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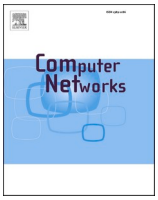

Blockchain-based Initiatives: Current state and challenges

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ABSTRACT

Blockchain is considered a distributed ledger that can transact securely and trustfully without involving any third party. It has caused a lot of interest in various sectors, like government, finance, banking, etc. Blockchain technology is suitable for areas where multiple data storage and transaction types generally require the third party to authenticate the transactions involving transaction cost and authentication issues. In this paper, various aspects of Blockchain technology applications in public concern sectors have been analyzed in detail. This paper also reviews the multiple case studies and implementations of Blockchain technology in these sectors and their current status that provide a detailed insight into all the aspects of its application. This paper finally comes up with various implementation requirements in Government, Health, Finance, Economics, and Energy. Further, it identifies the challenges in successfully implementing Blockchain technology in these mentioned sectors to provide a reference for future deployments.

1. Introduction

Blockchain technology's inception is considered from Satoshi Nakamoto's famous paper on Bitcoin that describes Blockchain technology as a means of direct financial transaction between parties without and trusted third party [1]. It is a decentralized ledger in which all transactions are safely accumulated in blocks, with each block connected to the next in a chain. When a new block is attached to the chain, it is appended. The Blockchain consists of a distributed database containing records of all the transactions and events, and it is a special form of distributed ledger that maintains a log of stored data in the form of the ledger in which a new transaction or information can be appended at the end. It does not allow any modification in the already stored data items. Any newly created data is not directly added instantly, but it is collected in batches in the form of a block, and then these blocks are further approved by consensus algorithms then only these data items are added into the existing Blockchain. A sample transaction in the Blockchain has been depicted in Fig. 1.

Researchers have classified the Blockchain into three types [2,3]:

a Public Blockchain: It allows anyone to create, modify, and validate the block, and every node can participate in the consensus process. Every user having similar resources possesses equal authority in creating a new node. It is also known as Permissionless or Public Permissionless Blockchain.
b Private Blockchain: It allows only a set of certified users in the network to make, modify, and create transactions inside the ledger. Only a limited number of users can be allowed in the consensus and new block generation. It is also referred to as Permissioned or Private Permissioned Blockchain.
c Hybrid (federated) blockchain: This type of Blockchain is a mixture of public and private Blockchain that makes a balance between these two and offers attributes of both. It allows each user to participate in the consensus mechanism but allows only certain users to create a new node explicitly designated. It is also considered a Public Permissioned Blockchain.

The high level of investment by Governments and enterprises in implementing Blockchain technology for various initiatives is an indicator of potential benefits. Various pilot projects based on are ongoing,

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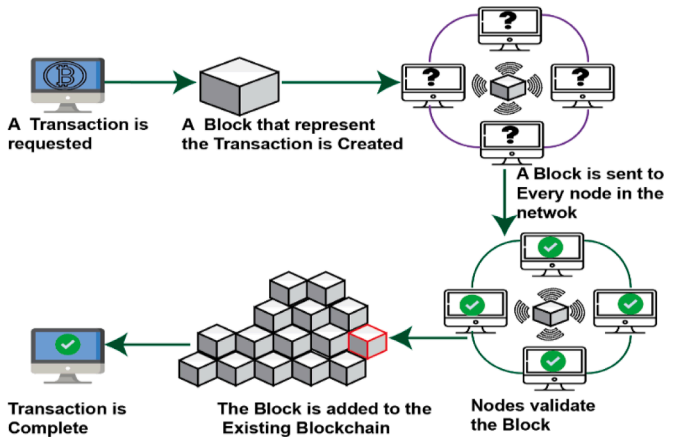

Fig. 1. Sample blockchain transaction.

Fig. 2. Broad application domains of the Blockchain.

and it is being used and proposed in every domain where a secure and reliable transaction is required. The analysis of multiple case studies and final outputs will further guide the best suitable approach for Blockchain application in various aspects [4]. Blockchain can be implemented in various domains like government, banking, healthcare, legal, economy, supply chain, real estate, Internet of things (IoT), etc., to improve efficiency, security, and other related aspects. The acronyms and abbreviations used in this paper are listed in Table 1.

The broad application domains of Blockchain technology have been shown in Fig. 2. Some of the application domains are Government, Health, Finance, Economics, and Energy. Blockchain technology application in these domains has been briefly defined here, and further analysis is given in section 2.

The security issues related to the government data exchanges can be addressed using Blockchain technology. The lack of trust in the election process is rising as a "most serious crisis" in recent years, and disenchantment from the process and lack of confidence are increasing day by day. In the case of Blockchain-based implementation for the electoral process, the votes can be traced accurately and counted quickly if the voters have been correctly identified and entered into the system. The Blockchain-based system will eliminate the requirement of citizen's data duplication by different government agencies, and the same data can be shared. Data stored using distributed ledger technology is secure from malicious modification or deletion. Using the distributed ledger technology, the Government needs not spend money on the massive data centers resulting in reduced maintenance cost. A significant chunk of around 2 billion citizens is out of the banking domain, and there is much scope for improving financial inclusiveness.

According to the world bank survey in 2014, around 18 percent of citizens do not have access to financial services due to the lack of digital identity or the inability to offer proof of identity [5]. There are many issues in the old financial system, like high transaction fees, financial viability for the current financial system. Some of the significant issues of inclusive growth in the financial sector can be resolved using Blockchain technology by reducing the transaction cost and time, reducing the investment cost in infrastructure building, and facilitating secure digital identity. So, Blockchain technology in the financial sector is an emerging application. The financial industry's size is enormous; there is a significant scope to introduce Blockchain technology in the financial sector. The use of Blockchain in financial services is at its early stage. Global institutions and regulators have recognized that Blockchain provides a significant role in fast-tracking rapid growth and financial inclusion. Introduction of the Blockchain technology in the finance sector has complex obstacles that require a combined creative solution from private and Government players to support the ecosystem. The energy sector comprises millions of transactions related to the trade and distribution of energy, which can be transformed using Blockchain technology. Blockchain technology uses the decentralized platform to optimize and control data at the facilities level in the energy sector, which results in high productivity in the existing grids, peer to peer transmission, support, and creation of the micro-grids [6].

Blockchain technology will be beneficial for the health sector. This technology can be used to maintain and exchange health records and manage the medicine supply chain management since this technology is decentralized and secure, which will provide an efficient solution to the health sector [7]. The health sector's big challenge is the isolated electronic health records maintenance by various entities that are not connected. Since the exchange of information is costly, each system needs different data standards and processes that are challenging to inter-operate [8]. The patient's record is distributed through other systems, making it hard for doctors to access their medical history.

The supply chain management of medicines is also a significant concern since many medical items are susceptible to a specific temperature range [9]. When exposed to a particular range of temperatures, the drug will not be effective as per the expected outcome or, in some cases, can also harm [10]. With the use of Blockchain technology in supply chain management, medical professionals can track and verify the medicines according to the environmental conditions and decide to

Table 1
Abbreviation Table.

Abbr.	Full-Form
IoT	Internet of Things
KSI	Keyless Signature Infrastructure
EPSRC	Engineering And Physical Sciences Research Council
DLT	Distributed Ledger Technology
EHR	Electronic Health Record
AEMO	Australian Energy Market Operator
PMA	Palestine Monetary Authority
KYC	Know Your Customer
MICR	Magnetic Ink Character Recognition
SEDB	Singapore Economic Development Board
MAS	Monetary Authority of Singapore
CSIRO	Commonwealth Scientific And Industrial Research Organization
UCC	Uniform Commercial Code
OBP	Outcome-Based Payment
KPIs	Key Performance Indicators
IRR	Intellectual Property Right
P2P	Peer To Peer
ICT	Information and communications technology
PoW	Proof of work
PoS	Proof of stake
FBA	Federated Byzantine Agreement
PBFT	Practical Byzantine Fault Tolerance
PoA	Proof-of-Authority
PoET	Proof of elapsed time

discard or accept medicine as per medical standards. Blockchain technology can create better coordination between machine-to-machine communications in industries using the IoT device [11]. Also, it makes a decentralized marketplace for consumers and explains the Blockchain application in the IoT ecosystem [12]. Blockchain technology will create decentralized governance and drastically change the organization's current management scenario [13].

The economist Hernando de sotto states that poor people cannot access the formal economy and hesitant to share transaction information due to the unreliable record-keeping systems in developing countries. These countries can harness the potential benefits of Blockchain technology to become a developed economy. The benefits of using Blockchain are very high compared to the traditional record management system, like less cost and resources required to implement the Blockchain technology [14]. The concept of the digital economy is 20 years old. Still, today it got an appropriate technological platform recently in the form of Blockchain 2.0, which involves economic and financial applications, money transfers, and transactions. Economic and financial applications include the traditional loan and mortgage application process, financial markets like stocks, bonds, derivatives, contracts, other property assets [15].

