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REVIEW ARTICLE

BLOCKCHAIN-ENABLED FRAMEWORKS FOR THE DEVELOPMENT OF SMART CITIES

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ABSTRACT

Blockchain technology has emerged as a revolutionary agent in innovative city development by providing secure, transparent, and decentralized data management of multiple urban systems. Its application reaches various fields, including energy distribution, waste management, transportation, e-governance, and public safety. Through the use of blockchain, smart cities can provide tamper-proof records, enhance stakeholder trust, and streamline complex processes such as identity verification, land registration, and real-time utility billing. The application of blockchain within the Internet of Things (IoT) also enhances data integrity and automation within smart infrastructure. Smart contracts also facilitate the adequate provision of services and reduce administrative expenses. While specific issues are brought about by scalability, regulatory uncertainty, and high energy requirements in specific blockchain platforms, which represent potential hurdles, ongoing advancements in consensus algorithms and blockchain interconnectivity offer promising solutions. This paper presents the main applications, benefits, and drawbacks of blockchain in smart cities, as well as its potential to facilitate increased transparency, efficiency, and citizen engagement in urban governance.

KEYWORDS

Blockchain technology, Smart cities, Decentralized data management, Internet of Things (IoT)

1. INTRODUCTION

Nowadays, cities around the world are becoming smarter by leveraging cutting-edge technologies to address everyday problems. Smart cities utilize digital tools to enhance their day-to-day operations, from managing traffic and power supplies to ensuring public safety and optimizing the use of resources, such as water, waste management, energy, etc. (Bhushan et al., 2020). One of the most exciting technologies driving this transformation is blockchain (Kumar et al., 2023). Blockchain initially gained popularity through cryptocurrencies like Bitcoin; now its applications are expanding far beyond that. Today, it is being applied in many different areas to help cities become more secure, transparent, and efficient. This article examines how blockchain is being utilized in smart cities and its role in shaping the cities of the future.

2. WHAT IS BLOCKCHAIN?

Blockchain is similar to a digital ledger that keeps track of important information, such as transactions and communications. It can be thought of as a special notebook where, once something is written down, it cannot be changed or erased (Shilpi and Ahad, 2020). What makes it even more unique is that only one person maintains this notebook, which is shared simultaneously with many people. Everyone has their copy, so if someone tries to tamper with the information, it is easy for others to trace out the difference. This shared system makes blockchain decentralized, transparent, and highly secure.

3. WHAT IS A SMART CITY?

A smart city uses the latest technology and data to make everyday life better and easier. It helps solve problems in areas such as traffic,

electricity, waste management, and safety. For example:

- Traffic lights that change depending on how many cars are on the road
- Smart meters that keep track of how much electricity people use
- Trash cans that send a message when they are full and need to be emptied

The primary goal of a smart city is to make things more convenient for people and to utilize resources more efficiently.

4. WHY USE BLOCKCHAIN IN SMART CITIES?

Blockchain can help address some significant challenges that cities face. For example:

- Changing data secretly – On blockchain, once something is recorded, it cannot be changed easily, so it is tough for anyone to mess with the data.
- Lack of trust – People can see what is happening at every step, which builds trust between citizens and the government.
- Things taking too long – Blockchain can use smart contracts to do tasks automatically, which saves time and effort (Johari et al., 2021; Malsa et al., 2021).

5. APPLICATIONS OF BLOCKCHAIN IN SMART CITIES

Figure 1 presents the significant applications of blockchain in smart cities.

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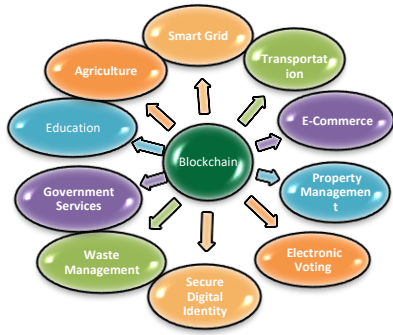


Figure 1: Applications of Blockchain in Smart Cities

5.1 Smart Grid

Blockchain can help track the production and consumption of energy. For example, if someone has solar panels on their house and produces excess electricity, they can sell it to their neighbors using blockchain technology. This way, people can trade energy directly, which reduces waste and saves money.

