Written examination in Operating Systems

February 17th 2025

Last name: _____

First name: _____

Student number: _____

Mit dem Bearbeiten dieser schriftlichen Prüfung (Klausur) bestätigen Sie, dass Sie diese alleine bearbeiten und dass Sie sich gesund und prüfungsfähig fühlen. Mit dem Erhalt der Aufgabenstellung gilt die Klausur als angetreten und wird bewertet.

By attending this written exam, you confirm that you are working on it alone and feel healthy and capable to participate. Once you have received the examination paper, you are considered to have participated in the exam, and it will be graded.

- Use the provided sheets. Do *not* use own paper.
- You are allowed to use a *self prepared*, *single sided DIN-A4 sheet* in the exam. Only *hand-written originals* are allowed, but no copies.
- Do *not* use a red pen.
- Time limit: *90 minutes*
- Turn off your mobile phones!

Grade: _____

Questions:	1	2	3	4	5	6	7	8	9	10	11	**Σ**
Maximum Points:	6	6	10	10	16	7	9	6	5	7	8	90
Achieved Points:												

1.0: 90.0-85.5, **1.3**: 85.0-81.0, **1.7**: 80.5-76.5, **2.0**: 76.0-72.0, **2.3**: 71.5-67.5,
2.7: 67.0-63.0, **3.0**: 62.5-58.5, **3.3**: 58.0-54.0, **3.7**: 53.5-49.5, **4.0**: 49.0-45.0, **5.0**: <45

Question 1)

Points: ..... of 6

1 Point (1) Describe how memory protection works.

1 Point (2) Name one singletasking operating system.

1 Point (3) Name one multitasking operating system.

1 Point (4) Name one single-user operating system.

1 Point (5) Name one multi-user operating system.

1 Point (6) Name one real-time operating system

Question 2)

Points: ..... of 6

½ Point (1) GNU HURD implements a...

☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

½ Point (2) Linux implements a...

☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

½ Point (3) MacOS X implements a...

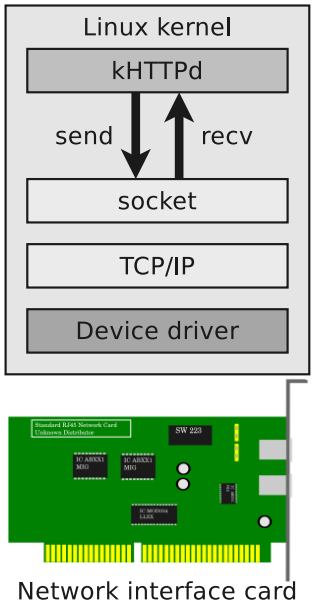
☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

½ Point (4) Windows NT4/Vista/XP/7/8/10/11 implements a...

☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

2 Points (5) Name <u>one</u> advantage and <u>one</u> drawback of microkernels.

2 Points (6) In class we discussed the concept of the kernel-based web server kHTTPd (see image). Explain one benefit and one drawback of this concept.



Question 3)

Points: ..... of 10

4 Points (1) Name and explain one advantage and one drawback of the autonomous subsystems (e.g. Intel Management Engine or AMD Platform Security Processor) in modern PCs.

2 Points (2) Describe the purpose of the firmware in the computer.

1 Point (3) Give the name of the firmware in classic computers from the early 1980s to the late 2000s.

1 Point (4) Give the name of the firmware in modern computers.

1 Point (5) Explain what the boot loader is.

1 Point (6) Explain where the boot loader is stored.

Question 4)

Points: ..... of 10

2 Points (1) Explain why an initial RAM disk (`initrd`) or than initial RAM file system (`initramfs`) are used.

1 Point (2) Describe the task of a `getty` process.

1 Point (3) Specify how many `getty` processes the operating system starts.

1½ Points (4) Name the three sorts of process context information the operating system stores.

½ Point (5) Explain why the process control block (PCB) does not store all process context information.

1 Point (6) Explain the task of the dispatcher.

1 Point (7) Explain the task of the scheduler.

1 Point (8) Name one drawback of preemptive scheduling.

1 Point (9) Name one drawback of non-preemptive scheduling.

Question 5)

Points: ..... of 16

1½ Points (1) Name the three main components the CPU contains.

1½ Points (2) Name the three digital bus systems each computer system contains according to the Von Neumann architecture.

3 Points (3) Explain the tasks that are carried out by the three bus systems of subtask (2).

2 Points (4) Name the two groups of Input/Output devices for computer systems that are distinguished according to their minimum transfer unit.

