



Technische
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Institute for
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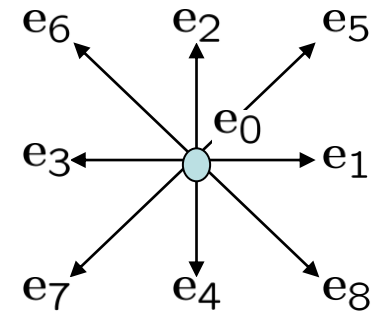
A Lattice Boltzmann CUDA-GPU-Implementation On Non-Uniform Grids

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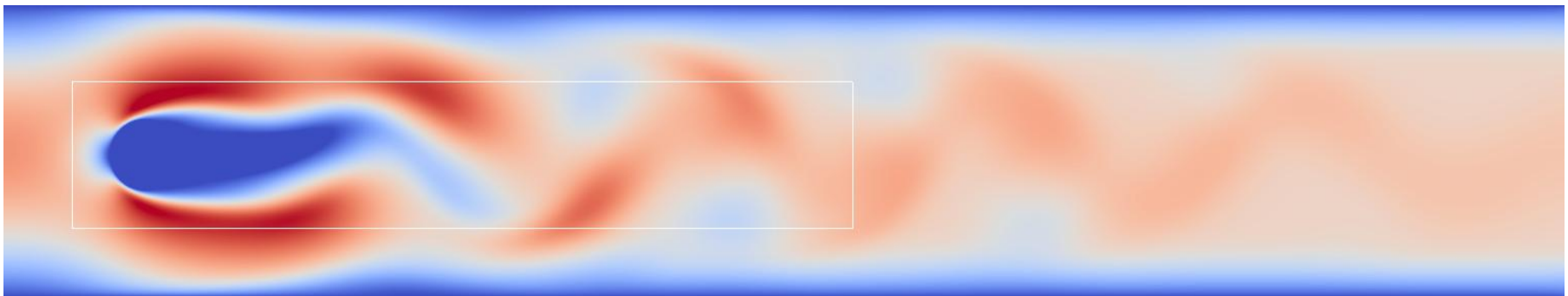
Computational Fluid Dynamics (CFD)

Lattice Boltzmann:

- Fluid solver
- Cartesian grids
- Suitable for implementation on GPGPUs



D2Q9 model

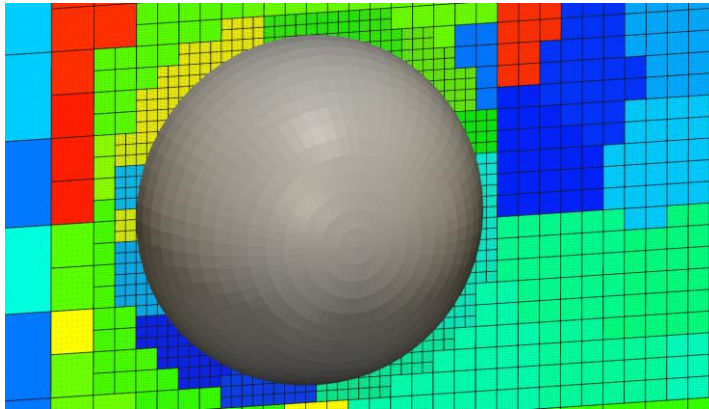


General Purpose Graphics Processing Unit (GPGPU)

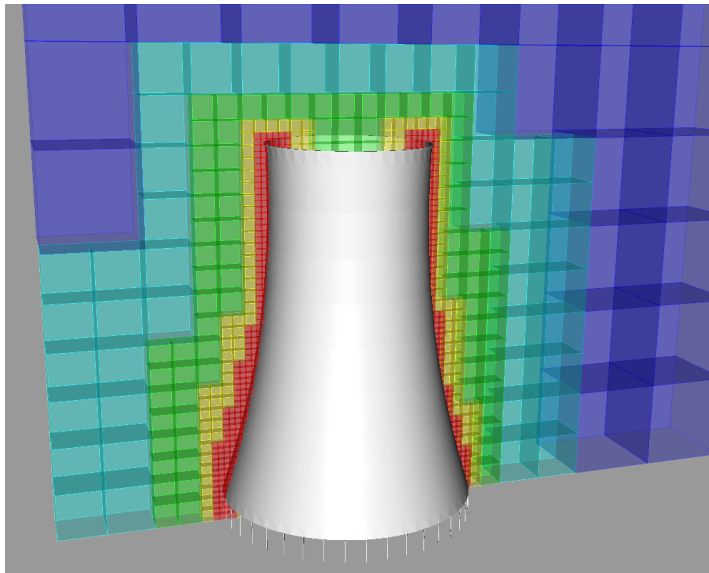
- 30 multiprocessors with 8 processors each = 240 Processors
- Cores running at 1,3 GHz
- 4 GB device memory
- Memory bandwidth = 102 GB/sec
- 933 GFlops of theoretical single precision floating point performance (NVIDIA)
- CUDA –SDK



