Section 5: Intro to Lab 3

CSE 451 18WI

Announcements

- `racetest` and `pkilltest` will be run as part of lab 3 grading
- **user** - New GDB command for stepping through user programs in GDB
    - E.g., `user ls` will let you step through `ls.c` in GDB when exec-ed!
- Multirun test script on Discussion Board
    - Use it! It should help find any concurrency issues
- +1 late days. Total: 5.
- Please fix `read()` to return 0 (EOF) when a pipe's write end is closed and there are no bytes left.

Part 1: Create a User-Level Heap

- User level programs call **`malloc`** and **`free`** to manage heap memory
    - Free list keeps track of free blocks in heap
    - **`malloc`** - Returns a free block of memory in the heap
    - **`free`**- Frees a block of memory in the heap
    - **`calloc`**- Like malloc, but zeros out memory first
    - We have provided malloc and free for you in *user/umalloc.c*
        - Or you can copy your implementation from 351 (just kidding, please don't)
- But what happens when there is no space left in the heap for **`malloc`** to return???

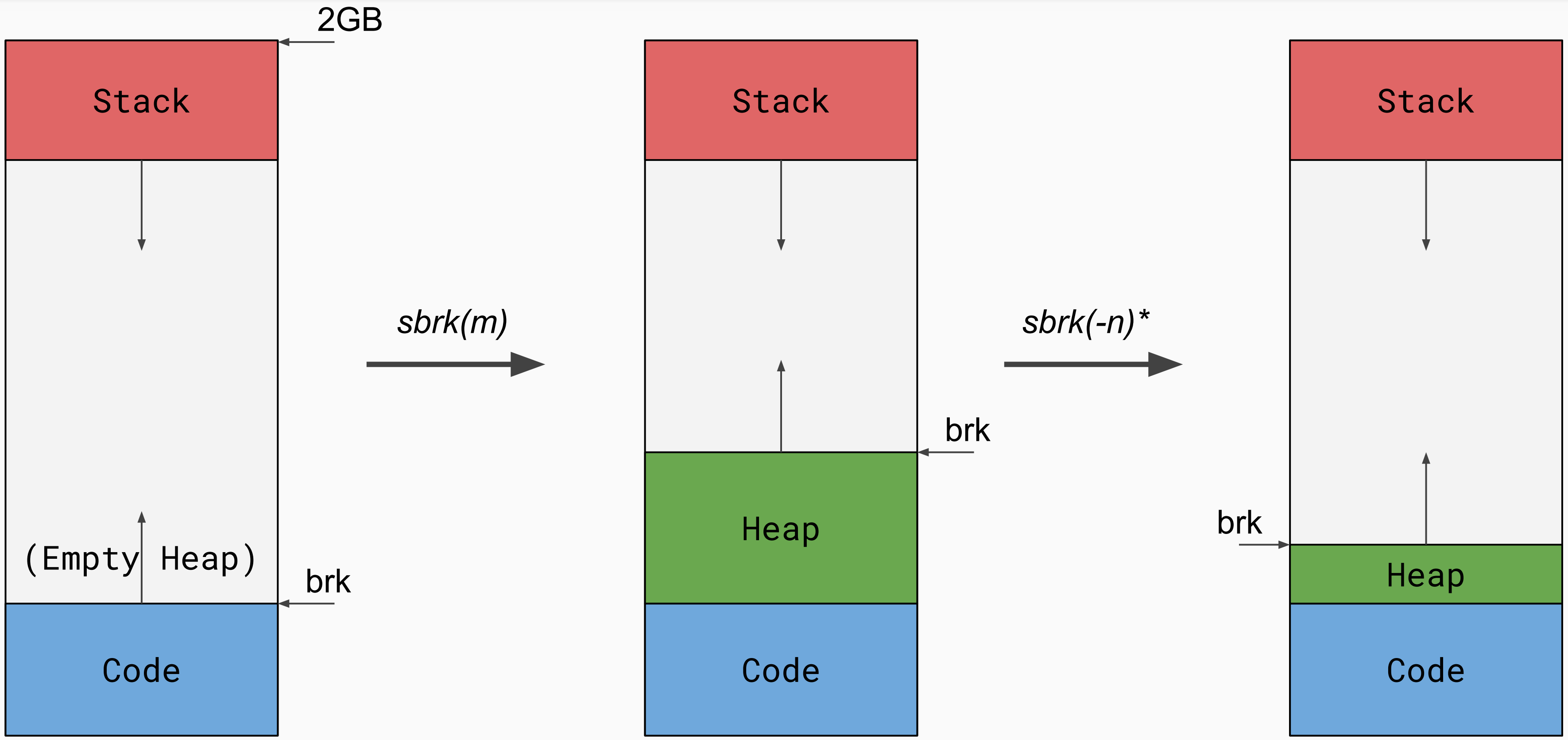
sbrk (set program break)

