Klaus Pohl
Harald Hönninger
Reinhold Achatz
Manfred Broy (Eds.)

# Model-Based Engineering of Embedded Systems

## The SPES 2020 Methodology

# Model Based Engineering Of Embedded Systems The Spes 2020 Methodology

Camilla Rothe

**Model Based Engineering Of Embedded Systems The Spes 2020 Methodology:**

Model-Based Engineering of Embedded Systems Klaus Pohl,Harald Hönninger,Reinhold Achatz,Manfred Broy,2012-11-08 Embedded systems have long become essential in application areas in which human control is impossible or infeasible The development of modern embedded systems is becoming increasingly difficult and challenging because of their overall system complexity their tighter and cross functional integration the increasing requirements concerning safety and real time behavior and the need to reduce development and operation costs This book provides a comprehensive overview of the Software Platform Embedded Systems SPES modeling framework and demonstrates its applicability in embedded system development in various industry domains such as automation automotive avionics energy and healthcare In SPES 2020 twenty one partners from academia and industry have joined forces in order to develop and evaluate in different industrial domains a modeling framework that reflects the current state of the art in embedded systems engineering The content of this book is structured in four parts Part I Starting Point discusses the status quo of embedded systems development and model based engineering and summarizes the key requirements faced when developing embedded systems in different application domains Part II The SPES Modeling Framework describes the SPES modeling framework Part III Application and Evaluation of the SPES Modeling Framework reports on the validation steps taken to ensure that the framework met the requirements discussed in Part I Finally Part IV Impact of the SPES Modeling Framework summarizes the results achieved and provides an outlook on future work The book is mainly aimed at professionals and practitioners who deal with the development of embedded systems on a daily basis Researchers in academia and industry may use it as a compendium for the requirements and state of the art solution concepts for embedded systems development       **Advanced Model-Based Engineering of Embedded Systems** Klaus Pohl,Manfred Broy,Heinrich Daembkes,Harald Hönninger,2016-11-29 This book provides a comprehensive introduction into the SPES XT modeling framework Moreover it shows the applicability of the framework for the development of embedded systems in different industry domains and reports on the lessons learned It also describes how the SPES XT modeling framework can be tailored to meet domain and project specific needs The book is structured into four parts Part I Starting Situation discusses the status quo of the development of embedded systems with specific focus on model based engineering and summarizes key challenges emerging from industrial practice Part II Modeling Theory introduces the SPES XT modeling framework and explains the core underlying principles Part III Application of the SPES XT Framework describes the application of the SPES XT modeling framework and how it addresses major industrial challenges Part IV Evaluation and Technology Transfer assess the impact of the SPES XT modeling framework and includes various exemplary applications from automation automotive and avionics Overall the SPES XT modeling framework offers a seamless model based engineering approach It addresses core challenges faced during the engineering of embedded systems Among others it offers aligned and integrated techniques for the early validation of engineering artefacts including requirements and

