Robust and accurate co-simulation master algorithms applied to FMI slaves with discontinuous signals using FMI 2.0 features

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Abstract

Error control in system simulation using co-simulation techniques is a task for the employed simulation master. With the availability of the FMI standard version 2.0 and rollback capabilities of simulation slaves, master algorithms can be implemented with support of error controlled integration. Particularly, for automated integration tools, the problem-specific dynamic adjustment of communication interval lengths becomes a necessity to obtain reliable co-simulation results while maintaining calculation efficiency.

The article discusses various master algorithms and time step adjustment strategies using a test case with discontinuous input/output signals. As expected, fixed-step Gauss-Jacobi and Gauss-Seidel algorithms are found to be generally unsuited for the task. Accuracy can only be improved by reducing communication step sizes, thus creating a large computation overhead in simulation time spans with smoothly changing or constant variables.

Iteration-based time step adjustment rules are an improvement, yet cannot recognize discontinuities resulting from time-event. Since the traditional Richardson/step-doubling error estimate also fails to recognize discontinuous signal changes, a slope-based modified Richardson-test is introduced and successfully applied. This new method reliably detects discontinuities and allows the master to adjust its communication step size accordingly.

Finally, it is concluded that a suitable master algorithm for such problems is the non-iterating Gauss-Seidel with modified Richardson communication interval adjustment.

Keywords: FMI, co-simulation, master algorithm, error control, adaptive