Stability and Performance of Stochastic Models

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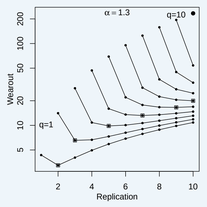
PERFORMANCE

Matrix-Analytic Models

Steady-state analysis of Markov models is rigorously performed with *matrix-analytic method* both in explicit form and in accurate numerical analysis allow to treat sophisticated models including the *split-merge-type* queues, *queueing-inventory* systems and *heterogeneous multiclass* systems which arise in the fields of *Internet of Things*, *Distributed Computing*, NAND Storage.

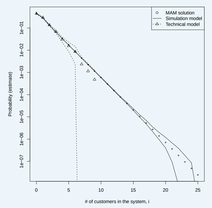


Regenerative Simulation

Discrete-event simulation (e.g. by generalized semi-Markov processes) equipped with *regenerative estimation* (including *artificial regeneration* by means of exponential splitting) as well as *perfect sampling* is applied to sophisticated queueing models (multiclass multiserver, cluster, retrial, split-merge etc.). The results are applicable in the fields of *wireless communication*, *distributed computing*, social service.

Reliability and Energy Efficiency

Energy efficiency is studied by the cross-validated *three-level modeling*: analytical, simulation and technical level models, with applications to *speed scaling* systems such as the laptops, wearable devices, as well as *data centers*. *Reliability models* equipped with split-based simulation allow to study degradation processes in *aging and wearing* systems available both in biology and technology.



STABILITY

Structured Markov Chains

Explicit *negative drift* stability criterion of *skip-free Markov chains* is established for the processes with automata-type transitions by *matrix-analytic method*, which being combined with *regenerative analysis* complete the steady-state analysis of *multiclass and multiserver queueing models* of high-performance computing systems e.g. *supercomputers*.

Regenerative Stability Analysis

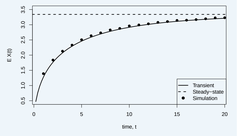
Stability analysis of stochastic models for telecommunication systems beyond the framework of Markovian setting requires a refined mathematical technique. We deduce *balance relations* between the arrived and departed work in a given time interval, and then apply asymptotic results for *renewal and regenerative processes*. This leads to the necessary stability conditions and *explicit expressions* for some stationary performance indexes. To deduce sufficient stability conditions, we assume *instability* and obtain a contradiction with predefined assumptions. The *coupling method* and *stochastic monotonicity* are widely used as well. In particular, the *optical buffers*, cascade systems, *state-dependent* systems and a wide class of multiclass *retrial systems* describing wireless communication are investigated.

Statistical stability analysis of Markov chains allows to test the stability when explicit conditions are unavailable. Simulation helps to study extended Erlang loss queueing model for the cognitive wirless networks.

FINE-GRAINED ANALYSIS

Transient Analysis

Transient analysis of special models such as the *quasi-birth-death* processes with small phase state space or the so-called *N-model* is useful in the field of *cognitive radio* and *skills-based* systems.



Rare Events

Rare event probability estimation has become a large area of research in the reliability engineering and system safety domains. Crude Monte Carlo becomes highly inefficient when the event of interest gets rarer, thus other advanced methods must be applied, including both asymptotic method (based on the *large deviation* theory), *variance reduction* and *accelerated simulation* technique. At the same time, *asymptotic analysis* allows to estimate the rare event probability using stochastic comparison technique.

Gaussian and Mixed Processes

Extremal indices and output properties of queues are studied for systems with mixed service time distributions. *Gaussian queues* are studied from *asymptotic and simulation* perspective. Applications of these results are within the heterogeneous distributed systems such as *volunteer computing* and telecom.