Chapter 7 - Lecture

Stallings 9e

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

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

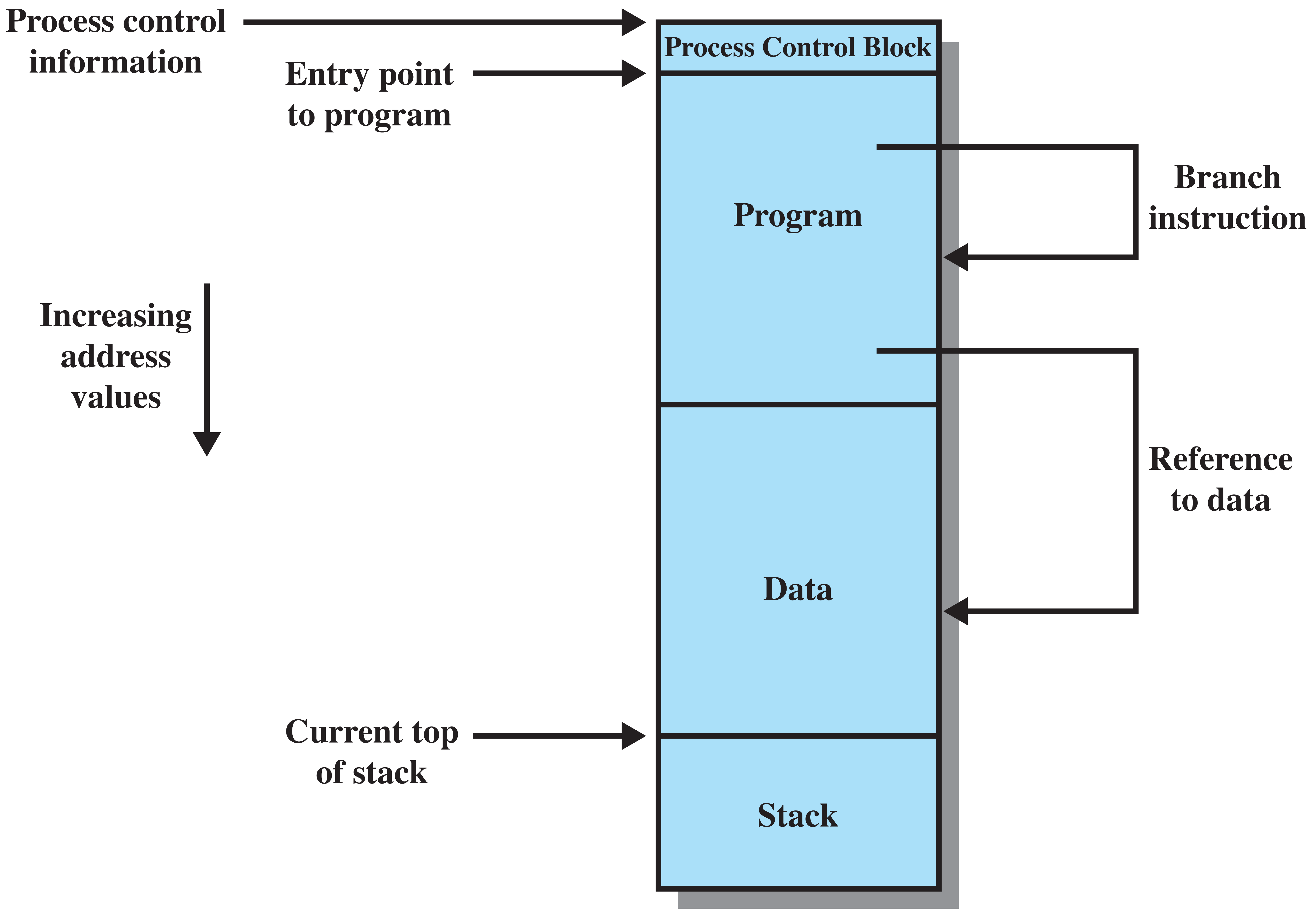


Figure 7.1 Addressing Requirements for a Process

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 run 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

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

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

Memory Management Requirements

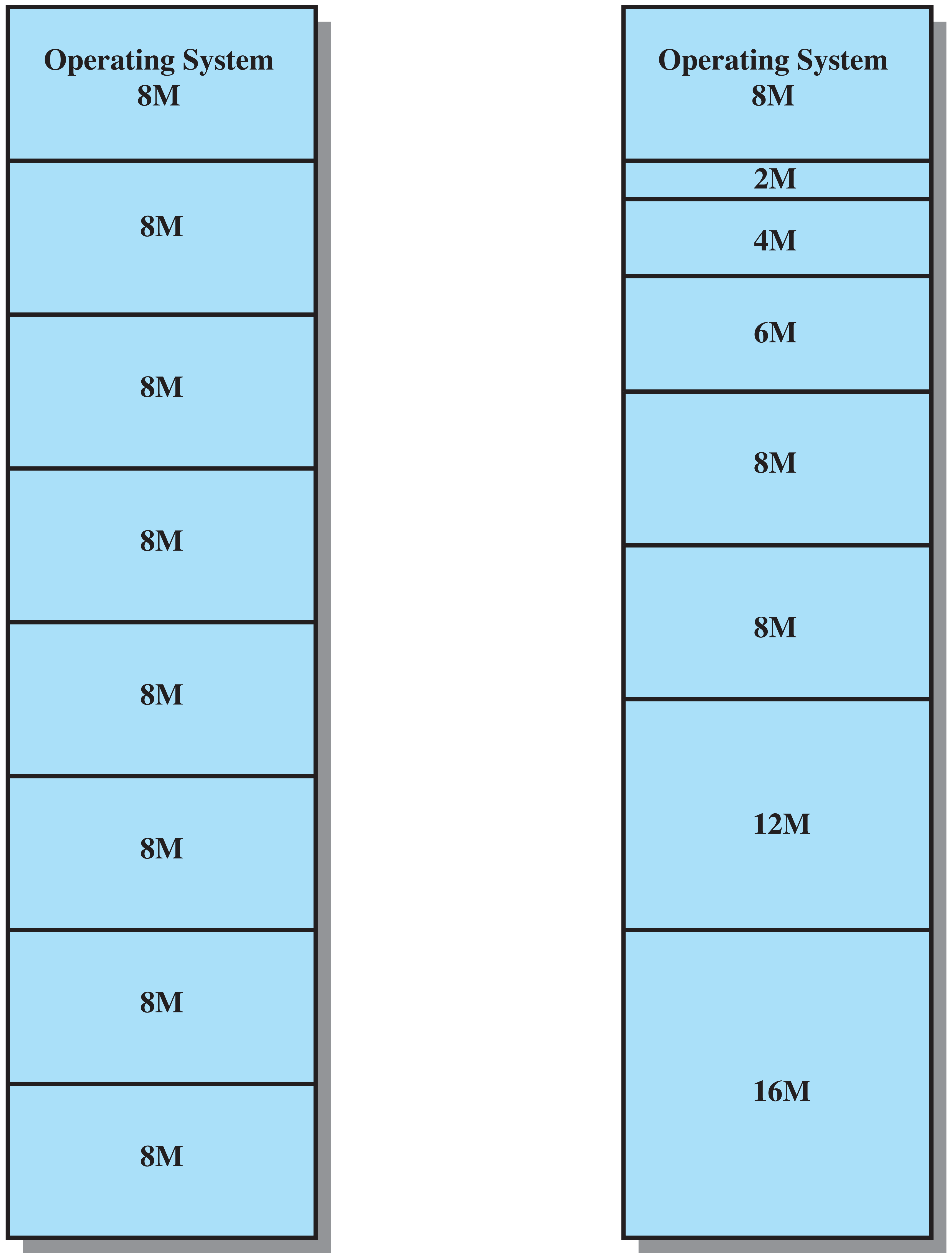
- Physical Organization
  – Memory available for a program plus its data may be insufficient
    - Overlaying allows various modules to be assigned the same region of memory
  – Programmer does not know how much space will be available

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

Fixed Partitioning

- Fixed partitioning in main memory is inefficient.
  - Any program, no matter how small, occupies an entire partition.
  - What about the memory left over if the program does not fit perfectly.
  - This is called **internal fragmentation**.



