Design and implementation of a system for generating and certifying bank cheques using blockchain

***Abstract*—Cheques are a means of payment. It is a vehicle for so-called scriptural money. Because of its cashless nature, cheques are subject to shortcomings in terms of both security and ease of use. This article presents a system for dematerialising cheques, facilitating their certification and tracking through the use of revolutionary web3 technologies such as blockchain, interplanetary file systems and decentralised applications. Until now, issuing a cheque has required the physical contribution and presence of both the drawer and the bearer. We are offering the drawer of a bank the possibility of issuing a cheque digitally and managing it, as well as the possibility of designating the bearer or not. For the account manager, the possibility of better satisfying the customer's needs by optimising processing time and automating tasks that do not require his or her involvement. All these operations, of course, take place in a secure environment, a security offered by the blockchain with its use of cryptography and decentralised file system**

Keywords—scripturale, certification, décentralisation, blockchain, cheque

I. Introduction

Since around 650 BC, money has been an essential settlement asset in commercial transactions. Since then, money has undergone a number of changes and now comes in a variety of forms (fiduciary, scriptural, electronic and virtual) and uses a number of different methods (means of payment). Among the existing means of payment, the cheque, given its importance in the banking system, has attracted our attention. Despite the rise of electronic payments, cheques remain a common means of payment. According to a study by the BCEAO, in 2019, cheques will account for almost 10% of payments in the WAEMU zone and will be used particularly for large-value transactions. However, because of its physical handling and the limitations associated with the use of cashless currencies, cheques are one of the most sensitive means of payment: its integrity (can be damaged and become worthless), its credibility on the value it speculates (the debit account to be in deficit compared to the amount issued by the cheque), its handling (physical document to be transmitted to the bearer by the drawer), its authenticity (can be forged), the slowness of the clearing process, the physical handling of the document, the risk of fraud, and the lack of confidence of merchants in this means of payment. Despite the problems associated with the use of cheques, they remain an appropriate choice in French-speaking countries for large-value transactions and international payments (they provide transparency and traceability). It is therefore necessary and essential to work on improving the cheque clearing process, the security of the document and user confidence in this means of payment.

In this context, the dematerialisation of cheques has emerged as a necessary solution to meet the expectations of all parties (drawers and drawees), reduce the threats to cheques and meet the requirements of financial institutions. With the rise of the web through the birth of web 3 with blockchain, the secure use of decentralised web services and technologies offered by the use of blockchain, the possibility of issuing assets in a secure manner and ensuring their continuity and integrity are all advantages to the dematerialisation of cheques. Blockchain, with its secure and decentralized technologies, will make it possible to guarantee the integrity and durability of the assets issued, while ensuring the transparency of the entire process.

The challenge is to digitise cheque issuance via a secure network, guaranteeing the identity of the issuer and the ownership of the issuing bank, while optimising cheque processing and cashing times. This approach would meet the expectations of users and financial institutions, while offering new prospects for the future of the banking system. The result will be fewer physical cheques in circulation, it will be easier to issue cheques via the Internet, cheques issued without funds will be eliminated, cheque processing and cashing times will be optimised, and the value of cheques issued, cashed and not yet cashed will be tracked in real time.

II. FUNCTIONING OF CHEQUES IN THE BANKING SYSTEM AND RELATED CONSTRAINTS

A. Selecting a Template (Heading 2)

Cheques are widely used as a means of payment in the banking systems of most countries, particularly the member countries of the WAEMU and ECOWAS. It is mainly used for international and large-value transactions (value depending on the country), both commercial transactions between companies and transactions between individuals. By studying the characteristics, authentication and cashing of cheques, we can gain a better understanding of how they work in the banking system and the shortcomings associated with them.