functional and technical designs the management of product variants and their variability modular safety assurance and deployment of embedded software *Model-Based Engineering of Embedded Systems* ,2012-11-10 **Model-Based Engineering of Collaborative Embedded Systems** Wolfgang Böhm,Manfred Broy,Cornel Klein,Klaus Pohl,Bernhard Rumpe,Sebastian Schröck,2020-12-14 This Open Access book presents the results of the Collaborative Embedded Systems CrESt project aimed at adapting and complementing the methodology underlying modeling techniques developed to cope with the challenges of the dynamic structures of collaborative embedded systems CESs based on the SPES development methodology In order to manage the high complexity of the individual systems and the dynamically formed interaction structures at runtime advanced and powerful development methods are required that extend the current state of the art in the development of embedded systems and cyber physical systems The methodological contributions of the project support the effective and efficient development of CESs in dynamic and uncertain contexts with special emphasis on the reliability and variability of individual systems and the creation of networks of such systems at runtime The project was funded by the German Federal Ministry of Education and Research BMBF and the case studies are therefore selected from areas that are highly relevant for Germany s economy automotive industrial production power generation and robotics It also supports the digitalization of complex and transformable industrial plants in the context of the German government s Industry 4 0 initiative and the project results provide a solid foundation for implementing the German government s high tech strategy Innovations for Germany in the coming years **Software Architectures** Manfred Nagl,Bernhard Westfechtel,2024-04-26 This textbook concentrates on processes activities and results related to software architectures It describes the separation of architecture artefacts corresponding to their nature their logical or their modeling level on one hand and at the same time emphasizes their integration based on their mutual relations Design or development processes demand for integration as different artifacts must be elaborated which are mutually dependent and need to be in a consistent form The book is structured in four parts The introductory Part I deals with the relevance of architectures the central role of the design subprocess both in development or maintenance and the importance of the decisions and artefacts in the overall result Another topic is the spectrum of views an architecture language has to offer and that there are different architectures to be regarded from abstract and static to detailed technical and specific Part II then discusses important topics onthe architecture level It deals with adaptability especially for embedded systems with integrating styles pattern notations with different reuse forms and how to find them with the role of architectures for integrating different existing systems and with reverse and reengineering of legacy systems Next Part III covers architecture modeling and its relation to surrounding activities as well as architectures to surrounding other results The single chapters are on transformation between requirements and architectures architectures and programming architectures and project management and organization as well as architectures and their relations to quality assurance or documentation Eventually Part IV summarizes the main messages

and presents open problems both for every single chapter and across chapters Every chapter focuses on a specific problem it addresses a question it answers the attention it demands a message it conveys and further open questions it raises The chapters are mostly independent which implies a certain redundancy yet it allows lecturers and their students to either use the book as the basis of teaching software architecture or design or to just pick those aspects that need special attention in a more advanced course     *Complex Systems Design & Management* Eric Bonjour,Daniel Krob,Luca Palladino,François Stephan,2018-11-19 This book contains all refereed papers accepted during the ninth edition of the conference that took place at the Cit Internationale Universitaire de Paris on December 18 19 2018 Mastering complex systems requires an integrated understanding of industrial practices as well as sophisticated theoretical techniques and tools This explains the creation of an annual go between forum in Paris dedicated to academic researchers industrial actors working on complex industrial systems architecture modeling engineering These proceedings cover the most recent trends in the emerging field of Complex Systems both from an academic and a professional perspective A special focus is put on Products services development in a digital world The CSD M Paris 2018 conference is organized under the guidance of CESAM Community http cesam community en CESAM Community has been developed since 2010 by the non profit organization CESAMES Association to organize the sharing of good practices in Enterprise and Systems Architecture and to certify the level of knowledge and proficiency in this field through CESAM certification     **Computer Safety, Reliability, and Security. SAFECOMP 2022 Workshops** Mario Trapp,Erwin Schoitsch,Jérémie Guiochet,Friedemann Bitsch,2022-09-06 This book constitutes the proceedings of the Workshops held in conjunction with SAFECOMP 2022 which took place in Munich Germany in September 2022 The 23 full papers included in this volume were carefully reviewed and selected from 27 submissions 17th International ERCIM EWICS ARTEMIS Workshop on Dependable Smart Embedded Cyber Physical Systems and Systems of Systems DECSoS 2021 3rd International Workshop on Dependable Development Operation Continuum Methods for Dependable Cyber Physical System DepDevOps 2022 9th International Workshop on Next Generation of System Assurance Approaches for Critical Systems SASSUR 2022 1st International Workshop on Security and Safety Interaction SENSEI 2022 3rd International Workshop on Underpinnings for Safe Distributed Artificial Intelligence USDAI 2022 5th International Workshop on Artificial Intelligence Safety Engineering WAISE 2022     **Design Methodology for Future Products** Dieter Krause,Emil Heyden,2021-12-13 Design Methodology for Future Products Data Driven Agile and Flexible provides an overview of the recent research in the field of design methodology from the point of view of the members of the scientific society for product development WiGeP Wissenschaftliche Gesellschaft f r Produktenwicklung e V This book aims to contribute to design methods and their implementation for innovative future products The main focus is the crucial data driven agile and flexible way of working Four topics are covered in corresponding chapters Methods for Product Development and Management Methods for Specific Products and Systems Facing the Challenges in Product Development