2 Points (5) Describe the different operating principles of the two groups of subtask (4).

2 Points (6) Name two examples for each group from subtask (4).

1 Point (7) Mark the concept where the CPU must check periodically whether data is available

☐ Direct Memory Access ☐ Interrupt driven ☐ Busy waiting

1 Point (8) Mark the concept where reading data causes no CPU workload

☐ Direct Memory Access ☐ Interrupt driven ☐ Busy waiting

1 Point (9) Name the cache write policy that uses so called dirty bits.

1 Point (10) Explain for what reason dirty bits are used.

Question 6)

Points: ..... of 7

1 Point (1) Explain why it is wrong to call SSDs Solid State Disks.

1 Point (2) Name two advantages of SSDs over HDDs.

1 Point (3) Explain why erase operations on flash memory are more complex than read operations.

4 Points (4) Draw the structure of a hard disk drive schematically. Explain with your drawing(s) the meaning of the following terms:

- Sector (= Block)
- Track
- Cylinder
- Cluster

Question 7)

Points: ..... of 9

1 Point (1) Describe the information inodes store.

1 Point (2) Name two examples of metadata in the file system.

1 Point (3) Describe what a cluster in the file system is.

1 Point (4) Describe how directories in the Linux file systems are technically implemented.

1 Point (5) Explain why moving a large file within a file system is always faster than copying it.

½ Point (6) `Documents/MasterThesis/thesis.tex` is an/a...

☐ absolute path name ☐ relative path name

½ Point (7) `/home/<username>/Mail/inbox/` is an/a...

☐ absolute path name ☐ relative path name

1 Point (8) Describe what the File Allocation Table (FAT) is and the information it stores.

1 Point (9) Describe the objective of the journal in a journaling file system.

1 Point (10) Describe a benefit of using a journaling file system compared with using a file system without a journal.

Question 8)

Points: ..... of 6

1½ Points (1) Name the three values that are required to store an extent.

1 Point (2) Describe the benefit of using extents compared with direct addressing of the clusters.

½ Point (3) Name <u>one</u> Linux file system that implements block addressing.

½ Point (4) Name <u>one</u> Linux file system that implements journaling.

½ Point (5) Name <u>one</u> Linux file system that implements extents.

½ Point (6) Name <u>one</u> Windows file system that implements the file allocation table.

½ Point (7) Name <u>one</u> Windows file system that implements journaling.

½ Point (8) Name <u>one</u> Windows file system that implements extents.

½ Point (9) Name <u>one</u> file system that implements copy-on-write.

Question 9)

Points: ..... of 5

5 Points (1) Perform the deadlock detection with matrices and check if a deadlock occurs.

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

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

Question 10)

Points: ..... of 7

7 Points

(1) Develop a pub simulation software. Glasses are filled by a bartender, and a guest consumes their content.

- The number of available glasses is limited. The bar has only 20 glasses.
- Process `bartender` fills glasses and places them on the bar.
- Process `guest` removes glasses from the bar and consumes their content.
- Mutual exclusion when accessing shared resources (taking a glass) is necessary to avoid inconsistencies.
- If all glasses are filled, the process `bartender` must be blocked.
- If all glasses are empty, the process `guest` must be blocked.

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

```
typedef int semaphore;




void bartender (void) {

  while (TRUE) {



    fillGlass;
    placeGlassOnBar;



  }
}

void guest (void) {

  while (TRUE) {



    removeGlassFromBar;
    emptyGlass;



  }
}
```

Question 11)

Points: ..... of 8

The output of the `ps` command contains helpful information about the processes in the operating system.

```
$ ps -eFw
UID      PID   PPID  C      SZ    RSS PSR STIME TTY        TIME CMD
root       1      0  0   42090  12820   0 Aug29 ?      00:00:03 /sbin/initroot
root       2      0  0       0      0   4 Aug29 ?      00:00:00 [kthreadd]
...
bnc     2149   1782  1  258958 133484   7 Aug29 ?      00:11:20 xfwm4 --display :0.0  ...
bnc     2474   1782  0  137013  54512   8 Aug29 ?      00:03:28 xfce4-panel --display :0.0 ...
bnc     2478   1782  0  166034 138652  15 Aug29 ?      00:00:20 xfdesktop --display :0.0 ...
bnc     3252   2474  3 8590107 577484   9 Aug29 ?      00:51:07 /opt/google/chrome/chrome
bnc     3530   1721  0  157125  62824   0 Aug29 ?      00:00:44 /usr/libexec/gnome-terminal-server
bnc     3568   3530  0    3271   9556  15 Aug29 pts/0  00:00:01 bash
root    6706      1  0    7087  10556   3 Aug29 ?      00:00:00 /usr/sbin/cupsd -l
root    6737      1  0   44549  18680  12 Aug30 ?      00:00:00 /usr/sbin/cups-browsed
bnc    72577  72539  0    2773   7224   4 Aug31 pts/1  00:00:00 /bin/bash
bnc    90775  72577  1  279130 187352   9 09:39 pts/1  00:00:04 okular thesis.pdf
bnc    94414   3568  0    2861   4952   6 11:19 pts/0  00:00:00 ps -eFw
```

1 Point (1) Explain the information in the column `UID`.

1 Point (2) Explain the information in the column `PID`.

1 Point (3) Explain the information in the column `PPID`.

1 Point (4) Explain the information in the column `SZ`.

1 Point (5) Explain the information in the column `RSS`.

1 Point (6) Explain the information in the column `TTY`.

1 Point (7) Explain the information in the column `TIME`.

1 Point (8) Name the parent process of the process that has printed this overview of the processes in the command-line interface.