Chapter 10: Virtual Memory

Lesson 02:

Address mapping and translation

Objective

- Understand the address mapping functions
- Learn translating of the program pages in virtual to the physical addresses space
- Learn that a virtual page translating to physical page frame is of same or integral multiple of size in the physical address space
- Introduce to the page table and page fault concept

Address mapping

Linear Mapping

- Assume that we wish to represent a large distance *x* in terms of a small distance *y* on a map
- Then we assume a linear mapping function
- When we scale the distance of *x* to *y*, then with linear mapping,

$$y = c_0 \,.\, x + (c_{1y} - c_{1x})$$

Linear Mapping

- When x doubles and changes by x, the y also changes by $c0x$
- The $dy/dx = c0$, a constant in linear mapping
- Here c_0 is proportionality constant
- c_{1x} is a constant independent of x and is the base distance for the origin $x = 0$
- c_{1y} is a constant independent of y and is the base distance for the origin, $y = 0$

Example of virtual address page mapping

- When a virtual page of size $n \times 4$ kB translates to physical page frames, each of size = 4 kB, where n is an integer

Translation mapping

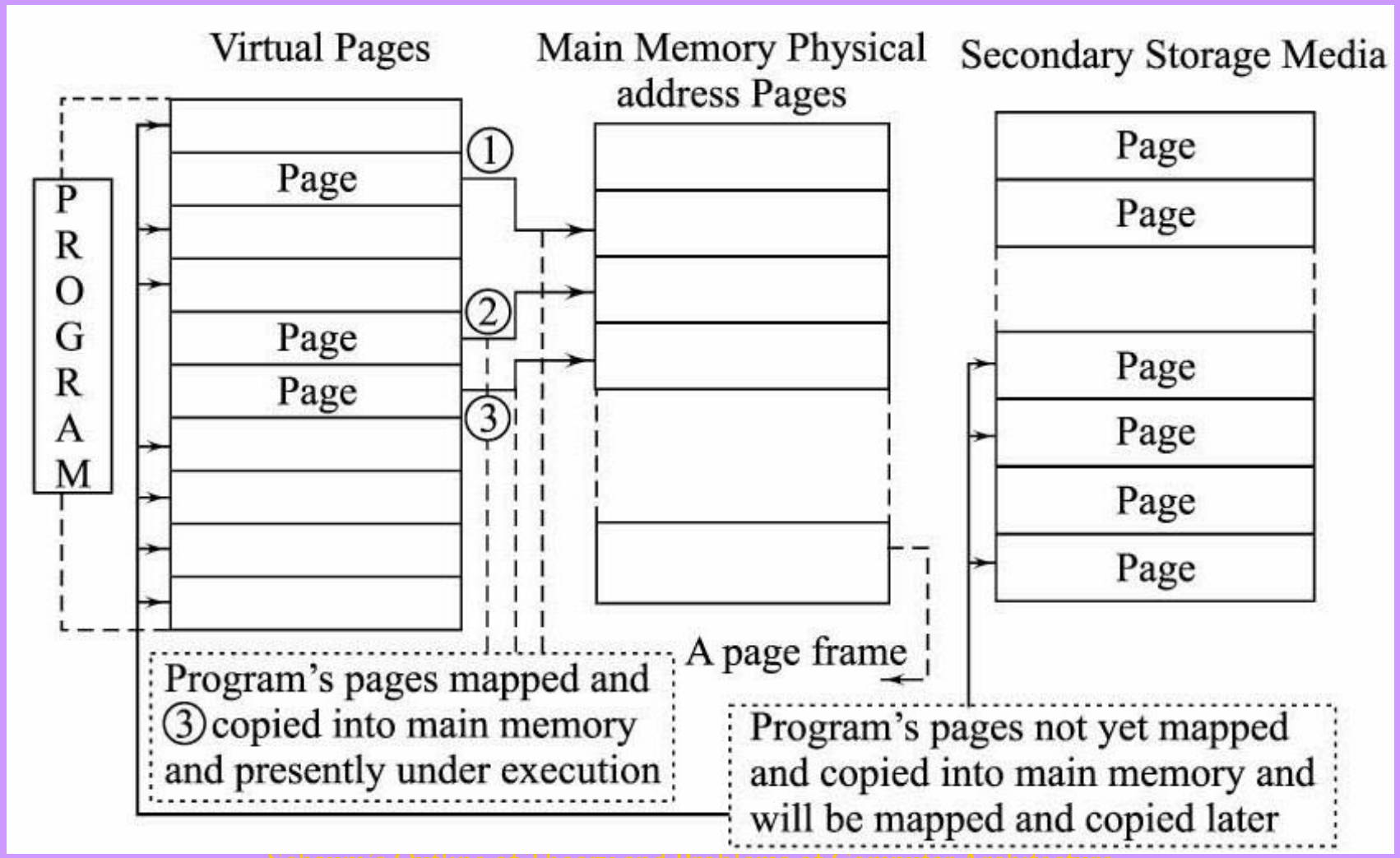
- A linear mapping case— the $dy/dx = 1$ and $c0 = 1$, but $(c_{1y} - c_{1x})$ is not zero and reflects the amount of translation
- The $dy/dx = c0 = 1$ is a constant in linear translation mapping

