

A Generalized Timed Petri Net Model for Performance Analysis

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Abstract—We have developed a Generalized Timed Petri Net (GTPN) model for evaluating the performance of computer systems. Our model is a generalization of the TPN model proposed by Zuberek [1] and extended by Razouk and Phelps [2]. In this paper, we define the GTPN model and present how performance estimates are obtained from the GTPN. We demonstrate the use of our automated GTPN analysis techniques on the dining philosophers example. This example violates restrictions made in the earlier TPN models. Finally, we compare the GTPN to the stochastic Petri net (SPN) models. We show that the GTPN model has capabilities for modeling and analyzing parallel systems lacking in existing SPN models. The GTPN provides an efficient, easily used method of obtaining accurate performance estimates for models of computer systems which include both deterministic and geometric holding times.

Index Terms—Deterministic delays, dining philosophers, embedded Markov chain, Markov models, performance analysis, Petri nets.

I. INTRODUCTION

WE present a Generalized Timed Petri Net (GTPN) model for evaluating the performance of computer systems. The GTPN model is an efficient, easily used tool for calculating exact performance estimates for many models of computer systems. For example, in [3] we derive exact performance estimates of multiprocessor memory and bus interference for fixed memory cycle times. Only approximate solutions existed previously for many of the models we studied.

Petri nets are a graph model of computation [4]. Modifying Petri nets so that time is represented has recently been an active research area. The goal of these models is to analyze system performance as an extension of the reachability analysis. Our model is a generalization of the timed Petri net (TPN) model proposed by Zuberek [1] and extended by Razouk and Phelps [2]. The TPN model associates firing frequencies and deterministic firing times with each transition in the net. Both Zuberek and Razouk and Phelps restrict the allowed nets in order to propose algorithms for building the net's reachability graph. They further restrict the allowed nets in order to analyze the net's reachability graph. Our generalization, the GTPN

model, removes all of these restrictions. We present efficient algorithms for building the reachability graph of an arbitrary bounded net and we show how to analyze that reachability graph in the general case.

For the purpose of performance analysis we view the GTPN as a stochastic process. The time-in-state is a deterministic function for each state of the net. However, a probability distribution is defined over the possible next states based on the firing frequencies. The GTPN analyzer automatically generates the associated discrete parameter, embedded Markov chain and calculates performance estimates.

Stochastic Petri nets (SPN's) are an alternate method of representing time in Petri nets for the purpose of performance analysis. Continuous-time SPN models were proposed by Natkin [5], Symons [6], and Molloy [7]–[9], and generalized by Marsan, Balbo, and Conte [10] and Dugan, Trivedi, Geist, and Nicola [11]. The Generalized continuous-time SPN (GSPN) model [10] associates an instantaneous or exponentially distributed firing time with each transition. The Extended SPN (ESPN) model [11] allows general firing time distributions and then defines restrictions on the net which are necessary for efficient solution.

Molloy [7], [9] has also proposed a discrete-time SPN model with transition firing times that are geometrically distributed. The discrete-time SPN model is especially interesting because it can represent deterministic firing times, thus bridging the gap between the SPN and TPN models. However, the representation of deterministic firing times has two restrictions in the discrete-time SPN: 1) a firing time must be a nonzero multiple of some unit time step, and 2) all conflicting actions having deterministic delays must be equally likely.

The GTPN can represent geometric holding times, and thus also bridges the gap between the TPN and SPN models. Furthermore, deterministic firing times can be any nonnegative real value, including zero, and we can assign arbitrary next-state probabilities to conflicting transitions. Thus, the GTPN has some attractive features lacking in existing SPN models.

