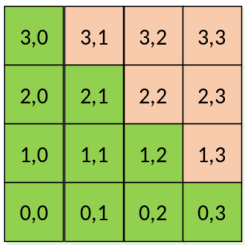
Assignment 2 (100 marks)

Write an MPI program to perform the following computation for the elements in the lower triangular matrix of a square matrix A of dimension n X n (shown in green in the left figure). Assume double elements.



$A^{t+1}(i,j) = A^t(i,j) - A^t(i+1,j)$ – Equation (1)

Pseudocode is given below.

1. Initialize the matrix with random values
2. For 20 iterations
   do
      $A^{t+1}(i,j) = A^t(i,j) - A^t(i+1,j)$ for elements in the lower triangular matrix
   done

Note: t represents the time step number (starting from 1)

Compare and contrast the timings for 1D rowwise and 2D domain decomposition schemes (these should be part of the same code). You may choose any MPI function for communication. Assume that the number of row processes and the number of column processes are given as input. The size n of an n X n matrix will also be given as input.

Submission instructions

1. You must run the code on Prutor and collect the timings from the console. When you click Run on Prutor, the below configurations will run. The timings (that you print from your code) will be shown for the following configurations in the below loop order. Thus there will be 8 invocations of your code (4 process counts, 2 different data sizes for each process count). The data size will be specified in terms of number of elements n in an n X n matrix.

```
for px in 2
   for py in 2, 4
      for size in size1, size2
         mpirun ... ./code px py size
```

Assume the datatype of size to be long long int.
Note 1: size is the total number of elements (type double) in a row/column of the matrix.
Note 2: The total number of processes = px * py.

2. Use Prutor to submit your code (this will be your final submission). Click on submit only when you want to submit your code for evaluation. ONLY 1 student from each group should submit the code, i.e. there should be only 1 submission per group. Duplicate submissions will incur a penalty of 5%.
3. You should not use #pragma in Prutor while collecting the timings for the assignment.
4. Execute your code for 5 times and report the timings based on these 5 runs (details below). Note it may take longer to get the display (output) on Prutor due to several remote logins to execute your code. However, it should still finish within 10 minutes.
5. Use MooKIT to submit the report (details below). Only 1 group member must submit. Duplicate submissions will incur a penalty of 5%.
6. Hardcoding (in any form) will incur 50% penalty.
7. Plagiarism will incur 100% penalty.

Plot

Plot the time (in seconds) for each matrix size for each decomposition (1D and 2D) for each process count, i.e. 4 plots in the graph. A sample plot is shown in Figure 1 (all elements are not shown). Use boxplots (from the 5 executions) for every data point in a plot. Plot the times in Y-axis for each process tuple (px, py) in (x-axis). You should report the total time taken by the loop (step 2 in the pseudocode), excluding initialization etc.

Report

Summarize coding methodology in 250 words. Summarize your observations (regarding various aspects of performance as you have learnt in this course) in 250 words. Submit a single pdf containing the code explanation, observations, plot and the code. Click on Assignment 2 on MooKIT to submit.

Suggestions

- Follow the above instructions carefully
- Document your code
- Early submission credits (bonus): +15%, +10%, +5%

Due date: 12-04-2023

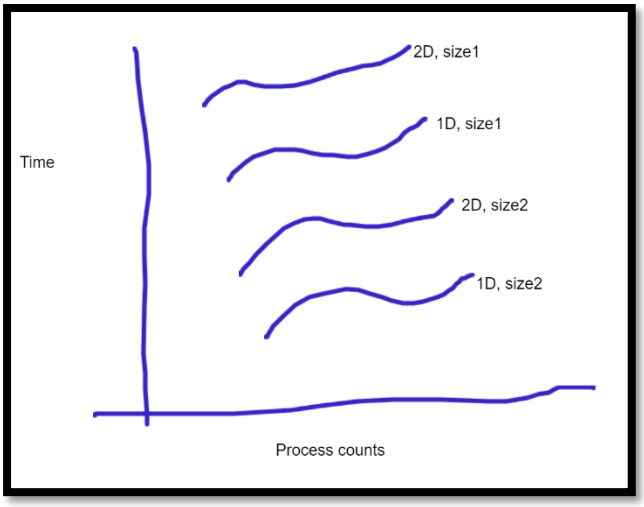


Figure 1: Example Plot (add legend, x and y axes tick marks etc.)