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A Survey of Blockchain in Governance: Framework Selection and Future Implementation in Indonesian Government

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Abstract

Blockchain technology enables users to connect without the need for a third party or central server. This is achieved through the use of a decentralized system, ensuring that all data and information transacted are encrypted, verified, validated, and stored using mathematical consensus algorithms. This leads to Blockchain being recognized as a technology characterized by decentralization, security, anonymity, transparency, immutable data, and trust. Blockchain is frequently associated with digital currency, although digital currency is just one of the outcomes of applying Blockchain technology, resulting in cryptocurrencies. Currently, Blockchain technology is a trend among academics and practitioners who are researching and developing Blockchain technology for application in various domains, including government. Government systems and public servants often encounter issues related to data security. Hence, the research has the purpose to offer comprehension and perspectives on implementing Blockchain technology within the government sector to enhance public service information security. The research was carried out by reviewing Scopus-indexed international articles published between 2019 and 2023, which are relevant to frameworks, consensus algorithms, and applications employed in the governmental domain. The research outcomes revealed that the Hyperledger Fabric framework, coupled with the Practical Byzantine Fault Tolerance (PBFT) algorithm, is the most suitable option for potentially developing Blockchain-based government or public service applications for future implementation. Regarding this research, there are future challenges in the form of constructing prototypes and evaluating their effectiveness and efficiency. Therefore, further research and development efforts are essential to ensure that the application of Blockchain technology in the government sector can be realized as required in the future.

Keywords: *Blockchain, Framework, Consensus Algorithm, Government, Public Services, E-Government.*

1. Introduction

Blockchain technology enables the implementation of a highly secure and decentralized system that ensures transaction privacy is not under the control of a third-party organization. In this system, outgoing and incoming data is encrypted and stored in closed compartments known as distributed ledgers, which are distributed across the entire network in a verifiable and immutable manner [1]. Blockchain cannot be exclusively identified as Bitcoin because Bitcoin is just one of many cryptocurrencies, but Blockchain is used to create cryptocurrency applications [2]. Each Blockchain application has its own Blockchain network, but with interoperability features that enable smooth transactions between Blockchain networks [3].

Blockchain has gained tremendous attention in various fields such as food, pharmaceuticals, real estate, logistics, and is actively being developed by industry and academia for various financial and non-financial applications [4]. This has made it one of the most trending technologies that has attracted significant interest from the academic and practitioner communities [5]. Blockchain technology has also caught the attention of governments worldwide in recent years due to enhanced security, improved traceability, and cost-effective infrastructure, enabling Blockchain to penetrate various domains or sectors [6].

The benefits of security are often not considered important until a security breach occurs [7]. Handling sensitive data such as government information demands a secure and reliable environment, which can be easily provided by Blockchain [8]. Many government departments are starting to build Blockchain-based data sharing protocols that take into account fairness, privacy, auditability, and compatibility with various Blockchains [9], as the decentralized nature of Blockchain replaces third-party control organizations or central servers, implemented with smart contracts (SC), and powered by transactions on the Blockchain [10].

Based on the background that has been previously explained, there are still several issues and challenges that need further investigation. The research is conducted using a survey technique and combines all international articles indexed in Scopus from the period of 2019 to 2023 that are related to the topic of Blockchain application in the government domain and discuss the frameworks used. Through this research, the author aims to provide insights into:

1. Frameworks used in government Blockchain.
2. Consensus algorithms used in government Blockchain.
3. Blockchain applications employed in government.
4. Potential future applications of Blockchain in government.

This survey paper will provide a comprehensive understanding of the implementation of Blockchain in government, the selection of suitable frameworks and algorithms for government Blockchain, and will encompass related challenges, benefits, and opportunities. Furthermore, this survey paper will also identify directions for future research that can help enhance and expand the use of Blockchain in the government context.

2. Literature Review

2.1. History and Timeline of Blockchain

As Blockchain technology continues to evolve, it is important for us to understand its history and timeline of development. Understanding the history of Blockchain helps us grasp the value and potential of this technology in the current context. The following is an introductory summary of the history of Blockchain, which can be seen in Figure 1:

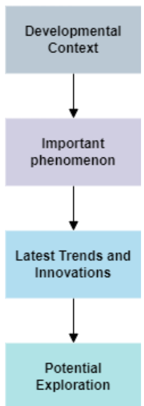

Figure 1. Summary of Blockchain History

Explanation of Figure 1 regarding the summary of Blockchain history is as follows:

1. Development Context: The history of Blockchain provides information about the context and background of how computer system and security technology evolved into the current Blockchain technology, starting from 1979 to 1996.

