OPERATING SYSTEMS

Memory Management - 3

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OPERATING SYSTEMS

Course Syllabus - Unit 3

UNIT 3: Memory Management

Main Memory: Hardware and control structures, OS support, Address translation, Swapping, Memory Allocation (Partitioning, relocation), Fragmentation, Segmentation, Paging, TLBs context switches .Virtual Memory - Demand Paging, Copy-on-Write, Page replacement policy - LRU (in comparison with FIFO & Optimal), Thrashing, design alternatives - inverted page tables, bigger pages. Case Study: Linux/Windows Memory.

Course Outline - Unit 3

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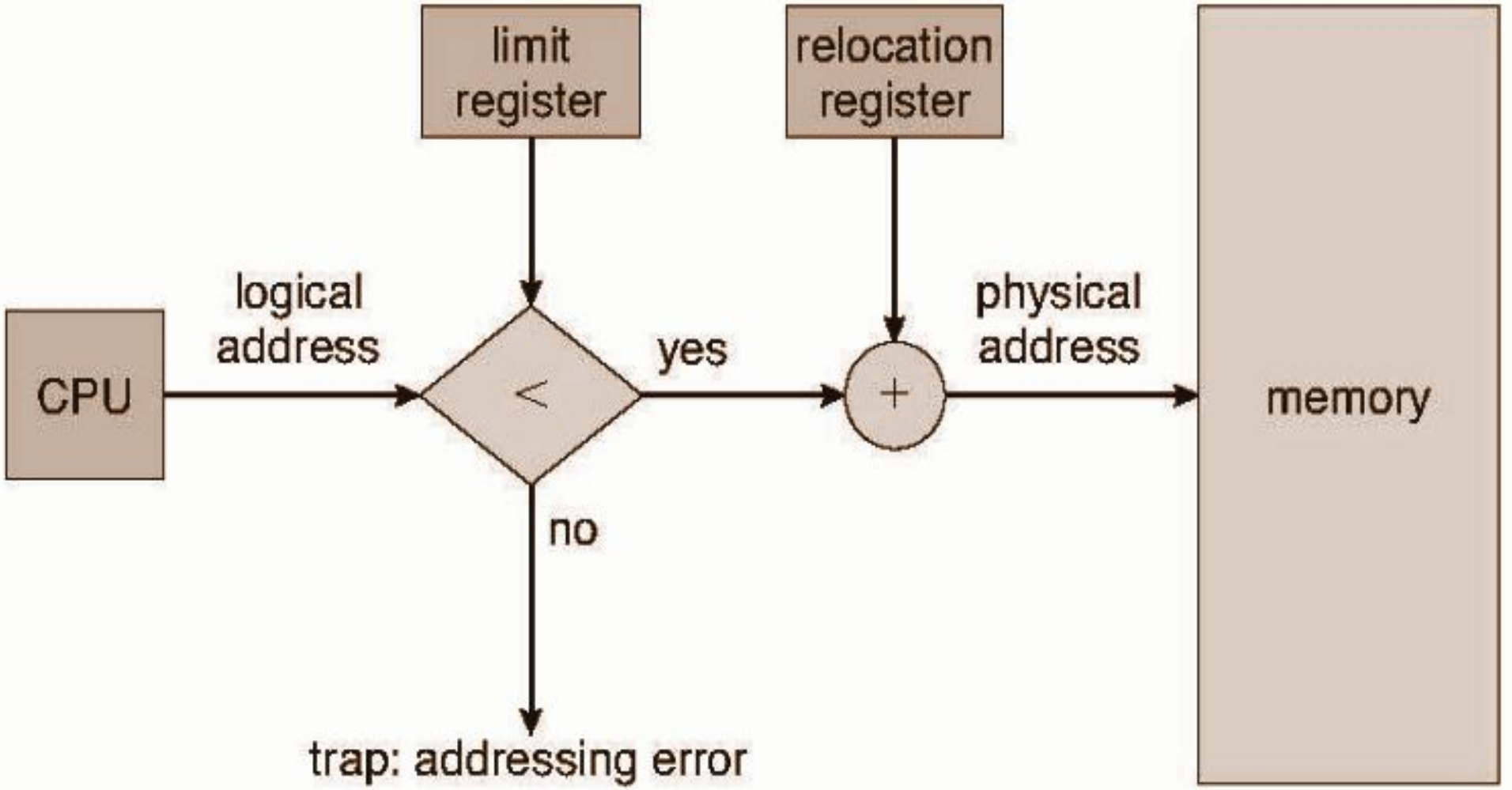
Topic Outline

