"Implementation of Blockchain Technologies in Smart Cities, Opportunities and Challenges"

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Abstract A blockchain can be thought of as the shared distributed ledger type of technology that stores the information of every transaction in its network. The blockchain has emerged with vast diversity of applications in the economical and non-economical areas. Blockchain technology has the potential to provide a robust span of solutions to the issues faced in the implementation of smart cities. As such, it displays the potential to create smart types of contracts more securely, by eliminating the need for centralized authority. A blockchain can be envisioned as a secure decentralized database that stores information utilizing a peer-to-peer type of network. The blockchain can be seen as a type of special stack, where blocks could be placed or stacked on top of each other. Subsequent blocks composing the blockchain have to be linked to each other by cryptographic type of hash. In contemporary times an increasing interest in the concept of blockchain technology has been observed. This secondary research utilizes detailed literature review of multifaceted sources of information, such as peer-reviewed and quality academic journal articles from renowned databases. With the introduction of blockchain, numerous fields like banking, finance,

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healthcare, and supply chain shall experience positive effects. The sustainability of smart cities can be further enhanced and ensured with the application of blockchain technology. One major aspect wherein blockchain can play an essential role is real estate and smart cities. Blockchain and Smart Cities concepts are fated to influence the future of our planet in numerous ways. Incorporating blockchain into the expansion of Smart Cities will make it possible to have a cross-cutting platform that connects the cities' different services, adding greater transparency and security to all services and processes.

Keywords Blockchain technology · Smart cities · Opportunities · Challenges

1 Introduction

A blockchain, also known as a distributed ledger, represents a write-only data platform sustained through a large number of nodes that do not entirely divulge in one another. Numerous research studies bring together blockchain, image, and video processing algorithms. Some of these applications may entail actions against false videos, processing of medical images, encryption of images, followed by the management of the digital content rights. The outlined approaches enable making sure that video has not been tampered with in connection to time stamping, making it possible to be listed as proof in the court of law. Blockchain innovation's core segment is being entailed in an innovative set of procedures that enables information to be exchanged between different elements within a system. In that way, there are no intermediaries because members belonging to the system can be connected via identities, which are encrypted and with each other using distributed communication. Transactions are subsequently attached to a particular type of changeless ledger chain and distributed to each single node. With the increased incidences of information breaches, fraud, and extortion, numerous types of projects are utilizing blockchain innovation technologies in processing identity and document approvals. Validation by the means of blockchain is being enabled via timestamping, checking for legitimacy, and end-to-end encryption [9].

The blockchain can be conceptualized as a heap, in which the individual blocks are being stacked on top of the other. In this sequence, each subsequent block in blockchain is connected to each other by the special type of hash, called, cryptographic hash. The generated first block in blockchain is called the genesis block. These blocks are stored in the memory of the computers and run as a distinctive type of computer process. Knowing that each block is being constructed on top of the previous block, desired immutability is attained. The immutability implies inherent difficulty to fake/change a block and easiness to detect the tampering. Additional analogies for blockchain system can be visualized as the ledger book, whereby each block represents a separate page in the ledger, and each transaction represents an individual asset transfer on a ledger page. Each member in Blockchain includes nearly the same copy of the blockchain ledger. A blockchain transaction entails a transaction record in blockchain, similarly to a record warehoused in MySQL database. The blockchain network can either be in a government/public or private setting. In government run/public type blockchain, everyone is enabled to read or write transaction data with no need for various types of authorizations. In the private type of blockchain, no more than authorized nodes are enabled to read or write the transactional type of data inside the blockchain [4, 6].

2 Blockchain Enabling Technology Types

A blockchain imitates a central computing service by the means of a disseminated protocol, operated via nodes connected by the means of the Internet. In technical sense, the blockchain is supplanting the present integrated ledger structures with the decentralized types. A blockchain utilizes encoding systems, and it does not carry out the participation of a third part, thus making it stable and dependable. A blockchain is comprised of a distinct data blockchain. In this sense it is important to envision that building blocks can be constructed and scanned by particular participants. Its submissions are unchanging, clear, plain, and easy to use. Operations are documented sequentially in a constantly evolving databank. Computer structure is connected via the world wide web, whereby customers at every computer can obtain or disseminate information to different computers. In conclusion, the info is then being replicated and set aside via the structure by the means of a shared system. As such, it promotes mutual trade of substantial value devoid of a vital liaison [6, 7, 9, 14].

Blockchain technology is dependent on to extend significant capacity for effecting fundamental alterations in a wide range of company styles, operating processes, and enterprises by enhancing accounting and examining. Being in a kind of specific and multidimensional landscape, the necessity arises to recognizing the major alterations in the private, governmental, and business-related fields. The present point of interest relating to blockchain innovation is using it in execution and approval of shop trades. This implies the rationale signifying the fact that its progress was profoundly rubbed by the money-driven trades. Presently, the blockchain is proliferating via other economic markets [9].

Figure 1, displays the essential elements of a blockchain.

(1) Replicated ledger: As a part of the blockchain, information is not deposited at a main viewpoint. Blocks tend to be dispersed and reproduced between the nodes. Every node includes a copy of the completed record book. As such, a peril of informational loss is being eliminated.

