Multiple Virtual Storage

Lesson 5: MVS Concepts and Terminology

Lesson Objectives

- **In this lesson, you will learn:**
  - MVS concepts
  - The concepts of
    - Address Space
    - Paging
    - Swapping

5.1: MVS Concepts

Overview

- **Two main component of MVS are:**
  - Virtual Storage
  - Multiprogramming
- **In MVS, the concepts of Virtual storage and Multiprogramming are closely related.**
- **In a way, they refer to the same functionality in MVS.**
- **Let us see each of these components and understand what is MVS.**

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5.2: Virtual Storage

Concept of Virtual Storage

- **Virtual storage is a facility that simulates a large amount of main storage by treating DASDs storage as an extension of real storage.**
- **In other words, when virtual storage is used, the processor appears to have more storage than it actually does.**

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5.3: Addresses Spaces

Concept of Address Space

- To search information in a location, an address is required that indicates storage location.
  - An address space is a complete range of addresses that can be accessed by the computer.
  - The number of digits allowed to represent an address limits the maximum size of a computer's address space.
  - For example: Suppose a computer records its addresses using six decimal digits. Then such a computer can access storage with addresses from 0 to 999,999.
- Main storage consists of millions of individual storage locations, each of which can store one character or byte of information.
  - To refer to a particular location, we can use an address, which indicates the storage location's offset from the beginning of memory.
  - The first byte of storage is at address 0, the second byte of storage is at address 1, and so on.
  - Each successive byte of main storage has an address that is one greater than the previous byte of storage.

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An address space is simply the complete range of addresses - and as a result, the number of storage locations - that can be accessed by the computer.

5.3: Addresses Spaces

Concept of Address Space (contd.)

- The original System/370 processors used 24-bit binary numbers to represent an address.
  - Since the largest number that can be represented in 24 bits is about 16 million, an address space on a System/370 cannot contain more than 16M bytes of storage.
- 370-XA processors, in XA mode, operate using 31-bit addresses.
  - So the largest address space that can be used is 2 GB.

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5.3: Addresses Spaces

Concept of Address Space(contd.)

- One way to think of Virtual Storage is that it lets the computer push its address space to the maximum capacity allowed by the address format, even if the amount of real storage installed on the processor is less than the maximum capacity of the address format.
- So, in 370-mode, virtual storage can simulate a 16 MB address space, even if only 4 MB or 8 MB of real storage is actually installed.

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5.4: MVS

MVS Address Space

- In MVS, the concept of virtual storage is taken one step further.
  - MVS not only simulates more storage, but it also uses real storage to simulate several address spaces, each of which is independent of the other.
  - Hence the name Multiple Virtual Storage (MVS).
  - MVS uses real storage and areas of DASD storage, called page data sets, in combination to simulate several virtual storage address spaces.
  - When multiple virtual storages are used, the total amount of virtual storage that can be simulated is almost limitless. This is because MVS can create an almost unlimited number of address spaces.
  - However, the size of an address (24 bits or 31 bits) still limits the size of each individual address space to 16 MB or 2 GB.

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5.4: MVS

MVS Address Space

- Furthermore, various factors limit the number of address spaces that can be simulated. Some of them are:
  - The speed of the processor
  - The amount of real storage installed effectively
- Although an MVS system can support more than one address space at a time, the CPU can access only one address space at a time.

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5.4: MVS

MVS Address Space

- When CPU is accessing instructions and data from a particular address space, that address space is said to be in control of the CPU. So the program in that address space will continue to execute until MVS intervenes and places the CPU in control of another address space.
- Multiple virtual storage is how MVS implements multiprogramming.
- Each background job or time sharing user is given its own address space.

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5.4: MVS

MVS Address Space

- So each job or user can access up to 16MB or 2GB of virtual storage independently of any other job or user on the system at the same time.
- To pass control from one job or user to another, MVS transfers control of the CPU to the other job's or user's address space.
- Then the CPU can access instructions and data in that address space until MVS is ready to pass control to a job or user in yet another address space.