- Contiguous Allocation
- Hardware Support for Relocation and Base Register
- Multiple Partition Allocation
- Fragmentation

Contiguous Allocation

- Relocation registers used to protect user processes from each other, and from changing operating-system code and data
- Base register contains value of smallest physical address
- Limit register contains range of logical addresses => each logical address must be less than the Limit register
- MMU maps logical address dynamically
- It can then allow actions such as kernel code being transient and kernel changing size

Hardware support for Relocation and Base Register

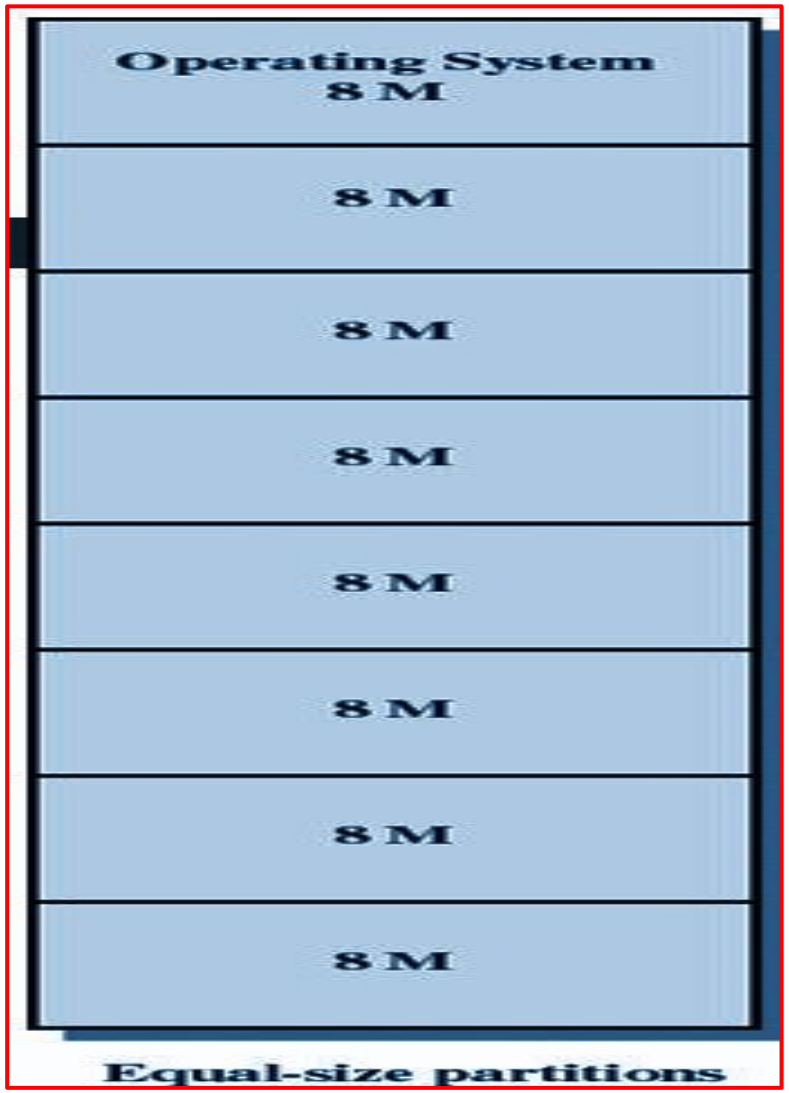


Multiple Partition Allocation

- Multiple-partition allocation
  - Degree of multiprogramming limited by number of partitions - Fixed or Variable
  - Variable Partition sizes for efficiency (sized to a given process' needs)
  - Hole or Contiguous Chunk (CC) – block of available memory; CC of various size are scattered throughout memory

