



Mirosław Staron



Automotive Software Architectures

An Introduction

Second Edition

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*To my family – Sylwia, Alexander, Viktoria
and Cornelia*

Foreword

“The fear of error is the error itself.” Famous philosopher G.F.W. Hegel, whose 250th birthday we currently commemorate, underlined the very necessity of innovation and thinking out of the box. Innovation needs guidance but must not be overconstrained. As engineers, we should follow critical rules but also allow error and learn from it—in order to move forward and not administrate the past. This book will provide guidance toward innovative automotive architectures and services—along the lines of Hegel.

Software and IT are the major drivers of modern cars—both literally and from a marketing perspective. Modern vehicles have more than 70 electronic control units (ECUs), with premium cars having more than 100 such embedded computer systems. Some functions, such as engine control or dynamics, are hard real-time functions, with reaction times going down to a few milliseconds. Practically all other functions, such as infotainment, demand at least soft real-time behaviors.

The complexity of automotive systems and services is growing fast. Each automotive area has its own requirements for computation speed, reliability, security, safety, flexibility, and extensibility. Automotive electronic systems map functions such as braking, powertrain, or lighting controls to individual software systems and physical hardware. The resulting complexity has reached a limit that demands an architectural restart (Fig. 1). At the same time, innovative functions such as connectivity with external infrastructures and vehicle-to-vehicle communication demand IT backbone and cloud solutions with service-oriented architectures (SOA).

Software and IT in vehicles and their environments are evolving at a fast pace. Multimodal mobility will connect previously separated domains like cars and public transportation. Mobility-oriented services such as car sharing create completely new ecosystems and business models far away from the classic “buy-your-own-car” approach. Autonomous driving demands highly interactive services with multisensor fusion, vastly different from the currently deployed functionally isolated control units. Connectivity and infotainment have transformed the car into a distributed IT system with cloud access, over-the-air functional upgrades, and high-bandwidth access to map services, media content, other vehicles, and surrounding

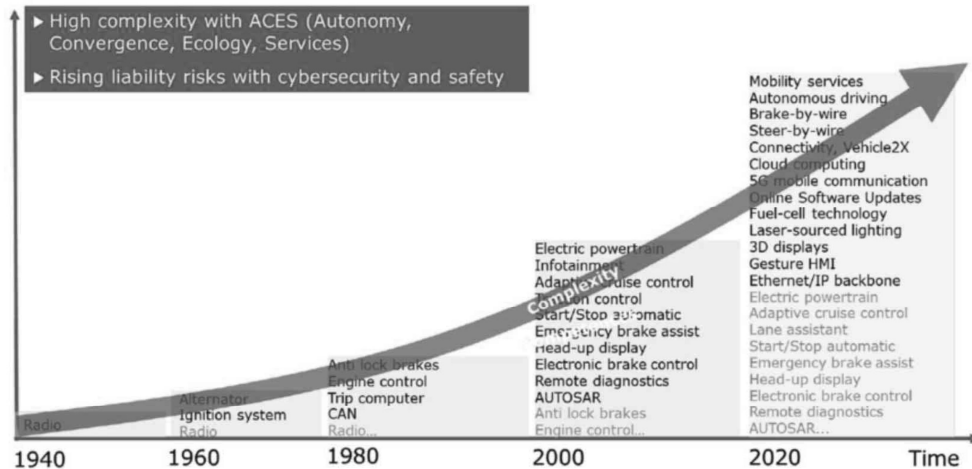


Fig. 1 The convergence of IT and EE fuels automotive technology

infrastructure. Energy efficiency evolves the classic powertrain toward high-voltage hybrid and electric engines.

The major driver in the 2020s is convergence. We face a fast integration of the previously separated concepts of IT and E/E. Software engineering for automotive systems encompasses modern embedded and cloud technologies, distributed computing, real-time systems, mixed safety and security systems, and, not least, the connection of all that to long-term sustainable business models.

Automotive engineers must master both domains, paired with functional safety and cybersecurity. Today automotive software is spearheading IT innovation. The everyday relevance of automotive software to today's software engineers is high, and it is the focus of this book to bring this message to practitioners.

Technology trends are converging across industries (Fig. 2). What used to be a clear-cut differentiation can be summarized today by the quest for ACES, i.e., autonomous systems, convergence, ecology, and services. Business trends are similar in developed and emerging economies. Ten years ago, only 2 out of 10 most valuable public companies by market capitalization were tech companies. Today, almost all are highly driving, and driven by, software technology. Failures to recognize future trends and challenges would be like entering the next decade with all senses closed.

While converging to the new normal, priorities are shifting heavily. Autonomy, until recently still a number one shooting star, has started its slowdown along the hype cycle. At the same time, ecology gets to speed with a high focus especially of the young generation on our future and the sustainability of our earth. Convergence levers the two forces of competitiveness and innovation toward a sustainable business prospective for technology companies. Services are the major driver. Services are very appealing and we have been talking about them for many years. It follows the Kano model at its best because a good service for a mediocre product can create real excitement. Provide 24/7 online support and you earn a big “wow” if you deliver.

