Fundamentos de los Sistemas Operativos

Departamento de Informática de Sistemas y Computadoras (DISCA)
Universitat Politècnica de València

fSO

Part 4. Memory management

Exercises

UT09, UT10, UT11 and UT12

Content

1 CONTIGUOUS ALLOCATION 2

2 SPARSE ALLOCATION 2

3 VIRTUAL MEMORY 3

3.1 Replacement algorithms 3

3.2 Thrashing 4

4 APPENDIX: NOTES ABOUT EXERCISES RESOLUTION 5

1 Contiguous allocation

1. Let consider a system where memory allocation is done by using multiple fixed size partitions. What will determine the limit of multiprogramming level in that system?

2. Indicate whether the following statements are true (T) or false (F) and explain why.
   - **a.** Fixed partition-based memory management uses the compaction method to solve the problem of external fragmentation.
   - **b.** The physical address space depends on the system address bus.
   - **c.** The logical address space is limited by the size of the physical memory.
   - **d.** Process compaction in contiguous allocation can only be done with dynamic memory allocation of processes.

3. What algorithms are used to manage memory with multiple variable size partitions? What type of fragmentation may occur in these systems?

4. Let a system managed by multiple variable size partitions without compaction. At a given instant, there is the following memory occupation:

0 ... 1200K

S.O. (80K)	P1 (180K)	Free (400K)	P2 (100K)	Free (150K)	P3 (90K)	Free (200K)

   - **a.** In the input queue there are processes on the following order: P4 (120 K), P5 (200 K), and P6 (300 K). The queue is FIFO. Assuming that no processes finish decide what technique between best fit and worse fit is more convenient to allocate the incoming processes and why.
   - **b.** From the initial situation suppose that the input queue has the following processes P4 (151 K), P5 (240 K) and P6 (200K), in that order. Assuming that no processes finish decide which technique between best fit and worse fit is convenient to allocate the incoming processes and why.

2 Sparse allocation

5. Suppose that a process emits logical address 2453 and that paging is used with pages of 1024 words.
   - **a.** Indicate the pair of values (page number, offset) corresponding to that address.
   - **b.** Explain if it is possible that such logical address be translated into the physical address 9322.

6. Indicate which of the following mechanisms of memory management can produce external fragmentation: variable partitions, paging, segmentation and segmentation with paging.

7. In a memory system with **two levels paging** that allows grouping pages into page directories. Each page directory may contain up to 1024 pages. The system logical address space is 4 GByte, page size is 4 KByte and the page descriptor size is 4 bytes. The physical address space is up to 1 GByte. Describe the structure of logical and physical addresses in this system.

8. In a system with **two levels paging** the first level is used to divide a logical address space into regions while the second level is used to divide a region into pages. The logical address space size is 4 GByte, the physical address space is 2 GByte and page size is of 4 KByte. Assuming that in a region cover 512 pages and that a page descriptor of any level is 8 byte:
   - **a.** What is the structure of the **physical and logical addresses**?
   - **b.** For given process what is the maximum space in bytes dedicated to its page tables?

3 Virtual memory

3.1 Replacement algorithms

13. A System with virtual memory based on **demand paging**, with main memory size of 5000 words and page size of 1000 is words. At any given time there are 3 processes P1, P2 and P3 in the system that generate the following sequence of logical addresses (have been staged pairs composed of process and the logical address): (P1, 1023) (P2, 0224) (0783 P1) (P3, 3848) (1089 P3) (P3, 0098) (2345 P2) (P1, 0787) (1654 P1) (P3, 2899) (P3, 3008) (1111 P3). Make a diagram of the situation of each page into physical memory in the following cases:

a. Using **the optimal algorithm** with global replacement.

b. Using **the optimal algorithm** with local replacement.

14. Given a system with virtual memory by **demand paging**, where:

- A logical address consists of 12-bit, 3 of which are for the page number.
- A physical address contains 11 bits.
- There are two processes (A and B), and all of the physical memory is shared between these two processes alike.
- A **local scope page replacement algorithm** is used.

