National University of Computer and Emerging Sciences, Lahore Campus

	Course:	**Parallel and Distributed Computing**	**Course Code:**	**CS-3006**
	Program:	**BS (Computer Science)**	**Semester:**	**Spring 2023**
	Duration:	**N/A**	**Total Marks:**	**46**
	Submit Date:	**22-Feb-2023**	**Weight**	**2.5%**
	Section:	**BCS (6E-6F)**	**Page(s):**	**6**
	Exam:	**Assignment 01**	**Roll No.**	

Name & Section:

Submit assignment in Wednesday's class on 22 Feb 2023. Submission after that will not be accepted.
Attempt all questions on the assignment 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: [2+2+2 marks, CLO # 1] – Amdahl's Law

Suppose we have a system with one processor and a serial program. We want to upgrade this system and we have the following two options.

i. Increase the number of processors from 1 to 8 and parallelize 40% of the code.
ii. Increase the number of processors from 1 to 4 and parallelize 70% of the code.

Calculate speedup in each case and identify which one is better?

$\boxed{1 \cdot i}$

$$\text{Speedup} = \frac{1}{(1-P)+(P/n)} \; ; \; P = 0.4 \; ; \; n = 8$$

$$= \frac{1}{(1-0.4)+(0.4/8)} = \frac{1}{0.6+0.05} = \frac{1}{0.65}$$

$$\boxed{\text{Speedup} = 1.538 \approx 1.54}$$

$\boxed{1 \cdot ii}$

$$\text{Speedup} = \frac{1}{(1-P)+(P/n)} \; ; \; P = 0.7 \; ; \; n = 4$$

$$= \frac{1}{(1-0.7)+(0.7/4)} = \frac{1}{0.3+0.175} = \frac{1}{0.475}$$

$$\boxed{\text{Speedup} = 2.10}$$

* 70% parallelize code with 4 processors provides better performance than 40% parallelize code with 8 processors

<u>Question # 2: [4 + 6 marks, CLO # 1] – Karp-Flatt Metric</u>

Assume a sequential program *S* has an execution time of *400* 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)	214	123.84	96.62	84.92
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.

[2a]

(i) Speed up = $\frac{400}{214}$ = 1.869 ≈ 1.87

(ii) Speedup = $\frac{400}{123.84}$ = 3.229 ≈ 3.23

(iii) Speed up = $\frac{400}{96.62}$ = 4.139 ≈ 4.14

(iv) Speedup = $\frac{400}{84.92}$ = 4.71

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 below.

[2.b]

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

(i) $e = \dfrac{(1/1.87) - (1/2)}{1 - (1/2)} = \dfrac{0.5347 - 0.5}{0.5} = 0.07$

(ii) $e = \dfrac{(1/3.23) - (1/4)}{1 - (1/4)} = 0.08$

(iii) $e = \dfrac{(1/4.14) - (1/6)}{1 - (1/6)} = 0.09$

(iv) $e = \dfrac{(1/4.71) - (1/8)}{1 - (1/8)} = 0.1$

- *As 'e' is steadily increasing with p, it suggests that parallelization overhead is also contributing to poor speedup. Therefore, we need to reduce this overhead to improve speedups.*

Question # 3: [2+2+3+3 marks, CLO # 1] – Evaluating Static Interconnections

Calculate (a) diameter, (b) arc connectivity, (c) cost and (d) bisection width for:

i. 4x4 two-dimensional mesh with wraparound links

[3.i]

★ 4x4 2-d mesh with wraparound

Diameter = $2\lfloor \sqrt{p}/2 \rfloor = 2\lfloor \sqrt{16}/2 \rfloor = 2\lfloor 2 \rfloor = 4$

Arc Connectivity = 4, as 4 links will be removed

Cost = $2p = 2(16) = 32$

Bisection Width = $2\sqrt{p} = 2\sqrt{16} = 8$

ii. 4x4 two -dimensional mesh with no wraparound links

[3. ii]