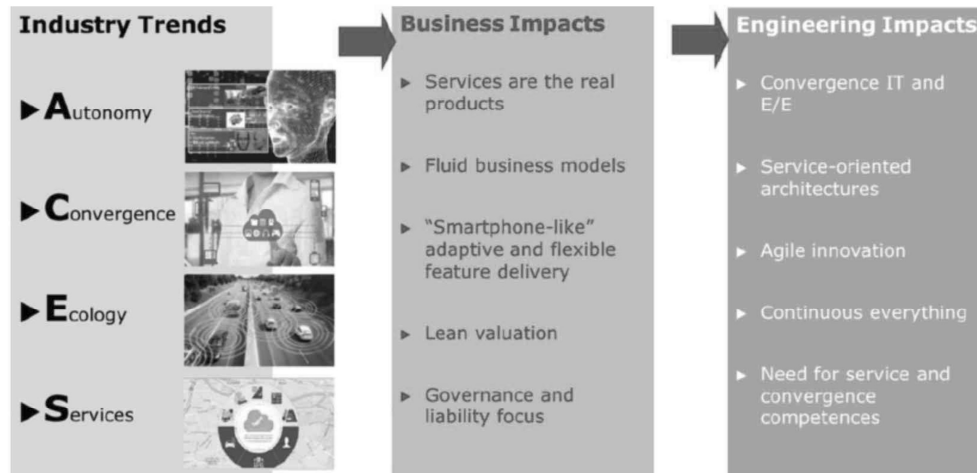


Fig. 2 Prepare for the future: ACES makes digital winners

To master this fast-growing complexity, automotive software needs a clear architecture. Architecture evolution today is the major focus across companies, and thus the book arrives just at the right time. The impacts of architecture are manifold, such as systems modeling, testing, and simulation with models in the loop; the combination of several quality requirements such as safety; service-oriented advanced operating systems with secure communication platforms, such as adaptive AUTOSAR (Automotive Open System Architecture); multisensor fusion and picture recognition for ADAS (advanced driver-assistance systems) and autonomous driving; distributed end-to-end security for flexible remote software updates directly into the car's firmware; and connectivity of cloud technologies and IT backbones with billions of cars and their onboard devices for infotainment, online apps, remote diagnosis, and emergency call processing.

This second edition of the already classic primer on Automotive Software comprehensively introduces to automotive software architecture. Authored by renowned expert Miroslaw Staron, this book provides a guided tour through the methodology and usage of automotive software architecture. Starting with a brief introduction to software architecture paradigms, it quickly moves to current application domains, such as AUTOSAR. Architecture analysis with methods such as ATAM (Architecture Trade-off Analysis Method) of the Software Engineering Institute provides hands-on guidance, keeping in mind the current paradigm shift from classic networking controllers toward the three-tier model of future automotive IT.

Miroslaw Staron with his coauthors target with this book both engineers and decision-makers in the automotive electronics and IT domain. They guide engineers, developers, and managers along the convergence of the two worlds of IT and embedded systems. Education however has only in rare cases dedicated programs for engineering these converging IT and embedded systems. Business models will evolve toward flexible service-oriented architectures and ecosystems. Reference

points based on industry standards such as three-tier cloud architectures, adaptive AUTOSAR, and Ethernet connectivity facilitate reuse across companies and industries. The classic functional split is replaced by a more service-oriented architecture and delivery model. Development in the future will be a continuous process that will fully decouple the rather stable hardware of the car from its functionality driven by software upgrades. Hierarchic modeling of business processes, functionality, and architecture from a systems perspective allows early simulation while ensuring robustness and security. Agile service delivery models combining DevOps, micro-services, and cloud solutions will allow functional changes far beyond the traditional V approach.

The techniques presented in this book are not supposed to be the ultimate truth. Yet they provide direction in this fast-evolving field. It will help you as well as your organization to grow your maturity. Our society and each of us depend on seamless mobility, and so we need to also trust these underlying systems of infrastructure and vehicles. Let us evolve the necessary technology, methods, and competencies in a positive direction to stay in control of automotive software and avoid the many pitfalls of classic IT systems. For this matter, I wish you all the best and success.

As with all architecture independent of application domain, do not forget to deliver value and results to your markets. Your future is based on your competitiveness—both corporate and personal. It is not those to succeed who now shrink engineering and IT innovation, but those who navigate well in the magic triangle of quality, competitiveness, and innovation. Thinker, politician, and novelist Goethe got it straight: “Knowing is not enough; we must apply. Willing is not enough; we must do.” This is the wake-up call to use innovation and guts to stay competitive amidst a meager economic outlook. Business history is littered with the skeletons of those who take neither ownership nor risks.

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