

Usage-Based Insurance Policy Auction Mechanism

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An auction mechanism is developed for the UBI blockchain platform to enhance consumer trust. The study identifies correlations between driving behaviors and associated risks to determine a driver's score. A decentralized bidding algorithm is proposed and implemented on a blockchain platform using elliptic curve cryptography and first-price sealed-bid auctions.

Keywords: usage-based insurance ; blockchain ; auction mechanism

1. Introduction

The internet of vehicles (IoV) is a cloud-based vehicle operation information platform that provides big data and information services from multiple sources. Comprehensive protection measures are required to ensure the security of IoV information ^[1]. To promote the technological development of self-driving smart vehicles, IoV communication technology and the IoV policies of various countries are both primarily focused on increasing demand for IoV ^{[2][3]}. Car dealers and chip manufacturers have adopted strategic alliances and optimized their technical capabilities to capture a larger market territory ^[4].

Usage-based insurance (UBI) is a type of automobile insurance that leverages driving technology to determine a car's status by analyzing driving data to calculate insurance premiums on the basis of driving behavior ^[5] instead of the owner's age, gender, or accident record. However, conventional UBI car insurance has some disadvantages. The vehicle must be equipped with an onboard diagnostic device (OBD) that monitors and collects driving data. Nonetheless, a potential concern arises in relation to the susceptibility of the device employed in this context, the OBD system, to tampering by the vehicle owner through software modifications. Consequently, the data collected from OBDs may encounter skepticism from authorities ^[6]. In an effort to address this issue, the present study has developed a blockchain-based UBI platform. By leveraging blockchain technology, the platform facilitates the publication of digitized driving data on the chain in an encrypted or otherwise verified manner, while simultaneously safeguarding personal privacy. Moreover, this approach ensures the credibility of the data and generates value by creating readable and trustworthy intangible assets. As the rightful possessor of these assets, the car owner can exercise unrestricted control over them, such as by providing the corresponding data to insurance or financial organizations in order to obtain individually tailored insurance rates.

After receiving owner authorization, the IoV blockchain platform encrypts vehicle data—such as driving time, period, speed, mileage, and braking—and uploads them to the chain. After the owner's consent is obtained, other operators on the chain can create customized financial services on the basis of these data ^{[7][8]}. For example, car owners with safer driving habits could obtain more favorable car insurance premiums.

However, it is important to note that the IoV blockchain financial platform is currently in the proof-of-concept stage ^{[9][10]}. The advent of the blockchain ecosystem is anticipated to drive a new wave of car owners who recognize the fundamental principles of "data belonging to users" and "data as an asset" ^[11]. This paradigm shift implies that consumers, particularly car owners operating within the blockchain framework, will reevaluate their perspectives on personal information and privacy. For enterprises, the expanded participation within the ecosystem will enable the provision of a wide range of supplementary services for car owners ^[12]. The utilization of blockchain technology ensures the protection of driver privacy, while the integration of automated UBI technology enhances profitability for insurers. Moreover, the platform proposed in this study has the potential to facilitate reliable and transparent pricing mechanisms for insurers, resulting in benefits for customers. Additionally, the platform could aid automobile manufacturers in refining their products by granting them access to extensive datasets derived from driving activities.

2. IoV Infrastructure with Blockchain

In recent years, the financial industry has poured resources into blockchain technology. However, achieving its goals regarding this technology, implementing it in business, and creating fundamental scientific or technological financial services have been challenging [13]. A blockchain financial platform for vehicle networking could collect driving behavior, cryptographically store these data, and transmit the data to the blockchain in real time [14][15]. Because the blockchain is incorruptible, companies can link insurance and financial services to authentic and reliable driving information on the chain. Providing car owners with faster and more convenient financing applications, insurance claims, and personalized product recommendations could significantly improve internal enterprise operations and the customer experience [16]. For example, the Data Hub platform built by the electric car manufacturer Tesla regularly collects data from the driving computer of each Tesla car and also has an official open API [17]. Tesla's blockchain team wrote its own decentralized application (DApp) and smart contracts to establish nodes through charging stations. After the owner is authorized, the DApp directly connects to the official API, and the electric vehicle is designated. The trip computer data are then input to the DApp, and the DApp uploads the data from the node to the chain on the basis of the smart contract [18].

To create financial insurance products that meet individual needs, information from various sources is required, such as driving habits, vehicle information, and consumption habits [19]. Auditing the authenticity of these data is expensive and limits their usage in the business process. For example, to confirm the authenticity of accounts receivable, a bank must also ensure that the statements of both parties and stakeholders are genuine [20]. High audit costs have led to numerous incidents of fraud; however, companies that require financing turnover have enormous operating pressures during information review periods.

Many blockchain developers have shifted their focus to the decentralized finance field by using the incorruptibility of the blockchain to achieve code enforcement (known as Code is Law). This method can greatly reduce the cost of some financial institution activities, such as deposits and lending [21].

