REGISTRATION AND VERIFICATION OF BIRTH CERTIFICATE USING BLOCKCHAIN TECHNOLOGY

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Abstract- The importance of a Birth certificate cannot be overemphasized as it provides age proof, means for issuance of National Identify Number, Citizenship certificate, and is required for job applications and relevant official identities like an international passport. The need to have a digitized, trustworthy, available and reliable system of Birth Certificate management is paramount. Currently, birth data/registration in most cases exists on paper or as siloes of birth records, which may differ from place to place with no form of interoperability within the same country. This implies birth information only exists at the place where birth is registered hence forgery of birth certificates is on the increase as these birth certificates and declaration of age issued by the courts are unverifiable. This jeopardizes the credibility of both the people who hold birth certificates and the government agency that issues them. This system registers birth and issues certificates, stores a digital copy of the certificate, and verifies the integrity of the certificate by the way of smart contracts on a permissioned Corda platform which uses the decentralized technology that blockchain offers. The following technologies are used: hash functions, RSA cryptography, digital signatures, peer-to-peer networks, and smart contracts in this project. The designed system guarantees a simplified registration process and offers increased data transfer, transparency, and effective record maintenance.

Keywords - Birth Certificate, Birth Registration, Blockchain technology, Birth Validation, Corda Platform

I. INTRODUCTION

The healthcare system is an information-intensive domain, it is critical to be able to capture, process, and store massive amounts of health data in real-time, whether it's clinical, research, or administrative. In both developed and developing countries, healthcare data, which includes but is not limited to birth records, is largely utilized for making choices, increasing the efficiency and quality of healthcare systems, and conducting research to advance medical science. There are around 140 million births worldwide [1] and birth data is typically kept in siloes of paper, physical files, or digital formats [2], these siloes of birth records differ from place to place with no form of interoperability within the same country which implies birth information only exists at the place where birth is registered. However, emerging economies like Nigeria, face the issue of transitioning from paper-based health information systems to digital forms that allow for an integrated computerized health information system [3].

One of the 10 key vital records that the United Nations recommends be documented is birth registration [4]. Birth registration is a type of civil registration that establishes an individual's legal identification and is a universal, continuous, permanent, and compulsory record accountable for national planning [5].

A birth certificate (BC) is a legal document provided after a person's birth is registered to identify them as a citizen of a country when that information is not readily available; there is a provision for a competent court of law to issue a birth attestation or age declaration, which is commonly referred to as evidence of age. All of these documents are available in print format [2] and access to such records, whether with or without duplicates, is extremely difficult in the event of theft or loss. Although as noted by [1], an electronic document cannot effectively replace a physical birth certificate; however, with the availability of various scanning and printing technologies, birth certificate forgery is on the rise, putting the integrity of birth certificate holders and the government bodies that issued the certificate in jeopardy. The simplicity of change has been aided by the lack of tools for BC verification and validation [7]. It is required to verify that a person's birth certificate is legitimate and that the holder is the rightful owner. More importantly, the birth record must be validated to ensure that the information included within is correct and that the birth certificate was issued by a legitimate source. [8]. Distributed computing is vital in healthcare as it ensures that patient information is available to everyone who needs it and at the time, it is needed. In Nigeria, the poor flow of information among various places of care leads to a reduction in the quality of healthcare services. However, there exists a risk of data tampering or deletion when using distributed computing which we seek to address.

Blockchain Technology (BCT) being an emergent digital technology [9], and with the rapid increase in cryptocurrency valuation in recent years, has received extensive momentum in different industrial, public,

and business sectors; notably in the financial and banking domains. A blockchain is a shared database or decentralized ledger [10] which enables data to be recorded (but not changed or erased) and shared among multiple entities. It is a decentralized data structure made up of blocks connected in a chain, with each block containing records or transactions in chronological sequence [11]. Birth registration is a continuous and permanent record of the occurrence, as are significant events such as marriage, death, and so on [12]. Events of an individual can be recorded using blockchain technology, which has the advantages of being a distributed ledger, immutable, and secure. A decentralized ledger is what Blockchain Technology (BCT) is [10] and every transaction made on the network is recorded in a 'block,' which is made up of hashed data from the whole transaction history. This distributed ledger is made up of a chain of information 'blocks,' each of which is identifiable by a cryptographic signature, making the information shared transparent [13] [14]. BC registration, verification, and validation are all being considered using BCT.

The credibility of Nigerian birth certificates has been rated low by a Danish Report partly due to the level of corruption in the Nigerian civil service [15]. Hence, the integrity of most of the birth certificates or declaration of age and the issuing authorities is questionable. Verification and validation of individual birth certificates is a major challenge as identified by [7].

