TENTAMEN / *EXAM*

TDDB68

Processprogrammering och operativsystem /
Concurrent programming and operating systems

2017-08-21, 14:00–18:00

Jour: Mikael Asplund (0700895827)

Hjälpmedel / *Admitted material:*

– Engelsk ordbok / *Dictionary from English to your native language*;
– Miniräknare / *Pocket calculator*

General instructions

- This exam has 6 assignments and 8 pages, including this one.
  Read all assignments carefully and completely before you begin.
- Please **use a new sheet of paper for each assignment**, because they will be corrected by different persons.
  Sort the pages by assignments and number them consecutively.
- You may answer in either English or Swedish. **English is preferred** because not all correcting assistants understand Swedish.
- Write clearly. Unreadable text will be ignored.
- Be precise in your statements. Unprecise formulations may lead to a reduction of points.
- Motivate clearly all statements and reasoning.
- Explain calculations and solution procedures.
- The assignments are *not* ordered according to difficulty.
- The exam is designed for 40 points. You may thus plan about 5 minutes per point.
- **How much to write?** No general policy, but as a rule of thumb: Questions for 0.5p can typically be answered properly in a single line. Correct and concise answers to questions for 1p usually require a few lines. Code and figures should be commented properly.
- Grading: U, 3, 4, 5. The preliminary threshold for passing is 20 points.

Good luck!

1. **Multiple choice quesions (10p)**

   Below are 10 multiple choice questions. Please answer them by removing the last page of the exam, fill the appropriate boxes, and hand it in together with the rest of your answers. Please note that there might be more than one correct option. Each question below can give 0 or 1 point(s), and to get 1 point you must have identified exactly the right set of choices.

   (a) Consider the program below. How many times will it outout the line "Hello"?

```
#include <stdio.h>
#include <unistd.h>
int main()
{
  fork();
  printf("Hello\n");
  fork();
  printf("Hello\n");

  return 0;
}
```

   A) 2 times
   B) 3 times
   C) 4 times
   D) 6 times

   (b) Which of the following are possible states for a system process (as described in the course literature):

   A) Waiting
   B) Ready
   C) Forking
   D) Controlling

(c) Assume a single-CPU system and the following set of processes with arrival times (in milliseconds), expected maximum execution time (ms), and priority (1 is highest, 5 is lowest priority). The time quantum is 2ms, and to break a tie between two processes arriving simultaneously to the queue, you can assume that a newly arrived process will be put first.

Process	Arrival time	Execution time	Priority (as applicable)
P_1	0	6	5
P_2	1	3	2
P_3	5	1	4
P_4	6	3	3
P_5	8	2	1

Which of the scheduling policies below could result in the following execuction trace?

$$P_1, P_1, P_2, P_2, P_1, P_1, P_2, P_3, P_4, P_4, P_1, P_1, P_5, P_5, P_4$$

A) FIFO

B) Round-robin

C) Shortest-job first with preemption

D) Priority scheduling with preemption

(d) Which of of the following events will take place when switching from one process (old) to another (new).

A) Changing the set of currently open files to match with the new process.

B) Copying data from the process control block (PCB) of the new process into the interrupt vector table.

C) Storing CPU register states into the PCB of the old process.

D) Updating registers relating to memory management (e.g., base address pointer).

(e) Which of the following memory management tasks can be performed by the MMU:

A) Memory protection

B) Page table lookup

C) Page replacement

D) TLB lookup

(f) The following is an excerpt from the Wikipedia article on the WannaCry ransomware (accessed 2017-06-01):

> The WannaCry ransomware attack was a worldwide cyberattack by the WannaCry ransomware cryptoworm, which targeted computers running the Microsoft Windows operating system by encrypting data and demanding ransom payments in the Bitcoin cryptocurrency.
> The attack began on Friday, 12 May 2017, and within a day was reported to have infected more than 230,000 computers in over 150 countries. Parts of Britain's National Health Service (NHS), Spain's Telefonica, FedEx and Deutsche Bahn were hit, along with many other countries and companies worldwide. Shortly after the attack began, a web security researcher who blogs as "MalwareTech" discovered an effective kill switch by registering

a domain name he found in the code of the ransomware. This greatly slowed the spread of the infection, effectively halting the initial outbreak on Monday, 15 May 2017, but new versions have since been detected that lack the kill switch. Researchers have also found ways to recover data from infected machines under some circumstances.
WannaCry propagates using EternalBlue, an exploit of Windows' Server Message Block (SMB) protocol. Much of the attention and comment around the event was occasioned by the fact that the U.S. National Security Agency (NSA) had discovered the vulnerability in the past, but used it to create an exploit for its own offensive work, rather than report it to Microsoft. It was only when the existence of this vulnerability was revealed by The Shadow Brokers that Microsoft became aware of the issue, and issued a "critical" security patch on 14 March 2017 to remove the underlying vulnerability on supported versions of Windows. but many organizations had not yet applied it.

