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 the 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

This research is supported by NSF CAREER award MIP-9625014, SRC contracts 97-DJ-487, 99-TJ-694, and 2002-TJ-1024, and a grant from Intel Corporation.

H. Zheng is with IBM, Essex Junction, VT 05452.
E. Mercer is with Brigham Young University, Provo, UT 84602.
C. Myers is with the ECE Dept., University of Utah, Salt Lake City, UT 84112.

Modular Verification Of Timed Circuits Using Automatic

AN Whitehead

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 power of words has be evident than ever. They have the ability to inspire, provoke, and ignite change. Such could be the essence of the book **Modular Verification Of Timed Circuits Using Automatic**, a literary masterpiece that delves deep in to the significance of words and their impact on our lives. Compiled 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 impact on readers.

https://wwwnew.greenfirefarms.com/book/virtual-library/HomePages/magic_the_gathering_the_brothers_war_artifacts_cycle_book_1.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

What is a Modular Verification Of Timed Circuits Using Automatic PDF? A PDF (Portable Document Format) is a file format developed by Adobe that preserves the layout and formatting of a document, regardless of the software, hardware, or operating system used to view or print it. **How do I create a Modular Verification Of Timed Circuits Using Automatic PDF?** There are several ways to create a PDF: Use software like Adobe Acrobat, Microsoft Word, or Google Docs, which often have built-in PDF creation tools. Print to PDF: Many applications and operating systems have a "Print to PDF" option that allows you to save a document as a PDF file instead of printing it on paper. Online converters: There are various online tools that can convert different file types to PDF. **How do I edit a Modular Verification Of Timed Circuits Using Automatic PDF?** Editing a PDF can be done with software like Adobe Acrobat, which allows direct editing of text, images, and other elements within the PDF. Some free tools, like PDFescape or Smallpdf, also offer basic editing capabilities. **How do I convert a Modular Verification Of Timed Circuits Using Automatic PDF to another file format?** There are multiple ways to convert a PDF to another format: Use online converters like Smallpdf, Zamzar, or Adobe Acrobats export feature to convert PDFs to formats like Word, Excel, JPEG, etc. Software like Adobe Acrobat, Microsoft Word, or other PDF editors may have options to export or save PDFs in different formats. **How do I password-protect a Modular Verification Of Timed Circuits Using Automatic PDF?** Most PDF editing software allows you to add password protection. In Adobe Acrobat, for instance, you can go to "File" -> "Properties" -> "Security" to set a password to restrict access or editing capabilities. Are there any free alternatives to Adobe Acrobat for working with PDFs? Yes, there are many free alternatives for working with PDFs, such as: LibreOffice: Offers PDF editing features. PDFsam: Allows splitting, merging, and editing PDFs. Foxit Reader: Provides basic PDF viewing and editing capabilities. How do I compress a PDF file? You can use online tools like Smallpdf, ILovePDF, or desktop software like Adobe Acrobat to compress PDF files without significant quality loss. Compression reduces the file size, making it easier to share and download. Can I fill out forms in a PDF file? Yes, most PDF viewers/editors like Adobe Acrobat, Preview (on Mac), or various online tools allow you to fill out forms in PDF files by selecting text fields and entering information. Are there any restrictions when working with PDFs? Some PDFs might have restrictions set by their creator, such as password protection, editing restrictions, or print restrictions. Breaking these restrictions might require specific software or tools, which may or may not be legal depending on the circumstances and local laws.

Find Modular Verification Of Timed Circuits Using Automatic :

magic the gathering the brothers war artifacts cycle book 1
maintenance of electrical systems lab manual ebook www
love stargirl 2 jerry spinelli
lunchmoney lewis bills piano sheet blogspot com
makalah sistem pemilu di indonesia kumpulan makalah
managerial accounting 13th edition solutions
man machine chart
manhwa soul land 2 bahasa indonesia komikqa
mammals of the neotropics volume 2 the southern cone chile argentina uruguay paraguay eisenberg john f mammals of the neotropics
love by toni morrison
lullaby of birdland chords
ma islamiat notes in urdu
maintenance planning guide sap
longman exam skills proficiency listening and speaking audio cassettes
management meeting and exceeding customer expectations 10th edition

Modular Verification Of Timed Circuits Using Automatic :

John Deere Integral 31 Tiller Operators Manual 110 112 ... For sale is an original John Deere 31 Integral Rotary Tiller Operator's Manual. This tiller applied to the John Deere 110 and 112 Garden Tractors. John Deere - Service Manual 110 and 112 Lawn and ... This service manual contains service and maintenance information for JOM Deere 110 and. 112 Lawn and Garden Tractors (Serial. No. -100,000),. The manual is ... Manuals and Training | Parts & Service Download, view, and purchase operator and technical manuals and parts catalogs for your John Deere equipment. Download and purchase manuals and publications ... John Deere 110 112 Round Fender Garden Tractor & 30 ... John Deere 110 112 Round Fender Garden Tractor & 30 Tiller Owners(2 Manual s) ; Quantity. 1 available ; Item Number. 234419360906 ; Brand. John Deere ;

