Memory Management (1)

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CSE325 Principles of Operating Systems

10/16/2019

Multiprogramming

- Simple uiprogramming with a single segment per process
- Uniprogramming disadvantages
  - Inefficient use of CPU time
  - Inflexibility of job scheduling
- Need multiprogramming

Memory Management Requirements

- **The OS must fit multiple processes in memory**
  - memory needs to be subdivided to accommodate multiple processes
  - memory needs to be allocated to ensure a reasonable supply of ready processes so that the CPU is never idle
  - memory management is an **optimization** task under **constraints**

Memory Management Wish-list

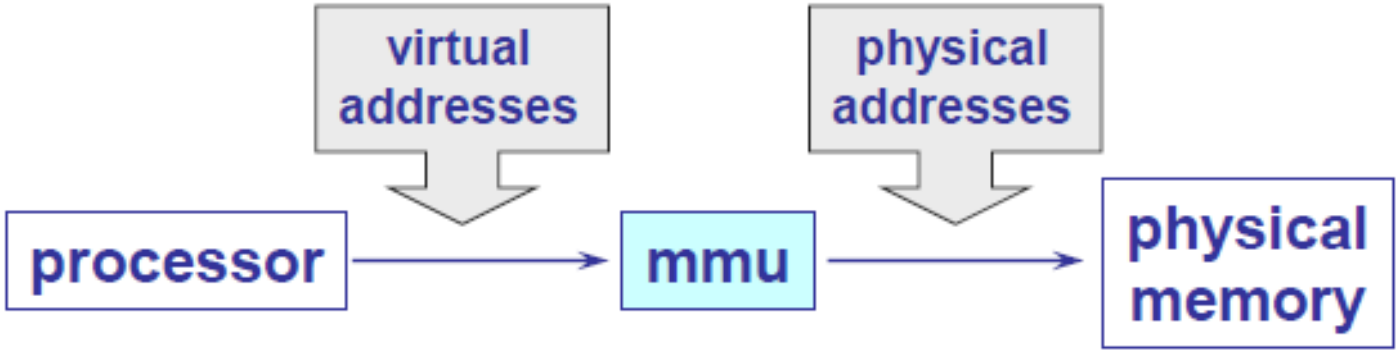
- Sharing
  - multiple processes coexist in main memory
- Transparency
  - Processes are not aware that memory is shared
  - Run regardless of number/locations of other processes
- Protection
  - Cannot access data of OS or other processes
- Efficiency: should have reasonable performance
  - Purpose of sharing is to increase efficiency
  - Do not waste CPU or memory resources

Virtual Addresses for Multiprogramming

- To make it easier to manage memory of multiple processes, make processes use virtual addresses (which is not what we mean by "virtual memory" today!)
  - virtual addresses are independent of location in physical memory (RAM) where referenced data lives
    - OS determines location in physical memory
  - instructions issued by CPU reference virtual addresses
    - e.g., pointers, arguments to load/store instructions, PC …
  - virtual addresses are translated by hardware into physical addresses (with some setup from OS)

