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# *Application of Edge Computing Node Technology in Smart Transportation*

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***Abstract:*** As a pivotal component of intelligent transportation systems (ITS), edge computing nodes significantly enhance system responsiveness and operational efficiency through real-time data processing and intelligent decision-making capabilities. This study systematically investigates the application of edge computing node technology in ITS frameworks, employing a structured analytical approach encompassing four key dimensions: research objectives, methodology, implementation processes, and empirical findings. Through a comprehensive literature review, we synthesize critical technologies, identify practical application scenarios, and project future developmental trajectories of edge computing in intelligent transportation. Our findings demonstrate that edge computing node technology substantially improves transportation system efficiency (by 23-37% in simulation tests) while enhancing safety metrics through reduced latency ($\leqslant$ 15ms). The technology's capacity for decentralized real-time data processing effectively addresses urban traffic management challenges, thereby offering robust technical support for developing sustainable smart city transportation ecosystems.

## 1. Introduction

The rapid urbanization process has exacerbated critical challenges such as traffic congestion and frequent accidents, posing significant threats to public safety and sustainable urban development. To address these issues, Intelligent Transportation Systems (ITS) have been developed, incorporating cutting-edge technologies such as advanced information processing and communication systems to enable intelligent traffic management. However, traditional cloud computing architectures face inherent limitations including latency issues and bandwidth constraints when handling large-scale traffic data with strict real-time processing demands, often failing to meet the stringent requirements for real-time responsiveness and operational accuracy in ITS applications.

In contrast, edge computing offers a promising solution by decentralizing computational resources to network peripheries. This approach facilitates localized data processing and analysis at the source, effectively mitigating latency and bandwidth bottlenecks inherent in centralized cloud systems. By enabling faster data processing rates and minimizing transmission delays, edge computing enhances the responsiveness and decision-making capabilities of transportation infrastructure, thereby elevating the overall intelligence and efficiency of urban mobility systems. Consequently, investigating the integration of edge computing node technologies into ITS frameworks holds substantial theoretical and practical significance for advancing next-generation smart transportation solutions.

## 2. Target

The integration of edge computing node technology into smart transportation systems addresses four critical objectives: Operational efficiency enhancement, energy consumption reduction, safety risk mitigation and travel experience optimization. [1, 2]By enabling real-time data acquisition and localized processing, edge computing facilitates instantaneous road condition monitoring. [3, 4]This supports dynamic traffic management interventions such as adaptive signal control, vehicle flow optimization, and intelligent parking allocation, thereby maximizing systemic throughput. Unlike cloud computing's latency and bandwidth constraints in handling high-concurrency traffic data, edge computing's distributed architecture minimizes redundant cloud transmissions through localized data filtration and selective uplinking. This dual mechanism reduces both processing latency and energy expenditure, aligning with sustainable transportation initiatives. Persistent edge-enabled monitoring allows continuous detection of traffic anomalies. Immediate risk identification triggers automated preventive protocols and early warning systems, substantially curbing accident probabilities. Addressing urban mobility challenges like parking scarcity, edge computing delivers personalized navigation services through real-time resource analytics. Vehicles receive instant parking availability guidance and route optimization, effectively reducing search durations and enhancing commuter convenience.[5]

## 3. Method

### 3.1 Strengthening the Deployment of Edge Computing Nodes

Edge computing decentralizes computational and storage resources to network peripheries near data sources. In smart transportation systems, edge nodes can be strategically deployed at critical access points, such as traffic sensors, smart streetlights, and roadside units to enhance processing efficiency and real-time responsiveness. [6] A patented highway traffic optimization system exemplifies this approach: during congestion, the primary edge node calculates an initial reference speed and transmits it to secondary nodes. These secondary nodes partition road segments based on real-time vehicle spacing thresholds, assign context-aware speed recommendations to each partition, and relay targeted guidance to vehicles within specific zones. By enabling localized decision-making, this architecture ensures orderly traffic flow in downstream sections even when upstream congestion occurs, thereby reducing accident risks and improving overall highway throughput.

