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Development Situation of Software Defined Vehicles

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Abstract

With the acceleration of the "new four modernizations" of the automobile industry, "software defined vehicles" has gradually become the consensus of the field. Software drives the innovation of automobile technology, leads the wave of differentiated development of automobile products, and is gradually becoming the foundation and core of automobile informatization and intellectual development. With the arrival of the era of "software defined vehicles," the supply chain system of the automobile industry will be reformed, and the core competitive factors of the industry will also change. Therefore, this article studies the development trend of the automobile industry under the background of "software defined vehicles," aiming to help reshape the automobile industry chain and accelerate the development and reform of the automobile industry.

Keywords

Software Defined Vehicles, Revolution of the Automobile Industry, Development Situation.

1. Introduction

With the development of "new four modernizations" of the automobile industry, automotive software, automotive chips, automotive operating system, automotive electronic and electrical architecture, etc., is becoming more and more critical [1,2]. Their status is no less than or even more important than the three traditional components of the engine, transmission, and chassis [3]. It can be seen that "software defined vehicles" overturn the conventional automotive industry supply chain and reshape the automotive industry ecosystem. Its development will drive the overall reform of the supply chain system of the automobile industry.

Software-defined vehicles refer to the future cars determined by software technology with artificial intelligence as the core [4]. The differentiated competition of intelligent networked vehicles in the future is mainly dominated by software, and 90% of innovation comes from software [5,6]. The software will be deeply involved in the entire vehicle definition, development, and validation process and will continue to optimize the customer experience and create value.

The driving factor of software defined vehicles are embodied in: thousands of users need to use, a rich selection of applications, OTA (Over-the-Air Technology) update software[7], user-level without hardware upgrades and shorter development cycle, rich vehicle deformation management, rapid iterative updates after mass production, open application ecosystem services, efficient scalability of the plug and play the original equipment manufacture(OEM) level. Fundamentally, its essence is to achieve flexible expansion of vehicle functions and user needs through rapid iteration of the software and to bring consumers a new way of human-computer interaction and intelligent experience through a software update to create a new consumption pattern [8].

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In the era of “software defined vehicles," software architecture determines hardware architecture. Only decoupling software and hardware and developing a complete tool chain can separate software release vehicles from model release vehicles, achieve the rapid development and iteration of model functions.

2. The Development of Software Defined Vehicles

The era of“software defined vehicles” has come. From the perspective of data, “digital” vehicles have exceeded 100 million lines of software source code in 2015, and with the growth of code quantity (software quantity), the complexity of software code in the vehicle is increasing day by day, and the number of software code lines of self-driving vehicles in the future may reach 300 million lines [9]. From the perspective of time, the proportion of automotive software in the vehicle's value is rising. In this context, domestic and foreign enterprises have joined the “software defined vehicles” development tide.

2.1 The Development Status of Foreign

The development of “software defined vehicles" is reshaping the supply chain of the automotive industry. Nowadays, the software is becoming more and more important in the automobile industry. The entry of new technology companies makes the supply chain boundary gradually blurred, and the original core competitive elements of the automobile industry have changed substantially. According to the Boston Consulting Group, China's intelligent vehicle industry will exceed $200 billion by 2035, making it the world's largest market for driverless cars.

In this context, foreign enterprises have set up their software centers to improve software capabilities and catch up with the development tide of the era of “software defined vehicles." For example, Volkswagen AG developed its own MEB pure electric platform and invested heavily in setting up a software center. At the same time, Volkswagen AG designed a new E3 electronic architecture, which planned to reduce 70 ECUs to 3 domain controllers. In May 2019, To keep up with the trend of "software defined vehicles," Genera Motors also released a next-generation Electrical and Electronic Architecture(EEA) that supports vehicles OTA.

2.2 The Development Status of Domestic

At the policy level, the government has issued “Made in China 2025”, “New Energy Vehicle Industry Development Plan (2021-2035)” and other documents to adhere to the development direction of "new four modernizations", focusing on innovation and development, breaking through key bottleneck technologies, and improving the basic scientific research capacity of the industry. The construction of a new industrial ecology optimizes the industrial development of the environment and other aspects of specific planning.

