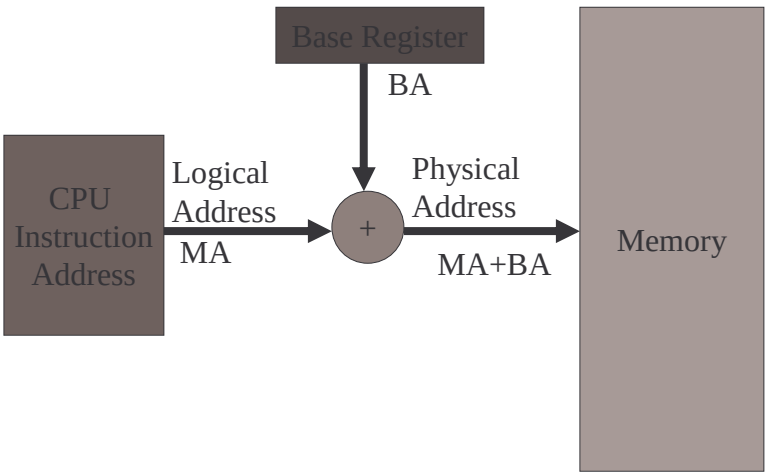
Relocation

- Correct starting address when a program should start in the memory
- Different jobs will run at different addresses
  - When a program is linked, the linker must know at what address the program will begin in memory.
- Logical addresses, Virtual addresses
  - Logical address space , range (0 to max)
- Physical addresses, Physical address space
  - range (R+0 to R+max) for base value R.
- User program never sees the real physical addresses
- Who translates virtual to physical addresses?
  - Program rewritting at loading time
  - Help from relocation registers at execution time

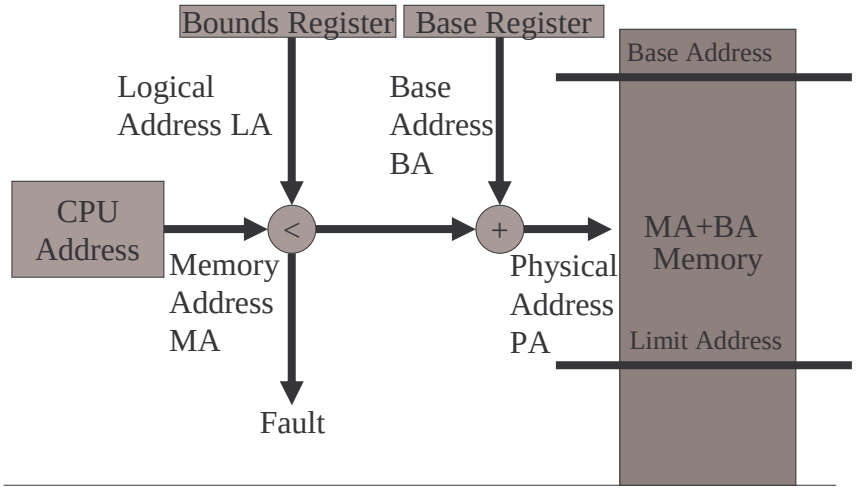
Relocation Register



Protection

- Problem:
  - How to prevent a malicious process to write or jump into other user's or OS partitions
- Solutions:
  - Memory protection code
  - Base bounds registers

Base Bounds Registers



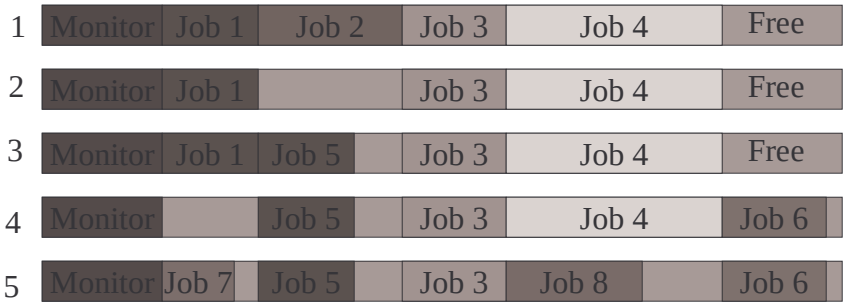
Memory Management (More…)

- Batch System
  - Multiprogramming with fixed partitions
  - In the memory until job finishes
  - Keep CPU busy
- Timesharing Systems
  - No enough memory to hold all active processes
  - Swapping (whole process)
  - Virtual memory (partial process)

Swapping

- Move the whole process to/from disk
- Allows several processes to share a fixed partition
- Processes that grow can be swapped out and swapped back in a bigger partition

