Implementation and performance studies of a three-phase model solver

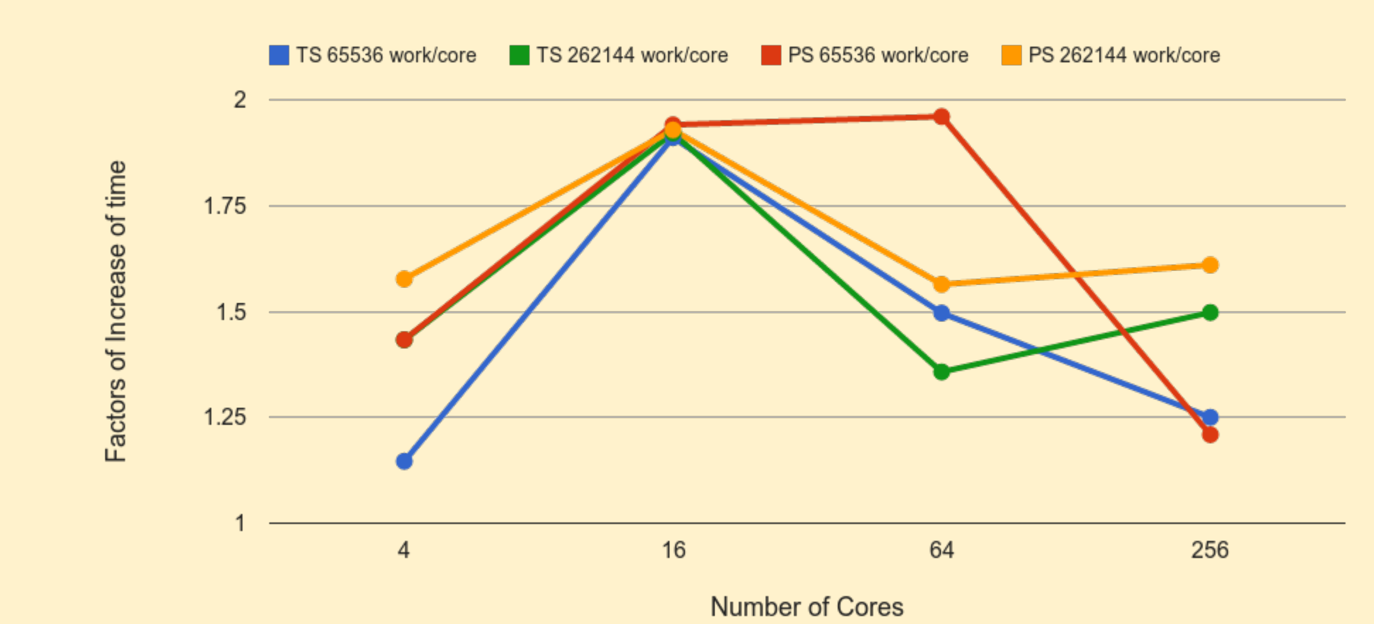
UPPSALA UNIVERSITET

Alexandra Redlund
Alexandra.Redlund.6620@student.uu.se

Gong Cheng
Gong.Cheng.2068@student.uu.se

Conclusion

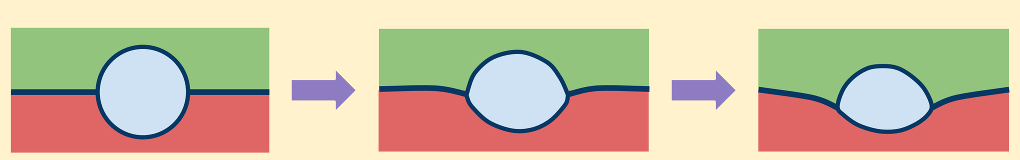
The three-phase model solver was implemented in parallel. The almost constant number of iterations was as expected. The results of weak scalability confirm that the algorithm can be scaled up for different size of three-phase problems and expanded to multi-phase models.



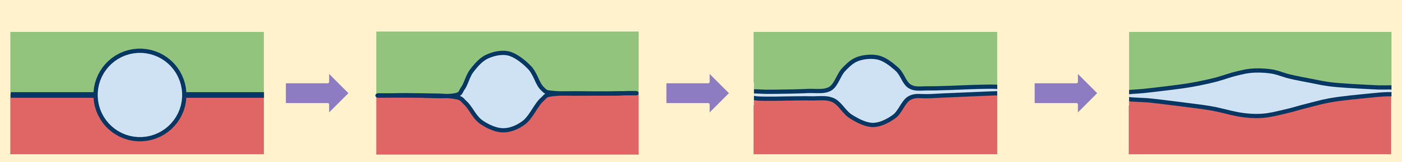
*TS: Total Spreading. **PS: Partial Spreading

The weak scalability test for four cases, each with the same workload per core. The factors are the increase of time after one refinement of mesh.

