B.Sc. Engg. CSE 5th Semester

09 December 2023 (Morning)

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION

DURATION: 3 HOURS

WINTER SEMESTER, 2022-2023

FULL MARKS: 150

CSE 4547: Parallel and Distributed Systems

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 6 (six)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. a) Consider the following two code snippets. If run with one thread per logical core, threads started by the program in snippet 1 print out their thread numbers in random order while threads started by the program in snippet 2 always print out their results in the same order. Explain why. 8 (CO1) (PO1)

```c
#include <stdio.h>
#include <omp.h>
int main()
{
    printf("Hello, World:");
    #pragma omp parallel
        printf(" %d", omp_get_thread_num());
    printf("\n");
    return 0;
}
```

Code Snippet 1: Sample C program for Question 1. a)

```c
#include <stdio.h>
#include <omp.h>
long fib(int n) {return(n < 2 ? 1 : fib(n - 1) + fib(n - 2));}
int main()
{
    int n = 45;
    # pragma omp parallel
        {
            int t = omp_get_thread_num();
            print("%d: %ld\n", t, fib(n+t));
        }
    return 0;
}
```

Code Snippet 2: Sample C program that prints "Hello World!" for Question 1. a)

b) Let a program P be composed of a part R that can be ideally parallelized, and of a sequential part S; that is, $P = RS$. On a single processor, S takes 10% of the total execution time and during the remaining 90% of time R could run in parallel. Determine the maximal speedup reachable with an unlimited number of processors. 7 (CO1) (PO1)

c) A problem Π comprises two subproblems, Π_1 and Π_2, which are solved by programs P_1 and P_2, respectively. The program P_1 would run 1000s on the computer C_1 and 2000s on the computer C_2, while P_2 would require 2000s and 3000s on C_1 and C_2, respectively. The computers are connected by a 1000-km long optical fiber link capable of transferring data at 100 MB/sec with 10 msec latency. The programs can execute concurrently but must transfer 10 (CO1) (PO1)

either (a) 10 MB of data 20,000 times or (b) 1 MB of data twice during the execution. What are the best configurations and approximate runtimes in cases (a) and (b)?

2. a) Consider the time-event diagram given in Figure 1. The dots in the diagram represent distinct events and the arrows represent message transmissions. A subset of the events is labeled from a to f. 5 + 5 (CO2) (PO1)

   i. Timestamp each event based on the Vector Clock algorithm.

   ii. For each of the following pairs of events, determine if the happened before relations is ensured.
   - a, b
   - b, d
   - c, e
   - c, f

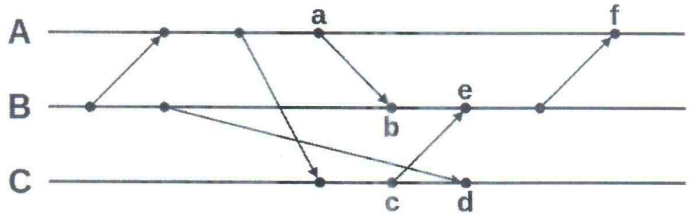

Figure 1: Time-event diagram for Question 2. a)

b) Discuss the challenges faced when clock synchronization algorithms developed for traditional distributed systems are used in wireless networks. Propose a suitable solution for wireless systems that can overcome these challenges. 15 (CO3) (PO2)

3. a) Discuss how Wi-Fi-based location services are established to track the position of the nodes in the system. 6 (CO2) (PO1)

b) Compare among the centralized, distributed, token-based, and decentralized mutual exclusion algorithms in terms of the number of messages needed to be propagated for a single process to get exclusive access to a shared resource. 9 (CO1) (PO1)

c) Consider the network in Figure 2. The Nodes $S_1, ..., S_5$ are subscribed to some data items. These data items are published by the nodes P_1 and P_2. Propose a suitable policy that will allow proper coordination in the system. What kind of communication method should be selected for the policy? Justify your answer. 10 (CO3) (PO2)

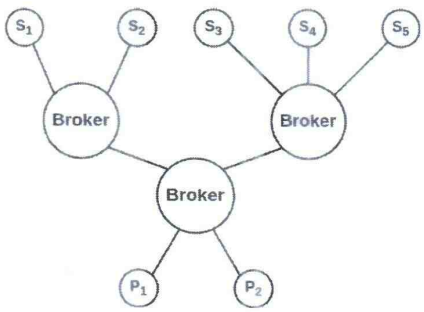

Figure 2: The subscriber-publisher system for Question 3. c)

4. a) Differentiate between the Global Positioning System and Logical Positioning System. For both systems, give an example scenario where they can be applied. 7 (CO2) (PO1)

b) Explain how conflict is avoided when multiple nodes simultaneously try to elect a leader in a ring topology. Provide a suitable example to justify your answer. 8 (CO2) (PO1)

c) Figure 3 depicts a wireless network where the letters denote the IDs of the node and the numbers denote their capacity. The node F initiates an election to select a leader for the network. Show the steps the network will go through during the election process. 10 (CO3) (PO2)
Assume that whenever a node receives messages from multiple nodes simultaneously, it will always selects the node based on the alphabetical order of the their IDs. For example, if a node receives messages from B, F, and G, it will accept the message from B while discarding the other messages.
Similarly, if multiple nodes have equal capacity, then the node whose ID comes first in the alphabet will be considered for the role of leader.

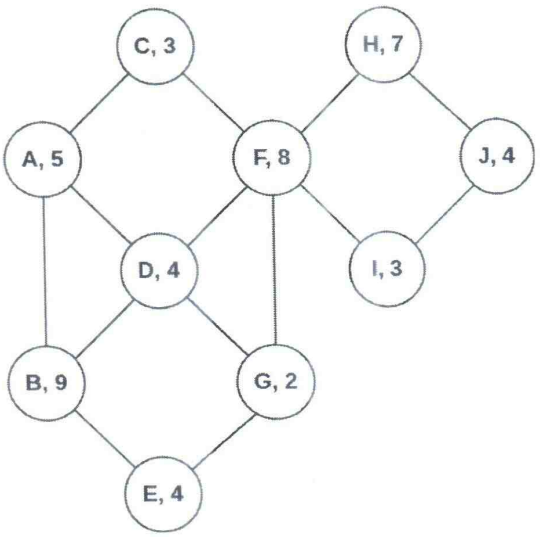

Figure 3: The wireless network for Question 4. c)

5. a) What are the goals of using wrappers and interceptors in middleware? Explain how they achieve these goals 7 (CO2) (PO1)

b) Compare between two different approaches to request dispatching in local area clusters. 8 (CO2) (PO1)

c) What is an object server? How does it vary from traditional servers? 5 (CO2) (PO1)

d) Briefly discuss the three prevailing types of parallelism in modern systems. 5 (CO2) (PO1)

6. a) Give an explanation why $T_{par} \leq T_{seq} \leq p \cdot T_{par}$, where T_{par} and T_{seq} are the parallel and sequential execution times of a program, respectively, and p is the number of processing units used during the parallel execution. 7 (CO1) (PO1)

b) Is the following statement true or false? Justify your answer with proper explanation: 5 (CO1) (PO1)

"If speedup $S < p$ then efficiency $E > 1$"

c) If processing units are identical, then in order to minimize parallel execution time, should the work (or computational load) of a parallel program be partitioned into equal parts and distributed among the processing units? Justify your answer. 5 (CO1) (PO1)

d) Determine the bisection bandwidths of 1D-mesh (chain of computers with bi-directional connections), 2D-mesh, 3D-mesh, and the hypercube. 8 (CO1) (PO1)