Memory management

Pages - fixed-size block of logical memory

Frames - fixed-size block of physical memory

page table - to translate logical to physical addresses

Hit ratio(α**) –** percentage of times that a page number is found in the associative registers

- Consider α = 80%, 20ns for TLB search, 100ns for memory access
- EAT = 0.80 x (20+100)+ 0.20 x (20+100+100)= 140ns

- Consider hit ratio -> α = 98%, 20ns for TLB search, 100ns for memory access
- EAT = 0.98 x 120 + 0.02 x 220 = 122ns

Q. The memory access time is 1 nanosecond for a read operation with a hit in cache, 5 nanoseconds for a read operation with a miss in cache, 2 nanoseconds for a write operation with a hit in cache and 10 nanoseconds for a write operation with a miss in cache. Execution of a sequence of instructions involves 100 instruction fetch operations, 60 memory operand read operations and 40 memory operand write operations. The cache hit-ratio is 0.9. The average memory access time (in nanoseconds) in executing the sequence of instructions is __________.

Sol. Total instruction=100 instruction fetch operation +60 memory operand read operation +40 memory operand write op

Total instruction=200 instructions (operations)

Time taken for fetching and reading instructions= 160(0.9(1)+0.1(5)) = 224ns
Memory operands Write operations time = 40(0.9(2)+0.1(10)) = 112ns

Total time taken for executing 200 instructions = 224 + 112 = 336ns
Average memory access time =336 ns/200=1.68ns

Q. Let the page fault service time to 10 ms in a computer with average memory access time being 20 ns. If one page fault is generated for every 10^6 memory accesses, what is the effective access time for the memory?

Sol.
P = page fault rate
P = 1/10^6

EA = p × page fault service time + (1 – p) × Memory access time
$=1/10^{\wedge 6} \times 10 \times 10^{\wedge 6} + (1-1/10^{\wedge 6}) \times 20 \cong 29.9$ ns

Belady’s anomaly

It is a phenomenon where increasing the number of page frames results in an increase in the number of page faults for a given memory access pattern.

- The reference String is given as 0 1 5 3 0 1 4 0 1 5 3 4.

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Case 1: Number of frames = 3

Request	**0**	**1**	**5**	**3**	**0**	**1**	**4**	**0**	**1**	**5**	**3**	**4**
Frame 3			5	5	5	1	1	1	1	1	3	3
Frame 2		1	1	1	0	0	0	0	0	5	5	5
Frame 1	0	0	0	3	3	3	4	4	4	4	4	4
Miss/Hit	Miss	Miss	Miss	Miss	Miss	Miss	Miss	Hit	Hit	Miss	Miss	Hit

Number of Page Faults = 9

- The reference String is given as 0 1 5 3 0 1 4 0 1 5 3 4.

Case 2: Number of frames = 4

Request	**0**	**1**	**5**	**3**	**0**	**1**	**4**	**0**	**1**	**5**	**3**	**4**
Frame 4				3	3	3	3	3	3	5	5	5
Frame 3			5	5	5	5	5	5	1	1	1	1
Frame 2		1	1	1	1	1	1	0	0	0	0	4
Frame 1	0	0	0	0	0	0	4	4	4	4	3	3
Miss/Hit	Miss	Miss	Miss	Miss	Hit	Hit	Miss	Miss	Miss	Miss	Miss	Miss

Number of Page Faults = 10