A Survey on Blockchain-Based Computation Offloading in the Internet of Vehicles

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Abstract

As additional technologies are integrated, smart vehicles increasingly employ computationally intensive applications like autonomous driving and real-time navigation, which increases response times and worsens user experience. To solve this problem, the concept of edge computing, which can help vehicles offload time-sensitive tasks to edge servers or other devices, has been introduced into Internet of Vehicles (IoV). Blockchain improves the reliability of computation offloading (CO) in IoV by making up the problem of information leakage during the CO process. This paper reviews recent surveys and studies on how blockchain can be used in CO in IoV.

Ⅰ. Introduction

The Internet of Vehicles (IoV) is an application of Internet of Things (IoT) and intelligent transportation systems (ITS). With the increase of vehicular applications and the need to process a large amount of map and sensor information, the computing capabilities of smart vehicles are facing challenges. The primary challenge is that the limited computing resource of vehicles in IoV are insufficient to complete these computation-intensive task in a timely manner, which degrades user' experience and put users at risk.

To solve above mentioned problem, edge computing is deployed to offload the computing tasks of vehicles in IoV, which decreases the response latency and improves users' experience. The computation offloading (CO) enables vehicles to offload extensive computing tasks to roadside units (RSUs) or edge servers. Due to different computing capabilities and states of vehicles, some powerful or parked vehicles with idle computing resources also actively participate to assist other vehicles to finish computing tasks. However, CO suffers from the possibility of leaking sensitive and personal information of vehicles, which results in the security threat for vehicles. Besides, vehicles which usually frauds RSU that it wants to provide service but it won't do that and vehicles who usually fails to finish the service before deadline are difficult to distinguish, which can cause a large number of CO failure cases.

Blockchain, an emerging technology with distributed records which can treat information along with CO process as a transaction and stored into a block consisting of a large number of independent transactions, overcomes the unauthorized release of confidential information. The transactions in the block are hashed and then broadcasted to the nodes participating in the blockchain. Blockchain is introduced to increase the security of vehicular communication and provide reputation and incentive mechanisms, which can help IoV to recognize the vehicles want to participate are reliable or not. The decentralization, immutability, transparency and traceability of blockchain can also be beneficial to computing offloading of the IoV. The contributions of this survey paper are summarized as follows.

1. This paper provides a comprehensive review of recent research contributions in blockchain utilization for secure offloading computation extensive task on the edge.
2. It also defines the step-by-step process for Reputation-based CO Using Blockchain.
3. Later on, this manuscript also highlights the challenges and future direction in CO in IoV using blockchain.

Ⅱ. Computing Offloading of IoV with Blockchain

With an increasing number of applications appearing in the IoV, the vehicles' constrained computing capabilities significantly reduces performance on time-sensitive tasks [1]. To overcome this limitation, edge computing is introduced to overcome the problem, which deploys RSU combined with a mobile edge computing server (MEC) to help smart vehicles complete the computing task [2]. However, locations with high-density vehicles and constrained resources are easily overwhelmed by a large number of requests for computing offloading in a short time. Therefore, nearby vehicles which have idle computing resources are used to alleviate this performance issue. The main problem is that it is difficult for RSU to distinguish between unreliable service vehicles that are willing to help finish computing task and reliable service vehicles that have same willingness in a short time. Blockchain can provide a distributed, immutable, transparent reputation record to find reliable vehicles while using encryption and anonymous technology to

enhance security during the CO process. [3-5] propose their own blockchain-based edge computing or fog computing frameworks while discussing how CO allocation decision is made. However, papers cited above do not clearly explain the encryption and anonymous process using blockchain in CO process. Besides, how to verify computing tasks sent by CO request vehicles and results sent by CO service vehicles transmitted by RSU is not discussed.

Reputation-based CO Using Blockchain

Figure 1 shows the blockchain-based vehicle to vehicle CO framework, where blockchain is used to store reputation of vehicles in IoV. Besides, the private blockchain is deployed among RSUs and vehicles can not access blockchain, which can improve efficiency of reaching consensus among blockchain participants and avoid vehicles privacy leaks.

If RSU receives CO requests from a vehicle, firstly it checks the reputation scores of vehicles nearby that want to participate to assist RSU in CO and chooses the vehicle with highest reputation score which is stored in blockchain. Secondly, RSU transmits the computing task to service vehicle selected and waits to verify the result after service vehicle finishes the computing task. Thirdly, if service sends right result before deadline, RSU will send the result to requesting vehicle and record a new transaction in blockchain with a new reputation score which decided by original score and time consumed by the service vehicle.

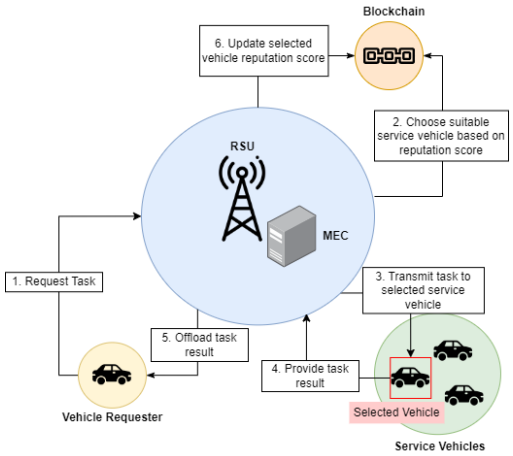

Figure. 1. Overview of Blockchain-based CO

Ⅲ. Challenges and Future Directions

A. Scalability

Because of the large scale of vehicles in the daily lives, scalability is significant for IoV to handle their request, which influences offloading success rate. Besides, blockchain also needs to get consensus along the system working time while consensus mechanisms are time-consuming process. Therefore, one of the directions is enhancing the scalability of network and blockchain.

B. Security and Privacy

Although blockchain has already enhanced the security and privacy of CO process by keeping sensitive information, end devices and routing process are also vulnerable to attacks. Besides, there is a lack of research on clearly expressing how to identify malicious servers and malicious vehicles. As a result, security is also important future direction.

C. Integration with Other Technologies

Emerging technologies such as Artificial Intelligence (AI), 5G, beyond 5G (B5G) and Software Defined Networking (SDN) can significantly influence the performance while enhancing scalability and security of CO system. For instance, AI can be used to scientific and efficient computing offloading allocation management.

Ⅳ. Conclusion

Achieving reliable and efficient CO in the Internet of Vehicles is crucial to the development of intelligent transportation system. In this field, blockchain provides unique secure information storage environment, transparent reputation management and incentive mechanism. However, combining blockchain into the system also needs to face scalability, security and privacy problems, while emerging technologies such as AI and SDN can also be integrated into this system to provide some enlightening influences. In summary, this paper emphasizes the importance and impact of using blockchain to improve security and performance in the computing offloading in vehicular network.

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