

Intelligent Peer-To-Peer Banking Framework: Advancing The Frontiers of Agent Banking For Financial Inclusion In Nigeria Via Smartphones

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Abstract

The advent of the retail point of sale (POS) system as a critical component of the traditional retail infrastructure seeks to advance client payment-ease for goods and services rendered by vendors as well as the effective collection of funds by the vendor. It also aids the vendor to collect in advance monies that the client may wish to spend later on goods and services. Thus, the POS has since become a necessity in modern retail stores as its increased usage has seen a transformation from a single machine to a cloud and smart platforms. Our study seeks to model a conceptual framework for decentralized POS as adapted to smartphones. This will enhance cashless transaction irrespective of a customer's location globally and locally. Built around the block-chain technology, it seeks to minimize challenge(s) of time, installation requirements incurred with the adoption of automatic teller machine (ATM), location and citing of agent-banking in a rural area with low tele- and tech-penetration.

Keywords: Block-Chain; agent banking; cryptocurrency; android platform; smartphones;

1. Introduction

The scope and speed of evolution in the customer behavior, banking regulations, the many emergence of competitors as well as the emergence of new technologies (as the future portends) – implies that future banking will not be a continuation of the past (Kurose and Ross, 2013; Ojugo and Eboka, 2019a; 2020a). This is because new technologies will emerge to transform the banking industry and revolutionize the entire process by providing both opportunities and challenges to many financial institutions. The global market had its financial crisis that saw the almost and near-collapse of the economic system. And with the passage of time, the banking industry has largely recovered from a financial perspective; while, capitalization has improved significantly though with a struggle in the revenue growth as banks tends to cut their operational cost. Many of the banks are playing catch-up with the exponential increase in customer expectations (Morris, 2016; Popper, 2016). These features and other factors as in figure 1, makes the banking industry and business even more difficult as many tech companies are redefining boundaries with banking solutions that use insight and digital technologies to Improve customer experience across the many banking product lines. These new competitors threatens legacy financial institutions of all sizes such that failing to respond to these changes – may eventually lead to the demise of less agile organizations (Wemembu et al, 2014; Ojugo et al, 2013).

In Nigeria, the scene is not left out as a relapse of the banking institution to meet with the client needs in relation to the adoption and adaptation of emerging technologies, will see such legacy banking institutions losing revenue (Okonta et al, 2014; Ojugo and Eboka, 2019b; 2020b). But, some merits of these technologies (inasmuch as they portend doom and lose of revenue for non-complaint banks) – is that they also proffer benefits and opportunities that these banks can leverage upon such as Big Data, advanced analytics and other new techs to improve the customer

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experience, build further client trust, loyalty and increase revenue for the banking institutions. It is projected that there will be a 30% increase in operating profits for banking institutions that adapt digital techs by 2020 (Ojugo et al, 2013a; 2013b).

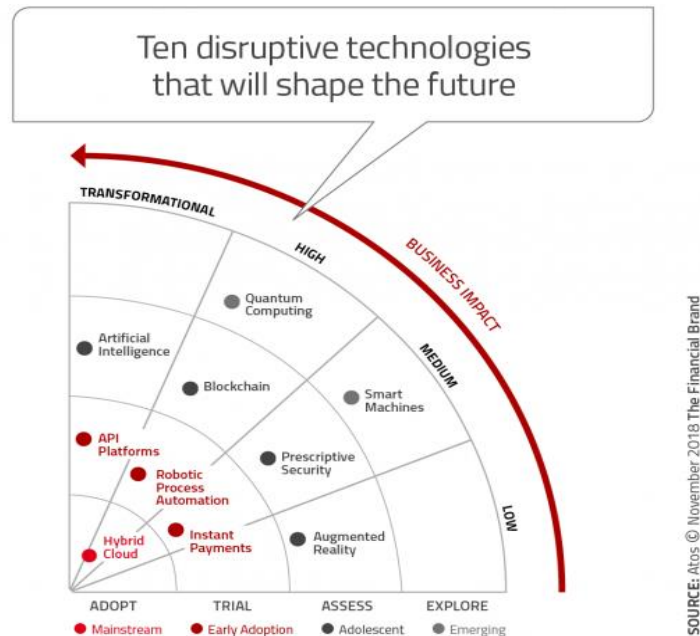


Fig. 1: Ten Technologies to shape future Banking

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1.1. Technology in Banking / Financial Institutions

