Blockchain and e-Governance in Smart Cities

Blockchain has emerged as a transformational technology with the ability to disrupt and evolve multiple domains. As a decentralized, immutable distributed ledger, Blockchain technology is one of the most recent entrants to the comprehensive ideology of Smart Cities. The rise of urbanization and increased citizen participation have led to various technology integrations in present-day cities. E-governance in smart cities is a type of governance that aims to make effective use of information and communication technology (ICT) to improve services provided by the government to people and will increase participation in decision-making and policy formulation. This will improve governance and advance the digital transformation of government.

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1. Introduction

Blockchain is decentralized, secure, auditable and enables smart execution of transactions. It is a distributed ledger where data are shared over a peer-to-peer network securely and consistently. Blockchain technology is presently one of the most quickly developing technologies and is reasonable for most applications. Blockchain is a circulated framework; there are no specific delegates between the users. In this way, manufacturers can manage their clients in a straightforward manner. Trust is an innate segment of these business connections as it is necessary to be confided in the stakeholders and market. To accomplish the transactions using Blockchain, the executive's objectives are cost, quality, speed, reliability, risk decrease, supportability and adaptability disintermediation or bypassing agents guarantees are done, yet it is not very clear that Blockchain will have these impacts on all types of industry and that it will perform all tasks well [1].

Blockchain technology means both positive and negative effects on the business world. With the assistance of Blockchain, business activities in smart cities have changed a large amount. Developing Advancements have additionally influenced smart city executives. The advent of Blockchain technology offers greater spatial and temporary flexibility. New technologies bring jobs, production and marketing closer together, and encourage major change through rethinking, redesigning and rebuilding cities and their functions. Blockchain technology is influencing almost all the areas of the market, such as in the globalized creation and the circulation of agri-business formation Blockchain reestablished center around the security, quality and the approval of a few significant rules in agricultural (horticulture) and food supply chains. The developing worries about sanitation and defilement chances have re-established the concentration on upgraded recognizability over the flexible food supply chain [2]. Ongoing innovations and advancements with Blockchain can give an important and useful arrangement ensuring detectability of farming produce and removes the requirement for a confided-in incorporated position. Today, Blockchain technology is used in various cities of the world and it is growing day by day and, today, all the smart cities are being made with the help of this technology. The reason for the growth of this technology is that it helps in reducing our effort and saves a lot of time. In the current scenario, sometimes Blockchain anchor is alluded to as a troublesome technology and it has potential to change the present business measures, which we are as of now utilizing, or it can interfere with advancement cycles and change plans of action drastically.

2. Benefits of Blockchain Implementation in Smart Cities

The integration of business models with Blockchain improves transparency, security, trust, cost minimization, accountability and efficiency. Blockchain-enabled contracts bring rising levels of efficiency to smart cities [3]. To impact changes in other specialized fields, Blockchain technology can be combined with technologies such as Smart cities, Big Data, IoT and Artificial Intelligence. Benefits of implementing Blockchain in smart cities are securing the supply chain, creating transparency, boosting track and trace systems, automating the purchase process and more streamlined operations.

Agriculture is the backbone of most developing countries and the means for most of their revenue, as crops are supplied to other countries to meet their demands and sometimes these sent crops prove contaminated, deliver late, etc., which

directly affects the trade. Therefore, [4] suggests the use of Ethereum Blockchain and smart contracts for better traceability of the whole soybean process from the production of seed to the product delivery; the whole process is centralized in nature and eliminates the middlemen. For future work, they argue that it is necessary work on flaws related to scalability, governance, identity registration and privacy, as well as that the payment mode should be restructured where parties will be paid using cryptocurrency on successful physical delivery of products by the smart contracts in an automated and centralized manner.

However, the implementation of Blockchain technology may look simple, but it is difficult to implement, as it is not yet fully developed. There is a need for highly skilled professionals and the collaborative participation of people to build a common system. It is challenging to answer how Blockchain brings more value to smart cities management and organizations as Blockchain is not a Distributed Computing System. Scalability is also an issue in the Blockchain. Some Blockchain solutions consume too much energy and Blockchain transactions are sometimes inefficient. Also, it is not completely secure to use.

