Operating Systems ID2206
English version (only for ID2206 HT16)
2017-08-21 8:00-12:00

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 for 6 credits

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 40 basic points only at most 36 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: 21 basic points
- E: 23 basic points
- D: 28 basic points
- C: 32 basic points
- B: 36 basic points and 12 higher points
- A: 36 basic points and 18 higher points

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

Name:____________________________ Persnr:____________________________

1 Operating systems

1.1 what happens? [2 points]

If we give the command sequence below, what will the result be?

```
> echo "cd foo grep bar" | grep bar | wc -w
```

Answer: 4

1.2 commands in a shell [2 points]

Give a short description of the commands below.

- `mkdir`
- `cd`
- `cat`
- `ln`

Answer: Have a look using `man`.

Name:____________________________ Persnr:____________________________

2 Processes

2.1 why on the heap? [2 points]

In the code below we have allocated three arrays where one is on the heap, which array and why is it allocated on the heap and not on the stack?

```
#include <stdlib.h>
#include <stdio.h>

#define MAX 4

int h[MAX];

int *foo(int *a, int *b, int s) {

  int *r = malloc(s * sizeof(int));

  for(int i = 0; i < s; i++) {
     r[i] = a[i]+b[i];
  }
  return r;
}


int main() {
  int f[MAX];

  for(int i = 0; i < MAX; i++) {
    f[i] = i;
    h[i] = i*10;
  }

  int *g = foo(f, h, 4);

  printf("a[2] + b[2] is %d\n", g[2]);

  return 0;
}
```

Answer:

Name:____________________________ Persnr:____________________________

2.2 Limited direct execution [2 points*]

In the implementation of an operating system one will use so called limited direct execution, what are the limitations?

Answer:

3 Scheduling

3.1 shortest time-to-completion first [2 points]

Assume that we have a scheduler that implements *short time-to-completion first*. We have three jobs that arrive at time 0, 10 and 30 ms and take 60, 30 and 10 ms. What is the average turnaround time?

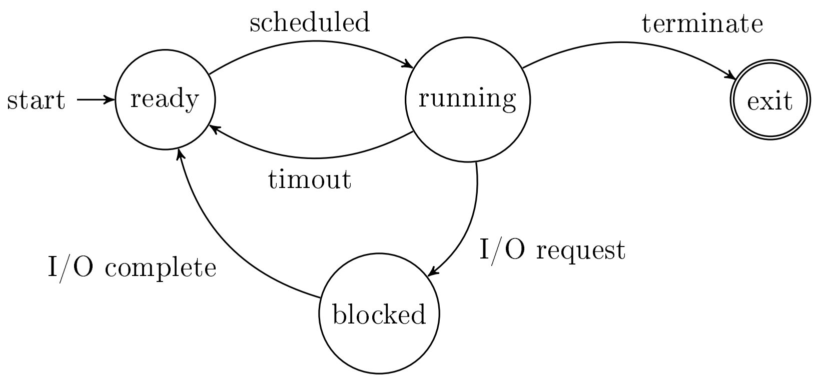
Answer:

Name:____________________________ Persnr:____________________________

3.2 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:



3.3 lottery [2 points*]

There are schedulers that are based on a lottery where you allocate a number of tickets to each process, pick a number and let the winning process execute for a certain amount of time. In these schedulers it not the turnaround time nor the reaction time that you want to minimize, what is it that we want to acheive?

