The Implications of Uncertainty in the Results of Simulation Models

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Abstract

Simulation is a common engineering tool used to investigate the performance of complex systems where the input parameters are usually stochastic. As a consequence, simulation models contain both simulation and input uncertainty in their estimates. In this work, through an illustrative example, we show the implications of uncertainty in the results of simulation models and why it is important to acknowledge and, whenever possible, to quantify uncertainty in the simulation results. To investigate the implications of uncertainty in the results of simulation models a simple queue model was built in Simio® University Enterprise Edition v 10.165. The model consists of a single source of arrivals, single queue, and *s* servers providing the same service. After being served, customers leave the system. Balking and reneging were not considered in the model. Two input parameters were considered in the model, namely the inter-arrival time and the service time, and two output responses were considered, namely the average number of customers in the system and the average time spent in the system. Several scenarios were run with different number of replications, different traffic intensities, different number of servers, different variances, different distributions, different parameter values, and different seeds. The run length of each scenario was 1,825 days, which included 365 days of warm-up. The specified warm-up period was enough for the system to reach steady state for all the experiments. Due to the simplicity of the system, one would expect to obtain accurate results in the simulation model. However, the results show that this was not always the case. As it is known, the intrinsic output-uncertainty (or simulation uncertainty) tends to decrease with the increase in the sample size, but interestingly in this work, for *M/M/s* systems, the highest individual absolute error was always observed for 400 replications, regardless of the configuration, which was not the lowest number of replications. Although the experiments of this work are simple queue models, the situation can be actually worse, because the uncertainty level in more complex systems may be much higher than the ones observed here. These results do not indicate that simulation results cannot support decision-making or have no use. Rather, the results show that it is important to adequately inform decision-makers and simulation stakeholders about the uncertainties and the consequent risks involved in their decisions while using simulation models. As the quote says: "something is better than nothing". A partially informed decision has higher chances of success than a simple blind guess.

Keywords
Simulation, Uncertainty, Queue Model.

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Biography

Anna Paula Galvão Scheidegger is a Ph.D. candidate in the Industrial and Systems Engineering department at Texas A&M University. She holds a master's degree in Industrial Engineering from Universidade Federal de Itajubá, Brazil.

She earned a B.S. in Control and Automation Engineering from Universidade Federal de Itajuba, Brazil. She has three simulation competition awards, she has participated in SAE AeroDesig competitions during her undergraduate degree and has published journal and conference papers. Her research interests include modeling, simulation, and uncertainty quantification with applications in operations, disaster management, and human behavior. Her email address is apscheidegger@tamu.edu.