(2) Cryptography: Information, being deposited in the blockchain, is being encoded via the robust encoding type of set of rules. Therefore, the dependability of the combined operations and files is being reinforced by the means of numeral autographs.

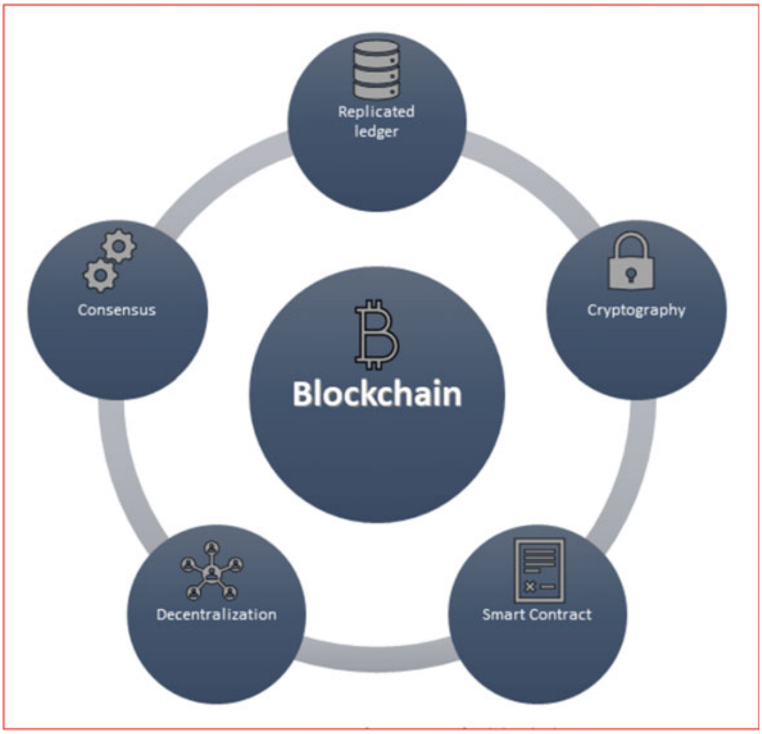

Fig. 1 Critical composing elements of Blockchain technology

(3) Consensus: Each building block includes a various total of operations. Operations must be authenticated prior to being added together to a standing building block. In Hyperledger type of structure, the validating nodes tend to be present to validate each block before attaching them into the chain.
(4) Decentralization: Aggregate transactions are distributed not including centralized type of control. Decentralization affords a sought after, safety and trust in the data, AND
(5) Smart contract: Blockchain delivers the electronic form of the contract connecting two sides. The smart contract can be visualized as the computer encryption aimed to numerically enable, authenticate, or impose various arbitration types [9].

Table 1 depicts the aggregate literature review of the Blockchain related research activities to be applied in the Smart cities. It starts chronologically from the year 2016 up until the year 2019, and it includes various Blockchain platforms (i.e., Ethereum, Bitcoin, Hyperledger Fabric, Multichain, Block-VN, and BigchainDB). It is being followed by data types (e.g., Medical history, user data, electricity, e-voting, supply chain, video, etc.). Finally, there are descriptions of its applications, such as patients' personal immutable medical record, secure electronic voting system,

Table 1 Summary of Literature review in regard to Blockchain related research articles to be applied in the smart cities

Year	Blockchain platform	Date type	Description
2016	Ethereum	Medical history	Patient's personal immutable medical record
2017	Bitcoin	User data	User-centric access control of personal data
2017	Hyperledger fabric	Anonymized dataset	Consensus based data transfer between data broker and data receiver
2017	Ethereum	Distributed energy resources	Distributed energy resources control system for smart grids
2017	Multichain	Electricity	Proof-of-concept based blockchain for electricity trading in smart industry
2017	Block-VN	Vehicular information	Distributed network of vehicles in smart city
2017	BigchainDB	Supply chain data	Storage of products data of food supply chain
2017	Hyperledger fabric	Video	Smart contract and network service based blockchain for video delivery
2018	Ethereum	E-voting	A secure electronic voting system based on blockchain
2019	Hyperledger fabric	Drug records	Integrity management of drug supply chain for smart hospitals
–	Hyperledger fabric	Video, metadata	Data verification system for CCTV surveillance camera for smart cities

Source [9]

integrity managing of prescription medications' supply chains for Smart hospitals and customer-centrical control of individual information) [9].

Blockchain technology initially was mentioned in a research publication by Haber and Stornetta, in 1991. To better comprehend blockchain technology it is essential to describe some of its elementary notions:

(1) **Nodes**: represent a most elementary Blockchain's component. The blockchain is being constructed utilizing a distinct web of nodes. In real life the nodes could be visualized to computers;
(2) **Transactions**: Every distinct segment in a Blockchain implies the particular operation. If there is a desire to alter a worth on the Blockchain a new transaction will have to be generated, transmitting the computer-generated type of paper money from single bank account to another (all of which constitutes another

type of transaction). In order for a particular operation to be recognized, it ought to be endorsed by at least 50%+1 of the present nodes;

(3) **Block**: shows a way as to how a blockchain retains the information. A building block entails the information from numerous, distinct, transactions. Each block is connected to the previous block by a cryptographic type of hash. The sum of these blocks are, in turn, being stored in each, particular node; AND

(4) **Account**: Blockchain accounts entail two distinctive variables, a private and a government key. The account owner is essentially the private key bearer. Contrary to previous centralized technologies, in Blockchain, in the scenario of the loss of the private key, the possibility to claim the account, does not exist [15].