The grid refinement



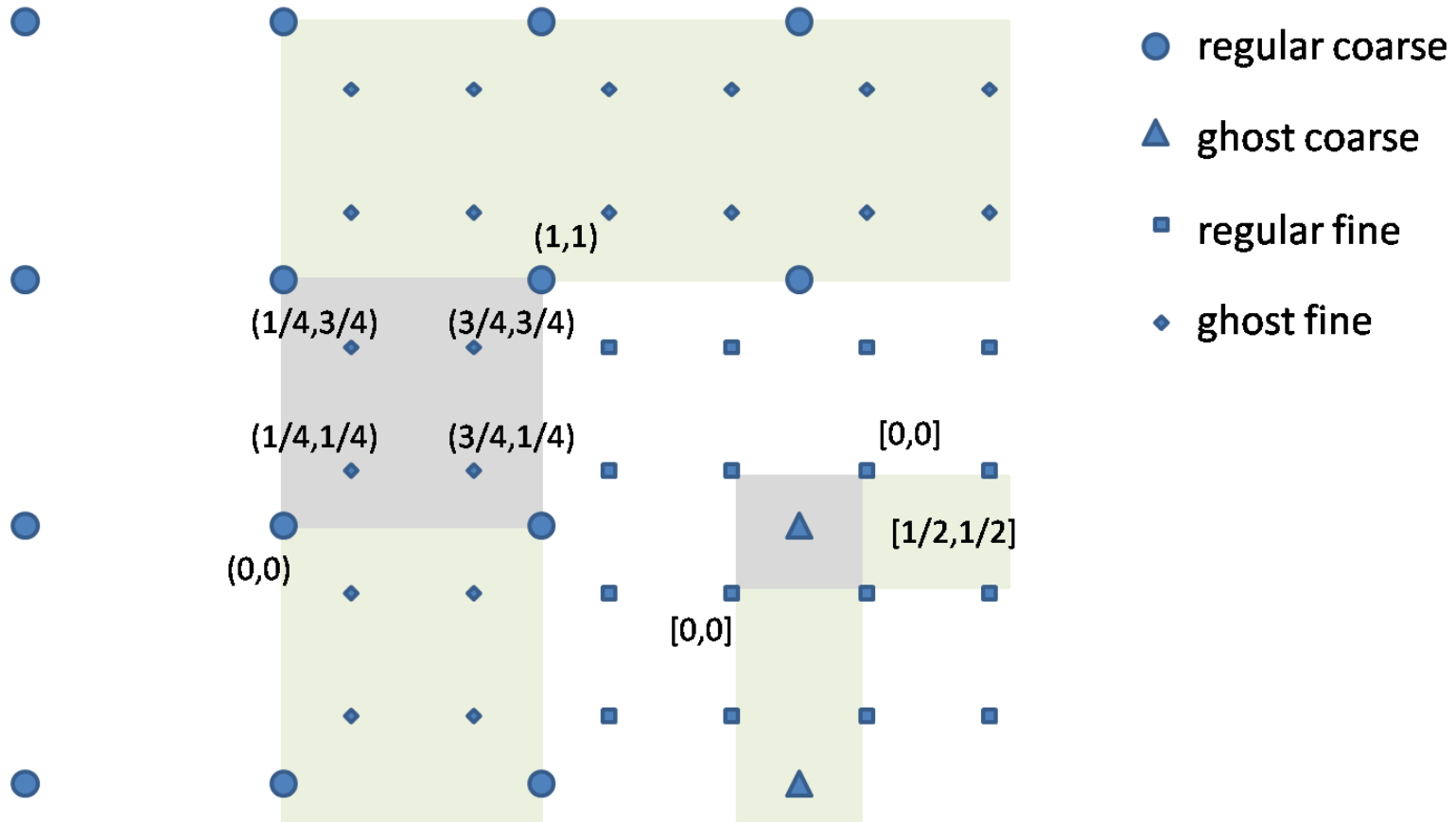
- fine grids and short time steps in locations of higher interest