* 4x4 2-d mesh with no wraparound

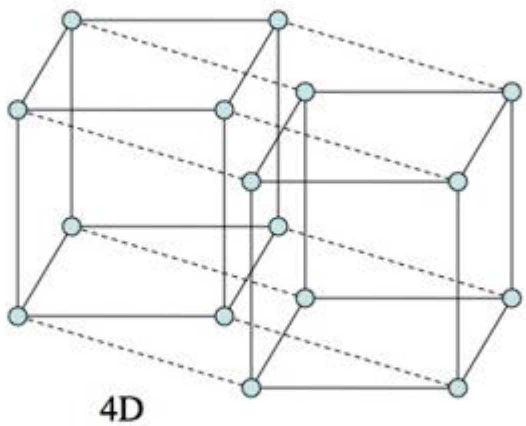
Diameter = $2(\sqrt{p}-1) = 2(\sqrt{16}-1) = 2(3) = 6$

Arc Connectivity = 2

Cost = $2(p-\sqrt{p}) = 2(16-\sqrt{16}) = 2(12) = 24$

Bisection Width = $\sqrt{p} = \sqrt{16} = 4$

iii. Four-dimensional hypercube (size=*16 Nodes*)



Diameter = $\log_2(p) = \log_2(16) = 4$

Bisection width = $p/2 = 16/2 = 8$

Arc connectivity = $\log_2(p) = \log_2(16) = 4$

Cost = $(p * \log_2(p))/2 = (16 * \log_2(16))/2 = 32$

iv. A complete binary tree of 3 levels as shown in the image below:

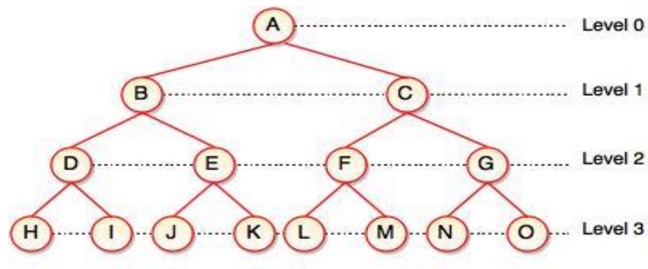


Fig. Complete Binary Tree

Diameter $= 2 \cdot \log((p+1)/2) = 2 \cdot \log(16/2) = 2 \cdot \log(8) = 2 \times 3 = 6$

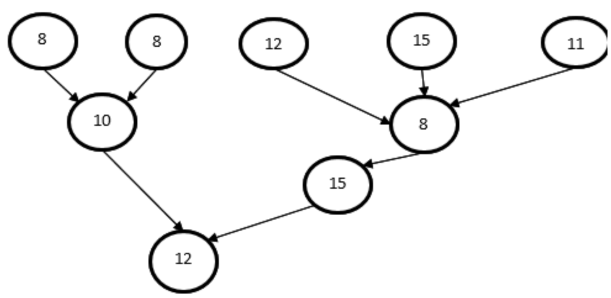
Arc Connectivity = 1

Bisection Width = 1

Cost $= p - 1 = 15 - 1 = 14$

Question # 4: [2+4+4 marks, CLO # 1] - Concurrency

Analyze the following task-dependency graph and calculate:



(i) The maximum degree of concurrency

Maximum degree of concurrency = 5

(ii) Critical Path Length

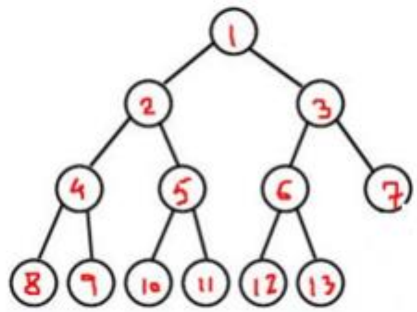
Critical Path Length = 15 + 8 + 15 + 12 = 50

(iii) The average degree of concurrency

Average degree of concurrency = (8 + 8 + 12 + 15 + 11 + 10 + 8 + 15 + 12) / 50 = 1.98

Question # 5: [2+2+2+2+2 marks, CLO # 1] – Task Interaction Graph

Analyze the following task-interaction graph and calculate:



(i) The maximum degree of concurrency

Maximum degree of concurrency = 7

(ii) ~~Critical Path Length~~ Critical Path

If processing time (i.e. weightage) is same for each node then there are multiple paths e.g. 1-2-5-11

(iii) Maximum possible speedup assuming large number of process are available

Maximum possible speedup assuming large number of process are available = 13 / 4

(iv) Minimum number of processes needed to obtain the maximum possible speedup

Minimum number of processes needed to obtain the maximum possible speedup = 6

(v) Maximum speedup if number of processes are limited to 4

Maximum speedup if number of processes are limited to 4 = 13 / 5