

Blockchain Mortgage Management System GOMA/D.R.CONGO Case Study

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ABSTRACT

This research is about blockchain mortgage management, Goma/D.R.Congo case study. The general objective pursued by this research is to set up a mortgage management system model based on the blockchain to solve the problems of double mortgages, purchase of mortgaged properties, or sued in the court and data confidentiality made available to the public.

To achieve the assigned objective, this work uses different methodologies among which:

❖ *Action design research, Analysis, documentary technique, interview technique, prototyping, and unified Process.*

As a result, the developed system being a blockchain technology which addresses its distribution aspect, takes into account the access rights of the different users. Security is provided by a blockchain in which accounts have addresses and title keys. which reinforces security measures for hackers.

The particularity of this research lies at the level where loans granted outside financial institutions are recorded in the system to broaden the scope of application.

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ABBREVIATIONS AND ACRONYMS

AUS: Acte Uniforme des suretés

COM: Component Object Model

IEC: International Electrotechnical Commission

ISO: International Organization for Standardization

MVC: Model View Controller

MVT: Model View Template

OHADA : Organisation pour l'Harmonisation en Afrique du Droit des Affaires

OMG: Object Management Group

OODBMS: Object Oriented Database Management System

PSC: Project Steering Committee

RDBMS: Relational Database management System

I. INTRODUCTION

Securing property is a very crucial element in society, knowing that what we have is a guarantee to lend money. We are talking about the mortgage if there was initially a guarantee of the debt. This guarantee becomes a mortgage after we have gone to the curator of real estate titles to affix the mortgage visa. Mortgage management is not tied to a single service. It's a whole chain of services. Reason why information management in the blockchain remains inevitable. Blockchain is inevitable in data security requiring the intervention of several services using decentralized data. As part of this work, several separate services are involved as each will enter data into a shared system. These services are:

- Financial institutions;
- Land affairs;
- Creditors who are natural persons (a contribution because they are often ignored);
- etc.

By approaching the blockchain, we see a distributed information where a service or individual can access a data which were introduced by someone else who can allow him to use it or draw conclusions according to his needs.

1.1. BACKGROUND

For the development of society, credit remains a means used by most individuals and legal entities. This credit can be requested either from legal persons (financials institutions such as banks and cooperatives), or

from natural persons (individuals). Credit is sought for different reasons. The creditor first analyzes whether the request requires a positive response or not.

To access it, the mortgage is the guarantee per excellence to be paid as stipulated in the loan contract. However, it is not enough to own mortgage of a building of its debtor to protect the loan in its entirety. The mortgage being evaluated in relation to the loan granted, security is essential so that the loan transactions do not generate conflicts in the days to come.

The blockchain is used in a technology where there are several intermediaries who must share several pieces of information. One department processes information that is recorded in the system, another will need it as part of its activities and retrieves it for use. The same information may be useful to ordinary citizens in the future.

It is in this distribution of information that there may be problems. Information used in a block can be corrupted by interception by other users or malicious people.

As part of this research, the information of several services or people is necessary, namely:

- The creditor who can be a natural or legal person. The latter granted the credit to another person (debtor). His information is necessary.
- The debtor, any person who contracts a loan according to certain clauses of the contract, which binds him to his creditor.
- Property, this concerns the propriety mortgaged to guarantee or cover the debt in the event of non-payment according to the prescriptions of the loan contract.
- Land affairs, this one intervenes since any mortgaged property must be registered in its registers. We are talking about the visa of the head of land affairs division.
- The court, a dispute may arise from the loan contract signed between the debtor and his creditor for non-performance of it. This dispute may result in an auction of the mortgage.
- Notarial service, the notary is also competent in the event that the file has not gone to court, for the sale of the mortgage in compliance with the legal texts.

The complexity lies at the level where a building or property is mortgaged but put up for sale by the owner. The new or purported buyer may imprudently so without asking the land affairs services to find out if the said property is not mortgaged or in conflict. Which becomes an invisible dispute that arises from this purchase.

There are cases where a building or property given as collateral for a second loan. Which demonstrates the existence of a forgery on the part of the debtor and an invisible loss for the creditor. The forgery by the fact that the property was mortgaged in the past but by trickery, he produced another title knowing that the original must be held by the first creditor.

The mortgage can also be subject to seizure of property if a dispute arises before the court. This information is also crucial. This seizure of property may result in an auction or full payment of the debt.

The property can be sold at auction in front of the notarial service. It is always the continuity of the dispute arising from a loan contract signed between two parties, including the creditor and the debtor.

In all cases, the new or alleged buyer must access certain information to be reassured that the property is not in dispute. This information that passes through a blockchain. A creditor can also access information related to a building or property offered as a mortgage to secure the debt before deciding whether the loan can be validated or rejected.

1.2. SIGNIFICANCE

The importance of this research is to provide a solution framework for the various sales made in Goma city without checking the state of the property purchased. This solution to be given will allow the various services involved in the mortgage to record the data which will be made available to other services or individuals to access on it easily.

1.3. RESEARCH CONTENT

1.3.1. Statement of the problem

The mortgage is a very delicate matter that requires special attention. From the transfer of securities to a creditor under the loan agreement, to payment or not to achieve the restitution of the securities or the procedure for the auction of the mortgaged building to be carried out before the competent courts that can cover the debt. It is a chain that requires the intervention of the debtor, creditor, land affairs department for registration of mortgage, notary or court.

In 2016, actors from the Lantmäteriet strategy consultancy Kairos Future, along with the telecom Telia Company and the blockchain startup ChromaWay, began to explore potential blockchain applications for real estate in Sweden. Quickly identifying property purchase and land transfer as a compelling use case. The consortium developed a prototype in which real estate transactions would be put on the blockchain the moment an agreement to sell is reached and remain until the land title is transferred. The prototype sought to limit

information asymmetries by allowing all parties — banks, land registry, brokers, buyers, and sellers — to monitor the progress of the transaction, and potentially produce cost savings of more than €100m a year (McMurren, Andrew, & Stephaan, 2018).

A blockchain-based business process to securitize mortgages (Rossum B. V., A blockchain-based business process to securitise mortgages, 2018). In this research, a model has been created to innovate the business process to securitize mortgages. This new innovative business process can also serve as basis for the securitization of other loans such as : small to large business loans, car loans, credit card loans, and student loans.

Several problems are to be reported in the mortgage management of buildings, namely:

- A double mortgage to obtain credit;
- A possible sale of the building mortgage;
- The existence of a hidden dispute over the mortgaged property before the competent court;
- Inaccessibility to mortgage information without moving before buying a building;
- Non-transparency of shared information;
- Non-traceability of data in a corporate network.

Starting from the problems noted above, we started from the question according to which:

❖ How can a blockchain management system based on mortgaged be modeled to achieve the solution of the problems mentioned above?

This main question which can has several branches, will guide us throughout this research.

1.4. FINAL GOAL

1.4.1. General objective

The general objective pursued by this research is to set up a mortgage management system model based on the blockchain to solve the data problems of security, confidentiality and protects against the risk of malicious intent or hijacking, since the nodes monitor the system and check each other.

1.4.2. Specific objective

By planning to set a new mortgage model, the data will be placed on a security public common portal for services or individuals approved in the granting of credit to debtors, services committed to mortgage registration, courts, as well as the service notarial, which will give the possibility to the public to access it so as not to come across a disputed purchase by trusting to informations displayed online as is the result of blockchain.

1.5. MAIN THEORY

Securitisation starts at the borrower that want to fund real estate, usually the borrower's house. Mortgages loans are loans specifically used to fund housing and are issued by "originators." Originators are commercial banks or financial institutions who offer loans to the public, like ING or Rabobank. In the first phase, the borrower searches the market for the best funding instrument in various commercial banks. When the borrower finds a commercial bank who wants to funds their house, a customer screening is performed. This screening is conducted to estimate the creditworthiness of the borrower. When the originator approves the creditworthiness of the customer, the originator accepts the piece of real estate as collateral for the loan (Rossum B. V., A blockchain-based business process to securitise mortgages, 2018).

In this section, we briefly summarize the main contributions of this thesis. We categorize them according to the services involved in the blockchain, namely:

On the scientific level, to set up a model proposing the combination of several technologies for an efficient blockchain system that can overcome the real problems related to mortgages with a new information technology solution and which will be a reference for those approaches the same angle as us.

On a personal level, we explore the implementation of a blockchain information processing model on mortgage properties by learning new concepts.

On the practical or social level, the result found is a framework beneficial to a major part of the population of the city of Goma having the ability to afford properties and to creditors, natural and legal persons.

To creditors by the fact that credits must have guarantees. As part of this work, we focus on the security to guarantee the debt, especially since there are debts whose guarantee is tangible movable property. This security is a property with an authentic title recognized by land law. The titles presented must be verified if they have never undergone mortgages before granting a loan. Given that we have raised in our problematic, the possibility for a debtor in bad faith to make a double mortgage, the proposed model solves this kind of problem. A property already mortgaged, will alert.

The natural person creditor is not ignored. It can also lend a sum of money and receive a mortgage which will be registered with the land affairs department.

Verifying authenticity of the document can be done using blockchain and eliminates the need for centralized authority. The document certification service helps in Proof of Ownership (who authored it), Proof of Existence

(at a certain time) and Proof of Integrity (not tampered) of the documents. Since it is counterfeit-proof and can be verified by independent third parties these services are legally binding. Using blockchain for notarization secures the privacy of the document and those who seek certification.

It also eliminates the need for expensive notarization fees and ineffective ways of transferring documents. Stampery is a company which can stamp email or any files using blockchain. It simplifies certifying of emails by just emailing them to an email specifically created for each customer. Law firms are using Stampery's technology for a very cost effective way to certify documents.

All these operations must be verified before any validation because once made available to the public, they are authentic.

