Operating Systems

BITS Pilani
K K Birla Goa Campus

Dr. Lucy J. Gudino
Dept. of CS and IS

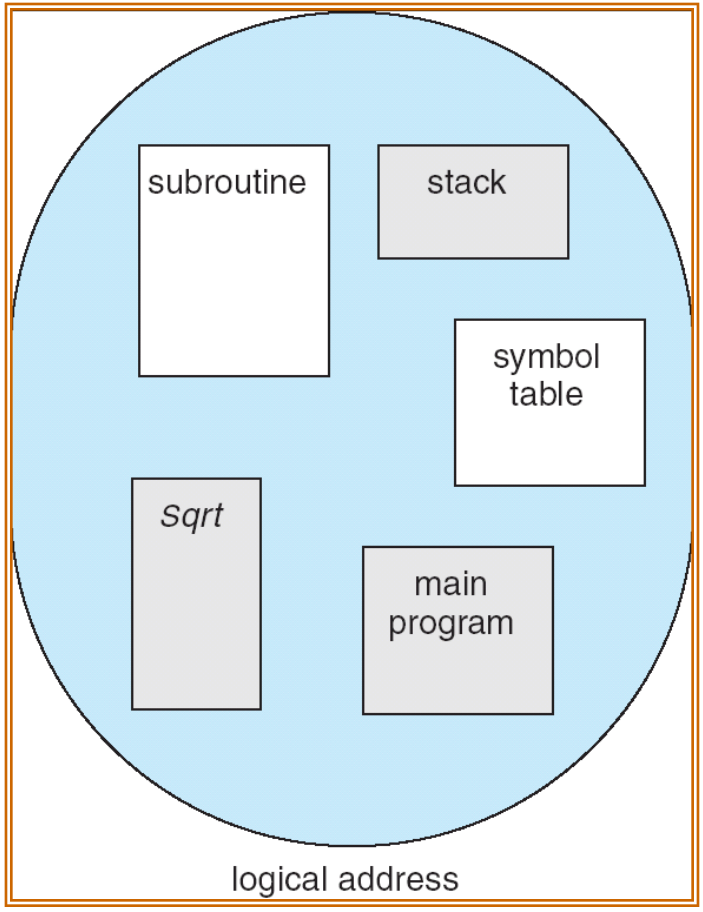
Last Class

- Memory protection:
  - Page to be read-write, read-only or execute only
  - **Valid-invalid** bit attached to each entry in the page table
  - Page – Table Length Register (PTLR)
- Shared pages
- Structure of the page table
  - Hierarchical Paging
  - Hashed Page Tables
  - Inverted Page Tables

Segmentation

- Memory-management scheme that supports user view of memory
- A program is a collection of segments.
- Each segment has a distinct purpose
- A segment is a logical unit such as: main program, procedure, function, local variables, global variables, stack, symbol table, arrays etc.
- Segment may be of different sizes

