

# FORMAL METHODS

Week 1

Lecture 2

Lecturer: Maira Zulfiqar

## Limitations of software formal specifications

**The Main Point of Formal Methods is Not**

- To show “correctness” of entire systems  
(What **is** correctness? Always go for specific properties!)
- To replace testing entirely  
(Formal methods work on source code or, at most, bytecode)  
(Some properties are not formalizable)
- To replace good design practices

# Formal Methods In Systems Engineering

**Maurice H. ter Beek, Stefania  
Gnesi, Alexander Knapp**



## **Formal Methods In Systems Engineering:**

**Formal Methods in Systems Engineering** Peter Ryan, Chris Sennett, 2012-12-06 As computer technology is used to control critical systems to an increasing degree it is vital that the methods for developing and understanding these systems are substantially improved The mathematical and scientific foundations currently used are extremely limited which means that their correctness and reliability cannot be ensured to an acceptable level Systems engineering needs to become a fully fledged scientific discipline and formal methods which are characterised by their firm mathematical foundations are playing a vital role in achieving this transition This volume is based on the proceedings of the Formal Methods Workshop FM91 held in Drymen Scotland 24-27 September 1991 This was the second workshop sponsored by the Canadian and US governments to address the role of formal methods in the development of digital systems Traditionally formal methods have evolved in isolation from more conventional approaches and one of the aims of this workshop was to emphasise the benefits of integrating the two areas The workshop concentrated on the themes of quality assurance design methods and mathematical modelling techniques Particular emphasis was given to safety and security applications Among the topics covered in this volume are what is a formal method social research on formal methods current quality assurance methods and formal methods a pragmatic approach to validation integrating methods in practice composition of descriptions and topics in large program formal development Formal Methods in Systems Engineering provides an overview of many of the major approaches to formal methods and the benefits which can result from them It is relevant to academic and industrial researchers industrial practitioners and government workers with an interest in certification Formal Methods: Foundations and Applications Haniel Barbosa, Yoni Zohar, 2023-12-01 This book constitutes the refereed proceedings of the 26th Brazilian Symposium on Formal Methods SBMF 2023 held in Manaus Brazil during December 4-8 2023 The 7 full papers and 2 short papers presented in this book were carefully reviewed and selected from 16 submissions The papers are divided into the following topical sections specification and modeling languages testing and verification and validation *NASA Formal Methods* Julia M. Badger, Kristin Yvonne Rozier, 2014-04-23 This book constitutes the refereed proceedings of the 6th International Symposium on NASA Formal Methods NFM 2014 held in Houston TX USA April 29-May 1 2014 The 20 revised regular papers presented together with 9 short papers were carefully reviewed and selected from 107 submissions The topics include model checking theorem proving static analysis model based development runtime monitoring formal approaches to fault tolerance applications of formal methods to aerospace systems formal analysis of cyber physical systems including hybrid and embedded systems formal methods in systems engineering modeling requirements and specifications requirements generation specification debugging formal validation of specifications use of formal methods in safety cases use of formal methods in human machine interaction analysis formal methods for parallel hardware implementations use of formal methods in automated software engineering and testing correct by design design for verification and property based

design techniques techniques and algorithms for scaling formal methods e g abstraction and symbolic methods compositional techniques parallel and distributed techniques and application of formal methods to emerging technologies

**Formal Methods and Software Engineering** Karin Breitman, Ana Cavalcanti, 2009-11-18 Formal methods for development of computer systems have been extensively studied over the years A range of semantic theories specification languages design techniques and verification methods and tools have been developed and applied to the construction of programs used in critical applications The challenge now is to scale up formal methods and integrate them into engineering development processes for the correct and efficient construction and maintenance of computer systems in general This requires us to improve the state of the art on approaches and techniques for integration of formal methods into industrial engineering practice including new and emerging practice The now long established series of International Conferences on Formal Engineering Methods brings together those interested in the application of formal engineering methods to computer systems Researchers and practitioners from industry academia and government are encouraged to attend and to help advance the state of the art This volume contains the papers presented at ICFEM 2009 the 11th International Conference on Formal Engineering Methods held during December 9-11 in Rio de Janeiro Brazil