Answer:

Name:____________________________ Persnr:____________________________

4 Virtual memory

4.1 segmenting [2 points]

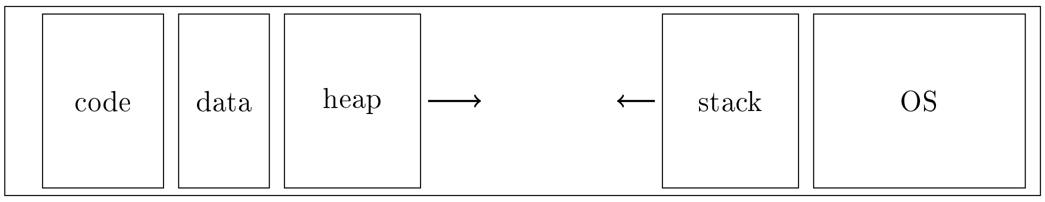
When we use segmentation to handle pysical memory we could have problems with external fragmentation. This is avoided if we instead use paging. How is it that we can avoid external fragmentation using paging?

Answer:

4.2 the memory [2 points]

In Linux, and many other operatingh systems, a process has a virtual address space. In this space it will hold its own areas: stack, code, global data and heap. The adress space also includes the operating system. Draw a schematic image over how these areas are typically arranged. Also include for the stack and heap in which direction they grow.

Answer:



4.3 more memory [2 points*]

If a virtual address is 32 bits we can atmost address a memory of size 4 GiByte. Assume memory is cheap and we can afford a machine that has 64 GiByte of memory. How can we utilize such a machine without changing the size of the virtual address?

Answer:

5 Memory management

5.1 malloc() [2 points]

In Linux (and all Unix dialecst) malloc is a library procedure and not a system call. Why is ist a library procedure? Would it not be quicker if we called the operating system directly, in the end it will manage the memory any way.

Answer:

5.2 best-fit vs first-fit [2 points]

One strategy to find a suitable memory block is to find the block that best suites our needs (without being too small); this must by all aspects be the a good strategy. Another approach is to simply take the first block that is found even if it is considerably larger than what we need. What would the benefit be for the latter strategy and what is the possible downside?

Answer:

5.3 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 coudl 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:

Name:____________________________ Persnr:____________________________

6 Concurrent programming

6.1 thing in the heap [2 points]

If we have a multithreaded program the threads can of course read and write global variables and thus aork with shared data structures. How is it with data structures that one thread allovcates on the heap, can these structures be readn written to by other threads?

Answer:

6.2 deadlock, almost [2 points]

What is the difference between so called deadlock and livelock?

Answer:

Name:____________________________ Persnr:____________________________

6.3 the world is not simple [2 points*]

In the program below we have two procedures that both will update a global variable `count` by 1000 steps. In order to run these procedres in two threads the update is protected by two flags, `a` and `b`. Each process will first set its own flag and then continue only if the other process has not set its flag. The world is not always simple and if we have a processor that only provides "total store order" strange things can happen - explain what could happen.

```
void *ping(void *arg) {

 int i;

 for(i = 0; i < 1000; i++) {
   while(1){
     a = 1;
     if(b != 1) {
      count++;
      a = 0;
      break;
     } else {
      a = 0;
     }
   }
 }
}
```

```
void *pong(void *arg) {

 int i;

 for(i = 0; i < 1000; i++){
   while(1){
     b = 1;
     if(a != 1) {
      count++;
      b = 0;
      break;
     } else {
      b = 0;
     }
   }
 }
}
```

Answer:

Name:____________________________ Persnr:____________________________

7 File systems and storage

7.1 remove a file [2 points]

If we us the command `rm` we will nit remove a file rather remove a hard ink to a file. How do we remove the actual file?

Answer:

7.2 two out of three [2 points]

Assume that we have a simple file system without journaling where we write directly to inodes, bit maps and data blocks. Also assuem that we have a crash and the we when creating a file only are able to do two of the three required updates. In each of the cases below, explain the problem we will have.

- inode and bitmaps

  Answer:

- bitmaps and data blocks

  Answer:

- inode and data blocks

  Answer:

7.3 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:

8 Virtualization

8.1 how slow [2 points]

When we run a full operating system in a virtualized environment the execution will take longer time since we then have a virtualization in two levels. How much slower will a computaion intensive program run: almost as fast, half speed or typically a factor ten slower? Motivate your answer.