User's View of a Program



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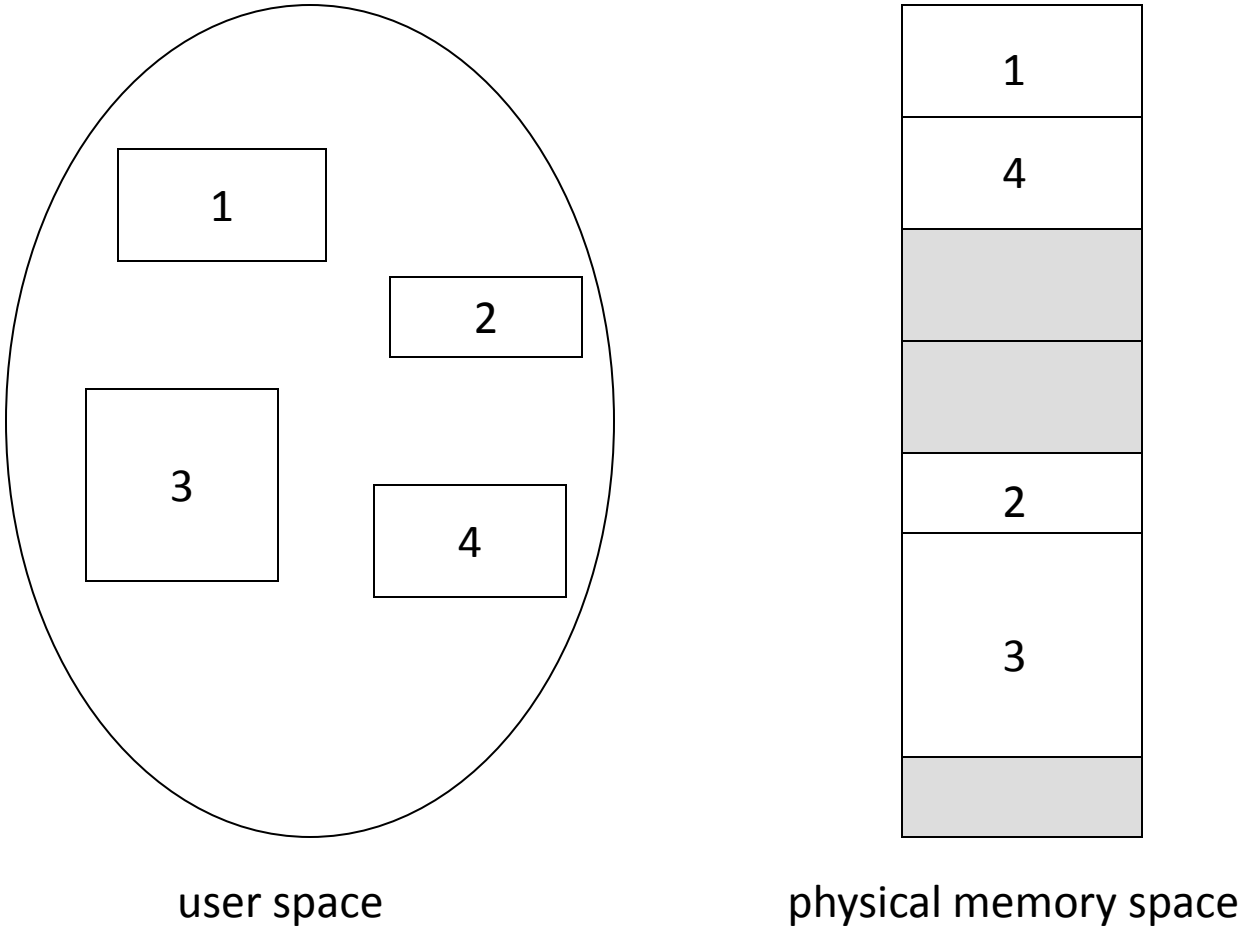
- Each segment has a distinct purpose
- A segment is a logical unit such as: main program, procedure, function, local variables, global variables, stack, symbol table, arrays etc.
- Segment may be of different sizes.
- A process is loaded by loading all of its segments into dynamic partitions that need not be contiguous.
- The whole process is still loaded into memory, but the segments that make up the process do **not have to be loaded** contiguously into memory
  - **Space within a segment is contiguous**

