Lecture-9

Chapter - 8

Computer Organization and Architecture Designing - William Stallings

Virtual Memory

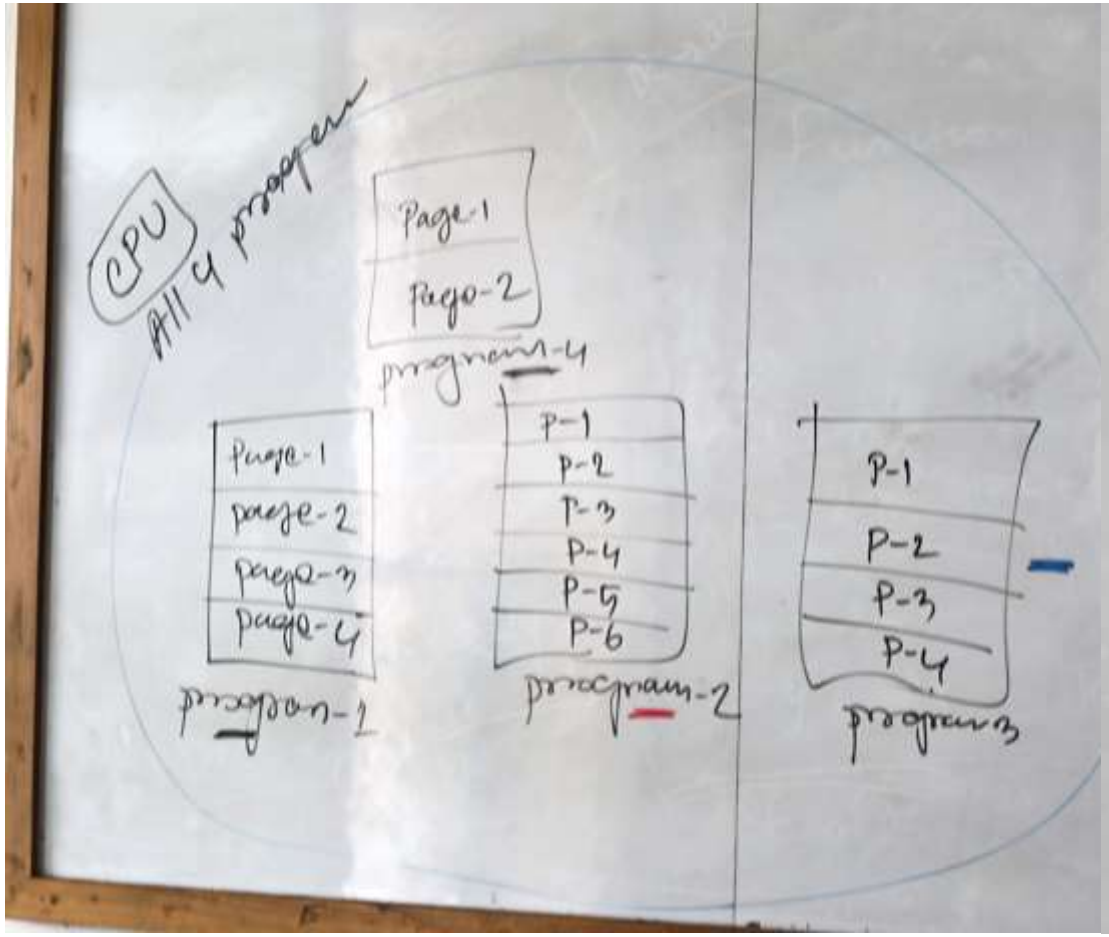
Virtual Memory

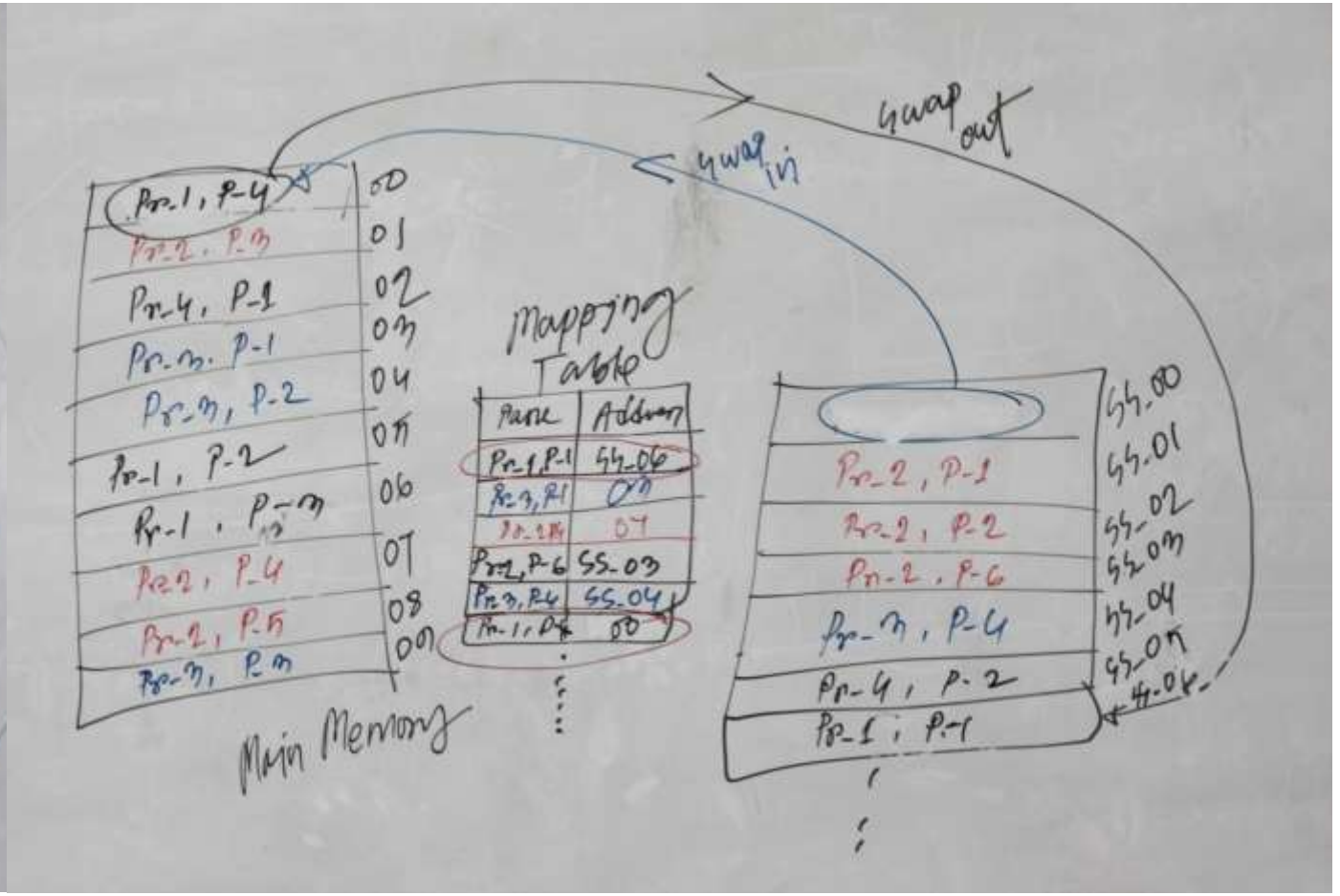
Virtual Memory:

