Design and Implementation of Roadside Intelligent Information Interaction System Based on Edge Computing

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Abstract. Under the influence of artificial intelligence (AI), Internet of Things (IOT) and big data technology, V2X vehicle infrastructure cooperative technology is rapidly applied to intelligent traffic management and road condition services. However, the existing roadside traffic control equipment has difficulty in data aggregation and processing, that cannot meet the application requirements of the intelligent connection and edge calculation of the V2X vehicle infrastructure cooperative device. In this paper, the "edge computing + end-edge-cloud collaboration" mode is used to construct the roadside intelligent information interaction system. As an intelligent connection node between roadside traffic management system and V2X vehicle infrastructure cooperative system, the design makes roadside video analysis and real-time data fusion and push function come true. Because of its lightweight intersection deployment mode, regional-level road condition diagnosis and optimization control capabilities, it has broad application prospects.

1. Introduction
With the influence of artificial intelligence (AI), Internet of Things (IOT) and big data technology, China's road traffic information technology is also developing rapidly. For example, the application of V2X vehicle infrastructure cooperative technology helps to drive the openness of traffic management data and enhance the intelligence of traffic control and travel service levels. However, the existing roadside traffic management equipment has the pain points of system isolation, data fusion difficulty, and weak processing capability, which can not meet the application requirements of intelligent, networking, and low-latency equipment for V2X vehicle infrastructure cooperative technology. As a smart node based on edge computing, the roadside intelligent networked information interaction system and equipment is promoting data interaction between roadside traffic information systems and vehicle networking systems, and accelerating road coordination technology innovation and application to improve people's smart travel experience.

2. The requirements of intelligent end-edge node
The existing conventional roadside intelligent information system is usually composed of a plurality of vertical independent systems, including an electronic police system, a traffic control system, and a V2X Internet of vehicles system. These three systems are respectively established in the public
security video private network, so they are independent of each other, and the data is interacted at the central platform layer. The typical system architecture is shown in Figure 1.

![System Architecture Diagram]

**Figure 1. Existing roadside information system structure**

In the context of the intelligent connected technology and the V2X intelligent connected vehicle service platform, new requirements are put forward for the roadside intelligent information system, as follows:

1. **Multiple parallel communication**
   With the rapid development of intelligent traffic detection and sensing technology, video detectors, induction coils, microwave detectors, RFID electronic identification, etc. have been widely used in traffic signal control systems, illegal capture systems and monitoring systems. However, because of non-uniform communication protocols, various traffic systems separated from each other, the characteristics of the multivariate data have large differences. Therefore, data cross-utilization, fusion, mining and display cannot be achieved.

2. **Fast processing and real-time interaction**
   With the continuous increase of traffic data and the rich application scenarios of traffic services, higher requirements are put forward for the rapid processing and real-time interaction of traffic data. For example, in order to meet the real-time requirement of the V2I scenario, it is necessary to exchange and process traffic data at the front end of the road and communicate with the internet of vehicles in real time, instead of the long delay mode include of data transmission, center processing and feedback.

3. **Unification of signal control data and protocol**
   Traffic signal, as the most basic data of traffic, is the key point of traffic service. However, at present, there are long-standing barriers for signal control manufacturers, which are independently developed and communication protocols are not uniform. In order to meet the requirement of the wide application of signal data and new technology, a unified interface protocol for roadside intelligent information interaction system is developed. The basic data of signal control of each manufacturer can be gathered and interacted in a unified way, which can solve the problem that data can not be interconnected and shared among different enterprises, meet the needs of traffic managers and traffic participants for signal control data, and lay a solid foundation for further standardizing the signal control industry and promoting its sound development.
2.4 Edge calculation

In the future, autopilot technology requires roadside devices to have the ability of edge processing, that is, data pre-processing and pre-filtering, extracting feature information from a large number of data, and then transferring the processed data to the cloud for further processing, rather than transferring all the original data to the cloud. Thus it can greatly reduce the restriction of network bandwidth on high-speed data transmission, and reduce the pressure of data processing in the central cloud.

Therefore, in order to realize the mutual generalization of data between different detection modes and different traffic systems, and to meet the strong demand of multi-information collection, edge processing and low-latency interaction of roadside traffic control terminals, a roadside intelligent information interaction device based on edge Computing is developed, and a roadside intelligent information interaction system is built to exchange and locate traffic data in real time at the intersection. Rationally, it is of great significance to meet the needs of practical applications.

3. Architecture of roadside intelligent information interaction system

Based on the existing roadside intelligent information system, the application system of data aggregation, processing and interactive sharing of roadside multi-terminal is established by using edge computing architecture. The roadside intelligent information interaction system which meets the requirements of intelligent connected technology and V2X Internet of vehicle service platform is designed, and the technical framework of roadside intelligent information interaction device is formulated, as shown in Figure 2.

