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## Blockchain in Government: A Primer

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**Abstract** Blockchain refers to a highly secure and decentralized ledger system on which information can be stored but cannot be altered. It is a technology that builds a trustworthy service in an untrustworthy environment. It has evolved beyond cryptocurrencies to general purpose and can be used across an array of applications. It is now being implemented in various industries with government being one of them. Governments around the world are taking advantage of blockchain technology to improve the efficiency and delivery of public services. This primer provides an overview on blockchain in government. Our purpose is to discuss several applications that are both representative and meaningful.

**Keywords** blockchain, government, applications

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### 1. Introduction

A blockchain is a decentralized network consisting of data records or “blocks” that cannot be modified by a single actor. It refers to a range of general purpose technologies to exchange information and transact digital assets in distributed networks [1]. It has recently emerged as a disruptive innovation with a wide range of applications, potentially able to redesign our interactions in business, politics, and society at large. Blockchain technology has been taunted as one of the most transformative technologies of our time with the most obvious use cases being the application in the cryptocurrency space. Blockchain is the technology used by developers of cryptocurrencies, like Bitcoin, to enable exchange of financial “coins” between participants without a trusted third party to ensure the transaction. One important feature in blockchain technology is decentralization. No one computer or organization can own the chain. Instead, it is a distributed ledger via the nodes connected to the chain. Blockchain is used in many areas as illustrated in Figure 1 [2].

Using blockchain for government services make government bodies more efficient, secure, speedy, and trustworthy. For these reasons, the governments of many countries have expressed interest in the technology. By using blockchain, governments can reduce administrative costs, increase transparency and improve service delivery. A blockchain-based government has the potential to solve legacy pain points and enable the following advantages [3]:

- Secure storage of government, citizen, and business data
- Reduction of labor-intensive processes
- Reduction of excessive costs associated with managing accountability
- Reduced potential for corruption and abuse
- Increased trust in government and online civil systems



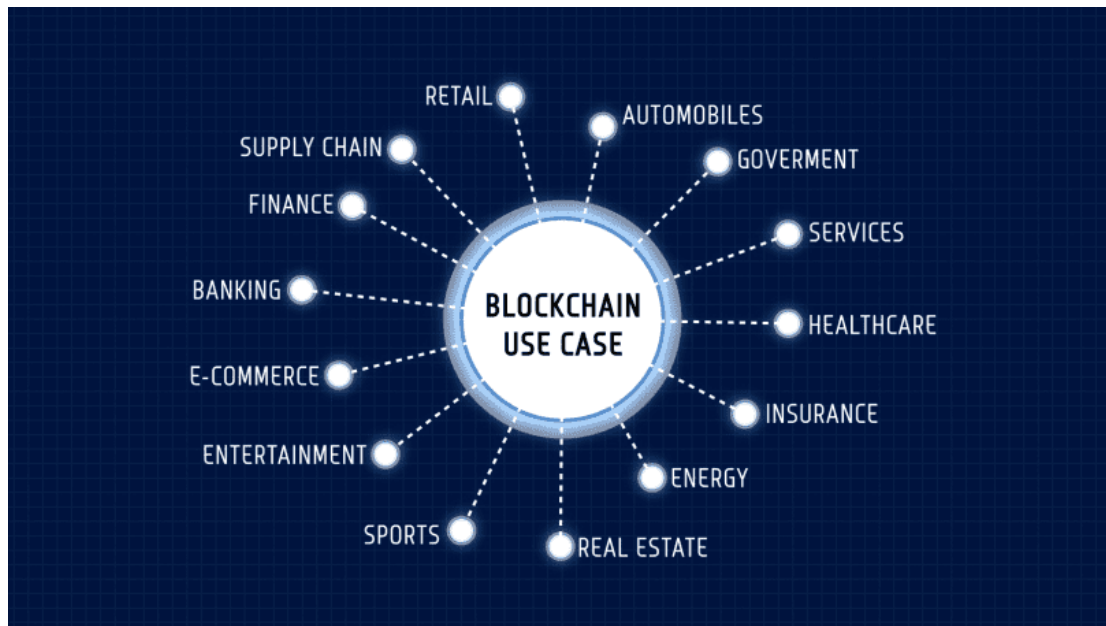


Figure 1: Blockchain is used in many areas [2].