5.2 Smart Transportation

Smart contracts on the blockchain can help manage tolls, traffic lights, and public transportation systems, including buses and trains. For example, if a car breaks a rule, a fine can be given automatically. Everything is recorded safely, so there is no cheating or confusion.

5.3 Smart E-Commerce

Innovative E-Commerce in Smart Cities is established by integrating sophisticated technologies, data-driven decision-making, and green urban infrastructure to deliver a seamless, efficient, and personalized shopping and service experience.

- a) Smart Infrastructure Integration
 - IoT and Sensors: Smart shelves, inventory trackers, and delivery monitoring systems give real-time data between warehouses and stores.
 - Smart Logistics: Networked traffic systems and automated warehouses make faster, optimized delivery routes possible through AI and GPS.
 - Urban Planning Support: E-commerce centers are strategically located through the use of big data analytics to minimize congestion and emissions.
- b) Adoption of Advanced Technologies
 - Artificial Intelligence (AI): Facilitates personalized offers, chatbots, and demand prediction.
 - Blockchain: Ensures secure transactions, transparent supply chains, and establishment of consumer confidence through traceable product sources.
 - 5G and Edge Computing: Provide fast data processing for augmented reality (AR) shopping, real-time monitoring, and intelligent payment systems.
- c) Citizen-Centric Services
 - Hyperlocal Delivery Models: Facilitated by intelligent transportation and information, minimizing time and carbon footprint.
 - Digital Wallets and Smart Payments: Seamlessly integrated with city-level platforms for transport, utilities, and retail.
 - Smart Vending and Pop-up Shops: Intelligent kiosks that forecast and replenish according to local consumption habits.
- d) Benefits of doing this include:
 - Minimized traffic and emissions through optimized logistics
 - Improved consumer convenience and personalization
 - Economic boost to local economies and SMEs through digital inclusion
 - Enhanced transparency and traceability in supply chains

5.4 Smart Property Management

Smart Property Management (SPM) in smart cities is established by integrating digital technologies with urban infrastructure to enhance the efficiency, transparency, and sustainability of property ownership, operation, and maintenance, both public and private (Dewan and Singh, 2020). Smart property management can help with the following:

- I. Digital Infrastructure and IoT Integration
 - Smart sensors and IoT devices monitor utilities (electricity, water, HVAC), structural health, occupancy, and maintenance needs in real time.
 - Smart meters provide detailed usage data, enabling accurate billing and consumption tracking.
- II. Blockchain for Property Records
 - Blockchain technology ensures secure, tamper-proof digital land and property registries.
 - Reduces fraud, delays, and paperwork in title transfers, lease agreements, and zoning compliance.
 - Facilitates smart contracts for automatic execution of property-related agreements (e.g., rent payments, escrow settlements).
- III. AI and Predictive Maintenance
 - Artificial Intelligence (AI) analyses building usage and performance data to predict failures and schedule preventive maintenance.
 - Reduces costs and downtime while extending asset life.
- IV. Centralized Management Platforms
 - Property managers use centralized dashboards to oversee operations across multiple buildings—handling energy use, security, maintenance, and tenant services.
 - These platforms often integrate with city-wide innovative systems for traffic, waste, and utilities.
- V. Citizen and Tenant Participation
 - Mobile apps and web portals enable residents and owners to:
 - Monitor bills and service requests
 - Report issues instantly
 - Participate in feedback and community governance
- VI. Data-Driven Decision Making
 - Data collected from smart properties feeds into urban analytics platforms, supporting better policy-making in zoning, taxation, and urban development.

5.5 Smart Electronic Voting

Smart Electronic Voting refers to the development of secure, transparent, and efficient systems for casting, recording, and counting votes in elections that utilize advanced digital technologies, including blockchain, biometric authentication, cryptographic security, and Internet of Things (IoT) devices (Shinzeer et al., 2024). In smart voting, voters use secure devices: mobile, kiosk, or online portals to cast votes electronically. User interfaces are designed to be friendly and accessible to persons with disabilities. For authentication and voter verification, biometric methods (such as fingerprint and facial recognition), digital ID cards, or multi-factor authentication ensure that only eligible voters participate.