Technology is changing the way many businesses operate and deliver products to consumers in many sectors. It highlights that banks are at a crossroad in that the advent of financial techs and new techs such as block-chain will continue to disrupt the financial market. Thus, though these techs creates threats – they also unveil many opportunities for financial services to reinvent themselves and thrive beyond all odds (Ojugo and Eboka, 2014; Oyemade et al, 2016; Ojugo and Otakore, 2018a). Some features that will impact the financial market in the nearest future will include (Ojugo et al., 2015; Oyemade et al, 2016):

1. Financial institutions need paradigm shift from physical interactions to digital engagement of a client experience. This will improve the growth in revenue, reduce operational cost as well as improve customer experience
2. The efficiencies of digital-only competition will have banks investing more in intelligent automation. Thus, optimizing their investment cost through reinvention of their back-office processes and the consequent replacement of aging infrastructure to reduce in the long-term, operational cost.
3. Adaptation to open banking will open new frontiers to cost reduction and revenue growth as new product lines will be developed and segments served that will provide differentiated products and monetization opportunities.
4. With customer data becoming product for many financial institutions, the need for enhanced security and insight via artificial intelligence (AI) will become a differentiator from both a compliance and customer trust perspective. This can lead to reduced cost and potential business growth.

1.2. Decentralized Payment System: A Panacea To Financial Inclusion

The Nigerian market is currently witnessing an upward inflow and the incorporation of financial- and new-techs. This inflow includes (and not limited) agent-banking becoming a new way of bringing banks closer to the customers as well as peer-to-peer buying and selling thriving via platforms Jumia, Konga, OLX etc (Ojugo and Otakore, 2018b; Ojugo and Eboka, 2018). This has advanced use and versatility of point of sale (POS) as adopted by many medium-

scale businesses in Nigeria today. However, a step further in this evolution is the advent of the peer-to-peer payment system made more manifest via the block-chain technology bringing about more flexibility, decentralization of the banking process amongst others (Zhang et al, 2011; Dye et al, 2008; White, 2011; Tanebaum and Wetherall, 2010).

The decentralized mobile POS System is a powerful, feat-rich and mobile-enabled software suite that automates the payment system in a given environment. With the 21st century reforms on the circulation and distribution of currency, domestic circulation companies' profitability improvement, sale increase, decrease of circulation expense and necessity to raise efficiency of circulation system is increasing now. And there is an opening of secondary market in the point of increase and pattern change of consumption demand, and internal rise of personnel expenses of purchasing power by elevation of national income level, traffic congestion etc. (Ojugo et al, 2012; 2013a; Yoro and Ojugo, 2019), and circulation company's customer service improvement and buries of various goods, sale. This study is about a method to use POS system that is becoming more important in the world because it is safe and fast (Ojugo and Ekemini, 2019).

1.3. The Android Platform (AP) For Mobile Smartphones

The AP is a leading platform for mobile devices with its open source feat to distinguish it from other smart mobile platforms such Windows Phone and iOS (Ojugo et al, 2015; Agam, 2011; Zhang et al, 2011). It is not a distribution of traditional Linux, neither is it a set collection of replaceable components/software ported on a device. Its open source platform is built by Google with OS, middleware and applications for mobile platforms based on the Linux kernel. Thus, enabling developers write apps in Java with support for C/C++ (Bhupinder and Vijay, 2010; Bray, 2010). Its success in its licensed under Apache2, allows third party porting of other developments to the platform. Since its release, it has constantly been improved upon either in feats, supported hardware, and at same time extended to new device types from the originally intended mobile ones (Maia et al, 2010). Recent efforts on the AP are geared to enhance real-time capabilities so it is used in embedded systems (Divya, 2012; Pernel et al, 2013; Ojugo et al, 2015).

