Written examination in Operating Systems

February 05, 2023

Last name: _____

First name: _____

Student number: _____

Signature: _____

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Please write only your student number — but **not your name** — on this or any of the following sheets. By omitting your name a pseudonymized correction of your exam can be achieved. The first page with your name will be removed before correction and consequently the corrector cannot be biased when correcting your exam. By putting your student number on all pages you make sure that even in the case the stapling gets lost each page can be attributed to your exam.

Student number: _____

Result:

Question:	1	2	3	4	5	6	7	8	9	10	11	Total
Points:	10	6	10	8	8	10	9	6	6	10	8	91
Score:												

1.0: 91-86.5, **1.3**: 86-82, **1.7**: 81.5-77.5, **2.0**: 77-73, **2.3**: 72.5-68,
2.7: 68-63.5, **3.0**: 63.5-59, **3.3**: 59-54.5, **3.7**: 54.5-50, **4.7**: 50-45.5, **5.0**: <45

Question 1 **Points:** ....(max. 10 points)

Decide whether the following statements are correct or wrong and explain shortly why.

(a) Since operating systems based on a micro-kernel architecture are more robust, basically all relevant modern operating systems are based on this architecture.   □ True   □ Wrong

_____

_____

(b) In some scenarios a singletasking computer system can execute programs faster than a multitasking system.   □ True   □ Wrong

_____

_____

(c) A fork bomb is a problem for computers with very little resources, e.g., embedded systems.   □ True   □ Wrong

_____

_____

(d) The kernel of an operating system may implement more than one scheduling algorithm.   □ True   □ Wrong

_____

_____

(e) Semaphores can be used to implement mutexes.   □ True   □ Wrong

_____

_____

(f) Interrupts are used to simplify debugging. □ True □ Wrong

(g) Every x86 compatible CPU starts in Real Mode. □ True □ Wrong

(h) The rotational speed of a hard disk drive (HDD) is the only limiting factor of its performance. □ True □ Wrong

(i) The block size of the storage devices defines an lower bound for the cluster size of a file system. □ True □ Wrong

(j) The File Allocation Table of a VFAT file system grows over time when more files are created. □ True □ Wrong

Question 2   **Points:** ....(max. 6 points)

Give a command that can be used to...

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

(b) concatenate the content of different files or print out the content of a file.

(c) modify the cron jobs for the current user.

(d) modify a certain pattern in a file.

(e) print out lines from the beginning of a file in the shell.

(f) list the content of the current directory.

(g) sort the lines of a text file.

(h) create an archive file.

(i) delete files or directories.

(j) output a string in the shell.

(k) create a hard link.

(l) modify the permissions of files or directories.

Question 3 **Points:** . . . . (max. 10)

(a) Explain why it is impossible to implement the optimal replacement strategy OPT. (1)

(b) Mark the memory management method that. . . (3)
- 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 randomly a free block.
  □ First Fit
  □ Next Fit
  □ Best fit
  □ Random
- searches for a free block, starting from the latest allocation.
  □ First Fit
  □ Next Fit
  □ Best fit
  □ Random
- searches for a free block, starting from the beginning of the address space.
  □ First Fit
  □ Next Fit
  □ Best fit
  □ Random

(c) • Name the three components the CPU contains. (3)

- Name the three digital bus systems each computer system contains according to the Von Neumann architecture.

(d) Explain the tasks of the Southbridge. (1)

(e) Explain in which situations a page fault exception occur. (1)

(f) Explain in which situations an access violation exception or general protection fault exception occur. (1)

Question 4   **Points:** . . . .(max. 8 points)

(a) Name the three sorts of process context information the operating system stores.

(b) Explain the task of the dispatcher.

(c) Explain the task of the scheduler.

(d) Explain what the PID is.

(e) Explain what the PPID is.

(f) Describe the effect of calling the system call `fork`.

(g) Describe the effect of calling the system call `exec`.

(h) Explain why some operating systems have one or more system idle processes.

Question 5   **Points:** ....(max. 8 points)

(a) Explain the advantage of using the operations signal and wait compared with busy waiting.

(b) Name two problems that can arise from blocking.

(c) Explain the difference between signaling and blocking.

(d) Mark the scheduling method that is implemented by message queues.
   ☐ Round Robin
   ☐ LIFO
   ☐ SJF
   ☐ FIFO
   ☐ LJF

(e) Specify how many processes can communicate with each other via a pipe.

(f) Explain the effect, when a process tries to write data into a pipe without free capacity.

(g) Explain the effect, when a process tries to read data from an empty pipe.

(h) Name the two different types of pipes.

(i) Name the two different types of sockets.

Question 6   **Points:** .... (max. 10 points)

(a) Specify the net capacity of a RAID 0 array.

(b) Specify the net capacity of a RAID 1 array.

(c) Specify the net capacity of a RAID 5 array.

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

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

(f) Give the number of drives that can fail in a RAID 0 array without data loss.

(g) Give the number of drives that can fail in a RAID 1 array without data loss.

(h) Give the number of drives that can fail in a RAID 5 array without data loss.

(i) Name <u>one</u> advantage of software RAID compared with hardware RAID.

(j) Name <u>one</u> drawback of software RAID compared with hardware RAID.

