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BloFoPASS: A blockchain food palliatives tracer support system for resolving welfare distribution crisis in Nigeria

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ABSTRACT

With population rising to approximately 200 million Nigerians – fast-paced, urbanization has continued to advent food insecurity with maladministration, corruption, internal rife, and starvation. These, threatened the nation's unity with the lockdown of 2020; and consequently, have now become the trend. Nigeria must as a nation, re-examine her methods in the administration of palliatives (in lieu of food and relief) distribution – as the above-listed issues have become of critical need in the equitable distribution of reliefs, both from the humanitarian agency view, and the Government (State and Federal). They have noticed non-transparency, corruption, and data inadequacies, as major drawbacks in its management. Our study presents a blockchain ensemble for the administration of food palliatives distribution in Nigeria that first ensures, that all beneficiaries be registered, and the food palliatives are sensor-tagged and recorded on the blockchain. Results show the number of transactions per second and page retrieval abilities for the proposed chain were quite low with 30-TPS and 0.38seconds respectively – as compared to public blockchain. Proposed ensemble eliminates fraud that is herein rippled across the existing system, minimizes corrupt practices via sensor-based model, provides insight for stakeholders, and minimize the error in reported data on the supply chain.

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1. INTRODUCTION

The emergence of COVID-19 and the global challenges experienced therein with the pandemic lockdown [1] – surprised many nations and unveiled their unpreparedness to tackle the range of multi-faceted issues [2], and Nigeria is a case in point [3], [4]. The era witnessed a range of complications such as the closure of school infrastructure [5], the adoption of social distancing to curb spread [6]–[8], restricted migration of residents [9], and wearing of nose-masks [10]. Post-COVID-19 reports revealed: (a) nations experienced food insecurity [11] – necessitating the distribution of reliefs/palliatives by both Federal/State Governments [12] alongside donor agencies as means to placate hunger [13], [14], (b) that the closure of

public facilities had disruptions with negative learning outcome [15], [16], and (c) witnessed short-and-long-term costs and economic implications (e.g. instability with adjusting to new realities, and adapting to these new paradigms as the new normal) all across the world [17]–[19]. Career path for social welfare administration is the integral practice of the profession called social work [20], [21]. It portends to imbibe and advance the principles of equity and non-partisan perspectives/ideals. It upholds tenets on which social justice is anchored [22]. But, the progressive rise in corruption in the Nigerian government – not only advances the dearth of social welfare and injustice [23]–[25] it is become emboldened with her officials decorated as togas of unscrupulousness as well as is now painfully paraded with impunity within her almost every fabric of governance [26]–[28]. This has continued to cripple whatever chastity and sanctity remain [29] as studies have noted that her governance is bedeviled by the crisis of maladministration, internal rife, and corruption. Nigeria, through her various tiers of governance, must rejig her policies and robustly enforce them, if we wish to get back on track with sound governance of her citizens [30]–[32].

The diversion of these palliatives (i.e. food and drugs) has since become a global challenge and norm for many nations. Food assets often traverse a vast chain of farmers, processors, distributors, wholesalers and retailers, transporters and storage facilities before reaching the end-users [33]. Whatever the food produced, it must undergo pre-, production, and post-production phases – making this journey, an unseen dimension with varying uncertainties. However, diversion of food, incorrect and unauthenticated record transaction(s), data pilferage, inefficient transactions, lack of trust among chain partners, and other corrupt practices have been found to ripple within and/or fester across the food supply chain [34]. Also, consumers are more interested in the quality, safety and authenticity of foods purchased via online medium [35]. To tackle this as associated with palliative relief response, we aim to implement blockchain technology for pandemic palliative distribution in Delta State. A palliative supply chain is a process that explains how palliatives/relief (i.e. food and drugs) traverse from their source of origin and ends up in our houses. Many welfare administration policies with relief distribution – have been known to face issues such as: (a) credibility and traceability in the system, required by an end-user, (b) difficulty of managing risks, and (c) delays/disruption from the lack thereof and insufficient relief records. The study extends Akazue *et al.* [36] noting the following challenges: (a) the unwillingness of stakeholders to disclose accurate data and framework processes for the employed palliatives value-chain, (b) that State/Federal Government had no palliatives supply chain model, and welfare administration witnessed unregulated policies, rife with nepotism and corruption, (c) no measure to precisely and timely disseminate data to stakeholders on the chain, and (c) previous models did not provide the needed user trust-level, system transparency, and transaction security and transparency to ensure palliatives distribution is crisis-free, especially as it pertains to PSC quality and safety. We implement a blockchain-based food palliative support system (BLOFoPASS) via an RFID, hyper-ledger fabric to aid improved administration, transaction authentication/validation with distribution ease – to eliminate fraud, corruption, and other errors.

