CSC 4103 - Operating Systems
Fall 2009

Lecture - XVI
Main Memory - I

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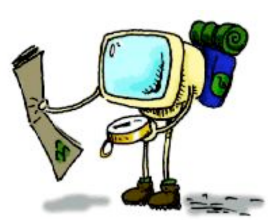
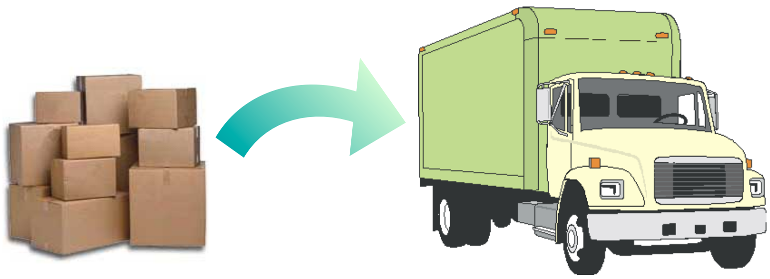
Roadmap

- Midterm Discussion
- Project 1 Discussion
- Main Memory
  - Introduction
  - Contiguous Allocation
  - Dynamic Allocation Algorithms
  - Fragmentation
  - Address Binding
  - Address Protection



Memory Management Requirements

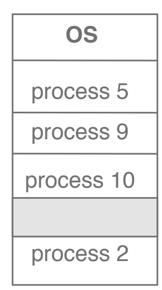
- **The O/S must fit multiple processes in memory**
  - ✓ memory needs to be subdivided to accommodate multiple processes
  - ✓ memory needs to be allocated to ensure a reasonable supply of ready processes so that the CPU is never idle
  - ✓ memory management is an **optimization** task under **constraints**



Fitting processes into memory is like fitting boxes into a fixed amount of space

Memory Allocation - contiguous

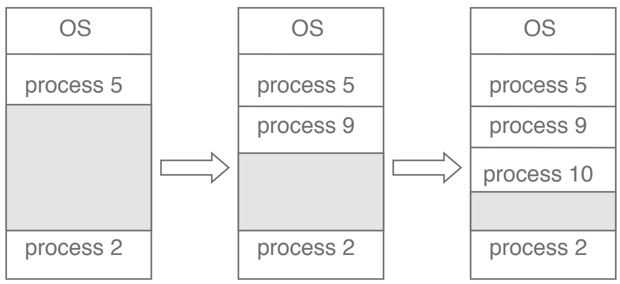
- Fixed-partition allocation
  - Divide memory into fixed-size partitions
  - Each partition contains exactly one process
  - The degree of multi programming is bound by the number of partitions
  - When a process terminates, the partition becomes available for other processes



➔no longer in use

Memory Allocation (Cont.)

- Variable-partition Scheme (Dynamic)
  - When a process arrives, search for a hole large enough for this process
  - Hole – block of available memory; holes of various size are scattered throughout memory
  - Allocate only as much memory as needed
  - Operating system maintains information about:
    a) allocated partitions b) free partitions (hole)



Dynamic Storage-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

Example

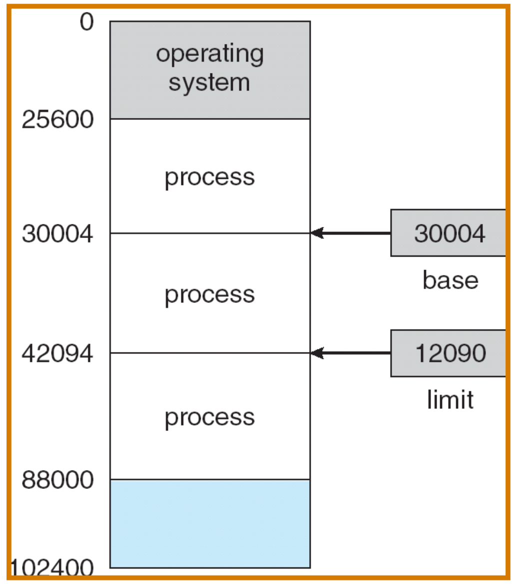
Given five memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would each of the first-fit, best-fit, and worst-fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order)? Which algorithm makes the most efficient use of memory?