This research uses blockchain technology to record each birth record and ensure that the data is accurate. This new technology is a transactional asset database that organizes transactions in blocks and adds them to a chain of existing blocks, allowing for decentralized and transactional data exchange over a vast network of participants. Maintaining a continuously growing list of data known as blocks and linking them in a distributed fashion (blockchain) in such a way that they are secure against tampering is made possible with this technology. Blockchain is a distributed database of transaction records (Distributed Ledger) shared among participants. Cryptographic techniques are used in this technology to check logged transactions and ensure that no record is duplicated on each network node. This approach enables a new sort of distributed software architecture in which components can build confidence by agreeing on shared states.

II. BRIEF HISTORY OF BIRTH CERTIFICATE AND BLOCKCHAIN

Since 1900, birth certificates have been amended every ten years, for around 12 revisions. The number of entries on a birth certificate has increased from 33 in 1900 to more than 60 in 2003, reflecting the evolution of the document. The date and place of birth, whether there were multiple gestations, the mother's age and race, legitimacy, paternal name and age, and previous live births were all part of the original text of the birth certificate. An open-ended format was used to collect data. However, as remarked by W. A. Plecker in 1915, there was an increasing demand for "simplicity in phrasing beauty and convenience in arrangement, spacing, and print, among the adjustments he suggested, were the requirement for the word 'Boy or Girl, [16].

With the establishment of the Bitcoin network in 2009, the first of several current cryptocurrencies, blockchain technology became well known. The transfer of digital information that represents electronic cash tokens happens in a distributed system like Bitcoin and comparable systems. Bitcoin users can digitally sign and transfer their rights to that information to another user, and the Bitcoin blockchain publicly records this transfer, allowing all network participants to independently verify the transactions' legitimacy. When a publishing node publishes a block, transactions are added to the blockchain. A block is made up of two parts: a block header and block data. This block's metadata is contained in the block header as seen in figure 1. A list of authenticated and authentic transactions that have been uploaded to the blockchain network is contained in the block data. To ensure validity and authenticity the suppliers of digital assets in each transaction (mentioned in the 'input' values) ensure that the transaction is properly constructed and cryptographically signed. A distributed set of nodes maintain and manages the Bitcoin blockchain independently. This, together with cryptographic procedures, renders the blockchain computationally infeasible against later attempts to alter the ledger (modifying blocks or forging transactions). Many cryptocurrency systems, such as Bitcoin and Ethereum, have been made possible by blockchain technology. As a result, blockchain technology is frequently associated with Bitcoin or cryptocurrency solutions in general. The technology, on the other hand, is suitable for a wider range of applications and is being researched in several industries. [17]. Since its creation, blockchain technology has undergone many revisions known as generations, ranging from Blockchain 1.0 through 4.0. (Swan et al., 2015, Xu et al., 2017). The first generation of technology began in 2009 with the launch of the bitcoin network, which saw the birth of the first cryptocurrency. The notion revolved around payments and how they could be used to generate bitcoin. In 2010, the second generation of blockchain technology was introduced, which comprised smart contracts and financial services for diverse applications. This generation advocated blockchain development using the Etheruem and Hyperledger frameworks. The third-generation blockchain converged towards

decentralized applications and developing decentralized applications, various study topics including health, governance, IoT, supply chain, business, and smart city were studied. [20]. Etheruem, hyperledger, and other platforms were used, as they could code smart contracts for a variety of decentralized applications [21], [22]. The fourth generation mainly focuses on services such as public ledgers and distributed databases in real-time. This level has seamless integration of Industry 4.0-based applications. The current specifications of Industry 4.0 require an enterprise resource-planning platform that can provide automation and integration of different execution platforms as a single coherent unit. It uses the smart contract which eliminates the need for paper-based contracts and regulates within the network by its consensus [23].

i. Smart Contracts

Smart contracts are digital codes allowing terms contingent on the decentralized consensus that is tamper-proof and typically self-enforcing through automated execution (Lin William Cong, 2013). The smart contract was conceived by [24]. He explained that cryptographic protocols could make it possible to write computer software that resembled contractual clauses and would narrow opportunities to terminate its performance obligations. In the following years, scholars [25] have studied computer-based contractual languages. Smart contracts are gaining increasing popularity in both public and private domains as they enable peer-to-peer operation on the public blockchain and have the potential to improve efficiency and transparency in business collaborations.

ii. Related Works

Certification procedures are an integral component of our daily lives. A certificate verifies the existence or possession of specified characteristics or acquired skills. In most circumstances, the bureaucratic procedures for producing a certificate by an institution and handing it out in print form to the bearer are time-consuming, costly, and offer a lot of room for fraudulent documents to be issued. Scammers now have a plethora of tools to fabricate paper certificates thanks to technological advancements, thus having technology that protects against these nefarious acts is extremely important.

