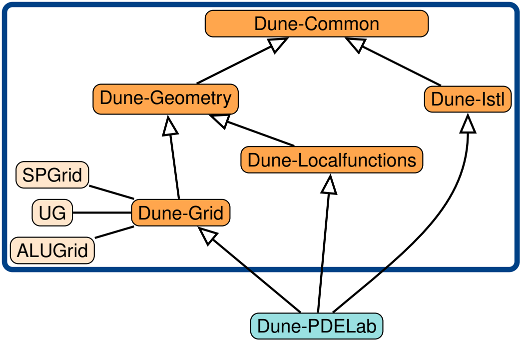
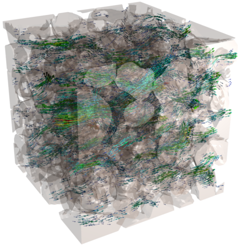
LUND UNIVERSITY

An Efficient Python Framework for DG Methods

Andreas Dedner, Robert Klöfkorn

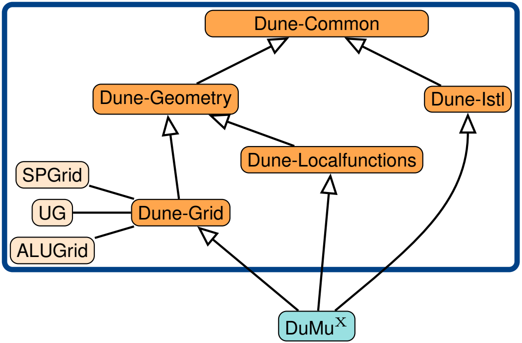
Dune Modules

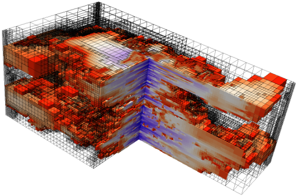




- Dune-Common basic infrastructure and build system
- Dune-Geometry implementation of generic geometry classes
- Dune-Grid abstract grid interface
- Dune-Istl Iterative Solver Template Library (Krylov, PAMG, ...)
- Dune-Localfunctions implementation of shape functions, ...
- Dune-PDELab discretization module

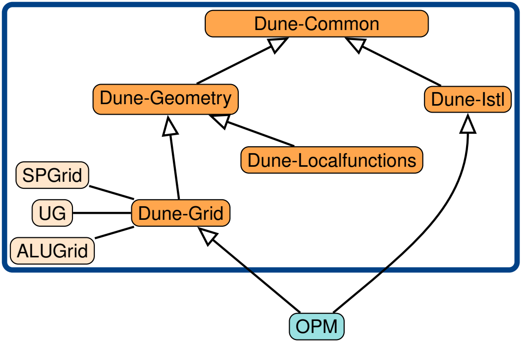
Dune Modules

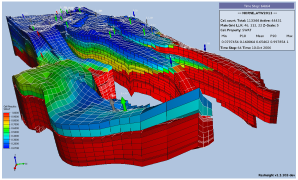




- Dune-Common basic infrastructure and build system
- Dune-Geometry implementation of generic geometry classes
- Dune-Grid abstract grid interface
- Dune-Istl Iterative Solver Template Library (Krylov, PAMG, ...)
- Dune-Localfunctions implementation of shape functions, ...
- DuMu^X flow and transport processes in porous media