and Model Based Engineering in Product Development This publication starts with the agile strategic foresight of sustainable mechatronic and cyber physical systems moves on to the topics of system generation engineering in development processes followed by the technical inheritance in data driven product development Product improvements are shown via agile experiential learning based on reverse engineering and via combination of usability and emotions Furthermore the development of future oriented products in the field of biomechatronic systems sustainable mobility systems and in situ sensor integration is shown The overcoming of challenges in product development is demonstrated through context adapted methods by focusing on efficiency and effectiveness as well as designer centered methods to tackle cognitive bias Flow design for target oriented availability of data and information in product development is addressed Topics of model based systems engineering are applied to the function driven product development by linking model elements at all stages and phases of the product The potential of model based systems engineering for modular product families and engineering of multidisciplinary complex systems is shown *Intelligent Computing* Kohei Arai,Supriya Kapoor,Rahul Bhatia,2018-11-01 This book gathering the Proceedings of the 2018 Computing Conference offers a remarkable collection of chapters covering a wide range of topics in intelligent systems computing and their real world applications The Conference attracted a total of 568 submissions from pioneering researchers scientists industrial engineers and students from all around the world These submissions underwent a double blind peer review process Of those 568 submissions 192 submissions including 14 poster papers were selected for inclusion in these proceedings Despite computer science s comparatively brief history as a formal academic discipline it has made a number of fundamental contributions to science and society in fact along with electronics it is a founding science of the current epoch of human history the Information Age and a main driver of the Information Revolution The goal of this conference is to provide a platform for researchers to present fundamental contributions and to be a premier venue for academic and industry practitioners to share new ideas and development experiences This book collects state of the art chapters on all aspects of Computer Science from classical to intelligent It covers both the theory and applications of the latest computer technologies and methodologies Providing the state of the art in intelligent methods and techniques for solving real world problems along with a vision of future research the book will be interesting and valuable for a broad readership Reference Architectures for Critical Domains Elisa Yumi Nakagawa,Pablo Oliveira Antonino,2023-03-14 This book presents reference architecture as a key blueprint to develop and evolve critical software intensive systems emphasizing both the state of the art in research and successful industrial cases After outlining the theoretical foundations of reference architecture and presenting an overview of a number of reference architectures proposed over the recent years this book dives into a set of critical application domains including defense health automotive avionics and Industry 4 0 highlighting the respective most relevant reference architectures that have impacted these domains the experience and lessons learned insights gained benefits and drawbacks and factors that make these

