

1. A certain computer provides its users with a virtual-memory space of 2^{32} bytes. The computer has 2^{18} bytes of physical memory. The virtual memory is implemented by paging, and the page size is 4096 bytes. A user process generates the virtual address 11123456. Explain how the system establishes the corresponding physical location. Distinguish between software and hardware operations.

2. A page-replacement algorithm should minimize the number of page faults. We can do this minimization by distributing heavily used pages evenly over all of memory, rather than having them compete for a small number of page frames. We can associate with each page frame a counter of the number of pages that are associated with that frame. Then, to replace a page, we search for the page frame with the smallest counter.

a. Define a page-replacement algorithm using this basic idea. Specifically address the problems of (1) what the initial value of the counters is, (2) when counters are increased, (3) when counters are decreased, and (4) how the page to be replaced is selected.

b. How many page faults occur for your algorithm for the following reference string, for four page frames?

1, 2, 3, 4, 5, 3, 4, 1, 6, 7, 8, 7, 8, 9, 7, 8, 9, 5, 4, 5, 4, 2.

c. What is the minimum number of page faults for an optimal page-replacement strategy for the reference string in part b with four page frames?

1. $4096 = 2^{12}$ 字节 \Rightarrow 页面大小, 页表大小 2^{20}

11123456 % 4096 = 2816 \Rightarrow 页内偏移

11123456 / 4096 = 2715 \Rightarrow 页号

虚拟地址低 12 位作为页面中的偏移量

高 20 位为在页表中的偏移量, 也就是页号

通过页表将虚拟页号映射到物理页号

硬件操作: MMU 从虚拟地址中提取页号, 并查询页表

软件操作: 若虚拟页不在内存中, 从磁盘中取出页面, 放入

空闲的物理帧, 并更新页表, 将 111216 与该帧号关联

物理地址就是: 物理帧号 $\times 2^{12}$ + 页内偏移量 = 帧号 \times 页大小 + 偏移量

从页表读取的物理地址左移 12 位 加上页内偏移量

2.

a. (1) 0

(2) 当一个新页面与该页帧相关联

(3) 不成功

(4) 选择计数器最小的页帧，计数器相同，使用FIFO

b. 串	缺页	计数器
1. 1	页帧: 1	✓ 1 0 0 0
2. 2	页帧: 1 2	✓ 1 1 0 0
3. 3	页帧: 1 2 3	✓ 1 1 1 0
4. 4	页帧: 1 2 3 4	✓ 1 1 1 1
5. 5	页帧: 5 2 3 4	✓ 2 1 1 1
6. 3	页帧: 5 2 3 4	✓ 2 1 1 1
7. 4	页帧: 5 2 3 4	✓ 2 1 1 1
8. 1	页帧: 5 1 3 4	✓ 2 2 1 1
9. 6	页帧: 5 1 6 4	✓ 2 2 2 1
10. 7	页帧: 5 1 6 7	✓ 2 2 2 2
11. 8	页帧: 8 1 6 7	✓ 3 2 2 2
12. 7	页帧: 8 1 6 7	3 2 2 2
13. 8	页帧: 8 1 6 7	3 2 2 2
14. 9	页帧: 8 9 6 7	✓ 3 3 2 2
15. 7	页帧: 8 9 6 7	3 3 2 2
16. 8	页帧: 8 9 6 7	3 3 2 2
17. 9	页帧: 8 9 6 7	3 3 2 2
18. 5	页帧: 8 9 5 7	✓ 3 3 3 2
19. 4	页帧: 8 9 5 4	✓ 3 3 3 3
20. 5	页帧: 8 9 5 4	3 3 3 3

21. 4 页帧: 8954 3333

22. 2 页帧: 2954 ✓ 4333

缺页 13 次

C. 串 缺页

1. 1 页帧: 1 ✓

2. 2 页帧: 1 2 ✓

3. 3 页帧: 1 2 3 ✓

4. 4 页帧: 1 2 3 4 ✓

5. 5 页帧: 1534 ✓

6. 3 页帧: 1534

7. 4 页帧: 1534

8. 1 页帧: 1534

9. 6 页帧: 6534 ✓

10. 7 页帧: 6574 ✓

11. 8 页帧: 8574 ✓

12. 7 页帧: 8574

13. 8 页帧: 8574

14. 9 页帧: 8579 ✓

15. 7 页帧: 8579

16. 8 页帧: 8579

17. 9 页帧: 8579

18. 5 负帧: 8579

19. 4 负帧: 8549 ✓

20. 5 负帧: 8549

21. 4 负帧: 8549

22. 2 负帧: 8249 ✓

缺负 11次