Evaluating Exascale FEA Backends for Fusion Digital Twins

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The UKAEA's mission is to develop commercially viable fusion energy. Current fusion technology is yet to break even on power out compared to power in, thus designs for future reactors, which necessarily must exceed break even, carry a great amount of uncertainty. With cost estimates of a first of a kind fusion reactor in the order of billions of euros, any design flaw making it through to the construction stage will be an expensive mistake.

Thankfully, software can help. By simulating a fusion reactor prior to construction, the design can be tested and refined for a considerably lower cost. However, covering all the necessary scales and physics for a digital twin of a fusion reactor requires computational resources at the exascale.

In this work, a number of potential finite element backends for a multiphysics reactor simulation are evaluated. The sheer scale makes open source a practical necessity and scalability is the primary performance metric. From the plethora of open source finite element libraries, the most promising are selected and compared against a number of objective, unbiased criteria.

None of the tested back ends scored perfectly in all criteria, so a method and rationale for weighting the results to select the best one for the purpose is presented.