Hey Kernel, give me more heap space!

sbrk(n)

- Increments the Heap by *n* bytes, resetting the *program break*
    - Program break determines the max space that can be allocated to the data segment, where the heap lies
- Returns -1 if there is not enough space
- Otherwise, returns the previous heap limit (i.e. the *old* top of the heap)

sbrk(n) Visual Diagram



* Note that you don't need to support negative increments for Lab 3!

shell

All I do is fork fork fork no matter what!

Part 2: Starting Shell

- You'll be adding init (**`user/init.c`**) process that forks off a shell
- Shell will spawn other programs
- Try piping in the shell
  - E.g. **`ls | wc`**

Stack On Demand

(dynamic stack growth)

User: `sub $0x30, %rsp`

Kernel: Stack Attack Alert! Stack Attack Alert!

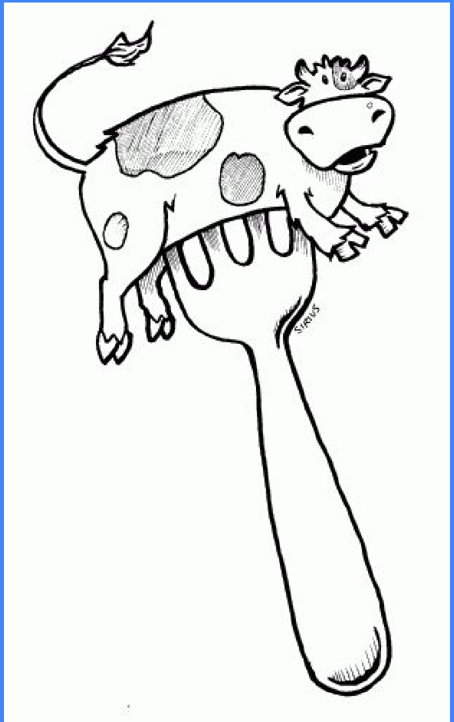
Part 3: On-Demand Stack Growth

- `exec()` fixed the stack size but we want to support stack growth
- What exception occurs when a user reads/writes to an unallocated part of the stack?
- What limits are there?

COW Fork

(copy-on-write)

Stop! Wait a minute! I might not even write there!



Part 4: Copy-on-write Fork

- What are some inefficiencies with our lab 2 fork implementation?

Discuss amongst yourselves.

Hint: Look at the comment for **vspacecopy**.