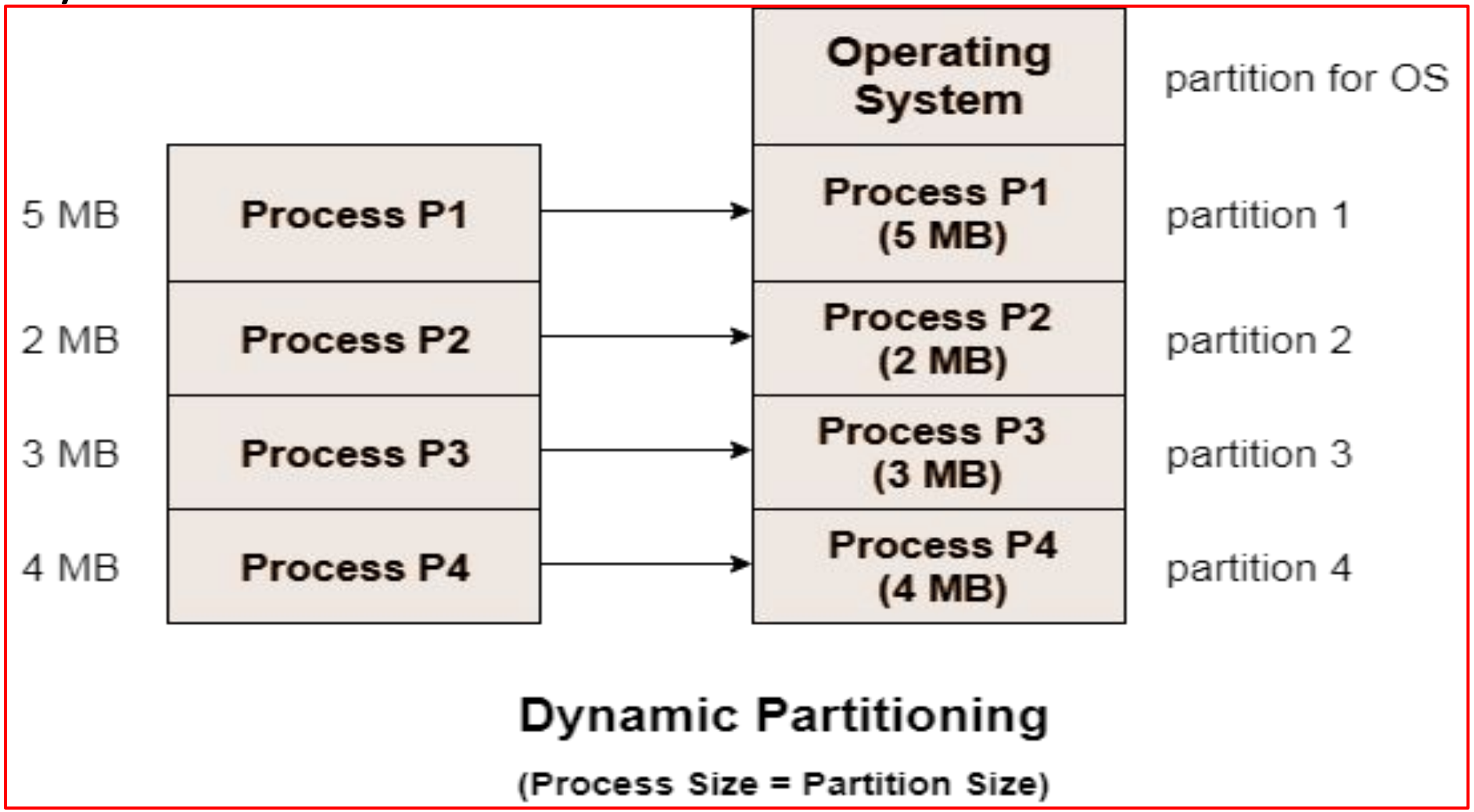
400 KB=> Fixed Partitions of 40 KB => 10 partitions

