Sample solution of the written examination

Operating Systems

November 22th 2016

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	Σ	Grade
Maximum points:	10	5	5	6	10	7	8	9	10	10	10	90	—
Achieved points:													

Last name: First name: Student number:

Question 1)

Points: .....

Maximum points: 1+1+2+2+1+1+1+1=10

a) At any given moment, only a single program can be executed. What is the technical term for this operation mode?

Singletasking

b) What are half multi-user operating systems?

Different users can work with the system only one after the other, but the data and processes of the different users are protected from each other.

c) Name one advantage and one drawback of monolithic kernels.

- *Advantages:*
  - *Fewer context switching $\Longrightarrow$ better performance*
  - *Grown stability*
- *Drawbacks:*
  - *Crashed components can not be started separately in the kernel and may cause the entire system to crash*
  - *Kernel extensions cause a high development effort, because for each compilation of the extension, the complete kernel need to be recompiled*

d) Name one advantage and one drawback of microkernels.

- *Advantages:*
  - *Components can be exchanged easily*
  - *Best stability and security in theory, because fewer functions run in kernel mode*
- *Drawbacks:*
  - *Slower because of more context switches*
  - *Development of a new (micro)kernel is a complex task*

e) Describe, what an administrator can do with the command `whoami`.

Check (print) the own username in the shell.

f) Describe, what an administrator can do with the command `chmod`.

Modify the permissions of a file or directory.

g) Describe, what an administrator can do with the command `head`.

Print out lines from the beginning of a file in the shell.

h) Describe, what an administrator can do with the command `touch`.

Create an empty file.

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Question 2)

Points: .....

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

a) Name two rotating magnetic digital data storages.

Hard Disk Drive, Drum memory, Floppy Disk.

b) Name two non-rotating magnetic digital data storages.

Magnetic-core memory, Magnetic tape, Magnetic stripe card, Compact cassette (Datasette), Bubble memory.

c) Name three benefits of data storage without moving parts compared with data storage with moving parts.

Lower power consumption, lesser waste heat, mechanical robustness, no noise generation.

d) What is random access?

The media does not need to be searched sequentially from the start – such as with magnetic tapes – to locate a specific location (file).

e) Name one non-persistent data storage.

Main memory (DRAM).

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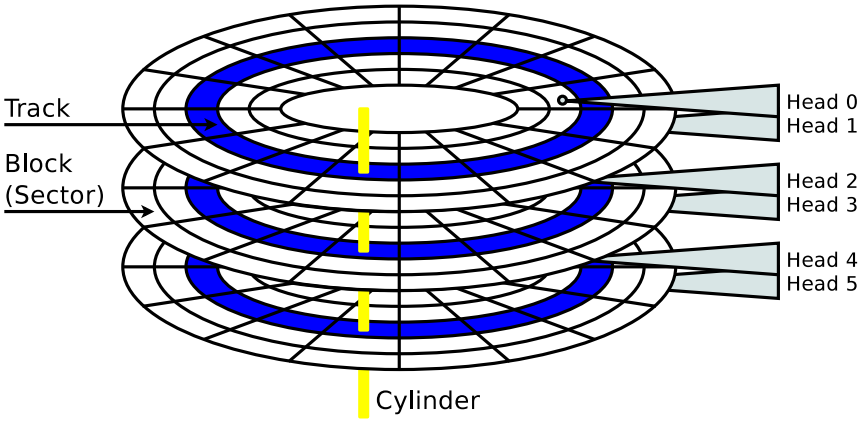
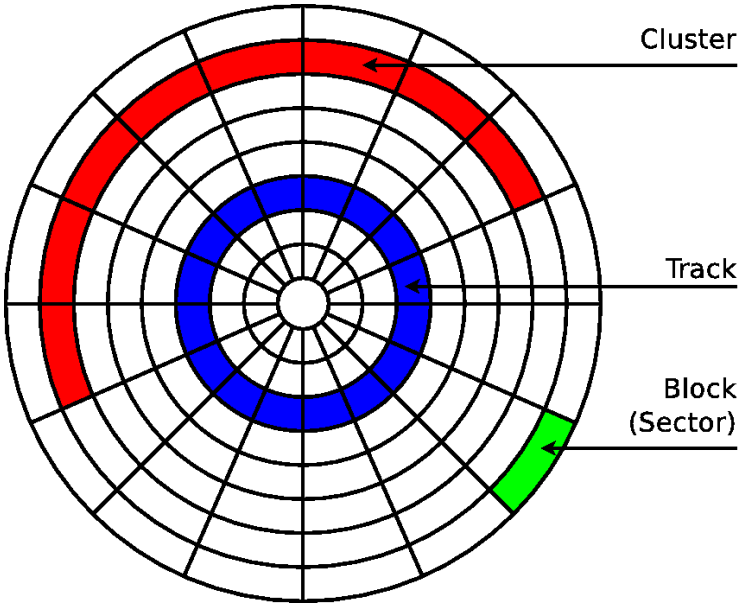
Question 3)

Points: .....