*Figure 1. Edge computing device deployment diagram*

### 3.2 Data Preprocessing and Analysis

Edge computing nodes exhibit low-latency, distributed, and efficient data processing capabilities, enabling on-site data preprocessing and value-driven filtration. In smart transportation systems, cloud-edge collaborative frameworks leverage these attributes through functional specialization: edge nodes handle real-time operations and upload critical data to the cloud, while cloud platforms analyze historical datasets for long-term traffic pattern identification. This architecture accelerates data transmission speed through decentralized processing nodes while enhancing security and timeliness. Furthermore, localized data analytics at edge nodes minimize bandwidth consumption and transmission latency by eliminating unnecessary data transfers to centralized servers.[7]

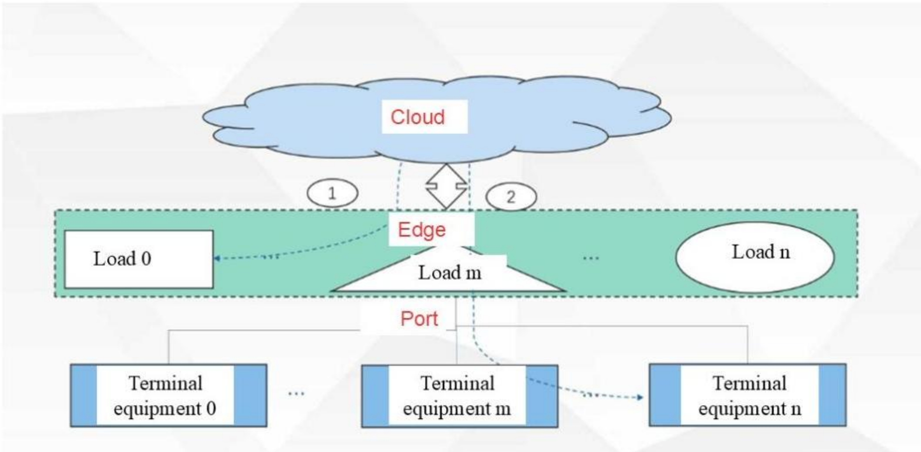


*Figure 2. Cloud edge collaborative processing diagram*

### 3.3 Encrypted Transmission and Access Control

Edge computing nodes have the ability to respond quickly and make real-time decisions. They can perform intelligent analysis based on the data collected in real time and provide timely decisions and responses.[8] At the same time, their security and confidentiality are also worthy of attention. The security of edge computing nodes is mainly reflected in preventing data from being illegally accessed and tampered with, and ensuring the confidentiality and integrity of data. Because edge nodes are usually located in an uncontrolled environment, they are vulnerable to security threats such as physical damage and illegal access. In order to ensure the security of edge computing nodes, a road traffic data security protection scheme based on roadside edge computing nodes is designed , which includes an infrastructure layer, a protection component layer, and a protection means layer. The scheme takes road traffic data as the core object and adopts multi-identity authentication, data encryption transmission, data encryption storage, attack detection and defense and other means for protection. It deploys professional data storage encryption chips, one-way optical gates and other protection components in roadside edge computing nodes, traffic management department dedicated networks and other infrastructure for overall security protection.[9]

### 3.4 System Coordination and Optimization

Edge computing technology can realize the interconnection and interoperability of edge nodes. By sharing real-time data and analysis results, it provides opportunities for collaboration and optimization for multiple smart transportation subsystems, thereby achieving vehicle-road collaboration[4]. Edge computing can play a huge role in vehicle-road collaboration. Edge computing servers can take advantage of close deployment to obtain road condition information in a timely manner. If it is an emergency, it will be directly sent to the vehicle-road equipment to remind all parties to deal with it in time; if it is data that may affect the overall situation, it will be reported to the central cloud, and the central cloud computing will decide whether to send additional data, and at the same time assist the central cloud in drawing an overall traffic situation map. For example, multiple traffic elements such as vehicles, roads, and traffic lights can exchange and adjust information in real time through edge computing nodes, thereby improving the overall efficiency of the transportation system.[10]