architectures sustainable The book finishes with the most relevant directions for future advances in reference architectures The content of this book is useful for researchers and advanced professionals in industry in the areas of computing and engineering as well as in critical application domains that increasingly require interconnected large and complex software intensive systems *Model-Based Testing for Embedded Systems* Justyna Zander,Ina Schieferdecker,Pieter J. Mosterman,2011-09-15 What the experts have to say about Model Based Testing for Embedded Systems This book is exactly what is needed at the exact right time in this fast growing area From its beginnings over 10 years ago of deriving tests from UML statecharts model based testing has matured into a topic with both breadth and depth Testing embedded systems is a natural application of MBT and this book hits the nail exactly on the head Numerous topics are presented clearly thoroughly and concisely in this cutting edge book The authors are world class leading experts in this area and teach us well used and validated techniques along with new ideas for solving hard problems It is rare that a book can take recent research advances and present them in a form ready for practical use but this book accomplishes that and more I am anxious to recommend this in my consulting and to teach a new class to my students Dr Jeff Offutt professor of software engineering George Mason University Fairfax Virginia USA This handbook is the best resource I am aware of on the automated testing of embedded systems It is thorough comprehensive and authoritative It covers all important technical and scientific aspects but also provides highly interesting insights into the state of practice of model based testing for embedded systems Dr Lionel C Briand IEEE Fellow Simula Research Laboratory Lysaker Norway and professor at the University of Oslo Norway As model based testing is entering the mainstream such a comprehensive and intelligible book is a must read for anyone looking for more information about improved testing methods for embedded systems Illustrated with numerous aspects of these techniques from many contributors it gives a clear picture of what the state of the art is today Dr Bruno Legeard CTO of Smartesting professor of Software Engineering at the University of Franche Comt Besan on France and co author of Practical Model Based Testing **Model-based Systems Engineering with the SPES Modeling Language** Wolfgang Böhm,Manfred Broy,Walter Koch,Nikolaus Regnat,Bernhard Rumpe,David Schmalzing,2025 **Model-Based Engineering of Embedded Real-Time Systems** Holger Giese,Gabor Karsai,Edward A. Lee,Bernhard Rumpe,Bernhard Schätz,2010-10-09 Thetopicof Model BasedEngineeringofReal TimeEmbeddedSystems brings together a challenging problem domain real time embedded systems and a lution domain model based engineering It is also at the forefrontof integrated software and systems engineering as software in this problem domain is an essential tool for system implementation and integration Today real time bedded software plays a crucial role in most advanced technical systems such as airplanes mobile phones and cars and has become the main driver and cilitator for innovation Development evolution veri cation con guration and maintenance of embedded and distributed software nowadays are often serious challenges as drastic increases in complexity can be observed in practice Model based engineering in general and model based software development in particular advocates the

notion of using models throughout the development and life cycle of an engineered system Model based software engineering re forces this notion by promoting models not only as the tool of abstraction but also as the tool for veri cation implementation testing and maintenance The application of such model based engineering techniques to embedded real time systems appears to be a good candidate to tackle some of the problems arising in the problem domain *Model-Based Design of Adaptive Embedded Systems* Twan Basten,Roelof Hamberg,Frans Reckers,Jacques Verriet,2013-03-15 This book describes model based development of adaptive embedded systems which enable improved functionality using the same resources The techniques presented facilitate design from a higher level of abstraction focusing on the problem domain rather than on the solution domain thereby increasing development efficiency Models are used to capture system specifications and to implement manually or automatically system functionality The authors demonstrate the real impact of adaptivity on engineering of embedded systems by providing several industrial examples of the models used in the development of adaptive embedded systems **Model-Based Design for Embedded Systems** Gabriela Nicolescu,Pieter J. Mosterman,2018-09-03 The demands of increasingly complex embedded systems and associated performance computations have resulted in the development of heterogeneous computing architectures that often integrate several types of processors analog and digital electronic components and mechanical and optical components all on a single chip As a result now the most prominent challenge for the design automation community is to efficiently plan for such heterogeneity and to fully exploit its capabilities A compilation of work from internationally renowned authors Model Based Design for Embedded Systems elaborates on related practices and addresses the main facets of heterogeneous model based design for embedded systems including the current state of the art important challenges and the latest trends Focusing on computational models as the core design artifact this book presents the cutting edge results that have helped establish model based design and continue to expand its parameters The book is organized into three sections Real Time and Performance Analysis in Heterogeneous Embedded Systems Design Tools and Methodology for Multiprocessor System on Chip and Design Tools and Methodology for Multidomain Embedded Systems The respective contributors share their considerable expertise on the automation of design refinement and how to relate properties throughout this refinement while enabling analytic and synthetic qualities They focus on multi core methodological issues real time analysis and modeling and validation taking into account how optical electronic and mechanical components often interface Model based design is emerging as a solution to bridge the gap between the availability of computational capabilities and our inability to make full use of them yet This approach enables teams to start the design process using a high level model that is gradually refined through abstraction levels to ultimately yield a prototype When executed well model based design encourages enhanced performance and quicker time to market for a product Illustrating a broad and diverse spectrum of applications such as in the automotive aerospace health care consumer electronics this volume provides designers with practical readily adaptable modeling solutions for their