3 Accompanying Features of the Blockchain Technology

Main features of Blockchain technology are being described, in detail, below:

(1) **Decentralization**—the data is being reposited in a number of locations, as numerous nodes are in the grid;

(2) **Scalability**—refers to the fact that there is an endless number of nodes in the grid;

(3) **Safety/Security**—utilizing a present expertise a Blockchain is in theory impossible to crack. As discussed earlier, in order for the business operation to be authorized 50% in addition to one additional node in the network are required to acknowledge it. In the event, whereby an attacker and potential intruder manages to change a blockchain or modify a particular single data portion, a new-found block is formed that is required to be authenticated by all the devices inside the blockchain network. 50% of data plus one node should be altered in order for illegal operations to be recognized and all of them must be broken down into/hacked simultaneously. If any single node is to react in a different way comparing to the others, the cryptographical hash linked node is checked, and node should be disregarded by the network while waiting for it to return to actual informational edition.

(4) **Intelligence**—past the elementary Blockchain technology it is still feasible to compose the custom code for every submission in a separate manner, thereby leaving space for several regulations and use instances; AND

(5) **Auditability**—since every block is connected to the previous one by the means of a hash, the Blockchain permits to circumnavigate through entirety of the blocks all the way up to the "Genesis" block. It represents the initial block of the Blockchain, thereby allowing for sequential tracing of all modifications [15].

Blockchain represents a regionalized P2P network utilizing the sum of produced operations are authenticated via the recorded nodes. These are then documented in a disseminated and unchangeable type of ledger. Therefore, the compromised

	Bitcoin	Hyperledger Fabric	Ethereum	Multichain	IOTA[a]	EOS.IO	Libra
Release year	2009	2017	2015	2015	2016	2018	2020
source	Open-source	Open-source	Open-source	Open-source	Open-source	Open-source	Open-source
Network Type	Public	Private	Public	Private	Public	Public	Public
Ledger type	Permissionless	Permissioned	Permissionless	Permissioned	Permissionless	Permissioned	Permissioned
Hashing algorithm	SHA-256	• SHAKE256 • SHA3	• Ethash • KECCAK-256	SHA-256	Curl-P-27	SHA-256	• SHA-3 • HKDF • Ed25519
Consensus algorithm	PoW	PBFT	• PoW • PoS (Serenity)	PoW	• PoW • Tangle	DPoS	LibraBFT[b]
e-currency	bitcoin (BTC)	N/A	Ether (ETH)	N/A [c]	IOTA	EOS	Libra
TPS	7	3500	15-20	200-1000	500-800	4000	1000
Smart contracts	Bitcoin Script	Chain-code	Smart contract	Smart Filters [d]	Not supported[e]	Smart contract	Move composed Smart contract

Fig. 2 List of contemporary blockchain platforms with source, network, algorithm, and ledger types. *Source* Majeed et al. [17]

algorithm signifies the hearth of blockchain technology. As such, it ensures the vital dependability of the network. More precisely, since no fundamental authority is present to confirm the created occurrences, each operation must be authenticated by the blockchain nodes by the means of a joint arrangement (i.e., accord). In the discussion, below, the elements of the most prevalent consensus kinds are being listed and discussed:

(1) **Proof-of-Work (PoW)**—a transaction is being authorized when at least 50% plus one of the nodes accept it in the P2P network,
(2) **Proof-of-Stake (PoS)**—each particular node that entails more capital has impacts bigger likelihood to partake in the consent and make a block.
(3) **Proof-of-Importance (PoI)**—the nodes able to build the block impact the largest number of transactions in the network. AND
(4) **Proof-of-Authority (PoA)**—only particular nodes are unequivocally permitted to establish new blocks and fortify the blockchain [1].

Figure 2, listed, above, represents a list of contemporary Blockchain platforms including source, network, algorithm, and ledger types. It compares and contrasts various Blockchain platforms (i.e. Bitcoin, Ethereum, Hyperledger fabric, Multichain, IOTA, EOS.IO, and Libra) with release years (2009–2020), types of sources (open versus closed), hashing algorithms, etc.

4 Smart City—The Origins

The starting point relating to the smart city comes from the progress in the quality of life of citizens and optimum supply operation of the city, due to the modern increase in speed in urban living. The progress in public services and infrastructure has improved the quality of life. These improvements were achievable due to the world wide web (WWW) and Internet, communication, and information technology improvements.

Special prospects stemming from the idea of smart cities include variety of efficient and effective public services, augmented by improved infrastructure, all of which are being easily accessible and more interactive. Vision of smart city became a reality with the potential of the Internet of things (IoT) concept.

