Basic Memory Management

- Storage Hierarchy
- Memory Management Problems
- Fixed Partitions for Multiprogramming
- Variable Sized Partitions
- Memory Allocation Strategies

Storage Hierarchy

Cost

- $600 a chip
- $10^{-2}$ per byte
- $10^{-4}$ per byte
- $10^{-8}$ per byte

Size

- 32-64 bits
- 4-128 words
- 512-16k words

- $2^{13}$ bytes
- $2^{27}$ bytes
- $2^{30}$ bytes
- $2^{40}$ bytes
General Memory Problem

- Limited (expensive) physical resources: Main memory
  - E.g. Windows Vista recommends 1G and prefers 2G RAM
  - We want to use it as efficiently as possible

- Abundant, slower resources: Disk

Scenarios of Memory Management Problems

- Many programs, total size is less than memory size
  - Technically possible to pack them together
  - Will programs know about each other’s existence?

- One program, using lots of memory
  - Can you only keep part of the program in memory?

- Lots of programs, total size exceeds memory size
  - What programs are in memory, and how to decide?
Responsibilities of Memory Manager

- Manage memory hierarchy
  - Monitor used and free memory
  - Allocate memory to processes
  - Reclaim (De-allocate) memory
  - Swapping between main memory and disk

Mono-programming No Swapping

- Run one process at a time
  - simplest possible memory management scheme
- Memory is shared only between OS and the process.
- Three different ways to organize memory
Overlaying

Used when the process memory requirement exceeds the physical memory space

- Main Program
- Overlay Manager
- Overlay Area
- Overlay 1
- Overlay 2
- Overlay 3
- Secondary Storage

Second Storage

Used when the process memory requirement exceeds the physical memory space.

Multiprogramming with Fixed Partitions

- Divide memory into $n$ (possibly unequal) partitions.
- Problem:
  - Internal Fragmentation

Free Space
Fixed Partition Allocation

- Separate input queue for each partition
  - Requires sorting the incoming jobs and putting them into separate queues
  - Problems?

- One single input queue for all partitions.
  - Find a job for fitting in an available partition
    - Available Fit
    - Best Fit
  - Problems?
Relocation

- Correct starting address when a program should start in the memory
- Different jobs will run at different addresses
  - When a program is linked, the linker must know at what address the program will begin in memory.
- Logical addresses, Virtual addresses
  - Logical address space, range (0 to max)
- Physical addresses, Physical address space
  - range (R+0 to R+max) for base value R.
- User program never sees the real physical addresses
- Who translates virtual to physical addresses?
  - Program rewriting at loading time
  - Help from relocation registers at execution time

Relocation Register
Protection

Problem:
- How to prevent a malicious process to write or jump into other user's or OS partitions

Solutions:
- Memory protection code
- Base bounds registers

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Base Bounds Registers

- Logical Address LA
- Base Address BA
- Physical Address PA
- Base Address
- Limit Address

CPU Address
- Memory Address MA
- Fault
- MA+BA Memory

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