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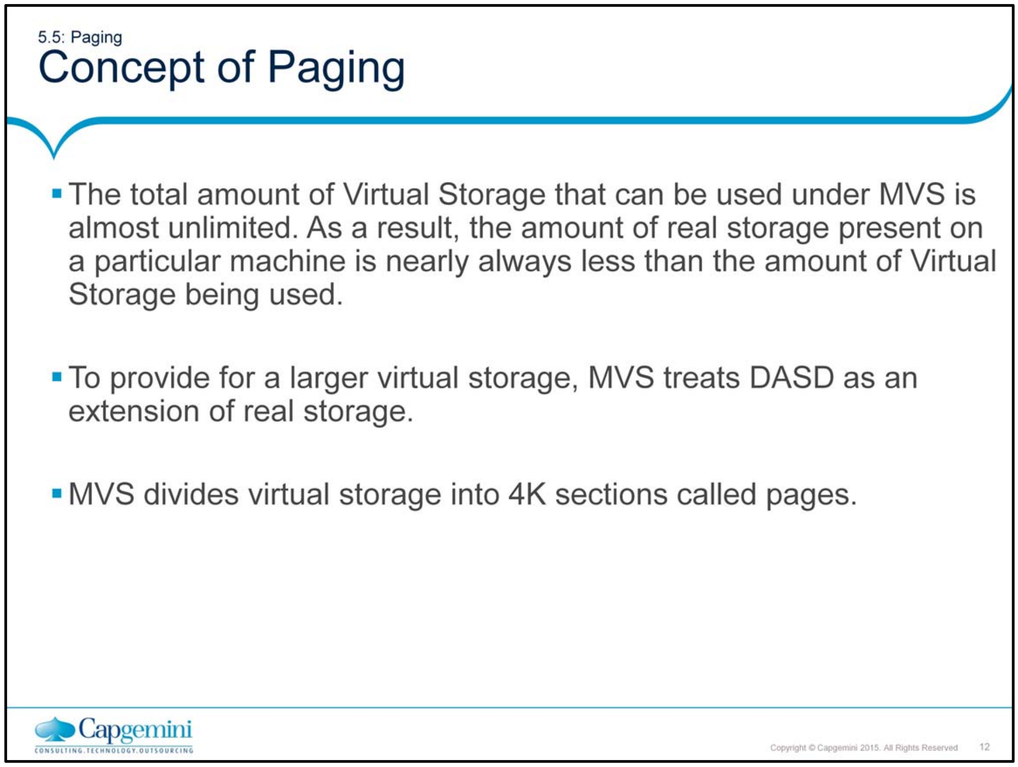
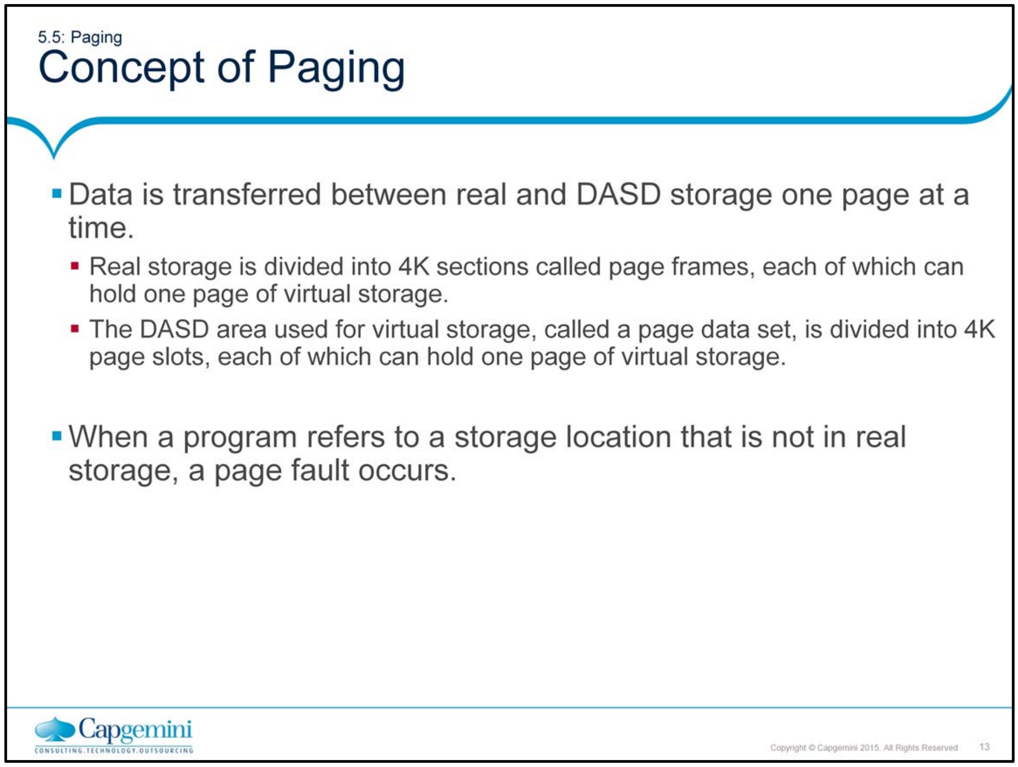


