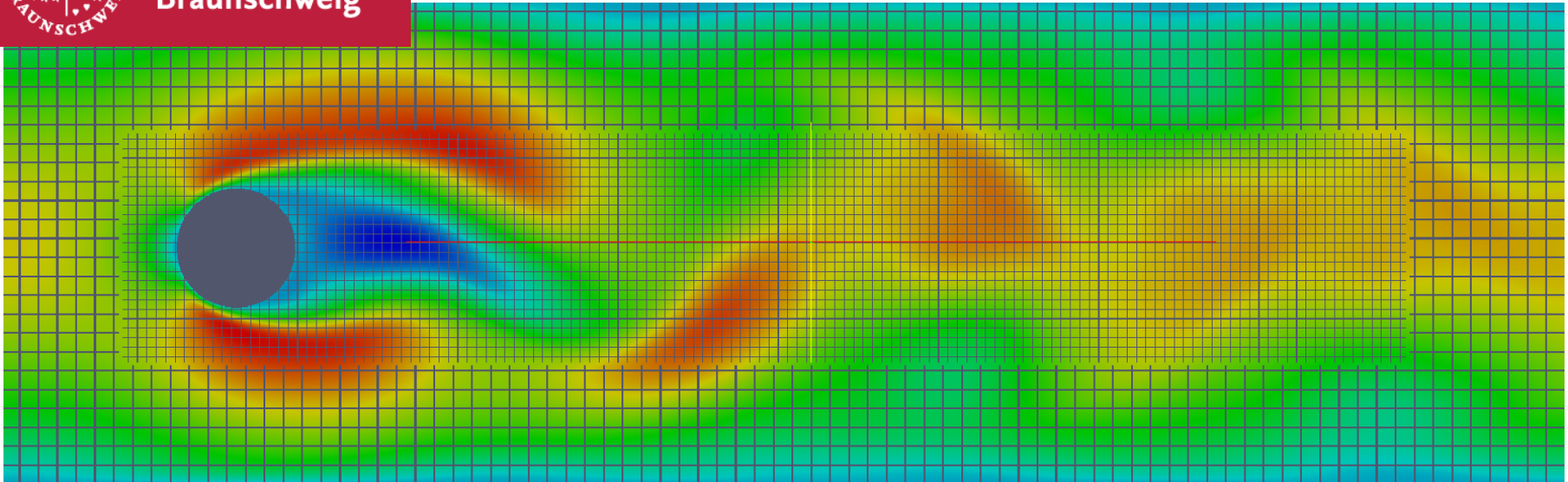




Technische
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A multi-core implementation of the lattice Boltzmann method for non-uniform grids

Kostyantyn Kucher, Sören Freudiger, Martin Geier, Maik Stiebler, Manfred Krafczyk

16.03.2010

The multi-scale lattice Boltzmann equation

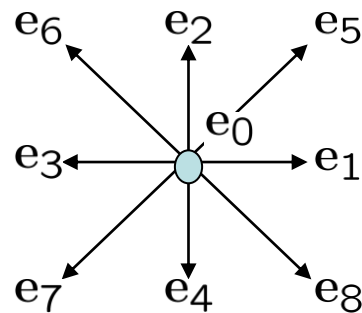
The lattice Boltzmann equation

$$f_i(\mathbf{x} + \mathbf{e}_i \Delta t, t + \Delta t) - f_i(\mathbf{x}, t) = \Omega(f_i(\mathbf{x}, t))$$

BGK (Bhatnagar-Gross-Krook) - relaxation term

$$\Omega(f_i(\mathbf{x}, t)) = -\frac{\Delta t}{\tau} (f_i(\mathbf{x}, t) - f_i^{eq}(\mathbf{x}, t))$$

