Modular Verification of Timed Circuits Using Automatic Abstraction

Hao Zheng, Eric Mercer, *Member, IEEE*, and Chris Myers, *Member, IEEE*

Abstract—The major barrier that prevents the application of formal verification to large designs is state explosion. This paper presents a new approach for verification of timed circuits using automatic abstraction. This approach partitions the design into modules, each with constrained complexity. Before verification is applied to each individual module, irrelevant information to the behavior of the selected module is abstracted away. This approach converts a verification problem with big exponential complexity to a set of sub-problems, each with small exponential complexity. Experimental results are promising in that they indicate that our approach has the potential of completing much faster while using less memory than traditional flat analysis.

Index Terms—timed circuits, modular verification, abstraction.

I. INTRODUCTION

IN order to continue to produce circuits of increasing speed, designers are considering aggressive circuit styles such as self-resetting or delayed-reset domino circuits. These circuit styles can achieve a significant improvement in circuit speed as demonstrated by their use in a gigahertz research microprocessor (guTS) at IBM [1]. Designers are also considering asynchronous circuits due to their potential for higher performance and lower power consumption as demonstrated by the RAPPID instruction length decoder designed at Intel [2]. This design was 3 times faster while using only half the power of the synchronous design. The correctness of these new *timed circuit* styles is highly dependent upon their timing parameters, so extensive timing verification is necessary during the design process. Unfortunately, these new circuit styles cannot be efficiently and accurately verified using traditional static timing analysis methods. This lack of efficient analysis tools is one of the reasons for the lack of mainstream acceptance of these circuit styles.

In [3], a hierarchical approach to verification based on trace theory is proposed for the analysis of speed-independent circuits. In this approach, a model of a circuit at one level is regarded as the implementation of the model at the higher level and as the specification of the model at the lower level. The model at the higher level is more abstract and has less implementation details. A circuit is a correct implementation if it conforms to its specification. Trace theory has proved to

be an excellent model for verifying circuits, and it is trace theory that this paper utilizes to justify its approach.

In [4], [5], trace theory is extended with a representation where time is modeled as multiples of a discretization constant. Unfortunately, the state space explodes if the delay ranges are large and the discretization constant is set small enough to ensure exact exploration of the state space. In [6], timed automata are introduced to model the behavior of real-time systems. It provides a simple and general way to annotate state-transition graphs with timing constraints using a finite number of real-valued *clocks*. Although this approach eliminates the need to discretize time, the number of timed states is dependent on the size of the delay ranges and number of concurrently enabled clocks which can quickly explode for even relatively small systems. Representing possible clock values with convex polygons, or zones, [7] alleviates this problem in practice. The zone based representation is the one used by most modern timing verifiers such as ATACS [8]–[10], VINAS-P [11], ORBITS [12], [13], KRONOS [14], and UPPAAL [15]. One feature common to these tools is that they require state space exploration which can explode even for modest size examples.

There do exist many methods and approaches to address the state explosion problem. In [16], [17], the state space of a transition system is represented symbolically using Bryant's *ordered binary decision diagram* [18]. The symbolic approach has been shown to be capable of representing systems with more than 10^{20} states. There has been some success at the verification of timed systems using binary decision diagrams [19], [20]. Asynchronous systems consist of concurrent processes without a global synchronizing clock. State explosion is particularly serious for asynchronous systems because all possible interleavings among concurrently executed events need to be explored. A number of techniques have been proposed to minimize the number of interleavings that are explored, including stubborn sets [21], partial orders [22], and unfoldings [23]. There has also been some success at applying partial orders to formal timing verification [11], [24]. Although the approaches described above have been successful in verifying systems with increased sizes, many realistic systems are still too large to be handled.

