Simulation of Large-Scale Models in Modelica: State of the Art and Future Perspectives

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State-of-the-art Modelica tools are very effective at converting declarative models based on differential-algebraic equations into ordinary differential equations. However, when confronted with large-scale models of distributed systems with a high number of states (1000 or more) or with large algebraic systems of equations (1000 or more unknowns), they face a number of serious efficiency issues, that hamper their practical use for system design:

- Localized interaction is not exploited
- Localized system activity is not exploited
- Systems with activity on widely different time scales are penalized
- Localized influence of events and discontinuities is not exploited
- Systems with large-scale algebraic constraints are not considered
- Repetitive structures are not exploited

Overcoming these limitations would enable Modelica tools to effectively support the design of large-scale, distributed cyber-physical systems.

The paper analyses these issues in detail, reviews promising research trends from the literature, and points out strategies for improvement. It also introduces the ScalableTestSuite package, a library of scalable test models that can be used to assess the performance of existing tools with large-scale systems, as well as to help developing advanced solution methods in this field.