

Hardware Software Co Design

Jørgen Staunstrup, Wayne Wolf

Hardware Software Co Design:

A Practical Introduction to Hardware/Software Codesign Patrick R. Schaumont, 2010-09-09 This is a practical book for computer engineers who want to understand or implement hardware software systems It focuses on problems that require one to combine hardware design with software design such problems can be solved with hardware software codesign When used properly hardware software co sign works better than hardware design or software design alone it can improve the overall performance of digital systems and it can shorten their design time Hardware software codesign can help a designer to make trade offs between the exibility and the performance of a digital system To achieve this a designer needs to combine two radically different ways of design the sequential way of dec position in time using software with the parallel way of decomposition in space using hardware Intended Audience This book assumes that you have a basic understanding of hardware that you are miliar with standard digital hardware components such as registers logic gates and components such as multiplexers and arithmetic operators. The book also assumes that you know how to write a program in C These topics are usually covered in an introductory course on computer engineering or in a combination of courses on digital design and software engineering Hardware/Software Co-Design Giovanni DeMicheli, M.G. Sami, 2013-11-11 Concurrent design or co design of hardware and software is extremely important for meeting design goals such as high performance that are the key to commercial competitiveness Hardware Software Co Design covers many aspects of the subject including methods and examples for designing 1 general purpose and embedded computing systems based on instruction set processors 2 telecommunication systems using general purpose digital signal processors as well as application specific instruction set processors 3 embedded control systems and applications to automotive electronics. The book also surveys the areas of emulation and prototyping systems with field programmable gate array technologies hardware software synthesis and verification and industrial design trends Most contributions emphasize the design methodology the requirements and state of the art of computer aided co design tools together with current design examples Hardware/Software Co-Design Jørgen Staunstrup, Wayne Wolf, 2013-04-17 Introduction to Hardware Software Co Design presents a number of issues of fundamental importance for the design of integrated hardware software products such as embedded communication and multimedia systems This book is a comprehensive introduction to the fundamentals of hardware software co design Co design is still a new field but one which has substantially matured over the past few years This book written by leading international experts covers all the major topics including fundamental issues in co design hardware software co synthesis algorithms prototyping and emulation target architectures compiler techniques specification and verification system level specification Special chapters describe in detail several leading edge co design systems including Cosyma LYCOS and Cosmos Introduction to Hardware Software Co Design contains sufficient material for use by teachers and students in an advanced course of hardware software co design It also contains extensive explanation of the fundamental concepts of the

subject and the necessary background to bring practitioners up to date on this increasingly important topic

Hardware/Software Co-Design and Co-Verification Jean-Michel Bergé, Oz Levia, Jacques Rouillard, 2013-03-09 Co Design is the set of emerging techniques which allows for the simultaneous design of Hardware and Software In many cases where the application is very demanding in terms of various performances time surface power consumption trade offs between dedicated hardware and dedicated software are becoming increasingly difficult to decide upon in the early stages of a design Verification techniques such as simulation or proof techniques that have proven necessary in the hardware design must be dramatically adapted to the simultaneous verification of Software and Hardware Describing the latest tools available for both Co Design and Co Verification of systems Hardware Software Co Design and Co Verification offers a complete look at this evolving set of procedures for CAD environments The book considers all trade offs that have to be made when co designing a system Several models are presented for determining the optimum solution to any co design problem including partitioning architecture synthesis and code generation When deciding on trade offs one of the main factors to be considered is the flow of communication especially to and from the outside world This involves the modeling of communication protocols An approach to the synthesis of interface circuits in the context of co design is presented Other chapters present a co design oriented flexible component data base and retrieval methods a case study of an ethernet bridge designed using LOTOS and co design methodologies and finally a programmable user interface based on monitors Hardware Software Co Design and Co Verification will help designers and researchers to understand these latest techniques in system design and as such will be of interest to all involved in embedded system design The Codesign of Embedded Systems: A Unified

