Memory Management

Chapter 7

1

Memory Management

- Subdividing memory to accommodate multiple processes
- Memory needs to be allocated to ensure a reasonable supply of ready processes to consume available processor time

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Memory Management Requirements

- Relocation
  - Programmer does not know where the program will be placed in memory when it is executed
  - While the program is executing, it may be swapped to disk and returned to main memory at a different location (relocated)
  - Memory references must be translated in the code to actual physical memory address

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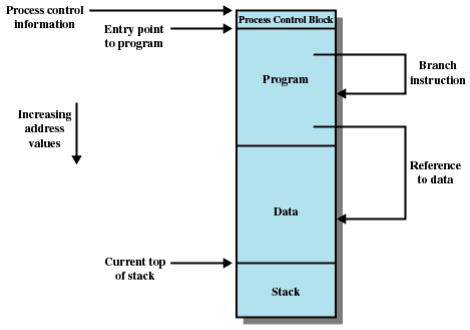

Figure 7.1 Addressing Requirements for a Process

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Memory Management Requirements

- Protection
  - Processes should not be able to reference memory locations in another process without permission
  - Impossible to check absolute addresses at compile time
  - Must be checked at rum time
  - Memory protection requirement must be satisfied by the processor (hardware) rather than the operating system (software)
    - Operating system cannot anticipate all of the memory references a program will make

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Memory Management Requirements

- Sharing
  - Allow several processes to access the same portion of memory
  - Better to allow each process access to the same copy of the program rather than have their own separate copy

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Memory Management Requirements

- Logical Organization
  - Programs are written in modules
  - Modules can be written and compiled independently
  - Different degrees of protection given to modules (read-only, execute-only)
  - Share modules among processes

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Memory Management Requirements

- Physical Organization
  - Memory available for a program plus its data may be insufficient
    - Overlaying allows various modules to be assigned the same region of memory
  - Programmer does not know how much space will be available

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Fixed Partitioning

- Equal-size partitions
  - Any process whose size is less than or equal to the partition size can be loaded into an available partition
  - If all partitions are full, the operating system can swap a process out of a partition
  - A program may not fit in a partition. The programmer must design the program with overlays

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Fixed Partitioning

- Main memory use is inefficient. Any program, no matter how small, occupies an entire partition. This is called internal fragmentation.

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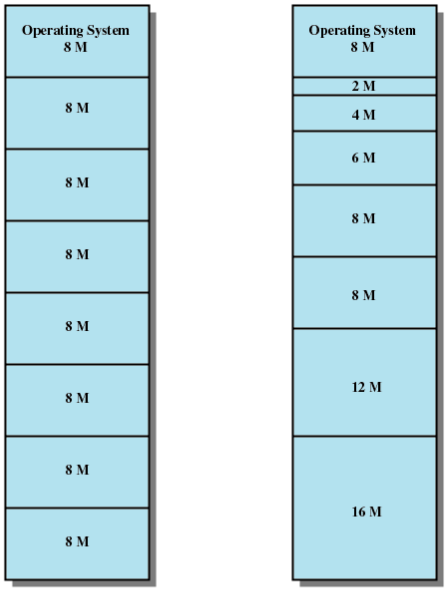

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Figure 7.2 Example of Fixed Partitioning of a 64-Mbyte Memory

Placement Algorithm with Partitions

- Equal-size partitions
  - Because all partitions are of equal size, it does not matter which partition is used
- Unequal-size partitions
  - Can assign each process to the smallest partition within which it will fit
  - Queue for each partition
  - Processes are assigned in such a way as to minimize wasted memory within a partition

