# Intelligent network connection technology based on 5G intelligent highway

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**Abstract.** Intelligent highways are important practical scenarios in the application of modern intelligent transportation systems. The rapid development of 5G intelligent network technology provides important technical support for improving the travel efficiency of autonomous driving in intelligent transportation systems and reducing the risk of collisions. This paper introduces the technology of 5G intelligent network connection, discusses the integration application of intelligent highway scene and intelligent network connection technology, and finally predicts the future development trend of the intelligent transportation system.

## 1 Introduction

With the rapid development of the information industry, the application scope of mobile communication technology has long been not limited to simply transmitting information but has penetrated all aspects of people's lives and has become a necessary hardware device for social development and people's production and life. Among them, 5G technology has brought mobile communication technology to a new level of development. The use of 5G technology has made various industries develop rapidly, and people's lives are undergoing major changes due to the application of 5G technology. Among them, intelligent networked autonomous driving technology is one of the important research contents, and the intelligent upgrade of highways plays a key role in realizing 5G intelligent networked automatic driving technology [1].

## 2 5G intelligent networking technology

The intelligent network uses network technology and mobile communication technology to exchange intelligent information, improve driving safety and energy-saving effect, and the ultimate goal is to realize autonomous driving. This is a new technology related to multiple industries such as automobiles, the Internet, and electronics. The development of 5G technology is mature, and the relevant standards of intelligent network connection are gradually improving and entering the commercialization stage.

5G intelligent network connection needs to realize three technical capabilities: perception capability, communication capability, and computing capability [1]. Perception capabilities require vehicle-side multi-sensor fusion and roadside global perception. Communication capabilities mainly rely on 4G, 5G, C-V2X private network, Internet of

Things, RFID antenna equipment, and high-precision positioning reference stations. The computing power is mainly realized by the roadside edge, cloud, and onboard computing unit.

The main scenarios for the future application of intelligent network technology are roughly divided into urban and marginal scenarios. The traffic environment of conventional roads is open, which is difficult in the initial stage of intelligence, while the traffic environment of expressways is closed, and it is easier to achieve better results by using intelligent network technology in expressways. Therefore, the combination of intelligent network technology, highway environment, and targeted research and development can promote the application of connected autonomous vehicles.

# 3 Expressway 5G intelligent network technology

In recent years, various countries have been promulgating relevant policies to promote the development of industries related to intelligent network connection, and building intelligent highways have become an important part of it. Many emerging technologies are used in intelligent highways, among which 5G intelligent network, Internet of Things, Beidou satellite, cloud computing, blockchain, big data, artificial intelligence, edge computing, and other technologies are widely used. These technologies continuously improve the establishment of the infrastructure monitoring system, realize the intelligentization of the road network operation perception system, ensure the reliability of the communication resource security system, conduct real-time monitoring of the forecast and early warning system, improve the efficiency of the emergency security system, and enable the travel service system more convenient.

## 3.1 Blockchain-based Intelligent Transportation System

Blockchain technology can upgrade various transportation systems from the aspects of transportation, information, communication, control, vehicles and machinery, to optimize traffic congestion and maximize the effectiveness and efficiency of limited transportation resources.

Blockchain has many excellent characteristics, the most important is its decentralization [2]. In the entire blockchain, each node is equal, and each node will store the data on the entire blockchain. When a block is attacked, even if the node is damaged, it still does not affect the integrity of the entire blockchain ledger. As a result, the application of cutting-edge technologies such as blockchain technology to intelligent transportation can improve road safety, ease traffic congestion, reduce energy consumption, and reduce environmental pollution. It can also improve the energy efficiency of the transportation system, strengthen the integration of traffic information, and better coordinate traffic management and monitoring.

From the blockchain operation to the vehicle-road coordination system [3], the roadside and vehicle-mounted intelligent terminals upload information in real time. Asymmetric encryption based on blockchain technology encrypts each information separately, and each node has a separate decryption private key to prevent information leakage. The distributed ledgers based on blockchain technology build a P2P node network by multiple roadside nodes, and realize comprehensive data collection based on the principle of co-construction and sharing.

After the expressway toll collection method is based on the actual driving route, it is necessary to confirm the uniqueness of the driving route and ensure that it is accurate, fair and without objection. Based on blockchain technology, the distributed accounting of vehicle traffic information is realized, and the license plate recognition result and electronic

label information are used as the accounting content, which can solve the problem of data loss after traditional single-point failure, and make the expressway ETC system more orderly, security and stability [4]. At the same time, because the blockchain can record the location of the vehicle in real time, people can judge the traffic congestion in real time, to carry out intelligent traffic guidance. Due to the emergence of smart contracts, the government can intelligently adjust the charging standards of each road section on the chain, and set different charging modes at different times and different road conditions.

