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Self-Adopting Hybrid Simulation Models of Heterogeneous Telecommunication Networks

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Discrete-event and analytical simulation are two widely used approaches to simulating telecommunication networks. But the growth in size and complexity of modern networks increases the need for hybrid simulation models. Discrete-event simulation of very large networks can last days. On the other hand, assumptions and approximations of analytical models result in significant accuracy loss and may produce unreliable results for complex heterogeneous networks.

Vladimir Kalashnikov led a project of creating a hybrid system simulation package. The objective of hybrid simulation is to keep the accuracy of discrete-event simulation and the speed of analytical models. A typical approach is to focus the simulation on a small part of a network and model the rest using analytical models. Where possible, the nodes of networks are simulated analytically. So, the question is how to "split"a model into analytical and discrete-event components.

The paper presents a self-adopting method of splitting a discrete-event model into the analytical and discrete-event sub-models and generates a new “reduced” discrete-event model. This method utilizes piece-wise linear aggregates [3] as a discrete-event formalism, QNA (Queuing Network Analyzes) method [6] for analytical modeling, LRM (Likelihood Ratio Method) sensitivity estimates [1, 2, 5] for transformation of network models and TES Processes [4] as traffic generators that should replace "analytical"parts of the initial model.

At the first step, characteristics of the model are estimated using the QNA method. The general approach of QNA is to approximately characterize the arrival process by two moments and then analyze individual queues individually.

For the next step, it is necessary to select the part of the model of special interest. This part will be simulated using discrete-event simulation approach. The goal of this step is to determine what portion of the rest of the model could be replaced by the analytical model. To keep the accuracy of simulation, we should simulate explicitly all the modes having significant influence on the selected part of the model. LRM sensitivity estimates are used as a measure of that influence. These estimates allow for the obtaining of sensitivity coefficients during a single simulation run.

The last step is replacing remote “insensitive” elements with random traffic generators. These generators should generate outgoing traffic close to the initial traffic of the replaced elements. In addition, implementation of TES traffic generators in the package allows one to create random processes with original autocorrelation functions. TES generators are described in [4].

The final discrete-event model consists of the selected part of special interest, neighboring elements and TES generators that replaced the residual part. The paper provides numerical results that show the accuracy of the method and performance estimates.

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