- coarse grids and long time steps in regions of low interest

The grid refinement

Interpolation cells

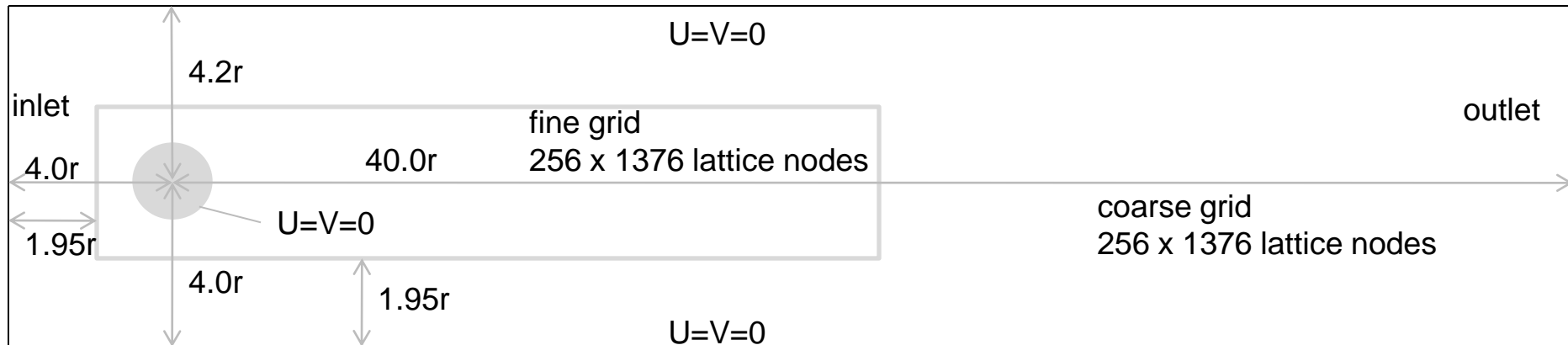


Geier, Greiner and Korvink 2009

Validation

The flow past a cylinder

Schäfer and Turek 1996



Validation

Re	Parameter	incompressible	compressible
20	Cd	5.58904	5.41912
	Cl	0.0090671	0.0085598
100	Cd	3.24188	3.22707
	Cl	0.977958	1.00898
	St	0.3	0.3

Re	Parameter	Crouse	Schäfer and Turek
20	Cd	5.585-5.627	5.57-5.59
	Cl	0.017-0.0119	0.0104-0.011
100	Cd	3.2645-3.2650	3.22-3.24
	Cl	0.9492-1.0709	0.99-1.01
	St	0.305-0.3076	0.295-0.305

Performance Analysis

- NUPS – number of node updates per second
- compare uniform case and non-uniform case
- degrees of freedom equal
- 100.000 time steps
- 3 diff. Resolutions (2.4 GB / 640 MB / 170 MB of device memory)

Performance Analysis

Relation of Performance (uniform and non-uniform)

	Resolution [nodes]	NUPS [x10 ⁶]	NUPS [%]	Time [s/10 ⁵ Δt]
Uniform	2048x15360	911.62	100.00	3450.73
Non-uniform*	2x1024x15360	828.07	90.84	5223.46
Uniform	1024x7680	920.59	100.00	854.27
Non-uniform*	2x512x7680	835.27	90.73	1294.62
Uniform	512x3840	902.55	100.00	217.83
Non-uniform*	2x256x3840	767.71	85.06	352.13

* effective number of NUPS - no coarse nodes under fine grid

Conclusion

Conclusion:

- combination of uniform LBM with grid refinement on GPGPU is possible
- good performance compared to the uniform application

Acknowledgments

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