Ph.D Research Proposal

Doctoral Program in Scientific Computing

Concurrent and Performant GPU/Heterogeneous Runtime System For Many-Task Computational Framework

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ABSTRACT

Recent trends in high performance computing present larger and more diverse computers using multicore nodes possibly with accelerators and/or coprocessors and reduced memory. These changes pose formidable challenges for applications code to attain scalability. Software frameworks that execute machine-independent applications code using a runtime system that shields users from architectural complexities offer a portable solution for easy programming. The Uintah framework, for example, solves a broad class of large-scale problems on structured adaptive grids using fluid-flow solvers couled with particle-based solids methods. However, the original Uintah code had limited scalability as tasks were run in a predefined order based solely on static analysis of the task graph and used only message passing interface (MPI) for parallelism. By using a new hybrid multithread and MPI runtime system, this research has made it possible for Uintah to scale to 700K central processing unit (CPU) cores when solving challenging fluid-structure interaction problems. Those problems often involved moving objects with adaptive mesh refinement and thus with highly variable and unpredictable work patters. This research has also demonstrated an ability ro run capability jobs on the heterogenous systems with Nvidia graphics processing unit (GPU) accelerators or Intel Xeon Phi coprocessors. The new runtime system for Uintah executes directred acyclic graphs of computational tasks with a scalable asynchronous and dynamic runtime system for multicore CPUs and/or accelerators/copressors on a node. Uintah's clear separate between application and runtime code has led to scalability increases without significant changes to application code. This research concludes that the adaptive directed acyclic graph (DAG)-based approach provides a very power abstraction for solving challenging multiscale Multiphysics engineering problems. Excellent scalability with regard to the different processors and communications

performance are achieved on some of the largest and most powerful computers available today.