**CHAPTER 4 - Memory**

**Questions 1**

Consider the following page reference string: e, c, b, e, a, g, d, c, e, g, d, a

With 4 frames, how many page faults would occur with the following page replacement algorithms? Fill in the tables accordingly.

RS: reference strings; F0: frame 0, F1: frame 1, etc.

*Hint: all frames are initially empty, so your first unique pages will all cost one fault each.*

1. Optimal

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| RS | e | c | b | e | a | g | d | c | e | g | d | a |
| F0 | e | e | e | e | e | e | e | e | e | e | e | a |
| F1 |  | c | c | c | c | c | c | c | c | c | c | c |
| F2 |  |  | b | b | b | g | g | g | g | g | g | g |
| F3 |  |  |  |  | a | a | d | d | d | d | d | d |
| Page fault? | x | x | x |  | x | x | x |  |  |  |  | x |

Total page fault: 7PF

2. LRU

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| RS | e | c | b | e | a | g | d | c | e | g | d | a |
| F0 | e | e | e | c | c | b | e | a | g | d | c | e |
| F1 |  | c | c | b | b | e | a | g | d | c | e | g |
| F2 |  |  | b | e | e | a | g | d | c | e | g | d |
| F3 |  |  |  |  | a | g | d | c | e | g | d | a |
| Page fault? | x | x | x |  | x | x | x | x | x |  |  | x |

Total page fault: 9

3.Second chance

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| RS | e | c | b | e | a | g | d | c | e | g | d | a |
| F0 | e | e | e | E\* | e | c | b | a | g | G\* | G\* | g |
| F1 |  | c | c | c | c | b | a | g | d | d | D\* | d |
| F2 |  |  | b | b | b | a | g | d | c | c | c | a |
| F3 |  |  |  |  | a | g | d | c | e | e | e | e |
| Page fault? | x | x | x |  | x | x | x | x | x |  |  | x |

Total page fault: 9

**Questions 2**

**1.** True or False? A program does not need to be stored in memory in its entirety.

**2.** True or False? A physical address space is at least as large as a virtual address space.  
3. When does a page fault occur?

**4.** True or False? In a pure demand paged system a page is never brought into memory until it is needed.

1. A machine has 48 bit virtual addresses and 32 bit physical addresses. Pages are 8 KB. How many entries are needed for the page table?

2^35 pages

1. For each of the following decimal virtual addresses, compute the virtual page number and offset for a 4-KB page and for an 8 KB page: 20000, 32768, 60000.

2.1 Page size = 4KB

20000 = page number \* 4 \* 1024 + offset

|  |  |  |
| --- | --- | --- |
| Virtual address | Page number | Offset |
| 20000 | 4 | 3616 |
| 32768 | 8 | 0 |
| 60000 | 14 | 2656 |

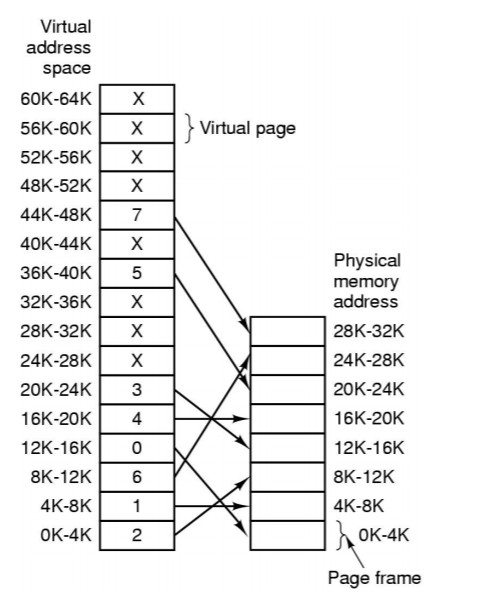
2.2 Page size = 8KB

20000 = page number \* 8 \* 1024 + offset

|  |  |  |
| --- | --- | --- |
| Virtual address | Page number | Offset |
| 20000 | 2 | 3616 |
| 32768 | 4 | 0 |
| 60000 | 7 | 2565 |