Example of Translation mapping

- A virtual page of size N bytes translates to N bytes at main memory
- A virtual page at base address x translates to physical page frame at main memory base address y, then all virtual addresses from x to x + N– 1 corresponds to physical addresses from y to y + N– 1

Meaning of address translation to page frame

Virtual memory pages translation to main memory page frames



Meaning of Constants in address translation

- Base address $c1x$, the address of first byte on the page) for each virtual page is different
- Base address $c1y$, the address of first byte on the page) for each main memory page is also different
- c_{1y} may also depend on c_{1x}

Example

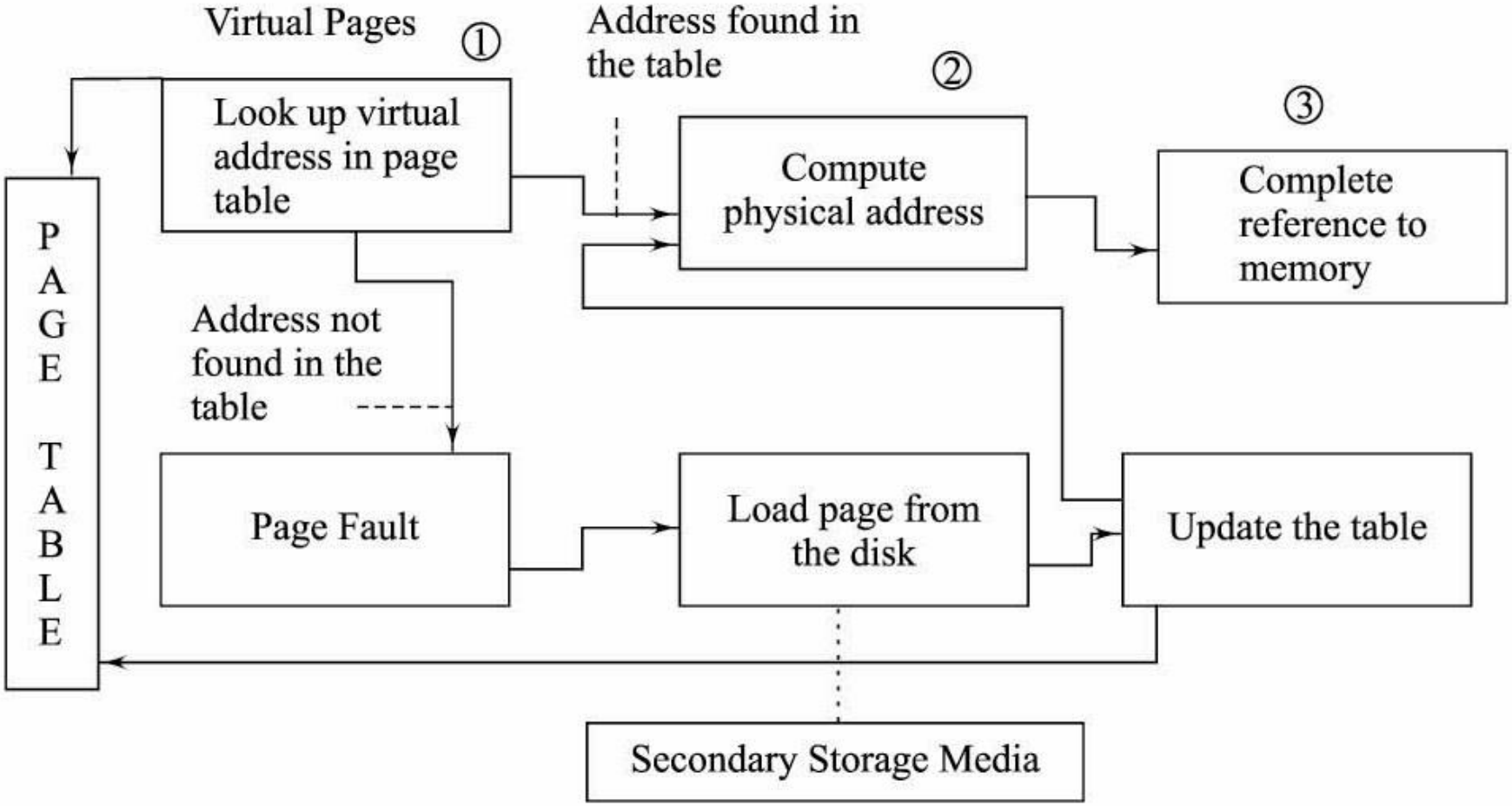
- Assume— a virtual page has addresses between 0xffff e000 to 0xffff efff
- Page size = (0xffff efff – 0xffff e000 + 1) = 4 × 1024 B = 4 kB
- Assume that a page frame is a set of addresses where the page can fit

Page frame

- A page frame in main memory may be between 0x00 7000 to 0x 00 7fff, also 4 kB
- If the page frame is loaded with the page starting at 0xffff e000, then there is address translation from virtual page base address 0xffff e000 to main memory physical page frame address 0x00 7000
- A virtual address 0xffff e0a9 is reference from physical address 0x00 70a9

Address translation process

Address translation processes



Referencing the memory by a user program instruction

- The operating system accesses a *page table*
- Page table— a data structure in memory that holds the mapping of virtual to physical addresses, to determine whether or not the virtual page containing the address referenced by the operation is currently mapped onto a physical page frame

Referencing the memory by a user program instruction

- The operating system determines the physical address that corresponds to the virtual address from the page table
- The operation proceeds, using the physical address to access the main memory

The virtual page containing the referenced address

- If not currently mapped on to a physical page frame, then a *page fault* occurs
- On page-fault— the operating system fetches the page containing the requested data from memory, loading it into a page frame and updating the page table with the new translation

Page read from disk

- Once the page has been read into the main memory from disk and the page table updated, the physical address of the page can be determined and the memory reference completed
- If all of the page frames in the system already contain data, one of them must be evicted to the magnetic or other media to make room for the incoming page

Summary

We learnt

- The address mapping function is linear
- Address translates from virtual address space to physical address space
- When a virtual page of size $n \times 4$ kB translates to physical page frame, it has size = 4 kB, where n is an integer

We learnt

- A page table helps in referencing a virtual page address word from a physical address page frame
- On page fault, the page loads from virtual memory

End of Lesson 02 on

Address mapping and translation