In embedded systems (automotive or robotic), its ability to meet deadlines, time constraints is a critical specification part in its design as such systems must response to stimuli within a certain pre-specified real-time constraints. Thus, the reliability of software has not to focus only on the functional failures but require and detailed evaluation of the ability of the system to meet these timing specifications (Bhupinder and Vijay, 2010). From a device mainly used for phone calls and messages, the mobile phone (smartphone) is become a multi-purpose device. Though, the technology is favored by its size, there exists some limitations such as thermal constraints, battery consumption and computational powers – all of which limits it usage and capabilities. But, Harmen (2012) investigated the possible increase in speed of smartphones by offloading computational heavy app functions via cloud computing. He developed an app used to compute heavy tests, and the results showed that it is not beneficial to use cloud computing to carry out these types of tasks; it is faster to use the smartphone. Ojugo et al (2015) in Pernel et al (2013) and Agam (2011) The AP is an eco-system of software component implemented on the mobile smartphone device or unit infrastructure, eased by its portability, mobility, complex functions now adapted to computer systems etc as in figure 2. Its various components are described as thus:

- a. Linux OS provides basic functionality such as security, process/memory management and networking to support vast device drivers. It handles human machine interfaces, file systems, network access etc. Its kernel is modified by Google to use low memory killer, specific inter-process communication system, kernel log feats, shared memory system and many other changes as developed. It runs standard Vanilla Linux, merging specific changes into its kernel. Recent release aimed at real-time Linux kernel is its v4.0.3 codenamed Ice Cream Sandwich.
- b. Library with Google's *libc* called *Bionic*, media/graphics (OpenGL/ES), browser-webkit and light-database SQLite. DVM (Dalvik Virtual Machine) completely differs from Sun's JVM and uses register based byte code to conserves memory, max performance and can instantiate many of its apps multiple times, with each app having its own private copy running. DVM uses Linux for memory management and multi-threading to support the Java language. DVM uses *bionic* (not compatible with *glibc*) so that its native libraries are faster to implement with small custom *pthread* to support services such as system and logging capabilities. Writable data segments are small so as to be loaded into memory with each process. This keeps code size small so that Linux loads only once, all read-only pages. *Bionic* is used: (a) to avoid inclusion of GPL code at user-level in its platform where BSD is used, and (b) for small memory footprint devices with high speed CPUs at relatively low frequencies.

Bionic libc does not handle C++ exceptions (though omitting such lower level exceptions pose no problem as Java is Android’s primary language. It handles exceptions internally). *Bionic* has no priority inheritance for mutexes as implemented in *glibc*. Available in its kernel and accessed via own library in system calls, its lack of priority inversion disqualifies it for real-time capability as applied in robotics/automotive. Google’s reason for a complete new VM from scratch as accomplished with DVM’s register-based byte code is to reduce patent infringement risk. Thus, existing real-time apps modified for JVM cannot easily be ported to DVM.

- c. Application Framework provides higher-level services to apps such as Java classes amongst others. Its use can vary between and/or with varying implementations.
- d. Application/Widget are Android routine distributed apps such as email, SMS, calendar, contacts and Web browser.