- Separation of user logical memory from physical memory
- Only part of the program needs to be in memory for execution
- Logical address space can therefore be much larger than physical address space
- Allows for more efficient process creation
- Virtual memory takes program address and maps them to RAM addresses
- With no virtual memory: the program crash if we try to access more RAM that we have
- With virtual memory: mapping gives us flexibility in how we use the RAM
- Virtual memory mapping let us use our disk to give the illusion of unlimited memory

Virtual memory can be implemented via: Demand paging and Demand segmentation

Virtual Memory





Virtual Memory Diagram

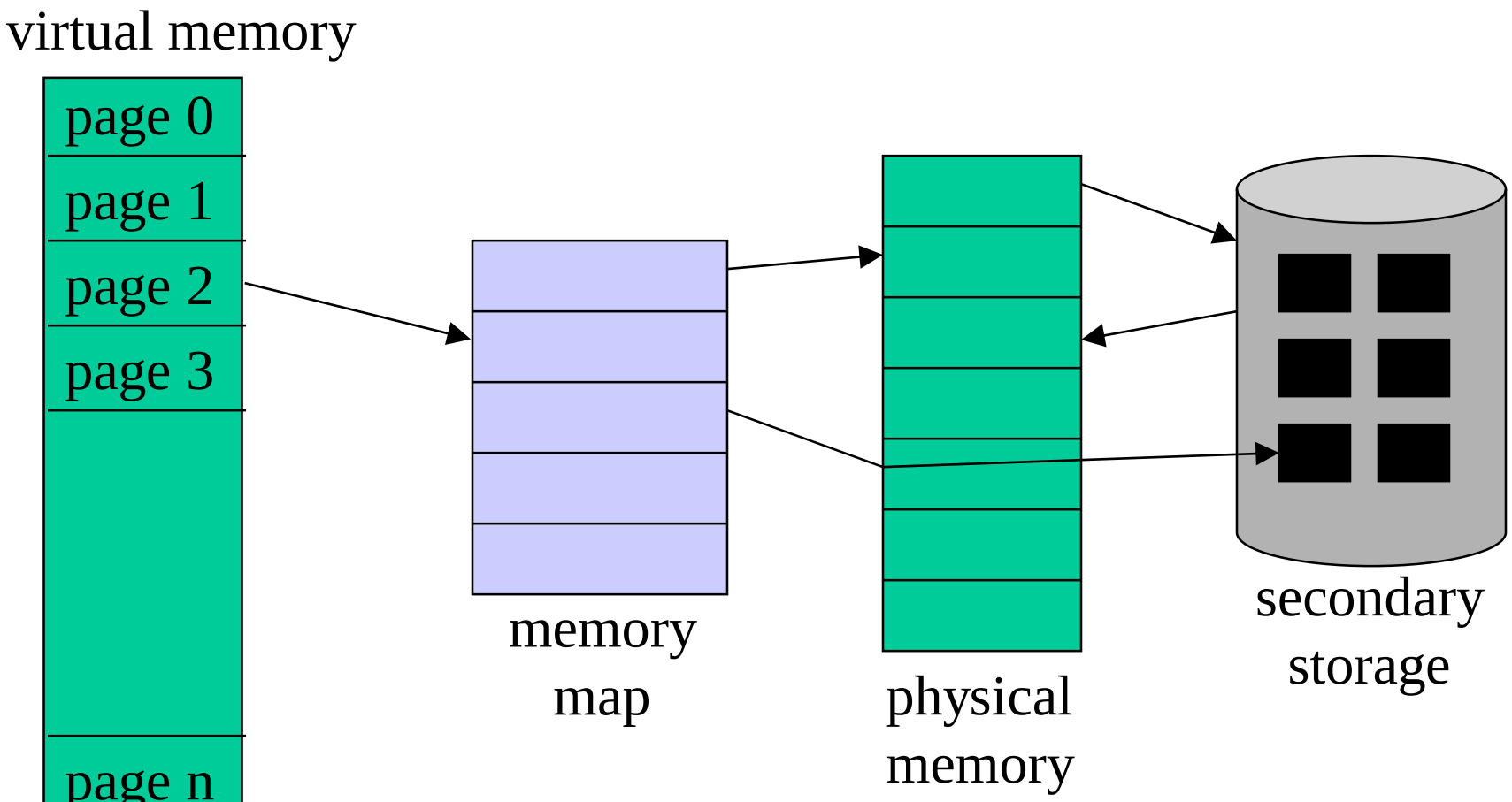
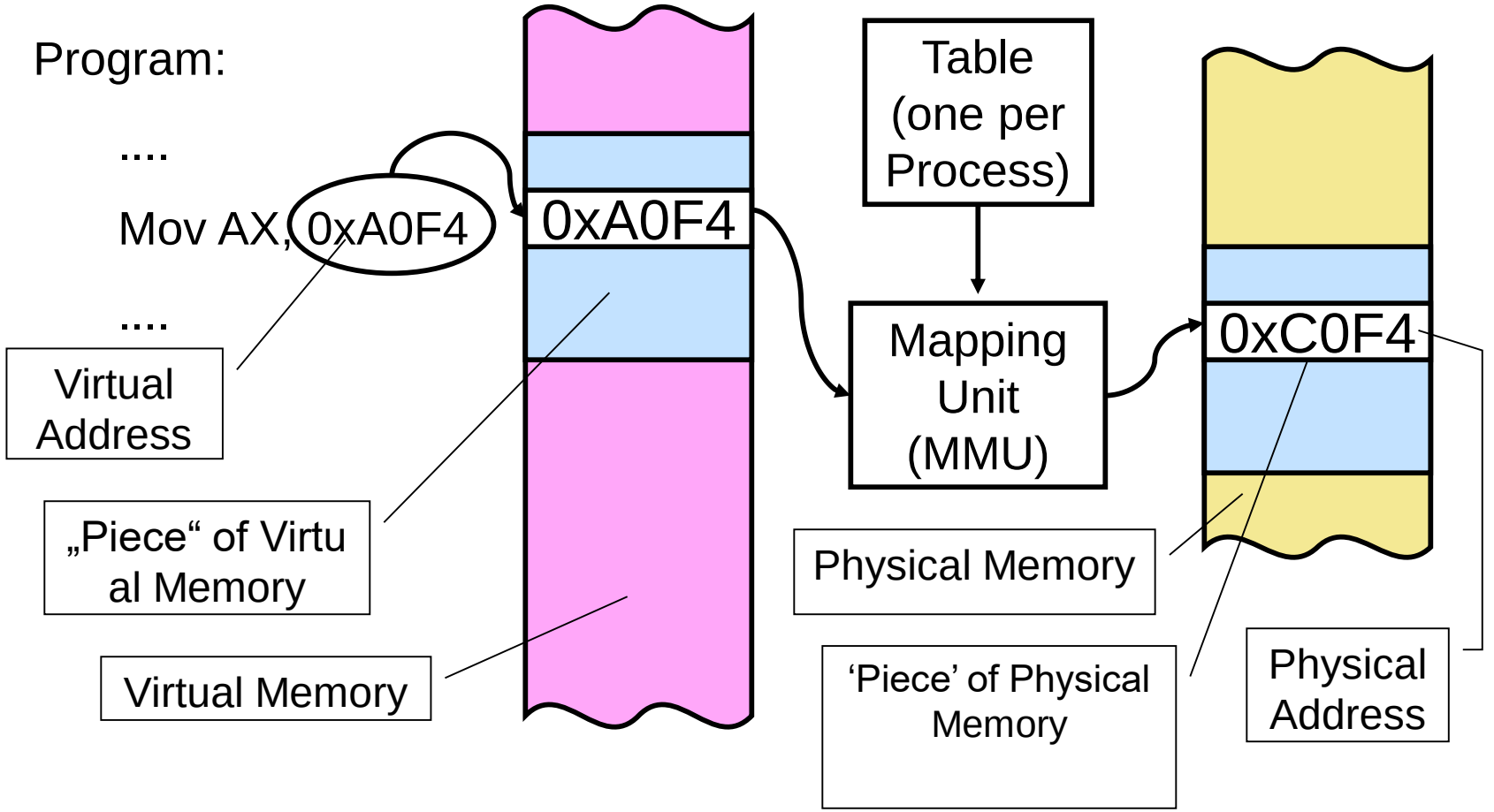


