Preparing Uintah for Intel Xeon Phi-based Supercomputers

John Holmen, Damodar Sahasrabudhe, Daniel Sunderland, Alan Humphrey, and Martin Berzins

Motivation
- The Uintah Computational Framework is being used to predict performance of next-generation, large-scale clean coal boilers
- Uintah enables the simulation and analysis of complex chemical and physical reactions
  - Emphasizes large-scale simulations across a diverse set of the largest of supercomputers

Target Application
- In large-scale boiler simulations such as those facilitated by Uintah, radiation is the dominant mode of heat transfer
- To help address this bottleneck, Uintah’s Reverse Monte-Carlo Ray Tracing (RMCRT) approach for modeling radiative heat transfer has been targeted for Xeon Phi-specific optimization
- RMCRT creates potential for scalable parallelism
  - Multiple rays can be traced simultaneously at any given timestep and/or cell

Challenges
- The Xeon Phi is based on Intel’s MIC Architecture, which poses new challenges for Uintah as it requires greater attention to:
  - Data movement
  - Thread-scalability, and
  - Vectorization
- To help mitigate diverging code paths when addressing these challenges, Sandia National Lab’s Kokkos C++ Library is being incorporated within Uintah
  - Enables performance portability across diverse and evolving architectures
  - Enables multi-threaded task execution per the current implementation within Uintah

Target Architecture
- To support predictive simulations, efforts are underway to leverage the increasing adoption of the Intel Xeon Phi in current and emerging supercomputers
- Overarching goal is to understand how to prepare Uintah to run well and scale on machines such as the ALCF’s Aurora

Results
- Out-of-the-Box RMCRT performance against Dual Sandy-Bridge Processors:
  - 1st Gen Xeon Phi (KNC): ~34% decrease in performance
  - 2nd Gen Xeon Phi (KNL): ~67% increase in performance
- KNC-based efforts identified a need for multi-threaded task execution

Acknowledgements

This material is based upon work supported by the Department of Energy, National Nuclear Security Administration, under Award Number(s) DE-NA0002375.
This research utilized equipment donations to the University of Utah’s Intel Parallel Computing Center at the SCI Institute
This research utilized time on Texas Advanced Computing Center resources awarded by NSF, XRAC under Award Number(s) MCA08X004