



Curbing Ghost Worker Fraud in Developing Countries Using Consortium Blockchain

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ABSTRACT

One of the major issues facing the governments of developing countries, such as Nigeria, is ghost worker fraud. Ghost worker fraud refers to all practices relating to employee impersonations that have salary cost effects on the government. More than one hundred billion Naira (220 million US dollars), is lost annually due to ghost workers fraud in Nigeria. Solutions such as the development and implementation of the Integrated Payroll and Personnel Information System (IPPIS) by the Nigerian government did not solve the problem. Blockchain technology offers the promise of improved transparency, auditability, autonomy, security, and efficiency. To address the problem of ghost worker fraud, in this paper, we investigate blockchain and its relevance to ghost workers fraud and other forms of corruption in Nigeria. We also examine the problems of the Integrated Payroll and Personnel Information System (IPPIS). We then propose the use of a consortium blockchain framework to tackle ghost worker fraud and detail the type of consensus algorithm and the blockchain structure required. This framework could substantially reduce cases of ghost worker fraud in Nigeria and elsewhere.

CCS CONCEPTS

• Security and privacy → Distributed systems security; Trust frameworks.

KEYWORDS

Blockchain, Payroll, Corruption, Ghost Worker, IPPIS

ACM Reference Format:

Musa Ibrahim Bello and Daniel R. Thomas. 2023. Curbing Ghost Worker Fraud in Developing Countries Using Consortium Blockchain. In *Proceedings of the 9th ACM International Workshop on Security and Privacy Analytics (IWSPA '23)*, April 26, 2023, Charlotte, NC, USA. ACM, New York, NY, USA, 7 pages. <https://doi.org/10.1145/3579987.3586569>

1 INTRODUCTION

Blockchain is a digital technology that brings together networking, data management, cryptography, and incentive mechanisms to strengthen the checking, execution, and recording of transactions among users [45]. Numerous industries including manufacturing,

oil, construction, and mining are already using blockchain [24]. Despite the potential benefits of blockchain, many developing countries such as Nigeria have not deployed it. Nigeria is blessed with human, capital and natural resources and yet in the middle of 2022, 95.1 million people representing 49% of its population lived in abject poverty [32]. This is a result of the high rate of corrupt practices and unemployment. The unemployment rate in Nigeria was forecast to reach 33% by the end of 2022 [10].

The government as the biggest employer of labour is faced with challenges of ghost workers fraud, which is one of the causes of unemployment [15]. Solutions such as the development and implementation of the Integrated Payroll and Personnel Information System (IPPIS) by the Nigerian government did not solve the problem due to the massive influence of humans within the centralized system. Centralized systems lead to bureaucracy that bred favoritism, nepotism, and abuse of authority, [23], in contrast, blockchain does not restrict authority to the center alone but enables independent auditing [38]. The decentralized system distributes equal powers to relevant members in the network for checks, and approvals and prevents tampering with the data. Thus, using blockchain could help minimise issues of ghost workers and corrupt practices in developing the countries like Nigeria.

In this paper, we examine ghost worker fraud in Nigerian public service. We propose the integration of blockchain technology into the existing IPPIS for better transparency, auditability and data security. We propose a framework for the blockchain based IPPIS including the blockchain architecture, consensus and guidance for proper implementation with Hyperledger fabric. Our contributions are summarized as follows:

- We investigate ghost worker fraud in Nigeria.
- We give an overview of the relevant aspects of blockchain, its applications, and adoption.
- We propose a blockchain based IPPIS framework to curb ghost worker fraud in Nigeria and elsewhere

2 BACKGROUND OF BLOCKCHAIN AND RELATED WORK

Blockchain technology is considered a disruptive technology. It is the core platform on which Bitcoin, Ethereum, and other digital currencies run. Blockchain is distributed and decentralized, capable of storing records, events, and transactions and set rules on how this information is updated [41]. The technology has the potential to manage several security challenges as it can eliminate central controls that gives power to a selected few [47]. It is can be more secure than the conventional centralized systems because it use cryptographic hash functions to ensure its data integrity [30]. Numerous industries are already using blockchain [24]. Blockchain

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has been used in financial institutions: Banking, Fintech, Insurance, Consumer Finance, Housing Finance, etc. [33]. The global cryptocurrency market cap was 3 trillion dollars in of 2021, though it fell to 1 trillion dollars by 2023 following numerous frauds.

