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PROGRAM MANAGEMENT FOR BLOCKCHAIN-BASED PROJECTS BALANCING INNOVATION AND GOVERNANCE

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Abstract

The underlying technology of Bitcoin, commonly known as the Blockchain, has since been embraced by the business world and other sectors, including finance and health, among others. It has numerous potential advantages in terms of innovation, specifically, decentralized, trustless and a fixed, non-editable record of transactions and information. This document examines the use of blockchain technology within e-government platforms to resolve important infrastructure problems linked to data protection and system reliability, together with assault prevention methods against cross-site scripting SQL injection and denial-of-service attacks. A blockchain-based e-government system implements the Delegated Proof of Stake (DPoS) consensus method to provide protected peer-to-peer interactions between government entities and their stakeholders. A permissioned blockchain network enables trustworthy decentralized service management for tax filing functions combined with land registry systems and electronic procurement options. This research evaluates specific blockchain program management methods and governance frameworks which focus on minimizing project risks while optimizing resources while increasing stakeholder cooperation. The framework demonstrates blockchain's ability to transform public service delivery through secure features while it advances sustainable e-government operational practices.

Keywords: Blockchain Technology, Program Management, Decentralized Governance, Innovation, Governance Frameworks.

I. INTRODUCTION

The extensive reach of internet connectivity has motivated multiple nations to embrace technological progress for the transmission of knowledge and services toward home constituents and global associates. The combination of enhanced service quality by providers alongside convenient home-based access for citizens results in more efficient operation, reduced public office wait times, and reduced travel costs through e-government services. Due to their shared purpose of providing public information free of competition, government networks are often better able to communicate with one another than private sector networks. As the IoT, smart cities, and smart homes continue to advance at a rapid pace, the number of devices utilizing e-government services is expected to skyrocket in the next years[1][2]. Nearly every nation's government now offers some kind of electronic service to its residents and other interested parties through the web and mobile apps, as reported in the 2014 United Nations e-government study [3].

Using electronic computers, e-government systems gather, store, and process a large amount of private data about people, workers, clients, goods, studies, and financial situation, among other things. The loss of opportunities, financial benefits, and users' trust and confidence are typically the results of such information being compromised [4]. It was discovered that over 80% of e-government websites worldwide were susceptible to SQL injection and cross-site scripting (XSS) since appropriate authentication procedures were not used for user input data [5]. Malware and DoS have recently become major concerns for several countries' networks [6]. For example, in 2015, the United States government was hit by a massive e-government hack that exposed the personal information of more than 4 million government workers. This included details like social security numbers, passwords, identities, and security clearances.

It would appear that blockchain technology is a viable option for creating a trustworthy decentralized platform for data sharing [7]. While its foundational technology was initially established for digital currency exchange, it has since discovered privacy and security uses in numerous other domains, including the IoT [8], smart home [9], smart city [1], educational systems [10], and healthcare. Many nations have launched blockchain initiatives to investigate the possibility of using blockchain technology to provide citizens with public services, even if governments worldwide have not completely embraced blockchain technology in the public sector [11]. Projects like these often target specific services, like electronic residency, electronic health records, property registry, etc. The integration of blockchain technology with e-government systems is still in its infancy, and no universal framework has been suggested.

A. Research Motivation and Significance/Aim

The rapid evolution of blockchain technology offers unprecedented opportunities to revolutionize traditional systems by enhancing transparency, security, and efficiency across various domains. However, its implementation, particularly in complex and regulated environments like e-government, presents unique challenges that demand a careful balance between fostering innovation and ensuring robust governance. Effective program management is crucial to address these challenges, enabling organizations to navigate technical complexities, align stakeholder interests, and manage risks while driving the adoption of blockchain solutions. By integrating structured governance frameworks with agile innovation practices, blockchain projects can achieve scalable, secure, and sustainable outcomes, paving the way for transformative advancements in public and private sector operations. Key contributions of the study are following below:

- Introduced a blockchain-based e-government system enabling secure and transparent interactions among government departments (G2G), citizens (G2C), and businesses (G2B), ensuring efficient data exchange and validation.
- Proposed the Delegated Proof of Stake (DPoS) consensus mechanism for transaction validation and block creation, offering computational efficiency, scalability, and enhanced security.

