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Blockchain and 6G for Secure and Transparent Smart City Transactions



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Abstract

Urban environments are evolving into highly connected smart cities, generating massive volumes of heterogeneous data across transportation, energy, healthcare, and public service infrastructures. Ensuring secure, transparent, and efficient management of urban transactions presents critical challenges for traditional centralized systems, which are prone to cyber threats, data tampering, and operational inefficiencies. Blockchain technology offers a decentralized and immutable framework that enables tamper-proof recording, traceability, and automated execution of transactions through smart contracts. Integration with sixth-generation (6G) networks provides ultra-low latency, high-speed communication, and massive IoT connectivity, facilitating real-time validation and management of urban operations. This chapter investigates the synergistic potential of combining blockchain and 6G technologies to establish resilient frameworks for smart city transactions. Key considerations include interoperability of heterogeneous IoT devices, scalability of blockchain networks, privacy-preserving mechanisms, and regulatory and ethical challenges. Case studies of energy distribution, intelligent transportation, and public service delivery highlight practical implications and performance enhancements achieved through this integration. Findings demonstrate that blockchain-6G frameworks can enhance transparency, operational efficiency, and citizen trust while addressing critical challenges associated with secure data exchange and real-time decision-making in urban ecosystems. Future research directions emphasize energy-efficient protocols, AI-assisted smart contract automation, and standardized frameworks to enable sustainable and scalable smart city infrastructure.

Keywords: Blockchain, 6G Networks, Smart Cities, IoT Interoperability, Secure Transactions, Transparent Urban Infrastructure

Introduction

The evolution of urban environments into smart cities has led to highly interconnected infrastructures where data-driven operations underpin critical services such as transportation, energy distribution, healthcare, and public administration [1]. These ecosystems generate enormous volumes of heterogeneous data from IoT devices, sensors, and citizen interactions, requiring frameworks that can efficiently manage, process, and secure this information [2]. Traditional centralized management systems face significant challenges in meeting these requirements, as are vulnerable to single points of failure, cyberattacks, and operational inefficiencies, potentially compromising urban service delivery and citizen trust [3]. The

increasing complexity of urban operations demands innovative technological solutions capable of ensuring transparency, security, and real-time responsiveness [4],[5].

Blockchain technology offers a decentralized and immutable framework for managing urban transactions, providing traceability, tamper-proof records, and automated execution through smart contracts [6]. The distributed nature of blockchain eliminates reliance on a central authority, enhancing the reliability and auditability of transactions across diverse urban sectors [7]. Smart contracts enable automatic enforcement of operational rules for services such as digital payments, energy trading, and identity management, improving efficiency while reducing the risk of fraud [8]. By integrating blockchain into smart city frameworks, urban planners and service providers gain mechanisms that ensure accountability, transparency, and trustworthiness across all levels of municipal operations [9],[10].

Sixth-generation (6G) wireless networks complement blockchain by providing ultra-low latency, massive device connectivity, and high-speed communication, supporting real-time data transmission across dense urban ecosystems [11]. The network facilitates instantaneous interaction between IoT devices, sensors, and management platforms, enabling seamless execution of critical operations including autonomous transportation, smart energy distribution, and emergency response systems [12],[13]. Reliable 6G connectivity ensures that blockchain-based transaction validation occurs without delays, sustaining operational performance and allowing smart cities to respond dynamically to fluctuating demands, resource allocation, and urban mobility challenges [14],[15].