Fragmentation

- **External Fragmentation** – total memory space exists to satisfy a request, but it is not contiguous (in average ~50% lost)
- **Internal Fragmentation** – allocated memory may be slightly larger than requested memory; this size difference is memory internal to a partition, but not being used
- Reduce external fragmentation by **compaction**
  - Shuffle memory contents to place all free memory together in one large block
  - Compaction is possible *only* if relocation is dynamic, and is done at execution time

Logical Address Space

- Each process has a separate memory space
- Two registers provide address protection between processes:
- Base register: smallest legal address space
- Limit register: size of the legal range

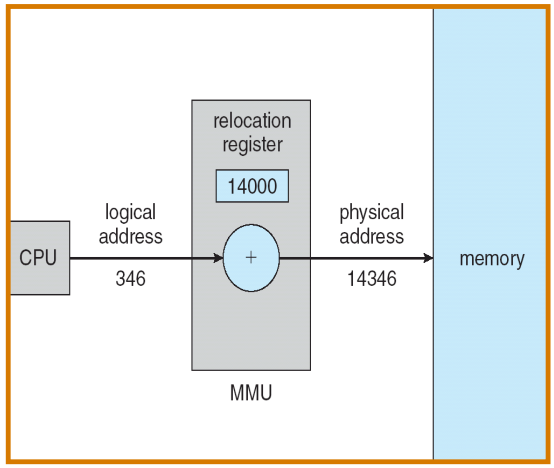


Address Binding

- Addresses in a source program are generally symbolic
  - eg. int count;
- A compiler binds these symbolic addresses to relocatable addresses
  - eg. 100 bytes from the beginning of this module
- The linkage editor or loader will in turn bind the relocatable addresses to absolute addresses
  - eg. 74014
- Each binding is mapping from one address space to another

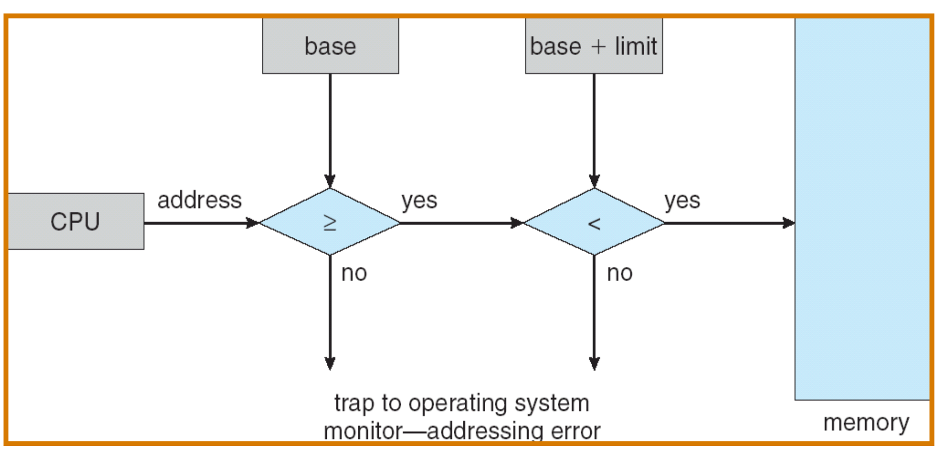
Memory-Management Unit (MMU)

- Hardware device that maps virtual to physical address
- In MMU scheme, the value in the relocation register (base register) is added to every address generated by a user process at the time it is sent to memory
- The user program deals with *logical* addresses; it never sees the *real* physical addresses



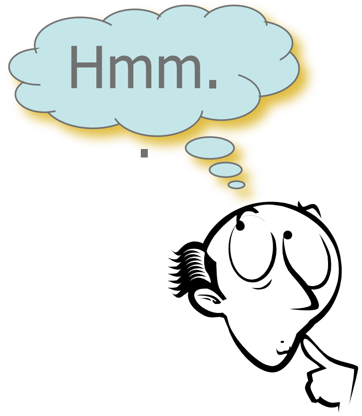
HW Address Protection

- CPU hardware compares every address generated in user mode with the registers
- Any attempt to access other processes' memory will be trapped and cause a fatal error



Summary

- Main Memory
  - Contiguous Allocation
  - Dynamic Allocation Algorithms
  - Fragmentation
  - Address Binding
  - Address Protection



- Next Lecture: Continue with Main Memory
- Reading Assignment: Chapter 8 from Silberschatz.

Acknowledgements

- "Operating Systems Concepts" book and supplementary material by A. Silberschatz, P. Galvin and G. Gagne
- "Operating Systems: Internals and Design Principles" book and supplementary material by W. Stallings
- "Modern Operating Systems" book and supplementary material by A. Tanenbaum
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