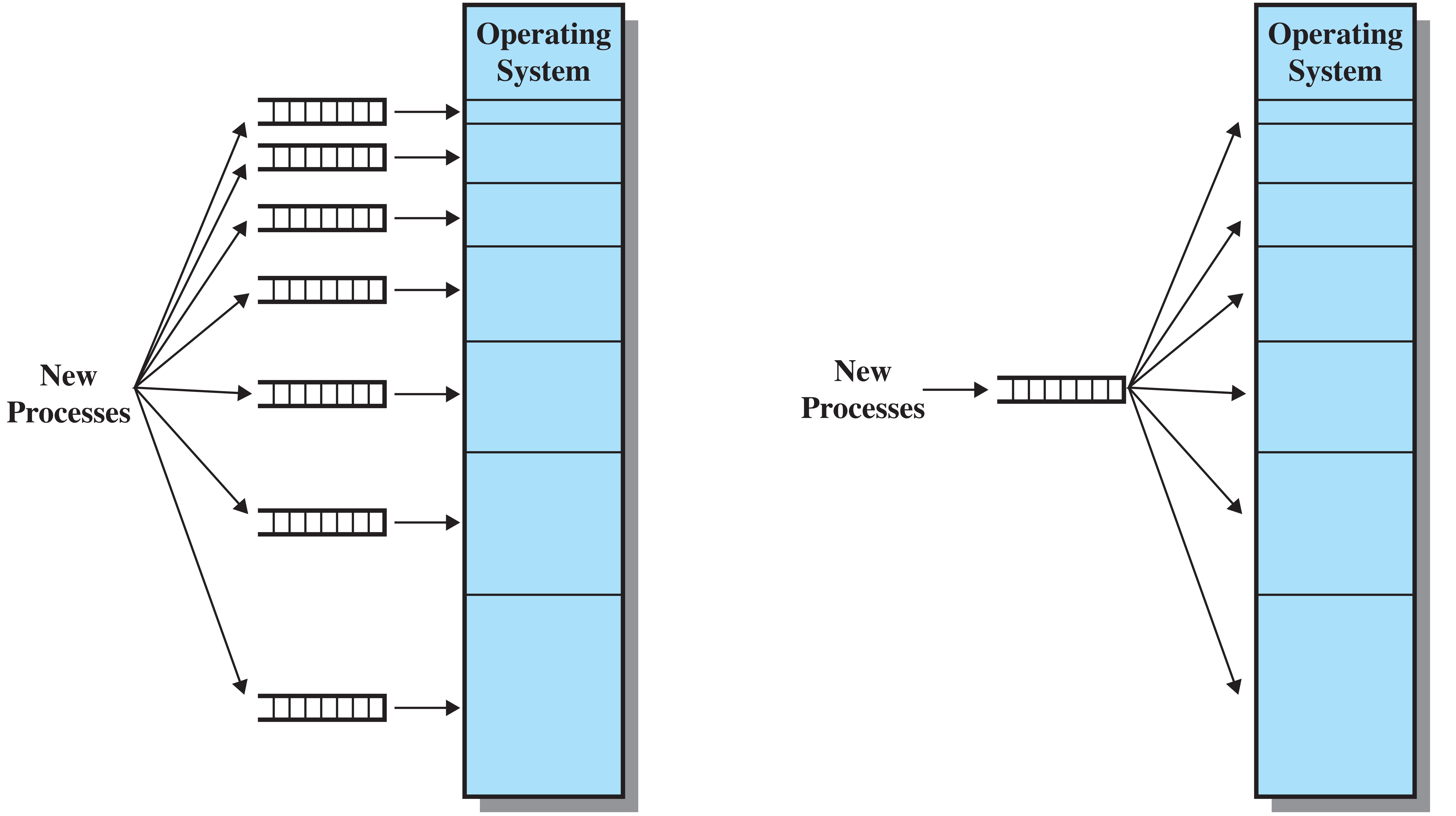
(a) Equal-size partitions

(b) Unequal-size partitions

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



(a) One process queue per partition

(b) Single queue

Figure 7.3 Memory Assignment for Fixed Partitioning

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

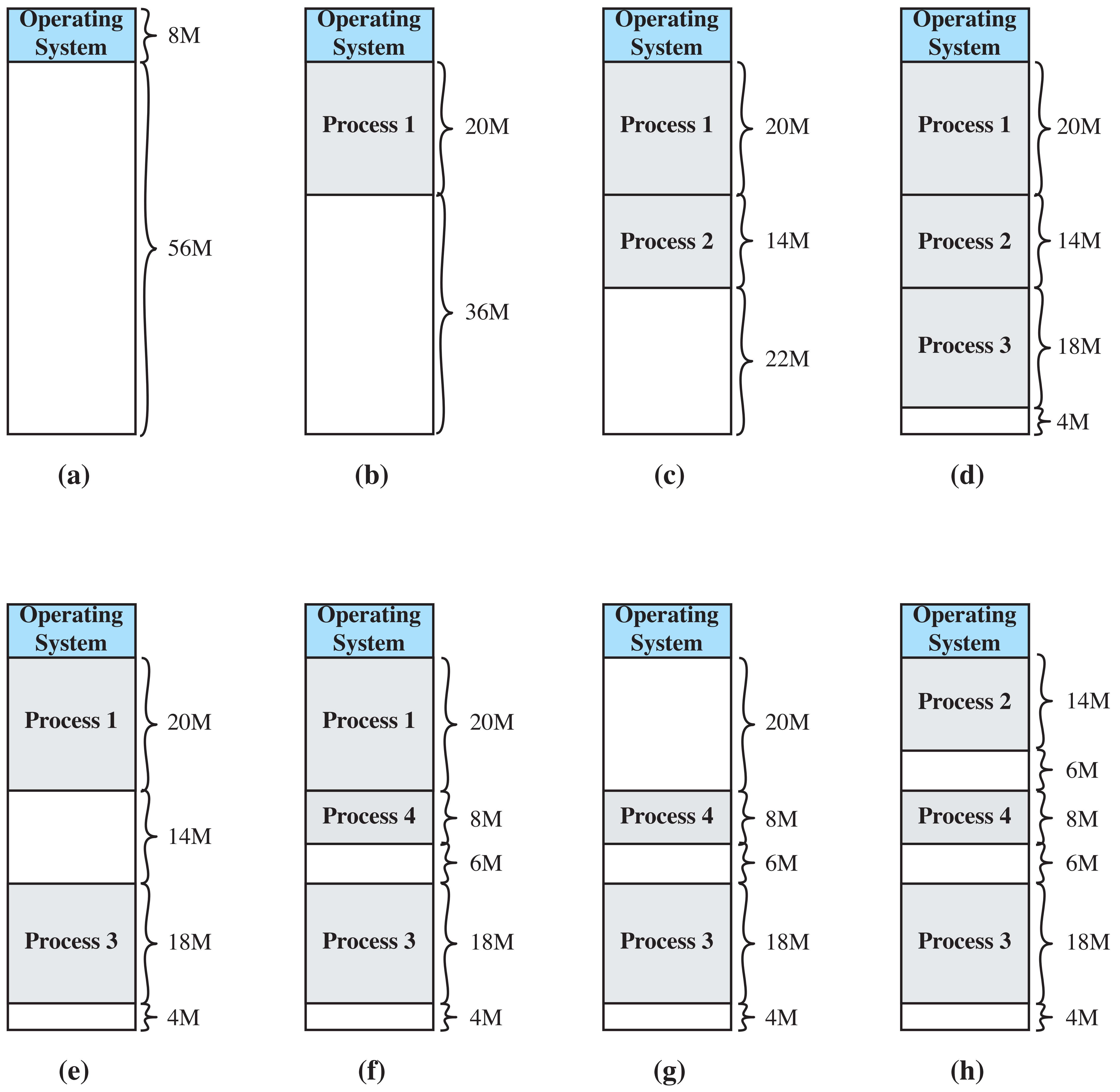


Figure 7.4 The Effect of Dynamic Partitioning

Dynamic Partitioning Placement Algorithm

- Operating system must decide which free block to allocate to a process.
  - Let's look at some algorithms.
- Best-fit algorithm
  - Chooses the block that is closest in size to the request
  - Despite its name: worst performer overall
  - Since smallest block is found for process, the smallest amount of fragmentation is left
    - leaves blocks too small to reallocate
  - Memory compaction must be done more often