Logical View of Segmentation



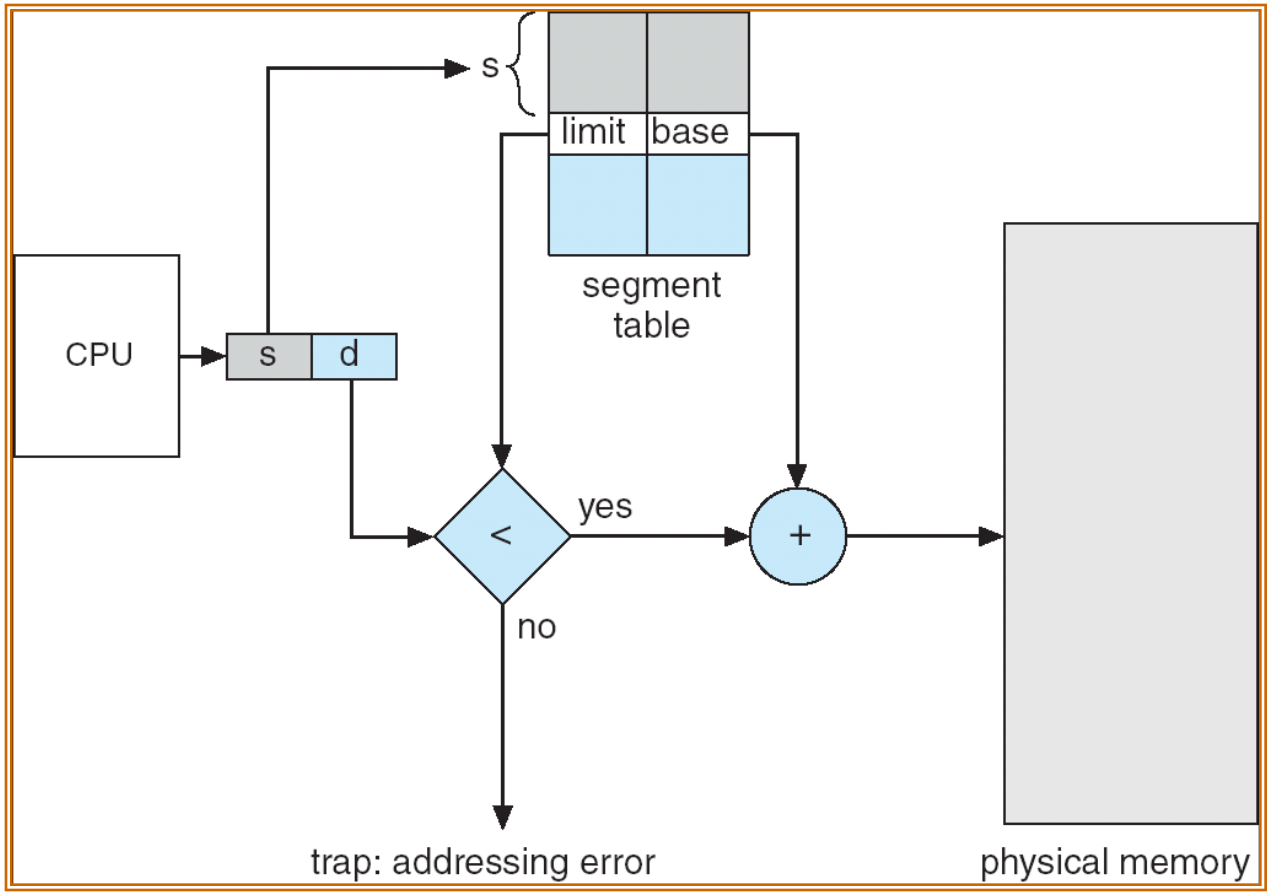
Contd…

- Each segment has protection bits
  - Read-only segment (code)
  - Read-write segments (data, heap, stack)
  - Allows processes to share code and data
- Logical address consists of a two tuple: <segment-no, offset>,
- A segment table keeps track of every segment in a particular process
  - Each entry contains base and limit
    - **base** – contains the starting physical address where the segments reside in memory
    - **limit** – specifies the length of the segment
  - Also contains protection information (sharing allowed, read vs. read/write)