2. Key Events: The concept and popularity of utilizing Blockchain technology in the financial sector and decentralized systems with smart contracts, starting from 2008 to 2014.
3. Trends and Innovations: The development of Blockchain technology frameworks for use in various fields, including industry and business, starting from 2015 to 2019.
4. Exploration of Potential: Research and development related to environmentally friendly technology, Blockchain interoperability, and scalability by academics and practitioners for application in various fields, started from 2020 until the writing of this research.

To gain a better understanding of the history of Blockchain, please refer to Figure 2 below:

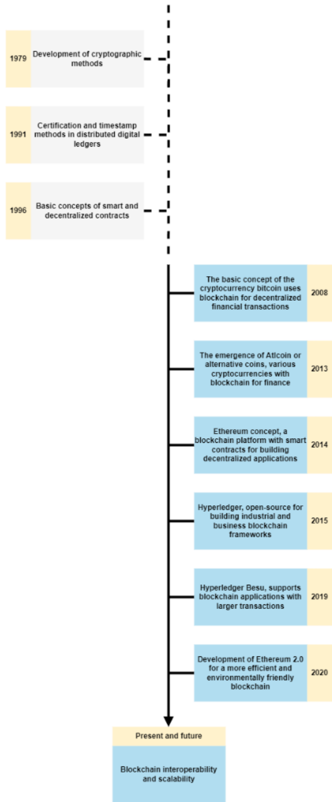

Figure 2. Blockchain Timeline

The explanation of Figure 2, the Blockchain Timeline, can be elaborated based on the literature review as follows:

1. 1979: The first discussions about a protocol in computer security that could be trusted by mutually suspicious groups using the development of cryptographic methods [11].
2. 1991: Development of certification or timestamping on digital documents using one-way hash functions in a distributed digital ledger on a connected computer network [12].
3. 1992: Methods to improve the efficiency of timestamping on digital documents and its constraints, as well as the introduction of a new algorithm called "linked-timestamping" that can be automatically verified by anyone [13].
4. 1996: The foundational concept of digital smart contracts and their potential application in the development of new digital markets or currencies, making them more efficient and decentralized [14].
5. 2008: The concept of Bitcoin and the explanation of using Blockchain technology to build a decentralized electronic financial system [15].
6. 2013: The emergence of various alternative cryptocurrencies or altcoins that utilize Blockchain technology and expand the use of Blockchain in various economic and financial aspects [16].

7. 2014: The concept of Ethereum, which is a Blockchain platform that enables the development and launch of decentralized applications with smart contracts. Additionally, new concepts like DAO (Decentralized Autonomous Organization) and decentralized applications that can be built within Ethereum were introduced [17].
8. 2015: The emergence of Hyperledger, an open-source initiative for building distributed and decentralized Blockchain frameworks for business and industry, developed by the Linux Foundation [18], with one of its platforms being Hyperledger Fabric for building secure and reliable Blockchain applications [19].
9. 2019: Hyperledger Besu, specifically designed to support Ethereum Blockchain applications with features like PoW (Proof of Work) and PoA (Proof of Authority) consensus for managing large-scale transactions [20].
10. 2020: The development of Ethereum 2.0, which enables transaction validation and the creation of new blocks to be done in a more efficient and environmentally friendly manner [21].

2.2. Blockchain Framework in Government

The Blockchain framework is essentially a structure that provides the foundation for building the architectural design, governance, management, and implementation of processes in interconnected networks using Blockchain technology [22]. The Blockchain framework encompasses components such as protocols, peer-to-peer (P2P) networks, cryptography, consensus algorithms, nodes [23], data models, and other components that enable the development, operation, and interaction with the Blockchain [24].