Dynamic Partitioning Placement Algorithm

- First-fit algorithm
  - Scans memory from 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

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

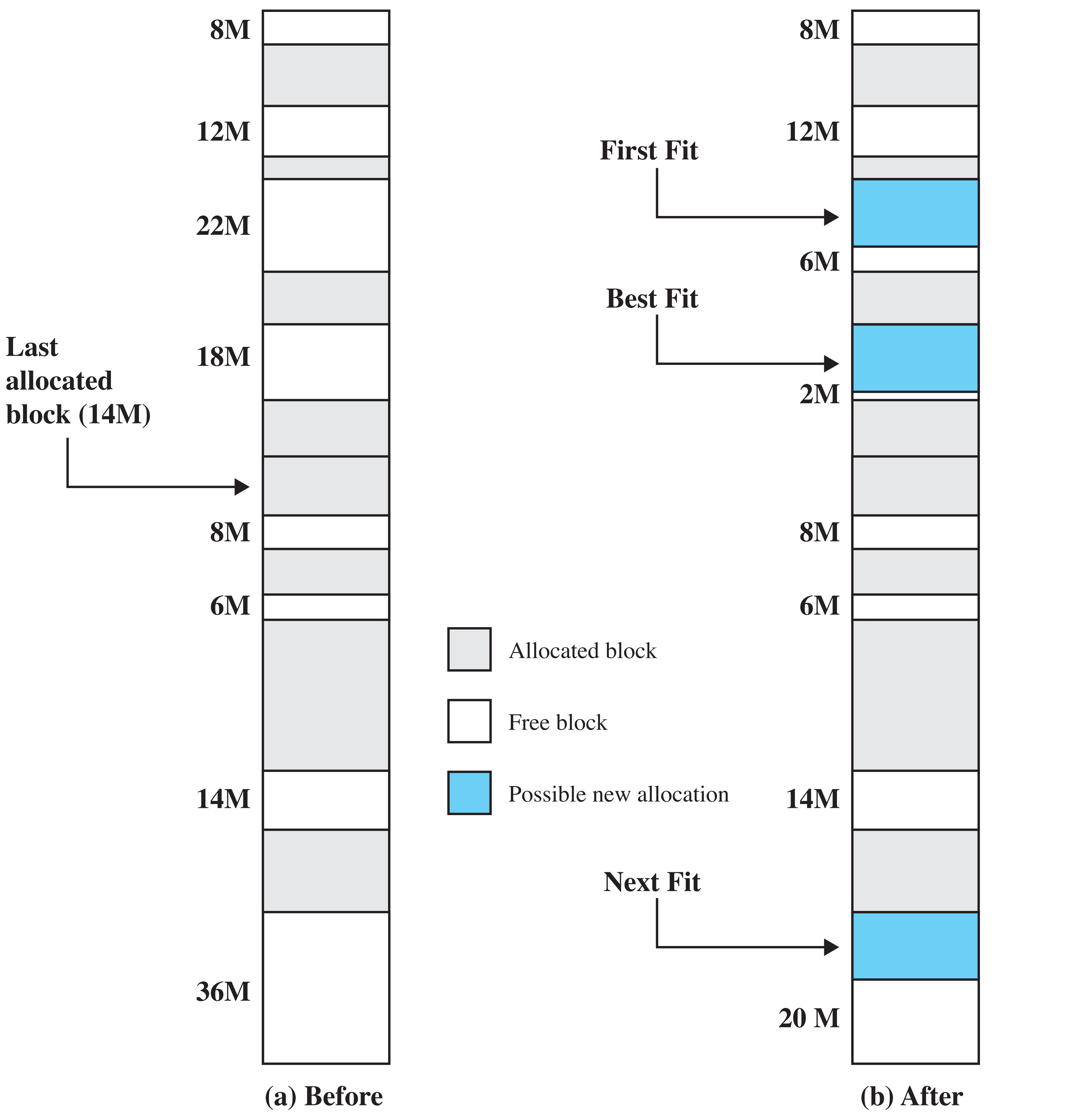


Figure 7.5 Example Memory Configuration before and after Allocation of 16-Mbyte Block