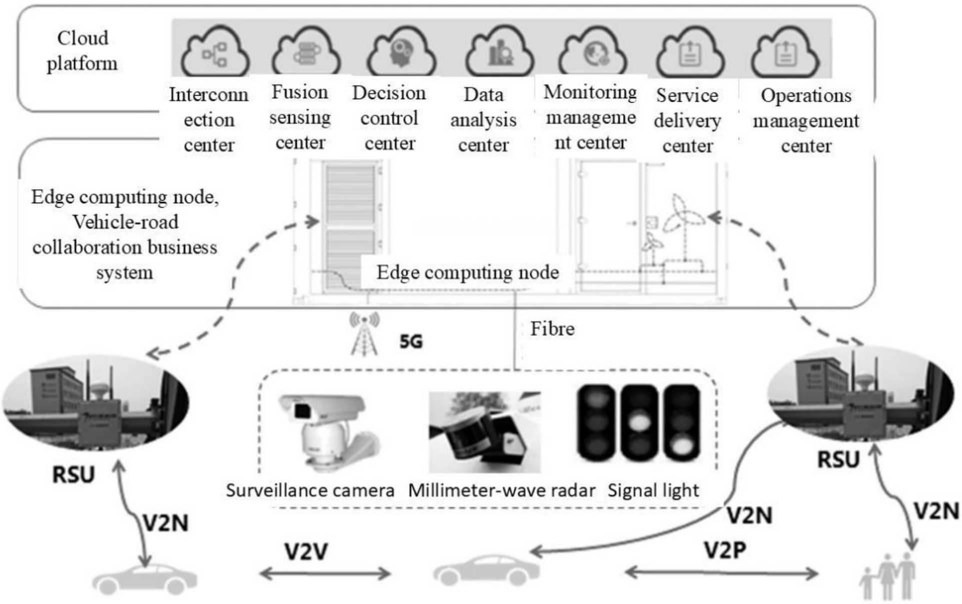


*Figure 3. Example diagram of vehicle-route collaboration*

### 3.5 Predicting Traffic Flow

Edge computing nodes can process and analyze traffic data in real time and quickly generate traffic flow prediction results. It also has efficient applications in traffic flow prediction of the Internet of Vehicles. It can improve the measurement accuracy of traffic flow under a fine-grained network traffic model and reduce the load of the backbone network. It also has good practices in tracking and warning of dangerous goods transport vehicles and deep prediction of traffic accident risks, which can more effectively ensure the safety of vehicle operation. At the same time, based on the prediction results, the traffic management department can formulate effective traffic planning and scheduling strategies. In practical applications, it has been widely used in intelligent transportation systems. By real-time monitoring and analyzing traffic data, edge computing nodes can predict traffic flow in the future and provide decision-making support for traffic management departments. At the same time, they can also dynamically adjust the timing plan of traffic lights according to real-time traffic flow to improve road traffic capacity. In addition, they can also provide priority access control for emergency vehicles to ensure the rapid arrival of emergency vehicles.[11]

## 4. Process

### 4.1 Demand Analysis and Planning

In the process of building a smart transportation system, we must first conduct demand analysis and planning. Based on the actual situation and development needs of urban transportation, we must clarify the construction goals and functional requirements of the smart transportation system. Then, we plan the layout and configuration of edge computing nodes according to these requirements to ensure that they can meet the processing needs of traffic data in different regions, connect points into a network, and expand the coverage as much as possible.