D2Q9 model

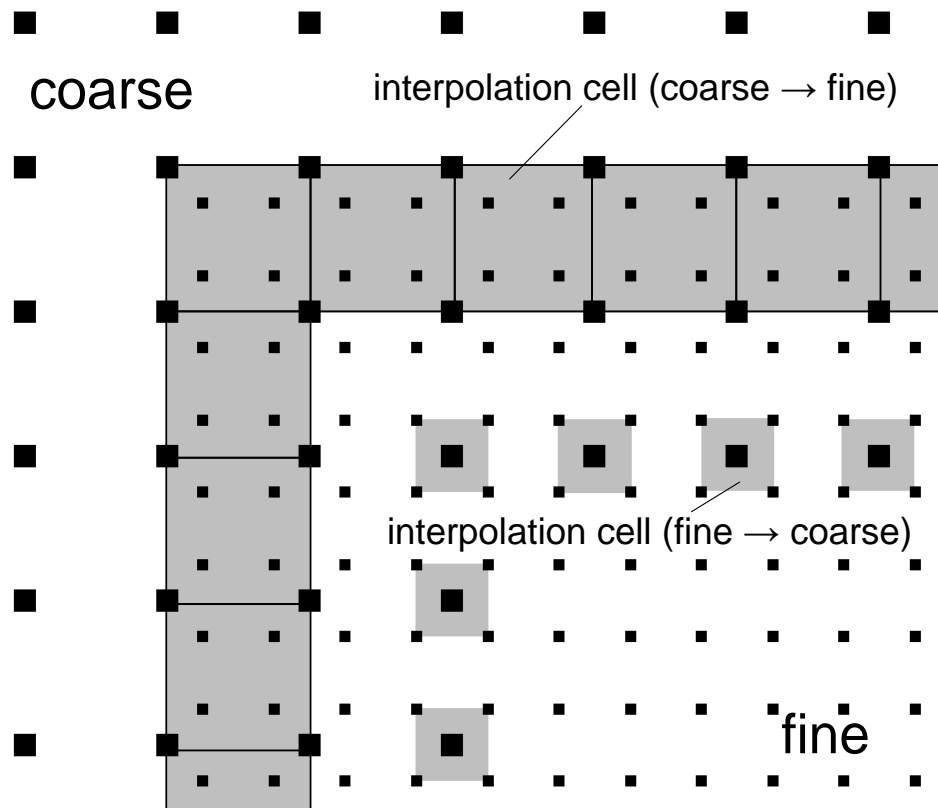


*Qian, d'Humières,
Lallemand 1992*

