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STAR: Creating More Efficient and Scalable Computation for Astrophysics Research

A group of researchers at Louisiana State University's Center for Computation & Technology, or CCT, and LSU's Department of Physics & Astronomy have recently been awarded $799, 682 by the National Science Foundation to create a new model of computation that would radically benefit applications that support studies of the evolution and merger of close binary star systems. When scaled to reflect physically meaningful domain sizes and resolutions, the model could potentially transform the understanding of stellar evolution.

Today, whole classes of computational science and engineering applications are emerging as scaling-impaired. The main factors limiting scalability for these applications are: 1) ***S****tarvation*--insufficient concurrent work to maintain high utilization of resources; 2) ***L****atencies*--delay of remote resource access and services; 3) ***O****verheads*--work for management of parallel actions and resources on critical path that is not necessary in a sequential variant; and 4) ***W****aiting* for contention resolution--delays due to lack of availability of oversubscribed shared resources. All of these factors (SLOW) are difficult to avoid using today's programming models. A new computational strategy, one that replaces CSP (Communicating Sequential Processes) is required to achieve dramatic increases in performance.

Hartmut Kaiser, team lead of CCT's STE||AR group, is the principal investigator for the grant to develop this new program, which he calls "INSPIRE: STAR: Scalable Toolkit for Transformative Astrophysics Research."

The STAR project proposes to provide transformative intellectual contributions that focus on achieving a deeper understanding and realizing an immediate impact on the field of astrophysics and computer science. The results of the research will explore and relate directly to one of the most commonly used algorithmic techniques in scientific applications, adaptive mesh refinement (AMR).

"The impact of this research isn't limited only to the advancement of astrophysics, computer science, and engineering, but also significantly affects the field of computer science as a whole by enhancing the understanding and capability of efficient realization of scalable computing of any size. This capability extends beyond the conventional means and practices in that it targets the difficult strong scaling problem in addition to supporting the traditional weak scaling regime so prevalently employed on the largest supercomputing platforms of today," said Kaiser.

"The broader impact of STAR extends even further. For example, many problems in physics and engineering require the simultaneous solution of coupled systems of equations arising from different physical processes that are typically governed by equations of various types (hyperbolic, elliptical, and parabolic), and that require different discretizations and numerical strategies for their solution. Well-known examples of these problems in astrophysics are supernova explosions, star formation, galaxy formation, stellar mergers, and stellar evolution incorporating the effects of rotation and tidal forces. All of the above include fluid dynamics, dynamic gravity, thermal and radiative transport, particle transport, and nuclear energy generation in various combinations."

"In the broader arena of problems in physics and engineering that are relevant to national security, materials science and energy policy, one encounters similar multi-physics challengers in the stewardship of the nuclear weapons stockpile, ab-initio modeling of novel materials, nuclear energy generation, and the confinement of high temperature plasmas. All of these problem areas can greatly benefit from the results of STAR."

Other researchers on this project include LSU Department of Physics & Astronomy Ball Family Distinguished Professor Geoffrey Clayton and Professor Juhan Frank.

For more information on the STE||AR group, visit: http://stellar.cct.lsu.edu/.

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