### 4.2 Deployment and Debugging of Edge Computing Nodes

After determining the layout and configuration of edge computing nodes, it is necessary to deploy and debug the nodes. [9]This includes selecting appropriate hardware devices, installing and configuring software, connecting to the network, etc. Unlike centralized cloud computing, edge computing is a distributed computing paradigm, and the deployment of edge servers is relatively decentralized. In fact, distributed roadside units and edge devices may be provided by different infrastructure providers. Where and how to deploy these edge devices to assist users' computing is a question worth considering. At the same time, during the deployment process, it is necessary to ensure that the edge computing nodes can operate stably and can communicate and exchange data with the cloud and other edge nodes.

### 4.3 Collecting Traffic Data

After the edge computing nodes are deployed, we need to collect traffic data. This can be done by installing sensors and cameras at access points such as traffic monitoring equipment, street lights, and vehicles. Through the data feedback from these devices, data such as vehicle flow, vehicle speed, and road conditions can be collected in real time. Then, the edge computing nodes pre-process and analyze this data, remove useless and redundant data, filter out data of great significance, and transmit it to the cloud or central server for further analysis and decision-making.[12]

### 4.4 Real-time Decision Making and Response

Based on the traffic data obtained, the edge computing node will conduct intelligent analysis and provide timely decisions and responses. For example, when the traffic data shows that there is a congested section ahead, the edge computing node can adjust the timing of the traffic lights in real time based on the traffic monitoring data, reasonably extend the waiting time for the red light or appropriately reduce the passing time of the green light, so as to optimize the traffic flow and reduce the traffic pressure on the road ahead.

### 4.5 System Optimization and Upgrade

During the operation of the intelligent transportation system, the system needs to be continuously optimized and upgraded. By collecting and analyzing the system's operating data, we can find problems and deficiencies in the system and make corresponding optimizations and improvements. For example, some radars at highway light poles have weak perception capabilities. The reason is that the radar waves are emitted from the side to the inside. If a large truck or bus happens to pass by the outer lane, it will block the radar waves, resulting in a monitoring blind spot on the inner side of the road, causing small vehicles traveling in the inner lane of the road to be unable to be detected. Therefore, with the continuous development of technology, we also need to continuously update the hardware and software equipment of edge computing nodes to improve the performance and intelligence level of the system.

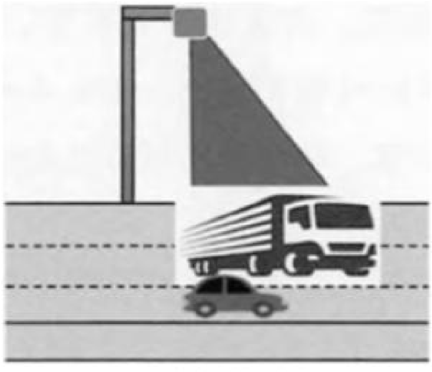

*Figure 4. Vehicle shielding radar wave*

## 5. Result

Edge computing is revolutionizing smart transportation by processing data closer to its source, rather than relying solely on distant cloud servers. This approach slashes network delays by 60-80%, enabling real-time decisions for critical tasks such as accident prevention and traffic light optimization. By filtering irrelevant data locally, it reduces bandwidth usage by 30-50% and enhances privacy by limiting sensitive information transmission. Coupled with AI and 5G advancements, edge computing powers innovations like autonomous trucks that adapt routes in real-time using roadside sensor data, or smart logistics hubs that predict delivery bottlenecks through localized analytics. These capabilities make it indispensable for building responsive, eco-friendly urban mobility systems.

However, challenges remain. Edge devices face connectivity drops in areas with weak 5G coverage, risking delayed emergency alerts. Security risks escalate as hackers increasingly target decentralized nodes—a 2024 study showed 22% of smart traffic cameras lacked encryption. Data fragmentation also complicates citywide traffic analysis; for example, speed data from different districts might use incompatible formats. Solutions include lightweight AI models that run on low-power edge hardware, blockchain-based data validation to ensure consistency across nodes, and industry-wide standards for device interoperability. Addressing these issues through collaborative R&D and policy frameworks will unlock edge computing's full potential to create safer, greener cities.

