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Research Article

Blockchain and NFC for Real Estate Certificate Management: An Albanian Case Study

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Abstract: This paper presents a novel framework designed to enhance the certification of real estate ownership and transactions through the integration of Ethereum blockchain technology, Near Field Communication (NFC), and smart contracts. The proposed architecture establishes a secure, transparent, and efficient digital certificate management system by leveraging immutable blockchain records, decentralized document storage via the InterPlanetary File System (IPFS), and NFC paper tags for effective physical-to-digital integration. The implementation employs encryption keys, Quick Response (QR) codes, and NFC tags to ensure data integrity and accessibility. A user-centric design has been developed to accommodate various stakeholders, including property owners, buyers, notaries, and land registry officials. This solution significantly improves upon traditional real estate transaction methods by facilitating end-to-end digital transactions, enhancing transparency and traceability, and substantially reducing the risk of fraud. By empowering participants to execute transactions and update records on a decentralized platform, this system fosters increased trust and operational efficiency within the Albanian real estate market. Furthermore, the design ensures compatibility with existing tax and payment procedures, providing a seamless transition for all stakeholders involved. The findings of this project aim not only to revolutionize real estate practices in Albania, but also to offer a scalable model for global implementation. By addressing the challenges associated with property certification and transactions, this innovative system contributes to a safer, more transparent, and efficient real estate environment. This framework is characterized by legal compliance, enhanced traceability, and robust fraud prevention mechanisms, ultimately paving the way for a modernized approach to real estate management in Albania and beyond.

Keywords: ***Blockchain; Cadastre; Ethereum; NFC; Smart Contracts***

1. Introduction

The existing land and real estate registration system in Albania exhibits significant complexity and ambiguity, characterized by the distinct management practices employed by each county[1]. According to the 2023 EU progress Report on Albania [1], substantial challenges persist in the area of the real estate ownership. These challenges encompass the incomplete resolution of transitional issues, including privatization, legalization, and the establishment of stable property administration. The property registration is a time-consuming and costly process that involves technical and legal services, registration, taxes, and cadastral services [2-3]. Buying and selling property in Albania[2] is characterized by significant complexity, necessitating extensive manual documentation, physical document exchanges, and personal

[1] Peter Van Asperen, "Survey on Costs for Registration and Transfer of Real Estate and Mortgages for the ECE region", 2019, Published *by United Nations Economic Commission for Europe (UNECE)* Available: http://www.unece.org/index.php?id=53567.
[2] Arlind Rama, "Property Rights in Albania: Challenges and Perspectives", 2013, Doi: 10.13140/RG.2.2.31135.25763.

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verification. This results in a sluggish and opaque system that is vulnerable to errors and fraudulent activities [4]. There is an urgent need for a digital system that can enhances transparency, accountability, accessibility, and verifiability in real estate transactions. However, it is essential that these new systems are integrated seamlessly with Albania's existing frameworks for legal real estate transactions. This integration must address methodological requirements related to documentation, taxation, payment processing, notarial involvement, issuance of certificates, and registration with land registry authorities.

To reap the benefits of digitalization while maintaining compliance, this paper proposes the development of an Ethereum blockchain-based system to certify property rights and transactions in Albania [5]. This system will enable the entire lifecycle of a property sale to be handled electronically, from the issuance of a digital certificate to the completion of the transfer of ownership in the land registers [6]. The system comprises smart contracts that establish property rules and transfers on an immutable ledger, IPFS storage of the relevant documents, encryption keys to ensure adequate access, QR code and NFC for quick verification, PDF certificates for user convenience, and an interface designed to meet the needs of all parties.

The structure of the paper is organized as follows. Related Works and Background are covered in Section 2. Section 3 outlines the existing real estate registration process and its workflows in Albania. Section 4 describes a proposed blockchain-based cadastre system. Section 5 examines Smart Contracts for managing, verifying, and executing transactions. Section 6 presents the proof-of-concept prototype and testing and additionally discusses the scalability, security and legal challenges. The user adaption strategy is described in Section 7. The final section concludes with a summary and recommendations for future work.

2. Background and Related Works

2.1. Background

Blockchain technology improves the credibility and openness of transactions by its mechanism that guarantees digital transactions occur on an immutable decentralized ledger [7]. The precision with which an audited digital ledger records transactions raises the bar considerably, enhancing resistance against unauthorized manipulation or hacking. This technology is implemented in the financial, healthcare, education [8, 9], energy, public administration [10], real estate [11], and many other sectors to ensure the consistency and dependability of data. Security is an attribute of blockchain technology due to its decentralized architecture [12]. Even if a single computer is compromised, the entire system is protected by blockchain technology, which distributes the responsibility of secrecy across numerous computers. Furthermore, it substantially diminishes transaction expenses, a factor of utmost importance in sectors such as finance and healthcare that heavily depend on the timely dissemination and safeguarding of confidential data. Blockchain technology could significantly transform the property transaction process by promoting trust among all participants in the real estate industry, enhancing transaction speed, and improving record accuracy [13].

Blockchain solutions can be implemented on Ethereum, Hyperledger, Corda, MultiChain, Stellar, Quorum, Ripple, etc. [14]. Ethereum is an established blockchain platform that substantially enhances the fundamental functionalities of blockchain by incorporating smart contracts. These contracts facilitate dependable and efficient transactions, including decentralized financing (DeFi) and digital asset management using action execution performed autonomously to control predetermined conditions [15].