Fig. 9.1, p.291

What is Virtual Memory



Supporting Video Link

Virtual Memory Mapping

Virtual memory is a layer of indirection

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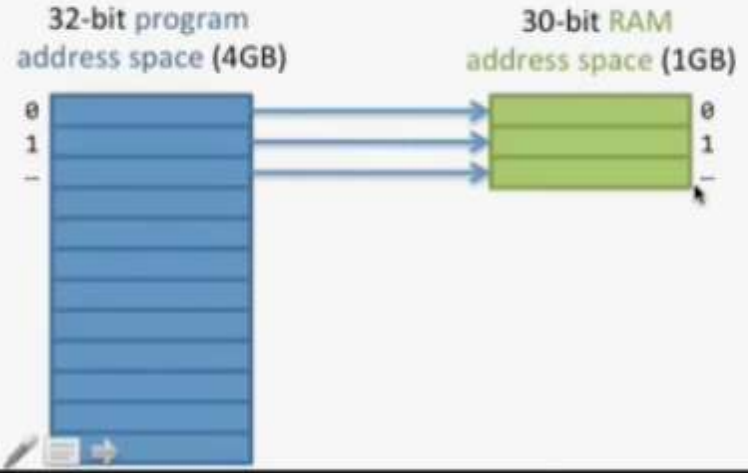
"Any problem in computer science can be solved by adding indirection."

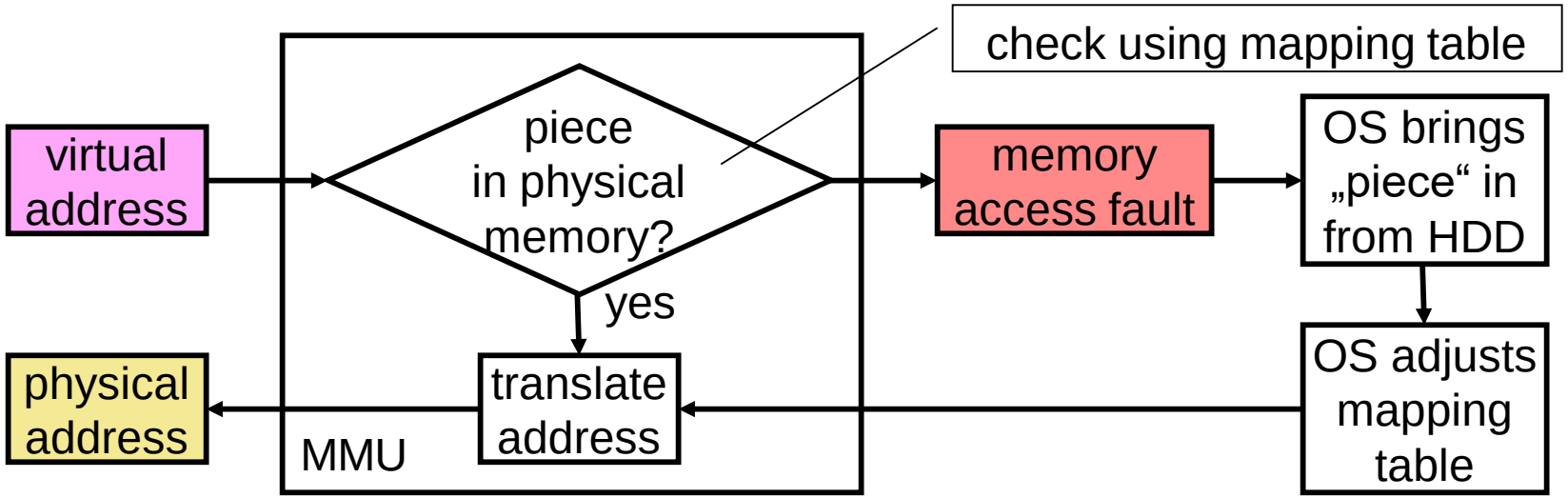
Without Virtual Memory

Program Address = RAM Address



The Mapping Process Flowchart

- Usually every process has its own mapping table
- Not every piece of VM has to be present in PM
  - "Pieces" may be loaded from HDD as they are referenced
  - Rarely used "pieces" may be discarded or written out to disk (→ swapping)