The main evolving use case of Blockchain technology is a smart contract. It will automatically execute the condition as the pre-smart contract contains some of the agreement conditions like payments etc. The smart contract will transparently run pre-agreement that all parties agreed previously. In 2015 Visa and DocuSign displayed a smart contract for car leasing without the manual filing of forms [16].

Various surveys and literature reviews have been conducted on different aspects of Blockchain adaptability in different domain domains. These reviews are in specific areas and do not cover all the major areas of public concern. These reviews are based on individual areas that have been included in section 2. Few studies have tried to cover different domains, but these are not comprehensive and just discuss the fundamental aspects of usability [17,18,19]. A comparative study of the most recent literature reviews of Blockchain-based initiatives has been presented in Table 2.

This research work includes the major domains of public concern, namely Government, Health, Finance, Economic, and Energy, and reviews existing Blockchain-based systems in these domains and analyses the various challenges, requirements, and future applications. This review provides a platform for further research and helps in choosing future research directions. The main contribution of this research paper is as follows:

- Presented an overall view of Blockchain implementation benefits and scope of implementation
- Presented and reviewed the current initiatives in the major sectors of public concern, namely in the field of Government, Health, Finance, Economic, and Energy
- Identified the requirements for implementing Blockchain in various areas of identified sectors.
- Highlighted the challenges for the successful implementation of Blockchain in these areas of public concern.

This article is organized further as follows. In Section 2, various public concern areas, namely in the field of Government, Health, Finance, and energy-based initiatives, have been summarized. Multiple factors required for Blockchain implementation in these areas have been discussed. Section 3 highlights the significant challenges in implementing Blockchain technology in these areas that have been explained and analyzed. Further, this paper examines these factors in Section 4 and finally concludes the outcomes. Fig. 3 categorically shows the organization of the article.

Many countries have started projects for blockchain implementation in the public sector. These initiatives are mainly in the initial stage

Table 2
Comparative study of most recent literature reviews of blockchain-based initiatives in the public sector

Ref	Theme of Survey	Sector covered	Implementation Challenges for Blockchain	Further Research directions
[20]	Survey on the application of blockchain technology in the public sector to check its role in workflow management.	Public Administration (Government)	Covered only related to the governance model	Partial, only provided a general discussion without any specific direction for future research.
[21]	Review the relevance of Blockchain use in the public sector	Public Administration (Government)	No	No
[22]	To review the effectiveness of Blockchain in the public sector and its advantages	All major aspects of Public Sector	No	No
[17]	To investigate the blockchain applicability in fulfilling the security requirements of the public sector	Government	No	Partially only for security aspects in e-governance
[23]	To review the public procurement model and application of Blockchain	Public Procurement	No	No
[24]	To investigate the articles based on blockchain technology application in the financial sector and their impact	Financial Sector	Yes, but only for the Financial sector	Yes, but only for the Financial sector
[25]	To provide a systematic review of literature available on Blockchain application in government services	All major aspects of Public Sector	No	No
[26]	To provide a systematic review of literature in the field of healthcare using Blockchain	Healthcare	Yes, but only for healthcare	Yes, but only for healthcare
[27]	To review the application of Blockchain in various domains	Finance, Healthcare, governance, energy	No	Partial that just provided some domains of application
[28]	Reviews the country-wise initiatives using Blockchain in the public sector	Public procurement, tendering, property registration	No	No
Our Review	An extensive study of blockchain-based initiatives in different public sector initiatives has been presented. It also provides various implementation challenges and further research directions for each sector.	Covers all significant aspects of public concern, namely Government, Health, Finance, Economics, and Energy	Completely covered for each sector	Completely covered for each of the major sectors of public concern

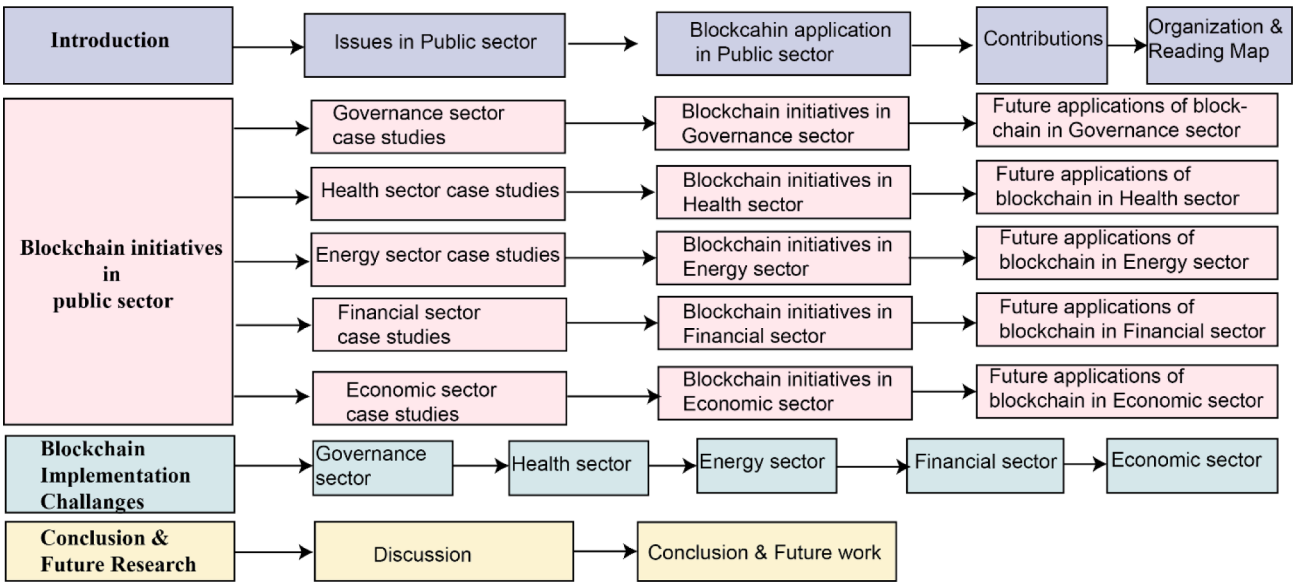

Fig. 3. The organization of the paperBlockchain initiatives in Public Sector.

and being evaluated. Only a few initiatives are at a mature stage, but more and more countries are joining the blockchain platform for public sector systems. In this section, the various blockchain implementation in public sector initiatives around the world is presented.

1.1. Government sector case studies

The Government application is highly dependent on reliable and timely information that is safe from unauthorized disclosures and modifications [29]. These Government applications vary from voting, legal aid, startup support, land registry, civil supply, etc. Some significant aspects/requirements of the government sector need to be addressed [19]. These factors are mainly Data Reliability, Trust Management, Immutability of records, Personal data control, Transparency [30]. Some other factors inherent in these factors are Security, Privacy, Authentication, which are essential for Data Reliability.

These factors are necessary for a government system that records a big chunk of personal and confidential data. Without trust and security of records, the public will be hesitant to use these systems. The majority of government policies and decisions are based on available records that need reliable and transparent data records for quality decisions.

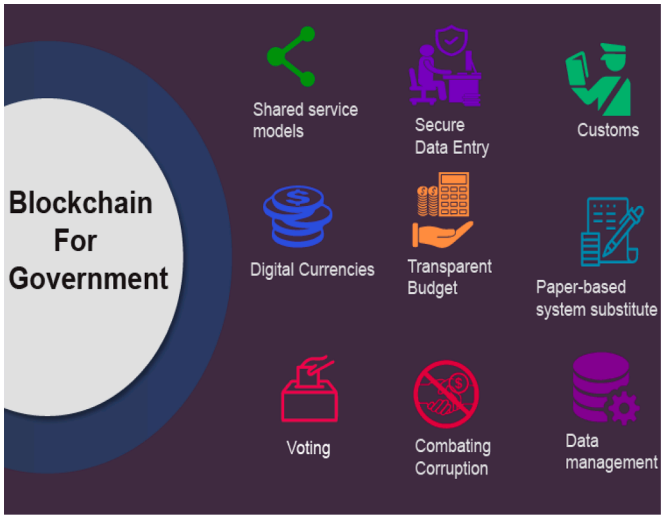

Fig. 4. Blockchain applications in Government.

Blockchain is a robust technology that can be very useful in government sector schemes and systems [31] [32]. In this section, various initiatives in different aspects of government have been summarized using Blockchain technology. Blockchain applications in government have been outlined in Fig. 4. Table 3 summarizes all the Blockchain-based initiatives in the Government sector, and Fig. 5 shows the initiatives country wise.