**NASA Formal Methods** Jyotirmoy V. Deshmukh, Klaus Havelund, Ivan Perez, 2022-05-19 This book constitutes the proceedings of the 14th International Symposium on NASA Formal Methods NFM 2022 held in Pasadena USA during May 24-27 2022 The 33 full and 6 short papers presented in this volume were carefully reviewed and selected from 118 submissions The volume also contains 6 invited papers The papers deal with advances in formal methods formal methods techniques and formal methods in practice The focus on topics such as interactive and automated theorem proving SMT and SAT solving model checking use of machine learning and probabilistic reasoning in formal methods formal methods and graphical modeling languages such as SysML or UML usability of formal method tools and application in industry etc

**Formal Methods and Hybrid Real-Time Systems** Cliff B. Jones, Zhiming Liu, Jim Woodcock, 2007-09-04 This Festschrift volume is published to honour both Dines Bjørner and Zhou Chaochen on the occasion of their 70th birthdays The volume includes 25 refereed papers by leading researchers current and former colleagues who congregated at a celebratory symposium held in Macao China in the course of the International Colloquium on Theoretical Aspects of Computing ICTAC 2007 The papers cover a broad spectrum of subjects

**Formal Methods for Trustworthy Computer Systems (FM89)** Karen Summerskill, Dan Craigen, 2013-11-11 The 1989 Workshop on the Assessment of Formal Methods for Trustworthy Computer Systems FM89 was an invitational workshop that brought together representatives from the research commercial and governmental spheres of Canada the United Kingdom and the United States The workshop was held in Halifax Nova Scotia Canada from July 23 through July 27 1989 This document reports the activities observations recommendations and conclusions resulting from FM89

1 Purpose of Workshop The primary purpose for holding FM89 was to assess the role of formal methods in the development and fielding of trustworthy

critical systems The need for this assessment was predicated upon four observations 1 Critical systems are increasingly being controlled by computer systems 2 Existing techniques for developing assuring and certifying computer based critical systems are inadequate 3 Formal methods have the potential for playing the same role in the development of computer based systems as applied mathematics does for other engineering disciplines and 4 Formal methods have had limited impact on the development of computer based systems and supporting technologies The goal of the workshop was to complete the following tasks 1 Assess the problems retarding the development of trustworthy critical systems 2 Determine the potential impact of applying formal methods techniques to the development of trustworthy critical systems 3 Determine the research and development required to facilitate a broader application of formal methods techniques 4

**Systems of Systems Engineering** Mo Jamshidi, 2017-12-19 As technology presses forward scientific projects are becoming increasingly complex The international space station for example includes over 100 major components carried aloft during 88 space flights which were organized by over 16 nations The need for improved system integration between the elements of an overall larger technological system has sparked further development of systems of systems SoS as a solution for achieving interoperability and superior coordination between heterogeneous systems Systems of Systems Engineering Principles and Applications provides engineers with a definitive reference on this newly emerging technology which is being embraced by such engineering giants as Boeing Lockheed Martin and Raytheon The book covers the complete range of fundamental SoS topics including modeling simulation architecture control communication optimization and applications Containing the contributions of pioneers at the forefront of SoS development the book also offers insight into applications in national security transportation energy and defense as well as healthcare the service industry and information technology System of systems SoS is still a relatively new concept and in time numerous problems and open ended issues must be addressed to realize its great potential This book offers a first look at this rapidly developing technology so that engineers are better equipped to face such challenges

**Formal Methods and Software Engineering** Zhiming Liu, Jifeng He, 2006-11-23 This book constitutes the refereed proceedings of the 8th International Conference on Formal Engineering Methods ICFEM 2006 held in Macao China in November 2006 The 38 revised full papers presented together with three keynote talks were carefully reviewed and selected from 108 submissions The papers address all current issues in formal methods and their applications in software engineering

