The HYTEG Finite-Element Framework for Scalable Geophysics Simulations

Motivation:
structured refinement of unstructured triangular or tetrahedral meshes

- high geometric adaptability in two or three dimensions
- excellent performance through matrix-free multigrid methods
- parallel scalability through fully distributed data structures

Domain Partitioning
- partitioning of the unstructured coarse grid into macro-primitives
- efficient stencil-based kernels through structured refinement in each macro-primitive
- macro-primitives serve as interfaces for communication
- load balancing — primitives are distributed among parallel processes

Application: Stokes + Energy Transport

$$\begin{align*}
-\Delta u + \nabla p &= - Ra \hat{r} \\
\text{div} \ u &= 0 \\
\partial_t T + u \cdot \nabla T &= Pe^{-1} \Delta T
\end{align*}$$

- coupled system for velocity u, pressure p and temperature T
- parallel multigrid solver for the Stokes problem

References
International Journal of Parallel, Emergent and Distributed Systems, 2018