- In India, the State of Andhra Pradesh is developing a "Blockchain-based Land Title Registry," applying Blockchain technology for the land title registry to provide a secure and transparent way for land trading [18].
- Australia Post has taken the initiative named "Blockchain-Based Voting" for secure E-Voting using Blockchain. The permission is granted to the voters using a digital access key, and the ballot is secured using the cryptographic technique. However, the preference of vote given by the voter is also protected from being publicly available. The initiative is in the initial stage [33].
- Canadian Department of Innovation, Science and Economic Development has taken the initiative named "The Blockchain Corridor Report" that explains the need for Blockchain technology to solve bottlenecks in industries' startups. Also, Blockchain can be used to solve policy and regulatory issues, monitor the process, and improve spending Issues in the field of research and development. The initiative is in the initial stage [34].
- Netherland's legal aid board has used Blockchain technology to create a secure and faster acknowledgment process for legal support. As the legal support board consists of no lawyers, by using Blockchain, we can first check the income of the individual who wants to have legal aid and adjudged his/her eligibility for free legal help. The lawyer can also work on different legal aids until he/she has not consumed all his credits allocated to him for the year 2017 [35].
- In India, the State of Andhra Pradesh is developing a "Civil Supplies Registry" that employs Blockchain technology to securely store public aids and land records that are generally prone to cyber-attacks. The State of Andhra Pradesh is engaged with some local startups working to make Blockchain-based services [36].
- United Arab Emirates, Smart Dubai office is developing a "Dubai Blockchain Strategy" as Blockchain technology provides secure safe, and simple transactions. That will give rise to safe, efficient, and impactful city experiences [37].

Table 3
Blockchain-based initiatives in the Government sector

Ref	Country	Initiative Name	Sector	Type of Blockchain	Blockchain Application	Features	Status
[18]	India	Civil Supplies Registry	State of Andhra Pradesh	Permissioned	Benefits/ Entitlements	Security of records	Project in Development
	Australia	Blockchain-Based Voting	Australian Post	Permissioned	Secure E-Voting using Blockchain	Access Control and secure balloting	Initial stage
[34]	Canada	The Blockchain Corridor Report	Canadian Department of Innovation, Science and Economic Development	Permissioned	Strategy/Research	Solving the policy and regulatory issues, monitoring the process	Initial stage
[35]	Netherlands	Improving Requests for Legal Aid	Legal Aid Board	Public	Law/Legal Enforcement/Courts	Adjudging the eligibility for free legal, Lawyer work based on credit allocated	Initial Stage
[36]	India	Blockchain-based Land Title Registry	State of Andhra Pradesh	Permissioned	Land Title Registry	secure and transparent land trading	Project in Development
[37]	United Arab Emirates	Dubai Blockchain Strategy	Smart Dubai Office	Public	Strategy/Research	safe, efficient and impactful city experiences	Project in Development
[38]	Estonia	i-Voting	E-Estonia, E-Governance	Permissioned	Voting/Elections	Voting as per timing and will, Saving the cost and machinery	Completed
[41]	Estonia	Blockchain-based Keyless Signature Infrastructure (KSI)	E-Estonia	Public	Cybersecurity (Critical Infrastructure)	Immutable, data privacy and Network is free form compromise	Completed
[40]	South Korea	Local Government Voting	Gyeonggi-do Province	Permissioned	Voting/Elections	secure and reliable voting, easiness in the allocation of budget	Completed

Fig. 5. Blockchain initiatives in Government.

- The Estonian Government has completed a Blockchain-based i-Voting system that is useful for the Estonian citizens to cast their votes using the Internet throughout the world as per their timing and will. Estonia becomes the first country to use the i-Voting in the national parliamentary election of 2007. That will save the Government's cost and machinery and make the voting process simple and secure [38].
- E-Estonia has completed an initiative named "Blockchain-based Keyless Signature Infrastructure (KSI)" that can be used in Blockchain applications. It will make the unauthorized modification of the available data in the Blockchain networks impossible. Also, KSI makes sure that all the Blockchain network data is free from any compromise and achieves 100% data privacy [39].
- South Korea, Gyeonggi-do Province, has completed an initiative named "Local Government Voting" to enable the citizens to propose their project idea for government aid requirements. The citizens will vote for the available proposals. Blockchain-based voting will help secure and reliable voting and enable the Government to select the project's ideas and allocate the budget. Previously this was done using the paper-based or online system. Still, the project's selection was not reliable and tamper-proof, which is prone to the corrupt practices of backdoor selection by the officials [40].

1.1.1. *Further applications of blockchain in government*

There are various domains under the government sector where Blockchain can be effectively applied. These are

1.1.1.1. Identity management / national identity. Digital Identity is a fundamental building block of the digital world. There are various forms of digital identity that provide access control, information security, and authentication. There are several issues like user control over their data and privacy in traditional digital identity [42]. Blockchain has been proposed to fulfill the self-sovereign identity principles that can provide

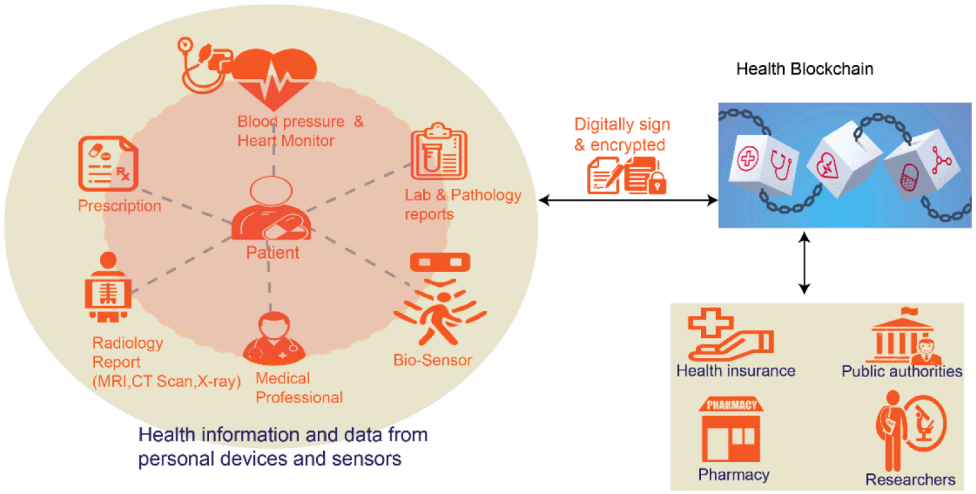

Fig. 6. Blockchain application healthcare.

user control, anonymity, and security to the user information. Many Blockchain-based identity management systems have been proposed. Still, some implications are like a key-management, identity revocation, and infrastructure building in Blockchain usage in identity management that need to be considered [43].

1.1.1.2. Financial support to citizens. Throughout the world, governments and other aid agencies are providing financial support for inclusive development. Corruption is a significant hindrance to the full utilization of resources. Blockchain can help identify beneficiaries, check the cash flow, and transparency of records. It can remove the intermediaries like credit card companies to save a big chunk of transaction costs [44].

1.1.1.3. Public distribution system. Public distribution systems aim to support poor citizens in fulfilling their food needs. It deals will the procurements of food grains and the distribution of these items to the poor. There are many frauds and corruption issues in this domain and a loss of food grains. It also takes place due to improper management and tracking. Blockchain can serve as a platform to eradicate the inherent administrative corruption and reaching out to maximum beneficiaries while safeguarding the food grain quality [45].

1.1.1.4. Tax collection. Taxation is the backbone of any country to run its financial needs. In developing countries, there is a different set of taxation regulations at the country and state levels. Also, the centralized or manual storage of records has a chance for alteration. By integrating the different sets of records from asset management, income tax, value-added tax, and invoicing into the Blockchain platform, a robust and immutable record management system can be developed to stop taxation fraud and government loss revenues [46].

1.1.1.5. Law enforcement and evidence management. Evidence is the basis that defines the outcome of any investigation and judicial process. It is crucial to maintain the evidence in the sequence of events, and their integrity should also be maintained for providing justice. Influential violators can try to alter the evidence that will be difficult to spot in the case of a traditional evidence management system. In the case of Blockchain, every aspect of evidence and communications can be documented and accessible to authorized entities only. It can help significantly in law enforcement and storing tamper-proof evidence [47].

1.1.1.6. The legal and judicial process. Apart from evidence management, several aspects of the judicial process can be enhanced in some cases and can be replaced using Blockchain. Notary services and intermediaries in case of some validation can be dissolved entirely or replaced using Blockchain to reduce corruption and bribing.

In many cases, the legal proceedings go for a long wait due to a lack of judges and delay from various staff involved in the judicial process. These petty cases related to fines and contract violations can be easily handled using Blockchain and smart contract technology. It will lessen the load on judges, and they can be involved in other important cases. It will also remove the chances of bias, corruption, bribe, and unnecessary delays [48].

1.2. Health Sector Case Studies

The health sector is one of the core sectors of any country. This sector has started adopting Information Technology in various domains of its operation like patient record management, sharing of records, the supply chain for healthcare, etc. These records vary from simple patient contact details to various personal medical records and historical archives of patients [49] [50]. A general structure of the Blockchain application in healthcare is given in Fig. 6.

