Research on the Development Strategy of the Internet of Vehicles

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Abstract. Firstly, this paper discusses several challenges faced by the existing single-vehicle intelligent driving and intense demand for connecting, then proposes the system architecture of the Internet of Vehicles from the perspective of communication capability and application support. Finally, the paper puts forward development strategies for the autonomous driving, forming a global wide recognition.

1. Introduction
The Internet of Vehicles (IoV) is the convergence point of automobile industry, information industry and transportation industry. It is an important manifestation of the application of new generation information and communication technologies such as 5G and artificial intelligence. Autonomous driving is the key application of automobile intelligence and networking development, as well as the core service for the deployment of IoV, which has huge industrial development potential and application market space in the future, of far-reaching significance for promoting the industrial transformation and upgrading, system innovation and integration development of the traditional automobile industry, transportation industry and electronic information industry.

2. Single-vehicle intelligent driving and connected autonomous driving
Technically, there are two different realization paths for the current autonomous driving: single-vehicle intelligent driving and connected autonomous driving[1].

The single-vehicle intelligent mainly relies on the vehicle's own vision, millimeter-wave radar, lidar and other sensors for environmental perception, computational decision-making, and control execution. Based on the existing single-vehicle driving, the connected autonomous driving aims to connect the transportation participation elements of "pedestrian-vehicle-road-cloud", expanding and facilitating the capability upgrade of intelligent driving, and accelerating the maturity of autonomous driving applications. In terms of environmental perception, it enables vehicles to obtain more information than the single one, such as NLOS perception or solve problems that are easily affected by harsh environments. In the process of calculation and decision-making, systematic decision between vehicles, vehicles and roads is improved, such as solving the problem of vehicle priority management and traffic intersection optimization control. Besides, cooperating in control execution to intervene in vehicle driving behavior, for example remotely controlling vehicles to get out of trouble.

The development of connected autonomous driving will accelerate the construction and improvement of the new infrastructure system of “pedestrian-vehicle-road-cloud” collaboration, facilitate the application and promotion of 5G, artificial intelligence and other information and
communication technologies in vertical industries, and stimulate the realization of new models and new business formats for automobile and transportation services.

3. Challenges of single-vehicle intelligence and intense demand for connecting

3.1. Environmental perception
At present, there are still some deficiencies of single-vehicle intelligent in the reliability of sensors and the ability to respond to emergencies. First, vehicles are vulnerable to shelter, bad weather and other environmental conditions, i.e., crossroads, tunnel entrances, etc. Through vehicle-road collaboration and vehicle-vehicle collaboration, networking can greatly expand the perception range of single vehicle, enabling vehicles to detect unknown situations in advance, so as to deal with situations that are currently difficult to respond to in autonomous driving test and accident, e.g., the sudden entry of the target. In addition, there are also difficulties in target prediction and driving intention game[2]. Networking can directly provide the key result status information, for example the status of signal lights, the next action intention of surrounding vehicles, the best driving route under current road conditions, etc., reducing the complex calculation process based on sensor information, and accurately understand the intention of surrounding traffic participants.

3.2. Computational decision-making
The main functions of computational decision-making can be divided into two categories: one is target recognition of environmental perception data, the other is decision planning of driving route and vehicle action according to the result of perception and vehicle driving task. On the hardware, computing decisions are mainly carried out on the multi-core heterogeneous distributed computing platform based on CPU, GPU, DSP, AI chip, MCU, etc. The contradiction between computing power and power consumption is an important bottleneck encountered by the current single-vehicle intelligent driving computing platform. Meanwhile, the traffic behavior is more of a "game" among many participants, it is difficult to provide the best solution in the decision-making and planning of path actions for single-vehicle intelligence.