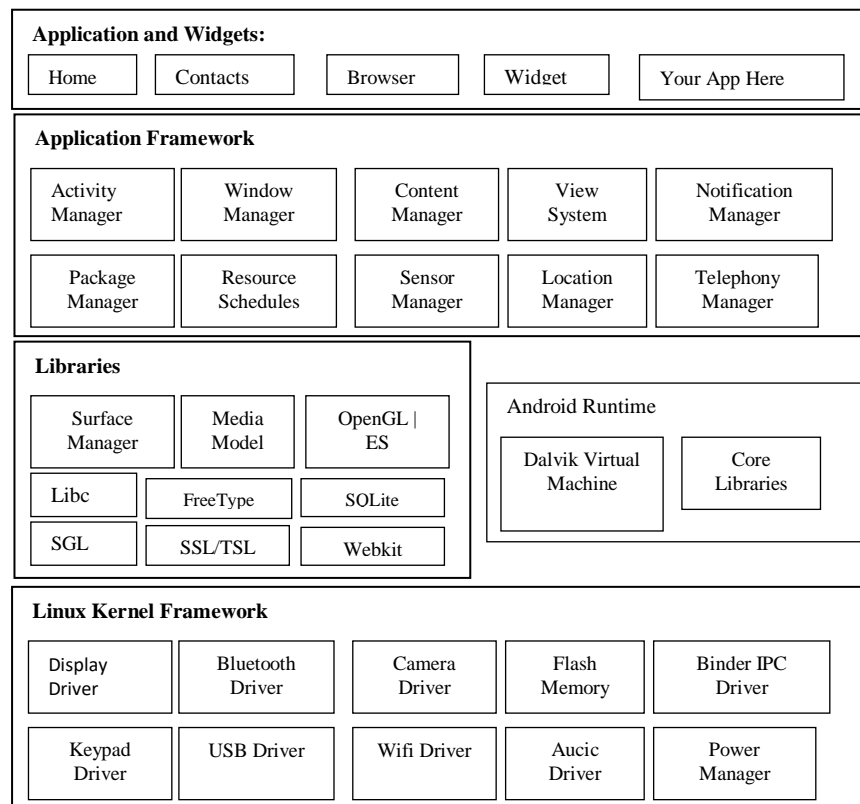


Fig 2: The Android OS Platform

1.4. Formulation of Problem Statement

As we traverse through the various cities, towns and villages across Nigeria – it becomes eminent that tele-penetration is becoming more and more visible. The process of locating a stationary POS or an automatic teller machine (ATM) is often quite burdensome – even with the proliferation of banks and financial institution agents (known as agent banking). Individuals often transport to any stationary agent within their reach; And sometime, having located one – are over-billed on each transaction. Every transaction has a certain fee. This is one of the major reasons customers will prefer to queue at an ATM; instead of paying such transaction charge(s) or fee(s). Often times also, the delay and worries to both the sender and receiver with latency and delays during peak periods – can be quite frustrating. Also, the cost penalties incurred by banks in setting-up, installation of infrastructure and facilitating their reach to their clients (old and prospective) – must be matched by a consequent return on investment for such investment to be embarked upon. Banking institutions have sought to ease these challenges through provision of automatic teller machines (ATM), stationary agent banks and cashback centers that employ the use of Point of sale equipment, to mention a few. These

were aimed to rescue end-users from proximity of location of these banking policies and relieve them of cost incurred in a bid to access these facilities.

While, the abovementioned have witnessed many successes; there are still a few setbacks and penalties cum costs incurred in citing these infrastructures in semi-urban and rural settlements. These includes: (a) over-billed transaction fees by banking institutions through their agent banking and cashback policies, (b) tele-penetration, denial of service and service-provision challenges, (c) stationary point of sale equipment, and (d) inability to retrieve monies from E-Wallets on demand for future use.

The study seeks to address the problem raised above as thus:

- a. It resolves the challenge of over-billing of clients who seek to perform money transfer transactions via the use of this effectively secured and seamless block-chain platform. This, will help clients perform highly secured, peer-to-peer authenticated transactions safely with less transaction fee, irrespective of location.
- b. It resolve the challenges in the cost of setting up and citing an ATM infrastructure, agent banker and/or cashback POS agent in a rural area where there are low incentives or returns on investment (ROI) via its peer-to-peer framework.
- c. It resolves the challenge of denial of service cum service-provision via its adoption as a lightweight Android platform that allows great ease in usability, portability, scalability and mobility.

This solution can easily be powered by banking institutions in Nigeria as a means to buy-in towards effective service provision to better as well as efficiently satisfy their customers. It is also a good product cum platform that will attract investors as well as create employment opportunity in the country. This is because the adoption of information and communication technology (ICT) and the advent of block-chain as a means to further the financial institution cannot afford to leave Nigerian Portfolio behind.

2. The Block-Chain Model, Framework, Structure and Internal Workings

2.1. The Block-Chain: Concepts, Structure and Working

Block-chains have been found to be intrinsically linked to a Bitcoin – though the tech is applicable to all digital asset transaction that can be exchanged online. Block-chain basically uses *cryptographic* proof(s) for any two willing party wishing to execute and/or partake in an online transaction; instead of the *trust license* in the third party. Each transaction is protected via a *digital signature*. The sender initiates an online transaction encoding it with the receiver's *public key* and digitally signs it with his/her *private key*. To spend the money, the owner of the cryptocurrency needs to prove ownership of his/her private key (Nakamoto, 2008; Bahga and Madisetti, 2016). The receiver of the currency verifies the validity of the digital signature (i.e. ownership of the private key on the transaction using sender's *public key*). Each transaction is then broadcast to every node on the network and recorded in a public ledger after verification. Each transaction must be verified for validity before recorded in the public ledger. Verifying a node must ensure two factors namely (Odieta, 2018; Peters et al, 2015): (a) the spender owns both the digital currency and the digital signatures used to verify transaction(s), and (b) the spender have sufficient cryptocurrency in his/her account as the framework must check every transaction against the spender's account (i.e. public key) in the ledger to ensure he/she has sufficient balance in his/her account (Barcelo, 2014).