Consequently, the smart city emerged as one of the primary generators in IoT applications. The complete city is thereby protected with the physical items, which are, in turn, intertwined with the IoT scheme. The four building blocks that can be joined together utilizing IoT concepts are (1) data, (2) phenomena, (3) people, and (4) processes. The Internet of Everything (IoE) came out including the people in the IoT paradigm, where an interlocked network is grouped in IoE. In conclusion, the image of a smart city is incorporated with IoE foundation blocks to enable encouraging services in the future [16].

5 Smart Cities—The Concept

Smart Cities can be visualized as ecosystems that are usually characterized as networks of connecting appliances. Their environs are customarily portrayed as puzzling systems created within a prism of supply mutuality. Gretzel et al. added four progressively essential elements that exist in this ecosystem's characterization of a smart city. These are (1) self-organization, (2) interaction or engagement, (3) balance, and (4) lightly combined performers with common purposes [9].

The Smart City notion is characterized in the literature in various ways. Researcher Komninos depicts smart cities and associated areas as environments with a great capacity for knowledge creation, expansion, and innovation. They are including the ingenuity of population and institutions with digital infrastructures to operate in the physical, institutional, and digital spaces of cities. The opacity of this notion triggers problems in comprehending the way as to how information technology influences the development of smart cities [15].

6 The Smart City—The Model

The high-level point of view of the smart city paradigm is depicted in Fig. 2. It displays how the differint components in a smart city convey to each other in order to deliver the services in smart cities. Various sorts of elements are part of smart cities. These elements interrelate with each other by the means of cellular and/or Internet services (e.g., ZigBee, Wi-Fi, 3G/4G/5G/6G). The smart energy, smart mobility, and smart grid, and various services in the smart city surroundings. The macro or microcell entities represent a type of communication gadgets utilized to make available services on demand [16].

As depicted in Fig. 3, the Smart city model displays critical connections and interactions between Smart City with Fog computing and internet of things (IoT)

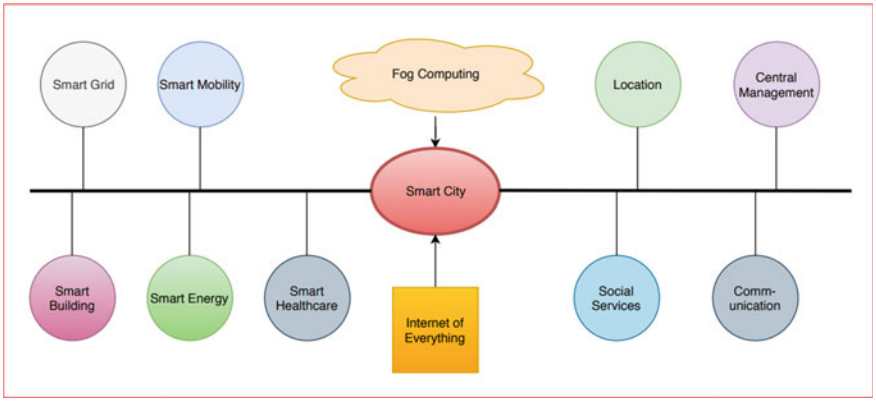

Fig. 3 The model of the smart city. *Source* Singh et al. [16]

as the main building blocks. Additional contributing elements are being exemplified in smart grid(s), smart buildings, smart energy, smart mobility, social services, communication, location, capital management, and smart healthcare [16].

7 Primary Objectives of the Smart Cities

In order to make certain that the advantages associated with urban growth are fully utilized, urbanization management policies ought to enable access to the electronic infrastructure and services for the entirety of its residents. The attainment of confidential data through the Internet of Things (IoT) represents one of the major objectives of smart cities. Therefore, the establishment of this data security is of utmost importance. Therefore, most administrations invest regularly in the development of smart cities with many designated facilities for its inhabitants. The modern city already represents a robust network of interconnected technologies, and according to Cisco technologies, 500 billion devices are expected to be connected to the Internet by the year 2030. In this context, the researcher Gartner stated that about 10 billion interconnected objects are expected to be utilized by smart cities by 2020 [15].

8 Smart City as a Summation of Paradigms

Smart City represents a sum of paradigms spread across various realms, such as people, economy, government, mobility, environment, and life on our planet earth. As such, it is inherently designed to address a range of utilization instances, such as: (1) environmental monitoring, (2) analysis of the traffic, (3) utility monitoring, (3) smart public transportation, (4) electronic voting system, (5) e-commerce, (6) jobs, (7) local occurrences, (8) real-time incident reporting, (9) medical services, etc. Data analysis gathered among the above-mentioned spheres permits the city administration to enhance the infrastructure and adjust its services. A smart city additionally represents, rather unique type of environment with integrated information and communication technologies creating interactive spaces that bring along computational capabilities to the physical world [15].

9 Composing Elements of the Smart Cities

A Smart City is designed to incorporate key elements that allow data centralization, elements that can take many shapes, starting from a simple website to complex applications, backed by specialized hardware. The accessibility of the data ought to be guaranteed in a way that the system can be freely accessed by citizens, enabling them to propose changes and corrections in an interactive way [15].