This paper is an extended version of [12]. In Section II, we describe untimed Petri nets and the previous TPN models. In Section III we describe the GTPN model and in Section IV we show how the GTPN model is analyzed. In Section V, we demonstrate the use of our automated GTPN analysis techniques on the dining philosophers

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Proceedings Of The Fourth International Workshop On Petri Nets And Performance Models

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Proceedings of the Fourth International Workshop on Petri Nets and Performance Models (PNPM91), December 2-5, 1991, Melbourne, Australia Telecom Australia, 1991 The proceedings of the Fourth International Workshop on title December 1991 Melbourne Australia Twenty six papers four research briefs and two keynote addresses present research results and directions in the areas of Petri nets and their timed and stochastic extensions and in their application to a wide variety of systems including computing communication and manufacturing No subject index Acidic paper Annotation copyrighted by Book News Inc Portland OR *Modellierung, Integration und Analyse von Ressourcen in Geschäftsprozessen* Thomas Schuster, 2014-07-30 Gesch ftsprozess und Ressourcenmodelle k nnen bislang nur eingeschr nkt zur Untersuchung des Ressourceneinsatzes genutzt werden da relevante Eigenschaften nicht ad quat abgebildet werden Aus diesem Grund wird in dieser Arbeit die Resource Modeling Language RML konzipiert und durch Ressourcen Netze in die Gesch ftsprozessmodellierung integriert Zur Modellierung und Analyse wird das Werkzeug RAvEN konzipiert Die Analyse des Ressourceneinsatzes erfolgt durch Simulationsexperimente **Proceedings of the Fourth International Conference on Computer Integrated Manufacturing and Automation Technology, Troy, New York, October 10-12, 1994**, 1994 Annotation Proceedings of the October 1994 conference Papers cover topics including agile manufacturing and related concepts with emphasis on system integration and applications while panel discussions address government programs such as the Technology Reinvestment Projects Other topics include process modeling and planning Petri net theory integrated design and assembly planning holonic manufacturing systems and discrete event dynamic systems Annotation copyright by Book News Inc Portland OR The Fourth International Workshop on Rapid System Prototyping Nick Kanopoulos, 1993 RSP 93 was held in Research Triangle Park North Carolina June 1993 Papers discuss prototyping tools problems issues techniques applications environments and design and test methodologies No index Acidic paper Annotation copyright by Book News Inc Portland OR *Model-Driven Dependability Assessment of Software Systems* Simona Bernardi, José Merseguer, Dorina Corina Petriu, 2013-10-22 Over the last two decades a major challenge for researchers working on modeling and evaluation of computer based systems has been the assessment of system Non Functional Properties NFP such as performance scalability dependability and security In this book the authors present cutting edge model driven techniques for modeling and analysis of software dependability Most of them are based on the use of UML as software specification language From the software system specification point of view such techniques exploit the standard extension mechanisms of UML i e UML profiling UML profiles enable software engineers to add non functional properties to the software model in addition to the functional ones The authors detail the state of the art on UML profile proposals for dependability specification and rigorously describe the trade off they accomplish The focus is mainly on RAMS reliability availability maintainability and safety properties Among the existing profiles they emphasize the DAM Dependability Analysis and Modeling profile which

attempts to unify under a common umbrella the previous UML profiles from literature providing capabilities for dependability specification and analysis In addition they describe two prominent model to model transformation techniques which support the generation of the analysis model and allow for further assessment of different RAMS properties Case studies from different domains are also presented in order to provide practitioners with examples of how to apply the aforementioned techniques Researchers and students will learn basic dependability concepts and how to model them using UML and its extensions They will also gain insights into dependability analysis techniques through the use of appropriate modeling formalisms as well as of model to model transformation techniques for deriving dependability analysis models from UML specifications Moreover software practitioners will find a unified framework for the specification of dependability requirements and properties of UML and will benefit from the detailed case studies

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Stochastic Petri Nets Falko Bause,Pieter S. Kritzinger,1996 Any engineer who is responsible for the design and development of discrete systems such as embedded software for control or telecommunication systems knows that the most important quality of the final product is that it be functionally correct Once assured that the system behaves correctly it is also important that it be efficient in that its running cost is minimal or is optimum in whatever quantitative measure is chosen Stochastic Petri nets have been developed over the last decade with exactly these objectives in mind This book is an introduction to Stochastic Petri nets and arose out of a desire by the authors to collect all one needs to understand Stochastic Petri net theory in one volume The intention of this book is not to give an overview of several or all Stochastic Petri net models appearing in the literature but to stress a combined view of functional and performance analysis in the context of some Stochastic Petri net models The book contains a reference to several Stochastic Petri net tools which are available to help the reader apply the theory contained in this volume USP F r sicher funktionierende DV Systeme **Proceedings, 4th**

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