In the Blockchain framework, every transaction is designed using smart contracts (SC), which contain predefined logic, rules, and conditions [25]. Smart contracts are computer programs that run across the entire Blockchain network to execute transactions and fulfill contract requirements automatically without the need for human intervention [26]. To understand the Blockchain framework, please refer to Figure 3 below:

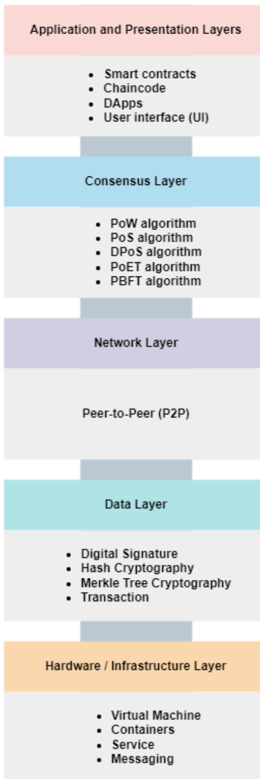

Figure 3. Architecture of the Blockchain Framework Layers

To understand the Blockchain framework applied in government or public service sectors, the researcher presents data and information based on a literature review. There are 20 (twenty) internationally indexed Scopus articles discussing the implementation of Blockchain technology in government, as shown in Table 1 below

Table 1. Review of The Blockchain Framework In Government

Research	Year	Country	Framework
[27]	2023	China	Ethereum
[28]	2021	Saudi Arabia	Chain of Trust
[29]	2021	Thailand	European Interoperability Framework
[30]	2021	-	Blockchain Publik
[31]	2022	Dubai (UAE)	Hyperledger Fabric, CORDA, Ethereum
[32]	2020	European Union (EU)	Hyperledger Fabric
[33]	2019	-	Ethereum
[34]	2019	Russia	-
[35]	2022	China	-
[36]	2023	China	License Accountability and Compliance (LAC): OpenChain dan Hyperledger Composer
[37]	2021	China	
[38]	2023	India	Blockchain diizinkan : Hyperledger Fabric, R3 Corda, Quorum
[39]	2019	Netherlands	Blockchain diizinkan: Hyperledger Fabric, Corda, dan Quorum
[40]	2021	Indonesia	Blockchain Privat: Hyperledger Fabric dan Corda Enterprise
[41]	2021	Mexico	Blockchain Privat: Hyperledger Fabric dan Corda Enterprise
[42]	2022	Korea	-
[43]	2023	China	-
[44]	2020	Iran	-
[45]	2020	Dubai (UAE)	Hyperledger Fabric
[46]	2021	Brazil	-

In Table 1, there are several Blockchain frameworks, which can be explained as follows:

1. OpenChain: A framework with a transparency service architecture in data sharing practices, enabling data reuse and supporting compliance requirements [36].
2. Hyperledger Fabric: A distributed ledger framework with a modular architecture that provides security, flexibility, and Blockchain scalability [18].
3. Hyperledger Composer: An open development tool and framework designed to simplify the development of Blockchain applications [18].
4. R3 Corda: An encrypted framework capable of creating a secure environment for the storage and analysis of information [47].
5. Quorum: A framework that supports smart contracts with the Solidity programming language, easy to implement, and does not require execution costs for miners or users in the mathematical transaction process on the Blockchain network [48].
6. Corda: A specialized framework for business and financial Blockchain applications that offers security, privacy, and interoperability features among institutions [49].
7. Corda Enterprise: A paid framework designed for the needs of larger and more complex organizations, featuring scalability and Corda services, and easy implementation [50].

2.3. Blockchain Consensus Algorithms in Government

Consensus algorithms in Blockchain are mathematical consensus mechanisms that enable every connected node in the Blockchain network to agree on block creation, which includes incentive mechanisms and promotes effective Blockchain operations as the basis for building trust in the Blockchain [51]. Consensus algorithms play a crucial role in simultaneously maintaining security, scalability, and decentralization in the Blockchain network [52].

In government, consensus algorithms are responsible for determining how to write, validate, and approve data entries into the Blockchain ledger network [23]. Consensus algorithms determine the configuration of the Blockchain architecture to be implemented, including conflicting goals of security, speed, privacy, and transparency [22]. This technology is considered highly resistant to hacking, once data is stored, it cannot be altered, and it is nearly impossible to tamper with or forge [53]. To understand the concept of consensus algorithms, please refer to Figure 4 below:

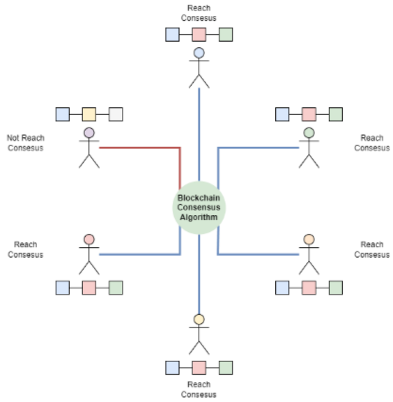

Figure 4. Concept of Blockchain Consensus Algorithms

To understand the Blockchain consensus algorithms applied in government or the public service sector, the researcher presents data and information based on a literature review. There are 20 (twenty) internationally indexed Scopus articles discussing the implementation of Blockchain technology in government, as shown in Table 2 below:

Table 2. Review of Blockchain Consensus Algorithms In Government

Research	Year	Country	Consensus Algorithms
[27]	2023	China	Proof of Work (PoW)
[28]	2021	Saudi Arabia	Proof of Work (PoW), Proof of Stake (PoS), Practical Byzantine Fault Tolerance (PBFT), Delegated Proof of Stake (DPoS)
[29]	2021	Thailand	Proof of Work (PoW), Proof of Stake (PoS), dan Practical Byzantine Fault Tolerance (PBFT)
[30]	2021	-	Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Proof of Authority (PoA)
[31]	2022	Dubai (UEA)	Hyperledger Fabric: Kafka-based Consensus, Raft Consensus, Practical Byzantine Fault Tolerance (PBFT); CORDA: BFT (Byzantine Fault Tolerance); Ethereum: Proof of Work (PoW), Proof of Stake (PoS), Proof of Authority (PoA)
[32]	2020	European Union (EU)	Kafka-based Consensus, Raft Consensus, Practical Byzantine Fault Tolerance (PBFT)
[33]	2019		Proof of Work (PoW), Proof of Stake (PoS), Proof of Authority (PoA)
[34]	2019	Russia	-
[35]	2022	China	-
[36]	2023	China	-
[37]	2021	China	-
[38]	2023	India	Hyperledger Fabric: Practical Byzantine Fault Tolerance (PBFT); R3 Corda: Notary; Quorum: Quorum Chain Consensus (QCC)
[39]	2019	Netherlands	Practical Byzantine Fault Tolerance (PBFT), Proof of Authority (PoA)
[40]	2021	Indonesia	Practical Byzantine Fault Tolerance (PBFT) dan Notary Service
[41]	2021	Mexico	Practical Byzantine Fault Tolerance (PBFT) dan Notary Service
[42]	2022	Korea	Proof of Stake (PoS)
[43]	2023	China	-
[44]	2020	Iran	Proof of Work (PoW), Proof of Stake (PoS)
[45]	2020	Dubai (UAE)	Practical Byzantine Fault Tolerance (PBFT)
[46]	2021	Brazil	-

In Table 2, there are several Blockchain consensus algorithms, which can be explained as follows:

1. Proof of Work (PoW): PoW is a consensus algorithm used in the Bitcoin Blockchain and many other Blockchains. It involves solving computational tasks that require significant computing power to verify and validate transactions. The completion of these tasks takes time and computational resources, which secures the network against attacks and ensures transaction integrity [15].
2. Proof of Stake (PoS): PoS uses coin ownership (stake) as a determinant factor in block leader selection and transaction validation. Coin holders with a larger stake have a higher probability of being chosen as block leaders. PoS is more energy-efficient compared to PoW [51].
3. Practical Byzantine Fault Tolerance (PBFT): PBFT is a consensus algorithm designed for distributed systems where multiple parties can communicate and cooperate to reach an agreement. PBFT allows for parallel transaction processing and is resistant to attacks by malicious parties. Each block leader is selected in rotation to initiate transactions, and all stakeholders must reach a majority consensus on proposed transactions before they can be confirmed [54].
4. Delegated Proof of Stake (DPoS): DPoS is a variant of PoS that involves the selection of a group of delegates responsible for transaction validation and block leader selection. These delegates are chosen by coin holders through a voting mechanism. DPoS offers faster transaction latency and higher scalability compared to traditional PoW and PoS [51].
5. Proof of Authority (PoA): PoA is a consensus algorithm in which predefined authorities or trusted entities are allowed to validate transactions. The identities of the authorities are guaranteed, and transactions can be quickly verified. PoA is useful in environments that require fast and trusted transactions [51].
6. Kafka-based Consensus: This algorithm leverages Kafka's ability to manage ordered and reliably delivered messages. Each node in the network can send messages to Kafka topics, which are then distributed to other nodes. In the consensus process, these nodes use these messages to reach an agreement on the order and validity of transactions within the Blockchain [55].
7. Raft Consensus: This algorithm divides roles in the system into leaders and followers, where the leader leads the consensus process and coordinates operations with followers. Raft Consensus offers an efficient leader election mechanism, consistent log replication, and quick recovery from failures [56].
8. Notary Service: Notary Service is a component used in several Blockchain platforms to ensure the authenticity and validity of transactions or documents stored in the Blockchain. Notary Service acts as an authority entity in verifying digital signatures and providing authenticatable proof. By using Notary Service, users can verify data integrity and ensure that transactions on the Blockchain are valid and unaltered [57].
9. Quorum Chain Consensus (QCC): A consensus algorithm specifically developed for the Quorum Blockchain platform. Quorum is a Blockchain platform developed by J.P. Morgan for business and financial purposes. QCC enables a group of nodes in the Quorum network to reach an agreement on the state of the Blockchain. This algorithm offers a high level of scalability, strong reliability, and efficiency in conducting transactions in complex business environments [58].

