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AUGUST/RESIT EXAMINATIONS 2021/2022

MODULE: CA4006 - Concurrent and Distributed Programming

PROGRAMME(S):

CASE	BSc in Computer Applications (Sft.Eng.)
ECSAO	Study Abroad (Engineering & Computing)
ECSA	Study Abroad (Engineering & Computing)

YEAR OF STUDY: 4,O,X

EXAMINER(S):

Dr. Takfarinas Saber	(Internal)	(Ext:6831)

TIME ALLOWED: 2 Hours

INSTRUCTIONS: **Answer all questions.**

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO.
The use of programmable or text storing calculators is expressly forbidden.

There are no additional requirements for this paper.

QUESTION 1 ***[TOTAL MARKS: 25]***

Q 1(a) **[8 Marks]**

With the help of an example, define latency and throughput. Describe two systems: one where the goal is to minimise latency and another one where the goal is to maximise throughput. What is the computing environment associated with each goal?

Q 1(b) **[10 Marks]**

You have designed a system that is composed of 8 components. Figure Q 1(b) shows the organisation of the components and their respective throughputs (in request per second).

- What is the overall throughput that the system could achieve? Explain your answer.
- You were told that the bottleneck component is run on the cloud and the cloud provider charges $1,000 for every 1 request increase per second in throughput. To improve the performance of the system, your company pays the cloud provider to increase the throughput to 120 Req/s. Is that a good idea and why?

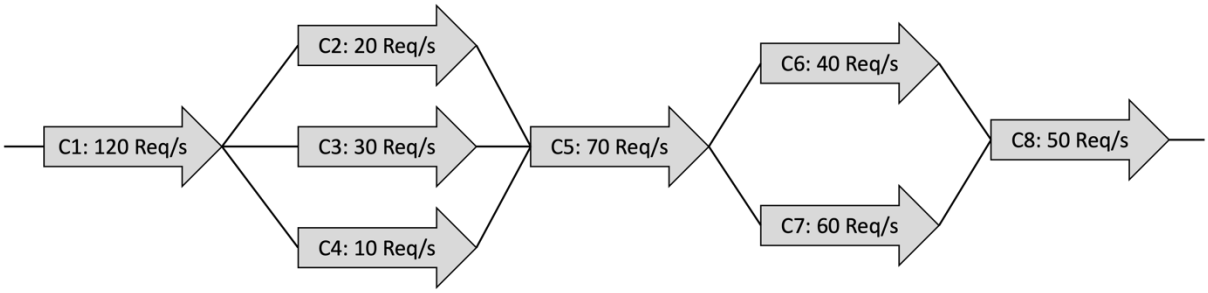

Figure Q 1(b). Throughput of each component composing the system

Q 1(c) **[7 Marks]**

You have written a program that takes 100ms on a single processor. If you were told that you could achieve a speedup of 2 on 4 processors, compute the percentage of serial and parallelisable sections in your program. How much speedup would you achieve on 8 processors?

[End of Question 1]

QUESTION 2 ***[TOTAL MARKS: 25]***

Q 2(a) **[10 Marks]**

What are the advantages of monitors over spinlocks? What is the mechanism that monitor uses to achieve each advantage? Show two alternatives for using monitor in Java?

Q 2(b) **[5 Marks]**

One of the monitor concepts is the monitor invariant. Describe this concept. In which case the monitor invariant is relaxed? Explain with the help of an example.

Q 2(c) **[10 Marks]**

Analyse the code in Figure Q 2(c) which is supposed to manage operations on a bank account and print its balance (but only when the balance is negative). Describe in words the working of the code in Figure Q 2(c). Describe an example where the code would not work as expected. Describe a solution you would bring to solve the problem. Provide a code snippet that shows your solution.

```
Class Account{
      private double balance = 0.0;
      public void synchronized deposit(double d){
            int balance = balance + d;
      }
      public void synchronized withdraw(double w){
            int balance = balance - w;
            If (balance < 0)
                  notify();
      }
      public void synchronized printBalance(){
            if (balance >= 0)
                  wait();
            System.out.println("Balance=" + balance);
      }
}
```

Figure Q 2(c). Java Code for Bank Account

[End of Question 2]

QUESTION 3 ***[TOTAL MARKS: 25]***

Q 3(a) **[10 Marks]**

Explain the general idea behind the 'Epidemic' algorithm in Replication Systems for Distributed Systems? Explain its relationship with epidemics (rapid spread of infectious disease) in a community.
What assumptions should a Replication System meet to enable the implementation of the epidemic algorithm.
Using an example, describe two epidemic propagation models. Compare them in terms of complexity and reliability.

Q 3(b) **[8 Marks]**

One approach to ensure mutual exclusion in distributed systems is using the centralised algorithm. Describe this algorithms on an example. What are characteristics of this algorithm in terms of number of exchanged messages and delay before entry.

Q 3(c) **[7 Marks]**

Before implementing the centralised mutual exclusion in a distributed system, it is necessary to dynamically elect one node to take the role of coordinator. Describe an algorithm that will allow you to achieve that. Show the working of this algorithm on a peer-to-peer distributed system with 8 nodes.

[End of Question 3]

QUESTION 4 ***[TOTAL MARKS: 25]***

Q 4(a) **[8 Marks]**

Using an example, explain the concepts of 'location transparency', 'location independence', and 'cache' in the context of a Distributed File System? What are the benefits of using a cache for such system?
What is referred to the 'cache-consistency' problem? How can you solve it?

Q 4(b) **[10 Marks]**

Three hosts are communicating with one another in a distributed system. Their clocks run at different speeds:

- Process A has dC/dt = 1.2 (a fast clock)
- Process B has dC/dt = 1 (a perfect clock)
- Process C has dC/dt = 0.8 (a slow clock)

The following messages are sent (T denotes real time in seconds).

- A sends a message to B at time T=20
- A sends a message to C at time T=50
- A sends a message to B at time T=60
- C sends a message to A at time T=80
- B sends a message to C at time T=90

Assuming all messages take exactly 10 real-time seconds to arrive:
What are the timestamps of the three processes if we use Lamport's algorithm to enforce a global logical clock? Explain each step of your answer.

Q 4(c) **[7 Marks]**

What is the main issue with Lamport's algorithm when enforcing a global logical clock? Provide an example showcasing the problem. Briefly name and describe an alternative algorithm that would solve the problem faced by Lamport's algorithm.

[End of Question 4]

[END OF EXAM]