Maximum points: 1+1+2+1=5

- Draw the structure of a hard disk drive schematically. Explain with your drawing(s) the meaning of the following terms:
  a) Sector (= Block)
  b) Track
  c) Cylinder
  d) Cluster





Last name: First name: Student number:

Question 4)

Points: .....

Maximum points: 6

a) Why causes batch processing an acceleration effect, when multiple tasks are executed?

Because auf the automation. No time is wasted for switching between the users.

b) Name an application of batch mode, which is still popular today.

Batch files and shell scripts.

c) What is spooling?

Spooling removes I/O workload from the CPU by using additional Hardware.

d) What is the name of the quasi-parallel program or process execution?

Multitasking.

e) Describe what this command does:

```
$ echo "ERROR" >> /tmp/msg.txt
```

The command prints out the string ERROR and forwards it into the file /tmp/msg.txt. If the file does not already exist, it is created. If the file already does exist, the string ERROR is concatenated to the content of the file.

f) What is swapping?

The process of relocating data from the main memory to the SDD/HDD and back.

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Question 5)

Points: .....

Maximum points: 1,5+1,5+3+1+1+2=10

a) Which three components contains the CPU?

Arithmetic logic unit, control unit, memory.

b) Which three digital bus systems contains each computer system according to the Von Neumann architecture?

Control bus, address bus, data bus.

c) Which tasks are carried out by the three digital bus systems of subtask b)?

Control bus. Transmits commands (e.g. read and write requests) from the CPU and returns status signals from the I/O devices

Address bus: Transmits memory addresses.

Data bus: Transmits data between CPU, main memory and I/O devices.

d) What is the Front Side Bus?

It is the bus between CPU and chipset. It contains the address bus, data bus and control bus.

e) Which two components contains the chipset?

Northbridge und Southbridge.

f) Name the task of each component of the chipset.

The Northbridge is used for the connection of main memory and graphics card(s) with the CPU. It is located close to the CPU for rapid data transfer. The Southbridge is used for „slow“ connections like Ethernet, SATA and USB.

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Question 6)

Points: .....

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

a) Name <u>one</u> RAID level, which improves the data transfer rate for write.

RAID-0 or RAID-5.

b) Name <u>one</u> RAID level, which improves the reliability.

RAID-1 or RAID-5.

c) How many drives are allowed to fail in a RAID 0 array without data loss?

None.

d) How many drives are allowed to fail in a RAID 1 array without data loss?

At least a single drive must work properly.

e) How many drives are allowed to fail in a RAID 5 array without data loss?

A single drive maximum is allowed to fail.

f) Name <u>one</u> advantage and <u>one</u> drawback of software RAID compared with hardware RAID.

Benefit: No cost for additional hardware.

Drawback(s): Operating system dependent, additional CPU load.

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Question 7)

Points: .....

Maximum points: 1+3+1+1+2=8

a) Which information stores an inode?

It stores a file's metadata, except the file name.

b) Name three examples of metadata in the file system.

Metadata are among others the size, UID/GID, permissions and date.

c) What is a cluster in the file system?

File systems address clusters and not blocks of the storage device. Each file occupies an integer number of clusters.

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

If a file requires more than 12 clusters, these clusters are indirectly addressed via clusters that contain only cluster numbers.

e) Name one advantage and one drawback of small clusters in the file system compared with large clusters.

Advantage: Decreasing capacity loss due to internal fragmentation.

Drawback: Rising overhead for large files.

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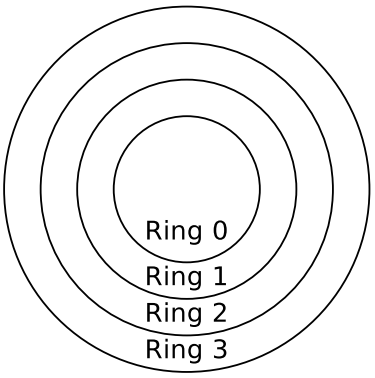
Question 8)

Points: .....

Maximum points: 1+1+1+1+2+2+1=9

x86-CPUs contain 4 privilege levels („rings“) for processes.



a) In which ring runs the kernel of the operating system?

In ring 0 (= kernel mode) runs the kernel.

b) In which ring run the applications of the users?

