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Conference Report High Performance Computing for Policy Formulation - The Benefits and Risks -

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Conference Report
High Performance Computing for Policy Formulation
- The Benefits and Risks -

University of California Washington Center
1608 Rhode Island Avenue, NW
Washington, DC

June 1-2, 2011

Summary

In June 2011, Lawrence Livermore National Laboratory's Center for Global Security Research conducted a conference to explore the opportunities and challenges that complex modeling capabilities available as a result of evolving High Performance Computing (HPC) present to policy formulation and decision-making. Conference objectives included enhancing the dialogue between computer scientists and policy architects and establishing a common framework for future discussions, analysis, research and collaboration.

Policy and scientific needs for HPC were identified in areas such as materials science, biology, and data analysis. However, the existence of sufficient drivers to sustain the anticipated development costs of HPC was questioned. There was confidence that Moore's Law was still healthy and that 20 petaflops would be achieved in a few years, although tension in the industry exists between technological capability and the ability to profitably manufacture and market at volume. In addition, current trends in energy consumption by large computers are not sustainable. On the other hand, HPC has a history in which even the pioneers and advocates have underestimated the applications that ultimately emerged.

Given the growing availability and potential for using HPC for complex modeling, a better understanding of HPC technology and modeling methods can help facilitate the appropriate use of this capability. It was generally recognized that technical input to the decision-making process is needed, and that there may be many applications of HPC for formulation of policy and regulatory law ranging from real-time consequence management to the development of national energy policy. However, it was less clear to what extent use of HPC-based modeling would have broad use. One participant suggested that all major policy decisions in the US were impacted by HPC, but others were more circumspect, contending that it was sufficient to use more traditional (and less complex) analysis that could be carried out on a laptop.

To focus the discussion, breakout groups were organized to explore HPC applications for national missile defense, modeling the U.S. electric grid, and drug control policy. All three groups observed that HPC was not in widespread use in their areas but were able to identify key elements where it could be used effectively. One consistent driver for the use of HPC was the need to analyze large amounts of data with a requirement for rapid, near-real-time solutions. Additionally, the enormous challenge of integrating the interaction of physical and social systems into a model was identified. Advantages in using HPC included faster time to solution or, in some cases, to market and the ability to process large amounts of data rapidly.

Common roadblocks to HPC use were skepticism in the reliability of the model results including the real or perceived difficulty of accurately simulating a complex system with vast amounts of integrated data and the concomitant difficulty of validating the model. In general there was less confidence in the modeling of the social aspects than in the physical ones.

Key issues needing further consideration are:

- How to increase the level of understanding of the HPC technology in diverse disciplines.

- How to effectively utilize the results generated by complex models.

- How to use complex modeling results to develop insight or formulate questions to guide policy and regulation formulation. This is clearly an issue to which a substantial effort, quantitative and qualitative, needs to be directed.

- How to effectively evaluate and communicate the confidence we have in the model results, and how to assess the associated impact on decision-making.

Drivers for the use of HPC and complex modeling

The major drivers for the use of HPC that emerged from conference discussions were the need to distill very large data sets, the demand for near-real-time results, and the ever-increasing complexity of the systems to be modeled and understood.

- Frequently the first two of these drivers are linked. For example battle management using a ballistic missile defense requires rapid processing of large amounts of data. Managing resource deployment during and immediately after a natural disaster can require rapid decision making with consideration of many inputs.

- Other situations do not require quick response time but deal with physically complex systems, such as the understanding of natural or anthropogenic impacts on the environment and evaluating potential mitigation or regulatory schemes. In the case of environmental policy-making, the use of models is embedded in many statutes. Model results were described as critical to development of policy and decision-making. The impacts of HPC use could therefore be significant.

- When a wide range of human interactions within a system must be modeled, HPC can be useful. Here, drivers include the need to incorporate computational social science into the decision-making process, such as understanding and predicting the response of legitimate markets or illicit drug activities to policies, regulations and enforcement actions.

Barriers to use of HPC in decision-making

Numerous potential barriers to wider use of HPC in decision-making were discussed.

- Technological barriers to the expansion of HPC are hardware, software, power consumption and cost. The current trend in power consumption in high-end computers cannot be sustained as capability increases. In addition, the growing performance gap between state-of-the-art high performance computers and those sold in high volume generates marketing and manufacturing problems in the industry. Cost is also an issue.

- Acceptance of the results of modeling is a critical issue. Many policy-makers have mixed feelings about using simulation as part of the decision-making process. Effective use of HPC simulation tools requires subject matter experts who must be able to communicate effectively with the decision makers. This was seen as a two-way street. The policy-makers need help understanding which questions to ask and the modelers need to explain the results in a manner that allows them to be used in the decision process.

- Developing and maintaining a cadre of capable modelers is a potential barrier. Most models are already complex and are growing even more so. Many are highly multidisciplinary and require multidisciplinary teams of experts to use them correctly. Several participants pointed out that HPC models generally were not usable by non-experts. This may be particularly true in computational social science because it is a hybrid field, making it difficult even for experts to accurately assess the value and validity of a model. Even "the cloud" was seen as only truly helpful if the user understood how to use it.