![Figure 2. Architecture of roadside intelligent information interaction system](image)

Based on edge computing technology, this paper designs and implements the roadside intelligent information interaction device, as shown in Figure 3. The device supports a variety of road-side traffic sensing, monitoring, information dissemination equipment information aggregation interface mode, formulates multiple traffic data access specifications and communication protocols, and forms communication specifications including road traffic signal, video card surveillance cameras and various traffic detectors. The device supports the rapid processing of traffic signal data, traffic flow data and traffic video structured data. Under the environment of intelligent connection, the intelligent node of interaction between roadside traffic control terminal and V2X Internet of vehicle service platform is constructed. Its main functions include: roadside connection, video analysis, data processing and real-time data push.
3.1 Roadside network Federation

According to the demand of traffic control terminal data IOT interaction, the roadside intelligent network information interaction system needs to support the connection mode of traffic data interaction interface, formulate the access specification and communication protocol of traffic data, and form the communication specification of terminals including road traffic signal, video interface monitoring camera and various traffic detectors. Therefore, the information aggregation interface unit of the roadside intelligent network interconnection information exchange device needs to realize the following access ports:

- Two independent network interface: data interaction with electric police video card system and traffic control system to obtain traffic video data, traffic flow data and traffic signal data.
- Two USB communication interface (supporting access to 4G and 5G communication modules): data interaction with OBU device of V2X Internet of vehicle service platform.
- One HDMI interface: supports data push to LED screen.

3.2 Video Parsing

Each roadside electric police video card camera and vehicle RSU device captures real-time road condition information, which has about 1 GB data per second. To process these data in real time, it needs about 300 Tflops operation speed. Intelligent Networked Vehicles need real-time push data (millisecond delay). It is obviously unrealistic to transmit such large data to the cloud for processing, and then return the response. A delay of several hundred milliseconds may be the difference between valid data and invalid data.

Video analysis and processing unit of roadside intelligent network information interaction device integrates Huawei Ascend (Rising) series Atlas200 AI acceleration module, provides 16TOPS@INT8 super AI computing power, supports 16-channel high-definition video real-time analysis, realizes image second-level search, real-time traffic video stream analysis function, extracts structured traffic video data, monitors and recognizes traffic incidents, and Traffic abnormal state is dynamically detected.
3.3 Data processing
Data aggregation, processing and interaction unit uses Hi3559A Cortex A73/53 quad-core processor, 4GB RAM and 32GB ROM minimal system to realize characteristics research of multi-element traffic data. Combined with traffic signal data, traffic flow data and traffic video structured data, the data processing interactive unit can extract traffic control information, safety hint information, traffic accident information, traffic incident information, etc., complete the data fusion of traffic characteristic indicators, and perform data forwarding service according to the standard interface protocol.

3.4 Real-time data push
System pushes the following information to V2X Internet of vehicle service platform and intelligent connected on-board unit of intelligent connected vehicle in real time:

- Real-time traffic light color information and remaining time information of traffic lights at forward intersections and traffic status information of entry lanes at intersections.
- Traffic control information such as vehicle restriction and prohibition, road construction information ahead and road construction bypass information ahead.
- Safety information such as school ahead, pedestrian crossing, etc.
- Traffic incident information and traffic accident information in front of the road.
- Video information corresponding to traffic operation of roadside detectors.

Remind the driver to pay attention to the speed, and provide the basis for the driver route selection and guidance.

4. Application of Roadside intelligent information interaction system
Roadside intelligent information interaction system can realize the following application scenarios:

4.1 End-edge intelligent node with AI processing function
Roadside intelligent information interaction device integrates mainstream AI computing components in the industry, and adopts key technologies such as intelligent heterogeneity and end-edge-cloud collaboration. Unlike the traditional cloud-based artificial intelligence, the system is based on the neural network computation of field application equipment, i.e. embedded AI. Through off-line training of the neural network, it realizes the recognition and processing of real-time 16-channel high-definition video stream data, and reports real-time road condition data in the form of structured data.

Because the operation is dispersed in the near-end equipment near the data source, the system no longer needs to process the video data stream back to the cloud at a long distance. It has better real-time performance, higher efficiency and shorter delay, and the requirement of network bandwidth is reduced accordingly. At the same time, through edge computing application, it can synchronize device data and communicate with other devices safely, even without connecting to the Internet, to maximize the reliability, security and privacy protection capabilities, to meet the application of public security video private network and traffic private network environment.

4.2 Lightweight roadside deployment platform
Roadside intelligent information interaction system can realize rapid roadside deployment without changing the existing conventional roadside architecture and layout. And it does not control the roadside equipment, and does not affect the normal operation of the original system. On the premise of accessing up to 16 channels of high-definition video stream data, a group of roadside intelligent information interaction system can access multiple intersection devices at the same time, which simplifies multiple sets of devices into one set. On the one hand, it saves investment, on the other hand, it is also easy to maintain, and it is suitable for upgrading the existing conventional roadside intelligent information system.
4.3 Road condition diagnosis and optimal control at regional level
Roadside intelligent information interaction system can realize real-time traffic information processing, optimize intersection timing, release guidance information and other functions at the end side when accessing multi-intersection roadside equipment to work together. With V2X vehicle infrastructure cooperative service platform and public security traffic management platform, it can effectively help to improve and improve the traffic conditions at road junctions and alleviate traffic congestion.

5. Conclusion
As the main component of the end-edge intelligent node of V2X vehicle infrastructure cooperative service platform, the roadside intelligent information interaction system is the optimization and innovation of the conventional roadside intelligent information system. Thus, the significant structural change and function upgrading caused by quantitative change can be produced, which not only meets the new demand of V2X vehicle infrastructure cooperative service platform for roadside intelligent information system, but also achieves regional road condition diagnosis and optimization control, thus greatly improving the efficiency of urban traffic management and traffic conditions. Because of its lightweight way of intersection deployment and low cost investment when reconstruction or new construction, the system can promote the open interconnection of traffic management information, provide standardized data services for intelligent connected Vehicles, and create favorable conditions for the comprehensive promotion of V2X vehicle infrastructure cooperative technology.

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