# A Complete Review of Application of Blockchain in Emerging Fields

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**Abstract.** Blockchain technology has become one of the most innovative ways to conduct financial transactions. It has gained a lot of attention from academics and business in recent years, making it a popular area of research. Transaction records are stored using this decentralized method. A blockchain network's size increases in tandem with the number of nodes and transactions, leading to problems with data processing speed, storage capacity, and latency. The scalability of a blockchain network is directly impacted by these issues. Scalability is currently one of the primary problems with blockchain technology and a subject of continuous investigation. Increasing system throughput, reducing costs, and improving blockchain efficacy seem to be the main goals of the proposed scaling solutions. Therefore, we review, compare, and evaluate the literature using these specific criteria. A review of earlier survey articles based on blockchain technology is also included. The upcoming open research challenges and blockchain applications are also thoroughly examined in this paper.

**Keywords:** Data immutability, scalability, smart contracts, ledgers, consensus methods, and blockchain.

## 1 Introduction

The development of intelligent transportation systems have called for good quality data management solutions. Contemporary vehicular systems are exposed to a number of requirements varying from secure data exchange, fraud prevention, legal and regulatory enforcement that are hard to accomplish on traditional vehicle management systems. Blockchain, with its unchangeable and distributed architecture, can provide a feasible solution. Motivated by the need for automation, continuous monitoring, and secure data storage, we explore here how Blockchain can assist in addressing these challenges. It integrates data from multiple sources, giving a unified view of the technology's impact on control of the vehicle. The automotive industry is getting digital with its advances in blockchain, 5G and IoT. Conventional vehicle management systems suffer from security, transparency and efficiency problems. A potential solution is offered by the decentralized and tamperproof nature of blockchain technology. The study deals with significant challenges and identifies the research gaps as it reviews the state-of-art in blockchain based vehicle management.

## 2 Literature Survey

For the betterment and security, efficiency and transparency of vehicular network and IOT, now a days a new game changer alternative is raised “The blockchain”. By illustrating key issues and research contributions, this section surveys recent advances and blockchain based applications in some domains. Paying special attention to secure communication and system

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control, Ashna et al. (2024) studied the integration of blockchain into 5G-enabled vehicular networks. Reliable network architectures cannot be developed with- out validation environments, as indicated in the paper [1]. In the same context Hwang and Nguyen (2024) has emphasized the importance of blockchain to achieving data integrity and secure micro communication for autonomous vehicles, In a related study, Aliesawi et al[6] mentioned blockchain's role in providing strong integrity and trust, privacy and authenticity in the autonomous system. (2024) have proposed and pointed out its capability in securitizing IoV communication systems against hacking. Consensus processing is a method that applied by Moessner et al. [3]. (2024) worked on resource reservation, added reliability to the time critical aspects of automotive using blockchain. Nguyen et al. (2024) studied resource allocation problems in 6G-powered V2X networks, and showed how blockchain could be utilized for secure, real-time data transmission [6]. Consensus algorithms and power management Anwar et al. (2024) used blockchain technology with reinforcement learning for optimizing scheduling and energy distribution in demand response management from Electric Vehicle (EV) using blockchain-based reinforcement learning. Zaboli et al[19] recently proposed energy-efficient consensus methods. (2024) to reduce the environmental impact of blockchain use in EV energy control. To augment the scalability and reduce the computational load in blockchain-enabled VAC, Tawalbeh and El-Latif (2024) proposed the use of a lightweight, energy-efficient consensus mechanism such as Proof-of-Stake (PoS). For smart city infrastructure enabled by blockchain, Ghosh and Rawat (2024) focused on privacy-preserving data transfer between automobiles and urban infrastructure including parking space and traffic signals [23]. Blockchain and deep learning combined can improve data-driven decision-making in smart city systems A R. R. B., & Parasar (2024) [9] Philip, and Paul (2024) presented a blockchain-centric approach to Incident response management in IoT based Vehicular environment with aim at data integrity and accountability [4]. As for improving transparency in insurance and judicial organizations, Mubarek et al [5]. (2024) have studied the application of blockchain technology to store immutable evidence related to the auto accidents. Digital Right's Management Paul et al [17]. (2024) highlighted control of digital rights in Internet of Vehicles (IoV) using block chain with guarantee of reliability and integrity. for the decentralized platoon control, the work of Wang and Saghiri (2024) conducted SWOT analysis of blockchain, stating the ability of it to ensure data integrity and secure decision-making [20]. Ghosh & Rawat (2024) examined about the convergence of blockchain and AI for secure data analysis and energy management in self-governing systems.

