CSE 421/521 - Operating Systems
Fall 2013

Lecture - XII
Main Memory Management

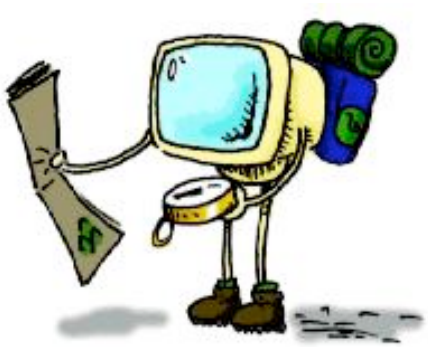
Tevfik Koşar

University at Buffalo

October 10th, 2013

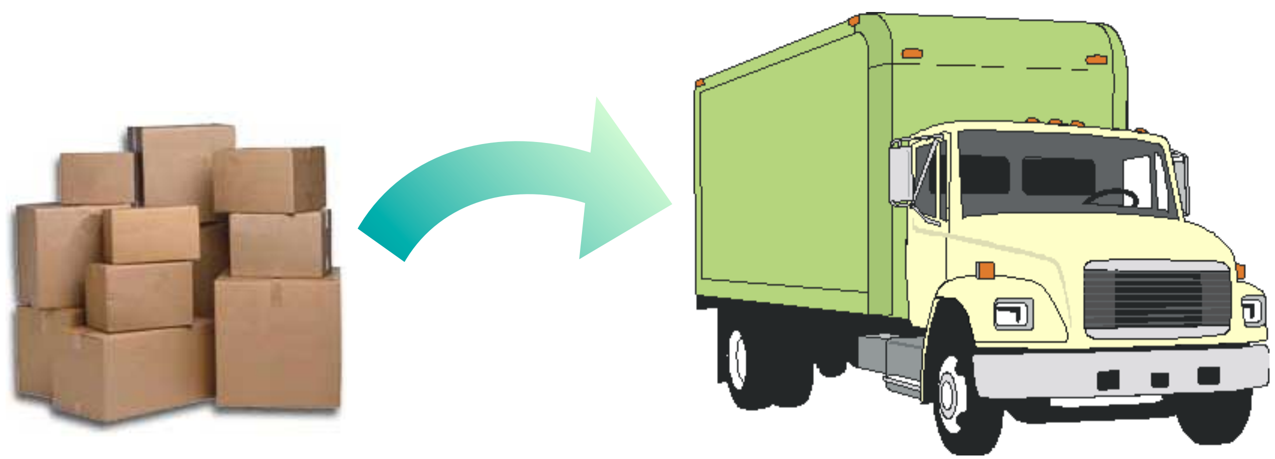
Roadmap

- Main Memory Management
  - Fixed and Dynamic Memory Allocation
  - External and Internal Fragmentation
  - Address Binding
  - HW Address Protection



Memory Management Requirements

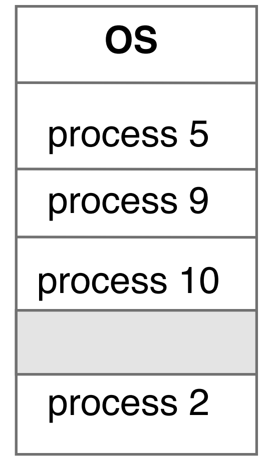
- **The O/S must fit multiple processes in memory**
  - ✓ memory needs to be subdivided to accommodate multiple processes
  - ✓ memory needs to be allocated to ensure a reasonable supply of ready processes so that the CPU is never idle
  - ✓ memory management is an **optimization** task under **constraints**