In practice, circuits often have inherent modular structures. Compositional verification methods based on *assume-guarantee reasoning* [25]–[27], exploit the modular structure of circuits. Verifying a circuit component in this approach necessitates behavioral assumptions on connecting components to reduce complexity in the model. The assumptions must later be discharged as part of the correctness proof for connecting

Modular Verification Of Timed Circuits Using Automatic

Thomas Ottmann

Modular Verification Of Timed Circuits Using Automatic:

Automated Technology for Verification and Analysis Susanne Graf,Wenhui Zhang,2006-10-11 This book constitutes the refereed proceedings of the Third International Symposium on Automated Technology for Verification and Analysis ATVA 2006 held in Beijing China in October 2006 The 35 revised full papers presented together with abstracts of three keynote papers were carefully reviewed and selected from 137 submissions **Modular Synthesis and Verification of Timed Circuits Using Automatic Abstraction** Hao Zheng,2001 Model Checking Software Alastair Donaldson,David Parker,2012-07-18 This book constitutes the thoroughly refereed proceedings of the 19th International SPIN workshop on Model Checking Software SPIN 2012 held in Oxford UK in July 2012 The 11 revised full papers presented together with 5 tool papers and 4 invited talks were carefully reviewed and selected from 30 submissions The papers are grouped in topical sections on model checking techniques parallel model checking case studies model checking for concurrency and tool demonstrations **Formal Modeling and Analysis of Timed Systems** Kim G. Larsen,Peter Niebert,2004-04-08 This book constitutes the thoroughly refereed post proceedings of the First International Workshop on Formal Modeling and Analysis of Timed Systems FORMATS 2003 held in Marseille France in September 2003 The 19 revised full papers presented together with an invited paper and the abstracts of two invited talks were carefully selected from 36 submissions during two rounds of reviewing and improvement All current aspects of formal method for modeling and analyzing timed systems are addressed among the timed systems dealt with are timed automata timed Petri nets max plus algebras real time systems discrete time systems timed languages and real time operating systems *10th International Symposium on Asynchronous Circuits and Systems* ,2004 IEEE Computer Society Order Number P2133 T p verso **Automata, Languages and Programming** Thomas Ottmann,1987-07-08 This volume contains the proceedings of the 14th International Colloquium on Automata Languages and Programming organized by the European Association for Theoretical Computer Science EATCS and held in Karlsruhe July 13 17 1987 The papers report on original research in theoretical computer science and cover topics such as algorithms and data structures automata and formal languages computability and complexity theory semantics of programming languages program specification transformation and verification theory of data bases logic programming theory of logical design and layout parallel and distributed computation theory of concurrency symbolic and algebraic computation term rewriting systems cryptography and theory of robotics The authors are young scientists and leading experts in these areas **Digest of Technical Papers** International Conference on Computer-Aided Design,1984 *25 Years of Model Checking* Orna Grumberg,Helmut Veith,2008-06-17 This Festschrift volume published in celebration of the 25th Anniversary of Model Checking features papers based on talks at the symposium 25 Years of Model Checking 25MC which was part of the 18th International Conference on Computer Aided Verification Deductive Program Design Manfred Broy,1996-06-18 Advanced research on the description of distributed systems and on design calculi for software and

hardware is presented in this volume Distinguished researchers give an overview of the latest state of the art

Dissertation Abstracts International ,2002   **American Doctoral Dissertations** ,2001   *Computer-aided Verification* ,2001   **XI Brazilian Symposium on Integrated Circuit Design** Marcelo Lubaszewski,Vladimir Castro Alves,1998 Topics in this book on integrated circuit design include hardware software codesign of embedded systems the ALFA HUERTA project rapid prototyping digital testing and digital design   Computer and Information Sciences - ISCIS ... ,2004