Multiple Partition Allocation - Static or Fixed Partitions



Multiple Partition Allocation - Dynamic or Variable Partitions

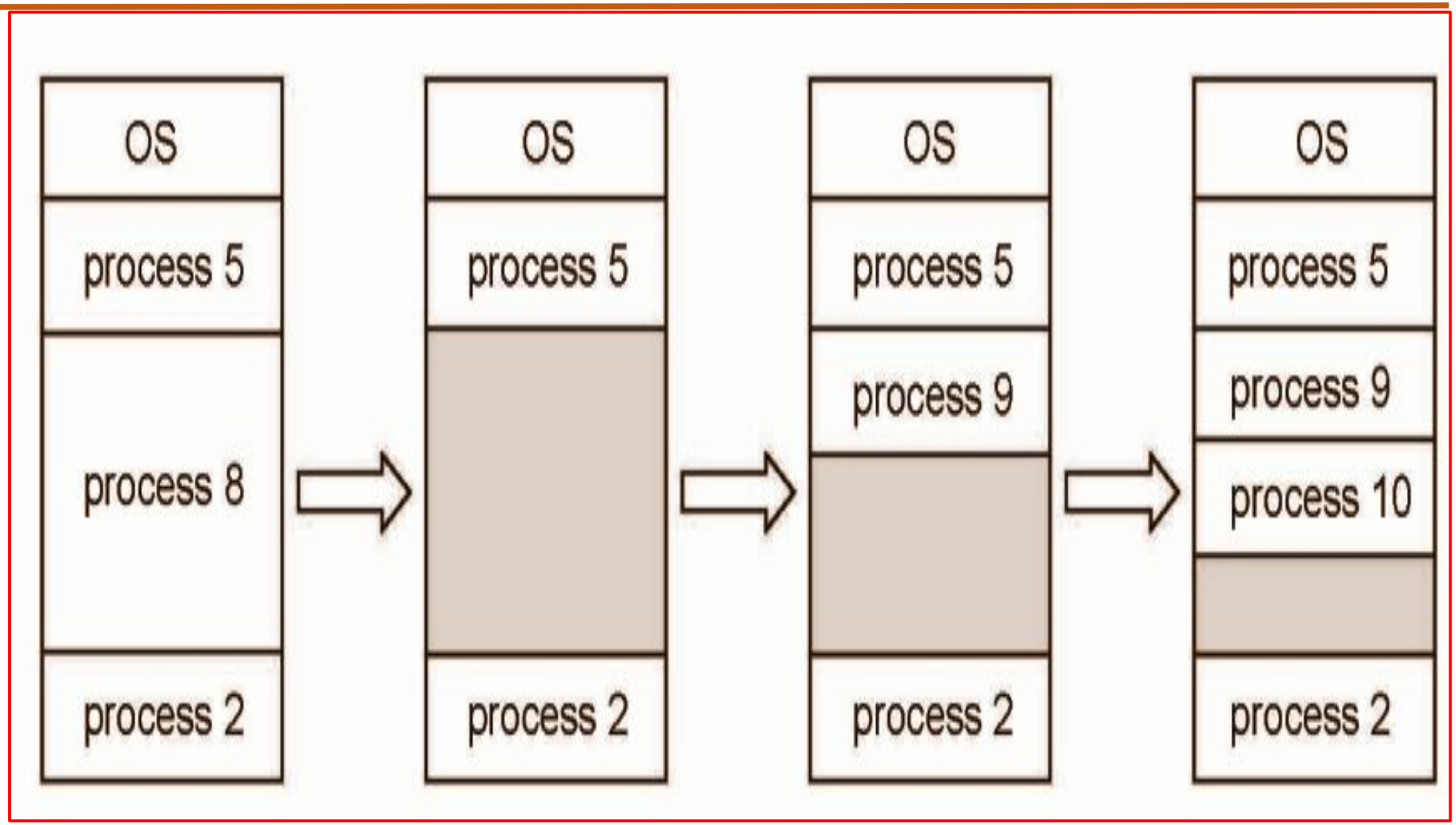
- Dynamic or Variable - Partition allocation



Multiple Partition Allocation

- When a process arrives, it is allocated memory from a free CC large enough to accommodate it
- Process exiting frees its partition, adjacent free partitions combined
- Operating system maintains information about:
  - allocated partitions
  - free CC or partitions

Multiple Partition Allocation - Dynamic or Variable Partitions



Multiple Partition Allocation

How to satisfy a request of size n from a list of free CC ?