Numerous IoT devices require memory and computational complexities to deal with modern computing gadgets. Shortage of computational power makes them defenseless against a broad scope of cyber-attacks. They addressed the problem of security issues in relation to distributed refusal of service (DDOS) attacks in the IoT system. They used a changed smart contract that empowers a superior resistance mechanism against DDoS and rogue device assaults. Kim et al. introduced an idea of utilizing blockchain technology to address and resolve the security problems of a sensor-based platform. IoT gadgets represent the main components of smart homes, smart factories, and intelligent appliances. A blockchain-sourced authentication protocol was offered to focus on security problems. By utilizing that protocol, the IoT environment can become efficient and stable. They utilized this feature of blockchains in the IoT environment to safeguard the verification at runtime of sensors and actuators. The utilization of smart contracts makes it easy to automate the business logic and assists in saving time with the guarantee of zero error security. Significant volume of work has been performed in the area of video forensics. This improvement allows the video proof to be utilized in court cases. Recent techniques utilized for video falsification uncovering are primarily based on an autoencoder with periodic convolutional neural networks, augmented by an autoencoder with a go turn algorithm, watermarking techniques, and digital signatures. It was further proposed to include autoencoders and intermittent neural networks-based architecture to discover the video falsification. They produced a unique content-based signature to detect inter and intraframe falsified videos. In extension, irrespective of whether an image examination innovation is produced, there is a multitude of cases of breakdown due to the sensor-based restriction. This may similarly occur when restricting images for injurious aims. The Privacy Act takes into consideration the creation of CCTVs for public places, which requires reaching out to the owners of CCTVs to acquire video information. However, this represents a rather lengthy procedure. Irrespective of whether a video is acquired, it is difficult to utilize in open organizations due to the fact that video is not safeguarded to be an original video that has not been manipulated. Panwar et al. proposed an arrangement to provide sensor information confirmation through cryptographic algorithms implementing a log sealing system and creating permanent portions of evidence used for log verification. The structure ensures that sensor information and log-fixed data could be put away in untrusted storage with the proposed verification system ensuring its integrity. However, this structure depends on the dependability of the instrument; for example, Intel SGX store up the fixed data in an incorporated way. False news became a worldwide issue that raises extreme difficulties for human culture and the majority rules system [9].

10 Application of the Blockchain Technology in the Smart Cities

From its inception, Blockchain technology was perceived through its relationship with bitcoin. Recently, its possible utilization has been investigated in other fields of activity. These may include smart contracts, logistics, and systems' management. Utilizing the promise of Blockchain, researchers and developers are aiming to increase people's trust in digital communities. This can be easily accomplished by Blockchain systems through their decentralized and open nature. Provision of a single source of truth and a single starting point for new initiatives represent some of the examples. Domains and applications of using blockchain technology in cybersecurity are presented [15].

These are shown in Fig. 4.

Figure 4, depicts the interaction between Blockchain domains and associated applications in Smart cities. Cybersecurity influences the need for the existence of Blockchain. Blockchain furthermore branches to distinct types of applications, process models, and communications infrastructure(s). In the end, the applications may involve, financial system, intelligent transportation system, IoT, Smart grid, data center networking, voting systems, and healthcare networks [15].

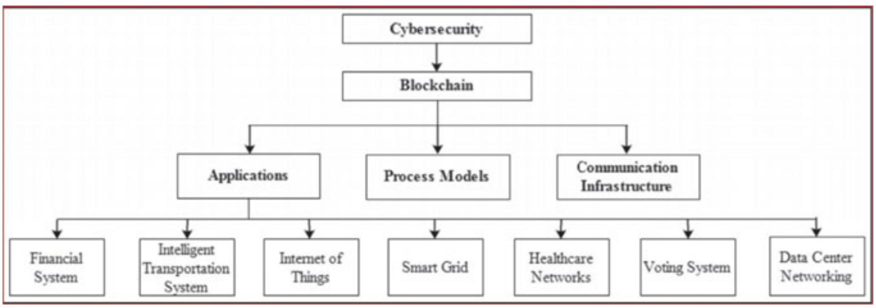

Fig. 4 Domains and applications of blockchain technology in smart cities. *Source* Rotună [15]

Blockchain technology is capable to augment the openness of local and regional institutions. It does so while enabling the communication of sensitive data without compromising security and confidentiality. In this sense, blockchain may be utilized in the advancement of smart cities. This can be achieved by utilizing an interoperable platform enabling the citizens to proactively participate in the decision-making processes. These processes affect the communities they belong to. They may also operate as a tool for managing the reputation of companies in relation to the activity related to the environment. The administration of a smart city via its systems generates a considerable volume of sensitive data that requires an oversized storage environment. According to latest data, cyber-attacks still pose a real security concern in realm of the online transactions. To mitigate the effects of these phenomena, blockchain technology utilizes a distributed model that increases the degree of entropy. This is being achieved by implicitly reducing the vulnerability of the systems it supports. The technology-based cryptography architecture makes it unlikely that transactions will be reversed or altered. Whenever a new transaction is broadcast on the network, the nodes have the obligation to validate and include it in the copy of the distributed ledger. In an invalidation scenario, it must simply ignore it. The consensus is reached when most of the participants composing the network decide on a single state. Furthermore, all participants in the system possess a personal key or signature utilized during creation of a transaction. This key allows the association between the user who created a particular transaction and the recipient of that transaction. At the same time, since the ledger is distributed and validated by the entire network, a transaction is associated with a single user and cannot be registered multiple times on the blockchain [15].