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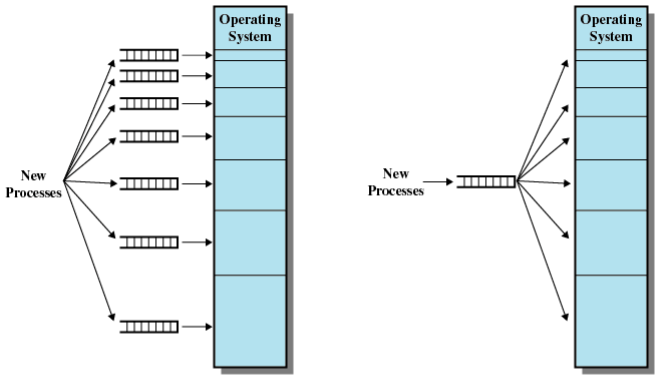

Figure 7.3 Memory Assignment for Fixed Partitioning

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Dynamic Partitioning

- Partitions are of variable length and number
- Process is allocated exactly as much memory as required
- Eventually get holes in the memory. This is called external fragmentation
- Must use compaction to shift processes so they are contiguous and all free memory is in one block

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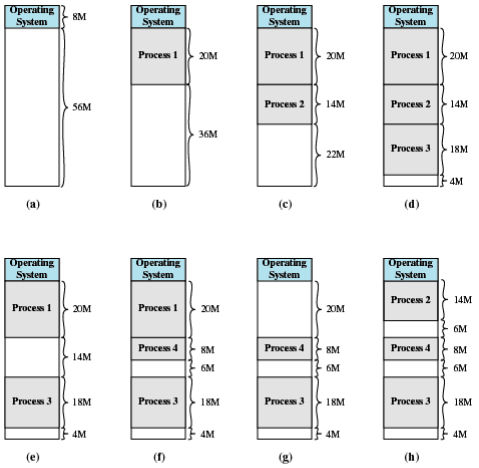

Figure 7.4 The Effect of Dynamic Partitioning

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Dynamic Partitioning Placement Algorithm

- Operating system must decide which free block to allocate to a process
- Best-fit algorithm
  - Chooses the block that is closest in size to the request
  - Worst performer overall
  - Since smallest block is found for process, the smallest amount of fragmentation is left
  - Memory compaction must be done more often

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Dynamic Partitioning Placement Algorithm

- First-fit algorithm
  - Scans memory form the beginning and chooses the first available block that is large enough
  - Fastest
  - May have many process loaded in the front end of memory that must be searched over when trying to find a free block

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Dynamic Partitioning Placement Algorithm

- Next-fit
  - Scans memory from the location of the last placement
  - More often allocate a block of memory at the end of memory where the largest block is found
  - The largest block of memory is broken up into smaller blocks
  - Compaction is required to obtain a large block at the end of memory

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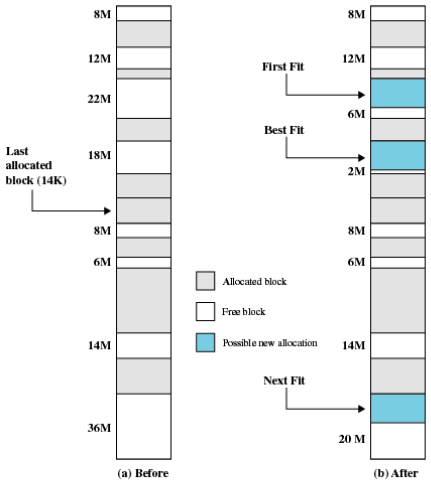

Figure 7.5 Example Memory Configuration Before and After Allocation of 16 Mbyte Block

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Buddy System

- Entire space available is treated as a single block of 2^U
- If a request of size s such that $2^{U-1} < s <= 2^U$, entire block is allocated
  - Otherwise block is split into two equal buddies
  - Process continues until smallest block greater than or equal to s is generated