Saic, Changan, and other OEMs have set up software centers and invested a lot of research and development strength at the industry level. Talent demand has gradually changed from "hard" to "soft" professional direction. With their rich experience and advantages in the computer and software industries, Internet tycoons such as Baidu and Tencent have cooperated with traditional automobile enterprises to enter the field of intelligent network connection and automatic driving, becoming the focus of investment at present. In this context, Huawei has also joined the wave of industry chain transformation in the automotive industry and proposed to replace EE architecture with CC (computing and communication) architecture. In the future, Huawei plans to achieve the goal of software and hardware separation, hardware update, software upgrade, and sensor expansion under CC architecture to realize the "software defined vehicles" in the real sense and sustainable value.

3. Existing Problems with Software Defined Vehicles

The development trend of “software defined vehicles” is not only an excellent opportunity for the automobile industry but also brings significant challenges to the industry. Throughout the history of global automotive industry development for a hundred years, with the increasing functions and

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demands of new models, automobiles are no longer straightforward travel tools, but gradually transformed into intelligent terminals [10]. There are as many as 150 electronic controllers on automobiles, with over 100 million codes. The maturity of software plays a crucial role in the development of automobiles.

At present, the development mode of automotive software is still challenging. OEMs have jumped out of the traditional production mode with more technical freedom, but this transition stage also needs the support of technology and management mode. At present, the division of automobile software level is not clear enough; enterprises have less investment in the research and development of critical technologies. The use of software technology is more conservative; these are the problems that need to be solved. Given the trend of "software defined vehicles," enterprises need to adjust their organizational structure and professional skills, reshape their supply chain, and redefine the operation mode of a whole set of life cycle processes such as development, production, after-sales, and maintenance of automotive products.

In addition, the technological transformation of automobiles(such as the application of OTA technology) will continue to bring difficulties to automobile supervision [11].

Whether from the perspective of automotive testing or automotive supervision, it is necessary to incorporate the automotive "software" dimension as soon as possible to protect the "software defined vehicles".

4. Industry Development Situation

From the perspective of technological change, "software defined vehicles" are bound to become the ultimate direction, summarized as four challenges, four trends, and three core technology pillars. The four challenges respectively refer to security, real-time, bandwidth bottleneck, and computing power black hole. The four trends are computing centralization, software, hardware decoupling, platform standardization, and applied ecology. The three core technology pillars refer to the chip, automotive operating system, and the data closed loop.

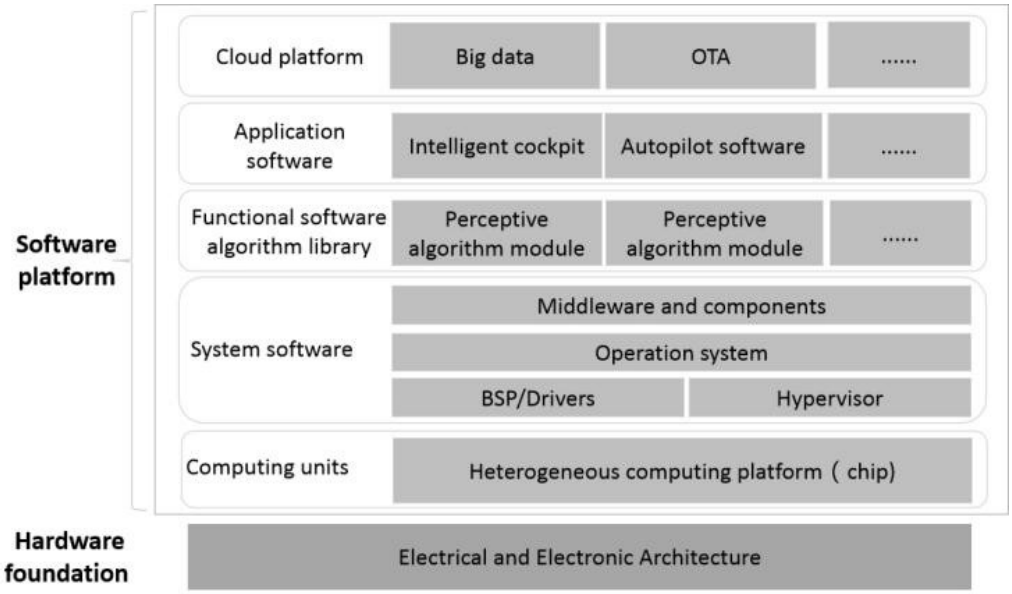

Fig. 1 The overall architecture of software defined vehicles

From the point of view of industrial transformation, software-defined vehicles will reshape the whole automotive industry, which can be summarized as four main trends:

The automotive industry is constantly developing following the logic and rhythm of the IT industry;

Industrial ecological reconstruction, schema cooperation instead of tower structure supply chain;

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Value chain paradigm shift, profit upward, software and intelligent parts become the biggest profitable segment of the automotive industry;

The elimination game kicked off, new forces into the leading role, the industry ushered in a hundred years of great change.

The overall architecture of software defined vehicles is shown in Fig. 1. The new EEA is the hardware foundation of software defined vehicles, and a well-designed primary software platform is needed to realize software defined vehicles. The chip and operating system (OS) are the keys to building the underlying software platform, and OTA is the software's core that can accelerate the upgrade iteration of future vehicles. Therefore, the development of electrical and electronic architectures, operating systems, chips, and OTA technologies is critical to implementing software defined vehicles.

4.1 EEA

EEA was first proposed by Delphi. As a complex electronic system, the automobile can be divided into several subsystems, such as power, chassis, and infotainment. Each subsystem comprises multiple electronic control units (ECUs) connected to form an extensive network structure. The prominent role of the EEA is to define the connection mode and network topology among these ECUs.

The traditional distributed EEA has many problems, such as complex network structure, redundant ECU, unreusable framework, ununified OTA, inability to define new functions by software, and inability to upgrade hardware [12]. Therefore, driven by software defined vehicles, the EEA of intelligent vehicles is accelerating its evolution from distributed to centralized, and the ultimate form is the on-vehicle central computer [13]. The development of EEA is shown in Fig. 2[14].

From the distributed ECU architecture to the domain architecture, the degree of computing concentration is significantly improved, the decoupling of software and hardware is reflected, and Ethernet is interconnected as the backbone network in the automobile. As this trend continued to evolve, central computing architectures emerged. The final form of an onboard main calculator can provide an open software platform to form a larger collaborative computing network.

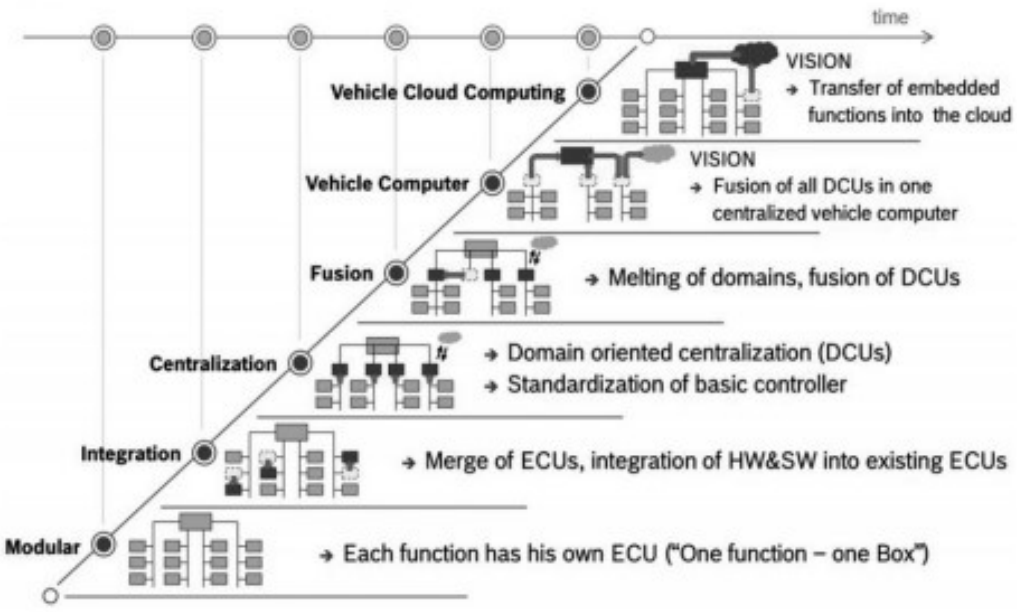

Fig. 2 Evolution of electrical and electronic architecture [15]

It can be said that the core evolution logic of the EEA is to provide an open and well-resourced hardware platform by reducing the number of ECUs and the length of the entire vehicle harness, which can not only make software development more convenient and efficient but also facilitate the software management of subsequent OTAs.

