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DAG Software Architectures for Multi-Scale Multi-Physics Problems at Petascale and Beyond[1]

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The challenge of computations at Petascale and beyond is to ensure how to make possible efficient calculations on possibly hundreds of thousands for cores or on large numbers of GPUs or Intel Xeon Phis. An important methodology for achieving this is at present thought to be that of asynchronous task-based parallelism. The success of this approach will be demonstrated using the Uintah software framework for the solution of coupled fluid-structure interaction problems with chemical reactions. The layered approach of this software makes it possible for the user to specify the physical problems without parallel code, for that specification to be translated into a parallel set of tasks. These tasks are executed using a runtime system that executes tasks asynchronously and sometimes out-of-order. The scalability and portability of this approach will be demonstrated using examples from large scale combustion problems, industrial detonations and multi-scale, multi-physics models. The challenges of scaling such calculations to the next generations of leadership class computers (with more than a hundred petaflops) will be discussed.

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