## 2. Overview of Blockchain

Blockchain (BC) technology is a permanent record of online transactions. It is a distributed tamper-proof database, shared, and maintained by multiple parties. It is a new enabling technology that is expected to revolutionize many industries, including business. It has the potential for addressing significant business issues. The BC technology allows participants to move data in real-time, without exposing the channels to theft, forgery, and malice.

The term “blockchain” refers to the way BC stores transaction data – in “blocks” that are linked together to form a “chain.” The chain grows as the number of transactions increases. Since every entry is stored as a block on a chain, the care you receive is added to your personal ledger. The first Blockchain was conceived in 2008 by an anonymous person or group known as Satoshi Nakamoto, who published a white paper introducing the concept of a peer-to-peer electronic cash system he called Bitcoin [4]. Blockchain is a distributed ledger database that consists of records or transactions or various digital incidents that are executed by the participants. Blockchain technology can assist in achieving the seven objectives of SCM: their cost, quality, speed, dependency, risk reduction, sustainability as well as flexibility. The concept of blockchain is shown in Figure 2 [5].

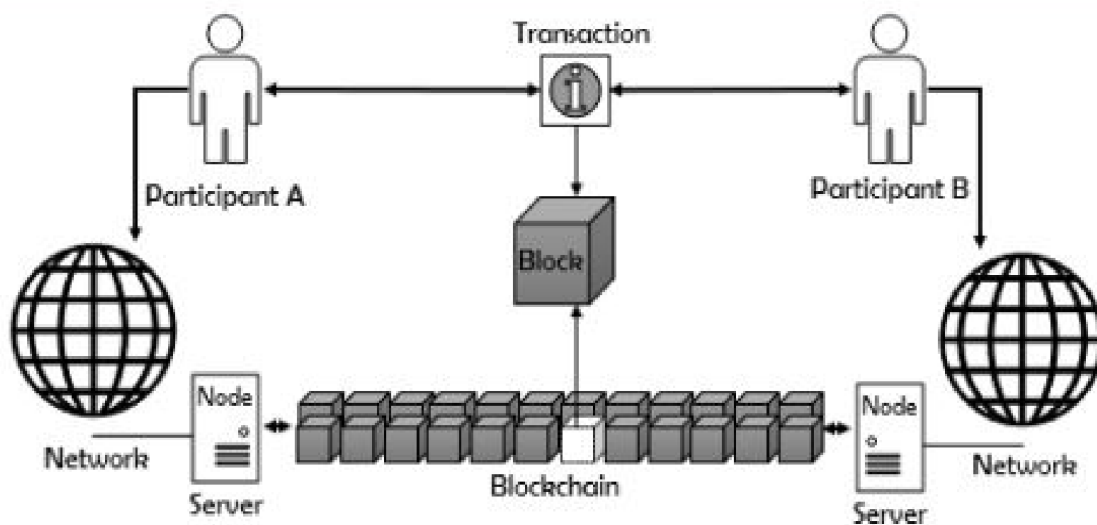


Figure 2: The concept of blockchain [5]



At its core, blockchain is a distributed system recording and storing transaction records. In a blockchain system, there is no central authority. Instead, transaction records are stored and distributed across all network participants. Rather than having a centrally located database that manages records, the database is distributed to the networks and transactions are kept secure via cryptography. BC eliminates the need for a middleman that traditionally may facilitate such transactions.

Fundamentally, blockchains are distributed digital database that record and maintain a list of transactions taking place in real time. They may also be regarded as decentralized ledgers that sequentially record transactions or interactions among users within a distributed network. They have the following properties [6]:

- Firstly, they are autonomous. They run on their own, without any person or company in charge.
- Secondly, they are permanent. They are like global computers with 100 percent uptime. Because the contents of the database are copied across thousands of computers, if 99 per cent of the computers running it were taken offline, the records would remain accessible and the network could rebuild itself.
- Thirdly, they are secure and tamper-proof. Each record in blockchain is time stamped and stored cryptographically. The encryption used on blockchains like Bitcoin and Ethereum is industry standard, open source, and has never been broken.
- Fourthly, they are open, allowing anyone to develop products and services on them.
- Fifthly, as blockchain is a shared system, costs are also shared between all of its users.

The Blockchain was designed so transactions are immutable, i.e. they cannot be deleted. Thus, blockchains are secure and meddle-free by design. Data can be distributed, but not copied. When it comes to digital assets and transactions, you can put almost anything on a Blockchain. Different scenarios call for different Blockchains. Blockchain is used for different purposes as depicted in Figure 3 [7].

