H5Fed - A HDF5 based Finite Element Data Library

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ABSTRACT

Over the last decades the finite element method has become a widespread discretization technique of modern numerical analysis for solving partial differential equations in many fields of science and engineering. The size of problems has grown from a few thousand elements to tens of millions and even beyond. Increasingly, parallel computers are used to solve the resulting systems of linear and non-linear equations. Simultaneously, the amount of data from these calculations has grown accordingly but handling them on today's massively parallel systems is still difficult. Also, in anticipation of future high performance computing architectures, where the number of processing cores will increase significantly but memory per core will not, a new paradigm is needed. We have therefore defined H5Fed for storing finite element data on the basis of H5Part [1] and on top of the HDF5 data storage library.

H5Fed offers an application programming interface (API) to read and write hierarchically structured meshes, seamlessly, both on serial and parallel computers. It provides adjacency relations for all topological entities of a mesh, both upward and downward. All adjacency relations are computed on the fly on the basis of element to element relations. In the paper we show, that this can be done very efficiently. In the finite element method the mesh is associated with a wide range of data, such as information on boundary conditions applied to specific parts of the mesh boundary, material properties associated with the elements and the degrees of freedom of the finite element discretization; thus, a simple and flexible approach is required for storing associated data. For maximum flexibility H5Fed associates data with any topological entity of the mesh. Also, data associated with topological entities may be of different type, such as integer, double, complex, scalar, arrays and tensors.

H5Fed will integrated into existing codes and frameworks, either by using the native API or by using the GridFactory concept, provided by the "Distributed and Unified Numerics Environment" (Dune) toolbox [2] [3].

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