FSI∗ce
A Modular Simulation Environment for Fluid-Structure Interactions

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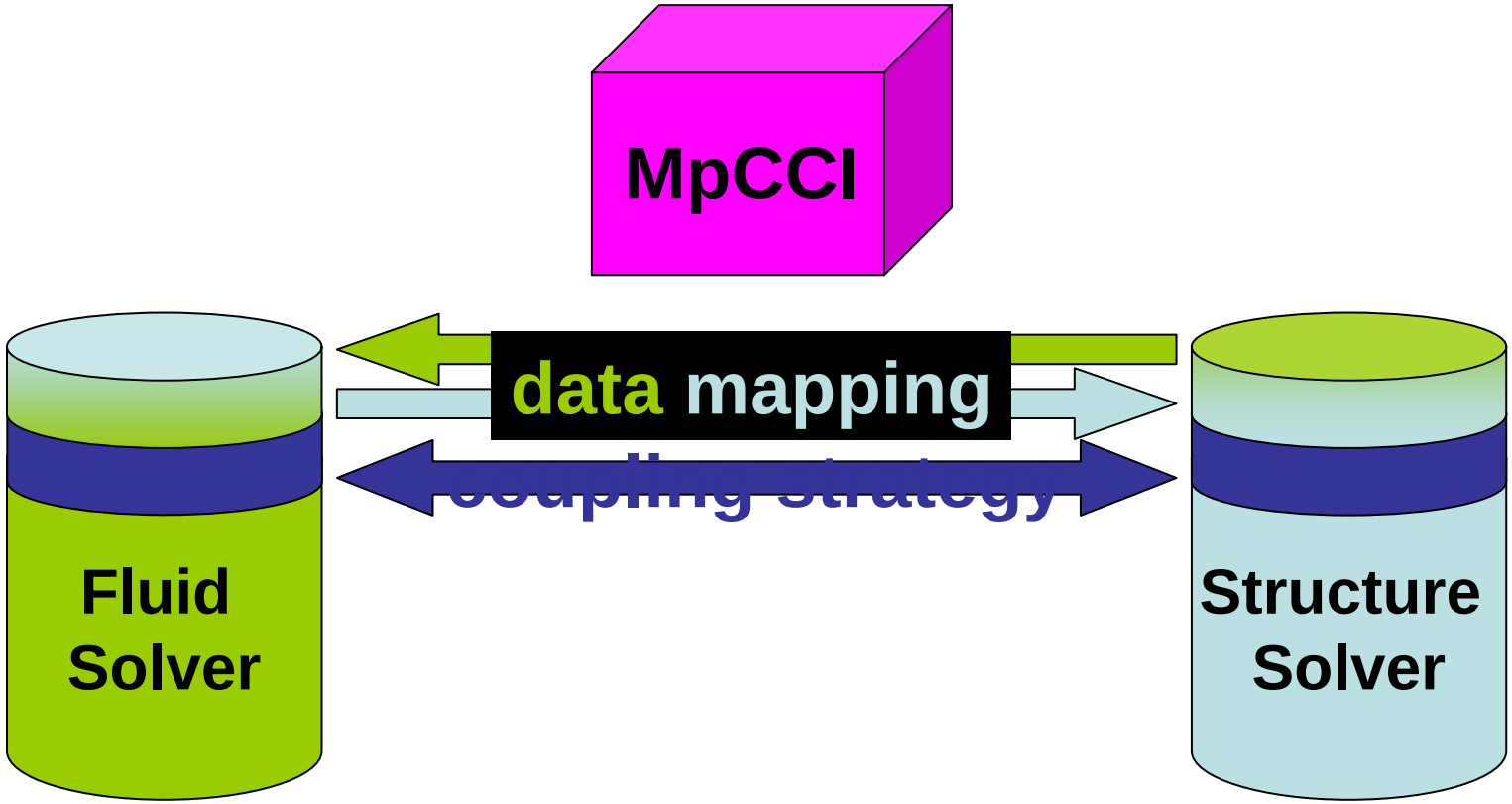
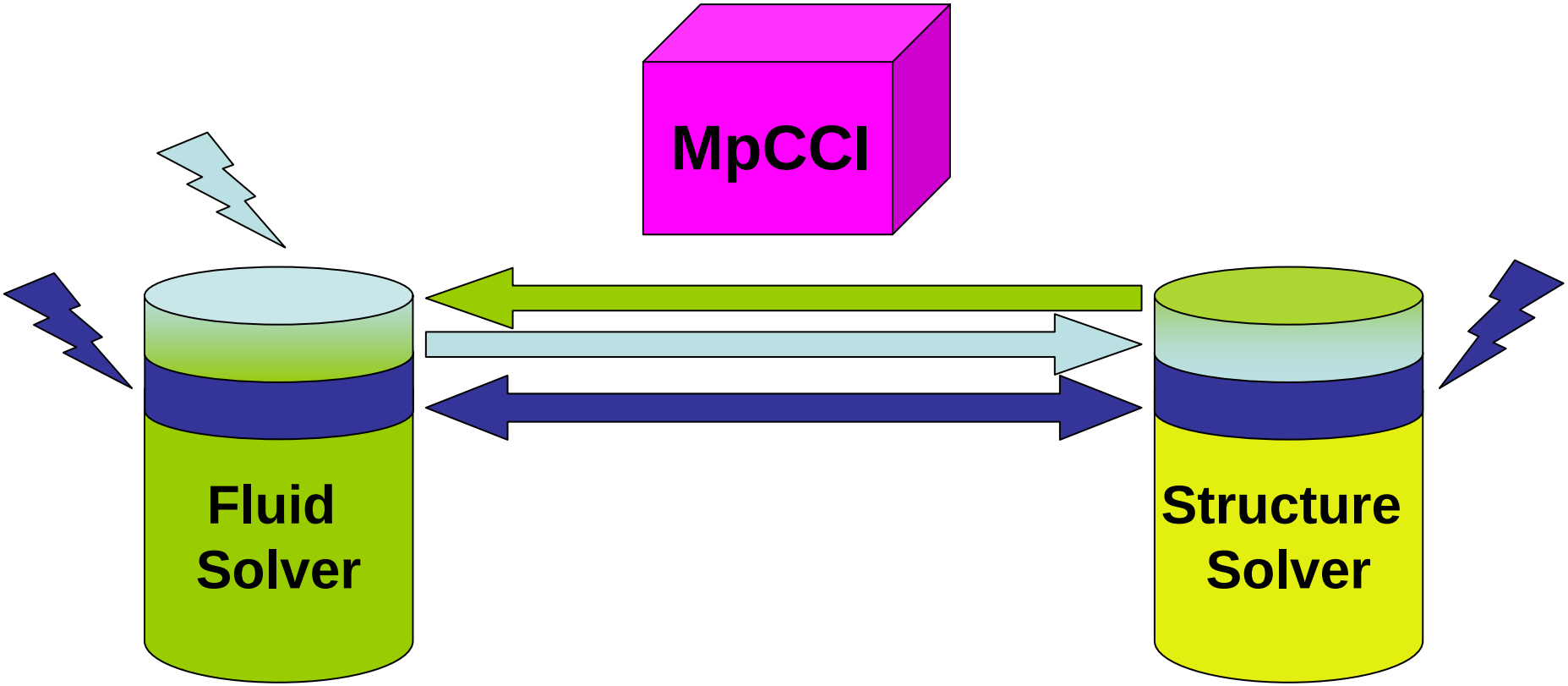
Outline