Smart contracts are agreements wherein the conditions are autonomously executed via the storage of code lines on the blockchain [16]. These code lines directly encode the contractual terms. Soldering of smart contracts and Ethereum enables the development of complex applications that execute conventional procedures in a decentralized setting [17]. By decreasing reliance on intermediaries and implementing safeguards against fraudulent activity, this solution significantly improves the system's security. Due to the elimination of intermediaries and the incorporation of deterrent mechanisms against fraudulent activity, the system's security is substantially enhanced through the implementation of this strategy [18]. A reduction in dependence on external evidence is achieved through the assurance that all parties involved can place trust in the finalization of a transaction. This innovation is especially groundbreaking in industries like real estate, where smart contracts can secure and automate the purchasing and selling process, significantly decreasing the probability of disputes and duplicity.

2.2. Related Works

The use of digital certificates for property rights has become an interesting topic in recent years, with various solutions being proposed to solve the problems associated with traditional paper-based certificates [19]. One of the biggest challenges is ensuring the authenticity and integrity of these certificates, as they often contain sensitive personal and financial information.

Decentralized technologies such as blockchain and IPFS have emerged as promising solutions to address these challenges. Blockchain technology facilitates the creation of tamper-proof and immutable records of transactions [20], while IPFS enables the decentralized storage of large files and documents [21]. The combination of these technologies allows for the development of a secure and decentralized system for managing and verifying property certificates [22-24].

Our literature review indicates that the real estate industry in the United States, Sweden [25], and Georgia [26,27] have implemented blockchain technology to address issues related to corruption in the registration and transfer process of property. Some studies suggest utilizing smart contracts and tokenization to simplify property transactions and enhance market liquidity.

In their paper [28], the authors employ blockchain-based public opinion polls to analyze the economic and social viability of property investment opportunities. Findings from this study shed light on how businesses may respond to this technology. Statistics indicate that most professionals in the Portuguese real estate sector sufficient knowledge of blockchain technology. The authors argue that blockchain remains relatively new and is seldom discussed within the Portuguese real estate industry.

According to another study [29], real estate management systems can benefit from the increased efficiency and transparency provided by blockchain technology, as demonstrated through the practical application of Ethereum smart contracts.

Meanwhile, authors of [30] illustrate how blockchain technology could enhance operational efficiency and decision-making quality in the real estate business by providing an overview of recent advancements in the field. Research of this nature suggests that blockchain will have a significant impact on the future of property management.

Several projects have investigated the use of blockchain and IPFS for property certificates. For instance, the ***BitProperty*** platform employs blockchain technology to establish a decentralized registry of property ownership [31], enabling users to buy, sell, and rent properties using smart contracts. Similarly, the ***Propy***[3] platform utilizes blockchain and smart contracts to streamline the buying and selling process, thereby reducing the need for intermediaries and increasing transparency.

In addition to these technical solutions, efforts have been made to standardize the format and content of property certificates. For example, the European Union has developed the European Certificate of Succession (ECS) [32], which aims to simplify the cross-border recognition of property rights.

Our proposal seeks to create a fully decentralized and autonomous system for managing and verifying property certificates, leveraging blockchain and IPFS technology to ensure the authenticity and integrity of the certificates. This approach addresses the significant limitations of prior digitization efforts, which either focus on trading real estate or do not provide a single source of truth for ownership verification. Additionally, our system incorporates end-to-end encryption, meaning that the blockchain holds encrypted data, enhancing security and privacy, as well as integrating other decentralized storage systems such as IPFS to store more data related to the certificate. By integrating these advanced technologies, our solution simplifies the process of buying, selling, and renting properties while establishing a reliable framework for ownership verification that is accessible for trustworthy for all stakeholders involved.

3. Current Real Estate Registration Process and Its Issues in Albania

This section outlines the essential steps required to complete the title transfer process as illustrated in Fig. 1. To begin it is necessary to obtain the original purchase contract, which includes the deed, transfer, lease, and legalization documentation. This contract serves as the foundation for the property and includes

[3] D Propy, "Propy White Paper", 2017, Available: https://propy.com/browse/wp-content/uploads/2019/04/Propy-White-Paper-17-Jul-2017.pdf

vital details regarding its history and characteristics. Following this, it is important to obtain the latest certificate of property completion, which verifies that that the property has been fully constructed and complies with all relevant regulations and standards. Once both the original contract and completion certificate have been obtained, the seller must provide a new electronic certificate to facilitate the transfer of each part of the property being transferred. This certificate must be signed and notarized by the seller and should include all pertinent information about the property, such as the unique identification code, zoning, classification, type, size, value, and address.