3 BLOCKCHAIN ARCHITECTURE

Blockchain runs on a distributed and decentralized network where transactions are verified and stored [20]. Blockchain is an append-only list of records called blocks, that are connected and secured using cryptography. Each block contains transaction data, timestamp, and cryptographic hash of the previous block [20]. The hash of each block is created from the hash of the previous block and the data from the current block. This provides integrity as alteration of data in a block must alter the hash value of that block and in turn affect all the subsequent blocks [30]. The blockchain structure is comprised of a block header and block body (transaction data). As shown in Figure 1, the header encapsulates the timestamp, Merkle root as well as other components including the previous block hash [48].

Peers are responsible for updating and maintaining the ledger in compliance with a particular consensus algorithm. The algorithm sets out rules on how and who creates new blocks. There are several consensus algorithms implemented on blockchain network, some of which include; *Proof of Work (PoW)*, this is Bitcoin's consensus algorithm through which miners compete to append blocks and mint new currency. The algorithm is energy intensive and is environmentally destructive. *Proof of Stake (PoS)*, Unlike the PoW, the algorithm needs validators to hold and stake tokens to validate block transactions. It reduces the computational work needed and changes how blocks are being verified by means of tokens. Some drawbacks of PoS is, participants must buy tokens, network control can be directly bought as well (rather than indirectly through buying hardware as in PoW). *Proof of Activity (PoA)*, this is a hybrid of PoW and PoS, it combines the potentials of both the two systems. Consensus algorithms play important role in blockchain design and management and it depends on structure, purpose or network so it is important to consider the appropriate type of consensus algorithm to adopt in blockchain development.

3.1 Hyperledger Fabric

Hyperledger Fabric is a type of consortium blockchain. We propose the use of Hyperledger for the framework because it easily supports the creation of blockchain networks with better security and performance. Hyperledger Fabric is an open-source decentralized distributed system which executes Distributed Applications (Dapps) [35]. Hyperledger Fabric supports the development and deployment of permissioned blockchain for enterprises. It possesses a configurable and modular blockchain architecture that permits business enterprises to satisfy their various needs. Consensus in Fabric is used inside the ordering service where blocks are arranged and ordered. In terms of performance and scalability, Hyperledger provides high performance (over 3500 transactions per seconds according to IBM research in 2018) and scalable network though it can be affected by block size, consensus and size of the network [8].

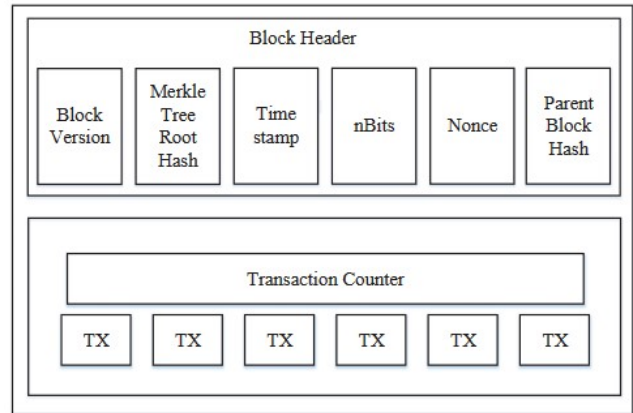


Figure 1: Blockchain Structure
Source: Sanka, 2021 [39]

There are three steps of transaction flow, which are execution, order, and validation. Each transaction can be executed in separate peer and can be executed before consensus from the ordering service is executed [3]. The basic functions in Hyperledger version 1.4x include init, invoke, and query. Init is useful for installing and instantiating chaincodes so the transactions can run. Invoke is useful for calling transactions from chaincodes that have been installed and instantiated, query is for checking what transactions were carried out in the process (Christidis, 2016). The transaction flow as shown in Figure 2 undergo the following steps:

- The client makes a transaction and sends it to all endorsing peers.
- Each endorsing peer authorizes transaction execution and makes endorsement signatures.
- Clients collect support signatures from endorser peers through the ordering service.
- Ordering services create transaction blocks and maintain orders with a timestamp.
- When supporting partners receive a block of transactions, they will assess the transaction against its authorization policy, then determine the validity of the transaction.