- concept of FSI*ce
- data transfer for non-matching grids
  - octree
  - neighboorhood search
- coupling control
  - multigrid
  - further potential

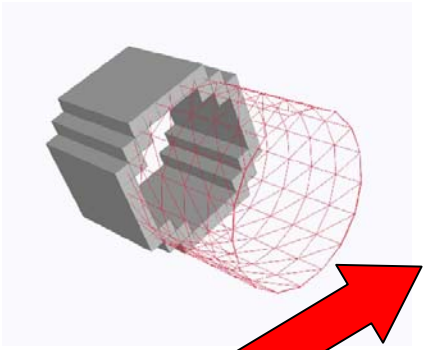
Plug-and-Play for FSI



Plug-and-Play for FSI



Plug-and-Play for FSI



FSI*ce

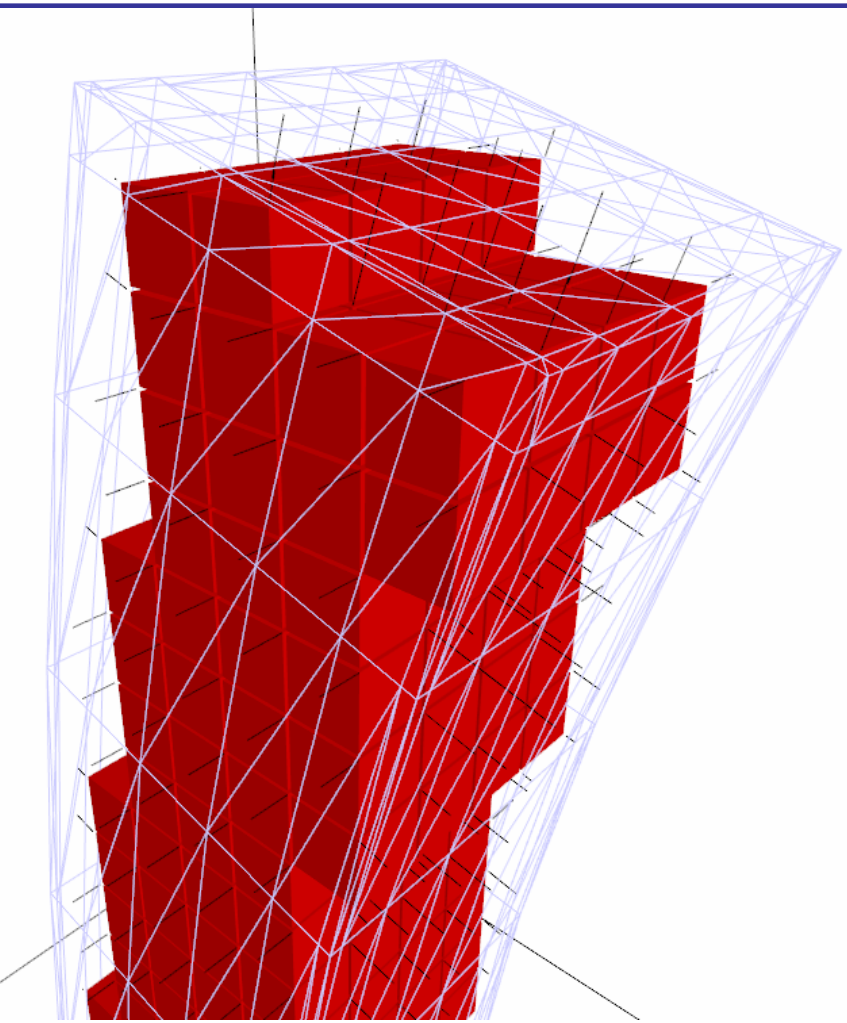
Coupling Strategy

Central Surface Mesh

Fluid Solver

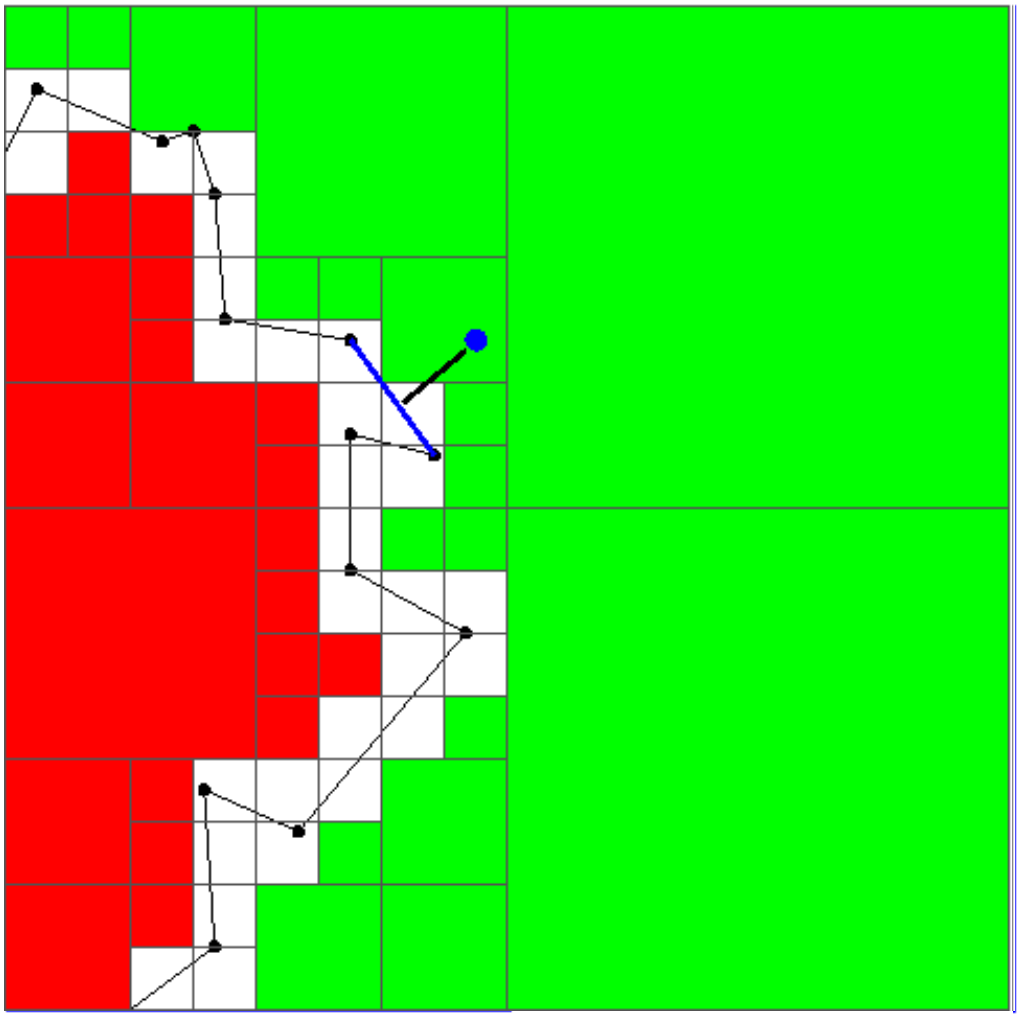
Structure Solver

Data Mapping

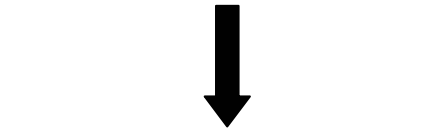


- **any types** of solver grids
- tools:
  - neighbourhood search
  - interpolation/projection