Answer:

8.2 set the IDT [2 points*]

When a hypervisor starts a virtulalized operating system, the virtualized system will want to set the register that controls the location of the IDT. What is the problem and how is it solved?

Answer:

Name:___________________________ Persnr:___________________________

9 Implementation

9.1 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:____________________________

9.2 fork [2 points]

If we run the program below, what will be printed on the terminal? Make sure that you get the order right.

```
int x = 0;

int main() {

  int pid;

  pid = fork();

  if(pid == 0) {
    x = x + 10;
    sleep(1);
  } else {
    sleep(1);
    x = x + 2;
    wait(NULL);
  }
  printf("x is %d\n", x);

  return 0;
}
```

Answer:

Name:____________________________ Persnr:____________________________

9.3 Boba [2 points]

Assume that we have a program `boba` trhat 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 pid = fork();

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

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

Answer:

9.4 pipes [2 points]

In the code below we have a program that creates a ppe and then use this pipe to send messages (not shown). What would the equivalent skeleton code look like for program that opens the same pipe for reading the messages?

```
int main() {
  int mode = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
  mkfifo("sesame", mode);

  int flag = O_WRONLY;
  int fd = open("sesame", flag);
   :
   :
}
```

Answer:

```
int main() {
  int flag = O_RDONLY;
  int fd = open("sesame", flag);
    :
    :
}
```

9.5 a directory [2 points]

A directory is in Linux represented in the same way as a file i.e. an inode that is pointing to a data block and the data block holds the name and identifiers of the files in the directory. This mean that we use the same system calls when we read a directory as we use when we read a file - true or false? Motivate.

Answer:

9.6 sbrk() and then what [2 points*]

You can use the system call `sbrk()` to allocate more memory for the heap but how can a process return memory?

Answer:

Name:____________________________ Persnr:____________________________

9.7 an expensive operation [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. What is the code doing and when is it executed?

```
    :
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.

Name:____________________________ Persnr:____________________________

9.8 volitile [2 points*]

In the code below you see that `count` and `turn` are declared as `volatile`. Why is it important to declare some variables as `volatile` when we work with multithreaded code?

```
int loop = 100000;
volatile int count = 0;
volatile int turn = 0;

void *toggle(void *args) {

  int id = ((struct ids*)args)->id;
  int od = ((struct ids*)args)->od;

  for(int i = 0; i < loop; i++) {
    while(turn != id) {}
    count++;
    turn = od;
  }
}
```

Answer:

Name:____________________________ Persnr:____________________________

9.9 character device [2 points*]

We can create so called *character device* and interact with it using `ioctl`. In the code below, describe what `fd`, `JOSHUA_GET_QUOTE` and `buffer` is and how the *device* could work.

```
if (ioctl(fd, JOSHUA_GET_QUOTE, &buffer) == -1) {
  perror("Hmm, not so good");
} else {
  printf("Quote - %s\n", buffer);
}
```

Answer:

Name:____________________________ Persnr:____________________________

9.10 AC/DC [2 points*]

If we have allocated a two dimensional array `table` and then want to sum all its values we can do this using the code below. What in the code below will give us an unwanted behaviour and how could we improve the execution time? Motivate.

```
#define ROWS 4000
#define COLS 1000

int table[ROWS][COLS];

int main() {

   :
   long sum = 0;

   for(int c = 0; c < COLS; c++) {
       for(int r = 0; r < ROWS; r++) {
         sum += table[r][c];
       }
   }
   :

}
```

Answer:

Name:____________________________ Persnr:____________________________

Answer:

Answer:

Answer:

Answer: LANGProblemet är att anrop til tjänsten kan dubbleras och utför a mer än en gång. Man löser det genom att enbart ha s.k. idepotenta operationer dvs operationer som kan processas flera gånger utan att tillståndet förändras mer än vid första anropet.