Use of high performance computing in neutronics analysis activities

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Abstract

Reactor design is an iterative process among various disciplines including reactor physics, thermal fluid dynamics, mechanics, reactor and plant dynamics, fuel behavior, and instrumentation and control. It requires a wide range of modeling and simulation tools that can accurately predict key system performance and safety characteristics. Most code systems used for reactor design were developed more than thirty years ago and were tailored to operate within the computing resources at that time. One specific focus of the reactor design process involves predicting the power distribution throughout the reactor geometry which is obtained by solving the Boltzmann transport equation for both neutrons and gamma rays. It should not be a surprise that enhanced prediction capabilities that reduce the uncertainties and biases in the various areas of reactor design activities can be achieved by improving the underlying methodologies and making use of the improved computing resources. Such improvements are important to minimize the costly and lengthy procedures of building multiple representative mockup experiments to confirm the predictions.

Over the last 20 years numerous improvements have been made to the solution techniques applied to the Boltzmann transport equation primarily resulting in better Monte Carlo (stochastic) and discrete ordinate solvers (deterministic tools). In both cases, improvements in the representation of the geometry and nuclear data have been made which improve the overall accuracy of both tools. More recently, focus is on improving the resolution of the solution such that detailed pin-wise reaction rate (power and transmutation) have been targeted which necessitates improved geometric modeling and thus more computing power. The focus of this abstract and presentation is to introduce and discuss the challenges of solving the Boltzmann transport equation with respect to large scale parallel machines. This work is part of the Advanced Modeling and Simulation office of DOE.
[http://www.ne.doe.gov/AdvModelingSimulation/overview.html]