Preparing Uintah for Intel Xeon Phi-based Supercomputers

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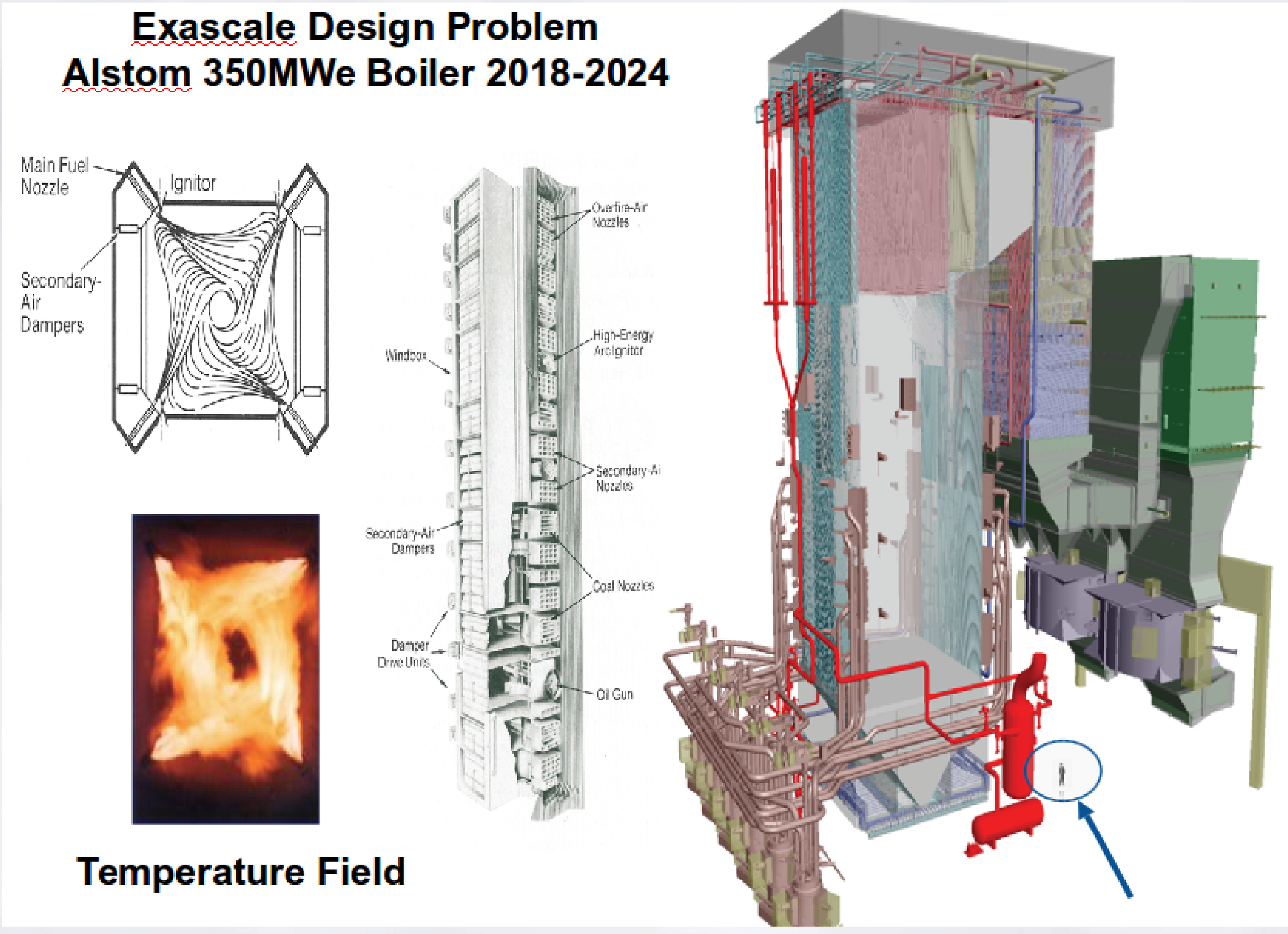
Motivation

