Virtual Memory

Chapter 8
Hardware and Control Structures

- Memory references are dynamically translated into physical addresses at run time
  - A process may be swapped in and out of main memory such that it occupies different regions
- A process may be broken up into pieces that do not need to be located contiguously in main memory
- All pieces of a process do not need to be loaded in main memory during execution
Execution of a Program

• Operating system brings into main memory a few pieces of the program
• Resident set - portion of process that is in main memory
• An interrupt is generated when an address is needed that is not in main memory
• Operating system places the process in a blocking state
Execution of a Program

• Piece of process that contains the logical address is brought into main memory
  – Operating system issues a disk I/O Read request
  – Another process is dispatched to run while the disk I/O takes place
  – An interrupt is issued when disk I/O complete which causes the operating system to place the affected process in the Ready state
Advantages of Breaking up a Process

• More processes may be maintained in main memory
  – Only load in some of the pieces of each process
  – With so many processes in main memory, it is very likely a process will be in the Ready state at any particular time

• A process may be larger than all of main memory
Types of Memory

• Real memory
  – Main memory

• Virtual memory
  – Memory on disk
  – Allows for effective multiprogramming and relieves the user of tight constraints of main memory
  – Programming convenience
Thrashing

- Swapping out a piece of a process just before that piece is needed
- The processor spends most of its time swapping pieces rather than executing user instructions
Principle of Locality

• Program and data references within a process tend to cluster
• Only a few pieces of a process will be needed over a short period of time
• Possible to make intelligent guesses about which pieces will be needed in the future
• This suggests that virtual memory may work efficiently
Support Needed for Virtual Memory

- Hardware must support paging and segmentation
- Operating system must be able to manage the movement of pages and/or segments between secondary memory and main memory
Paging

• Each process has its own page table
• Each page table entry contains the frame number of the corresponding page in main memory
• A bit is needed to indicate whether the page is in main memory or not
Paging

(a) Paging only

P : present
M: modified
Modify Bit in Page Table

- Modify bit is needed to indicate if the page has been altered since it was last loaded into main memory
- If no change has been made, the page does not have to be written to the disk when it needs to be swapped out
Figure 8.3 Address Translation in a Paging System