# Hardware Software Codesign of Embedded System

## CPSC689-602

### Rabi Mahapatra

# Today's topics

- Course Organization
- Introduction to HS-CODES
- Codesign Motivation
- Some Issues on Codesign of Embedded System

# Readings In Hardwaresoftware Codesign

**Santanu Chattopadhyay**

**Readings In Hardwaresoftware Codesign:**

*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 **Readings in Hardware/Software Co-Design** Giovanni De Micheli,Rolf Ernst,Wayne Wolf,2001-06-19 Embedded system designers are constantly looking for new tools and techniques to help satisfy the exploding demand for consumer information appliances and specialized industrial products One critical barrier to the timely release of embedded system products is integrating the design of the hardware and software systems Hardware software co design is a set of methodologies and techniques specifically created to support the concurrent design of both systems effectively reducing multiple iterations and major redesigns In addition to its critical role in the development of embedded systems many experts believe that co design will be a key design methodology for Systems on a Chip Readings in Hardware Software Co Design presents the papers that have shaped the hardware software co design field since its inception in the early 90s Field experts Giovanni De Micheli Rolf Ernst and Wayne Wolf introduce sections of the book and provide context for the paper that follow This collection provides professionals researchers and graduate students with a single reference source for this critical aspect of computing design Over 50 peer reviewed papers written from leading researchers and designers in the field Selected edited and introduced by three of the fields most eminent researchers and educators Accompanied by an annually updated companion Web site with links and references to recently published papers providing a forum for the editors to comment on how recent work continues or breaks with previous work in the field **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

**Multicore Systems On-Chip: Practical Software/Hardware Design** Abderazek Ben Abdallah,2013-07-20 System on chips designs have evolved from fairly simple unicore single memory designs to complex heterogeneous multicore SoC architectures consisting of a large number of IP blocks on the same silicon To meet high computational demands posed by latest consumer electronic devices most current systems are based on such paradigm which represents a real revolution in many aspects in computing The attraction of multicore processing for power reduction is compelling By splitting a set of tasks among multiple processor cores the operating frequency necessary for each core can be reduced allowing to reduce the voltage on each core Because dynamic power is proportional to the frequency and to the square of the voltage we get a big gain even though we may have more cores running As more and more cores are integrated into these designs to share the ever increasing processing load the main challenges lie in efficient memory hierarchy scalable system interconnect new programming paradigms and efficient integration methodology for connecting such heterogeneous cores into a single system capable of leveraging their individual flexibility Current design methods tend toward mixed HW SW co designs targeting multicore systems on chip for specific applications To decide on the lowest cost mix of cores designers must iteratively map the device s functionality to a particular HW SW partition and target architectures In addition to connect the heterogeneous cores the architecture requires high performance complex communication architectures and efficient communication protocols such as hierarchical bus point to point connection or Network on Chip Software development also becomes far more complex due to the difficulties in breaking a single processing task into multiple parts that can be processed separately and then reassembled later This reflects the fact that certain processor jobs cannot be easily parallelized to run concurrently on multiple processing cores and that load balancing between processing cores especially heterogeneous cores is very difficult **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 **Behavioral Modeling for Embedded Systems and Technologies: Applications for Design and Implementation** Gomes, Luis,Fernandes, Jo?o M.,2009-07-31 This book provides innovative behavior models currently used for developing embedded systems accentuating on graphical and visual notations Provided by publisher *Introduction to Embedded Systems* Manuel Jiménez,Rogelio Palomera,Isidoro Couvertier,2013-09-11 This textbook serves as an introduction to the subject of embedded systems design using microcontrollers as core components It develops concepts from the ground up covering the development of embedded systems technology architectural and organizational aspects of controllers and systems processor models and peripheral devices Since microprocessor based embedded systems tightly blend hardware and software components in a single application the book also introduces the subjects of data representation formats data operations and programming styles The practical component of the book is tailored around the architecture of a widely used Texas Instrument s microcontroller the MSP430 and a companion web site offers for download an experimenter s kit and lab manual along with Powerpoint slides and solutions for instructors 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 **Modern VLSI Design** Wayne Wolf,2008-12-21 The Number 1 VLSI Design Guide Now Fully Updated for IP Based