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

Memory Allocation

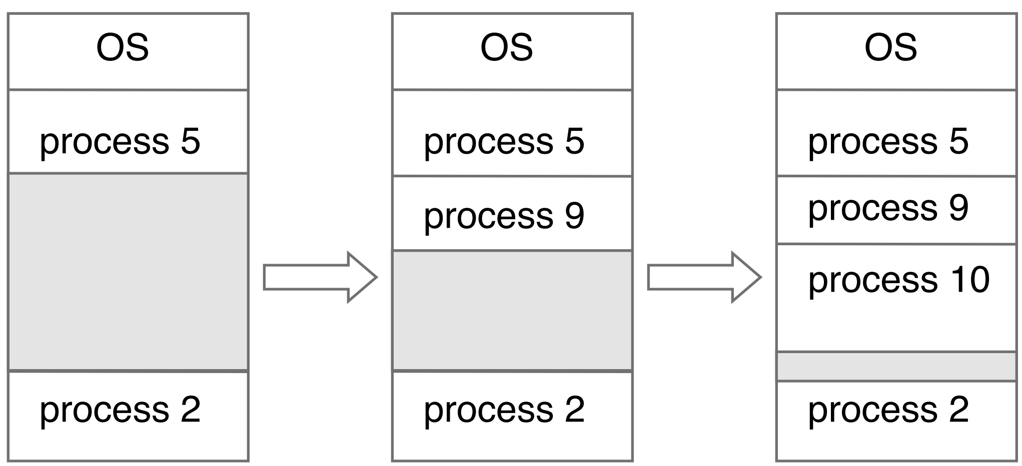
- Fixed-partition allocation
  - Divide memory into fixed-size partitions
  - Each partition contains exactly one process
  - The degree of multi programming is bound by the number of partitions
  - When a process terminates, the partition becomes available for other processes



➔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)



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

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 is faster.

Best-fit is better in terms of storage utilization.

Worst-fit may lead less fragmentation.

Example

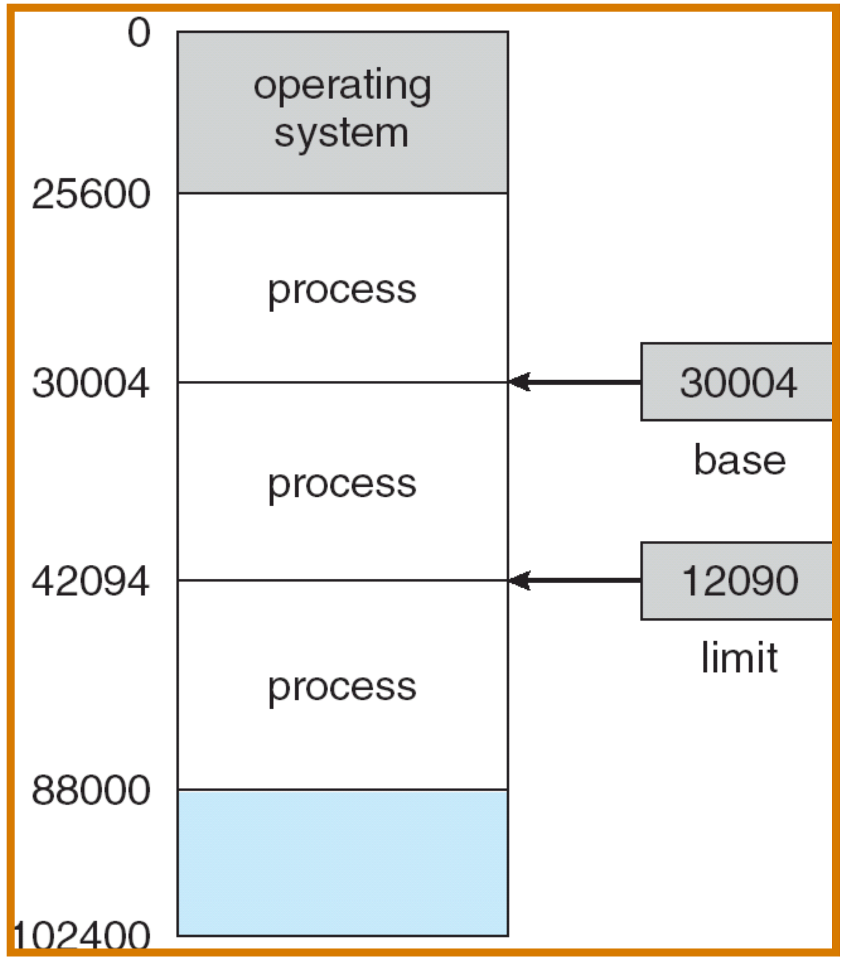
Given five memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would each of the first-fit, best-fit, and worst-fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order)? Which algorithm makes the most efficient use of memory?