Based on the technological domain development, different expert systems are being used by many countries for automated analysis and decision-making processes and shared by many constituents like nurses, doctors, health workers, management, and government entities [51,52]. There various factors of data management that need serious concern for large-scale adaptability and trust in the system. There are some specific requirements for this field. These are anonymity, control of personal data, privacy, immutability, decentralization, and proper authorization of records [53]. Few of them can be solved using centralized storage with appropriate authentication. Still, specific requirements, like the control of personal records, anonymity, and immutability, are challenging to implement in this scenario [54].

The health sector is one of the prominent fields that has seen many Blockchain-based initiatives due to the inherent requirement of data privacy, anonymity, immutability, and security of records [55,56]. All these requirements make the Blockchain the most suitable tool for the health sector. Many projects have been completed, and many more initiatives are either at the pilot project state or development stage. Some of the major initiatives have been summarized in this section.

- The Russian president signed a law that allows the use of Blockchain technology in healthcare and medical services. The ministry of health in Russia has taken the initiative named "Blockchain application in public health records" that uses the Blockchain for storing, identifying, and authenticating personal patient records to have

Table 4
Blockchain-based initiatives in the Health sector

Ref	Country	Initiative Name	Sector	Type of Blockchain	Blockchain Application	Features	Status
[64]	Russia	Blockchain Applications in Public Health	Ministry of Health, Vnesheconom bank	Permissioned	Personal Health Records	Better cooperation between different healthcare department,	Initial stage
[35]	Nederlands	Public Healthcare Benefits Subsidy	CAK organization Netherland	Public	Personal Health Records	Speeding the subsidize administrative and financial process for healthcare services	Project in Development
[35]	Netherlands	Healthcare Process Authorization	Healthcare Institute	Public	Personal Health Records	speedily authorization in emergency case	Project in Development
[35]	Netherlands	Requesting Medical Devices	Gemeente Stichtse Vecht	Permissioned	Benefits/Entitlements, "Personal Health Records	remove bottlenecks, speed up the process of requesting medical device	Project in Development
[58]	Dubai	Global Blockchain Council	Dubai Future Foundation	Permissioned	Strategy/Research Development	public-private cooperation between government agencies	Initial stage
[59]	United Kingdom	DLT in Energy, Healthcare, Banking, and Policy-Making	EPSRC	Permissioned	Strategy/Research	transparent, secure and privacy-preserving system	Initial stage
[65]	Canada	Blockchain Research Institute	City of Toronto	NA	Strategy/Research	Better health management and Economic growth	Project in Development
[62]	Estonia	Health Records	Estonian e-Health Records	Permissioned	"Personal Health Records	real-time visualization of patient's records	Completed
[63]	Estonia	X-Road Interoperability Services	E-Estonia	Permissioned	"Personal Health Records	Securing patient records	Completed

Fig. 7. Blockchain initiatives in the Health sector.

better cooperation between different healthcare departments related to the patient health record. The initiative is in the initial stage [57].

- The Netherlands has taken the initiative named "Public Healthcare Benefits Subsidy," which uses Blockchain to speed up the administrative and financial process to subsidize healthcare services. The project is in the development stage [35].
- The Netherland healthcare institute has taken the initiative named "Healthcare Process Authorization" to develop an application using Blockchain for the people in case of an emergency to get authorization process from different health providers smoothly. As health providers always do not know each other, but by using Blockchain, they can trust various health providers and get authorization speedily that will result in the immediate treatment process for the person in an emergency. The initiative is in the development stage [35].
- The municipality of Stitches Vecht, Netherland, has taken the initiative named "Requesting Medical Devices" using Blockchain to request medical devices like wheelchairs and stairs, etc. secure and speedy. The procurement process requires many eligibility checks, supply, and delivery acknowledgments. This advanced system can handle these issues and remove these bottlenecks and speed up the process. The initiative is in the development stage [35].
- Dubai Global Blockchain Council planned to establish a "Global Blockchain council" for securing Public health records, business, tourism, title transfer, gold, and diamond trading. Using Blockchain, the Council will establish public-private cooperation between various government agencies, health providers, new startups, and business entities [58].
- The United Kingdom-based Engineering and Physical Sciences Research Council (EPSRC) has taken the initiative named "Distributed Ledger Technology (DLT) in Energy, Healthcare, Banking, and Policy-Making" for making transparent, secure, and privacy-preserving system in the healthcare sector. This initiative is in the initial phase [59].
- Health and Human Services of the United States have taken the initiative named "Blockchain in Healthcare Code" that uses Blockchain technology to manage patients' identity management and store patient records. Later these records are required by the healthcare providers, and it also secures the shared channel for data sharing related to the patient record [60].

- The Canadian government planned to establish the Blockchain Research Institute in the City of Toronto to intensify the Blockchain-based initiative, research, and development of new strategies in the Government and health sectors to better health management process Economic growth. This initiative is in the development stage [61].
- Estonia government had completed a Blockchain initiative," E-Health Records," in partnership with the Guardtime to secure the 1 million patient records using KSI and Oracle databases real-time visualization into the patient's records [62].
- E- Estonia had completed an initiative named "X-Road Interoperability Services" that use Blockchain to secure the record of 1 million patient [63].

Table 4 summarizes all the Blockchain-based initiatives in the Health sector, and Fig. 7 shows the initiatives country wise.

1.2.1. Further applications of blockchain in the health sector

1.2.1.7. Health data exchange in a secure and reliable manner. Electronic Health Record (EHR) has helped improve patient health records, but there are security and privacy issues during information exchange and collaboration in this system. Blockchain technology can help in exchanging information in a trusted and reliable manner [66].

1.2.1.8. Sharing health records for research while maintaining anonymity. Health records are required for research and analysis purposes, but the main problem is patients are not interested in sharing their details due to privacy concerns. Blockchain can help provide the health details while maintaining the anonymity feature that will fulfill the privacy requirements and provide complete data sets to research institutions with a high accuracy level [46].

1.2.1.9. Health data interoperability for cooperation between various agencies using different standards. In current EHR systems, there is a lack of interoperable data standards that hinders the collaboration with a different system and lacks collaborative decision making that is the need of time. Patients suffer from various diseases, consult with different medical experts and different hospitals. These organizations and medical experts may use different types of systems. There is a need for complete interoperable systems so that information can be collected and collaborated from various organizations and individuals [67].

1.2.1.10. Efficient health insurance claim processing. Health insurance processing is a tedious and time-consuming task at the same time; many frauds are taking place by submitting false details to claim money from insurance agencies. Also, multiple claims are possible for fake claims. There is a need to integrate different health insurance companies' records and link them with health service providers [68]. It will resolve the issue of fraudulent health insurance claims and help in the efficient and fast processing of insurance claims [69].

1.2.1.11. Efficient and reliable drug and medical equipment supply. There are several cases of fake medicines and vaccines that can be life-endangering, especially in the case of developing countries. The traceability of products and supplies during transit is also a significant factor. Blockchain technology can be used to develop a system that can guarantee the authenticity of the medical supply and real-time monitoring of supplies during transit. It can also help the big organizations with multiple locations in optimal use of medical resources and automated ordering while maintaining a safe level of stored medical supplies like medicines, vaccines, medical equipment, etc. [70,71].

1.3. Energy sector case studies

Rapid changes occur in the energy sector, moving from a conventional energy generation model to a non-conventional generation that further requires a different transmission mode and tariff [72,73]. This sector also adopts IT-based solutions for monitoring the consumption and bill generation based on various parameters instead of the previous manual based straightforward tariff and billing [74]. Energy farming by individuals and private organizations, mobility and electric vehicle use, and charging, IoT-based applications in this sector is growing. Still, various factors are hindering their growth [75]. These collaborations of a significant number of participants and smart grid applications require a secure and reliable platform that can facilitate safe and reliable communication [76,77].