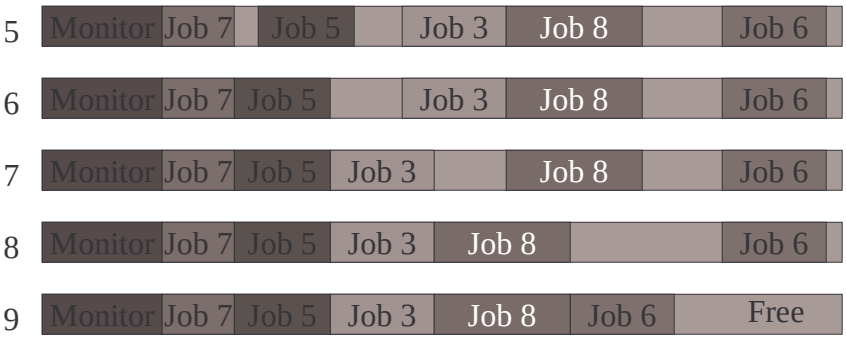
Variable-Sized Partitions and Fragmentation



- Fixed Partitions ←→Variable-sized Partitions
- External Fragmentation
  - **How to solve it?**

Compaction

- What is it? What does it looks like?
- Assumes all programs are relocatable
- Processes must be suspended during compaction
- Need be done only when fragmentation gets very bad



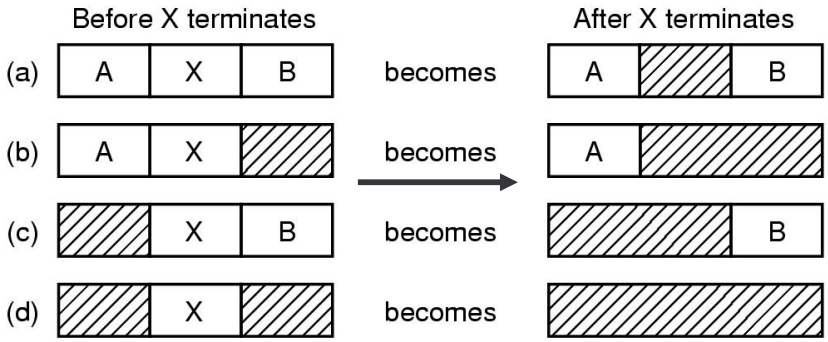
Memory Management with Bitmaps

- Use bitmaps for memory status (free or allocated)
- Memory is divided into allocation units.
  - One allocation unit corresponds to 1bit in the bitmap
  - 0: free, 1: allocated
- Size of allocation unit
  - The smaller the allocation unit, the larger the bitmap.
- Problem: allocation
  - When a new process arrives, the manager must find consecutive 0 bits in the map.
  - Searching a bitmap for a run of a given length is a slow operation.

1	0	1	0	1	0	0	0	1	0	1	0	0	1	0

Memory Management with Linked Lists

- Use a linked list of allocated and free memory segments (called hole)
  - sorted by the address or by the size



Four neighbor combinations for the terminating process X

Memory Allocation Strategies

- **Best Fit**
  - Uses the hole whose size is equal to the need, or if none is equal, the hole that is larger but closest in size.
  - Problem: Creates small holes that can't be used.
- **First Fit**
  - Uses the first available hole whose size is sufficient to meet the need.
  - Problem: Creates average size holes.
- **Next Fit**
  - Minor variation of first fit: search from the last stopped place.
  - Problem: slightly worse performance than first fit.
- **Worst Fit**
  - Uses the largest available hole.
  - Problem: Gets rid of large holes making it difficult to run large programs.
- **Quick Fit**
  - maintains separate lists of holes for some of the more common sizes requested. When a request comes for placement it finds the closest fit.
  - A very fast scheme, but merge is expensive. If merge is not done, memory will quickly fragment in a large number of holes into which no processes fit.

How Bad Is Fragmentation?

- Statistical arguments - Random sizes
- First-fit
- Given N allocated blocks
- 0.5∗N blocks will be lost because of fragmentation
- Known as 50% RULE

Memory Management Problems

- Fixed partitions
  - suffer from internal fragmentation
- Variable-sized partitions
  - suffer from external fragmentation
- Compaction
  - suffer from overhead
- Overlays
  - painful for programmers
- Swapping
  - requires writing to disk sectors

Summary

- Swapping
- Variable Partitions
- Memory Management Problems

- Next lecture: Virtual Memory (I)