The total amount of virtual storage that can be used under MVS is almost unlimited. As a result, the amount of real storage present on a particular machine is nearly always less than the amount of virtual storage being used.
To provide for the larger amount of virtual storage MVS treats DASD storage as an extension of real storage.
MVS divides virtual storage address space into contiguous 4K (4096 bytes) blocks; each block called a PAGE.
Data is physically transferred from virtual storage to central storage in PAGES; the process is termed PAGING.
In the central storage the 4Kb page block is termed FRAME and the expanded storage it is EFRAME.
The DASD area used for virtual storage (referred to as auxiliary storage), holds many PAGES of virtual storage.



When a program refers to a storage location that is not in central storage, a page fault occurs.
Then a page-in is said to occur, whereby MVS locates the page that contains the needed data either on expanded storage or on auxiliary storage and transfers it into central storage.
The new page may overlay data in the central storage page frame or, the data in a page frame would be moved to auxiliary storage in order to produce space for the new page. This is called page-out.
MVS keeps track of what pages are in what page frames by maintaining tables that reflects the status of real storage and of each address space. The real storage frames that contain those tables cannot be paged out; they must always remain in real storage as long as their associated address spaces are active.

5.5: Paging

Concept of Paging

- When a page fault occurs:
  - MVS locates the page that contains the needed data on DASD and transfers it into real storage. This operation is called a “page-in”.
    - In some cases, the new page can overlay data in a real storage page frame.
  - Sometimes, data in a page frame has to be moved to a page data set to make room for the new page. That is called a “page-out”.

5.5: Paging

Concept of Paging

- The real storage frames that contain those tables cannot be paged out. They must always remain in real storage as long as their associated address spaces are active.
- Either way, “the process of bringing a new page into real storage is called paging”.
- At any given moment, page frames in real storage contain pages from more than one address space.
- MVS keeps track of the pages that are in particular page frames by maintaining tables that reflects the current status of real storage and of each address space.

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MVS keeps track of what pages are in what page frames by maintaining tables that reflects the current status of real storage and of each address space.

5.5: Paging

Concept of Paging

- The paging process is managed by several components of MVS. The three major components are:
  - Real Storage Manager (RSM)
  - Auxiliary Storage Manager (ASM)
  - Virtual Storage Manager (VSM)

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5.5: Paging

Concept of Paging

- RSM:
  - It manages real storage.
  - It directs movements of pages among real and auxiliary.
  - It builds segment and page table.
- ASM:
  - It keeps track of the contents of the page dataset and swap dataset.
  - Page dataset contains virtual pages that are currently occupying a real storage frame.

5.5: Paging

Concept of Paging

- VSM:
  - It controls allocation / de-allocation of virtual storage.
  - It maintains storage use information for Storage Management Facility (SMF).

5.6: Swapping

Concept of Swapping

- Depending on the amount of real storage that a system has, and the types of jobs it is processing, MVS can efficiently multiprogram only a certain number of jobs at once.
- So, using a process called swapping, MVS periodically transfers entire address spaces in and out of virtual storage. These address spaces are temporarily unavailable for processing.

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5.6: Swapping

Concept of Swapping (contd.)

- When an address space is swapped out, its critical pages – the ones that contain the tables that keep track of the location of each virtual page for the address space – are written to a special data set called a swap data set.
- Later, when the system can accommodate the job again, the address space is swapped in so that it can be processed again.

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5.6: Swapping

Concept of Swapping(contd.)

- The figure on the following slide depicts the following:
  - Four address spaces are currently swapped in. The gray color indicates the address space that is currently in control.
  - Four additional address spaces are swapped out. They cannot compete for virtual storage or the CPU until they are swapped in.