## 3 Applications of Blockchain in Various Aspects

Blockchain ensures ownership transfers, and car registrations are recorded without any tampering. Example: All parties with access to an immutable ledger, according to Geetha et al., could help to halt ownership transfer fraud by blockchain technology. (2024). Usage scenario in the course of sales, changes in ownership are automatically verified and recorded by smart contracts. Besides, fleet companies benefit from blockchain's fragmented data sharing capability, which cuts down the operation cost and raises the efficiency. For instance, Philip et al. (2024) discuss decentralized fleet monitoring systems based on blockchain that ensure the secure sharing of data of location data on vehicles, fuel consumption and maintenance plans. This system also helps with automatic evaluation and payout of insurance claims. Kakkar et al. (2024) illustrate how blockchain technology could eliminate delays and human mistakes by automatically activating insurance payouts based on predefined conditions. Blockchain can trace car parts from the start of the manufacturing process right up to the end, ensuring all components are genuine and of good quality. Nguyen et al. (2024), for example, study the possibility of using blockchain technology for the monitoring of components from producers to assembly units to combat the counterfeit industry. Encrypted V2V communication in real time is vital for the success of the IoV ecosystem. Blockchain helps to make this better by providing a secure ledger for exchanging data. Al-Khatib et al. (2024), for example, propose blockchain as solution to IoV security issues such as illegal data access and data manipulation.

## 4 Methodology

The methods used in the cited studies, which concentrate on the incorporation, verification, and assessment of blockchain technologies inside vehicle management systems, represent a wide range of strategies. A thorough explanation of the methodology used in the examined publications may be found below:

### 4.1 SLR of the literature

Many studies, such as the studies performed by Kakkar et al. (2024) and Geetha et al. (2024) performed in-depth literature reviews to identify the current problems and envisioned blockchain applications in vehicular management. The searching of databases, quality screening of articles, underpinning of proposed solutions on a number of key criteria(s) such as function, scale and levels of security were part of the process.

### 4.2 Design of Blockchain Architecture

Further pros and cons of blockchain were shown in comparison against other technologies, for example centralised databases compared to decentralised blockchain networks. Papers like Philip et al. (2024) and Al-Khatib et al. (2024) proposed design-specific blockchain architectures for individual automotive use cases. The approaches included: Comparing blockchain attributes and applications (eg., driver ownership, supply chain tracking, insurance automation). Elements like distributed ledgers, smart contracts, consensus processes, and user interfaces had to be developed and incorporated in the architecture. Prototypes were implemented using the widely-used blockchain implementations Ethereum and Hyperledger.

### 4.3 Simulation Based Evaluation

Nguyen et al. examined blockchain-assisted vehicle management systems using simulation techniques. (2024) and Saghiri et al. (2024). Frameworks and Tools Used: Simulation tools like OMNet++ and MATLAB were used to simulate the interaction between cars and blockchain nodes. We evaluated performance metrics such as energy efficiency, throughput and the transaction delay. Prior to deploying blockchain applications in real-world environments, these simulations allowed researchers to assess their functionality under controlled conditions.

### 4.4 Development and Testing of Smart Contract

Alternatively, to automate operations such as fleet management, insurance claims and ownership transfer, smart contracts were also described in media reports such as Kakkar et al. (2024) and Nguyen et al. (2024). The following were the testing methods of smart contract verification: Checking if the contract is executed correctly on different occasions It is a checking method to determine if the agreement in the test case is implemented on a day off or extreme narrow road.