### 3.2 Intelligent transportation system based on big data

Traffic big data has the characteristics of large data volume, many data types, and low data value. In terms of operation management, traffic big data is mainly reflected in the toll management and monitoring system [5]. Through big data connection to the monitoring system, combined with intersection toll management, vehicle management can be effectively improved, and problems such as vehicle evasion, malicious license plate change, and blocking photos can be detected promptly. At the same time, based on the analysis of vehicle data and toll data collected by ETC, it can make basic predictions of traffic flow at other high-speed card points, predict the upcoming peak traffic flow in advance, and make early warnings. Big data's operation and management efficiency for intelligent highways is incomparable to manual management. Big data supervision can also form scientific data information, and managers can adjust the development direction of highways through this information [6].

In terms of highway safety management, traffic big data can directly combine various road condition data and climate data to provide help for highway road safety management. Using big data to analyze expressway vehicles during holidays can easily predict congested sections, sections prone to accidents, and other information that will impact traffic, so that drivers can know the information in advance to plan and avoid, and prevent obstacles to travel. During the holidays, managers can monitor the running conditions of the highway, fully grasp the traffic flow, road conditions and other information on the highway, establish a platform for real-time data sharing, and share the real-time road conditions to the mobile terminals or vehicle broadcasts of drivers and passengers to reduce the congestion of highways, thereby reducing the probability of traffic accidents [7].

While the expressway brings convenience to people's life and economic growth to the region, the difficulty of expressway road maintenance is also increasing. Using traffic big data, the expressway operation department uploads the daily maintenance and repair information of the highway, which can realize the information sharing of road maintenance needs, supervise the expressway maintenance department to regularly detect the use of the expressway, and timely maintain and repair the highway, to lay a foundation for the long-term use of the highway.

### 3.3 Intelligent transportation system based on artificial intelligence

The addition of artificial intelligence technology can effectively improve the expressway's capabilities in emergency response, monitoring, management, service, and decision-making, and meet the requirements of the road network to be "knowable, measurable, controllable, and serviceable". Among the various technologies of artificial intelligence, highway management services can focus on technologies such as machine vision, intelligent drones, and 3D vision [8].

The application scenarios of machine vision in expressway operation management include not only traditional traffic accident detection and early warning, illegal parking incident alarm, but also seven scenarios including road surface detection, automatic

identification of road spills, illegal behavior alarm, traffic flow/traffic incident monitoring and employee service monitoring.

Through the mounted cameras and mounted speakers of intelligent drones, it can be applied to scenarios such as emergency on-site real-time management and control, illegal infringement of road property and right-of-way supervision, overload and over-limit supervision and so on. In addition, intelligent drones can also conduct road maintenance and inspection on highways, solve the problems of detours, low efficiency and insecurity in outfield exploration, provide some intuitive and complete data, and solve physical blind spots.

Once the emergency scene is destroyed or canceled, it cannot be restored. By applying unmanned aerial vehicles, machine vision and other technologies, the integrity of the highway accident scene environment can be maintained, and the resurgence, measurement and analysis of the scene situation can be realized through the event simulation based on three-dimensional map.

### 3.4 Intelligent transportation system based on edge computing

Facing the problem of high network load brought about by the accelerated development of the Internet of Things, and the requirements of high bandwidth and low latency for some applications, the international standards organization ETSI proposed edge computing technology in 2014. Edge computing technology adds intelligence and computing units at the edge of the network, which can provide cloud computing capabilities and 1T service environment, and realize business localization functions and short-distance deployment. Edge computing is used in the highway vehicle-road coordination system to improve computing capacity, in which the RCU roadside computing unit of the private network provides computing services for highway roadside equipment and passing vehicles when practical. The roadside electromechanical equipment of the intelligent transportation system in the expressway can be roughly divided into four categories: perception, release control, communication network and service. The system-generated data can be divided into structured, semi-structured, and unstructured data.

The expressway has an urgent demand for efficient and safe service level. The number of highway sensing devices has increased, and the accuracy has also improved. The amount of unstructured data collected such as images has increased, and the working process of network communication system and monitoring center has also produced pressure. Edge computing technology can extract effective data, avoid a large amount of data redundancy, and integrate data for data value mining, shorten decision-making fusion and accelerate the response process.

The intelligent transportation system uses IP cameras and OBUs as intelligent terminals, uses pressure gauges and stress gauges as the collection terminals of distributed cluster data, and requires the network bandwidth and data processing capabilities of the cloud platform the traffic control center to be strengthened. Standalone systems like tunnel control and power supply and distribution management need to be integrated with other systems on the highway. The remote bandwidth, cloud resource sharing and low-latency applications brought by edge computing can better achieve independent system integration and data fusion. Edge computing is an important part of developing intelligent transportation systems and intelligent network. [9]

The edge computing in the intelligent highway is to perform local real-time processing and decision-making on the information of the highway area through the edge computing unit, and establish a hierarchical decision-making system together with the traffic control center. While reducing data redundancy and data processing, the delay of traffic guidance and control is reduced, as shown in Figure 1.
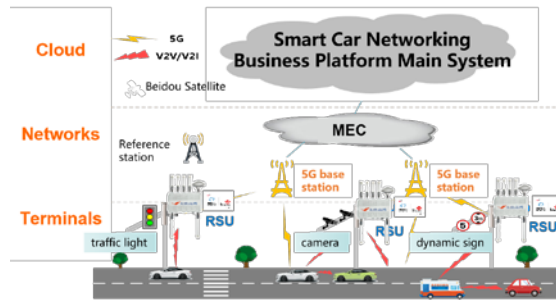
**Fig. 1.** Expressway intelligent transportation based on intelligent edge computing.

