Written examination in Operating Systems

July 7th 2014

Last name: _____

First name: _____

Student number: _____

I confirm with my signature that I will process the written examination alone and that I feel healthy and capable to participate this examination.
I am aware, that from the moment, when I receive the written examination, I am a participant of this examination and I will be graded.

Signature: _____

- Provide on all sheets (including the cover sheet) your *last name*, *first name* and *student number*.
- Use the provided sheets. Own paper must *not* be used.
- Place your *ID card* and your *student ID card* on your table.
- You are allowed to use a *self prepared*, *single sided DIN-A4 sheet* in the exam. Only *handwritten originals* are allowed, but no copies.
- You are allowed to use a non-programmable calculator.
- Answers, written with pencil or red pen are *not* accepted.
- Time limit: *90 minutes*
- Turn off your mobile phones!

Result:

Question:	1	2	3	4	5	6	7	8	9	10	11	12	13	**Σ**	Grade
Maximum points:	6	12	13	7	7	6	8	4	9	5	4	4	5	90	—
Achieved points:															

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Question 1)

Points: .....

Maximum points: 6

Which command is used to...

a) print out the path of the present working directory in the shell?

b) create a new directory?

c) create an empty file?

d) concatenate the content of different files or print out the content of a file?

e) print out lines from the end of a file in the shell?

f) print out lines from the beginning of a file in the shell?

g) delete files or directories?

h) place a string in the shell?

i) create a link?

j) search a file for lines, which contain a search pattern?

k) modify the permissions of files or directories?

l) terminate a process?

Last name: First name: Student number:

Question 2)

Points: .....

Maximum points: 5+5+1+0,5+0,5=12

a) Specify for each storage the access method.

Storage	**Access method**	
CD-R/CD-RW/DVD-R	☐ sequential	☐ random access
CD-ROM/DVD-ROM	☐ sequential	☐ random access
Floppy disk	☐ sequential	☐ random access
Hard disk drive (HDD)	☐ sequential	☐ random access
Flash memory	☐ sequential	☐ random access
Main memory (DRAM)	☐ sequential	☐ random access
Magnetic-core memory	☐ sequential	☐ random access
Punch card	☐ sequential	☐ random access
Punched tape	☐ sequential	☐ random access
Magnetic tape	☐ sequential	☐ random access

b) Specify for each storage how read operations are carried out.

Storage	**Read operation**			
CD-R/CD-RW/DVD-R	☐ electric	☐ mechanic	☐ magnetic	☐ optical
CD-ROM/DVD-ROM	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Floppy disk	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Hard disk drive (HDD)	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Flash memory	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Main memory (DRAM)	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Magnetic-core memory	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Punch card	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Punched tape	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Magnetic tape	☐ electric	☐ mechanic	☐ magnetic	☐ optical

c) Name the two basic cache write policies.

d) With which cache write policy of question c) may inconsistencies occur?

e) With which cache write policy of question c) is the system performance lower?

Last name: First name: Student number:

Question 3)

Points: .....

Maximum points: 1+6+6=13

a) Why is it impossible to implement the optimal replacement strategy OPT?

b) Perform the provided access sequence with the replacement strategy Least Recently Used (LRU) with a cache with a capacity of 4 pages (*Also calculate the hit rate and the miss rate!*)

Requests:	**1**	**3**	**4**	**2**	**5**	**4**	**1**	**5**	**2**	**1**	**5**	**3**
Page 1:												
Page 2:												
Page 3:												
Page 4:												

Hit rate: Miss rate:

c) Perform the provided access sequence with the replacement strategy FIFO with a cache with a capacity of 4 pages (*Also calculate the hit rate and the miss rate!*)

Requests:	**1**	**3**	**4**	**2**	**5**	**4**	**1**	**5**	**2**	**1**	**5**	**3**
Page 1:												
Page 2:												
Page 3:												
Page 4:												

Hit rate: Miss rate:

Last name: First name: Student number:

Question 4)

Points: .....