The block-chain model maintains a digitally distributed ledger that helps it track the order of transactions, as they are broadcasted to every node in the peer-to-peer network. These transactions are not serialized in the order in which they are generated. Thus, the peer-to-peer network employs the ledger as proof of work means (and the need for the system) to ensure as well as avoid the double-spending of a cryptocurrency on the network (Narayanan et al, 2015). Since transactions are passed node by node through the block-chain network, there are no guarantee that the order in which they are received at any one node, is the same order in which the transaction(s) are generated. Thus, they system must develop a mechanism that ensures the entire block-chain network can agree regarding the order of transactions. This is quite a daunting task and feat in such a distributed system. However, the network resolves this challenge by placing each transaction in groups called blocks as can be seen in figure 4a, which are then linked in a chain of blocks through the network as in figure 4b respectively. The transactions in one block are considered to have

happened at the same time. These blocks are linked to each other (like a chain) in a proper linear, chronological order with every block containing the hash of the previous block (Osterland and Rose, 2018).

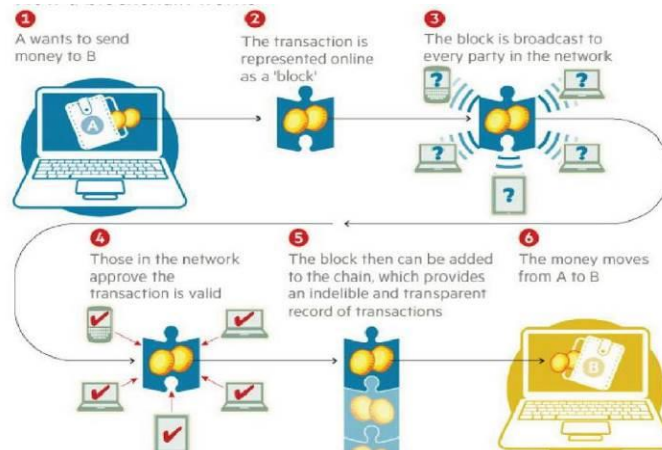


Figure 3: Block Chain Workings

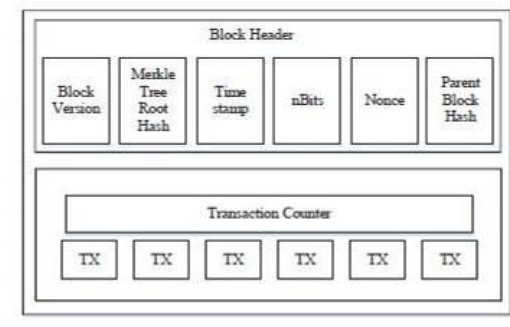


Figure 4a: Structure of a block

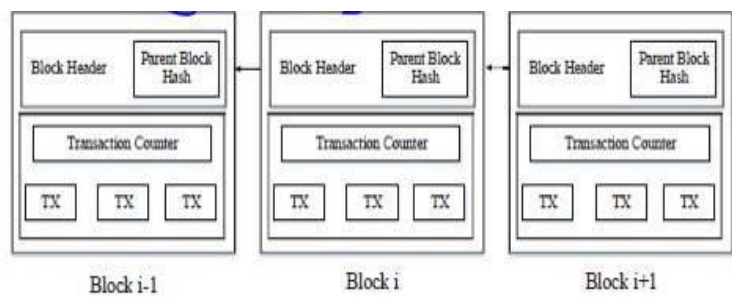


Figure 4b: Blocks transactions on the Block-Chain

2.2. Transaction Maintenance in Block-Chain Model

In many cases just like in the block-chain network, questions abound such as how is the order of transaction maintained since they are broadcasted to every other node in the peer-to-peer (P2P) network. It suffices to note here, that just like the block-chain network in which transactions do not come in the order in which they are generated and recorded on the ledger; There is then need for the system to avoid the challenge of double-spending of the digital currency (Eung-Ha et al, 2013; Sun and Xie, 2013). Considering that the transactions are passed from one node to another through the block-chain network, there is no guarantee that the order in which they are received at a certain node – is the same as the order in which these transactions were generated. It implies that there is a need to develop a mechanism so that the network can agree regarding the order of transactions; And quite a daunting task such a *distributed* system (Lanxiaopu, 2012; Bonneua et al, 2014). The block-chain solves this by first, challenge by placing the transaction(s) in groups called blocks; And then, linking these blocks through a chain. Thus, the name block-chain technology as all transactions in a block – is considered to have occurred at the same time. These blocks are chain-linked to each other in a proper linear, chronological order with every block containing the hash of the previous block (Sharma et al, 2018).

3. Experimental Framework

3.1. Proposed Experimental Block-Chain Model Design