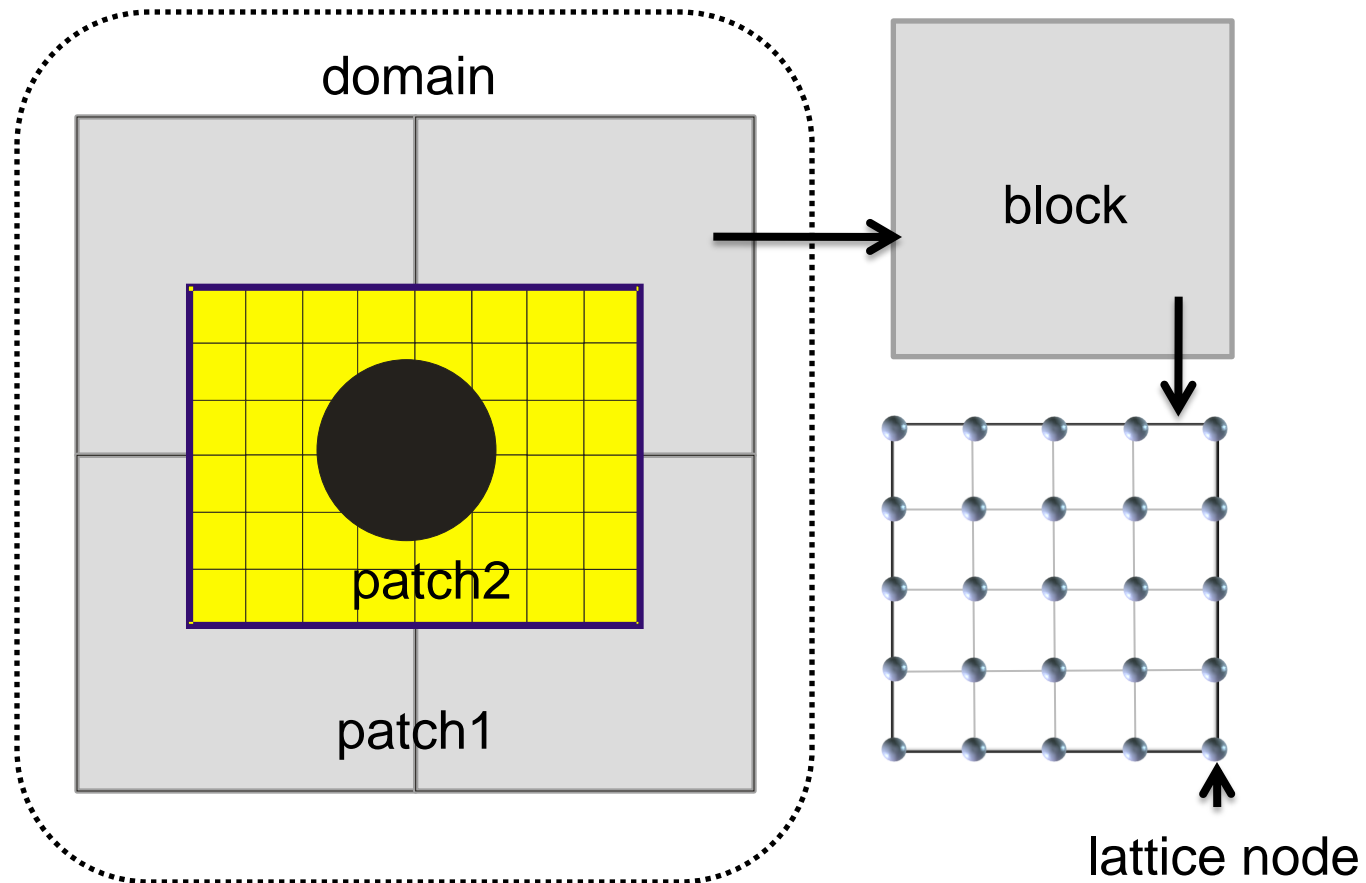
The multi-scale lattice Boltzmann equation