- **First-fit:** Allocate the first CC that is big enough to accomodate the request of size n

- **Best-fit:** Allocate the smallest CC that is big enough; must search entire list, unless ordered by size. It produces the smallest leftover CC

- **Worst-fit:** Allocate the largest hole; must also search entire list. It produces the largest leftover hole

Multiple Partition Allocation - Additional Input

- **Buddy System:** In buddy system, sizes of free blocks are in form of integral power of 2.
- Example: 2, 4, 8, 16 etc. Up to the size of memory.
- When a free block of size 2k is requested, a free block from the list of free blocks of size 2k is allocated.
- If no free block of size 2k is available, the block of next larger size, 2k+1 is split in **two halves** called **buddies** to satisfy the request.
- **Next fit:** Next fit is a modified version of first fit. It begins as first fit to find a free partition. When called next time it starts searching from where it left off, not from the beginning.

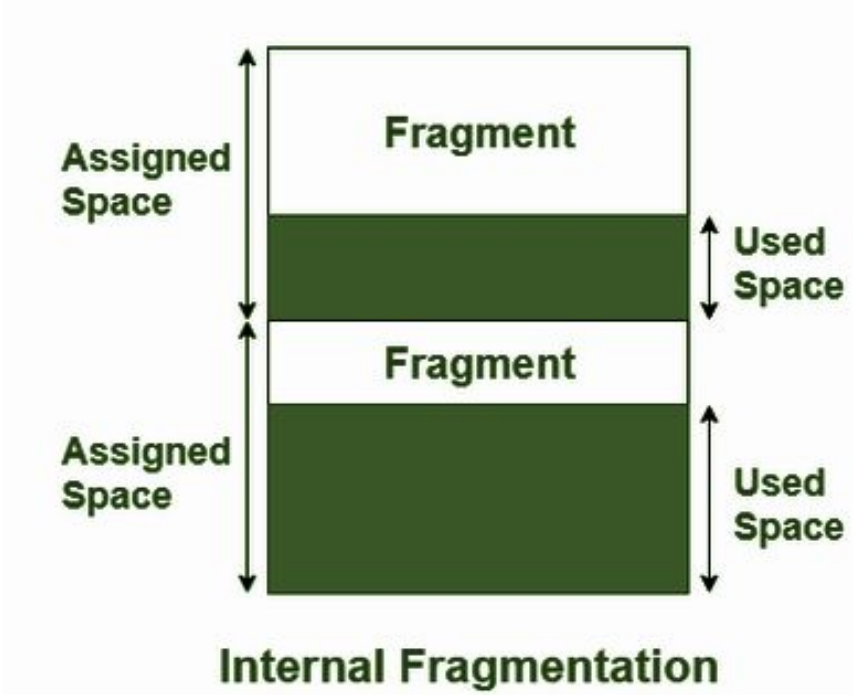
Fragmentation

- **Fragmentation** => is an unwanted problem where the memory blocks cannot be allocated to the processes due to their small size and the blocks remain unused.

- It can also be understood as when the processes are loaded and removed from the memory they create free space or hole in the memory and these small blocks cannot be allocated to new upcoming processes and results in inefficient use of memory.

