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Distributed steady-state simulation of telecommunication networks with self-similar teletraffic

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Abstract

Recent measurement studies of teletraffic data in modern telecommunication networks have shown that self-similar processes may provide better models of teletraffic than Poisson processes. If this is not taken into account, it can lead to inaccurate conclusions about performance of telecommunication networks. We show how arrival processes with self-similar input influences the run-length of a distributed steady-state simulation of queueing systems in telecommunication networks. For this purpose, the simulation run-length of $SSM/M/1/\infty$ queueing systems in the method based on the batch means, conducted for estimating steady-state mean waiting times is compared with the results obtained from simulations of $M/M/1/\infty$ queueing systems when a single processor and multiple processors are used. We also investigate speedup conducted stochastic simulation of $SSM/M/1/\infty$ queueing systems on multiple processors under a scenario of distributed stochastic simulation known as MRIP (Multiple

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Replications In Parallel) in a local area network (LAN) environment on Solaris operating system. We show that, assuming self-similar inter-event processes (i.e., $SSM/M/1/\infty$ queueing systems), many more observations are required to obtain the final simulation results with a required precision, as the value of the Hurst parameter H increases, than when assuming Poisson models, exhibiting short-range dependence (i.e., $M/M/1/\infty$ queueing systems) on a single processor and multiple processors. Our results show that the time for collecting many numbers of observations under the MRIP scenario is clearly reduced as traffic intensity and the value of the Hurst parameter increase, and as the engaged processor increases one to four. In particular, the value of H influences much more the speedup than traffic intensity and the engaged processor.

Keywords: Long-range dependent self-similar process; Hurst parameter; Distributed steady-state simulation; Simulation run-length; Speedup

1. Introduction

There are two issues considered in this paper.

- First, we show how self-similarity of arrival processes influences the run-length of sequential stochastic simulation of queueing systems. For this purpose, the simulation run-length of $SSM/M/1/\infty$ queueing systems, [1] conducted for estimating steady-state mean waiting times is compared with the results obtained from simulations of $M/M/1/\infty$ queueing systems. In both cases, simulations were stopped when the final estimates were achieved with the relative precision (see Section 4) not larger than 10%, for a 95% confidence interval (CI).
- Second, we investigate speedup conducted stochastic simulation of$SSM/M/1/\infty$ queueing systems on multiple processors under the MRIP scenario [23,24,34].

Leland et al. [25] claimed that a self-similar process is needed to model the behaviour of a time series well enough to capture its impact on queueing performance, while Ryu and Lowen [41] claimed that the self-similarity of the arrival process needs to be taken into account only when the traffic intensity and the buffer size are very large. Heyman [16] examined how the Markov-modulated Poisson process and FBM model proposed in the literature perform on two data sets of LAN traffic. Both models overestimated loss probabilities in the area of interest. The effects of a finite buffer of size b could be estimated by calculating the probability that the infinite buffer has greater than b items in it. This approximation may be fundamentally inaccurate for calculating small loss probabilities and modest values of b. Heyman [17] also found that the approximation is more accurate for heavy-tailed distributions rather than those without power-law tails. Further investigation of the accuracy of this approximation is required.

[1] Here, SSM means a self-similar arrival process with an exponential marginal distribution.