

## M5470 : Introduction to Parallel Scientific Computing

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### Homework 5

**Due Date and Time:** 2 April 2025, Wednesday, 11 pm

**Question 1:** Using the skeleton code provided, write the MPI parallel version of the solver for two-dimensional unsteady heat conduction. The discretization is performed using second-order central-differencing scheme for spatial derivatives and the explicit Euler time-stepping scheme.

The main component of the parallel code is a two-dimensional halo exchange. First, ensure that the halo exchange is working correctly inside one time step. To do this check, you can assign the values equal to `'rank*10+i+j'` to the array of temperatures. For example, `'rank=3'` will have values starting with 30 while `'rank=7'` will have values starting from 70. Then, after one halo exchange, print out the values of `'xleftghost'`, `'xrightghost'`, `'ybotghost'` and `'ytopghost'` to file from each rank. Check that the expected values are printed out in each file.

Once you are satisfied that the communication operations are taking place correctly, you can run the code for multiple time steps with the correct initialization.

As with HW3, run the code for  $n = 800$  and  $t_{en} = 0.001$ . The solution at the final time step is written to the file `'T_x_y_ {timestamp}.dat'`. You can visualize the solution by running `'plot_contours.m'` in Matlab. Note that `'plot_contours.m'` assumes that the entire solution is in one file. You will have to modify this file to be able to read in different portions of the solution from different files.

- (a) Run the serial code, and the parallel codes with 2 x 2, 2 x 4 and 4 x 4 processors. For each, show contour plots at 3 selected time steps other than at  $t = 0$ . For each of these selected time steps, show one line plot with multiple lines corresponding to serial, and parallel runs.
- (b) Tabulate the differences between the serial and the parallel runs at the end of 10 time steps. The differences should be almost close to machine precision.

- (c) Tabulate the time taken per time step for the serial and parallel runs. In the MPI program, you will have to use `MPI_Wtime` for determining the time taken.

**Question 2:** (Optional) Use MPI derived data types and use them to send messages during the halo exchange. Quantify the difference in time due to the use of these derived data types.

**General Instructions:**

1. Please prepare a short report with any plots or figures you generated with very brief (2 or 3 lines) comments. Do not waste time and effort in re-typing the question.
2. Submit the pdf on google classroom.
3. Upload your codes as well as the report pdf to Github.