ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION **WINTER SEMESTER, 2022-2023**
DURATION: 3 HOURS **FULL MARKS: 150**

CSE 6197: Distributed and Parallel Computing

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.

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

   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

   c) Figure 1 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
   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.

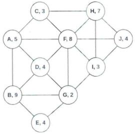

Figure 1: The wireless network for Question 1c.

2. 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. 8

   b) Discuss how parallelism can be integrated into the different levels of modern system architecture. 5

   c) What are the prevailing types of parallelism in modern systems? Explain how each of the achieve parallelism. 5

   d) Briefly discuss the architecture of RAM model using suitable figures. 7

3. a) Differentiate among the different variants of the RAM model. 7

b) What is the race condition? How do the different variants of PRAM deal with the race condition? Explain each of their advantage and disadvantages. 10

c) How feasible is the PRAM model beneficial in real-life scenarios? How is it utlized? 8

4. a) Consider the time-event diagram given in Figure 2. 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

   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

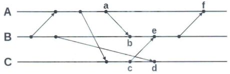

Figure 2: Time-event diagram for Question 4a.

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

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

b) Compare among the centralized, distributed, toke-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

c) Consider the network in Figure 3. The Nodes $S_1, ..., S_7$ are subscribed to some data items. These data items are published by the nodes $P_1, ..., P_4$. 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

6. a) Determine the bisection bandwidths of 1D-mesh (chain of computers with bi-directional connections), 2D-mesh, 3D-mesh, and the hypercube. 9

b) Consider a chord architecture for a P2P system that uses 5-bit keys to map data items to the nodes. The system consists of nodes with the following IDs: 1, 6, 14, 18, 21, 29, 30 where every node is connected to the immediate next node in the system. Additionally, a shortcut connection between any two nodes will exist if both have even or odd IDs. A lookup request for the data item with key 20 is made to the node 21. Draw the structure of the system and write down the steps required to service the request. 8

c) You have been assigned the task of designing the architecture of a search engine. The search engine will be a distributed system where the users will have access to a simple application with limited computation capabilities. The bulk of the tasks, such as generating queries 8

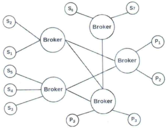

Figure 3: The subscriber-publisher system for Question 5c.

from the users' input, ranking the etched websites using some predefined algorithms, and generating the HTML files to be viewed on the user application, will be executed in remote servers. There will be multiple databases that store the web pages.
Suggest an architectural model that is best suited for your task. Discuss how the different components and connectors will be organized in the model.