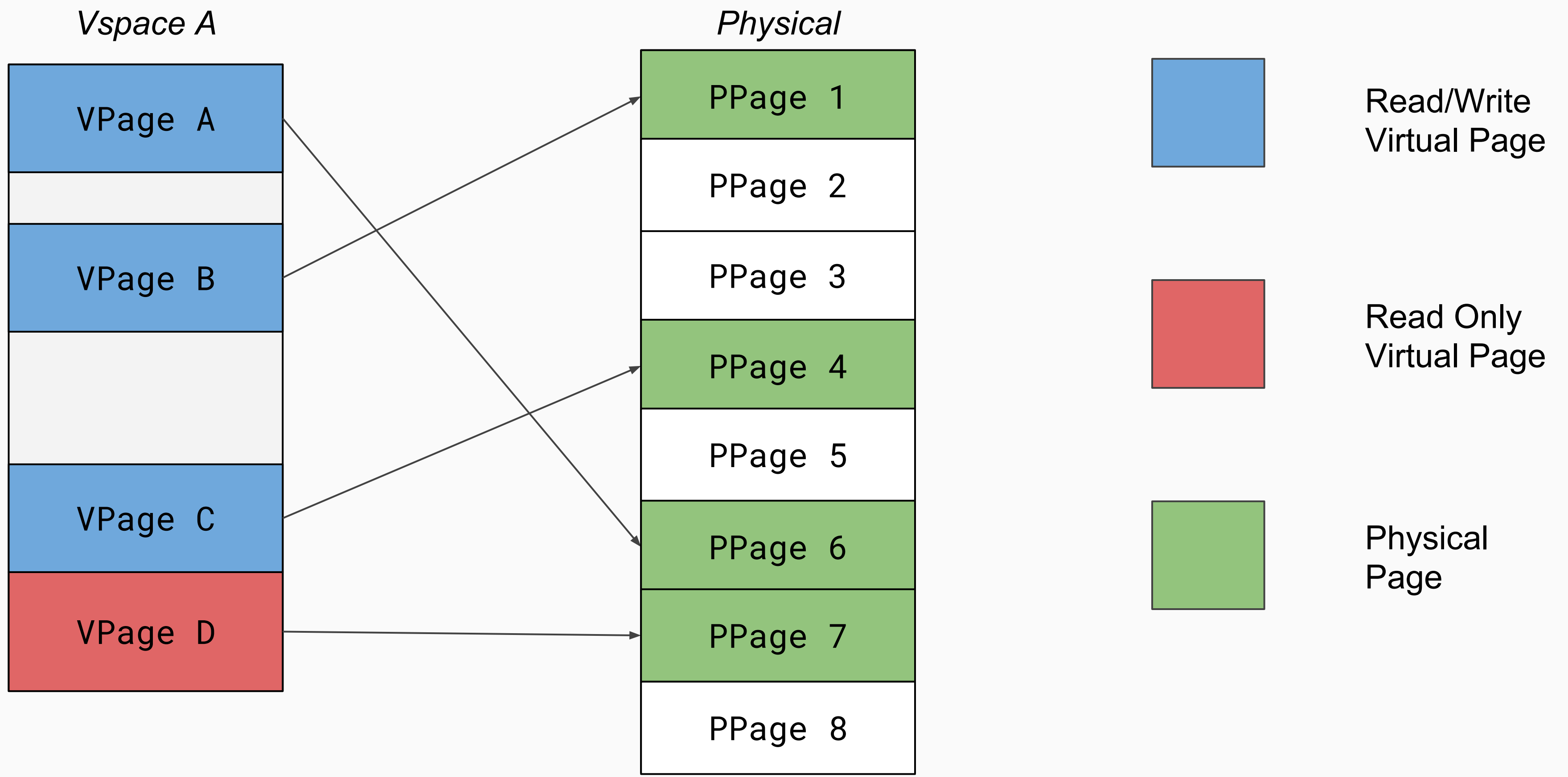
Part 4: Copy-on-write Fork

In lab2's fork, the mapped pages for the same data are **disjoint**! As a consequence:

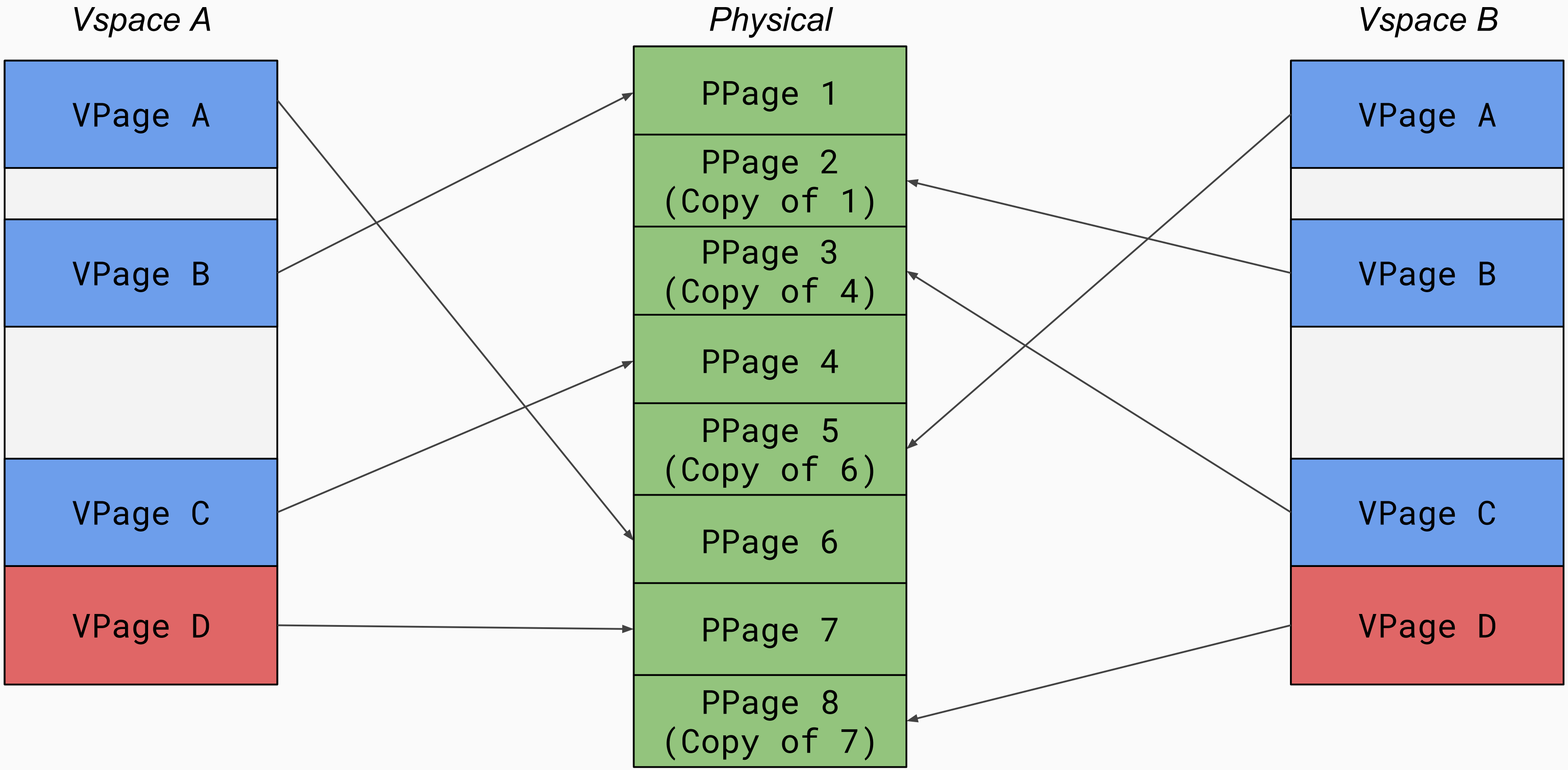
- Child and Parent use multiple physical pages for the **same unchanging code**!
- If child does **`exec()`**, we throw away the vspace copy created in **`fork()`**!

