Toward Extremely Scalable Computational Scale Bridging Algorithms for Problems in Structural Mechanics

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Abstract

A computational scale bridging approach for multiscale problems in structural mechanics is considered. More precisely, we combine the FE^2 algorithm with a highly scalable domain decomposition method (FETI-DP) which builds the core of the FE2TI software package. The FE2TI package is used in the project EXASTEEL on the simulation of dual-phase steel materials which is funded within the German priority program "Software for Exascale Computing - SPPEXA". In the FE^2 approach macroscopic material properties are computed from material properties at the microscopic level. For the macroscopic level, no phenomenological material law is assumed to be known. This approach incorporates phenomena on the microscale into the macroscopic problem by solving many independent microscopic problems on representative volume elements (RVEs). In order to create an implementation suitable to scale up to several hundreds of thousands of cores, in FE2TI, a highly scalable implementation of our irFETI-DP (inexact reduced Finite Element Tearing and Interconnecting - Dual Primal) domain decomposition method is used as a solver for the microscopic RVE problems. As a standalone solver, irFETI-DP was shown to be scalable on up to 786 432 Mira BG/Q cores. Weak scalability results for the FE2TI method are presented, scaling on the complete BG/Q JUQUEEN at JSC Jülich, Germany (458752 cores) and on the complete BG/Q Mira at Argonne National Laboratory, USA (786 432 cores).

References

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