MODULAR DESIGN OF UG APPLICATIONS

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The numerical simulation framework UG supports unstructured grids, adaptivity, multigrid methods and parallel computing for the finite element and finite volume solution of partial differential equations. Object-orientation and modularization shield the complexity from the user and allow to put the development emphasis on the *problem class* level, i.e. discretization methods and application-specific functionality. For complex applications the design of these problem classes is nontrivial if reusability and flexibility are desired. We present a software library based on the numerical framework UG, which provides these features. The library contains several numerical methods which can be easily interchanged and combined: finite volume methods, discontinuous Galerkin methods, higher order Runge-Kutta methods, MMOC, ELLAM,... The library targets single-phase flow, transport and multiphase flow in porous media.

The solvers for linear and nonlinear systems and time-stepping schemes are implemented in UG in an object-oriented way. They are completely problem-independent, parallelized and support the full functionality of multilevel methods on adaptively refined unstructured grids. We explain the structure of these *numerical procedures*, show how they can be accessed and combined on a script language level and present interfaces to CAD tools and grid generators which enable the treatment of complex geometries.

We then explain how this approach can be applied to the next level of abstraction, the problem class. The basic idea behind frameworks like UG is that the problem class code can be much smaller than the supporting framework. As the applications based on the framework grow more complex, however, the demand for a clean modular design of this component arises. The concept of numerical procedures can be extended to the problem class level. Their object oriented structure makes it possible to combine discretization methods and application specific data, while hiding the complexity of the parallel adaptive code from the user.

Finally we show applications of the library: Multigrid solution of discontinuous Galerkin methods, combination of discontinouos Galerking and mixed finite element methods, and adaptive multigrid solution of porous media problems in complex geometries on MIMD supercomputers.