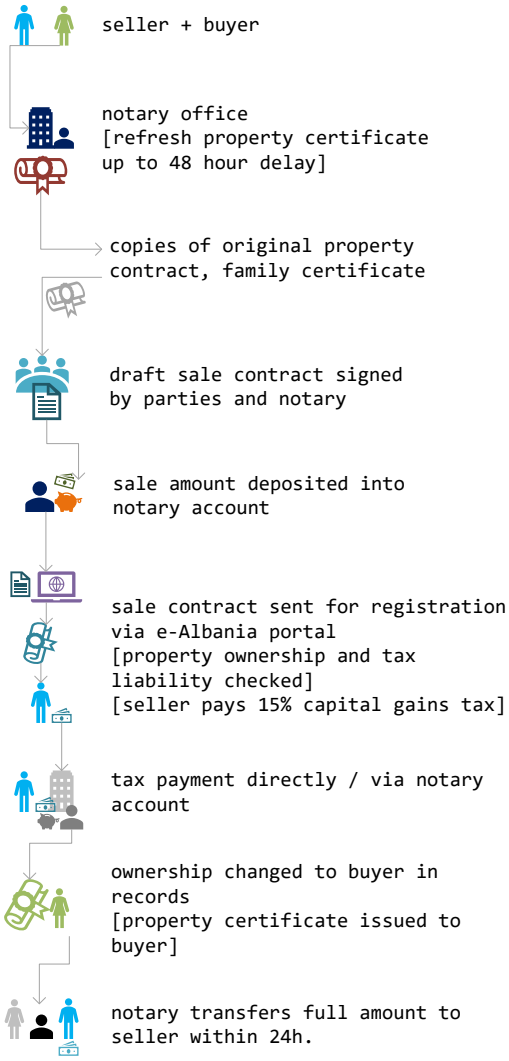

Figure 1. The existing real estate registration flow

Additionally, the seller is required to provide an updated version of the previous property certificate, which consolidates all prior property agreements into a single document. This certificate must be signed and notarized by the seller and should indicate the date of legalization. Prior to the ownership transfer, the property certificate needs be updated at the notary's office, a process that must be finalized within 48 hours of the transfer request. When the ownership change occurs, it is crucial that the property certificate be updated at the notary, again within 48 hours of the transfer request.

At the time of transfer, the property must be free of mortgage liens. If a mortgage is identified, the buyer must be notified, and the creditor's approval for the transfer is required. The buyer must also confirm that all utility bills, including electricity and water, are settled and that the seller is absolved of these responsibilities. Lastly, the buyer is responsible for paying all applicable fees associated with the property transfer, including all taxes and other charges, which must be paid in full before the transfer can be finalized.

The operation of the Immovable Property Registration Office (IPRO)[4] and the implementation of privatization legislation faces several significant challenges. Firstly, the reliance on manual record-keeping such as the use of paper *'Kartela,'* can hinder property transactions and cause delays due to cumbersome bureaucratic process. Additionally, the decentralized nature of the IPRO system can obstruct real estate transactions and access to property records particularly for individuals who are unable to visit registrars in person. Although digital systems were introduced in 2019, the slow advancement of technology infrastructure raises concerns about efficiency, security, and reliability. Moreover, neglecting to update the manual system with accurate and complete information can undermine the integrity of the property registration process and potentially resulting in legal entanglements. It is essential to enhance the efficiency, transparency and fairness of real estate transactions. To tackle these issues, we propose the integration of blockchain technology into real estate registration and transaction processes.

4. Blockchain-Based Cadastre system

The proposed system leverages decentralized technologies including blockchain and IPFS to manage and verify unique property certificates. Its objective is to enhance the current process and boost the integrity and trustworthiness of property certificates.

4.1. The Proposed Workflow

The architecture of the proposed workflow system consists of various components, including a blockchain network, an IPFS network, smart contracts, a user interface, gateways, and interfaces. Fig. 2 illustrates the proposed workflow of the system we will be implemented.

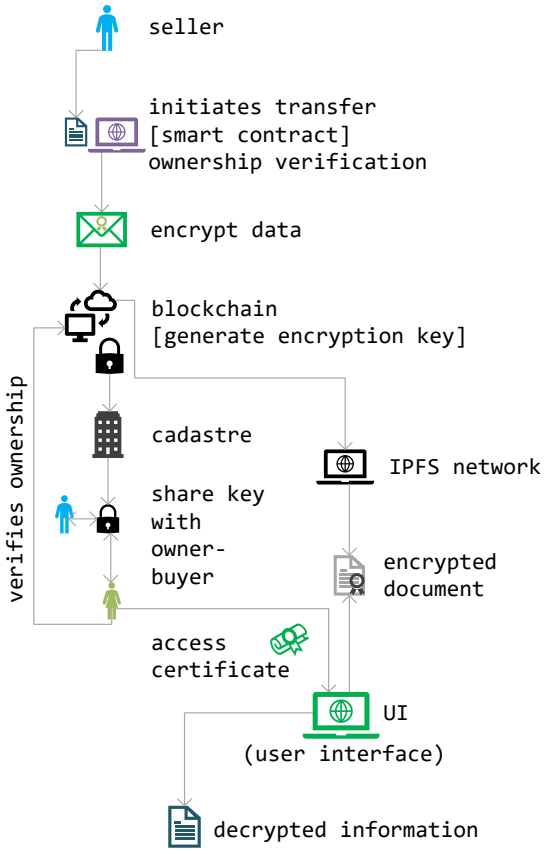

Figure 2. The proposed workflow of the system

[4] World Bank, "World Bank Integrated Land Management and Geospatial Infrastructure, Albania: Status Review of the Immovable Property Registration Office (IPRO) Now Superseded by the State Cadaster Agency (ASHK) Services and Data Quality", 2019 Available: https://documents1.worldbank.org/curated/en/481771562052486554/pdf/Albania-Status-Review-of-the-Immovable-Property-Registration-Office-IPRO-Services-and-Data-Quality.pdf.