After careful observations with the agent banking model as well as the use of banking mobile applications (that tends to drive mobility and portability of transactions through the use of 2-step digi-pass authentication) by many banks and financial institutions, the following problems remains to be address namely usage issues, software update, system requirements, tracking promotions, mobile compatibility, connectivity issues etc.

However, the adoption of a decentralized network of nodes to conduct intermediary tasks over the Internet is quite laudable. The adaptation of the block-chain model by the proposed system employs these node with the distributed ledger approach, which seeks to eliminate the need for a trusted third party. All transactions are recorded in a digital ledger, and is publicly made available and fully distributed to all member nodes. Each node (member) holds a valid copy of the ledger, the network itself is able to certify asset ownership and clear transactions providing a mechanism with higher security than the current central ledger approach. Each transaction is visible to all (networked) node(s) and immutable once they are recorded in the ledger. Moreover, the distributed ledger seeks to increase transaction speed and decrease transaction cost(s) because all operations are performed via peer-to-peer mode between the corresponding parties rather than directly by trusted third parties. The distributed ledger consists of the following:

1. Network of Nodes is comprised of interconnected members and computers over the Internet. Each node is responsible for maintaining the ledger and verifying all transaction(s). Thus, the distributed system benefits from a high number of nodes in that the greater the number of members involved in verifying transaction(s), the higher the mutual processing power.
2. Tokens are simply transactions made on the block-chain network

Thus, data exchange uses the block-chain model even with malicious attempts. The security feats (namely the block-chain adaptation provided by the application) will be transparent to its users – such that it employs an end-to-end encryption at each client’s and/or user’s end. This helps each user protect its demographic data, personal data that may be uploaded during the process of the transaction(s) as well as their banking information. We model the security framework to make such agent banking transactions more “dependable” and achieve the following features:

- Implement an integrated community-cloud so that users can sign-in unto the cloud infrastructure with the block-chain encryption model at the client’s end for improved data integrity and privacy against adversary (from a user’s end) and yield a more dependable and secured peer-to-peer transaction.
- Storage support is provided for the integrated community-cloud with a remote server (that is completely oblivious and transparent to user).
- Data, at client’s end is secured via the block-chain model (to protect user data and message contents at end-to-end connection within the community cloud). SSL protects the username and password – alongside NAT, firewall and gateway that are implemented within the (Intranet) framework.
- Sync, selected content in mobile devices to any available cloud technology on the model and ensure they are available anywhere and anytime you want to access or manage them which also takes out anxiety of losing important files, if device is damaged, lost or stolen.
- Recommend suitable security models from existing benchmarks to improve user confidence in cloud computing services.