B. Maintaining the Integrity of the Specifications

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The first point to note is the physical nature of cheques. It is a written means of payment, authorising the beneficiary to withdraw the sum marked above the signatory's bank in accordance with Law No. 2000-12, which specifies its mandatory content: name, precise amount, identity of the payer, place of payment, date and place of creation, and the signature of the issuer. However, in the WAEMU and ECOWAS, the vulnerability of cheques to fraud, alteration or incomplete issuance raises problems of collection and financial risks, requiring strengthened security protocols to guarantee their integrity.

It should also be noted that to obtain a cheque book in the UEMOA and ECOWAS, the customer must have a bank account, submit a formal request, present identification and sign an account agreement. Although the chequebook can be sent by post or withdrawn at a bank, access is restricted for the underprivileged or in rural areas, where banking services are limited, which is a major obstacle to the widespread use of cheques.

Cheque authentication, which is crucial in the WAEMU and ECOWAS, involves verification of the signature and funds by the bank. It involves three stages: checking the watermark, which is difficult to forge and is similar to the security of an identity card or bank note; examining the mandatory information and detecting signs of fraud such as altered colours or printing errors; and finally, confirming with the issuing bank that the cheque is legitimate. Given the slowness and frequent errors in the process, which can lead to fraud and financial loss, improving the efficiency of the authentication system is essential.

Cheques are cashed in WAEMU and ECOWAS via the issuing bank or the beneficiary's bank, which must authenticate the cheque and confirm that the funds are available. The process can be lengthy, leading to detrimental payment delays, especially for small businesses. To make these transactions more fluid, banks need to optimise their verification and payment systems to reduce collection times.

Constraints on the use of cheques in the UEMOA and ECOWAS zones are mainly due to vulnerability to fraud, slow authentication and collection processes, and difficulties of access for certain populations. These factors limit its effectiveness as a means of payment. Banks therefore need to strengthen security measures and modernise their infrastructures to speed up verification and collection, thereby reducing financial risks and improving accessibility, particularly for small businesses and people in underserved areas.

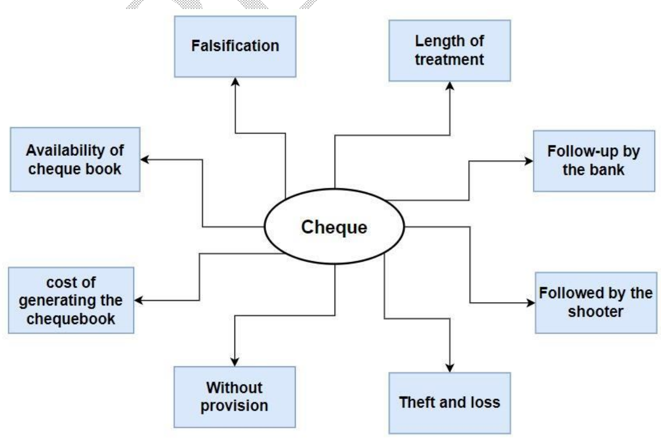

Fig. 1. Problems relating to the use of physical cheques

III. THE ETHEREUM BLOCKCHAIN

The Ethereum blockchain represents a significant advance in distributed ledger technologies. Unlike Bitcoin, which focuses primarily on cryptocurrency transactions, Ethereum provides a platform for the development of decentralised applications through the use of smart contracts. The latter, written mainly in Solidity, behave like autonomous programs that execute transactions or other specified actions when predefined conditions are met.

