UNIVERSITAT POLITÈCNICA DE VALÈNCIA
Departamento de Informática de Sistemas y Computadores (DISCA)

fSO

FINAL exam
Januray 23th, 2020

etsinf
Escola Tècnica Superior d'Enginyeria Informàtica

SURNAME		NAME		Group
ID		Signature		

- **Keep the exam sheets stapled.**
- **Write your answer inside the reserved space.**
- **Use clear and understandable writing. Answer briefly and precisely.**
- **The exam has 9 questions, everyone has its score specified.**
- **Remember that you have to appropriately explain your answers to get the full corresponding score**

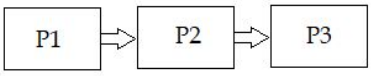
1. Considering the execution without errors of the following code, answer the following questions: :

(1,2 points = 0,6 + 0,4 + 0,2)

```
 1 #include <all_needed.h>
 2 int main() {
 3     int i;
 4     pid_t pid;
 5
 6     for (i=0; i<2; i++) {
 7         pid = fork();
 8         if (pid != 0) {
 9             sleep(10 - 4 * i));
10             break;
11         }
12     }
13     if (i == 2) sleep(2);
14     while (wait(NULL) =! -1);
15     exit(0);
16 }
```

1 **a)** ¿How many processes are created along its execution? Draw the relationship diagram between them.

3 processes are created. The initial process executes the for loop for i = 0, creating a child with fork () and then goes on suspension for 10 seconds, after which it exits the loop with break. The created child does the same but is suspended for 6 seconds, the newly created child no longer executes the for loop since i = 2 and goes to sleep for 2 seconds. All created processes await their possible children. The process scheme is a chain.



b) ¿What processes stay on zombie state?¿for how long?

Possible zombie states only occur in child processes. The first child is suspended along 6 seconds and his parent along 10 seconds, therefore it is in zombie state during 4 seconds. The second child is suspended along 2 seconds and his parent along 6 seconds, therefore it is also in zombie state during 4 seconds.

c) Considering a multiprogrammed system and that the execution time of the instructions is negligible compared to sleep times, how long does the program take to run?

Since the processes run concurrently, the execution time is the longest suspension time, that is, 10 seconds.

2. Be a timeshare system with a short-term scheduler with two ready queues: Queue0 managed by Round Robin with quantum q = 1ut and Queue1 managed by FCFS. The policy between queues is preemptive priorities, having Queue0 the highest priority. New processes and those that come from I/O access go to Queue0, and demote to Queue1 when they consume a CPU quantum while not having ended the actual CPU burst. If several events occur at the same time, they are ordered as: new, coming from I/O and quantum end. There is a single I/O device managed by FCFS. Three processes, A, B and C, arrive to this system whose arrival times and standing alone execution profiles are the following: :

Process	Arrival time	Standing alone profile
A	0	2 CPU + 3 I/O + 4 CPU
B	1	1 CPU + 1 I/O + 2 CPU
C	2	4 CPU + 2 I/O + 1 CPU

(1,6 points = 1,2 + 0,4)

a) Fill the following execution time diagram:

T	Queue1	Queue0	CPU	I/O queue	I/O	Event
0		(A)	A(1)			A arrives
1	A	(B)	B(0)			B arrives
2	A	(C)	C(3)		B(0)	C arrives
3	C, A	(B)	B(1)			
4	B, C		A(0)			
5	B		C(2)		A(2)	
6	B		C(1)		A(1)	
7	B		C(0)		A(0)	
8	B	(A)	A(3)		C(1)	
9	A		B(0)		C(0)	
10	A	(C)	C(0)			B ends
11			A(2)			C ends
12			A(1)			
13			A(0)			
14						A ends
15						
16						
17						
18						

b) Indicate turnaround time and waiting time for every process.

