

# The Application of 5G Communication Technology in Intelligent Transportation Systems

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## Abstract

With the continuous development of communication technology, 5G technology has been widely applied in all aspects. In China, where a vast population base translates into high travel demands and severe traffic congestion, intelligent transportation systems (ITS) emerge as a crucial solution. This paper delves into the integration of 5G and ITS, exploring the application of 5G technology in this vital field through literature review and case analysis. It meticulously examines the specific applications of 5G in three key areas: autonomous driving, traffic management, and intelligent travel services. Moreover, it addresses the challenges faced by 5G in this domain, along with potential countermeasures and future development trends. Leveraging its technical attributes of extensive connectivity, large capacity, high speed, and low latency, 5G technology significantly enhances the reliability, safety, and efficiency of intelligent transportation systems. It has not only propelled the development of ITS but also laid a solid foundation for constructing an efficient, safe, and sustainable urban transportation environment.

## Keywords

**5G Communication Technology; Intelligent Transportation System; Autonomous Driving; Traffic Management; Intelligent Travel Service.**

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## 1. Introduction

With the acceleration of urbanization and the sharp increase in the number of motor vehicles, problems such as traffic congestion and frequent accidents have become increasingly prominent. Intelligent transportation systems (ITS) have become the core direction to solve these problems. Led by the construction of a strong transportation country, intelligent transportation systems The proposed reliable transportation field that integrates economy, convenience, smoothness, efficiency, intelligence, foresight and safety [1]. By building intelligent platforms, vehicle networking architectures, and intelligent traffic signal regulation systems, the road traffic capacity has been enhanced and the road operation efficiency has been improved. While intelligent transportation systems have significantly propelled the informatization of transportation and enhanced public convenience and quality of life, several challenges persist. These include constraints imposed by traditional communication technologies, prohibitive construction costs, and suboptimal efficiency in management, maintenance, and services.

Meanwhile, with the development of Internet information technology, people have entered the fifth generation of mobile communication technology (5G) era. Compared with 4G, 5G has ultra-high bandwidth, ultra-low latency (millisecond level) and massive connection capabilities, which can provide great assistance in building intelligent transportation systems. However, there is currently an imbalance between communication technology and infrastructure construction. There are research gaps in multi-scenario adaptation, security protocol specifications, and cost control.

This article aims to systematically study and review the application and development of 5G communication technology in intelligent transportation systems, and make suggestions and plans for future development directions. Utilizing literature review and case analysis, it examines relevant studies from recent years and conducts in-depth case research. By summarizing previous scholars' findings and analyzing real-world cases of 5G-enabled smart transportation projects, the article aims to predict the future trajectory of 5G and intelligent transportation integration. It provides valuable references for researchers in this field and offers both theoretical support and practical guidance to advance the development of intelligent transportation systems.

## 2. Overview of 5G Communication Technology

5G communication technology takes the new air interface design as its core architecture. In terms of spectrum resource utilization, it adopts a hybrid deployment strategy of "low frequency wide coverage + high frequency high capacity". The low-frequency band (Sub-6GHz) relies on a mature cellular network architecture to ensure wide-area continuous coverage, while the high-frequency band (millimeter wave, 24GHz and above) breaks through the rate bottleneck with its ultra-large bandwidth characteristics. The core technical principle is Massive MIMO (Massive Multiple-Input Multiple-Output), building antenna arrays, using network slicing technology to establish high-precision independent communication links, and allocating network resources in a dynamic manner to ensure that complex algorithms can achieve a good state of efficient operation [2]. In addition, 5G also relies on the full-duplex communication mode, significantly enhancing communication efficiency.

Compared with 4G, 5G has significant improvements in coverage area, transmission speed, low latency and high capacity. Specifically, the rate has increased by 10 to 100 times, and the peak rate of smart terminal users accessing the Internet can reach an uplink rate equivalent to 1.25G/s, with a bandwidth transmission capacity of 10Gbps [1]. The latency has been reduced from 50 milliseconds in 4G to less than 10 milliseconds, with an empty port latency of 1ms and end-to-end latency reaching the millisecond level [1]. The connection density has been increased by 10 times, supporting up to 1 million devices per square kilometer. Mobility support has been increased from 350km/h to 500km/h. With these features, 5G technology can reduce the constraints of communication space, accelerate the transmission rate of large videos, and provide broadband application support for AR virtual reality and other technologies. Meanwhile, extremely low latency has also driven the development of technologies such as autonomous driving, traffic management, remote medical surgeries, and remote mechanical control.

