Virtual Memory

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[Weatherspoon, Bala, Bracy, McKee, and Sirer]

Where are we now and where are we going?

- How many programs do you run at once?

- a) 1
- b) 2
- c) 3-5
- d) 6-10
- e) 11+

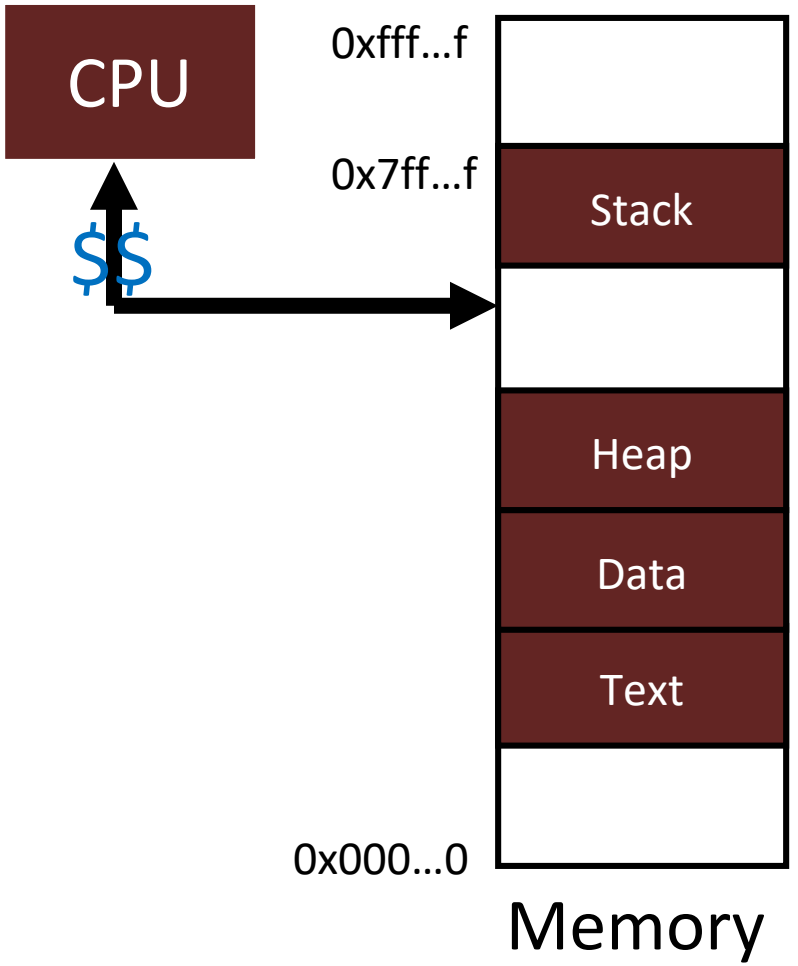
Big Picture: Multiple Processes

How to run multiple processes?

- *Time-multiplex* a single CPU core (multi-tasking)
  - Web browser, skype, office, … all must co-exist
- Many cores per processor (multi-core) or many processors (multi-processor)
  - Multiple programs run *simultaneously*

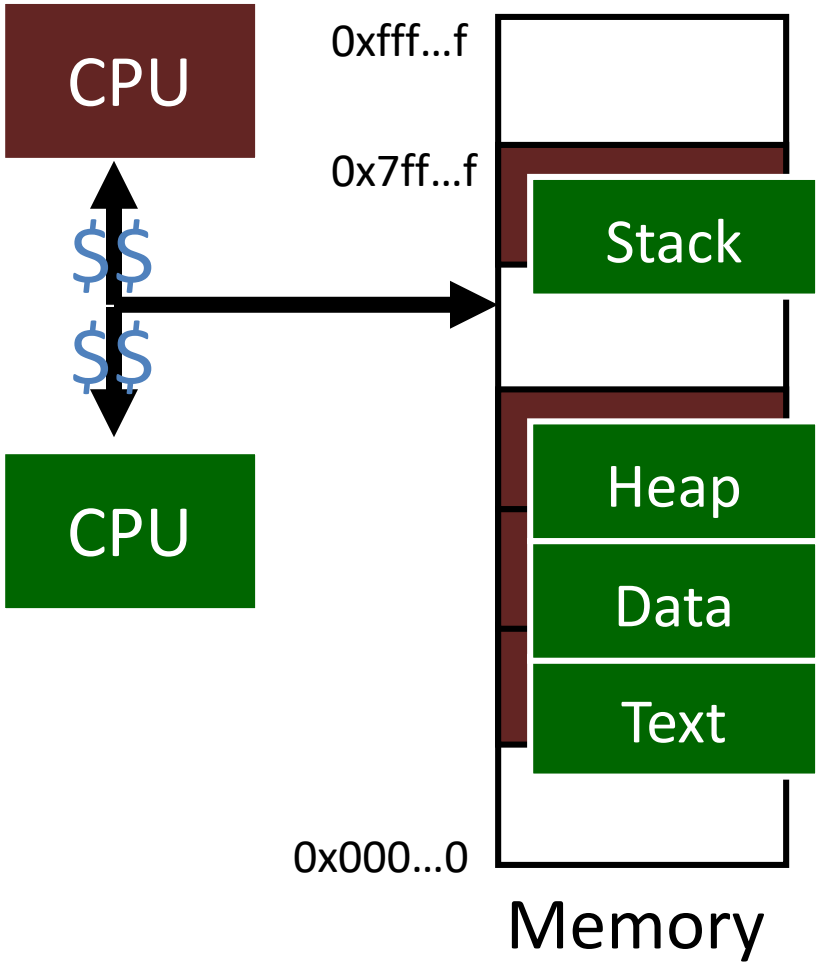
Processor & Memory

- CPU address/data bus...
- … routed through caches
- … to main memory
  - Simple, fast, but…



