NSSC2 Exercise 1

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April 2021

1 Task 1

- **(a) Describe the advantages/disadvantages of a two-dimensional decomposition (compared to a one-dimensional decomposition).**

  Advantages: The grid/calculations can be shared more equally than with one-dimensional decomposition, especially for a domain where x and y resolutions are somewhat equal. More processes have to communicate with each other but the size for each package sent is smaller compared to the 1D decomposition.

  Disadvantages: More communication necessary, more work has to be put into actually distributing calculations between the different processes. When a domain is much larger in one axis a one-dimensional decomposition could be much more effective than a two dimensional decomposition.

- **(b) Using a ghost layer based decomposition, how could multiple independent Jacobi iterations be achieved before communication has to happen? Comment in which situation (w.r.t the available bandwidth or latency between processes) multiple independent iterations are potentially advantageous.**

  Keeping the boundary values (values of the ghost layer) constant for multiple iterations in which only the inner grid points are reevaluated are possible. In this case a fixed number of iterations could be defined after which communication happens. Having multiple independent iterations can be beneficial when communication acts as a bottle neck e.g. when the latency is high or the bandwidth low leading to time intensive communication between different processes. This method might be less accurate or slower in convergence. Therefore it has to be taken into consideration whether the time gained by less communication is outweighing possible additional iterations needed to achieve the demanded accuracy.

- **(c) Describe the conceptual differences between a hybrid OpenMP/MPI-parallelization over a pure MPI-parallelization.**

  For the pure MPI-parallelization that was used for this exercise, the domain was decomposed into smaller domain regions on which the different MPI-processes performed serial calculations individually. In this case the MPI-library does not need to support multithreading. For a hybrid OpenMP/MPI-parallelization the calculations of the smaller domains for each individual processes could be parallized using OpenMP (similarly to the exercise in NSSC1). In this case it is important to consider how the message passing is handled. For example only the master thread could communicate, leading to the other threads sleeping during the communication but thus assuring all relevant data is sent and received. Another option is letting a few threads handle communication while the others compute, leading to a better use of resources while making the communication itself more complicated. The use of OpenMP itself can influence compiler optimization and can lead to a loss of computational performance, due to additional overhead.

- **(d) How big is the sum of all L2 caches for 2 nodes of the IUE-cluster 1 ?**

  The IUE-cluster has 10 regular compute nodes which are each equipped with two INTEL Xeon Gold 6248 processors. These processors have 20x 1 MiB L2 Caches each (1), making it 40 L2 Caches per Node and a total of 80 L2 Caches for two regular compute nodes with a total size of 80 MiB.