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

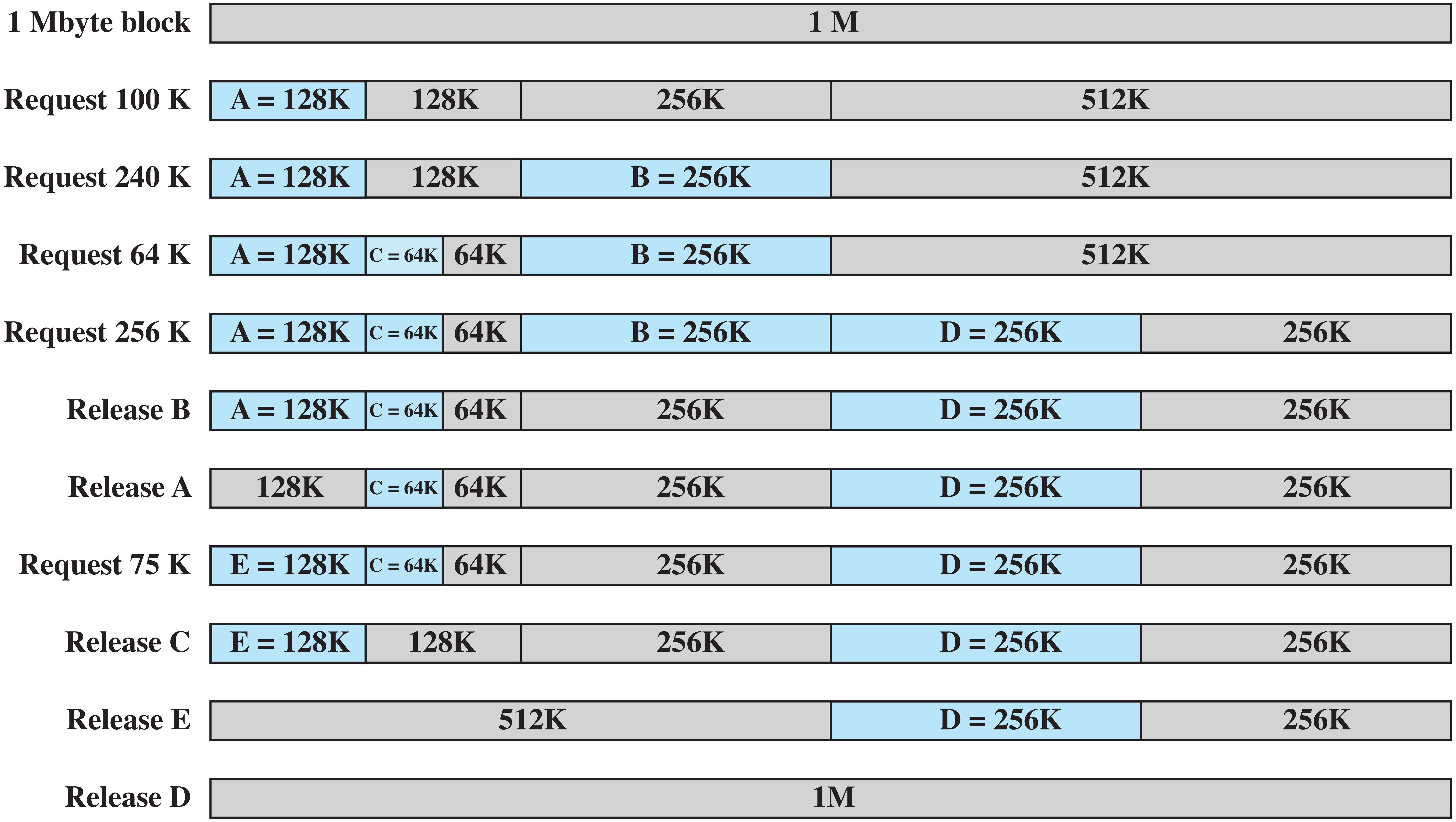


Figure 7.6 Example of Buddy System

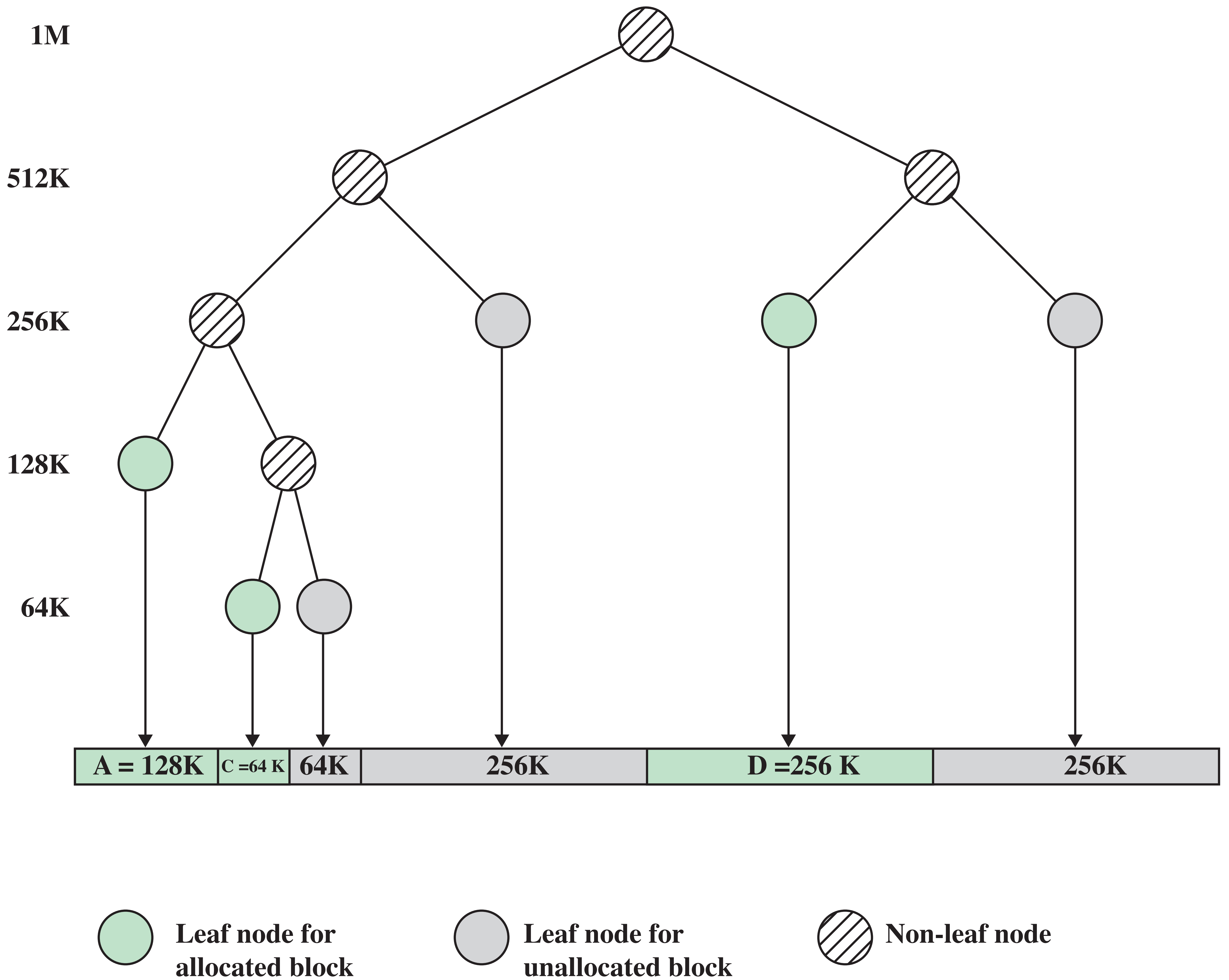


Figure 7.7 Tree Representation of Buddy System

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

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

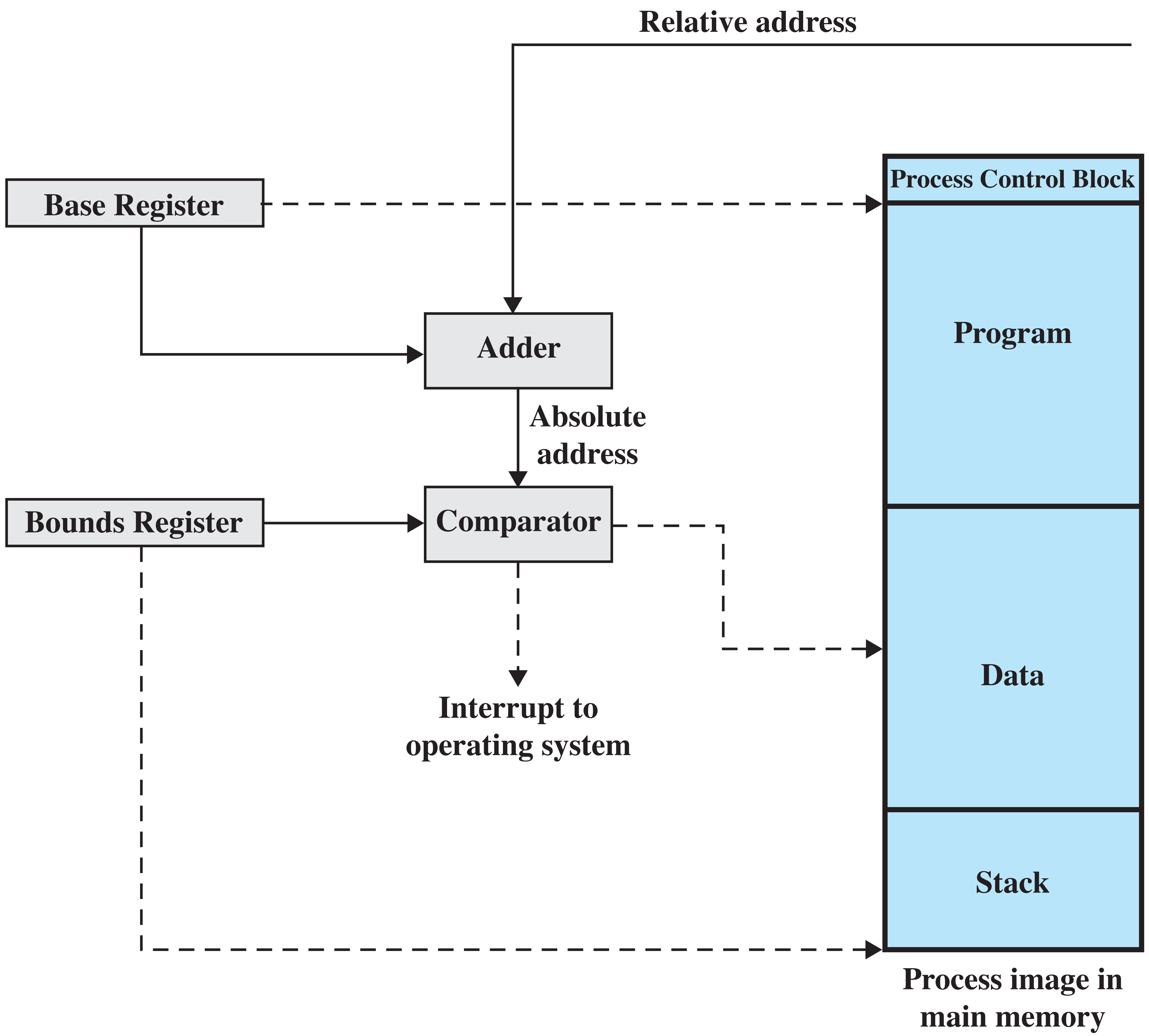


Figure 7.8 Hardware Support for Relocation

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

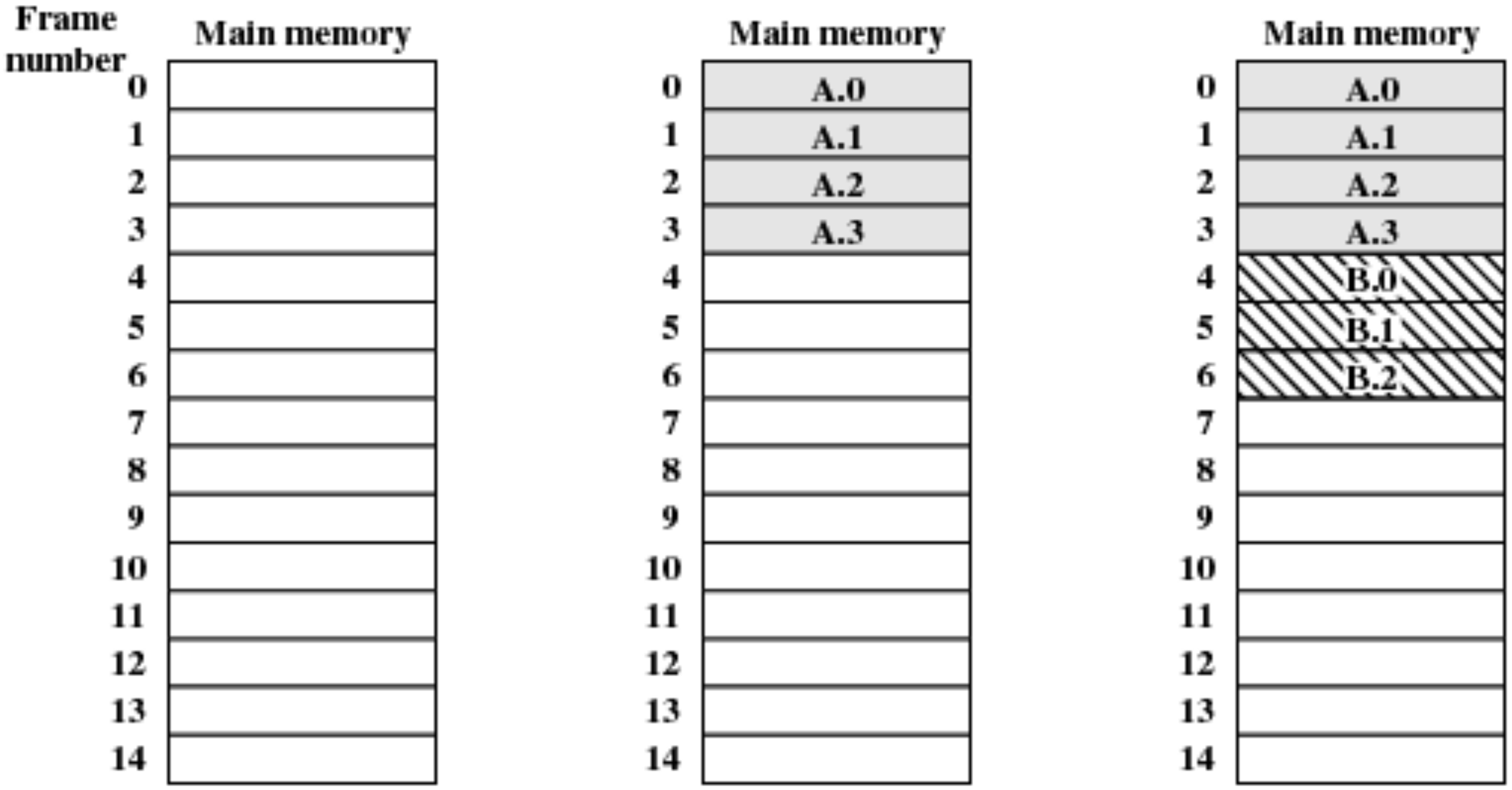
Registers Used during Execution

- 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

Paging