A Blockchain-based smart city has many limitations, it yields high integrity but has unstable information reliability without some form of independent or impartial system that can manage or check the integrity of data going into the Blockchain [5]. A Blockchain-based smart city can offer transparency and trust to its citizens, and this trust and transparency are as valuable as the reliability of the raw data fed into the system and the way it is further treated [6]. Further, [7] tells us about the benefits of the implementation of IoT and Blockchain together. We all know how important IoT is nowadays, however, IoT has some problems related to privacy and security which can be overcome by integrating Blockchain technology. This results in improved efficiency in smart cities networks, and thus gives us a transparent view of a system. Many people are not aware of the Blockchain, so it is often implemented on a large scale [8].

Blockchain can connect technologies that can be helpful for people in many ways. The more we use this technology the more benefit we can derive from it. Blockchain has the ability and potential to make things easier to use and access. This is has led to creating many small and big networks as well. Therefore, there are many such applications of Blockchain that can be implemented in cities:

- Easy and smart payments: Blockchain provides security when performing payments and requests are sent to the respective virtual machines while performing the payments. In addition, it continually updates the information regarding the payments and maintains a proper history;

- Identity Services: nowadays, many organizations use this technology for identification purposes. They use unique login services and authenticate personal identity using the same, which helps prevent identity theft and fraud;

- Transportation Management: provides a single link of payment for various forms of public transport, which includes ridesharing services. A person using a taxi and bus can pay through a single-mode using Blockchain technology;

- Government Services: it helps in maintaining a proper record of documents and identity information of the citizens. This technology will enable the delivery of focused and personalized government services.

3. Application Areas of Blockchain in e-Governance

The concept of e-governance comprises ways in which governments can govern and serve their citizens in the best possible manner through the use of new-age technologies. It promotes enhanced citizen participation and has gained widespread attention in the last decade. In this digital age, we have numerous technologies that can act as an enabler for e-governance. The newest entrant to the club is Blockchain technology, proving a decentralized peer-to-peer platform for trust and transparency. In recent years, multiple government agencies have adopted the use of Blockchain technology for rendering citizen-centric services. The distributed ledger technology allows individuals to conduct transactions in a secure and automated manner. In this section, we address the question of how Blockchain technology can mitigate the challenges of modern cities and facilitate the development of urban ecosystems. We carry out a comprehensive literature review and identify five key application areas of e-governance wherein Blockchain has emerged as an enabler technology. The section illustrates prominent works for (1) Energy Trading, (2) Smart Healthcare, (3) e-voting, (4) Supply Chain and (5) Real Estate. **Table 1** summarizes some of the prominent works for the above application areas.

Table 1. Blockchain Application Areas for e-Gov & Smart Cities.

Theme		Publications
Blockchain & e-governance	Energy Trading	[9][10][11][12][13][14][15][16]
	Smart Healthcare	[17][18][19][20][21][22][23][24]
	e-voting	[25][26][27][28][29]
	Supply Chain	[30][31][32][33][34][35][36][37]
	Real Estate	[38][39][40][41][42][43][44]

