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) Why is there no use in increasing the number of processors beyond a certain point in a multiprocessor system?

b) Describe the multiple cooperative masters OS model for Unix on multiple processors.

c) Compare the main techniques involved in domain decomposition and control decomposition.

d) What is the latency for wormhole routing?

e) What is prefetching and what benefits do we get from it?

f) Explain the situations under which cache inherence problem can arise.

g) Explain the following types of dependencies between instructions:

i) Antidependence

ii) Output dependence

iii) Resource dependence

(7x4)

2. Choose amongst the following architectures for the applications given below. Also, suggest possible communication mechanisms.

- Asymmetric UMA
- Multiple Instruction Single Data (MISD)
- Hierarchical cluster NUMA architecture.
- Single Instruction Multiple Data (SIMD)

Give proper justification for your architectural choice.

i) A database application has several modules providing specialized functions. Some of the modules are tightly coupled together, share data and communicate heavily with each other. Such a close group of modules interacts regularly with other similar sets of modules. Groups of such closely interacting sets of modules occasionally communicate with each other.

ii) For weather forecasting, the environmental space is represented as a grid of 3-dimensional sub spaces. The weather parameters (temperature, relative humidity, dust concentration etc) for each sub-space are collected in the form of arrays and manipulated by various operations to predict the weather conditions such as rainfall, possible storms etc.

iii) A Protein structure analysis application performs computational simulations using voluminous data on the protein molecular composition, to analyze the 3D protein structures. The computations are similar and involve several nested DO loops.

(6x3)

3.

a) Write a parallel pseudocode for performing an even-odd transportation sort on a linear array of *n* processors. Show the computation time and the communication time at each step. What is the overall time complexity? Illustrate the sorting process for a sequence of 8 numbers: 3,1, 9, 7,5,2,0,6

b) Write the pseudocode for performing a shuffle of n data items kept in a linear array of n processors. What is the time complexity? Illustrate the shuffle process for a sequence Z,X,F,G,T,H,U,J.

c) Write the pseudocode for PI calculation on a multiprocessor system of *p* processors using the approximation formula: = Π= $W^*\Sigma_{(i=1,,N)}\ 4/(1+(x_i)^2)$, where the PI area is defined between 0 and 1, N is the total number of intervals between 0 and 1 and W is the width of each rectangle W=1/N. Is there ant need for synchronization in this algorithm?

(6+6+6)

4.

a) Define the following terms:

i) Bisection width of a network
ii) Perfect shuffle operation
iii) Perfect inverse shuffle
iv) Scalability
v) Network latency
vi) K-ary n-cube networks
vii) Network throughput
viii) Node degree

b) Compare Multistage Networks with Crossbar switch in terms of wiring complexity, minimum latency and routing capability.

([8x1.5]+6)

5.

a) A program has only two modes of operation; purely sequential mode for 40% of the program and fully parallel for the remaining program. The program is run on a multiprocessor system in which the total number of processors *n* is much greater than the maximum degree of parallelism of the program *m (n>>m)*. Calculate the percentage increase in speedup performance of the multiprocessor system when the number of processors is increased from 4 to 10 for the following models, ignoring all system overheads.

i) Fixed workload model
ii) Fixed execution time model
iii) Memory bound model. Assume that the workload is increased by 25% more than the maximum available parallelism, when memory size is increased. Thus the workload is increased 5 times when the maximum number of processors is 4 and increased 12.5 times when the number of processors is 10.

b) Discuss how the communication overheads may offset the advantages of parallel processing.

([3x5]+3)

6.

a) Suggest methods of vectorizing the following DO loops:

i)
```
Do     30    I  = 1,N
A(I) = 2*C(I)+B(I)
30     C(I+1)=B(I)+A(I+2)
```

ii)
```
DO 20 K  =  2 , N
DO   30     L= 2, N
       DO   40 M=  1, N-1
            A(K,L,M) =  (A(K, L-1,M) + A(K,L+1,M))/2
       40   CONTINUE
30     CONTINUE
20     CONTINUE
```

iii)
```
DO     20    K = 1,N
       A[K]  = B(K,1)+ C(K,1)
       DO    30    L = 2, N+1
             D(K) = D(K) + B(K,L)*C(K,L)
       30    CONTINUE
       DO    40    M=1,N+1
             E(K+1) =  E(K)+B(K,M)
       40    CONTINUE
20     CONTINUE
```

b) Compare the distributed memory model and the shared memory model for parallel programming in terms of various parameters.

c) What is symmetric multiprocessor? Discuss about its advantages.

([2+3+3]+6+4)

7.

a) Draw the schematic for a hierarchical bus based architecture with distributed caches for a multiprocessor system and describes the working of the system. What are the advantages of having a hierarchy of busses?

b) Differentiate between data flow and control flow processing approaches.

(9+9)