Logical vs. Physical Address

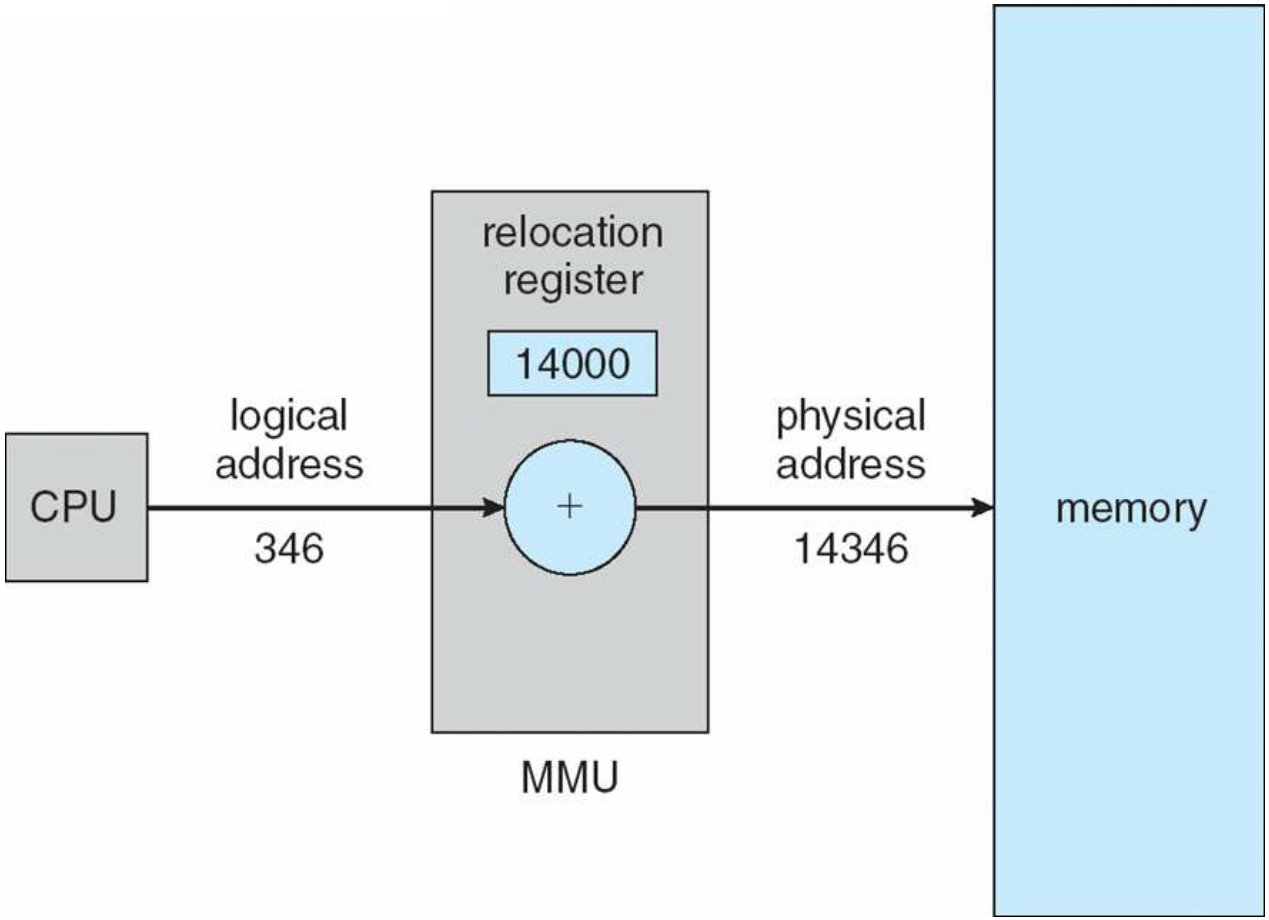
- **Logical address** – generated by the CPU; also referred to as **virtual address**
- **Physical address** – address seen by the memory unit



Old Technique #1: Fixed-Sized Partitions

- One of the simplest methods for allocating memory is to divide memory into several fixed-sized partitions
- Each partition may contain exactly one process.
- Degree of multiprogramming limited by number of partitions
- when a partition is free, a process is selected from the input queue and is loaded into the free partition.
- When the process terminates, the partition becomes available for another process.

Fixed-Sized Partitions

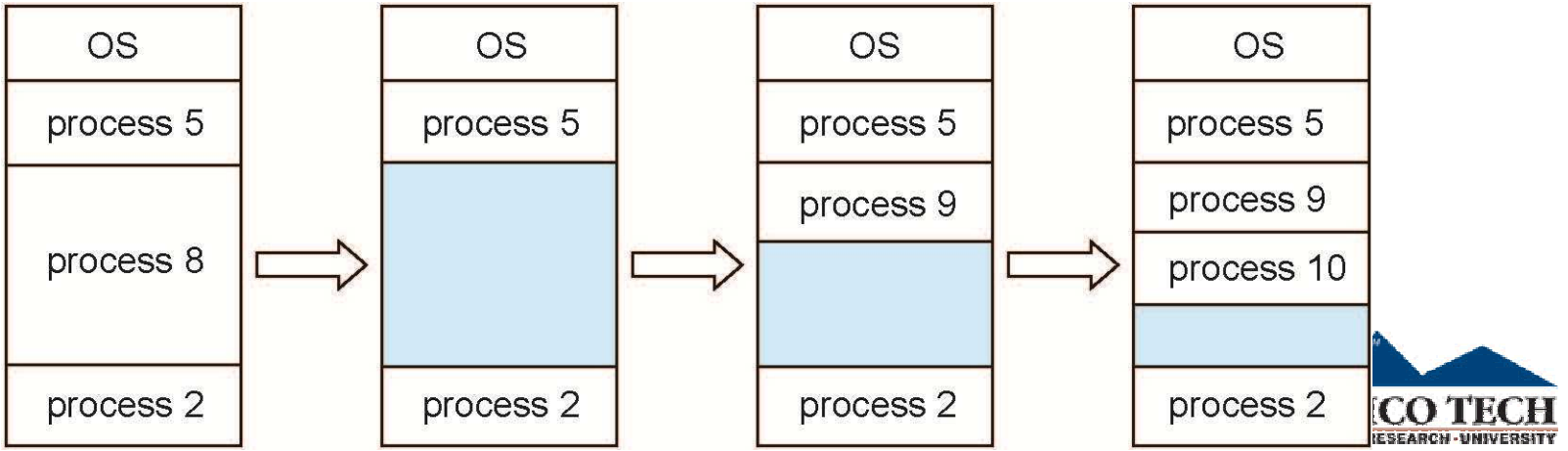


Memory Allocation

- Main memory must support both OS and user processes
- Limited resource, must allocate efficiently
- **Contiguous allocation** is one early method
- Main memory usually into two **partitions**:
  - Resident operating system, usually held in low memory with interrupt vector
  - User processes then held in high memory
  - Each process contained in single contiguous section of memory