Which of the following protection measures could have reduced the impact of this attack?

A) Two-factor authentication
B) Faster updates of critical security patches
C) Proper backup procedures
D) Encryption

(g) Which of the following are classical scheduling algorithms (as described in the course literature):

A) Shortest-job first scheduling
B) Burst-first scheduling
C) Priority scheduling
D) Timer scheduling

(h) Which of the following virtualization configurations are possible when using *paravirtualization*:

A) Host running Ubuntu Linux on a x86-64 machine, Guest running Windows 10 for x86-64
B) Host running Windows 10 on a x86-64 machine, Guest running Ubuntu Linux for x86-64
C) Host running Ubuntu Linux on a x86-64 machine, Guest running Linux for ARM
D) Host running Ubuntu Linux on an IA-32 machine, Guest running Ubuntu Linux for x86-64

(i) Which of the following statements about Banker's algorithm are true?

A) It is a deadlock-preventing algorithm.
B) It is a deadlock-avoiding algorithm.
C) It is a deadlock detection algorithm.
D) It can be used when there are multiple instances of a resource.

(j) Which of the following can be said to constitute vulnerabilities

   A) Lack of input validation in a program
   B) An email with a virus attached
   C) The Android operating system
   D) Clear-text storage of passwords

2. **Synchronization (7p)**

   The monitor construct can be implemented by using semaphores. Consider a monitor that has one condition variable `condx` and functions `f1 ... fn`. First assume that `signal(condx)` is only called *at the end of a function*.

   (a) Explain how each function body `fx` should be modified to ensure mutual exclusion to the monitor by providing pseudocode. Explain any additional variable you introduce and how they should be initialised.

   ```
   %Your pseudocode here
   Body of fx
   %Your pseudocode here
   ```

   (1p)

   (b) Provide pseudocode for the operations `wait(condx)` and `signal(condx)` and and explain any additional variable you introduce and how they should be initialised. (3p)

   (c) Now consider the possibility that `wait(condx)` can be called in the middle of a function `fx`. Describe the necessary changes that must be made (through new pseudocode). (3p)

3. **Deadlocks (7p)**

   (a) Construct a resource allocation graph with four processes and four resource instances such that

   (i) the graph has a cycle and the processes on the cycle are deadlocked;

   (ii) the graph has a cycle and the processes on the cycle are *not* deadlocked.

   (3p)

   (b) Consider the following resource allocation problem in a system with 3 resources (R1-R3), and 4 processes (P1-P4). The table indicates the currently allocated resources and in parenthesis the maximum possible demand.

	R1	R2	R3
P1	0 (0)	1 (6)	2 (3)
P2	0 (0)	3 (5)	2 (3)
P3	0 (1)	0 (0)	0 (6)
P4	1 (1)	2 (3)	0 (6)

   The currently available resources are: [4, 2, 2]. Use Banker's algorithm to determine if the request [0, 2, 1] from Process P2 should be granted. (4p)

4. **Processes and scheduling (6p)**

   (a) Define the terms *process*, *kernel-level thread* and *user-level thread*, and explain the differences between them. (3p)

   (b) Given a single-CPU system and the following set of processes with arrival times (in milliseconds), expected maximum execution time (ms), and priority **(5 is highest, 1 is lowest priority)**.

Process	Arrival time	Execution time	Priority (as applicable)
$P1$	0	1	1
$P2$	3	4	2
$P3$	5	3	3
$P4$	7	2	4
$P5$	8	2	5

   For each of the following scheduling algorithms, create a Gantt chart (time bar diagram, starting at $t = 0$) that shows when the processes will execute on the CPU. Where applicable, the time quantum will be 2 ms. Assume that a task will be eligible for scheduling immediately on arrival. If you need to make further assumptions, state them carefully and explain your solution.

   i) FIFO;

   ii) Round-robin;

   iii) Priority Scheduling *with* preemption.

   (3p)

5. **Memory Management (5p)**

   (a) What is *thrashing* in a virtual memory system? How does it occur? And what can be done about it? (2p)

   (b) LRU is a popular strategy for page replacement in virtual memory. However it is just a heuristic technique. What is the (theoretical) *optimal* page replacement strategy, why is it not applicable in practice, and how does it differ from LRU? (2p)

   (c) How can segmentation and paging be combined? (1p)

6. **File systems (5p)**

   (a) What is/are the main (technical) purpose(s) of *opening* a file?
   What kernel data structures does the `open()` system call manipulate and how, and what does it return? (2p)

   (b) Some systems provide file sharing by maintaining a single copy of a file. Other systems maintain several copies, one for each of the users sharing the file. Discuss the relative merits of each approach. (3p)

Intentionally empty page.

Multiple choice form for answering question 1. Please put X:s in the appropriate cells:

	A	**B**	**C**	**D**
1 a)				
1 b)				
1 c)				
1 d)				
1 e)				
1 f)				
1 g)				
1 h)				
1 i)				
1 j)				