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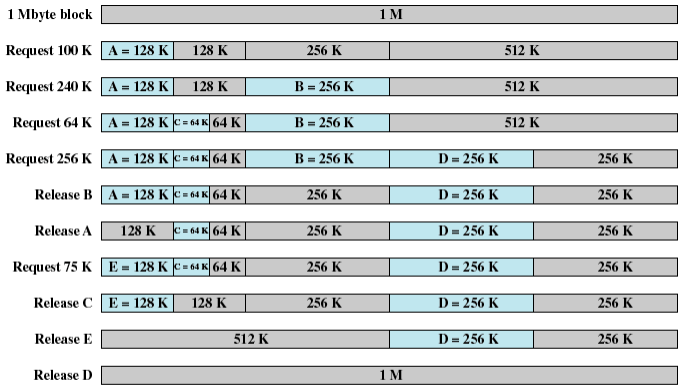

Figure 7.6 Example of Buddy System

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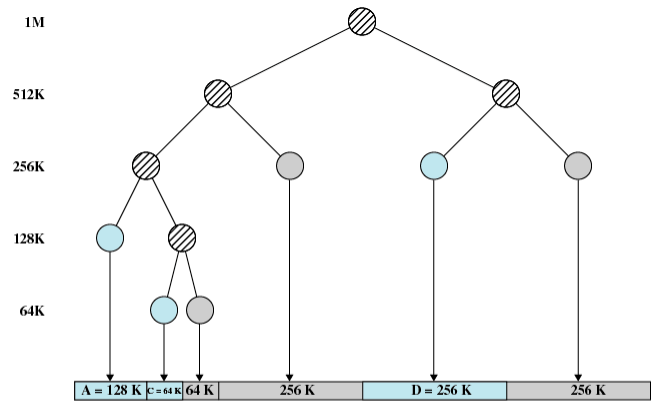

Figure 7.7 Tree Representation of Buddy System

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Relocation

- When program loaded into memory the actual (absolute) memory locations are determined
- A process may occupy different partitions which means different absolute memory locations during execution (from swapping)
- Compaction will also cause a program to occupy a different partition which means different absolute memory locations

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Addresses

- Logical
  - Reference to a memory location independent of the current assignment of data to memory
  - Translation must be made to the physical address
- Relative
  - Address expressed as a location relative to some known point
- Physical
  - The absolute address or actual location in main memory

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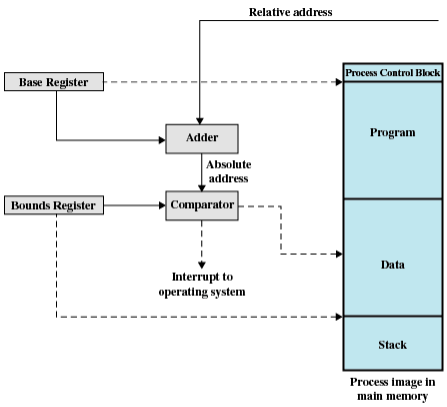

Figure 7.8 Hardware Support for Relocation

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Registers Used during Execution

- Base register
  - Starting address for the process
- Bounds register
  - Ending location of the process
- These values are set when the process is loaded or when the process is swapped in

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Registers Used during Execution

- The value of the base register is added to a relative address to produce an absolute address
- The resulting address is compared with the value in the bounds register
- If the address is not within bounds, an interrupt is generated to the operating system

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Paging

- Partition memory into small equal fixed-size chunks and divide each process into the same size chunks
- The chunks of a process are called pages and chunks of memory are called frames
- Operating system maintains a page table for each process
  - Contains the frame location for each page in the process
  - Memory address consist of a page number and offset within the page

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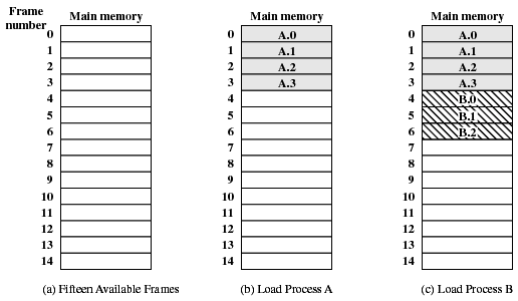
Assignment of Process Pages to Free Frames