3. The figure below shows a virtual address space from 0 to 64K and 32K of physical memory. There are 16 pages and 8 frames and transfers between memory and disk are in pages. Give the physical address corresponding to the following virtual addresses, explain how did you get the answer?:

a) 20 b) 4100 c) 8300

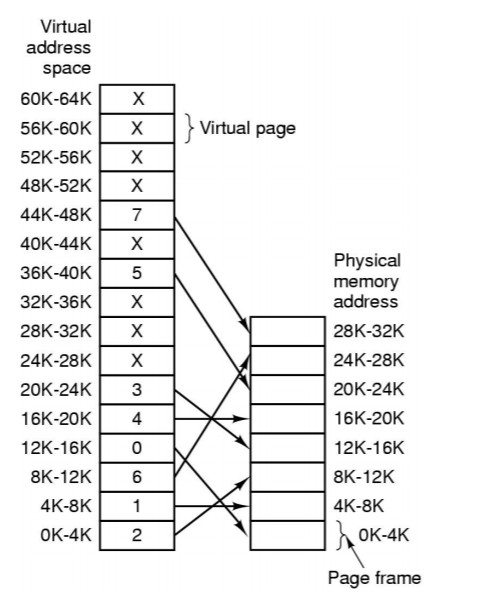


4. A memory free in 3 frames. How many page fault occur after running as the following page 7, 0 , 1, 2 , 0, 3, 0 , 4, 2 , 3 , 0 , 3 , 2 , 1, 2, 0, 1, 0 , 7 using FIFO

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **7** | **0** | **1** | **2** | **0** | **3** | **0** | **4** | **2** | **3** | **0** | **3** | **2** | **1** | **2** | **0** | **1** | **0** | **7** |
| F1 | 7 | 7 | 7 | 0 | 0 | 1 | 2 | 3 | 0 | 4 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 1 |
| F2 |  | 0 | 0 | 1 | 1 | 2 | 3 | 0 | 4 | 2 | 3 | 3 | 3 | 0 | 1 | 1 | 1 | 1 | 2 |
| F3 |  |  | 1 | 2 | 2 | 3 | 0 | 4 | 2 | 3 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 2 | 7 |
| PF | x | x | x | x |  | x | x | x | x | x | x |  |  | x | x |  |  |  | x |

=> 13PF

2. With given page table and 16 bit virtual address, that is split 4 bit page numbers and 12 bit offset. If user references the address 15016, which physical address is in memory?



Answer: ? 2728

3. A memory free in 4 frames. How many page faults do occur after running as the following page 2 3 2 0 1 5 2 4 5 3 2 5 2 using LRU

Answer:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2** | **3** | **2** | **0** | **1** | **5** | **2** | **4** | **5** | **3** | **2** | **5** | **2** |
| F1 | 2 | 2 | 3 | 3 | 3 | 2 | 0 | 1 | 1 | 2 | 4 | 4 | 4 |
| F2 |  | 3 | 2 | 2 | 2 | 0 | 1 | 5 | 2 | 4 | 5 | 3 | 3 |
| F3 |  |  |  | 0 | 0 | 1 | 5 | 2 | 4 | 5 | 3 | 2 | 5 |
| F4 |  |  |  |  | 1 | 5 | 2 | 4 | 5 | 3 | 2 | 5 | 2 |
| PF | x | x |  | x | x | x |  | x |  | x |  |  |  |

=> 7PF

4. A memory free in 4 frames. Which state of the memory after the page 4 is accessed when the requested page as 2 3 2 0 1 5 2 4 5 3 2 5 2 using LRU

6. Assume that the Page Table below is in effect. The number of lines per page is 400. The actual memory location for line 1634 is \_\_\_\_\_34\_\_ .

|  |  |
| --- | --- |
| Page Number | Page Frame Number |
| 0  1  2  3  4 | 8  10  5  11  0 |

7. A computer has four page frames. The time of loading, time of last access, and the R and M bits for each page are as shown below (the times are in clock ticks):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Page | Loaded | Last ref | R | M |
| 0 | 226 | 280 | 0 | 0 |
| 1 | 160 | 265 | 0 | 1 |
| 2 | 110 | 270 | 1 | 0 |
| 3 | 120 | 285 | 1 | 1 |