The system enables secure access to real estate certificates through a decentralized network that guarantees safe and reliable retrieval. The process includes the following steps:

1. Information is entered through the front-end interface.
2. The information is encrypted and transmitted to the blockchain network for storage and verification.
3. The encrypted data is then sent to the IPFS network for storage.
4. The user interface retrieves the encrypted information from both the blockchain and IPFS networks and decrypts it for user access.

The proposed solution system offers several advantages including elimination of the intermediaries, reduced costs, enhanced transparency, and improved security. By leveraging decentralized technologies, the system efficiently and securely manages and verifies property certificates.

The proposal emphasizes the prioritization of verifying property certificates over the issuance process. While the issuance process will continue, the focus will be on strengthening the security and reliability of the verification process. It specifies that the data linked to the certificate will be stored on a blockchain network, ensuring the integrity of the information.

Moreover, the proposal highlights the critical need for verifying ownership certificates, given that traditional methods are vulnerable to forgery, which can lead to disputes and fraud. The goal is to establish a tamper-proof and secure environment for storing and verifying property certificates through blockchain technology.

Additionally, the proposal involves using IPFS to store documents and images associated with property certificates. This integration will facilitate faster and more efficient retrieval of the certificates while preserving the security and integrity of the data.

The success of the proposed system hinges on the effective implementation of this approach and the development of a robust and secure decentralized network. This initiative represents a significant advancement in improving the property certification process and ensuring safe and reliable access to property certificates.

4.2. The Architecture

As shown in Fig. 3, the cadastre employs an encrypted certificate that necessitates a specific encryption key for decryption. This key serves a dual function: it not only decrypts the data stored on the blockchain and IPFS but also enhances the system's security by making it ineffective without the key.

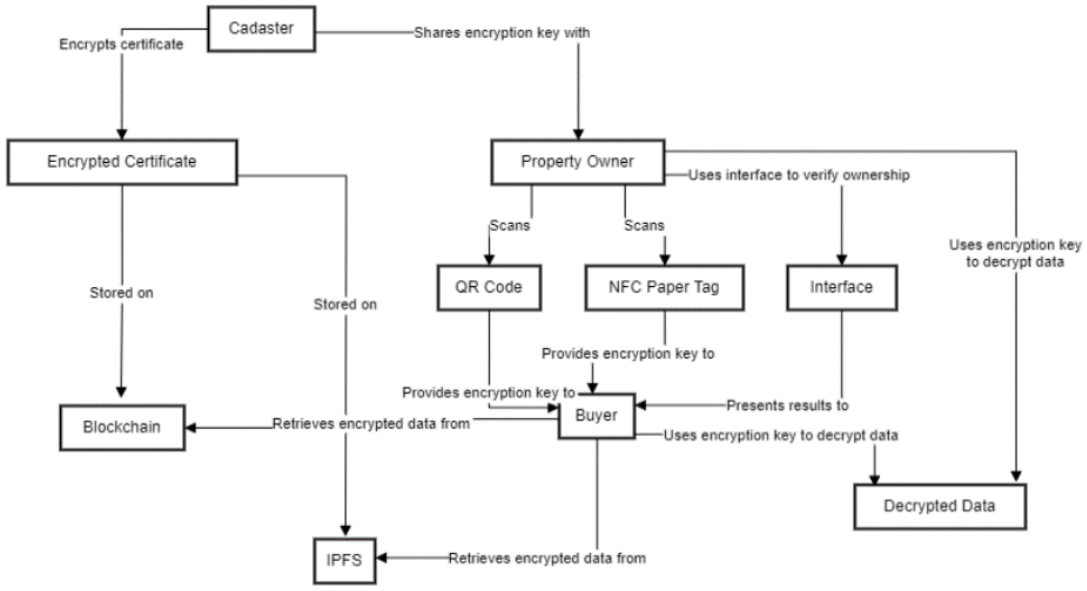

Figure 3. The architecture of the proposed system flow

The encryption key is provided to the property owner, granting them access to their certificate. Alternatively, the land registry securely stores this key on its private servers to assist the owner in case of a critical loss. The owner can

share the encryption key with a prospective buyer through a QR code. If necessary, the Land Registry can issue a physical copy of the certificate embedded with an NFC paper tag that contains the encryption key, thereby preventing unauthorized duplication and ensuring secure transmission. This key allows the buyer to verify the ownership of the property. Additionally, the owner can utilize the system interface to present results directly to the buyer.

4.3. Technologies

The following technologies are utilized for the implementation of the proposed systems:

1. ***Blockchain Network:*** This is a decentralized network comprising multiple nodes used for storing and managing property certificates through the Ethereum EVM. The Ethereum Virtual Machine (EVM) oversees the blockchain's state and enables smart contract execution of smart contracts on the Ethereum network [33-34]. Smart contracts are deployed and executed within the blockchain EVM to facilitate the creation and encryption of property certificates prior to their transfer to the blockchain and the IPFS network.
2. ***IPFS network:*** Similar to the blockchain network, the IPFS network is designed not for transaction data storage but for housing files, such as property photographs, scanned documents, or topographical images. It efficiently stores large files within the same environment as the blockchain network [35].
3. ***Gateways:*** These are servers configured with NGINX Reverse Proxy serving as intermediaries between the blockchain/IPFS networks and the user interface. The gateways receive information from the user interface and distribute it to the relevant nodes within each network.
4. ***User Interface:*** Constructed using JavaScript, the user interface allows users to view property certificates from the blockchain and IPFS networks and perform certificate decryption. This interface is hosted on edge networks via Cloudflare or Netlify.
5. ***Encryption Algorithm:*** The project will use the AES-256 encryption algorithm to ensure the security and privacy of property certificates.
6. ***Web Technologies:*** The development of the user interface leverages modern web technologies such as ReactJS, Web3JS, crypto-js, and IPFS-client.