To the population of the city of Goma by careful verification of the property put up for sale in the proposed model, knowing that the land affairs department intervenes in the blockchain because it is authorized in the registration of mortgages. Through this verification, we try to reassure ourselves whether the money released is on the right track or not, by accessing information that once had the meaning of confidentiality. This access goes further since a building even being mortgaged, remains the property of the debtor so, when it is sued in court, it means that it is under seizure. Therefore, this information is also crucial.

A significant contribution to this circuit in which the mortgage is the key element in the blockchain, from the creditor to the pretending buyer to counter debtors in bad faith.

Blockchain Technology

We explain the concept of the blockchain by explaining how Bitcoin works since it is intrinsically linked to the Bitcoin in the following chapter. However, the blockchain technology is applicable to any digital asset transaction exchanged online.

1.6. SCOPE

Our data covers the period from 2016 to May 2023 in Goma city, Province of North Kivu in the DRC. In the matter, is in the services involved in the right of surety (banks, creditors natural persons, division of land affairs, notarial service and court).

Apart from the introduction and conclusion, the remaining of the study is structured as follows:

- ❖ Chapter 2: literature review: is this section, In this part, we discuss the salient points as well as some definitions consistent with our study.
- ❖ Chapter 3: Blockchain implementation: in which, we create the system that can secure mortgages

II. LITERATURE REVIEW

The real estate securities law of the African states in the franc zone had been modernized during the colonial era by land decrees which dealt not only with real estate rights but also with land registration.

2.1. MORTGAGE

The mortgage is the assignment of a determined or determinable building belonging to the grantor as security for one or more claims, present or future, provides that they are determined or determinable (ISSA-SAYEGH, Joseph; Paul-Gerard, POUGOUE; Filga, Michel SAWADOGO; Koffi, MAWUNYO AGBENOTO; François, ANOUKAHA; Emmanuel, BOKALLI, 2018).

Ordinance no. 2021-1192 of September 15, 2021 reformed security law. The "mortgage is a surety constituted on an immovable property which is allocated to the payment of a debt. The property struck with inalienability not being in the trade within the meaning of article 2397 of the civil code, they are not likely this is the case even if the inalienability results from a contractual clause inserted in a deed of sale (Leveneur, 2012). The mortgage confers on the creditor a right of preference and a resale right allowing him to pursue the sale in whatever hand the property is. (see also "Suite (right of)").

In the event that two mortgage registrations, taken on the same day on the same building, come into competition and where the debtor's assets are insufficient to fulfill their rights holders, the distribution of debtor's funds is made by contribution: the balance of the sale price of the encumbered building is distributed among the mortgage creditors in proportion to the amount of their admitted claims (Legifrance, appeal: 14-17941, BICC n°830, 2015). The rules relating to the mortgage are not identical to those which govern the suretyship: when it is granted to guarantee the debt of a third party, the mortgage does not imply any personal commitment on the part of the person who does not is not the debtor, to satisfy the obligation of others.

Registration preserves the right of the creditor for a period fixed by law, and at the end of which, if the debt has not been paid, he must renew it. In the absence of completion of the final publication of a judicial mortgage within the prescribed period, the provisional publication is null and void on the date of payment, and in this case, the creditor cannot retain the sums which have been paid to him in violation of the rule of equality of unsecured creditors (Legifrance, appeal no. 09-13113, BICC no. 763, 2012). The mortgage is generally

granted by the debtor on one of his real estate assets, but it can also relate to a building belonging to a third party who has stood surety. In the latter case, the bond is said to be "real".

Pursuant to Article L. 642-12, paragraph 4, of the Commercial Code, the transfer of assets subject to a mortgage guaranteeing the repayment of loans granted to the debtor to finance the acquisition of these assets transfers to the assignee the burden of the mortgage and obliges him to pay the installments due from the transfer of ownership agreed with the creditor, it does not entail novation by substitution of debtor : the latter remains debtor of the monthly payments charged to the assignee. The hypothecary creditor, who has retained the benefit of his surety guaranteeing this debt and the resulting resale right, may exercise this right against the defaulting assignee, within the limit of the unpaid installments after the assignment (Legifrance, appeal no. 17-29009, BICC no. 908 , 2019).

a. The suretyship

The suretyship is the "historic" personal surety, known for a long time in French law, and the only personal security that the Civil Code regulates defined. Article 2288 defines suretyship as follows: it is "the contract by which a surety undertakes towards the creditor to pay the debt of the debtor in the event of default by the latter. Pour generously its guarantee, the creditor can obtain several sureties, guarantors of the same debt. These warnings are then appointed co-trustees. (Piette, 2022-2023).

The suretyship is a contract concluded between the creditor and the surety. This is a contract unilateral, because it only gives rise to obligations on the part of the surety. The parties are however free to transform their suretyship into a synallagmatic contract, by the stipulation, at the expense of the creditor, of obligations in return for those assumed by the surety: for example, a partial forgiveness of debt, the granting of a delay, or even the release of another surety.

The unilateral nature of the suretyship does not mean that the creditor is released from any obligation towards the surety. Some texts impose obligations information or compliance with the surety's future subrogation recourse. These bonds are not however not likely to transform the suretyship contract into a synallagmatic contract, because they cannot be analyzed as consideration for the surety's commitments. (Moutil, 2020).

b. Fundamental principles of a modern law of securities

Principles, which reflect the provisions of the Model Law, sum up, in general terms objectives, the objectives to be achieved and the principles to be applied so that the reform of the law of security interests helps to produce the desired economic development. First, they can be taken as basis for assessing a country's security law, identifying particular issues that need to be resolved in the country, and facilitate the development of consensus on the task at hand. They can also serve as criteria for evaluating a draft law and make it possible to measure the progress made during the reform process. Finally, once the law has been adopted and implemented, they can still be used during the monitoring process discussed above.

The Core Principles are not intended to impose a particular solution on a country - there are often several ways to achieve the same result - but to indicate the result to be achieved. Like everything together general principles, they must be read in the light of the law and practice of the country in question and do not should not be taken in absolute terms; exceptions to these principles will be inevitable.

The security must remain effective and enforceable in the event of bankruptcy or insolvency of the debtor on the property from which the security has been created.

Can registration be seen as a condition of validity of the mortgage? The uniform act gives an imprecise answer. According to Article 206 of the AUS, "As long as the mortgage deed is not registered, it shall not be binding on third parties and shall constitute to the parties thereto an exchange of promises which shall impose on them the obligation to have the deed registered" The review of this provision shows that beyond the advertising role assigned to mortgage registration, the OHADA legislator also tends to make the registration an implied term of validity of the mortgage by considering the hypothesis as being a synallagmatic promise in the absence of registration, especially since in the absence of registration of the hypothec granted, the creditor remains unsecured. Such an equivalence of Article 206 of the UAS could be not only subject to many litigations, but also to the misappropriation of the object of registration. To guard against all this, the best approach for the OHADA legislator could be to rewrite Article 206 of the UAS to remove any ambiguity about the nature of the listing, which remains primarily a requirement for publicity, not a formal condition of the mortgage agreement in the absence of which the mortgage agreement is void between the mortgage beneficiary and the grantor.

2.2. BLOCKCHAIN

When you think of computer systems that process large amounts of data, these are usually clusters of servers made up of several mainframe computers and running in an air-conditioned facility that come to us at the mind. Distributed computing is at the opposite end of the spectrum; in this guy system, data is stored

disparately in a network of servers weakly connected. Blockchain is a concept particularly interesting that applies distributed computing.

A blockchain is a type of distributed data that is stored in multiple computers in a peer-to-peer network and which preserves the integrity of the data, despite their decentralized character. In a blockchain, transactions are recorded in "blocks" that are stored in each of the computers on the network. The transactions validated stored in a block are linked to all previous transactions, forming like a blockchain. A new transaction is validated by checking it against previous transactions in the blockchain stored in the computer. Since the blockchain is stored in multiple computers, stored data may be more difficult to hack than traditional methods, which store all data in a central location.

A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system. And, once entered, information can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made. To use a basic analogy, it is easy to steal a cookie from a cookie jar, kept in a secluded place than stealing the cookie from a cookie jar kept in a market place, being observed by thousands of people. Bitcoin is the most popular example that is intrinsically tied to blockchain technology. It is also the most controversial one since it helps to enable a multibillion-dollar global market of anonymous transactions without any governmental control. Hence it has to deal with a number of regulatory issues involving national governments and financial institutions. However, Blockchain technology itself is non-controversial and has worked flawlessly over the years and is being successfully applied to both financial and non-financial world applications.

2.2.1. Origin of Blockchain

Shortcomings of current transaction system: » Cash is useful only in local transactions and in relatively small amounts. » The time between transaction and settlement can be long. » Duplication of effort and the need for third-party validation and/or the presence of intermediaries add to the inefficiencies. » Fraud, cyberattacks, and even simple mistakes add to the cost and complexity of doing business, and they expose all participants in the network to risk if a central system, such as a bank, is compromised. » Many people in the world don't have access to a bank account and have had to develop parallel payment systems to conduct transactions. And transaction volumes will explode with the rise of Internet of Things (Mathur, n.d).

1. Definition

Blockchain is a transaction secured ledger database shared by all the members participating in an established, distributed network of computers is used in many domain (initially used in financial exchange).

A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system. And, once entered, information can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made. Bitcoin, the decentralized peer-to-peer digital currency, is the most popular example that uses blockchain technology. The digital currency bitcoin itself is highly controversial but the underlying blockchain technology has worked flawlessly and found wide range of applications in both financial and nonfinancial world. The main hypothesis is that the blockchain establishes a system of creating a distributed consensus in the digital online world. This allows participating entities to know for certain that a digital event happened by creating an irrefutable record in a public ledger. It opens the door for developing a democratic open and scalable digital economy from a centralized one. There are tremendous opportunities in this disruptive technology and revolution in this space has just begun. This white paper describes blockchain technology and some compelling specific applications in both financial and nonfinancial sector. We then look at the challenges ahead and business opportunities in this fundamental technology that is all set to revolutionize our digital world (Michael Crosby, Google Nachiappan, Yahoo Pradhan Pattanayak, Yahoo Sanjeev Verma, Samsung research America Vignesh Kalyanaraman Fairchild Semiconductor, 2015).

