

**Introduction to the  
Numerical Solution  
of  
Markov Chains**

**William J. Stewart**

# Numerical Solution Of Markov Chains

**Brigitte Plateau, William J.  
Stewart, Manuel Silva**



## **Numerical Solution Of Markov Chains:**

**Introduction to the Numerical Solution of Markov Chains** William J. Stewart, 2021-01-12 A cornerstone of applied probability Markov chains can be used to help model how plants grow chemicals react and atoms diffuse and applications are increasingly being found in such areas as engineering computer science economics and education To apply the techniques to real problems however it is necessary to understand how Markov chains can be solved numerically In this book the first to offer a systematic and detailed treatment of the numerical solution of Markov chains William Stewart provides scientists on many levels with the power to put this theory to use in the actual world where it has applications in areas as diverse as engineering economics and education His efforts make for essential reading in a rapidly growing field Here Stewart explores all aspects of numerically computing solutions of Markov chains especially when the state is huge He provides extensive background to both discrete time and continuous time Markov chains and examines many different numerical computing methods direct single and multi vector iterative and projection methods More specifically he considers recursive methods often used when the structure of the Markov chain is upper Hessenberg iterative aggregation disaggregation methods that are particularly appropriate when it is NCD nearly completely decomposable and reduced schemes for cases in which the chain is periodic There are chapters on methods for computing transient solutions on stochastic automata networks and finally on currently available software Throughout Stewart draws on numerous examples and comparisons among the methods he so thoroughly explains

**Numerical Solution of Markov Chains** William J. Stewart, 1991-05-23 Papers presented at a workshop held January 1990 location unspecified cover just about all aspects of solving Markov models numerically There are papers on matrix generation techniques and generalized stochastic Petri nets the computation of stationary distributions including aggregation disaggregation

**Computations with Markov Chains** William J. Stewart, 2012-12-06 Computations with Markov Chains presents the edited and reviewed proceedings of the Second International Workshop on the Numerical Solution of Markov Chains held January 16 18 1995 in Raleigh North Carolina New developments of particular interest include recent work on stability and conditioning Krylov subspace based methods for transient solutions quadratic convergent procedures for matrix geometric problems further analysis of the GTH algorithm the arrival of stochastic automata networks at the forefront of modelling stratagems and more An authoritative overview of the field for applied probabilists numerical analysts and systems modelers including computer scientists and engineers

**Numerical Methods for Structured Markov Chains** Dario A. Bini, Guy Latouche, Beatrice Meini, 2005-02-03 Intersecting two large research areas numerical analysis and applied probability queuing theory this book is a self contained introduction to the numerical solution of structured Markov chains which have a wide applicability in queuing theory and stochastic modeling and include M/G/1 and GI/M/1 type Markov chain quasi birth death processes non skip free queues and tree like stochastic processes Written for applied probabilists and numerical analysts but accessible to engineers and scientists working on

telecommunications and evaluation of computer systems performances it provides a systematic treatment of the theory and algorithms for important families of structured Markov chains and a thorough overview of the current literature The book consisting of nine Chapters is presented in three parts Part 1 covers a basic description of the fundamental concepts related to Markov chains a systematic treatment of the structure matrix tools including finite Toeplitz matrices displacement operators FFT and the infinite block Toeplitz matrices their relationship with matrix power series and the fundamental problems of solving matrix equations and computing canonical factorizations Part 2 deals with the description and analysis of structure Markov chains and includes M/G/1 quasi birth death processes non skip free queues and tree like processes Part 3 covers solution algorithms where new convergence and applicability results are proved Each chapter ends with bibliographic notes for further reading and the book ends with an appendix collecting the main general concepts and results used in the book a list of the main annotations and algorithms used in the book and an extensive index

