Lab 3 Details

CSE 451 22sp

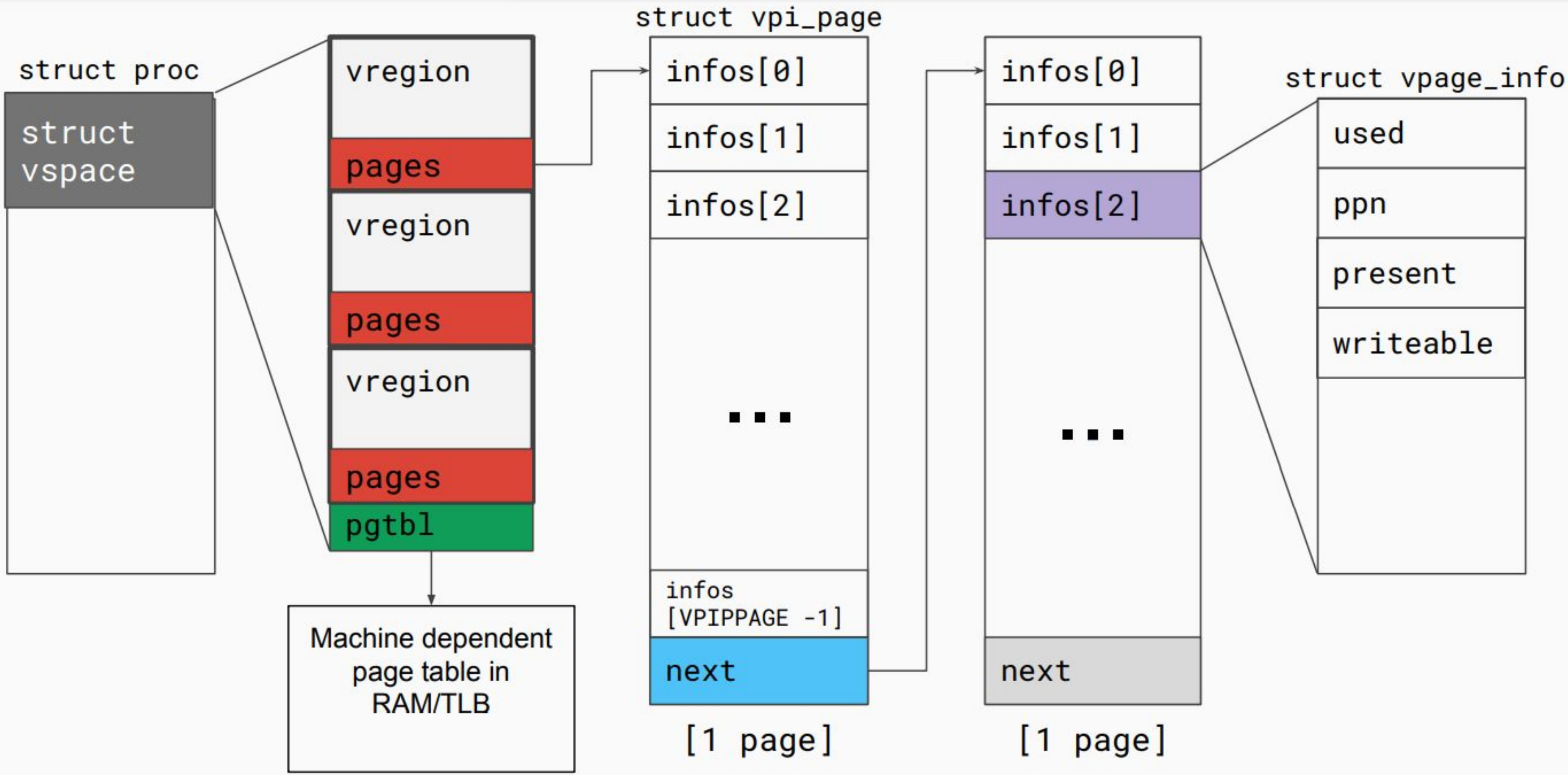
Admin

- Lab 3 due 5/12
    - Design doc feedbacks should be out next week (hopefully)

Today’s Agenda

- More detail on vspace and vspace functions
- Some discussion questions on lab 3
- Hopefully, some time at the end for open questions

vspace Visual Diagram



vregions vs Page Tables

- Both have virtual to physical address mappings
- **vspace.pgtbl**
  - Used by hardware to translate virtual addresses to physical addresses
  - **CR3** register holds the top level page table (i.e. **vspace.pgtbl**)
  - TLB caches virtual -> physical mappings
- **vspace.regions**
  - Portable *architecture independent* software representation of the address space
  - Used by kernel to track/update mappings without affecting hardware page table lookups
  - May be incomplete at times (e.g. mappings in exec())
- How do we update the page table to reflect the vspace regions?

vspaceinvalidate(vs)

- “Transforms a vspace into the architecture dependent page table”
  - I.e. virtual mappings in `vs.regions` are reflected in `vs.pgtbl`
  - Git analogy: commit vspace changes to the page table
- Call when you’ve changed a mapping in `vs`.

Pop Quiz: When will you be calling `vspaceinvalidate` in Lab 3?

vspaceinstall(p)

- "Installs the page table into the page table register"
  - I.e. CR3 = `vs.pgtbl`
  - In x86, this flushes the TLB!
  - Git analogy: pushes your committed changes to the TLB/CR3
- If there were changes in the vspace, call after invalidating

Pop Quiz: When will you be calling `vspaceinstall` in Lab3? Can you ever get away without calling `vspaceinstall`?

Handling Page Faults in x86-64

- CR2 register holds the faulting linear address (but since virtual paging is turned on, this is the virtual address)
  - How do you read or load a control register?
  - (look in trap.c in the default case)
- tf->err holds the exception error code
  - You can use this to determine the type of fault

- More info: https://wiki.osdev.org/Exceptions#Page_Fault

More on Error codes

- rcr2() returns address attempted to be accessed on page fault
- Last 3 bits of tf->err
  - B2 is set if fault occurred in user mode
  - B1 is set if fault occurred on a write
  - B0 is set if it was a page protection issue. This is not set if the page is not present
- What will the error code be if the page fault was from touching the stack region of memory?
- From touching a copy-on-write page?

Copy-on-write Fork FAQ

- How do we keep track of physical pages and refcounts?
  - Coremap!
- What vspace functions need to be modified to support COW fork, and how?
  - vspacecopy()
- What do the fields of a page (struct `vpage_info`) need to be after a copy-on-write fork?
      - fields to consider: used, ppn, present, writeable
- What happens to a page that is already read-only before COW fork?

More COW

- What needs to be changed in the `core_map_entry` to support COW fork?
    - Ref count, (and a lock for the core map)

- Can the kernel cause a copy-on-write page fault?
    - Sure! E.g. accessing the user buffer during a read() system call
- Synchronization in modifying the **vspace** in page fault in COW fork?
        - Not needed -- current process has exclusive access to its own vspace (no multithreading)
        - **However, the ref count on the physical page could be concurrently modified**
- What can happen if a copy-on-write fork is not synchronized?

Helper Macros and Functions

P2V: physical addr to virtual addr

V2P: virtual addr to physical addr

PGNUM: physical addr to page number

va2vpage_info: virtual addr to vpi_info

Any questions?