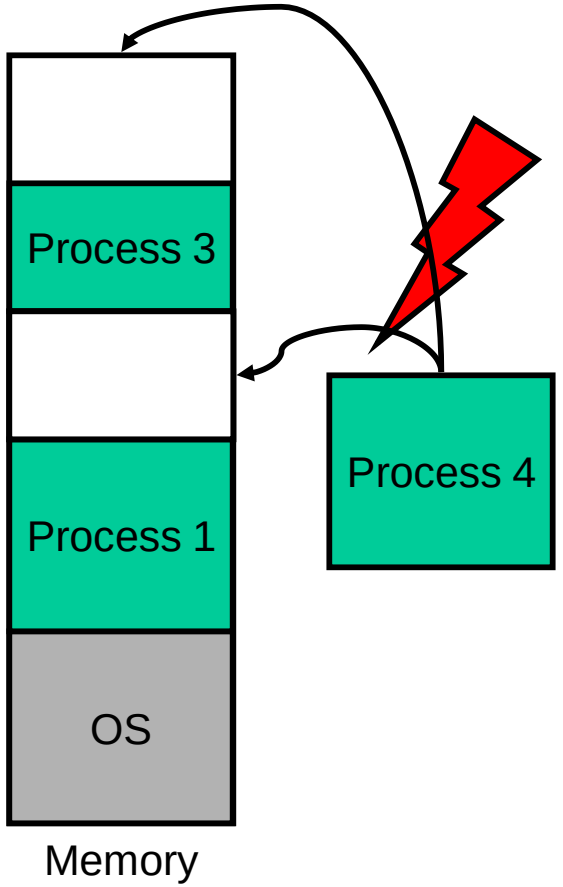


Why Virtual Memory (VM)

To overcome shortage of memory

- Efficient memory management needed
- Process may be too big for physical memory
- More active processes than physical memory can hold

- Requirements of multi-programming
  - Efficient protection scheme
  - Simple way of sharing



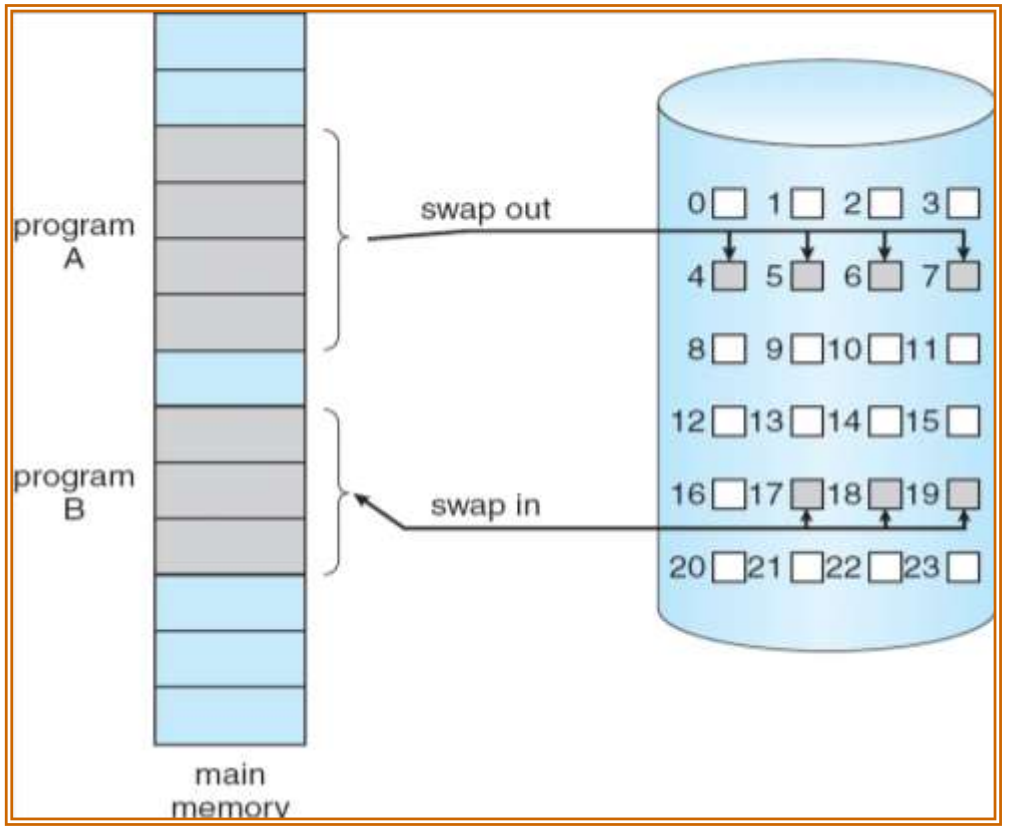
Demand Paging

- **Demand paging** is a virtual memory technique where only necessary program pages are loaded into physical memory, reducing memory usage.
- When a page is accessed but not in memory, it is retrieved from secondary storage.
- This approach improves resource sharing and reduces initial loading time, but can cause performance issues if there are frequent page faults.
- Various strategies, like page replacement algorithms, are used to handle page evictions.

- Here are the advantages of Demand Paging:
  - Efficient memory utilization
  - Faster program startup
  - Effective resource sharing
  - Reduced disk I/O operations
  - Flexibility in program size
  - Improved overall system performance

