Analysis of the Computation Time of Co-Simulation Methods

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Co-simulation or solver coupling methods are used in various fields of applications. Examples can be found in [1] and [2]. The basic idea of co-simulation is to decompose an overall system into coupled subsystems. The formulation of the coupling conditions between two subsystems depends on the considered problem. For mechanical models, the coupling conditions can be described by constraint equations (constraint coupling [3]) or by constitutive equations (applied force coupling [4]). A co-simulation approach can be used advantageously for analyzing complex problems, for example the simulation of systems including different physical disciplines so that different specialized subsystem solvers have to be coupled in time domain. Another possible application of co-simulation methods, which is discussed here, concerns the parallelization of a monodisciplinary model.

The methods presented here are weak coupling approaches, which implies that each subsystem is solved independently from the other subsystems within a macro-time step. Information (i.e. coupling variables) is only exchanged between the subsystems at certain communication-time points. The unknown coupling variables are approximated in the subsystems within a macro-time step. The separate integration of the subsystems is the crucial point for parallelizing the computation.

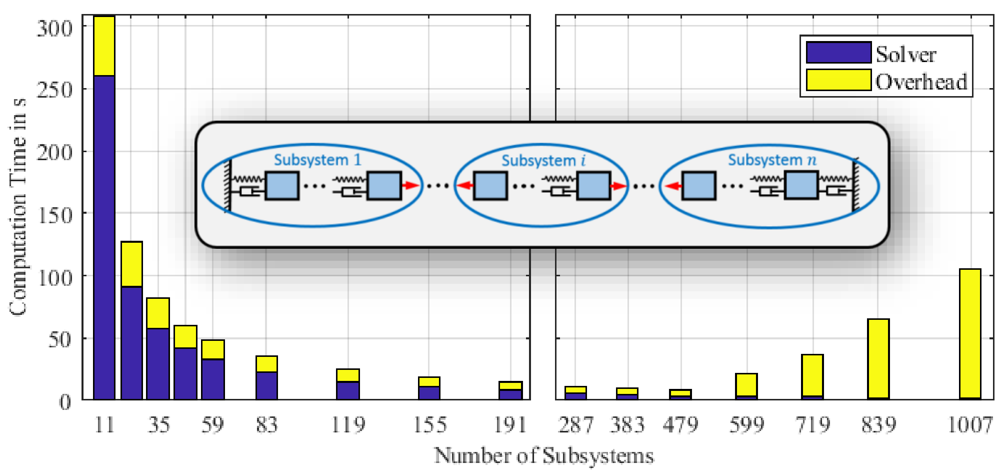

Fig. 1: Computation time of a co-simulation using a various number of subsystems (overall system: multibody system with 1.0e6 degrees of freedom)

To examine the effect of various factors (communication-step size, approximation order of the coupling variables, continuity of the coupling variables, subsystem solver settings) on the computation time, a co-simulation test model is defined. The test model consists of a series of masses that are connected by nonlinear spring/damper-elements. This structure allows the generation of models with any desired number of degrees of freedom very easily. The model can be split up into an arbitrary number of subsystems. The subsystems are solved with the IDA solver from the SUNDIALS (Suite of Nonlinear and Differential/Algebraic Equation Solvers) package [5]. This implicit DAE solver is based on a variable-order variable-coefficient BDF implementation combined with either direct (sparse) or iterative methods for solving the linear system within the Newton iteration. For the present studies, the direct sparse linear solver is used.

Computations for this research were carried on the Lichtenberg high performance computer of the TU Darmstadt.

References

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