BE5-R3: PARALLEL COMPUTING

NOTE:

1. **Answer question 1 and any FOUR questions from 2 to 7.**
2. **Parts of the same question should be answered together and in the same sequence.**

Time: 3 Hours **Total Marks: 100**

1.

a) Differentiate between sequential computer and parallel computer.

b) What do you mean by shared memory? Briefly describe shared memory parallel computer.

c) Define network diameter. What are the diameters of a Mesh, a Pyramid and a Hypercube networks?

d) Draw a diagram for different types of memory architecture for building parallel, distributed and cluster computers.

e) What do you mean by cost-optimality of a parallel system?

f) Briefly explain store-and-forward communication.

g) Distinguish between blocking communication call and non-blocking communication call.

(7x4)

2.

a) What do you mean by speedup of a parallel algorithm? State speedup Folklore Theorem and prove it.

b) State the Folklore Theorem related to the effect on running time of reducing the number of processors on a parallel computer and prove it.

c) Define efficiency of a parallel algorithm. Comment on the following cases, when efficiency of a parallel algorithm is

   i) less than one,

   ii) equal to one,

   iii) greater than one.

(6+6+6)

3.

a) What do you mean by memory access in the case of Parallel Random Access Machine (PRAM)? Describe different types of Concurrent Write (CW) Access to Memory in the PRAM.

b) Consider a sequence S of $n \geq 2$ values $\{x_1, x_2, \ldots \ldots, x_n\}$, as well as a datum x, are stored in the shared memory of a PRAM and assume that $x \neq x_i$ for all i, $1 \leq i \leq n$. Write a parallel algorithm to compute the following:

   i) If $xi < x$ for all i, $1 \leq i \leq n$, then the largest of the x_i's.

   ii) If $x_i > x$ for all i, $1 \leq i \leq n$, then the smallest of all x_i's.

iii) If some x_i are smaller than x and some are larger, then the average value of those smaller and the average value of those larger.

(10+8)

4.

a) What do you mean by network topology? Write short notes on the following topologies, and relatively compare them in terms of degree of a processor and longest distance between two processors:
   i) Mesh of trees,
   ii) Cube-connected cycles,
   iii) Shuffle-exchange.

b) A sequence of n numbers $\{x_1, x_2, \ldots \ldots, x_n\}$ is stored in the processors of a hypercube model of parallel computation such that P_i contains x_i for all i, $1 \leq i \leq n$. Design a parallel algorithm for sorting a sequence on the network model such that when the algorithm terminates, P_i stores the i-th smallest number. Deduce the running time of the algorithm.

(10+8)

5.

a) What is a de Bruijn network? Draw such an interconnection network for d = 2 and k = 4, when the number of processors $N = d^k$.

b) Describe Star interconnection network, and draw such a network for the number of processors N = 4!.

c) What are various techniques used for optimization of parallel code. Apply instruction reordering technique to optimize the following codes.

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I1:   Load R1, A
I2:   Load R2, B
I3:   Add R2, R1, R2-delayed
I4:   Load R3, C
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d) Explain C/S access memory organization for vector access.

(5+5+5+3)

6.

a) Describe the diagrams for n = 8 in each case, how the odd-even merging circuit and the odd-even-merge sorting circuit operate. Compare the circuits in terms of their depth, width and size.

b) Write a short note on Memory Access Unit (MAU) for the PRAM. Describe how an efficient MAU could be realized with the help of an odd-even merging circuit and an odd-even-merge sorting circuit.

(9+9)

7.

a) State the Maximum Sum Subsequence (MSS) problem. Design a sequential (RAM) algorithm to solve the problem, and deduce the computational complexity of your algorithm.

b) Explain in detail vectorization of code.

c) Explain butterfly network with its permutations. Give two examples.

(8+5+5)