- Credibility of model results and communication of uncertainty emerged as very important topics. The lack of credibility in the eyes of the decision-maker was seen as an impediment to more widespread use of the complex modeling enabled by HPC in policy and regulatory formulation. Uncertainty is sometimes interpreted as uselessness, rather than an inherent feature of numerical modeling that does not totally negate the results. While the technical community has some experience and expertise in assessing uncertainty, the practice not universal. Furthermore, uncertainty in model results is more than a quantitative matter for experts to assess. In addition, more effective tools for the communication of uncertainty are needed. Visualization was singled out as one of the most effective communication tools, but its use in uncertainty communication is relatively new and an area of active research. Taken together, better assessment and communication of uncertainty could enhance, rather than hinder, the use of numerical modeling to inform policy and decision-making.

<u>Risks of using modeling and HPC in policy formation</u>

In addition to barriers, some risks associated with the use of complex modeling and HPC were brought out. Two key examples are:

- **The right-result risk.** There can be the temptation to disregard the models that give unwanted answers and embrace or even build models that provide the desired result. Another manifestation of this risk is the sponsor-tuned model that is manipulated to give the answer the customer wants.
- **Pursuit of perfection.** Over-confidence in model results and even the occasional expectation of perfection were also seen as problems. In this case standards are set too high and completely accurate results from models are discarded. At times model results are rejected when people realize they are imperfect. The good is thrown out with the bad. In the mirror-image, the customer could become seduced by the power of the model and fail to recognize its limitations. An undesirable consequence of this is employing

the model beyond its limits and basing decisions on incorrect information. The establishment and recognition of model limitations is therefore of critical importance to the successful employment of models in decision-making. This is not necessarily easy. As HPC capability grows and models become increasingly complex, verification and validation become very difficult. In fact, in Computational Social Science validation can be problematic.

Conclusions

HPC will continue to expand, but the pace may be slowed pending the emergence of applications of sufficient importance to justify HPC's costs. It is not clear how these drivers will emerge, but historically they have. The modeling and policy communities have much to learn from each other to ensure that opportunities are recognized and exploited, and that results are properly understood. Evaluation, communication, and tolerance of uncertainty will have major roles in this expansion.

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Center for Global Security Research

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June 1-2, 2011

June 1

7:30 – 8:15 **Conference Registration/Continental Breakfast**

8:15 – 8:30 **Welcome and Expectations for the Workshop**
Ronald Lehman, Director, Center for Global Security Research, LLNL

8:30 – 9:30 **Plenary Presentations – Science in Support of Decision-Making**
Vision for High Performance Computing's Role in Policy Formulation and Regulation
Steven Koonin, Undersecretary of Energy for Science

High Performance Computing – Current and Potential Capabilities
Stephen Wheat, Intel Corporation

9:30 – 10:00 **Break**

10:00 – 12:00 **High Performance Computing for Decision-making: Utility, Credibility, Cost Effectiveness**
Moderator: Pat Falcone, Office of Science and Technology Policy
This panel will highlight some overarching issues that need to be considered for optimal use of complex modeling and simulation capabilities.

Misunderstanding Models in a Regulatory Environment
Wendy Wagner, University of Texas at Austin

Visualizing Uncertainty
Christopher Johnson, University of Utah

Decision-making under highly uncertain conditions
Steven Popper, RAND Corporation

Computational Social Science
Lee Hoffer, Department of Anthropology, Case Western Reserve University

Applications of High Performance Computing
John Daly, Center for Exceptional Computing

The Role of Scientific and Technical Support in Foreign Policy Negotiations
Raymond Arnaudo, Office of the Secretary, Policy Planning, Department of State

12:00 – 1:30 **Lunch and Distinguished Speaker**
China's Rise as a Supercomputing Power
Dona Crawford, Associate Director, Computation

1:30 – 1:45 **Introduction to Breakout Sessions**
Don Prosnitz, Lawrence Livermore National Laboratory

1:45 – 4:15 **Breakout Sessions**

1. *Modeling, Simulation, and HPC to Inform National Drug Control Policy*
   Leader: Laura McNamara, Sandia National Laboratory
   Rapporteur: Don Prosnitz, Lawrence Livermore National Laboratory
2. *Modeling, Simulation, and HPC to Inform National Security Decision-Making*
   Leader: Michael Nacht, Goldman School of Pubic Policy, UC Berkeley
   Rapporteur: Dana Rowley, Lawrence Livermore National Laboratory
3. *Modeling, Simulation, and HPC to Inform Electricity System Transformation*
   Leader: Robin Newmark, National Renewable Energy Laboratory
   Rapporteur: Eileen Vergino, Lawrence Livermore National Laboratory

4:15 – 4:45 **Closing Plenary Presentation**
Real Time Virtual World and Gaming Technology and the Systems that Support It
Chris Collins, CEO of Tipodean Technologies

June 2

7:30 – 8:15 **Continental Breakfast/Session Overview**

8:15 – 8:30 **Administrative Announcements**

8:30 – 9:30 **Plenary Session**
Introduction: Tomás Díaz de la Rubia, Deputy Director for Science and Technology, LLNL
Decision Makers and Data: Creating the Art of the Possible (Confronting Technological Literacy Gaps among Leaders and Creating Decision Support Structures for more Effective Performance)
Adm. Thad Allen, RAND Corporation

9:30 – 9:45 **Break**

9:45 – 11:45 **Breakout Session Reports and Discussion**
Laura McNamara, Michael Nacht, and Robin Newmark

11:45 – 12:00 **Next Steps and Closing Remarks**

12:00 **Adjourn**