These technologies collectively enable the creation of a secure, decentralized, and transparent solution for managing and verifying property certificates. The proposed system aims to provide a safe and reliable solution using blockchain and IPFS technology. The success of the project will depend on the effective implementation of this approach and development of a robust and secure decentralized network.

5. Smart Contracts for Managing, Verifying, and Executing Transactions

The smart contract is deployed in the Solidity programming language [37]. The effectiveness of the proposed system relies significantly on the proper implementation of this smart contract. In this section, we present the pseudocode for the primary functions of the smart contract which include (1) Identity access management, (2) Certificate Creation, and (3) Data Decryption on the front end. The code snippet below defines an identity ***'access management system'*** using role-based permissions. Algorithm 1 illustrates the identity access management system of the proposed solution.

Algorithm 1: Identity Access Management

```
permissions[Role.Admin]["createCertificate"] = true;
permissions[Role.Admin]["revokeCertificate"] = true;
permissions[Role.Admin]["viewAllCertificates"] = true;
permissions[Role.CertificateIssuer]["createCertificate"]= true;
function hasPermission(Role userRole, string memory permission) public view
returns (bool)
{
    return permissions[userRole][permission];
}
```

It grants specific permissions to different user roles including (1) *Admin role,* which can create certificates, revoke, and view all certificates; (2) *CertificateIssuer role*, which is authorized to create

certificates. The *"hasPermission"* function verifies if a given user role possesses specific permission by referencing the *"permissions"* mapping.

This code facilitates access control for various certificate management functions based on the user's assigned role, ensuring only authorized users can execute specific actions within the system.

The code in Algorithm snippet 2 represents the certificate creation process. The function ***addCert()*** performs the following tasks:

- It accepts arrays of PropertyID, publicData, encryptedData, State, and photoHash as parameters.
- Initially, it checks whether the caller is an issuer by evaluating the *'isIssuer'* variable. If the caller is not an issuer, the function exits immediately.
- It then iterates through the total number of certificates using a *for* loop.
- For each certificate, the function checks if it already exists using the *'certificate exists'* variable. If it does, the function exits immediately.
- If the certificate doesn't exist, it creates a new object in the certificate mapping using the *PropertyID* as the key.
- The certificate object contains the corresponding values from the input arrays: PropertyID, publicData, encryptedData, State, and photoHash.
- Finally, the function increments the totalCerts variable by 1 to keep track of the total number of certificates.

Algorithm 2 presents the pseudocode for the certificate creation process.

Algorithm 2: Certificate Creation Pseudocode

```
function addCert(PropertyID[], publicData[], encryptedData[], State[], photoHash[])
{
if (isIssuer)
        return;
for (i=0, i<totalCerts, i++) {
        if(certificateExixts)
                return;
        certificates[PropertyID[i]] = {
                PropertyID[i],
                publicData[i],
                encryptedData[i],
                State[i],
                photoHash[i]
               }
        totalCerts+1;
      }
}
```

This function allows an authorized issuer to create multiple certificates in a single transaction by providing the necessary data for each certificate. It ensures that duplicate certificates are not generated and maintains a count of the total number of certificates in the system.

Meanwhile, the pseudocode presented in Algorithm 3 demonstrates the decryption process on the front end.

Algorithm 3: Decrypting Data in the frontend

```
Let decrypted;
Try
{
        decrypted = AES.decrypt(encData, pass).toString(Utft8).split(';');
          { //decrypting image
                Const ipfs = ipfsClient(ipfsGateway);
                Const chunks = [];
                For await (const chunk of ipfs.cat(photoHash)) {
                {
                        let chunkString= new TextDecoder().decode(chunk);
                        chunks.push(chunkString);
```

```
12:                     }
13:                 decrypted.push(AES.decrypt(chunks.join(''), pass). toString(Utf8));
14:                 }
15:             if(decrpyted.length ===1)
16:                 throw new Error("Empty decryption")
17:     }
```

The purpose of this code is to decrypt the encrypted data (*`encData`*) and the associated image (stored on IPFS) using the provided password or encryption key (`pass`). It retrieves the image data chunks from IPFS, decodes them, and decrypts the combined chunks. The decrypted data and image are then stored in the `decrypted` array for further use on the front end.

6. Proof of Concept Prototype and Testing

The project is implemented by using the Geth (Go Ethereum) client to interact with the Ethereum blockchain, which is deployed on a server running Ubuntu 20.04 with 4GB RAM and a 2.2GHz processor. The Ethereum network serves as the foundation for managing property certificates and executing smart contracts. IPFS was integrated for decentralized document storage, ensuring that property-related documents are securely stored and retrievable. Ethereum was selected for its established ecosystem, robust security features, and support for smart contracts. The decentralized nature of Ethereum and its widespread adoption make it ideal for ensuring the immutability and trustworthiness of property certificates, while its active development community provides ongoing improvements and scalability solutions. Fig. 4 provides the final configuration for genesis block on Geth.

```
Which consensus engine to use? (default = clique)
 1. Ethash - proof-of-work
 2. Clique - proof-of-authority
> 2

How many seconds should blocks take? (default = 15)
> 15

Which accounts are allowed to seal? (mandatory at least one)
> 0x193D9169748Bf8C4D1A1B605CB4cc0e33d5b34fc
> 0x

Which accounts should be pre-funded? (advisable at least one)
> 0x193D9169748Bf8C4D1A1B605CB4cc0e33d5b34fc
> 0x

Should the precompile-addresses (0x1 .. 0xff) be pre-funded with 1 wei? (advisable yes)
> yes

Specify your chain/network ID if you want an explicit one (default = random)
> 8369
INFO [09-27|15:46:46.080] Configured new genesis block

What would you like to do? (default = stats)
 1. Show network stats
 2. Manage existing genesis
 3. Track new remote server
 4. Deploy network components
>
```