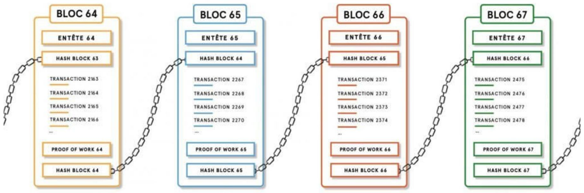

Fig. 2. The blockchain registry

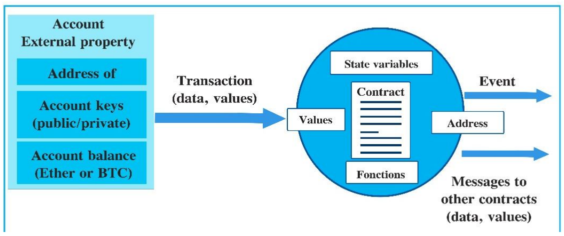

Fig. 3. How smart contracts work

```
pragma solidity ^0.8.4;
import "hardhat/console.sol";
contract Compte {
  string nom;
  string prenom;
  uint montant;
  function setNom(string memory _nom) public {
    nom = _nom;
  }
  function getNom() public view returns (string memory) {
    return nom;
  }
  function setPrenom(string memory _prenom) public {
    prenom = _prenom;
  }
  function getPrenom() public view returns (string memory) {
    return prenom;
  }
}
```

Fig. 4. Solidity code example

The Ethereum blockchain architecture incorporates mechanisms such as the Merkle tree, which ensures the integrity of transactions by grouping the cryptographic signatures of transactions in a block.

This structure enables rapid verification of the inclusion of transactions in a block without the need to revise the entire chain.

Another key concept is Zero-Knowledge Proofs (ZKP), which allow a party to prove that an assertion is true without revealing any information other than the truth of the assertion itself. This offers significant advantages in terms of the confidentiality and security of transactions.

The flexibility of the Ethereum blockchain enables the tokenisation of assets, which consists of converting rights over real or financial assets into digital tokens, and the creation of non-fungible tokens (NFTs), which are unique and can represent the ownership of digital or physical goods. These features pave the way for new applications in finance, the arts, the collection of valuables, and much more.

For a more in-depth look at concepts such as zero-knowledge proof and the Merkle tree in the context of the Ethereum blockchain, it is advisable to consult the technical documentation and scientific articles dedicated to these subjects, which explain in detail how these concepts work and are applied in the Ethereum blockchain system.

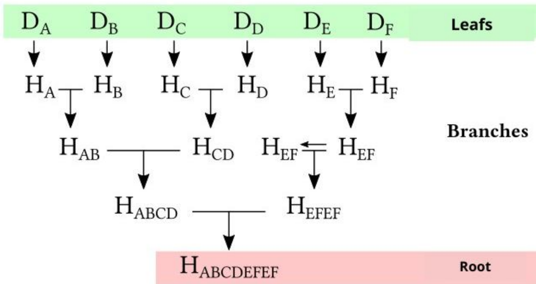

Fig. 5. Merkle tree [26]

IV- STATE OF THE ART

A. *State of the art of some existing cheque-related solutions*

1- PRIMRAI in Senegal

PAIMRAI stands for Projet D'Appui Institutionnel à la Mobilisation des ressources et à l'Attractivité des investissements.

According to a publication dated 11 June 2020 on the website [21], the Government of the Republic of Senegal has launched a software programme to monitor and manage unpaid cheques on behalf of its RecetteGénérale du Trésor. This tool will enable them to take the right decisions in real time to effectively recover cheques that have not been credited to the Treasury account. The tool is to be developed using web technologies, in particular SQL databases and DotNet technology, according to the accompanying document launching the call for tenders for the project on the web page. The advantages of this system would be the monitoring and management of cheques not yet credited to the Treasury account.

The limitations of these systems are:

- it will be necessary to contact the banks to obtain the information that a cheque has indeed been deposited, since before it can be considered as not having been credited, the cheque must be recognised as having been issued;
- the use of web2 subjects the system to the insecurities present on this generation of web, namely identity theft and denial of service attacks, to name but a few.

2- Cheque Chain in Dubai

Emirates NBD, Best Bank of Dubai, is a bank in the Emirates that uses blockchain to make cheques secure. Cheque Chain enables a QR code, a unique identifier, to be printed on each sheet of cheque books traditionally issued. This unique code registers each cheque on the blockchain, making it easier for the bank to check and validate the cheque. This considerably reduces the risk of fraud by making the cheque almost forgery-proof and requiring the use of scanners to identify and authenticate it.

