Platypus: A Scalable, Open-Source, GPU-Accelerated MOOSE App for Multiphysics Fusion Simulations

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The present landscape of Finite Element Method (FEM) Multiphysics tools is largely dominated by closed-source software geared towards small-scale simulations. Even popular open-source packages like `MOOSE` [1] are not yet ready to scalably leverage GPU-accelerated architectures. This presents a challenge to the fusion industry in the form of generating qualification data for components, modelling future reactors, and developing digital twins/shadows. In this work, we present `Platypus` [2]: a `MOOSE` app for simulating multiphysics systems using the FEM approach in large-scale engineering with complex geometry, with the intent of utilising MPI parallelism and GPU acceleration for scalability in High-Performance Computing systems. It does so by bypassing `MOOSE`'s FEM backend, `libMesh` [3], and instead representing the problem in terms of `MFEM` [4] objects and solvers, which support GPU acceleration and high-order finite elements spanning the de Rham complex. These capabilities will enable us to perform large scale analyses of UKAEA's upcoming experiments HIVE [5] and CHIMERA [6]. We present preliminary analyses of `Platypus`' CPU and GPU performance, at different matrix assembly levels. These are demonstrated on toy models like simple diffusion, as well as fusion-relevant problems, like first wall component heating.

References

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