Initially physical memory is empty, obtain the evolution of main memory page allocation corresponding to the following sequence of logical addresses: (1035 A) (B, 312) (A, 530) (B, 780) (A, 600) (A, 2000) (B, 1400) (B, 927) (1030 A) (1720 A)

Note: the pair (a, x) indicates (process, dir. logic in decimal)

16. Be a **demand paging** system with **global replacement scope** and main memory with 4 frames. At a given time the following sequence of references to pages is issued:

1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6

Consider that the frames are initially empty and they are assigned in frame id order. Obtain the number of **page faults** that occur with the following replacement algorithms:

a. LRU

b. Optimum

17. A virtual memory system with **demand paging** and **LOCAL LRU** page replacement with the following features:

- Page size: 512 words
- Number of frames in memory: 6
- LRU implemented using counters
- Frame allocation by increasing frame id and proportional to the number of process pages.

At t = 11 two processes A and B enter the system, whose sizes are 4000 and 2030 words, respectively. The page tables of both processes are shown below for that time (v = valid, i = invalid, cont = time instant at which page has been referenced).

Process A page table		
Frame	Valid bit	Counter

Process B page table		
Frame	Valid bit	Counter

0		I	
1		I	
2	2	V	10
3	5	V	3
4		I	
5	4	V	5
6		I	
7		I	

0		i	
1		i	
2		i	
3	1	v	2

From this moment the following references are generated:

(A, 250), (A, 1600), (B, 53), (B, 1500), (A, 1550), (B, 260), (A, 3115)
(B, 2029), 3000 (A), (A, 50), 2000 (A), (B, 1200), (A, 3015)

Show the **final content of memory and calculate the physical addresses** that produce the **last four logical addresses** referenced.

18. On a virtual memory system with **demand paging and local replacement**, each process have assigned a maximum of 4 frames. The maximum logical size of a process is 4K pages (3 digits in hexadecimal), while the page size is 4KBytes. The following table contains information about the Pr_1 process at a given time "t":

Pr_1 process information at time "t"					
Frame (Hexadecimal)	**Page** (Hexadecimal)	**Load time**	**Last reference time**	**R bit (reference)**	**M bit (modified)**
E7	A72	60	160	0	0
E8	A71	105	105	1	1
E9	C70	26	120	0	0
EA	C73	20	110	1	1

Then the Pr_1 process emits logical address B745AC.

Get the physical address corresponding to that logical address assuming the following page replacement policies:

a. FIFO
b. LRU
c. Second chance (assume that the pointer to the next victim points to the A71 page)

Note. Use hexadecimal notation to reduce calculations.

3.2 Thrashing

20. Tell whether the following statements about the model of the active area are **true (T) or false (F)** and explain your answer:

a. If the sum of the sizes of the working set windows of the various processes on a system is greater than the number of frames in physical memory, then thrashing happens.

b. If a process's logical address space is 1024 pages and its working set size at a given time is 512 pages, then the process will cause thrashing in all cases.

c. An MMU that could cause an interruption every fixed number of references to memory and manage the referenced bit, could calculate exactly the active area size.

d. In a system with active area window size of 1024, the working set size at a given time "t" would be 1024 if, and only if, the last 1024 pages of references sequence are different.

e. If the number of frames that are assigned to a given process increases, then the working set size will also increase.

21. Given the following sequences of references issued by a given process:
... 5 5 8 3 2 2 3 2 3 5 8 2 9 7 (t_1) 7 9 2 2 9 10 9 10 9 10 9 10 10 2 (t_2) ...
using the working set model with active area Δ = 10. Indicate whether the following statements are **true (T) or false (F)** and explain your answer.

- **a.** The working set size is 10 at both t1 and t2.
- **b.** The working set at t2 is made of frames {2, 9, 10}.
- **c.** The working set at t1 is made of pages {2, 3, 5, 7, 8, 9}.
- **d.** With the provided information we cannot know which pages define the working set at t1 and t2, we also need to know the process locality of reference.
- **e.** The working set size at t2 is 4.
- **f.** If this process has 6 frames allocated at t1 them it will not produce any page fault between t1 and t2.

22. In a time-sharing system which processes A and B have been executed and along their execution the following page reference sequence has been observed:

Time	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19
Process/Page	A1	B2	A3	B4	A2	B1	A5	B6	A2	B1	A2	B3	A7	B6	A3	B2	A1	B2	A3	B6

Bearing in mind that the working set window size is 4, obtain the working sets for A and for B at T6, T10, T14 and T19.

4 Appendix: Notes about exercises resolution

- The criteria applied to the valid bit in page descriptors is the following: 1 means page allocated in physical memory and 0 means page not allocated, "v" means valid and "i" means invalid.
- In exercises where there is memory assignment to processes and nothing is specified about how it is dome, we will suppose that physical memory is initially free and that memory frames are assigned in increasing frame id order as they are allocated by page faults.