Various ways to secure certificates have been offered, however, they have all been found to be problematic. The signature is used to authenticate the document, which is in the form of a paper, and the authentication is provided by the certificate. However, forgery is achievable due to current document printing and scanning technologies. [27]. [28] In their article "Certificate Verification Using Blockchain and Transcript Generation," stated, "To overcome this disadvantage, a technology known as blockchain enters our lives as a rescuer." Institutions, students, and service providers were the three actors in the plan all actors used a single hash as a key, making it publicly available once they know the hash. This is a flaw in their approach.

[19] Many security solutions and standards have been proposed over the years to improve the security levels of the aforementioned smart applications, but the existing solutions are either based on centralized architecture (having a single point of failure) or have high computation and communication costs, which drives home the point. Furthermore, most existing security solutions have only addressed a few areas of security and do not address scalability, robustness, data storage, network latency, auditability, immutability, or traceability. Blockchain technology could be one of the solutions to the aforementioned problems. [19], [29].

Using the system analysis and design (SAD) methodology, [30] created an electronic system for birth registration and record management, which required the use of several clients and server-side development tools, including Hypertext Markup Language (HTML), JavaScript, and Cascading Style Sheet (CSS), Hypertext Pre-Processor (PHP), and My Structured Query Language (MySQL). As a result, the model was thoroughly tested and evaluated, demonstrating its ability to record births, maintain registers, and test the issues associated with record storage, such as verification, retrieval, and duplications. However, the user interfaces for birth registration and birth certificate preparation for various accredited institutions were not user-friendly.

The system designed by [7] was explicitly for Birth Certificates and similar to [28] design but runs the AES algorithm and stores the data in the IPFS. [7] in 2019, introduced a system designed for effective innovation to store birth records that cannot be tampered with, easy to maintain, reliable, and can be successfully shared. These techniques are also utilized to replace the verification methods of passwords, pins, smartcards, keys, and tokens. This system is implemented on a local blockchain network using public and private keys and the RSA algorithm is used for user login and registrations. Its drawback is seen, as the original document was not stored anywhere nor does it have the functionality to generate the certificates online.

III. PROPOSED SYSTEM

In this section, our proposed solution is to use blockchain technology in storing birth certificates to ensure the integrity of such data. Figure 1 shows the block diagram of the proposed system for birth registrations, certification, and verification making

our system simple and accessible from different nodes. Birth data is collected in the form of blocks (i.e., Smart contracts). This data can be directly mined by government organizations for record and verification purposes. The flow of our proposed system can be described as follows with the assumption that every birth is taken and recorded in a hospital or primary health care centre, or by a local birth attendant.

The theoretical architecture is depicted in figure 1.