	Process A	Process B	Process C
Turnaround time	14 - 0 = 14	10 - 1 = 9	11- 2 = 9
Waiting time	5	5	2

3. In the next piece of code lines 7, 13 and 25 are completed each one with one instruction.

(1,2 points = 0,4 + 0,4 + 0,4)

```
1  #include <all_needed.h>
2
3  int V = 0;
4  pthread_t thr1, thr2;
5
6  void *thread1( void *ptr ){
7     /**complete**/
8     V = 1;
9     printf("T1 V=%d\n",V);
10 }
11
12 void *thread2( void *ptr ){
13    /**complete**/
14    V = V + 10;
15    printf("T2 V=%d\n",V);
16 }
17
```

```
18 int main(int argc, char* argv[]){
19    pthread_attr_t atrib;
20    pthread_attr_init(&atrib);
21
22    pthread_create(&thr1,&atrib, thread1, NULL);
23    pthread_create(&thr2,&atrib, thread2, NULL);
24
25    /**complete**/
26    V = V + 100;
27    printf("Main V=%d\n",V);
28 }
...
```

Several possibilities are proposed below to complete these lines. Indicate for every possibility the messages that will be displayed on the screen after the code execution explaining your answer .

a) line 7 - sleep(1);
line 13 - sleep(3);
line 25 - sleep(2);

T1 V=1
Main V=101
The main thread ends before thread2 and ends the process, without thread2 being able to print.

b) line 7 - sleep(5);
line 13 - sleep(2);
line 25 - pthread_exit(0);

T2 V=10
T1 V=1
pthread_exit call causes the main thread to end on line 25 (without doing printf) but allows the other two threads to continue, and therefore can take out the V values, first thread2 and then thread1.

c) line 7 - sleep(5);
line 13 - pthread_join(thr1,NULL);
line 25 - pthread_join(thr2,NULL);

T1 V=1
T2 V=11
Main V=111
In this case, thread2 waits for the end of thread1 and the main thread waits for the end of thread2.

4. Given the following code that uses POSIX threads and semaphores:

```
#include <semaphore.h>

sem_t sem_A, sem_B;

void *compute(void *param) {

   ...
}
```

```
int main(void) {

   pthread_t th[10];
   pthread_attr_t attr;
   int n;
   sem_t sem_C;

   sem_init(&sem_A, 0, 1);
   sem_init(&sem_B, 0, 0);
   sem_init(&sem_C, 0, 4);

   pthread_attr_init(&attr);
   for (n=0; n<10; n++) {
      pthread_create(&th[n], &attr, compute, NULL);
   }

   ...
}
```

The programmer wishes to use the declared semaphores to solve different issues that will arise when the threads that are created are executed concurrently.

(1,0 points = 0,4 + 0,6)

4

a) Indicate three situations or three purposes for which semaphores are useful in concurrent programming.

- To solve the problem of mutual exclusion when accessing shared resources.
- To synchronize processes/threads, establishing an order or precedence in their execution.
- To limit the number of processes/threads that can concurrently access to a resource

b) Considering both the area in which semaphores *semA*, *semB* and *semC* have been declared, as well as their initialization in the proposed code, and taking into account that semaphores will be used by threads *th[n]* inside **compute()** function, indicate which semaphores *semA*, *semB* or *semC* would be adequate for each of the situations described on the previous section a).

- sem_init(&sem_A, 0, 1) ⇒ Access control to mutual exclusion areas
- sem_init(&sem_B, 0, 0) ⇒ Threads synchronization
- sem_init(&sem_C, 0, 4) ⇒ It could be used to control that the number of threads that access a resource does not exceed 4, however sem_C variable is local to main() function so the compute() threads will not be able to access it.

