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Research Paper

Past, Present and Future of Automotive Software Engineering

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ABSTRACT: *There is an explosive growth in amount of software found in vehicles. The software may have very few lines of code in a vehicle to over several million lines of code; there is nothing extraordinary in it in case of premium cars. Important innovative functionality is realized in software in the automotive industry today. Automotive systems can be vehicle-centric functional domains like powertrain control, chassis control, and active/passive safety systems and passenger-centric functional domains covering multimedia/telematics, body comfort, and Human-Machine Interface. In this paper, major areas of potential innovation domains, powertrain, connectivity, active safety, and assisted driving are considered. The amount of software will increase over the years because of future innovations; adaptive cruise control, lane keeping, etc. leading to the ultimate goal of autonomous driving. Innovation in vehicle-centric functional domains requires ever-increasing size of quality automotive software.*
KEYWORDS: *Software, Standardization, C-ITS, ISO 26262, AUTOSAR, RTE, ECU, OEM, CAN*

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I. INTRODUCTION

Increased attention is required to assess and improve the quality of automotive software. Software-driven innovations can come with software defects. The software may be vulnerable to unscrupulous hacking. Safety is one of the most important quality attributes of a vehicle. It needs special attention during the life cycle of a vehicle. Failures in software may be costly and life threatening. The failure or malfunctioning of an automotive system may result in serious and fatal injuries causing even death of people. Functional safety standards give safety-critical systems; the ISO26262 standard and its various latest generations are the functional safety standard for the automotive domain, geared toward passenger cars, trucks, buses, and motorcycles. These safety standards are guidelines for development projects in automotive industry. Increased cost and time are needed for compliance with these standards; due to huge amount of manual work, however, is the cause of concern. This paper deals with these above aspects.

II. EVOLUTION OF AUTOMOTIVE SOFTWARE ENGINEERING

The modern vehicle manufacturer assembles the components developed and built and actually constructed by ancillary suppliers; though the specifications of the components are defined and given to the suppliers by OEMs (Original Equipment Manufacturers) or car manufacturers. It is almost customary that the components come with their own Electronic Control Units (ECUs) and software stack. These individual software stacks, when added together, make a huge software code in modern vehicles. This basis of a decentralized architecture has several advantages which lead to a clear separation of concerns; integration and communication are actualized via a Controller Area Network (CAN) bus or FlexRay. Well defined protocols govern the exchange of messages for the components to interact with each other. Connecting or disconnecting components from the CAN bus or FlexRay make adding or removing of functionality possible. Strict adherence to the alignment with the interface protocols makes the isolated design of components possible. This type of development eventually leads to super abundance of ECUs and their corresponding software stacks. .

The introduction of AUTOSAR (Automotive Open System Architecture) standard provides a generic layered architecture that shields the basic infrastructure of ECUs. It provides a rather high-level interface to develop functionality. AUTOSAR maps functionality to the available ECUs and it provides a basic software layer. This layer consists of standardized software modules; the modules being mostly without any specific functionality. The layer offers services to implement the functional part of the application software. AUTOSAR provides a runtime environment (RTE), a middleware that shields off a network of ECUs and takes care of the information exchange between the application software components and between the basic software layer and the applications. The application layer consists of application software components. The software components interact with the runtime environment leading to less ECUs and a better balance of functionality over ECUs.

AUTOSAR in the automotive industry allows the suppliers to provide functional components based on AUTOSAR standard. The application of AUTOSAR is a major step in separating applications from the computing infrastructure. However, there is still room for improvement. There is an increasing need for computing power, especially in hybrid cars and cars with advanced driver support. The computing power can be provided by a collection of ECUs or by introducing general purpose hardware in the form of central processing units (CPUs) and graphics processing units (GPUs). The latter may be a better and sustainable optional development.

A similar development happened to consumer electronics; dedicated hardware was replaced by general-purpose hardware, and functionality was realized in software instead of application-specific hardware. The general purpose hardware in the automotive system is a complete design philosophy. This leads to a centralized automotive architecture with a few high-performance multicore processors and a vast collection of sensors and actuators connected to the central processing unit. This design will impose severe constraints on the overall functional safety of the system.

Software in the automotive domain is developed in Matlab/Simulink and more recently SysML; from the developed models, C code is generated. Of course, some functionality is developed directly in C. General software quality metrics frameworks establish the quality of Matlab/Simulink and SysML models and automotive software architectures in general. In the area of functional safety, model-driven techniques may be applied to support functional safety development process and safety assurance. ISO26262 standard based meta-model tooling can make a wonder for safety case construction and assessment. Automotive Embedded Software Systems utilize the general notion of designing automotive software systems. Status Report on Automotive Software Development illustrates the current challenges in automotive software development. This gives an overview of the current development methods and tools. Future directions on domain-specific languages and scenario based virtual validation methods based on industrial projects may be obtained from the literature.

III. C-ITS

Cooperative-Intelligent Transport[1] Systems (C-ITS) facilitate cooperative, connected, and automated mobility. C -ITS deals with traffic management systems, traffic light controllers and vehicle onboard units. Such complex and heterogeneous systems have independent uses. They demand a strategy to facilitate their convergence. The C-ITS transport systems give higher energy-efficiency and safety. Car manufacturers and automotive suppliers are redefining efficient software development methods. The Intelligent Transport Systems (ITS) are “systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.” The ITS systems are used to make transportation safe and economical by combining data from vehicles and other sensors on the roadway with weather information. C-ITS enables cooperative communication between ITS systems by allowing road users and traffic managers to share information for the purpose of improving traffic safety and driver comfort and reducing traffic congestion. The vehicles also act as sensors.

IV. TOWARDS AUTONOMOUS AND CO-OPERATIVE DRIVING

Autonomous and cooperative cars will become a reality in near future. Developments such as Google-car, the autopilot functionality of Tesla, and Uber self-driving cars have accelerated the development of autonomous driving. More and more advanced driving assistance systems (ADAS) are being introduced, which can be interpreted as paving the road to full autonomous driving. Development of autonomous driving involves developed C-ITS. Standardization in the car itself and standardization of C-ITS Systems are needed. Other challenges related to supporting autonomous cars via C-ITS Systems are scalability, robustness, security, etc. These challenges have to be addressed before a large-scale introduction of autonomous driving is made possible.

V. CONCLUSION

This paper has dealt with the past, present and future and gradual evolution of automotive software engineering. The trend towards autonomous and cooperative driving has been discussed. The C-ITS system has also been discussed. The readers’ attention is drawn to the following references in this context.

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