4 APPLICATIONS AND SIGNIFICANCE OF BLOCKCHAIN

In this section, blockchain applications are reviewed, to show the successes, significance, and level of adoption of the technology. Khun et al. designed a decentralized blockchain application and called it TokenTrail. It focuses on traceability requirements of multi-hierarchical assembly structure [21]. The architecture was based on consortium Ethereum network, which ensures a trusted and shared database within an economic processing framework. The framework addresses risks identified for conventional systems as well as cost and data risks that arise from the interference of intermediaries. Testing scenarios were created using Hyperledger Fabric to study different criteria and use cases for healthcare applications. They evaluated representative test case scenarios to

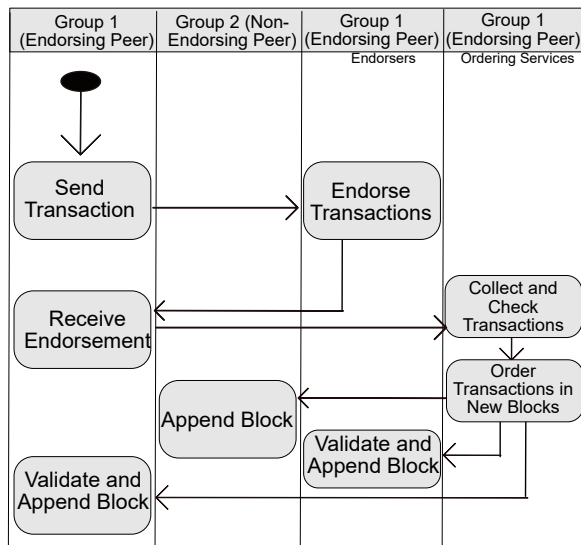


Figure 2: Consensus in hyperledger fabric

assess the blockchain enabled-security [4]. R3 is an enterprise software company that leverages on blockchain technology to enhance business enterprise. It ensures business transactions are managed among peers concerned without exposing other participants in the network. It accommodates over 200 firms most of which are banks [6]. The above examples show the acceptance of blockchain both in literature and in practice. Therefore, the technology may also be useful for payroll systems.

4.1 Blockchain adoption in developed and developing countries

Blockchain is adopted and utilized in many developed and developing countries. Georgia, a country in Europe, was the first to store land titles on a blockchain platform. The country’s land registry has been using blockchain since 2016. In 2017, the project was extended to accommodate land services like mortgage, new title deeds and sales [40]. Similarly, Dubai also runs its land registry on a blockchain. The government has recorded 56 000 transactions on blockchain with a total value of Dhs 228.5 billion which is equivalent to 51 billion pounds in 2018, ranking the city 10th position globally for property registration [12]. On the other hand, Honduras’s government also built a similar blockchain land registry but it was unsuccessful due to the rigidity and inflexibility of their present non-digital land record system [37].

Estonia has been using blockchain for over a decade. In early 2017, the country transferred one million of its citizens’ record on the blockchain network [22]. The country later expanded its use of blockchain to cover security, legislative, health and other registries. The Estonian Guardtime (Estonian Software Company) developed a keyless Signature Infrastructure (KSI) to protect the network against threats. In view of this, the American government paid Estonia and Galois 1.8 billion dollars to study and verify the

KSI system [11]. Singapore’s government uses blockchain to prevent bank and invoice fraud. The technology’s algorithm can reject duplicated invoices issued by customers. Before the implementation of blockchain technology, the sum of 200 million dollars was defrauded from Standard Chartered Bank due to duplication of invoices. Blockchain does not allow duplication, hence, duplication of invoices is no longer practicable [27].

5 CORRUPTION AND GHOST WORKER FRAUD IN DEVELOPING COUNTRIES

This section reviews the related literature that provides the necessary background on corruption and ghost worker fraud in developing countries, and on the Integrated Payroll and Personnel Information System (IPPIS) in Nigeria. IPPIS is the payroll platform the Nigerian Government uses to pay its employees.