**Numerical Solution of Markov Chains** WJ Stewart (ed),1991 **Numerical Solution Of Markov Chains** W.J. Stewart, **Formal Methods for Performance Evaluation** Marco Bernardo,Jane Hillston,2007-06-06 This book presents a set of 11 papers accompanying the lectures of leading researchers given at the 7th edition of the International School on Formal Methods for the Design of Computer Communication and Software Systems SFM 2007 held in Bertinoro Italy in May June 2007 SFM 2007 was devoted to formal techniques for performance evaluation and covered several aspects of the field **Stability and Conditioning Issues on the Numerical Solution of Markov Chains** Tugral Dayar,1994 *International Workshop on the Numerical Solution of Markov Chains* ,1991 **Computations with Markov Chains** William J Stewart,1995-02-28 *Numerical Solution of Markov Chains* Amr Lotfy Elsayad,2002 This project deals with techniques to solve Markov Chains numerically

**Numerical Methods in Markov Chains and Bulk Queues** T. P. Bagchi,J. G. C. Templeton,2012-12-06 **Queueing Networks and Markov Chains** Gunter Bolch,Stefan Greiner,Hermann de Meer,Kishor S. Trivedi,2006-04-27 Critically acclaimed text for computer performance analysis now in its second edition The Second Edition of this now classic text provides a current and thorough treatment of queueing systems queueing networks continuous and discrete time Markov chains and simulation Thoroughly updated with new content as well as new problems and worked examples the text offers readers both the theory and practical guidance needed to conduct performance and reliability evaluations of computer communication and manufacturing systems Starting with basic probability theory the text sets the foundation for the more complicated topics of queueing networks and Markov chains using applications and examples to illustrate key points Designed to engage the reader and build practical performance analysis skills the text features a wealth of problems that mirror actual industry challenges New features of the Second Edition include Chapter examining simulation methods and applications Performance analysis applications for wireless Internet J2EE and Kanban systems Latest material on non Markovian and fluid stochastic Petri nets as well as solution techniques for Markov regenerative processes Updated

discussions of new and popular performance analysis tools including ns 2 and OPNET New and current real world examples including DiffServ routers in the Internet and cellular mobile networks With the rapidly growing complexity of computer and communication systems the need for this text which expertly mixes theory and practice is tremendous Graduate and advanced undergraduate students in computer science will find the extensive use of examples and problems to be vital in mastering both the basics and the fine points of the field while industry professionals will find the text essential for developing systems that comply with industry standards and regulations

**A First Course in Stochastic Models** Henk C. Tijms, 2003-04-18 The field of applied probability has changed profoundly in the past twenty years The development of computational methods has greatly contributed to a better understanding of the theory A First Course in Stochastic Models provides a self contained introduction to the theory and applications of stochastic models Emphasis is placed on establishing the theoretical foundations of the subject thereby providing a framework in which the applications can be understood Without this solid basis in theory no applications can be solved Provides an introduction to the use of stochastic models through an integrated presentation of theory algorithms and applications Incorporates recent developments in computational probability Includes a wide range of examples that illustrate the models and make the methods of solution clear Features an abundance of motivating exercises that help the student learn how to apply the theory Accessible to anyone with a basic knowledge of probability A First Course in Stochastic Models is suitable for senior undergraduate and graduate students from computer science engineering statistics operations research and any other discipline where stochastic modelling takes place It stands out amongst other textbooks on the subject because of its integrated presentation of theory algorithms and applications

Numerical solution of Markov chains (NSMC'99) Brigitte Plateau, William J. Stewart, Manuel Silva, 1999

