ABSTRACT

Application of inhomogeneous continuous time Markov chains for call center modeling

by Maciej, Rafał BURAK

In this thesis we focus on call center modeling and analysis. In recent years call centers have become an integral part of products and services delivered by both commercial and public institutions, with their economic impact reflected by a large number of publications specifically dedicated to call centre design and management. In terms of modeling, such centres represent service systems for which the arrival process of service requests is generated by a large population of independently acting customers, which makes it a classic example of a stochastic Poisson process. Therefore, the service systems are usually modeled as Markovian assumptions based queuing systems.

One of the most important aspects related to real service system modeling and analysis is their inherent time-variability, particularly with regard to the arrival process, which strongly depends on the time of day, day of the week or month etc., and such a varying demand has to be paired with an appropriate number of servers.

The most commonly used modeling approaches developed for practical applications, e.g. personnel planning, are based on stationary approximations, i.e. by using a stationary queuing model and applying its results to separate time periods assuming constant rates and the system being stationary. Alternative approaches, e.g. employing numerical solution of systems of differential equations describing the time-inhomogeneous behavior of queuing models are much more precise, yet they are considered time consuming and restricted in application to relatively small systems.

In this thesis we propose modifications to the uniformization algorithm used for solving time-inhomogeneous Markovian queuing models, thus rendering the algorithm feasible for practical applications. In particular, we modify the widely used steady-state detection technique by using the convergence properties of the subordinated DTMC in order to strictly bound the error of the solution (and consequently avoid the so called premature steady-state detection) while significantly improving the efficiency of the uniformization algorithm. What is more, we propose a state reduction method to downsize the computational complexity being a function of the system size from $O(K^2)$ to approximately $O(K^{1.3})$. The latter modification is applicable to any Markovian birth-and-death queuing models, in particular the state-dependent ones, and allows such modeling of system characteristics that extends the standard Erlag-C or Palm/Erlang-A models - examples of those include call blocking or customer balking and abandonment.

We test our efficiency improvements on numerical examples to verify the proposed model assumptions in situations replicating time-dependent system changes typical for call centers. Additionally, we utilize a true call center data example to test the efficiency gains offered by the application of our method.

Maciej Burak

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