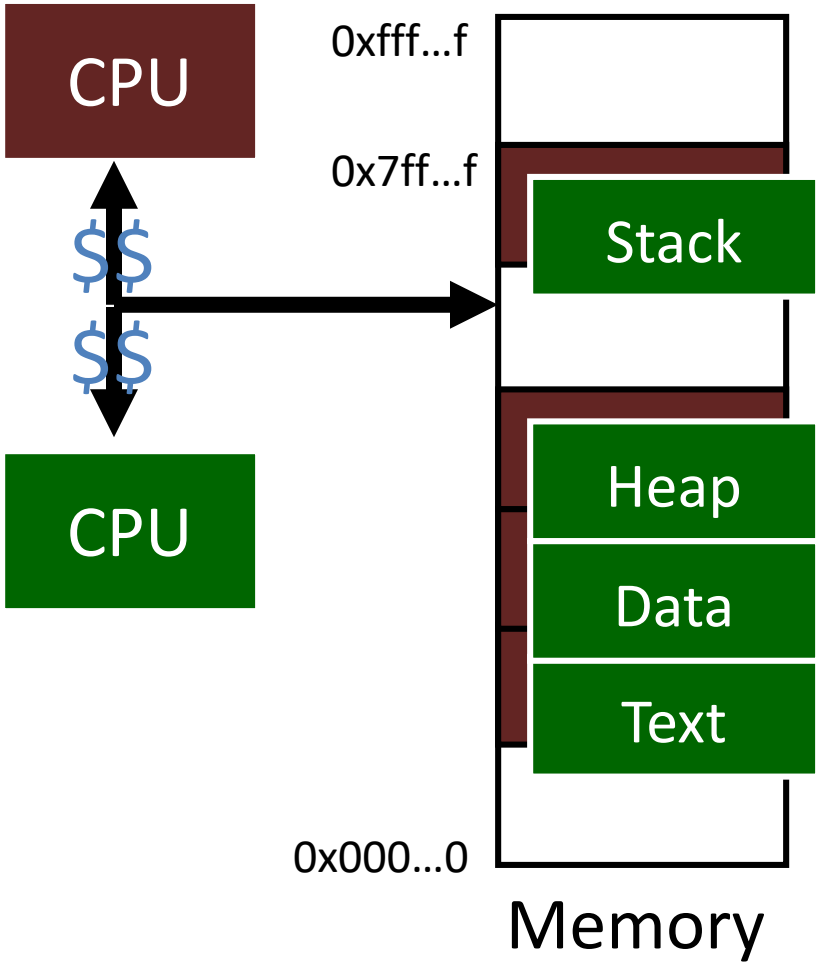
Multiple Processes

- Q: What happens when another program is executed concurrently on another processor?

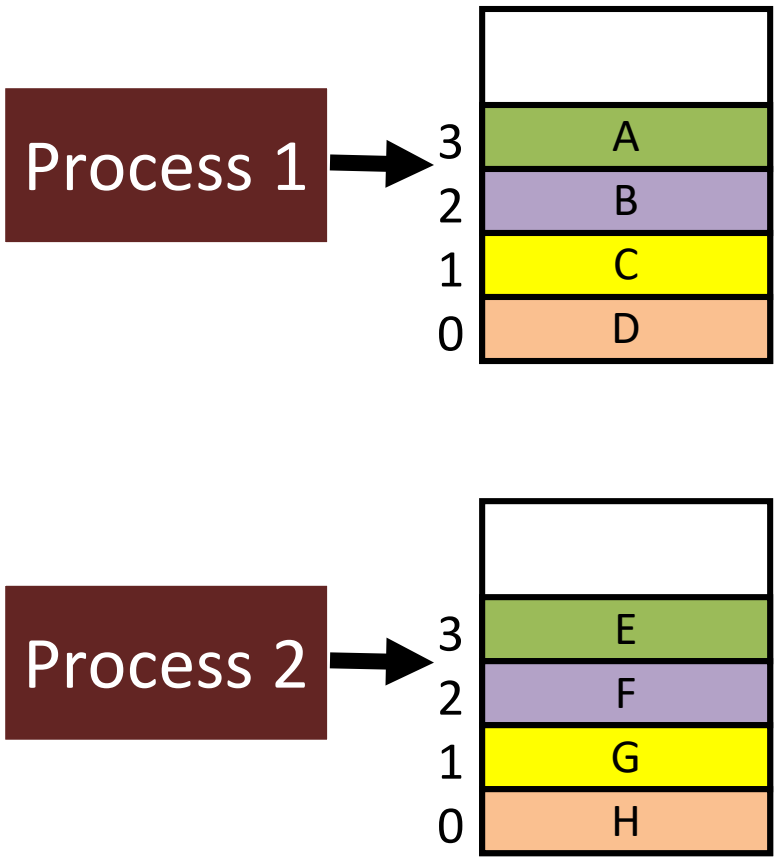


Multiple Processes

- Q: Can we relocate second program?