11 Application of Blockchain Technology in the Development of the Smart Cities

A smart city provides its inhabitants with the facility to interact with public administration and local communities, utilizing digital technologies for increased efficacy and safety. Through its persistent and at the same time distributed storage, blockchain permits the development of a large number of new interaction models. It is important to note that these models could not be designed within a centralized model. Public administrations are starting to realize the potential of the blockchain model as a platform for communication and transactions in the implementation of electronic services for local communities [15].

Figure 5, discusses the critical interaction between Smart city's citizens in connection to the primary circle involving computational intelligence, blockchain, IoT, etc. Secondary circle involves mobility, industry and services, governance, and health care. Finally, the third circle involves air quality monitoring, internet of value (IoV), traffic control, various sensors, information transparency, shared medical data, etc. [3, 13, 17].

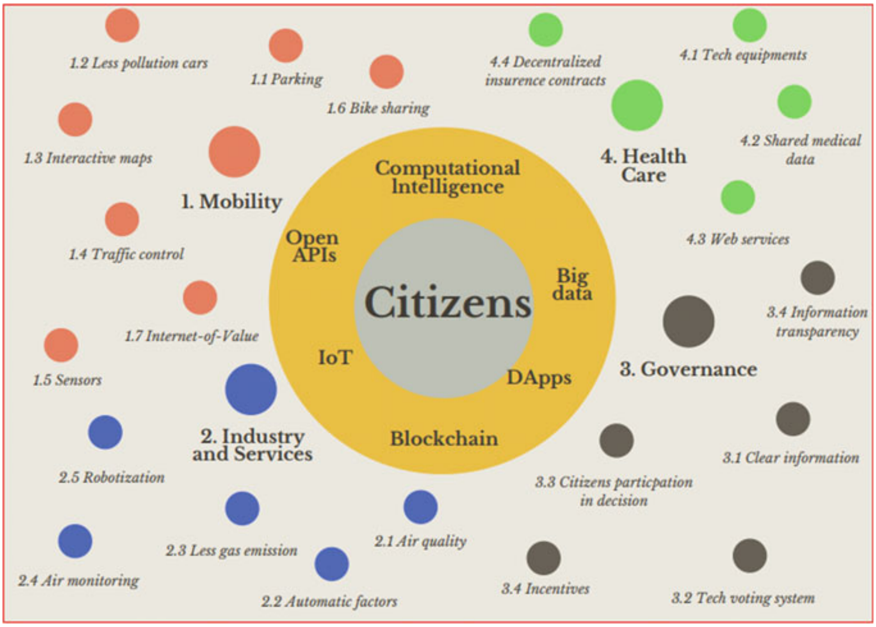

Fig. 5 The scope of smart cities with blockchain as potential trend. *Source* Oliveira et al. [13]

Fig. 6 The classical compared to SSI type of digital identification. *Source* Rotună et al. [15]

12 Digital Identity

Digital identity represents the information regarding an entity. It is utilized by the information systems to embody an external agent, in a form of a person, an organization, an application, or a device. ISO 24760-1 classifies this identity as an "entity-associated set of attributes". Digital identity data permits the automatic verification of a user networking with a system and allows access to the services supplied by the system [15].

13 SSI Digital Identity

Self-Sovereign Identity (SSI) represents a kind of digital identity enabling the user with the complete and final control of its identity. Utilizing SSI, users and firms may store their identity data on their devices and can efficiently deliver them to those in need of validation. Therefore, through an application, on mobile phone or computer, the user manages the elements that make up the identity. This application also controls access to this set of information. Identity related information may include birth dates, citizenship, university diplomas, or licenses. As part of the application, the user is initially assigned a self-generated identification number derived from the public key and a corresponding private key. This key pair is different from the combination of username and password. After its creation by the user, automatic mathematical calculations must be performed making decryption almost impossible This kind of identity may be implemented to identify the citizens of a smart city using blockchain technology. All of this ensures storage, secure timestamping, and decentralized hosting. This model removes the need for passwords and guarantees authentication with a high degree of security. An example of successful implementation is the Estonian e-Residency program allowing clients outside the EU to create a digital identity that can be utilized to set up a business in Estonia [15].

14 Blockchain Architecture for Smart Cities

Smart cities utilize various technologies and infrastructure to ensure a better quality of life for urban residents. In addition, there is also a need for a good environment for business development, optimization of resource use, and transparency for public administration. These goals may be achieved by utilizing blockchain working as a tool for decentralized and distributed ecosystems. Features, such as safety and transparency, shared information, common updating of the database, and information validation, provided by blockchain technology, empowers all smart city customers. Blockchain technology permits the interactions between citizens and local governments without the need for a central authority. Smart contracts optimize the functioning of the smart community through their ability to automatically execute transactions without the intervention of an operator [10, 15].

A blockchain-based Smart City model using SSI is illustrated in Fig. 7.