- Partition memory into small equal fixed-size chunks called page **frames**.
- Processes divided into **pages** as well
- Page frames and pages are of equal size
  - try “pagesize” command
- 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

Assignment of Process Pages to Free Frames



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

Assignment of Process Pages to Free Frames

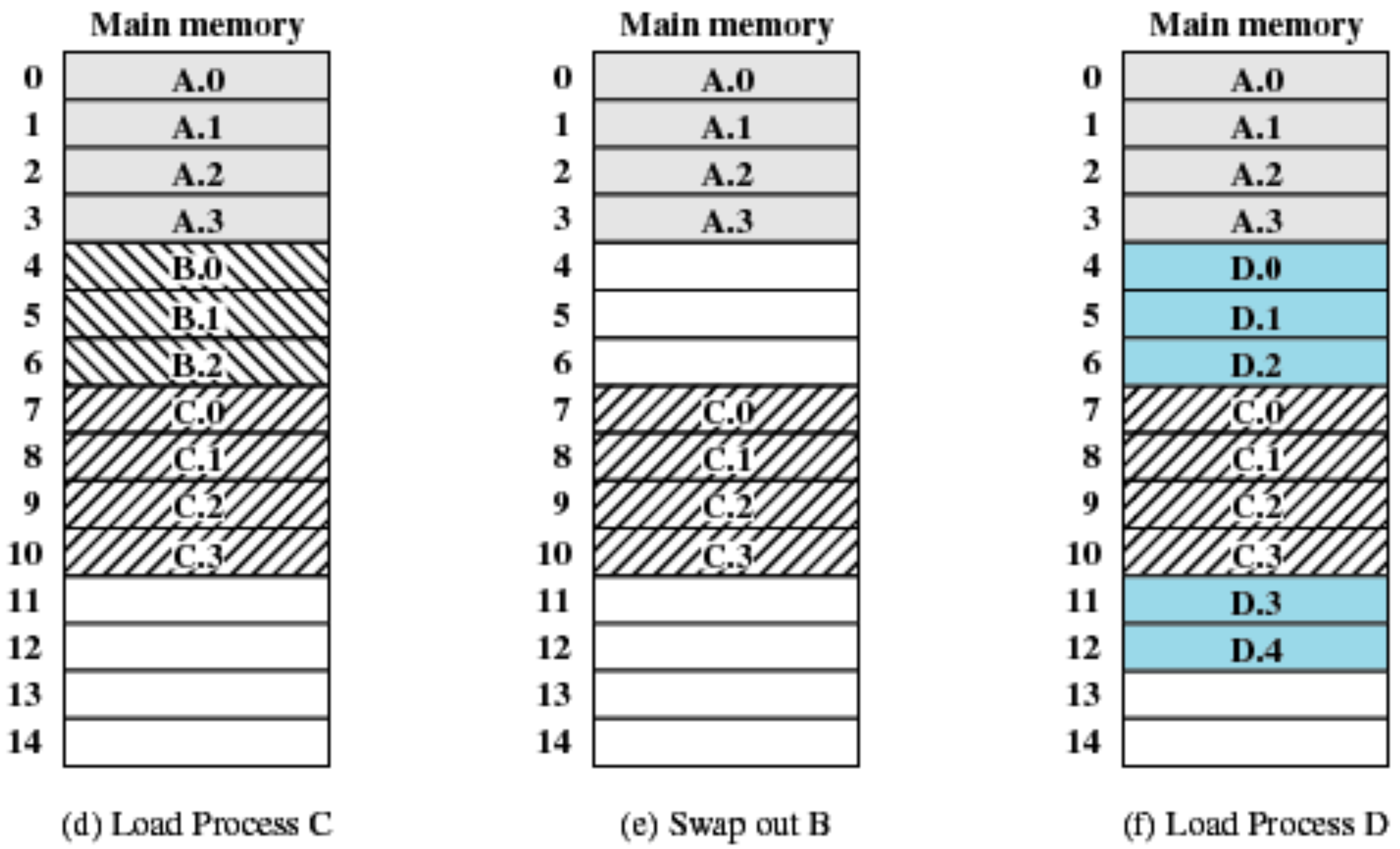


Figure 7.9 Assignment of Process Pages to Free Frames

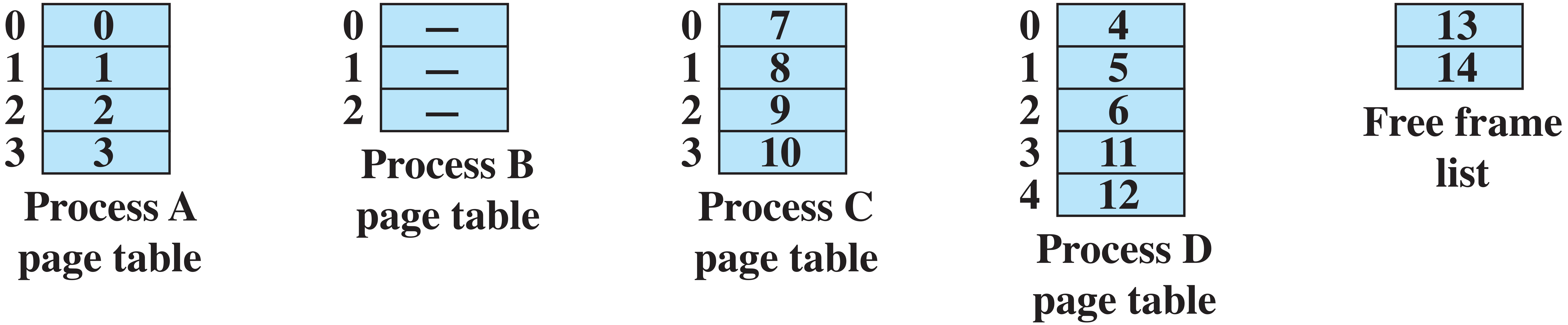


Figure 7.10 Data Structures for the Example of Figure 7.9 at Time Epoch (f)

Paging

- The page frames are of equal size.