Figure 4. The final configuration for genesis block on Geth

6.1. The Implemented System

The flow of the entire innovative process is illustrated in Fig. 5.

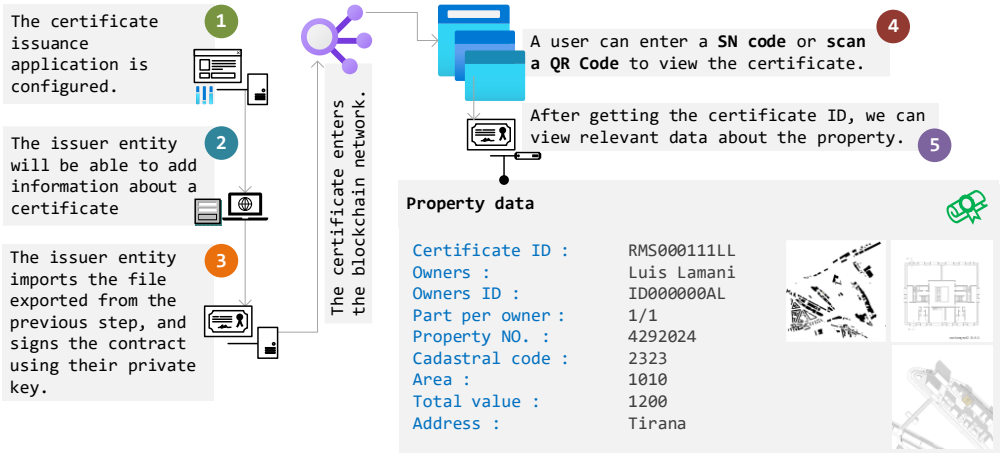

Figure 5. The flow of the entire innovative process

Once the certificate issuer's entity application is set up, it is authorized to enter the property certificate information into the system and sign the data using its private key. After this process, the certificate is uploaded to the blockchain network, making it accessible to interested stakeholders via a serial or QR code.

6.2. Blockchain and IPFS Server Benchmarks

This section presents various tests and evaluations of the developed prototype, focusing on performance assessment specifically regarding CPU and RAM usage on the server side, both without and with the implementation of IPFS.

The project constitutes a distributed system that comprising three servers, each designated for specific role in measuring the performance of the IPFS and blockchain services and their interactions. The first server hosts both the IPFS and blockchain nodes, serving as the primary node in the network and actings as a gateway for other nodes to connect. This configuration simulates a real-world scenario where the two services interact on the same server, allowing for direct measurement of their performance and evaluation of their mutual effects.

The second server is dedicated solely to hosting the IPFS node. Acting as a secondary node within the network, it serves as a gateway for other nodes to connect to the IPFS network. By isolating the IPFS node in this manner, the performance of the IPFS service can be evaluated independently, free from any interference from the blockchain service.

The third server is dedicated to hosting a single blockchain node, functioning as another secondary node and a gateway for other nodes to connect to the blockchain network. By hosting exclusively on the blockchain node, the performance of the blockchain service can be assessed in isolation, without the interference of the IPFS service.

All three servers are configured to communicate in a peer-to-peer manner, enabling them to interact as equal participants within the network. This setup allows for the measurement of the overall performance of the network and evaluation of the impact of the different services on one another.

The primary goal of this distribution is to measure the performance of the IPFS and blockchain services while examining their interaction. By evaluating the effectiveness of each service independently and in conjunction with the other valuable insights into their interplay can be gained, leading to optimization strategies that enhance overall network performance. This information can be used to improve the design and implementation of future updates.

Using the abovementioned methodology, RAM, CPU, and bandwidth usage were measured over a 3-minutes period in 1-second intervals. The first 12 minutes were left idle to establish a baseline for the test. Following this idle period, 60 certificates were deployed. It is important to note that these certificates were issued using the first server as a gateway/entry point (serving both as the Blockchain & IPFS node). This node is responsible for distributing data among other services and servers.

6.2.1. Blockchain and IPFS node

Fig. 6 presents the tests of the node with blockchain and IPFS.

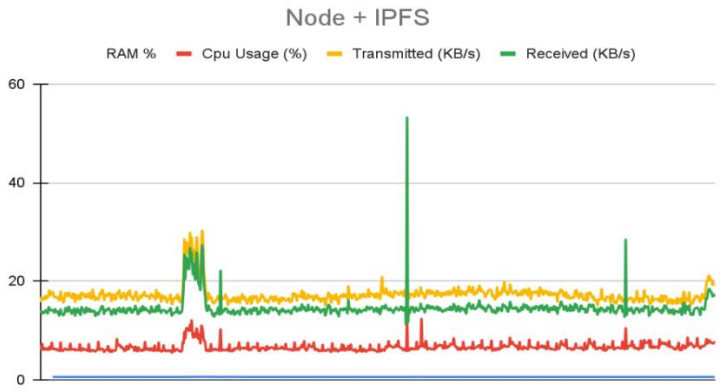

Figure 6. Node and IPFS testing

The initial disc space required for this server is minimal. 3.09 GB of disc space is needed for both a blockchain node and an IPFS node. The CPU utilization metrics indicate a stable baseline over a short

period, with CPU usage averaging around 7% on a single core. The lack of an increase in CPU utilization indicates consistent performance. Similarly, the RAM usage metrics show a stable baseline, maintaining a constant usage of 500MB, with no significant fluctuations observed.