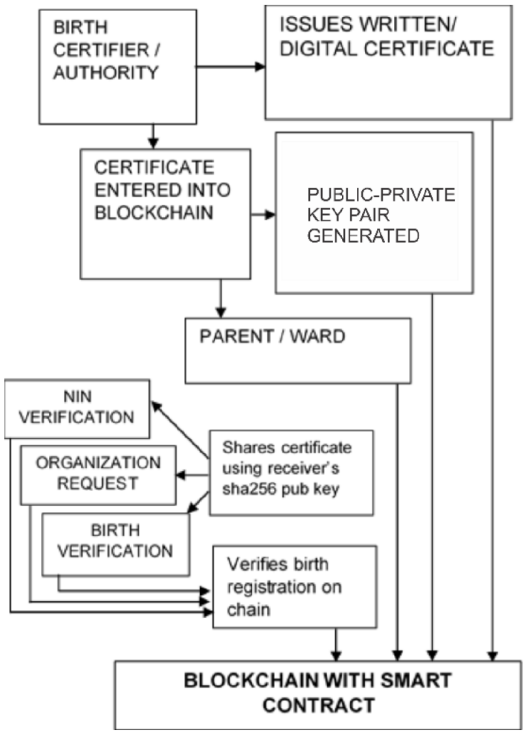

Figure 1: Proposed Blockchain Architecture for Birth Certificate

System Design

The system comprises of the Sender and Receiver node registered on the blockchain network. In the event of a birth, birth data is added to the blockchain, which becomes part of the ledger transactions. Before birth certificate data is entered into the chain, the smart contract verifies the authenticity of such data and checks that both sender and receiver nodes are signed in the case of a transfer. For each certificate entered into the chain, a unique hash is generated, with a timestamp. These hashes are generated by some cryptographic functions that ensure that every certificate on the blockchain is uniquely identified. Corda abstracts the public key of the nodes and offers a human-readable nomenclature for nodes in the chain. On provision of such a name, a birth certificate owner could send his/her birth token to the name/account specified. The developed system is built on a consortium principle since birth data stored on the ledger is only visible to the owner and whomever the owner sends it to. Hospital attendants, citizens (individuals and organizations/agencies), and governments are all participants in our blockchain data sharing scenario. The Hospital attendant carries out birth registrations for every new birth, these data help to offer better sharing and verification solutions to citizens' birth certificates using permissioned blockchain technology. (Figure 1). Name, city, gender, father, mother, paternal grandfather, paternal grandmother, maternal grandfather, maternal grandmother, and witness are among the usual data required for a complete birth certificate processing. A form for collecting data for a new born makes up the frontend node. It connects to the backend of the blockchain, and when the form is successfully submitted, the transaction is added to the blockchain. The following rights are granted to the other nodes on the blockchain: "connect," "receive," "create," and "issue". These permissions allow the nodes to carry out specific tasks. One of the important characteristics of the suggested data sharing solutions is the generate permission, which allows the node to build a stream for exchanging data. The "issue" permission allows a node to create assets, whilst the "mine" permission allows them to help add verified blocks to the chain by offering solutions. Furthermore, only chosen qualified nodes can access or consume client data via the smart contract by subscribing to the respective public streams. This ensures that everyone in the chain does not have access to citizens' birth certificates.

Design Implementation

The following actors/nodes have been used in the project, to form a module.

New Birth: A new birth serves as the entry point into the system. Once birth takes place,

Certifier/Registrar: is required to commit the birth details into the chain. This module is a point of human authentication in the system, and it consists of a form that collects relevant information about the new born and a credibility check by the certifier/registrar to ensure that information presented is valid. The registration centre, town/village, LGA state, volume year, entry no, full name, sex, date of birth, place of birth, the full name of the father, full name of the mother, and name of the registrar are all mandatory fields on the form. Upon successful entrance, a pair of private and public keys are generated, granting access to the child's blockchain wallet. The certifier/registrar could be a private or public regulator in this case.

Requester: could be an organization (public or private) or an individual or group of individuals that require a user's birth certificate. For a successful transaction, the requester sends his public address to the user whose birth verification is needed. The user

sends a copy of his birth certificate to the public address of the requester including his public address for verifying that the token is from the right source. The requester then accesses the received token (birth certificate) by providing his wallet address (private address in this case) which brings a completion to the transaction.

Calculating Private and Public Keys

For every transaction in the DLT, the system calculates its unique hash and transaction ID. The public key serves as the address to which the Digital birth certificate is sent. To calculate the (pubkey, n) and a pricey

First, we have to choose two prime numbers p and q, then we calculate

$$n(p, q) = p \cdot q. \quad (1)$$

After that, we calculate Euler's quotient function

$$\phi(n(p, q)) = (p - 1) \cdot (q - 1) \quad (2)$$

only if p and q are prime numbers. Otherwise, it is an NP problem.

Then we can use a random pubKey, which is not a divisor of$\phi(n)$ and is smaller than

$$\phi(n) \quad (3)$$

Calculating priKey means calculating b in the following equation:

$$a \cdot \phi(n) + b \cdot pubKey = 1 \quad (4)$$

Where we can use the extended Euclidean algorithm. Now we can delete$p$, q and $\phi(n)$.

IV. RESULTS AND DISCUSSION

Experimental Setup

Corda is a scalable, permissioned peer-to-peer (P2P) distributed ledger technology (DLT) platform that enables the building of applications that foster and deliver digital trust between parties in regulated markets, this private blockchain platform ensures that transactions are only visible to the participating parties. Our system is built on Corda with nodes named Sender and Receiver to demonstrate the owner and receiver of birth certificate data. The User Interface (UI) interface is defined in Angular to send API calls to initiate transactions in the DLT. The system consists of three modules, the DLT, the Backend, and the Interface. RSA cryptography is utilized to generate the public-private key pairs. The public key is to be shared with others to receive tokens (birth certificate data, in our case). Our private key is used to sign our transactions so that nobody can spend or have access to our tokens in the blockchain. Upon filing the form, a pair of private-public keys are generated which provide access to a child's wallet.