**Handbook of Systems Engineering and Management** Andrew P. Sage, William B. Rouse, 2014-12-31 The trusted handbook now in a new edition This newly revised handbook presents a multifaceted view of systems engineering from process and systems management perspectives It begins with a comprehensive introduction to the subject and provides a brief overview of the thirty four chapters that follow This introductory chapter is intended to serve as a field guide that indicates why when and how to use the material that follows in the handbook Topical coverage includes systems engineering life cycles and management risk management discovering system requirements configuration

management cost management total quality management reliability maintainability and availability concurrent engineering standards in systems engineering system architectures systems design systems integration systematic measurements human supervisory control managing organizational and individual decision making systems reengineering project planning human systems integration information technology and knowledge management and more The handbook is written and edited for systems engineers in industry and government and to serve as a university reference handbook in systems engineering and management courses By focusing on systems engineering processes and systems management the editors have produced a long lasting handbook that will make a difference in the design of systems of all types that are large in scale and or scope

Formal Methods for Industrial Critical Systems Michael Dierkes, Charles Pecheur, 2013-09-16 This book constitutes the thoroughly refereed conference proceedings of the 18th International Workshop on Formal Methods for Industrial Critical Systems FMICS 2013 held in Madrid Spain in September 2013 The 13 papers presented were carefully selected from 25 submissions and cover topics such as design specification code generation and testing based on formal methods methods techniques and tools to support automated analysis certification debugging learning optimization and transformation of complex distributed dependable real time systems and embedded systems verification and validation methods tools for the development of formal design descriptions case studies and experience reports on industrial applications of formal methods impact of the adoption of formal methods on the development process and associated costs application of formal methods in standardization and industrial forums

*Formal Methods for Industrial Critical Systems* Maurice H. ter Beek, Dejan Ničković, 2020-08-28 This book constitutes the proceedings of the 25th International Workshop on Formal Methods for Industrial Critical Systems FMICS 2020 which was held during September 2 3 2020 The conference was planned to take place in Vienna Austria Due to the COVID 19 pandemic it changed to a virtual event The 11 full papers presented in this volume were carefully reviewed and selected from 26 submissions The papers are organized in topical sections as follows Quantitative Analysis and Cyber Physical Systems Formal Verification of Industrial Systems Temporal Logic and Model Checking The book also contains a lengthy report on a Formal Methods Survey conducted on occasion of the 25th edition of the conference

**FM 2005: Formal Methods** John Fitzgerald, Ian J. Hayes, 2005-08-25 This volume contains the proceedings of Formal Methods 2005 the 13th International Symposium on Formal Methods held in Newcastle upon Tyne UK during July 18 22 2005 Formal Methods Europe FME [www.fmeurope.org](http://www.fmeurope.org) is an independent association which aims to stimulate the use of and research on formal methods for system development FME conferences began with a VDM Europe symposium in 1987 Since then the meetings have grown and have been held about once every 18 months Throughout the years the symposia have been notably successful in bringing together researchers tool developers vendors and users both from academia and from industry Formal Methods 2005 confirms this success We received 130 submissions to the main conference from all over the world Each submission was carefully refereed by at least three reviewers Then after an intensive in depth

discussion the Program Committee selected 31 papers for presentation at the conference They form the bulk of this volume We would like to thank all the Program Committee members and the referees for their excellent and efficient work Apart from the selected contributions the Committee invited three keynote lectures from Mathai Joseph Marie Claude Gaudel and Chris Johnson You will find the abstracts papers for their keynote lectures in this volume as well

An innovation for the FM2005 program was a panel discussion on the history of formal methods with Jean Raymond Abrial Dines Bjørner Jim Horning and Cli Jones as panelists Unfortunately it was not possible to reflect this event in the current volume but you will find the material documenting it elsewhere see the conference Web page

**PROCEEDINGS OF THE 20TH CONFERENCE ON FORMAL METHODS IN COMPUTER-AIDED DESIGN - FMCAD 2020** Alexander Ivrii, Ofer Strichman, 2020-09-11 Formal Methods in Computer Aided Design FMCAD is a conference series on the theory and applications of formal methods in hardware and system verification FMCAD provides a leading forum to researchers in academia and industry for presenting and discussing ground breaking methods technologies theoretical results and tools for reasoning formally about computing systems FMCAD covers formal aspects of computer aided system design including verification specification synthesis and testing

