CMSC412 Discussion

11/07/2012

(note: based on Daozheng's slides from last semester)

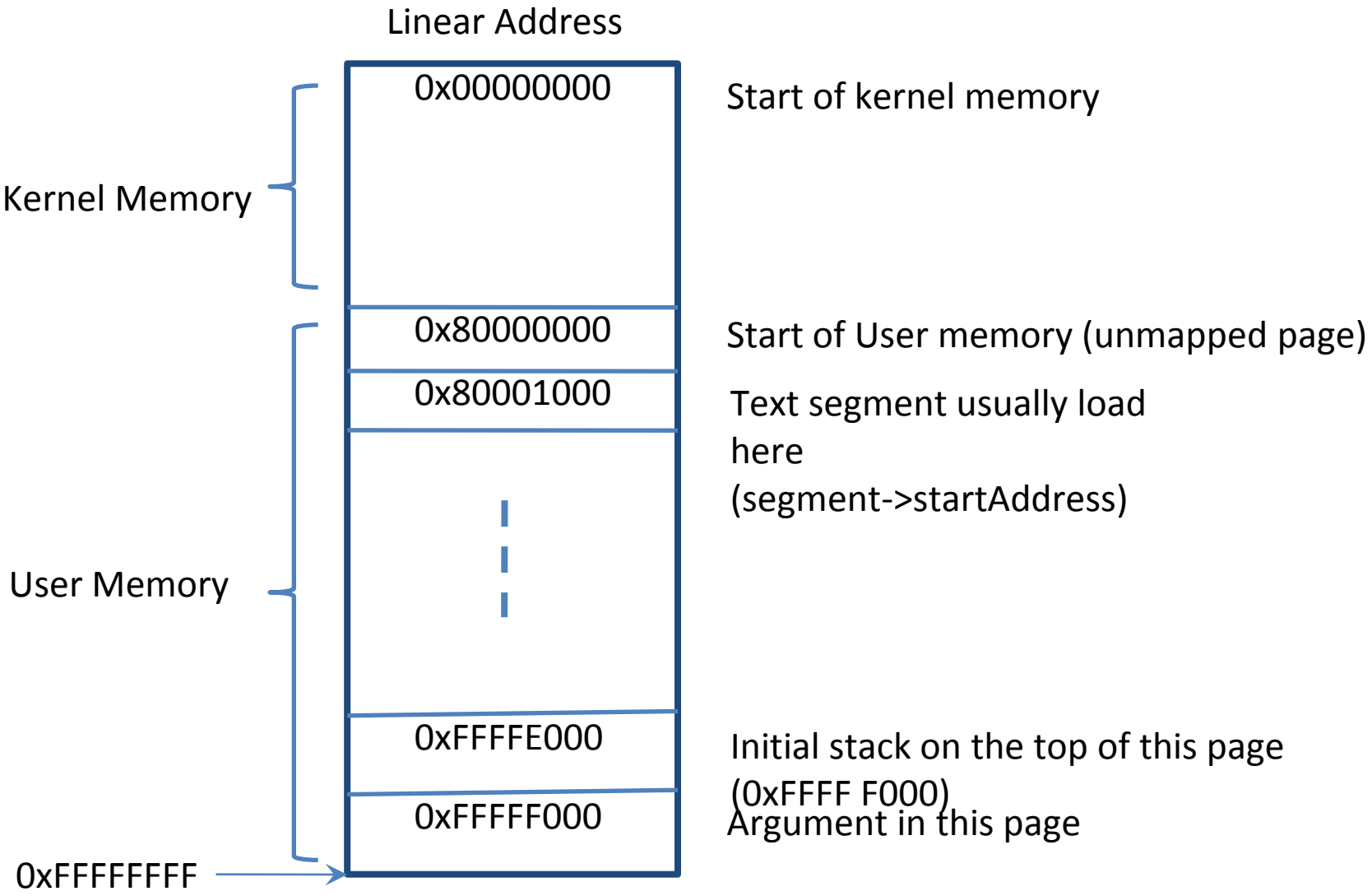
Overview

- **Project 4**
  - **using virtual memory instead of segmentation**
    - **set up for this in Part I**
  - **userseg.c -> uservm.c**
  - **demand paging and paging to disk**

Project 4

- **Part II**
  - **User Memory Mapping**
  - **Demand Paging and Paging to Disk**
  - **Recommendations:**
    - **Start the coding from copying functionality from userseg.c to uservm.c**
    - **Add pageability later**

Part II – User Memory Mapping



Copy_From_User & Copy_To_User

- bool Copy_From_User(void *destInKernel, ulong_t srcInUser, ulong_t bufSize)
- bool Copy_To_User(ulong_t destInUser, void *srcInKernel, ulong_t bufSize)

