Application and Research Analysis of Distributed Computing and Edge Computing in Vehicle Road Collaboration

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Abstract. With the development of intelligent transportation, vehicle road collaboration has become an important part of intelligent transportation, and the realization of vehicle road collaboration has become the goal of the new era. The main computing technology in the new era of distributed computing is applied in many fields, and the integration of distributed computing into vehicle road collaboration has become a research hotspot. Based on the in-depth analysis and summary of previous studies, this paper expounds the basic connotation of distributed computing, edge computing and vehicle road collaboration around the application scenarios of vehicle road collaboration, combs the cloud edge end system architecture, summarizes the core technologies such as vehicle road cloud, task unloading, real-time data processing, information security, summarizes the application scenarios such as autonomous driving, smart bus, real-time traffic monitoring, and analyzes the current research hotspots and challenges. Finally, it looks forward to the future development directions such as combining quantum computing and large language model, in order to accelerate the development of vehicle road collaboration and the process of intelligent transportation.

Keywords: Distributed computing, Edge computing, Vehicle road collaboration, Cloud edge end.

1. Introduction

Distributed computing is widely used in many fields - distributed computing is the computational power "base" of AI and an important part of AI [1]. Edge computing applies edge nodes to participate in computing and is applied in many fields - to meet the needs of real-time health data collection and analysis in medical treatment through edge computing [2]. The automotive industry is moving towards networking and intelligence. Vehicle road coordination has become an important part of intelligent transportation and an important direction of intelligent transportation development [3].

However, there are related technical challenges in vehicle road collaboration - the traditional cloud platform is difficult to meet the needs of vehicle road collaboration with large amount of information, strong dynamics and strong information interaction [4]. Distributed computing and edge computing provide technical support for it, and are widely used in vehicle road coordination. Chen et al. Proposed a collaborative awareness framework, which uses small-scale characteristics to achieve real-time edge computing and avoid network congestion in vehicle road collaboration [5]; Bute mset al. Proposed a distributed task unloading scheme, which processes tasks in parallel by selecting vehicles with idle computing resources nearby [6]; Zhao w et al. Proposed a distributed task unloading framework based on DRL to ensure that the roadside unit can meet the role of task allocation, computing resources and responsiveness in autonomous driving [7].

This paper summarizes the previous research results, and expounds the core technology, application fields, research hotspots, practical challenges and prospects for future development of distributed computing and edge computing in vehicle road collaboration, so as to facilitate future scholars to better study this important field.

2. Introduction to Related Concepts

Distributed computing is a technology that distributes computing tasks to multiple independent computing nodes (computers or servers) for parallel processing. The core idea is to decompose the complex task into multiple subtasks, and hand over the tasks to multiple computers for cooperation.

Edge computing is a computing mode that calculates near the data source. Its core idea is to deploy computing resources at the edge of the network [8], and distribute computing tasks to servers at the edge of the network to reduce the delay of information transmission.

Vehicle road collaboration is a new technology that relies on wireless communication, sensor and information interaction to achieve dynamic real-time data interaction and collaborative work. It has great potential in easing traffic congestion and improving driving comfort [9].

The system architecture is cloud side end architecture. The cloud is composed of multiple high-performance servers and storage devices, which have powerful computing and storage capabilities and can be used as the global central node; The edge end is composed of multiple edge nodes deployed at the edge of the network, which can independently complete data storage and computing tasks; The terminal device is the end - point of the cloud - side - end architecture and has the ability to sense the environment and collect data.

3. Key Core Technologies and Application Areas

3.1. Key Core Technologies

As depicted in Figure 1, the Vehicle-Road-Cloud Architecture relies on the collaborative processing of tasks among the cloud, the vehicle end, and the road section. The vehicle end is equipped with a variety of sensors, including cameras and millimeter wave radars, which play the role of environmental perception and vehicle control [10]. The road end is composed of roadside units and base stations, which can analyze data in real time and reduce communication delay [7]. The cloud has powerful computing power and data storage capacity, allocating resources and tasks. This coordination system meets the requirements of low delay, high efficiency and strong real-time interaction in vehicle road coordination.

