National University of Computer and Emerging Sciences, Lahore Campus

Course Name:	Parallel and Distributing Computing	Course Code:	CS3006
Degree Program:	BS (CS)	Semester:	Spring 2023
Exam Duration:	60 Minutes	Total Marks:	30
Paper Date:	25/02/23	Weight	12.5
Exam Type:	Midterm I	Page(s):	4

Student : Name:_____ **Roll No.**_____ **Section:** _____

Instruction: Attempt all questions on the question paper. Rough sheets can be used but it should not be attached. If you think some information is missing then assume it and mention it clearly.

Question # 1: [5+2 marks, CLO # 1]

From the given options, select the best answer.

i. **GPU is an example of**
   - *a.* ***Shared Memory SIMD***
   - b. Distributed Memory SIMD
   - c. Shared Memory MIMD
   - d. Distributed Memory MIMD

ii. **Multi-stage Omega network has _____ switching nodes.**
   - a. log p
   - *b.* ***p/2 × log p***
   - c. p × log p
   - d. P^2

iii. **The _____ of a task-_____ graph is usually a _____ of the _____ of the task-dependency graph:**
   - a. edge-set; interaction; superset; nodes
   - b. edge-set; mapping; subset; edge-set
   - c. edge-set; interaction; subset; edge-set
   - *d.* ***edge-set; interaction; superset; edge-set***

iv. **The use of _____ decomposition comes into play when we _____**
   - a. speculative; are not sure of the dependencies between tasks
   - b. speculative; are not sure of the size of the search space from before
   - *c.* ***exploratory; are not sure of the size of the search space from before***
   - d. recursive; want to avoid divide and conquer strategies

v. **We can increase performance of a uniprocessor by**
   - a. Increasing clock frequency
   - b. Increasing instructions per cycle
   - c. Multithreading
   - *d.* ***Any one from above can be used***

vi. **70% of a program's execution time occurs inside a loop that can be executed in parallel and rest 30% in serial. What is the maximum speedup we should expect from a parallel version of the program executing on 8 CPU?**
   - *a.* ***2.58***
   - b. 3.06

c. 4.02
d. 4.08

Question # 2: [08 marks, CLO # 1]

Assume a sequential program *S* has an execution time of *500* seconds. Further, assume that S_p is a parallel variant of *S*. After an experimental evaluation over different number of processors, the following running times were achieved: -

P	2	4	6	8
Execution Time (seconds)	294	203.84	176.62	164.92
Speedup				
Karp-Flatt Metric				

a) Calculate Speedups for each of the experimental configurations in the space provided below and then write your answers in the table above.

500/294 = 1.7006

500/203.84 = 2.4529

500/176.62 = 2.8309

500/164.92 = 3.0317

Speedup = T(S) / T(P)

1/((F +(1-F)/p)

b) Calculate the Karp-Flatt metric values in the space provided below and then write your answers in the table above. You also have to interpret the results of Karp-Flatt metric and write your opinion accordingly.

$$e = \frac{1/S - 1/p}{1 - 1/p}$$

((1/1.70) – (1/2)) / (1 – 1/2) = 0.18

((1/2.45) – (1/4)) / (1 – 1/4) = 0.21

((1/2.83) – (1/6)) / (1 – 1/6) = 0.22

((1/3.03) – (1/8)) / (1 – 1/8) = 0.23

Since 'e' is increasing with p, it suggests that parallelization overhead is also contributing to the poor speedup. Hence, we need to reduce this overhead to improve speedups.

Question # 3: [10 marks, CLO # 1]

What is Fat Tree Routing? Draw a Fat tree having 4 levels with 8 leaf nodes. Provide a comparative analysis with a star topology with same number of nodes in terms of cost, diameter, bisection width and arc connectivity. You have to mention which routing is better in terms of each evaluation parameter.