## 3. The Application of 5G Communication Technology in Intelligent Transportation Systems

### 3.1 The Application of 5G in Autonomous Driving

The deep integration of 5G technology and the autonomous driving system of intelligent new energy vehicles has established a new paradigm for intelligent transportation. The transmission speed of 4G technology is limited, with the maximum transmission speed being only 100Mb/s and the network rate delay reaching 50ms. This makes it impossible to achieve real-time control of high-speed moving vehicles, thus restricting the development of autonomous driving and vehicle-road coordination technologies. However, with technical features such as millisecond-level latency, gigabit-level bandwidth and wide-area coverage, 5G networks can break through the bottlenecks of traditional 4G networks in the field of Internet of Vehicles [3].

The core of realizing autonomous driving technology lies in building a dynamic network of integrated communication among "vehicles, roads and clouds". In an autonomous driving system, the immediate response at each stage of vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communication is crucial to driving safety and traffic efficiency. The realization of millisecond-level low-latency communication between vehicles enables them to respond promptly to the driving conditions of surrounding vehicles, such as automatic braking, automatic overtaking and

other autonomous driving functions. Under the low latency feature of 5G technology, the braking distance is significantly reduced compared with 4G technology, achieving "super perception" between vehicles. Meanwhile, 5G technology also has significant applications in real-time notifications and precise navigation: it alerts drivers whether there are traffic jams or accidents on the road ahead, and at the same time, it conducts real-time communication with infrastructure such as traffic lights, road markings, and indication signs, enabling the autonomous driving platform to promptly understand road information and make precise responses, greatly enhancing driving comfort and safety. The integration of 5G network technology and satellite communication technology can achieve centimeter-level positioning, helping to locate vehicle positions in real time and obtain road information. This enables drivers to plan navigation routes promptly and also facilitates traffic management departments in locating and locating individual vehicles, significantly reducing the incidence of traffic accidents. In addition, the high speed and stability of 5G communication can ensure that the autonomous driving system maintains stable information exchange even in bad weather, complex road conditions or network congestion, and will not experience control failure due to communication interruption [4]. The large capacity and high bandwidth of 5G technology enable the seamless transmission and reception of vast amounts of data, including high-definition maps and real-time traffic condition videos. This significantly enhances vehicles' environmental perception capabilities, making autonomous driving more precise and intelligent.

Based on practical examples, the "5G Vehicle-Road-Cloud-Control Integration: Building the First City-level Ultra-Stable Autonomous Driving" project jointly developed by China Telecom Suzhou Branch, Tianyi Transportation, and ZTE Corporation has deployed and activated over 160 base stations along more than 160 kilometers of roads in Xiangcheng District, Suzhou. Through URLLC technology and end-to-end dual-route backup solutions, A super-stable parallel link has been achieved. Chongqing Mobile has built an intelligent all-domain perception road in Guangyang Island Smart Innovation Ecological City relying on 5G communication technology. It adopts the system design of "5G + front-end MEC+C-V2X" for vehicle-road coordination. By taking advantage of the low latency and high bandwidth characteristics of 5G networks, it has achieved functions such as high-precision positioning, assisted driving, and autonomous driving. In conclusion, 5G technology holds a significant position in the integrated construction of vehicles, roads and clouds, and the development of autonomous driving benefits from the wide application of 5G communication technology.

### **3.2 The Application of 5G in Intelligent Transportation Management**

In the field of intelligent transportation management, 5G technology, with its wide connection and high capacity technical features, is constantly changing the model and pattern of transportation management services. Through 5G networks, the traffic management center seems to have gained a pair of X-ray eyes, enabling it to observe the dynamic veins of urban traffic without any time lag. Whether it is the distribution of vehicles, driving speed or traffic density, all are under control [5].