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

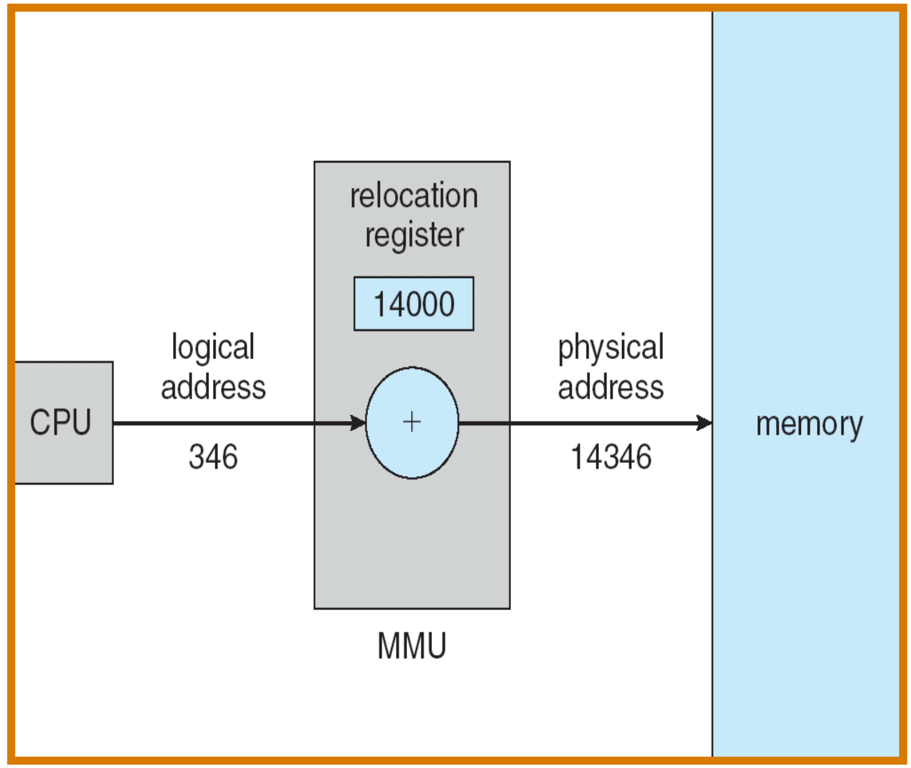
Logical Address Space

- 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



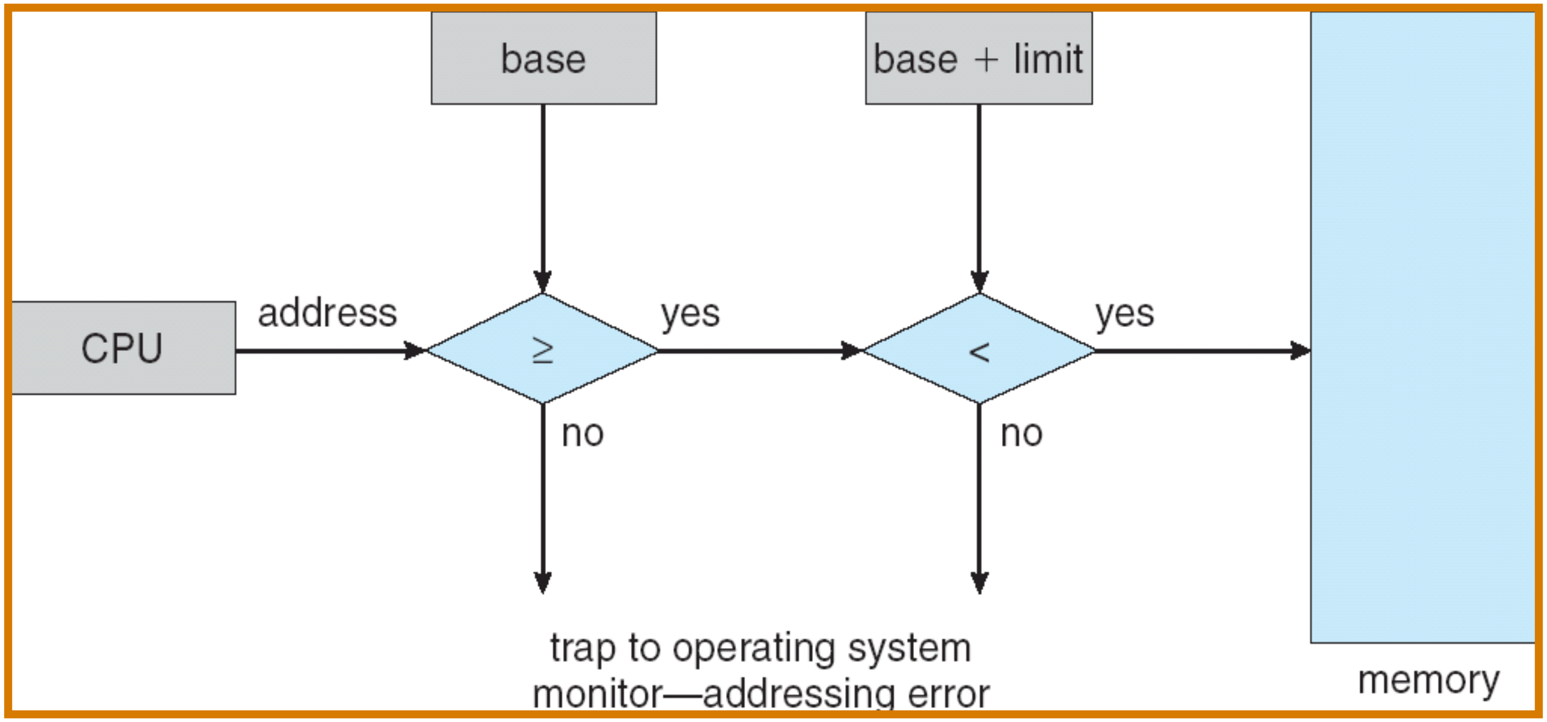
Memory-Management Unit (MMU)

- Hardware device that maps logical 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