(a) Fifteen Available Frames (b) Load Process A (c) Load Process B

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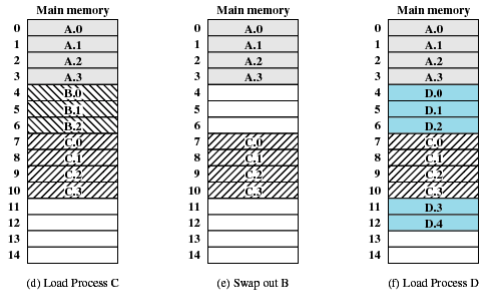
Assignment of Process Pages to Free Frames



(d) Load Process C (e) Swap out B (f) Load Process D

Figure 7.9 Assignment of Process Pages to Free Frames

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Page Tables for Example

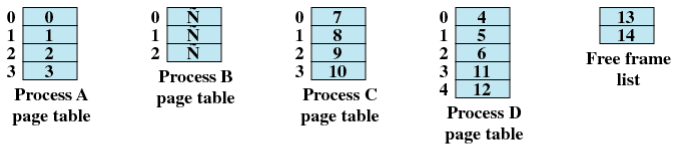

Figure 7.10 Data Structures for the Example of Figure 7.9 at Time Epoch (f)

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Segmentation

- All segments of all programs do not have to be of the same length
- There is a maximum segment length
- Addressing consist of two parts - a segment number and an offset
- Since segments are not equal, segmentation is similar to dynamic partitioning

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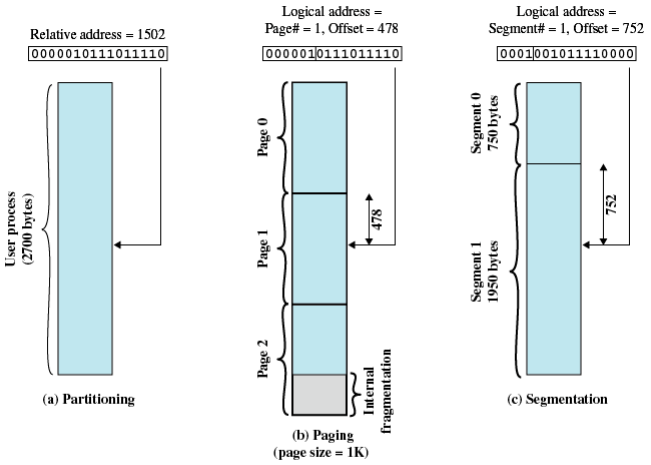
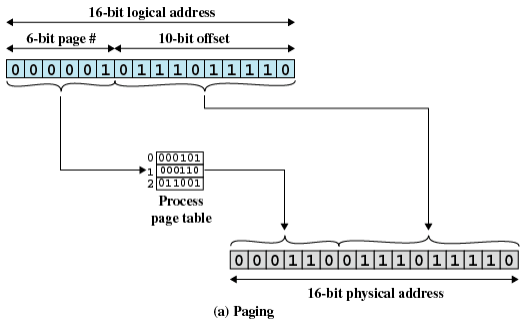


Figure 7.11 Logical Addresses



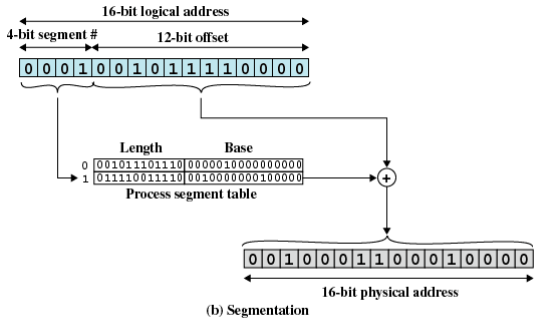


Figure 7.12 Examples of Logical-to-Physical Address Translation

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