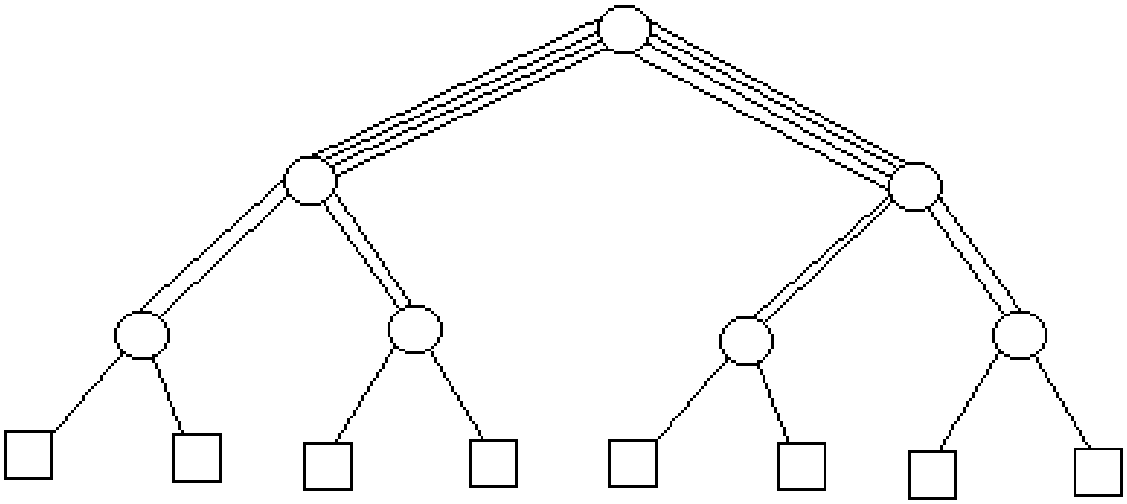
Answer

Cost, diameter, bisection width and arc connectivity

	diameter	bisection width	arc connectivity	Cost
Star	2	1	1	p-1
Fat Tree	2 log ((p+1)/2)	1	1	n x 2^n

p = number of nodes
n = number of levels

For the following tree, we have number of nodes 15 and levels 3, starting from 0.



In terms of above evaluation parameters, start has less cost and diameter however all traffic has to be passed through center node. On the other hand, fat tree manages the traffic well with distributed nodes and larger bandwidth at edges with large traffic.

Question 4: [6 + 4 marks, CLO # 2]

(i) Show the output of the following program:

```
#include <iostream>
#include <omp.h>
using namespace std;
int main() {
   int nums[10] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };
   omp_set_num_threads(3);
#pragma omp parallel for schedule(static, 3)
   for (int j = 0; j < 10; j++) {
      nums[j] *= (j+3);
      int x = omp_get_thread_num();
      cout << "At thread: " << x << " iteration: ";
      cout << j << endl;
   }

   for (int i = 0; i < 10; i++) {
      cout << nums[i] << " ";
   }
   cout << endl;

   return 0;
}
```

At thread 0,0,0 iteration 0,1,2
At thread 1,1,1, iteration 3,4,5
At thread 2,2,2 iteration 6,7,8
At thread 0 iteration 9

nums = [3,8,15.....]

At thread: 0 iteration: 0
At thread: 0 iteration: 1
At thread: 0 iteration: 2
At thread: 1 iteration: 3
At thread: 1 iteration: 4
At thread: 1 iteration: 5
At thread: 2 iteration: 6
At thread: 2 iteration: 7
At thread: 2 iteration: 8
At thread: 0 iteration: 9
3 8 15 24 35 48 63 80 99 120

Semaphores

(ii) **In general, what would you have to do if you are not allowed to use "OpenMP `for` construct" and you have to explicitly map the iterations to threads? Illustrate your answer with OpenMP code or pseudocode**

We would have to make sure the iterations managed by different threads are mutually exclusive. We may use the thread-ID for this purpose (as a different value to initialize each threads iterations, and the number of threads as a separation or jump value between each iteration for a specific thread.