This solution secures the cheque by marking it with a code recorded in the blockchain. While this solution makes the cheque more secure and easier to validate, it does not provide any reassurance about the availability of the funds it issues. What's more, the cheque remains physical, requiring the presence of both parties throughout the encashment process and the use of scanners.

B. *State of the art of blockchain-enabled secure documents*

Any dematerialised document or data passing through an information system could benefit from a blockchain to be certified and traced. The ultimate aim is to provide the content with a certificate to protect it against unauthorised modification throughout its life cycle. Here is an overview of blockchain applications already in place or planned.

1- Medical data

In healthcare, this type of data integrity has the potential to improve, or even radically change, many current practices that are considered standard by hospitals, insurers and patients

a. Blockchain applied to medical records

Medical data is confidential because of its personal and intimate nature. However, in certain situations, it can be very useful for care staff to have rapid access to a patient's medical file, in the event of an accident or medical emergency. In this way, emergency treatment can be ensured and appropriate treatment given with immediate access to the patient's history.

b. Using blockchain in the healthcare sector to combat counterfeit medicines and falsified vaccination certificates

According to the WHO, one in 10 medicines sold worldwide is counterfeit. This is a particular concern in regions where access to medicines is limited and counterfeit alternatives are part of the landscape, having a negative impact on business models, healthcare policies and patient safety.

c. Using blockchain in healthcare to get rid of medicine leaflets and reduce the number of drug recalls

Around 13% of recalls in the pharmaceutical industry are due to problems with the package leaflet, the paper leaflet containing technical information about the contents of each box. To tackle this problem, a group of healthcare organisations including the pharmaceutical players involved have joined forces to develop electronic medical information leaflets that will replace their paper counterparts in the future. The project, called PharmaLedger, aims to create a secure communication channel between the various stakeholders - patients, hospitals, doctors, industry and health authorities - that ensures the accuracy of medical information and the confidentiality of patient data. Blockchain technology could make this possible, as it assigns a permanent sequence of records to blocks of data containing the medical information of records.

2- The Land Registry

In Africa, having a simple address or a title deed is not so obvious, given that 90% of rural areas are not registered. It is impossible to identify the rightful owners of thousands of plots of land, which creates conflicts. Cadastres in dozens of cities across the developing world suffer from similar problems. Many citizens simply do not trust the system. Some do not know whether they are legal owners, even though they have a deed of sale. Others want to buy land but don't know if the seller legally owns it.

a. Ghana

In Ghana, the NGO Bitland aims to enable institutions and private individuals who wish to survey their land and register their land deeds on a blockchain via a form available on the Internet. The first steps taken in Ghana will certainly be replicated across the continent

b. Honduras

Honduras, which has experienced massive fraud and scams linked to property titles and hacking of the database listing land holdings, set about implementing a blockchain-based land registry system in 2015. This will make it possible to authenticate the land registry in real time, protect mortgages, contracts and mining rights, trace all transactions and encourage owners, more than 60% of whom are not registered with the land registry, to list their properties officially in order to secure them.

3- Diplomas

At MIT, a diploma (containing images, text and a signature) is associated with the unique identifier of graduating students. This data is encrypted, using an MIT private key, and stored in the blockchain. Graduates can then send their diplomas to recruiters, who can check the authenticity of the information on the dedicated platform.

The fact that the diplomas are in the blockchain ensures their authenticity, much more so than in paper format or in 'simple' digital format, which is relatively easy to falsify using the software available on the market. When MIT adds a diploma obtained by a student to the blockchain, this information can no longer be altered.

Another advantage is speed: recruiters do not have to compare an authentic diploma with the diploma submitted by applicants. The verification service automatically certifies the association between a person and a diploma, thanks to a simple link (or file) sent by the applicant. The tool instantly checks that the information transmitted is identical to that stored on the blockchain.

