Chair for Computation in Engineering
Chair of Computational Modeling and Simulation
ANSYS Germany GmbH

Modeling: ★★☆☆☆
Mathematics: ★★★☆☆
Programming: ★★★★☆

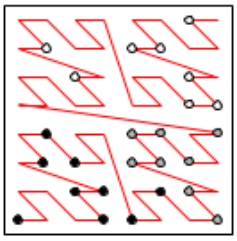
Software Lab:

Parallel Sort for Discrete Spatial Data

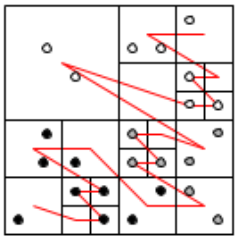
Setting

Space Filling Curves (SFC), e.g. Hilbert curves or Z-curves (Morton curves), are a powerful concept for organization of discrete spatial data, in particular in massive parallel settings. An inherent order is obtained by mapping of 2D or 3D coordinates to a 1D index while preserving locality (close indices typically close in space, e.g. Morton code), see usage in the figure below. Often, though, spatial data is not yet in SFC order, thus requiring parallel sort algorithms in case of large datasets.

Point cloud in Morton order, SFC defines parallel partitioning (3 partitions)

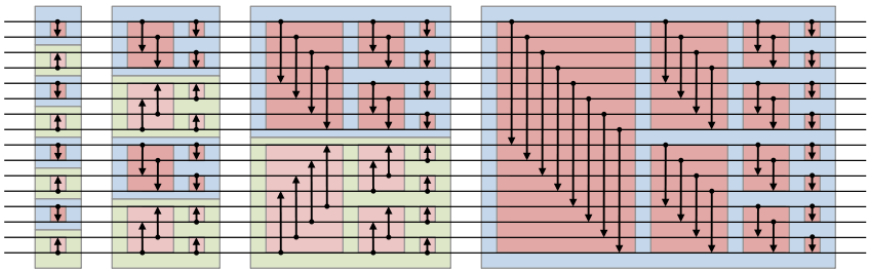


Grouping points into adaptively sized cells (e.g. max. 2 points/cell) gives octree-like structure



Task

Implement a distributed memory parallel sorting algorithm (e.g. bitonic sort) in C++ using MPI, test your implementation regarding parallel performance, optimize, and potentially try other algorithms.



Bitonic sorting network (from https://en.wikipedia.org/wiki/Bitonic_sorter)

As a sample application, a heavy-weight scalar field $s(A)$ defined on a 3D sample point cloud A and distributed across processes, should be interpolated onto another point cloud B.

- For each point in A compute the Morton code (Z-curve)
- Sort the scalar field $s(A)$ according to the Morton code of each point in A
- Approximate $s(B)$, e.g. for each point in B simply assign value of a point of A “close on SFC”

Supervisors

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References

[1] D. Żurek, M. Pietroń, M. Wielgosz, K. Wiatr: The comparison of parallel sorting algorithms implemented on different hardware platforms. Computer Science, 14 (4), 2013.

[2] H. Sundar, D. Malhotra, G. Biros: HykSort: A New Variant of Hypercube Quicksort on Distributed Memory Architectures. ICS 2013, Eugene, Oregon, USA, 2013.