Today

• Overview of memory
• The role of operating systems in memory management.
Program → Process

For a program to become process, and be executed on CPU, it should first be loaded from the hard disk into memory.
Execution cycle of an instruction

• CPU fetches the next instruction from memory.
• Operands of the instruction are loaded from memory and stored into registers.
• Store the output of the instruction into a register.
• Copy the result into memory.
Storage Hierarchy

- Hard Disk
- Memory
  - Cache (L1, L2, L3)
  - Registers
Memory

• A large array of words.
• Word = 4 or 8 bytes.
• One address for every word.
• Content:
  – Instructions
  – Data
Memory Management

• The operating system dictates how the memory is shared among processes.

• Basic concerns:
  – Allocation
  – Protection
  – Relocation
Allocation strategy

• Should processes have contiguous space of physical addresses in memory?
• Is memory partitioned into fixed- or variable-sized segments?
  – If variable-sized segments, which allocation algorithm is used?
    • First fit: allocate first hole that is big enough.
    • Best fit: allocate the smallest hole that is big enough.
    • Worst fit: allocate the largest hole.
Fragmentation

- External fragmentation
  - First-fit, Best fit
  - There is enough total memory space to satisfy a request but the available spaces are small and not contiguous.

- Internal fragmentation
  - Break the physical memory into fixed-sized blocks and allocate memory in units based on block size.
  - The allocated memory is slightly larger than the requested memory.
Physical VS virtual address

• Each time a process is loaded into memory may occupy different space of physical addresses.
  – It may not be contiguous.

• But the program code uses fixed virtual addresses.
  – Example: JMP 0x56789AB1 (jump to a particular program point)
  – The program is written as if it will run with an infinite contiguous memory space.
Address translation

• The CPU understands virtual addresses.
• The memory unit understands physical addresses.
• The OS and specialized hardware are responsible for translating virtual addressed into physical addresses.
• The translation mechanism gives protection.
Segmented Memory

- Allocation and protection scheme.
- Each process is contained in a single contiguous section in memory.
Segmented Memory

• The OS is responsible to load the Base and Bound registers.
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Coming up...

• Next lecture: Paging
• HW3 released today
  • Deadlock exercises can be solved
  • Due on Monday.
• Short concise answers!