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- Defined the roles of full and lightweight nodes in the blockchain network, optimizing resource usage while maintaining transaction authenticity and system integrity.
- Developed a strategic framework for program management in blockchain-based projects, focusing on planning, stakeholder collaboration, risk management, and resource allocation to support seamless technology adoption.
- Explored governance models, including on-chain and off-chain approaches, to address decentralized decision-making challenges and enhance the operational and regulatory framework of blockchain systems.

II. BLOCKCHAIN-BASED E-GOVERNMENT SYSTEM

Figure 1 shows the e-government framework that is built on blockchain technology. The picture depicts a two-way arrow G2G indicating a connection between various government agencies and private organizations, enabling p2p data sharing and validation.

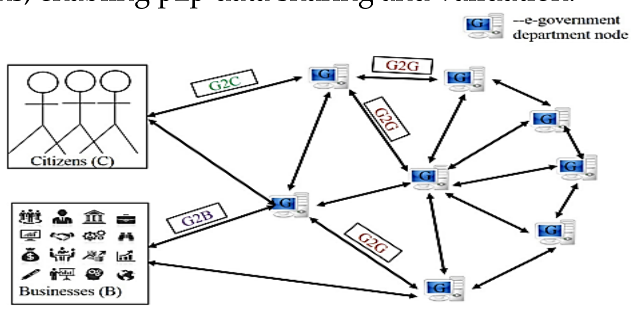

Fig. 1. The proposed blockchain-based e-government network

An G2C bidirectional arrow symbolizes the exchange of data between individuals and the government, including that which is required when applying for a passport, visa, marriage license, birth certificate, business permission, or tax return. Economic growth is mostly driven by information exchange between public and private entities, as shown by a G2B double-direction arrow. This includes electronic procurement, tax and insurance clearance forms, and electronic auctions.

In a permissioned (private) blockchain, nodes that are new to the network are approved by their peers. When an e-government (G) or user (C or B) node joins the network, its peers assign e-government tokens to build up its network node. A node's capacity to store records in the blockchain is directly proportional to the quantity of e-government tokens. In order to store their tokens, each user has their own personal e-government blockchain wallet. His or her blockchain address will receive a stake-transferred record after it is submitted.

Any node can become a delegate on the network by using a DPoS protocol. The many government agencies that comprise the e-government system cast ballots to choose a delegate responsible for verifying the transactions and adding the new block to the blockchain. Token generation, network node setup, and random node joining are all subject to approval by the remaining e-government nodes, making this method suitable for security requirements. All data recorded on the permissioned blockchain is verifiable, auditable, and open to scrutiny.

A. Network node

Blockchain terminology distinguishes between two types of nodes: full nodes and lightweight nodes [12]. To validate transactions and blocks to their fullest extent, a full node must download an entire copy of the blockchain when it joins the network. To ensure that transactions are legitimate, a lightweight node will just download the block headers when it connects to the network rather than the entire blockchain. Lightweight nodes typically refer to a copy of a trustworthy full node of the blockchain in order to transfer their transactions that impact their blockchain wallets.

B. Delegates and witnesses voting

The continued operation of the network depends on the consensus of its peers regarding the status of the transactions in each block and the method for adding them to the blockchain. The computational efficiency of the DPoS in adding transactions and sealing a block led to its adoption as the consensus algorithm in this case [13]. As a quick overview, the DPoS can be seen as a form of representative democracy in which e-government nodes vote with their records to choose other nodes to join the network. Network security and the selection of witnesses to verify transactions and sign blocks are responsibilities of the delegates.

C. New node creation

A summary of the steps required to add a node to the planned e-government network is provided. While regular users are limited to setting up lightweight nodes, any government agency that operates online can join the blockchain by establishing a full network node [14].