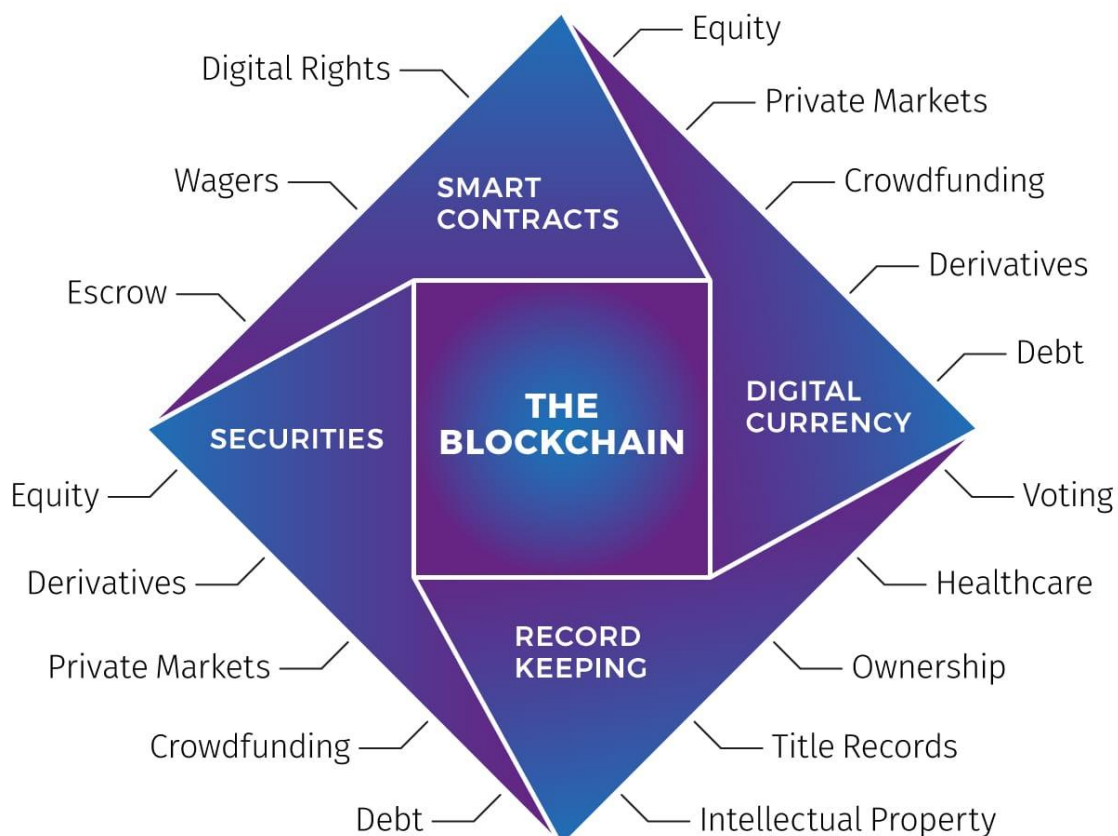


Figure 3: Different purposes of blockchain [7]



The BC technology currently has the following features [8,9]:

- 1. Peer-to-Peer (P2P) Network:** The first requirement of BC is a network, an infrastructure shared by multiple parties. This can be a LAN at a small scale or the Internet at a large scale. All nodes participating in a BC are connected in a decentralized P2P network. Transactions are broadcast to the P2P network. Due to some limitations of P2P networks, some vendors have provided cloud-based BCs.
- 2. Cascaded Encryption:** A BC uses encryption to protect transaction data. Blocks are encrypted in a cascaded manner, i.e. the encryption result of the previous block is used in encrypting the current block. The BC is secured by public key cryptography, with each peer generating its own public-private key pairs.
- 3. Distributed Database:** A BC is digitally distributed across a number of computers. Each party on a BC has access to the entire database and no single party controls the data or the information. Since BC is decentralized, there is no need for central authorities such as banks.
- 4. Transparency with Pseudonymity:** Each node or participant on a blockchain has a unique 30-plus-character alphanumeric address that identifies it. Users can choose to remain anonymous or provide proof of their identity to others.
- 5. Irreversibility of Records:** Once a transaction is entered in the database and the accounts are updated, the records cannot be altered. Records on the database is permanent, chronologically ordered, and available to all others on the network.

