

Chapter 10: Virtual Memory

Lesson 01:

Virtual memory organisation

Objective

- Understand the virtual memory, virtual addresses, and physical addresses

Virtual memory page and page frame

Levels in memory system

- Hard disks or CDs or memory sticks or other media— form the lowest layer of the memory hierarchy
- DRAMs or core memory— form the main memory level of the hierarchy

Access to a program in virtual memory system

- Programs cannot directly access data stored on the media (for example, hard disk)
- Instead, the address space divided into pages of a program
- Pages— the contiguous blocks of data that are stored onto the media

Page

- **Page**— a fixed size memory area (set of addresses)
- The size depends on the memory system used in a particular computer system
- Each page has a contiguous fixed size block of data

Example of a virtual memory page

- Assume— a virtual page has addresses between 0xffff e000 to 0xffff ffff
- Page size = $(0xffff\ ffff - 0xffff\ e000 + 1) = 8 \times 1024\ B = 8\ kB$

Page frame

- A set of addresses where the page can fit
- Example— a page frame in main memory between 0x00 2000 to 0x 00 3fff
- Total number of addresses in the page frame = $(0x00\ 3fff - 0x00\ 2000 + 1) = 8 \times 1024\ B = 8\ kB$
- The page frame is of size 8 kB and it can be allotted to a virtual memory page

Page size

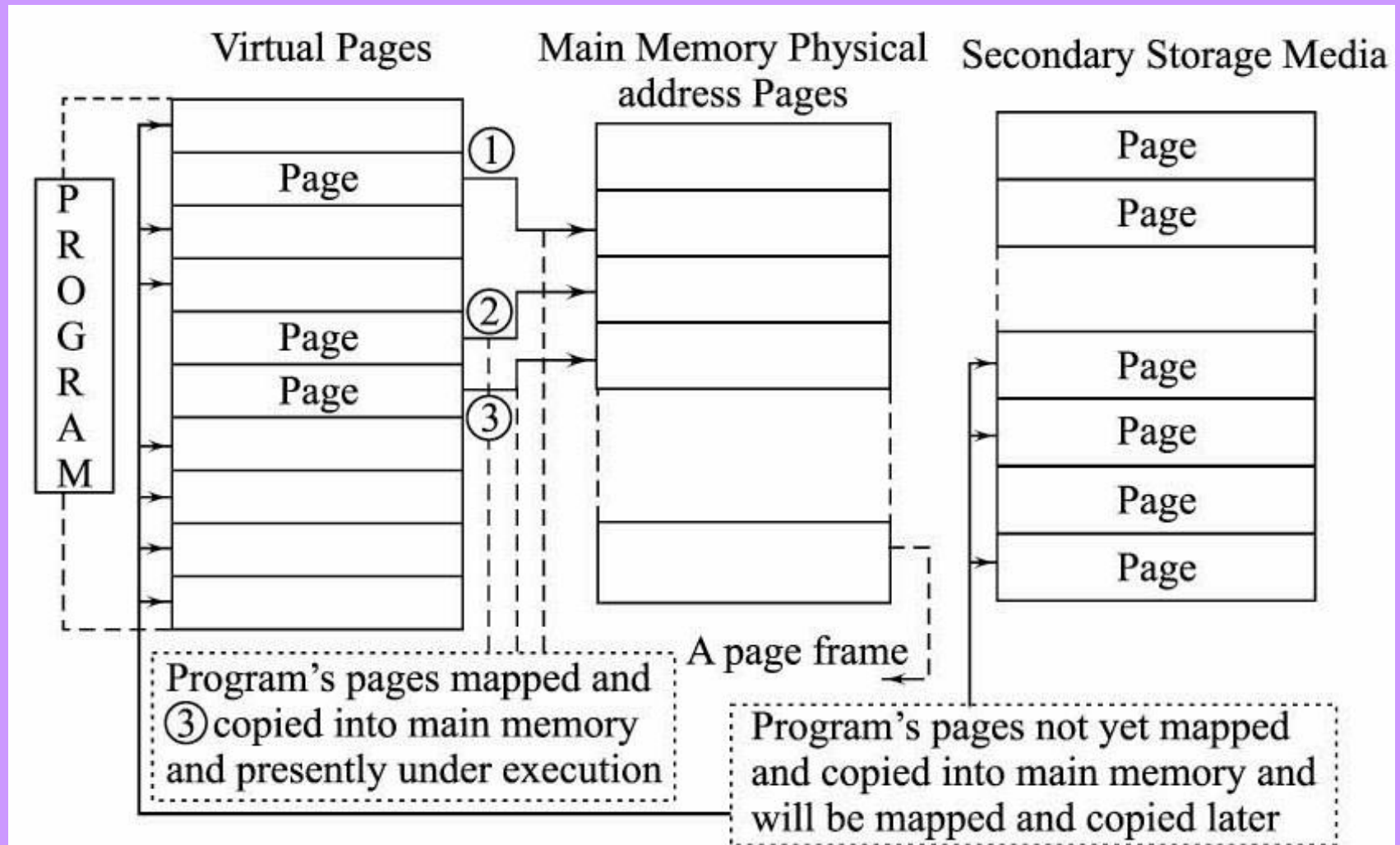
- A typical page size 4 kB or 8 kB
- 2 kB to 8 kB in most systems
- Some systems provide support for pages of multiple sizes