2. Two Types of Software Architecture

Software systems can be implemented in a variety of ways. However, one of the fundamental choices that must be made while putting a system into place has to do with its architecture, or how its parts are arranged and connected.

Centralized and distributed architectures are the two main types of software architecture. The components of centralized software systems are dispersed and linked by a single central component. As opposed to centralized coordination or control, dispersed system components instead form a network of interconnected components. The picture shows system components, also known as nodes, as circles, and connections between them as lines. The specifics of what these parts accomplish and what data is transmitted across the nodes are not crucial at this time. The fact that there are these two distinct methods of arranging software systems is crucial.

An illustration of a distributed architecture without a central element shows components connected to one another. It is a centralized architecture where each component is connected to one central component. The components are not connected with one another directly. They only have one direct connection to the central component (Daniel, 2017).

A file may be duplicated when transmitted. On the other hand, when the quantity transferred is a digital one, it is important to ensure that the person who transmits does not keep a copy. This is called the double spend problem. This problem was solved by the bitcoin blockchain. By solving this problem, the blockchain allows the transfer of a correct value from one node to another.

3. Why use blockchain?

It makes it possible to eliminate the intermediaries which can be:

- The notary
- Accountant
- The lawyer.

Blockchain is a technological revolution for several reasons, among which:

- Transmission of value (properties, cars and other goods) in a secure way thanks to smart contracts;
- No more intermediaries in the sales process. Less expensive and even more secure;
- Fast worldwide transfer;
- More capacity thanks to thousands of computers (nodes) working in the same network;

4. Potential areas of blockchain

Blockchain is not a general competence but intervenes in many areas such as:

- Digital rights
- Online betting
- Fair markets
- Derivative markets
- Debt management
- Health Insurance
- Micro finance
- Ecommerce
- Payment system
- Elections
- Intellectual properties
- Etc.

The blockchain grows when you add blocks. The blocks are added in chronological order. The Ethereum blockchain makes it possible to host smart contracts with Ether as currency.

The blockchain is designed to be durable and is not controlled by any entity. Each computer is a member of this community.

5. The Advantages of Distributed Systems (Daniel, 2017)

The major advantages of a distributed system over single computers are :

- ❖ Higher computing power
- ❖ Cost reduction
- ❖ Higher reliability
- ❖ Ability to grow naturally

a. Higher Computing Power

Combining the computing power of all connected machines yields the computing power of a distributed system. As a result, distributed systems often possess greater computing capacity than any individual machine. This has been demonstrated to be accurate even when contrasting isolated supercomputers with distributed systems made up of computers with relatively low processing capability.

b. Cost Reduction

Over the past 20 years, the cost of commonplace computers, memory, disk space, and networking hardware has decreased significantly. The starting costs of distributed systems are higher than the initial price of individual computers because distributed systems are made up of numerous computers. The price of building, running, and maintaining a supercomputer is still significantly greater than the price of building, running, and maintaining a distributed system. This is especially true because a distributed system's individual machines can be replaced without significantly affecting the entire system.

c. Higher Reliability

The greater reliability of a distributed system stems from the fact that even when one computer crashes, the entire computer network can still function. One single point of failure does not exist in a distributed system. The remaining elements can take over if one element fails. As a result, a distributed system is often more reliable than a single supercomputer.

d. Ability to Grow Naturally

A distributed system's computing power is the sum of the computing power of each of its component parts. By incorporating more computers into the system, one can boost its overall processing power. As a result, the system's overall computational capacity can be raised gradually and precisely. This demonstrates how the need for computing power is growing across a wide range of enterprises. When compared to individual computer computational power growth, distributed systems see incremental growth. Until they are replaced with a more potent computer, individual computers deliver the same amount of power. As a result, processing power grows discontinuously, which is rarely seen by those who use computing services.

6. The Disadvantages of Distributed Systems

The disadvantages of distributed systems compared to single computers are:

- ❖ Coordination overhead
- ❖ Communication overhead
- ❖ Dependency on networks
- ❖ Higher program complexity
- ❖ Security issues

a. Coordination Overhead

In distributed systems, the participants are not coordinated by a centralized body. As a result, the coordination must be carried out by the system's constituent parts. Coordination overhead refers to the difficult chore of coordinating work among coworkers in a distributed system, which consumes time and resources that could be used for the actual computing task.

b. Communication Overhead

Communication is necessary for coordination. As a result, communication between the computers that make up a distributed system is required. As a result, a communication protocol must exist and messages must be sent, received, and processed. This demands time and resources that cannot be used for the actual computing work, hence the phrase "communication overhead."

c. Dependency on networks

A medium is necessary for all forms of communication. Information is transferred between entities communicating with one another through the medium. Messages sent via a network are how computers in dispersed systems communicate with one another. The difficulties that networks present have an impact on the coordination and communication between the computers that make up a distributed system. However, without a network, a distributed system, communication, and consequently coordination between nodes would not exist, explaining the need on networks.

d. Higher program complexity

Writing software and programs is necessary to solve a computing problem. Any software in a distributed system must address additional issues including coordination, communication, and network utilization due to the drawbacks already discussed. The software becomes more sophisticated as a result.

e. Security issues

Delivering and sharing data via a network entails delivering data that is essential to the actual computer process. Sending data through a network, however, raises security issues since shady actors could abuse the system to gain access to and profit from it. Therefore, security issues must be addressed in every distributed system. The distributed system has greater security issues the less restricted access is to the network that the distributed nodes use to communicate.

7. Miner

A miner is a user who participates in the network's security and integrity by processing and confirming transactions sent over the network. He is responsible for building the new blocks.

Apart from what is said above, the miner plays the following roles:

- ✓ Host a copy of the blockchain
- ✓ Add new lists of transactions (blocks) to the blockchain
- ✓ Verify blockchain integrity
- ✓ Execute smart contracts

8. Signature

The digital signature of a document guarantees both the content of this document and the authenticity of the person who is the author. For this, the author takes a digital fingerprint of the document (its hash) and encrypts it with his private key.

- The signature is used to prove ownership of an address without exposing its private key.
- Prove that there was no tampering.

9. Private and public key

A key is a term from cryptography. It is a string that allows to sign, encrypt and decrypt a message. A distinction is made in cryptography between private keys, which must be secret, and public keys, which can be disclosed to everyone.

- Each account in the ethereum network has a private and public key;
- Each Ethereum account is represented by an address which is simply a hash of the public key;
- Accounts can use their private key to sign a transaction, returning a signature of that transaction;
- Anyone can verify the generated signature, public key, signature address, and verify message integrity;
- Each private key is different from the other
- The public key can be recovered from the private key
- Private key cannot be recovered from public key
- Private key=>public key=>Ethereum account

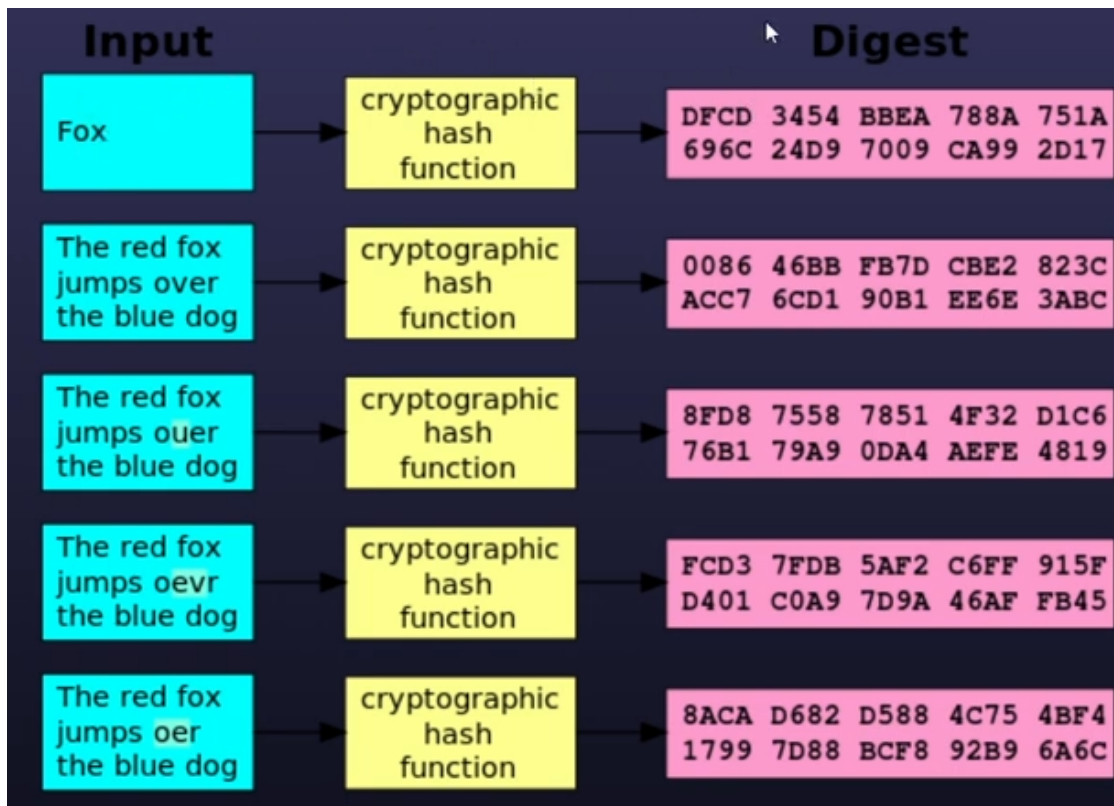


Figure III: (Stolfi, 2008)

Interpretation

- The same data produces the same output at the hash level;
- The output is quick to calculate;
- It is not possible from the output to find the input except exception;

To secure the data, there are keys (public or private) which will allow the results to be read. We can have a result during decryption if we obtained a key but we will not know the entry. The exception occurs when the administrator gives access to network members to know the entry. In this case, he can also share the private key. But from the start it is the public key which is shared to facilitate the reading of the encrypted data.

