

Paper Name : Operating System

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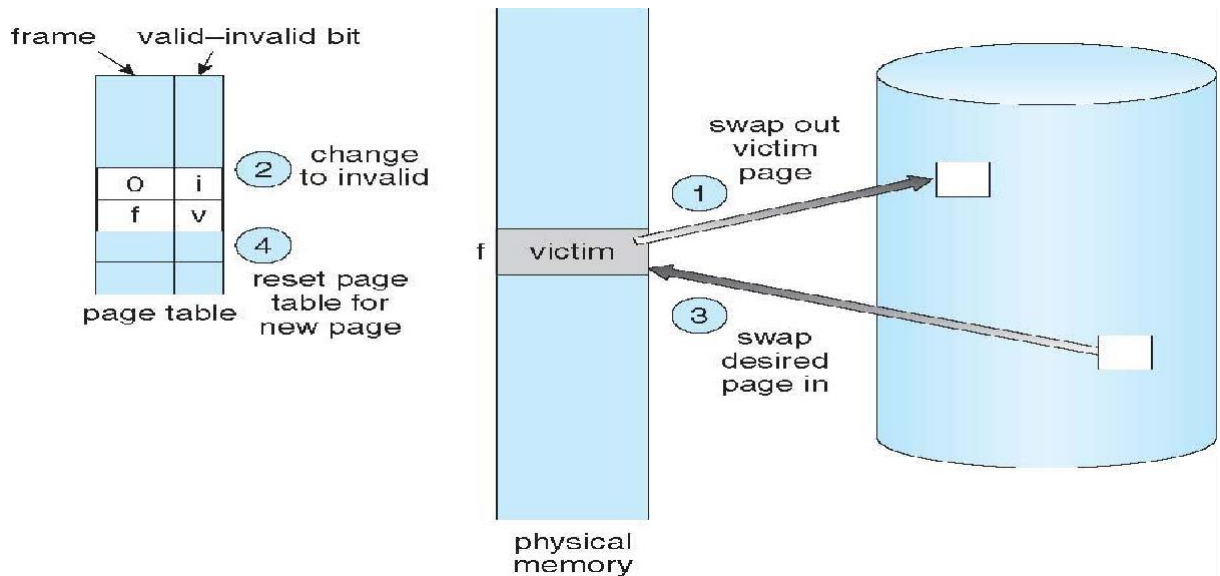
Memory Management :

Basic Page Replacement –

Page replacement takes the following approach. If no frame is free, we find one that is not currently being used and free it. We can free a frame by writing its contents to swap space and changing the page table (and all other tables) to indicate that the page is no longer in memory. We can now use the freed frame to hold the page for which the process faulted. We modify the page-fault service routine to include page replacement:

1. Find the location of the desired page on the disk.
2. Find a free frame:
 - a. If there is a free frame, use it.
 - b. If there is no free frame, use a page-replacement algorithm to select a victim frame
 - c. Write the victim frame to the disk; change the page and frame tables accordingly.
3. Read the desired page into the newly freed frame; change the page and frame tables.
4. Restart the user process.

When we select a page for replacement, we examine its modify bit. If the bit is set, we know that the page has been modified since it was read in from the disk. In this case, we must write the page to the disk. If the modify bit is not set, however, the page has not been modified since it was read into memory. In this case, we need not write the memory page to the disk: it is already there. This technique also applies to read-only pages (for example, pages of binary code). Such pages cannot be modified; thus, they may be discarded when desired. This scheme can significantly reduce the time required to service a page fault, since it reduces I/O time by one-half if the page has not been modified.



Page Replacement Algorithms :

1. FIFO Page Replacement –

A FIFO replacement algorithm associates with each page the time when that page was brought into memory. When a page must be replaced, the oldest page is chosen. Notice that it is not strictly necessary to record the time when a page is brought in. We can create a FIFO queue to hold all pages in memory. We replace the page at the head of the queue. When a page is brought into memory, we insert it at the tail of the queue.

- **Reference string: 7,0,1,2,0,3,0,4,2,3,0,3,2,1,2,0,1,7,0,1**
- **3 frames (3 pages can be in memory at a time per process)**

reference string

7	0	1	2	0	3	0	4	2	3	0	3	2	1	2	0	1	7	0	1
7	7	7	2		2	2	4	4	4	0							7	7	7
	0	0	0		3	3	3	2	2	2		0	0				1	0	0
		1	1		1	0	0	0	3	3		1	1				2	2	1
												3	2						

page frames

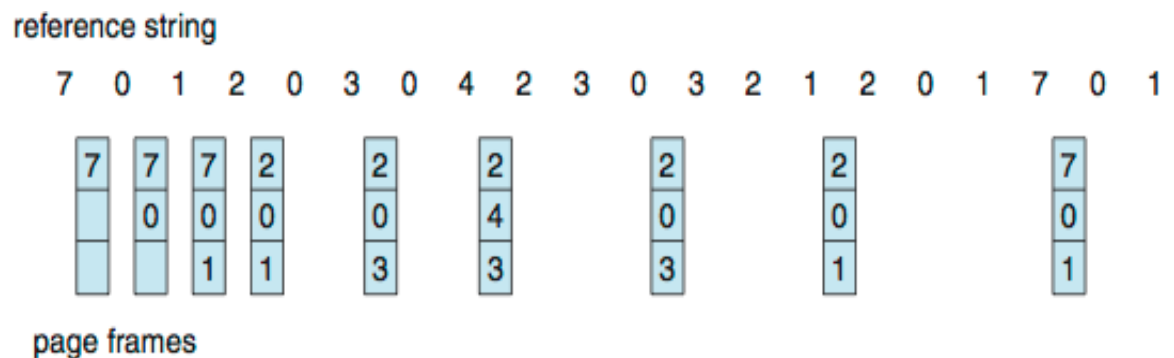
Number of page faults = 15

Adding more frames can cause more page faults!