How might we address these issues? What are some cases we'll have to design for?

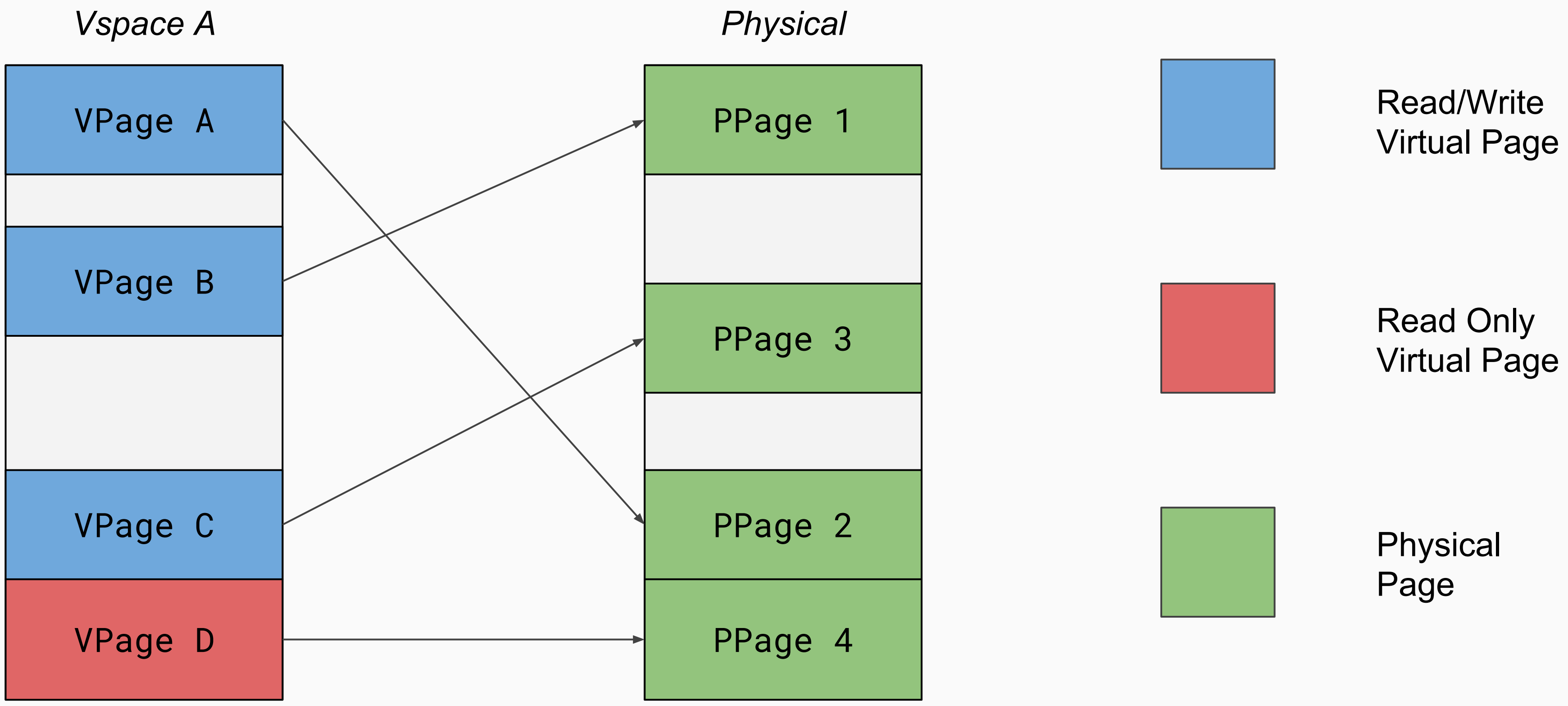
Lab 2 Fork Visual Diagram before fork()