Compatible ... John Deere 110 and 112 Lawn and Garden Tractors John Deere 110 and 112 Lawn and Garden Tractors Operator's Manual. If you own a John Deere 110 or 112 Lawn and Garden Tractor, then you will want this ... Quick Reference Guides | Parts & Services | John Deere US Operator's Manual. You operate the best equipment. Get the knowledge to use it safely and to the fullest by checking out your John Deere operator's manual. John Deer Attachment Operator Manuals, J & D Lawn Tractor 42 Front Blade Serial # 5001 and up Operator's Manual for John Deere 110 and ... 48-Inch Rotary Tiller Operator's Manual, fits John Deere 318 and 420 31 tiller attachment to late 110 Mar 22, 2021 — I am working on attaching a 31 tiller to a late manual lift 110. I have the tiller and mule drive but no belts. The picture shows the rear ... John Deere 35 Rotary Tiller Manual This is the complete operator's manual for the John Deere 35 rotary tiller. This owner's manual contains information on operating, adjusting, ... Praxis English Language Arts: Content Knowledge Study ... The Praxis® English Language Arts: Content Knowledge test is designed to measure knowledge and competencies that are important for safe and effective beginning ... PRAXIS II 5038 Free Resources - Home Jul 29, 2019 — PRAXIS II 5038 Resources: Free Study Guide and Quizlet Flash Cards. ... Some free PRAXIS 2 resources for hopeful English teachers and English ... Praxis II English Language Arts Content Knowledge (5038) Praxis II English Language Arts Content Knowledge (5038): Study Guide and Practice Test Questions for the Praxis English Language Arts (ELA) Exam · Book ... Praxis English Language Arts: Content Knowledge (5038) ... Course Summary. This informative Praxis 5038 Course makes preparing for the Praxis English Language Arts: Content Knowledge Exam quick and easy. Praxis 5038 Eng Lang Arts Content Knowledge & Dg Guide The Praxis® 5038 English Language Arts Content Knowledge study guide is fully aligned to the skills and content categories assessed on the exam. Praxis® (5038) English Language Arts Study Guide Our Praxis® English Language Arts (5038) study guide includes 1000s of practice questions, video lessons and much more. Start studying today! Praxis II English Language Arts Content Knowledge (5038) Praxis II English Language Arts Content Knowledge (5038): Rapid Review Prep Book and Practice Test Questions for the Praxis English Language Arts Exam ... Praxis English Language Arts: Content Knowledge (5038) ... Oct 31, 2023 — The Praxis English Language Arts: Content Knowledge (5038) exam assesses the reading, language use, and writing skills of prospective ... Praxis ELA - Content Knowledge 5038 Practice Test This Praxis English Language Arts practice test will support your study process, and gives you a practice opportunity designed to simulate the real exam. The Essential Theatre by Brockett, Oscar G. - Amazon.com The Tenth Edition of THE ESSENTIAL THEATRE will inspire readers to become excited about theatre. The combined authorship of an authoritative theatre ... The Essential Theatre - Oscar Gross Brockett, Robert J. Ball The Tenth Edition of THE ESSENTIAL THEATRE will inspire readers to become excited about theatre. The combined authorship of an authoritative theatre ... The Essential Theatre by Oscar G. Brockett Robert J. Ball The Essential Theatre Review This The Essential Theatre book is not really ordinary book, you have it then the world is in your hands. The benefit you get by ... Amazon.com: The Essential Theatre, Enhanced FREE delivery December 28 - 29.

Details. Arrives after Christmas. Need a gift ... Cengage Learning; 10th edition (March 28, 2013). Language, English. Paperback ... Here is a link to almost any textbook's free PDF version. : r/unt Need a pdf for Essential Cell Biology 6th edition isbn: 978-1-324 ... Introduction to the Practice of Statistics, 10th edition. By David S ... Editions of The Essential Theatre by Oscar Gross Brockett The Essential Theatre 10th Edition. Published January 1st 2011 by Cengage ... Goodreadswww.goodreads.comFREE - In Google Play. View. The Essential Theatre, 11th Edition - Cengage Hardcopy textbook for Brockett/Ball//Fleming/Carlson's The Essential Theatre. Buy direct for hassle-free returns. Included in Cengage Unlimited. free read [pdf] The Essential Theatre - YUMPU Sep 15, 2022 — The Eleventh Edition includes an all-new chapter devoted to musical theatre, new Then and Now boxes that link theatre history to present-day, ... [PDF] The Essential Theatre by Oscar Brockett eBook - Perlego The Eleventh Edition includes an all-new chapter devoted to musical theatre, new "Then and Now" boxes that link theatre history to present-day, and numerous new ... Got my Theatre textbook today, and look who's on ... - Reddit It's The Essential Theatre: Tenth Edition by Oscar G. Brockett and Robert J. Ball. The ISBN is 9780495807971 so you can find the exact edition.