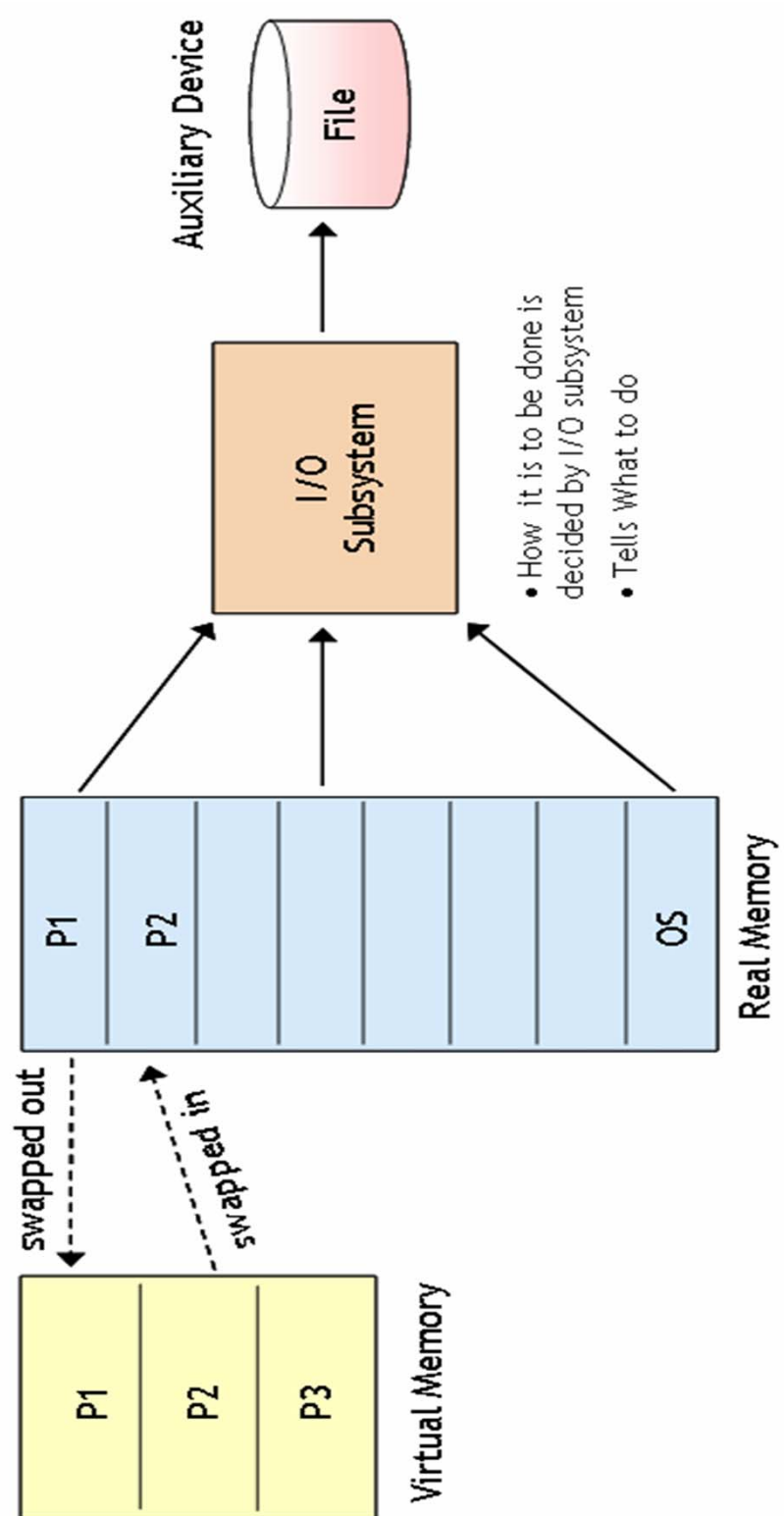Good performance, low overhead
Possible wastage of memory
Virtual Memory implementation:
Based on assumption for a task, not all code and data is needed in real memory at all times.
It is implemented on a combination of real plus auxiliary storage.
Operating system takes responsibility of bringing rest part of tasks in real memory when required.
Advantage: Code and data size are independent of the real memory.

Virtual Storage:

Auxiliary Device

File

I/O Subsystem

- How it is to be done is decided by I/O subsystem
- Tells What to do

P1
P2

OS

Real Memory

swapped out

swapped in

P1
P2
P3

Virtual Memory

2.3: Basic Characteristics of Mainframe O/S
Concept of Spooling

- In Multiprogramming, common problem is of sharing access to I/O devices among programs.
  - For example: Two programs writing to printer
  - However, if two programs that are executing at the same time, try to write output to a printer, then the output from both programs will be intermixed in the printout and multiprogramming will not hold true.
  - Another way is to share access to input and output devices among the programs that execute together in multiprogramming O/S.

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Spooling:
SPOOL is an acronym for simultaneous peripheral operations on-line.
Spooling refers to putting jobs in a buffer, a special area in memory or on a disk, where a device can access them whenever it is ready.
The most common spooling application is print spooling.
Spooling also lets you place a number of print jobs on a queue instead of waiting for each one to finish before specifying the next one.

2.3: Basic Characteristics of Mainframe O/S
How is Spooling implemented?

- Output to printer is intercepted and written to a disk that is "spooled"

- On completion of program "spooled", output is queued for Printing.

- This queue is processed by O/S print routine.

- The O/S print routine is multi-programmed along with application programs.

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Spooling:
Spooling is used to provide shared access to printer devices.
Spooling manages printer output for applications by intercepting it and instead directing it to a disk device. When the program is finished, the O/S collects its spooled print output. and directs it to the printer.
In a multiprogramming environment, each program's spooled output is stored separately on disk so that it can be separately printed.
Since disk devices are much faster than printers, programs that produce spooled print output can execute faster than programs that access printers directly.

Summary

- In this lesson, you have learnt:
  - The basics of command processing using:
    - the batch mode
    - the online processing mode
  - Batch processing is the oldest form of processing data. For example: punch card.
  - The mainframe characteristics like time sharing, multiprogramming, spooling, and virtual storage that form the basic for the MVS O/S

Summary

Review Question

- Question 1: Virtual Storage simulates ___ memory.
  - real
  - virtual
  - disk

- Question 2: Spooling is same as buffering.
  - True / False

- Question 3: In multiprogramming, the ___ is reclaimed during the idle cycles.
  - CPU
  - memory
  - output