- given from/to addresses + size, copy data around
- key difference: address translation
- page may be paged out to disk (can worry about later)

Copy_From_User & Copy_To_User

- "User pages may need to be paged in from disk before being accessed."
  - Page_Fault_Handler
- "Before you touch (read or write) any data in a user page, **disable the PAGE_PAGEABLE bit**."
  - Section "Copy Data Between Kernel and User Memory"

Copy_From_User & Copy_To_User

- May want to write a claim_a_page function which does the following
  - Given a linear address in user space
    - Allocate a page for this linear address if it is not present
    - Disable the PAGE_PAGEABLE bit to make the page not able to be paged out to disk
    - Need to access user context's page directory
- May want to write an unclaim_a_page function which enables the PAGE_PAGEABLE bit

Copy_From_User & Copy_To_User (cont.)

- **"Be very careful with race conditions in reading a page from disk. Kernel code must always assume that if the struct Page for a page of memory has the PAGE_PAGEABLE bit set, IT CAN BE STOLEN AT ANY TIME. The only exception is if interrupts are disabled; because no other process can run, the page is guaranteed not to be stolen."**
  - **You may choose to do this outside the claim_a_page or the unclaim_a_page functions.**
    - **In case multiple pages need to be claimed or unclaimed, an atomic section needs to be enable only once.**
    - **Note: an atomic section is not enabled when copying the data**

Copy_From_User & Copy_To_User (cont.)

- All pages should be claimed before data copying starts.
- All pages should be unclaimed after data copying finishes.

Create_User_Context

- Linear memory space is identical for all processes now
- Base address is always 0x8000 0000
- Size is always 0x8000 0000
- User context's page directory (pageDir) is used in paging to validate and map user memory accesses to physical memory.

Destroy_User_Context

- Free stuff
- Before: free malloc'd memory
- Now: free pages

Switch_To_Address_Space

- **Spec:**
  - **"You will also need to add code to switch the PDBR (cr3) register as part of a context switch. For this, in Switch_To_Address_Space you should add a call to Set_PDBR (provided for you in lowlevel.asm), after you load the LDT. You will use the pageDir field in the User_Context structure that will store the address of the process's page directory."**

Read the Source!

Load_User_Program Overview

- Find maximum virtual address
- Determine size for argument block
- Determine size needed for memory block (to run process)
- Create User_Context(size)
- Load segment data into memory
- Format argument block
- Fill in code entry point
- Fill in addresses of argument block and stack

Load_User_Program Overview

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Load_User_Program Overview

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- **Create User_Context**~~(size)~~
- **Load segment data into memory**
- **Format argument block**
- **Fill in code entry point**
- **Fill in addresses of argument block and stack**

Load_User_Program Overview

- Determine size for argument block
- Create User_Context
  - also need to initialize pageDir
- Load segment data into memory
  - bit more complicated since not malloc'd
  - and now everything is at specific locations
- Format argument block
  - again, everything is at specific location
- Fill in code entry point
- Fill in addresses of argument block and stack
  - again, specific locations (Note: "userContext stuff" is in user (logical) addresses

Load_User_Program

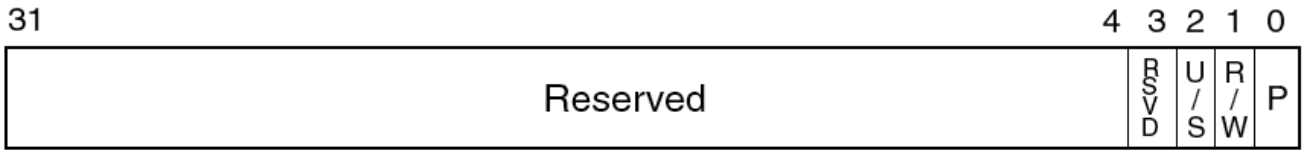
- Allocate page directory for a user process (Alloc_Page)
  - userContext->pageDir
    - Contain entries to address the kernel memory
      - Copy entries value of the bottom half of the kernel page directory (0-2GB for kernel space)
- Set the PDBR to be the newly allocate page directory (Why?)
- Allocate pages for segment data and copy values (Alloc_Pageable_Page)
  - Is it similar to what Copy_To_User is doing?
  - Claim all pages for the segment data, copy the data, and then unclaim all pages (claim_a_page & unclaim_a_page)

Load_User_Program (cont.)

