Automotive Systems and Software Engineering

Yanja Dajsuren • Mark van den Brand
Editors

Automotive Systems and Software Engineering

State of the Art and Future Trends

Springer

Editors
Yanja Dajsuren
Eindhoven University of Technology
Eindhoven, The Netherlands

Mark van den Brand
Eindhoven University of Technology
Eindhoven, The Netherlands

ISBN 978-3-030-12156-3 ISBN 978-3-030-12157-0 (eBook)
https://doi.org/10.1007/978-3-030-12157-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Software is "conquering" the world. There is hardly any piece of equipment that does not have software in it. This is certainly true for the automotive domain. The amount of software has grown from a few lines of code in the 1970s to millions of lines of code in modern cars. This trend is estimated to continue in the next years given all the innovations in electric/hybrid cars, autonomous cars, and connected cars. Software is clearly an innovation engine in the automotive domain, it has led to safer and more efficient vehicles on one hand and more comfort on the other hand. There are also challenges related to the infiltration of software in vehicles, such as security, robustness, and trust. Unfortunately, software has also led to many recalls over the last years, and, recently, software was misused to meet emission regulations, the Dieselgate affair. The automotive industry is moving from the mechanical engineering domain to system/software engineering field, including the role of software as the glue to connect components and to provide functionality.

The Eindhoven University of Technology started in 2008 with a master program Automotive Technology, an interdisciplinary master program of various departments among other Mechanical Engineering, Electrical Engineering, and Mathematics and Computer Science. In the discussions on the curriculum, the importance of software was pointed out and a few software-related courses, real-time architecture, and software and system engineering were introduced. A few years later, a master's program on Automotive System Design leading to the degree of Professional Doctorate in Engineering (PDEng) was launched and in 2014 a bachelor's program on automotive started. This means that the Eindhoven University of Technology offers an entire curriculum on automotive and automotive software engineering as an important ingredient. Of course, apart from such educational programs, the university is involved in numerous research projects related to automotive and to automotive software engineering, for instance, the project Hybrid Innovations for Trucks (HIT) with DAF Trucks and other automotive suppliers and FP7/OPENCOSS (Open Platform for EvolutioNary Certification Of Safety-critical Systems), a large-scale integrated project with a consortium of seventeen companies from nine countries. These research projects have highlighted the importance of software in the automotive domain; furthermore, they were the key enablers for

building up automotive software engineering expertise. The research projects have resulted in PhD theses in the area of quality of software architecture (see Chapter "Defining Architecture Framework for Automotive Systems"), modeling of functional safety standards (see Chapter "Safety-Driven Development and ISO 26262"), and an integrated design methodology of automotive software architectures and functional safety.

Based on these observations we thought that it was a good time to work on a book with an overview of the state of the art in automotive software development, from both an academic and an industrial point of view. The original idea for this book was to transform the PhD thesis of Yanja Dajsuren (editor of this book) into a text book. Later we decided to invite other authors to contribute to the book to broaden its scope. We composed a list of possible authors both from industry and academia following the book structure and we started inviting them. Although everybody reacted enthusiastically, obtaining contributions from the industrial authors was a challenge; projects have always had priority over papers. This is less of an issue in the academic world. Therefore, we had to drop a couple of chapters from the industrial authors to avoid further delay in publication.

The intended audience for the book are, on one hand, researchers from academia who are interested in learning the fundamental challenges related to software in automotive engineering, for instance, to security and safety. On the other hand, it is for practitioners who need an insight into the state-of-the-art developments in the area of research within academia. Although the book is not written as lectures notes, it can be used in advanced (post-)master's courses on software and system engineering. The book contains multiple interesting case studies that can be used for student projects.

The sixteen chapters cover all the important aspects of the field. Chapter "Automotive Software Engineering: Past, Present, and Future" discusses the evolution of automotive software engineering and future trends based on the past, present, and future of our research group. Chapter "Requirements Engineering for Automotive Embedded Systems" presents the notion of a requirement in general and describes the types of requirements used when designing automotive software systems. Chapters "Status Report on Automotive Software Development" and "State-of-the-Art Tools and Methods Used in the Automotive Industry" provide explore state-of-the-art methods in software development and testing from an industrial perspective and discuss the current challenges in the development process. The provided information can be used for optimal planning of development processes for future automotive systems and for further insights. Chapters "Software Reuse: From Cloned Variants to Managed Software Product Lines" and "Variability Identification and Representation for Automotive Simulink Models" present the novel tool-suites to enable software reuse in different granularities point of view. Chapter "Defining Architecture Framework for Automotive Systems" proposes an architecture framework for the automotive systems to facilitate the architecture-driven development process. Chapter "The RACE Project: An Informatics-Driven Greenfield Approach to Future E/E-Architectures for Cars" presents the results of the RACE project, which aims to redefine the architecture of future cars from