3.2. The Nigerian Frontier for The Integrated Platform

The study provides a community-cloud model and support for users at Federal University of Petroleum Resources Effurun Nigeria. The model achieves this via a native app for mobile device (operable from Android v2.2) with support for web-service to allow Internet connectivity ease and connection to remote server and cloud-provider services via an API call (adapter). The framework will masks all the block-chain’s underlying technical nuances between application-model and data-model such as session management, connectivity, authentication and authorization. The user’s demographic data during registration Its employs a 2-layer security as handled by both the

block-chain model and SSL/TSL applied to all data as backed by the cloud firewall. At the user's end, it employs the block-chain model solution to protect its data; while SSL protects username and password. Tools used for the development of this native app include Android SDK, Kotlin, Apache XAMPP and Google's Android Studio. This native app is enabled and ported on any Android platform from v2.2 with forward compatibility. The system implements as mentioned above for these reason: (a) it is computationally, mathematically secure against brute force attacks, (b) quite flexible, (c) its small-size Java codes and support for C(++/#), (d) memory size required is small as ported on AP. Thus, has no effect on smartphone speed and performance, and (e) ease of integration as implemented with Java and support for C-language into its web browsers with ease of connectivity. Web-browser used includes Safari, Firefox etc – all of which enable block-chain encryption on SSL/TLS to protect data transfer between user(s) and server. However, data transfer over the Internet between the sender and recipient remains unprotected, no matter how good SSL in use is.

3.3. *Rationale for Implementation*

The block-chain model has become an easily adopted and adapted secure model in recent times. It is more secured, its data encryption is more mathematically efficient, is elegant cryptographic algorithm with a model whose strength resides in the key-length options. Time required for an intruder to crack algorithm is directly proportional to length of key used to secure data transfer or communication. It allows a choice between 256-bit and above implementation, making it exponentially stronger. There are no significant tradeoffs in functionality, speed and memory – as implementation on Android Studio makes it quite portable for target device. Required memory is relatively small and does not affect device speed even with extra functionalities. Target Android OS is v2.2 with forward compatibility to v4.0. This will bring closer to users, cloud technology with its many benefits at a cheap price.

3.4. *Workings of Proposed System*

Our P2P (peer-to-peer) system allows retail locations to accept card payments without updating their cash registers to read cards directly. The system will generally achieve these with proper installation: (a) it will read off client data from customer's registered bank details, (b) ascertain if funds in client's account are sufficient for any transaction(s), (c) transfers funds from a customer's account to another account, and (d) records the transaction as well as prints a receipt of successful transaction(s). The system can store needed data and processing transaction appropriately. System will be ported on the AP to ease connectivity, portability and accessibility. It will bridge gap of transaction between a POS agent and customers. System was implemented using Kotlin and Android emulator as in figure 5 through 11 respectively. It lets a user to download the native app and create an account so as to be able to sign-in and perform money transaction requests from other user's within his/her location. The app then performs a block-chain encryption of user data before they are backed up too either to the remote server (backup domain controller – BDC) or to the integrated cloud provider's server via a cloud service API call (adapter). Output has a user friendly landing screen with useful information to guide and direct the user on what the app does. The app contains login screen, sign up screen, home screen, transactions screen, request screen, balance top up screen and receive funds screen.

4. **Summary, Recommendation and Conclusions**

The incessant need of users to protect stored, online data continues to foster the field of Data Forensic, which aims at measures to help detect network intrusion alongside keeping such adversaries off-bay via biometrics and cryptography so as to achieve the needed data non-repudiation, confidentiality, security and integrity for client end-to-end transaction. Cloud infrastructure is a system that enables 5-essential feats namely: self-provision, pay-per-use, on-demand resources availability, scalability and resource pooling. It consists of a physical layer of hardware resources necessary to support cloud services (such server, storage and network devices) and an abstraction layer of software-deployed on physical layer to manifests as cloud feats such as virtualization, grid computing, outsourcing and utility computing. Thus, study yields an integrated cloud on Android platform for smartphones as motivated by the need to proffer clients' transaction the much required security.

