Operating Systems ID1206

Exam

2018-01-12 14:00-18:00

Instruction

- You are, besides writing material, only allowed to bring one self hand written A4 of notes.
- All answers should be written in these pages, use the space allocated after each question to write down your answer.
- Answers should be written in Swedish or English.
- You should hand in the whole exam.
- No additional pages should be handed in.

Grades

The exam is divided into a number of questions where some are a bit harder than others. The harder questions are marked with a star *points**, and will give you points for the higher grades. The exam is thus divided into basic points and points for higher grades. First of all make sure that you pass the basic points before engaging with the higher points.

Note that, of the 24 basic points only at most 22 are counted, the points for higher grades will not make up for lack of basic points. The limits for the grades are as follows:

- Fx: 12 basic points
- E: 13 basic points
- D: 16 basic points
- C: 20 basic points
- B: 22 basic points and 6 higher points
- A: 22 basic points and 10 higher points

The limits could be adjusted to lower values but not raised.

Name:_____ Persnr:_____

1 Processer

1.1 what is the problem? [2 points]

The code below might compile but we do a severe error. Which is the error and what could happen?

```
#include <stdlib.h>

#define SOME 42  // should be  2..47

int *some_fibs() {

  int buffer[SOME];

  buffer[0] = 0;
  buffer[1] = 1;

  for(int i = 2; i < SOME; i++) {
     buffer[i] = buffer[i-1] + buffer[i-2];
  }
  // buffer contains SOME Fibonacci numbers
  return buffer;
}
```

Answer: The array `buffer` is allocated on the stack and will most likely be overwritten in the next procedure call.

Name:_____ Persnr:_____

1.2 memory map [2 points]

Below is a, somewhat shortened, printout of a memory mapping of a running process. Briefly describe the role of each segment marked with `???`.

```
> cat /proc/13896/maps

00400000-00401000 r-xp 00000000 08:01 1723260            .../gurka ???
00600000-00601000 r--p 00000000 08:01 1723260            .../gurka ???
00601000-00602000 rw-p 00001000 08:01 1723260            .../gurka ???
022fa000-0231b000 rw-p 00000000 00:00 0                  [???]
7f6683423000-7f66835e2000 r-xp 00000000 08:01 3149003    .../libc-2.23.so ???
    :
7ffd60600000-7ffd60621000 rw-p 00000000 00:00 0          [???]
7ffd60648000-7ffd6064a000 r--p 00000000 00:00 0          [vvar]
7ffd6064a000-7ffd6064c000 r-xp 00000000 00:00 0          [vdso]
ffffffffff600000-ffffffffff601000 r-xp 00000000 00:00 0  [vsyscall]
```

Answer: The first three segments are: code, read-only data and global data for the running process `gurka`. Then there is a segment for the *heap*. The segment marked with `lib-2.23.so` is a shard library. In the uppermost region we find the segment of the *stack*.

Name:_____ Persnr:_____

1.3 Arghhh! [2 points]

Assume that we have a program `boba` that writes "Don't get in my way" to `stdout`. What will the result be if we run the program below and why is this the result? (the procedure `dprintf()` takes a file descriptor as argument)

```
int main() {

  int fd = open("quotes.txt", O_RDWR | O_CREAT, S_IRUSR | S_IWUSR);

  int pid = fork();

  if(pid == 0) {
    dup2(fd, 1);
    close(fd);
    execl("boba", "boba", NULL);
  } else {
    dprintf(fd, "Arghhh!");
    close(fd);
  }
  return 0;
}
```

Answer: In `dup2(fd,1)` we redirect `stdout` to the opened file. Boba will write its line to the file `quites.txt`. At the same time the mother process will write "Arghhh!" to the same file. The two processes will share the file current position and combine the write oprations. The result is a mixture of the two texts in the file `quotes.txt` i.e. the texts will not overwrite each other.

Name:_____ Persnr:_____

1.4 list of free blocks [2 points]

If we when implementing `malloc()` and `free()` choose to save the free blocks in a linked list that is ordered by their address, we will have a certain advantage. When we free a block we can insert it in the list and perform an operation that reduces the external fragmentation. What can we do and why is it an advantage to have the blocks order by address? Show with a drawing what information is used and how the operation is performed.

Answer: We will immediately be able to tell if the adjacent blocks can be merged with the new block to form a larger block. If the blocks were not ordered by address we would have to search through all blocks.

