

Inria Project Lab C2S@Exa

Using MaPHyS with the TRACES software

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Context & Motivation

TRACES: numerical simulation of radio-active waste storage in profound geological layers

- ❖ Temporal discretization: implicit
- ❖ Spatial discretization: Mixed Hybrid Finite Element Method
- Algebraic linear system whose unknowns are associated to the mesh faces
- Parallel inversion of the resulting linear algebraic system is the most challenging part of the numerical integration

Hypr has been used in the first parallel version of TRACES

MaPHyS

MaPHyS: Massively Parallel Hybrid Solver

Algebraic additive Schwarz preconditioner for the Schur complement

How to use MaPHyS

- o Sequential interface
- o Parallel interface

MaPHyS use

Standard sequential use of MaPHyS

A. Analysis stage

→ Input: $Ax = b$

- o Reading the Matrix
- o Sequential partitioning of the matrix
- o Constructing the subgraphs
- o Assigning each partition to a fixed process

→ Output: Distributed system and some fields needed for the parallel solving

B. Solving stage

- o Parallel solving of the system

Traces-MaPHyS interface

Parallel interface

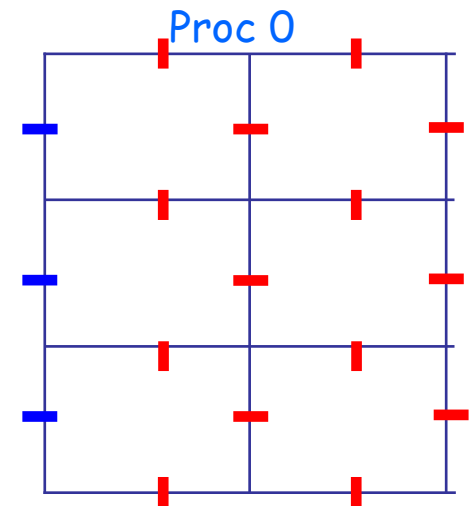
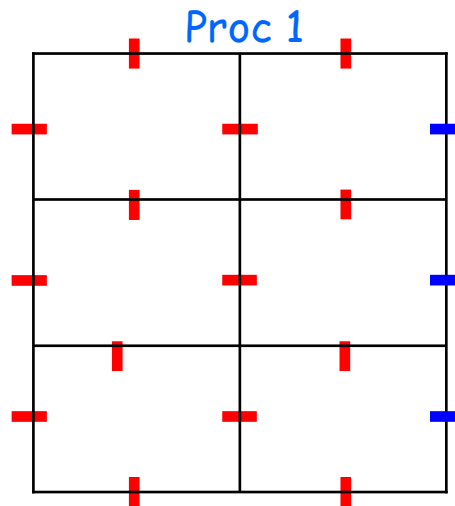
Governing idea

Create a structure of data that would be generated by MaPHyS pre-treatment stage

Fields to be defined

Myndof, myndofinterior, myndofintrf, mysizeintrf, gballintrf, mynbvi, myindexvi, myptrindexvi, myindexinterf, myinterface, myndoflogicintrf, mylogocintrf

New Numbering of DOFs



Reordering the indices of the matrix and Putting it in the storage form of MaPHyS

Performance: PCG/AMG

Mesh: hexahedral, 428 400 elements, 1 305 230 faces

Stopping criterion: $10 \text{ e-}10$

Calculations were run on PlaFRIM cluster

MaPHyS	
Number of Processes	CPU Time(s) Solve+Setup
8	40.41
16	16.43
32	6.57
64	3.05
128	2.6
256	1.94
512	1.35

Hypre: PCG/AMG	
Number of Processes	CPU Time(s) Solve+Setup
8	2.81
16	1.66
32	1.18
64	1.97
128	4.7
256	8.5

MaPHyS solver leads to a better scalability

Hypre solver leads to a more efficient reduction of CPU time

Performance: PCG/AMG

Mesh: hexahedral, 2 506 140 elements, 7 591 723 faces

Stopping criterion 10^{-10}

Calculations were run on PlaFRIM cluster

Hypre: PCG/AMG	
Number of Processes	CPU Time(s) Solve+Setup
8	36.34
16	18.03
32	9.2
64	5.01
128	6.67
256	9

MaPHyS	
Number of Processes	CPU Time(s) Solve+Setup
8	Run out of memory
16	Run out of memory
32	Run out of memory
64	39.3
128	16.84
256	9.14

Hypre solver leads to a more efficient reduction of CPU time

MaPHyS solver leads to a better scalability, but the use of some number of sub-domains is required

Conclusion

- ❖ A distributed MaPHyS-TRACES interface has been developed
- ❖ Numerical tests show:
 - Hypre solver leads to a more efficient reduction of CPU time while using a small number of sub-domains
 - MaPHyS solver leads to a better scalability, but the use of some number of sub-domains is required