EXASCALE ALGORITHMS FOR SYNTHESIZING PARAMETERS OF STOCHASTIC COMPUTATIONAL MODELS FROM QUALITATIVE AND SEMI-QUANTITATIVE SPECIFICATIONS

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Abstract: The success of high-performance computing has facilitated the rapid development of increasingly complex models of natural and engineered systems by biologists, physicists, chemists, and even financial engineers. While the development of such models requires considerable domain knowledge and arguably little knowledge of the science of computing itself, we survey a key problem in computational modeling that cuts across boundaries of scientific disciplines and motivates the development of new massively parallel high-performance algorithms: the synthesis of parameters for stochastic computational models.

The overall structure of stochastic computational models can often be obtained from first principles by using our understanding and insight into the physical system that is being modeled. However, several components of a computational model are not readily obtained from first principles. Very often, model designers incorporate such information in the model as parameters. The model designer chooses these parameter values carefully so that the computational model replicates the behavior of the natural or engineered system being modeled. Naturally, a key problem in computational modeling is the identification of such parameters.

While the insight of the domain knowledge expert was sufficient to estimate parameters of small stochastic models, there is an urgent need to develop massively parallel algorithmic techniques for synthesizing parameters of large and complex stochastic models. In this talk, we will survey massively parallel algorithms for synthesizing parameters of stochastic models from semi-quantitative and qualitative specifications. We will study the use of stochastic temporal logics for describing the expected behavior from complex stochastic models, and argue that domain-oriented flavors for temporal logics will facilitate the development of discipline-specific formal frameworks for specifying correctness of computational models. Using such qualitative and semi-quantitative behavioral specifications, we will survey recently developed high-performance algorithms for synthesizing parameters of stochastic models. Our survey will include statistical hypothesis testing based simulation annealing approaches, the use of symbolic decision procedures, and the design of approximation algorithms based on metric embeddings. We will use examples from computational systems biology and computational finance to illustrate the algorithms we survey.

Bio: Dr. Jha is an Assistant Professor with the Computer Science Department at the University of Central Florida, Orlando. He received his Ph.D. in Computer Science at Carnegie Mellon University. Before joining Carnegie Mellon, Dr. Jha graduated with B.Tech (Honors) in Computer Science and Engineering from the Indian Institute of Technology Kharagpur. His current research interests include automated verification and synthesis of stochastic and hybrid systems with emphasis on applications to computational finance and biochemical modeling. Dr. Jha has also worked on more traditional formal validation and machine learning problems at Microsoft Research, General Motors and INRIA, France. Dr. Jha is an author of several papers accepted at very selective international conferences and journals in computer science, and is a reviewer for prestigious publications and conferences including Theoretical Computer Science, IEEE Transactions on Automatic Control, ACM TECS, Annals of Mathematics and Artificial Intelligence, Microprocessors and Microsystems, and IEEE Computers. Dr. Jha is also a member of the Alpha Quant Club - a network of academicians and industry leaders interested in mathematical finance.