Reference to a page

- The system copies it into the main memory and allow page to be accessed by processor
- May require that another page of data be copied from the main memory to the magnetic or other media (secondary memory) in order to make room for the incoming page

Virtual memory

Virtual memory organisation



Each program's virtual address space

- Own virtual address space
- The set of addresses that the program uses for load and store operations

The physical address space

- The set of addresses used to reference locations in the main memory
- The term *virtual address*— describe addresses in the virtual address spaces
- The terms *physical address*— describe addresses in the physical address spaces

The virtual address space

- Divided into pages
- Some of which have been copied into page frames
- Page frame— slots in the main memory where a page of data can be stored because they have been referenced recently, and some of which are resident only on the disk

Pages alignment

- Always on a multiple of the page length, so they never overlap
- The terms *virtual page*— describe a page of data in the virtual
- The terms *physical page*— describe a page of data in the physical address spaces, pages that have been loaded

Virtual memory

- Allows a computer to act as if its main memory were much larger than it actually is
- When a program references a virtual address, it cannot tell, except by timing of the latency of the operation, whether the virtual address was resident in the main memory of the computer or whether it had to be fetched from the secondary media

Shuffle of pages into and out of the main memory

- Thus, the computer can shuffle pages into and out of the main memory as needed— similar to the way that cache lines are brought into and out of the cache as required
- Allows the programs to reference more data than can be stored in the main memory at any one time

Example

- Assume— system has 48-bit virtual addresses
- 36-bit physical addresses
- 128 MB of main memory
- Assume page size in the system— 4096-byte (4 kB) pages
- Find system's support to how many virtual and physical pages in the address spaces

Solution for 48-bit addresses in virtual space

- Page size = 4096 B = 2^{12} B
- So 12 bits of the virtual and physical addresses must be used for the offset of a referenced byte within a page
- Virtual page number VPN length = $(48 - 12) = 36$ bits long
- Virtual address space can support 2^{36} virtual pages

Solution for 48-bit addresses in virtual space

- Physical page number PPN = $(36 - 12) = 24$ bits long
- Physical address space can support 2^{24} physical page frames

Summary

We Learnt

- Pages are — the contiguous blocks of data that are stored onto the media
- Pages are of sizes 2 kB to 8 kB and of fixed length
- Program references on load and store instructions by virtual addresses
- The computer can shuffle pages into and out of the main memory as needed

We Learnt

- Virtual address space divided into pages
- Some of which have been copied into page frames at the physical address space at main memory at a given instance
- Allows the programs to reference more data than can be stored in the main memory at any one time

End of Lesson 01 on
Virtual memory organisation