Fragmentation

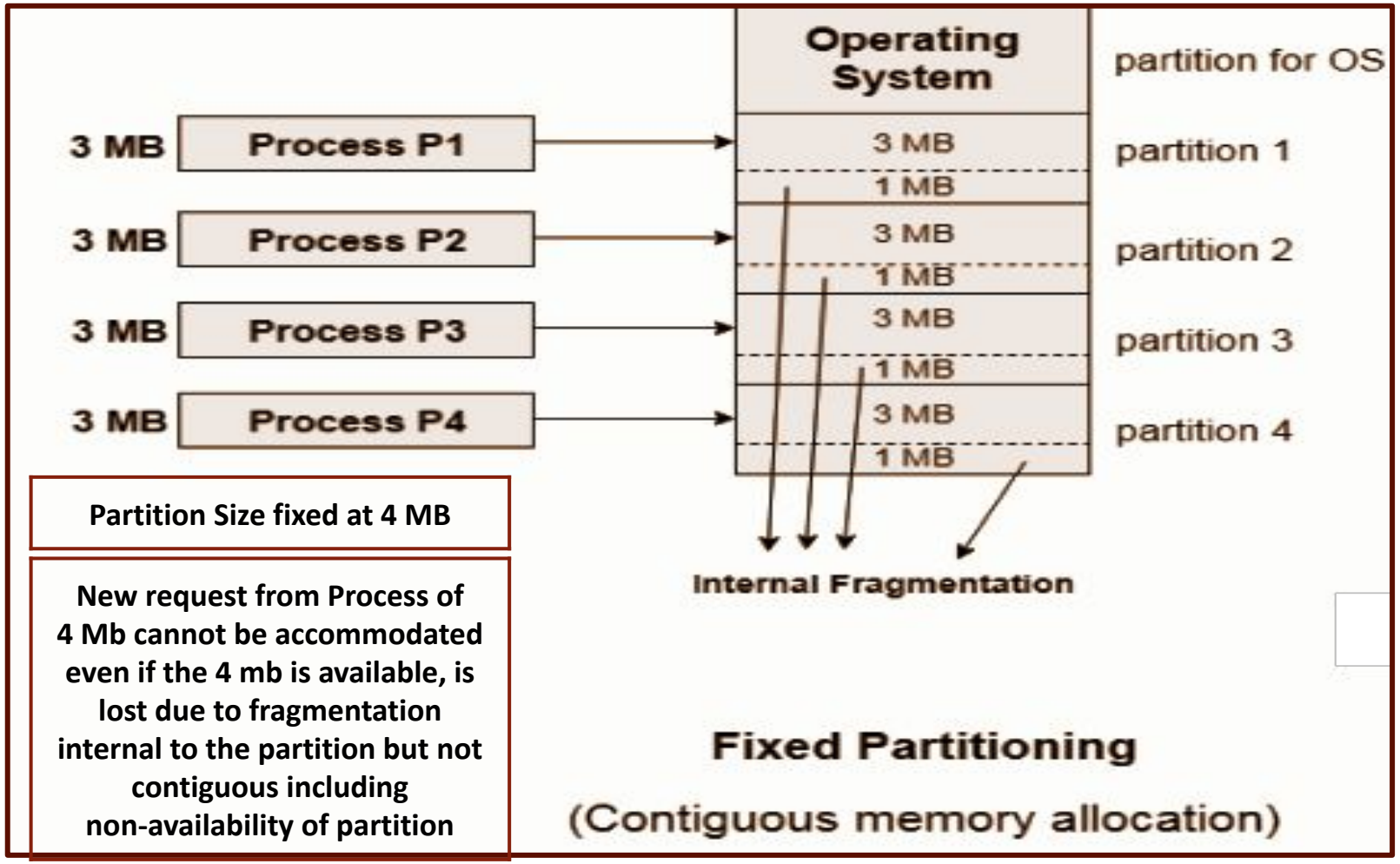
- **Internal Fragmentation** => allocated memory may be slightly larger than requested memory; this size difference is memory internal to a partition, but not being used



Internal Fragmentation

Fragmentation

- Static or Fixed - Partition allocation



Fragmentation

- **External Fragmentation** => total memory space exists to satisfy a request, but it is not contiguous : New Request of 426K must wait

100 Kb	Free
417 Kb	Occupied
88 Kb	Free
200 Kb	Free
300 Kb	Free
212 Kb	Occupied
112 Kb	Occupied
276 Kb	Free

Fragmentation

Internal Fragmentation	External Fragmentation
In internal fragmentation fixed-sized memory blocks square measure appointed to process.	In external fragmentation, variable-sized memory blocks square measure appointed to method.
The solution of internal fragmentation is best-fit block.	Solution of external fragmentation is compaction, paging and segmentation.