Is this the same as fixed partitioning?

- With paging, data blocks are small (e.g., 4K)
- A program can occupy more than one page
- Pages need not be contiguous in memory

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

Segmentation

- Since segments are not equal, segmentation may look a bit like dynamic partitioning...

So is it the same or is

something different?

- A program may occupy more than one segment
- Segments need not be contiguous in memory

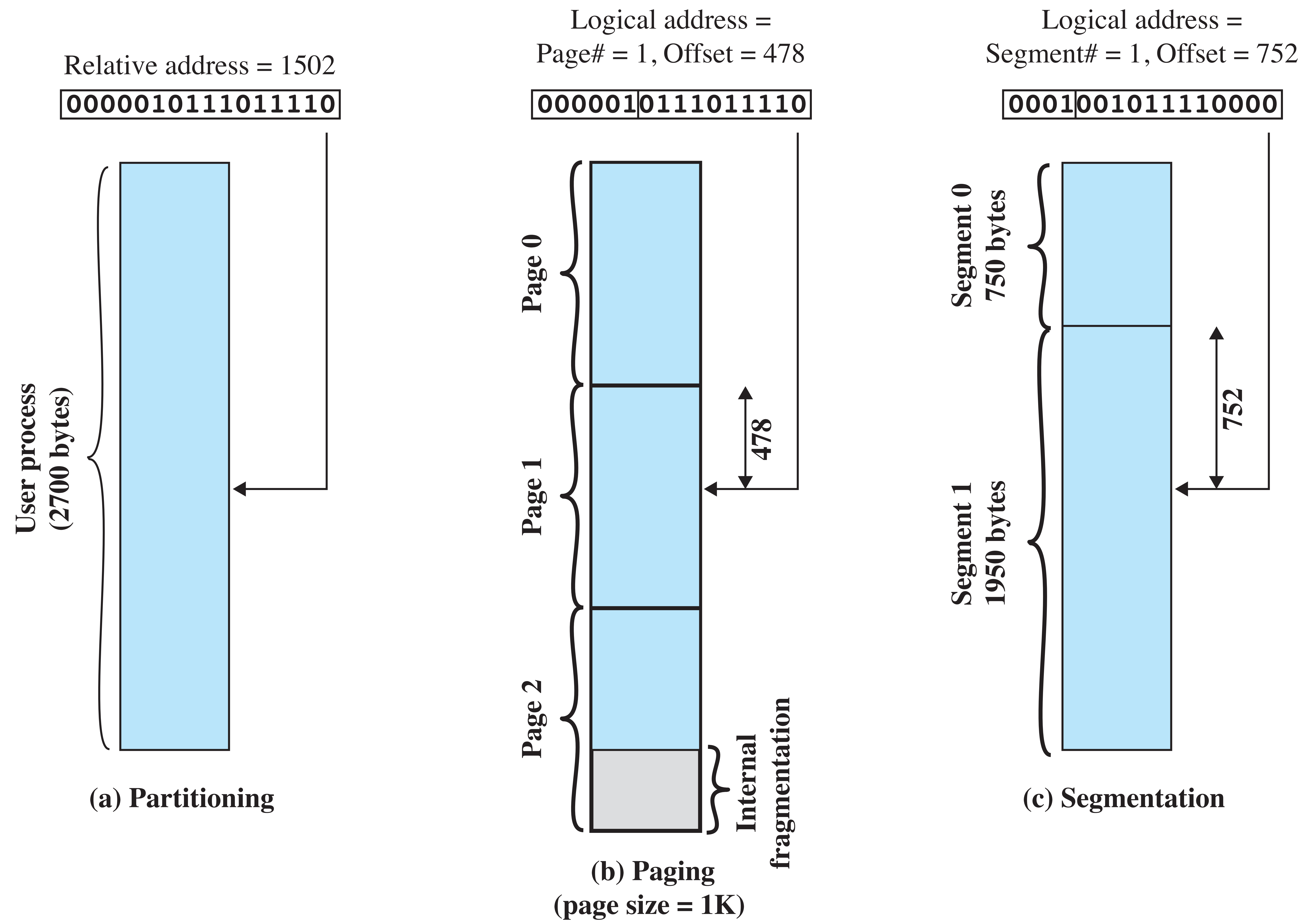


Figure 7.11 Logical Addresses

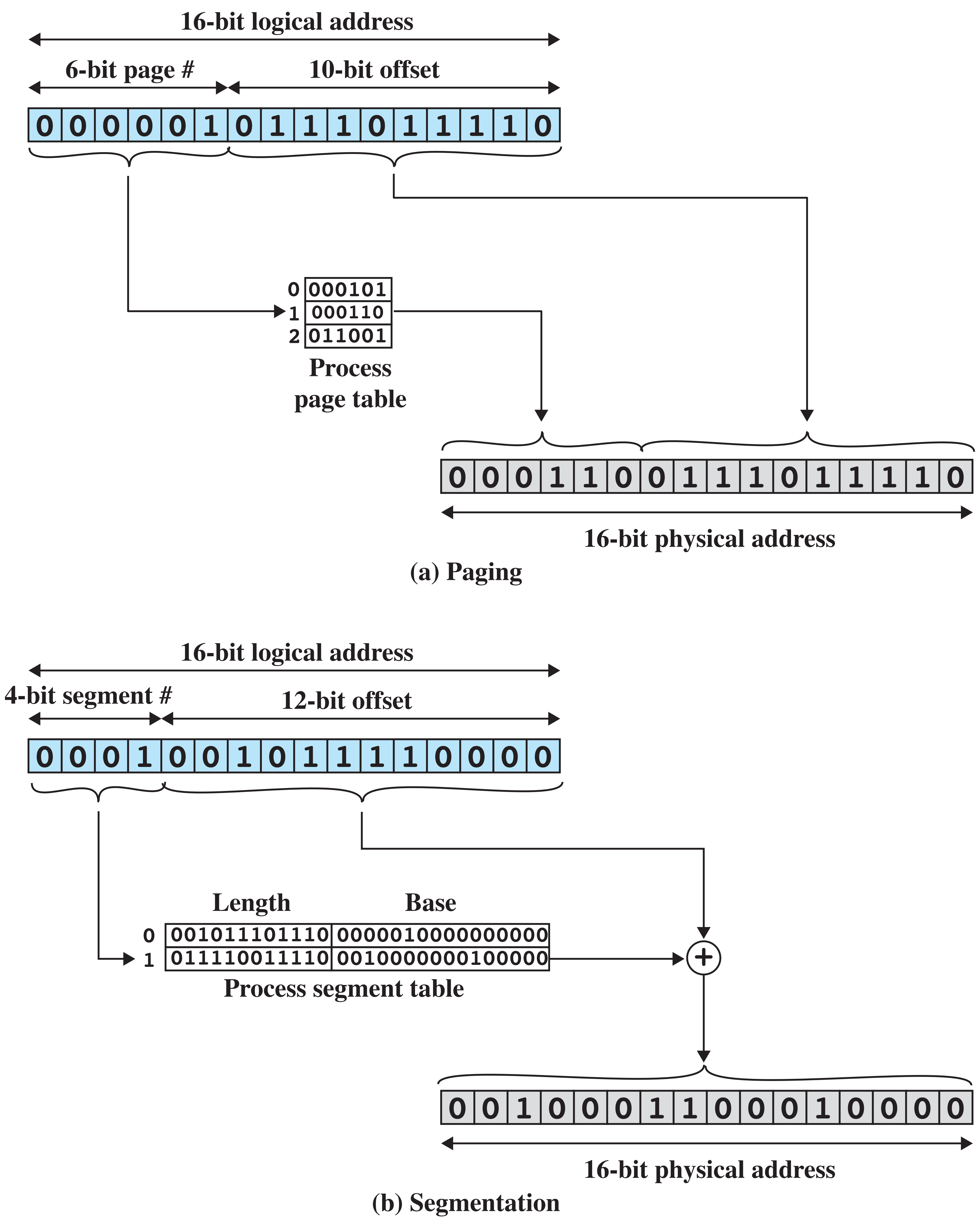


Figure 7.12 Examples of Logical-to-Physical Address Translation