- **Partial Spreading: Evolution of interface position**



- **Total Spreading: Evolution of interface position**



Introduction

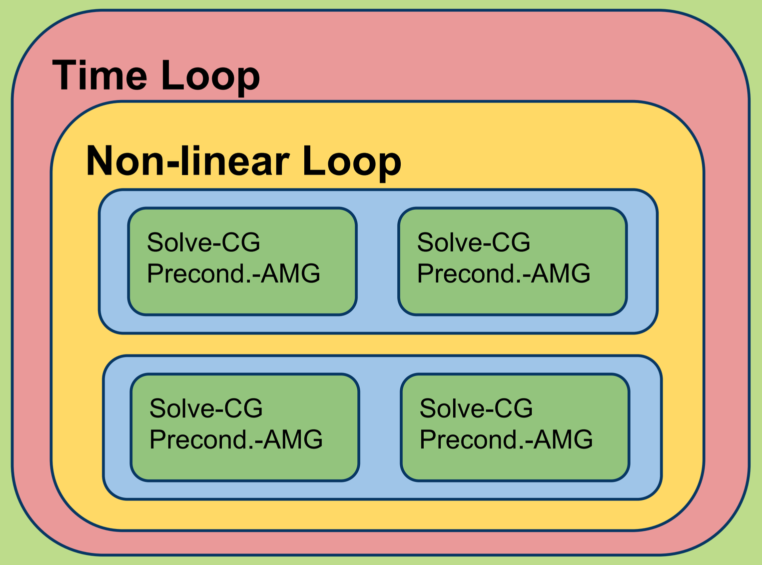
This project is concerned with simulating three-phase systems of fluids. The phases are modeled as a concentration varying in space and time that attains distinct values inside the different phases. The transitions between distinct concentration values represent the interfaces between the fluids.

Aim

Develop an efficient and distributed solver for the three-phase problem and evaluate performance of the solver for total and partial spreading cases with different problem sizes by running on the UPPMAX cluster.

Method

The problem is discretized using the finite element method in space and the backward Euler method in time. In each time step, the system is solved by using an inexact Newton method. After permuting the system matrix to a block-diagonal form, we simplify the problem to be ¼ of the original system and solve the matrix by using a preconditioned CG method.



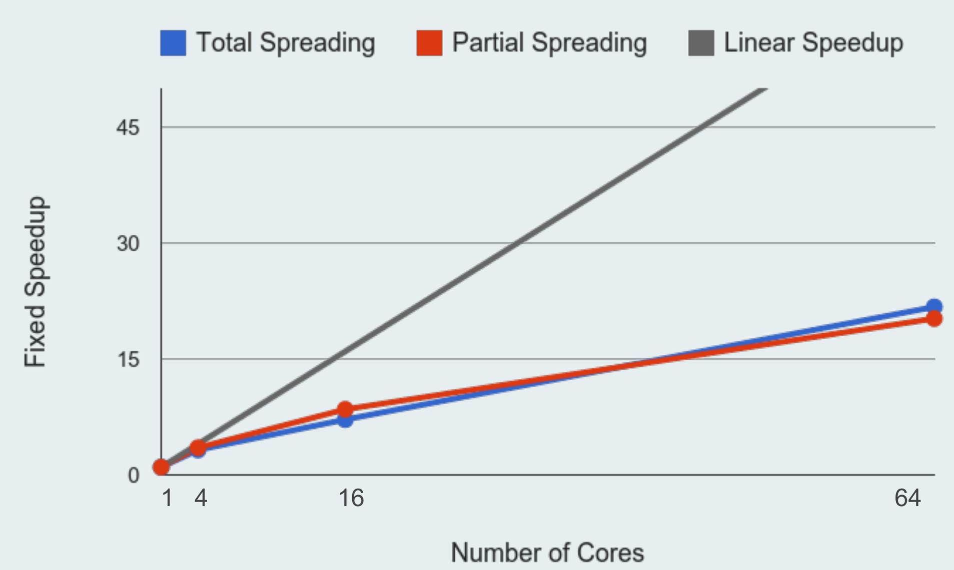
Results

The problem of total spreading is more complex than partial spreading. As a result, more steps are needed to achieve the same stopping criteria. The slight increase in the number of inner iterations is caused by the preconditioned AMG solver.

Refinements	7	8	9	10	11	12
System Size(DOF)	66,564	264,196	1,052,676	4,202,500	16,793,604	67,141,636
Partial Spreading	21/2	22/3	22/4	23/4	23/5	24/5
Total Spreading	41/3	35/3	32/4	30/4	28/5	27/5

Number of Newton method and inner linear solver iterations.

The fixed speedup is evaluated for the system with 4,202,500 degrees of freedom (10 refinements). For one more refinement, we can get similar performance by using four times as many cores.



Fixed speedup for 10 refinements of total spreading and partial spreading.

Supervisor: Maya Neytcheva, Ali Dorostkar
Department of Information Technology, Uppsala University

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