- The smallest change in the input will change the output.

10. Ethereum

Ethereum is a decentralized trading system that enables users to establish smart contracts. These "smart contracts" are based on a computer system to confirm or enforce a mutual commitment. They are put into use and openly accessible in a blockchain. These contracts are paid for using Ethereum's Ether unit of account. Trading platforms refer to it by its appropriate abbreviation, "ETH". With a market valuation of more than €448 billion as of October 2021, Ethereum is the second-largest decentralized cryptocurrency.

11. Smart contract

Smart contracts are digital contracts stored on a blockchain that are automatically executed when predetermined terms and conditions are met. When talking about smart contracts, we are referring to:

- Byte code stored in the blockchain
- Writing in a very high level language: solidity
- The compilation
- Execution in the Ethereum Virtual machine
- Deployment of byte code in Ethereum
- The impossible modification and deletion of the contract once on the blockchain
- Accessibility on all up-to-date nodes
- Interaction with the contract is only possible if there is a virtual machine that interprets

2.2.3. Management

Management is the coordination and administration of tasks to achieve a goal. Such administration activities include setting the organization's strategy and coordinating the efforts of staff to accomplish these objective through the application of available resources. Management can also refer to the seniority structure of staff members within an organization (Indeed, 2023).

2.2.3. Information System

A system is a hardware system, software system, or combination, which has components as its structure and observable inter-process communications as its behavior (Kvng, 2023).

An information system is a formal, sociotechnical, organizational system designed to collect, process, process, store, and distribute information (wikipedia, 2023).

Information system has been defined in terms of two perspectives: one relating to its function; the other relating to its structure. From a functional perspective; an information system is a technologically implemented medium for the purpose of recording, storing, and disseminating linguistic expressions as well as for the supporting of inference making. From a structural perspective; an information system consists of a collection of people, processes, data, models, technology and partly formalized language, forming a cohesive structure which serves some organizational purpose or function. The functional definition has its merits in focusing on what actual users - from a conceptual point of view- do with the information system while using it. They communicate with experts to solve a particular problem. The structural definition makes clear that IS are socio-technical systems, i.e., systems consisting of humans, behavior rules, and conceptual and technical artifacts. An information system can be defined technically as a set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision making and control in an organization. In addition to supporting decision making, coordination, and control, information systems may also help managers and workers analyze problems, visualize complex subjects, and create new products. (Management Information Systems, 2011-2012).

A group of related elements that work together to gather, process, distribute, and receive feedback in order to achieve a goal.

arrangement of people, information, processes, interfaces, networks, and technology that work together to support and enhance a company's daily operations as well as its management's requirement for problem-solving and decision-making.

Management information system

For historical reasons, many of the different types of Information Systems found in commercial organizations are referred to as "Management Information Systems". However, within our pyramid model, Management Information Systems are management-level systems that are used by middle managers to help ensure the smooth running of the organization in the short to medium term. The highly structured information provided by these systems allows managers to evaluate an organization's performance by comparing current with previous outputs. (Sharma, n.d)

Literature gaps

Mortgage in DR Congo in general, City of Goma/Province of North Kivu in particular, has a problem related to mortgage management. Credits are granted by financial institutions to individuals and companies through guarantees (mortgages). In this chain of mortgages, many services must intervene, including:

The land affairs department where mortgages are registered, which produces the Financial Institution-Bank-Land Affairs Service relationship. Sometimes, the notary service and the courts intervene in the event of a dispute.

On the other hand, Lamda citizens may need to pay for the plots but they come across those subject to court and court seizure.

This chain must be secure to prevent a service from withdrawing a mortgage without the approval of another service intervening directly, but also that the system allows the lamda citizen to be able to check if the building put up for sale is not under seizure or mortgage.

III. BLOCKCHAIN IMPLEMENTATION

3.1. INTRODUCTION

In this chapter we will present the prototype of the system developed within the framework of the blockchain based on the mortgage while citing the different tools used.

3.1.1. Methodology

Research methodology is a systematic framework used to solve the research problem using the best and most feasible methods to conduct the research while aligning with the purpose and objectives of your research (Pamplona, 2022).

To troubleshoot, we'll use:

❖ **Action design research** : used to develop implementations in close cooperation with users and generate knowledge by designing an artifact.

❖ **Analysis**: the data collected by interview is analyzed to get a general overview of mortgage management from one service to another. This analysis will bring out a common framework for all the other services taking into account the observation drawn on the ground.

❖ **Documentary technique** by consulting various works and research of our predecessors.

❖ **Interview technique** by questioning certain services and people about mortgage management and its problems.

❖ **Model**: The model for running a blockchain mortgage system is depicted in figure 1.1 of our thesis. The model takes into account the land affairs department, which is the first to intervene in mortgage management, since a plot without a recognized title within this department can in no way constitute a mortgage. Secondly, creditors who are financial institutions or natural persons who can lend money who can intervene either, to find out if a previous mortgage does not exist and to record new data. Third, we go back to the land department to register the mortgage. Fourthly, if the debt is not paid, a lawsuit before the courts for the seizure of the building which can lead to an auction sale, otherwise, it is the sale before the notary of the city. Fifth, the alleged buyer of a property for verification of the state of the building. The following figure, is our own model:

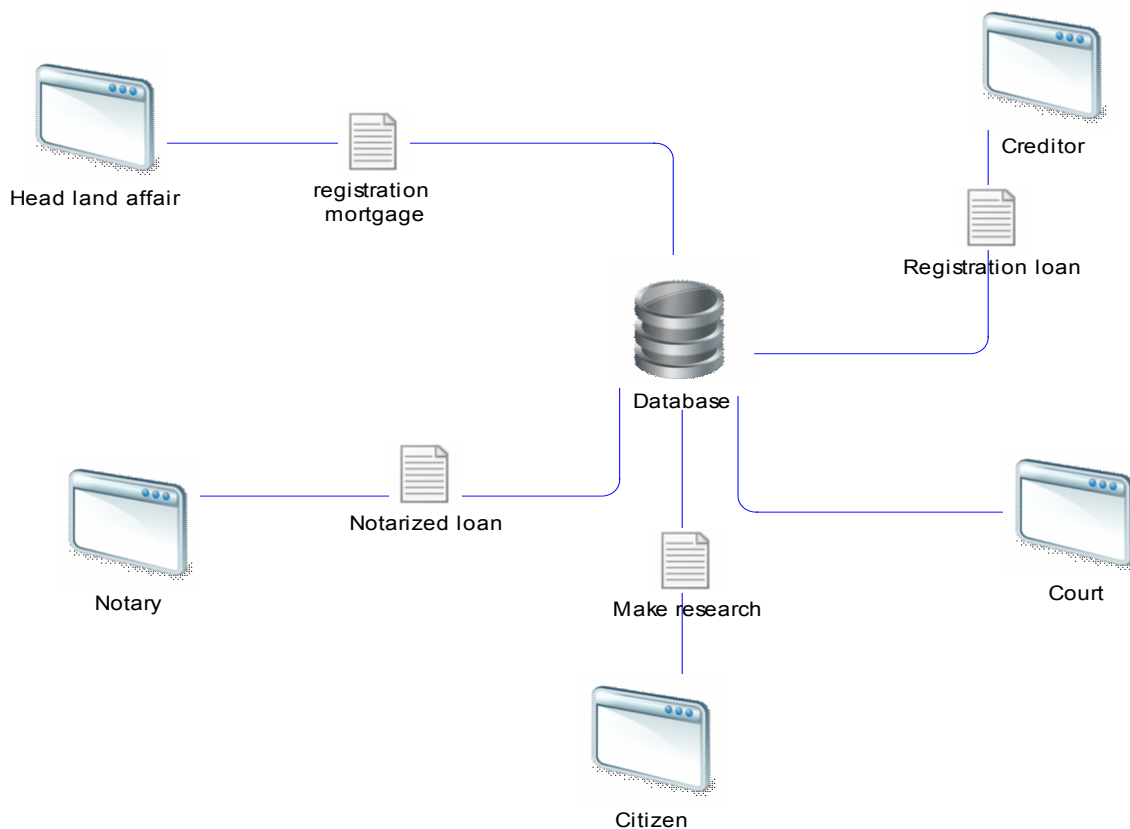


Figure III Model system

- ❖ **Prototyping** which is a process of making prototype. This one, is an incomplete and non-definitive example of what the final product or object may be.
- ❖ **Program Evaluation Review Technique (PERT)** : This approach allowed us to represent our project in a directed graph, whose vertices represent the anteriority constraints and are therefore oriented towards the posterior tasks. The vertices are represented by rectangles including the earliest and latest start and end dates as well as the reference and the duration of the task.
- ❖ **Unified Process (UP)** : This method contains a modeling language called UML allowing us to design an information system starting from diagrams.

3.2. INTRODUCTION

In this chapter we will present the prototype of the system developed within the framework of the blockchain based on the mortgage while citing the different tools used.

3.3. BLOCKCHAIN

3.3.1. Development tools

3.3.1.1. Visual studio code

Visual Studio Code is an extensible code editor developed by Microsoft for Windows, Linux, and macOS. Features include debugging support, syntax highlighting, smart code completion, snippets, code refactoring, and built-in Git. It was developed by Microsoft for Windows, Linux and macOS and supports multiple languages including Python, C, C++, C#, php, java, Node.js, html, css, javascripts etc.



Figure 32: visual studio code logo

Visual Studio Code is our environment in which some extensions were downloaded such as solidity.

