Memory

Virtual Memory

Copy on Write

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Other data you *do* want to update (e.g., a document containing an exam answer template)

Such pages can be marked with another flag: *copy on write* — again, as long as the hardware supports this

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Other processes still see the original, unmodified data

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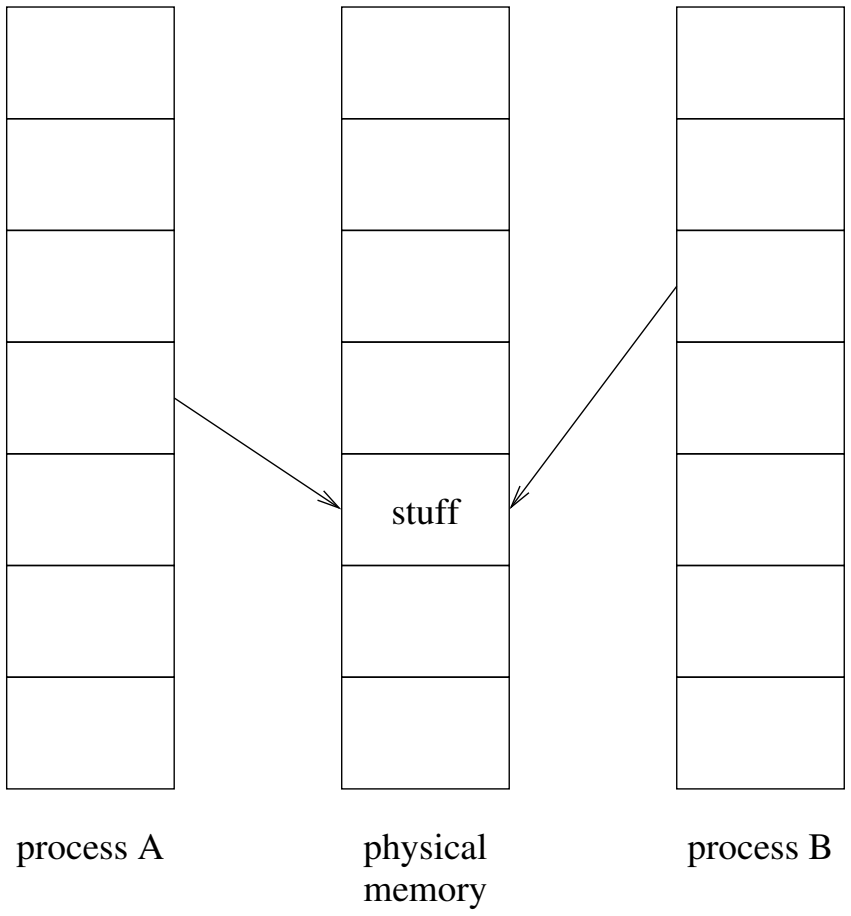
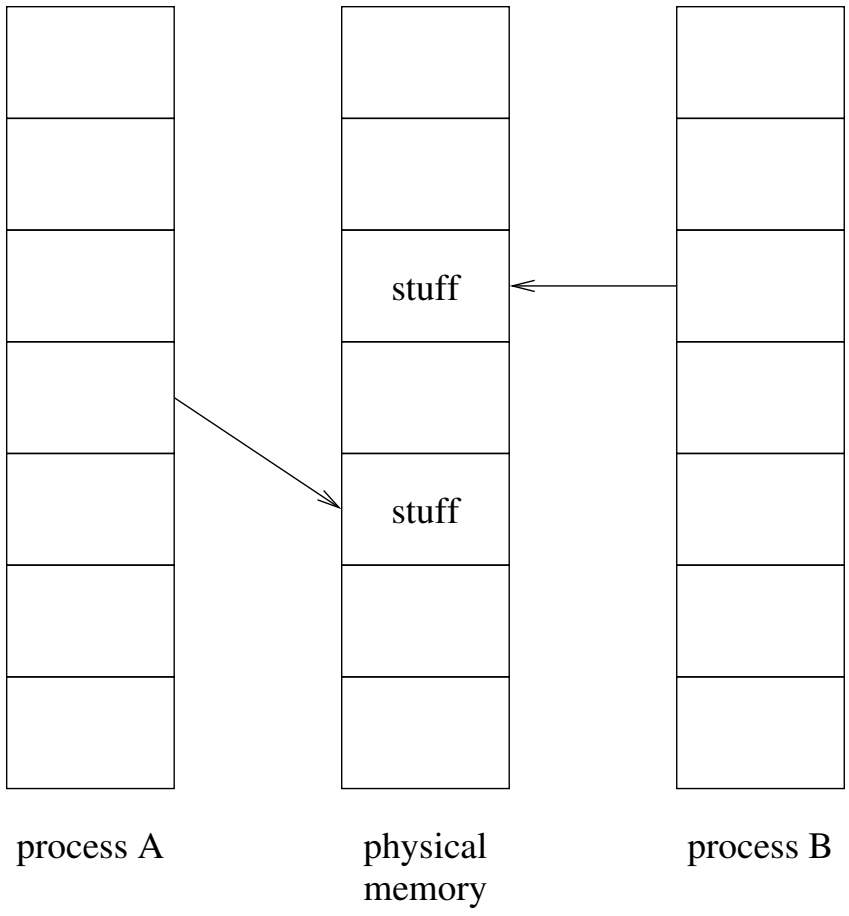