5. Taking into account the process inheritance mechanism in Unix and the POSIX calls, answer to the following sections: **(1,2 points = 0,6 + 0,6)**

5

a) Assuming that there are no errors in system calls, complete the following C program with the necessary instructions and system calls (one underlined line number) so that the next command line be executed:

$ cat < f1 2> ferr | grep ".c" > f2

```
 1  #include <unistd.h>
 2. #include <fcntl.h>
 3. #define readfile O_RDONLY
 4. #define newfile (O_RDWR | O_CREAT | O_TRUNC)
 5. #define mode644 (S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH)
 6. int main() {
 7.     int pipeA[2];
 8.     int fd1,fd2;
 9.     pipe(pipeA);
10.     if (fork()) {
11.         fd1 = open("ferr", newfile, mode644);
12.         fd2 = open("f1",readfile);
13.         dup2(pipeA[1], STDOUT_FILENO);
14.         dup2(fd1, STDERR_FILENO);
15.         dup2(fd2, STDIN_FILENO);
16.         close(pipeA[0]); close(pipeA[1]); close(fd1); close(fd2);
17.         execlp("cat", "cat", NULL);
18.      } else {
19.         fd1 = open("f2",newfile, mode644);
20.         dup2(pipeA[0], STDIN_FILENO);
21.         dup2(fd1, STDOUT_FILENO);
22.         close(pipeA[0]); close(pipeA[1]);close(fd1);
23.         execlp("grep", "grep", ".c", NULL);
24.         }
25.      }
26.      return 0;
27. }
```

b) Fill in the file descriptor tables of the parent process after executing line 15 and the child process after executing line 21. Tables content has to be consistent with section a) requirements and implementation.

Parent file descriptor table on line **15**	
0	f1
1	pipeA[1]
2	ferr
3	pipeA[0]
4	pipeA[1]
5	f err
6	f1
7	

Child file descriptor table on line **21**	
0	pipeA[0]
1	f2
2	STDERR
3	pipeA[0]
4	pipeA[1]
5	f2
6	
7	

6. Assume a 1-GByte partition formatted with a Minix file system with the following features:
- 32-byte i-nodes with 7 direct pointer to zones, 1 indirect and 1 double indirect
- 16-bit (2 bytes) pointers to zone
- 16-byte (14 for name and 2 for i-node) directory entries
- **1 Block = 1 Zone = 2 KBytes**

(1,2 points = 0,8 + 0,4)

6

a) Obtain the sizes of each header element considering a maximum number of 32768 (32K) i-nodes.

Boot block	Superblock	i-nodes map	Zone map	i-nodes	Data area

1 Boot block, 1 Superblock, 2 Blocks to inodes map, 32 Blocks to zones map and 512 Blocks to i-nodes

i-nodes map → 32768 / 2K*8 = $2^5\ 2^{10} / 2^1\ 2^{10}\ 2^3$ = 2 Blocks

Maximum number of zones = 1 GB / 2KB = $2^{30} / 2^1\ 2^{10}$ = 512 K zones
Zones map → Nº of zones / block size in bits = 512 K / 2K*8=$2^9\ 2^{10} / 2^1\ 2^{10}\ 2^3 = 2^5$ = 32 Blocks

i-nodes → 32768 * 32 Bytes / 2KBytes = $2^5\ 2^{10}\ 2^5 / 2^1\ 2^{10}$ = 512 Blocks

b) The file system considered contains the root directory with 30 empty directories and 30 files. Half of the files (15) are regular files and the other half are symbolic links to those regular files. Explain the number of occupied i-nodes.
Every file or directory created occupies an i-node. We take into account that symbolic links use their own i-node. Therefore, 1 i-node of the root directory + 30 nodes of the empty directories + 15 nodes of the regular files + 15 nodes of the link type files, gives us a total of 61 busy i-nodes.

Explain the size in bytes of the root directory.
The root directory will have: 2 entries "." and ".." + 30 directory entries + 15 regular file entries +15 symbolic link type file entries. This is:

62 directory entries x 16 bytes = 992 bytes

7. A system with demand paging with two level paging has a maximum process size of 4GBytes, a page size of 4KBytes and a total of 4096 entries at the first paging level. The following table shows information to instant t = 25 for process P and process S. Process S is an operating system process that has been allocated in memory into frames with the highest addresses available on this system.