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4.2 Vehicle OS

With the development of automobile electrification, intelligence and network connection, vehicle OS (VOS) has become one of the most important parts of the vehicle. VOS is the key of the traditional vehicle to realize intelligent vehicle upgrades. It is a set of programs running in the vehicle. Its main functions include managing hardware resources, hiding internal logic, providing a software platform, providing interfaces, and providing essential services for upper-layer applications.

The classification of VOS is shown in Fig. 3. VOS is divided into vehicle-controlled operating system and on-vehicle operating system [15].

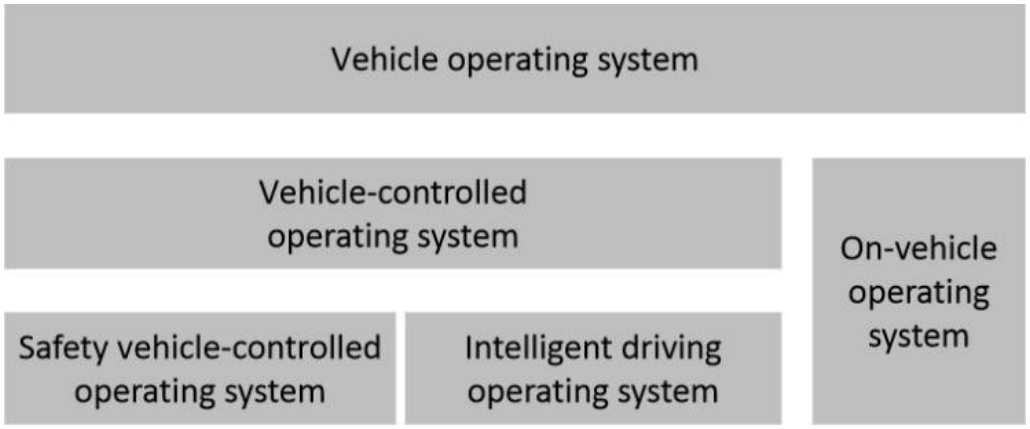

Fig. 3 The classification of Vehicle operating system

The vehicle-control operating system refers to the software set that runs on the heterogeneous hardware of the intelligent vehicle base computing platform and supports the realization of functions and safe and reliable operation of intelligent networked vehicle driving automation. It is divided into safety vehicle-controlled operating system and intelligent driving operating system. Safety vehicle-controlled operating system is mainly oriented to classic vehicle control field, and intelligent driving operating system is mainly oriented to intelligent driving field. The on-vehicle operating system runs on the on-vehicle chip, manages and controls the software set of on-vehicle software and hardware resources of intelligent connected vehicles, and provides services for intelligent connected vehicles except the realization of driving automation functions, such as Navigation, multimedia entertainment.

At present, the VOS of China still faces serious challenges. Although Huawei, Baidu, Ali, and other powerful enterprises have emerged in intelligent VOS and on-vehicle operating system in China, the development of China's VOS is still in the early stage. It still needs to be strengthened in intelligent vehicle control operating system, On-vehicle key core technology research and development, software and hardware compatibility and adaptation, and ecological supportability needs to be strengthened.

Therefore, in the future, China should do a good job in the top-level design of the safe and controllable OS, promote the research and development and industrialization of OS technology, focus on strengthening the promotion of domestic OS applications, establish OS standards and testing mechanisms, comprehensively improve the level of information security of China's OS, and provide important support for the healthy and sustainable development of the Intelligent Connected Vehicle industry and the construction of automobile power.

4.3 Chip

From the perspective of the global automotive chip market, the market share of automotive chips in the global electronics industry is increasing year by year, giving birth to a huge market opportunity.

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With the arrival of the era of automobile intelligence, network connection, and sharing, the application of intelligent network automobile chips will be more extensive. In terms of the industrial situation, the chip layout of Intelligent Connected Vehicle covers many aspects such as sensing, computing, control, communication, security, etc. Fig. 4 shows the types of Intelligent Connected Vehicle.