Transfer of a Paged Memory to Contiguous Disk Space

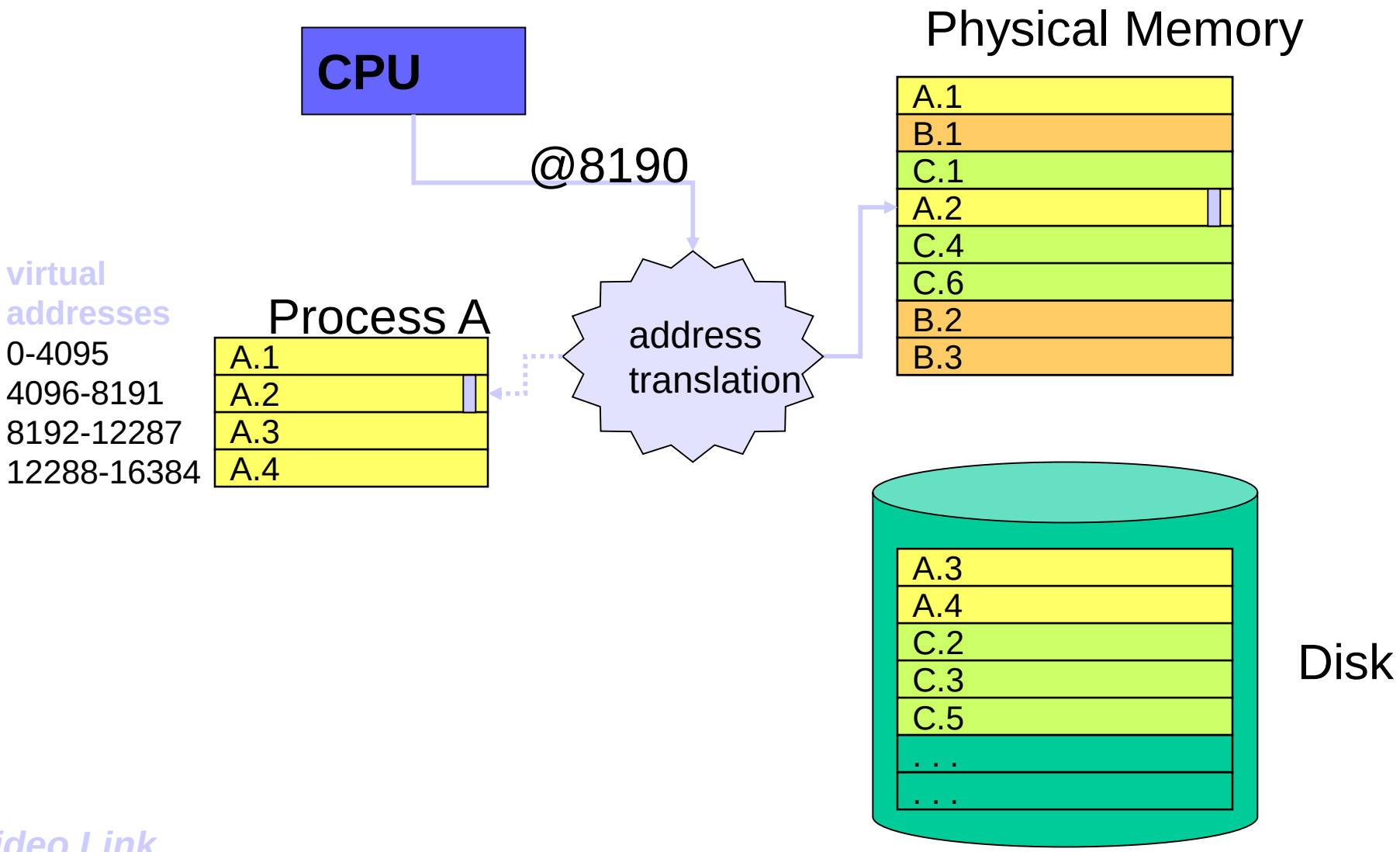
- Swapping is a technique used to replace pages or segments of data in memory.
- It enables a computer to execute programs and manipulate data files larger than main memory.
- When the operating system needs data from the disk, it performs an exchange of a portion of data in main memory (called a page or segment) with a portion of data on the disk.
- Swapping is commonly performed in operating systems like OS/2, Windows, and UNIX, and it is often referred to as paging.
- The process of moving a set of paged data sets from auxilia ry storage to real storage during the execution of a job is known as swap-in.
- Conversely, when data is moved from real storage back to auxiliary storage, it is called swap out.



What is a Process

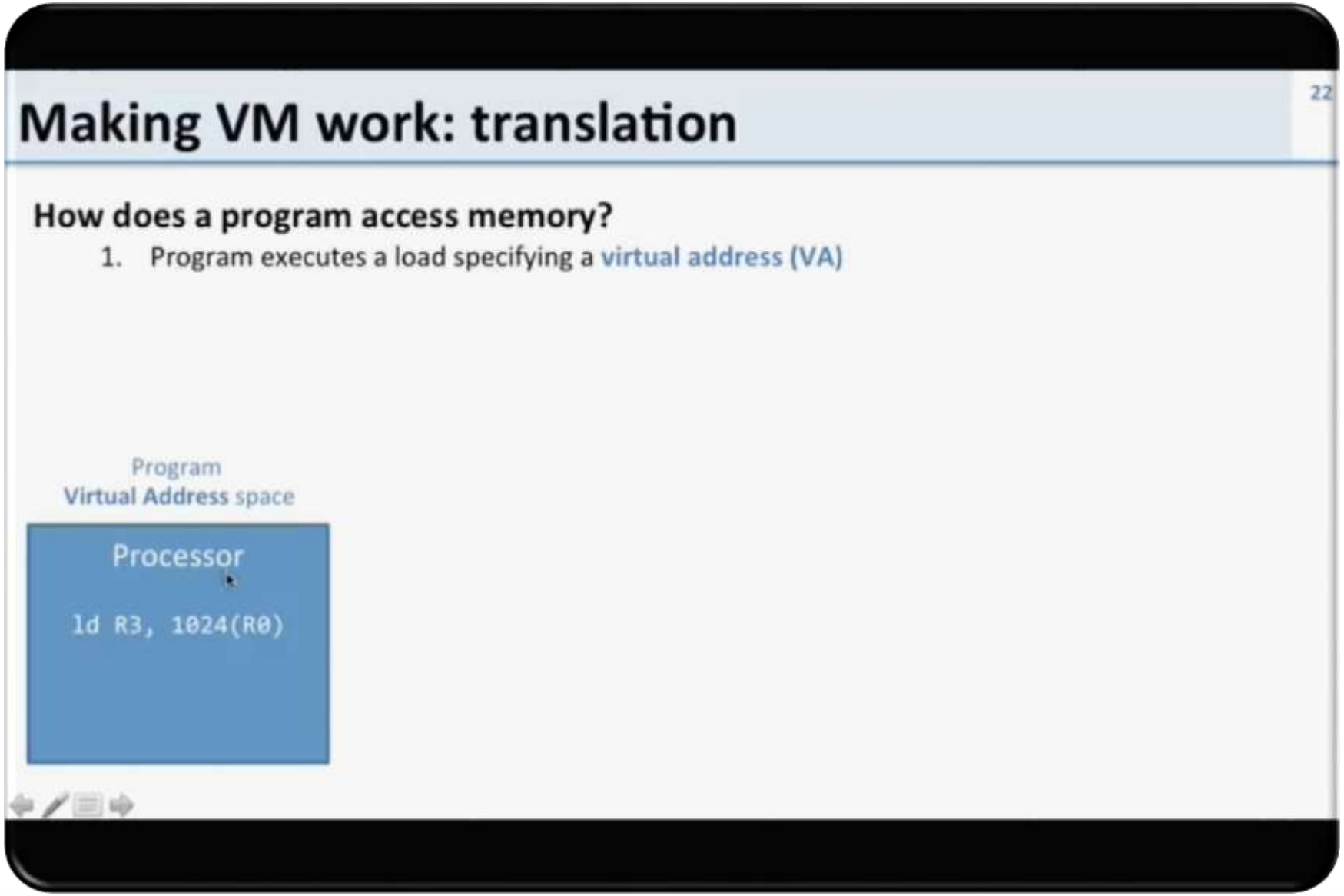
- A **process** in virtual memory is typically refers to the state of a running program.
- It includes essential components such as a program counter, page table, and register values.
- The program counter keeps track of the next instruction to be executed.
- The page table maps virtual addresses to physical addresses in memory.
- Register values store the current execution context of the process.