Blockchain infrastructure links the local community with public administration. The admission to the ledger is permitted to all community members. Every member possesses its own synchronized copy of the common ledger. Furthermore, each participant has a Digital Self-Sovereign Identity that is utilized to authenticate the person

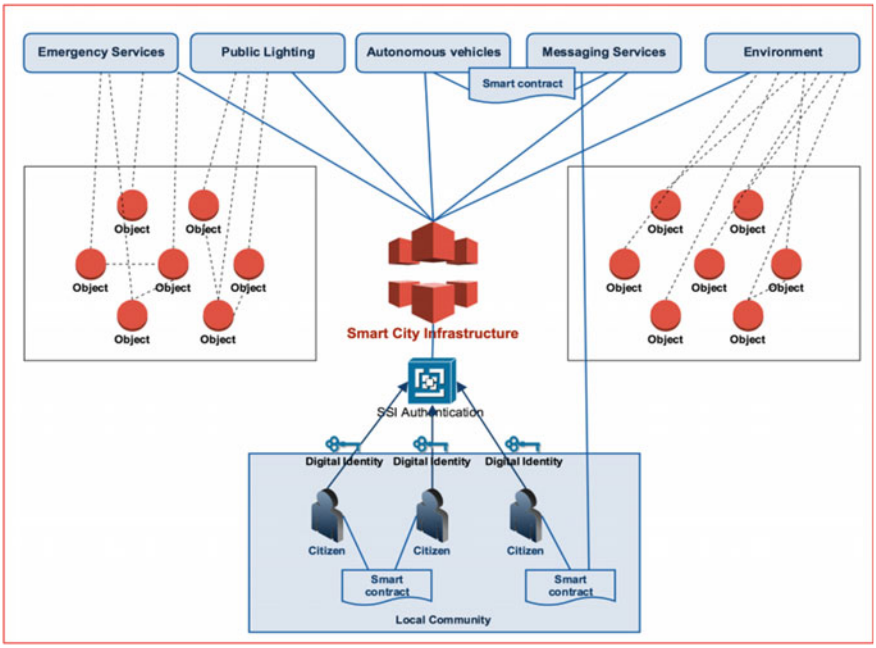

Fig. 7 Blockchain architecture model in smart cities. *Source* Rotună et al. [15]

in transactions. The utilization of central authorities is supplanted by a community of peers in the form of an interconnected network where each peer has its own identity. The ecosystem comprises IoT devices located in various locations, which record and transmit securely real-time data regarding the city environment. Various types of Smart contracts may be classified between citizens, between public authorities, and between citizens and public authorities for services. Smart contracts are stored on the blockchain thus decreasing the potential for fraud attempts [15].

15 Opportunities in the Application of the Blockchain Technology

The technology has played a main part when it comes to the advancement of cities. Stemming from first human settlements to the massive impacts of the industrial revolution to today, technological advancements have impacted our lives in a variety of ways. Experts envisage that the way we live today will change dramatically within the next decades. Big demographic and social change, followed by climate change shall impact our lives in the future and may impose an extreme burden on our existing city infrastructures [12].

Providing a sufficient amount of goods and services for people and huge cities will be especially challenging. Many cities won´t have the capacity for so many people, for instance in many parts of the world the electric grid is not made to provide electricity for such a huge number of inhabitants. The infrastructure must be renewed, and an interdisciplinary way of thinking will be needed. All over the world futurists are working on plans on how to make future cities more livable for such a massive gain in population. These imperatives have given rise to the birth of the idea of Smart Cities. Smart Cities is the idea of improving the efficiency of resource usage and facilitating the provision of new services within cities; by adding a digital layer to metropolitan area infrastructures through technology in an intelligent way in order to improve inhabitants' quality of life. Furthermore, Smart Cities aims to save money by reducing costs and also improving sustainability. Smart Cities' purpose is to use technology to enhance livability. The plan to create Smart Cities is not an easy plan. It needs to integrate communication technology as well as all sorts of information technology, together with important social aspects, to augment the standard of living considering the fact that urbanization will be increasing drastically in future [12].

The three major drivers of the requirement for Smart Cities are:

(1) Anticipated rapid urbanization in the future;
(2) Climate change; and
(3) Logistical pressures.

There is a strong impression that without addressing these three challenges, the world's mega-cities are predestined to become increasingly chaotic, inefficient, and susceptible to become increasingly controlled by the criminal elements [2, 4].

The scenario where Blockchain technology can have major impacts on Smart Cities is in the area of crime prevention, more specifically, the crimes involving forgery and counterfeiting may be prevented from alteration through the use of Distributed Ledger Technology (DLT).

As stated above, it can be concluded that the three principal drivers of the requirement for Smart Cities are: (1) Anticipated rapid urbanization over the coming decades; (2) Climate change; and (3) the Logistical demands. The notion that without addressing these three issues, the world's mega-cities are destined to become increasingly chaotic, inefficient, and susceptible to being controlled by criminal elements [4, 8, 16, 18].