Design and the Newest Technologies Modern VLSI Design Fourth Edition offers authoritative up to the minute guidance for the entire VLSI design process from architecture and logic design through layout and packaging Wayne Wolf has systematically updated his award winning book for today s newest technologies and highest value design techniques Wolf introduces powerful new IP based design techniques at all three levels gates subsystems and architecture He presents deeper coverage of logic design fundamentals clocking and timing and much more No other VLSI guide presents as much up to date information for maximizing performance minimizing power utilization and achieving rapid design turnarounds

**Tool-Based Requirement Traceability between Requirement and Design Artifacts** Bernhard Turban,2013-04-16 Processes for developing safety critical systems impose special demands on ensuring requirements traceability Achieving valuable traceability information however is especially difficult concerning the transition from requirements to design Bernhard Turban analyzes systems and software engineering theories cross cutting the issue embedded systems development systems engineering software engineering requirements engineering and management design theory and processes for safety critical systems As a solution the author proposes a new tool approach to support designers in their thinking in order to achieve traceability as a by product to normal design activities and to extend traceability information with information about design decision rationale **High-Performance Embedded Computing** Marilyn Wolf,2014-03-17 High Performance Embedded Computing Second Edition combines leading edge research with practical guidance in a variety of embedded computing topics including real time systems computer architecture and low power design Author Marilyn Wolf presents a comprehensive survey of the state of the art and guides you to achieve high levels of performance from the embedded systems that bring these technologies together The book covers CPU design operating systems multiprocessor programs and architectures and much more Embedded computing is a key component of cyber physical systems which combine physical devices with computational resources for control and communication This revised edition adds new content and examples of cyber physical systems throughout the book including design methodologies scheduling and wide area CPS to illustrate the possibilities of these new systems Revised and updated with coverage of recently developed consumer electronics architectures and models of computing Includes new VLIW processors such as the TI Da Vinci and CPU simulation Learn model based verification and middleware for embedded systems Supplemental material includes lecture slides labs and additional resources **Embedded Systems** Santanu Chattopadhyay, *Electronic Design Automation for IC System Design, Verification, and Testing* Luciano Lavagno,Igor L. Markov,Grant Martin,Louis K. Scheffer,2017-12-19 The first of two volumes in the Electronic Design Automation for Integrated Circuits Handbook Second Edition Electronic Design Automation for IC System Design Verification and Testing thoroughly examines system level design microarchitectural design logic verification and testing Chapters contributed by leading experts authoritatively discuss processor modeling and design tools using performance metrics to select microprocessor cores for integrated circuit IC designs design and

verification languages digital simulation hardware acceleration and emulation and much more New to This Edition Major updates appearing in the initial phases of the design flow where the level of abstraction keeps rising to support more functionality with lower non recurring engineering NRE costs Significant revisions reflected in the final phases of the design flow where the complexity due to smaller and smaller geometries is compounded by the slow progress of shorter wavelength lithography New coverage of cutting edge applications and approaches realized in the decade since publication of the previous edition these are illustrated by new chapters on high level synthesis system on chip SoC block based design and back annotating system level models Offering improved depth and modernity Electronic Design Automation for IC System Design Verification and Testing provides a valuable state of the art reference for electronic design automation EDA students researchers and professionals     Designing Embedded Processors Jörg Henkel,Sri Parameswaran,2007-07-27 As we embrace the world of personal portable and perplexingly complex digital systems it has befallen upon the bewildered designer to take advantage of the available transistors to produce a system which is small fast cheap and correct yet possesses increased functionality Increasingly these systems have to consume little energy Designers are increasingly turning towards small processors which are low power and customize these processors both in software and hardware to achieve their objectives of a low power system which is verified and has short design turnaround times Designing Embedded Processors examines the many ways in which processor based systems are designed to allow low power devices It looks at processor design methods memory optimization dynamic voltage scaling methods compiler methods and multi processor methods Each section has an introductory chapter to give a breadth view and have a few specialist chapters in the area to give a deeper perspective The book provides a good starting point to engineers in the area and to research students embarking upon the exciting area of embedded systems and architectures     *EDA for IC System Design, Verification, and Testing* Louis Scheffer,Luciano Lavagno,Grant Martin,2018-10-03 Presenting a comprehensive overview of the design automation algorithms tools and methodologies used to design integrated circuits the Electronic Design Automation for Integrated Circuits Handbook is available in two volumes The first volume EDA for IC System Design Verification and Testing thoroughly examines system level design microarchitectural design logical verification and testing Chapters contributed by leading experts authoritatively discuss processor modeling and design tools using performance metrics to select microprocessor cores for IC designs design and verification languages digital simulation hardware acceleration and emulation and much more Save on the complete set     **A Practical Introduction to Hardware/Software Codesign** Springer,2012-11-26     **High Performance Embedded Architectures and Compilers** André Seznec,Michael O'Boyle,Joel Emer,Margaret Martonosi,Theo Ungerer,2009-01-12 This book constitutes the refereed proceedings of the Fourth International Conference on High Performance Embedded Architectures and Compilers HiPEAC 2009 held in Paphos Cyprus in January 2009 The 27 revised full papers presented together with 2 invited keynote paper were carefully reviewed and