## 3.5 Intelligent transportation system based on high precision positioning

Aiming at the problem that it is difficult to achieve high-precision satellite positioning in an occluded environment, a fusion positioning scheme of 5G, Beidou, vehicle sensing and other technologies is proposed, and a set of indoor and outdoor integrated high-precision positioning system architecture based on 5G + Beidou is formed. The architecture is used to develop high-precision positioning equipment and cloud services for vehicles, achieving a technological breakthrough of 0.1-meter positioning accuracy in occluded environments, and providing seamless indoor and outdoor high-precision positioning and path navigation for unmanned vehicles. The architecture is shown in Figure 2.
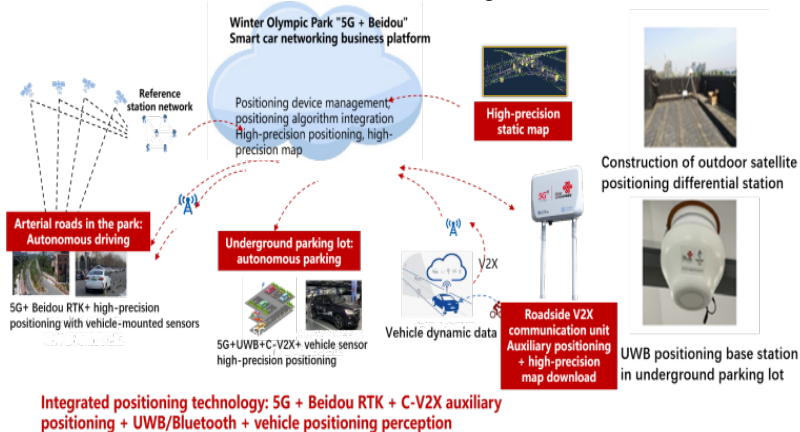


**Fig. 2.** Indoor and outdoor integrated high-precision positioning system based on 5G + Beidou.

By deploying 5G base stations, Beidou ground-based enhancement stations, and intelligent roadside equipment equipped with positioning capabilities, a multi-source fusion high-precision positioning system based on 5G+Beidou can be constructed. Through the high-precision location service platform, services such as centimeter-level precise positioning, real-time trajectory tracking, and dynamic path planning can be realized. The organic combination of cloud location information and the vehicle's perception capabilities helps self-driving cars achieve high-precision autonomous driving. The indoor and outdoor integrated high-precision positioning system based on 5G + Beidou + UWB is deployed in the underground parking lot to help realize the autonomous parking business, including quick search for parking spaces and driving in and out, and precise parking.

## 4 New trends in intelligent transportation systems

### 4.1 In-depth application of artificial intelligence technology

The introduction of new generation technologies such as cloud computing and big data makes modern and traditional intelligent transportation systems very different. The modern intelligent transportation system can intelligently connect and systematize the traditional independent subsystems, and produce more intelligent applications. In addition, the data fusion and sharing among various systems has also become a development trend. Intelligent traffic management can continue to combine innovative applications related to new technologies such as blockchain and big data, integrate the data, algorithms and businesses in the model according to the specific traffic scenarios of the industry in the original system, and build an innovative computing framework under the combination of traditional industry applications and scientific computing.

### 4.2 The construction of the intelligent network connection system brings innovative changes in traffic management

With the development of 5G or next-generation wireless communication technology, smart cities, intelligent traffic management and related service platforms are also accelerating and improving. The construction of the intelligent networked system is also an inevitable result of technological development in the new era. With the rapid development of intelligent transportation networks, the overall development of intelligent transportation networks has been gradually promoted. The management and operation of intelligent transportation construction are progressing steadily. An intelligent network connection is widely used in congestion and safety control, information service, operation service, and other aspects. It is an important control node and data acquisition terminal of traffic condition perception network, bringing innovative changes to intelligent transportation management.

## 5 Summary

With the continuous improvement of the standards of 5G intelligent network technology, the increasing investment in technology research and development has proved that the intelligent development of the transportation system is an inevitable trend, and the deployment of intelligent highways also provides security for the application of the internet automatic driving vehicle. The intelligent highway supported by 5G intelligent network technology will move towards a higher level of intelligence, bring different travel experiences, and provide support for the development of intelligent transportation.

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