Languages for Parallel Architectures J. W. de Bakker,1989-11-24 Presents mathematical methods for modelling parallel computer architectures based on the results of ESPRIT s project 415 on computer languages for parallel architectures Presented here are investigations incorporating a wide variety of programming styles including functional logic and object oriented paradigms Topics covered include Philips parallel object oriented language POOL lazy functional languages the languages IDEAL K LEAF FP2 and Petri net semantics for the AADL language   *CONCUR '92* Walter Rance Cleaveland,1992 This book contains a selection of research papers describing recent advancesin the theory of concurrent systems and their applications The papers were all presented at the CONCUR 92 conference which has emerged as the premiere conference on formal aspects of concurrency The authors include such prominent researchers as R Milner A Pnueli N Lynch and V R Pratt The results represent advances in the mathematical understanding of the behavior of concurrent systems topics covered include process algebras models of true concurrency compositional verification techniques temporal logic verification case studies models of probabilistic and real time systems models of systems with dynamic structure and algorithms and decidability results for system analysis A key feature of CONCUR is its breadth in one volume it presents a snapshot of the state of the art in concurrency theory Assuch it is indispensible to researchers and would be researchers in theformal analysis of concurrent systems PUBLISHER S WEBSITE   **Protocol Specification, Testing, and Verification, IX** Ed Brinksma,Giuseppe Scollo,Chris A. Vissers,1990 Researchers and practitioners concerned with the application of formal methods to the design description analysis implementation and testing of open systems contributed to this book It is the ninth in a successful series of annual volumes   *Twelfth International Conference on VLSI Design* VLSI Society of India,IEEE Circuits and Systems Society,1999 The proceedings of the January 1999 conference consist of 103 papers 11 talks and six tutorials The papers are grouped under the headings of TCAD to ECAD low power testing co design and synthesis analog design multi valued logic verification digital signal processor DSP logic synthesis   Fundamentals of Computation Theory ,1999   *Westinghouse Engineer* ,1967

Modular Verification Of Timed Circuits Using Automatic Book Review: Unveiling the Power of Words

In some sort of driven by information and connectivity, the ability of words has become more evident than ever. They have the ability to inspire, provoke, and ignite change. Such is the essence of the book **Modular Verification Of Timed Circuits Using Automatic**, a literary masterpiece that delves deep to the significance of words and their effect on our lives. Published by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we shall explore the book is key themes, examine its writing style, and analyze its overall affect readers.

https://matrix.jamesarcher.co/book/publication/Documents/hardcover%20home%20diy%20manual.pdf

Table of Contents Modular Verification Of Timed Circuits Using Automatic

Modular Verification Of Timed Circuits Using Automatic Introduction

Modular Verification Of Timed Circuits Using Automatic Offers over 60,000 free eBooks, including many classics that are in the public domain. Open Library: Provides access to over 1 million free eBooks, including classic literature and contemporary works. Modular Verification Of Timed Circuits Using Automatic Offers a vast collection of books, some of which are available for free as PDF downloads, particularly older books in the public domain. Modular Verification Of Timed Circuits Using Automatic : This website hosts a vast collection of scientific articles, books, and textbooks. While it operates in a legal gray area due to copyright issues, its a popular resource for finding various publications. Internet Archive for Modular Verification Of Timed Circuits Using Automatic : Has an extensive collection of digital content, including books, articles, videos, and more. It has a massive library of free downloadable books. Free-eBooks Modular Verification Of Timed Circuits Using Automatic Offers a diverse range of free eBooks across various genres. Modular Verification Of Timed Circuits Using Automatic Focuses mainly on educational books, textbooks, and business books. It offers free PDF downloads for educational purposes. Modular Verification Of Timed Circuits Using Automatic Provides a large selection of free eBooks in different genres, which are available for download in various formats, including PDF. Finding specific Modular Verification Of Timed Circuits Using Automatic, especially related to Modular Verification Of Timed Circuits Using Automatic, might be challenging as theyre often artistic creations rather than practical blueprints. However, you can explore the following steps to search for or create your own Online Searches: Look for websites, forums, or blogs dedicated to Modular Verification Of Timed Circuits Using Automatic, Sometimes enthusiasts share their designs or concepts in PDF format. Books and Magazines Some Modular Verification Of Timed Circuits Using Automatic books or magazines might include. Look for these in online stores or libraries. Remember that while Modular Verification Of Timed Circuits Using Automatic, sharing copyrighted material without permission is not legal. Always ensure youre either creating your own or obtaining them from legitimate sources that allow sharing and downloading. Library Check if your local library offers eBook lending services. Many libraries have digital catalogs where you can borrow Modular Verification Of Timed Circuits Using Automatic eBooks for free, including popular titles.Online Retailers: Websites like Amazon, Google Books, or Apple Books often sell eBooks. Sometimes, authors or publishers offer promotions or free periods for certain books.Authors Website Occasionally, authors provide excerpts or short

