



国际知名大学原版教材——信息技术学科与电气工程学科系列

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Real-time Systems

实时系统

C. M. Krishna
Kang G. Shin

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清华大学出版社



本书特色

1. 理论性强。对许多问题用数学语言进行了形式化描述，给出了相关的公式、定义、定理，并进行了推导或证明。本书集中了两位作者从事实时系统教学和研究工作近20年所取得的成果，同时也包含了该领域国际上许多最新的研究成果。

2. 可读性好。每章通过许多例题阐述了相关实时系统的设计方法和性能评价方法，分析了目前许多先进的实时系统的各个方面。因此本书不仅理论性强，同时也非常注重理论联系实际，便于读者阅读。

3. 注重系统设计与性能评价。全书以实时系统的设计方法和性能评价方法为主线展开，讲述了多种实时系统的设计方法和性能评价方法，同时也介绍了几种进行实时系统设计和性能评价的工具。读者学会了这些设计方法和评价工具，对研究和开发其他实时系统很有帮助。

4. 硬件和软件结合。大多数实时系统是由硬件和软件共同组成的，本书在分别介绍硬件部分和软件部分的工作原理、设计方法和性能分析方法的同时，也给出了在设计实时系统时软件与硬件如何做到平衡。

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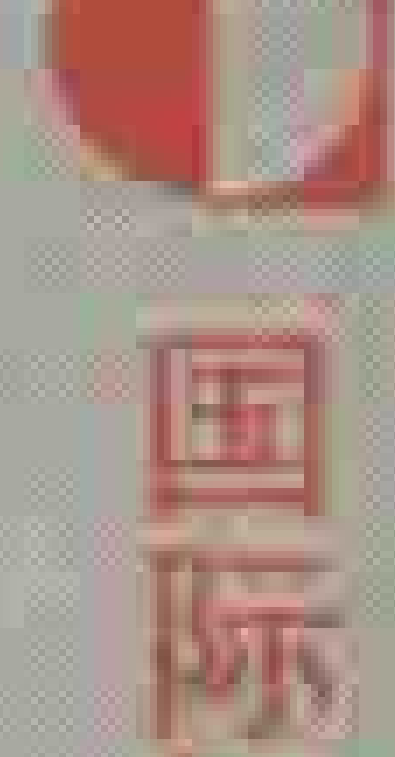


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REAL-TIME SYSTEMS

C. M. Krishna

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The University of Michigan

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出版说明

郑大钟

清华大学信息科学与技术学院

当前,在我国的高等学校中,教学内容和课程体系的改革已经成为教学改革中的一个非常突出的问题,而为数不少的课程教材中普遍存在“课程体系老化,内容落伍时代,本研层次不清”的现象又是其中的急需改变的一个重要方面。同时,随着科教兴国方针的贯彻落实,要求我们进一步转变观念扩大视野,使教学过程适应以信息技术为先导的技术革命和我国社会主义市场经济的需要,加快教学过程的国际化进程。在这方面,系统地研究和借鉴国外知名大学的相关教材,将会对推进我们的课程改革和推进我国大学教学的国际化进程,乃至对我们一些重点大学建设国际一流大学的努力,都将具有重要的借鉴推动作用。正是基于这种背景,我们决定在国内推出信息技术学科和电气工程学科国外知名大学原版系列教材。

本系列教材的组编将遵循如下的几点基本原则。(1)书目的范围限于信息技术学科和电气工程学科所属专业的技术基础课和主要的专业课。(2)教材的范围选自于具有较大影响且为国外知名大学所采用的教材。(3)教材属于在近5年内所出版的新书或新版书。(4)教材适合于作为我国大学相应课程的教材或主要教学参考书。(5)每本列选的教材都须经过国内相应领域的资深专家审看和推荐。(6)教材的形式直接以英文原版形式印刷出版。

本系列教材将按分期分批的方式组织出版。为了便于使用本系列教材的相关教师和学生从学科和教学的角度对其在体系和内容上的特点和特色有所了解,在每本教材中都附有所约请的相关领域资深教授撰写的影印版序言。此外,出于多样化的考虑,对于某些基本类型的课程,我们还同时列选了多于一本的不同体系、不同风格 and 不同层次的教材,以供不同要求和不同学时的同类课程的选用。

本系列教材的读者对象为信息技术学科和电气工程学科所属各专业的本科生,同时兼顾其他工程学科专业的本科生或研究生。本系列教材,既可采用作为相应课程的教材或教学参考书,也可提供作为工作于各个技术领域的工程师和技术人员的自学读物。

组编这套国外知名大学原版系列教材是一个尝试。不管是书目确定的合理性,教材选择的恰当性,还是评论看法的确切性,都有待于通过使用和实践来检验。感谢使用本系列教材的广大教师和学生的支持。期望广大读者提出意见和建议。

Real-time Systems

影印版序

《实时系统》(Real-time Systems)一书由美国 Massachusetts 大学的 C. M. Krishna 教授和 Michigan 大学的 Kang G. Shin 教授共同编写。两位教授从事实时系统及相关领域的教学与研究已经很多年,发表了大量学术论文,取得了很多项研究成果,也出版过多本实时系统方面的书籍。