2. MATERIALS AND METHODS

2.1. Food palliatives distribution crisis

The increased globalization as well as the quest for a system to implement the distribution of funds and material reliefs (or palliatives) by a nation's government to her citizen – has birthed traceability systems [37] due to the sensitive nature of policies formulated around such events and consequent implementation. An example – is the food supply chain (FSC) – which details a plethora of technology, tools, and processes used in the distribution of food(s) as an asset, usually from its origin (or source), and via the various actors on the chain till it finally reaches its asset consumer (or destination) [36]. The FSC is a dynamic, complex, and chaotic process with a range of issues from regulation, standardization, transportation, food quality and safety, the performance of the traceability system, and its overall inefficiencies [38]. The FSC consists of a set of chained or linked activities such as production, processing of foods, data acquisition and recording of the processed food, and product consumption [39]–[42]. The dynamic movement of the food on a chain constitutes a complex process whose behavior impacts are directly proportional to the performance of the system therein [43], [44].

Traceability systems for the food supply chain have been found to yield some benefits including (a) data transparency, (b) food chain efficiencies and collaboration for optimized food production and processing, (c) food quality and safety via an effective distribution and recall chain, (d) reduces food wastage, and (e) reduced risk for businesses and consumers [45]–[48]. It is thus, imperative to formulate policies in Nigeria to help monitor and administer social welfare palliatives distribution via the internal/external frameworks (a set of plan-do-check-act events) of a food supply chain [49]. It must become a concerted effort that seeks to address the many inherent concerns that include (and not limited to): (a) dysfunctional maladministration of palliatives [50], (b) ineptitude and internal rife [51], (c) unavailability of a

traceability FSC-system [52], and (d) corruption due to unavailable records vis-à-vis distribution of the palliatives [29], [49].

Food security ensures the availability of food, and the consequent capability therein – to access the food asset anytime, anywhere – and to therein meet the dietary nutritional needs of its consumer provisioning a healthier life [37], [53]. A food traceability system enables partners and stakeholders on the chain – to both be able to distribute assets as well as recall such assets when found to be defective, for food provenance. Thus, it propagates food safety and quality – aiding partners to trace an asset's journey from the pre-, production, and post-production phases. It thus, leads to the deployment of a transparent and authentic record-chain for a food ecosystem. The ensemble will mitigate waste, encourage partner collaboration, reduce economic burden to recall assets, contamination of the food assets, and disease outbreaks. Also, with the plethora of people, technology, and processes involved in the production, processing, and delivery of this food asset due to its sensitive nature (either purchased or as palliatives), the former ushers in a minefield of unknown impediments that can degrade performance and introduce diseases to the food asset chain among other challenges. The birth of the advent heralded online mode of food assets distribution via the use of the Internet. Examples include JumiaFood, Olingo, and Glovo [36].

2.2. Welfare and relief distribution in Nigeria

The crux or focal point of social welfare administration – is its capability to always critically appraise the processes and management of assets to be distributed. The COVID-19 era witnessed palliatives as distributed by both Governments and donor agencies. These, however, also came with flaws and crises as observed and generated by the social s system in Nigeria. With the palliatives distribution – studies report that the many ills within the social works infrastructure yielded the painful experiences of the common citizen; And, these can be attributed to (a) the possible lack of data, (b) ineptitude of the approach adopted/adapted, and (c) lack and shortage of staff vi-a-vis their unprofessionalism of conduct [54]. The crisis with palliative distribution was obvious as the outcry resounded with a thunderous clamor of marginalization, outright neglect of governance, and the aloofness of government officials.