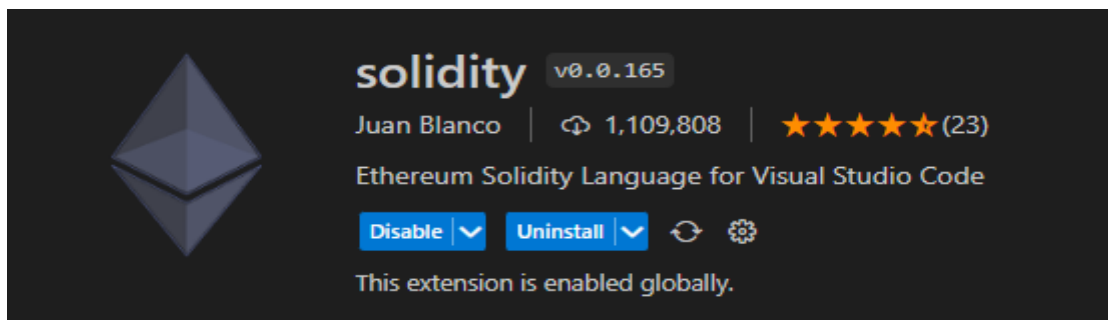


Figure 33: Solidity extension

The Ethereum Network team specifically developed Solidity, an object-oriented programming language, for building and developing smart contracts on Blockchain systems. It is used to develop smart contracts for the blockchain system, which apply business logic and provide a chain of transaction records. Python, C, and JavaScript had a significant impact on Solidity. It supports libraries, complex user-defined programming, and inheritance. Solidity is the primary language utilized by systems that run the Ethereum network.

3.3.1.2. Node.js

Node.js is a single-threaded, open-source, multi-platform runtime environment for creating network-based and server-side applications that are quick and scalable. It utilizes a non-blocking, event-driven I/O architecture and the V8 JavaScript runtime engine, making it effective and appropriate for real-time applications. 18.17.1 is our node.js version.

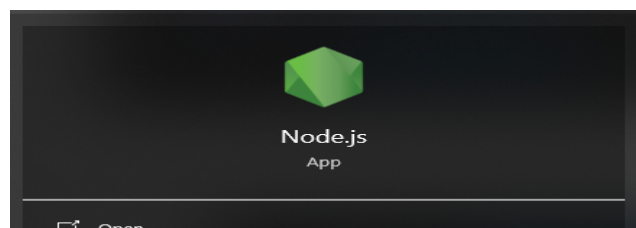


Figure 34: node.js icon

By installing node.js we got access to npm commands which are useful for running solidity codes. npm package manager command performs a long tasks list. Is just a registry and library for javascript software package.

3.3.1.3. React

Since 2013, Facebook (now Meta) has created React, a free JavaScript library also known as React.js or ReactJS. Through the building of components that depend on a report and the generation of an HTML page (or section) on each modification to the report, the primary goal of this library is to make it easier to create single-page web applications.

React is a library that only controls the application's user interface, which is referred to as the view in the MVC model. Thus, it can be used in conjunction with a different library or an MVC framework like AngularJS. The efficiency and versatility of the library set it apart from its rivals. It uses a virtual DOM and updates the browser's rendering only when necessary.

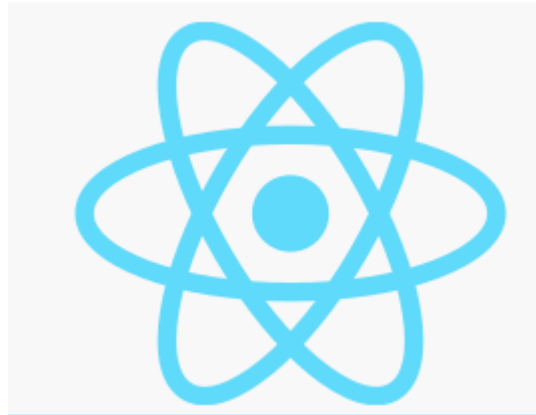


Figure 35: React logo

3.3.1.4. Hardhat

The Ethereum software development environment is called Hardhat. It is made up of many parts that may be used to edit, compile, debug, and deploy your dApps and smart contracts, together forming a whole development environment.



Figure 36: hardhat logo

3.3.1.5. Ganache

Creating Ethereum apps is quicker, simpler, and safer thanks to Ganache, an Ethereum simulator. It can be executed deterministically and comes with all the common RPC features and functions (such events), which makes development a breeze. When we need to simulate blockchain, we can use ganache.

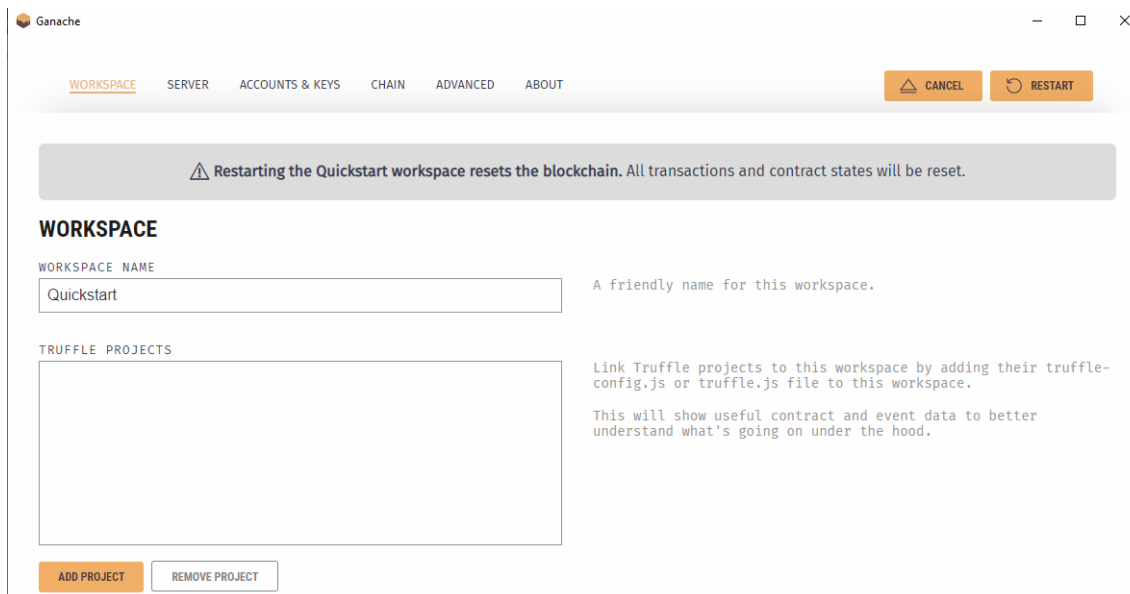


Figure 37: garnache workspace

To continue with the simulation, the blockchain project can be added to the garnache workspace. Once added, we can determine what condition the system is in. We'll be aware if it's already been deployed.

3.4. BLOCKCHAIN PROGRAMMING

To start, we created a folder called "SUBMIT THESIS" in which we manually created the project called "Thesis_Blockchain_ULK". This created project was opened in VS code.

Once the project is open in the IDE, we create a contract folder with the "mkdir contract" command.

We access our contract with the command "cd contract" in the terminal of VS Code and initialize it with the command "npm init -y" and it generates the json packages in the contract.



Figure 38: json package

Having created the contract with a json file, we install the hardhat still in our contract.

```
SUBMIT THESIS\Thesis_Blockchain_ULK\contract> npm install --save-dev hardhat
```

Figure 39: hardhat installation

To make a choice of the type of project to create, we type a hardhat command "npx hardhat@2.9.1" and allow us to choose "Create a basic sample project".

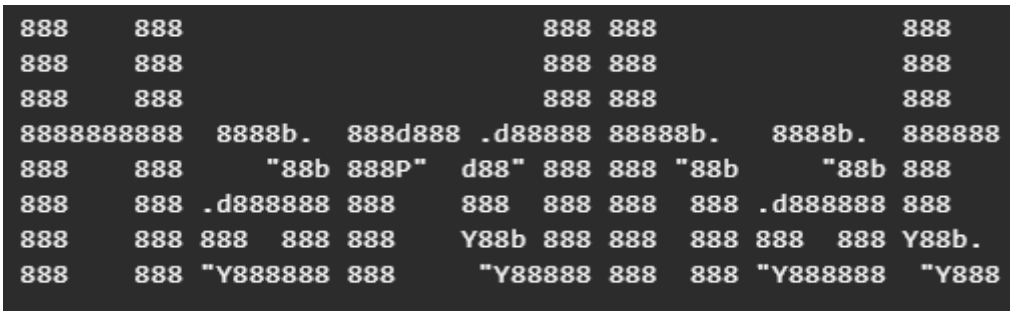


Figure 310: hardhat logo

We install the ethereum waffle components always in our command prompt.

```
SUBMIT THESIS\Thesis_Blockchain_ULK\contract> npm install -D @nomiclabs/hardhat-waffle ethereum-waffle chai @nomiclabs/hardhat-ethers ethers
```

This directly generates the contract with a "Greeter.sol" file, a solidity file.

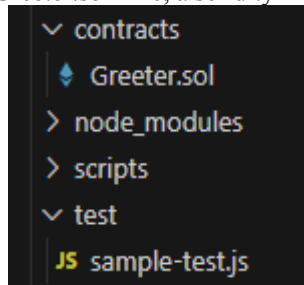


Figure 311: Generating file resulting from the bellow command

With all the above commands executed, the files generated in different projects are as follows.