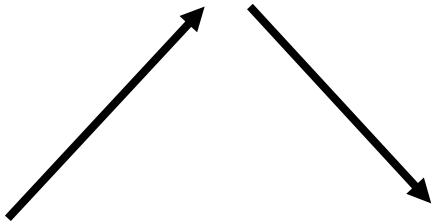
Data Mapping



central mesh



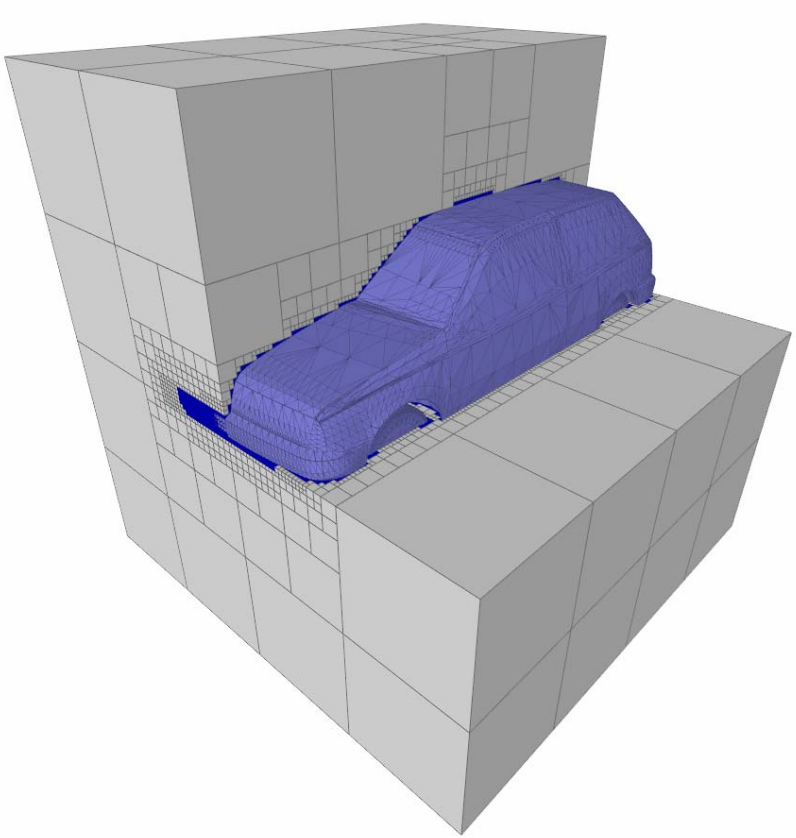
octree



grid point

triangle + projection

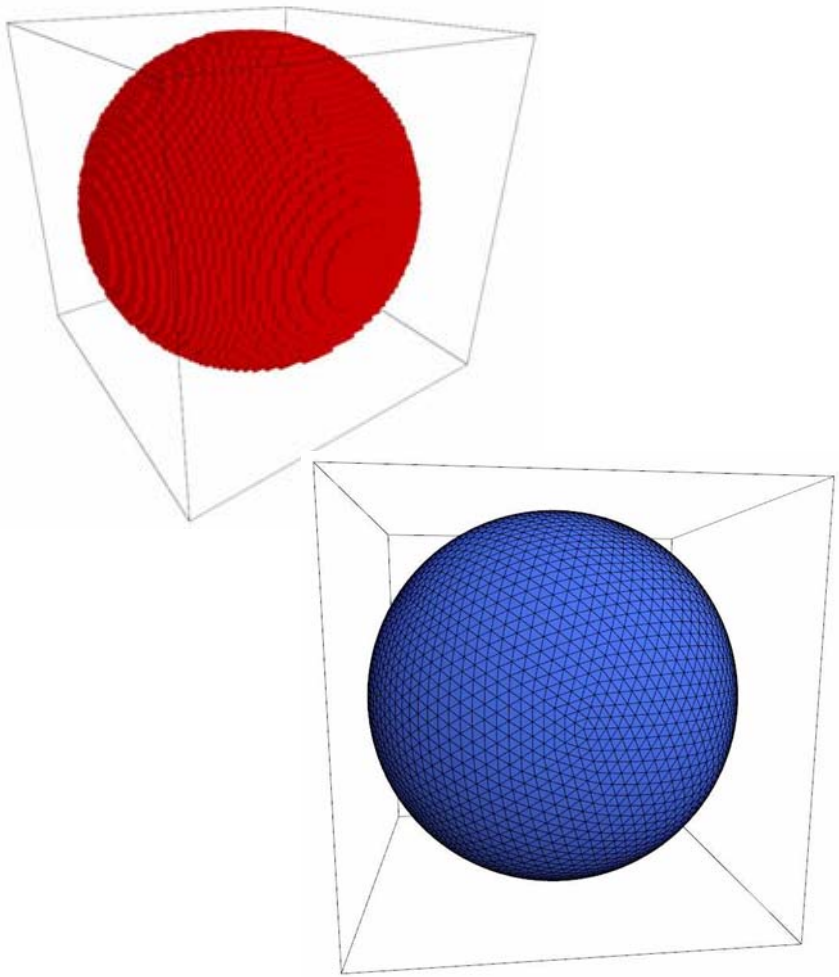
Data Mapping – Octree Generation



octree depth	time (sec)	nodes
7	0.8	203,905
9	4.9	3,288,225
11	48.2	52,662,337
13	662.8	842,687,105