stories for free on their websites. While this might not be the Modular Verification Of Timed Circuits Using Automatic full book , it can give you a taste of the authors writing style.Subscription Services Platforms like Kindle Unlimited or Scribd offer subscription-based access to a wide range of Modular Verification Of Timed Circuits Using Automatic eBooks, including some popular titles.

FAQs About Modular Verification Of Timed Circuits Using Automatic Books

How do I know which eBook platform is the best for me? Finding the best eBook platform depends on your reading preferences and device compatibility. Research different platforms, read user reviews, and explore their features before making a choice. Are free eBooks of good quality? Yes, many reputable platforms offer high-quality free eBooks, including classics and public domain works. However, make sure to verify the source to ensure the eBook credibility. Can I read eBooks without an eReader? Absolutely! Most eBook platforms offer web-based readers or mobile apps that allow you to read eBooks on your computer, tablet, or smartphone. How do I avoid digital eye strain while reading eBooks? To prevent digital eye strain, take regular breaks, adjust the font size and background color, and ensure proper lighting while reading eBooks. What the advantage of interactive eBooks? Interactive eBooks incorporate multimedia elements, quizzes, and activities, enhancing the reader engagement and providing a more immersive learning experience. Modular Verification Of Timed Circuits Using Automatic is one of the best book in our library for free trial. We provide copy of Modular Verification Of Timed Circuits Using Automatic in digital format, so the resources that you find are reliable. There are also many Ebooks of related with Modular Verification Of Timed Circuits Using Automatic. Where to download Modular Verification Of Timed Circuits Using Automatic online for free? Are you looking for Modular Verification Of Timed Circuits Using Automatic PDF? This is definitely going to save you time and cash in something you should think about.

Find Modular Verification Of Timed Circuits Using Automatic :

hardcover home DIY manual
collection music theory manual
children bedtime story novel
framework investing simplified
trauma healing workbook hardcover
reference math workbook grade 1

manual book paranormal romance series
award winning AI in everyday life
collection cozy mystery bookshop
coloring activity book how to
step by step cybersecurity basics
photography manual how to
music theory manual hardcover
award winning Bookstagram favorite
fitness training manual 2025 edition

Modular Verification Of Timed Circuits Using Automatic :

Descartes: Meditations on First Philosophy: With ... - Amazon This authoritative translation by John Cottingham of the Meditations is taken from the much acclaimed three-volume Cambridge edition of the Philosophical ... Descartes: Meditations on First Philosophy: With ... This is an updated edition of John Cottingham's acclaimed translation of Descartes's philosophical masterpiece, including an abridgement of Descartes's ... Descartes: Meditations on First Philosophy René Descartes. Edited by John Cottingham, University of Reading. Introduction by Bernard Williams. Publisher: Cambridge University Press; Online publication ... Meditations on First Philosophy René Descartes was born at La Haye near Tours on 31 March. 1596. He was educated at the Jesuit Collège de la Flèche in Anjou, and. Meditations on First Philosophy by Rene Descartes Source: Meditations on First Philosophy in which are demonstrated the existence of God and the distinction between the human soul and the body, by René ... Meditations on First Philosophy, with Selections from the ... Meditations on First Philosophy, with Selections from the Objections and Replies. René Descartes, John Cottingham (Translator), Bernard Williams (Introduction). René Descartes: Meditations on First Philosophy Publisher: Cambridge University Press; Online publication date: May 2013; Print publication year: 2013; Online ISBN: 9781139042895 ... John Cottingham (ed.), René Descartes: Meditations on ... by J Cottingham · 1986 · Cited by 100 — Descartes's Meditations on First Philosophy, published in Latin in 1641, is one of the most widely studied philosophical texts of all time, and inaugurates many ... Descartes: Meditations on First Philosophy: With Selections ... Apr 18, 1996 — This authoritative translation by John Cottingham, taken from the much acclaimed three-volume Cambridge edition of the Philosophical Writings of ... Meditations On First Philosophy by R Descartes · Cited by 1055 — RENE DESCARTES. MEDITATIONS ON FIRST PHILOSOPHY deficiencies of my nature? And we cannot say that this idea of God is perhaps materially false and that ... Sample Hunter Safety Test Test your hunting knowledge with this 10 question hunter safety practice test. You need to answer 8 out of 10 questions correctly to pass!