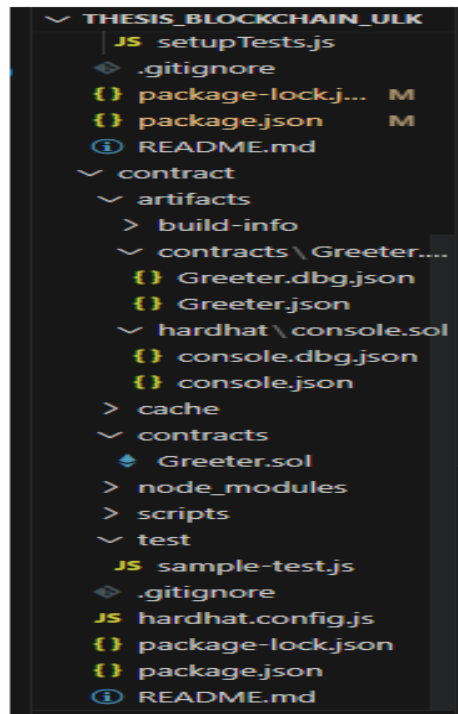


Figure 312: All generated files

With all these files, it is possible to view the different accounts generated. For the moment it is a block of 20 accounts numbered from 0 to 19.

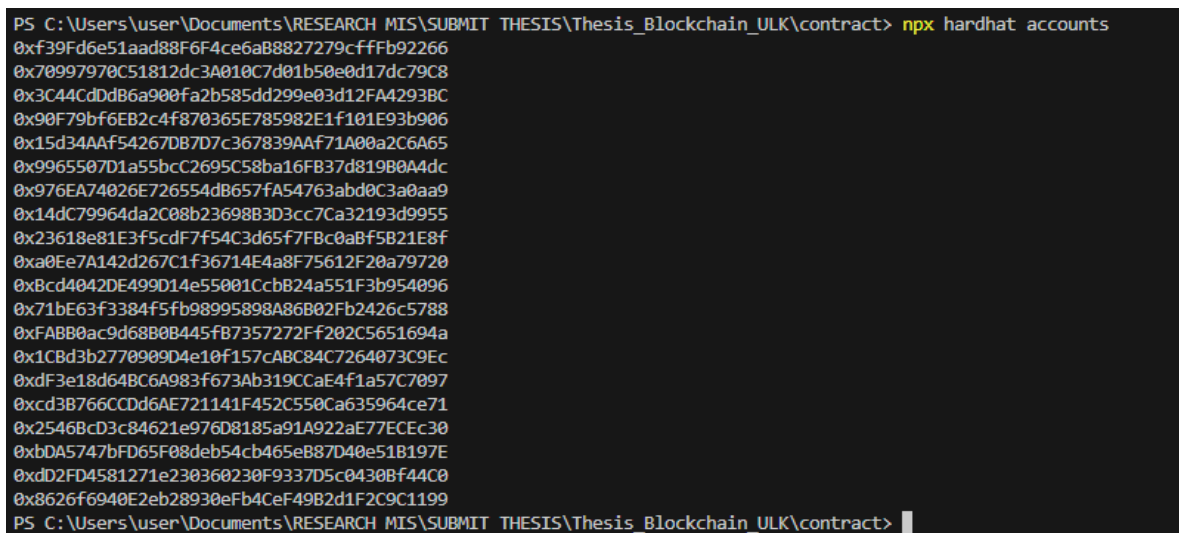
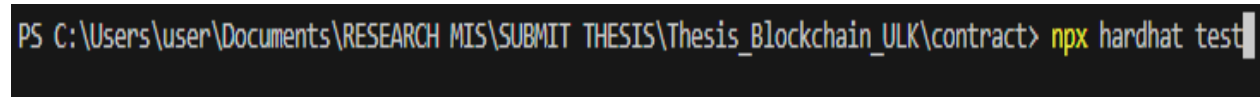


Figure 313:View block accounts

Each time we have a new method created in the "Greeter.sol" file, we must compile for these modifications to be taken into account in the json configuration file.

As there is generated js file in test folder, we can test and expect result. To do this, the following command is used:



On the previous figure we displayed our different accounts without private keys. Now we are going to display the nodes of our blockchain.

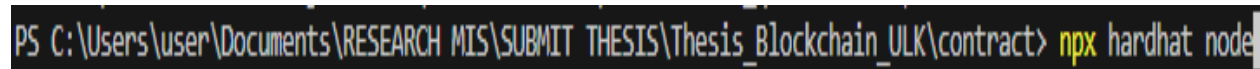


Figure 314:nodes account command

We have already seen our different addresses with their private keys, place to download metamask in our browsers. In the context of this work, only the metamask extension of chrome interests us. A software wallet for cryptocurrencies called MetaMask is used to communicate with the Ethereum network. Through a browser extension or mobile application, it enables users to access their Ethereum wallet, which can subsequently be used to connect with decentralized applications.



Figure 315:Metamask logo

Once metamask is installed, we need to configure it. In this process, a recovery key will be produced and boxes to be completed to be reassured if we hold the recovery key.



Er



Figure 316:Recovery secret keys

By confirming the recovery key, the first account will be created. It remains to change the Ethereum network to a local network using port 8545.

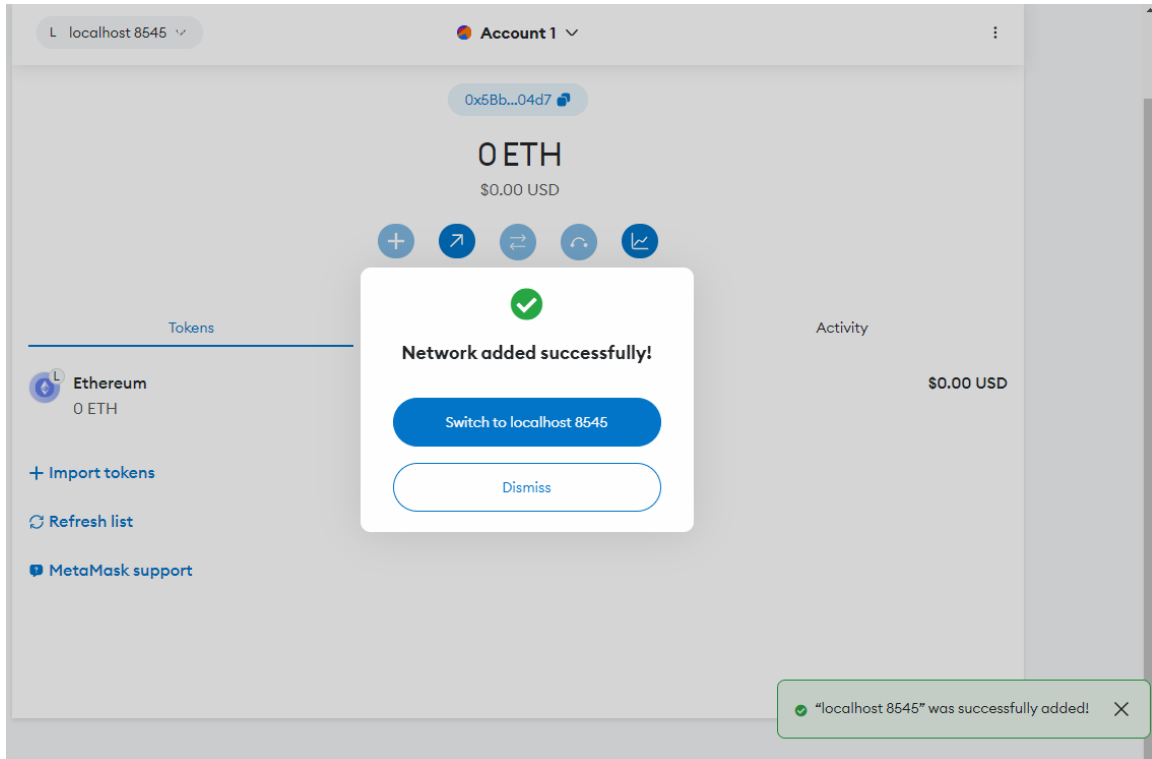


Figure 317: localhost account

We need to import accounts from our blockchain. Remember that with the "npx hardhat node" command we saw all the addresses (accounts) with their private keys. These keys are going to be used to create accounts in metamask in a graphical way. To do this, we copy the private key of an account and paste it into a metamask account configuration box. In other words, we talk about importing an account.

