The Institute for Sustained Performance, Energy, and Resilience (SUPER)

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Over the next five years (2012–2016), computational scientists working on behalf of the Department of Energy's Office of Science (DOE SC) will exploit a new generation of petascale computing resources to make previously inaccessible discoveries in a broad range of disciplines including chemistry, fusion energy, materials science, and physics. The computational systems underpinning this work will increase in performance potential from tens to hundreds of PFlop/s, and will evolve significantly from those in use today: concurrency will scale exponentially; accelerators such as graphical processing units (GPUs) will be utilized; and even the memory hierarchy will change with the incorporation of a new generation of persistent devices (e.g., phase change memory). To ensure that DOE's computational scientists can successfully exploit this emerging generation of leadership-class computing systems, the University of Southern California (USC) has assembled a broad team of computer scientists with the expertise to address their most pressing challenges: (a) end-to-end performance optimization, including single-node performance, interprocessor communication, load balancing and I/O; (b) performance portability for new systems, including heterogeneous processors and new memory hierarchies; (c) management of energy consumption; and (d) resilient computation.

The organization and goals of this SciDAC-3 institute are based on the collective experience that our team members have acquired over the past ten years of SciDAC. We have chosen to organize a broadly-based project with expertise in compilers and other system tools, performance engineering, energy management, and resilience as all of these require skills in measurement, source analysis, and performance modeling and optimization. Leadership within SUPER is distributed to reflect this broad range of expertise, as reflected below in the table of investigators. We will follow the successful strategy developed in the SciDAC-2 Performance Engineering Research Institute (PERI) of developing interfaces between tools, integrating them, and applying the resulting synergistic apparatus to real DOE applications. This approach will produce a robust and comprehensive end-to-end application optimization infrastructure that would otherwise be beyond the reach of any one research group. Our strategy does not merely encourage collaboration between DOE SC's computer science investigators, it demands such interactions, further stimulating our research work.

To maximize the impact of our research and engagement activities on DOE's computational science community, we will adopt a two-pronged strategy. First, we will work with DOE computing centers and their vendors to integrate, deploy, test, and document tools that automate, streamline, and integrate end-to-end application and system measurements and analysis. Second, we will follow the proven strategy from PERI of actively engaging computational teams in other scientific disciplines with both long-term liaisons that exploit proximity and prior history to work effectively. It is our goal to identify such liaisons with the SciDAC-3 SC Application Partnerships. Through such direct engagement with SC Application Partnerships, we expect to apply the most advanced autotuning and multi-objective optimization techniques to DOE's most strategic applications, thus pushing the envelope on both computer science and computational science advances on emerging petascale platforms.

Collaborating Institutions and PIs:

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[1] Optimization
[2] Outreach and tutorials
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[4] Application engagement
[5] Energy efficiency
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[7] Institute director
[8] Automatic performance tuning