Which page will LRU replace?, lấy thời gian lâu nhất không dùng đến => page 1

1

8. A computer has four page frames. The time of loading, time of last access, and the R and M bits for each page are as shown below (the times are in clock ticks):

Page Loaded Last ref. R M

------------------------------------------------------------------------------

0 226 280 0 0 => class 0

1 160 265 0 1 => class 1

2 110 270 0 0 => class 0

3 120 285 1 1 => class 3

Which page will Second Chance replace? (NRU)

Page sẽ bị thay thế đầu tiên do không có cơ hội lần thứ 2 (R = 0)

Với thuật toán NRU thì class 0 ưu tiên bị thay thế đầu tiên nên page 0 sẽ bị thay thế đầu tiên

9. A memory free in 3 frames. How many page hits do? Assume that the running as the following page 7, 0 , 1, 2 , 0, 3, 0 , 4, 2 , 3 , 0 , 3 , 2 , 1, 2, 0, 1, 0, 7 using LRU

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **7** | **0** | **1** | **2** | **0** | **3** | **0** | **4** | **2** | **3** | **0** | **3** | **2** | **1** | **2** | **0** | **1** | **0** | **7** |
| F1 | 7 | 7 | 7 | 0 | 1 | 2 | 2 | 3 | 0 | 4 | 2 | 2 | 0 | 3 | 3 | 1 | 2 | 2 | 1 |
| F2 |  | 0 | 0 | 1 | 2 | 0 | 3 | 0 | 4 | 2 | 3 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 0 |
| F3 |  |  | 1 | 2 | 0 | 3 | 0 | 4 | 2 | 3 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 7 |
| PF | x | x | x | x |  | x |  | x | x | x | x |  |  | x |  | x |  |  | x |

=> 12PF

1. A computer provides the user with virtual address space of 2^32  
    (2 to the power 32) bytes. Pages of size 4096 (4K or 2^12) bytes  
    are used for implementing virtual memory where the total physical  
    memory is equal to 2^18 bytes. If the hexadecimal virtual  
    address is 23456111, the page number in hexadecimal would be?

23456111 = 0010 0011 0100 0101 0110 0001 0001 0001

Số trang địa chỉ ảo là 20 bit đầu, offset là 12 bit sau

=> số trang địa chỉ ảo là 0010 0011 0100 0101 0110 = 23456

10. A computer has four page frames. The time of loading, time of last  
 access, and the R and M bits for each page are as shown below   
 (the times are in clock ticks):  
  
 Page Loaded Last Ref. R M  
 0 230 285 1 0  
 1 120 265 => LRU 0 0 => NRU, 2nd  
 2 140 270 0 1  
 3 110 => FIFO 280 1 1  
  
 (a) Which page will NRU replace? (1)  
 (b) Which page will FIFO replace? (3)  
 (c) Which page will LRU replace? (1)  
 (d) Which page will second chance replace? (1)

11. Consider a logical address space of 64 pages of 2048 words each, mapped   
 unto a physical memory of 32 frames.  
  
 a) How many bits are there in logical address?

64x2024 => 2^15

17  
 b) How many bits are there in physical address?

32 x 2024 => 2^16

16

12. A system with 32 bit virtual address. If the page size is 4 KB and each table entry occupies 4 bytes, what is the size of the page table?

Consider a swapping system in which the memory consists of the following hole sizes: 10K, 4K, 20K, 15K, 9K. Assume worst fit algorithm is used. Which holes are taken for successive segment requests of 8K,

13. If there are 64 pages and the page size is 2048 words, what is the length of logical address?

14. A system with 32 bit virtual address. If the page size is 4 KB and each table entry occupies 4 bytes, what is the size of the page table?

total pages = 2^20, số lượng trang

size of page table = 4B \* 2 ^ 20 = 4MB, kích thước bản trang

size of virtual memory = 2^ 20 \* 4KB = 4GB, kích thước bộ nhớ ảo