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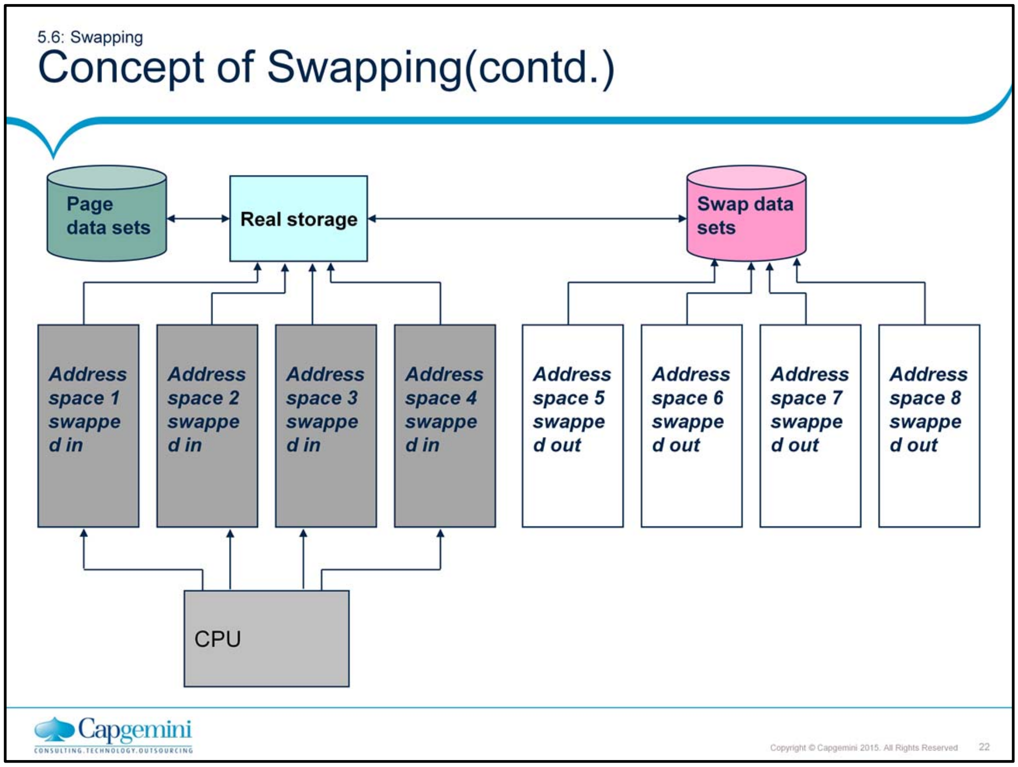
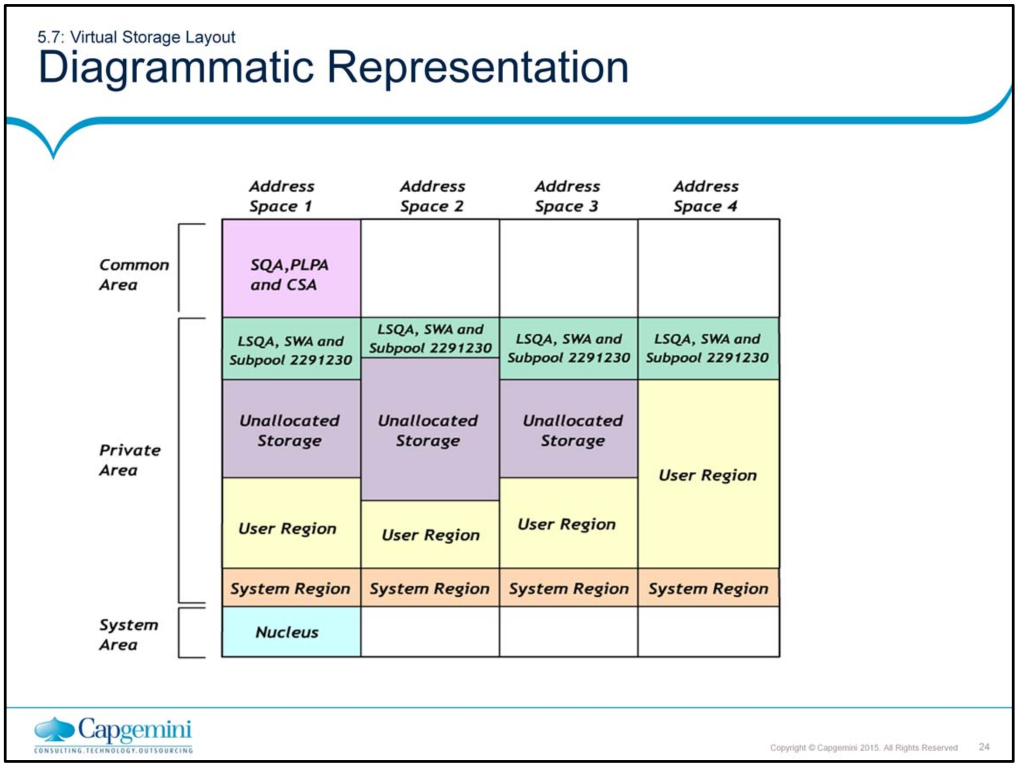