Also, such collaboration with unknown entities lacks trust between different objects. Overall the energy sector requires a technology that can guarantee secure and reliable communication/exchange, authentication, transparency, trust, and immutability [78,79,80]. Blockchain is gaining ground in this sector, and many systems/applications have been proposed based on Blockchain technology in the energy sector to resolve the bottlenecks. In this section, some major Blockchain implementations

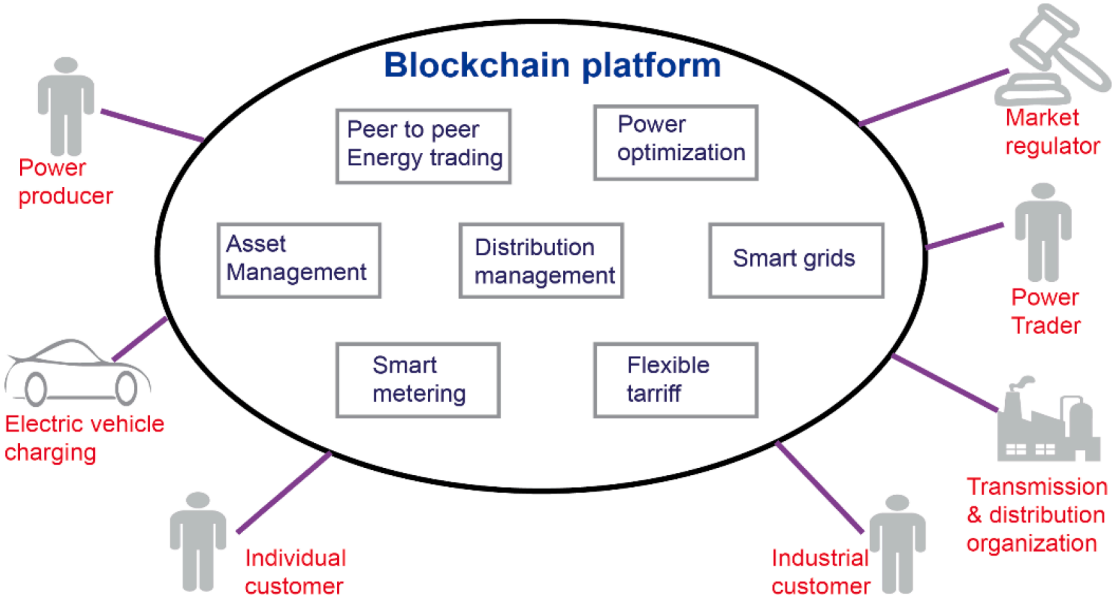

Fig. 8. Blockchain in Energy Sector.

Table 5
Blockchain-based initiatives in the Energy sector

Ref	Country	Initiative Name	Sector	Type of Blockchain	Blockchain Application	Features	Status
[81]	Netherlands	Toxic Waste Transport	Human Environment and Transport Inspectorate	Permissioned	Compliance/Reporting, Regulatory	automate approvals process for toxic waste removal, reduced cost, reduced time	Project in Development
[19]	Australia	Regulatory Hackathon	RegHack DownUnder	NA	The heavily controlled energy sector	Provided solutions Heavily regulated energy sector	Initial stage
[64]	Australia	Blockchain-Powered Distributed Energy and Water Systems	Australia DPMC - City of Fremantle	Permissioned	Public Utilities	Assessed the use of Blockchain in the energy and water sector	Initial stage
[35]	Netherlands	Waste Sector Data Sharing	Gemeente Utrecht	Permissioned	Data Marketplace/Data Monetization, Public Utilities	The automated waste removal process	Project in Development
[84]	United States - Federal	Small Business Innovation Research (SBIR)	Department of Energy	Public	Research/Standards, Public Utilities	real-time data, tamper-proof measurement of data	Initial Stage
[85]	United States - State Government	Renewable Energy Credit Marketplace	State of Illinois	Permissioned	New Products/ Services, Public Utilities	tax credits for the production of Green Energy, increase traceability, liquidity of tax credits	Initial Stage

Fig. 9. Blockchain initiatives in the Energy sector.

in the field of energy have been reviewed. Major applications and structure of Blockchain applications in the energy sector have been given in Fig. 8.

Table 5 summarizes all the Blockchain-based initiatives in the Energy sector, and Fig. 9 displays the initiatives country wise.

- Human Environment and Transport Inspectorate, the Netherlands, is working on an initiative named "Toxic Waste Transport" that will use Blockchain technology for managing toxic waste transportation. In the old system, the management of these tasks is paper-based and requires all the parties involved in the toxic waste removal to have their administration. Using Blockchain will automate the process of approvals from different authorities for toxic waste removal. The process takes less cost and time as compared to the old system using Blockchain [81].
- Australian government body named "DownUnder" has started an initiative called "Regulatory Hackathon" that organized a one-week program having representatives from finance and government sectors to judge and encouraged the Blockchain-based solutions for the heavily controlled energy sector [19].
- The city of Fremantle, Australia, initiated a "Blockchain-Powered Distributed Energy and Water Systems" that will assess the use of Blockchain technology in energy and water system. This initiative also supports the Australian Energy Market Operator (AEMO), Western Power, for low carbon emission [35].
- Gemeente Utrecht, Netherlands, is working on the initiative named "Waste Sector Data Sharing". The Blockchain-based waste removal process is automated and is efficient in terms of cost and time by connecting the waste weight data per container to the transporters, mediators, and final processors. Previously the parties involved in the waste removal have a different administration; using Blockchain, there will be a joint administration [35].
- The United States Department of Energy initiated a project named "Small Business Innovation Research", which encourages Blockchain technology to create robust and less vulnerable Energy systems. Blockchain and IoT in electric meters will give real-time and tamper-proof data measurement [82]. This initiative is in the pilot implementation stage [83].
- State of Illinois, United States, initiated a "Renewable Energy Credit Marketplace" using Blockchain to give the tax credits for Green Energy production that will increase the traceability and liquidity of tax credits and results in better green energy outcomes [58].

1.3.1. *Further Applications of Blockchain in the Energy Sector*

These are many possible applications of blockchain technology in the

Table 6
Blockchain-based initiative in the Finance sector

Ref	Country	Initiative Name	Sector	Type of Blockchain	Blockchain Application	Features	Status
[38]	Tunisia	eDinar Digital Currency	Tunisian Post	Permissioned	Digital Currency (Central Bank Issued)	Easiness in all financial transactions.	Completed
[96]	Australia	Developments in Financial System Architecture	Reserve Bank of Australia	Permissioned	Digital Currency (Central Bank Issued)	DLT currency	Initial stage
[97]	Palestine	Palestinian e-Currency	Palestine Monetary Authority	Permissioned	Digital Currency (Central Bank Issued)	secure, transparent, easy to use, corruption-free financial infrastructure	Initial stage
[101]	Canada	RegTech Hackathon	Ontario Securities Commission	Public	Regulatory	Robust, Efficient, Transparent capital markets, Easy KYC process	Project in Development
[102]	China	Central Bank Digital Currency	People's Bank of China	Public	Digital Currency (Central Bank Issued)	increase the international transactions, attracts more investors, easy access to financial services	Project in Development
[100]	Barbados	Central Bank Digital Currency	Barbados Central Bank	Permissioned	Digital Currency (Central Bank Issued)	Cryptocurrency for financial transactions	Completed

Fig. 10. Blockchain initiatives in the Finance sector.

field of the energy sector. These have been discussed in this section:

1.3.1.12. Interoperability with different service providers. In the energy sector, different organizations are using different platforms. Also, in the case of new micro-grids, there is a need for collaboration among various organizations to utilize energy resources better. Blockchain can be a possible solution in the energy sector case as in the case of other sectors to provide a platform for interoperability among different service providers. Users will have a choice also to choose the best available options as per the conditions [86].

1.3.1.13. Varying and real-time electricity valuation and invoicing. Instead of fixed tariffs for electricity and other energy supplies, there is a need for varying tariffs based on the demand and available resources. In traditional systems, it is not possible to implement such solutions. Blockchain technology can provide a flexible and real-time valuation of generated resources and invoices based on defined parameters and demand-supply links [87,88].

1.3.1.14. Electricity generation and Load forecasting. In this connected and highly energy-dependent world, nothing can be assumed without electricity. There is a gap between demand and supply and also a lack of proper supply. The load requirements vary in different areas at different times. Sometimes it is very high and sometimes low, but due to lack of smart implementation, there is a similar supply all the time. Blockchain-based electricity supply chains and smart grids can accurately predict the load and balance requirements at different locations [89].

1.4. Finance sector case studies

The finance sector is one of the significant users and where Blockchain has been implemented at the initial stage [90]. This sector's new decentralized business model is also a major facilitator of rising Blockchain applications [91,92]. Blockchain technology emerged from bitcoin and seemed more suitable in the financial sector in comparison to other sectors. Real-time, fast, automated, and reliable solutions are the financial sector's requirement with transparency and security of records [93,94]. Blockchain technology can solve the finance sector's needs like cost-effective solutions by automating the tasks, reliability, security of records, trust management while transacting with unknown parties, transparency, efficiency, and reduced time. In this section, the finance sector's existing Blockchain applications have been reviewed and presented [95]. Table 6 sums up all the Blockchain-based initiatives in the Finance sector, and Fig. 10 indicates the initiatives country wise.

