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Advances in Petri Nets 1989

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Preface

The idea behind the series of volumes "Advances in Petri Nets" is to present to the general computer science community recent results which are the most representative and significant for the development of the area.

The main source of papers for "Advances" are the annual "European Workshops on Applications and Theory of Petri Nets"; the "best" papers from the past workshops are considered for the series (however, they go through an independent refereeing process and, if accepted, they often appear in "Advances" in a quite revised and extended form). Independently of the workshop papers, "Advances" present also papers submitted directly for publication in "Advances" - potential authors are encouraged to submit papers directly to the Editor of "Advances".

The main aims of "Advances" are:

(1) to present to the "outside" scientific community a fair picture of recent advances in the area of Petri nets, and

(2) to encourage those interested in applications and the theory of concurrent systems to take a closer look at Petri nets and then join the group of researchers working in this fascinating and challenging area.

To facilitate (2) above "Advances" also contain surveys and tutorials on various topics from Petri nets. The current volume contains a tutorial on stochastic Petri nets written by M. Ajmone Marsan and a tutorial on the use of Petri nets in flexible manufacturing written by M. Silva and R. Valette.

"Advances in Petri Nets 1989" covers the 9th "European Workshop on Applications and Theory of Petri Nets" held in Venice, Italy in June 1988. I would like to thank the members of the program committee and especially the chairman G. de Michelis for the help in selecting papers from the workshop to be submitted for "Advances".

This volume contains also descriptions of two Basic Research Actions from the ESPRIT Programme of the European Communities that deal with Petri Nets. E. Best describes the DEMON project centered around Petri nets, and U. Montanari describes the CEDISYS project where Petri nets play an important role.

Special thanks go to the referees of papers in this volume who very often are responsible for considerable improvements of papers presented here. The referees were:
M. Ajmone Marsan, A. Bergadano, E. Best, J. Billington, Ph. Chretienne, Tam-Anh Chu, F. De Cindio, G. De Michelis, R. Devillers, A. Filurin, U. Goltz, C. Hanen, A. Hany, R. Hopkins, G. Hura, M. Jantzen, K. Jensen, V. Kotov, H.-J. Kreowski, B. Krogh, M. Main, D. Marinescu, G. Mauri, A. Mazurkiewicz, A. Merceron, G. De Michelis, A.S. Morozov, T. Murata, M. Nielsen, M. Ornaghi, L. Pomello, R. Razouk, W. Reisig, N. Shilov, M. Silva, C. Simone, D. Simpson, E. Smith, P. Starke, I. Suzuki, P.S. Thiagarajan, J.P. Tsai, Shengru Tu, R. Valette, R. Valk, K. Voss, M. Zamboni, W. Zuberek.

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G. Rozenberg
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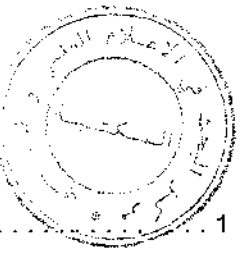

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STOCHASTIC PETRI NETS: AN ELEMENTARY INTRODUCTION

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ABSTRACT - *Petri nets in which random firing delays are associated with transitions whose firing is an atomic operation are known under the name "stochastic Petri nets". These models are discussed, with the purpose of explaining why they were proposed in the performance evaluation field, why random delays with negative exponential probability density functions are mainly used, and what are their strong and weak points. An effort is made to summarize the lines of research that are currently being pursued, and to explain what new results would be regarded as breakthroughs and have the most impact on the use of this modeling technique in the application field.*

KEY WORDS - Stochastic Petri nets, Performance evaluation, Markov chains, Queues.

CONTENTS

1 INTRODUCTION

Petri nets (PN) [1,2,3], in their various shapes and sizes, have been used for the study of the *qualitative* properties of systems exhibiting concurrency and synchronization characteristics.

The use of PN-based techniques for the *quantitative* analysis of systems requires the introduction of temporal specifications in the basic, untimed models.

This fact has been recognized since a fairly long time, and several different proposals for the introduction of temporal specifications in PN have appeared in the literature. The main alternatives that characterize the different proposals concern

- the PN elements (either places or transitions) with which timing is associated,
- the semantics of the firing in the case of timed transitions (either atomic firing or firing in three phases),
- the nature of the temporal specification (either deterministic or probabilistic).

In this paper we consider PN models that are augmented with a temporal specification by associating a firing delay with transitions. The transition firing is atomic, i.e., tokens are removed from input places and put into output places with a single, indivisible operation. The specification of the firing delay is of probabilistic nature, so that either the probability density function (pdf) or the probability distribution function (PDF) of the delay associated with a transition needs to be specified. In the simplest case we assume that all delays have negative exponential pdf, but we also briefly consider the case of general pdf.

The class of models that we consider are normally referred to with the name Stochastic PN (SPN).

The goal of the paper is to discuss several points related to SPN, including

- why were SPN introduced,
- why exponential pdf are mainly used for the specification of timing,
- what are the strong and weak points of SPN,
- what research efforts are currently in progress,
- what would be the most important breakthrough results in the SPN field.

This paper is addressed to PN experts who are not familiar with the stochastic performance modeling field. For this reason, a brief overview of the classical approach to the performance evaluation of systems in a probabilistic framework is included in Section 2, where some elementary notions about stochastic processes, and queueing theory are summarized.

Section 3 contains the discussion on the various types of SPN models that were presented in the literature, together with some illustrative examples. Comments on the present and future research efforts are also included in this section.

Finally, Section 4 provides the concluding remarks.

In spite of the author's efforts to provide an objective overview of the SPN field, the discussion in the paper is probably biased, due to his particular background and experience. It is thus possible that some classes of SPN that were proposed by the author with his colleagues are presented with more emphasis than they deserve. On the other hand, in a paper like this one, it is necessary to express personal opinions, and to make a selection of the models to be presented. As regards the selection, it naturally favors the models with which the author is more familiar. As regards personal opinions, normally researchers tend to highly value their own work (says an Italian proverb: "every cockroach is beautiful to his mother"). Readers interested in the use of SPN models are thus adviced to carefully compare the original proposals in order to develop their own opinions about the suitability of the various modeling approaches to their particular application field.