- Allocate the page for argument block and stack and format argument block (Alloc_Pageable_Page)
  - Claim the page argument block, format the block, unclaim the page (claim_a_page & unclaim_a_page)
  - Which page to claim? (figure on slide 4)
- Allocate the initial page for the stack
- Update argBlockAddr and stackPointerAddr
- Set the PDBR back to be the original page directory (Why?)

Page Fault Error Codes

Interrupt 14—Page-Fault Exception (#PF) (Continued)



P	0	The fault was caused by a non-present page.
	1	The fault was caused by a page-level protection violation.
W/R	0	The access causing the fault was a read.
	1	The access causing the fault was a write.
U/S	0	The access causing the fault originated when the processor was executing in supervisor mode.
	1	The access causing the fault originated when the processor was executing in user mode.
RSVD	0	The fault was not caused by reserved bit violation.
	1	The fault was caused by reserved bits set to 1 in a page directory.

Figure 5-7. Page-Fault Error Code

Part II – Demand Paging

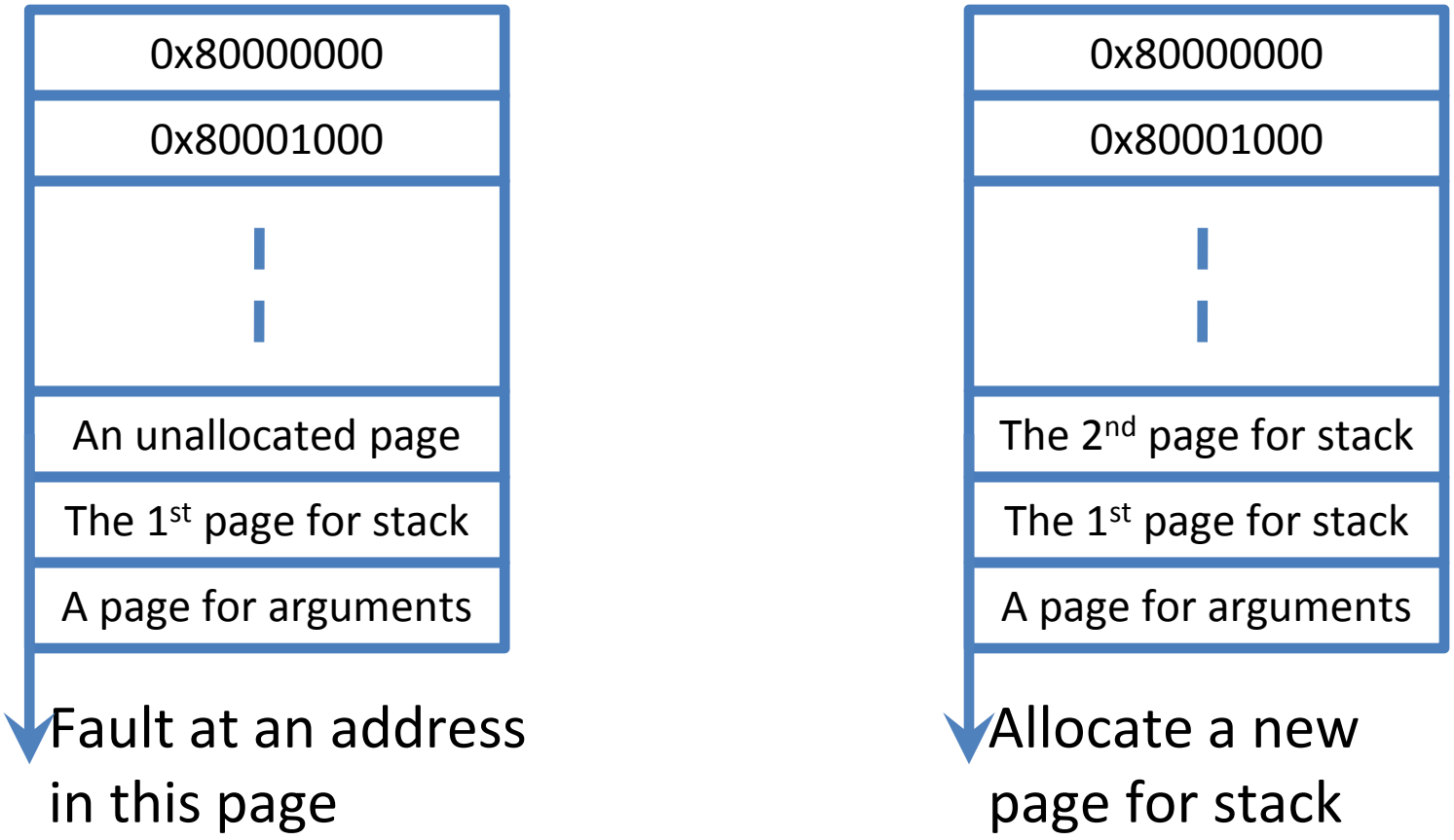
- Two valid fault conditions
  - The fault is within one page of current stack limit
  - The page is on disk
- Otherwise
  - Process termination
- Test: use rec.c to trigger a fault (memory pressure by stack expansion)