5.6 Secure Digital Identity

People can have a digital ID stored on the blockchain. This makes thoughtful citizens of a smart city. This ID is safe and easy to check. It can be used for tasks such as voting, applying for government services, or even entering official buildings without requiring paper documents.

5.7 Waste Management

Some cities use smart bins that send a message when they are full. With blockchain, this information can be shared, allowing garbage to be picked up at the right time. People who recycle more can even earn rewards, and these rewards can be recorded on the blockchain to ensure fairness.

5.8 Transparent Government Services

Blockchain can help ensure that government records, such as land documents, budgets, or complaints, are secure and cannot be tampered

with or altered. This helps people trust that the government is being honest and fair.

5.9 Smart Education

Blockchain can make the education system intelligent by maintaining secure, transparent, and tamper-evident records of academic credentials, certificates, and transcripts. It allows employers and institutions to verify instantly the qualifications, thereby eliminating fraud and manual processing. Smart contracts can be utilized to automate processes such as student registration, fee payment, and degree issuance. Blockchain can facilitate lifelong learning by storing a learner's entire educational history across institutions. By providing students with ownership of their academic records, blockchain promotes trust, responsibility, and international mobility in education systems while enhancing administrative effectiveness and minimising paperwork.

5.10 Smart Agriculture

Blockchain has the potential to transform agriculture into a more innovative, more transparent, and efficient sector. It facilitates real-time monitoring of crops from farm to fork, promoting food safety, traceability, and trust in the supply chain. Farmers can utilize smart contracts to automate the payment of fees, insurance claims, and input purchases, preventing delays and fraud. Blockchain also facilitates the accurate recording of soil health, crop cycles, and weather conditions, supporting data-driven decision-making. With IoT sensors and AI, blockchain enables farmers to access better market prices, financial inclusion, and sustainable agriculture.

6. BENEFITS OF BLOCKCHAIN IN SMART CITIES

Blockchain brings many advantages to smart cities, like:

- Transparency – Everything that happens is recorded and can be seen by everyone, so nothing is hidden.
- Security – It is tough for hackers to change the data.
- Efficiency – It saves time by cutting down on paperwork and mistakes.
- Trust – People can trust the system without having to trust the people running it.
- Cost-saving – It removes the need for middlemen, which saves money.

7. CHALLENGES AND LIMITATIONS

Even though blockchain is instrumental, it does have some downsides:

- Uses much energy – Some types of blockchain need much electricity to work.
- Not many people understand it – Many still do not know how blockchain works.
- Can be slow – It might take longer to process things than regular systems.
- Rules are unclear – Governments are still working on making laws and rules for using blockchain.

8. REAL-LIFE EXAMPLES

- New York City - New York City is a prime example of a smart city, using technology to improve urban living, sustainability, and city governance. Programs such as NYC Open Data, LinkNYC, and intelligent traffic systems support data-driven decision-making and enhance public services. The city utilizes IoT sensors for environmental monitoring, predictive analytics to prevent crime, and smart grids to optimize energy use. Initiatives in waste management, emergency response, and public Wi-Fi reflect a high commitment to innovation. Through inclusive digital strategies and public-private partnerships, New York continues to develop as a resilient, connected, and citizen-centric smart city.
- Singapore - Singapore is a global pioneer in smart city technology, using cutting-edge innovations to make urban life better. In its Smart Nation program, Singapore integrates IoT, AI, and big data analytics across various domains, including transportation, housing, and public security. Some of the significant projects involve autonomous buses, intelligent homes, and e-government platforms. With a robust digital infrastructure, people-centric services, and

sustainability goals, Singapore demonstrates how technology can create efficient, livable, and inclusive cities.

- Dubai, UAE – Dubai has big plans to become the world's first city to run its government using blockchain by 2030. They are already using it for tasks such as registering businesses and managing real estate.
- Estonia – This small European country is way ahead when it comes to technology. People there use blockchain for digital IDs and to safely store healthcare records (Bhushan et al, 2023; Raj et al., 2024).
- India – Some cities in India, like Pune and Hyderabad, are trying out blockchain for things like keeping land records safe and tracking how waste is collected and managed.

