Lecture Notes 8

Virtual Memory

- Virtual Address Space – Logical (or Virtual) view of process memory space
- Demand Paging – Pages are loaded on demand
  - Lazy Swapper – Swap only what is needed
  - Pager – Moves pages, not entire process
  - Memory Resident – The information is currently in memory
  - Page-Fault Trap – Exception when required page is not memory resident
  - Pure Demand Paging – Only bring pages in when they are needed
  - Locality of Reference – References typically exist within a local are
  - Performance
    - Effective Access Time – $(1 - p) \times ma + p \times$ page fault time
    - Page Fault Rate – The rate in which page faults occur per instruction
- Copy-on-Write – Pages are duplicated on first write
  - Zero-fill-on-demand – Pages are initially zeroed out
  - Virtual Memory fork – Child uses suspended parents memory space
- Page Replacement
  - Over Allocating – Putting too many processes in memory
  - Replacement
    - Victim Frame – The frame that will be swapped out
    - Modify bit (Dirty bit) – Keep track if page has been modified or not
  - Frame-Allocation Algorithm – How to allocate frames
  - Page-Replacement Algorithm – Decide what pages to replace
    - Belady's anomaly – Page fault rate increases with number of frames
    - FIFO Page Replacement – First in is first to be replaced
    - LRU Page Replacement – Page that hasn't been used for longest time is replaced
    - LRU Approximation Page Replacement
      - Reference Bit – Bit is set when it is referenced
      - Additional Reference Bits Algorithm – Use of bits that shift each period
      - Second-Chance Algorithm – Give a second chance if reference bit is set
      - Enhanced Second-Chance Algorithm – Recent, Modified
    - Counting-Based Page Replacement – Count the number of accesses
      - Least Frequently Used – Replace least frequently used page
      - Most Frequently Used – Replace the most frequently used page
    - Page Buffering Algorithms – Check to see if in the free-frame pool
    - Applications and Page Replacements – Some applications like databases perform terribly under virtual memory and need their own control

- Allocation of Frames
  - Minimum Number of Frames – How many frames at a minimum should a process have?
  - Equal Allocation – Divide all frames equally among processes
  - Proportional Allocation – Allocate based upon size of process
  - Global vs. Local Replacement – Replace from all frames or just the ones the process owns
- Thrashing – High paging activity where paging exceeds execution
  - Local Replacement Algorithm (Priority Replacement Algorithm) – Only allow process to replace its own frames, don't take from other processes
  - Locality Model – Processes typically execute in a small area of the program
  - Working-Set Model – Amount needed to execute within a locality
    - Working-Set Window – The range of pages recently used
  - Page Fault Frequency – The frequency in which page faults are occurring
- Memory-Mapped Files
  - File Mapping – Maps a file into memory space
  - Named Shared-Memory Object – Map a location of memory shared between processes that is named in the system
  - Memory-Mapped I/O – I/O devices are mapped into the memory space
- Allocating Kernel Memory
  - Power-of-2 Allocator – All allocations are of power size two
  - Buddy System – Each segment is divided in half, one is further subdivided
  - Coalescing – Two buddies can be combined to form larger space
  - Slab Allocation – One or more contiguous pages in memory make up a slab, a cache is used to allocate within the slab
- Other Considerations
  - Pre-paging – Pages are brought in before they are demanded
  - Page Size – What should the page size be? (Often fixed by the hardware)
  - TLB Reach – Amount of memory accessible from TLB
  - Inverted Page Tables
  - Program Structure
  - I/O Interlock