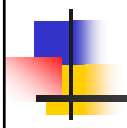


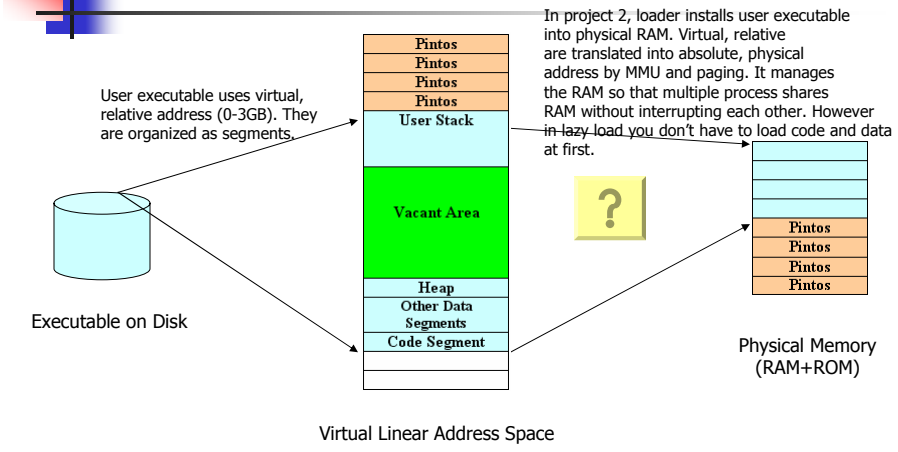
Pintos Virtual Memory Management Project (CS3204 Spring 2006 VT)

Yi Ma

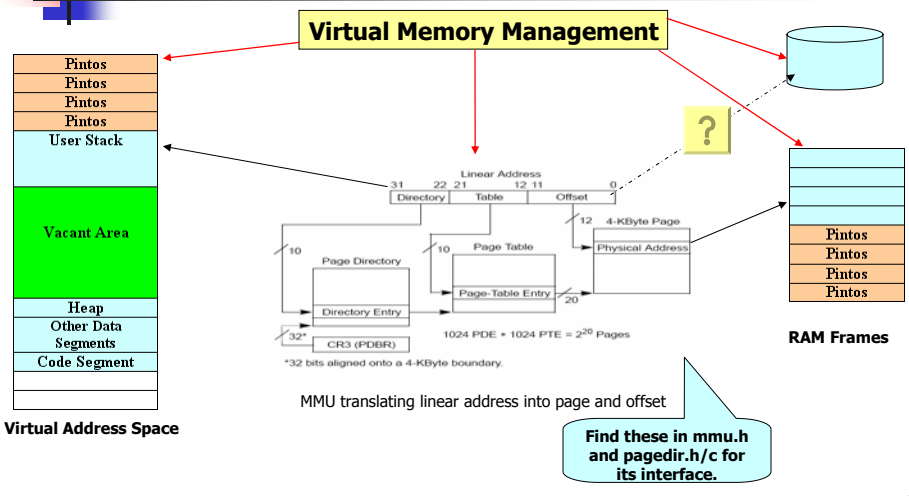
Outline

- Memory and Access
- Current Status in Pintos
- Requirements
- Suggestion

Memory



Virtual Memory Management



Current Status (after a successful project2)

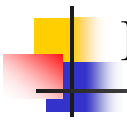
- Kernel's memory has been well handled.
- MMU—PD, PT, pagedir—address maps.
- Per-process page table (process.c).
- Preload data and code segment and stack (load, load_segment, and setup stack).
- Fixed stack and limited size and number of programs.

Requirement Overview

- Page Table Management
  - Address mapping and page fault
- Swapping
  - Choose a replacement alg., like a 1-bit clock alg. (NRU)
- Lazy loading
  - Load on demand
- Memory mapped files

Page Table Management

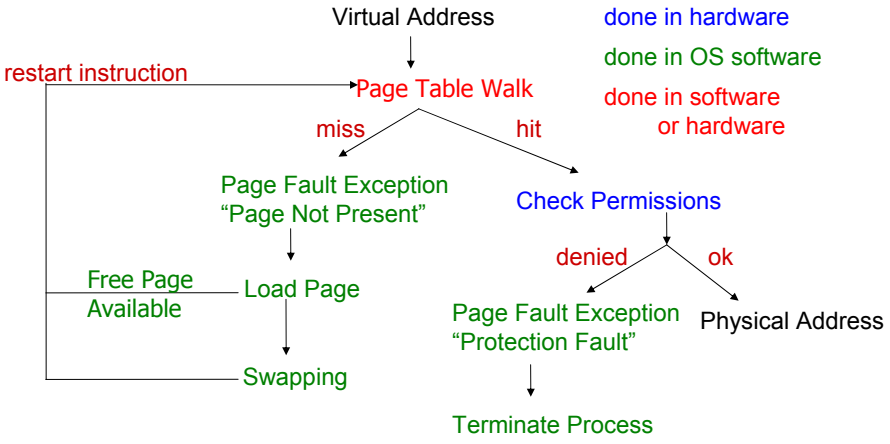
- Functionalities
  - Virtual mapped to physical
  - Locate page (RAM or SWAP)
  - Physical back to virtual (evicting)
  - This vs. PD & PT?
- Virtual vs. Physical Page
  - Install virtual page into a physical frame
  - Mapping through MMU's PD and PT
  - Keep track