5.1 Ghost Worker Fraud

Ghost worker fraud refers to all practices relating to employee impersonations that have salary cost effects. A ghost worker is a person included fraudulently on a payroll who does not do any work yet still collects salary. Ghost worker can also be an employee who has died or resigned from the company, but their data remains active for the benefit of other persons [19]. In Nigeria, billions of Naira (millions of US dollars) is spent on individuals who have not worked and have no reason to be paid. From 2014 to 2016, 84 000 ghost workers were weeded out of the government payroll system after careful and systematic screening [28]. Also, In 2021, Borno State Government discovered 22 556 ghost workers in its payroll, this was costing the government 420 million Naira which is equivalent to one million US dollars every month [42].

Ghost workers fraud in the Nigerian context are enabled by the centralized payroll systems it currently uses [26]. After assessing and analyzing relevant literature Mbuh et al. concluded that ghost workers cannot be eliminated no matter the intensity or complexity of the system [26]. Similarly, in a recent study, an empirical research using nonprobability sampling methodology was conducted based on face-to-face interviews and structured questionnaires on payroll fraud, it was found that payroll fraud can only be minimized but cannot be eliminated because there is no shared responsibility among heads of ministries, department, and agencies [36]. The study suggests that government requires a robust computerized system that will minimize and monitor the inflow of ghost workers. In the same vein, the issues of ghost workers fraud was examined using the Fraud Management Lifecycle and discovered that ghost workers inflate the wage bills and cut down employment opportunities for qualified applicants [31]. More so, the phenomenon of ‘identity masking’ and its implication in California Central Valley was reviewed. Through Interviews and fieldwork, it was revealed that supervisors usually take advantage of migrants and minors for employment purposes, rendering them ghost workers. They hid victims’ identities from the government and enjoy massive wage deductions from the ghost workers [17]. In Tanzania’s public universities, it was reported that there were numerous cases of ghost workers and exaggerated wage bills. It was found that there were 19 700 ghost workers in the payroll system. Measures for preventing

payroll fraud such as transparent employment policy and regular audits were recommended [25].

5.2 Integrated Payroll and Personnel Information System (IPPIS)

IPPIS is a computerized Human Resource Management Information and Payroll System that used by Ministries, Departments, and Agencies (MDAs) to perform various human resource functions. Implementation of IPPIS was part of public service reform programmes aimed at strengthening accountability and improved service delivery through the automation of human resource functions and providing reliable and timely information for decision making. Emanghe and Amoramo [14] examined the influence of IPPIS on the sustainability of university education in Nigeria after Covid-19 pandemic. The study revealed that university education in Nigeria after Covid-19 pandemic is significantly influenced by accurate budget estimates and the elimination of payroll fraud. The authors recommend that university budget estimation should be made through automation in order to guarantee sustainability.

Paul and Grace [34] explored electronic governance and corruption in Nigeria, combining insight from IPPIS implementation. The authors investigated the extent into which IPPIS reduces corruption in the Nigeria Public Service. They stated that there are mixed reactions regarding its effectiveness. The findings, however, support extending the application to all MDAs. They recommend that users should be constantly trained and encouraged to be upright while discharging their duties. In another study, [43] discovered that the implementation of IPPIS violated university autonomy. Meanwhile, Abdulsalam Nasiru et al., [1] investigated the impact of IPPIS on transparency in government payroll administration in the Nigerian Civil Service. It was a descriptive cross-sectional survey research design where questionnaires were administered. It was discovered that there is a significant relationship among IPPIS, transparency, and accountability. The authors recommend that government should strengthen the internal control mechanism of IPPIS so as to continuously and effectively deal with fraud and carry out routine audits and inspections of the application. Several studies recommend the improvement of IPPIS [2].

5.3 Why blockchain-base network is an option in curtailing ghost worker fraud in developing nations

In decentralized network, stakeholders in organizations must reach a consensus before approving transactions which is difficult on centralized systems [46]. Clients securely transmit files or transactions on fully decentralized network using end-to-end encryption which eliminates manipulations or data failure that arise from centralized networks [46]. Consensus protocols also plays important role in decentralized systems, it provides better solution for consortium blockchain as their number of nodes and security threats are lower [29].

