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Opportunities and Challenges: Blockchain Enables in Vehicle Edge Computing—A New Direction in the Internet of Vehicles

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Abstract: *The Internet of vehicles and blockchain are two major research hotspots in the field of academic research. By investigating the existing literature, this study summarizes and explains some key technologies or contents in the field of IoV and blockchain, such as the vehicular edge computing framework, task offloading optimization objectives, the organizational structure and working principle of blockchain, and the technical advantages of blockchain. This paper also surveys the current research articles related to the application of blockchain technology in the field of IoV, explains the technical benefits brought by the combination of IoV and blockchain from many aspects, and summarizes the future research directions and challenges that will be faced.*

Keywords: *Internet of vehicles; Blockchain; Vehicular edge computing; Technical benefit*

1. Introduction

As an important part of intelligent transportation system, Internet of Vehicles (IoV) realizes the real-time sharing and collaboration of traffic information through the information interaction between vehicles, vehicles and infrastructure, vehicles and pedestrians. With the rapid development of the Internet of Things, big data, cloud computing and other technologies, the application scenarios of the Internet of vehicles continue to expand, and it plays an increasingly important role in improving traffic efficiency, reducing traffic accidents, and optimizing travel experience[1].Blockchain technology, as a decentralized, secure and reliable distributed ledger technology, has been widely concerned and applied in recent years. It ensures the secure and transparent transmission and storage of data among multiple nodes through cryptographic algorithms and consensus mechanisms[2].

With the continuous development of Internet of vehicles and blockchain technology, the integration between them has become an inevitable trend in the development of the industry. By combining the advantages of blockchain technology, IoV can further improve data security, enhance trust mechanism, optimize collaboration efficiency, and inject new vitality into the development of intelligent transportation[3].

This paper will briefly introduce the two current hot research fields of vehicular edge computing and blockchain, summarize the current research status of the combination of these two technologies, and analyze the future research directions and possible challenges. The main work of this paper is as follows:

(1) In the Internet of vehicles (IOV) section, this paper focuses on the technical framework of vehicular edge computing, and summarizes the two major goals for the optimization of IOV task computing.

(2) In the block chain section, this paper starts with the definition of block chain, introduces its organizational structure, and points out the working principle and technical characteristics of block chain.

(3) In the research part of the combination of Internet of vehicles and blockchain, this paper enumerates the application examples of the combination of these two technologies from four different aspects to illustrate the advantages and many possibilities of the combination of blockchain and Internet of vehicles. Finally, the prospects and challenges of the combination of these two popular technologies are summarized.

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2. Vehicular Edge Computing

2.1. Vehicular Edge Computing Framework

Vehicles in the Internet of vehicles are endowed with certain computing, storage, sensing and communication capabilities. In order to solve the dilemma of low transmission rate and poor security in cloud computing when facing massive vehicle data processing, the on-board edge comes into being. The vehicular edge computing framework consists of three entities: remote cloud, edge cloud/and vehicle cloud[4].In other papers in the same field, these three entities have other names: cloud server, edge node, vehicle terminal. Figure 1 is the VEC system resource framework.

Generally, remote cloud has super computing power and long transmission delay, which is suitable for processing large-scale and complex data aggregation, data mining analysis, optimization and storage. However, it is not suitable for the processing of delay-sensitive tasks, and needs to consider the problems of transmission security.

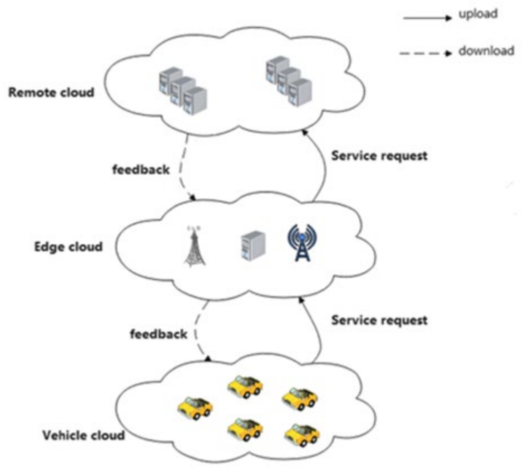

Figure 1: Resource framework diagram of VEC system.

