A computer whose processes have 1024 pages in their address spaces keeps its page tables in memory. The overhead required for reading a word from the page table is 500 nsec. To reduce this overhead, the computer has an associative memory which holds 32 (virtual page, physical page frame) pairs and can do look up in 100 nsec. What hit rate is needed to reduce the mean overhead to 200 nsec?

Solution

The effective instruction time is $100h + 500(1 - h)$, where h is the hit rate. 100 is the look up time & 500 is the overhead. Set the expression equal to 200 and solve for h. We get h must be 0.75 (or greater).

$$\begin{aligned} 100h + 500(1 - h) &= 200 \\ 100h + 500 - 500h &= 200 \\ -400h + 500 &= 200 \\ -400h &= -300 \\ h &= \frac{-300}{-400} \\ h &= \frac{3}{4} \implies 75\% \end{aligned}$$

Address Translation

Frame Number	Process ID	Page Number
0	1	2
1	1	1
2	2	1
3	3	0
4	1	3

Using the table above, translate the following:

1. To which physical address does virtual address 130 of process 1 map to? If this virtual address does not map to any physical address, write 'does not map'.

2. To which physical address does virtual address 17 of process 2 map to? If this virtual address does not map to any physical address, write 'does not map'.

3. Which virtual address of which process maps to physical address 50?

Solution

1. logical = $(1 \times 100) + 30 \implies 130$
   Physical = frame# = $1 \implies (1 \times 100) + 30 = 130$

2. Virtual address 17 does not map

3. Physical address = $(0 \times 100) + 50 = 50$ Where 0 is the frame#
   So, logical address = $(2 \times 100) + 50 = 250$ Where 2 is the page#

File system implementation

Consider a File system that maintains unique index node for each file in the system. Each index node includes 10 direct pointers, a single indirect pointer, and a double indirect pointer. The file system block size is 1024 bytes, and a block pointer occupies 4 bytes.

1. What is the maximum file size that can be supported by the index node?

2. How many disk operations will be required if a process read data from the N^{th} block of a file? Assume that the file is already open, the buffer cache is empty, and each disk operation read a single file block. Your answer should be given in terms of N.

Solution

1. $1024 * (10 + 2^8 + 2^8 * 2^8)$
   $\implies 2^{10} * (2^3 + 2 + 2^8 + 2^{16})$
   $\implies 2^{13} + 2^{11} + 2^{18} + 2^{26}$

2. $0 \leq N < 8$, One operation
   $8 \leq N < 256 + 8$, Two operations
   $256 + 8 \leq N < 2^{13} + 2^{11} + 2^{18} + 2^{26}$, Three operations