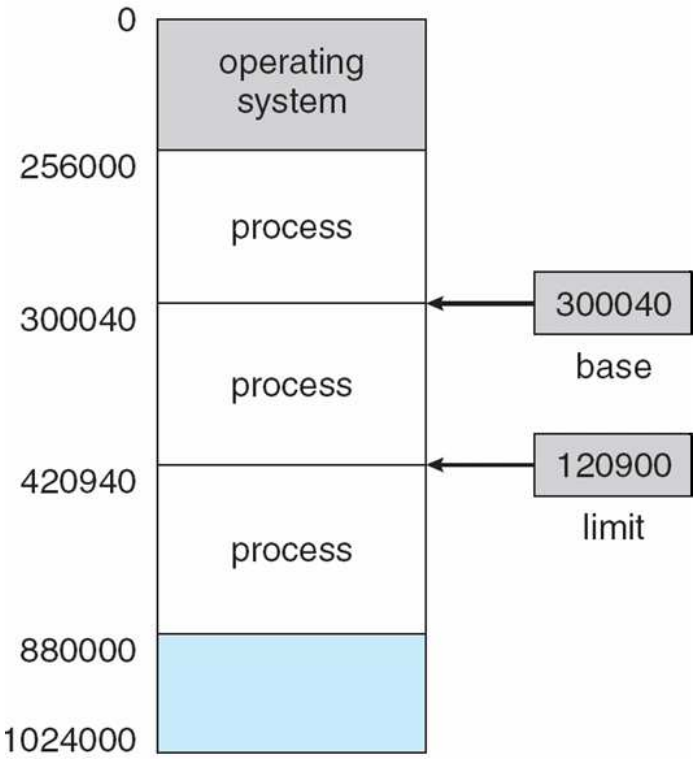
Old Technique #2: Variable Partitions

- **Variable-partition** sizes for efficiency (sized to a given process' needs)
- **Hole** – block of available memory; holes of various size are scattered throughout memory
- When a process arrives, it is allocated memory from a hole large enough to accommodate it
- Process exiting frees its partition, adjacent free partitions combined
- Operating system maintains information about:
  a) allocated partitions b) free partitions (hole)



Variable Partitions

- A pair of registers provide address protection between processes:
  - **base register:** smallest legal address
  - **limit register:** size of the legal range



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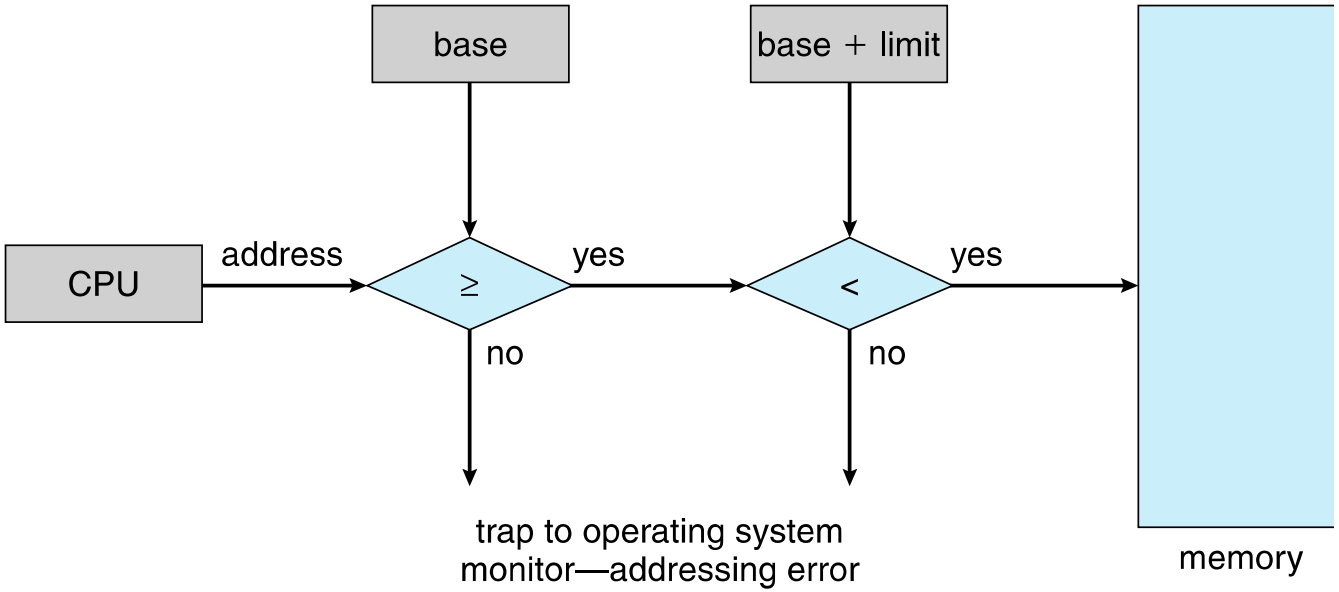
Hardware Address Protection