Hardware/Software Representation Sanjaya Kumar, James H. Aylor, Barry W. Johnson, Wm.A. Wulf, 1995-11-30 Current practice dictates the separation of the hardware and software development paths early in the design cycle These paths remain independent with very little interaction occurring between them until system integration In particular hardware is often specified without fully appreciating the computational requirements of the software Also software development does not influence hardware development and does not track changes made during the hardware design phase Thus the ability to explore hardware software tradeoffs is restricted such as the movement of functionality from the software domain to the hardware domain and vice versa or the modification of the hardware software interface As a result problems that are encountered during system integration may require modification of the software and or hardware resulting in potentially significant cost increases and schedule overruns To address the problems described above a cooperative design approach one that utilizes a unified view of hardware and software is described This approach is called hardware software codesign The Codesign of Embedded Systems develops several fundamental hardware software codesign concepts and a methodology that supports them A unified representation referred to as a decomposition graph is presented which can be used to describe hardware or software using either functional abstractions or data abstractions Using a unified representation based on

functional abstractions an abstract hardware software model has been implemented in a common simulation environment called ADEPT Advanced Design Environment Prototyping Tool This model permits early hardware software evaluation and tradeoff exploration Techniques have been developed which support the identification of software bottlenecks and the evaluation of design alternatives with respect to multiple metrics. The application of the model is demonstrated on several examples A unified representation based on data abstractions is also explored This work leads to investigations regarding the application of object oriented techniques to hardware design The Codesign of Embedded Systems A Unified Hardware Software Representation describes a novel approach to a topic of immense importance to CAD researchers and designers A Practical Introduction to Hardware/Software Codesign Patrick R. Schaumont, 2012-11-27 This textbook serves as an introduction to the subject of embedded systems design with emphasis on integration of custom hardware components with software The key problem addressed in the book is the following how can an embedded systems designer strike a balance between flexibility and efficiency The book describes how combining hardware design with software design leads to a solution to this important computer engineering problem The book covers four topics in hardware software codesign fundamentals the design space of custom architectures the hardware software interface and application examples The book comes with an associated design environment that helps the reader to perform experiments in hardware software codesign Each chapter also includes exercises and further reading suggestions Improvements in this second edition include labs and examples using modern FPGA environments from Xilinx and Altera which will make the material in this book applicable to a greater number of courses where these tools are already in use More examples and exercises have been added throughout the book If I were teaching a course on this subject I would use this as a resource and text If I were a student who wanted to learn codesign I would look for a course that at least used a similar approach If I were an engineer or engineering manager who wanted to learn more about codesign from a very practical perspective I would read this book first before any other When I first started learning about codesign as a practitioner a book like this would have been the perfect introduction Grant Martin Tensilica The Codesign of Embedded Systems Sanjaya Kumar, James H Aylor, Barry W Johnson, 1995-11-01

System Level Hardware/Software Co-Design Joris van den Hurk, Jochen A.G. Jess, 1997-12-31 Hierarchical design methods were originally introduced for the design of digital ICs and they appeared to provide for significant advances in design productivity Time to Market and first time right design These concepts have gained increasing importance in the semiconductor industry in recent years In the course of time the supportive quality of hierarchical methods and their advantages were confirmed System Level Hardware Software Co design An Industrial Approach demonstrates the applicability of hierarchical methods to hardware software codesign and mixed analogue digital design following a similar approach Hierarchical design methods provide for high levels of design support both in a qualitative and a quantitative sense In the qualitative sense the presented methods support all phases in the product life cycle of electronic products ranging