As illustrated in Figure 4, a blockchain comprises a peer-to-peer network of participant nodes, a distributed ledger consisting of immutable blocks of data, transactions recorded in the blocks, smart contracts to execute the transactions, and a consensus algorithm that decides the proposer of the next block [10]. There are two types of blockchains: public and private. Public Blockchains are cryptocurrencies such as Bitcoin, enabling peer-to-peer transactions. Private Blockchains use Blockchain-based platforms such as Ethereum or Blockchain-as-a-service (BaaS) platforms running on private cloud infrastructure. A private BC is an intranet, while a public BC is the Internet. Companies will be disrupted the most by public Blockchains.

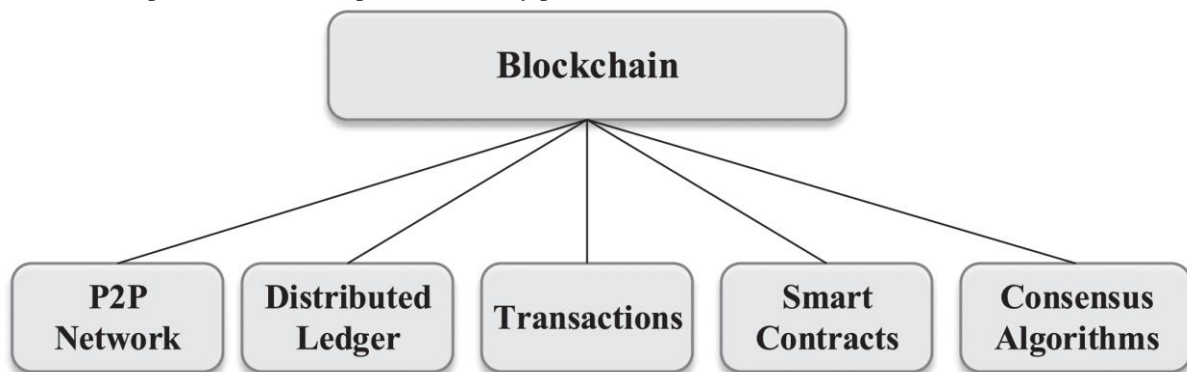


Figure 4: Components of a blockchain [10]

### 3. Blockchain for Government

Blockchain refers to a range of general purpose technologies to exchange information and transact digital assets in distributed networks. It is regarded as one of the most important technology trends that will influence business and society in the years to come. The whole point of using a blockchain is to let people, especially those who do not trust themselves, share valuable data in a secure, tamperproof way. Blockchain technology has the potential to provide benefits to government as it enables reduced costs and complexity, shared trusted processes, improved discoverability of audit trails, and ensured trusted recordkeeping [11]. The blockchain revolution is taking place at a time when people are losing faith in governments and this new decentralized technology seems to be giving people new hope.

There are a number of nations that have already started adopting blockchain technologies. Examples of blockchain applications by governments include the following [12-14]:

- **Australia:** This nation teamed up with IBM as one of the top countries in the world integrating blockchain into its record keeping process. The country is using the technology to combine its passport and birth certificate databases into one blockchain-backed base.
- **Chile:** The country uses Ethereum to track the money and data from the energy grid in order to curb corruption.
- **China:** Despite initially taking an aggressive stance against cryptocurrencies, China has been quite open and positive about blockchain development. China recognizes that the technology can potentially usher in massive developments within various sectors in which it can be applied. It has announced its plan to build a “Blockchain city,” based on blockchain technology.
- **Denmark:** The government of Denmark is exploring blockchain technology to effectively collect taxes on used car sales. It has geared efforts towards developing blockchain-based voting platforms.
- **Estonia:** Estonia is the most digital country in the world, with 99% of public services are in the blockchain. It represents an ideal example of how the blockchain can benefit governments. The government of Estonia was one of the first to become a “blockchain government” by venturing into the technology. This has helped to significantly reduce the time that it takes for the government to deliver services to the country’s citizens.
- **Ghana:** The Government of Ghana is using blockchain technology to solve two structural problems: determining the legal status of land ownership and solving longstanding miscommunication problems between the Ghanaian Land Commission, property owners, and financial institutions.
- **India:** The country has plans to carry out research on the proactive use of blockchain technology. Due to the high need for safe business, the number of Blockchain companies in India is growing.
- **Nigeria:** The Nigerian Federal Government has approved a national blockchain policy aimed at institutionalizing the technology in the country’s economy and security sectors. The approval of the national blockchain policy is a significant milestone, as it would ensure that blockchain technology is firmly embedded in Nigeria’s economy.
- **United Arab Emirates:** This is one of the countries that have fully embraced new technologies especially those that have a lot of potential for the future. The UAE government has launched a number of initiatives to promote the use of blockchain in the country. One of the most successful initiatives was the UAE Blockchain Strategy 2021, which helped the UAE government adopt the applications of blockchain in government and public sector to carry out its transactions.
- **South Korea:** This government announced a 4B Korean won (about \$3.5 million) award to set up a blockchain-enabled virtual power plant in the city of Busan, the country’s second-most populous city.
- **United Kingdom:** The nation has shown interest in decentralized ledger technology, particularly with regards to the potential blockchain applications in the public sector. The British government has recognized that this technology can transform the conduct of public and private sector organizations.
- **United States:** In the US, blockchain adoption is happening at both the Federal level and also at the local level. DARPA and the Pentagon are reportedly working on coming up with strong security protocols using blockchain technology.
- **Venezuela:** This is the first federal government to introduce a digital currency in 2018: the petro. The petro has since alleviated the country’s economic woes. It is acquired through through the website of the treasury of cryptoactives of Venezuela. This currency is supported by oil, gold, diamonds, among others. The primary goal of the government is to eradicate the American currency (dollar), and ensure that citizens do not use it as a method of payment. Many Venezuelans are relying on cryptocurrencies to hedge against fiat inflation.