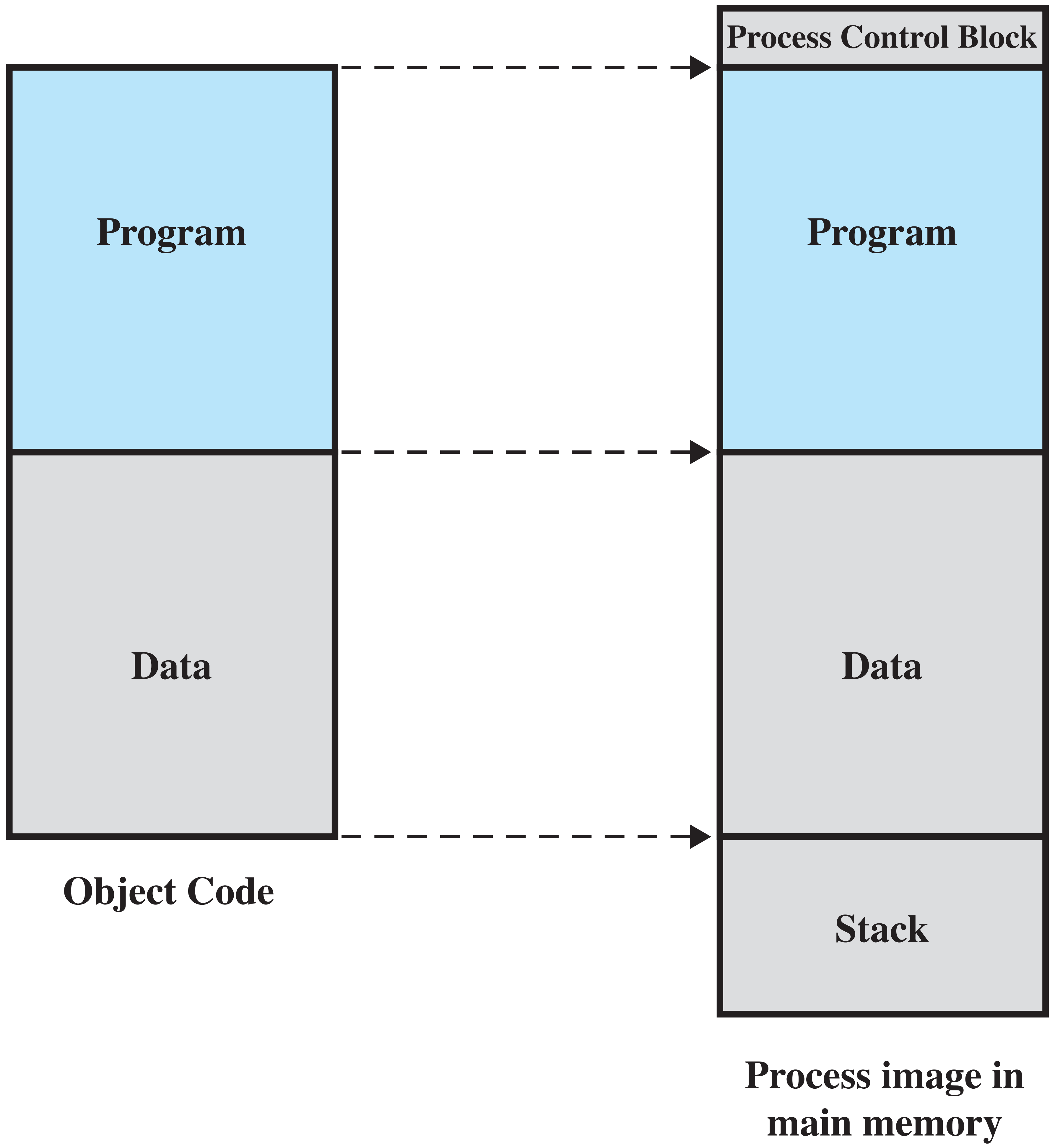


Figure 7.13 The Loading Function

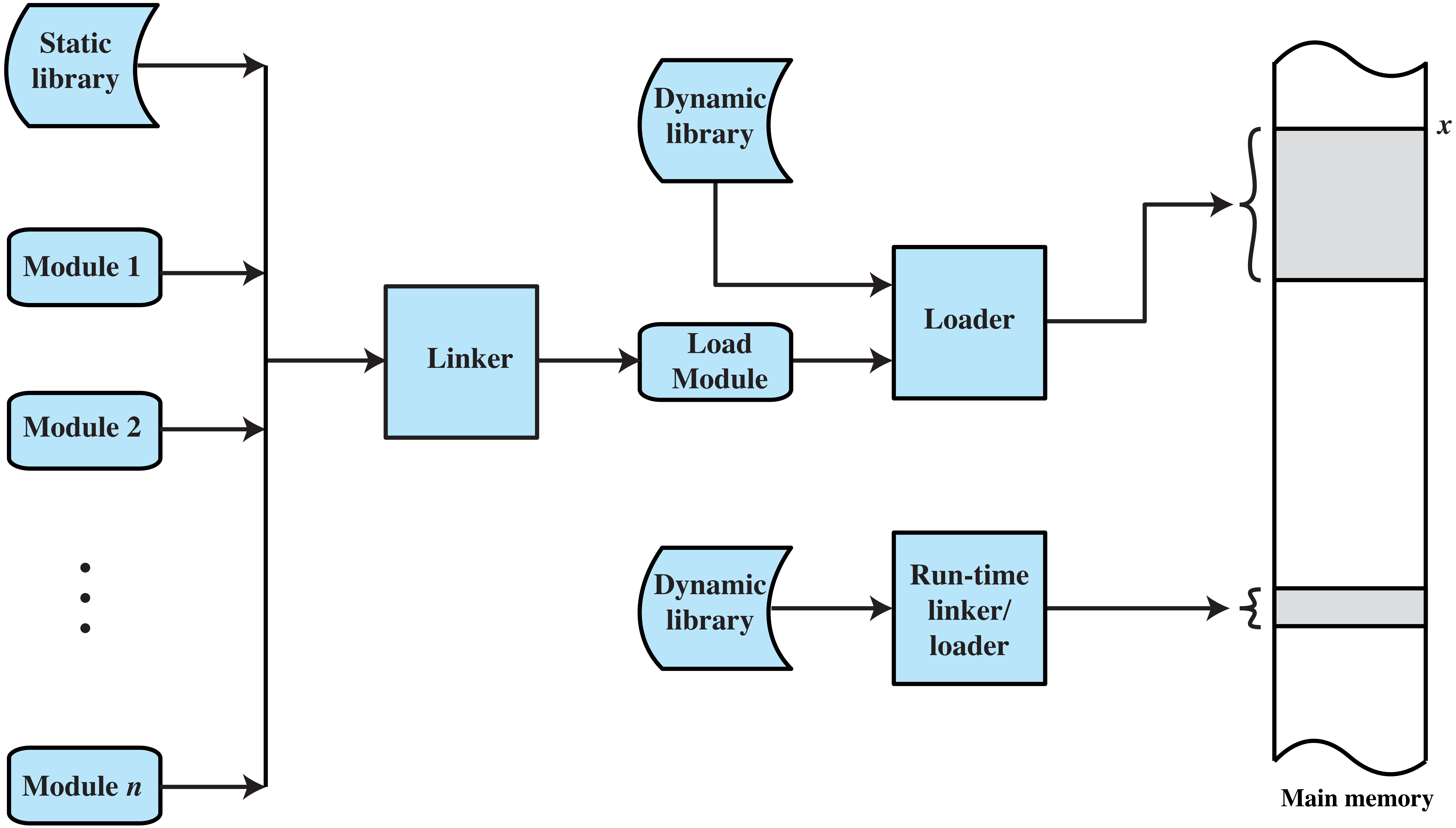


Figure 7.14 A Linking and Loading Scenario

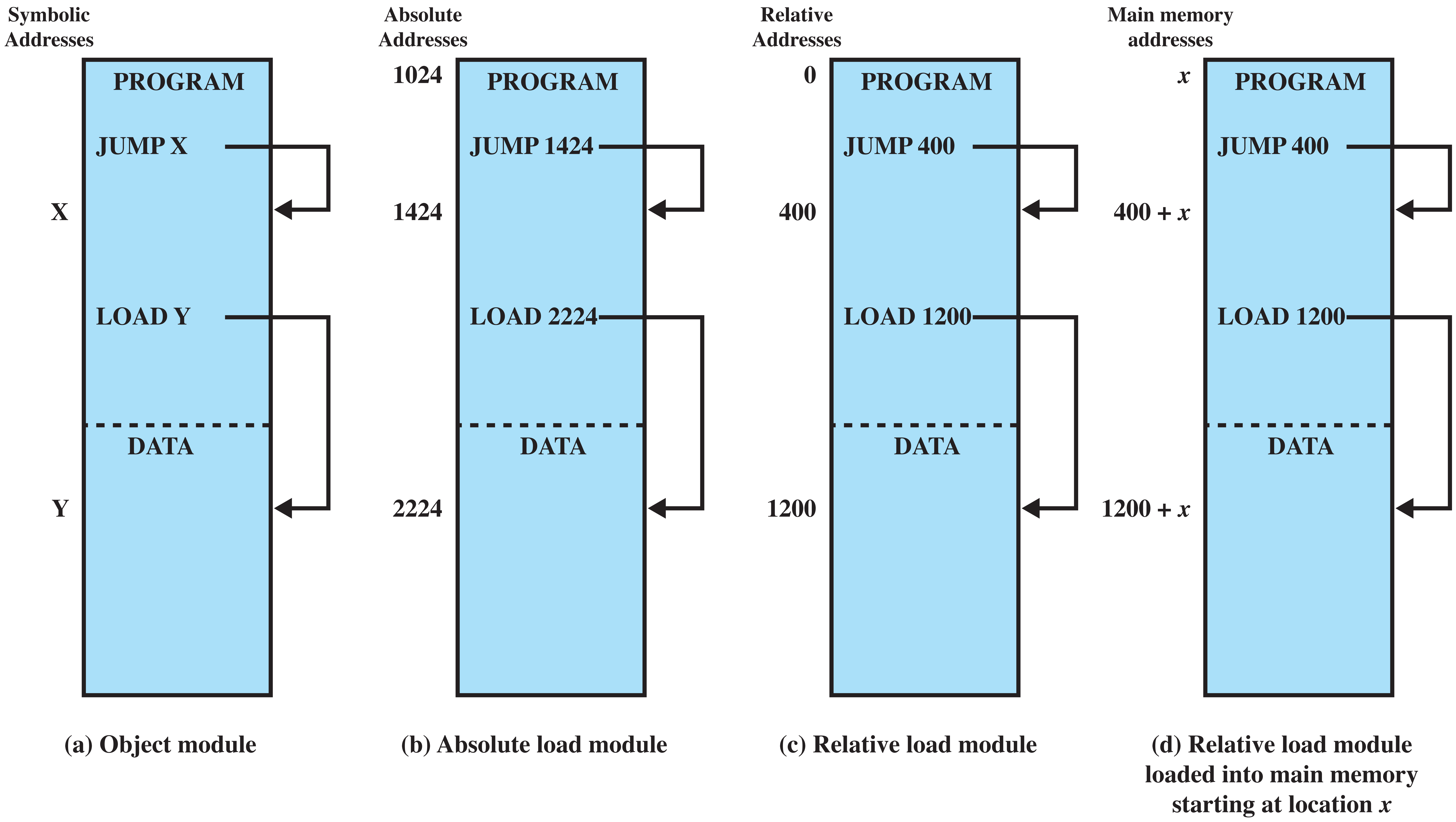


Figure 7.15 Absolute and Relocatable Load Modules

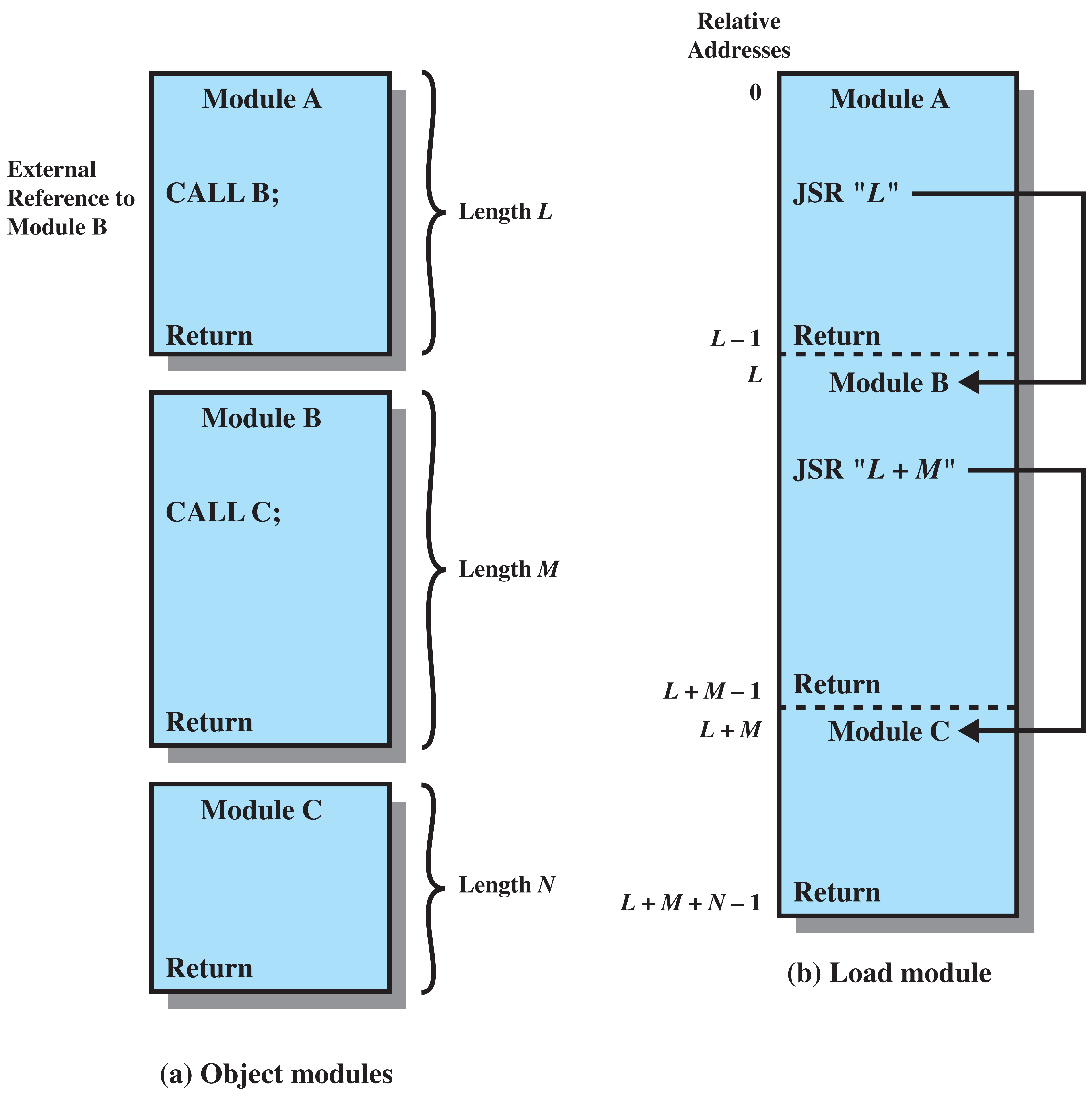


Figure 7.16 The Linking Function