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From the Dynamics of Sand to the Dynamics of Tanks: Using High Performance Computing to Advance the Pace of Innovation and Improve Designs in Mechanical Engineering

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Abstract: This presentation outlines a software infrastructure that supports physics-based simulation on heterogeneous and distributed parallel computing environments. The heterogeneous hardware infrastructure is assumed to be a combination of Central Processing Units (CPUs) and Graphics Processing Units (GPUs). The computational dynamics applications targeted for modeling and simulation include granular dynamics, rigid/flexible many-body dynamics, and fluid-solid interaction problems. The underlying theme of the software solution is that of partitioning the problem of interest into a number of sub-problems, each managed by a separate core/accelerator (CPU/GPU) pair. The five components at the cornerstone of the proposed Heterogeneous Computing Template (HCT) are: (a) support for multi-physics phenomena modeling; (b) scalable numerical methods for multi-GPU and multi-core hardware architectures; (c) methods for proximity computation and collision detection; (d) support for dynamic interconnect-based data exchange and inter-process communication; and (e) tools for carrying out visualization and post-processing in a distributed manner. Several engineering applications will be used to demonstrate how these five components are implemented to leverage a heterogeneous CPU/GPU cluster operated by the Simulation-Based Engineering Lab at UW-Madison. The talk will conclude with a brief discussion of current trends in high performance computing and how they are poised to change the field of Computational Science.

Speaker Bio: Associate Professor Dan Negrut received his Mechanical Engineering Ph.D. in 1998 from the University of Iowa, working under the supervision of Professor Emeritus Edward J. Haug. He spent six years working for Mechanical Dynamics, Inc., in the ADAMS/Solver group. In 2004 he served as an Adjunct Assistant Professor in the Department of Mathematics at the University of Michigan, Ann Arbor. He spent 2005 as a Visiting Scientist at Argonne National Laboratory in the Mathematics and Computer Science Division. At the end of 2005 Dan joined the Mechanical Engineering faculty at the University of Wisconsin-Madison. His interests are in Computational Science and he leads the Simulation-Based Engineering Lab (http://sbel.wisc.edu) at Wisconsin. He founded and is the co-director of the Wisconsin Applied Computing Center. The sponsors of this center include the National Science Foundation, NVIDIA Corporation, Microsoft Corporation, US Army, NASA, and several industry partners. Dr. Negrut's projects focus on high performance computing, large scale multibody dynamics, uncertainty quantification, numerical integration methods for dynamic systems, and fluid-solid interaction. Dr. Negrut received in 2009 a National Science Foundation Career Award. Since 2010 he is an NVIDIA CUDA Fellow. Dr. Negrut's lab currently operates the third fastest supercomputer at the University of Wisconsin-Madison.