These are just a few examples of how blockchain technology is being used to improve the efficiency of government services. There are more use cases of blockchain being explored by governments around the world.



#### 4. Applications

Blockchain can be used to improve the delivery of public sector services such as the issuance of title deeds, birth certificates, property transfers, business licensing, marital licenses, etc. Some of the uses of blockchain in government are shown in Figure 5 [12].



Figure 5: Uses of blockchain in government [12]

They are described as follows [12,15]:

- **Legal enforcement:** Governments can use data from public to monitor money transactions and ensure that the system does not facilitate illegal dealings. The implementation of blockchain for a government can be a key tool towards making sure that financial transactions in the digital domain remain legal. This can be handy towards curbing illegal dealings such as drug trafficking and money laundering.
- **Taxation:** Blockchain might be the long-awaited solution for eliminating double taxation. The decentralized ledger technologies have the capacity to foster more transparency in financial transactions.
- **Government Infrastructure:** Blockchain can help governments to ensure better protection over their critical infrastructure, thereby keeping cyber attacks at bay. A decentralized ledger can also be developed such that it is able to keep track of the integrity of government systems. This would significantly reduce the chances of attacks and data tampering.
- **Welfare Distribution:** Decentralized ledger technology allows governments to handle matters related to welfare with more efficiency. Blockchain can be used to deploy faster service delivery allowing citizens to benefit directly. Such systems would also be more efficient in getting more people out of poverty. Blockchain technology can be used to facilitate proper allocation of funds to government projects.
- **Energy:** The US Department of Homeland Security defines 16 critical infrastructures including energy, food and agriculture, transportation, etc. Energy management can be daunting to



governments. Governments can circumvent some of the issues revolving by coming up with efficient energy management systems that are based on the blockchain.

- **Tourism:** This is a very important sector for many nations. The US state of Hawaii has been looking for ways to develop blockchain solutions that can make it easier for tourists to enjoy what they have to offer. For example, cryptocurrencies can be used to make it easier for tourists to spend their money without having to worry about exchange rates.
- **Smart Cities:** A smart city uses information technology and data to integrate and manage physical, social, and business infrastructures to streamline services to its inhabitants. Blockchain technology can provide a safe and secure infrastructure for managing smart city applications such as energy management and transportation. For example, the city of Dubai is using blockchain to store and manage health records. By combining the security of blockchain with the efficiency of smart city technologies, governments are able to create a more seamless and secure experience for their citizens.
- **Central Banking:** Policy makers around the world are exploring ways to develop and issue central bank digital currencies in as little as the next five years. By eliminating the need for a central authority to issue and manage currency, blockchain could provide a more efficient, democratic alternative to traditional central banking.
- **Cross-Border Transactions:** Blockchain plays a crucial role at a place where security is needed the most. Border security is vital to every small and big nation. Globalization has made organizations to make more cross-border transactions. Blockchain has the potential to enable secure, efficient payments in cross-border transactions by removing the need for intermediaries. Multiple organizations are taking advantage of blockchain to enable cross-border transactions.
- **Digital Voting:** The reliability of the voting process has been a problem since the beginning of democracy. Citizens can cast votes the same way they initiate other secure transactions and validate that their votes were cast, or even verify the election results. Blockchain technology can decentralize the voting process so that elections can happen securely with transparency. It is ideal for digital voting systems especially because transparency is one of its strong suites. Individuals who are eligible receive a token that allows them to vote only once and each vote is stored as a node in the blockchain.
- **Cybersecurity:** Cybersecurity is ironically both a main benefit and potential weakness of blockchain technology. Data breaches do occur, and blockchain firms typically use these as learning lessons. Companies prefer to wait until the technology is more mature before entering.