Interpolation cells

*Geier, Greiner,
Korvink, 2009*

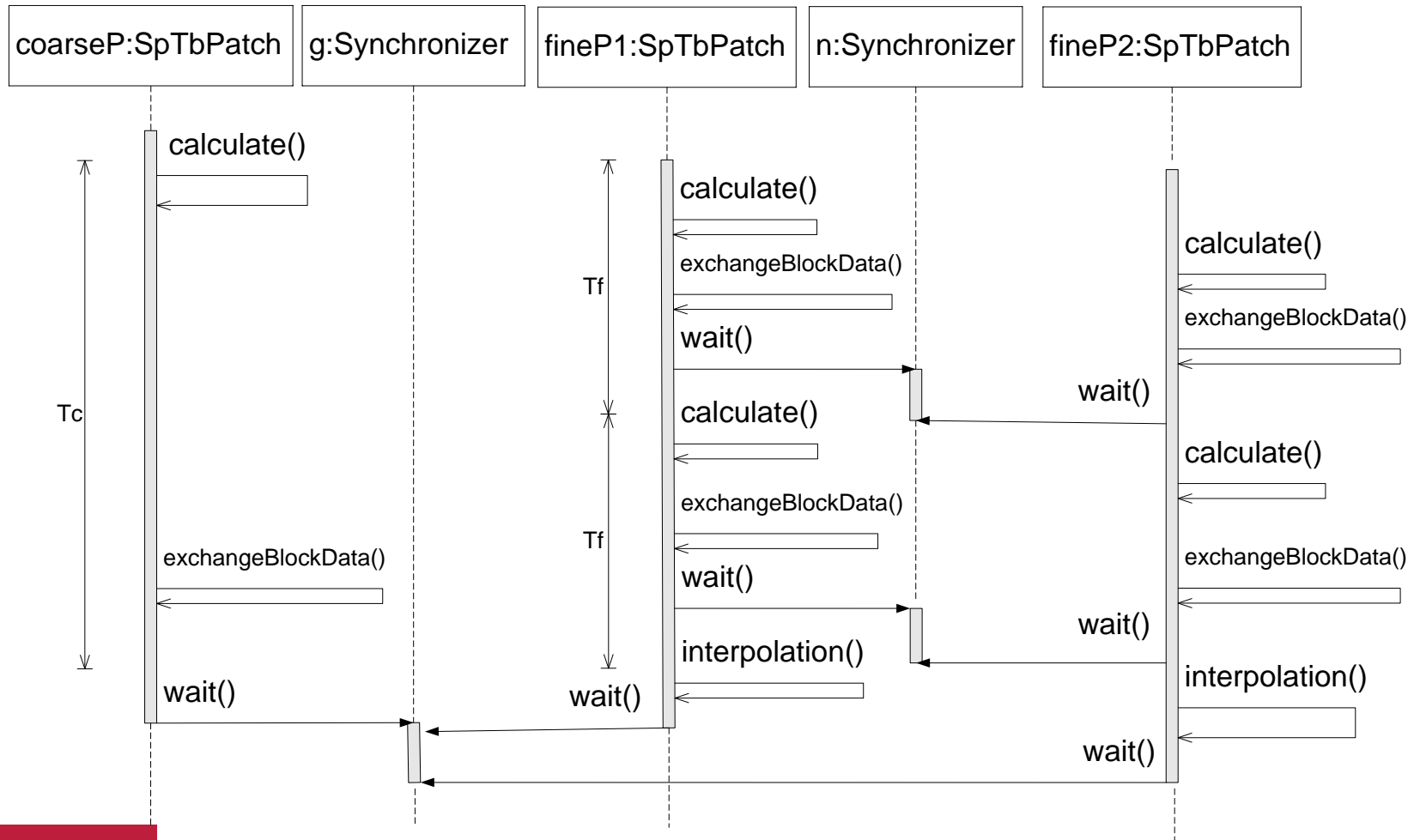


Geometric Partitioning of the Simulation Domain



Implementation

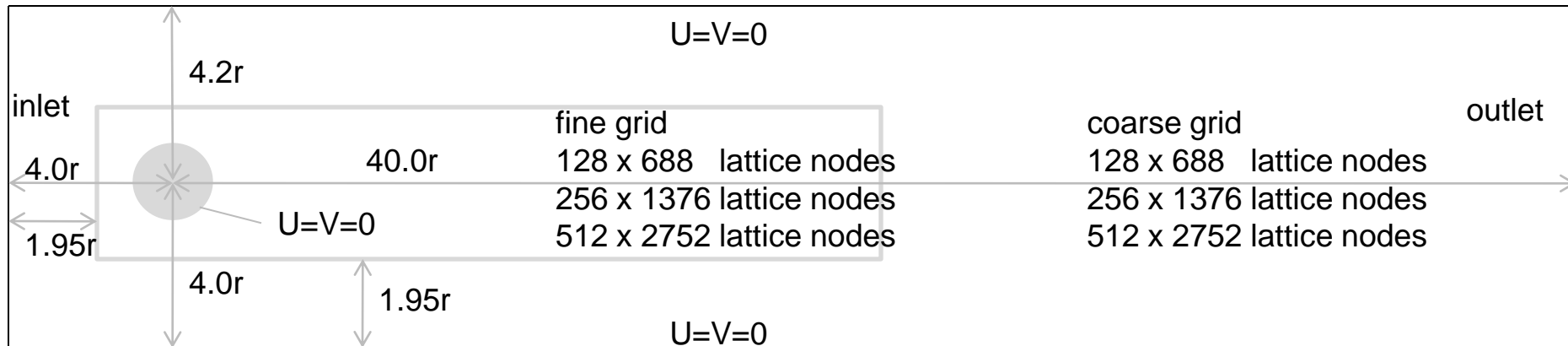
Synchronization



Validation

The flow past a cylinder

Schäfer und Turek 1996



Validation

Re = 20

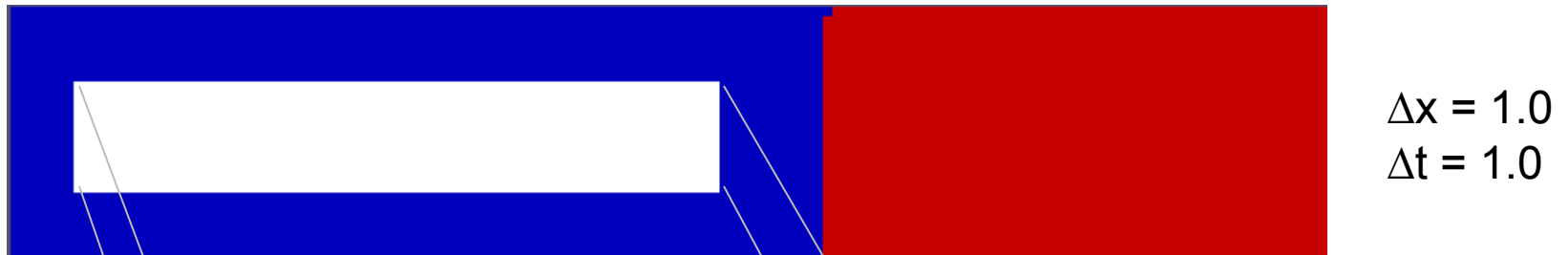
Parameter	SBB	QBB
resolution 128 x 688		
Cd	5.5972526	5.5807648
Cl	0.0042797	0.0073446
resolution 256 x 1376		
Cd	5.5870459	5.5731531
Cl	0.0162391	0.0101338
resolution 512 x 2752		
Cd	5.5778068	5.5745483
Cl	0.0107031	0.0102097
Parameter	Crouse	Schäfer and Turek
Cd	5.585-5.627	5.57-5.59
Cl	0.017-0.0119	0.0104-0.011