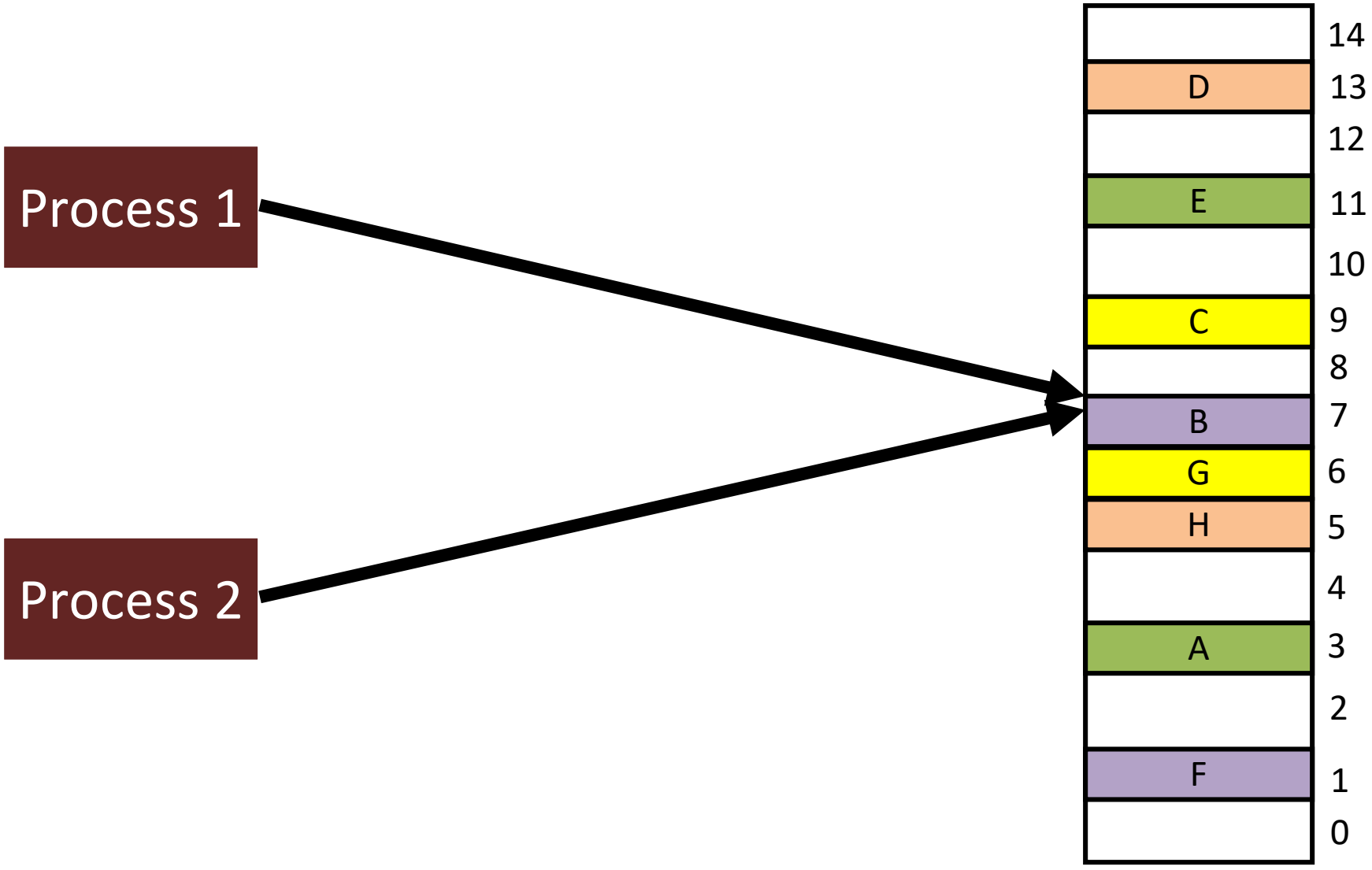


Big Picture: (Virtual) Memory



Give each process an illusion that it has exclusive access to entire main memory

But In Reality…



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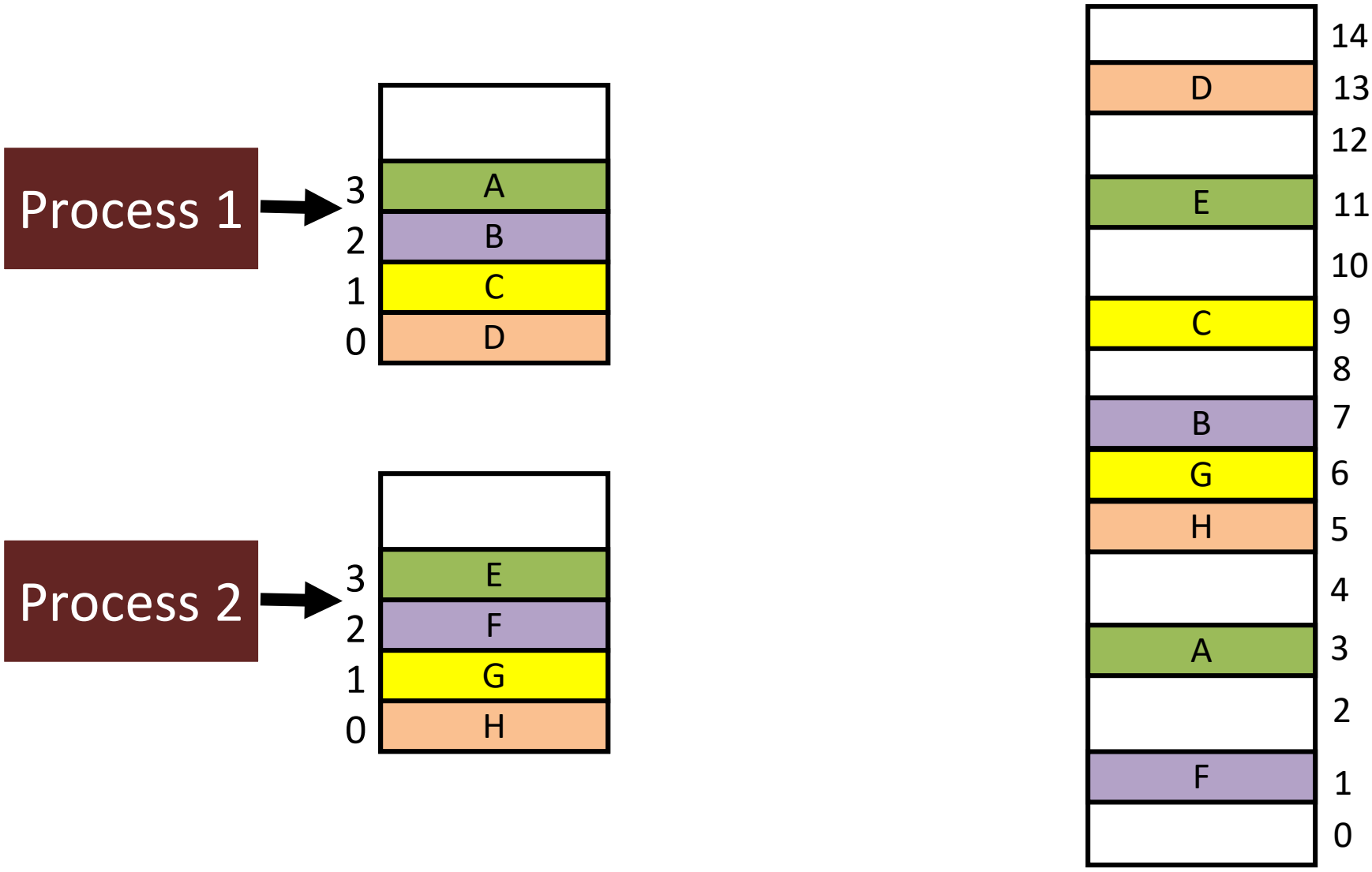