- La Poste Tunisienne, Tunisia, has completed an initiative named "eDinar Digital Currency" that makes Tunisia the first country to issue a Blockchain-based cryptocurrency. The Tunisian Government has agreed with Monetas to enable its digital currency to make payments, money transfers, and all financial transactions [40].
- Reserve Bank of Australia has taken the initiative named "Developments in Financial System Architecture". It is working on using DLT based currency for Australia's reserve bank. The initiative is in the initial stage [96].
- Palestine Monetary Authority (PMA) has taken the initiative named "Palestinian e-Currency" that makes the cryptocurrency the central currency for all the payments and financial transactions. That results in secure, transparent, easy to use, and corruption-free financial infrastructure to avoid the restriction that does not allow the reserve bank to issue its currency [97].
- Ontario Securities Commission, Canada, hosted a competition named "RegTech Hackathon," which highlighted the idea of using distributed ledger technology to make reliable, efficient, and transparent capital markets. The use of Distributed ledger technology will simplify the process of Know Your Customer (KYC) information collection [98].
- People's Bank of China is working on an initiative named "Central Bank Digital Currency" that will use cryptocurrencies, having the potential to reduce the frauds, forgery, corruption, and the cost of a transaction that will subsequently result in easy access to financial services. It will make the cryptocurrency easy to obtain, increase international transactions, and attract more investors, resulting in the economy's rapid growth [99].
- The Central Bank of Barbados has successfully implemented an initiative named "Central Bank Digital Currency" to use cryptocurrency in financial transactions. The reserve bank also keeps a significant chunk of physical currencies to manage the exchange rates [100].

1.4.1. Future Applications of Blockchain in the Finance Sector

1.4.1.15. Loan evaluation and risk assessment. Proper loan evaluation and risk assessment are very critical for the success of any financing agency. These assessments require information from different sources and the evaluation of various factors. In the case of human assessment, the time of processing is very high, and the chances of bias and corruption are very much. These factors affect the financial health of the organization negatively. The Blockchain-based approach can use interoperability concepts to integrate different data sources to investigate, and smart contracts can be used to make decisions based on defined factors intelligently automatically. This approach will reduce the processing time and chances of mistakes or corruption drastically [103].

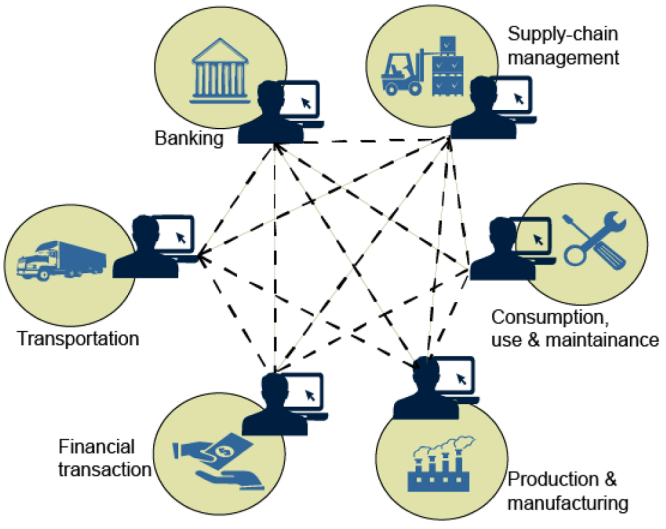

Fig. 11. Blockchain network in the economic sector.

1.4.1.16. Digitization and clearance of cheques. Cheques and other modes of payments can be automated using Blockchain technology to function effectively and securely. However, most financial institutions have been designed IT solutions and automated the financial transactions and cheque clearance facility that has reduced the processing time. Still, these automated systems need scanning and uploading Magnetic ink character recognition MICR-based cheques and other related documents prone to cybersecurity threats. A Blockchain-based cheque clearance system can provide an e-cheque facility that can be used across different platforms and organizations to offer a high security and transparency level with fast, automated transactions [104,105].

1.4.1.17. Customer verifications. Verification of customers or KYC is a regulatory requirement for the financial institution and very important for stopping fraud and foul plays. Generally, it is a manual process where customers or users submit their documents for physical verification in front of a verifying authority. Also, those documents need to be verified that is cumbersome and time-consuming. The KYC process can be automated with a high level of authenticity and removing any chance of fraud using Blockchain [106].

1.4.1.18. Payment gateways. Payment gateways are the most crucial factor in online transactions, and their security is prime for financial transaction user trust.

Blockchain-based payment gateways can significantly reduce transaction processing, and they can provide a high level of security. Transactions can be easily traced, and any fraudulent transaction attempt can be stopped.

1.5. Economic sector case studies

The digital economy is growing faster, and faster electronic commerce is fast becoming a standard instead of traditional marketplaces [91].

Even the conventional markets and other economic activities depend on collaboration between different entities and transactions of records [92,94]. The Blockchain application network in various aspects of the economic sector has been presented in Fig. 11.

This virtualization of the economy takes place in each domain and requires a trust management mechanism between unknown entities [27,107]. Another significant aspect of the economic sector is transparency, security, and transaction reliability [108,109]. These factors are suitable for Blockchain technology implementation to resolve such an important aspect and help further this sector's growth.

In this section, a summary of an existing blockchain-based system for the economic sector has been review. Table 7 abridges all the Blockchain-based initiatives in Economical sector, and Fig. 12 shows the initiatives country-wise.

- Singapore Economic Development Board (SEDB) and Monetary Authority of Singapore (MAS), in collaboration with IBM corporation, are working on the initiative named "IBM Blockchain Innovation Centre" to build expertise in the financial trading system using Blockchain. Several entities are also working with innovation centers like Infocomm Development Authority, financial institutions, Port Authority of Singapore, etc. [6].
- State of Colorado, United States, has taken the initiative named "Blockchain Legislative Study" to make records collection more secure from cyber-attacks. Also, the Distributed ledger technology

Table 7
Blockchain-based initiatives in the Economic sector

Ref	Country	Initiative Name	Sector	Type of Blockchain	Blockchain Application	Features	Status
[6]	Singapore	IBM Blockchain Innovation Centre	Singapore Economic Development Board, Monetary Authority of Singapore (MAS)	Permissioned	Economic Development	financial trading system	Project in Development
[35]	United States -State Government	Blockchain Legislative Study	State of Colorado	NA	Strategy/Research, Economic Development	records are more secure	Initial stage
[114]	Australia	Data Monetization	Data61 and CSIRO	Permissioned	Data Marketplace/Data Monetization	proof of concept further evaluation will be carried out	Initial stage
[115]	United Arab Emirates	Global Blockchain Challenge	Smart Dubai Office	Public	Economic Development	Simplification of the establishing process of industries	Initial stage
[112]	Belgium	Blockchain-based System for Port Container Release	Antwerp Port Authority	Permissioned	Supply Chain Management/Trade, Public Transportation	An automated process of container handling in ports, elimination of middle man in the process	Project in Development
[116]	United States -State Government	Smart UCC Filings	State of Delaware	Permissioned	Compliance/Reporting, Data Marketplace/Data Monetization	process of records submission related to laws of preservation and destruction documents	Project in Development

Fig. 12. Blockchain initiatives in the Economic sector.

will eliminate the paper-based records and the cost of updating the records manually. The initiative is in the initial stage [35].

- Data61 unit of Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, has taken the initiative named "Data Monetization" to review the implementation issues and the advantages of using Blockchain in Government and industries. The entity uses the proof of Blockchain concept, and industry and government experts will further evaluate it. The initiative is in the initial stage [110].
- Smart Dubai Office, United Arab Emirates, has taken the initiative named "Global Blockchain Challenge". It plans to improve people's life using Blockchain potential. The project objective is to discover the innovative Blockchain-based solution and support the Simplification of establishing the industries and empowering various start-ups and businesses. The initiative is in the initial stage [111].
- Belgium, Antwerp Port Authority, is working on the initiative named "Blockchain-based System for Port Container Release," which will make the process of container handling more efficient and secure. This system involves several parties like drivers, carriers, terminals, etc. Using Blockchain technology has digitalized all processes and eliminated the middle man involvement between different parties during the process of container handling in ports [112].
- State of Delaware, United States, is working on the initiative named "Smart Uniform Commercial Code (UCC) Filings" that uses the Blockchain to automate the process of records submission in line with the laws for the preservation and destruction of the documents [113].

1.5.1. *Further applications of blockchain in the economic sector*

1.5.1.19. Cross border supply-chain management. Due to globalization and cross border trade, the global supply-chain volume is rising rapidly. Rapid and accurate traceability and immutable supply trail can provide an authentic and reliable supply-chain management using Blockchain. Blockchain technology can effectively counter counterfeit products and any chance of fraud and mismanagement by maintaining an accurate and timely record of trails during the complete supply-chain process [117,118].

1.5.1.20. Outcome-based wages. Outcome-based payment (OBP) is a fascinating model to promote effectiveness and quality instead of quantity. Especially in healthcare and software development, it is being weighed, and implementation is in the initial stages. Various key

performance indicators (KPIs) are used to define efficiency and effectiveness. The OBP model can support merit and promote effective work culture instead of traditional volume-based payment. Still, various factors hinder its implementation and transparency of the model, like trust and accurate data availability, while preserving privacy and confidentiality. Blockchain technology can only solve these issues [119].

