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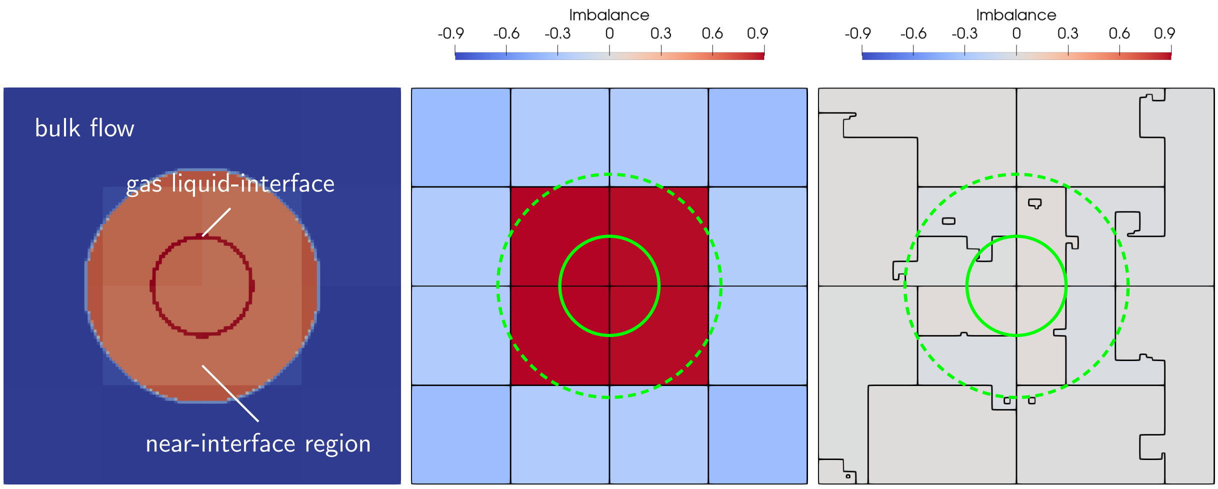
Bachelor's Thesis / Master's Thesis

Partitioning Algorithms for Load Balancing in Parallelized Multiphysics Simulations

One of the major challenges for efficient supercomputing is *load balance*, i.e. to distribute the application workload evenly across the processor units. To this end, parallelized CFD solvers, for example, decompose the computational domain into equally sized portions and assign each of these subdomains to one processor. However, this strategy presumes that all grid cells are of identical computational cost, for equal subdomain sizes (same number of grid cells) to imply equal processor workloads.
In complex multiphysics simulations, by contrast, the cell costs vary throughout the domain, depending on the local physics to be solved (Fig.1a). Hence, assigning the same number of cells to each processor leads to an uneven workload distribution (Fig.1b) This imbalance means an inefficient utilization of the supercomputer's ressources and can increase the simulation runtime drastically.
The present thesis therefore seeks to optimize domain decomposition strategies – usually referred to as *partitioning algorithms* – for the inhomogeneous cell costs of multiphysics simulations (Fig.1c).



(a) Computational costs of grid cells

(b) Processor load (sum of local cell costs) for equal subdomain sizes: workload imbalance ≈ 90%

(c) Processor load (sum of local cell costs) for adjusted subdomain sizes: workload imbalance < 5%

Figure 1: Domain decomposition of a 2D droplet simulation onto 16 processor units.

Work Packages:

- literature study on efficient partitioning algorithms for load balancing
- implement selected algorithms into standalone validation framework
- evaluate and compare efficiency, partitioning quality and other characteristics
- optimize implemented algorithms with respect to scalability on supercomputers

Prerequisites:

- basic knowledge of Fortran/MATLAB and Linux
- strong interest in algorithm design and code development
- self-reliant, diligent workstyle

Keywords:

partitioning algorithms, load balacing, high-performance computing (HPC), multiphysics simulations, twophase flows

Literature:

[1] Matthias Lieber and Wolfgang E. Nagel. "Highly scalable SFC-based dynamic load balancing and its application to atmospheric modeling". In: *Future Generation Computer Systems* 82 (2018). DOI: `10.1016/j.future.2017.04.042`.

[2] Ansgar Niemöller et al. "Dynamic load balancing for direct-coupled multiphysics simulations". In: *Computers & Fluids* 199 (2020). DOI: `10.1016/j.compfluid.2020.104437`.

Starting Date:
as soon as possible

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Auf das "Merkblatt für die Anfertigung von Bachelor- und Masterarbeiten" wird hingewiesen.