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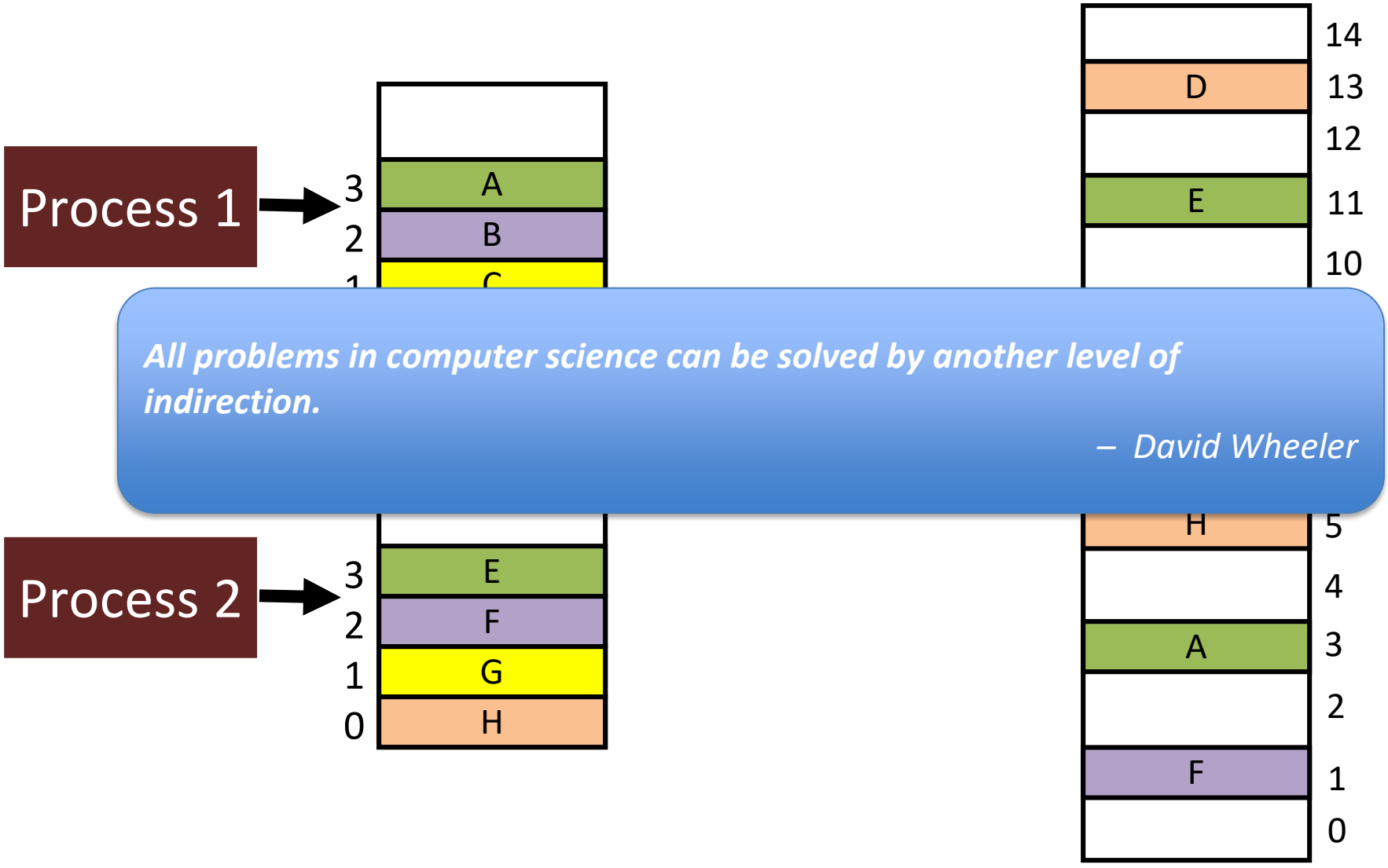

All problems in computer science can be solved by another level of indirection.