Networking is expected to share the computing power consumption of single vehicle, and give a global optimal driving strategy based on the cloud control platform. In terms of computing power, networking can directly give the sensing results of target, eliminating the complex calculation and analysis process of the sensor signal, e.g., the judgment of traffic lights, thus greatly reducing the demand for computing power of single vehicle. Besides, with the help of cloud computing, edge computing capabilities, the roadside computing power is supposed to be introduced, namely, installing visual sensors, lidar and other sensors on the roadside to distribute the roadside sensing results. For the driving strategy, in special scenarios, networking can collect the data information of the traffic participants within its scope, and provide a global optimal solution based on the status of all subjects, without giving the decision planning through "trial" and "game". At present, it has been verified and applied in specific scenarios of non-public open roads i.e., mines, ports and logistics.

3.3. Control execution
In the aspect of control execution, considering the collaborative processing between the autonomous driving system and human driving, as well as the reliability and safety of vehicle control, redundant backup and high real-time response of the control system are the main technical requirements. Networking can provide application modes for remote control driving and cooperative driving. For instance, in some dangerous or unsuitable places for humans to enter, use 5G remote control driving to operate vehicles on the far side. It has been applied in unmanned mines. In the vehicle formation, through the interaction of control and execution information, the rear vehicle can drive according to the unified command of the leader. Networking can separate the vehicle control and execution from the single vehicle, reducing the load of the perceptual computing task of the rear vehicle.
4. The architecture of IoV system

Relying on the information and communication technology, IoV support a wealth of basic applications and enhanced application types, and cross-research and collaborative development with intelligent transportation, autonomous driving and other fields. Therefore, the understanding and focus of the architecture of IoV system will be different from different aspects. This article describes the architecture from the perspective of communication capability and application support.

As shown in Figure 1, the overall system architecture can be divided into three parts: end, pipe and cloud. Supported by the common basic technology and information and communication security technology, environmental perception, data computing, and decision control can be realized, so as to provide safe, efficient and convenient IoV service[3]. From the protocol layer, the system architecture can be divided into device layer, network layer, platform layer and application layer, corresponding to the end, pipe and cloud in the architecture respectively.

End (device layer): The "end" of the IoV refers to various on-board terminals and infrastructure terminals with wireless communication capabilities, which can realize the information transmission and reception between the vehicle and other vehicles, between cloud platforms, as well as the sharing of vehicle and traffic status information. The terminal can carry out various V2X communications such as V2V, V2I, V2P, V2N, etc.

Pipe (network layer): Utilize communication technologies such as V2X and cellular network, including 4G/5G base stations, C-V2X road side unit (RSU), mobile edge computing (MEC) facilities, etc., to achieve all-round connection and information interaction including vehicle-to-vehicle, vehicle-to-road, vehicle-to-platform, vehicle-to-people and so on. It supports flexible configuration according to business requirements, while ensuring the safety and reliability of communication.

Cloud (platform layer and application layer): Cloud is a comprehensive information and service platform. The platform layer mainly includes data platform, open business platform, security management platform and support platform, which realizes data collection, calculation and analysis, decision-making, and supports security management, operation and maintenance management of open business. The application layer is oriented to various applications of the Internet of Vehicles industry (including road safety, traffic efficiency, autonomous driving, and infotainment applications) and application support systems, providing diversified public services and industrial applications. The platform layer and application layer can be deployed on the edge or central cloud according to business needs and network support capabilities.

Through the three-tier architecture of "end, pipe and cloud" and the four-layer protocol architecture of the Internet of Vehicles, traffic participants will form an informatization and digital mapping of the whole system. Cellular network (4G, 5G, etc.) can be combined with C-V2X to build a wide-coverage comprehensive network of cellular communication and direct communication, ensuring the continuity
of the Internet of Vehicles business. Through the introduction of artificial intelligence and big data technology, the computing capability of the communication network is enhanced, which realize massive data analysis and real-time computing decision-making, and establish an integrated IoV business support capability and system control platform.

5. Development suggestions

5.1. Enhance the industrial collaboration

Tackle key technologies. Aiming at key areas such as vehicle computing chips, vehicle operating systems, sensors and data processing, increase investment in innovation resources and accelerate the construction of a technology innovation system that is enterprise-dominated, market-oriented and deeply integrated with industry, university and research.