octree generation measured on a Pentium 4 2.4 GHz processor with 512 kB cache

Data Mapping – Neighbourhood Search

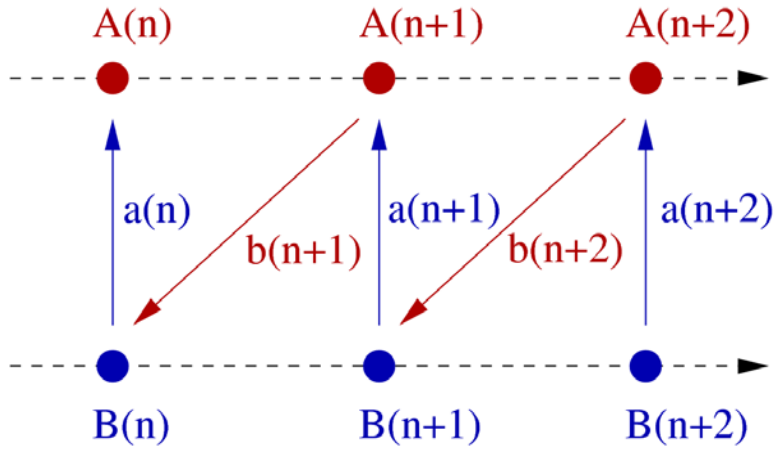


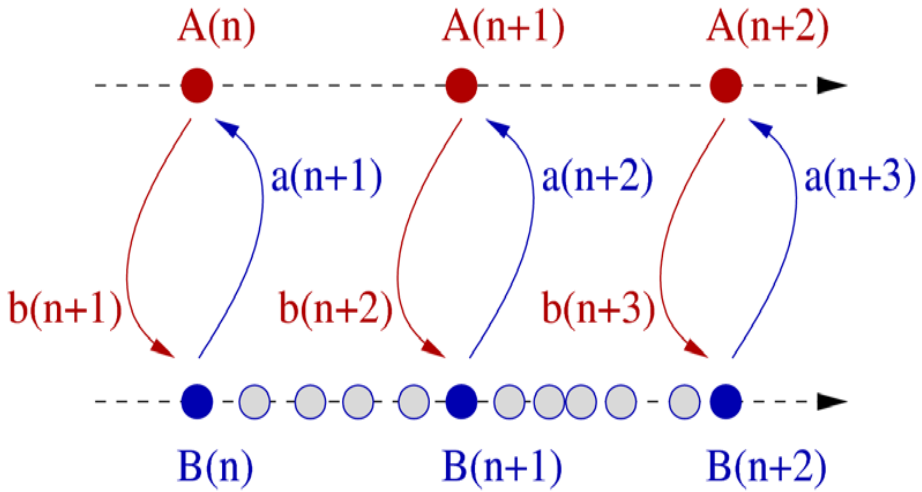
Cart.res.	# triang.	runtime
256	8,000	2.6 sec
512	8,000	10.1 sec
512	32,000	14.3 sec
512	128,000	17.4 sec

neighbourhood search measured on a Pentium M 1.6 GHz processor with 2048 kB cache