Question 7 **Points:** . . . . (max. 9)

(a) Show Belady's anomaly by performing the access sequence with the replacement strategy FIFO once with a cache with a capacity of 3 pages and once with 4 pages. Also calculate the hit rate and the miss rate for both scenarios. (8)

Requests: **3 2 1 0 3 2 4 3 2 1 0 4**

Page 1:												
Page 2:												
Page 3:												

Hit rate:

Miss rate:

Requests: **3 2 1 0 3 2 4 3 2 1 0 4**

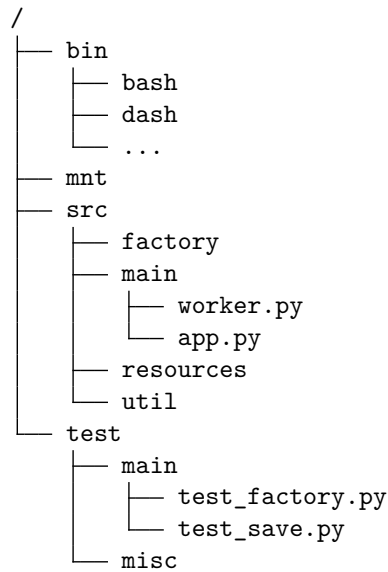| Page 1: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Page 2: | | | | | | | | | | | | |
| Page 3: | | | | | | | | | | | | |
| Page 4: | | | | | | | | | | | | |

Hit rate:

Miss rate:

(b) Explain why fragmentation in memory management is irrelevant for modern operating systems. (1)

Question 8 **Points:** . . . .(max. 6 points)

Take a look at the given file system tree.

```
/
├── bin
│   ├── bash
│   ├── dash
│   └── ...
├── mnt
├── src
│   ├── factory
│   ├── main
│   │   ├── worker.py
│   │   └── app.py
│   ├── resources
│   └── util
└── test
    ├── main
    │   ├── test_factory.py
    │   └── test_save.py
    └── misc
```
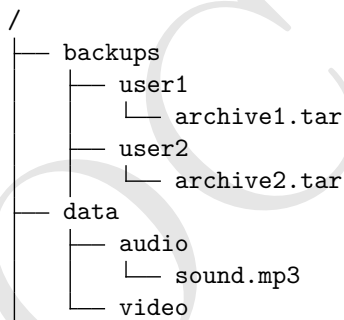
(a) Write down the absolute path to the file `test_save.py`:

(b) Write down the relative path from `src` to the file `app.py`:

(c) Write down the relative path from the `factory` directory to the file `test_save.py`:

(d) Another file system gets *mounted* at `/mnt`. The tree of this file system looks like this:

```
/
├── backups
│   ├── user1
│   │   └── archive1.tar
│   ├── user2
│   │   └── archive2.tar
├── data
│   ├── audio
│   │   └── sound.mp3
│   └── video
```

Write down the absolute path to the file `archive1.tar`:

(e) A symbolic link to sound.mp3 shall be created in the directory resources. Describe the information that needs to be added to the file system.
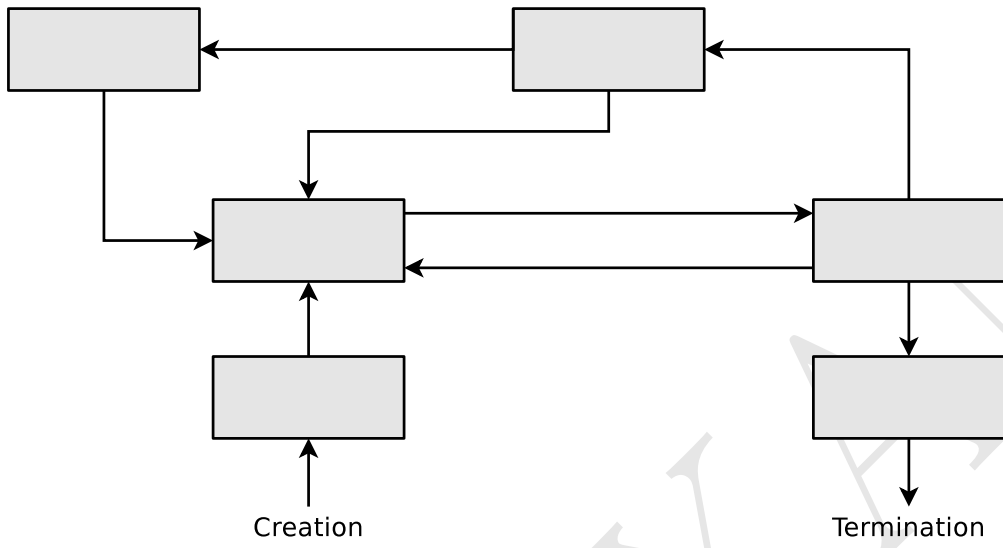
(f) A hard link to sound.mp3 shall be created in the directory resources. Describe the information that needs to be added to the file system.

Question 9 **Points:** . . . .(max. 6 points)

(a) Enter the names of the states in the diagram of the process state model with 6 states.

Creation

Termination

Question 10 **Points:** . . . . (max. 10)

(a) Explain which problem may occur when static priorities are used for scheduling. (1)

(b) Some systems implement one or more idle process. Explain what idle processes are good for. (1)

(c) The two processes P_A (4 ms CPU time) and P_B (26 ms CPU time) are both in state `ready` at time point 0 and are to be executed one after the other.
Fill the table with correct values. *(Hint: Runtime = Lifetime)* (6)

Execution order	Runtime P_A	P_B	Average runtime	Waiting time P_A	P_B	Average waiting time
P_A, P_B						
P_B, P_A						

(d) Explain what can be observed from the values you filled into the table in (c). (2)

Question 11 **Points:** . . . . (max. 8 points)

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

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

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