2.4. Blockchain Applications in Government

Currently, many governments are joining the global Blockchain adoption movement to move away from centralized and inefficient structures. It is expected that Blockchain will provide a more stable, measurable, and cost-effective architecture [59]. Blockchain can be utilized to enhance government services in terms of efficiency and effectiveness, such as transparency, lower costs, accurate record-keeping [60], traceable information, or Blockchain-based traceability systems [61].

Blockchain technology is one of the modern technologies ideally suited for developing digital governance services. Its ability to maintain information stability is crucial in digital governance systems as it enhances measures of information integrity and openness to prevent corruption [62]. Blockchain-based governance also offers the benefits of precise services and improved collaborative processes with various broad fields or sectors to promote the modernization of capacity and governance systems [63]. To understand the concept of applying Blockchain applications for collaborative digital governance, please refer to Figure 5 below:

Figure 5. Architecture of the Blockchain Framework Layers

To understand the Blockchain applications implemented in government or the public service sector, the researcher presents data and information based on a literature review. There are 20 (twenty) internationally indexed Scopus articles discussing the implementation of Blockchain technology in government, as shown in Table 3 below:

Table 3. Review of Government Blockchain Applications

Research	Year	Country	Blockchain Applications
[27]	2023	China	Data Sharing Protocol
[28]	2021	Saudi Arabia	e-Government Saudi Yesser
[29]	2021	Thailand	e-Government DIA Thailand
[30]	2022	Dubai (UAE)	e-Government Dubai
[31]	2020	European Union (EU)	e-Government Lintas Batas
[32]	2019	Russia	e-Government
[33]	2019	Dubai (UAE)	e-Health
[34]	2022	China	Digital Public Services
[35]	2023	China	Supply Chain Data Governance and Government
[36]	2021	China	e-Government
[37]	2023	India	Government Blockchain
[38]	2019	Netherlands	Business to Government Blockchain (B2G)
[39]	2021	Indonesia	Cloud-Based Blockchain
[40]	2021	Mexico	Government Governance
[41]	2022	Korea	e-Government (BigChainDB)
[42]	2023	China	Environmentally Friendly Supply Chain
[43]	2020	Iran	e-Currency for e-Government
[44]	2020	Dubai (UAE)	Dubai Real Estate
[45]	2021	Brazil	Blockchain-Based Accounting in Brazil

3. Discussion

3.1. The Right Blockchain Framework for Government

Based on Table 1, a review of Blockchain Frameworks in Government, grouping can be done to determine trends in which framework is commonly used in implementing Blockchain technology in the government or public service sector. To understand this grouping, please refer to Table 4 below:

Table 4. Review of Blockchain Government Applications

Platform	Total
OpenChain	1
Hyperledger Composer	1
Hyperledger Fabric	7
R3 Corda	1
Quorum	2
Corda	2
Corda Enterprise	2

In Table 4, it is shown that Hyperledger Fabric is the most widely used framework for implementing Blockchain technology in the field of government or public services. Hyperledger Fabric is a cost-free Blockchain platform that is permissioned, operates in a modular environment capable of simulating real-world network conditions and architectures based on specific needs, and has a consensus mechanism that requires collaboration among participants in the network, making it suitable for e-government services [32].