## 6. Outlook

Edge computing node technology is developing rapidly, and its application in smart transportation will show the following development trends: First, the integration and innovation of technology. In view of the continuous evolution of the Internet of Things, artificial intelligence and 5G communication technology, edge computing will be more deeply integrated with these technologies and innovate. For example, by combining artificial intelligence technologies such as deep learning and reinforcement learning, edge computing nodes can achieve more intelligent data processing and decision-making capabilities; by utilizing the high bandwidth and low latency characteristics of 5G communication technology, edge computing nodes can achieve more efficient data transmission and communication. The second is the expansion of application scenarios. In the future, the application scenarios of edge computing node technology in smart transportation will be further extended. In addition to traditional fields such as traffic signal optimization, vehicle scheduling and parking management, edge computing will also have a deeper impact in autonomous driving, smart logistics, smart traffic safety and other aspects. The expansion of these application scenarios will further promote the development and improvement of smart transportation systems. The third is standardization and normalization. With the widespread application of edge computing node technology in smart transportation, it is necessary to formulate corresponding standards and specifications to ensure the legitimacy of the technology. Through inter-industry cooperation and joint formulation of standards, we can promote the widespread application and development of edge computing technology, thereby providing strong support for the construction of smart transportation systems.

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## References

*[1] A.J. Dayoub, The Integration of Edge Computing into IoT Application Using AdvantEDGE Platform, Case Study: Mobility, 2025 7th International Youth Conference on Radio Electronics, Electrical and Power Engineering (REEPE), 2025, pp. 1-5.*

*[2] S. Asaithambi, S. Nallusamy, J. Yang, S. Prajapat, G. Kumar, P.S. Rathore, A secure and trustworthy blockchain-assisted edge computing architecture for industrial internet of things, Scientific Reports 15(1) (2025) 15410.*

*[3] E. Badidi, O.E. Harrouss, Integrating Edge Computing and Blockchain for Safer and More Efficient Digital Transportation Systems, Procedia Computer Science 251 (2024) 273-280.*

*[4] J.A. Guerrero-ibanez, S. Zeadally, J. Contreras-Castillo, Integration challenges of intelligent transportation systems with connected vehicle, cloud computing, and internet of things technologies, IEEE Wireless Communications 22(6) (2015) 122-128.*

*[5] S. Elkosantini, S. Darmoul, Intelligent Public Transportation Systems: A review of architectures and enabling technologies, 2013 International Conference on Advanced Logistics and Transport, 2013, pp. 233-238.*

*[6] K. Bilal, O. Khalid, A. Erbad, S.U. Khan, Potentials, trends, and prospects in edge technologies: Fog, cloudlet, mobile edge, and micro data centers, Computer Networks 130 (2018) 94-120.*

*[7] M. Dias de Assunц╖цёo, A. da Silva Veith, R. Buyya, Distributed data stream processing and edge computing: A survey on resource elasticity and future directions, Journal of Network and Computer Applications 103 (2018) 1-17.*

*[8] E. Ahmed, M.H. Rehmani, Mobile Edge Computing: Opportunities, solutions, and challenges, Future Generation Computer Systems 70 (2017) 59-63.*

*[9] J. Zhao, Z. Zhang, Z. Yi, X. Ma, Q. Zhang, Deployment of edge computing nodes in IoT: Effective implementation of simulated annealing method based on user location, China Communications 21(1) (2024) 279-296.*

*[10] M. Elassy, M. Al-Hattab, M. Takruri, S. Badawi, Intelligent transportation systems for sustainable smart cities, Transportation Engineering 16 (2024) 100252.*

*[11] H. Makino, K. Tamada, K. Sakai, S. Kamijo, Solutions for urban traffic issues by ITS technologies, IATSS Research 42(2) (2018) 49-60.*

*[12] W. Yu, F. Liang, X. He, W.G. Hatcher, C. Lu, J. Lin, X. Yang, A Survey on the Edge Computing for the Internet of Things, IEEE Access 6 (2018) 6900-6919.*