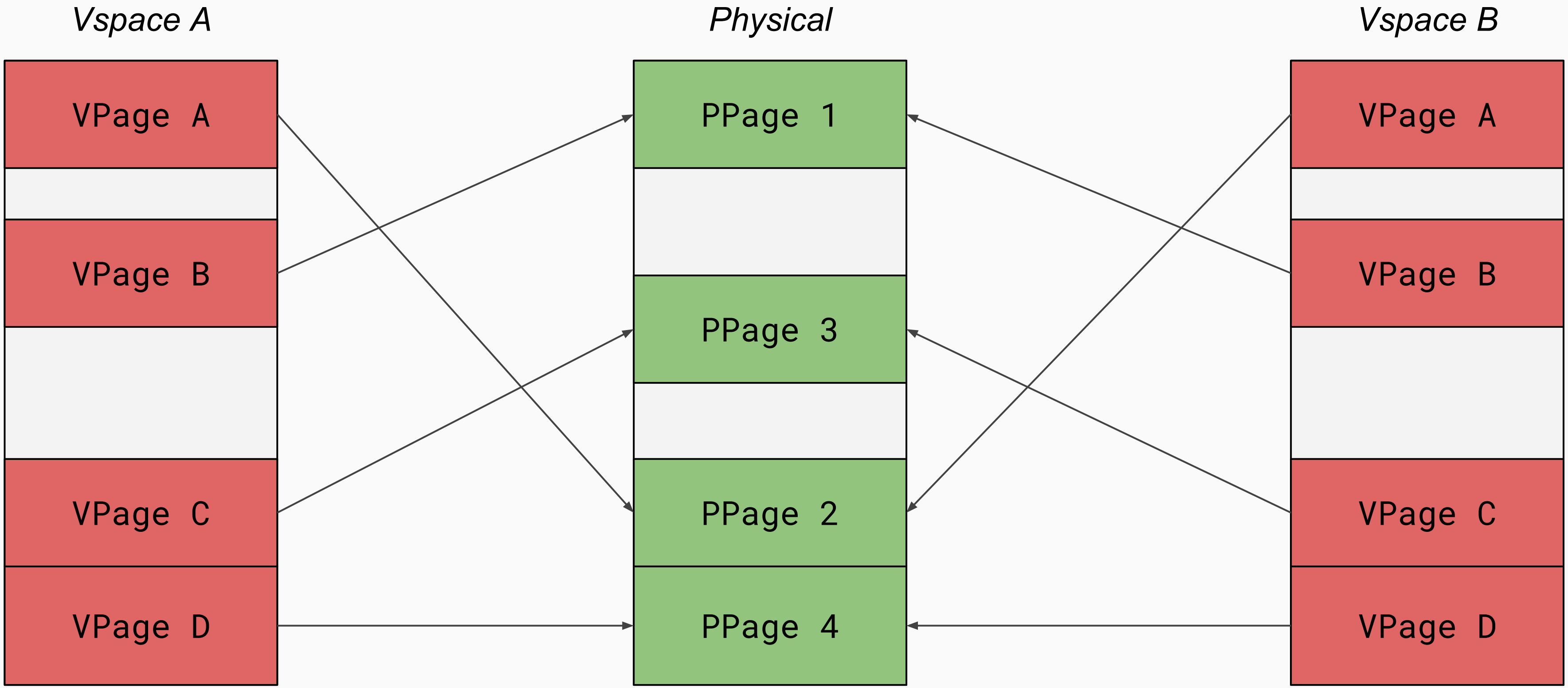
Lab 2 Fork Visual Diagram after fork()



