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Book review☆

Performance Modeling with Deterministic and Stochastic Petri Nets
Christoph Lindemann, Wiley-Interscience Series in Systems and Optimization, Wiley, New York, 1998, 405 pages, ISBN 0-471-97646-6.

The book provides a thorough discussion of the deterministic stochastic Petri net formalism that is becoming increasingly important for the numerical analysis of computer/communication systems.

Deterministic stochastic Petri nets (DSPNs) are presented as extensions of generalized stochastic Petri nets (GSPNs) that have received in the last 15 years considerable attention from performance evaluation professionals. DSPNs are characterized by the presence of immediate and timed transitions whose firing delays can be either constant (deterministic) or exponentially distributed random variables.

Obviously DSPNs without deterministic transitions are GSPNs and this is the type of extension that is considered in the book. While GSPN models of dynamic systems are known to yield Markov chains that can be used to evaluate their behaviours, DSPNs represent a formalism for the construction of much more complex stochastic processes. Algorithms and numerical techniques for the stationary analysis of DSPNs are presented in this book when the underlying probabilistic models are either semi-Markov or Markov regenerative stochastic processes.

The book is divided in four parts that address the basic formalisms used for the performance analysis of computer systems, the algorithms and numerical techniques for the solution of DSPN models, the application of the DSPN formalism for the analysis of some important case studies, and finally the description of the software package DSPNexpress that the author developed during the last few years and that implements most of the algorithms discussed in the book.

The book concludes with two appendices containing basic probability theory definitions and properties as well as the characteristics of some common probability distributions.

Part I is mainly represented by Chapter 2 that contains a fair introduction of the different modelling formalisms that are most common in the analysis of computer/communication systems. Keeping this discussion quite concise, the book avoids the overlapping with other books on the same topics and emphasizes the fact that its main objective is the discussion of the solution methods for a very specific class of stochastic Petri nets.

☆ Review copies of books which might be of interest to the readers of *Science of Computer Programming* should be sent to Prof. J. Bergstra (address: see inside front cover). Proceedings of conference will not normally be reviewed.

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Part II represents the core of the book where the research results produced by the author are deeply discussed and extensively compared with similar and complementary work published in the literature.

Chapter 3 introduces the basic definitions for timed Petri nets and discusses the techniques that can be used to construct the (often) huge state spaces typical of these models.

The structural properties that are "classical" within the analysis of un-timed Petri nets are quickly overviewed with some little flaws (see for instance the definition of conflicts and the discussion of the invariant properties of Petri nets with priority) that can be justified by the fact that this type of analysis is not the main objective of this book.

On the other hand, the advantages that the new techniques devised by the author for the time and space efficient construction of the reachability sets and graphs are discussed in full details. Experimental evidence is provided of the improvements that they yield with respect to other methods published in the literature. This comparison tends to (over)emphasize, somehow, the differences existing between the techniques published at the time of the proposals of the formalisms (when the main issues were the formalisms themselves and not the accompanying solution methods) and those proposed by the author.

Chapter 4 outlines the basic problems that affect the analysis of DSPNs when only one deterministic transition is enabled at any given time. The results discussed in this chapter represent the most important contribution that the author has made to the applicability of DSPN models to the analysis of realistic systems. Efficient formulas are discussed for the transient analysis of subordinated Markov chains, both in the case of marking independent and marking dependent firing delays of deterministic transitions. Special structures of these subordinated chains are exploited for reducing the computational effort of their solutions.

Numerical experiments are presented to support the outstanding improvements provided by these techniques.

Chapter 5 is devoted to the analysis of the more complex case of DSPNs with concurrent deterministic transitions. This is the most difficult chapter of the book where detailed derivations are presented for the transition matrices of the subordinated Markov chains in different situations. Two non-trivial DSPN models are used within this chapter to clarify the results represented by the different formulas when used in concrete cases. A more detailed description of state transition diagrams for these two examples could have been provided to make them truly effective in supporting the reader's understanding of these techniques.

Some questions remain on the adequacy of this chapter (within the balance of the book) that discusses at length many techniques that are not yet stable, are not yet part of the software package provided with the book, and are not used in the third part of the book that presents some relevant applications of DSPNs.

Part III is devoted to the application of the modelling techniques developed in Part II to the performance analysis of some aspects of multiprocessor architectures.

Its purpose is twofold: first, it presents some interesting results obtained with the use of DSPNs in the field of computer architecture design; second, it shows the modelling power of the formalism when used to address real design problems.

Chapter 6 contains a brief description of the elements of a taxonomy of multiprocessor architectures, setting the ground for the analyses contained in Chapters 7 and 8. Chapter 7 addresses the problem of the analysis of the architecture of the typical node of a MIMD multiprocessor system.

The DSPN formalism is used to provide a precise description of the node functionalities in the general case of an arbitrary load/store architecture as well as in the specific case of the node organization of the MANNA and META systems. A few performance results are presented for these two systems, but only approximate figures are produced since the models are characterized by the presence of concurrent deterministic transitions that would need the use of the techniques developed in Chapter 5, but whose implementation was not yet complete at the moment of the publication of the book.

Given these constraints, it would have been interesting to see a comparison between the results produced by discrete-event simulation and those of the GSPN approximations in which deterministic transitions are replaced by exponential ones. Moreover, some sensitivity analysis of the impact that low-variance distributions may have on these type of results could have been reported using phase-type distributions as well as simulation. Finally, it would have been interesting to have an estimate of the cost of the numerical solutions proposed in Chapter 6 when applied to models of this type.

Chapter 8 contains instead a nice and extensive analysis of Memory Consistency Protocols where the use of DSPN models shows its effectiveness. This chapter contains many results and the only criticism may refer to the difficulty of relating pictures with text (they are often very far a part) and of obtaining precise indications on the relative benefits of the different protocols.

Part IV is devoted to the description of the software package DSPNexpress whose object code is contained in the CD-ROM that is part of the book and that allows the interested reader to experiment with the DSPN formalism. Chapter 9 contains an overview of the organization of DSPNexpress and of its main features. Chapter 10 describes the graphical interface of DSPNexpress and can be considered as the user-manual that is needed for actually constructing and solving DSPN models.

Chapter 11 concludes this part of the book by providing additional information on the characteristic of DSPNexpress that can be used to construct more complex DSPN models and to interface DSPNexpress with other software.

Appendix A is a very brief primer to Applied Probability and has the merit of presenting basic results and properties of probability theory with the notation used throughout the book. Appendix B summarizes the properties of several discrete and continuous probability distributions which occur frequently in performance evaluation of computer and communication systems.

In summary, I consider this book a good piece of work that may be extremely valuable for professionals in academia and industry as well.

I found the book well written and easy to read for its emphasis on intuitive explanations of mathematical results rather than on rigorous formal proofs.

I believe that it can be considered as a supplementary textbook for an advanced course in Performance Evaluation of Computer/Communication Systems which can benefit from the accompanying DSPNexpress software package for the possibility of assigning interesting modelling and analysis projects to the students.

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