Fragmentation

- **First Fit** analysis reveals that given N blocks allocated, 0.5 N blocks lost to fragmentation
  - 1/3 may be unusable -> 50-percent rule

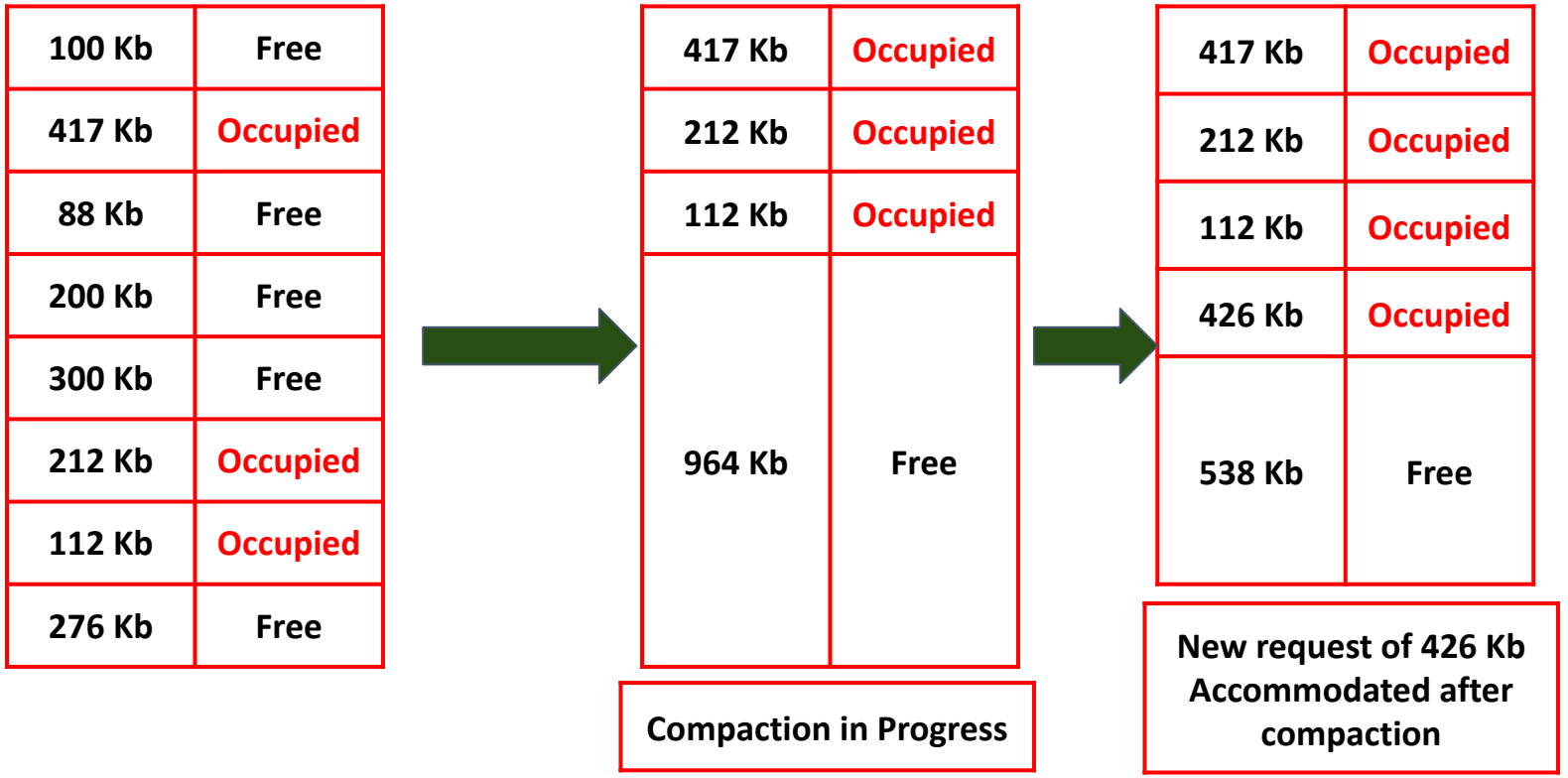
Fragmentation

- 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
  - I/O problem
  - Latch job in memory while it is involved in I/O
  - Do I/O only into OS buffers