Domain Decomposition for Load Balancing

METIS - Serial Graph Partitioning and Fill-reducing Matrix Ordering

Karypis, Kumar 1998

Patch1 : 2 Threads

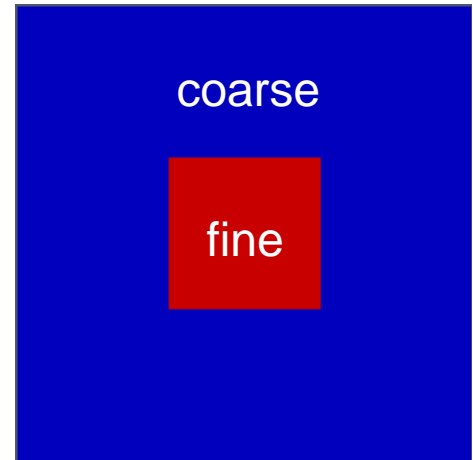
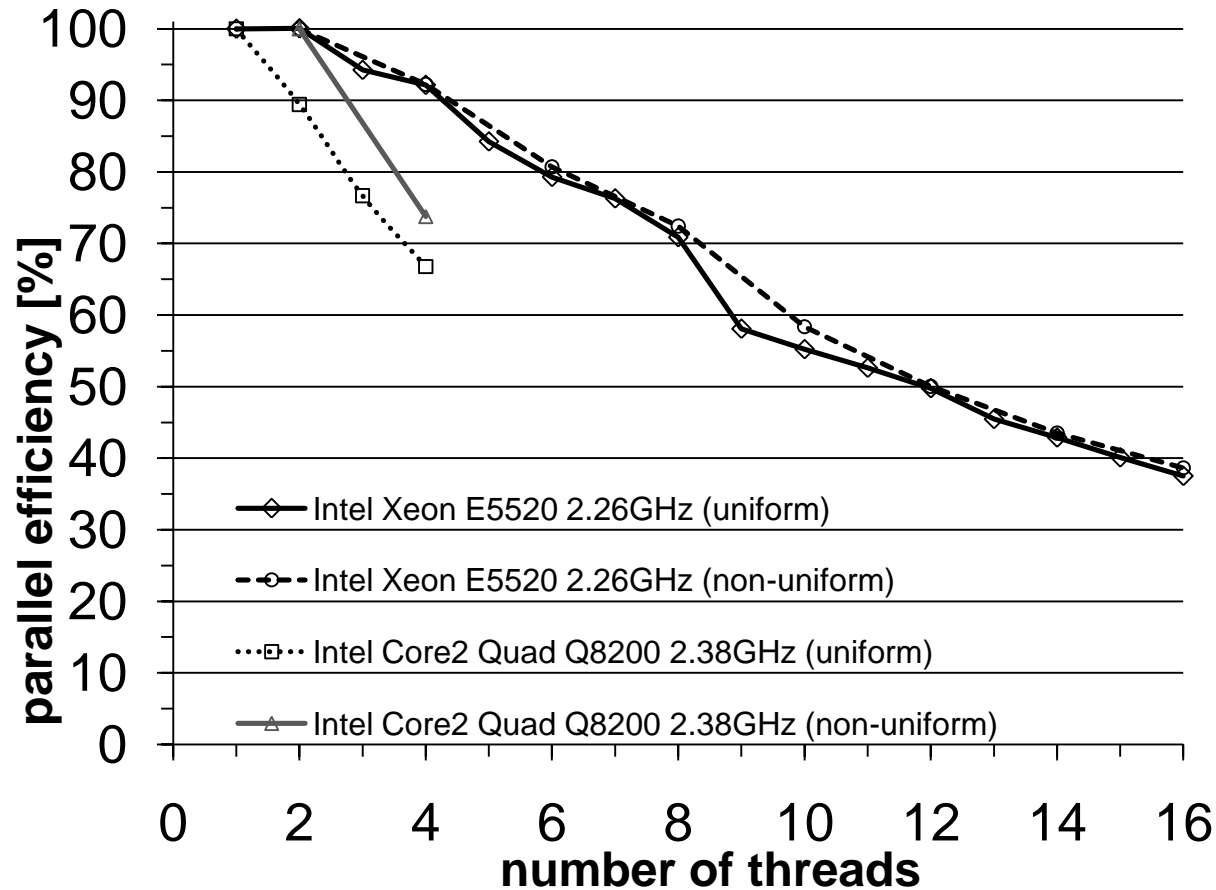