Grasp the synergy of common key technologies. Especially for the key common technologies of the industry that are difficult to be solved by a single enterprise, it is necessary to pay attention to the selection of technology paths, the schedule of technology deployment, technology standardization and open interface design, such as the "pedestrian-vehicle-road-cloud" communication network system. Strengthen the integration of standards for automobile, communication, transportation, public security and energy[3]. Explore a new mode of cross-industry standard cooperation, and jointly establish and improve the industry standard system for the Intelligent Connected Vehicles in terms of platform interface and application services. Power the construction and management of big data and cloud platform. Push forward the interconnection of various platforms, cross-platform information interaction and data sharing, and build a market-oriented mechanism for data use and maintenance. Accelerate the construction of comprehensive big data and cloud platform to support the scale development and continuous innovation of Internet of Vehicles applications.

5.2. Push the maturity of autonomous driving industry

Jointly issue a top-level plan and clarify the path selection. Make good use of the organization and coordination role of the Internet of Vehicles Industry Development Committee, strengthen the collaboration among automobile, information communication, transportation, electronics and other cross-industry fields, jointly formulate the development road-map and issue the top-level plan.

Build smart road infrastructure. Carry forward the in-depth integration of information communication and artificial intelligence technology with road traffic infrastructure, and improve the intelligent level of road infrastructure. Deploy edge computing capability and roadside sensing terminals in key areas. Coordinate the construction of network infrastructure based on LTE-V2X, 5G and other wireless communication technologies to improve its coverage on major highways and urban roads[4]. Improve the data access specification of roadside communication equipment and base station, as well as its integration and access ability with road infrastructure and intelligent control facilities. Strengthen the construction of laws, regulations and mechanisms. Make Plans ahead, pay close attention to the research and resolution of laws and regulations that restrict the development of the autonomous driving industry, construct a policy and regulation system for the autonomous driving industry in line with China's national conditions, and push timely formulation and revision of policies and regulations restricting the development of the industry.

5.3. Deploy and implement in phase

Strengthen the coordination of ministries and commissions and cooperation between ministries and provinces, encourage all parties in the industry chain to participate in the construction of simulation, closed, semi-open demonstration zones and test bases for intelligent connected vehicles applications[5]. Strengthen cross-departmental and ministry-provincial collaboration, promote the deepening of cooperation, data sharing, test mutual recognition in various demonstration zones, and accelerate the promotion of demonstration applications.
Give impetus to the construction and upgrade of smart road infrastructure in stages. From local pilot to whole area coverage, the top priority is key cities and highway sections where conditions permit for road infrastructure reconstruction, and gradually expand to regional and urban levels. From basic information interconnection to the extension of perception and computing capabilities, take priority to the networking of traffic lights and existing road traffic signs, then the deployment of sensing and computing roadside facilities such as edge computing platforms, radar, and visual cameras. Push the test verification and application demonstration of connected autonomous driving step by step. Accelerate the construction of application demonstration zones and pilot zones, and deepen multi-party cooperation, data sharing, mutual recognition of testing, facilitating the promotion of demonstration applications. Gradually push the construction of big data and cloud platform from regional to global, from sub-functional to full, propel the interoperability of various platforms, information interconnection and data sharing, and speed up the construction of an application service system based on connected autonomous driving[1]. Carry out the application demonstration in different scenarios, and explore the mature construction and operation modes. Power the demonstration and large-scale application of autonomous driving taxis and buses in characteristic towns, industrial parks, and smart cities, thus comprehensively improving residents' life and enhancing travel experience.

6. Conclusion
The Internet of Vehicles is driven by the superposition of policy, capital, and technology, especially the commercialization of 5G provides a good opportunity for the outbreak of the Internet of Vehicles. China should seize the rare historical development opportunity, adhere to the collaborative development path of networking, multi-party coordination of government, industry, and enterprises, actively create an industrial development environment, and promote the maturity of autonomous driving, forming a global wide recognition.

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