Studies have reported many of these accounts, with a view for a nation like Nigeria to rejig her policy formulation [55] and enforcement process, to monitor and evaluate challenges to the existing system without necessarily betraying the just quest for omnipotent advocacy in social justice cum transparency in her governance [30]. Thus, the government must have a purposeful need to tame its public officials from sequential inclination to corrupt practices [9]. It is evident that a lot of financial aid both in monetary and material form, was generated through foreign and local donors to assist citizens of this nation during the lockdown; Yet, these funds and material incentives were largely hijacked, hoarded by, and/or appropriated on to personal use of these official [56], [57].

In a bid to curb the spread propagation of the COVID-19 pandemic, many governments issued directives/policies of social distancing policies and closure of public gatherings in schools, market places – to mention a few. This, in conjunction with the lockdown protocol – rippled the crisis and uncertainty of food security in Nigeria. To placate and minimize the impact of such policies – both the Federal/State Government(s) initialized the campaign for social welfare via food distribution and other relief materials (especially for vulnerable citizens). These were aimed at cushioning the food insecurity effect throughout the nation [21]. In April 2020 – Delta State Government established several food banks located at Ibusa, Kwale, Sapele, Warri, Asaba, and Otujeremi. However, various criticism were sparked by this namely: (a) palliatives were not distributed to deserving citizens, (b) they were often divided along party lines with the people's democratic party as the ruling party, and (c) corruption and nepotism via the stock-piling of the palliatives [36].

2.3. Proposed blockchain methodology with data analysis

The palliatives supply chain yields a tracer management system with various dynamism, complexity, and functionality. Figure 1 presents a management scenario with 5-stakeholders as: donor, local government, ward(s) in the local government, polling units within the wards, and residents in the polling units.

Each stakeholder category consists of members that undertake and plays the same role(s) in the traceability support supply chain. The chains represent smart-contracts that runs on a blockchain. Each chain seeks to process a business transaction logic of the support system, and uploads the palliatives traceability data of all the stakeholder to the chain [58]. The target consumers – are residents and users to whom the palliatives, are to be distributed to; while users as stakeholders – are the auditors who can query the database for the complete traceability data of items and relief materials made available by the donor via the chain-5.

The BLOFoPASS provides target consumers and users (and representatives of the Federal/State Government and/or donor agency) with a history of donated reliefs and distribution mode as in Figure 1. With the requirement analysis, process inquiry, data design, and major technical activities – we model the smart contracts as a gateway to *K-chains* with capable transaction rules. With registration, each target

user/consumer is ceded a public and private key pair to digitally sign each operation on the distributed ledger. The framework employs weights all through the value chain – as means for internal validation and checks – such that on detecting anomalies (such as the address of stakeholder, transaction batch, and transport), they are easily flagged by the system [59], [60]. Listing 1 is the algorithm for implementing the BLOFoPASS system.