Other areas of application include e-government, e-identities, education, personal identity security, public health, public procurement, public finance, business licensing, transportation, land registration and ownership, social benefits, citizen engagement, digital currencies, culture, humanitarian relief, social assistance, and grant disbursements.

## 5. Benefits

Blockchain is technology that builds a trustworthy service in an untrustworthy environment. Blockchain technology is already being used by governments around the world to improve the way they manage sensitive data. It is also safe against fraud and hacking so you do not have to worry about your information being stolen. Blockchain can be used to streamline administrative processes in the government by eliminating third parties such as agents. It can be adopted by governments as the technology through which they launch their pilot projects. It has been identified as the most suitable technology for digital migration. It is more affordable since there are no middlemen to introduce markups. Many companies and banking institutions have been adopting blockchain technology to achieve more efficiency. Other benefits of blockchain government include the following:

- **Social Trust:** There are risks with any system. An important function of government is to maintain trusted information about individuals, organizations, assets, and activities. Social trust in the technology is an issue. Most people do not trust their government. Blockchain, with all its different



features, comes as the solution to this problem. Transparency changes some of the sentiments by allowing citizens to view and verify data. Blockchain can help build trust in new vaccines from inception to injection with a network powered by IBM Blockchain, such as the vaccine system in Figure 6 [16].



Figure 6: Blockchain can help build trust in new vaccines [16].

- **Cost Reduction:** The use of blockchain can lower the costs of government services and also limit redundancy, streamline processes, increase security, decrease the audit burden and even ensure that the data integrity is maintained.
- **Social Evils:** Governments are concerned that blockchain technology and cryptocurrencies are facilitating social evils such as money laundering, funding criminal activities, corruption, and tax evasion
- **Elimination of Corruption:** Combatting corruption in public procurement is another area where blockchains have been implemented and show promise for expansion. The costs to society of public-sector corruption and weak accountability are staggering. Blockchain technology serves a unique role in combating government corruption. In developing countries, blockchain applications for governments can help eliminate the main issue of corruption while also ensuring more effective deployment and distribution of resources.

## 6. Challenges

Blockchains cannot solve all problems. There is no one-size-fits-all blockchain system. Blockchain is not mature yet, as challenges exist for both adoption and technology development. It has yet to reach widespread adoption at scale. Other challenges include the following:

- **Security:** Defense and security are the major concerns of every nation. One of the major hurdles that have stood in the way of digitization for many governments is security. Bringing personal data of millions of people onto digital platforms presents a huge risk when the system is hacked. Several blockchain systems intentionally make their consensus protocols proprietary, making it difficult to trust in the correctness and security of the platforms.





- **Data quality:** Blockchain does not protect against data from untrustworthy sources. It cannot prevent well-formatted but incorrect or inaccurate data from being sent and stored in the system.

## 7. Conclusion

Blockchain technology is no longer limited to digital currencies. Today, many real-world blockchain government use cases have emerged. The excitement around using blockchain in the public sector is building at a large scale around the world. Blockchain technology could accelerate key government functions such as voting, identity verification, certifying transactions such for land-use registry, and safekeeping of medical records. It is an excellent tool that governments worldwide can use to build systems that are open and trustworthy and protect the citizens of their country. It provides governments with a fast, secure, efficient, and transparent way to deliver government services and communicate with their citizens.

Blockchains have been hailed as a building block for a new economy. Deemed by experts as the most important technological innovation since the Internet, blockchain is set to revolutionize the global economy. The Government Blockchain Association (GBA) is an international nonprofit, professional membership association, connecting individuals and organizations with blockchain technology solutions to government requirements. The GBA is all about driving authentic connectivity that the global initiatives support. GBA members comprise of over 2,000 leading industry experts representing the most comprehensive blockchain technology capacities in the world [17]. Many governments hope that blockchain will be a game changer for issues such as security and operational challenges. More information on blockchain government can be found in the books in [18-29].

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