- Belady's Anomaly - Belady's anomaly demonstrates that increasing the number of page frames may also increase the number of page faults.

2. Optimal Page Replacement

Replace page that will not be used for longest period of time. Use of this page-replacement algorithm guarantees the lowest possible page fault rate for a fixed number of frames.



Number of page faults = 9

For example, on our sample reference string, the optimal page-replacement algorithm would yield nine page faults, as shown in figure above. The first three references cause faults that fill the three empty frames. The reference to page 2 replaces page 7, because page 7 will not be used until reference 18, whereas page 0 will be used at 5, and page 1 at 14. The reference to page 3 replaces page 1, as page 1 will be the last of the three pages in memory to be referenced again. With only nine page faults, optimal replacement is much better than a FIFO algorithm, which results in fifteen faults. (If we ignore the first three, which all algorithms must suffer, then optimal replacement is twice as good as FIFO replacement.) In fact, no replacement algorithm can process this reference string in three frames with fewer than nine faults. Unfortunately, the optimal page-replacement algorithm is difficult to implement, because it requires future knowledge of the reference string.

3. LRU Page Replacement

As the name suggests, this algorithm is based on the strategy that whenever a page fault occurs, the least recently used page will be replaced with a new page.

reference string

7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1

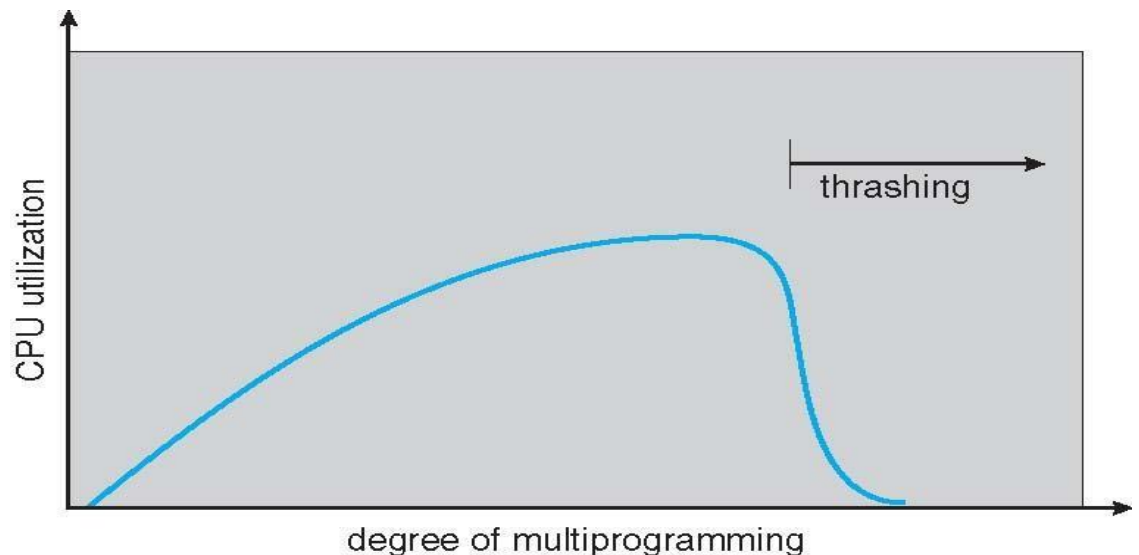
7	7	7	2		2		4	4	4	0			1		1		1		
	0	0	0		0		0	0	3	3			3		0		0		
		1	1		3		3	2	2	2			2		2		7		

page frames

Number of page faults = 12

Thrashing:

- If a process does not have “enough” pages, the page-fault rate is very high
 - Page fault to get page
 - Replace existing frame
 - But quickly need replaced frame back
 - This leads to:
 - ▶ Low CPU utilization
 - ▶ Operating system thinking that it needs to increase the degree of multiprogramming
 - ▶ Another process added to the system
- Thrashing \equiv a process is busy swapping pages in and out



Cause of thrashing :

The operating system monitors CPU utilization. If CPU utilization is too low, we increase the degree of multiprogramming by introducing a new process to the system. A global page-replacement algorithm is used; it replaces pages without regard to the process to which they belong. Now suppose that a process enters a new phase in its execution and needs more frames. It starts faulting and taking frames away from other processes. These processes need those pages, however, and so they also fault, taking frames from other processes. These faulting processes must use the paging device to swap pages in and out. As they queue up for the paging device, the ready queue empties. As processes wait for the paging device, CPU utilization decreases. The CPU scheduler sees the decreasing CPU utilization and increases the degree of multiprogramming as a result. The new process tries to get started by taking frames from running processes, causing more page faults and a longer queue for the paging device. As a result, CPU utilization drops even further, and the CPU scheduler tries to increase the degree of multiprogramming even more. Thrashing has occurred, and system throughput plunges. The page fault rate increases tremendously. As a result, the effective memory-access time increases. No work is getting done, because the processes are spending all their time paging. This phenomenon is illustrated in Figure 9.18, in which CPU utilization is plotted against the degree of multiprogramming. As the degree of multiprogramming increases, CPU utilization also increases, although more slowly, until a maximum is reached. If the degree of multiprogramming is increased even further, thrashing sets in, and CPU utilization drops sharply. At this point, to increase CPU utilization and stop thrashing, we must decrease the degree of multiprogramming.
