HDF5: A New Approach to Interoperability in Finite Element Tools

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ABSTRACT

With the tremendous amount of research done in the field of numerical methods for engineering, a sharp rise in the number of new algorithms and software tools (academic and commercial) have been observed in the past decades. The advent of such software tools has not only made the application of the methods easier, but it has also drastically increased the number of users and the applications of these numerical methods to engineering problems.

However, mostly these tools have been developed independently for solving problems of a particular kind, by particular methods on a particular scale, which leads to some limitations. One of these limitations, interoperability, is discussed in this paper and a methodology to resolve it for a small use-case of finite element problems at a continuum scale has been proposed.

The main idea revolves around the fact that, popular tools use formats like VTK, STL, or XDMF, among others, for transferring data of mesh, geometry, loads, etc., and not all the tools can understand or process these formats in a useful manner. To simply state it, there is not one standard format which can enable complete interoperability among these tools. In fact, this problem of interoperability also keeps us from transferring data from one scale to another, e.g. from an RVE to a continuum scale [1]. To enable the interoperability among tools, a methodology has been proposed to export data from Abaqus Output Database (ODB) [2] directly to HDF5 [3] containers as an example.

In this paper, a brief overview of the HDF5 data model is given, followed by a discussion pointing out why this HDF5 data model is a suitable interoperability tool to be used in the Finite Element Analysis (FEA) of engineering problems. After a short introduction of the Abaqus ODB and its underlying hierarchical structure, the procedure to import external libraries to Abaqus-Python is discussed along with the scripting procedure in Python. The customization of HDF5 containers is done for thermo-mechanical problems using h5py, a Python API for HDF5 files. The metadata for the problem is collected from Abaqus v6.14, and a methodology for the export of data from Abaqus to HDF5 containers is defined. Finally, an example of an HDF5 data model created using our scripts and the future scope of the work is shown.

The hierarchical structure of ODB and MDB (Model Database) are similar, and they serve the two main purposes in Abaqus software. The methodology we devise to extract data from ODB, can also be used to write data to a MDB, directly from HDF5 files after some alterations in the scripts. The ODB can be understood as a read-only mode, whereas MDB can be considered as read-write mode.

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