# EMBEDDED SYSTEM DESGIN

## A Unified hardware/Software Introduction

Frank Vahid

Tony Givargis

WILEY

# Embedded Systems Design A Unified Hardware Software Introduction

**Pong P. Chu**

**Embedded Systems Design A Unified Hardware Software Introduction:**

**Embedded System Design** Frank Vahid,Tony D. Givargis,2001-10-17 This book introduces a modern approach to embedded system design presenting software design and hardware design in a unified manner It covers trends and challenges introduces the design and use of single purpose processors hardware and general purpose processors software describes memories and buses illustrates hardware software tradeoffs using a digital camera example and discusses advanced computation models controls systems chip technologies and modern design tools For courses found in EE CS and other engineering departments **Embedded System Design** Frank Vahid,2007-04-03 Analysis and Synthesis of Distributed Real-Time Embedded Systems Paul Pop,Petru Eles,Zebo Peng,2013-03-19 Embedded computer systems are now everywhere from alarm clocks to PDAs from mobile phones to cars almost all the devices we use are controlled by embedded computers An important class of embedded computer systems is that of hard real time systems which have to fulfill strict timing requirements As real time systems become more complex they are often implemented using distributed heterogeneous architectures Analysis and Synthesis of Distributed Real Time Embedded Systems addresses the design of real time applications implemented using distributed heterogeneous architectures The systems are heterogeneous not only in terms of hardware components but also in terms of communication protocols and scheduling policies Regarding this last aspect time driven and event driven systems as well as a combination of the two are considered Such systems are used in many application areas like automotive electronics real time multimedia avionics medical equipment and factory systems The proposed analysis and synthesis techniques derive optimized implementations that fulfill the imposed design constraints An important part of the implementation process is the synthesis of the communication infrastructure which has a significant impact on the overall system performance and cost Analysis and Synthesis of Distributed Real Time Embedded Systems considers the mapping and scheduling tasks within an incremental design process To reduce the time to market of products the design of real time systems seldom starts from scratch Typically designers start from an already existing system running certain applications and the design problem is to implement new functionality on top of this system Supporting such an incremental design process provides a high degree of flexibility and can result in important reductions of design costs STRONGAnalysis and Synthesis of Distributed Real Time Embedded Systems will be of interest to advanced undergraduates graduate students researchers and designers involved in the field of embedded systems **The Essentials of Computer Organization and Architecture** Linda Null,Julia Lobur,2014-02-17 In its fourth edition this book focuses on real world examples and practical applications and encourages students to develop a big picture understanding of how essential organization and architecture concepts are applied in the computing world In addition to direct correlation with the ACM IEEE CS2013 guidelines for computer organization and architecture the text exposes readers to the inner workings of a modern digital computer through an integrated presentation of fundamental concepts and principles It includes the most up

to the minute data and resources available and reflects current technologies including tablets and cloud computing All new exercises expanded discussions and feature boxes in every chapter implement even more real world applications and current data and many chapters include all new examples **The Codesign of Embedded Systems: A Unified Hardware/Software Representation** Sanjaya Kumar,James H. Aylor,Barry W. Johnson,Wm.A. Wulf,2012-12-06 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 severalexamples 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 *Embedded SoPC Design with Nios II Processor and VHDL Examples* Pong P. Chu,2011-09-26 The book is divided into four major parts Part I covers HDL constructs and synthesis of basic digital circuits Part II provides an overview of embedded software development with the emphasis on low level I O access and drivers Part III demonstrates the design and development of hardware and software for several complex I O peripherals including PS2 keyboard and mouse a graphic video controller an audio codec and an SD secure digital card Part IV provides three case studies of the integration of hardware accelerators including a custom GCD greatest common divisor circuit a Mandelbrot set fractal circuit and an audio synthesizer based on DDFS direct digital frequency synthesis methodology The book utilizes FPGA devices Nios II soft core

processor and development platform from Altera Co which is one of the two main FPGA manufactures Altera has a generous university program that provides free software and discounted prototyping boards for educational institutions details at www altera com university The two main educational prototyping boards are known as DE1 99 and DE2 269 All experiments can be implemented and tested with these boards A board combined with this book becomes a turn key solution for the SoPC design experiments and projects Most HDL and C codes in the book are device independent and can be adapted by other prototyping boards as long as a board has similar I O configuration     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     *Embedded and Ubiquitous Computing* Edwin Sha,Sung-Kook Han,Cheng-Zhong Xu,Moon Hae Kim,Laurence T. Yang,Bin Xiao,2006-10-06 This book constitutes the refereed proceedings of the International Conference on Embedded and Ubiquitous Computing EUC 2006 held in Seoul Korea August 2006 The book presents 113 revised full papers together with 3 keynote articles organized in topical sections on power aware computing security and fault tolerance agent and distributed