– David Wheeler

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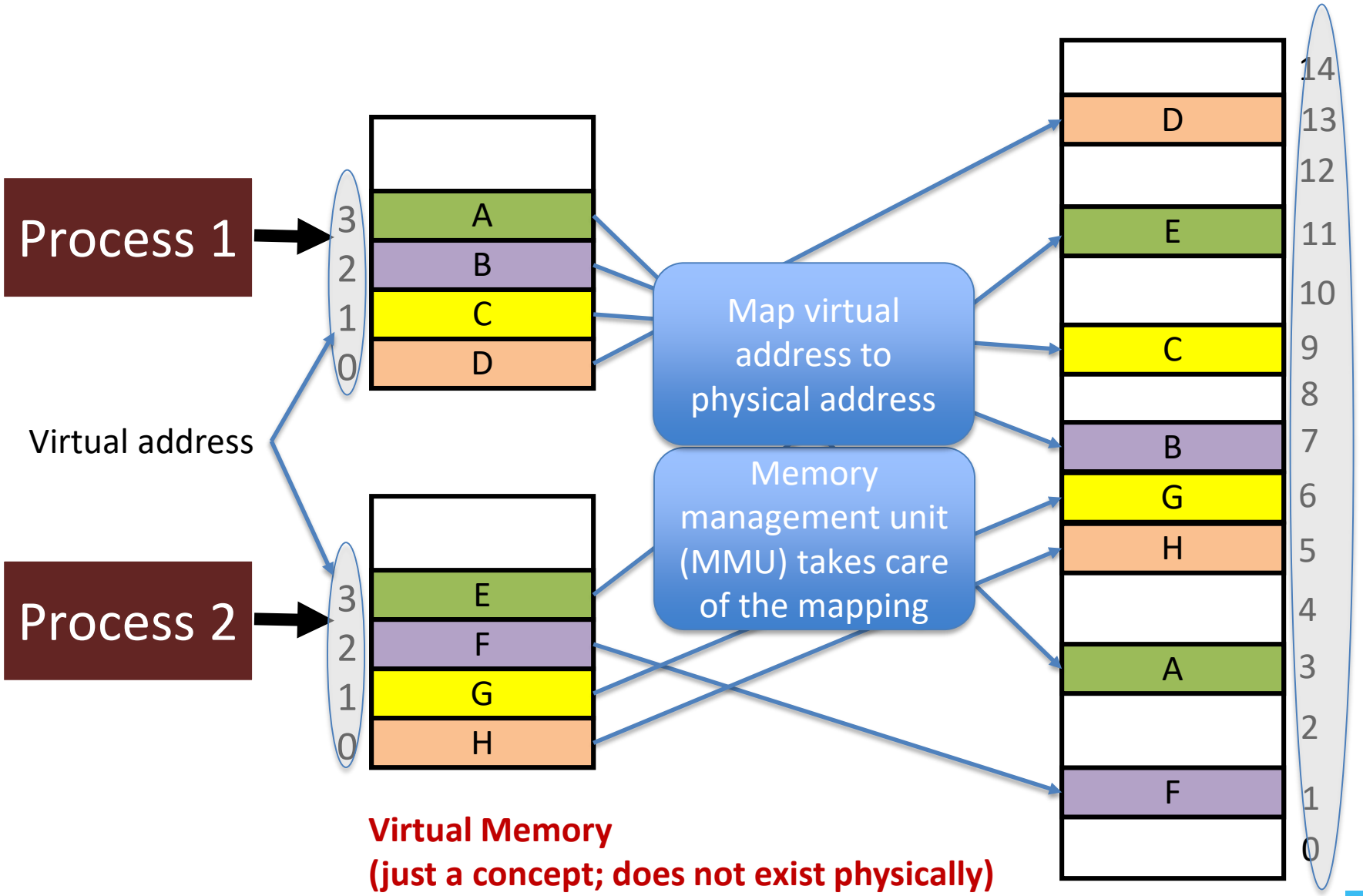