Edge cloud is located in the middle of the communication between remote cloud and vehicle cloud, and can be composed of edge servers, RSUs, BS, wireless Access points (aps) and other edge devices with computing, storage and communication capabilities such as mobile devices. The transmission delay from vehicle to EC is much lower than the transmission delay from vehicle to remote cloud, and it has strong computing power, so it can provide low-latency computing, cache, location awareness, emergency management and other services for vehicles, which is better suitable for data-intensive and delay-sensitive vehicle computing task processing. Edge computing is a functional extension of cloud computing, which is usually coordinated with cloud computing to obtain the most perfect task processing effect[5].

Vehicle cloud is an available resource formed by the integration of various idle vehicle resources. Its transmission delay is close to 0, but its computing power is limited, and because the vehicle will switch back and forward between the two roles of resource provider and resource demander, it is an unstable computing resource.

In addition, in the actual research work, the vehicular edge computing framework is flexible and changeable, which can only be the vehicle cloud, or the vehicle cloud and any other or the combination of both, and is determined specifically according to the vehicle computing environment and research scheme of the researcher[1,6].

2.2. Optimization Metrics for Vehicular edge Computing

Optimization objective is the main objective for researchers to achieve task unloading in VEC environment, which is mainly used to establish the task unloading model, and whether the objective reaches the optimal can be used as the criterion to judge the quality of the proposed research method. Delay and power consumption are two of the most common optimization objectives for offloading computing tasks in VEC environments.

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2.2.1. Minimize offloading latency

The offloading delay is the time it takes for the system to complete the computation of the task. Task offloading in Internet of vehicles is usually divided into three types: local execution, partial offloading and full offloading. In local offloading, the computation of tasks is completely completed by the vehicle itself, so only the computation delay of tasks needs to be considered. However, partial offloading and full offloading refer to the use of edge cloud resources to assist in the computation, so the transmission delay of tasks needs to be considered. In the latter two offloading methods, the selection of edge nodes and the amount of task offloading (complete offloading is not necessary to consider) are the decisive factors affecting the final processing delay. Minimizing system latency can help us find an ultimately appropriate uninstall plan.

2.2.2. Minimizing energy consumption

When vehicles or edge devices perform task processing, it is inevitable to generate some consumption of electricity or other resources. This energy consumption is divided into two types: transmission energy consumption and execution energy consumption. Generally speaking, vehicle users prefer to be able to complete the task calculation with less energy consumption, under the requirement of ensuring the task delay sensitivity. The emerging new energy electric vehicle market has gradually risen in recent years, and excessive energy consumption is extremely unfavorable for their battery life.

In addition, some articles also set up other optimization goals, such as user service quality[7].These optimization objectives can be freely combined to form a multi-objective optimization, and most of the current research uses the comprehensive optimization of delay and energy consumption.

3. Blockchain technology

3.1. Definition of blockchain

With the rapid expansion of the decentralized cryptocurrency bitcoin market, blockchain technology has begun to enter the public's vision with a unique role, and has more and more applications in all walks of life. Essentially, chain block is a kind of distributed books, rely on logic control functions such as intelligent contract for a complete storage system[8].

3.2. Organizational structure and working principle of blockchain

The organizational structure of blockchain is shown in Figure 2.Consider the blockchain as a log whose records are mapped into timestamped blocks, each identified by a unique cryptographic hash value. Each block refers to the hash value of its previous block, forming an inter-block link, thus creating a blockchain. Any node with access to this ordered, backlinked list of blocks can read it and get information about the data being exchanged[9].

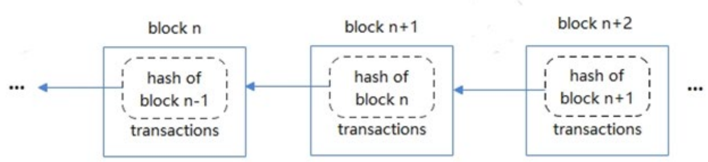

Figure 2: Organizational structure of blockchain.

Blockchain can be viewed as a combination of a set of object nodes. In the blockchain mechanism, a single node can act as an entry point for several different blockchain users to enter the network, and the replicas held by each node can also run on the same blockchain. These nodes thus form a peer-to-peer network. Users interact with the blockchain through a pair of private/public keys[10], the private key is used to sign their transactions, and the public key is used to address on the network.