Page Fault

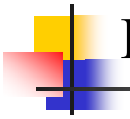
- Pre-project 3
  - Install new PD when switching
  - Setup all mapping
  - Fault on unmapped address and kill
- Post-project 3
  - Page_fault is no longer always an error
  - May have to swap in or load
- How
  - Get the faulting address
  - Find the page (file or swap)
  - Let it in (may require eviction of other page currently located in the frame.)
  - Update PTE

Address Translation Process



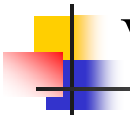
Confusing?

- Too many pages and tables?
- MMU: pde, pte
- Frame page
- Virtual page
- Swapped page
- Their cross links



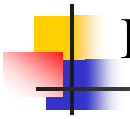
Frames

- Only user pool
- ram_pages in load.s and init.c?
- It's relation with current palloc.
- Two ways for your frame allocator.
- Where you initialize.



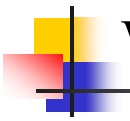
Virtual Pages

- It is the core of the virtual memory.
- Relation with user address space. (continuous or not)
- Relation with frames
- Relation with swap disk
- Relation with executable file
- Relation with MMU's PD and PT



Pages on disk

- Memory in 4KB pages
- Disk in 512B sectors
- How to organize the swap disk so that it could best conform page system
- Design data structure to implement the above design



What is the problem

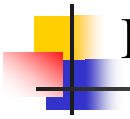
- Starting/end address of a page
- Permission of the page
- Location of the “virtual” page: RAM, SWAP, or File
- Keep track: when and what to update

Stack Growth

- First page allocated in setup_stack
- Look at memory layout: there is a vacant between heap and stack
- i386 "push" at most 32B to the stack at once
- Stack is growing downwards
- Catch the stack pointer—esp
- When: page_fault
- Limit the size of stack reasonably

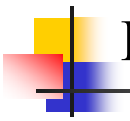
Swapping

- Loaded pages got evicted—swap out
- Evicted pages got reloaded—swap in
- Swap out on page fault and no free frame
- Swap in on page fault
- Manage Disk (track occupied or free sectors)
- No order
- Parallel



Evict a page

- Keep track where is the free frames
- Keep track who are evict-able frames
- Pick a replacement algorithm like 1-bit alg.
- Accessed/dirty bit in PTE
- Send it to swap
- Update PD & PT



Lazy Loading

- Now: load all loadable pages into RAM
- Lazy: load these only when needed
- Not swapping, use the executable file
- Keep track the location

Memory mapped files

- Keep a copy of an open file in memory
- Keep it in continuous virtual pages
- File size is not multiple of PGSIZE—stick-out, cause partial page
- Mapped IDs
- Don't map when: zero address or length, overlap, or console
- Address or pages are "virtual"
- System calls: mmap(fd, addr), munmap(ID)

On process termination

- Clean you page table
- Free your frames
- Free your SWAP
- Close all files

Other issues

- Access user data
  - In project 2, need only verify user address
  - In project 3, need handle actual access to the content of user memory
  - Need protect: check address, lock frame, read/write, and unlock.
- Synchronization
  - Allow parallelism of multiple processes
  - Page fault form multiple processes
  - E.g., A's page fault need I/O (swap, lazy load); B's page fault need not, then B should go ahead;
- Containers
  - Proper container will affect your design significantly
  - Bit map, hash, list, and array
  - How many copies?
  - Make it simple

Suggested Order

- Frame table management: your own "palloc"—modify or design new
- Switch to your allocator—modify process.c
- Virtual page table management
- Page Fault
- Stack growth, mmap, and reclamation
- Swap: accessed/dirty bits, alias, parallelism, and eviction algorithm
- http://courses.cs.vt.edu/~cs3204/spring2006/wmcquain/index.html

Other suggestions

- Go over your lecture notes
- Design before start
- Keep an eye on Dr. Back's project pages