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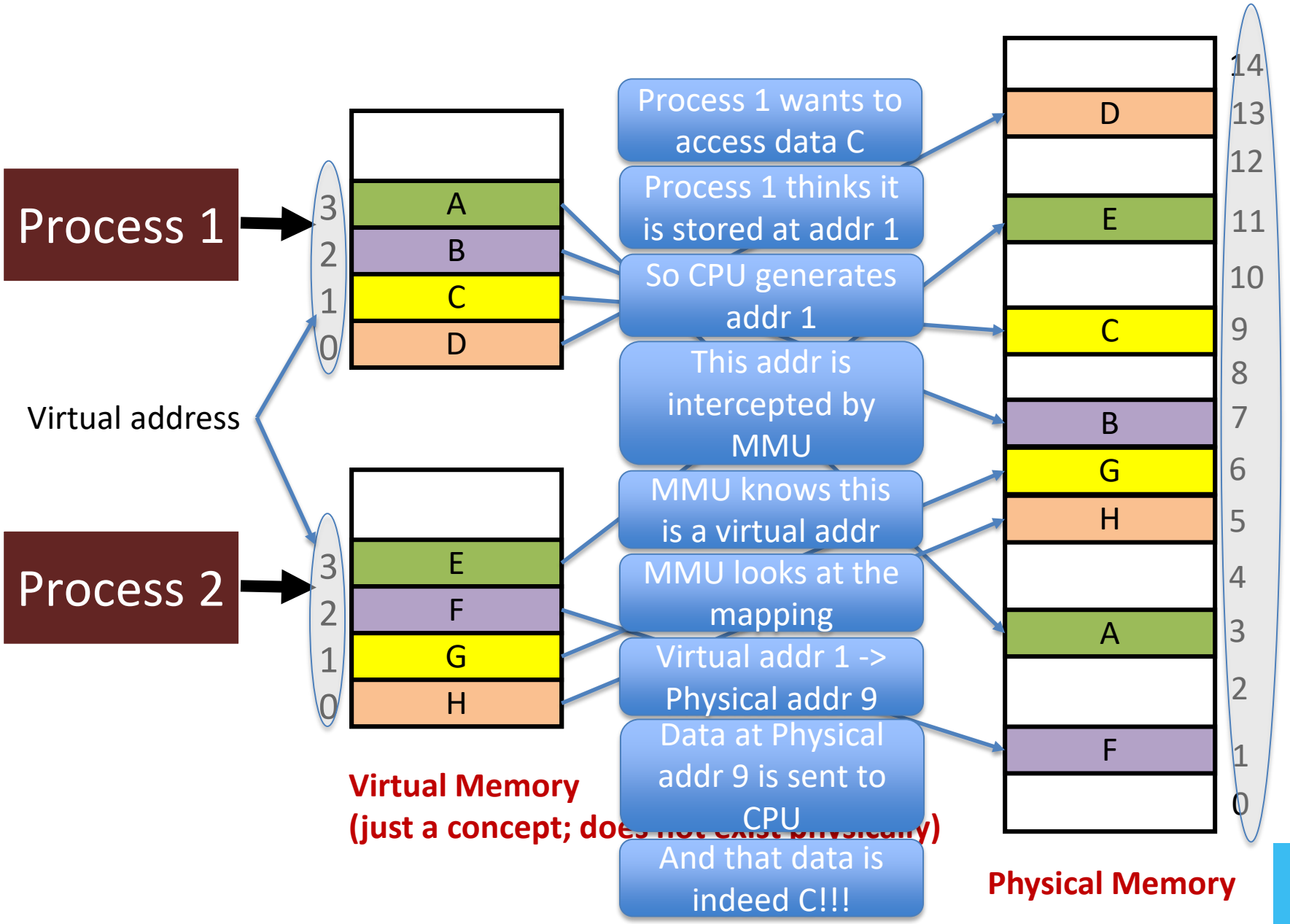

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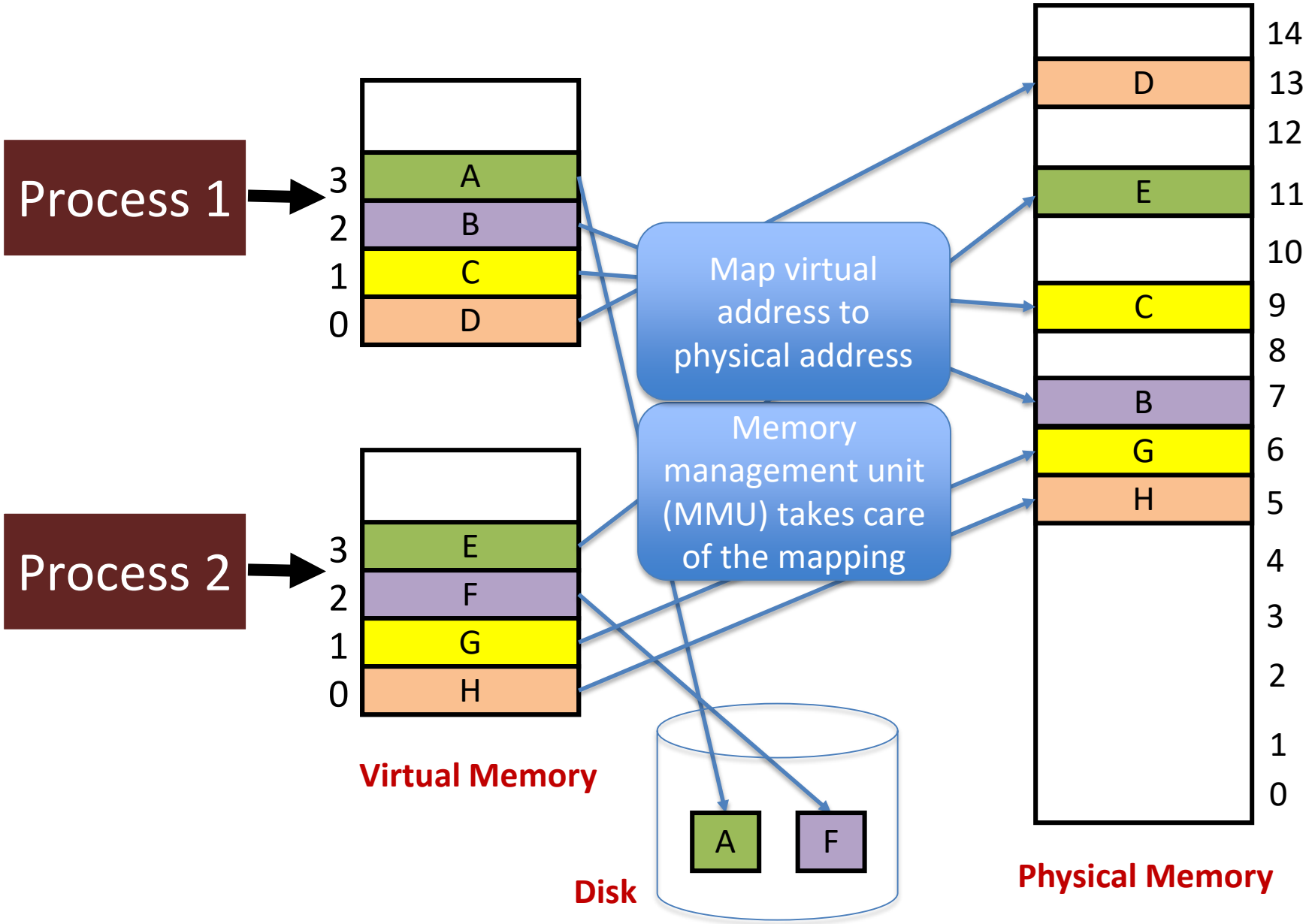
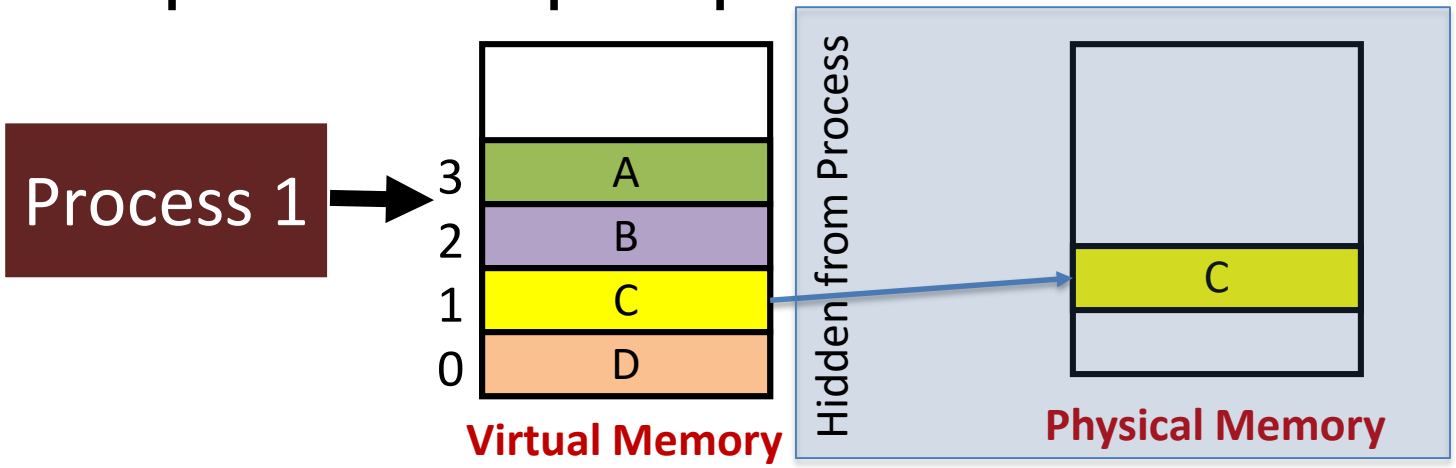