- 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

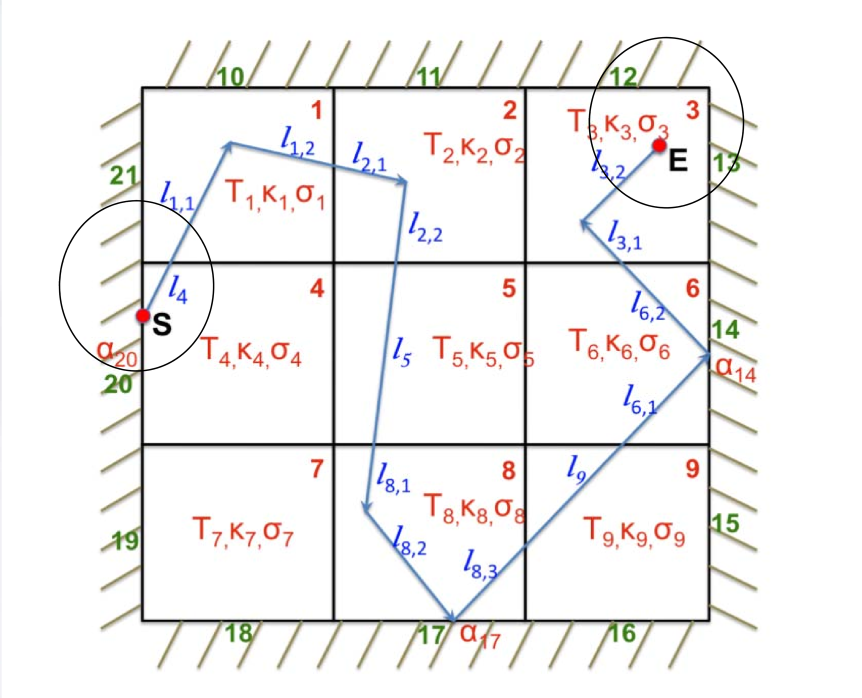


Target Architecture

- 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**

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



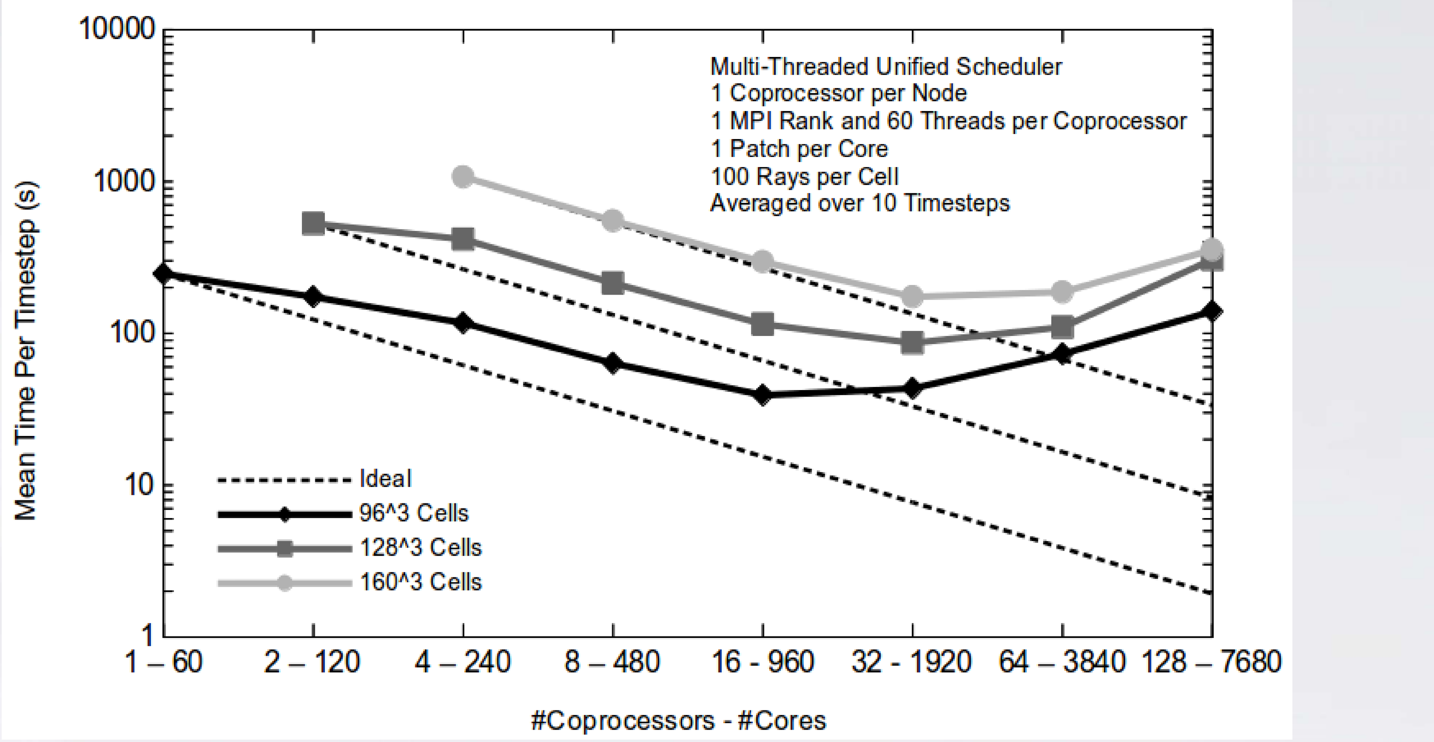
Challenges

- 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

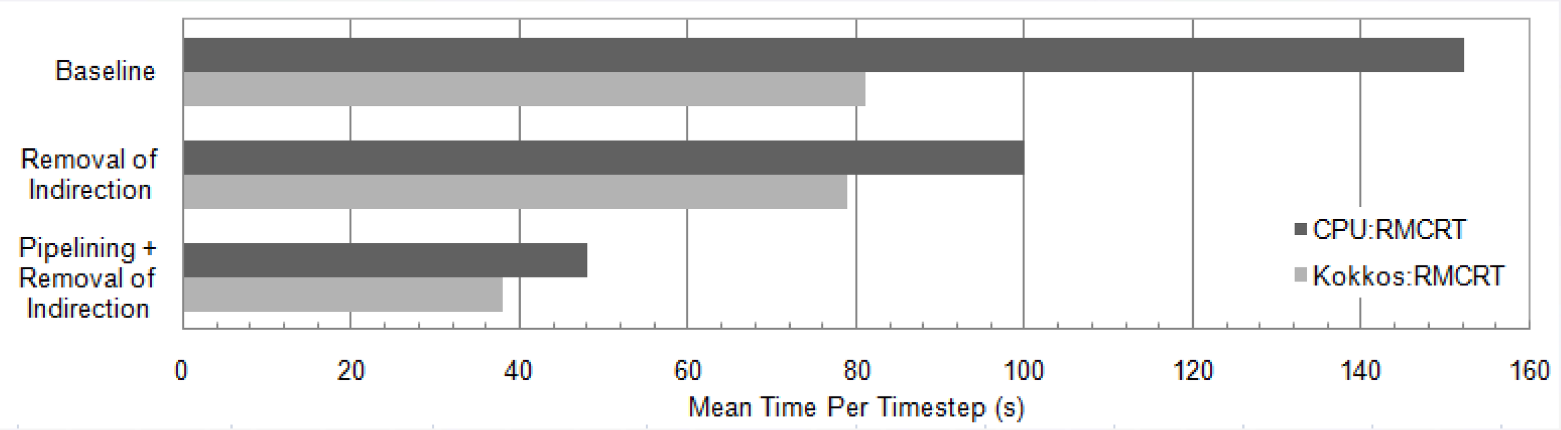
Results

- 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



Strong-scaling of single-level RMCRT across Knights Corner on TACC's Stampede

- Current efforts target algorithmic optimizations and characterizing performance of multi-threaded task execution on Knights Landing (KNL)



Preliminary results for single-level RMCRT optimizations on Knights Landing

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