As anticipated, CPU usage increases upon the deployment of certificates, as this process generates hashes and incorporates the certificates into the blockchain.

The accompanying graph illustrates the percentage of received data. As expected, when the user uploads property photos into the system, these images are stored on the IPFS server, representing the majority of the bandwidth indicated in the graph. Once the images are received and other blockchain data are integrated into the block, the information is synced with the other nodes, contributing to the overall transmitted network data.

6.2.2. Blockchain Node

The same principles apply to the member node, which receives data from the miner node and verifies the block using the same operations. The graph in Fig. 7 shows that the blockchain member node does not transmit significant data to the miner node. This observation may differ in the member node also functions as a gateway or is connected to numerous peers.

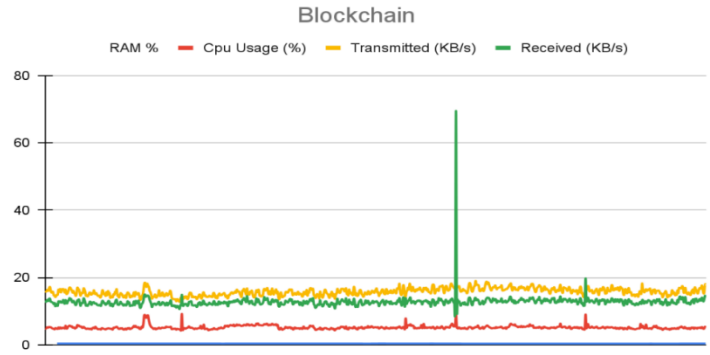

Figure 7. CPU, RAM, and Network usage for Blockchain node

As indicated in the graph, the amount of received data is relatively small, as the data stored on blockchain is limited. Typically, only references to images and additional data regarding certificates are stored.

The server, which exclusively hosts the blockchain node, also demonstrates this trend, with an insignificant increase in RAM usage, mainly due to system resources and processes.

6.2.3. IPFS node

Fig. 8 presents the measurements in the IPFS node. Since IPFS is mainly used for storing data, there is little concern about computing power. CPU usage is relatively flat and shows no significant or noticeable change.

The same can be said for transmitted bandwidth. IPFS member node appears not to transmit any data as it is not connected to any other peers.

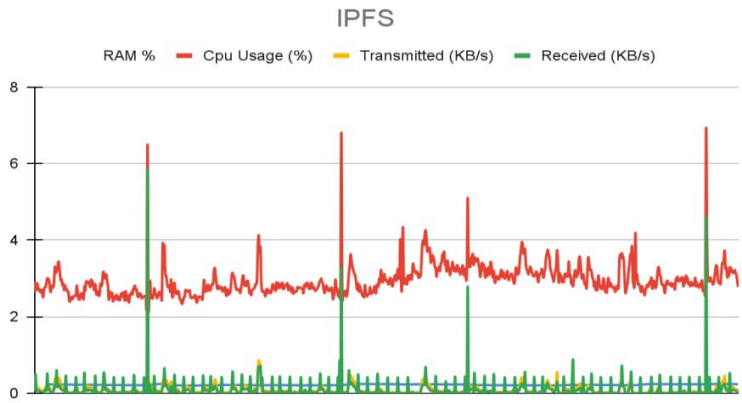

Figure 8. CPU, RAM, and Network Usage for IPFS Network

However, the received bandwidth shows a significant spike since the member node gets the photos from the central IPFS node. As mentioned above, IPFS operations are responsible for most bandwidth usage.

Consistency is observed in the server featuring only the IPFS node, with a similar pattern of minimal RAM usage increase. Changes in RAM usage primarily occurs when starting or shutting down services.

In conclusion, the benchmark results provide a comprehensive overview the server's initial behavior, particularly in idle conditions. The minimal disk usage, especially without substantial load, establishes a crucial baseline for determining the necessary HDD space for server operation. Although stability is observed in CPU and RAM usage metrics over a short duration, further follow-up is needed to better understand how the system will perform in the long term. These benchmarks assure the robust and stable baseline performance of the server infrastructure under various configurations and usage scenarios.

6.3. Client Benchmarks

These benchmarks, presented in Fig. 9, display the performance of the web application during the simultaneous deployment of 60 certificates. This analysis provides an overview and helps determine whether low-end PCs can run this application effectively. The tests were done conducted using Microsoft Edge, without any extensions installed, on a PC with the following relevant specifications:

CPU: Intel Xeon E5-1650 v2 @3.5GHz

RAM: 16GB.