from requirements analysis to application support Hierarchical methods furthermore allow for efficient digital hardware design hardware software codesign and mixed analogue digital design on the basis of commercially available formalisms and design tools In the quantitative sense hierarchical methods have prompted a substantial increase in design productivity System Level Hardware Software Co design An Industrial Approach reports on a six year study during which time the number of square millimeters of normalized complexity an individual designer contributed every week rose by more than a factor of five Hierarchical methods therefore enabled designers to keep track of the ever increasing design complexity while effectively reducing the number of design iterations in the form of redesigns System Level Hardware Software Co design An Industrial Approach is the first book to provide a comprehensive coherent system design methodology that has been proven to increase productivity in industrial practice The book will be of interest to all managers designers and researchers working in the semiconductor industry Hardware/Software Co-Design for Data Flow Dominated Embedded Systems Ralf Niemann, 1998-10-31 Introduces different tasks of hardware software co design including system specification hardware software partitioning co synthesis and co simulation Summarizes and classifies co design tools and methods for these tasks and presents the co design tool COOL useful for solving co design tasks for the class of data flow dominated embedded systems Primary emphasis is on hardware software partitioning and the co synthesis phase and their coupling A mathematical formulation of the hardware software partitioning problem is given and several novel approaches are presented and compared for solving the partitioning problem Annotation copyrighted by Book News Inc Portland OR The Codesign of Embedded Systems: A Unified Hardware/Software Representation Sanjaya Kumar, James H. Aylor, Barry W. Johnson, Wm.A. Wulf, 1995-11-30 Current practice dictates the separation of the hardware and software development paths early in the design cycle These paths remain independent with very little interaction occurring between them until system integration In particular hardware is often specified without fully appreciating the computational requirements of the software Also software development does not influence hardware development and does not track changes made during the hardware design phase Thus the ability to explore hardware software tradeoffs is restricted such as the movement of functionality from the software domain to the hardware domain and vice versa or the modification of the hardware software interface As a result problems that are encountered during system integration may require modification of the software and or hardware resulting in potentially significant cost increases and schedule overruns To address the problems described above a cooperative design approach one that utilizes a unified view of hardware and software is described This approach is called hardware software codesign The Codesign of Embedded Systems develops several fundamental hardware software codesign concepts and a methodology that supports them A unified representation referred to as a decomposition graph is presented which can be used to describe hardware or software using either functional abstractions or data abstractions Using a unified representation based on functional abstractions an abstract hardware software model has been implemented

in a common simulation environment called ADEPT Advanced Design Environment Prototyping Tool This model permits early hardware software evaluation and tradeoff exploration Techniques have been developed which support the identification of software bottlenecks and the evaluation of design alternatives with respect to multiple metrics. The application of the model is demonstrated on several examples A unified representation based on data abstractions is also explored This work leads to investigations regarding the application of object oriented techniques to hardware design The Codesign of Embedded Systems A Unified Hardware Software Representation describes a novel approach to a topic of immense importance to CAD researchers and designers alike A Practical Introduction to Hardware/Software Codesign Springer, 2012-11-26 Practical Introduction to Hardware/Software Codesign Patrick Schaumont, 2011-03-02 This is a practical book for computer engineers who want to understand or implement hardware software systems It focuses on problems that require one to combine hardware design with software design such problems can be solved with hardware software codesign When used properly hardware software co sign works better than hardware design or software design alone it can improve the overall performance of digital systems and it can shorten their design time Hardware software codesign can help a designer to make trade offs between the exibility and the performance of a digital system To achieve this a designer needs to combine two radically different ways of design the sequential way of dec position in time using software with the parallel way of decomposition in space using hardware Intended Audience This book assumes that you have a basic understanding of hardware that you are miliar with standard digital hardware components such as registers logic gates and components such as multiplexers and arithmetic operators The book also assumes that you know how to write a program in C These topics are usually covered in an introductory course on computer engineering or in a combination of courses on digital design and software engineering Hardware/Software Co-Design for Data Flow Dominated Embedded Systems Ralf Niemann, 1998-11-14 Many of the modern applications of microelectronics require hugeamounts of computations Despite all recent improvements in fabrication technologies some of these computations have to be performed in hardware in order to meet deadlines However controlling computations by software is frequently pre ferred due to the larger flexibility Hence in general modern applications re quire a mix of software based and hardware based computations Applications using this mix can be designed with the help of hardware software co design systems Many such co design systems have been described so far references can be found in this book but many of these are based on heuristics In this book Niemann describes a co design system which is based on sound modeling techniques This system has the following salient features Precise cost and performance figures Design decisions for implementing a certain function in hardware or software are based on cost and performance figures for the different design alternatives Hence good designs can only be expected if these figures are accurate In order to achieve excellent accuracy Niemann takes a new approach the cost of software implementations is derived from the data available about the target processors and from knowledge about the code size the performance of