In ring 3 (= user mode) run the applications.

c) Processes of which ring have full access to the hardware?

Processes in kernel mode (ring 0) have full access to the hardware.

d) What is a system call?

If a user-mode process must carry out a higher privileged task (e.g. access hardware), it can tell this the kernel via a system call. A system call is a function call in the operating system, which triggers a switch from user mode to kernel mode ($\Longrightarrow$ context switch).

e) What is a context switch?

A process passes the control over the CPU to the kernel and is suspended until the request is completely processed. After the system call, passes the kernel, the control over the CPU back to the user-mode process. The process continues its execution at the location, where the context switch was previously requested.

f) Name <u>two</u> reasons why user mode processes should not call system calls directly.

Working directly with system calls is unsafe and the portability is poor.

g) What alternatives exist, if user mode processes should not call system calls directly?

Modern operating systems provide a library, which is logically located between the user mode processes and the kernel.

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Question 9)

Points: .....

Maximum points: 4+2+1+1+2=10

a) A parent process (PID = 100) with the characteristics, described in the table below, creates a child process (PID = 200) by using the system call `fork()`. Enter the four missing values into the table.

	Parent Process	**Child Process**
PPID	99	*100*
PID	100	200
UID	25	*25*
Return code of `fork()`	*200*	*0*

b) Explain the difference between preemptive and non-preemptive scheduling.

When using non-preemptive scheduling, a process, which gets the CPU assigned by the scheduler, remains control over the CPU until its execution is finished or it gives the control back on a voluntary basis.

When using preemptive scheduling, the CPU may be removed from a process before its execution is completed.

c) Name <u>one</u> drawback of preemptive scheduling.

A process may occupy the CPU for as long as it wants and other (maybe more important) processes need to wait.

d) Name <u>one</u> drawback of non-preemptive scheduling.

Higher overhead compared with non-preemptive scheduling because of the frequent process switches.

e) Name <u>four</u> scheduling strategies, for which the CPU runtime (= execution time) of the processes are <u>not</u> required be known.
(Note: This means that only scheduling methods are correct here, which can be used in practice under realistic conditions.)

Priority-driven scheduling, First Come First Served, Last Come First Served, Round Robin with time quantum, Earliest Deadline First, Fair-Share.

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Question 10)

Points: .....

Maximum points: 10

a) Why does the process control block not store all process context information?

The content of the address space (user context) is not stored in the process table because it is too huge in size.

b) What is the task of the dispatcher?

It carries out the state transitions of the processes.

c) What is the task of the scheduler?

It specifies the execution order of the processes by using a scheduling algorithm.

d) What is a zombie process?

A terminated process which still appears in the process table. Its PID can not yet be assigned to a new process.

e) What is the task of the process control block?

The operating system stores the hardware context and system context in the process control block.

f) What is the PID?

Process ID $\Longrightarrow$ the unique process identification.

g) What is the PPID?

Parent Process ID $\Longrightarrow$ the process identification of the parent process.

h) Name (or describe) <u>one</u> useful application for the command `sed`.

This tool is used for the parsing and transforming of text.

i) Name (or describe) <u>one</u> useful application for the command `awk`.

This tool is used for text processing and data extraction and reporting.

j) What is `init` and what is its task?

`init` is the first process in Linux/UNIX. It has the PID 1. All running processes originate from `init`. `init` = father of all processes.

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Question 11)

Points: .....

Maximum points: 10

a) What must be considered, when inter-process communication via shared memory segments is used?

The processes need to coordinate the accesses themselves and to ensure that their memory accesses are mutually exclusive. A receiver process, cannot read data from the shared memory, before the sender process has finished its current write operation. If access operations are not coordinated carefully, inconsistencies occur.

b) According to which principle operate message queues?

☐ Round Robin ☐ LIFO ☒ FIFO ☐ SJF ☐ LJF

c) How many processes can communicate with each other via a pipe?

2

d) What is the effect, when a process tries to write data into a pipe without free capacity?

The writing process is blocked.

e) Which two different types of pipes exist?

Anonymous pipes and named pipes.

f) Which two different types of sockets exist?

Connection-less sockets (also called: datagram sockets) and connection-oriented sockets (also called: stream sockets).

g) What is a critical section?

Processes carry out read and write operations on common data. Critical sections may not be processed by multiple processes at the same time.

h) What is a race condition?

It is an unintended race condition of two processes, which want to modify the value of the same record.

i) Communication via shared memory segments works...

☒ memory-based ☐ stream-based
☐ object-based ☐ message-based

j) Communication via sockets works...

☐ memory-based ☐ stream-based
☐ object-based ☒ message-based