Process	Frame	Page	Last access time	Valid bit)
P	0x4A000	0xC71FF	5	1
P	0x4A001	0xC7200	10	1
P	-	0xA70C0	-	0
P	0x4A003	0xA73DC	15	1
S	0xFFFFE	0xB7001	20	1
S	0xFFFFF	0xB7002	25	1

Relying on the information provided answer the following sections:

(1,1 points = 0,5 + 0,2 + 0,4)

7

a) Logical address format and physical address format **indicating name and number of bits for every field**:

Logical address

With the maximum process size of 4 Gbytes we would have 32 bits distributed in 12 bits for the offset (page size 4 Kbytes), 12 bits to represent the first level page descriptor (4096 entries) and the remaining 8 bits for the second level page descriptor.

Physical address

Since the frames that delimit the final part of the physical memory are assigned to the S component of the Operating System (the 0xFFFFF frame would be the last and we need 5 digits hex x 4 = 20 bits for the frame number and 12 bits for the offset (page size = frame size).

b) Obtain the maximum number of 2nd level page descriptors that process P can use.

From section a) we would have 8 bits to represent the second level page descriptors (2^8 = 512 descriptors) that multiplied by the 4096 first level entries would give us 2^{12} x 2^8 = 2^{20} = 1M (1048576) maximum descriptors.

c) Obtain the corresponding Physical Addresses, as well as if there is a page fault, when accessing to the Logical Addresses indicated below:

Process → Logical address	***Physical address (or Page Fault)***
P→ 0xA70C0102	Page fault (page 0x A70C0 has its valid bit = 0 on the page table)
P→ 0xA73DC102	0x4A003102 (from the frame id corresponding to page 0xA73DC with valid bit = 1 and offset 102)
S→ 0xB7000102	Page fault (page 0x B7000 doesn't appear on the page table)
S→ 0x B7001003	0xFFFFE003 (from the frame id corresponding to page 0x B7001 with valid bit = 1 and offset 003)

8. Consider the system described in question 7 and the initial assignment of frames detailed in the table for the instant t = 25. Assume that demand paging is used with **LRU replacement policy, managed by counters**, with **LOCAL scope**, and that the system assigns 4 frames to process P and 2 to process S.

(1,5 points = 0,2 + 1,0 + 0,3)

8

a) From t = 26 processes P and S emit the following logical addresses sequence (in hexadecimal):
P:A70C0102, P:A74D0F02, P:A73DC102, P:C7200C10, P:C7200C11, P:A70C0102, S:B7003A00, S:B7001000

Obtain the reference string corresponding to the previous sequence:
P:A70C0, P:A74D0, P:A73DC, P:C7200, P:A70C0, S:B7003, S:B7001

b) Fill in the following table with the evolution of Main Memory content for the reference string obtained on the previous section. In each box, write the corresponding page at the top and the counter value at the bottom. You can fill in only the boxes where there is a change. .

Page→	Initial allocation	P:A70C0	P:A74D0	P:A73DC	P:C7200	P:A70C0	S:B7003	S:B7001
Frame	t = 25	t = 26	t = 27	t = 28	t = 29	t = 31	t = 32	t = 33
4A000	P:C71FF		P:A74D0					
	5		27					
4A001	P:C7200				P:C7200			
	10				29			
4A002	-	P:A70C0				P:A70C0		
	-	26				31		
4A003	P:A73DC			P:A73DC				
	15			28				
FFFFE	S:B7001						S:B7003	
	20						32	
FFFFF	S:B7002							S:B7001
	25							33
Mark page faults and replacements:		FP	FP (R)				FP (R)	FP (R)

TOTAL NUMBER OF PAGE FAULTS = 4 (3 de ellos con reemplazo)

c) Explain if the LRU replacement policy has achieved the optimal frame management, that is, if the number of page faults has been the same as the optimal replacement algorithm would have obtained.

No. The 3 replacements have to be reconsidered. In t = 27 there would be no changes, but in t = 32 the optimal algorithm would have chosen page S: B7002 as victim, so that in t = 33 no page fault would have happened.