V- THE SOLUTION WE PROPOSE

The proposed solution is the decentralisation and dematerialisation of the entire banking system associated with cheques, from generation to cashing. This solution offers the following services :

- Monitoring cheques from the time they are issued: This will enable the bank to keep an eye on the cheques issued;
- Monitoring of cheques that have not yet been cashed: This service enables cheques that have not yet been cashed to be monitored;
- Certification of cheques before they are issued: this will help to avoid bounced cheques;
- Cheque issue planning: This will make the cheque issue and transfer process easier and more flexible;

- Cashing management: This service will be responsible for keeping a permanent record of cashed cheques.

The bank cheque generation and certification system are a system that offers the above-mentioned modules in a user-friendly web 3 ecosystem secured and maintained by blockchain.

VI- SOLUTION DESIGN

The design of our solution is based on a number of studies which have enabled us to identify the tools needed to implement the system and to define the approach to be followed.

A- Hardware

The elements required to complete the project are as follows

- a text editor with the required extensions: this is: a utility in which code is written.
- an Ethereum development environment or an Ethereum virtual machine (EVM): this is a local Ethereum network, designed for development and enabling contracts to be deployed, tests to be run and code to be debugged on your machine.
- a frontend framework: this is the software infrastructure used to define the user-side rendering of an application.
- A crypto wallet integrated into the browser: this gateway makes it easier to link your browser to the blockchain network.
- Decentralised file manager: this is a protocol based on decentralising the data to be stored, making it accessible on the blockchain

1- Text editor

Our text editor is Visual Studio code, which is user-friendly and has resources (extensions) to make it easier to develop our solution.

2- Ethereum development environment

To run and test smart contracts locally, you need an Ethereum development environment.

These include :

- Hardhat: This is a professional environment created by Nomic Labs, which supports developers in the process of developing smart contracts and Dapps, from compilation to execution and testing. It embeds a local Ethereum network for development, and a CLI for interacting with basic functionalities. It focuses on debugging Solidity. It generates the skeleton of a Dapp and includes the configuration required to facilitate its deployment.
- Truffle: This is an integrated development environment, with a test infrastructure and a portfolio of assets. It generates the skeleton of an Ethereum application and a smart contract, as well as a frontend. Truffle enables Dapps to be deployed on a local blockchain.
- Remix: Remix is an open source web and desktop application. It is used to write, test and deploy smart contracts, and is a great playground for learning and teaching blockchain development.

3- Crypto wallet

A crypto wallet is what will allow us to have crypto accounts. Far from being simply a means of storing crypto, it will enable us to interact with the components of the Ethereum blockchain. The MetaMask browser extension allows us to have a crypto wallet in all browsers after installation.

4- The frontend framework

It will enable us to set up the interface for browser interaction and guarantee a great user experience. The one we'll be using is the famous React js. Framework written in JavaScript.

5- Decentralised file manager

With blockchain, the usual database management systems such as FTP and SFTP are out of the picture. It is therefore only natural to use a decentralised management system. The best known are IPFS and Swarm.

- IPFS

IPFS is a distributed file system for storing and accessing data. So, rather than storing data in a centralised database, IPFS distributes and stores data over a peer-to-peer network. This allows you to retrieve it easily when you need it.
IPFS also has an incentive layer known as Filecoin. This layer incentivises nodes around the world to store and retrieve this data. You can use a provider like Infura (which provides you with an IPFS node) or Pinata (which provides an easy-to-use service where you can "pin" your files to IPFS and take the IPFS hash and store it on the blockchain).

- Swarm

  Swarm is similar to IPFS in that it is a decentralised storage network, but there is one notable difference. While Filecoin is a separate system, Swarm's incentive system is integrated and enforced via smart contracts on the Ethereum blockchain to store and retrieve data.