an information processing point of view. Chapter "Development of ISO 11783: Virtual Terminal and Monitoring System for Agricultural Vehicles" summarizes the challenges of implementing modules such as sprayer and GPS using ISOBUS and proposes a format for implementing a virtual terminal for agricultural vehicles. Safety is one of the most important quality attribute of a vehicle that needs special attention in all the stages of the life cycle of a vehicle. In Chapter "Safety-Driven Development and ISO 26262" some of the most important aspects of functional safety from the perspective of ISO 26262 are discussed, namely, safety management, development process, architecture design, and safety assurance. Chapter "Introduction to Cooperative Intelligent Transportation Systems" introduces the overall system architecture and standards of European-wide Cooperative Intelligent Transportation/Transport Systems (C-ITS). This chapter is an introduction to the next three chapters that take three different perspectives on C-ITS, namely, intra-vehicle, inter-vehicle, and country-wide. The focus of this chapter lies on one hand on the architecture of C-ITS solutions and on the other hand on security and privacy of C-ITS. The final two chapters present a high level automotive trend watching on the analysis of electric and autonomous driving cars and market trends in ICT and Internet disrupting the transport sector.

Eindhoven, The Netherlands

Yanja Dajsuren
Mark van den Brand

Acknowledgments

Editing this book has been a great journey for us. We would like to express our gratitude to the following people, each of whom has contributed in a valuable way to the completion of this book.

Firstly, we would like to express our gratitude to the authors who took up the challenge besides their busy schedules. The authors shared challenges facing the automotive software engineering field and shared their vision for future research and development directions. We especially want to thank our contributors from the industry who worked extra hours to make this feasible and were very open and flexible toward feedback and comments from reviewers. Sometimes they would manage to spend time revising a chapter even with important deadlines for their projects. The authors from academy are also appreciated for their patience and collaboration for making this book editing process feasible. Each chapter is reviewed by an expert from industry and academy and underwent several revisions. All the authors were also involved in reviewing each others' works as well.

We also want to thank the publisher Arjen Sevenster (Atlantis Press), who first discussed the book opportunity in this field and motivated us for starting this project. Sharing the state of the art while discussing the challenges, research opportunities, and future trends will hopefully encourage more collaboration among researchers and practitioners in this field. The research and development opportunities are enormous. We hope the ever-changing automotive software engineering field will be joined by more and more researchers and engineers to advance it further.

Finally, we thank our editor at Springer, Ralf Gerstner, for making this book possible to be published in Springer and for his support and guidance during the editing process.

Contents

Part I Introduction

Automotive Software Engineering: Past, Present, and Future 3
Yanja Dajsuren and Mark van den Brand

Part II Automotive Software Development

Requirements Engineering for Automotive Embedded Systems 11
Miroslaw Staron

Status Report on Automotive Software Development 29
Florian Bock, Christoph Sippl, Sebastian Siegl, and Reinhard German

State-of-the-Art Tools and Methods Used in the Automotive Industry 59
Harald Altinger

Part III Automotive Software Reuse

Software Reuse: From Cloned Variants to Managed Software Product Lines 77
Christoph Seidl, David Wille, and Ina Schaefer

Variability Identification and Representation for Automotive Simulink Models 109
Manar H. Alalfi, Eric J. Rapos, Andrew Stevenson, Matthew Stephan, Thomas R. Dean, and James R. Cordy

Defining Architecture Framework for Automotive Systems 141
Yanja Dajsuren

Part IV E/E Architecture and Safety

The RACE Project: An Informatics-Driven Greenfield Approach to Future E/E Architectures for Cars 171
Alois Knoll, Christian Buckl, Karl-Josef Kuhn, and Gernot Spiegelberg

Development of ISO 11783 Compliant Agricultural Systems: Experience Report 197
Enkhbaatar Tumenjargal, Enkhbat Batbayar, Sodbileg Tsogt-Ochir, Munkhtamir Oyumaa, Woon Chul Ham, and Kil To Chong

Safety-Driven Development and ISO 26262 225
Yaping Luo, Arash Khabbaz Saberi, and Mark van den Brand

Part V C-ITS and Security

Introduction to Cooperative Intelligent Transportation Systems 257
Johan Lukkien

In-Vehicle Networks and Security 265
Timo van Roermund

Security for V2X 283
Marc Klaassen and Tomasz Szuprycinski

Intelligent Transportation System Infrastructure and Software Challenges 295
Horst Wieker, Jonas Vogt, and Manuel Fuenfrocken

Part VI Future Trends

Future Trends in Electric Vehicles Enabled by Internet Connectivity, Solar, and Battery Technology 323
Ben Rutten and Roy Cobbenhagen

Autonomous Vehicles: State of the Art, Future Trends, and Challenges ... 347
Piergiuseppe Mallozzi, Patrizio Pelliccione, Alessia Knauss, Christian Berger, and Nassar Mohammadiha