computing wireless communications real time systems embedded systems multimedia and data management mobile computing network protocols middleware and P2P and more **Real-Time Systems Design and Analysis** Phillip A. Laplante,2004-04-26 The leading guide to real time systems design revised and updated This third edition of Phillip Laplante s bestselling practical guide to building real time systems maintains its predecessors unique holistic systems based approach devised to help engineers write problem solving software Dr Laplante incorporates a survey of related technologies and their histories complete with time saving practical tips hands on instructions C code and insights into decreasing ramp up times Real Time Systems Design and Analysis Third Edition is essential for students and practicing software engineers who want improved designs faster computation and ultimate cost savings Chapters discuss hardware considerations and software requirements software systems design the software production process performance estimation and optimization and engineering considerations This new edition has been revised to include Up to date information on object oriented technologies for real time including object oriented analysis design and languages such as Java C and C Coverage of significant developments in the field such as New life cycle methodologies and advanced programming practices for real time including Agile methodologies Analysis techniques for commercial real time operating system technology Hardware advances including field programmable gate arrays and memory technology Deeper coverage of Scheduling and rate monotonic theories Synchronization and communication techniques Software testing and metrics Real Time Systems Design and Analysis Third Edition remains an unmatched resource for students and practicing software engineers who want improved designs faster computation and ultimate cost savings **Embedded Systems** Santanu Chattopadhyay, **Springer Handbook of Automation** Shimon Y. Nof,2009-07-16 Automation is undergoing a major transformation in scope and dimension and plays an increasingly important role in the global economy and in our daily lives Engineers combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities This handbook incorporates these new developments and presents a widespread and well structured conglomeration of new emerging application areas of automation Besides manufacturing as a primary application of automation the handbook contains new application areas such as medical systems and health transportation security and maintenance service construction and retail as well as production or logistics This Springer Handbook is not only an ideal resource for automation experts but also for people new to this expanding field such as engineers medical doctors computer scientists designers It is edited by an internationally renowned and experienced expert **Computer Organization, Design, and Architecture, Fifth Edition** Sajjan G. Shiva,2013-12-20 Suitable for a one or two semester undergraduate or beginning graduate course in computer science and computer engineering Computer Organization Design and Architecture Fifth Edition presents the operating principles capabilities and limitations of digital computers to enable development of complex yet efficient systems With 50 percent updated material 11 new sections and four revised sections this edition takes

students through a solid up to date exploration of single and multiple processor systems embedded architectures and performance evaluation **Embedded Systems Handbook** Richard Zurawski,2005-08-16 Embedded systems are nearly ubiquitous and books on individual topics or components of embedded systems are equally abundant Unfortunately for those designers who thirst for knowledge of the big picture of embedded systems there is not a drop to drink Until now The Embedded Systems Handbook is an oasis of information offering a mix of basic a <u>Modeling and Optimization of Parallel and Distributed Embedded Systems</u> Arslan Munir,Ann Gordon-Ross,Sanjay Ranka,2015-12-28 This book introduces the state of the art in research in parallel and distributed embedded systems which have been enabled by developments in silicon technology micro electro mechanical systems MEMS wireless communications computer networking and digital electronics These systems have diverse applications in domains including military and defense medical automotive and unmanned autonomous vehicles The emphasis of the book is on the modeling and optimization of emerging parallel and distributed embedded systems in relation to the three key design metrics of performance power and dependability Key features Includes an embedded wireless sensor networks case study to help illustrate the modeling and optimization of distributed embedded systems Provides an analysis of multi core many core based embedded systems to explain the modeling and optimization of parallel embedded systems Features an application metrics estimation model Markov modeling for fault tolerance and analysis and queueing theoretic modeling for performance evaluation Discusses optimization approaches for distributed wireless sensor networks high performance and energy efficient techniques at the architecture middleware and software levels for parallel multicore based embedded systems and dynamic optimization methodologies Highlights research challenges and future research directions The book is primarily aimed at researchers in embedded systems however it will also serve as an invaluable reference to senior undergraduate and graduate students with an interest in embedded systems research **FPGA Prototyping by VHDL Examples** Pong P. Chu,2018-01-25 A hands on introduction to FPGA prototyping and SoC design This Second Edition of the popular book follows the same learning by doing approach to teach the fundamentals and practices of VHDL synthesis and FPGA prototyping It uses a coherent series of examples to demonstrate the process to develop sophisticated digital circuits and IP intellectual property cores integrate them into an SoC system on a chip framework realize the system on an FPGA prototyping board and verify the hardware and software operation The examples start with simple gate level circuits progress gradually through the RT register transfer level modules and lead to a functional embedded system with custom I O peripherals and hardware accelerators Although it is an introductory text the examples are developed in a rigorous manner and the derivations follow strict design guidelines and coding practices used for large complex digital systems The new edition is completely updated It presents the hardware design in the SoC context and introduces the hardware software co design concept Instead of treating examples as isolated entities the book integrates them into a single coherent SoC platform that allows readers to explore both hardware and software programmability and