Hyperledger Fabric also serves as a platform for constructing distributed ledger solutions with a modular architecture that provides a high level of confidentiality, flexibility, resilience, and scalability. This allows solutions developed using Fabric to be adapted for any field [18]. To understand the concept of the Hyperledger Fabric framework mechanism in use, refer to Figure 6 below:

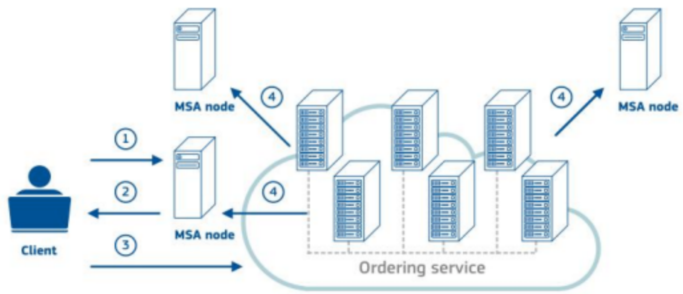

Figure 6. The Transaction Flow of The Hyperledger Fabric Framework

Figure 6 can be explained as follows: all participants in the network are uniquely identified through digital certificates embedded in the transacted messages. To achieve data sharing services on the Hyperledger Fabric infrastructure, verification, validation, digital signatures, block creation, and broadcasting to every node in the network are carried out by Member State Authorities (MSA) [32].

3.2. The Right Blockchain Consensus Algorithm for Government

Based on Table 2, a review of Blockchain Consensus Algorithms in Government, grouping can be performed to determine trends in the frameworks frequently used in implementing Blockchain technology in the government or public services sector. To understand this grouping, please refer to Table 5 below:

Table 5. Trends In Blockchain Consensus Algorithms In Government

Consensus Algorithm	Total
Proof of Work (PoW)	7
Proof of Stake (PoS)	7
Practical Byzantine Fault Tolerance (PBFT)	9
Delegated Proof of Stake (DPoS)	2
Proof of Authority (PoA)	4
Kafka-based Consensus	2
Raft Consensus	2
Byzantine Fault Tolerance (BFT)	1
Notary	1
Quorum Chain Consensus (QCC)	1
Notary Service	2

Table 5 shows that the Practical Byzantine Fault Tolerance (PBFT) consensus algorithm is the most widely used in implementing Blockchain technology in the government or public services sector. The PBFT consensus allows every participant in the Blockchain network to have a private key for digitally signing transactions and maintain their own copy of the data, preventing other entities from claiming authorship and other users from rejecting it. As a result, there are no single points of failure in the network due to the synchronization mechanism supported by the network. In case of participant failures, the latest system state can be resumed, allowing all participants to share the same fundamental truth at any time [32].

In the PBFT consensus algorithm, all participants or nodes must engage in the voting process to add the next block, and a two-thirds majority is required to achieve consensus [64], or at least 51% of the nodes in the network [65]. The PBFT consensus algorithm is designed to work efficiently in asynchronous systems, is not biased towards computational power, and has the advantage of providing transaction finality without confirmation. All nodes in the Blockchain chain mutually agree on the same state based on communication with each other, and it consumes minimal energy in performing mathematical processes or mining [66]. To understand the concept of how the PBFT consensus algorithm works, please refer to Figure 7 below:

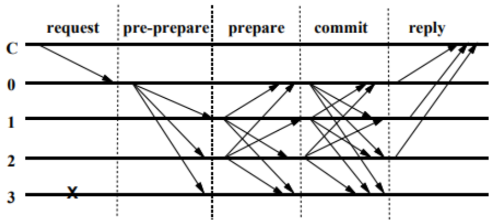

Figure 7. The Normal Operation of The PBFT Consensus Algorithm

Figure 7 can illustrate the normal operation of the PBFT consensus algorithm without major faults. Replica 0 is the primary, replica 3 is faulty, and C is the client, performing request, pre-prepare, prepare, commit, and reply operations. In this process, the new replicas are able to tolerate faults [54].