3. Development of UBI System

In UBI, driving data, such as vehicle usage and driving behavior, are analyzed in a cloud system [22]. UBI systems can determine driving risk more accurately than can conventional car insurance systems, which base risk on gender, age, and accident frequency [23]. One advantages of UBI is its high pricing flexibility [24]. For example, drivers who rarely use the accelerator and brake, have safe driving habits, obey traffic rules, and rarely drive during peak hours could have greater flexibility and discounts on insurance costs in a UBI scheme than for conventional auto insurance.

UBI typically requires an OBD to be installed in the car or a mobile app to record driving behavior [25]. Moreover, UBI could also use car maintenance records in addition to owner driving habits to more objectively price car insurance [26]. However, an urgent problem that is encountered when implementing UBI is determining how the owner's vehicle information and personal data can be obtained. An owner who values their privacy may be concerned about whether personal driving data will be adequately and safely stored; these doubts regarding privacy are a key barrier to the universal implementation of UBI [27][28].

4. Blockchain-Based Security Auction Algorithm

E-auctions are widely practiced in e-commerce, enabling bidders to participate directly in online product bidding processes [29]. However, in the case of sealed bids, an intermediary must be involved. They were incurring additional transaction costs to facilitate trade between buyers and sellers during the auction. Regrettably, there exists a need for more assurance regarding the trustworthiness of this third-party entity. Blockchain technology can be leveraged to tackle this predicament, offering the advantages of low transaction costs and the ability to establish smart contracts for both public and sealed bids. A blockchain is an immutable and distributed database that maintains transactional data within a peer-to-peer network [30]. The database operates decentralized to allow any member node in the overlay blockchain network to participate in its maintenance anonymously. Transactions between member nodes are recorded in cryptographic hash-linked data structures called blocks. Smart contracts are crucial in ensuring transactions' security, privacy, irrefutability, and immutability. All transactions are recorded in identical but decentralized ledgers. A smart contract encompasses essential details, such as the auctioneer's address, auction start time, deadline, the current winner's address, and the highest bid at the present moment [31].

Blockchain has garnered considerable popularity as an emerging decentralized and secure data management platform [32]. In proof-of-work-based consensus protocols, network nodes, referred to as miners, are motivated to verify new

transaction blocks by solving a cryptographic puzzle through a process known as “block mining”. This study primarily focuses on utilizing a blockchain network as an infrastructure for decentralized data management applications, considering the constraints imposed by computing resources. Allocative externalities take precedence when devising auction mechanisms for such a network.

The permissionless blockchain represents an exemplary decentralized and autonomous platform for data management in numerous applications, as it operates without requiring prior authorization [33]. Permissionless blockchains offer the advantage of rapidly establishing a self-organized data management platform capable of supporting a broad array of decentralized applications. Without the need for assistance or permission from trusted intermediaries, individuals can independently design smart contracts and freely develop decentralized applications.

5. UBI Maintenance System Using IoV and Blockchain

The growing interest in leveraging the decentralized nature of blockchain technology has sparked recent research efforts to develop authentication and authorization mechanisms for the IoV [27][34]. These mechanisms seek to eliminate the reliance on centralized third-party intermediaries. This study presents a comprehensive framework that facilitates decentralized and a privacy-centric data exchange in the IoV, explicitly focusing on monetized services. The framework is built upon a tiered blockchain architecture and employs the InterPlanetary file system for secure data storage and transfer [35]. Its main objective is to empower IoV data users to have fine-grained control over data sharing with entities authenticated by the blockchain. Two use cases are provided to demonstrate the practical application of the framework: an IoV data marketplace and decentralized connected vehicle insurance. These examples showcase the framework's versatility in enabling smart contract-based applications involving exchanging IoV data and cryptocurrencies. Furthermore, the paper conducts a thorough security analysis, evaluating the proposed framework against various attack scenarios, and presents comprehensive performance metrics from real-world implementation [36].

Existing data management solutions for IoV data encounter challenges in verifying data source credibility and maintaining data security [37]. However, the decentralized nature of blockchain technology offers promising solutions to address these challenges. Nonetheless, obstacles remain to overcome, such as computing resource consumption and data segmentation between on-chain and off-chain components. To solve these issues mentioned above, the paper presents a recent study proposing a blockchain-based information management system designed to handle vehicle-related data reliably [38]. The system adopts a sharding blockchain structure, where IoV nodes within a particular geographical area form sub-chains to enhance computational speed and reduce the workload on the main chain. Additionally, an on-chain and off-chain computing scheme based on trusted execution environments is proposed to ensure data source credibility and optimize the computational resource consumption of smart contracts [39].

In vehicle insurance, UBI has emerged as a contemporary and practical approach. Unlike traditional methodologies, UBI determines insurance premiums based on real-time driver behavior. However, challenges arise due to the need for more transparency in claims processing, resulting in delays and increased fraudulent activities. In response, decentralized technologies, particularly blockchain, have gained attention as a promising solution. Consequently, this study proposes a blockchain-based framework for implementing vehicular UBI and incentives within the IoV context.

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