develop complex and interesting embedded system projects The revised edition Adds four general purpose IP cores which are multi channel PWM pulse width modulation controller I2C controller SPI controller and XADC Xilinx analog to digital converter controller Introduces a music synthesizer constructed with a DDFS direct digital frequency synthesis module and an ADSR attack decay sustain release envelop generator Expands the original video controller into a complete stream based video subsystem that incorporates a video synchronization circuit a test pattern generator an OSD on screen display controller a sprite generator and a frame buffer Introduces basic concepts of software hardware co design with Xilinx MicroBlaze MCS soft core processor Provides an overview of bus interconnect and interface circuit Introduces basic embedded system software development Suggests additional modules and peripherals for interesting and challenging projects The FPGA Prototyping by VHDL Examples Second Edition makes a natural companion text for introductory and advanced digital design courses and embedded system course It also serves as an ideal self teaching guide for practicing engineers who wish to learn more about this emerging area of interest **Electronic Engineering and Computing Technology** Len Gelman,2010-04-21 Electronic Engineering and Computing Technology contains sixty one revised and extended research articles written by prominent researchers participating in the conference Topics covered include Control Engineering Network Management Wireless Networks Biotechnology Signal Processing Computational Intelligence Computational Statistics Internet Computing High Performance Computing and industrial applications Electronic Engineering and Computing Technology will offer the state of art of tremendous advances in electronic engineering and computing technology and also serve as an excellent reference work for researchers and graduate students working with on electronic engineering and computing technology *FPGA Prototyping by SystemVerilog Examples* Pong P. Chu,2018-05-04 A hands on introduction to FPGA prototyping and SoC design This is the successor edition of the popular FPGA Prototyping by Verilog Examples text It follows the same learning by doing approach to teach the fundamentals and practices of HDL synthesis and FPGA prototyping The new edition uses a coherent series of examples to demonstrate the process to develop sophisticated digital circuits and IP intellectual property cores integrate them into an SoC system on a chip framework realize the system on an FPGA prototyping board and verify the hardware and software operation The examples start with simple gate level circuits progress gradually through the RT register transfer level modules and lead to a functional embedded system with custom I O peripherals and hardware accelerators Although it is an introductory text the examples are developed in a rigorous manner and the derivations follow the strict design guidelines and coding practices used for large complex digital systems The book is completely updated and uses the SystemVerilog language which absorbs the Verilog language It presents the hardware design in the SoC context and introduces the hardware software co design concept Instead of treating examples as isolated entities the book integrates them into a single coherent SoC platform that allows readers to explore both hardware and software programmability and develop complex and interesting embedded