In terms of daily traffic operation management, the low latency of 5G technology enables traffic information to be promptly fed back to relevant departments, helping them make precise and timely decisions. For instance, in Huainan, Anhui Province, a "5G + Beidou" big data monitoring platform has been built. After a traffic accident occurs, the transportation department can quickly receive the location information of police cars equipped with Beidou positioning services. Meanwhile, the video and sensor information of the traffic accident can also be rapidly and stably transmitted to relevant departments through the 5G network Help them promptly dispatch the nearest police car and ambulance to the accident site to the scene; In Shanghai, China Mobile and Huawei have jointly launched the world's first 5G-A vehicle networking demonstration route. Along the way, information on traffic lights, vehicles and pedestrians on the roads can be sent to the driving vehicles in real time. At the same time, it also supports a series of intelligent functions such as automatic traffic light switching and autonomous switching of tidal lanes. It demonstrates a significant improvement in the

efficiency of traffic management algorithms after integrating 5G technology with machine learning and deep learning.

In terms of the intelligent design of roadside equipment, through 5G technology, roadside equipment can more effectively interact with traffic service platforms and on-board units for information exchange. Roadside equipment typically includes intelligent traffic lights, road surface sensors, surveillance cameras, and wireless communication modules, etc [6]. Intelligent traffic signals can automatically adjust the signal timing based on real-time traffic flow and vehicle speed data, reducing traffic congestion and improving traffic efficiency. Road surface sensors are used to detect road conditions such as wetness, water accumulation or traffic accidents, providing real-time road condition information for the traffic management system. Surveillance cameras and video analysis technology can help detect abnormal conditions on the road, such as driving in the wrong direction or speeding, and transmit the data in real time to the traffic management center for analysis and processing [6]. Relying on its technical features of low latency communication and large capacity, 5G networks can help accurately transmit sensor data and high-definition surveillance videos, thereby assisting traffic management departments in timely adjusting the duration of traffic lights, adjusting road sign guidance, and optimizing traffic dispatching, etc., making outstanding contributions to creating efficient transportation services.

In addition, in terms of emergency disaster relief management, 5G wireless technology has enabled efficient information transmission and command and dispatch. When encountering natural disasters and other emergencies, rescue teams can use 5G wireless technology to obtain detailed information about the accident site in real time and formulate scientific and effective rescue plans. Through 5G wireless technology, rescue vehicles can also be located and navigated in real time, improving the efficiency and success rate of rescue work. During the rescue process, the command center can track the location and driving status of the rescue vehicle in real time, quickly adjust the rescue plan, and ensure the smooth progress of the rescue work [7]. For instance, on July 1, 2025, when a sudden water gushing occurred in a karst cave in Xianfeng, Hubei Province, the emergency rescue team of China Mobile Hubei Company dispatched a large 5G emergency communication vehicle and achieved precise communication coverage inside the tunnel within 30 minutes. The stable 5G signal enabled the on-site disaster relief situation to be promptly transmitted back to the command center. Eventually, all five trapped people were safely rescued and reported their safety through 5G network video connection.

### **3.3 The Application of 5G in Intelligent Travel Services**

In the era of rapid development of the Internet, intelligent travel services have made significant contributions to providing passengers with a good travel experience. Intelligent travel refers to a travel model that effectively penetrates and integrates traditional transportation with the Internet by leveraging advanced technologies and concepts such as mobile Internet, cloud computing, big data, and the Internet of Things, breaks down information barriers, and enables more precise travel decisions, smoother travel processes, and more personalized travel experiences. In the travel service sector, 5G technology also plays a significant role. 5G wireless technology enables passengers to obtain various traffic information more conveniently. With the help of mobile phone apps and vehicle navigation and other terminal devices, passengers can receive relevant information about traffic conditions, subway and bus information, as well as parking lot data in the first place. In addition, 5G technology has also promoted the personalization and informatization of passenger services. Passengers can obtain precise forecasts of bus arrival times through mobile applications, making it more convenient for them to plan their trips. The digital transformation of bus stops, such as the display of real-time bus location information on electronic bus stop signs, has further enhanced passengers' travel experience. Meanwhile, the intelligent public transportation system can predict and respond to fluctuations in passenger demand in hot areas based on big data analysis of passenger flow, and formulate special operation plans for special events or holidays to ensure the balance of supply and demand in public transportation services [5]. In various modes of transportation such as bullet

trains, high-speed railways, airplanes, and ships, 5G technology is utilized to efficiently transmit a large amount of passenger data. Based on the real-time data flow, relevant railway and aviation departments make real-time adjustments to train schedules, flight schedules, and route planning changes. At the same time, information is promptly released to each passenger through 5G+ the Internet, and the most suitable itinerary is recommended for them. For instance, the "Junzilan" cruise ship, the first to achieve full 5G-A coverage on the Huangpu River, has adopted an innovative solution jointly developed by China Telecom Shanghai Branch and Huawei. It has set up 11 5G base stations on the upper and lower parts of the hull and deployed high-frequency 5G-A high-bandwidth base stations along the riverbank to ensure stable signal coverage. Tourists can enjoy a high-speed and stable network experience on cruise ships, and managers can also monitor passenger flow, ship positions and safety conditions in real time, achieving more efficient and intelligent operation and dispatching.