Address Translation

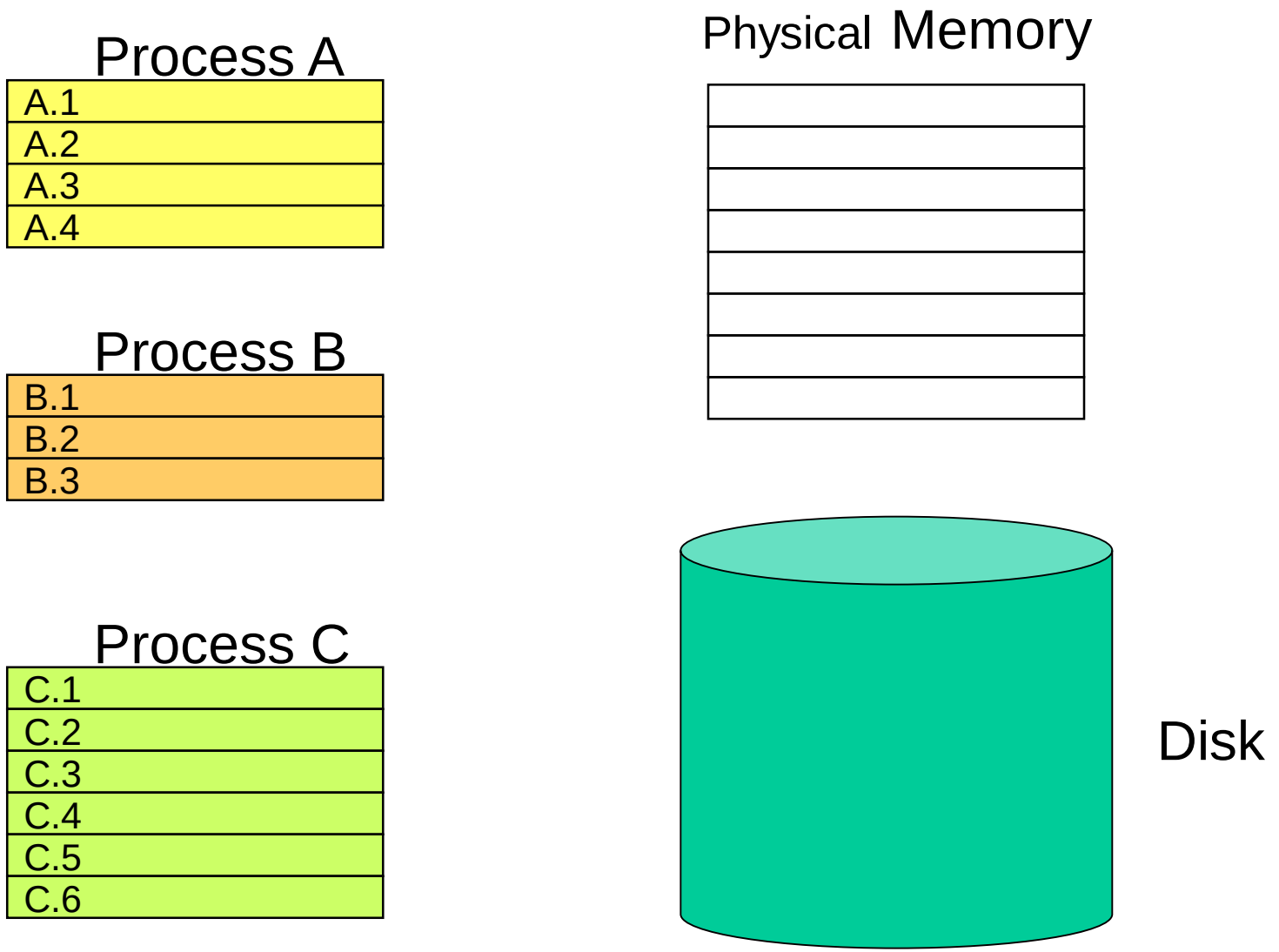


Supporting Video Link

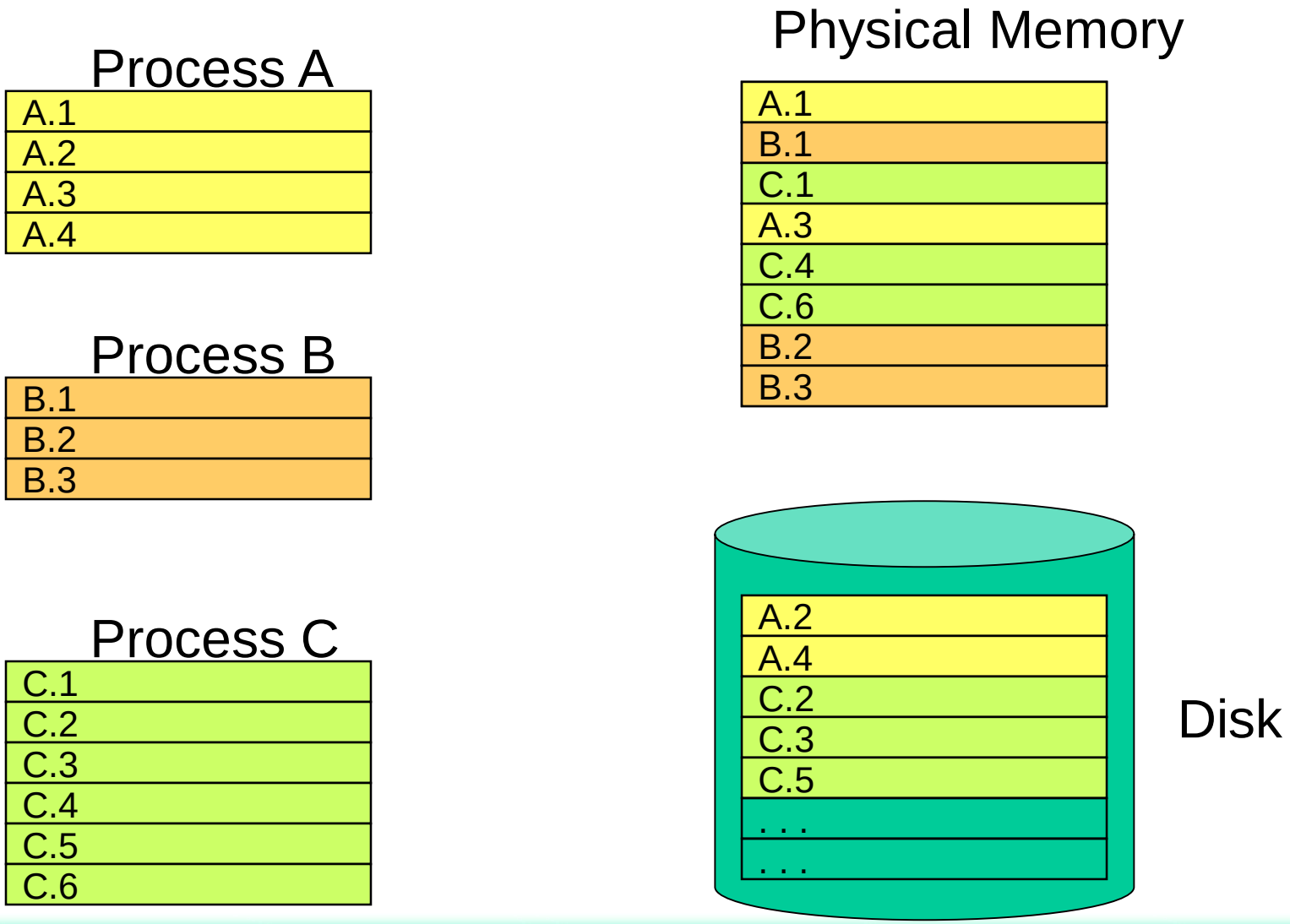
Address Translation



Address Translation Example

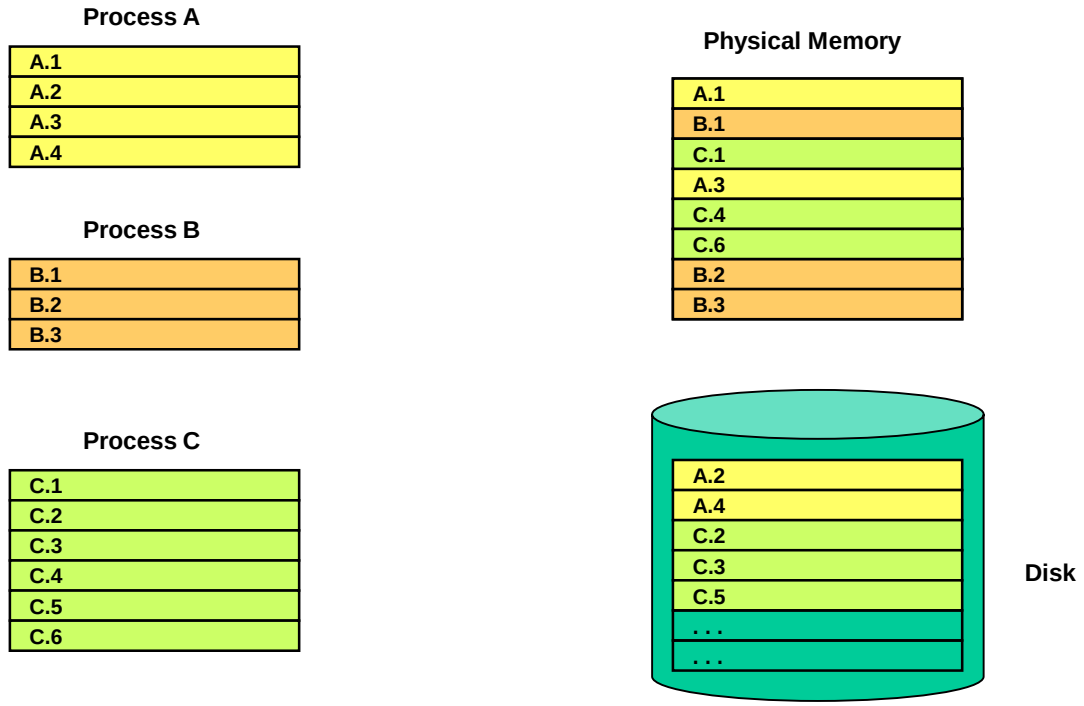


Example: Address Translation



Memory Protection

- Virtual memory ensures protection
- Process A cannot read/write into the memory of process B
- As we're going to see, this is easily enforced by the virtual memory address translation scheme



Paging and Page Table

Paging: is a memory management technique that divides physical memory and the virtual address space into fixed-size blocks called pages.

- Each process has its own page table
- Each page table entry contains the frame number of the corresponding page in main memory
- A bit is needed to indicate whether the page is in main memory or not

Page Table: Page table is a data structure used in virtual memory systems to map virtual addresses to physical addresses. It acts as a translation mechanism between the virtual address space of a process and the physical memory.

- The entire page table may take up too much main memory
- Page tables are also stored in virtual memory
- When a process is running, part of its page table is in main memory

Page Size and Page Faults

Page Size: Page size in virtual memory refers to the fixed-size blocks into which both the virtual address space and physical memory are divided.