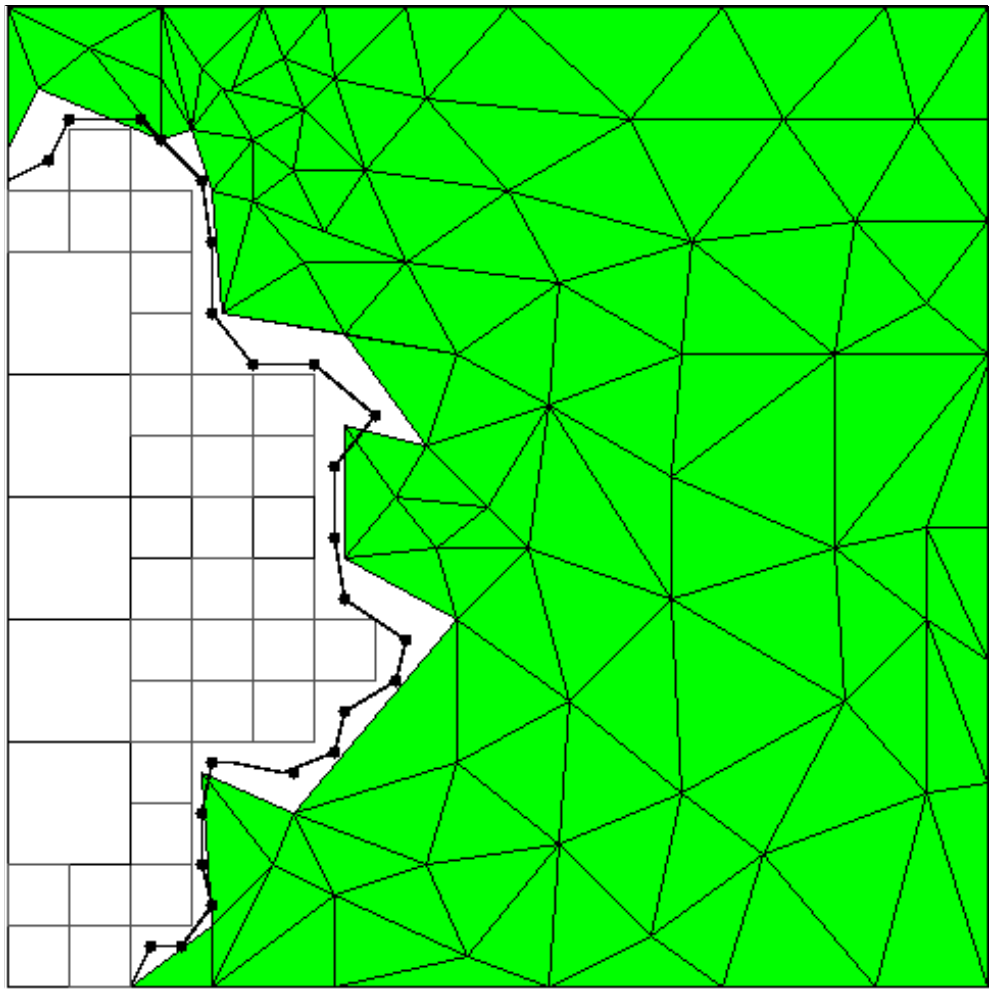
Coupling Control

- explicit/implicit
- subcycling
- next: multigrid





Coupling Control – Multigrid



solve fluid

exchange data

solve structure

exchange data

compute residual

restrict residual

solve coarse

Coupling Control – Multigrid

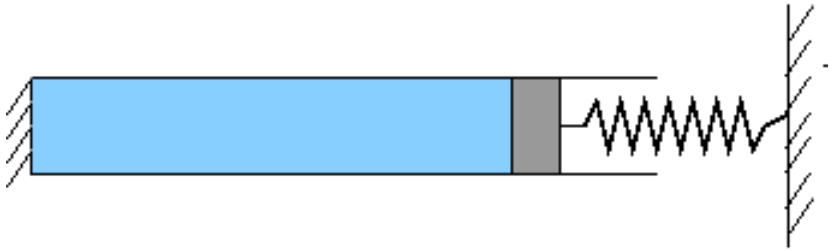
FSI*ce	**Solver**
multigrid cycles	multigrid functionality
restrict central mesh	extended data mapping

- setup-phase for central mesh hierarchy

Coupling Control – Multigrid

benefits of multigrid:

- Bijl, van Zuijlen, Boscher, ECCOMAS CFD 2006:



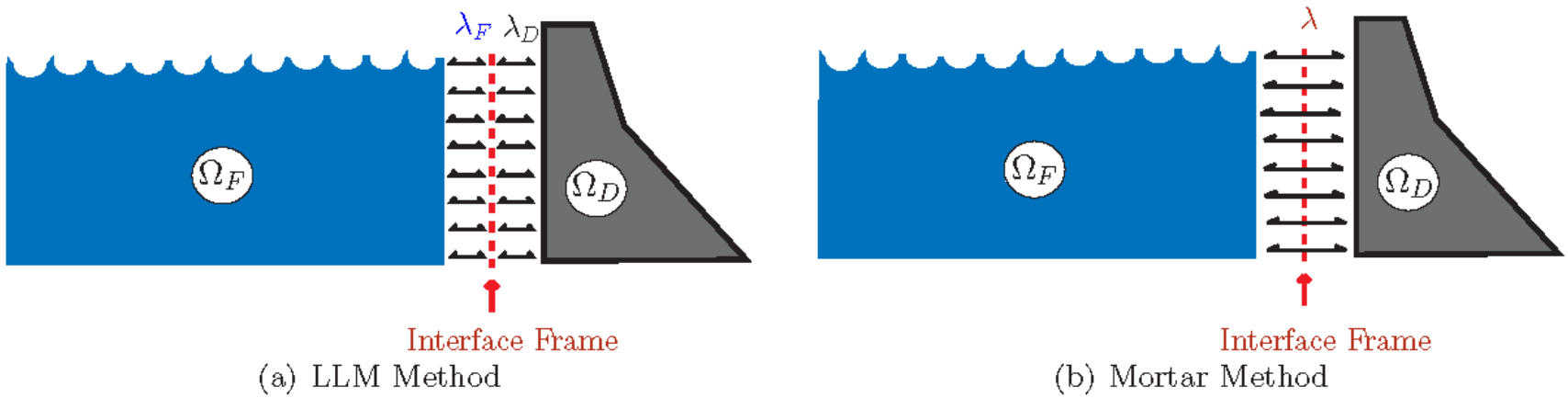
eff. gain: factor 10

1D linear piston problem

two-grid solver, coarsening in the fluid only

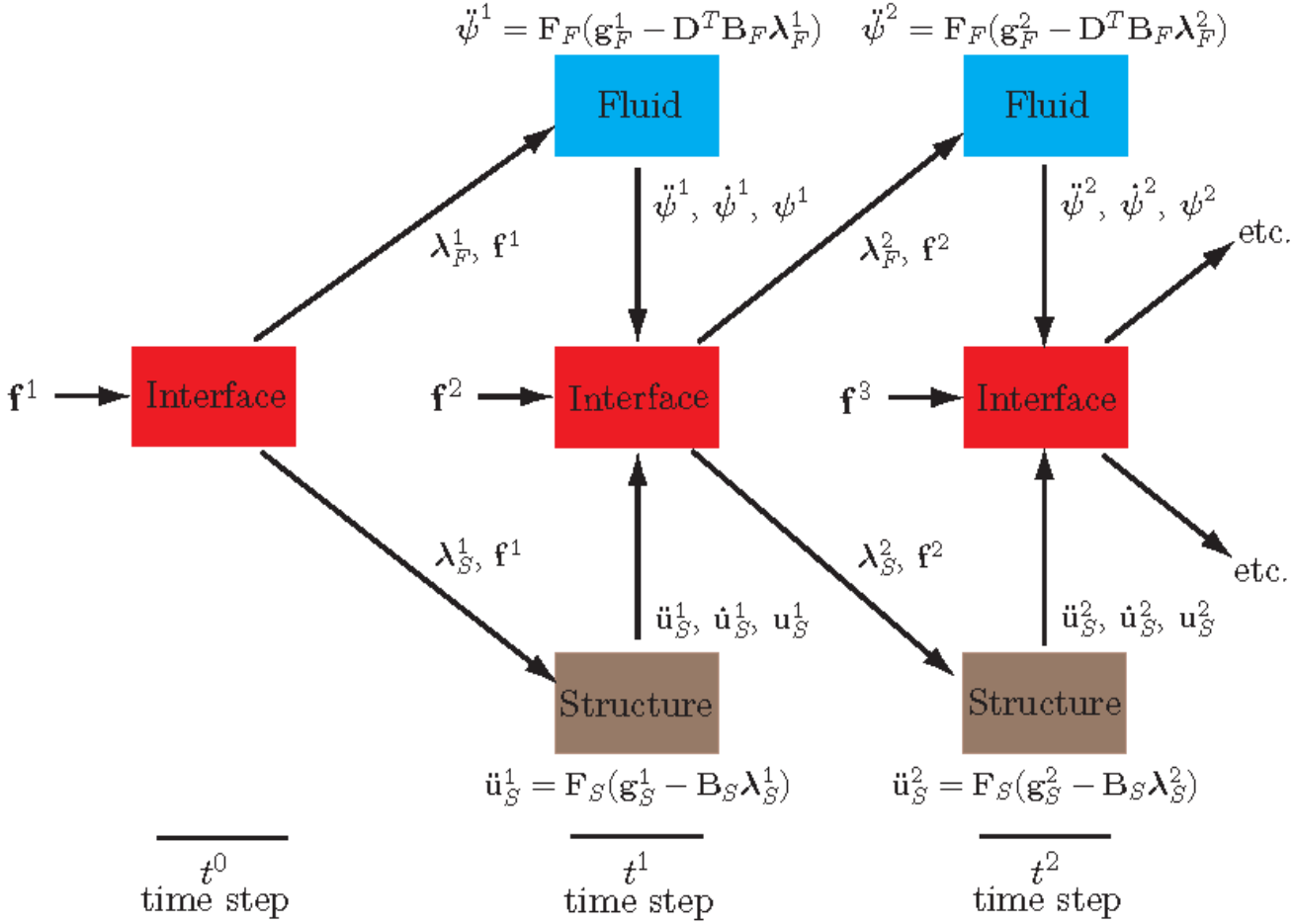
Central Mesh – Further Potential

- third numerical component: the wet surface
  - **LLM transient method** (Park, Felippa, Ohayon, 2001, Ross, 2006)