3.1. Energy Trading

In recent years, Blockchain has emerged as a leading technology for creating peer-to-peer energy trading platforms. Such trading systems prove beneficial for consumers and producers as they can directly trade energy without the need for an intermediatory. The immutable ledger technology has been termed by researchers as a "disruptive technology" in the field of energy trading. In the recent past, numerous start-ups have emerged presenting Blockchain-enabled solutions for energy management in a smart city environment. The solutions ensure trading fairness, ensure accurate billing cycles, mitigate intermediary costs, preserve user data privacy and facilitate automatic trades. The authors propose a decentralized platform for peer-to-peer energy trading and ensure a trade-off between economic efficiency and information privacy [10]. The work discusses a two-layered platform for the Ant-Colony Optimization method for auctioning and smart contracts for enabling faster trade settlements. The proposed decentralized platform is termed "DeMarket" and aims for prosumers to auction and trade electricity securely and efficiently. The platform uses digital tokens, called "EuroTokens," to ensure monetary settlements for trading purposes. According to the existing literature, Blockchain and IoT are favourable technologies that can be combined to create decentralized energy trading platforms. The authors highlight pertinent issues dealing with centralized trading platforms for distributed energy stations (DESs). A Blockchain-based electricity trading (B-ET) ecosystem is proposed that ensures payment security and privacy protection for energy trading transactions [11]. The proposed ecosystem comprises two subsystems namely Internet-of-Energy (IoE) subsystem and the Blockchain subsystem. The prior is used for connecting various distributed energy stations across the city whereas the latter ensures secure and reliable electricity trading by the use of smart contracts. The authors propose a new consensus mechanism named credit-based PoW, which is a modified version of the widely implemented Proof-of-Work (PoW) consensus algorithm. The newly proposed consensus algorithm is believed to have mitigated the challenges of high latency and randomness.

Smart transportation is one of the central areas to the concept of smart cities. On similar lines to ensuring intelligent management of energy systems, the authors propose a decentralized peer-to-peer (P2P) smart city energy model for interconnecting households and enabling energy trading among themselves [12]. The work aims to optimize the energy management of a city by collating neighbouring households and allowing energy surplus of them to trade their electricity using smart contracts. All interconnected households are collectively termed as a microgrid, which is connected to the Blockchain network for trading electricity with potential consumers. The proposed models make use of wireless sensor networks for monitoring the generation, transmission and consumption of electricity on a real-time basis. The native cryptocurrency of Ethereum, i.e., Ether (ETH), is used for ensuring monetary settlements. The Particle Swarm Optimization (PSO) algorithm coupled with a genetic algorithm is used for the efficient selection of source and destination nodes for electricity transmission. A relatable initiative for decentralized P2P energy trading is proposed by the authors for mitigating the imbalance of energy generation among various users in a community [13]. The Blockchain-enabled trading platform is a decentralized application (dApp) that uses Ethereum's smart contract for ensuring transactions. The rise of electric vehicles (EVs) and Connected Electric Vehicles (CEVs) propose enhanced safety, improved city governance and reduced dependency on oil and emission of greenhouse gases. It is believed that the concept of CEV can give rise to new business models for energy trading and decentralize the process of electricity distribution. The authors propose a decentralized electricity trading framework for CEVs that combines the implementation of Blockchain, machine learning and game theory [14]. The work discusses an adaptive bidding algorithm named "HLProfitX" for ensuring improved profitability during the sale and purchase of electricity. A new cryptocurrency Happy Light Coin (HLCoin) is introduced for ensuring monetary settlements.

3.2. Smart Healthcare

The authors present a decentralized Blockchain-enabled platform "GuardHealth" for patient data sharing [17]. The platform deals with sensitive information regarding a patient, thus ensuring confidentiality and data privacy. The proposed system uses a consortium Blockchain network for storing and sharing patient data through legitimate authentication. On similar lines of patient data sharing, the authors present a combination of secure file transfer methods and Blockchain technology

[18]. The model ensures secure patient data sharing across various clinical facilities of its visit. Blockchain and IoT are extremely complementing technologies and are being extensively used across various domains. In context to the same, the authors propose an architecture for combining the use of Blockchain technology and the Internet of Medical Things (IoMT). The work analyses the current challenges of IoMT and suggests ways of mitigating them using smart contracts and distributed ledger [19]. Blockchain is a huge success when it comes to its applicability for creating identity management systems. The authors propose a Blockchain-enabled identity management system for patients and healthcare professionals [20]. Each patient and healthcare professional are allotted a unique health ID for ensuring their secure identification and authentication across different eHealth domains. Every health ID is attested by a healthcare regulator and subsequently stored on the Blockchain network. Another example of storing patient-centric records using Blockchain is presented by the authors wherein they propose a telemedical laboratory service for performing clinical trials on patients through IoT medical devices [21].

