Chalmers University of Technology and Gothenburg University

Operating Systems
EDA093, DIT 401
Exam 2018-10-27

Date, Time, Place: Saturday 2018/10/27, 08.30-12.30, Hörsalar på hörsalsvgen

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) (4 p) Write the code of a program that can be used to make a copy of a certain file (specified by the user). This program should be run by two threads T1 and T2 belonging to two different processes P1 and P2 (T1 belongs to P1, T2 belongs to P2). T1 is the thread responsible for asking which file to copy (and the file name of the copy) while T2 is the thread responsible for making the actual copy.

   (b) (4 p) A multi-threaded process implemented using the many-to-one threading model can run both concurrently (on the same core) and in parallel (at different cores). True or false? Explain why.

   (c) (4 p) Why does the OS define a "terminated" state for a process and does not simply end the process? Provide an example of when this is useful.

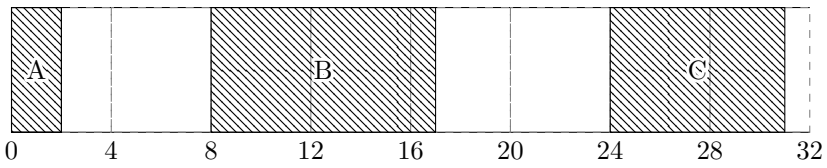
2. (12 p)

   (a) (4 p) Discuss the effects of underestimating and overestimating the parameter Δ of the working-set window.

   (b) (4 p) if the pages loaded in n frames using a certain page replacement algorithm are a subset of those loaded for $n+1$ frames using the same page replacement algorithm, then the Belady's anomaly cannot be observed. True or false? Discuss why

   (c) (4 p) If the Least Recently Used page replacement algorithm is implemented using reference bits why is it an approximation? Can you provide an example showing it is not exact?

3. (12 p) Consider the following allocation of 3 files (A of 2KB, B of 9KB and C of 7KB) on a 32KB contiguous zone on disk using 4KB block size:



   (a) (3 p) What is the quantity of internal fragmentation in the presented allocation? How can we reduce it? What other system parameter is then impacted and how?

   (b) (3 p) How much space would be used on disk in the best possible allocation with block sizes of 1KB, 8KB and 16KB? Detail your reasoning.

   (c) (3 p) Assume contiguous allocation has been used to arrive to the presented allocation. Give pros and cons of contiguous allocation and 2 examples of different operations on files that might have led to the final allocation.

   (d) (3 p) What are the two most commonly used data structures to keep track of free space? Present them briefly. Which one is more space efficient and when?

4. (12 p)

   (a) (2 p) Consider a CPU scheduling algorithm that favors those processes that have used the least processor time in the recent past. Why will this algorithm favor I/O-bound programs and yet not permanently starve CPU-bound programs?

(b) (3 p) What is the reason for having different time-quantum sizes on different levels of a multilevel queuing system?

(c) (3 p) What does the term "processor affinity" mean in the context of multiprocessor scheduling? Describe advantages and limitations of processor affinity.

(d) (4 p) Discuss the EDF policy (Description, properties: advantages and limitations/disadvantages).

5. (12 p)

(a) (2 p) What is a race condition? Explain the term and provide an example.

(b) (2 p) Consider two threads, A and B. Thread B must execute operation opB only after thread A has completed operation opA. How can you guarantee this synchronization using semaphores?

(c) (4 p) We have three threads, A, B, C (taking care of operations opA, opB, opC respectively) that can arrive to execute in any order. The initial values for the semaphores that they use, are: `semaphores semA=1, semB=1, semC=0`.

```
thread A:
  wait(semC);
  wait(semB);
  opA;    // some operation
  signal(semB);
  signal(semA);

thread B:
  wait(semA);
  wait(semB);
  opB;
  signal(semB);

thread C:
  wait(semA);
  wait(semB);
  opC; //some operation
  signal(semB);
  signal(semA);
  signal(semC);
```

Are the following executions possible or not and why? (i) opA opB opC (ii) opB opC opA (iii) opC opA opB (iv) opB opA opC

(d) (4 p) Consider 2 threads, A and B, which must forever take turns executing operation opA and operation opB respectively. Thread A must be the one that executes opA first. How can you guarantee that using semaphores? Formulate the safety and progress requirements and argue about the correctness of your solution.