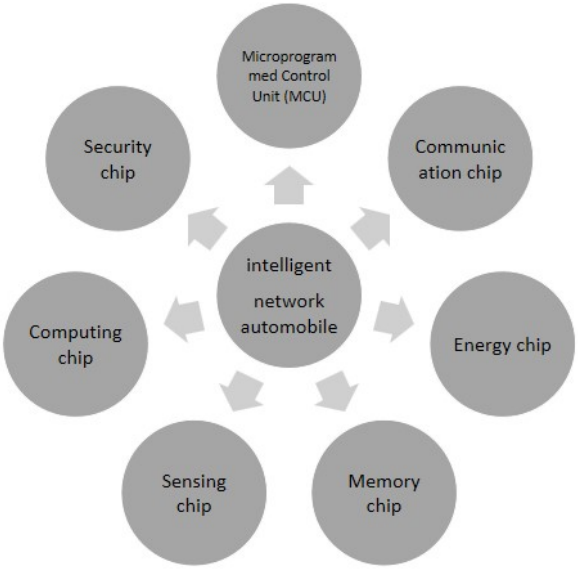

Fig.4 The types of Intelligent Connected Vehicle.

Even though the global automotive chip market is enormous, the current industrial scale of China's independent automotive chip industry is less than 5% of the world, especially advanced sensors, vehicle networks, ADAS, automatic driving, and other key system chips are all monopolized by foreign countries. The domestic is facing the "lack of core and soul" status quo.

In the era of "software defined vehicles," the government has issued many policies and guidelines to support the continuous research and development of domestic, independent chips to obtain high added value in the industrial chain.

In the context of "software defined vehicles," it is essential to carry brilliant and computation-intensive chips. Therefore, in the future, self-developed automotive chips are expected to break through the essential core technology, achieve the safety and reliability of automotive chips, enter the supply chain of world-class manufacturers, and gradually replace imported chips.

4.4 OTA

OTA technology is a kind of remote wireless upgrade technology, which is the core of the software. OTA is used to repair software defects, introduce new functions, and improve user experience. It realizes remote management of software through the interface of mobile communication, as a mature technology, OTA has been widely used in other business scenarios. In the automotive field, for example, Tesla has pushed OTA upgrades of 25 major versions since the launch of the first MODEL S.

Without the OTA software update, the software cannot define the vehicle. In the past, when a car encountered software failure or update problems, it needed to go to the 4S shop to brush, but now it can be realized through OTA online or offline upgrade [16,17].

The implementation of OTA upgrade technology will accelerate the upgrade iteration of automotive software in the future, and automotive products will be more differentiated and personalized. Each

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OTA creates a leapfrog experience optimization, realizes a product value remodeling, and creates a user hotspot.

OEM can continue to generate revenue with OTA upgrades by adding functions after a product is sold, providing preventive monitoring for potential vulnerabilities, resolving software glitches, and repairing information security vulnerabilities. The current automobile management system is mostly based on the "immutable" traditional automobile design. Today, OTA technology can not only upgrade in-car software and entertainment system, but also change key performance such as power and brake through OTA technology. Which conflicts with the current supervision system of automobile product access and production consistency.

“Opinions on Strengthening the Access Management of Intelligent Connected Vehicles Manufacturers and Products” issued by the Ministry of Industry and Information Technology pointed out that it is not allowed to upgrade the Self-driving function without authorization.

Therefore, the supervision of OTA will be the future development direction.

5. Conclusion

To sum up, building a vehicle digital architecture system decoupled from software, hardware, and vehicle platform is the foundation of software defined vehicles. A complete toolchain to support the rapid development and iteration of vehicle functions can truly achieve software defined vehicles through well-designed architecture, standardized hardware, and software infrastructure.

With the advent of the era of "software defined vehicles," the supply chain system of the automobile industry will be reformed, and the core competitive elements of the industry will also change. In the traditional closed automobile industry value chain, automobile manufacturers are only responsible for one link in the whole industrial value chain -- vehicle R&D and manufacturing. However, in the era of "software defined vehicles," the boundary of automobile manufacturers in the value chain of the vehicle industry will become more and more blurred. Therefore, research on the impact of "software defined vehicle" will help reshape the automotive industry chain and accelerate the development and reform of the automotive industry.

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