Big Picture: (Virtual) Memory

- From a process's perspective –



  - Process only sees the virtual memory
    - ✓Contiguous memory

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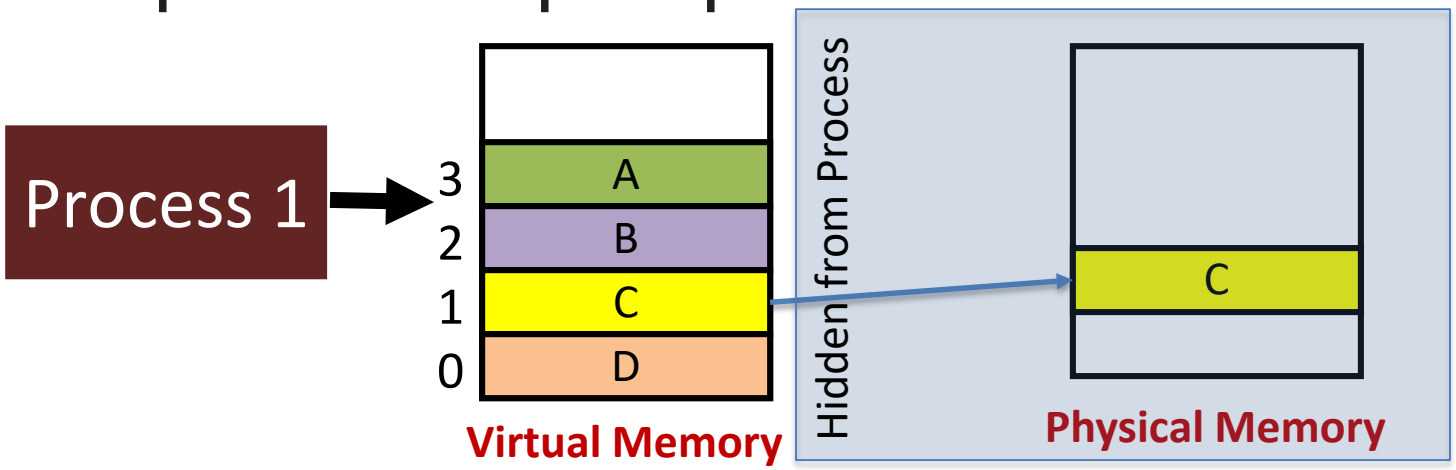

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  - ✓ Contiguous memory
  - ✓ No need to recompile - only mappings need to be updated