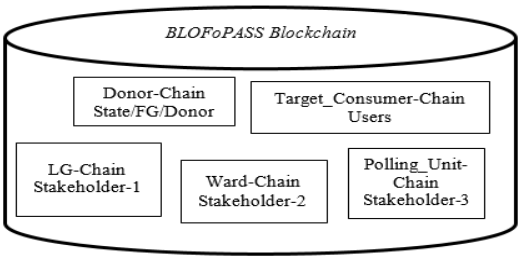

Figure 1. The BloFoPASS framework

Algorithm 1: Listing of the BLOFoPASS Chaincodes for the BLOFoPASS Framework

```
INPUT: get Donor_address_list, get Recipient_address_list, get p-bank_address,
get_transport_infor()
function check (input_adres): START
if (input_adres = = donor_adres) then
   return true: else endif
end
function insert_data (new-record: (paliativeID, batch_paliative, pal-bank_adres,
transactionID_transport): START
if true ←function check (pal-bank_address, transactionID_transport) then
   return transactionID_batch ←record_a_transaction (sha256(new_record)): else endif
end
function create_wallet (stakeholder_infor): START
if True ←function check (pal-bank_adres, transactionID_transport, input_addres) then
   return pal-bank_address ← wallet(stakeholder_infor): else endif
end
function enable_stakeholder (stakeholder_adres, pal-bank_adres, paliative_infor,
stakeholder_type): START
if True ←function check (pal-bank_adres, transactionID_transport, input_adres) then
   if (stakeholder_type = = known_stakeholder) then
   map_paliative ← put(stakeholder_infor, paliative_code);
   palliative_list ← add(stakeholder_infor);
   return true
endif: endif
function batch_paliative_insert (stakeholder_infor, paliatives_code,
paliatives_list_infor()): START
if True ←function check_map_paliative (pal-bank_adres, stakeholder_infor,
transactionID_transport) then
   return batch_transactionID ← record_transaction(sha256(paliatives_infor()): else
   endif
end
function palliative_send (stakeholder_adres, batch_transactionID, pal-bank_adres,
paliatives_quantity): START
if True ←function check_property (batch_transactionID, stakeholder_adres,
paliatives_quantity) then
   return transactionID_transport ←record_transaction (pal-bank_adres,
   transport_data): else
end if: END
function paliatives_recieve (stakeholder_adres, transactionID_transport): START
if True ←function check_recieved (stakeholder_adres, transactionID_transport) then
   return batch_transactionID ←record_transaction (stakeholder_adres,
   transactionID_transport): else
end if: END
```

2.4. The proposed BloFoPASS structure and chaincodes

The chaincode(s) as in Figure 2 shows various transition of palliatives between the various states of donor-stakeholders-user(s)/target_consumer – and details how the palliatives are distributed and change their state from one stakeholder to another. It also shows how these transactions use the smart-contracts logic to execute and regulate these transitions and thus, yields system traceability transparency and efficiency as these palliatives transit between the unique states [61].

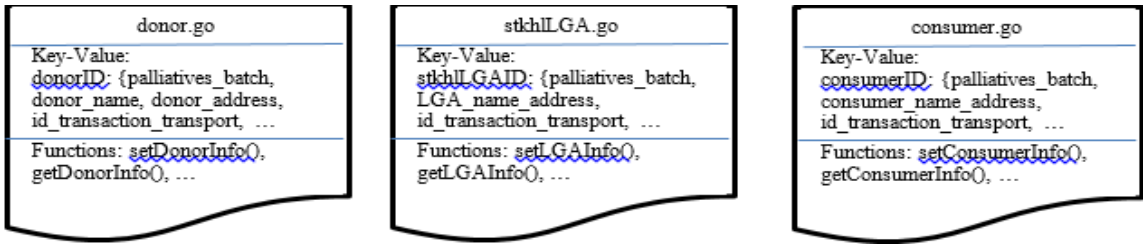

Figure 2. The deployed BloFoPASS structure and chaincodes

The BLOFoPASS (palliatives) asset records and states are stored in the ledger. Details of the smart contracts is as below [62]–[65]:

a) Stage 1: Ledger State – The palliatives represent a set of properties with assigned values – which creates a unique keyset as well as the state of the palliative. The palliartives_list, which is the complete keyset and the state of the palliative(s) is initialized as a record in the world state on the hyper-fabric ledger. It supports several states with various feats/attributes that allows the same ledger in its world-state to hold various forms of the same palliative, and different types of palliatives for use and adaption in compound social welfare palliatives administration (since relief and palliatives can mean items and products ranging from food, and drugs, on a supply chain). This – ultimately makes possible the capability of the system to evolve and update its state(s) and structure).
b) Stage 2: Proof-of-Trust – With a variety of roles (i.e. donors, stakeholders, target consumers, and users) alongside the varying transaction(s), transition of the palliatives amongst the various stakeholders, how different business interests ascertains who must approve a transaction, and also how individuals state keys work – are enshrined within the smart contract. This means that in BLOPASS, we set a rule in the namespace to define a business that processes a specific food, and later, set another rule to update all processed food assets to portray trust relations of the trade transactions. These concepts can be combined to implement the smart contract.
c) Stage 3: Smart Contract – Here, a smart-contracts code set all valid states for a food and the logic that transitions an asset from a state to another. Smart contracts are essential as they help us set key-business processes and information to be shared across various organs interacting on the network. It defines the various states of a business manages the various processes to move an asset between these states. In the BLOPASS network, the same smart contract is shared and used by the different nodes and by the different applications connected therein. Thus, it jointly executes a shared business data and process. All members of the network must agree a specific version of smart contract to be used.