  IPFS is the file manager we will be using for this project.

B- Methods

The approach that enabled us to stratify our project and bring it to a successful conclusion is set out above.

1- Identifying the players

The players identified as being directly involved in our system are mainly:

- The drawer

The drawer can log on to the system, issue a cheque or transfer request, view the list of requests (approved, rejected or cancelled) and view the status of cheques issued (cashed or not).

- The manager

The manager can authenticate himself, approve requests issued by the drawer (approved or not approved) and list the cheques issued (cashed or not).

- The cashier

As a cashier, I can authenticate myself, list the cheques issued and waiting to be cashed, order a collection, list the cheques issued and already cashed.

- The supervisor

The supervisor can authenticate, assign rights, list requests, list cheques and list users.

2- Message identification

We will now look at the various messages sent by the aforementioned actors during the course of the platform's use cases. When it comes to interactions involving a system and an actor, a message is the specification of a one-way communication between objects. It carries data with the intention of triggering an event (interaction) in the receiver.

A message is associated with two event occurrences: the sending event and the receiving event. In order to properly identify the messages generated or received by the actors, we need to ask ourselves

- for each "actor", which messages could trigger a behaviour expected by the system actor in the context of his activity;
- for the "system", which messages sent to a particular actor could contain useful information for that recipient

The interactions of the actors with the system are induced by the identification of the different messages exchanged by these actors with the system being designed. Thus, for the BCCMS system we have designed, the possible interactions between actors and the system are presented below.

The messages sent by the actors in the system are:

- Authentication messages ;
- Data entry ;

- requests for information.

Messages received by players :

- Information requested;
- display of data consultation requests.

Once we have identified the various players, we have an overview of their interactions with our system. Next, we present use case diagrams giving a detailed specification of these interactions

3- *Use case diagrams*

The use case diagram below summarises the way in which each physical actor in the system contributes in one way or another to its operation.

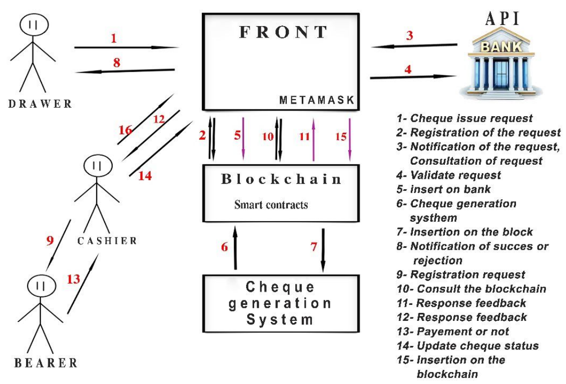

Fig. 6 System use case diagram

VII- RESULTS

The results of the work carried out as part of this project are presented in this section. The system developed is made up of modules. These modules are all important and work in synergy to ensure that the cheque generation process runs smoothly.

A. *Cheque issue request module*

This module concerns the bank customer and consists of three (3) pages:

- home page and platform connection page;
- cheque issue request page;
- management page for requests issued

1- *Home page and platform login*

It can be customised as the bank sees fit, with a description of the customer's bank and technical details on how to use the platform.

Users with a properly configured metamask wallet on their browser can connect to the account with a single click and access the dedicated interfaces. This page communicates with a smart contract that has a whitelist authorising only a known number of users.

2- *Cheque issue request page*

This page allows customers to enter information about the payment to be made, the cardholder's details, the funds to be disbursed and the date on which the cheque is to be issued.

When you try to access this page, a message appears asking you to log in.

3- Request management page

This lists all the cheques that have been requested to be issued, those already issued by the bank, those already cashed and those that have not been approved for issue, along with the reason for rejection. You need to be logged in to access it.

B- Cheque generation module

This module concerns the customer's account manager. It acts as a gateway between the customer and the customer's account manager. It enables the manager to receive customer requests and, if possible, issue the cheque. It consists of five (5) pages.