software implement at ions is computed by compiling the given function and then using static analysis for computing worst case execution times the cost of hardware implementation is estimated by running higher level synthesis tools the performance of hardware implementations is again computed by us ing static analysis **Dedicated Digital Processors** F. Mayer-Lindenberg, 2004-04-02 The recent evolution of digital technology has resulted in the design of digital processors with increasingly complex capabilities The implementation of hardware software co design methodologies provides new opportunities for the development of low power high speed DSPs and processor networks Dedicated digital processors are digital processors with an application specific computational task Dedicated Digital Processors presents an integrated and accessible approach to digital processor design principles processes and implementations based upon the author s considerable experience in teaching digital systems design and digital signal processing Emphasis is placed on presentation of hardware software co design methods with examples and illustrations provided throughout the text System on a chip and embedded systems are described and examples of high speed real time processing are given Coverage of standard and emerging DSP architectures enable the reader to make an informed selection when undertaking their own designs Presents readers with the elementary building blocks for the design of digital hardware systems and processor networks Provides a unique evaluation of standard DSP architectures whilst providing up to date information on the latest architectures including the TI 55x and TigerSharc chip families and the Virtex FPGA field programmable gate array Introduces the concepts and methodologies for describing and designing hardware VHDL is presented and used to illustrate the design of a simple processor A practical overview of hardware software codesign with design techniques and considerations illustrated with examples of real world designs Fundamental reading for graduate and senior undergraduate students of computer and electronic engineering and Practicing engineers developing DSP applications A Methodology for Hardware-software Codesign Myron Decker King, Massachusetts Institute of Technology. Department of Electrical Engineering and Computer Science, 2013 Special purpose hardware is vital to embedded systems as it can simultaneously improve performance while reducing power consumption The integration of special purpose hardware into applications running in software is difficult for a number of reasons Some of the difficulty is due to the difference between the models used to program hardware and software but great effort is also required to coordinate the simultaneous execution of the application running on the microprocessor with the accelerated kernel s running in hardware To further compound the problem current design methodologies for embedded applications require an early determination of the design partitioning which allows hardware and software to be developed simultaneously each adhering to a rigid interface contract This approach is problematic because often a good hardware software decomposition is not known until deep into the design process Fixed interfaces and the burden of reimplementation prevent the migration of functionality motivated by repartitioning This thesis presents a two part solution to the integration of special purpose hardware into applications running in software The first part addresses the