own practice **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 **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 **Embedded and Real Time System Development: A Software Engineering Perspective** Mohammad Ayoub Khan,Saqib Saeed,Ashraf Darwish,Ajith Abraham,2013-11-19 Nowadays embedded and real time systems contain complex software The complexity of embedded systems is increasing and the amount and variety of software in the embedded products are growing This creates a big challenge for embedded and real time software development processes and there is a need to develop separate metrics and benchmarks Embedded and Real Time System Development A Software Engineering Perspective Concepts Methods and Principles presents practical as well as conceptual knowledge of the latest tools techniques and methodologies of embedded software engineering and real time systems Each chapter includes an in depth investigation regarding the actual or potential role of software engineering tools in the context of the embedded system and real time system The book presents state of the art and future perspectives with industry experts researchers and academicians sharing ideas and experiences including surrounding frontier technologies breakthroughs innovative solutions and applications The book is organized into four parts Embedded Software Development Process Design Patterns and Development Methodology Modelling Framework and Performance Analysis Power Management and Deployment with altogether 12 chapters The book is aiming at i undergraduate students and postgraduate students conducting research in the areas of embedded software engineering and real time systems ii researchers at universities and other institutions working in these fields and iii practitioners in the R D departments of embedded system It can be used as an advanced reference for a course taught at the postgraduate level in embedded software engineering and

real time systems     *Modeling and Verification in Model-based Software Engineering* Alessandra Bagnato,2013 Embedded Systems including devices middleware and software for the creation of intelligent sub systems able of monitoring and controlling appliances are more and more part of our world everyday lives they are included in the basic infrastructure of society such as roads and railways and are key technologies used by millions of people every day Moreover the continuous rapid evolution of modern embedded systems has given rise to new challenges such as increasingly complex design processes that cause delays in time to market and cause escalation of overall design costs Additionally these systems are more prone to containing errors and it becomes more relevant to provide designers with effective tools to aid them in overcoming the difficulties related to the overall system design verification and validation This thesis contributes to the definition and to the development of a model based methodology grounded on the OMG s MARTE profile Modeling and Analysis of Real Type and Embedded Systems and on SysML profile to model requirements targeting an avionic case study with a particular attention to the reuse of the modelled components and to the benefits of their verification This thesis aims at discussing and illustrating the effectiveness of using a combination of UML MARTE and SysML languages at the different steps of the embedded system modelling efforts and to provide within this thesis a set of methodological guidelines steps and an approach to create design model stores and verify them     **Software Engineering for Embedded Systems** Robert Oshana,2013-04-01 This Expert Guide gives you the techniques and technologies in software engineering to optimally design and implement your embedded system Written by experts with a solutions focus this encyclopedic reference gives you an indispensable aid to tackling the day to day problems when using software engineering methods to develop your embedded systems With this book you will learn The principles of good architecture for an embedded system Design practices to help make your embedded project successful Details on principles that are often a part of embedded systems including digital signal processing safety critical principles and development processes Techniques for setting up a performance engineering strategy for your embedded system software How to develop user interfaces for embedded systems Strategies for testing and deploying your embedded system and ensuring quality development processes Practical techniques for optimizing embedded software for performance memory and power Advanced guidelines for developing multicore software for embedded systems How to develop embedded software for networking storage and automotive segments How to manage the embedded development process Includes contributions from Frank Schirrmeister Shelly Gretlein Bruce Douglass Erich Styger Gary Stringham Jean Labrosse Jim Trudeau Mike Brogioli Mark Pitchford Catalin Dan Udma Markus Levy Pete Wilson Whit Waldo Inga Harris Xinxin Yang Srinivasa Addepalli Andrew McKay Mark Kraeling and Robert Oshana Road map of key problems issues and references to their solution in the text Review of core methods in the context of how to apply them Examples demonstrating timeless implementation details Short and to the point case studies show how key ideas can be implemented the rationale for choices made and design guidelines and trade offs

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