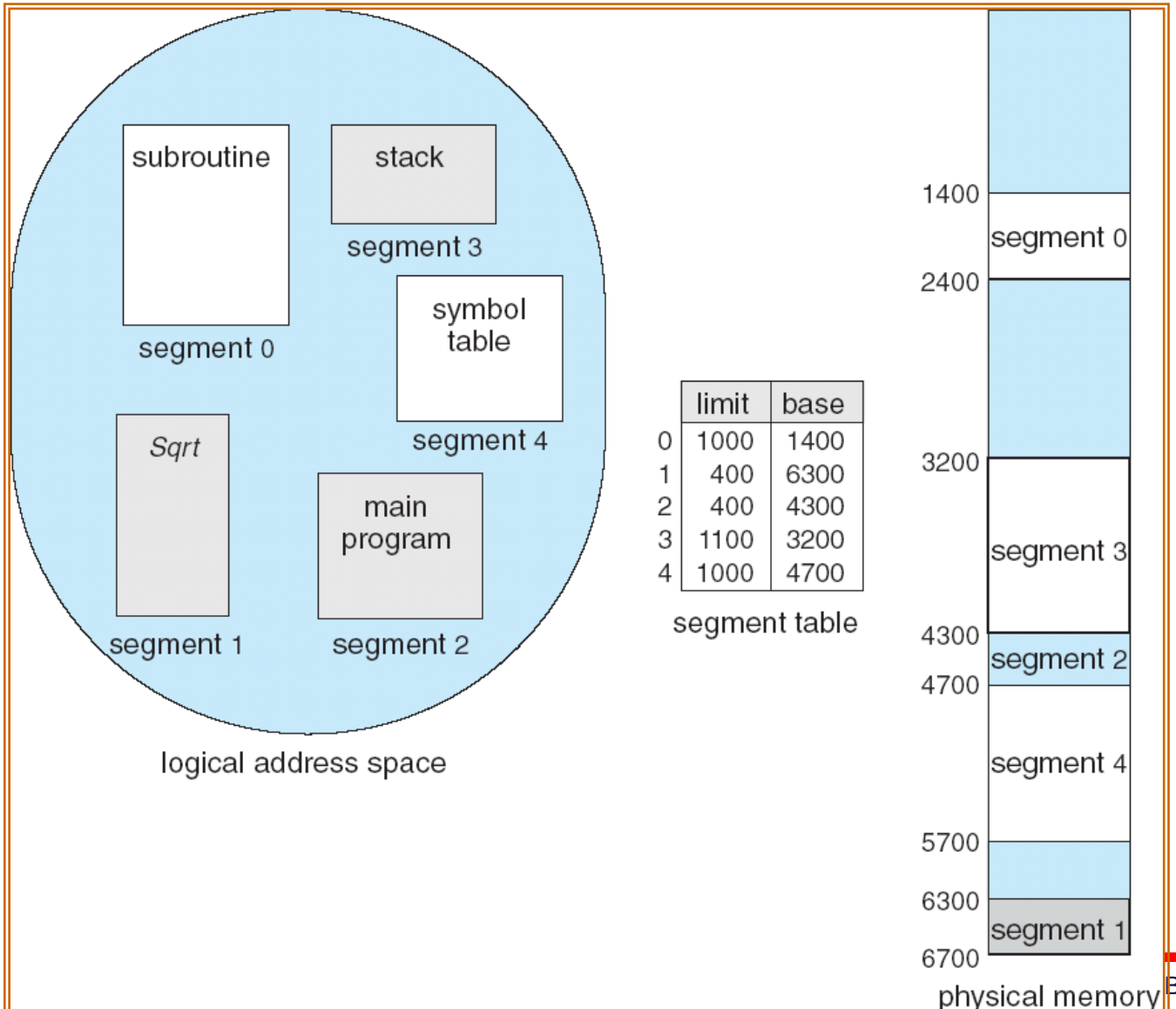
Segmentation Architecture

- Additional hardware support required:
  - Multiple base and limit registers, or
  - Segment table base pointer (points to table in memory)
- **Segment-table base register (STBR)** points to the segment table's location in memory
- **Segment-table length register (STLR)** indicates number of segments used by a program;
- segment number ***s*** is legal if ***s*** < **STLR**

Segmentation Hardware



Example of Segmentation



Segmentation Architecture (Cont.)

- Protection
  - With each entry in segment table associate:
    - validation bit = 0 $\Rightarrow$ illegal segment
    - read/write/execute privileges
- Protection bits associated with segments; code sharing occurs at segment level
- Since segments vary in length, memory allocation is a dynamic storage-allocation problem

Important points to be noted

- When a process is created:
  - Allocate space in virtual memory for all of the process's segments
  - Create a (mostly empty) segment table and store it in the process's PCB
- When a context switch occurs:
  - Save the OS's segment table in the old process's PCB
  - Load OS's segment table from new process's PCB, allocating space in physical memory if first time process runs
- If there's no space in physical memory:
  - Compact memory (move segments, update bases) to make contiguous space
  - Swap one or more segments out to disk

Contd…

- Advantages of segmentation:
  - Segments don’t have to be contiguous
  - Segments can be swapped independently
  - Segments allow sharing
- Disadvantages of segmentation:
  - Complex memory allocation (first-fit, etc.)
  - External fragmentation

Virtual Memory

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Introduction

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- How to increase the degree of multiprogramming ?
- Logical vs physical memory
- Virtual memory is a technique that allows the execution of processes that are not completely in memory.
- Motivation:
  - Programs often have code to handle unusual error conditions which is almost never executed.
  - Arrays, lists, and tables are often allocated more memory than they actually need.
  - Certain options and features of a program may be used rarely
  - Principle of locality
  - trashing is a condition where system spends more time in swapping than executing instructions