Source: Mike R. Ross, PhD thesis, 2006

Central Mesh – Further Potential



- stable
- parallel

Source: Mike R. Ross, PhD thesis, 2006

Central Mesh – Further Potential

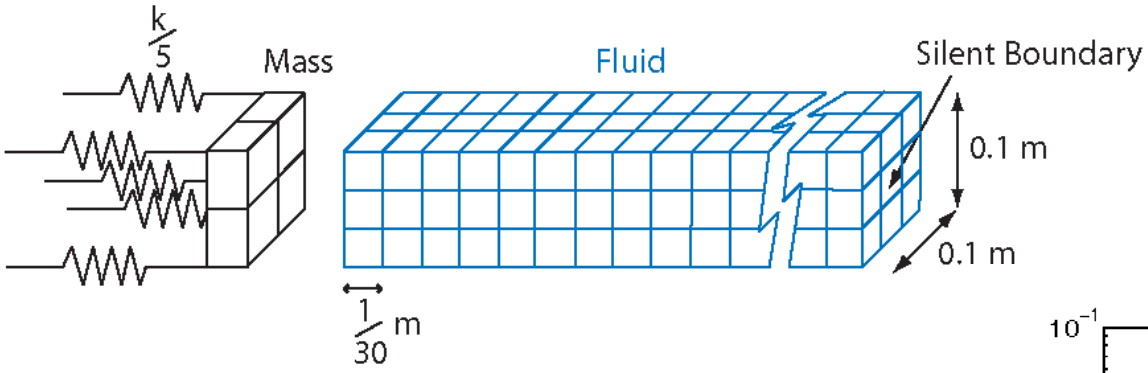
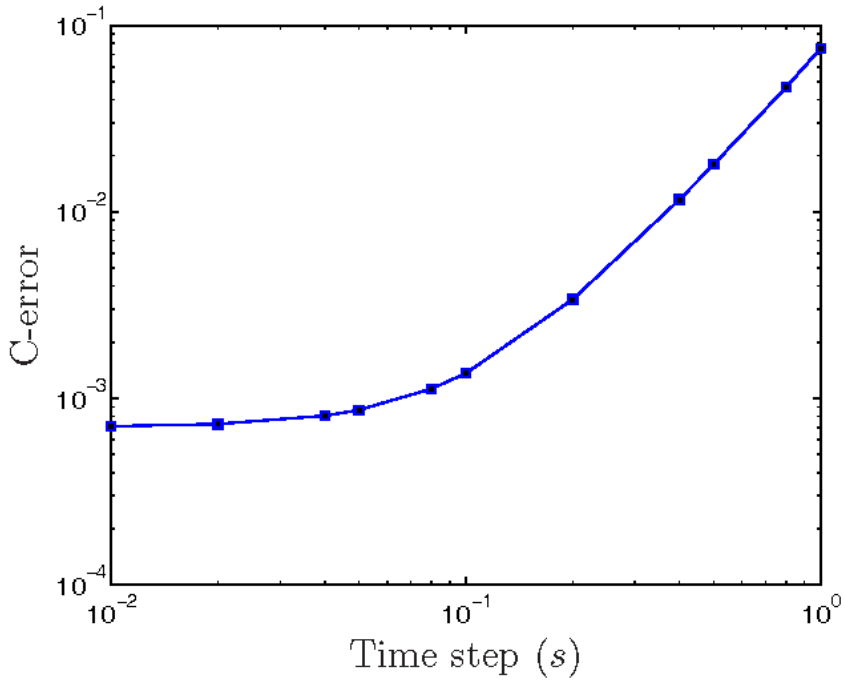
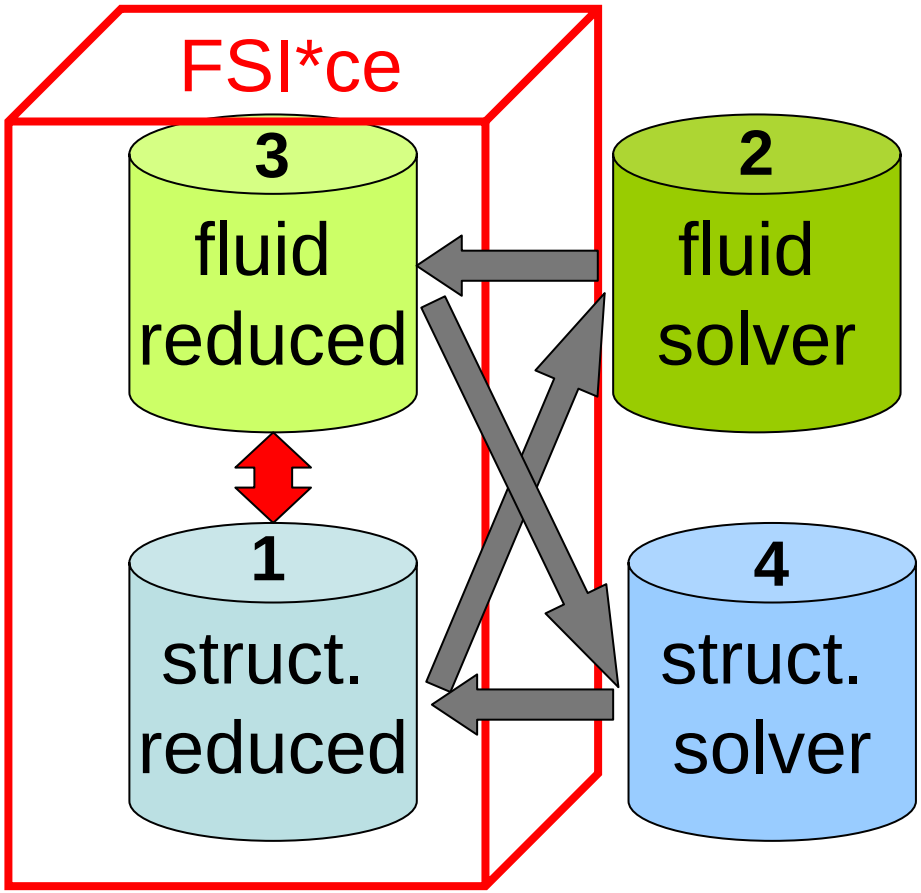


Figure 5.7: Model with non-matching meshes.

Source: Mike R. Ross, PhD thesis, 2006



Central Mesh – Further Potential



reduced order models

- implicit coupling
- black box solvers
- high efficiency

Vierendeels,
LNCSE 53, Springer, 2006.

Conclusion

- flexibility
  - solvers, coupling strategy
- enhanced coupling strategies
  - multigrid
  - interface equation
  - reduced order models