3. FINDINGS AND DISCUSSION

3.1. Throughput measure by transactions

We used the Riverbed Modeler 18.0 for test test metrics. Throughput determines a system's capability for the rate of actual data transfer within the system over the period as in Figure 3. Using this metric – we seek to measure and ascertain the number of transactions performed or run on the network per second, for the proposed BLOPASS. This can be efficiently seen as in Figure 3. Figure 3 reveals that the number of TPS obtained from graph is in tandem with [66] whereas the TPS for public-chains like Bitcoin, Litecoin, and Ethereum were observed via corresponding metrics test, to be quite low (i.e not above 30-TPS) [67]. This can be attributed to their being public chains that operate with a consensus mechanism via their adoption of proof of work (PoW).

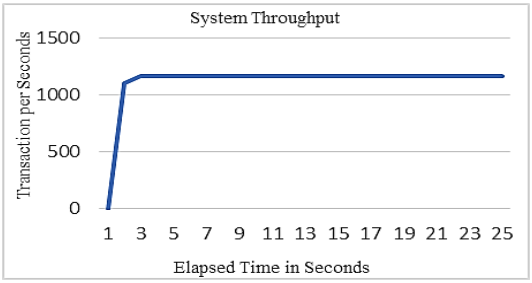

Figure 3. The BLOPASS framework throughput

The proof of work mechanism enables users to compute the problem during mining process [68] and it requires a lot of computational power and processing time. For example, it takes the Ethereum about 7 minutes to generate a block [69]. As above, these make such public chains ineffective to meet the needs of traceability management implementation. The observed TPS for this framework is about 1105.

3.2. Application response time performance

This performance metric seeks to determine the time interval between a user's request and application response time for feedback to the user. We achieve this by measuring the response time from a query on the https page as in Table 1 – which presents two (2) scenarios namely: (a) a population size of 2500-stakeholders (consisting of donors, stakeholders at the LGA/Ward/Poling units, users, and target consumers), and tripling the size to 7500-stakeholders from the varying categories. Thus, in the first scenario as shown in Table 1 with a population size of 2500-users, the response times for the queries were obtained as about 0.38seconds and 0.32seconds for the https pages retrieval [55]; For scenario 2 – there was naturally a longer response time of about 0.40seconds and 0.35seconds respectively for both the queries and https pages retrieval.

Querying traceability data implies reading data from the blockchain (hyper fabric) ledger, stored as a world state (i.e. a database that records only key-value pairs). Through the world-state, a query can retrieve directly the current key value (s) of a record sought for, without it traversing the whole ledger. This will improve the effectiveness and efficiency in the BLOPASS traceability network as agreed by [36].

Table 1. Application response time with scalability results

Transactions	Case 1		Case 2	
	Time	Population	Time	Population
Queries	0.38sec	2500	0.40sec	7500
Https	0.32sec	2500	0.35sec	7500

3.3. Disucssion of findings

The proposed traceability support system uses chaincodes to control query permission(s) and other transactions on the nodes; Thereby, protecting target_user privacy data effectively as in agreement with [36], [55]. Furthermore, we observed stakeholders' (i.e. donor and users) roles were encrypted via SHA256 protocol to secure sensitive data [70], upload to the chain, and prevent data leakage [71]. The ensemble divides the roles into five (5), represented via 5-chaincodes on the hyper fabric ledger [72] to help effectively handle the business transaction logic on the chain [73]. The model control was deployed via chaincode permission and encryption mechanism to enhance data security and privacy control for the support system traceability model [74]. The resulting model showed a low response time to the query request, alongside stable time convergence for the application throughput.

4. CONCLUSION

We present a palliatives support system based on a permissioned blockchain framework. This work has made these contributions: (a) employed the hyper fabric ledger for permissioned blockchain ledger to record world-state key values of generated blocks on the chain, (b) used a radio-frequency sensor-based data collection mode to identify the palliative(s) record on the framework, and (c) optimized the BLOPASS support system for food palliatives traceability and social welfare administration in Nigeria. The model sought to tackle the palliatives distribution crisis (concerning food and drugs) inherent in the social welfare administration of reliefs cum palliatives in Nigeria – through a high-performance, open-sourced, and user-friendly permissioned chain support model with transaction privacy and confidentiality.

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