3.3. Characteristics of blockchain

With the development of The Times, everything is gradually changing to digital. The blockchain is a shared public ledger that includes all confirmed transactions, and cracking the hidden information in the

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blockchain blocks is almost impossible. This is also the fundamental reason why bitcoin, a virtual currency, is widely popular in the world[11]. Figure 3 shows a typical transaction process that is digitally signed via blockchain.Blockchain has the characteristics of process trust and decentralization, which can build a trust base in a low-cost way under the scenario of multi-stakeholder participation[8].

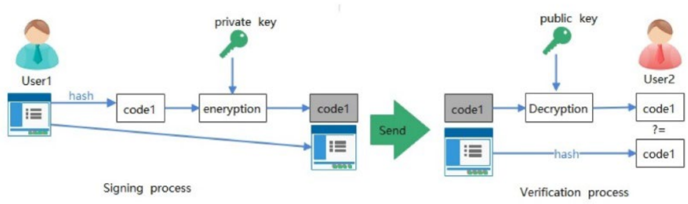

Figure 3: Process of transactions using digital signatures in blockchain.

Currently, blockchain is used in many fields, such as cryptocurrency, financial services, risk management, Internet of Things (IoT), public and social services, etc. However, there are still some security and technical challenges in this field, such as scalability, privacy leakage, selfish mining, etc., which hinder the widespread application of blockchain[12].

4. Blockchain technology

4.1. Vehicle users privacy protection

In the Internet of vehicles (IoV), vehicles will generate a large amount of data, which may contain users' private information, such as location information, driving trajectory, etc., and the disclosure of these information may have a negative impact on users. Through blockchain technology, automatic verification and recording of data can be realized to prevent data from being tampered or leaked, and improve data security. In literature [13], in order to ensure the security of the communication process of the Internet of vehicles, the author implemented a fine-grained anonymous identity authentication scheme for the Internet of vehicles based on encryption and decryption technology and blockchain technology, and adopted an authentication strategy combining dynamic attributes and static attributes. This scheme can reduce the redundancy of authentication process, protect user privacy, and make up for the shortcomings of traditional anonymous schemes in authentication efficiency and calculation cost.

4.2. Establishment of vehicle user trust mechanism

In literature [14], the author combines three sub-modules of message trust evaluation, vehicle trust update, and trust block creation and consensus to evaluate the credibility of messages, update vehicle trust, and suppress malicious behavior of vehicles. Based on the importance of events and the scalability of blockchain, the scalability and computational efficiency of the algorithm are improved.

4.3. Vehicle computing resource allocation

Literature [15] proposed a trusted task offloading model based on reputation in Internet of vehicles. The authors believe that when the credibility of edge nodes in the Internet of vehicles cannot be guaranteed, using the reputation of edge nodes recorded on the blockchain to evaluate their credibility can reduce the delay and energy consumption of task unloading. In their simulation experiments, compared with the common task unloading model, the trusted task unloading model reduces the delay and energy consumption by 25.58% to 27.44%.

4.4. Vehicle computing resource allocation

Literature [16] combined with blockchain smart contract designed a new type of vehicle edge computing resource trading mechanism. Before the user vehicle publishes the task request and the service vehicle receives the task request, the user vehicle needs to authenticate its identity and pay a certain amount of deposit. Only after the published task is completed normally, the service vehicle will receive the transaction fee, otherwise, the deposit of the service vehicle will be recovered to the task requesting

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vehicle. The advantage of this scheme is that it can ensure that malicious and misbehaving parking vehicles that maliciously obstruct and attack service requesters can be detected in time and punished appropriately.

5. Conclusions

In short, blockchain technology has a wide range of application prospects in the edge computing of vehicle networking. By combining the decentralization, non-tampering, smart contract and other characteristics of blockchain, the data security, real-time response ability and trust mechanism of the IoV system can be further improved, which provides strong support for the development of intelligent transportation, automatic driving and other fields. The complexity of the combination of the technical framework, how to design the algorithm, the scalability of the application, and the analysis of the possible security risks are the key problems to be solved in the future.

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