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. $0 \leq N < 10$, One operation
   $10 \leq N < 256 + 10$, Two operations
   $256 + 10 \leq N < 2^{13} + 2^{11} + 2^{18} + 2^{26}$, Three operations

- Contiguous Allocation : Each file occupies a set of contiguous blocks on the disk.
- Linked Allocation : Each file is a linked list of disk blocks: blocks may be scattered anywhere on the disk.
- Indexed Allocation : Brings all pointers together into the index block.

Disk Scheduling

- First-come, First-served: the requests are processed in the order they were received.
- Shortest Seek Time First: Process the request that is closest to the arms current position.
- SCAN: Process all the requests going in one direction until they are complete, and then change the direction of the arm and process the rest of the requests.
- C-SCAN: Process all the requests going in one direction. When arm reaches the end, start back at the beginning and finish out the rest of the requests.
- C-LOOK: Process all the requests in one direction, when the last request in that direction is completed, change the direction of the arm and process the rest of the requests in the other direction.

Page Replacement Algorithms

- First-in First-out (FIFO): when a page must be replaced, the oldest page is chosen.
- Optimal: Replace page that will not be used for the longest period of time.
- LRU: Replace the page that has not been used for the longest period of time.

Deadlock

Four conditions for deadlock:

- Mutual Exclusion
- Hold and Wait
- No Preemption
- Circular Wait

For calculating the needs matrix, we take maximum − current. To derive the safe order, We start with the initial work, and we check the current allocation and if that is less than the current work, that process is added to safe state & then we add the current allocation to the work available.

Segmentation

A virtual memory system supports 12 bits length virtual addresses. It uses pure segmentation with a maximum segment size of 2^{10} (1024) bytes. Suppose that the segment table for the currently running process looks as follows:

Segment #	V	P	Start	Length
0	1	1	0	200
1	1	0	1000	160
2	0	0	0	0
3	1	0	200	300

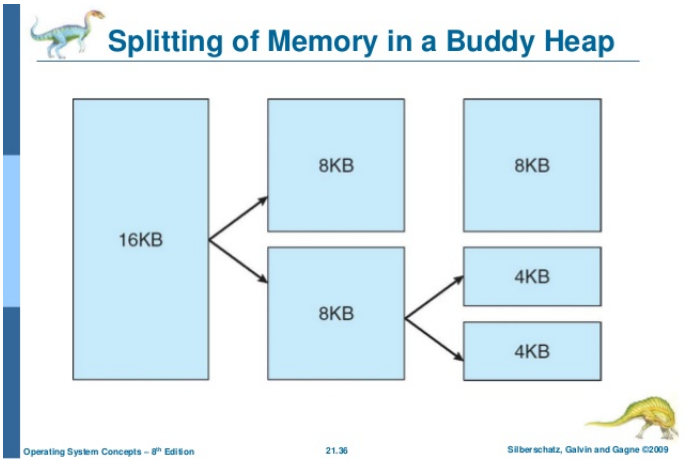
In the table above V and P are the segment 'valid' and 'protection' bits, 'start' represents the physical address of the start of the segment and 'Length' is the segments's length. $P = 1$ indicates that a segment is read-only.
Consider the following read and write operations. If the specified operation would succeed given the segment table shown above, give the physical address to which the specified virtual address would translate. If it would not succeed, state the reason that it would fail.

1. A write to virtual address 150
2. A read from virtual address 1025
3. A write to virtual address 400

Solution

1. $150 = (0 \times 1024) + 150$
   $150 < 200$
   This would fail because there is a protection bit $\implies$ read-only.
2. $1025 = (1 \times 1024) + 1$
   $1 < 1160$
   Physical address = 1001.
3. $4000 = (3 \times 1024) + 928$
   $928 > 500$
   This would fail because of a trap: Addressing error.

Buddy Algorithm



This would represent a request for < 4KB. In the example above one of the 4KB blocks would be allocated to the current request. Internal fragmentation is wasted memory visible only to the process making the memory request. Internal fragmentation occurs in buddy allocation because memory requests must be rounded up to the nearest power of 2.
So, for example if we had a request of 2KB, then the internal fragmentation would be $4KB - 2KB = 2KB$
External fragmentation is wasted memory visible to the system outside of the requesting processes. External fragmentation occurs because not all requests (even after they've been rounded up to the nearest power of two) are the same size; therefore, it is possible that a memory request will not be able to satisfied, even when there is enough total free memory in the system.
Basically: External fragmentation is because it's not contiguous.