

P. Hadjidoukas

Set 9 - MPI

Issued: May 25, 2023

Question 1: Quadratic Form

We want to compute the quadratic form

$$Q = \vec{v}^T \cdot A \cdot \vec{w} = \sum_{ij} v_i A_{ij} w_j \quad (1)$$

in parallel employing shared and distributed memory parallelism with OpenMP and MPI.

Given the $n \times n$ matrix A and the vectors v , w , the provided sequential code `main_seq.c` computes the quadratic form of Equation 1.

a) Put your OpenMP solution in `main_omp.c`.

The solution code can be found `main_omp.c`.

The initialization code uses a single parallel region and multiple `for` pragmas with `nowait` clause, minimizing thus the number of implicit barriers.

b) Parallelize the code for a distributed memory architecture. Using a block-row distribution every process must initialize only the needed portion of the objects $v;w;A$. Assume that n is a multiple of the number of processes. Put your solution in `main_mpi.c` and extend the Makefile accordingly.

The solution code can be found `main_mpi.c`.

Important points:

- `MPI_Init`, `MPI_Finalize`
- MPI rank and size + correct chunk size
- Initialization of local A
- Initialization of local v
- loop modification for local sum over i
- (collective) reduction between processes
- the final results in printed by one process

Hints:

- Block-row distribution: distribute the rows of the matrix to the available processes (ranks), as performed in the MPI diffusion code.
- Allocate and initialize only the portion of data needed by each rank.
- Take care of the different range of loop indices when you perform data initialization.
- Optimize MPI communication whenever this is possible.
- The application must produce the same output messages regardless of the implementation approach (i.e. only one rank prints).