Patch2 : 6 Threads



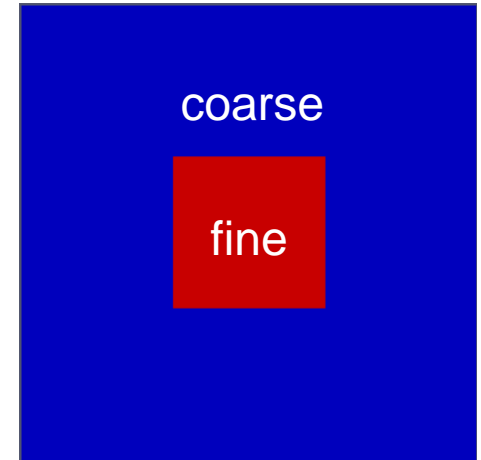
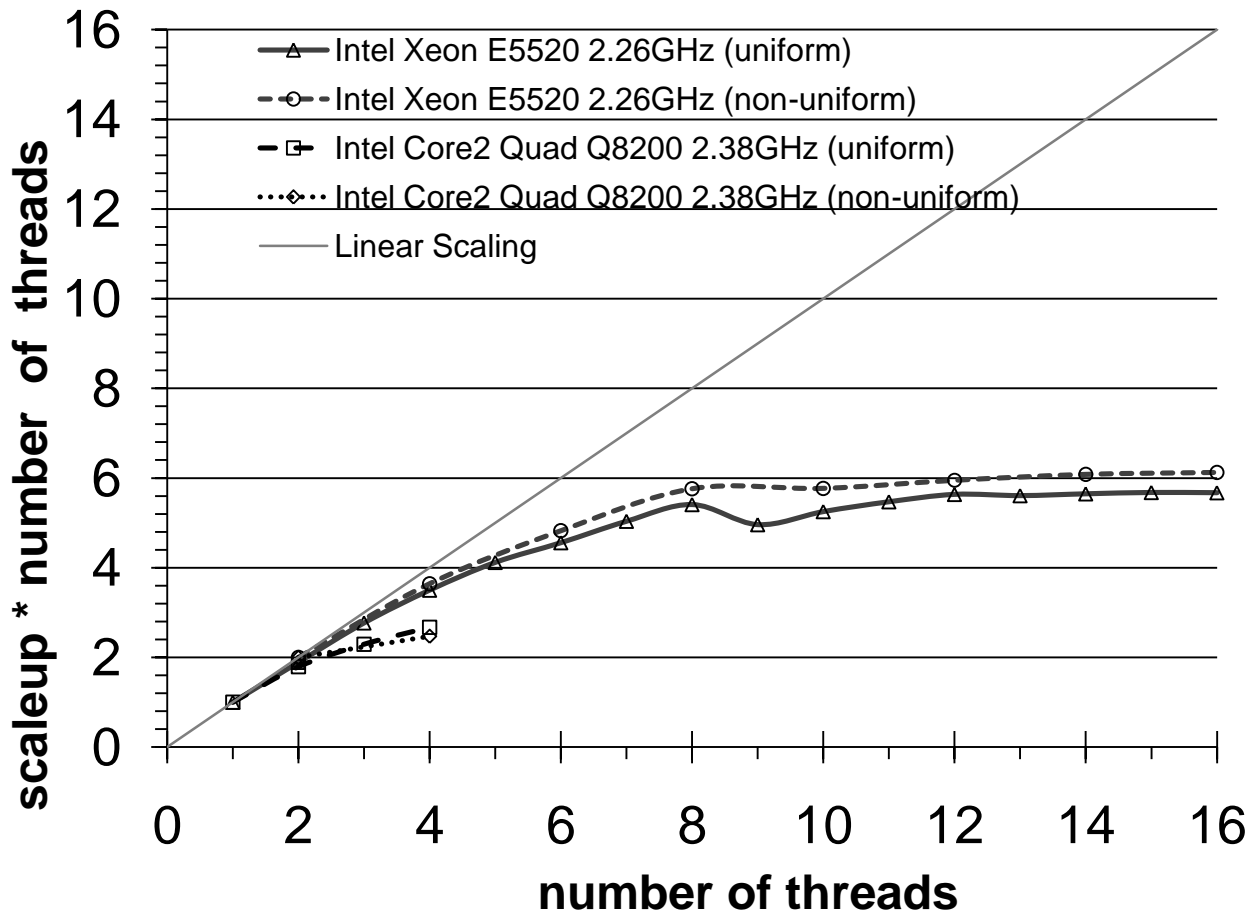
Performance Analysis

