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A Comprehensive Survey of AI-Driven Reward-Based Secure 6G Vehicle Communication Using Lightweight Blockchain

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Abstract: *The rapid growth of sixth-generation (6G) technology has made considerable advancements in developing intelligent transportation systems via ultralow latency, high reliability, and massive connectivity in vehicle-to-everything (V2X) communications. However, ensuring secure and efficient communication among vehicles is one of the greatest challenges for V2X technology because of cyber-attacks, data tampering, and lack of trust in the decentralized network. Artificial intelligence (AI) and lightweight blockchain have recently emerged as two potential techniques to guarantee secure and reliable communication among vehicles in 6G networks. Thus, this study will focus on providing an overview of the recent developments regarding reward-based secure 6G vehicle communication using AI-assisted lightweight blockchain techniques. This study will review the existing literature on AI-assisted V2X communications, blockchain security, and reward-based schemes. Furthermore, the current challenges such as latency problem, computational complexity, scalability issue, and high energy consumption in 6G blockchain vehicular networks will be examined. Finally, future research directions for blockchain-enabled 6G V2X communication will be suggested.*

Keywords: 6G, V2X communication, blockchain, artificial intelligence, vehicular networks, reward-based security, lightweight blockchain, federated learning

I. INTRODUCTION

The evolution of intelligent transportation systems has resulted in an increasing need for safe and reliable vehicle communication. The ability to exchange data between vehicles and infrastructures is essential in realizing smart traffic management, autonomous vehicles, and efficient communication among vehicles [1]. It is anticipated that the deployment of 6th generation communication will result in highly connected, low-latency, and high-speed vehicular networks [1].

Traditional vehicular communication systems pose various challenges, such as insecurity, violation of data privacy, and lack of trust between the communicating parties. AI can offer solutions to such challenges by making decisions and predicting possible anomalies in the network, whereas blockchain allows decentralization and security of data storage and validation [1], [2].

It has been shown that integrating AI and blockchain into 6G systems can provide better solutions in terms of security, scalability, and trustworthiness of the communication system [3]–[5]. This survey reviews recent advancements in 6G vehicular communication through AI-based reward models based on lightweight blockchain technology [6], [4].

This paper makes the following contributions:

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- An overview of 6G V2X communication [1]
- Survey of AI-based security mechanisms [2], [4]
- A survey on lightweight blockchain [3], [5]
- A review of reward-based communication model [6], [9]
- Research gaps and directions [7], [8]

II. BACKGROUND OF 6G V2X COMMUNICATION

6G technology promises to offer high-end functions like ultra-reliable low-latency communication (URLLC), massive machine-type communication, and intelligent networking, which can be effectively used in vehicular communication networks where immediate data transfer is essential [1], [5].

V2X communication entails:

- Vehicle-to-Vehicle (V2V)
- Vehicle-to-Infrastructure (V2I)
- Vehicle-to-Network (V2N)
- Vehicle-to-Pedestrian (V2P)

AI and machine learning algorithms have been extensively applied to route optimization, resource allocation, and traffic forecasting in the 6G V2X network to enhance the efficiency of the network as well as increase its security level [4], [8]. Studies have also demonstrated the capabilities of 6G IoT and intelligent networking in facilitating vehicular communication and autonomous systems [5].

III. AI-BASED SECURE VEHICLE COMMUNICATION

Artificial intelligence is a vital technology for the improvement of vehicular communication security and performance. Machine learning is used to identify the irregularities of the system operation, predict cyber attacks and optimize communication [4], [8].

Common AI approaches used in vehicular communication include the following:

Deep Learning

Reinforcement Learning

Federated Learning

Neural Networks

It was found that AI-driven reward-based communication strategies can promote vehicles' collaboration and sharing of truthful information in the network [6], [7].

IV. LIGHTWEIGHT BLOCKCHAIN IN 6G V2X

Blockchain technology is a decentralized and tamper-proof technology, which provides a solution for secure data sharing in vehicular networks. But traditionally used blockchain suffers from heavy computational cost, high energy consumption, and latency issues [3].

Lightweight blockchains have been designed to lower:

- Computational cost
- Energy consumption
- Latency issues
- The need for storage space

Studies prove that use of lightweight blockchains increases security and decreases complexity in vehicular networks without compromising on trust and transparency of information sharing in such networks [3], [6]. Integrating AI into such systems will further make secure communication easier and more effective in 6G V2X environment [1], [3].

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V. REWARD-BASED TRUST MANAGEMENT SYSTEMS

Reward-based systems help in encouraging the behavior of trustworthy nodes in vehicular networks by offering them rewards for their contributions [6].

The following are rewarded:

- Secure data sharing
- Adhering to network protocols
- Keeping the system safe from threats

Use of blockchain technology, especially smart contracts, makes it easier for automated reward distribution, which is essential for maintaining transparency and trust in trust management systems [6], [7].

VI. LITERATURE REVIEW OF SELECTED PAPERS

Paper [1] reviews the use of blockchain technology and AI in 6G wireless systems and identifies security threats and future trends in intelligent transportation systems.

Paper [2] introduces blockchain security schemes and decentralized communications architectures for secure vehicular network environments.

Paper [3] suggests a lightweight blockchain approach for ensuring security and efficient data exchange within the Internet of Vehicles.

Paper [4] investigates AI-powered V2X communication and intelligent traffic control systems.

Paper [5] examines the implementation and applications of 6G IoT and vehicular communication technologies.

Paper [6] covers intelligent transportation systems and communication architecture using blockchain technology.

Paper [7] discusses secure vehicular communication systems and trust management schemes.

Paper [8] describes AI and machine learning applications in 6G V2X communication systems.

Paper [9] explores semantic vehicle-to-everything (V2X) communication frameworks tailored for 6G networks.

VII. CHALLENGES AND RESEARCH GAPS

The following challenges are present in the use of AI for 6G vehicle communication:

- High computational complexity of AI models [4]
- Scalability issues in blockchain [3]
- Latency in communication [1]
- Security and privacy threats [7]
- Energy efficiency problems in blockchain networks [5]
- Non-existence of standardized protocol [8]

Some of the gaps in research are lightweight consensus algorithm, AI-based trust management model, and efficient reward-based security mechanism in 6G vehicular communication.

VIII. FUTURE RESEARCH DIRECTIONS

Possible areas for future research include:

- Federated learning techniques for secure communication [4]
- Edge computing in 6G V2X communication [5]
- Lightweight blockchain consensus protocols [3]
- Artificial intelligence intrusion detection system [7]
- Reward-based trust management mechanism [6]

All of these techniques will improve 6G vehicle communication security.

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IX. CONCLUSION

In this paper, the authors have surveyed AI-based reward mechanism in 6G vehicle communications using lightweight blockchain technology. The review analyzed the current research on the topic including AI technology, blockchain, and 6G V2X communication. Lightweight blockchain and artificial intelligence-based reward mechanism will provide an immense improvement in secure 6G vehicle communication [1]–[8].

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