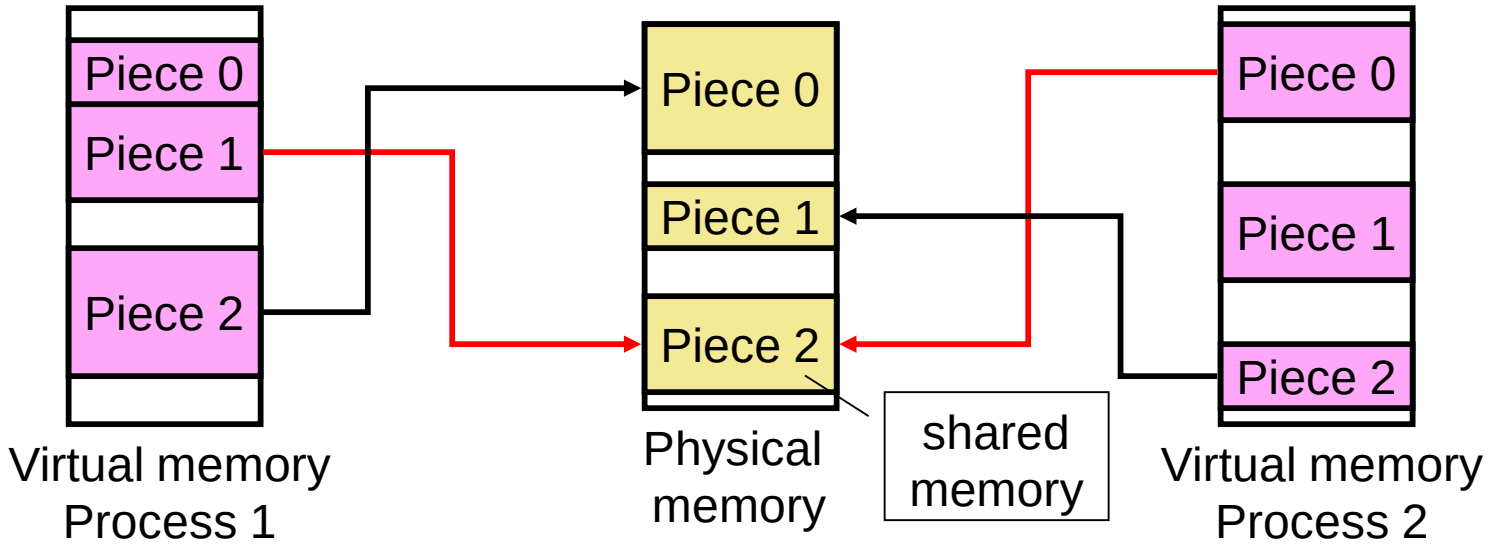
- It determines the granularity at which memory is divided.
- Both the virtual address space and physical memory are divided into pages of the same size.
- Page size is typically set by the operating system and remains constant.
- The most common page sizes are 4 KB, 8 KB, and 16 KB.

Page Faults: Page faults in virtual memory occur when a process references a page that is not currently present in physical memory.

- It happens when the required page needs to be fetched from secondary storage.
- Page faults are handled by the operating system, which retrieves the needed page.
- Handling page faults involves swapping pages in and out of memory.
- Page faults can impact system performance if they occur frequently.

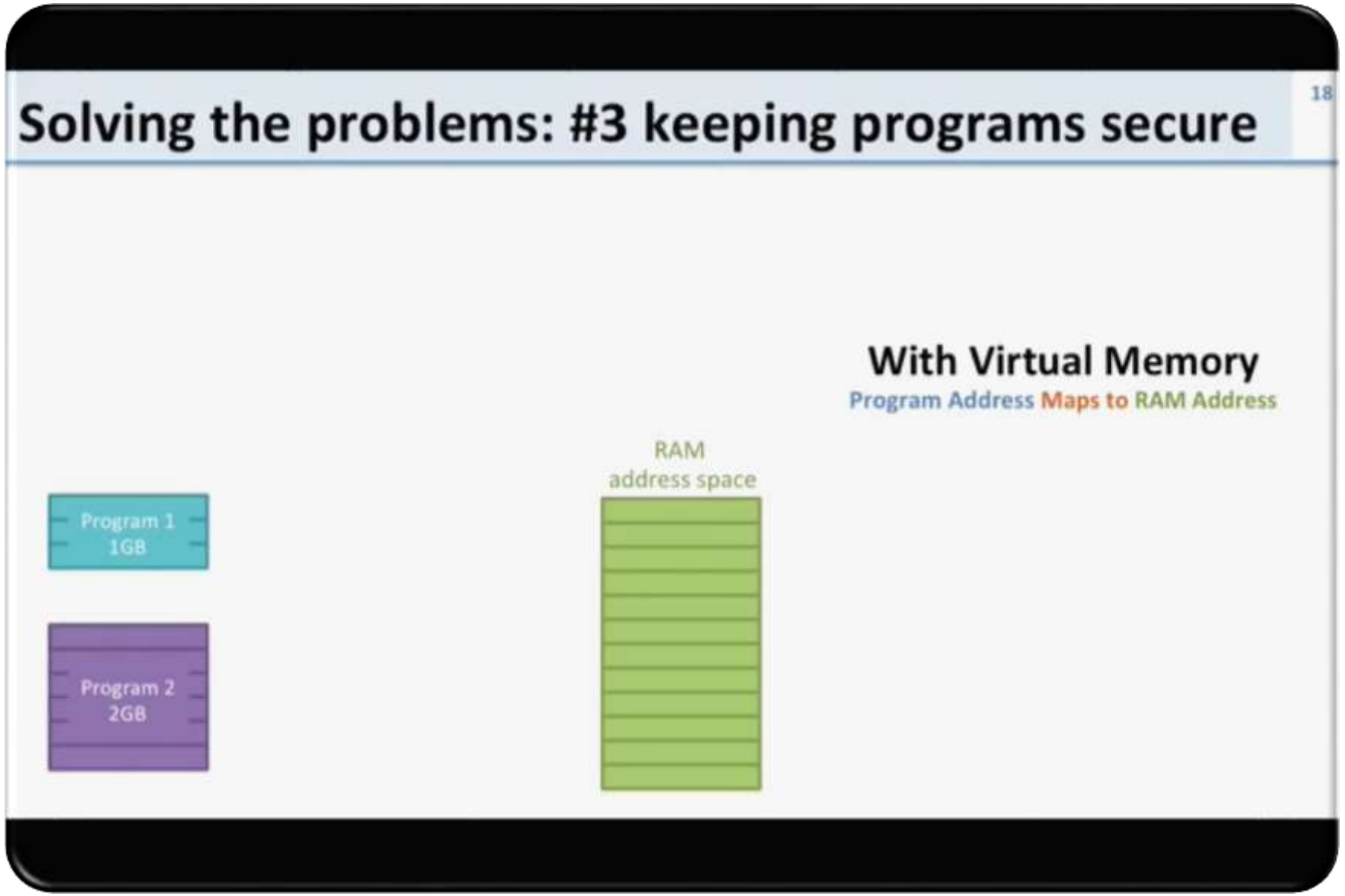
VM:Sharing

Pieces of different processes mapped to one single piece of physical memory



Supporting Video Link

VM:Sharing and Protection



Advantages & Disadvantagesof Virtual memory

Advantages of virtual memory:

- Efficient memory utilization
- Ability to run larger programs than available physical memory
- Process isolation and protection
- Simplified memory management

Disadvantages of virtual memory:

- Potential for increased page faults and slower performance
- Overhead of address translation and page table management
- Dependency on secondary storage for page retrieval
- Complexity in managing page replacement algorithms

Thank You