There are two, non exclusive, cases that we have to take care of 1/ the address of a block plus its size is equal to the address of the freed block 2/ the address of the freed block plus its size is equal to the address of the next block.

Name:_____ Persnr:_____

1.5 intern paging [2 points*]

When we implement memory internally for a process (for example in malloc()) we us a form of segmentation. This is why we could have problem with external fragmentation. If it's better to use paging why do we not use it when we implement internal memory management?

Answer: We would have to implement an address translator that in each memory reference divided the address in page number and offset. The page number would have to be translated to a frame address by using a page table. We would have to work with small pages in order to avoid internal fragmentation. The page tabel would be to large to handle. To do all this in software would be too costly.

One alternative would be to have very small pages, 16 bytes (large enough for two pointers), ald let the processes represent all object in tems of these. Not impossible and alsmost as memory is handled by some list based programming languages.

Name:_____ Persnr:_____

1.6 context [2 points*]

By the help of the library procedure `getcontext()`, a process can save its own so called `context`. We could build a library that allowed us to create new executing threads and manually switch between these by calling a scheduler.

Why would we want to build such a library, are there any advantages? What would the disadvantages be?

Answer: We would have a thread library were the treads are handled by the process itself. A switch between two threads would take less time compared to if we let the operating system do the switch (as is done in the pthread library). We would avoid many synchronization problems since we know that only one thread executes at any given moment.

A disadvantage would be that we would not be able to utilize a processor with several cores. We would also be completely blocked if a thread needs to do an I/O operation.

Name:_____ Persnr:_____

2 Communication

2.1 count [2 points]

What will be printed if we execute the procedure `hello()` below concurrently in two threads? Motivate your answer.

```
int loop = 10;

void *hello() {
  int count = 0;

  for(int i = 0; i < loop; i++) {
      count++;
  }
  printf("the count is %d\n", count);
}
```

Answer:

Name:_____ Persnr:_____

2.2 pipes [2 points]

If we have two processes, one producer and one consumer, that are communicating through a so called *pipe*. How can we then prevent that the producer sends more information than the consumer is ready to receive and thereby crash the system.

Answer: Pipes have built-in flow controll. If the consumer does not read from the pipe the producer will be suspended when it tries to write the filled pipe.

Name:_____ Persnr:_____

2.3 name space [2 points*]

Below is code were we open a socket and use the name space `AF_INET`. We will then be able to address a server using a port number and IP-address. There are other name spaces that we can use when working with sockets. Name one and decribe its advantages and disadvantages it might have.

```
struct sockaddr_in server;
server.sin_family = AF_INET;
server.sin_port = htons(SERVER_PORT);
server.sin_addr.s_addr = inet_addr(SERVER_IP);
```

Answer: We can use file names (`AF_UNIX`) as the name space. This has the disadvantage that we will not be reachable from other nodes in a network, we're limited to the node that we are running on. This of course has the advantage that we will not have to be exposed to the surrounding nodes. The implementation could also be more efficient since we will not have to use for example TCP.

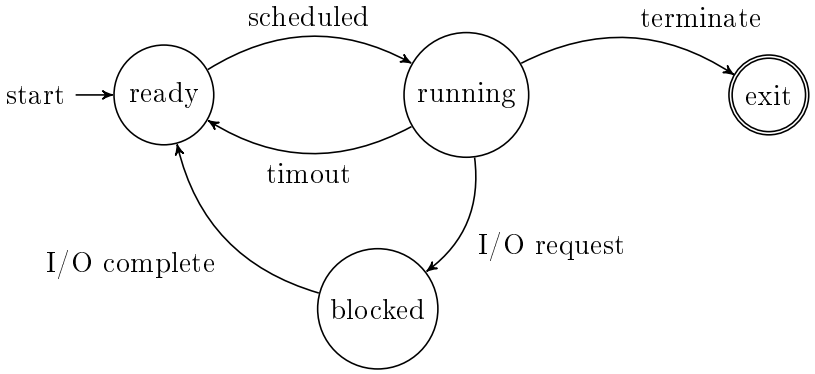
Name:_____ Persnr:_____

3 Scheduling

3.1 state diagram [2 points]

Here follows a state diagram for scheduling of processes. Enter the marked states and transitions to describe what states means and when a process is transferred between different states.

