Symbolic Initialization of Over-determined Higher-index Models

Lennart Ochel Bernhard Bachmann
lennart.ochel@fh-bielefeld.de bernhard.bachmann@fh-bielefeld.de
Bielefeld University of Applied Sciences, Department of Mathematics and Engineering
Am Stadtholz 24 - 33609 Bielefeld, Germany

Francesco Casella
francesco.casella@polimi.it
Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria
Piazza Leonardo da Vinci, 32 - 20133 Milano, Italy

The quantity of initial equations required in an object-oriented model can only be determined at system level. Since Modelica models are generally designed by components, it is difficult to calculate the amount of initial equations needed at system level, especially when changes are applied to the model, e.g. by adding or removing components. Therefore it is more convenient to define initial equations at component level. Consequently, the number of these equations is equal to the number of dynamic variables, i.e., the potential states. Due to component connections, algebraic dependencies between states may be introduced, which eventually lead to the removal of states when symbolic index reduction algorithms are applied. In this process, the corresponding initial equations are not automatically removed, which results in an over-determined initial system.

It is agreed that index reduction is necessary in object-oriented modeling to achieve full modularity without compromises, and suitable means to handle it have been developed over time, so it is obviously necessary to extend the handling to initialization as well. In the majority of cases the over-constrained initialization problem turns out to be consistent, and should therefore be handled automatically, without any intervention by the end user; inconsistent initialization problems should be reported in a user-friendly way.

This paper describes a symbolic algorithm that detects such redundant equations and determines if they are consistent or not. Consistent redundant initial equations can thus be removed automatically, and inconsistent ones can be reported to the modeler. The algorithm is implemented in OpenModelica, tested on several representative cases, and compared to previously presented concepts.

It works well for the recently developed package *OverdeterminedInitialization* from *ModelicaTest* containing various MSL-based test models, which end up in an recursively evaluable initial system. Furthermore, the developed algorithm takes care of singularities, if they occur during the consistency check. More complex problems end up with systems including algebraic loops. If they are not solvable symbolically, a numerical fall-back solution as well as advanced symbolic techniques are proposed.

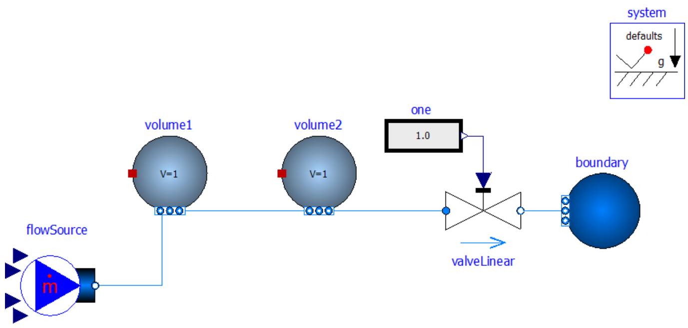

Figure 1: Over-determined fluid-example due to algebraic dependent states