Fragmentation

- **Compaction - Example**

- Shuffle memory contents to place all free memory together in one large block. New Request of 426K



Multiple Partition Allocation - Example

- Given five memory partitions of 100Kb, 500Kb, 200Kb, 300Kb, 600Kb (in order), how would 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?

First-fit:
212K is put in 500K partition
417K is put in 600K partition
112K is put in 288K partition (new partition 288K = 500K - 212K)
426K must wait

Best-fit:
212K is put in 300K partition
417K is put in 500K partition
112K is put in 200K partition
426K is put in 600K partition

In this example, best-fit turns out to be the best.

Worst-fit:
212K is put in 600K partition
417K is put in 500K partition
112K is put in 388K partition
426K must wait

Multiple Partition Allocation - Example

First-fit:

212K is put in 500K partition
417K is put in 600K partition
112K is put in 288K partition (new partition 288K = 500K - 212K)
426K must wait

212 Kb	417 Kb	112 Kb	426 Kb

100 Kb	Free
500 Kb	Free
200 Kb	Free
300 Kb	Free
600 Kb	Free

100 Kb	Free
212 Kb	Occupied
288 Kb	Free
200 Kb	Free
300 Kb	Free
600 Kb	Free

100 Kb	Free
212 Kb	Occupied
288 Kb	Free
200 Kb	Free
300 Kb	Free
417 Kb	Occupied
183 Kb	Free

100 Kb	Free
212 Kb	Occupied
112 Kb	Occupied
176 Kb	Free
200 Kb	Free
300 Kb	Free
417 Kb	Occupied
183 Kb	Free

First-fit

Multiple Partition Allocation - Example

Best-fit:
212K is put in 300K partition
417K is put in 500K partition
112K is put in 200K partition
426K is put in 600K partition

212 Kb	417 Kb	112 Kb	426 Kb

100 Kb	Free	100 Kb	Free	100 Kb	Free	100 Kb	Free	100 Kb	Free
500 Kb	Free	500 Kb	Free	417 Kb	Occupied	417 Kb	Occupied	417 Kb	Occupied
200 Kb	Free	200 Kb	Free	83 Kb	Free	83 Kb	Free	83 Kb	Free
300 Kb	Free	212 Kb	Occupied	200 Kb	Free	112 Kb	Occupied	112 Kb	Occupied
600 Kb	Free	88 Kb	Free	212 Kb	Occupied	88 Kb	Free	88 Kb	Free
		600 Kb	Free	88 Kb	Free	212 Kb	Occupied	212 Kb	Occupied
				600 Kb	Free	88 Kb	Free	88 Kb	Free
						600 Kb	Free	426 Kb	Occupied
								174 Kb	Free

Best-fit

Multiple Partition Allocation - Example

Worst-fit:
212K is put in 600K partition
417K is put in 500K partition
112K is put in 388K partition
426K must wait

212 Kb	417 Kb	112 Kb	426 Kb

100 Kb	Free	100 Kb	Free	100 Kb	Free	100 Kb	Free
500 Kb	Free	500 Kb	Free	417 Kb	Occupied	417 Kb	Occupied
200 Kb	Free	200 Kb	Free	88 Kb	Free	88 Kb	Free
300 Kb	Free	300 Kb	Free	200 Kb	Free	200 Kb	Free
600 Kb	Free	212 Kb	Occupied	300 Kb	Free	300 Kb	Free
		388 Kb	Free	212 Kb	Occupied	212 Kb	Occupied
				388 Kb	Free	112 Kb	Occupied
						276 Kb	Free

Worst-fit

Topic Uncovered in this Session

- Contiguous Allocation
- Hardware Support for Relocation and Base Register
- Multiple Partition Allocation
- Fragmentation

THANK YOU

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