Some data is shared; process B tries to update the data

Memory

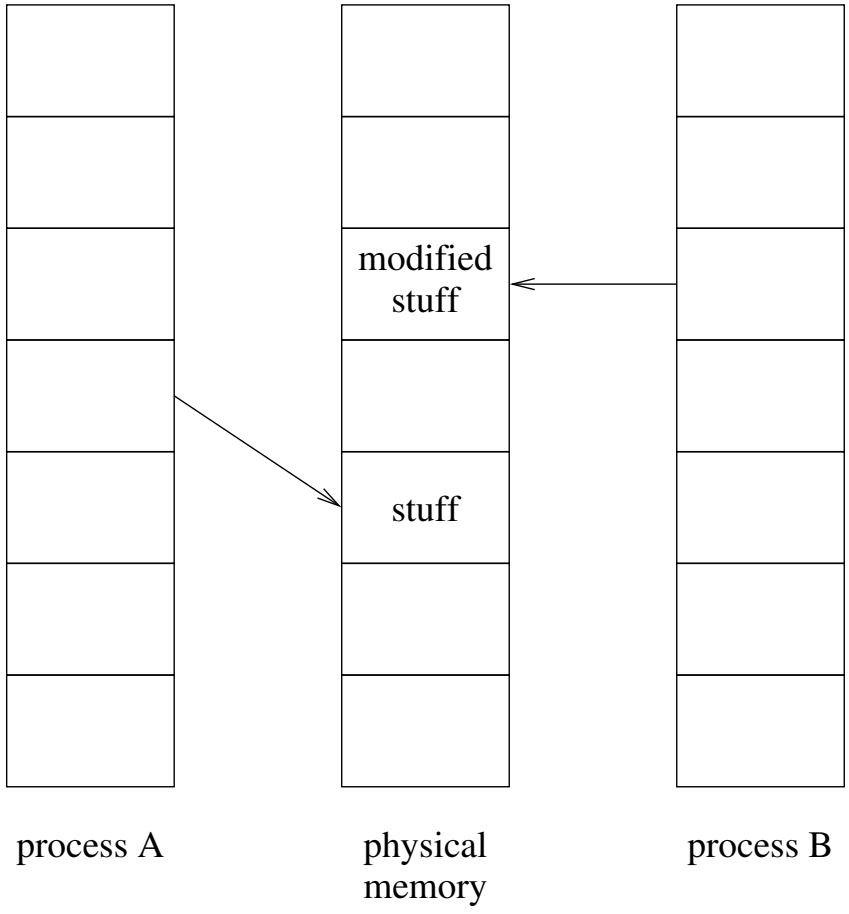
Virtual Memory



The OS takes over; copies the data to a new page; updates B's page mappings

Memory

Virtual Memory



The update continues and B modifies its own copy of the data

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So another reduction in memory use, page faults and so on