problem of generating infrastructure for hardware accelerated applications. We present a methodology in which the application is represented as a dataflow graph and the computation at each node is specified for execution either in software or as specialized hardware using the programmer's language of choice An interface compiler as been implemented which takes as input the FIFO edges of the graph and generates code to connect all the different parts of the program including those which communicate across the hardware software boundary This methodology which we demonstrate on an FPGA platform enables programmers to effectively exploit hardware acceleration without ever leaving the application space The second part of this thesis presents an implementation of the Bluespec Codesign Language BCL to address the difficulty of experimenting with hardware software partitioning alternatives Based on guarded atomic actions BCL can be used to specify both hardware and low level software Based on Bluespec SystemVerilog BSV for which a hardware compiler by Bluespec Inc is commercially available BCL has been augmented with extensions to support more efficient software generation In BCL the programmer specifies the entire design including the partitioning allowing the compiler to synthesize efficient software and hardware along with transactors for communication between the partitions The benefit of using a single language to express the entire design is that a programmer can easily experiment with many different hardware software decompositions without needing to re write the application code Used together the BCL and interface compilers represent a comprehensive solution to the task of integrating specialized hardware into an application Handbook of Hardware/Software Codesign Soonhoi Ha, Jürgen Teich, 2018-02-25 This handbook presents fundamental knowledge on the hardware software HW SW codesign methodology Contributing expert authors look at key techniques in the design flow as well as selected codesign tools and design environments building on basic knowledge to consider the latest techniques The book enables readers to gain real benefits from the HW SW codesign methodology through explanations and case studies which demonstrate its usefulness Readers are invited to follow the progress of design techniques through this work which assists readers in following current research directions and learning about state of the art techniques Students and researchers will appreciate the wide spectrum of subjects that belong to the design methodology from this handbook Hardware/Software Co-Design Giovanni Demicheli, Mariagiovanna Sami, 2014-01-15 **Readings in Hardware/Software Co-Design** Giovanni De Micheli, Rolf Ernst, Wayne Wolf, 2002 This title serves as an introduction ans reference for the field with the papers that have shaped the hardware software co design since its inception in the early 90s Embedded Systems - A Hardware-Software Co-Design Approach Bashir I Morshed, 2021-04-19 This textbook introduces the concept of embedded systems with exercises using Arduino Uno It is intended for advanced undergraduate and graduate students in computer science computer engineering and electrical engineering programs It contains a balanced discussion on both hardware and software related to embedded systems with a focus on co design aspects Embedded systems have applications in Internet of Things IoT wearables self driving cars smart devices cyberphysical systems drones and robotics. The hardware chapter discusses various microcontrollers including popular microcontroller hardware examples sensors amplifiers filters actuators wired and wireless communication topologies schematic and PCB designs and much more The software chapter describes OS less programming bitmath polling interrupt timer sleep modes direct memory access shared memory mutex and smart algorithms with lots of C code examples for Arduino Uno Other topics discussed are prototyping testing verification reliability optimization and regulations Appropriate for courses on embedded systems microcontrollers and instrumentation this textbook teaches budding embedded system programmers practical skills with fun projects to prepare them for industry products Introduces embedded systems for wearables Internet of Things IoT robotics and other smart devices Offers a balanced focus on both hardware and software co design of embedded systems Includes exercises tutorials and assignments

Hardware-Software Co-Design of Embedded Systems F. Balarin, Paolo Giusto, Attila Jurecska, Claudio Passerone, Ellen Sentovich, Bassam Tabbara, M. Chiodo, Harry Hsieh, Luciano Lavagno, Alberto Sangiovanni-Vincentelli, Kei Suzuki, 2012-12-06 Embedded systems are informally defined as a collection of programmable parts surrounded by ASICs and other standard components that interact continuously with an environment through sensors and actuators. The programmable parts include micro controllers and Digital Signal Processors DSPs Embedded systems are often used in life critical situations where reliability and safety are more important criteria than performance Today embedded systems are designed with an ad hoc approach that is heavily based on earlier experience with similar products and on manual design. Use of higher level languages such as C helps structure the design somewhat but with increasing complexity it is not sufficient Formal verification and automatic synthesis of implementations are the surest ways to guarantee safety. Thus the POLIS system which is a co-design environment for embedded systems is based on a formal model of computation POLIS was initiated in 1988 as a research project at the University of California at Berkeley and over the years grew into a full design methodology with a software system supporting it Hardware Software. Co Design of Embedded Systems. The POLIS Approach is intended to give a complete overview of the POLIS system including its formal and algorithmic aspects Hardware Software. Co Design of Embedded Systems. The POLIS Approach will be of interest to embedded system designers automotive electronics consumer electronics and telecommunications micro controller designers.

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