Within One Page of Current Stack Limit

- May want to create a new stack limit field
- Initialize it to be proper value in Load_User_Program
- Detect the within-one-page condition in Page_Fault_Handler and allocate the new stack page
- Update this field accordingly

Within One Page of Current Stack Limit

User Memory



Pages are on Disk

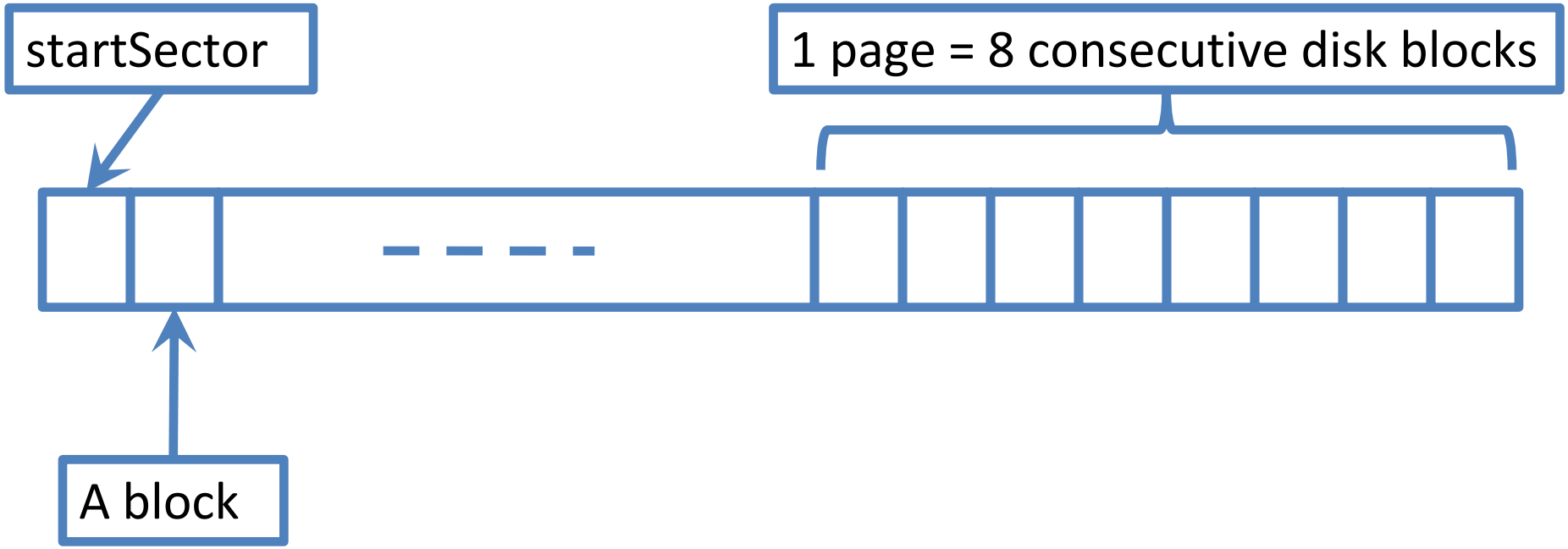
- Condition to check: kernelInfo == KINFO_PAGE_ON_DISK
- Allocate a new page (Alloc_Pageable_Page)
- Read the contents of the indicated block of space in the paging file into the allocated page (Read_From_Paging_File)
- Update the relevant page table entry
- Free the page-sized chunk of disk space in the paging file (Free_Space_On_Paging_File)

Paging to Disk

- Allocate_Pageable_Page
  - has codes to page out a page
  - Find_Space_On_Paging_File & Write_To_Paging_File
- Find your own way to manage paging file.
  - Write Init_Paging to initialize paging file structure
    - Call it in main.c (which location?)
  - Paging_Device (Get_Paging_Device)
    - The block device for paging file, the 1st disk block number, the number of disk blocks
  - To read and write the paging files
    - Block_Read and Block_Write
    - Initial blockNum for a page
      - [the 1st block number] + 8*pageTable->pageBaseAddr
    - Need to ensure a page cannot be stolen (why?)

Paging files

- **How many pages are on disk?**
- **Disk read and write is block by block**



Pseudo-LRU

- Optional implementation
- LRU in theory: in textbook (somewhere)
- http://en.wikipedia.org/wiki/Page_replacement_algorithm