Another advantage of using blockchain is its decentralized storage. Using blockchain-based storage system strengthens privacy; Attribute-based Encryption (ABE) is an important tool for solving privacy issues in cloud storage system because it permits it permits private key generator to access data. Blockchain provides users the

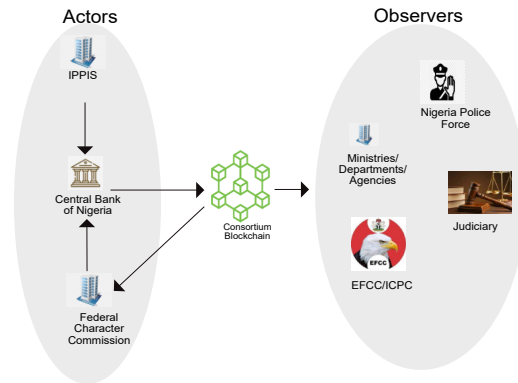


Figure 3: Proposed IPPIS blockchain-based framework for curbing ghost worker fraud

ability to generate distributed secret keys [7]. Security is another important reason for IPPIS in Nigeria to be decentralized. Files on a decentralized network are broken into fractions and distributed to different storage providers, a malicious node cannot decrypt a file completely, unlike the centralized storage system. In addition, data is stored in at least three or four locations, so if one location failed, it will not disrupt the whole system and data can still be accessible from other locations.

The use of reputation system in blockchain is another advantage. Reputation system is a mechanism that measures how community trust a node, based on previous transactions. The greater a node's reputation, the more trustworthy it is on the network [9].

6 PROPOSED FRAMEWORK FOR BLOCKCHAIN-BASED IPPIS

The framework proposed the integration of blockchain technology in the existing Integrated Payroll and Personnel Information System (IPPIS). Thus, there are two sections as shown in Figure 3, the IPPIS and the blockchain sections. While the IPPIS deals with the payrolling part, the blockchain stores immutable and transparent records of old and recent employees. These records shall be shared with other concerned agencies of government. The shared records are seen simultaneously by the other agencies responsible for fighting and preventing ghost workers. Immutability will enable fighting ghost worker fraud by providing a tamper-proof record so that records could not be altered at a later time. The blockchain will make all transaction records traceable and transparent simplifying auditing. Ghost worker fraud will become more difficult as all new recruits will be seen and monitored by police, judiciary, and other institutions responsible for fighting corruption, such as the Economic and Financial Crimes Commission (EFCC) and Independent Corrupt Practices Commission (ICPC).

6.1 Framework Architecture

The framework will comprise of the IPPIS, the government agencies concerned (Ministries, Departments, Agencies, Police, EFCC, Judiciary) and the shared blockchain ledger at the heart of the system as seen in the figure below. There will be two distinct groups of participants. The first group members are the actors which consist of the

IPPIS, Central Bank of Nigeria (CBN), and Federal Character Commission, while the second group members are the observers consisting of the police, judiciary and the MDAs. IPPIS sends monthly payroll to CBN for regular monthly salaries. CBN checks if there is an increment of staff based on the previous month's records. If there is an additional staff, then it (CBN) passes records to the blockchain shared ledger where other nodes are updated. The Federal Character Commission (FCC) plays an important role, it checks if the additional employee is legitimate and due process was followed during the recruitment. If due process was followed, then the Federal Character Commission (FCC) notifies the CBN and the CBN updates the blockchain. Each member of the network can query, view, and trace any transaction that needs to be audited or checked.

6.2 Proposed blockchain structure

The conventional blockchain structure is comprised of the block header and body. The head houses the metadata of the block while the body accommodates the transaction data as shown in Figure 4. The proposed structure will be a bit different from the conventional type. We introduced Agency ID in the header to be able to identify the sending agency for traceability and consultations. Agencies can be authenticated by a digital certificate which acts as an electronic credential and verifies that the person presenting it is truly who he claims to be. The transaction data will consist of Agency ID, employment type and position. These details will represent a single transaction.