selected from 97 submissions The papers are organized in topical sections on dynamic translation and optimisation low level scheduling parallelism and resource control communication mapping for CMPs power cache issues as well as parallel embedded applications *Algorithm-Architecture Matching for Signal and Image Processing* Guy Gogniat,Dragomir Milojevic,Adam Morawiec,Ahmet Erdogan,2010-10-20 Advances in signal and image processing together with increasing computing power are bringing mobile technology closer to applications in a variety of domains like automotive health telecommunication multimedia entertainment and many others The development of these leading applications involving a large diversity of algorithms e g signal image video 3D communication cryptography is classically divided into three consecutive steps a theoretical study of the algorithms a study of the target architecture and finally the implementation Such a linear design flow is reaching its limits due to intense pressure on design cycle and strict performance constraints The approach called Algorithm Architecture Matching aims to leverage design flows with a simultaneous study of both algorithmic and architectural issues taking into account multiple design constraints as well as algorithm and architecture optimizations that couldn t be achieved otherwise if considered separately Introducing new design methodologies is mandatory when facing the new emerging applications as for example advanced mobile communication or graphics using sub micron manufacturing technologies or 3D Integrated Circuits This diversity forms a driving force for the future evolutions of embedded system designs methodologies The main expectations from system designers point of view are related to methods tools and architectures supporting application complexity and design cycle reduction Advanced optimizations are essential to meet design constraints and to enable a wide acceptance of these new technologies Algorithm Architecture Matching for Signal and Image Processing presents a collection of selected contributions from both industry and academia addressing different aspects of Algorithm Architecture Matching approach ranging from sensors to architectures design The scope of this book reflects the diversity of potential algorithms includingsignal communication image video 3D Graphics implemented onto various architectures from FPGA to multiprocessor systems Several synthesis and resource management techniques leveraging design optimizations are also described and applied to numerous algorithms Algorithm Architecture Matching for Signal and Image Processing should be on each designer s and EDA tool developer s shelf as well as on those with an interest in digital system design optimizations dealing with advanced algorithms **Embedded Systems Handbook** Richard Zurawski,2018-09-03 Considered a standard industry resource the Embedded Systems Handbook provided researchers and technicians with the authoritative information needed to launch a wealth of diverse applications including those in automotive electronics industrial automated systems and building automation and control Now a new resource is required to report on current developments and provide a technical reference for those looking to move the field forward yet again Divided into two volumes to accommodate this growth the Embedded Systems Handbook Second Edition presents a comprehensive view on this area of computer engineering with a currently appropriate emphasis on developments in

networking and applications Those experts directly involved in the creation and evolution of the ideas and technologies presented offer tutorials research surveys and technology overviews that explore cutting edge developments and deployments and identify potential trends This first self contained volume of the handbook Embedded Systems Design and Verification is divided into three sections It begins with a brief introduction to embedded systems design and verification It then provides a comprehensive overview of embedded processors and various aspects of system on chip and FPGA as well as solutions to design challenges The final section explores power aware embedded computing design issues specific to secure embedded systems and web services for embedded devices Those interested in taking their work with embedded systems to the network level should complete their study with the second volume Network Embedded Systems **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

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## Readings In Hardwaresoftware Codesign Introduction

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