CZ4102 High Performance Computing

Assignment 1

Due on 15 September 2006, 11am.

1.   Given the declaration

int i [5][2][3];

(i)   Write a C program to check the order of the 3-d array elements stored in memory. Show the evidence on your screen output.
                                                                                                                       5 marks
(ii)   Show a pictorial mapping of the 3-D array to the linear memory.

2.   Based on your finding in question 1, write a C program to compute the sum of the integers on the 6 surfaces of a cube declared in **int i [100][100][100];** *15 marks* Your program should reduce the strided access to the memory as much as possible.

3.   The labels in a d-dimensional hypercube use d bits. Fixing any k of these bits, show that the nodes whose labels differ in the remaining $(d - k)$ bit positions form a $(d - k)$-dimensional subcube composed of $2^{(d-k)}$ nodes. *15 marks*

4.   A $\sqrt{p} \times \sqrt{p}$ *reconfigurable mesh* consists of a $\sqrt{p} \times \sqrt{p}$ array of processing nodes connected to a grid-shaped reconfigurable broadcast bus. A 4 x 4 reconfigurable mesh is shown in the following figure.
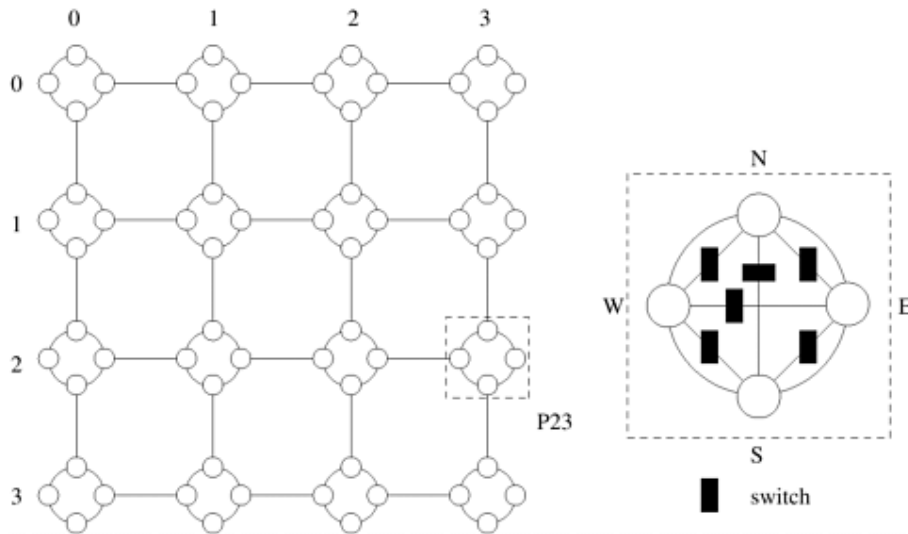

Each node has locally-controllable bus switches. The internal connections among the four ports, north (N), east (E), west (W), and south (S), of a node can be configured during the execution of an algorithm. Note that there are 15 connection patterns. For example, {SW, EN} represents the configuration in which port S is connected to port W and port N is connected to port E. Each bit of the bus carries one of *1-signal* or *0-signal* at any time. The switches allow the broadcast bus to be divided into subbuses, providing smaller reconfigurable meshes. For a given set of switch settings, a *subbus* is

a maximally-connected subset of the nodes. Other than the buses and the switches, the reconfigurable mesh is similar to the standard two-dimensional mesh. Assume that only one node is allowed to broadcast on a *subbus* shared by multiple nodes at any time.
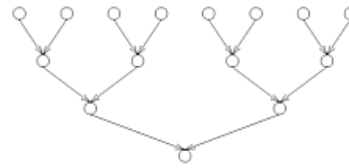
Determine the bisection width, the diameter, and the number of switching nodes and communication links for a reconfigurable mesh of $\sqrt{p} \times \sqrt{p}$ processing nodes. What are the advantages and disadvantages of a reconfigurable mesh as compared to a wraparound mesh?
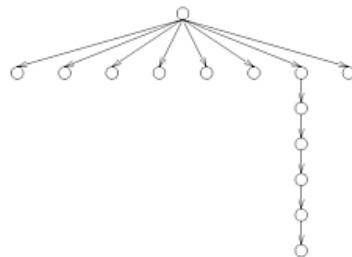
15 marks

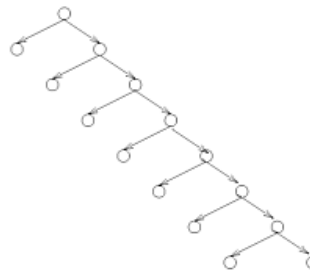5.   For the task graphs given in the following figures,
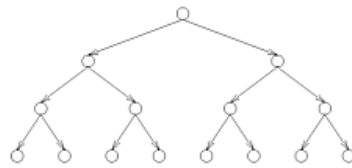
(a)   (b)

(c)   (d)

determine the following:

(i)   Maximum degree of concurrency.
(ii)   Critical path length.
(iii)   Maximum achievable speedup over one process assuming that an arbitrarily large number of processes is available.
(iv)   The minimum number of processes needed to obtain the maximum possible speedup.
(v)   The maximum achievable speedup if the number of processes is limited to (a) 2, (b) 4, (c) 8, and (d) 15.

20 marks

6.   Do a literacy research on the sequential version of Shell Sort, and
(i)   Write a 1-page summary of your research.
(ii)   Propose a mechanism to run the Shell Sort in parallel with a sufficient number of processors you need in order to shorten the sequential runtime. (You need not produce the parallel programs.)

30 marks

**(This individual assignment carries 15% of the final score.
Please hand in your work on time. We practice the honour system.)**

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