Login

To gain access into the blockchain, an organization is first registered into the platform and given a unique Authentication ID and a combination of characters as a password. On a successful sign-on, the system opens up the birth certificate form that has all the required details to be filled in including the ward's name, gender, city, paternal and maternal details. The login page is shown in figure 2.

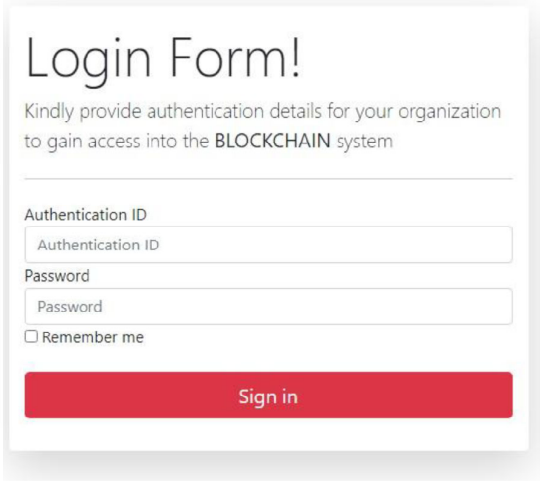

Figure 2: *Login form*

Internal Process

Figure 3: *Certificate form*

On filling the form in Figure 8 and pressing the submit button, the system converts the form documents into a JSON format and sends them to the backend for validation. Upon successful validation of

the JSON file, the system adds a new block with the JSON file to the chain deployed with Corda, an open Source Blockchain platform, and automatically generates a private-public key pair that holds the address of the just added block in the chain. The private key will be used to sign transactions in the future, while the public key will be used to communicate the transaction's address with the public.

USER INTERFACE

To gain access into the blockchain, an organization is first registered into the platform and given a unique Authentication ID and a combination of characters as a password. On a successful sign-on, the system opens up the birth certificate form that has all the required details to be filled in including the ward's name, gender, city, paternal and maternal details.

BIRTH CERTIFICATE FILL-IN

This provides an intractable interface to enter the details of the ward into the DLT. It collects information like name, gender, city, state, zip, mum, dad, registrar, etc.

TRANSACTION FLOW

The nodes are deployed using the command on Windows:

```
gradelew.bat deployNodes
```

To start up the DLT nodes on the console, the following command is run (Windows)

Figure 4 is a sample Birth certificate transaction between Sender and Receiver Node.

```
start CertificateTransferInitiator town: GK, state: Niger,
lga: GK, year: 2020, name: 1, sex: male, dob: 19012020,
fatherName: Salawu, motherName: Blessing,
registrarName: Matthew, receiver:
"O=Receiver,L=Nigeria,C=NG"
```

Figure 4: *Node Transaction*

The receiver gets access to the sent certificate data by running the following command

```
run vaultQuery contractStateType:
com.template.states.CertificateState
```

The command above exposes the contents of the ledger which shows the sent certificate data.

Figure 5 shows the process of updating the ledger and creating a 64-bit unique hash to present an unchangeable birth certificate record.

Figure 5: Ledger gets updated

Figure 6: shows the message confirming a blockchain has been successfully created to represent the birth certificate.

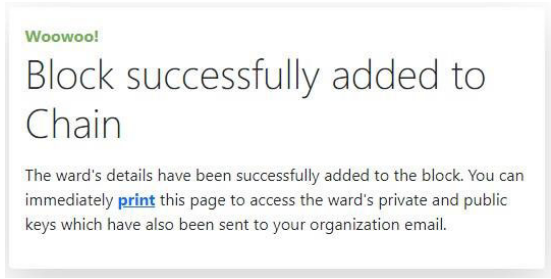

Figure 6: Successful ledger update

V. CONCLUSION

Birth records are an integral part of humans because they provide a sense of belonging. Various systems are utilized for storing and securing births records which include centralized databases and a combination of biometric and cryptography technologies. In this project, we have used blockchain technology on a Corda platform for providing seamless storage, security, and monitoring of the distribution of birth records, and web technologies like SPRING BOOT and Angular have been incorporated into this system which makes registration easily accessible over the internet. The implementation of Birth Certificate issuance with blockchain technology improves trust and reliability in the institution processing the certificate. This also provides a more secured and fraud-free system. In addition, a digitized birth certificate becomes tokens on the blockchain and are readily transferrable from one node to another based on the constraints provided in the smart contracts.

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