3.3. Appropriate Blockchain Applications for Government

Based on Table 3, a review of Blockchain Applications in Government, grouping can be performed to determine trends in the applications frequently used in implementing Blockchain technology in the government or public services sector. To understand this grouping, please refer to Table 6 below:

Table 6. Trends In Blockchain Applications In Government

Blockchain Applications	Total
Data Sharing Protocol	1
Supply Chain	1
e-Government	9
Environmentally Friendly Supply Chain	1
Digital Public Services	1
Database	1
Cloud	1
Accounting	1
Cross-Border e-Government	1
e-Currency	1
Real Estate	1
e-Health	1
Business to Government (B2G)	1

Table 6 shows that e-Government is the most widely used application in implementing Blockchain technology in the government or public services sector. Blockchain-based e-Government or Blockchain-based governance refers to the integration of resources and system integration between internal government business systems and parallel or subordinate external functional departments into a convenient, high-quality, affordable one-stop service for the public and businesses to complete parallel approvals, execute transparent, clean, and efficient online administrative management system operations, including within the internet portal [63]. To understand how Blockchain-based e-Government applications are implemented in government, please refer to Figures 8 and 9 below:

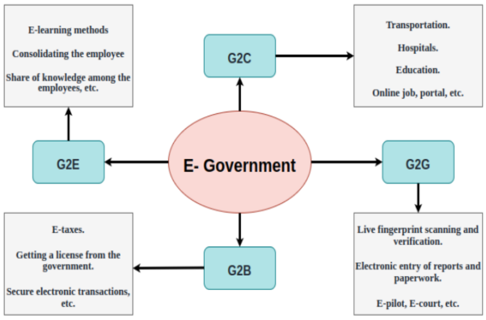

Figure 8. Types of E-Government

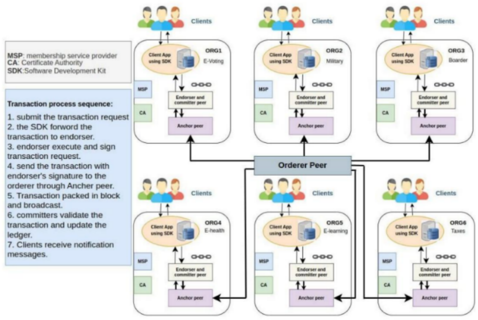

Figure 9. Multi-Organization System Architecture Based on Hyperledger Fabric

In Figure 8, it can be observed that in the context of e-Government, it is connected with government (G2G), business (G2B), education (G2E), and the public (G2C). Therefore, Figure 9 explains that the architecture and scenarios of e-Government using Blockchain technology aim to protect data and information from security breaches that could lead to financial and emotional losses for the public [67]. For the e-Government national database, the Hyperledger Fabric framework provides privacy protection, anti-disclosure measures, guaranteed quality, and security through smart contracts [68].

4. Conclusion

4.1. Blockchain for Government

This research was conducted by surveying internationally indexed Scopus articles related to the application of Blockchain in the government sector and Blockchain frameworks. The research aims to provide information, knowledge, and insights into collaborative e-Government applications empowered by Blockchain technology for governments. Collaborative governance systems involve interconnections between government to government (G2G), government to business (G2B), government to the public (G2C), and government to education (G2E) in terms of information transparency. Collaborative e-Government based on Blockchain technology in government governance and public services ensures information security, data resilience, privacy, anonymity, transparency, and effective traceability. To build collaborative e-Government, the Hyperledger Fabric framework is used as a distributed ledger, offering advantages in the security, interoperability, and scalability of the Blockchain network and its users. This is achieved through the use of the Particle Byzantine Fault Tolerance (PBFT) algorithm, which allows the Blockchain network to continue operating even in the presence of errors in achieving consensus or agreement among users or nodes.

4.2. Research Limitations

This research has limitations in terms of providing a detailed explanation of the technical mechanisms of the framework and consensus algorithms used in an application. Furthermore, the researchers have not been able to provide information on how applications using Blockchain technology work between application providers, users, and the architectural side of the Blockchain technology in the applied application.

4.3. Suggestions for Future Research

Based on the earlier discussion of research limitations, there are challenges for future research, namely: there is a need for further research and development regarding the technical mechanisms of the Hyperledger Fabric framework and the Practical Byzantine Fault Tolerance (PBFT) consensus algorithm in terms of their interoperability and scalability. Additionally, it is necessary to design the architecture of Blockchain-based government applications and build a prototype of the application to test its effectiveness and efficiency. This will help answer the questions of how and what is needed in the process of implementing Blockchain technology in the government or public services sector.

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