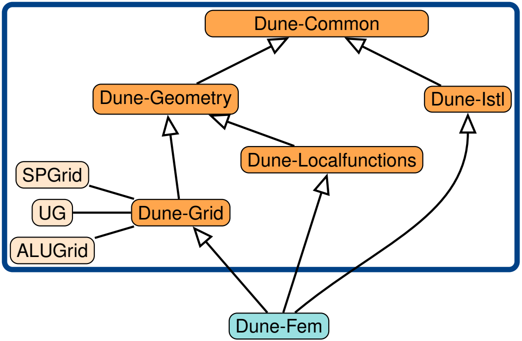
Dune Modules





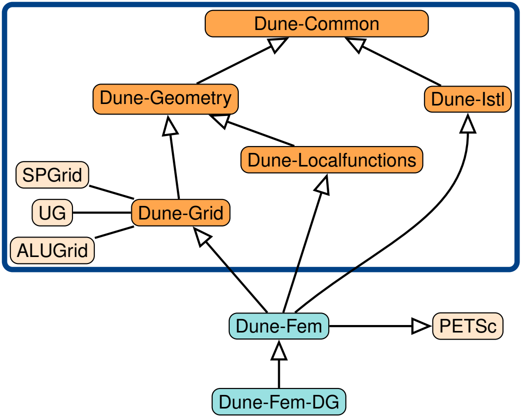
- Dune-Common basic infrastructure and build system
- Dune-Geometry implementation of generic geometry classes
- Dune-Grid abstract grid interface
- Dune-Istl Iterative Solver Template Library (Krylov, PAMG, ...)
- Dune-Localfunctions implementation of shape functions, ...
- Open Porous Media Initiative (SINTEF, Equinor, NORCE and others)

Dune Modules



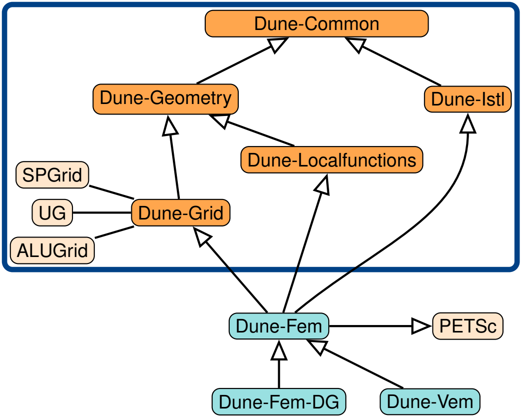
- Dune-Common basic infrastructure and build system
- Dune-Geometry implementation of generic geometry classes
- Dune-Grid abstract grid interface
- Dune-Istl Iterative Solver Template Library (Krylov, PAMG, ...)
- Dune-Localfunctions implementation of shape functions, ...
- Dune-Fem discretization module
  - discrete function spaces
  - data management for adaptivity
  - efficient communication (observer pattern)
  - data I/O and checkpointing
  - python bindings including FENICS UFL for variational description of PDEs.
  - ...

Dune Modules



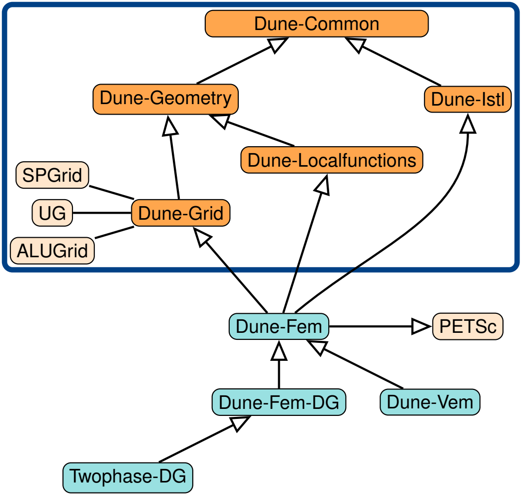
- Dune-Common
- Dune-Geometry
- Dune-Grid
- Dune-Istl
- Dune-Localfunctions
- Dune-Fem discretization module
- Dune-Fem-DG various DG schemes for advection-diffusion type problems

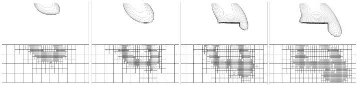
Dune Modules



- Dune-Common
- Dune-Geometry
- Dune-Grid
- Dune-Istl
- Dune-Localfunctions
- Dune-Fem discretization module
- Dune-Fem-DG various DG schemes for advection-diffusion type problems
- Dune-Vem implementation of Virtual Element method

