Design Pattern Enabling the Flexible Integration of Effects into a Basis Flow Model

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Abstract

The assessment of the long-term safety of a deep underground repository for radioactive waste requires a comprehensive understanding of the system and capable numerical tools. RepoTREND is a final repository simulator being developed by GRS for simulating the

- release of contaminants and
- their transport through the near-field and far-field to the biosphere including
- the estimation of the radiological consequences for man and environment.

It shall be applicable to different concepts of the final repository in different host formations.

For such simulation, additional to the underlying basic processes, such as the two-phase flow in porous media, a number of other effects have to be taken into account. These effects may transform system parameters that are fixed in the basic processes into variables. As a result the basic equations and global equation system change. For instance, the rock convergence dynamically changes the pore volume in some region. The convergence process is controlled by a number of additional factors, and the change of the pore volume is described by a nonlinear differential equation that has to be integrated into the global equation system. During a simulation of the processes in a repository for radioactive waste different effects as well as different combinations of these effects have to be considered. The relevance of effects depends on the environment parameters and may change during the simulation time.

One of the challenges in developing the structure for such simulator program is to enable a flexible choice of effects and their combination during a simulation and an easy way to extend the program by new effects.

On the other hand, it is intended to avoid accounting for all effects throughout every calculation or developing a special, non-reusable code for every application.

The paper presents a concept for realizing these requirements.

The basic process models a fluid flow in a medium described by equation(s) of the form:

(accumulation term) – (flow term) – (source term)=0

with basic variables X_i and constant equation parameters.

Further, an effect is defined as a process affecting the system in such a way that one/some parameters of the basic equations get variable (additional variables Y_i). Modelling an effect may lead to additional terms in the equations and to additional differential equations for Y_i which have to be introduced into the global equation system. It is important to mention that the structure of a block row of the global Jacobian-matrix is not changed by the introduction of an effect.

The concept of flexible introduction of effects into the simulation consists of several steps:

- Define a family of *Effects*. An *Effect* class encapsulates the related parameters und effect specific routines for pre-/post processing for a time/iteration step.
- Define a family of *Equations*. An *Equation* class encapsulates numerical calculation algorithms for one differential equation.
- Define a family of *Expert* objects that capture a current system state (relevant effects, basic model) and encapsulates the interaction of relevant *Effects* and *Equations*. Make these *Expert* objects interchangeable according to a changed system state. *Expert* objects

enable the loose coupling of data structure. By using *Expert* objects the explicit dependency between objects can be avoided. This concept enables the interaction of objects to be varied and modified independently of the objects themselves.

This concept ensures the implementation of new effects in an easy way according to the predefined pattern, flexibility, transparency and reusability in extending and developing the program.

Keywords: Reusability, Data Structure, Design Pattern