Note: In the figure on the above slide, four address spaces are currently swapped in. The gray color indicates the address space that is currently in control.
Four additional address spaces are swapped out. They cannot compete for virtual storage or the CPU until they are swapped in.

5.6: Swapping

Concept of Swapping (contd.)

- Swapping is same thing as paging, only at a higher level.
- Rather than moving small 4K pieces of virtual storage in and out of real storage, swapping effectively moves entire address spaces in and out of virtual storage.
- Since paging occurs only for address spaces that are currently in virtual storage, paging does not occur for address spaces that are swapped out.


5.7: Virtual Storage Layout
Diagrammatic Representation
Address Space 1
Address Space 2
Address Space 3
Address Space 4
Common Area
SQA,PLPA and CSA
Private Area
LSQA, SWA and Subpool 2291230
LSQA, SWA and Subpool 2291230
LSQA, SWA and Subpool 2291230
LSQA, SWA and Subpool 2291230
Unallocated Storage
Unallocated Storage
Unallocated Storage
User Region
User Region
User Region
User Region
System Region
System Region
System Region
System Region
System Area
Nucleus
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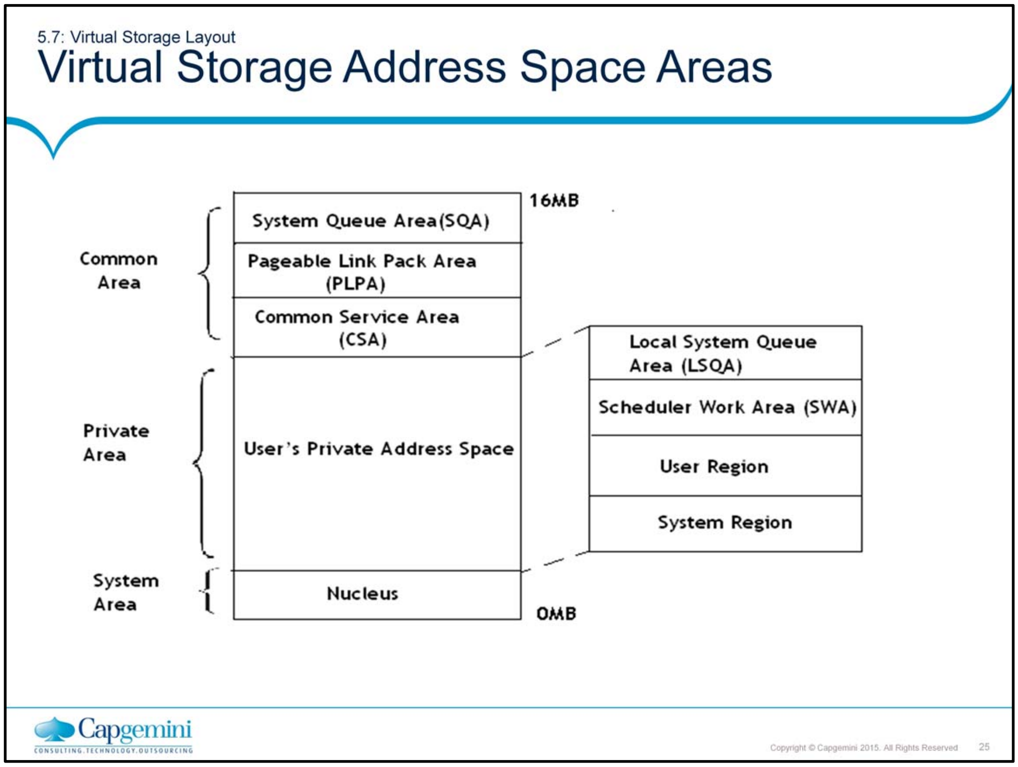
5.7: Virtual Storage Layout
Virtual Storage Address Space Areas
16MB
System Queue Area(SQA)
Common Area
Pageable Link Pack Area (PLPA)
Common Service Area (CSA)
Local System Queue Area (LSQA)
Scheduler Work Area (SWA)
Private Area
User's Private Address Space
User Region
System Region
