Chalmers University of Technology and Gothenburg University

Operating Systems
EDA093, DIT 401

Exam 2021-10-23

Date, Time: Saturday 2021/10/23, 08.30-12.30

Course Responsible:
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Auxiliary material: You may have with you
- An English-Swedish, Swedish-English dictionary.
- No other books, notes, calculators, etc.

Grade-scale ("Betygsgränser"):
CTH: 3:a 30-39 p, 4:a 40-49 p, 5:a 50-60 p
GU: Godkänd 30-49p, Väl godkänd 50-60 p

Exam review ("Granskningstid"):
Will be announced after the exam.

Instructions

- Do not forget to write your personal number, if you are a GU or CTH student and at which program ("linje").
- Start answering each assignment on a new page; number the pages and use only one side of each sheet of paper.
- Write in a **clear manner** and **motivate** (explain, justify) your answers. If it is not clear what is written, your answer will be considered wrong. If it is not explained/justified, even a correct answer will get **significantly** lower (possibly zero) marking.
- If you make **any assumptions** in answering any item, do not forget to clearly state what you assume.
- The exam is organized in groups of questions. The credit for each group of questions is mentioned in the beginning of the respective group. Unless otherwise stated, all questions in a group have equal weight.
- Answer questions in English, if possible. If you have large difficulty with that and you think that your grade can be affected, feel free to write in Swedish.

Good luck !!!!

1. (12 p)

   (a) (6 p) Given the following allocation of pages in frames (assume each column shows the frames' statuses after a page access has been completed) and assuming the Least Recently Used (LRU) page replacement algorithm is being used, compute a possible reference string that is compatible with this execution, specifying which requests resulted in a page fault.

1	1	1	1	1	6	6	6	6	4	4	4	4	14	14	14	14	14
-	2	2	2	2	2	1	1	1	1	5	5	5	5	5	5	2	2
-	-	-	4	4	4	4	2	2	2	2	6	6	6	6	6	6	3
-	-	-	-	5	5	5	5	3	3	3	3	7	7	7	7	7	7

   [**HINT:** Each column that changes implies a page fault (and the change is the page being requested). If the column does not change, you can pick from the ones in the column, but make sure you do not pick one that would make the table inconsistent (the one replaced later on must be the Least Recently Used). 1,2,2,4,5,6,1,2,3,4,5,6,7,14,14,14,2,3 is a valid string]

   (b) (3 p) Assuming now that the previous table is referring to FIFO page replacement, how many different strings could be compatible with it?

   [**HINT:** Each column that has a change implies a specific page has been accessed. Each column that has no change implies any page could have been accessed. Hence, multiple the number of pages in each column that has no change. 2*4*4=32]

   (c) (3 p) In which situation does thrashing occur?

   [**HINT:** sum(locality) of running processes > total memory]

2. (12 p)

   (a) (6 p) Knowing that users belong to groups according to the next table:

groups\users	u1	u2	u3
G1	x	x	
G2	x		x
G3			x

   (for instance, that user u1 belongs to G1 and G2), given the following list of files and associated owner/group:

File	Owner	Group
f1	u1	G1
f2	u2	G2
f3	u3	G2
f4	u4	G1

   and given the following list of commands executed in order that specifies which ones were successful and which where not:

User	Command	successful
u1	cat f1	yes
u2	rm f1	yes
u3	cat f1	no
u1	cat f2	yes
u2	rm f3	yes
u3	rm f4	no
u2	./f3	no
u1	./f3	no
u4	./f4	yes

tell which are the read/write/execute permissions (owner/group/other) for the 4 files. Motivate your answer.

[**HINT:** Each operation tell you whether a certain bit is 1 or 0. In some cases, you cannot say. Beware: some operations might fail because the file has been removed, you cannot infer bits in that case. It looks like this (in compact notation)
f1: 1??-?1?-???
f2: ???-1??-???
f3: ???-???-?1?
f4: ??1-???-?0?
]

(b) (6 p) What are the commonalities and the differences between Access Control Lists and Capabilities? Provide a sample setup (different from the one discussed in the course) and show how it would be implemented using Access Control Lists and Capabilities.

[**HINT:** Please refer to the relevant slides in the Security lecture]

3. (12 p)

(a) (4 p) What does it mean for a scheduling algorithm to potentially result in starvation? Explain how one of the scheduling algorithms (covered in the course) that can result in starvation works, also providing an example in which starvation is indeed happening.

[**HINT:** no guarantee that a process will run. Shortest job first (non-preemptive). Example: one process is each received every second and its duration is 1 second + process X received at second > 1 with duration > 1. X will be starved.]

(b) (4 p) Assume n processes are running. Process i is given $(\sum_{j=1}^{n} j) - i$ lottery tickets (we assume lottery scheduling). If $n = 4$, is more likely that process P1 or process P4 will run? By how much?

[**HINT:** tickets= 9,8,7,6. Hence, P1 has 0.3 prob and P4 has 0.2. P1 has 1.5 more chances than P4.]

(c) (4 p) Can caches influence the effectiveness of a scheduling algorithm? motivate your answer.

[**HINT:** Yes. Check the relevant slides in the scheduling lecture.]

4. (12 p) For each one of the following affirmations, state if you think they are true (T), false (F) or if they do not contain enough information to state whether they are true or false (?). Motivate your answers.

(a) (2 p) User-level threads cannot be scheduled by a preemptive scheduler.

(b) (2 p) Kernel-level threads cannot be scheduled by a preemptive scheduler.

(c) (2 p) A multi-threaded process can be in a state in which all its threads are not running.

(d) (2 p) A multi-threaded process can be in a state in which all its threads are waiting.

(e) (2 p) 2 processes (one forked from the other) can communicate using an unnamed pipe that has been created after issuing the fork command.

(f) (2 p) Knowing that an application X is using 2 cores in parallel is sufficient information to infer if multi-threading is being used by X.
[**HINT:** F F T T F F]

5. (12 p)

(a) (2 p) What is the difference between Type 1 and Type 2 hypervisors?
[**HINT:** Check slides lecture about Virtualization]

(b) (5 p) How does ballooning works? Show with a detailed example how a hypervisor would use it.
[**HINT:** Check slides lecture about Virtualization]

(c) (5 p) Discuss one similarity and one difference between the virtualization of memory from the perspective of an OS and that of a hypervisor.
[**HINT:** Possible answer: similarity: both allow a set of processes to run even if their logical memory exceeds the physical one. difference: OS has 1 level of decoupling, hypervisor might have 2 (itself and the OS) and this makes it more challenging for the hypervisor to keep its page table consistent.]