

Topics in Memory Management (Review)

- Uniprogrammed operating systems
 - Assembling, linking, loading
 - Static memory allocation
 - Dynamic memory allocation
 - Stacks, heaps
 - Managing the free list, memory reclamation
- Multiprogrammed operating systems
 - Includes most of the above topics
 - Static relocation
 - Dynamic relocation
 - Virtual vs. physical address
 - Partitioning (and compaction)
 - Segmentation
 - Paging
 - Swapping
 - Demand paging

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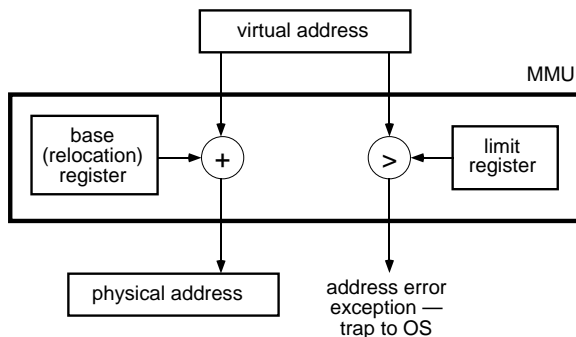
Static vs. Dynamic Relocation (Review)

- Problems with static relocation:
 - Safety — not satisfied — one process can access / corrupt another's memory, can even corrupt OS's memory
 - Processes can not change size (why...?)
 - Processes can not move after beginning to run (why would they want to?)
 - Used by MS-DOS, Windows, Mac OS
- An alternative: dynamic relocation
 - The basic idea is to change each memory address dynamically as the process runs
 - This translation is done by hardware — between the CPU and the memory is a *memory management unit* (MMU) (also called a *translation unit*) that converts virtual addresses to physical addresses
 - This translation happens for every memory reference the process makes

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Implementing Dynamic Relocation



- MMU protects address space, and translates virtual addresses
 - *Base register* holds lowest virtual address of process, *limit register* holds highest
 - Translation:
physical address = virtual address + base
 - Protection:
if virtual address > limit, then trap to the OS with an address exception

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Dynamic Relocation — OS vs. User Programs

- User programs (processes) address their own virtual memory
 - Run in relocation mode — indicated by a bit in the PSW — and in user mode
 - User programs can not change the relocation mode
- OS directly addresses physical memory
 - OS runs with relocation turned off, and in kernel mode
- When user program makes a system call:
 - CPU atomically goes into kernel mode, turns off relocation, traps to trap handler
 - OS trap handler accesses physical memory and does whatever is necessary to service the system call
 - CPU atomically turns on relocation, goes into user mode, returns to user program

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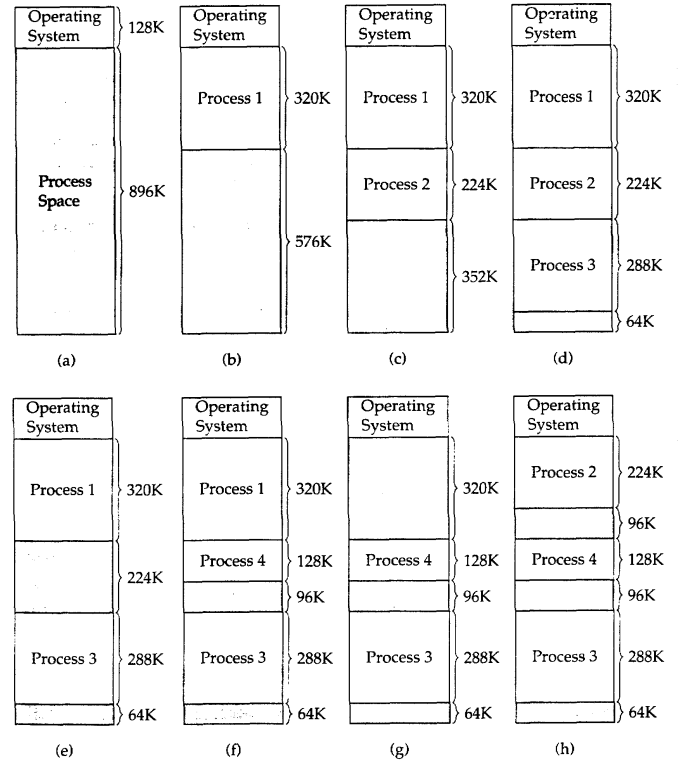
Dynamic Relocation and Partitioning

