

“Supercomputing Analytical Discovery of Plasma Instabilities in Fusion Energy Reactors”**Neil Shah, Northwest Guilford High School, Greensboro, NC and Yekaterina Shpanskaya, Math and Science School (Home School), Raleigh, NC – 2009 National Team Finalists**

Abstract: Few would argue that fusion energy has been the Holy Grail of renewable energy efforts. The success of this endeavor will have vast environmental, geopolitical, and economic impacts. The grand challenge is to produce more energy through a fusion reaction than that required to initiate the process in a reactor. A key bottleneck is the turbulence, or unstable motion, of the fusion plasma. Turbulence influences the degree of energy lost by plasma during the fusion process; therefore, controlling the turbulence is critical to viable energy production. Discovery of dynamic turbulent patterns and trends from the data produced by a computer-simulated fusion reaction offers a potential to reveal ways to control the turbulence. Yet, it presents a challenge: how to effectively and efficiently analyze the massive amounts of data, which is inherently complex, noisy, and high-dimensional. To address this challenge, we create a supercomputing analytical methodology to discover, track, and statistically quantify – both in space and time – the intricate patterns of dynamic plasma turbulence from extreme-scale fusion simulation data. This process can potentially predict the structure, dynamics, and function of fusion plasma turbulence. It could also enable similar analyses required in other disciplines, such as astrophysics and oceanography.

Mentor: Dr. Anatoli V. Melechko

“Optimizing the Direct Simulation Monte Carlo Algorithm for Multi-Core Processors”**Erika DeBenedictis, Albuquerque Academy, Albuquerque, NM and Tony Huang, La Cueva High School, Albuquerque, NM – 2008 National Team Finalists**

Abstract: The goal of this project is to create a physically realistic Direct Simulation Monte Carlo (DSMC) model and optimize its performance on multi-core processors. Objects moving through low-density environments, such as a spacecraft passing through the upper atmosphere, are difficult to experiment with directly, making accurate simulations of these objects especially important. DSMC is an appropriate modeling method for such simulations because it models low-density airflow efficiently and has the capability to simulate large regions. The model was subjected to a series of tests to ensure its validity and then applied to objects, such as the space shuttle, moving at supersonic in the upper atmosphere.

Although multi-core processors are a relatively new architecture, they have already become powerful enough to compute reasonably sized DSMC simulations. In this project, we have optimized the DSMC code to be efficient on multi-core processors, in the process encountering the memory bottleneck problem inherent to the architecture. Multi-core processors need high memory bandwidth to reach their potential performance.

Mentor: Dr. Erik DeBenedictis

“Improving Statistical Machine Translation Through Template-based Phrase-Table Extensions”

Hayden Metsky, Millburn High School, Millburn, NJ – 2008 National Individual Finalist

Abstract: With over 120 natural languages used throughout the world, translation is necessary for people to communicate effectively. Computer systems designed to translate text between languages, known as machine translation systems, often operate by analyzing previously translated documents to find phrases between two languages that are translations. These phrase translations form the phrase-table, which is used when translating. Using phrases rather than single words as the basis of translation is advantageous because phrases maintain changes in the ordering of words between languages. However, if a phrase in a sentence to be translated cannot be found in the phrase-table, the phrase is split into subphrases that can be found. When these subphrases are translated using the phrase-table, the translated sentence often contains a poor ordering of words. This research seeks to improve the local reordering problem by using existing phrase pairs in the phrase-table in order to generate new phrase pairs. The generated phrase pairs should maintain changes in word order between languages, just as phrase pairs already existing in the phrase-table do. Results obtained through an automatic evaluation method and through human evaluation of translations indicate that the proposed method does indeed improve the quality of machine translation.

Mentor: Dr. Nizar Habash