Answer:



3.2 reaction time [2 points]

When we want to reduce the reaction time we want to preempt a job even though the job is not completed. If we choose to do this we have one parameter to set, by changing this we can improve the reaction time. Which parameter is it? How should it be set and what unwanted consequence might it have?

Answer: We can decrease the time slot given to a process. Doing so will decrease the reaction time of processes. Jobs that are ready to run will be scheduled much quicker. The disadvantage is that we will increase the turnaround time and in the worst case spend a large part of the time switching between processes.

Name:_____ Persnr:_____

3.3 rate monotonic scheduling [2 points*]

A real time scheduler based on "Rate Monotonic Scheduling" (fixed priority where priority is determined by periodicity). is a relative simple scheduler. If we assume that deadlines are equal to the full peiodicity, how can we then describe the load of a system?

Do we have any guarantees that the scheluling will work i.e. that no deadlines are missed?

Answer: The load of a system can be described by the sum of e_i/p_i, where e_i is the execution time of a job and p_i its periodicity. The scheduling algorithm will always work if the load is less than $n * (2^{1/n} - 1)$ where n is the number of jobs (aprx: 69% for large n). It could work for higher loads but we have no guarantees.

Name:_____ Persnr:_____

4 Virtual memory

4.1 segmenting [2 points]

When we use segmentation to handle physical memory we could have problems with external fragmentation. This is avoided if we instead use paging. How is it that we can avoid external fragmentation using paging? Is there something that we risk?

Answer: Since all frames are of equal size and a process can be allocated any page, a page can always be reused. No pages are too small to be used. If the page size is large and requested segments are small we could have internal fragmentation.

Name:_____ Persnr:_____

4.2 almost right [2 points]

Below is a extract from a program that implements *Least Recently Used* (LRU). The code shows why LRU is expensive to implement and why one probably instead choose to approximate this strategy. How could we approximate the algorithm and which consequences would this bring? Could part of the algorithm be implemented in hardware?

```
    :
if(entry->present == 1) {

    if(entry->next != NULL) {

      if(first == entry) {
        first = entry->next;
      } else {
        entry->prev->next = entry->next;
      }
      entry->next->prev = entry->prev;

      entry->prev = last;
      entry->next = NULL;

      last->next = entry;
      last = entry;
    }
} else {

  :
}
```

Answer: The code unlinks an entry and places it last in a list that should be updated with the least used pages first. This operation must be done every time a page is referenced. If we only keep track of if a page has been used since we last checked this can be handled by one bit in a page table entry. This can be, and is, handled by hardware. When it is time to select a page for eviction a circular structure is searched for an entry with the value set to zero. Page table entries that are set to one are set to zero. This will give the page a second chance".

Name:_____ Persnr:_____

4.3 x86_64 addressing [2 points*]

In a x86-processor in 64–bit mode a PTE contains a 40-bit frame address. This is combined with a 12 bit offset to a physical address. This is 52 bits but a process only has a 48-bit virtual memory. What advantage is there to have a 52-bit physical address.

Answer:

Name:_____ Persnr:_____

5 File systems and storage

5.1 list the content of a directory [2 points]

If we want to list the content of a directory we can use the library procedure `opendir()`. Which information can we access directly form the structure pointed to by `entry` in the code below? Describe three important properties. Which information can we not find and where could this information be found?

```
int main(int argc, char *argv[]) {

  char *path = argv[1];

  DIR *dirp = opendir(path);

  struct dirent *entry;

  while((entry = readdir(dirp)) != NULL) {

    //  what information do we have?

  }
}
```

Answer: Det vi kan hitta direkt är: namn, typ och inod-nummer. Typen kan vara: fil, map, mjuk länk mm. Alla egenskaper (storlek, skapad, ändrad, ägare etc) för en fil måste vi hämta in filens inod.

5.2 remove a file [2 points]

If we us the command `rm` we will not remove a file, rather remove a hard link to a file. When is the file it self removed? How is this handled?

Answer:

Name:_____ Persnr:_____

5.3 log-based fs [2 points*]

In a log based file system we write all changes to a continuous log without doing any changes to existing blocks of a file. What is the advantage of writing new modified copies of blocks rather than do the small changes we want to do in the original blocks? If it is better, are there any disadvantages?

Answer: By always writing to the end of the log we do not have to move the arm of the disk. If we should write to all individual blocks we would have to move the arm, something that would decrease performance. We pay a price when a file is read, in the worst case the file is now spread all over the disk.