System Area
Nucleus
0MB
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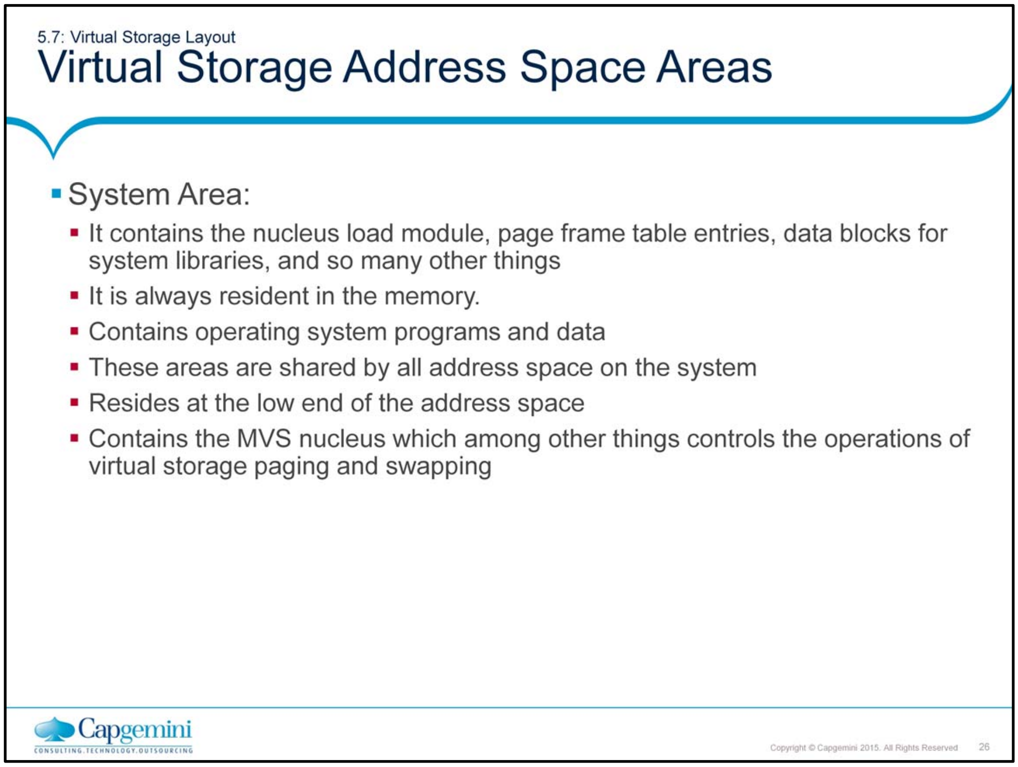
5.7: Virtual Storage Layout
Virtual Storage Address Space Areas
System Area:
It contains the nucleus load module, page frame table entries, data blocks for system libraries, and so many other things
It is always resident in the memory.
Contains operating system programs and data
These areas are shared by all address space on the system
Resides at the low end of the address space
Contains the MVS nucleus which among other things controls the operations of virtual storage paging and swapping
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5.7: Virtual Storage Layout

System Area

- The entire system area must be resident at all times so it operates in real mode
- It can't be paged or swapped

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5.7: Virtual Storage Layout

Common Area

- Common Area:
  - It contains parts of the system control program, control blocks, tables, and data areas.
  - System queue area(SQA) contains important system tables and data areas that are used by nucleus
  - Sqa is fixed in real storage
  - The common service area contains information that’s similar to information in sqa but that doesn’t have to be fixed in real storage

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5.7: Virtual Storage Layout

Common Area –Pageable Link Pack Area

- Contains operating system programs that don't have to be fixed in real storage in the nucleus.
- Not fixed in real storage.