**Continuous-Time Markov Chains and Applications** George G. Yin, Qing Zhang, 2012-12-06 This book is concerned with continuous time Markov chains It develops an integrated approach to singularly perturbed Markovian systems and reveals interrelations of stochastic processes and singular perturbations In recent years Markovian formulations have been used routinely for numerous real world systems under uncertainties Quite often the underlying Markov chain is subject to rather frequent fluctuations and the corresponding states are naturally divisible to a number of groups such that the chain fluctuates very rapidly among different states within a group but jumps less frequently from one group to another Various applications in engineering economics and biological and physical sciences have posed increasing demands on an in depth study of such systems A basic issue common to many different fields is the understanding of the distribution and the structure of the underlying uncertainty Such needs become even more pressing when we deal with complex and or large scale Markovian models whose closed form solutions are usually very difficult to obtain Markov chain a well known subject has been studied by a host of researchers for many years While nonstationary cases have been treated in the literature much emphasis has been on stationary Markov chains and their basic properties such as ergodicity recurrence and stability In

contrast this book focuses on singularly perturbed nonstationary Markov chains and their asymptotic properties Singular perturbation theory has a long history and is a powerful tool for a wide variety of applications 1990, the First International Conference on the Numerical Solution of Markov Chains ,1990

**Kronecker Modeling and Analysis of Multidimensional Markovian Systems** Tuğrul Dayar,2018-09-21 This work considers Kronecker based models with finite as well as countably infinite state spaces for multidimensional Markovian systems by paying particular attention to those whose reachable state spaces are smaller than their product state spaces Numerical methods for steady state and transient analysis of Kronecker based multidimensional Markovian models are discussed in detail together with implementation issues Case studies are provided to explain concepts and motivate use of methods Having grown out of research from the past twenty years this book expands upon the author s previously published book Analyzing Markov Chains using Kronecker Products Springer 2012 The subject matter is interdisciplinary and at the intersection of applied mathematics and computer science The book will be of use to researchers and graduate students with an understanding of basic linear algebra probability and discrete mathematics

**Computational Probability** Winfried K. Grassmann,2013-03-14 Great advances have been made in recent years in the field of computational probability In particular the state of the art as it relates to queuing systems stochastic Petri nets and systems dealing with reliability has benefited significantly from these advances The objective of this book is to make these topics accessible to researchers graduate students and practitioners Great care was taken to make the exposition as clear as possible Every line in the book has been evaluated and changes have been made whenever it was felt that the initial exposition was not clear enough for the intended readership The work of major research scholars in this field comprises the individual chapters of Computational Probability The first chapter describes in nonmathematical terms the challenges in computational probability Chapter 2 describes the methodologies available for obtaining the transition matrices for Markov chains with particular emphasis on stochastic Petri nets Chapter 3 discusses how to find transient probabilities and transient rewards for these Markov chains The next two chapters indicate how to find steady state probabilities for Markov chains with a finite number of states Both direct and iterative methods are described in Chapter 4 Details of these methods are given in Chapter 5 Chapters 6 and 7 deal with infinite state Markov chains which occur frequently in queueing because there are times one does not want to set a bound for all queues Chapter 8 deals with transforms in particular Laplace transforms The work of Ward Whitt and his collaborators who have recently developed a number of numerical methods for Laplace transform inversions is emphasized in this chapter Finally if one wants to optimize a system one way to do the optimization is through Markov decision making described in Chapter 9 Markov modeling has found applications in many areas three of which are described in detail Chapter 10 analyzes discrete time queues Chapter 11 describes networks of queues and Chapter 12 deals with reliability theory

**Numerical Methods for Simulation and Optimization of Piecewise Deterministic Markov Processes** Benoîte de Saporta,François Dufour,Huilong

Zhang,2015-12-14 Mark H A Davis introduced the Piecewise Deterministic Markov Process PDMP class of stochastic hybrid models in an article in 1984 Today it is used to model a variety of complex systems in the fields of engineering economics management sciences biology Internet traffic networks and many more Yet despite this there is very little in the way of literature devoted to the development of numerical methods for PDMPs to solve problems of practical importance or the computational control of PDMPs This book therefore presents a collection of mathematical tools that have been recently developed to tackle such problems It begins by doing so through examples in several application domains such as reliability The second part is devoted to the study and simulation of expectations of functionals of PDMPs Finally the third part introduces the development of numerical techniques for optimal control problems such as stopping and impulse control problems

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