- Physical memory is divided into *partitions*
 - A process is loaded into a free partition (a “hole” in the memory space)
- Fixed-size partitions:
 - Memory is divided into a predetermined number of fixed-size partitions
 - Partitions may be either of equal size, or of different (although fixed) sizes
 - Use first-fit, best-fit, etc. as discussed for dynamic allocation of heaps
 - Number of partitions limits the *degree of multiprogramming* — number of active processes
- Dynamic (variable-size) partitions:
 - When a process gets brought into memory, it is allocated a partition of exactly the right size

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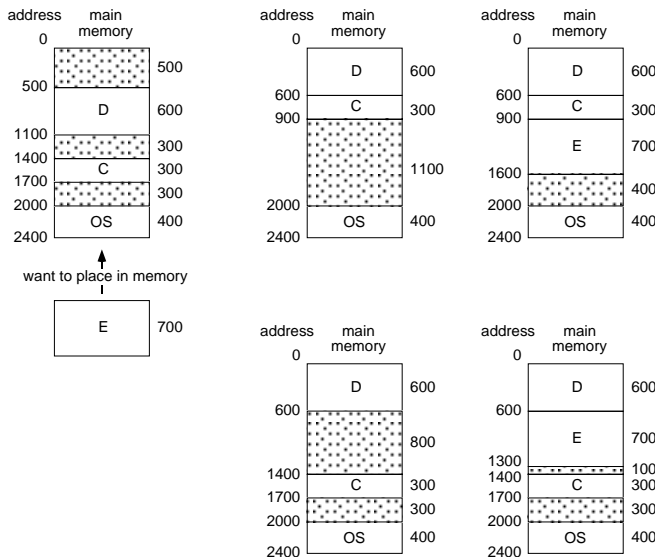
Effect of Dynamic Relocation with Dynamic Partitioning



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Compaction



- Evaluation:
 - Memory moved =
 - Space created =

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Swapping (Medium-Term Scheduling)

- If there isn't room enough in memory for all processes, some processes can be swapped out to make room
 - OS *swaps a process out* by storing its complete state to disk
 - OS can reclaim space used (not really...) by ready or blocked processes
- When process becomes active again, OS must *swap it back in* (into memory)
 - With static relocation, the process must be replaced in the same location
 - With dynamic relocation, OS can place the process in any free partition (must update the relocation and limit registers)
- Swapping and dynamic relocation make it easy to increase the size of a process and to compact memory (although slow!)

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UNIX Process Model (From Lecture 06)

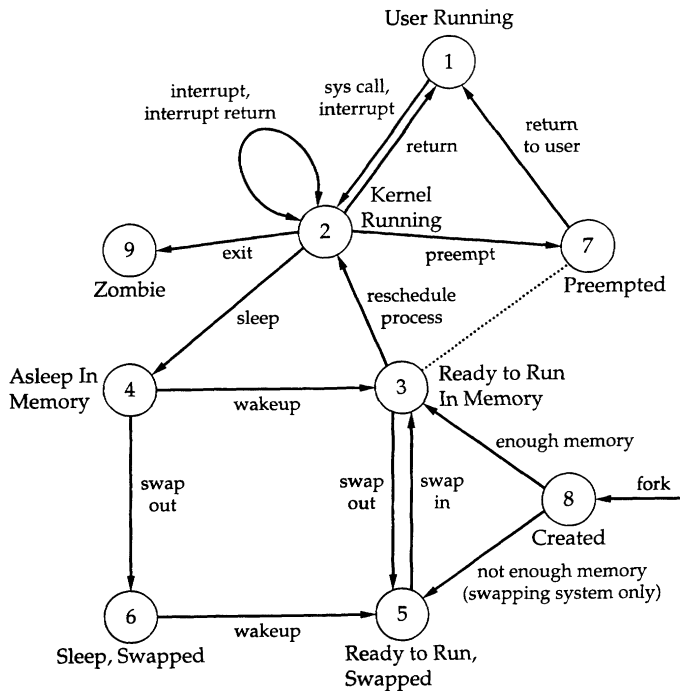


FIGURE 3.16 UNIX process state transition diagram [BACH86]

Figure from *Operating Systems*, 2nd edition, Stallings, Prentice Hall, 1995

Original diagram from *The Design of the UNIX Operating System*, M. Bach, Prentice Hall, 1986

Evaluation of Dynamic Relocation

Advantages:

- OS can easily move a process
- OS can allow processes to grow
- Hardware changes are minimal, but fairly fast and efficient
- ➔ Transparency, safety, and efficiency are all satisfied, although there is some small overhead to dynamic relocation

Disadvantages:

- Compared to static relocation, memory addressing is slower due to translation
- Memory allocation is complex (partitions, holes, fragmentation, etc.)
- If process grows, OS may have to move it
- Process limited to physical memory size
- Not possible to share code or data between processes