system projects The new edition Adds four general purpose IP cores which are multi channel PWM pulse width modulation controller I2C controller SPI controller and XADC Xilinx analog to digital converter controller Introduces a music synthesizer constructed with a DDFS direct digital frequency synthesis module and an ADSR attack decay sustain release envelope generator Expands the original video controller into a complete stream based video subsystem that incorporates a video synchronization circuit a test pattern generator an OSD on screen display controller a sprite generator and a frame buffer Provides a detailed discussion on blocking and nonblocking statements and coding styles Describes basic concepts of software hardware co design with Xilinx MicroBlaze MCS soft core processor Provides an overview of bus interconnect and interface circuit Presents basic embedded system software development Suggests additional modules and peripherals for interesting and challenging projects FPGA Prototyping by SystemVerilog Examples makes a natural companion text for introductory and advanced digital design courses and embedded system courses It also serves as an ideal self teaching guide for practicing engineers who wish to learn more about this emerging area of interest **Advanced Memory Optimization Techniques for Low-Power Embedded Processors** Manish Verma,Peter Marwedel,2007-06-20 In a relatively short span of time computers have evolved from huge mainframes to small and elegant desktop computers and now to low power ultra portable handheld devices Witheachpassinggeneration computersconsistingofprocessors memoriesandperipherals becamesmallerandfaster Forexample the rstcommercialcomputerUNIVACIcosted 1 million dollars occupied 943 cubic feet space and could perform 1 905 operations per second 94 Now a processor present in an electric shaver easily outperforms the early mainframe computers The miniaturization is largely due to the efforts of engineers and scientists that made the expeditious progress in the microelectronic technologies possible According to Moore s Law 90 the advances in technology allow us to double the number of transistors on a single silicon chip every 18 months This has lead to an exponential increase in the number of transistors on a chip from 2 300 in an Intel 4004 to 42 millions in Intel Itanium processor 55 Moore s Law has withstood for 40 years and is predicted to remain valid for at least another decade 91 Notonlytheminiaturizationanddramaticperformanceimprovementbutalsothesign icantdropinthepriceofprocessors hasleadtosituationwheretheyarebeingintegratedinto products such as cars televisions and phones which are not usually associated with c puters This new trend has also been called the disappearing computer where the computer does not actually disappear but it is everywhere 85 Digital devices containing processors now constitute a major part of our daily lives Asmalllistofsuchdevicesincludesmicrowaveovens televisionsets mobilephones digital cameras MP3 players and cars Whenever a system comprises of information processingdigitaldevicestocontrolortoaugmentitsfunctionality suchasystemistermedanembedded system Therefore all the above listed devices can be also classi ed as embedded systems **Embedded SoPC Design with Nios II Processor and Verilog Examples** Pong P. Chu,2012-05-14 Explores the unique hardware programmability of FPGA based embedded systems using a learn by doing approach to introduce the concepts and

techniques for embedded SoPC design with Verilog An SoPC system on a programmable chip integrates a processor memory modules I O peripherals and custom hardware accelerators into a single FPGA field programmable gate array device In addition to the customized software customized hardware can be developed and incorporated into the embedded system as well allowing us to configure the soft core processor create tailored I O interfaces and develop specialized hardware accelerators for computation intensive tasks Utilizing an Altera FPGA prototyping board and its Nios II soft core processor Embedded SoPC Design with Nios II Processor and Verilog Examples takes a learn by doing approach to illustrate the hardware and software design and development process by including realistic projects that can be implemented and tested on the board Emphasizing hardware design and integration throughout the book is divided into four major parts Part I covers HDL and synthesis of custom hardware Part II introduces the Nios II processor and provides an overview of embedded software development Part III demonstrates the design and development of hardware and software of several complex I O peripherals including a PS2 keyboard and mouse a graphic video controller an audio codec and an SD secure digital card Part IV provides several case studies of the integration of hardware accelerators including a custom GCD greatest common divisor circuit a Mandelbrot set fractal circuit and an audio synthesizer based on DDFS direct digital frequency synthesis methodology While designing and developing an embedded SoPC can be rewarding the learning can be a long and winding journey This book shows the trail ahead and guides readers through the initial steps to exploit the full potential of this emerging methodology     *Embedded System Design* Daniel D. Gajski,Samar Abdi,Andreas Gerstlauer,Gunar Schirner,2009-08-14 Embedded System Design Modeling Synthesis and Verification introduces a model based approach to system level design It presents modeling techniques for both computation and communication at different levels of abstraction such as specification transaction level and cycle accurate level It discusses synthesis methods for system level architectures embedded software and hardware components Using these methods designers can develop applications with high level models which are automatically translatable to low level implementations This book furthermore describes simulation based and formal verification methods that are essential for achieving design confidence The book concludes with an overview of existing tools along with a design case study outlining the practice of embedded system design Specifically this book addresses the following topics in detail System modeling at different abstraction levels Model based system design Hardware Software codesign Software and Hardware component synthesis System verification This book is for groups within the embedded system community students in courses on embedded systems embedded application developers system designers and managers CAD tool developers design automation and system engineering

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