3.3. e-voting

In recent times, e-voting has emerged as one of the most prominent application areas of Blockchain technology in e-governance. The characteristics of being decentralized, transparent, secure and anonymous makes Blockchain one of the most suitable technologies for conducting free and fair elections in modern democracies [25]. Blockchain has the potential to ensure the integrity of the entire electoral process. It is believed that Blockchain-enabled e-voting systems can mitigate the challenges of conventional voting systems [26]. Such challenges may comprise accurate voter identification, protection of voter privacy, the secure casting of votes and efficient vote counting. Countries such as India, Estonia and South Korea are working towards creating models for e-voting using Blockchain technology [27].

3.4. Supply Chain

Blockchain has seen significant success in the financial sector and, subsequently, researchers have started to explore its applicability across supply chain management [30]. A supply chain is a system comprising of various entities intended to deliver a particular product or service manufacturer to a customer. Conventional supply chains are centralized in nature, thus present numerous challenges of corruption, mishandling, product tampering and adulteration. Blockchain has emerged as a disruptive technology with the potential to change the working mechanisms of modern-day supply chains [31]. The distributed ledger technology presents transparency and real-time tracking of product flow across various checkpoints [32]. The authors explore various ways of integrating Blockchain into supply chain management systems [33]. The integration of blockchain with supply chain management can bring about considerable benefits in terms of cost-efficiency, reliability, traceability and reduced paperwork [34]. Moreover, the food industry is believed to be one of the biggest benefits of the applicability of Blockchain technology in supply chains [35]. Blockchain coupled with IoT proves to be a perfect combination for food supply chains and ensuring trust and identification of counterfeit products [36].

3.5. Real Estate

The real estate sector has great socio-economic value to the nation. One of the emerging application areas of Blockchain technology in e-governance is real estate and asset registration [38]. Blockchain facilities fast and secure transactions through smart contracts between two parties in a verifiable manner. Researchers and developers are gaining interest in creating architectures and frameworks for Blockchain-enabled land registry systems [39]. The systems are secure, transparent and support functionates of transfer of ownership and mortgage registration. Integration with Blockchain technology with the real estate sector ensures trust and reliability in keeping land records and supports national wealth creation [40]. Blockchain has the potential to improve the slow and inefficient real estate sector and eliminate unnecessary manual processes [41]. Concerns relating to loss or duplication of documents can be easily mitigated [42]. Due to the absence of intermediaries, Blockchain technology can reduce the cost of asset registries by a significant value [43]. Moreover, illegal or shadow real estate transactions can be identified and stopped by the use of Blockchain technology [44].

4. Conclusions

Blockchain is one of the fastest emerging technologies which has started to see applicability beyond the financial sector. Its characteristics such as immutability, data traceability, security and decentralized nature have been the major driving factors for ensuring its success. Herein concluded:

- New age disruptive technologies such as Blockchain, IoT, AI and Cloud can be combined together to render solutions for sustainable smart cities;

- Policymakers need to educate themselves with respect to Blockchain and understand the means and methods of its applicability across various areas of e-governance;

- Existing research suggests that countries have started working towards Blockchain integration in the form of pilot studies and, in years to come it will become a living reality;

- Emergence of Blockchain will eliminate the role of any third party intermediatory thus ensuring transparency, trust and growth in the economy;

- Blockchain integration with smart cities will give rise to new business models in domains of supply chain and energy trading. Individual citizens and government agencies will largely benefit economically from such new initiates;

- Citizen participation will see a significant rise in the decision-making process, thanks to the involvement of technologies such as Blockchain, IoT and AI. Higher levels of automation can be expected in decision making and problem solving;

- Overall, Blockchain will introduce a new sense of trust, transparency and security between citizens and governments.

Talking of future research directions, researchers can aim towards creating Blockchain applications supporting scalable transactions along with ensuring optimum levels of energy consumption. Applications of DeFi (Decentralized finance) for smart cities is another domain area for researchers to explore. Supply chain applications for perishable food items such as fruits and vegetables are an upcoming application area where new models can be proposed.

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