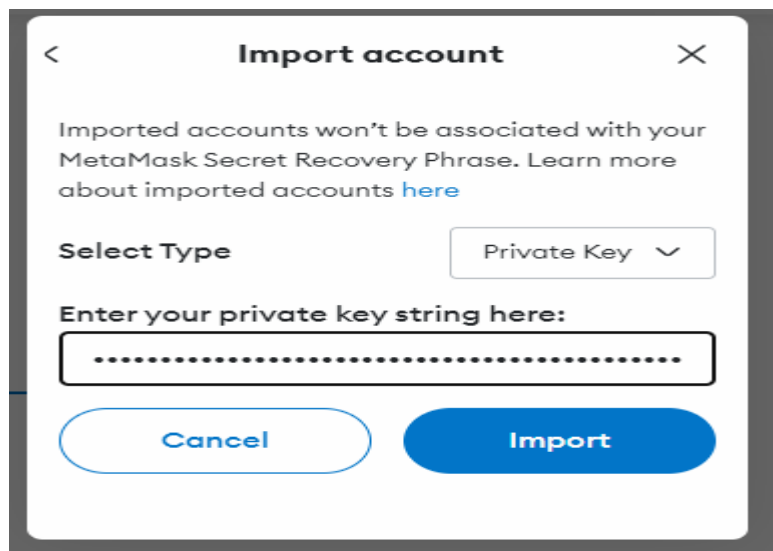


Figure 318: account importation

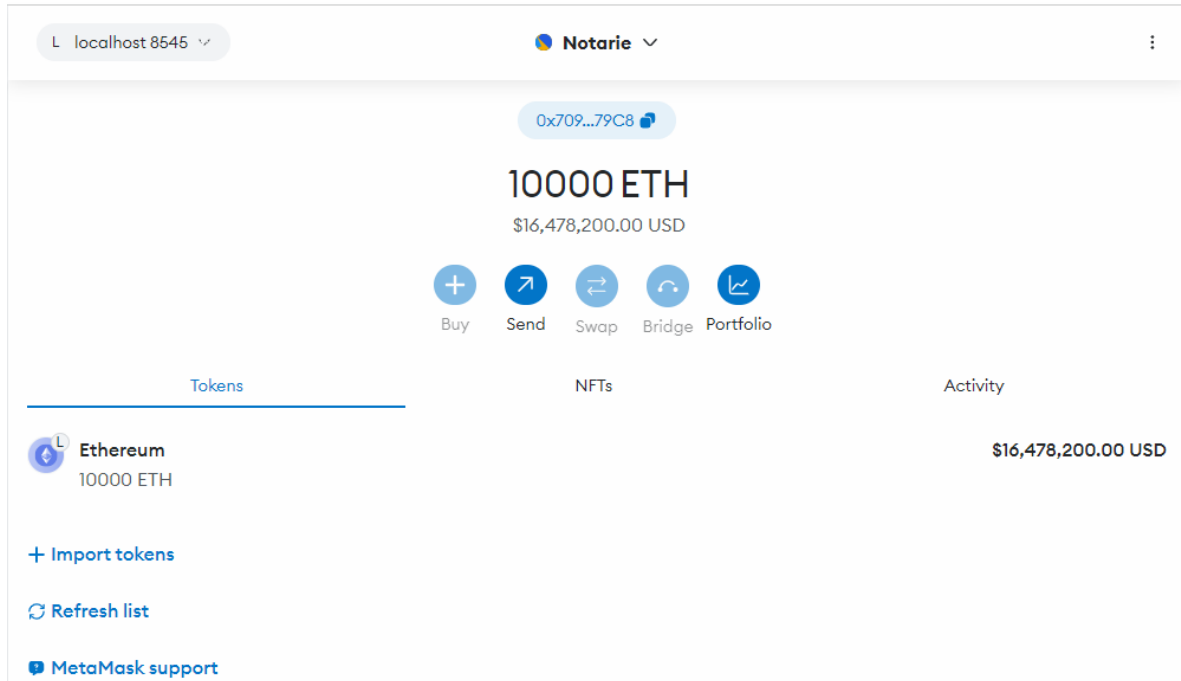


Figure 319: Notarie account

By default, our account has a balance of 10,000ETH. This allows him to carry out certain transactions. Now place the deployment of our blockchain in the local network configured in metamask.

```
\RESEARCH MIS\SUBMIT THESIS\Thesis_Blockchain_ULK\contract> npx hardhat run scripts/deploy.js --network localhost
```

Figure 320: deployment blockchain command

The above command generates the contract deployment key.

```
Greeter deployed to:0x5FbDB2315678afecb367f032d93F642f64180aa3
```

Figure III21: Private key deployed

We now create the client folder in the project with the command:

```
SUBMIT THESIS\Thesis_Blockchain_ULK> npx create-react-app client
```

Figure 322: client react command

The above command generates the client folder in which there are js files in the "src" subfolder. The most important of these files is "App.js" and "index.js".

Since we will need to spruce up our components, we upload bootstrap version 5.3.1.

```
\RESEARCH MIS\SUBMIT THESIS\Thesis_Blockchain_ULK\CLIENT> npm install bootstrap@5.3.1
```

Figure 323: Downloading bootstrap

The blockchain has many protocols among which, Bitcoin (BTC); Ethereum (ETH); Cardano (ADA); Binance SmartChain (BNB); Solana (SOL); Polkadot (DOT); Dogecoin (DOGE); Algorand (ALGO); Polygon (MATIC), etc.

As for us, the Ethereum protocol will be used.

```
\RESEARCH MIS\SUBMIT THESIS\Thesis_Blockchain_ULK\CLIENT> npm install ethers@5.6.1 --save-dev hardhat
```

Figure 324: ethereum installation

The big job is to link the web page to metamask. Each time we launch the web page, it will have to load metamask to verify the authenticity of the operation to be performed. Doing this is the Ethereum protocol. We are adding our scripts in App.js.

```
import React,{useState,useEffect} from 'react';
import { ethers } from "ethers";

function App() {
  const [greet,setGreet]=useState('');
  const [depositValue,setDepositValue]=useState('');
  const [greetingValue,setGreetingValue]=useState('');

  const provider = new ethers.providers.Web3Provider(window.ethereum);
  const signer = provider.getSigner();

  useEffect(() => {
    const connectWallet=async()->{
      await provider.send("eth_requestAccounts", []);
    }
  })
}
```

In order to query the blockchain state, such as account, block, or transaction details, query event logs, or evaluate read-only code using call, a provider is a read-only connection to the blockchain.

All actions that involve an account are wrapped by a Signer. A private key for an account is typically stored somewhere and can be used to sign different kinds of payloads.

The private key may be kept in memory (using a wallet) or protected by an IPC layer, such as MetaMask, which routes website interactions through a browser plug-in. This keeps the private key out of the website's reach and only allows interaction after requesting the user's permission and receiving authorization.

With the codes above, when you launch the index page, the metamask box is also loaded.

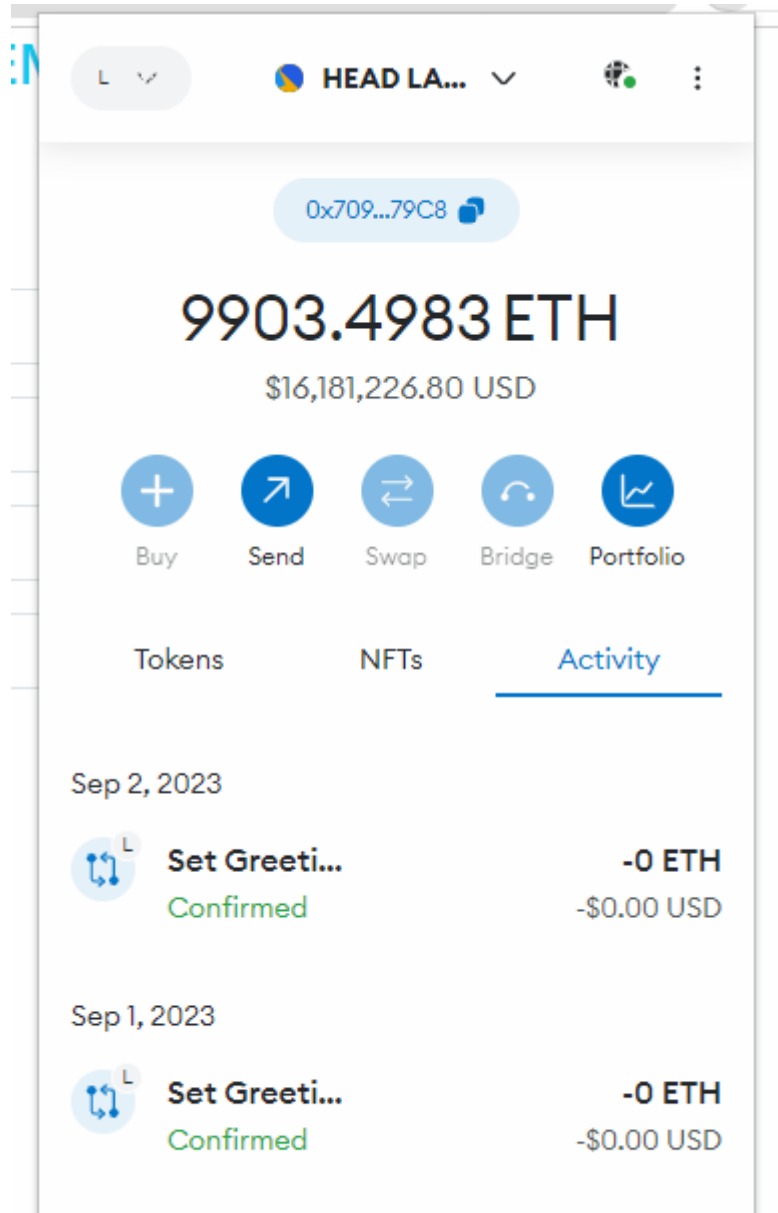


Figure 325: Head land account

You will notice that with the head land account of our local network 8545, there are transactions confirmed on September 1, 2023 and others on September 2, 2023. One can easily click on it to see the details for each date.

