Alexandria University
Faculty of Engineering
Comp. & Comm. Engineering
CC373: Operating Systems

جامعة الاسكندرية
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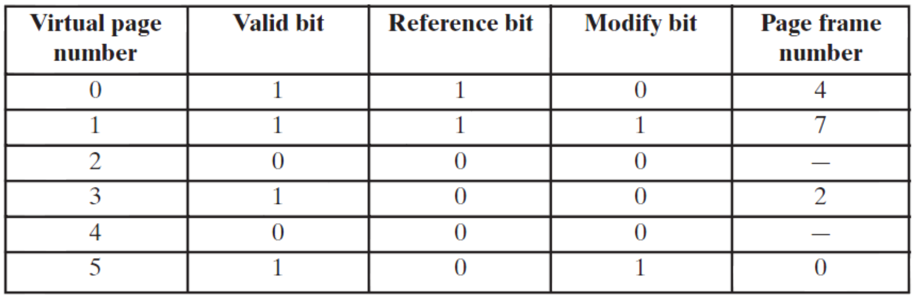
مادة نظم التشغيل

Sheet8

VIRTUAL MEMORY

1) What is the difference between simple paging and virtual memory paging?
2) Explain thrashing.
3) Why is the principle of locality crucial to the use of virtual memory?
4) What elements are typically found in a page table entry? Briefly define each element.
5) What is the purpose of a translation lookaside buffer?
6) Suppose the page table for the process currently executing on the processor looks like the following. All numbers are decimal, everything is numbered starting from zero, and all addresses are memory byte addresses. The page size is 1024 bytes.



Virtual page number	Valid bit	Reference bit	Modify bit	Page frame number
0	1	1	0	4
1	1	1	1	7
2	0	0	0	—
3	1	0	0	2
4	0	0	0	—
5	1	0	1	0

   a) Describe exactly how, in general, a virtual address generated by the CPU is translated into a physical main memory address.
   b) What physical address, if any, would each of the following virtual addresses correspond to? (Do not try to handle any page faults, if any.)
      i. 1052
      ii. 2221
      iii. 5499

7) Consider the following program.

```
#define Size 64
int A[Size; Size], B[Size; Size], C[Size; Size];
int register i, j;
for (j = 0; j< Size; j ++)
for (i = 0; i< Size; i++)
C[i; j] = A[i; j] + B[i; j];
```

Assume that the program is running on a system using demand paging and the page size is 1 Kilobyte. Each integer is 4 bytes long. It is clear that each array requires a 16-page space. As an example, A[0, 0]-A[0, 63], A[1, 0]-A[1, 63], A[2, 0]-A[2, 63], and A[3, 0]-A[3, 63] will be stored in the first data page. A similar storage pattern can be derived for the rest of array A and for arrays B and C. Assume that the system allocates a 4-page working set for this process. One of the pages will be used by the program and three pages can be used for the data. Also, two index registers are assigned for i and j (so, no memory accesses are needed for references to these two variables).

a) Discuss how frequently the page fault would occur (in terms of number of times C[i, j] = A[i, j] + B[i, j] are executed).
b) Can you modify the program to minimize the page fault frequency?
c) What will be the frequency of page faults after your modification?

8) Two questions:
   a) How much memory space is needed for the user page table of Figure 8.3?
   b) Assume you want to implement a hashed inverted page table for the same addressing scheme as depicted in Figure 8.3, using a hash function that maps the 20-bit page number into a 6-bit hash value. The table entry contains the page number, the frame number, and a chain pointer. If the page table allocates space for up to 3 overflow entries per hashed entry, how much memory space does the hashed inverted page table take?

9) Assuming a page size of 4 Kbytes and that a page table entry takes 4 bytes, how many levels of page tables would be required to map a 64-bit address space, if the top level page table fits into a single page?

10) Assume that a task is divided into four equal-sized segments and that the system builds an eight-entry page descriptor table for each segment. Thus, the system has a combination of segmentation and paging. Assume also that the page size is 2 Kbytes.
   a) What is the maximum size of each segment?
   b) What is the maximum logical address space for the task?
   c) Assume that an element in physical location 00021ABC is accessed by this task. What is the format of the logical address that the task generates for it? What is the maximum physical address space for the system?

11) Consider a paged logical address space (composed of 32 pages of 2 Kbytes each) mapped into a 1-Mbyte physical memory space.
   a) What is the format of the processor’s logical address?
   b) What is the length and width of the page table (disregarding the “access rights” bits)?
   c) What is the effect on the page table if the physical memory space is reduced by half?

How to submit the homework assignments?

- Solve the sheet individually without looking up the solution on the Internet. The sheet is to practice; it is a learning tool not an exam.
- Assignments are to be **handwritten**.
- Papers are to be scanned (I like camscanner app). Put all images in a pdf file (camscanner does that for you)
- Use MS Teams to submit
  - Your filename should be your user id