UNIVERSITY of WISCONSIN-MADISON
Computer Sciences Department
CS 537 A. Arpaci-Dusseau
Intro to Operating Systems Spring 2000

Memory Management

Questions answered in these notes

- How do processes share main memory?
- What are the advantages and disadvantages of static relocation?
- What are the advantages and disadvantages of dynamic relocation?
- How does the memory management interact with hardware?

Readings for this lecture

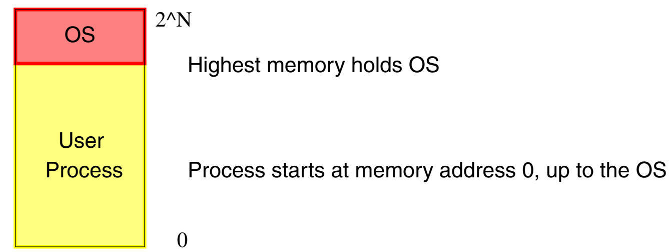
- See Homepage

Motivation

Simple uniprogramming with a single segment per process

Early batch monitors

Personal computers



Disadvantages

- Only one process can run at a time
- Process can destroy OS

Goals for Multiprogramming

Sharing

- Several processes to coexist in main memory

Transparency

- Processes not aware that memory is shared
- Run regardless of number and/or locations of processes

Protection

- Cannot corrupt OS or other processes
- Privacy: Cannot read data of other processes

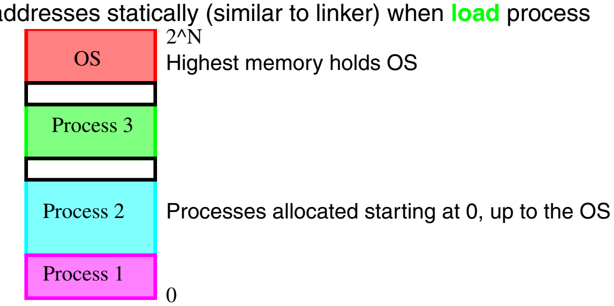
Efficiency should not be severely degraded

- Purpose of sharing is to increase efficiency
- Do not waste CPU or memory resources

Static Relocation

Transparency --> Relocation

- Processes can run anywhere in memory (can't predict in advance)
- Modify addresses statically (similar to linker) when **load** process



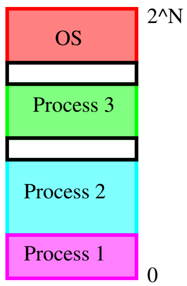
Advantages

- Allows multiple processes to run
- Requires no hardware support

Disadvantages of Static Relocation

Process allocation must be contiguous

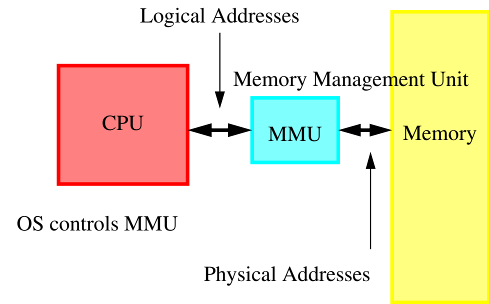
- Fragmentation: May not be able to allocate new process
  - What kind?
- Processes may not be able to increase address space
- Can't move process after it has been placed?



No protection: Destroy other processes and/or the OS

Dynamic Relocation

Change address dynamically at every reference



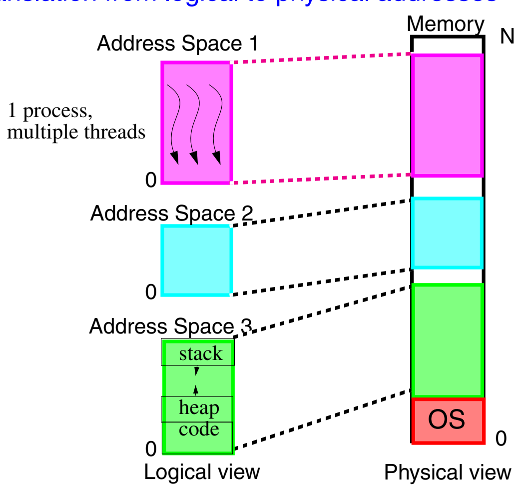
Program-generated address translated to hardware address

- Program addresses are called **logical or virtual** addresses
- Hardware addresses are called **physical or real** addresses.

Address space: View of memory for each process

Address Spaces

Translation from logical to physical addresses



Hardware Support

Two operating modes

- **Privileged (protected, kernel) mode**: When OS runs
  - When trap into OS (system calls, interrupts, errors)
  - Allows certain instructions to be executed
  - Allows OS to access all of physical memory
- **User mode:** When user processes run
  - Performs translation of logical address to physical address

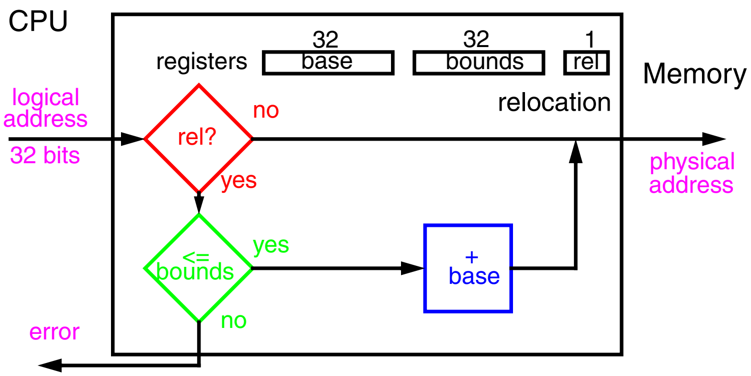
Base and Bounds registers for translation

- **Base register:** Start location for address space
- **Bounds register:** Last valid address the process may generate
  - Appears to have private memory of size equal to bounds register

Implementation

Translation on every memory access in user process

- Compare logical address to bounds register
  - If logical address is greater, then generate error
- Add base register to logical address to generate physical address



Managing Processes w/ Base and Bounds

Context-Switch

- Add base and bounds registers to PCB
- Steps during context-switch
  - Change to privileged mode
  - Save base and bounds registers of old process
  - Load base and bounds registers of new process
  - Change to user mode and jump to new process

Protection Requirement

- User process can not change base and bounds register
- User process can not change to privileged mode

What if don’t change base and bounds register when switch?

Pros and Cons of Base and Bounds

Advantages

- Supports dynamic relocation of address spaces
- Supports protection across multiple address spaces
- Cheap: Few registers and little logic
- Fast: Add and compare can be done in parallel

Disadvantages

- Each process must be allocated contiguously in real memory
  - Fragmentation: Can not allocate a new process
  - Solution: Swapping
- Must allocate memory that may not be used
- No Sharing: Cannot share limited parts of address space
  - (e.g., cannot share code with private data)