**Modern Formal Methods and Applications** Hossam A. Gabbar, 2006-06-28 Formal methods are a robust approach for problem solving It is based on logic and algebraic methods where problems can be formulated in a way that can help to find an appropriate solution This book shows the basic concepts of formal methods and highlights modern modifications and enhancements to provide a more robust and efficient problem solving tool Applications are presented from different disciplines such as engineering where the operation of chemical plants is synthesized using formal methods Computational biology becomes easier and systematic using formal methods Also hardware compilation and systems can be managed using formal methods This book will be helpful for both beginners and experts to get insights and experience on modern formal methods by viewing real applications from different domains

**Critical Systems: Formal Methods and Automated Verification** Maurice H. ter Beek, Stefania Gnesi, Alexander Knapp, 2016-09-12 This book constitutes the refereed proceedings of the Joint 21st International Workshop on Formal Methods for Industrial Critical Systems and the 16th International Workshop on Automated Verification of Critical Systems FMICS AVoCS 2016 held in Pisa Italy in September 2016 The 11 full papers and 4 short papers presented together with one invited talk were carefully reviewed and selected from 24 submissions They are organized in the following sections automated verification techniques model based system analysis and applications and case studies

**Formal Methods Applied to Complex Systems** Jean-Louis Boulanger, 2014-07-22 This book presents real world examples of formal techniques in an industrial context It covers formal methods such as SCADE and or the B Method in various fields such as railways aeronautics and the automotive industry The purpose of this book is to present a summary of experience on the use of formal methods based on formal techniques such as proof abstract interpretation and model checking in industrial

examples of complex systems based on the experience of people currently involved in the creation and assessment of safety critical system software The involvement of people from within the industry allows the authors to avoid the usual confidentiality problems which can arise and thus enables them to supply new useful information photos architecture plans real examples etc

**Formal Methods and Software Engineering** Jin Song Dong, Jim Woodcock, 2003-10-27 This book constitutes the refereed proceedings of the 5th International Conference on Formal Engineering Methods ICFEM 2003 held in Singapore in November 2003 The 34 revised full papers presented together with 3 invited contributions were carefully reviewed and selected from 91 submissions The papers are organized in topical sections on testing and validation state diagrams PVS HOL refinement hybrid systems Z Object Z Petri nets timed automata system modelling and checking and semantics and synthesis

**Formal Methods for Industrial Critical Systems** Stefania Gnesi, Tiziana Margaria, 2012-11-27 Today formal methods are widely recognized as an essential step in the design process of industrial safety critical systems In its more general definition the term formal methods encompasses all notations having a precise mathematical semantics together with their associated analysis methods that allow description and reasoning about the behavior of a system in a formal manner Growing out of more than a decade of award winning collaborative work within the European Research Consortium for Informatics and Mathematics Formal Methods for Industrial Critical Systems A Survey of Applications presents a number of mainstream formal methods currently used for designing industrial critical systems with a focus on model checking The purpose of the book is threefold to reduce the effort required to learn formal methods which has been a major drawback for their industrial dissemination to help designers to adopt the formal methods which are most appropriate for their systems and to offer a panel of state of the art techniques and tools for analyzing critical systems

**Formal Methods for Industrial Critical Systems** Kim Guldstrand Larsen, Tim Willems, 2019-08-23 This book constitutes the proceedings of the 24th International Conference on Formal Methods for Industrial Critical Systems FMICS 2019 held in Amsterdam The Netherlands in August 2019 The 9 regular papers presented in this volume were carefully reviewed and selected from 15 submissions The conference also featured invited talks by Jaco van de Pol Aarhus University and Twente University jointly with CONCUR and Holger Hermanns Universit t des Saarlandes and a special session on commercial formal methods in industry The aim of the FMICS conference series is to provide a forum for researchers who are interested in the development and application of formal methods in industry In particular FMICS brings together scientists and engineers who are active in the area of formal methods and interested in exchanging their experiences in the industrial usage of these methods The FMICS conference series also strives to promote research and development for the improvement of formal methods and tools for industrial applications



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