D. New block generation

The majority of peers randomly select one active witness from the list of active delegates to create each block. Another witness is assigned the responsibility of creating and validating blocks in order to join the blockchain network in the event that a witness fails to do so. A set time period of five seconds functions as the block generation timeframe in DPoS [13]. A clear explanation of DPoS consensus algorithm processes defines how new blocks become part of the blockchain records.

E. Security and privacy analysis

The salvation of confidentiality and integrity, along with service availability, represents the core necessity of e-government systems. The test for data confidentiality applies when information remains inaccessible to unauthorized users; data integrity requires complete protection from unauthorized alteration; data availability ensures access for authorized parties without DoS attack interference. The theoretical and qualitative evaluation of the e-government system's privacy and security performance is presented in this section.

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III. PROGRAM MANAGEMENT IN BLOCKCHAIN-BASED PROJECTS

Blockchain-based project program management needs a strategic framework to facilitate effortless decentralized technology adoption for organizational processes. Complex coordination between developers regulators and end-users characterizes these projects while demanding thorough planning as well as effective communication and risk management strategies. Project objectives wait for projects to blocks challenges from regulatory doubles and data safety together with scalability problems. Program management through iterative development combines agile techniques to enable suitable adaptation to quickly developing blockchain technologies. The delivery of innovative blockchain-based solutions depends heavily on nurturing functional collaboration among teams to maximize the benefits of this technology. The Key aspects include [15]:

- **Planning and Strategy:** Specific goals, identifying scope, and success measures based on the aspects of blockchain such as decentralization and transparency.
- **Stakeholder Management:** The concept of collaborative expectations means that industry developers, regulators, and end-users should come to a consensus.
- **Resource Allocation:** Budget resources, tools, and people prudently, however with regard to blockchain costs such as gas fees.
- **Risk Management:** Mitigate security threats, legal concerns and concerns of scale.
- **Execution and Monitoring:** Monitor the project, be transparent with the help of staking and other tools like smart contracts and respond to changes in the area of technology or regulation.
- **Evaluation:** Evaluate performance against set objectives in order to create better block chain projects in the future.

A. Definition and Core Functions of Program Management

Program management involves managing a group of closely linked activities within an organization to support programmes and bring out their value [16]. It centres its efforts on positioning these projects to support prevailing business concerns, and contribute enhanced stability to the success of an organization. Specifically, while project management is focused on the project delivery, PMM concerns the outcome of a set of linked projects. Core functions of program management are mentioned below:

1. Strategic Alignment:

Performs the Strategic Proactivity function to guarantee all the projects of the program are consistent with the organization’s strategic plan and supports the achievement of sustainable goals. Program managers continue to have an eye on value, which is what stakeholders get at the end of the day.

2. Governance:

Provides a clear, systematic approach for decision making and gives everyone the responsibilities it need to perform. These include things such as roles, responsibilities, and activities with regard to the program as well as management and control structures.

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3. Benefit Realization:
Concentrates on the search, design, and realization of the anticipated advantages arising from the program. This include monitoring so as to have credibility with the idea that the program is making a difference in the organization.

4. Resource Management:
Organizes the right amount of money, people, and equipment to be spend on several projects so as to ensure high rates of return and little wastage. Program managers address the issues of resource contention and determine what is more important.

5. Risk Management:
Institutes measures aimed at controlling factors that may compromise the success of the program. This involves managing risks at both a project and a program level, to guarantee cohesion and effective operational output.

IV. GOVERNANCE AND INNOVATION IN BLOCKCHAIN PROJECTS

Blockchain governance can be defined as the decision-making processes that occur within the projects or schemes which involves blocks systems especially decentralized systems. It stems from problems with blockchain protocols and its subtopics, smart contracts, and DAOs which lack a clear decision-making system [17].

The specific governance challenges are differentiated according to layers including infrastructure, application concerning company, and institution/country levels and according to stages including design, operation, evolution, and crisis. This is because the governance of blockchain applications and infrastructure is mostly compounded together. In terms of permissions, permission less blockchains require dedicated models of the DAO type, whereas permissioned ones can use similar models. The best reference source is recommended to be drawn from the open-source community in approaching the framework for establishment of effective governance.

