PENELOPE
dependability evaluation and the optimization of performability

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Abstract

A new performance and performability modeling tool is introduced in this paper. PENELOPE is the first tool which incorporates evaluation and optimization algorithms. It is the result of a combination between the performability modeling concept and Markov decision theory. Different algorithms are adopted and included in the tool under the unifying paradigm of reconfigurability as the basis for adaptation and optimization. In addition to transient and steady-state performability measures, also transient and stationary control functions can be computed and graphically presented. Model specification and specification of transient or stationary control functions can be separately performed and deliberately combined with each other. Besides providing a new modeling paradigm, the tool supports model creation, experimentation, storage and presentation of results by means of an easily usable interface and an integrated model data base system.

1 Introduction

During the last decade there has been an increasing interest in performability modeling [14]. The development of software tools supporting performability modeling and analysis has been an active area of research.

Metaphor [4], developed 1984, was the first tool for performability modeling. It addressed only a limited set of Markov models; input and output were textual. The tool SPNP [2] is a stochastic Petri nets package, which supports specification, generation, and solution of continuous time Markov chains (CTMCs). Steady-state, transient, and cumulative performability measures, defined by Markov reward models (MRMs), can be computed. The model description is done via C. The tool UltraSAN [3] is based on stochastic activity networks. In addition to numerical algorithms, UltraSAN provides also simulation methods. Surf-2 [1] has been developed for dependability and performability evaluation. Models can either be MRMs or generalized stochastic Petri nets. SPNP, UltraSAN and Surf-2 provide an output in tabular form. Additionally, Surf-2 allows a graphical representation of the results. Deterministic and general type time distributions are complementing exponential distribution in DSPNexpress [7] and in other work. Many more tools do exist, most of them being covered in the overview paper by Haverkort and Niemegeers [5].

This paper describes the new software package PENELOPE [10]. PENELOPE is the first tool which incorporates evaluation and optimization algorithms. It can be applied for the integrated computation of perfor-
formance/performability functions and of optimal control strategies. It constitutes the implementation of the concept of a combination between performability modeling and Markov decision theory [13].

In addition to transient and steady-state performability measures, also transient and steady-state control functions can be computed and graphically presented. Model specification and specification of transient or steady-state control structure can also be separately performed and deliberately combined with each other. This allows the immediate comparison of the impact of various control strategies for a given model on the resulting performance measures.

The specification of control strategies is built on the paradigm of reconfigurability [8, 9]. The intuition behind is, decisions must be made to reconfigure or not to reconfigure a system from one state to another in order to optimize a given performance/performability measure. The mapping of the reconfiguration options on internal model representations suitable for the optimization algorithms and the application of appropriate algorithms is hidden from the user.

PENELOPE provides a friendly usable interface for model generation and experimentation. In particular, the creation of model variations is supported as well as the execution of series of experiments and the integrated presentation of the results of those experiments. This includes the presentation of performability functions and, in particular, the presentation of control strategies. No interference of the user is necessary to prepare the graphical presentation of control strategies and performability functions. The control functions are automatically related to the original specification of reconfigurability options and series of experiments. Thus, the execution of an optimization study can be considered as a meta-experiment that comprises many single experiments which are related to each other.

This paper is organized as follows. Section 2 contains a description of the general functionality of PENELOPE. Section 3 illustrates by means of a simple example important features of the tool, such as model generation, experiment set-up and execution, or presentation of results. Section 4 concludes the paper.

2 Description of PENELOPE

PENELOPE is based on the theory of extended Markov reward models (EMRMs) [8, 9]. It offers a modeling methodology that combines MRMIs and Markov decision processes [13].

PENELOPE allows to create parameterized models of arbitrary finite size and to provide automatically the models with concrete values. To each parameter an arbitrary set of concrete values can be allocated. For each possible combination of parameter values, PENELOPE performs an experiment. Whole series of experiment can thus be easily specified and executed.

Additionally, PENELOPE offers the following functionalities: automated checking of model consistency, mechanism for hierarchical and iterative modeling, graphical preparation of experimental results, interactive preparation of computed strategies, printing of models and results for documentation purposes.