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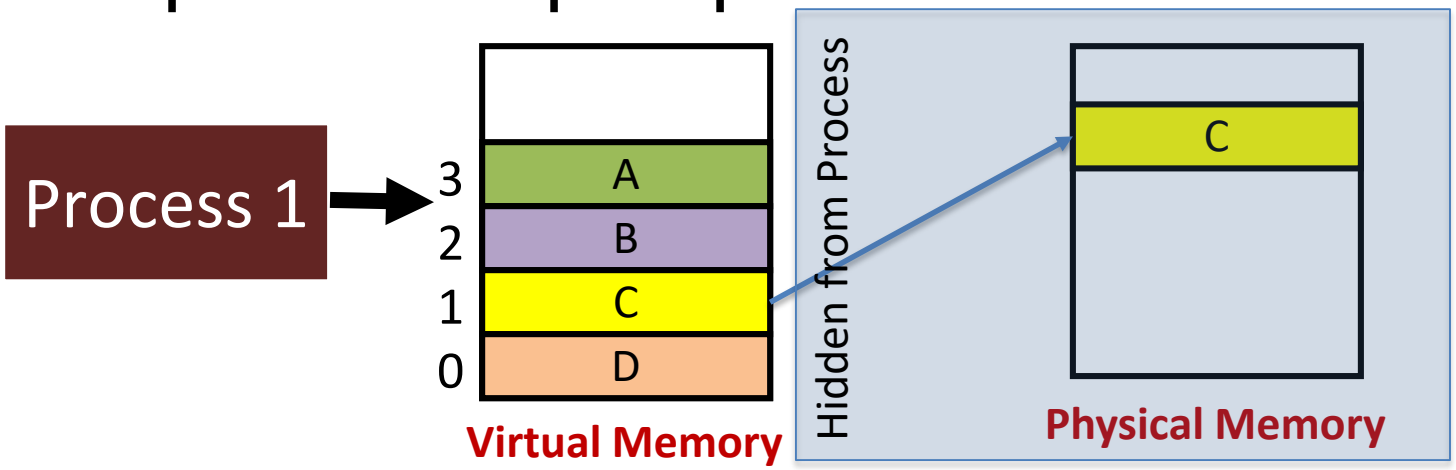

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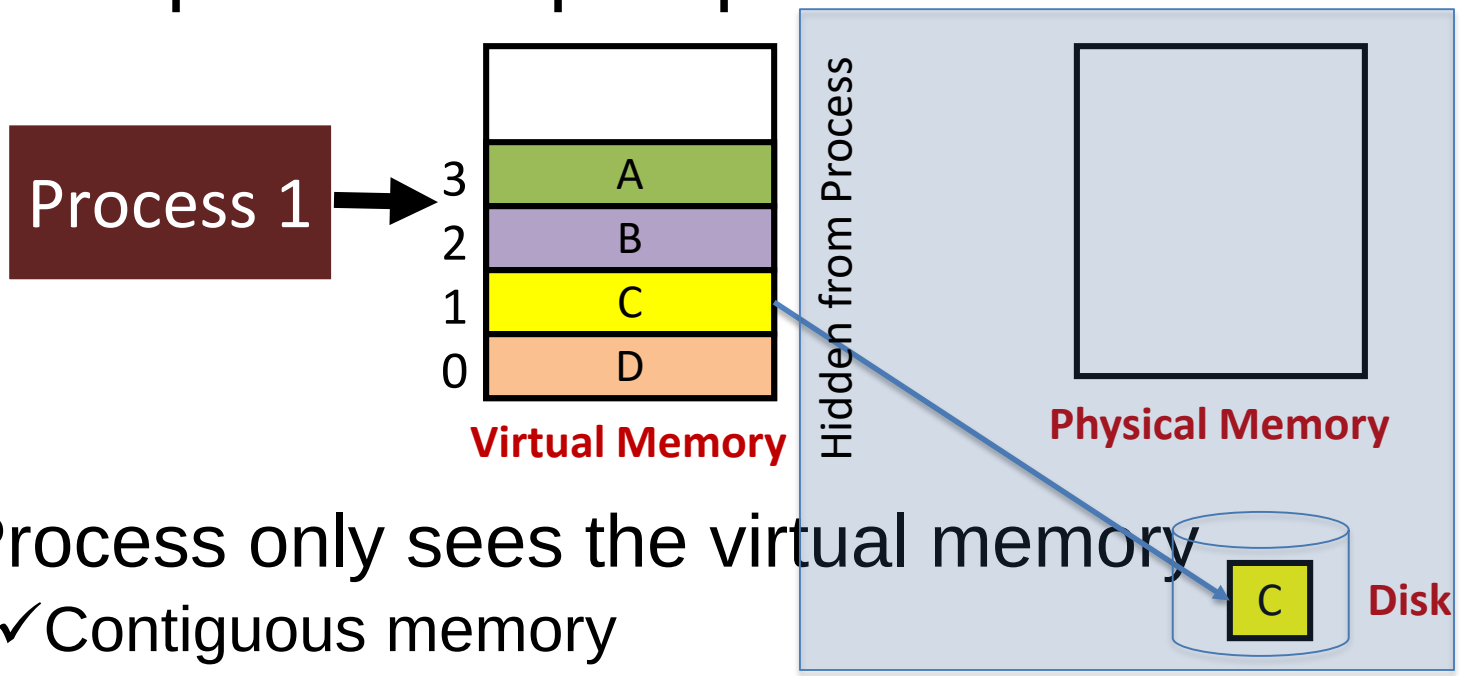

  - Process only sees the virtual memory
    - ✓Contiguous memory
    - ✓No need to recompile - only mappings need to be updated
    - ✓When run out of memory, MMU maps data on disk in a transparent manner

Next Goal

- How does Virtual Memory work?

- i.e. How do we create the “map” that maps a virtual address generated by the CPU to a physical address used by main memory?

Next Goal (after spring break!)

- How does Virtual Memory work?

- i.e. How do we create the “map” that maps a virtual address generated by the CPU to a physical address used by main memory?

Virtual Memory Agenda

What is Virtual Memory?

How does Virtual memory Work?

- Address Translation
- Overhead
- Paging
- Performance