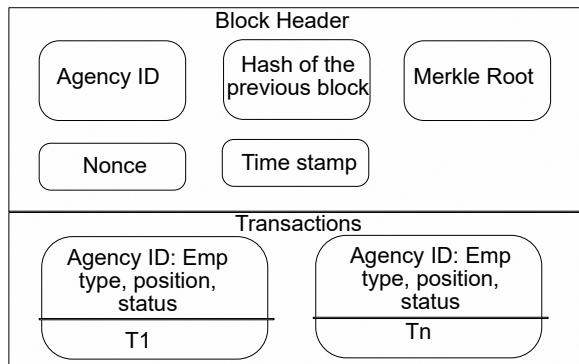


Figure 4: Proposed IPPIS blockchain-based block structure

6.3 Proposed consensus mechanism

Consensus in blockchain solves trust issues and make operations transparent and efficient. Consensus algorithms existed long before the invention of blockchain technology, it was first realized by Eisenberg and Gale in 1959 [13]. The algorithm was categorized into two; Non-byzantine Fault-tolerant Algorithm and Byzantine Fault-tolerant Algorithm [5] examples of Non-byzantine Fault-tolerant Algorithm include Viewstamped Replication (VR), Paxos and Practical Byzantine Fault-tolerant (PBFT) algorithm etc. On the other hand, Proof of Work (PoW), Proof of Stake (PoS), Proof of Burn (PoB) etc are all examples of Byzantine Fault Tolerant algorithm [5]. Practical Byzantine Fault Tolerant algorithm will be considered for

the framework. This is because our case study has a limited number of known nodes which are relatively trustworthy. Practical Byzantine Fault Tolerant algorithm is suitable for blockchain applications with limited number of trusted nodes [44] and the algorithm as non-proof-of-work avoids the usual high energy consumption and other mining complexities.

6.4 System Implementation

The proposed framework could be implemented with Hyperledger Fabric blockchain to provide appropriate consortium blockchain and other supports, though other platforms could be used instead. Using Hyperledger fabric, the following requirements are placed as follows:

- Peers: All the actors (IPPIS, CBN, FCC) and the observers (MDAs, Police, EFCC, Judiciary) as in Figure 3
- Ordering Service: PBFT consensus will be used by ordering service
- Endorsement policy: For transaction to be valid it must be endorsed by FCC and CBN
- Orderers: The FCC and CBN are the orderers while Police, Judiciary and other agencies serve as non-ordering peers
- Block: Hyperledger has different block header which can be utilized to build this network. The previous block hash, Merkle root and the block number could be retained in the block header. The time stamp and the block creator ID are recorded in the metadata section of the Hyperledger fabric block. All actors and observers receives block of transactions but only the actors determine the validity
- All other settings for the Hyperledger fabric are retained

6.5 Securing of the proposed system

Consortium blockchain is supported and secured by cryptographic approach. It ensures integrity, authenticity and non-repudiation by using hash function and digital signature [16]. Its distributed structure achieves a unified view through consensus protocols. The proposed framework will protect stakeholders from man-in-the-middle attacks and other forms of cyber-attacks because transactions will be cryptographically authenticated using digital signatures. More so, to strengthen the network from attackers taking control of consensus process, we recommend the integration of BrainChain approach. BrainChain is a scalable and efficient scheme that detects and mitigates attacks against taking over control of consensus process in permissioned blockchain [18]. Experimental results show that BrainChain can quickly and effectively detect and mitigate the attacks with high accuracy and an ignorable false positive rate which makes it a promising scheme to protect blockchain applications from DNS attacks.

7 CONCLUSION

Many developing countries particularly Nigeria have not tapped into blockchain technology yet. One of the foremost problems confronting the Nigerian government in terms of unemployment is the issue of ghost workers fraud. Ghost workers fraud has not only caused unemployment but also inflate wage bills and cut down employment opportunities for qualified applicants. In this paper, we propose an IPPIS blockchain-based framework to tackle ghost

workers fraud in Nigeria. We believe the framework when developed and harnessed properly will help prevent ghost workers fraud and so support growth and development in the country.

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