Guanjun Liu

Petri Nets

Theoretical Models and Analysis Methods for Concurrent Systems

Springer

Petri Nets

Guanjun Liu

Petri Nets

Theoretical Models and Analysis Methods for Concurrent Systems

Springer

Guanjun Liu
Department of Computer Science
Tongji University
Shanghai, China

ISBN 978-981-19-6308-7 ISBN 978-981-19-6309-4 (eBook)
https://doi.org/10.1007/978-981-19-6309-4

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

Petri nets, as the first true concurrent model, have been of good vitality since Dr. Carl Adam Petri pioneered them sixty years ago. Such a good vitality benefits from the outstanding work of Dr. Petri and other scientists and technicians in this field, indicating that Petri nets (including high-level extensions) have many advantages in modelling concurrent systems as well as in helping us understand, analyse, and improve these concurrent systems.

Concurrency is a universal phenomenon in our physical world. Even when an organisation or a team performs a task, concurrent operations are often taken in order to increase efficiency. In the current scientific times, lots of concurrent systems serve our work and life, but they must provide a correct and reliable service, or our safety and even lives are threatened. However, designing such a system is not an easy thing, because a number of concurrent, interactive, and even real-time actions are involved in its running so that its logical structures and dynamic behaviours are very complex. In consequence, we need one or multiple suitable models to help us understand and analyse the logical structures and dynamic behaviours of such a complex system, while Petri nets have been well used just due to their ability on simulating concurrence, interaction, real time, etc.

Purpose

In addition to a part of my research results, what this book focuses on is the basic theory of Petri nets as well as the Petri-nets-based model checking methods, so that it is suitable not only for senior researchers, but also for beginners aspiring to this field. The biggest feature of this book, I think, is a relatively systematic combination of the Petri net theory and the Petri-nets-based model checking methods. The Petri net theory can help readers systematically understand the nature of concurrence, interaction, and real time. The model checking methods are important practical techniques employed for checking errors in concurrent systems. So far, only few books combine them together.

Prerequisites

The Petri net theory and model checking methods have their roots in mathematical foundations such as discrete mathematics, propositional logic, automata theory, data structures, graph theory, and algorithms. It is expected that readers are familiar with the basic knowledge of these aspects when starting with this book.

Content

As for the Petri net theory, this book involves the basic knowledge of elementary net systems, including their interleaving semantics and concurrency semantics (Chap. 1), some structure concepts (Chap. 2), some subclasses with special structures (Chaps. 3 and 4), and some basic properties such as reachability, liveness, and deadlock (Chaps. 1–4). It also involves four high-level Petri nets: Knowledge-oriented Petri nets (Chap. 6), Petri nets with insecure places (Chap. 7), time Petri nets (Chap. 8), and plain time Petri nets with priorities (Chap. 10), focusing on different application fields. As for the model checking methods, this book involves computation tree logic (Chap. 5), computation tree logic of knowledge (Chap. 6), timed computation tree logic (Chaps. 9 and 10), as well as the Petri-nets-based checking methods for them. The basic principle of the reduced ordered binary decision diagram is also introduced in order to compress the state space used in these model checking procedures (Chaps. 5 and 6). Besides the above contents, this book also presents time-soundness for time Petri nets (Chap. 8) and secure bisimulation for Petri nets with insecure places (Chap. 7). They are both based on the bisimulation theory pioneered by Dr. Robin Milner, and thus this theory is also introduced briefly in this book.

Acknowledgements

I would like to thank all my colleagues for their hard work in fighting against COVID-19. COVID-19 forced me to stay at home; but on the other hand, I had enough time to write this book. I thank the National Nature Science Foundation of China (Nos. 62172299 and 62032019) and the Alexander von Humboldt Foundation of Germany. They supported my research so that a part of my research results can be written in this book. At last, I thank my wife, my daughters, and my mother for their selfless support.

Shanghai, China Guanjun Liu
July 2022

Contents