Dune Modules





- Dune-Common
- Dune-Geometry
- Dune-Grid
- Dune-Istl
- Dune-Localfunctions
- Dune-Fem discretization module
- Dune-Fem-DG various DG schemes for advection-diffusion type problems
- Dune-Vem implementation of Virtual Element method
- Twophase-DG implements two-phase flow using DG discretizations

Forward Facing Step 3d

Simulation details (XC4000 SCC Karlsruhe, 2008):

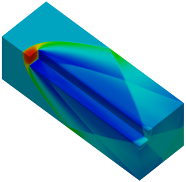
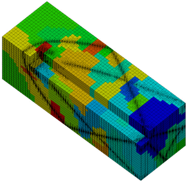
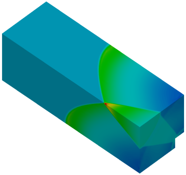
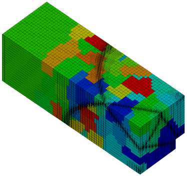
- stabilized DG approach with quadratic polynomials ($k = 2 \mathrel{\hat{=}} 50$ ukn. per cell)
- **fully unstructured** hexahedral grid (ALUGrid, also tetras)
- non-conforming grid adaptation in parallel (MPI)
  with dynamic load balancing (METIS)
- final adapted grid contains about 4.5 **million** grid cells (uniform grid about 95 million cells)
- **Adaptation** 5**%** and **load-balancing** about 10**-**15**%** of one timestep
- Load-balancing takes place approx. every 100**th timestep**

speedup for one timestep

K	$S_{128\to K}$	$\frac{128}{K} S_{128\to K}$
128		
256	1.97	0.985
512	3.73	0.933

ODE solving per timestep

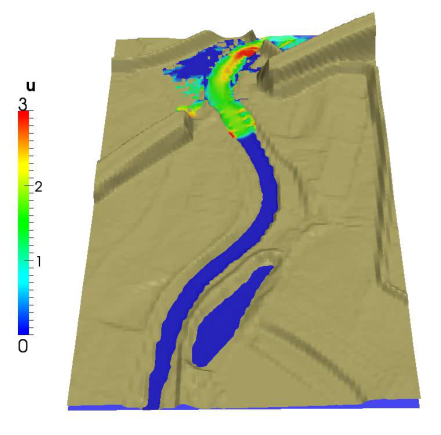
K	$S_{128\to K}$	$\frac{128}{K} S_{128\to K}$
128		
256	1.98	0.99
512	3.85	0.963

Robert Klöfkorn

Well-balanced Finite Volume scheme for shallow water

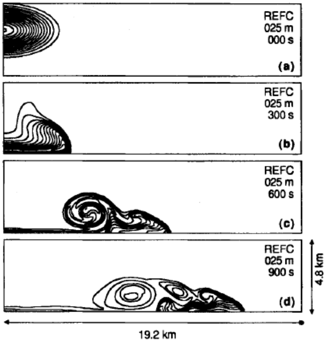
2nd order FV with wetting and drying

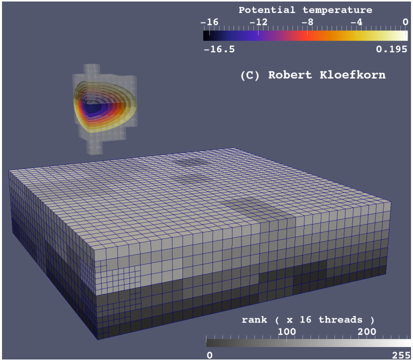


work by Axel Pfeiffer (Freiburg)

Density current test case

Reference solution: potential temperature Θ pertubation





Straka et al. Numerical Solutions of a Non-Linear Density Current: A Benchmark Solution and Comparisons, Int. J. Num. Meth. Fluids **17**, 1–22 (1993)