Discovering possible attack vectors in contracts is called security analysis. The amount of gas consumed and efficiency on the live blockchain network is performance testing.

### 4.5 Fusion of IoT and Blockchain

Research like Zaboli et al. (2024) and He et al. (2024) also explored how IoT devices could communicate with blockchain for real-time data managing and collecting. The system comprised: In-vehicle Internet of Things sensors to record real-time data such as position, speed and fuel levels Immutability and integrity were secured by safely transmitting the data for recording on to blockchain networks for predictive maintenance and route optimization, blockchain records were analysed using AI and machine learning.

### 4.6. Hybrid Model Optimisation

The hybrid approaches put out by Tawalbeh et al. (2024) and Waghanna et al. (2024) combine blockchain technology with other technologies such as fog computing, artificial intelligence, and reinforcement learning. The actions were as follows, creating hybrid models with fog nodes serving as middlemen to lessen the strain on the blockchain network is known as architecture design, AI algorithms were created to enhance decision-making and maximize the use of resources, Case studies like energy management in fleets of electric vehicles or decentralized platoon coordination were used to test the hybrid model.

### 4.7. Security and Privacy Enhancements

Researchers that concentrated on ways to improve blockchain's security and privacy features were Philip et al. (2024) and Ghosh et al. (2024). Important methods included, using zero-knowledge proofs and cutting-edge encryption standards to protect private car information. Creating role-based access controls to guarantee that blockchain records are only accessible by authorized parties.

### 4.8. Performance Benchmarking

Blockchain performance has been compared to that of conventional centralized systems in studies like Nguyen et al. (2024). Using empirical data from test environments or case studies, metrics like as fault tolerance, system scalability, and transaction speed were examined.

### 4.9. Comparative Case Studies

Comparative case studies were employed in a number of researches, such as Rajalakshmi (2024) and Khudair et al. (2024), to assess the efficacy of blockchain in actual vehicle management situations. The Identification of the Issues such as fleet management inefficiencies and fraud in car ownership transfers were noted. Therefore, Implementation of the Solution: Over a predetermined time, frame, blockchain-based solutions were implemented and observed. And the Performance gains were quantified and contrasted with conventional systems.

## 5 Block Diagram

A blockchain system for car management is depicted in the Fig 1, combining several applications such fleet monitoring, insurance automation, and ownership tracking.

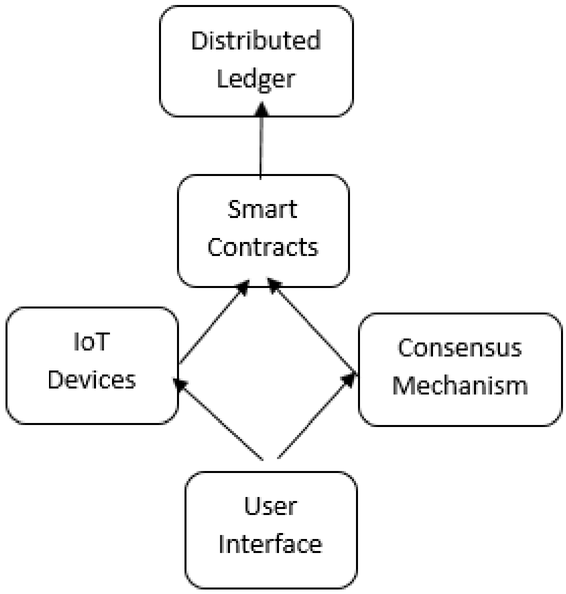


**Fig.1.** Blockchain-Enabled Vehicle Management System.

**5.1. Components**

**5.1.1 Distributed Ledger**

An unchangeable log of every piece of information pertaining to a car.