“实时系统”的发展非常迅速,特别是嵌入式计算机的出现并广泛应用,推动了实时系统的发展。在以往出版的相关书籍中,通常以一二个章节介绍一些具体的实时系统,如实时控制系统、实时数据库、实时操作系统、实时通信系统等,本书则全面分析并系统阐述了多种实时系统的工作原理、设计方法和性能评价方法。

本书可作为理工科相关专业研究生或高年级本科生的教材,也可作为参考书或研究用资料。另外,本书也是相关领域实习工程师必备的一本很好的工具书。本书的主要特点如下:

1. 理论性强。对许多问题用数学语言进行了形式化描述,给出了相关的公式、定义、定理,并进行了推导或证明。本书主要是根据两位作者从事实时系统方面的教学和研究工作近 20 年所取得的成果写成的,同时也包含了该领域国际上许多最新的研究成果。

2. 可读性好。每章都有许多例题,有些章有几十个例题,通过大量的例题阐述了相关实时系统的设计方法和性能评价方法,通过例题分析了目前许多先进的实时系统的各个方面。因此,本书不仅理论性强,同时也非常注重理论联系实际,便于读者阅读。

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每章后面都给出进一步阅读的建议,告诉读者如何深入学习,并附有参考书和相关论文,其中有许多论文是本书作者的研究成果。另外每章后面都有练习题,便于读者系统掌握本书的内容。

汤志忠 教授

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2001 年 7 月

ABOUT THE AUTHORS

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C. M. Krishna has been on the faculty of the University of Massachusetts since 1984. He has published in the areas of distributed processing, real-time systems, and fault tolerance, edited two volumes of readings for the IEEE Computer Society Press, and been Co-Guest-Editor of special issues of *IEEE Computer* and the *Proceedings of the IEEE* on real-time systems. Professor Krishna's current research deals with the reliability and performance modeling of real-time systems, fault-tolerant synchronization, distributed real-time operating systems, and real-time networks.

KANG G. SHIN

Kang G. Shin is Professor and Director of the Real-Time Computing Laboratory, Department of Electrical Engineering and Computer Science, The University of Michigan, Ann Arbor. He has authored and coauthored over 360 technical papers (about 150 of these in archival journals) and numerous book chapters in the areas of distributed real-time computing and control, fault-tolerant computing, computer architecture, robotics and automation, and intelligent manufacturing. Professor Shin is an IEEE Fellow, was the Program Chairman of the 1986 IEEE Real-Time Systems Symposium (RTSS), the General Chairman of the 1987 RTSS, the Guest Editor of the 1987 August special issue of *IEEE Transactions on Computers* on real-time systems, and an Editor of *IEEE Transactions on Parallel and Distributed Systems* from 1991–1995.

To our parents and family

PREFACE

Real-time systems have proliferated over the past few years. Today, computers are found embedded in almost everything, from toasters to cars to fly-by-wire aircraft. The computational workload of such embedded systems varies widely, from machines expected to do a few arithmetic operations every second to computers executing complex calculations at tremendous rates. The consequences of computer failure also vary widely, from burnt toast at the one extreme to the loss of life in an air crash or a chemical plant explosion at the other.

The objective of this book is to introduce readers to design and evaluation issues in such systems. We cover a wide range of topics; both hardware and software issues are treated in some detail. We expect this book to be used by both practicing engineers and graduate or final-year undergraduate students.

Some of the discussion is mathematical. Wherever possible, we have separated the more mathematical portions from the descriptive. This enables the text to be read at multiple levels. The more advanced sections are starred (★); these require additional perseverance or ability to understand them, and can be skipped if necessary. However, we urge the reader to avoid skipping the mathematical portions. Most often, avoidance of mathematics is grounded on nothing more substantial than a primitive fear of and negative associations with mathematical symbols. A true understanding of many of the issues covered here cannot be achieved without understanding their mathematical underpinnings.

This book contains far more material than can comfortably be covered in a one-semester course. Instructors may decide to concentrate on particular topics, for example, task assignment and scheduling, or fault-tolerance. Alternatively, they may decide to present a wide-ranging survey of the various topics of interest to the real-time systems engineer. To enable both approaches to be used, we have tried to make the chapters as independent of one another as possible. In addition, this allows the book to be used as a reference handbook by the practicing engineer. Typographical or other errors should be reported to the authors at

`rtbook@tikva.ecs.umass.edu`

We plan to maintain a page of errata on the World Wide Web at

<http://www.ecs.umass.edu/ece/gradfac/krishna.html>

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Many people have contributed to making this book a reality. We would like to thank Eric Munson of McGraw-Hill for commissioning it, and for being willing to countenance a delay of over a year beyond our original deadline. It is perhaps ironic that the authors of a book that deals largely with tasks meeting deadlines were themselves unable to meet their contracted deadline!

A number of our colleagues and students have read through this book, either in part or in its entirety, and provided valuable suggestions or pointed out mistakes. We list them below in random order.

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*C. M. Krishna
Kang G. Shin*

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