Computational Stochastic Modelling for Large-scale Systems: Methods and Applications

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Modelling and Simulation are important tools in design and analysis of systems. Most systems of interest are huge in details, and both the amount of required memory and the time to compute the solution pose a major difficulty: a problem known as the Curse of Dimensionality or State Space Explosion.

In this talk, we present our work on Computational Stochastic Modeling for large-scale systems, discuss the methods involved in the modeling process, and give few applications. In particular, we focus on Continuous time Markov Chains (CTMCs) which have been widely used as a stochastic formalism for design and analysis of systems in engineering and science. In this context, traditional methods for performance analysis typically require the generation, storage, and the processing of the underlying state space for the numerical solution. For steady state problems, the numerical solution phase can be reduced to the solution of linear equation systems of the form $Ax = 0$. The transient solutions for the CTMC can be obtained by solving a differential equation. Both transient and steady state solutions involve large-scale matrix computations.

Subsequently, we present parallel numerical computing techniques and compact data structures which we have developed to address largeness of systems. Using the discussed techniques, we demonstrate analysis of stochastic models with over 1.2 billion states and 16 billion transitions on a single and multiple workstations (equally, it involves solution of a sparse linear system with 1.2 billion equations and variables). In our knowledge, these are the largest models solved by the academic community working in this area. Finally, we discuss few applications in telecommunication systems, and overview the ongoing work.