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And complexity in swapping as now it has to track which processes are using a page and it can't swap a page until no-one is using it

But this is offset by the fact we will need to swap less as we are using memory more efficiently

Other Tricks

OSs often keep a page full of zeros

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If the process writes to that block, the OS does a copy-on-write shuffle behind the scenes, allocating and clearing a new writable page

Thus only allocating and clearing pages that are actually used

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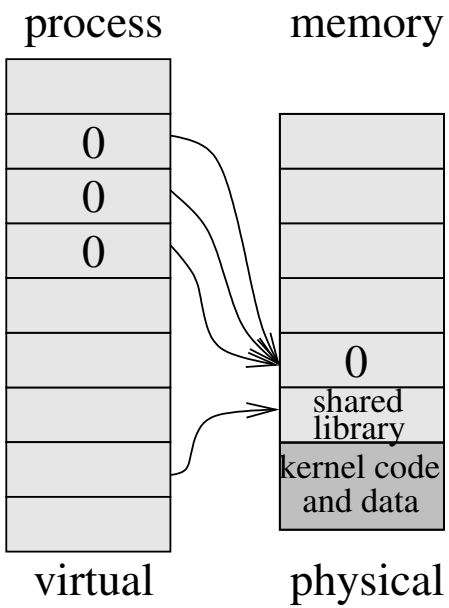
Other Tricks



Zero Page

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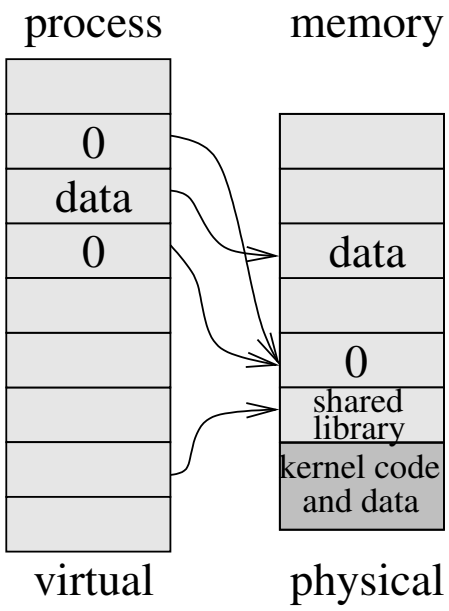
Other Tricks



Zero Page after a write

Other Tricks

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Parts of the virtual address space can be mapped on to things other than memory, e.g., files, the screen, sound card

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The OS can *mmap* (all or parts of) a file into memory: this means that reads and writes to "memory" are converted by the OS to reads and writes to that file (or screen, etc.)

Memory

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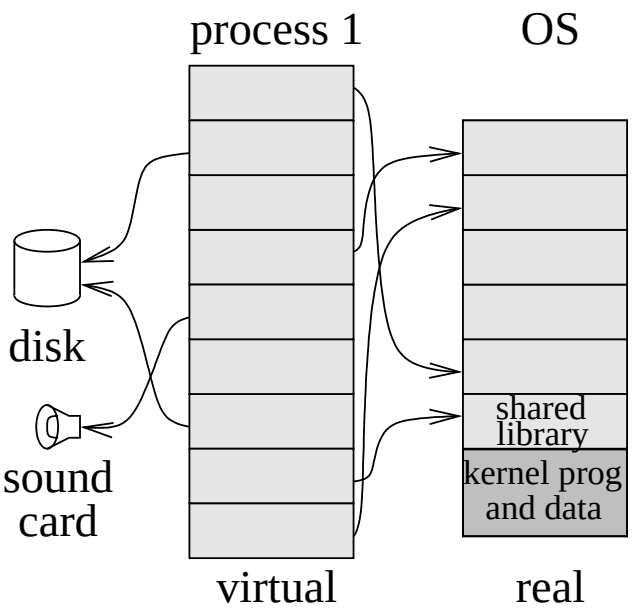

Memory map

Memory

Virtual Memory

The hugely simplifies the problem for the programmer: rather than having to work out the fiddly details for a given piece of hardware, they can simply write to what looks like an area of memory and the OS sorts out all the details

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Conclusion: TLBs solve many problems!

□