- Manager login page: The manager login page is reserved for bank employees and serves as a gateway to the module for bank employees. The rights it grants depend on the type of user logged in.
- Issued requests management page: this page shows the list of requests waiting to be issued and a form for validating a request after verification using the request id.
- Customer page: This lists all the customers managed by the administrator;
- customer details page: This page allows you to view the activity of a particular customer;
- page showing cheques awaiting issue: this page gives you the option of generating a cheque.

C- Cheque management module

This module is for bank counter managers. It shows the list of cheques waiting to be cashed. It allows the teller to select and validate a cheque withdrawal.

- Module connection page: The manager's connection page is reserved for bank employees and serves as the connection gateway to the module for bank employees. The rights granted depend on the type of user logged in.
- Presentation page for cheques waiting to be cashed: This shows the list of all cheques waiting to be cashed at bank level.
- Unissued cheques with reason page: This shows the list of cheques for which a request has been made and which have not been issued.

VIII- DISCUSSIONS AND PROSPECTS FOR IMPROVEMENT

A- Interpretation of results

Following our development, the platform we have put in place will limit the risks associated with the use of hand-written cheques. Among other things, our system for generating and certifying bank cheques makes it possible to..:

- certify cheques before they are issued;
- keep track of cheques in circulation;
- track cheques issued;
- optimise cheque cashing processing time;
- eliminate the need for physical cheques;
- make it easier to audit company finances

B- System limitations

The current version of the system for generating and certifying bank cheques is designed for use within a bank. It solves just one aspect of the banking system, namely the dematerialisation of bank cheques and their secure management. The system is limited by a number of dependencies:

- information relating to the bank's accounts: in fact, information such as the current balance of the system users' accounts with their bank is essential for optimising and automating certain tasks relating to the use of the system, such as:
    - authorising or rejecting requests on the basis of certain conditions deemed to be minimal, which would make the system easier to use for the manager (managing the issue of cheques smoothly, quickly and in real time);
    - to help the drawer make payment decisions by showing him his balance and suggesting payments to be made according to his habits.
- the system is limited to a use by companies-banks-sponsors: the fact that the validation of issue requests is not automated hampers the expansion of the system.
    - Too many requests for managers to handle when operating the system on a larger scale;
    - Too many bearers to satisfy at the same time: because of the ease with which the bank's users (drawers) can issue cheques, the latter will tend to issue more cheques in circulation, which would encourage the bank.
- Costs associated with using the system: The costs associated with using the machines on the Ethereum network generate costs for customers. Transaction costs on the blockchain at this stage of our development are quite high and can be reduced or even eliminated over time as we explore other solutions.

C- Prospects for improvement

In the future, the system developed could be applied to other means of payment, such as credit transfers, and could rationalise and limit the number of intermediaries involved in a credit transfer. The system, which has been set up in several banks, could also be interconnected to form a banking network. A banking network in which the clearing plan is managed automatically and decentralised. In addition, the exploration of less expensive solutions in terms of gas costs could reduce or even cancel out the costs associated with the use of blockchain (particularly with the introduction of a private blockchain). A mechanism for verifying the code transmitted to the bearer by the latter is also envisaged to ensure the clarity and transparency of transactions via our system. Collaboration with banks to use their resources (account information that could also be stored on the blockchain) would enable certain tasks to be automated and many other solutions to be put in place, such as artificial intelligence to assist businesses or any other drawer as well as bank agents interacting with our system.

IX- CONCLUSION

In this article, we present our system for generating and certifying bank cheques, a system made secure by the use of blockchain. Our system is designed to dematerialise bank cheques in a highly secure ecosystem.

To achieve this, we used tools based on blockchain technology, the EVM (Ethereum Virtual Machine) to deploy our DApp on the Ethereum blockchain, the IPFS (InterPlanetary File System) and programming languages such as Solidity and JavaScript.

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