5.7: Virtual Storage Layout

Virtual Storage Address Space Areas

- Private Area:
  - The Private Area is made up of :
    - System Region
    - User Region
    - Scheduler Work Area (SWA)
    - Local System Queue Area (LSQA)

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5.7: Virtual Storage Layout

Private Area

- Is the portion of address space that contains data that's unique for each address space
- Within each job's or user's private area there are 3 basic areas
- At the bottom of the private area is system region an area of storage used by operating systems program that provide services for users program running in private area

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5.7: Virtual Storage Layout

LSQA

- Local system area contains tables used to control private area including tables needed to manage the private area’s virtual storage
- It’s LSQA that’s written to the swap dataset when an address space is swapped out.
- Subpool 229/230 contains additional system Information.

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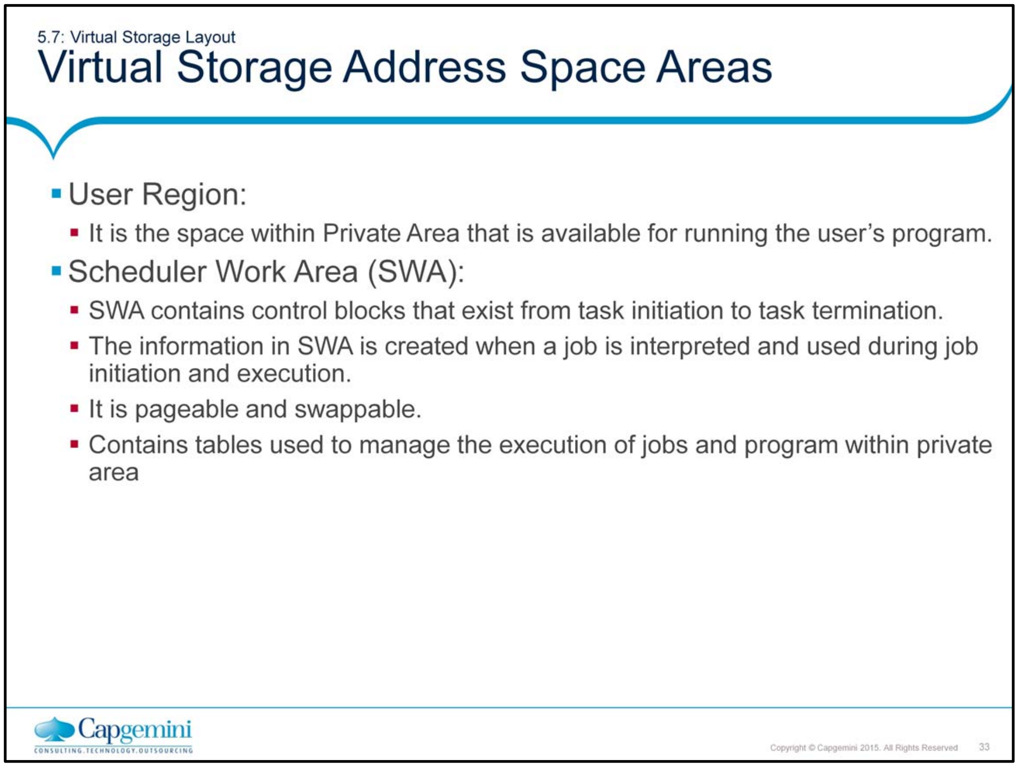
At the top of the private area are three local system areas that contain information that applies only to the private area of a particular address space



The rest of the private area ,which comprises most of the address space is either unallocated or allocated to a user region. It's in the user region that your program or programs actually execute

The size of the user region varies depending on the amount of storage required by the program being executed. If necessary, the user region can allocate all of the storage between the system region and the LSQA,SWA and subpool 229/230/On most MVS systems that amounts to about 10MB to 12 MB

5.7: Virtual Storage Layout

Demo

- Demo on:
  - The TSO Mainframe Environment
  - ISPF menu

Summary

- In this lesson, you have learnt about:
  - Various MVS concepts:
    - Multiprogramming and Virtual Storage are two main feature in MVS.
    - Paging and Swapping are necessary to ensure that pages needed for execution are there in the main memory.
    - Address space in which the pages are stored in datasets.

Review Question: Match the Following

1. Address Space	a. Page frames
2. Multiprogramming	b. Address space
3. Virtual Storage	c. Jobs
4. Paging	d. Pages
5. Swapping	e. page datasets

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