- **Smart Contracts:** Automates procedures such as claims and ownership transfers.
- **IoT Devices:** Used to collect Real-time data from sensors in cars.
- **Consensus Mechanism:** Guarantees the accuracy of transactions that are recorded.
- **User Interface:** Facilitates communication between the system and its stakeholders, including owners, manufacturers, and insurance.

## 6 Challenges, opportunities and Future Trends

Although the blockchain for vehicle management is advantageous, the technology has several limitations. The first is Scalability As blockchain networks scale, transaction costs and times increase. For example, blockchain might not be applicable to real-time management of vehicles where scalability is an issue as encountered in Saghiri et al. (2024) explain. Proof-of-Work (PoW) is a widespread consensus method, but its high energy needs make it less suitable for sustainable applications. For instance, Zaboli et al. (2024) propose the adoption of a hybrid or Proof-of-Stake (PoS) model for reducing energy consumption. Globalization of blockchain has stagnated, as all nations lack consistent rules. International policy frameworks are needed in order to standardize the implementation of blockchain technology in automotive systems (Wang, 2024). It is hard to make this transition from traditional centralised systems to blockchain-based systems. Blockchain in automotive management: Beyond its current applications the automotive management potential of blockchain is much larger than what we are already seeing now: Blockhain combined with AI can enhance autonomous car decision-making. For example, the use of AI-based analysis on blockchain recorded data for the purpose of improving vehicle routing and maintenance schedule is described by Ghosh et al. (2024). Safe data exchange between self-driving cars can be facilitated by blockchain to enhance safety and efficiency. One such example would be the application of blockchain in decentralized decision making for au- tomated vehicles as described by Nguyen et al. (2024). Studying alternate consensus strategies, like Delegated Proof-of-Stake (DPoS), offers a method of constructing a more sustainable blockchain. Tawalbeh et al. (2024), for example, explore energy-aware models to implement blockchain technology in large scale vehicle systems. Exactly, the blockchain-based IoV systems are the core of the smart city applications. He et al. (2024) is indicative of the potential scope of blockchain technology in creating integrated platforms to support the management of urban mobility.

## 7 Proposed Framework

Blockchain-based vehicle management system, in which said distributed ledger maintains immutable records of each transaction. If we take out an insurance claim and transfer ownership, both of these steps are carried out by smart contracts. Data may be collected and exchanged in real time through IoT connection. Consensus mechanism ensures the safety and dependability of MAC and the whole network. Interface: Provides the stakeholders with easily accessible ports.

## 8 Future Research

AI-Blockchain Integration: Applying AI analytics to improve decision-making. Blockchain models that are lightweight: cutting down on processing overhead. Create common standards for blockchain applications in automobiles using standardized frameworks. Blockchain integration for safe decision-making in autonomous vehicles. Blockchain's incorporation into smart cities and driverless cars creates new research opportunities and makes it possible to create safe and effective urban mobility systems.

## 9 Conclusions

Vehicle management could undergo a radical change thanks to blockchain technology. In the automobile industry, blockchain has the potential to revolutionize security, transparency, and efficiency by tackling obstacles and seizing possibilities. Future studies and innovations are built upon the findings of this survey. Blockchain technology offers a game-changing chance to solve persistent issues with car management systems. One of the main conclusions drawn from the cited publications is that: Data Integrity and Security: Blockchain's decentralized architecture offers a safe way to store and exchange car data, greatly lowering the risk of fraud and illegal access. By reducing delays and human error, smart contracts optimize processes including fleet management, insurance claim processing, and vehicle ownership transfers. Blockchain has a lot of promise, but issues like energy usage and scalability need to be resolved. Models that are hybrid and lightweight present encouraging options. Blockchain and IoT, AI, and fog computing together improve system capabilities by allowing predictive analytics and real-time decision-making in intelligent car systems. Making the switch to Proof-of-Stake (PoS), an energy-efficient consensus method, guarantees the long-term sustainability of blockchain technology in vehicle management. Stakeholders in vehicle ecosystems can develop trust by using privacy-preserving solutions offered by advanced cryptographic techniques, like as zero-knowledge proofs.

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