Maximum points: 1+1+2+3=7

a) Which two components contains the chipset?

b) Which two groups of Input/Output devices for computer systems are distinguished according to their minimum transfer unit?

c) Name two examples for each group from subtask b).

d) Which memory management method...

- produces many mini-fragments and works most slowly?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for the free block, which fits best?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- fragments quickly the large area of free space at the end of the address space?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- selects random a free and appropriate block?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for a free and appropriate block, starting from the latest allocation?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for a free and appropriate block, starting from the beginning of the address space?
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random

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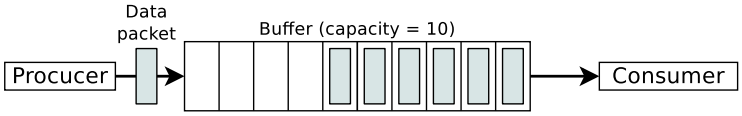
Question 5)

Points: .....

Maximum points: 7

- A producer writes data into the buffer and the consumer removes them.
- Mutual exclusion is necessary in order to avoid inconsistencies.
- If the buffer has no more free capacity, the producer must block itself.
- If the buffer is empty, the consumer must block itself.



For synchronizing the two processes, create the required semaphores, assign them initial values and insert semaphore operations.

```
typedef int semaphore;




void producer (void) {
  int data;
  while (TRUE) {                    // infinite loop
    createDatapacket(data);         // create data packet



    insertDatapacket(data);         // write data packet into buffer



  }
}

void consumer (void) {
  int data;
  while (TRUE) {                    // infinite loop



    removeDatapacket(data);         // remove data packet from buffer



    consumeDatapacket(data);        // consume data packet
  }
}
```

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Question 6)

Points: .....

Maximum points: 1+0,5+0,5+1+0,5+0,5+1,5+0,5=6

a) Explain, why virtual memory helps to better utilize the main memory.

b) What is mapping?

c) Which component of the CPU is used to implement virtual memory?

d) Name the two different virtual memory concepts.

e) With which concept of subtask d) does internal fragmentation occur?

f) With which concept of subtask d) does external fragmentation occur?

g) Which three sorts of process context information stores the operating system?

h) Which process context information of subtask g) is not stored in the process control block?

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Question 7)

Points: .....

Maximum points: 1+1+1+2+1+1+1=8

a) Which information stores an inode?

b) How can a UNIX file system (e.g. ext2/3), which does not implement extents, address more than 12 clusters?

c) Why do some file systems (e.g. ext2/3) combine the clusters of the file system to block groups?

d) What is the File Allocation Table (FAT) and what is its objective?

e) What is the objective of the journal in journaling file systems?

f) Name an advantage of journaling file systems versus file systems without a journal.

g) What is the advantage of using extents compared to the direct addressing of the clusters?

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Question 8)

Points: .....

Maximum points: 4

a) What is the effect of calling the system call `fork()`?

b) What is the effect of calling the system call `exec()`?

c) What are interrupts?

d) What are exceptions?

e) What is a critical section?

f) What is a race condition?

g) Why are race conditions hard to locate and fix?

h) How can race conditions be avoided?

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Question 9)

Points: .....

Maximum points: 1+2,5+2,5+3=9

a) Why exists a system idle process in some operating systems?

b) For which scheduling strategies must the CPU runtime (= execution time) be known?

- ☐ Priority-driven scheduling
- ☐ First Come First Served
- ☐ Last Come First Served
- ☐ Round Robin with time quantum
- ☐ Shortest Job First
- ☐ Longest Job First
- ☐ Shortest Remaining Time First
- ☐ Longest Remaining Time First
- ☐ Highest Response Ratio Next
- ☐ Earliest Deadline First
- ☐ Fair share

c) Which scheduling strategies are fair?

A scheduling method is „fair“ when each process gets the CPU assigned at some point.