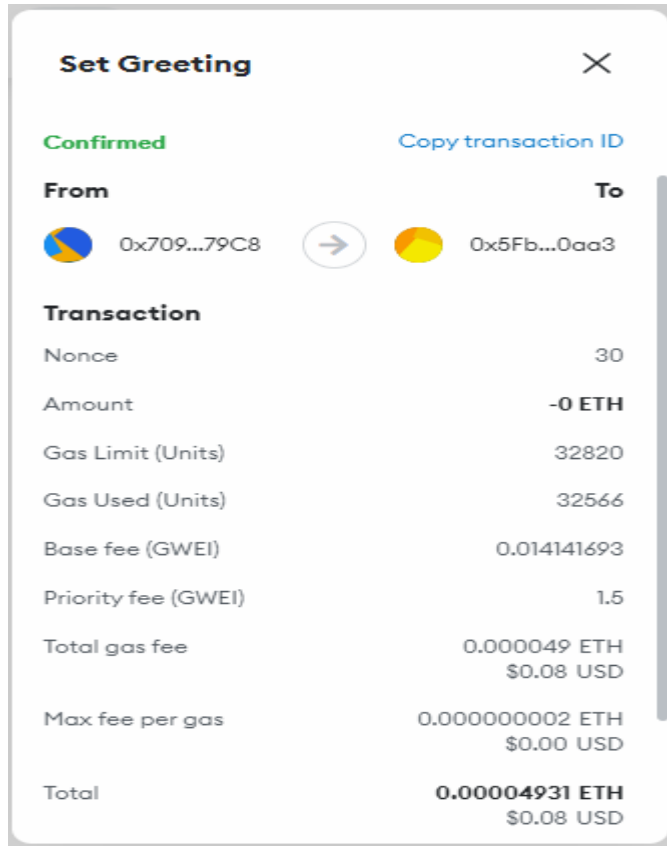


Figure 326: transaction details per date

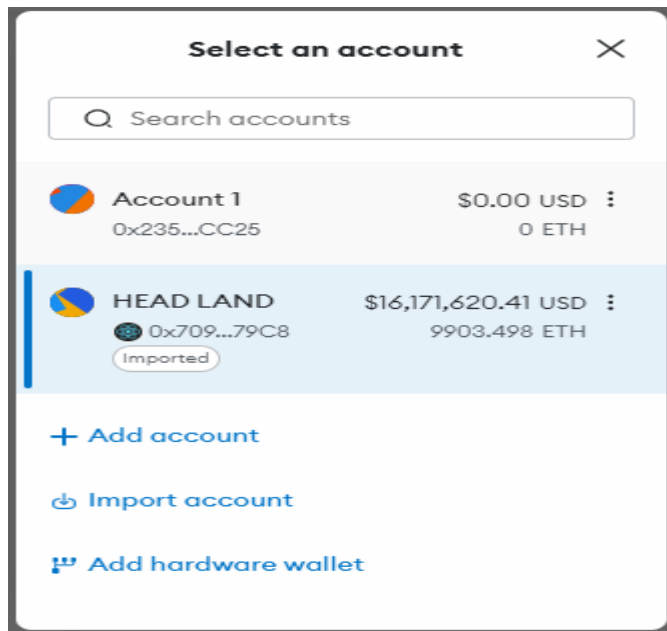


Figure 327: Available account

Since this is a prototype, we will put the page of the head land affair while recalling that it is the person who puts the visa on the mortgages (mortgage registration). Each time he can send the data, there will be interaction with metamask (intervention of the ethereum protocol) for the confirmation or rejection of the transaction.

localhost:3000

BLOCKCHAIN MORTGAGE MANAGEMENT SYSTEM

Mortgage Id : 73
Certificate number :
SU number :
Area :
Contract balance : 96.5 ETH

Mortgage Id
Certificate or contract number
SU number
Area

SEND

Let's register a mortgage of a building and click on the send button to see the reaction of ethereum.

The screenshot shows the mortgage management system interface with a MetaMask transaction confirmation overlay. The system interface displays the following information:

- Mortgage Id : 45
- Certificate number : Vol NG. 38 Folio 165
- SU number : 33.632
- Area : 3
- Contract balance : 96.5 ETH

The MetaMask overlay shows the following transaction details:

- Address: 0x5Fb...0aa3
- Amount: \$0.00
- Gas (estimated): 0.00004959 ETH
- Max fee: 0.00004966 ETH
- Total: \$0.08
- Amount + gas fee: 0.00004959 ETH
- Max amount: 0.00004966 ETH

Buttons: Reject, Confirm

Figure 328: mortgage page

The operation can be rejected or validated. If it is validated, the data will be displayed on the page and the history will be saved in the blockchain.

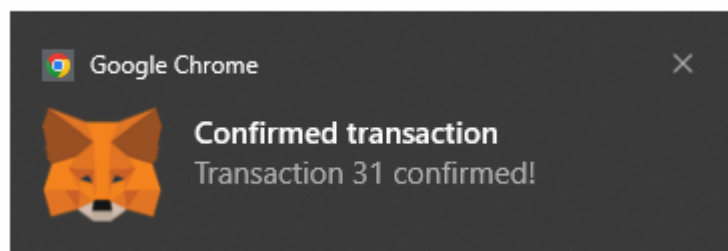


Figure 329: Confirmation notification

Figure 330: validation form

There are possibilities to use ganache to browse its smart contract and see the different addresses and their private keys.

ADDRESS	BALANCE	TX COUNT	INDEX
0x5C0df548A8D6DEB0299982B3C41e5a929d9D937	100.00 ETH	0	0
0x420EB304d8595AE801B099B41251eA8D6723E616	100.00 ETH	0	1
0x090a23408010B91F5371a334C81Ce8D02ea7f5a1	100.00 ETH	0	2
0x1145a54B3A77ad3dDeB15803fac83e7EfCe3a8ed	100.00 ETH	0	3
0x790DcDc16d83dE4d0E896FE9ee6f6a400eEe245B	100.00 ETH	0	4
0x52df2CB2f9e02F7a2fB2B8d8210926282915233C	100.00 ETH	0	5
0x25C039EfBd65D46deF6595cCe5b6D8b9bA3214FA	100.00 ETH	0	6
ADDRESS	BALANCE	TX COUNT	INDEX

Figure 331: blockchain account

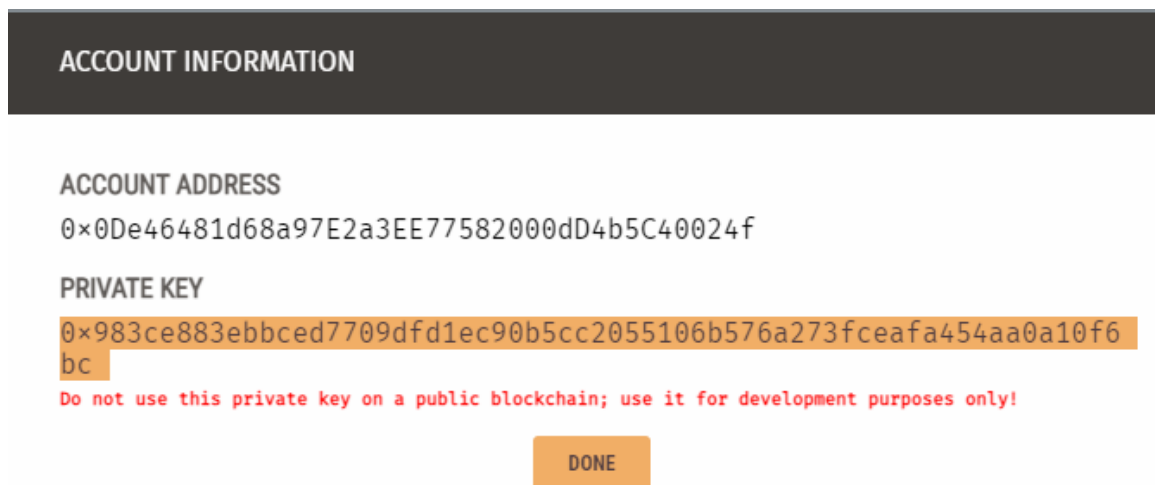


Figure 332: blockchain account

CONCLUSION

The real estate sector coupled with that of finance remains sensitive. Indeed, fraud, theft are common in this area. This is why the data linked to granting of credit with guarantee requires rational management. This prompted us to think about the blockchain for a data system distributed between several services or even domains.

However, our research focuses on blockchain mortgage management system, which started from the following problems:

- A double mortgage to obtain credit;
- A possible sale of the building mortgage;
- The existence of a hidden dispute over the mortgaged property before the competent court;
- Inaccessibility to mortgage information without moving before buying a building;
- Non-transparency of shared information;
- Non-traceability of data in a corporate network.

Starting from the problems noted above, we started from the research question according to which:

❖ How can a blockchain management system based on mortgaged be modeled to achieve the solution of the problems mentioned above?

This research question was answered by the designed system which takes into account different people involved in the granting of credits until researching the end user who is an ordinary citizen. To materialize this, we have developed a prototype web in solidity whose functionalities are summarized as follows:

For the creditor

- Enter the information about the granted loan

For the notary

- Notarize the pledge left as security for the loan granted

For the head land affair

- Register the mortgage in its registers in order to certify that the property as collateral is no longer available and therefore it is under seizure. This is manifested by the visa affixed to the order for the purpose of seizure of real estate.

For the court

- Register the file for execution when the seizing creditor seizes the court to proceed with the auction sale in payment of the outstanding debt. Or a file for the allocation of the building in payment of the claim.
- Register the decision rendered by the court to close the enforcement procedure.

For the citizen

- Do a search by entering the number of the plot that is put up for sale to reassured if it is not under seizure or even pledged.

Knowing that the essential element is the blockchain, the latter brings added value to the system so that:

✓ Blockchain boosts data in a corporate network's trust, security, transparency, and traceability, while also enabling cost reductions and introducing new efficiency.

✓ As a result of the nodes monitoring the system and checking one another, it guards against the potential of bad intent or hijacking. Gains in productivity and efficiency brought on by the blockchain's decision to transfer the management of exchanges to a computer protocol

By planning to set a new mortgage model, the data will be placed on a security public common portal for services or individuals approved in the granting of credit to debtors, services committed to mortgage registration, courts, as well as the service notarial, which will give the possibility to the public to access it so as not to come across a disputed purchase.

The fixed objective having been achieved, we believe that we have contributed our knowledge in solving the problems raised in the problematic of the research while opening a gap for future researchers to think about estate research via Global Positioning System (GPS).

RECOMMENDATIONS

Being at the end of our research which consists in putting a blockchain management system in other to overcome the multiple problems mentioned in statement of problem, to materialize it, we recommend the following:

To Democratic Republic of Congo government

- To put in place a good credit granting policy which also extends to natural person creditors as is the case with microfinance institutions and various banks.

- The good credit policy with guarantee will be possible by facilitating the management of these credits in a system operating in blockchain technology where it will support the different people involved in it such as the creditor, notary, custodian of real estate titles as well as the courts and tribunals.

- To popularize the use of the implemented system so that the average citizen becomes aware of it and appropriates it.

To creditor, notary, head land affair and court (internal users)

- To user the portal regularly, taking into account the functionalities it offers them.

To citizen

- To use the portal facilitating the control of buildings put up for sale before any purchase

By respecting the recommendations given, this proposed solution will be a panacea to the problems mentioned in the background of this research.

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