#### **4. Challenges and Coping Strategies**

5G technology has achieved remarkable results in the application of intelligent transportation systems, but it also faces many challenges.

Firstly, the construction of 5G networks requires a large amount of capital investment, including the construction of base stations and the upgrading of network equipment, which may lead to an increase in communication costs [8]. At the same time, in intelligent transportation systems, there is also a need for road test equipment capable of 5G communication, sensor devices for receiving data, and advanced intelligent automated driving vehicles, etc. All these will bring considerable cost input. To reduce the cost of 5G network construction, the government and operators should increase policy support and financial input. The government can introduce relevant policies to encourage operators to accelerate the construction of 5G networks. For example, the government can provide construction subsidies and support in the allocation of land resources. Meanwhile, operators can optimize their network construction plans and adopt methods such as sharing base stations to reduce construction costs [8].

Secondly, the guarantee of ultra-low latency technology in 5G technology is lacking and needs to be further optimized. In practical application cases, there are still many technical problems to be overcome in end-to-end low latency. Although 5G has improved data rates by using large-scale MIMO technology, beamforming technology and other methods, due to the propagation characteristics of millimeter waves, signals are more likely to be blocked and multipath reflected, which will inevitably lead to latency and data loss [9]. In addition, 5G networks must provide dedicated resources for diverse applications through network slicing to meet the low latency requirements of core applications. However, the current dynamic allocation mechanism of network slicing still needs to be further improved to adapt to complex traffic scenarios [9]. In the future, further research and breakthroughs are still needed to ensure the technical challenges of optimizing low-latency technology, as well as to optimize algorithms and hardware designs to meet increasingly complex application scenarios.

Finally, at present, the security and high reliability guarantee of 5G networks still faces many technical challenges. The fragmentation of laws and regulations is quite prominent. The standard system has not yet formed a complete framework. The compatibility test pass rate of V2X communication protocols from different manufacturers is not high, exposing the technical barrier of non-uniform interface standards [10]. There is a regulatory vacuum in the field of data security. Relevant departments need to enhance their regulatory efforts, and the government also needs to continuously optimize policies to ensure the security of 5G networks.

#### **5. Conclusion**

This article conducts research on the application of 5G technology in intelligent transportation systems. Against the backdrop of prominent issues such as traffic congestion and frequent accidents

during the urbanization process, although intelligent transportation systems are a solution direction, they are constrained by traditional communication technologies and high costs. However, the ultra-high bandwidth, ultra-low latency, and high-speed transmission characteristics of 5G can provide support and bring new opportunities to intelligent transportation, injecting vitality into the field. This article adopts the methods of literature review and case analysis to first elaborate on the 5G technical architecture, core principles, and performance improvements compared to 4G. From three aspects: autonomous driving of automobiles (ultra-perception between vehicles, real-time notifications, and precise navigation), intelligent traffic management (daily traffic, intelligent design of road test equipment, and emergency disaster relief), and intelligent travel services (providing real-time traffic information and personalized services), combined with cases from Suzhou, Chongqing, Shanghai and other places, the specific applications of 5G are analyzed. As can be seen from the above, 5G technology has greatly promoted the development of intelligent transportation systems and made outstanding contributions to traffic management, travel services and driving experience. In the future, with the continuous development and application of 5G technology, intelligent transportation systems will enjoy an even broader development prospect.

However, this article lacks certain theoretical derivations and mathematical formula calculations, which may lack theoretical persuasiveness. Moreover, the research on a single field is not in-depth enough. Subsequently, theoretical derivations and mathematical formulas of 5G core technologies (such as delay and channel capacity calculations) can be supplemented, focusing on a single field to dig deeper into the details and optimize the research plan to enhance persuasiveness.

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