The ongoing development of the Internet of Things (IoT)-based applications are paving the way towards the development of smart cities. Smart cities offer intelligent transportation, industry 4.0, smart healthcare, smart homes, smart banking, among others. These applications require immense security for handling data while improving the standard of citizens' life. To enable smart cities with enhanced security and privacy, we can use blockchain. Blockchain is a decentralized, traceable, transparent, and immutable ledger of transnational records in Peer-to-Peer (P2P) networks. Blockchain was first introduced as bitcoin that is a solution to transfer digital payments between different parties without the need for a central authority [3, 4, 17].

Other than improving the financial industry, blockchain has potential applications in many other fields such as the IoT, e-Commerce, accounting & auditing, e-Voting, asset management, identity management, supply chain, taxation, telecommunication, healthcare, and government/public services. The smart city comprises the ecosystem of smart environments provided in the city which can improvise its inhabitants' lifestyle. Smart city concerns with the adoption of information and communication technologies for enhancement in public welfare, economy, government services, environment, resource management, and urban planning. Smart cities envision the use of existing and developing digital technology to enhance every aspect of city life. One of the primary objectives of smart cities is reformed provision of fundamental services like housing, education, healthcare, transportation, energy, water, utilities, surveillance, and law enforcement. Smart cities mitigate the problems of population growth and expeditious urbanization by integrating social, business, and physical infrastructure of the city through technology. Recent advancements of technologies such as Information & Communication Technologies (ICT), blockchain, Big Data, machine learning, automation, Artificial Intelligence (AI), and the IoT will make smart cities more interconnected, instrumented, intelligent, livable, safer, sustainable, and resilient [5, 8, 9, 18].

The performance measures for the success of a smart city constitute the integration of fundamental services with seamless assimilation in the daily lives of its residents, thereby assuring the effective usage of resources and improving quality of life. However, this involves a huge amount of data traffic generated by information systems flowing through communication networks of city technological infrastructure. Blockchain is a solution to the key challenge of security, privacy, and transparency of this personal, organizational, and operational data [1].

16 Conclusion

A blockchain, also known as a distributed ledger, represents a write-only data platform sustained through a large number of nodes that do not entirely divulge in one another. Numerous research studies bring together blockchain, image, and video processing algorithms. Some of these applications may entail actions against false videos, processing of medical images, encryption of images, followed by the management of the digital content rights.

The blockchain can be conceptualized as a heap, in which the individual blocks are being stacked on top of the other. In this sequence, each subsequent block in blockchain is connected to each other by the special type of hash, called, cryptographic hash. The generated first block in blockchain is called the genesis block. These blocks are stored in the memory of the computers and run as a distinctive type of computer process. Knowing that each block is being constructed on top of the previous block, desired immutability is attained. The immutability implies inherent difficulty to fake/change a block and easiness to detect the tampering. Additional analogies for blockchain system can be visualized as the ledger book, whereby each block represents a separate page in the ledger, and each transaction represents an individual asset transfer on a ledger page. Each member in Blockchain includes nearly the same copy of the blockchain ledger. A blockchain transaction entails a transaction record in blockchain, similarly to a record warehoused in MySQL database. The blockchain network can either be in a government/public or private setting. In government run/public type blockchain, everyone is enabled to read or write transaction data with no need for various types of authorizations. In the private type of blockchain, no more than authorized nodes are enabled to read or write the transactional type of data inside the blockchain.

Blockchain-centered resolution for smart property provides a number of benefits over traditional centralized database systems. The first and most important advantage is the security against forgery. Since the blockchain depends on endorsement of transactions performed by verification of identity of all the parties in the network, false transactions cannot be verified without the authorization of all nodes in the network. This feature shall instantly resolve variety of the malicious issues faced stemming from identity stealing and fake payment plans. Transparency poses an additional significant advantage of the blockchain in contrast to traditional centralized databases. Since the blockchain is a decentralized shared database that is managed and coordinated across a network of devices (nodes), the data of every transaction remain constant among all the nodes. Therefore, numerous parties may utilize the exact same copy of data simultaneously. This is in contrast to centralized system where multiple nodes rely on siloed databases. This signifies improving the scope of transparency in the decentralized system. Another significant advantage of taking into consideration the blockchain as a solution for smart property systems is the efficiency. In theory, managing multiple copies of transactions in decentralized shared database in the blockchain could be considered inefficient in comparison to the siloed centralized database. In the real world, the organizations retain the copy of database including similar transaction data in situations such as data inconsistency, demanding expensive and time-consuming data resolutions. Consequently, utilizing a decentralized shared database solution such as blockchain may reduce the requisites for manual data resolution. As a consequence, a smart city cannot operate successfully if there is a lack of trust between organizations and gadgets comprising the network. Trust is the quintessence of combining all the components of a smart city together. The blockchain has proven itself to be a more efficient technology, as it offers framework for consensus in a decentralized ecosystem and provides complete transparency and immutability of information, thereby creating the blockchain as an essential layer of trust in the smart city. Many smart cities' exhaustive blockchain-centered decentralized solutions are being developed. As these platforms are expected to develop and mature, smart cities shall sooner or later function on a network of established blockchain solutions.

Smart cities have been increasingly becoming a reality, and their advanced services towards citizens often rely on IoT devices. Unfortunately, these IoT devices, are frequently poorly secured, leading to an optimal playground for cybercriminals, constituting a non-neglectable risk for the wide deployment and success of Smart cities.

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