1.5.1.21. Copyright and the intellectual right protection. Several aspects of copyright and intellectual property right (IPR) include recording the ownership, transfer of copyright and royalty payment, etc. Traditional copyright registration and processing are tiresome and time-consuming. This process becomes more difficult in the case of digital media content. License verification and pay per use concepts already use Blockchain technology. Blockchain technology can effectively resolve the current system's issues by countering piracy, lack of transparency, payment as per usage, and proper recording of rights and ownership transfer [120].

1.5.1.22. Human resource management and credential checks. In the process of human resource management, checking the credentials requires a lot of paperwork and heavily dependent on manual processing. These processes take lots of time and prone to chances of fraud and dishonesty. Hiring unqualified persons based on fake credentials can cause a significant loss to organizations and impedes job chances for honest people. Blockchain-based credential management and checks can effectively counter these issues [121].

1.5.1.23. Transparent crowdfunding. Crowdfunding is to collect funds from the masses either for any venture or for the cause. One of such a platform's major issues is the lack of transparency that makes it less acceptable for mass level adoption and sharing. Blockchain technology can provide a platform to monitor the funds, their utilization, and further incentives, if any, effectively and transparently [122].

2. Blockchain implementation challenges

Blockchain technology is gaining attention, and many implementations are taking place due to its advantages of immutability, reliability, security, and trust management. However, it is still in the initial stage and requires addressing many considerations to implement it successfully. In this section, various security challenges/concerns have been summarized based on different sector requirements.

2.1. Government sector implementation challenges

It is a new technology for the citizens that makes it less trusted and challenging to understand. As Blockchain-based Bitcoin currency is a trustless currency, the citizens need reasons to understand the new framework by interacting with the Government. However, citizens are facing problems accessing the Internet or gaining experience with the latest technology. Therefore, training needs to be provided to the citizen that is critical for the successful implementation. The major challenges have been summarised here:

2.1.1. Scalability

Scalability is a major concern for the vast user base as it will generate enormous user data, and Blockchain size will be enormous. Scalability issues are more prominent in public Blockchain. Such problems can be resolved using permissioned Blockchain as it has fewer users to verify the created blocks. Still, it is against the core idea of permissionless without any central authority structure. Such issues will give rise to trust issues [120].

2.1.2. Interoperability/compatibility

When viewed in a broader aspect, various entities collaborate, and in the case of government, such collaboration will be high. While designing a Blockchain platform, it should be kept in mind that all the entities involved should be on the same platform. Generally, the applications are designed and developed for some specific needs in isolation, and later when required to collaborate, interoperability and compatibility issues come up [121].

2.1.3. Reliability

Government structures generally need a structured and hierarchical structure. If implemented in a Blockchain-based system, such arrangements will create reliability issues, and public entities will have the same apprehension of reliability and trust in the system. If the system uses the pure decentralized structure as envisaged by Blockchain developers, the control, management, and throughput issues will arise. Hence a well-adjudged model to be applied to balance both the aspects is required [122].

2.1.4. Support infrastructure

One of the significant aspects that are required to implement any technology or system is support infrastructure. The skilled human resource will be one of the major constituents of this support infrastructure. Blockchain technology is in the nascent stage, and finding the required number of qualified professionals in this field is a significant challenge. It is propagated as a secure platform but also prone to human errors, and it needs regular updates. In the absence of skilled professionals, it will be challenging to provide support infrastructure to provide safe and reliable mechanisms [123].

2.2. Health sector implementation challenges

Blockchain has the potential to solve many problems in the health care sector. Still, the main concern is the coordination and cooperation across the various entities working in the healthcare sector and the agreement between these entities. In the year 2017, around 342 violation insecurity is reported, which contains10 million health records. Using Blockchain technology in the existing health record management system can counter the data tampering issue but cannot guarantee a solution to privacy problems [51,52].

Finally, the Healthcare sector is considered the main concern for any government, which is highly regulated. Also, any healthcare initiative has to be aware of any change in the landscape and diverseness across different countries that can be monitored using Blockchain-based record management. Any changes will reflect immediately. The health sector's challenges are more or less similar but have some added problems due to socio-cultural behavior.

2.2.1. Cultural resistance

Society is typically accustomed to paper-based activities or online healthcare systems where records are not shared [124]. Applying Blockchain technology in healthcare requires sharing records in distributed manners, and society needs to be educated to alienate their fears of data sharing.

2.2.2. Scalability restriction

Due to the large volume of transactions, scalability is a significant concern in the healthcare sector's case also. The available computing resources and large data record generation will hinder the system's scalability [125].

2.2.3. High cost of operation

The initial cost of development and implementation will be high, and it needs significant investment. The Government and the healthcare industry will have to analyze the various factors that require a financial investment. It is essential to find the mechanism to minimize and optimize the cost and resource requirements for Blockchain-based healthcare system implementation [126].

2.2.4. Standardization challenges

The Healthcare industry requires collaboration with different entities. For example, one medical lab can seek coordination with other labs, and one hospital can request a referral from other hospitals, etc. If there is no mechanism or common platform to share information, it will be an issue. The full utilization of such systems will not be possible [127]. Therefore, any specific organization, consortium, or government entity must work to standardize the healthcare applications. At least a standard structure should be defined for data exchange mechanisms, data format, and type of data that need to be stored [53].

2.2.5. Regulatory uncertainty

Regulatory concerns are the most crucial aspect, and its global charter needs to be defined in the case of various elements. Various legal issues vary from country to country, and Blockchain-based records are not recognized in every country. There is a need to identify the aspects that can be standardized globally and need collaboration from various stakeholders working in the ecosystem. The standards for medical records maintenance, liabilities, and privacy and security issues should be clearly defined and streamlined bounded by regulatory and legal frameworks [128–130].

2.2.6. Security and privacy concerns

Security and privacy are the foremost concern in the case of any online system, and in the case of data records related to personal health take more significance. Without alienating the apprehensions and providing complete security of records, the system's user will be skeptical of using the system [131]. However, Blockchain technology has been propagated as a secure and tamper-proof mechanism. Still, the privacy of records needs to be addressed and responded to be defined that which authorized authority can view the details and to which extent [40,132]. What type of anonymity is provided in records, and up to which level the privacy concerns have been handled? Such details should be explicitly defined and standardized [133].

2.3. Energy sector implementation challenges

Regardless of the bright future, there are many challenges faced by the energy sector. First, the quality and quantities of consumer records are insufficient compared to data needed to implement smart devices to control the energy sector. Secondly, as the targeted peoples benefitted from micro-grids and peer-to-peer processes still living in the rural area, they are dependent on the manual system, using traditional technology like SMS for the payments, and registering for the energy consumptions.

Since the whole transaction of Blockchain technology will use smartphone access, which will speed up the transactions using Blockchain technology. Largely the companies Grid Singularity, Power Ledger, and Energy Labs are working on a Blockchain-based system for the energy sector and other large utility companies as a consortium and investing in developing infrastructure for long term answers to the issues.

2.3.1. Resilience to security risks

Security is the foremost requirement of any system, but when it can affect each member of the country's life, then its security becomes paramount. Any failure in the energy sector systems like grids etc. can stop and hinder each activity. It can result in a total blackout of that region; hence, security is essential for this sector. Blockchain-based systems are relatively new, and it requires regressive testing, and expert developers in this field are also countable. Therefore resiliency to security risks is a big challenge [134].

2.3.2. High development cost

High development cost is one of the biggest hindrances in the large scale adoption of Blockchain technology. It will require infrastructure that will cost more in comparison to traditional systems like relational database storage. These conventional systems in the field of energy are generally available and are cost-efficient. There are several benefits of using Blockchain technology compared to traditional systems, including data integrity, trust, and tamper-proof records [135]. The benefits should outweigh the cost incurred on new ICT infrastructure and development and to be justifiable.

2.3.3. Regulatory and legal hindrance

The energy sector is mainly related to consumer rights and government social security requirements that need to be aligned with the regulatory and legal framework. Blockchain technology is a new technology, and outcomes of such systems, like smart contacts, etc., need to be incorporated and accepted by the legal framework [136].

2.3.4. Low adoption rate

Decentralized regulation or P2P trading in the field of the energy sector is still evolving, and the level of adoption is low. There are several benefits of such a system to consumers and producers. It will require some sort of testing, trust assurance measures, and pilot project implementations before large-scale adoption [136,137].

2.3.5. Scalability issues

Blockchain-based systems generate a high volume of data, and it increases exponentially with the increase in the number of users. Using such a system for a large user base will require high data storage capacity and techniques to handle the significant overhead [138,139,140].

2.3.6. Chances of centralization

Giant energy corporations mainly control the specific setup of the energy sector. The majority of current Blockchain architectures are based on a consortium Blockchain platform that is prone to malpractice if these energy corporations are involved [141]. On the other hand, if a Public Blockchain platform is used, then it will result in wastage of power resources in new node generation and time latency. Therefore, there is a chance of more centralized architecture in such a condition but needs some sort of strict government supervision [142]. This idea itself reflects towards centralization of records that need a serious review.