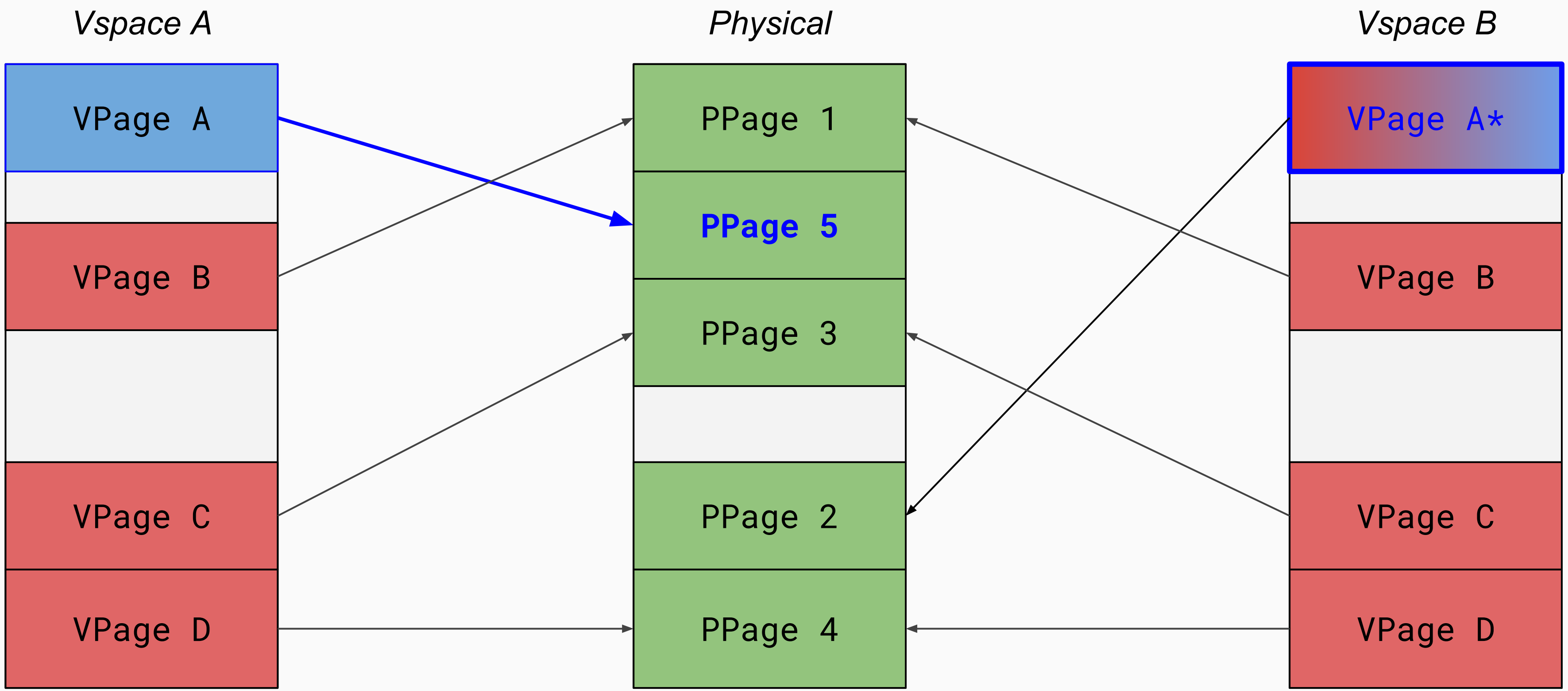
COW Fork Visual Diagram before a copy-on-write fork()



COW Fork Visual Diagram after a copy-on-write fork()



COW Fork Visual Diagram once Process A writes to VPage A



* Note: If Vspace B is the last reference, it makes sense to make its mapping writeable too, but you might not want to do that if there are multiple read-only mappings from other vspaces.

Part 4: Copy-on-write Fork

- Food For Thought
  - How to distinguish a copy-on-write page from a normal read-only page?
  - What happens when parent and child try to concurrently write to the same page?
  - Could the same physical page be mapped in more than two address spaces?
  - How to resolve the case when one process writes to a COW page?

Design Doc Feedback

- How did your implementation differ from your design?
- Thoughts and feedback?