Parallel Efficiency



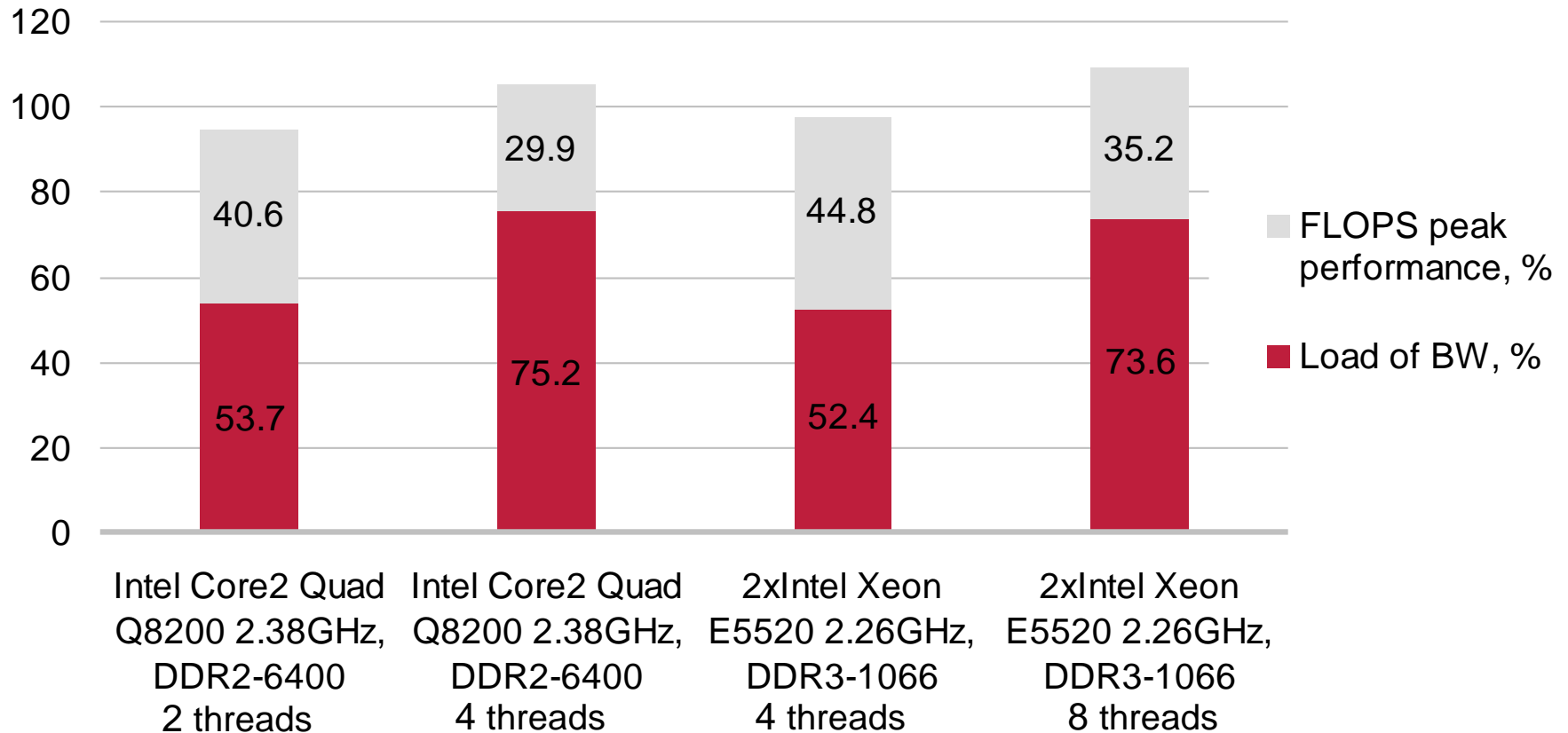
Performance Analysis

Scale up



Performance Analysis

Limitation by *Memory Bandwidth*:



Outlook

- Support of MPI
- Support of varying hierarchic setups
- Non-uniform Computational Fluid Dynamics in 3D
- Dynamic load balancing

Acknowledgments

- German BMBF funding the SKALB (Lattice-Boltzmann-Methoden für skalierbare Multi-Physik-Anwendungen) project (reference ID 01IH08003E).
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