Contd…

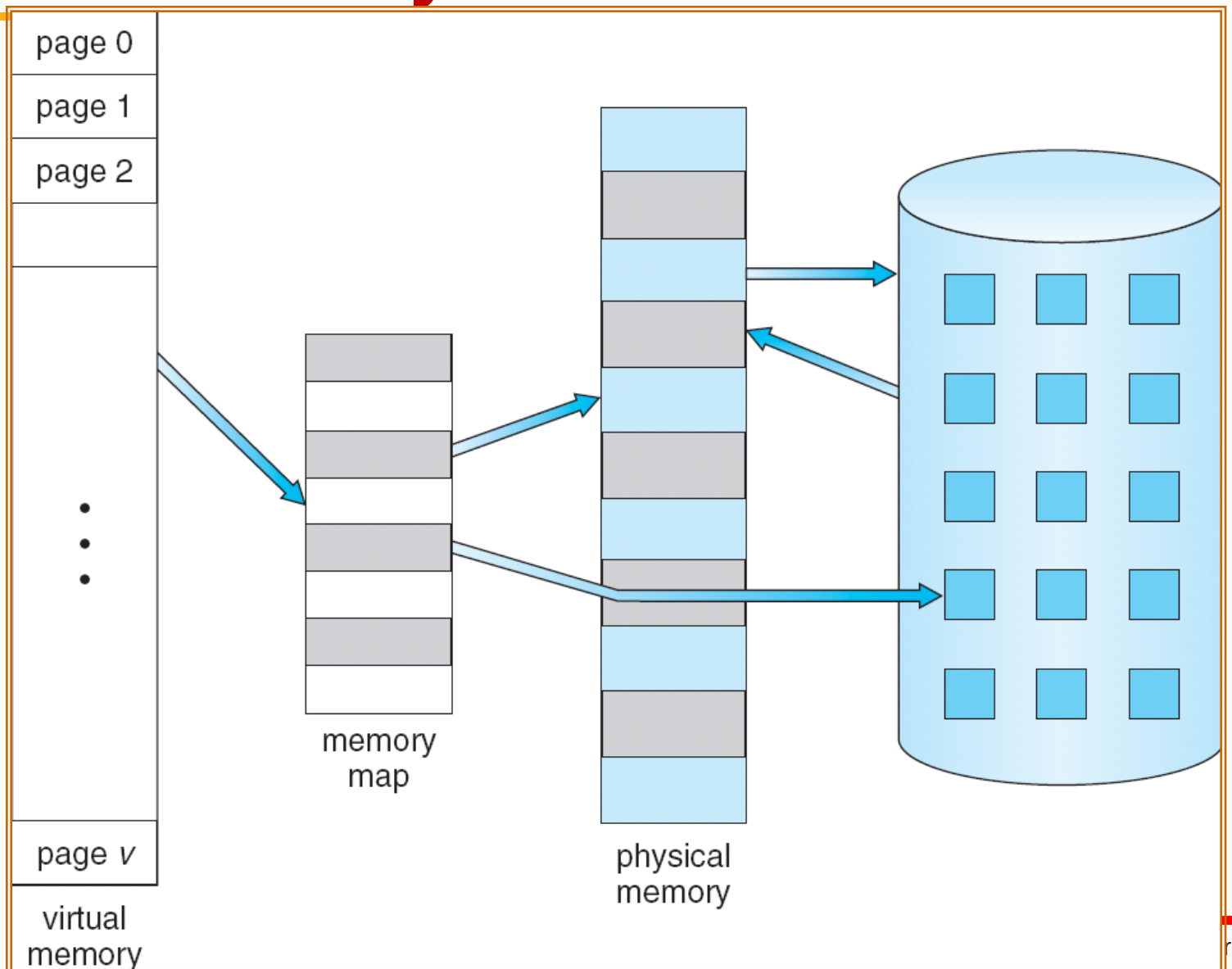
- Advantages:
  - A program would no longer be constrained by the amount of physical memory that is available
  - Because each user program could take less physical memory, more programs could be run at the same time
  - increases the CPU utilization and throughput
  - Less I/O would be needed to load or swap each user program into memory, so each user program would run faster

Background

- **Virtual memory** – separation of user logical memory from physical memory.
  - Only part of the program needs to be in memory for execution
  - Logical address space can therefore be much larger than physical address space
  - Allows address spaces to be shared by several processes
  - Allows for more efficient process creation

- Virtual memory can be implemented via:
  - Demand paging
  - Demand segmentation

Virtual Memory That is Larger Than Physical Memory



Virtual-address Space