A. Governance Models in Blockchain Projects

Governance characteristics in Blockchain Projects are directed by the fundamental attributes of blockchain technology such as decentralized, consensus, security, and trust. These features revolutionize conventional forms of corporate frameworks and systems of managing corporate entities [18].

- **Decentralized:** Blockchain is decentralized in which decision-making is done by a community of computers.
- **Consensus-based**: Blockchain uses consensus mechanism, where consensus across nodes ensure involvement in transactions without the input of a third party.
- **Secure:** Cryptography preserves the network integrity, checks which computer is authorized to make a decision, and prevents past information tampering.

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- **Thrustless:** Blockchain removes the requirement of a trusted middleman since an individual choice is made by the network and not by a single governing body.

B. On-Chain vs. Off-Chain Governance

Blockchain systems' governance is further categorized as on-chain and off-chain governance, along with their regulations and decisions [19].

1. On-Chain Governance:

On-chain is the rules and processes baked into blockchain protocol and infrastructure. These are then programmed through the system and set down guidelines for how the participants of the network should behave. On-chain decision-making powers are decided by the blockchain code known as the 'rule of code' and these are decision making powers that cannot be overcome. It may include rules where some of them control changes in lower or even higher set of rules. This means of governance also makes it possible to enforce the decisions arrived in the system.

2. Off-Chain Governance:

Off chain involves decision making, or regulations which is not embedded in the block chain platform. This may involve endogenous rules which are drawn from the reference community to facilitate the running of the community, for example, rules of change, protocols and procedures, and external rules which are imposed by third parties, for instance, national legislation and regulation, and contractual arrangements. Off-chain governance refers to the decisions made outside the blockchain that can affect the current running of the blockchain and its future change, but off-chain governance is not required on the blockchain.

C. Impact of blockchain technology on innovation

- **Transforming Operations Across Industries**: Global companies presently welcome Blockchain technology to secure better market positions worldwide.
- **Fostering Innovation for Economic Growth:** Industry growth alongside economic development depends heavily on innovation according to both policymakers and entrepreneurs [20].
- **Enhancing Flexibility, Agility, and Change**: Enterprises leverage blockchain technology to develop flexible processes that enable their long-term success and market dominance.
- **Decentralized and Transparent Ledger**: Blockchain operates as a decentralized distribution ledger which supports innovation through digital asset provenance tracking while enabling broad dataset access.
- **Improving Data Security and Trust:** Data security benefits from blockchain deployment along with enhanced trust factors which safeguard digital transaction integrity.
- **Facilitating New Business Models**: The integration of blockchain technologies enables organizations to develop efficient new transaction systems with auditable controls and smart contracts for fostering collaborative processes.
- **Complementing AI and Data Economy:** Blockchain can enhance AI by improving insight generation, managing data usage, and contributing to the establishment of a data economy.

V. LITERATURE REVIEW

This study highlights the previous study based on Program Management for Blockchain-Based Projects Balancing Innovation and Governance. Also provide summary Table 1 below:
In this study, Tijan et al. (2019) discusses blockchain technology, which offers decentralized data storage, and the potential for its advancement in environmentally friendly supply chain management and logistics. While blockchain's advantages have received the lion's share of attention in the financial industry, it can also help logistics by reducing order delays, product damage, human error, and the need for duplicate data entry. An extensive analysis of the present and future uses of blockchain technology in SCM and logistics is provided in this article [21].

In this study, Saha (2017) to learn about blockchain's potential applications and to determine its primary value proposition. The key ideas behind the technology and how they facilitate the many use cases were examined to achieve this. The second objective was to identify possible use cases for blockchain technology. The findings demonstrate that blockchain has the ability to revolutionize numerous industries through decentralization, efficiency gains, cost savings, and new forms of corporate organization; nevertheless, it is still in its infancy and has numerous obstacles that must be surmounted. When dealing with a number of parties when there is a lack of trust, blockchain technology becomes quite useful[22].