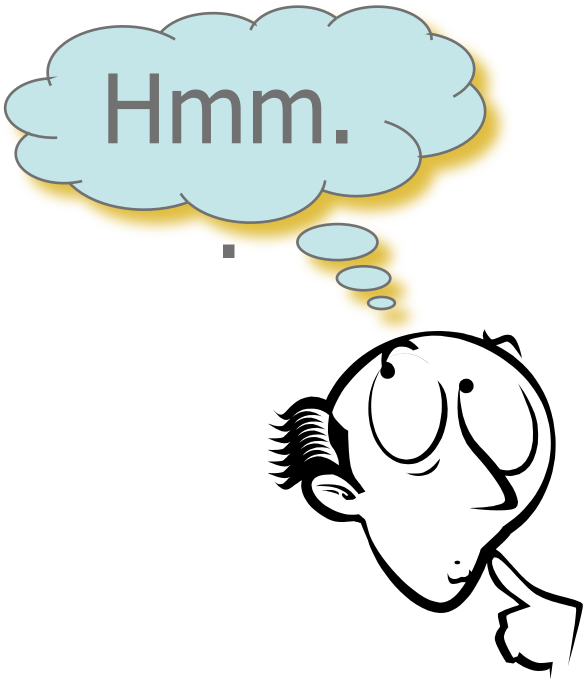
HW Address Protection

- 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 Management
  - Memory Allocation
  - Fragmentation
  - Address Binding
  - HW Address Protection



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
- R. Doursat and M. Yuksel from UNR