Hunter Safety Education Course Practice Test with Answers Test your hunting knowledge with this free hunter safety education course practice test ... Which covers: Alabama, Alaska, Arizona, Arkansas, California, Colorado ... Home Study/On-line Hunter Education Course Each site has a substantial amount of information, and all have review tests. The Today's. Hunter, Huntercourse.com and Hunter Ed Course sites will give the ... Hunter Safety Practice Test - Quiz, Trivia & Questions Dec 13, 2023 — Take up this hunter safety practice test below and get to learn more about hunting safety while testing what you already know. Most people frown ... Study Guide | California Hunter Ed Course Study Guide for the Official California Hunter Ed Course. Everything you need to know to successfully pass your exam. Hunter Ed PRACTICE TEST Flashcards Study with Quizlet and memorize flashcards containing terms like primary objective of hunter education program is to _____., Name three hunting related ... Hunter Safety Test Practice One Flashcards Study with Quizlet and memorize flashcards containing terms like The primary objective of hunder education programs is to, What are three behaviors of a ... Hunting Safety Quiz — Texas Parks & Wildlife Department Hunting Safety Quiz. Important: You must print and take results of each quiz with you on the test date as proof of completion of this online course. Official California Hunter Safety Course - Online Watch this 73-second sample to see how we put you in the hunter's camo. Comprehensive Instruction in California Hunting Safety Education. This official training ... California Hunter Education California requires hunter education training for those who have never held a California hunting ... exam. The Online Course and Follow-up class is designed for ... The Botany of Desire: A Plant's-Eye View of the World It is the story of four plants: apples, tulips, cannabis and potatoes. Reflecting the theme of the title, there are four human desires that are associated with ... The Botany of Desire He masterfully links four fundamental human desires—sweetness, beauty, intoxication, and control—with the plants that satisfy them: the apple, the tulip, ... The Botany of Desire The Botany of Desire: A Plant's-Eye View of the World is a 2001 nonfiction book by journalist Michael Pollan. Pollan presents case studies mirroring four ... The Botany of Desire: A Plant's-Eye View of the World In The Botany of Desire, Michael Pollan ingeniously demonstrates how people and domesticated plants have formed a similarly reciprocal relationship. He ... The Botany of Desire (TV Movie 2009) Michael Pollan, a professor of journalism and a student of food, presents the history of four plants, each of which found a way to make itself essential to ... The Botany of Desire In The Botany of Desire, Michael Pollan ingeniously demonstrates how people and domesticated plants have formed a similarly reciprocal relationship. He ... The Botany of Desire (2009) Watch The Botany of Desire (2009) online. Documentary based on the book of the same name by Michael Pollan, looking at ways in which plants have found a way ... The Botany of Desire by Michael Pollan In The Botany of Desire, Michael Pollan ingeniously demonstrates how people and domesticated plants have formed a similarly reciprocal relationship. He ... The Botany of Desire: A Plant's-Eye View of the World A fascinating and disturbing account of man's strange relationship with plants and plant science. Michael Pollan inspires one to rethink basic attitudes. Botany of Desire A Plants Eye View of the World In The Botany of Desire, Michael

Pollan argues that the answer lies at the heart of the intimately reciprocal relationship between people and plants. In telling ...