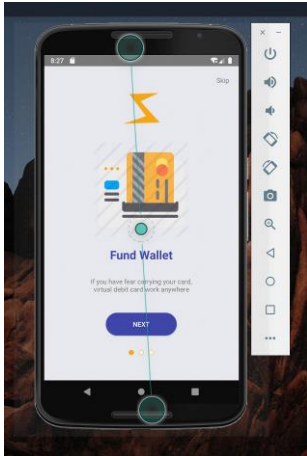


Figure 5. Wallet Feature Splash Screen

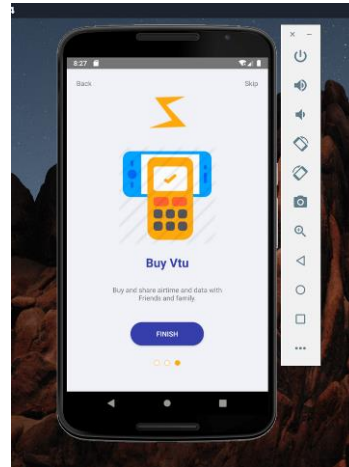


Figure 6. Virtual Transfer of Unit Feature

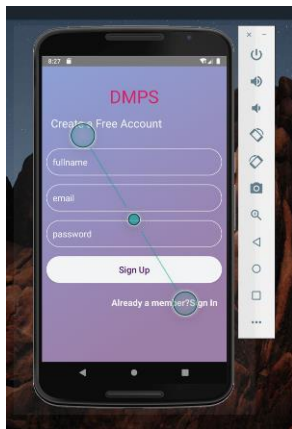


Figure 7a: User Registration Screen of Proposed System

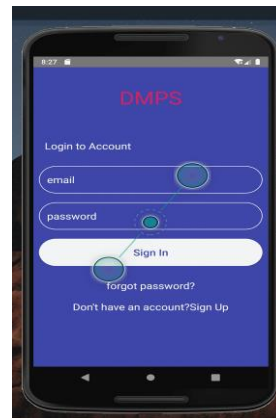


Figure 7b: Sign-Up screen of Proposed System

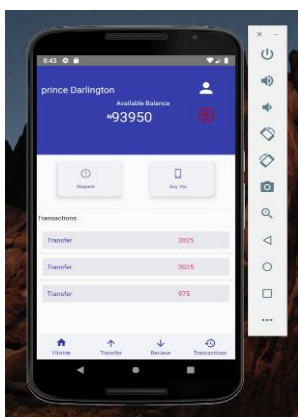


Figure 8: Dashboard Menu

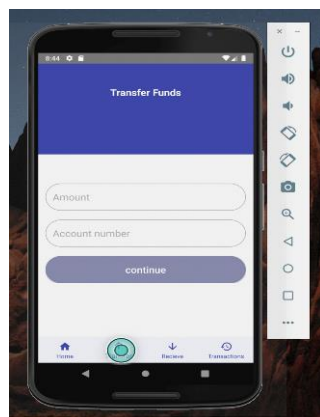


Figure 9a. Fund Transfer Screen

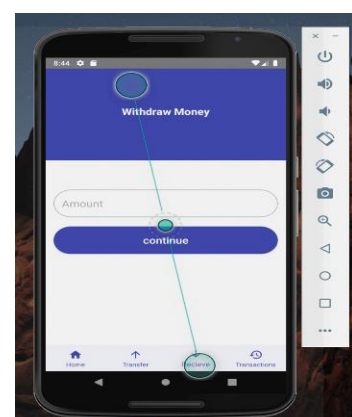


Figure 9b. Funds Withdrawal Screen

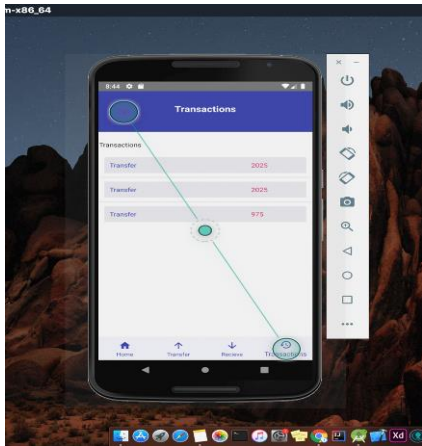


Figure 10: Transaction History Screen

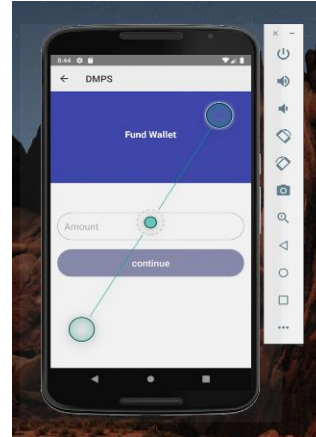


Figure 11: Wallet Screen with balance of Debit Card.

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