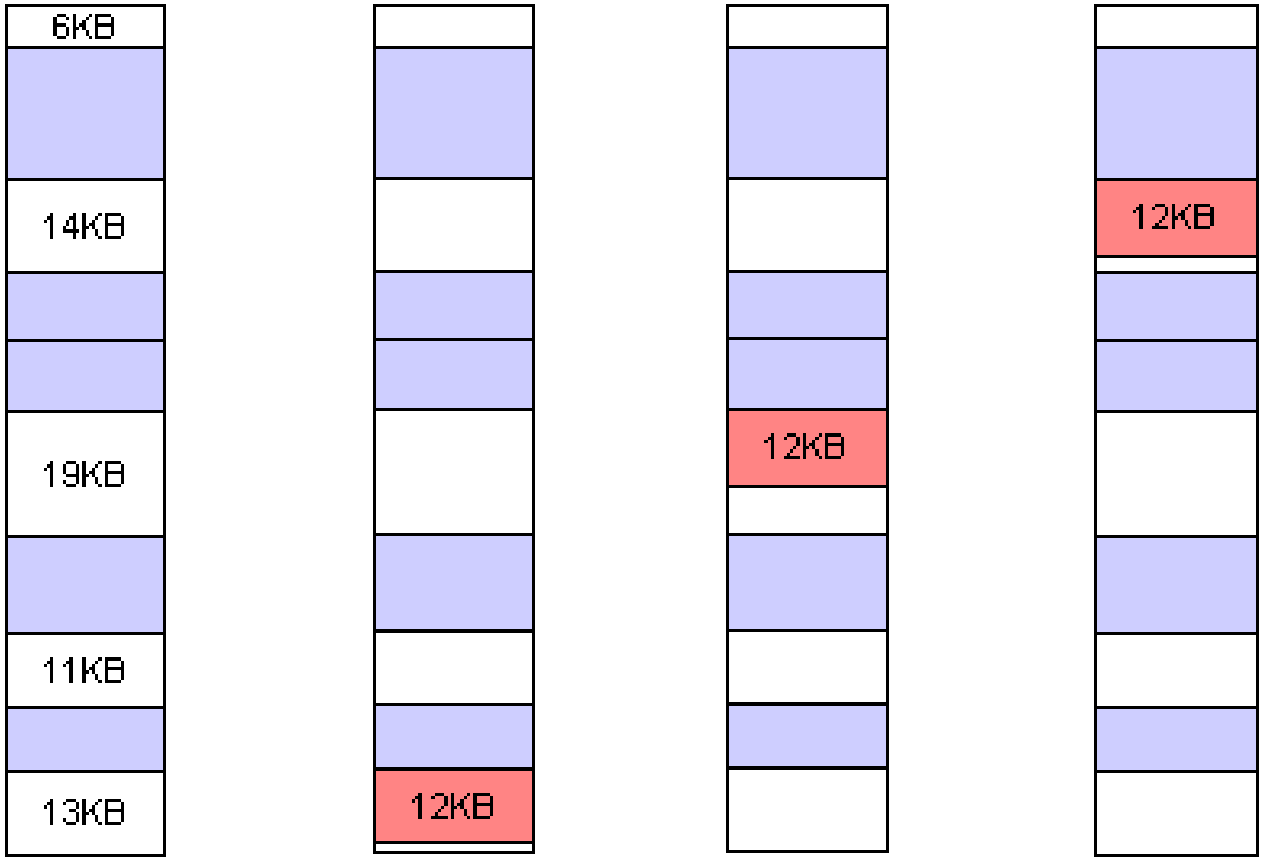
Dynamic Memory Allocation Problem

How to satisfy a request of size ***n*** from a list of free holes?

- **First-fit:** Allocate the ***first*** hole that is big enough
- **Best-fit:** Allocate the ***smallest*** hole that is big enough; must search entire list, unless ordered by size
  - Produces the smallest leftover hole
- **Worst-fit:** Allocate the ***largest*** hole; must also search entire list
  - Produces the largest leftover hole

First-fit and best-fit better than worst-fit in terms of speed and storage utilization

Allocation Example



Memory Best-fit Worst-fit First-fit

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