9. FUTURE OF BLOCKCHAIN IN SMART CITIES

In the future, blockchain technology could be utilized for a wide range of applications in smart cities, including the traceability of subsidies, donations, and public funds, as well as rental agreements, construction permits, and zoning approvals. It will also aid in the development of legal and Regulatory Frameworks. This will help build systems that do not require intermediaries and are free from corruption. As more people become aware of blockchain and the technology continues to improve, it can significantly transform how cities are run, making them fairer and more efficient. The future of blockchain in smart cities is not just about utilizing the latest technologies, but also about building trust, transparency, and resilience into urban ecosystems (Kumar et al, 2022). When combined with AI, IoT, and 5G, blockchain will enable self-regulating cities that are more inclusive, sustainable, and efficient.

10. CONCLUSION

Blockchain plays a significant role in making our cities more intelligent and trustworthy. It makes data safer, speeds up processes, and helps make fair decisions. Although there are still some challenges, the advantages of using blockchain in smart cities are too significant to ignore. With time and the proper knowledge, this technology can help build better, safer, and more advanced cities for everyone.

REFERENCES

- Bhushan, B., Khamparia, A., Sagayam, M. K., Sharma, S. K., Ahad, M. A., and Debnath, N. C., 2020. Blockchain for smart cities: A review of architectures, integration trends and future research directions. *Sustainable Cities and Society*, 61, Article 102360. <https://doi.org/10.1016/j.scs.2020.102360>
- Bhushan, B., Kumar, A., Agarwal, A. K., Kumar, A., Bhattacharya, P., and Kumar, A., 2023. Towards a secure and sustainable Internet of Medical Things (IoMT): Requirements, design challenges, security techniques, and future trends. *Sustainability*, 15(7), Pp. 6177. <https://doi.org/10.3390/su15076177>
- Dewan, S., and Singh, L., 2020. Use of blockchain in designing smart city. *Smart and Sustainable Built Environment*, 9(4), Pp. 695–709. <https://doi.org/10.1108/SASBE-06-2019-0078> Emerald
- Johari, R., Gupta, K., and Parihar, A. S., 2021. Smart contracts in smart cities: Application of blockchain technology. In *Innovations in Information and Communication Technologies*, Pp. 359–367. Springer. https://doi.org/10.1007/978-3-030-66218-9_42
- Kumar, R., Jain, V., Leong, W. Y., and Teyarachakul, S. (Eds.). 2023. *Convergence of IoT, Blockchain, and Computational Intelligence in Smart Cities*. CRC Press. <https://doi.org/10.1201/9781003353034>
- Kumar, R., Singh, R. C., and Khokher, R., 2022. Framework for modeling, procuring, and building systems for smart city scenarios using blockchain technology and IoT. In *The data-driven blockchain ecosystem*, Pp. 31–50. CRC Press. <https://doi.org/10.1201/9781003353034>
- Malsa, N., Vyas, V., Gautam, J., Shaw, R. N., and Ghosh, A., 2021. Framework and smart contract for blockchain enabled certificate verification system using robotics. In M. Bianchini, M. Simić, A. Ghosh, and R. N. Shaw (Eds.), *Machine Learning for Robotics Applications (Studies in Computational Intelligence, Vol. 960)*, Pp. 125–138. Springer Singapore. https://doi.org/10.1007/978-981-16-0598-7_10

Raj, G., Sharma, A. K., and Arora, Y., 2024. Analyzing the effect of digital technology on mental health. *Journal of Digital Wellbeing Studies*, 12(3), Pp. 45–58

Shilpi, S., and Ahad, M. A., 2020. Blockchain technology and smart cities: A review. *EAI Endorsed Transactions on Smart Cities*, 4(10), e2. <https://doi.org/10.4108/eai.13-7-2018.163846> EUDL

Shinzeer, C. K., Kushwaha, A. S., and Bhagat, A., 2024. Blockchain platform for prophylactic vaccine preparation using signature based secured authentication. *International Journal of Information Technology*, 16(7), Pp. 4209–4224. <https://doi.org/10.1007/s41870-024-01980-1>

