Parallel Processing

Programming Assignment 3

1 Goals

Generate a large square matrix A of size $n \times n$. Your goal is to find the determinant of this matrix, after performing LU decomposition of the matrix. $\det(A) = \det(L)\det(U) = 1 \cdot \det(U) = \prod_{i=1}^{n} u_{ii}$.

All steps should be performed in parallel on EXTREME. The parallel code for LU decomposition is similar to the parallel code for Gaussian elimination to solve a system of linear equations, which is given in the book in Chapter 8.

Your goal is to solve this FIND_DET problem on a mesh of processors. Please observe the following points.

1. Remember to start early, because EXTREME is a shared machine and there are users from all over campus. You submit jobs in batch mode, and may not get the result immediately. (During bad times, it takes a day or more for completion of even small jobs).

2. First get the basic programs correctly running. Then you can experiment with varying parameters, and more interesting variants of decomposing the workload and of MPI primitives.

2 Experiment

1. Write running code to solve the problem. You should try two or more different formulations (which are described in Chapter 8 of the textbook).

2. Measure the *timings*.
   If time permits, you can experiment with different values of n and p. The actual parameter ranges you vary will depend on various factors such as the workload on and the availability of the EXTREME nodes, OS limits etc..

3 Input and Testing

1. The program will take as inputs: n, p. Here, p is the number of physical processors (i.e., cores) you use on EXTREME. The array A is created by one process only. You can use a random number generator or any other mechanism.

2. While you debug your code, please work with small data sets. Check for correctness against the serial computation of the determinant of A.

4 Output

1. Prepare a **detailed report (PDF) describing your work.** The report must have the following sections/information.

   (a) **Formulation:** Describe each of the formulations of your parallel FIND_DET in about 2 pages. List clearly the MPI calls you used in the implementations.

   (b) **Parameter ranges:** Describe the ranges of the parameters you experimented with.

(c) **Results:** Give the tables and plot the graphs showing the *timing* variations, for the ranges of parameters you used. Remember to use appropriate scales for the graphs.

(d) **Analysis:** Analyse the results. Give your interpretation and reading of the results. You should address questions such as the following:

- Which formulation is better? under what (or all) circumstances? Why?
- Can you measure the computation time versus communication time? How do the formulations compare with each other with respect to this breakup of the time overhead?

Explain why you observe what you observe. In particular, any anomalous observations should be explained.

(e) **Lessons:** What insights you learned from this assignment.

5 Grading

The problem is reasonably well-formulated but the experimental approach is open-ended.

A non-running program may get zero credit. Your assignment will be judged on how *comprehensively* and *methodically* you have designed and run the experiment, and reported on the results. Your insights into the analysis of the results will also be considered in judging the assignment.