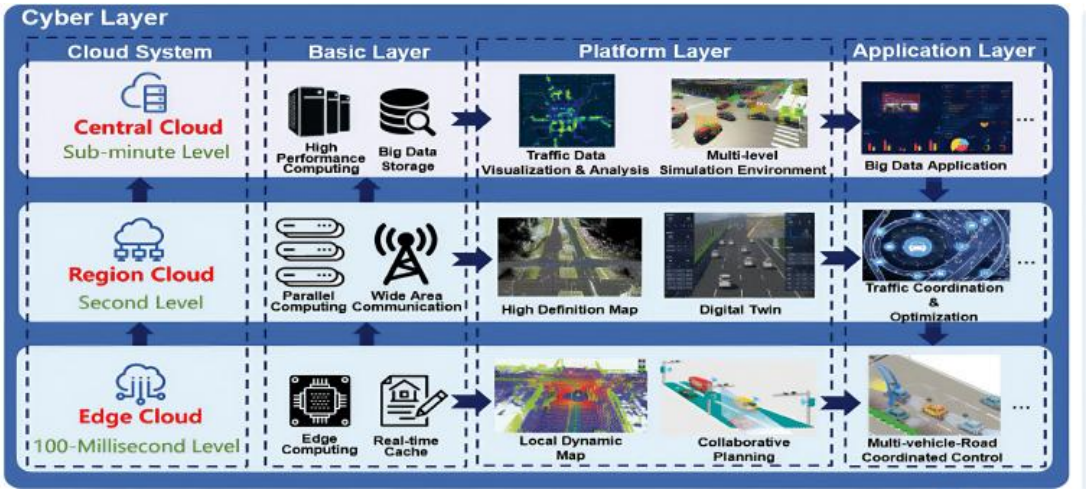

Fig. 1 the Vehicle-Road-Cloud Architecture [10]

Distributed resource allocation and edge task unloading are effective means to deal with a large number of real-time data in vehicle road collaboration. When real-time data occurs, the cloud server can achieve efficient and reasonable allocation of dynamic computing resources [11], while the edge server migrates tasks to the nearest edge server for parallel computing [6]. Efficient task unloading and resource allocation ensure real-time vehicle road interaction.

Edge computing performs data storage and calculation processing at the edge node, reduces information transmission delay, enhances calculation efficiency, provides technical support for the rapid response service of vehicle-road collaboration, plays a key role in intelligent autonomous driving and road condition detection and processing, and improves the data processing efficiency of vehicle-road collaboration.

At the same time, distributed computing uses a variety of privacy protection technologies to ensure that the data remains unsolvable homomorphic encryption to unauthorized third parties, the federal

learning mechanism to prevent data leakage, and the access control technology to ensure that only authorized parties can access sensitive data. In the process of data storage, transmission and processing, it effectively ensures the security of information and the safe data sharing of vehicle road coordination [12].

3.2. Application Fields

The autonomous driving application integrates the vehicle-road-cloud architecture, breaks the information barriers between traffic entities, and enables vehicles to obtain multiple types of information, such as the dynamics of surrounding vehicles, road conditions, and traffic signals, in real time, thus realizing real-time information interaction. Through the cloud platform, the connection between vehicles and road-end infrastructure can be established, and efficient coordination among all traffic participants can be achieved, thereby improving the safety and smoothness of the overall traffic operation.

The smart bus uses distributed computing to realize the information interaction between the bus and other subjects, eliminate the blind spot of the vehicle itself, and interact with the roadside equipment to improve the traffic efficiency. The information interaction with the cloud platform provides passengers with the real-time location of the bus [13].

The vehicle, road, and cloud work together to achieve the intelligent control of the road traffic network. The roadside equipment monitors the traffic flow, speed, and traffic congestion in real time, integrates the information on the cloud for comprehensive analysis, implements the adaptive control of signal lights to relieve traffic congestion, optimizes and manages the road traffic conditions, and enhances the efficiency and safety of traffic management.

With the help of distributed computing and edge computing, real-time information interaction is realized between vehicles and traffic facilities, offering safety early warning services for vehicles. These services include blind zone early warning, red light running early warning, road danger early warning, etc. The low-latency feature enables nearby information perception and data processing, and sends out early warnings. Information at the millisecond level, and effectively reduce the probability of traffic accidents.

4. Research Hotspots and Technological Challenges

4.1. Research Hotspots

Research on the rational scheduling of resources in the dynamic environment of distributed computing to improve the stability of the system; The optimization algorithm based on deep learning is applied to distributed computing to improve the ability of distributed computing to schedule complex tasks [11]; Research and improve the ability of edge computing data processing and real-time perception, and improve the reliability and efficiency of real-time computing.

4.2. Technical Challenges

The edge server needs to accept terminals in two different aspects and multiple unpredictable task sources, which makes it difficult to maintain stability under extreme conditions [7]; When there is too much data information, the system performance will decline significantly, and the data sources are different and unified, which may crash under high traffic conditions; No suitable mathematical model has been found to form the optimal control strategy to meet the needs of system dynamics, decentralization and time sensitivity.

5. Future Development Prospects

The combination of large language model (LLM) and edge computing explores the use of large models to drive autonomous driving and solve decision-making problems in complex scenes under the constraints of low delay feedback and data security; Develop group collaboration technology

based on edge computing, significantly reduce communication delay and path conflict and improve the overall efficiency of group operations through real-time collaboration between distributed nodes [14]; Quantum computing is used in edge tasks to break through the bottleneck of traditional computing and promote the development of edge computing in a more efficient and reliable direction.

6. Conclusion

This paper shows that distributed computing and edge computing have become the key technologies of vehicle road collaboration by building a cloud edge end architecture, efficient task unloading and resource allocation, and collaborative work of all terminals, in accordance with the requirements of vehicle road collaboration. However, the system still faces technical challenges such as insufficient stability in dynamic environments. The systematic review of this article provides a clear technical framework and future development direction for subsequent researchers. Currently, the integration of distributed and vehicle road collaboration is the development trend of smart transportation.

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