2.3.7. Development and infrastructure costs

The implementation of Blockchain technology in the energy sector or, more specifically, in smart grid architecture will require a very high initial cost in re-designing the grid network, upgrading the smart meters, and other ICT infrastructure [136]. The second issue is that it is still a nascent technology, and any change at a later stage will need significant changes again. In the case of the energy sector and smart grids, it is not possible to frequently change the base infrastructure. It is a considerable challenge in Blockchain adoption in this field.

2.3.8. Legal and regulatory support

Various legal and regulatory issues need to be resolved before Blockchain implementation in the energy sector. Currently, the energy sector's functioning and the current grid system are highly regulated by the Government. Once a paradigm shift is taken to adopt the Blockchain technology in this field will result in less government interference and more transactions and more authority to nodes that need changes in the legal framework and regulatory support to implement [143].

2.4. Financial sector implementation challenges

Blockchain technology has potential benefits in the finance sector, but the application is in the initial stage. It is a sophisticated technology and having many complexities that make it challenging to regulate and create a formally regulated infrastructure. It makes managers and offices take extra care while using it in the financial sector. The lack of a formal framework for the financial sector delays the Blockchain implementation in the financial sector. The existing companies are also taking

significant benefits from the current market, so there is less incentive to adopt Blockchain in the finance sector.

The speed of transactions in the Blockchain is significantly high as compared to the other option available currently. Still, its speed is limited as compared to the settlements in other developed countries. Therefore large-scale Blockchain implementation worldwide is being hindered.

2.4.1. Interoperability

Interoperability, especially in the financial sector, is a crucial requirement because different sectors, countries, and currencies can collaborate. There is no specific framework, and various companies and organizations are working and using another platform that is a major hindrance. This issue needs to be resolved, but Blockchain technology is still being adopted. It is in the early stage of adoption, and it seems complicated that a general structure will evolve, and all will accept it. Yet, within this limitation, interoperability issues need to be resolved so that major platforms can exchange and share transactions.

2.4.2. Standardization

There is no global standard / industrial standard for Blockchain-based financial system architecture that creates an issue in interoperability. Also, there is a dire need for a body that can prescribe and standardize it as the Internet Engineering Task Force did in the case of internet standards [92].

2.4.3. Talent acquisition

The financial sector is one of the major industries that employ software developers and other skilled IT workforce. Workforce specialized in Blockchain-based system development, maintenance, and operation needs many qualified people not available as per demand that will affect the financial sector's implementation [94].

2.4.4. Liability and legal framework

There is a need for a universal legal framework, and liability for individual activities must be fixed that legalizes the Blockchain-based financial transactions and currencies. Still, very few countries have adopted and recognized it.

2.4.5. Scalability

Scalability is a major issue for Blockchain-based systems, with many user bases and high transaction rates. The financial sector encompasses a significant number of users (around half of the living population). An extensive set of data is generated, requiring consideration for scalability challenges and methods to resolve them [90].

2.5. Economic sector implementation challenges

The challenges of the economic sector and more similar to the financial industry. The significant challenges for the economic sector have been summarized under the following headings:

2.5.1. Evolving technology

For adopting Blockchain technology in the economic sector, solutions to issues like speeding up the transaction, authentication method, data limitation will be critical [144].

2.5.2. Unclear controlling status

As the central governments control the creation and regulation of the currencies, adopting Blockchain and bitcoin in economic sectors is difficult until a clear approval policy is available for its approval and regulation by the present financial institutions [145,146].

2.5.3. High power consumption

In a Blockchain network, miners find the solution for validating the transaction at the rate of 450000 trillion per second that requires high power consumption [147,148].

2.5.4. Security and privacy

The Blockchain is divided into two types based on permission requirements, i.e., permissioned and permissionless Blockchain. Permissioned Blockchain technology can counter the majority of cybersecurity issues like illegal mining, etc. Still, some critical aspects of cybersecurity need to be reviewed.

2.5.5. Transition concern

Blockchain offers solutions that are significantly different from existing solutions. It requires considerable changes in the existing system. It requires a lot of planning and expertise that lead to the hurdle in adopting Blockchain for the present economic system [149].

2.5.6. Initial investment

Blockchain reduces the transaction cost and timeline, and it requires high capital costs in the initial stage that will hinder its adoption [146].

2.5.7. Data privacy

Data privacy is an essential characteristic required in financial transactions, and the same is needed in the case of Blockchain-based applications. Data privacy includes two major aspects anonymity and secrecy of data/transactions. Various schemes can be implemented to achieve data privacy in terms of financial transactions like Ring signature, Homomorphic encryption, Zero-knowledge proof, Pedersen Commitments, etc. However, these schemes cannot cover privacy in all aspects of operation like the sender, receiver, and transaction amount; also, the other elements like efficiency and computational time should be considered [150].

2.5.8. Operational resiliency

Blockchain-based systems store records in a distributed fashion. Each full node stores a copy of the blockchain that ensures that systems work even if a specific node fails, in contrast to centralized database systems that can collapse if the database node fails. The issues in the case of centralized database systems can be handled using proper backup techniques. However, still, performance will be a significant issue and result in failures due to a single node's failure. Blockchain-based systems are considered resilient, theoretically. However, very few systems have been implemented full-fledged based on a Blockchain platform. Still, these systems have not been appropriately tested and entirely in a realistic environment [151].

2.5.9. Governance

The primary aspect of Blockchain technology is its decentralized nature that results in removing the intermediaries and approving any transaction with the consensus process. Still, it creates a significant issue of governance structure and effective implementation of regulations. These issues need more considerable discussion and review using public or permissioned Blockchain networks. There are no specific guidelines over permissioned structure and control over the various decision-making related policies and procedures of design and dispute resolution. It is critical for maintaining the trust and require considerable research to avoid system vulnerabilities [152].

The consensus protocol is a fault-tolerant process in the Blockchain used to reach a necessary consensus on a new block to be added. It's a series of rules that dictate how often each participating node in the Blockchain contributes. Based on the type of Blockchain, i.e., Public or Private Blockchain, the consensus mechanism is different. In the public Blockchain, the PoW, PoS, and FBA consensus is common, and in the Private Blockchain, PBFT, PoA, and PoET are common [153].

2.5.10. Learning

Apart from technical issues and challenges that need to be tackled and can be, possibly resolved but informed and experienced workforce is

also an essential aspect that needs to be considered. It is crucial to educate the staff members and possible users (public) to provide reliable guidance and encourage them to utilize these types of systems. Unless and until the apprehensions of new technology are not answered, and benefits are not popularized, large scale implementation and adoption of Blockchain-based systems are difficult to achieve [154].

3. Discussion

Analyzing the various aspects of government, health, finance, energy, and economy requirements and reviewing the existing Blockchain-based implementations in these domains gives a clear idea about each domain's specific needs, the suitability of Blockchain technology in such scenario, and the challenges of implementation. All these sectors have a common requirement of trust management that is very difficult to be implemented using other traditional technologies. Elements like immutability, data controllability, secure communication, and transparency are also crucial for these sectors. All of these aspects can be successfully implemented using Blockchain technology. Although Blockchain technology is still evolving, the successful implementation in these domains reflects its ability for further implementation. The various challenges in these sectors have been categorically discussed, which will be very beneficial for any future application.

4. Conclusion

This paper has reviewed the various applications and current Blockchain projects in multiple domains of the public concern, namely Government, Health, Finance, Economic, and Energy. Almost all the countries are either using or in the process of applying Blockchain technology in Government and finance. This paper highlighted the requirements of Blockchain technology in these sectors. This paper further analyzed the issues and challenges in successful Blockchain implementation in these domains. These requirements and challenges can serve as a base point to examine any proposed model or architecture. They can help define the policy decisions to implement any new Blockchain-based project in a specific domain successfully. In section 3, each sector's challenges have been discussed in detail, and possible future applications under each sector have been categorically defined. Scalability and interoperability are two major technical aspects that need to be addressed for high Blockchain adaptation. Apart from these two technical aspects, a proper legal framework and the need for standardization to evolve a general framework for Blockchain-based application development need urgent attention.

Author contributions

Shadab Alam: Conceptualization, Writing- Original draft preparation, Methodology, Validation**. Mohammed Shuaib:** Conceptualization, Methodology, Investigation, Validation. **Wazir Zada Khan**: Writing - Review & Editing, Validation, Visualization. **Sahil Garg**: Visualization, Investigation, Methodology, Validation. **Georges Kaddoum**: Visualization, Investigation, Methodology, Validation. **M. Shamim Hossain**: Visualization, Investigation, Methodology, Validation. **Yousaf Bin Zikria**: Supervision, Methodology, Validation, Writing-Reviewing and Editing

Declaration of Competing Interest

None.

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