In this study, Kogon (2017) center on defining blockchain technology, outlining its basic operation, and discussing its potential uses. A distributed ledger that cannot be manipulated can be created by utilizing powerful cryptography, a predetermined sequence of events, and a large number of computers that can detect if data has been edited or tampered with. The technical description of blockchain technology is supplemented with both real-world and fictional examples of its use to assist demonstrate its capabilities. Although blockchain technology was first implemented for use in the financial sector, its use has since spread to numerous other industries thanks to the proliferation of innovative ideas [23].

In this study, Atzori (2017) seeks to address this deficiency by outlining the essentials of decentralized governance based on blockchain technology, which poses varied degrees of threat to the conventional tools of state power, citizenship, and democracy. Specifically, the article confirms the degree to which decentralized platforms and blockchain technology can be viewed as hyper-political instruments, able to control massive social interactions and do away with conventional centralized authority. The study draws attention to dangers associated with private companies' monopoly on dispersed ecosystem power, which can cause people to lose agency and eventually give rise to a global society without permanent borders [24].

In this study, Pereira, Tavalaei and Ozalp (2019) drawn from open-source literature, platform-ecosystem theory, and transaction cost economics, they analyze and contrast centralized platforms with blockchain-based platforms, or decentralized versus centralized governance types. They examine the scenarios in which blockchain-based platforms outperform centralized ones by basing their conceptual analysis on three dimensions: transaction cost, cost of technology, and community involvement [25].

TABLE I. PRESENTS THE LITERATURE REVIEW SUMMARY BASED ON PROGRAM MANAGEMENT FOR BLOCKCHAIN-BASED PROJECTS BALANCING INNOVATION AND GOVERNANCE.

References	Focus Area	Key Findings	Challenges	Key Contribution
Tijan et al. (2019)	Blockchain in logistics and supply chain	Blockchain can minimize order delays, damage to goods, errors, and multiple data entries.	Application of blockchain in logistics is still developing.	Review of blockchain's potential in logistics and supply chain management.
Saha (2017)	Blockchain's value proposition	Blockchain can disrupt and transform industries through disintermediation, cost reduction, and new business models.	Challenges in overcoming the early-stage development of blockchain technology.	Identifying the value of blockchain and its applicability in various sectors.
Kogon (2017)	Blockchain fundamentals and applications	Blockchain creates a tamper-proof ledger using cryptography and distributed networks.	Application beyond finance faces hurdles.	Overview of blockchain's fundamentals and its evolving use across industries.
Atzori (2017)	Blockchain and decentralized governance	Blockchain challenges traditional state authority, citizenship, and democracy.	Risk of private powers dominating distributed ecosystems.	Analysis of blockchain's role in decentralized governance and its political implications.
Pereira, Tavalaei and Ozalp (2019)	Blockchain vs centralized governance	Blockchain-based platforms may be more advantageous than centralized platforms in terms of transaction costs and community involvement.	Blockchain implementation costs and community engagement.	Comparison of decentralized vs. centralized governance models based on blockchain.

VI. CONCLUSION AND FUTURE WORK

The integration of blockchain technology into e-government systems offers a promising approach to enhancing the efficiency, transparency, and security of public services. By leveraging the decentralized and immutable nature of blockchain, governments can facilitate secure data exchange between stakeholders, prevent unauthorized access, and ensure the integrity of sensitive information. The proposed blockchain-based e-government framework which utilizes DPoS consensus can effectively tackle numerous operational challenges including data breaches and, inefficiencies, and scalability problems. The findings reveal how crucial it is for governments to use modern innovative technologies both for enhancing public delivery operations and citizen participation in public services.

Researchers need to develop standardized integration guidelines for blockchain implementation with e-government systems that handle interoperability issues and meet regulatory standards across global nations. Research into next-generation consensus algorithms, along with privacy protection approaches, seeks to maximize blockchain system scalability and security. Studying how AI and machine learning work with blockchain platforms allows organizations to create automated predictive capabilities for improved decision processes. Effectively evaluating the proposed framework requires diverse pilot applications in public service areas before applying it to real-world environments so preprocessing can be optimized.

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