- ☐ Priority-driven scheduling
- ☐ First Come First Served
- ☐ Last Come First Served
- ☐ Round Robin with time quantum
- ☐ Shortest Job First
- ☐ Longest Job First
- ☐ Shortest Remaining Time First
- ☐ Longest Remaining Time First
- ☐ Highest Response Ratio Next
- ☐ Earliest Deadline First
- ☐ Fair share

d) Which scheduling strategies operate preemptive?

- ☐ First Come First Served
- ☐ Round Robin with time quantum
- ☐ Shortest Job First
- ☐ Longest Job First
- ☐ Shortest Remaining Time First
- ☐ Longest Remaining Time First
- ☐ Fair share
- ☐ Static multilevel scheduling
- ☐ Multilevel feedback scheduling

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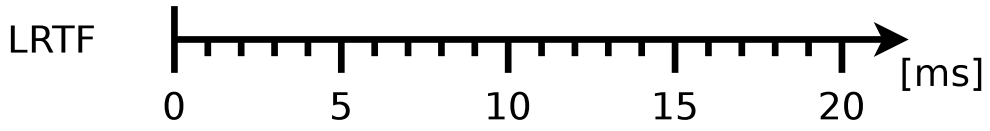
Question 10)

Points: .....

Maximum points: 3+1+1=5

Process	CPU runtime [ms]	Creation time [ms]
A	4	0
B	3	2
C	3	4
D	5	7
E	5	9

a) The processes A-E shall be executed on a single CPU system. Draw the execution order of the processes with a Gantt chart (timeline) for Longest Remaining Time First (LRTF).



b) Calculate the average runtime of the processes.

c) Calculate the average waiting time of the processes.

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Question 11)

Points: .....

Maximum points: 1+1+1+1=4

a) Name a sort of inter-process communication, which allows communication over computer boundaries.

b) Name a sort of inter-process communication, which can only be used for processes, which are closely related to each other.

c) Name a sort of inter-process communication, where the operating system does not ensure the synchronization.

d) Name a sort of inter-process communication, where the data remains intact without a bound process.

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Question 12)

Points: .....

Maximum points: 4

a) Does a deadlock occur?
Perform the deadlock detection with matrices.

$$\text{Existing resource vektor} = \begin{pmatrix} 9 & 6 & 8 & 7 \end{pmatrix}$$

$$\text{Current allocation matrix} = \begin{bmatrix} 2 & 0 & 2 & 3 \\ 2 & 1 & 2 & 0 \\ 1 & 3 & 2 & 1 \\ 3 & 1 & 0 & 1 \end{bmatrix} \qquad \text{Request matrix} = \begin{bmatrix} 1 & 0 & 2 & 2 \\ 5 & 3 & 2 & 2 \\ 2 & 0 & 4 & 4 \\ 4 & 3 & 0 & 1 \end{bmatrix}$$

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Question 13)

Points: .....

Maximum points: 1+0,5+0,5+0,5+0,5+0,5+0,5+0,5+0,5=5

a) What is the difference between emulation and virtualization?

b) Which sort of computer systems usually implement partitioning?

☐ Mobiltelefone ☐ Desktop PCs ☐ Mainframes ☐ Workstations

c) Name an example for application virtualization.

d) What is the function of the Virtual Machine Monitor (VMM)?

e) Where runs the Virtual Machine Monitor (VMM)?

☐ The VMM runs *hosted* as an application in the host operating system.
☐ The VMM runs *bare metal* and replaces the host operating system.

f) Can all physical hardware resources be virtualized when full virtualization is used? If this is not possible, give an example where it does not work.

g) Where runs the hypervisor when paravirtualization is used?

☐ The hypervisor runs *hosted* as an application in the host operating system.
☐ The hypervisor runs *bare metal* and replaces the host operating system.

h) Why is for paravirtualization a host operating system required?

i) Name a drawback of operating system-level virtualization (containers/jails).