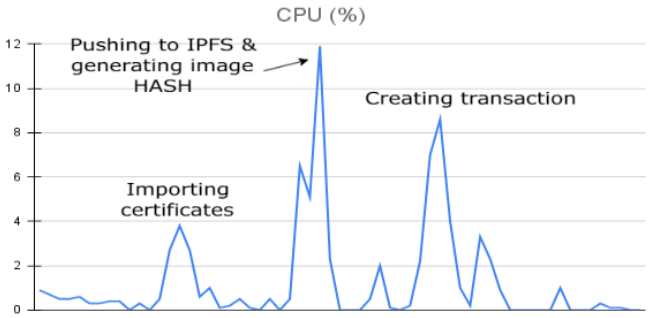

Figure 9. Client Node

As shown in the data, the most significant CPU spike occurs when images are being uploaded to the IPFS server. This is due to the fact that, prior to sending these images to the IPFS server, they are bundled together and encrypted, with the browser waiting for their hashes to be returned by the IPFS server. A simple spike occurs during transaction creation; however, the CPU usage is higher in this case, as the images involved are larger.

6.4. Scalability challenges

Addressing the scalability challenges discussed is crucial for the sustainable growth of the proposed system. By integrating solutions such as sharding, off-chain storage, and distributed pinning networks, the system can effectively handle increasing demands while ensuring performance and data integrity in both the blockchain and IPFS contexts.

Blockchain scalability [37] pose significant challenges, particularly in terms of transaction throughput. Furthermore, accumulation of the large volumes of transaction data can lead to increased resource requirements for maintaining the blockchain. To overcome these issues, Ethereum's future upgrade to sharded architecture (Ethereum 2.0) aims to improve scalability by distributing transactions across multiples shards, significantly increasing throughput and reducing strain on individual nodes. Additionally, utilizing off-chain storage through IPFS minimizes the data stored directly on the blockchain.

In the other hand, IPFS scalability presents its own set of challenges. The increase in stored property certificates could lead to performance issues related to data retrieval within a decentralized network. Moreover, to ensure data availability, significant resources are needed for "pinning" services, which maintain data in the IPFS network. To address these concerns, the planned implementation of distributed pinning networks will leverage IPFS cluster technology to ensure that property certificates are consistently pinned across multiple nodes, enhancing reliability and availability as the network grows.

6.5. Security challenges

This section introduces potential security risks associated with the blockchain and IPFS components of the proposed system, followed by mitigation strategies to address these risks. We have categorized those risks into three categories: blockchain, IPFS and NFC security risks, as presented in Table 1.

Table 1. Security challenges

Component	Identified Risks	Mitigation Strategies
Blockchain [38-40]	**51% Attacks**: An adversary gains control over 51% of the computational power, compromising transaction integrity.	**Consensus Algorithm Hardening**: Use of Proof of Stake or permissioned blockchain to reduce attack likelihood.
	Smart Contract Vulnerabilities: Potential exploitation through errors in code.	**Formal Verification and Audits**: Conduct rigorous checks before deployment to fix vulnerabilities.
	Private Key Theft: Loss or exposure of private keys leads to unauthorized access and actions.	**Secure Key Management**: Implement hardware security modules and multi-signature wallets for added protection.
IPFS [40-42]	**Data Integrity and Tampering:** Unauthorized modification if files are poorly managed	**Hash-based Integrity Checking**: Cryptographically hash all files and store hashes on the blockchain to ensure data immutability.
	Content Addressing Vulnerabilities: Risk of spoofing through CID manipulation.	**Data Encryption**: Encrypt all documents before uploading to IPFS
	Confidentiality Issues: No inherent encryption leads to potential unauthorized access.	**Access Control Mechanisms**: Utilize encryption keys and role-based permissions to manage file access.
NFC [41]	**Tag Cloning and Spoofing:** Potential for unauthorized parties to create counterfeit tags.	**Server-Side Validation:** Ensure robust validation of tags to verify authenticity against blockchain and IPFS before granting access to sensitive information.
	Man-in-the-Middle (MITM) Attacks: Interception of communication between NFC readers and backend systems.	**Encryption Protocols:** Use secure channels for NFC communications to prevent interception.
	Physical Tampering: Tags can be altered or destroyed, compromising links to digital records.	**Tamper-Evident Tags:** Use secure physical tags that indicate if tampering has occurred.

The identification and mitigation of these security challenges are crucial for ensuring the integrity and reliability of the proposed system. By employing the outlined strategies across blockchain technology, IPFS and NFC, the system can create a secure environment for real estate transactions, enhancing trust among users and stakeholders in Albania's evolving digital landscape.

6.6. Legal Challenges

Albania has initiated efforts to establish a regulatory framework for new technologies, culminating in the enactment of a law in 2020 that includes provisions for blockchain technology. This development is crucial for ensuring the reliability and security of transactions. Law 66/2020, titled "On Financial Markets Based on Distributed Ledger Technology," regulates not only the issuance and trading of virtual currencies and digital tokens but also the provision of innovative services, which are fundamental to distributed ledger technology. In Albania, this opens the possibility for such services to be offered not only by a single agency but also by multiple public or private agencies. These aspects are further elaborated and regulated within the law, alongside the statutes of the relevant authorities, although these are beyond the scope of this article.

7. User Adaption Strategy

7.1. Questionnaire Analysis

To assess user adoption of a blockchain-based property certificate management system in Albania, a survey was conducted, gathering 258 responses from citizens and administrative personnel. The survey aimed to understand a) difficulties citizens face obtaining certificates under the current system; b) willingness to adopt a decentralized system; c) familiarity with blockchain technology; and d) the influence of age and education level on technology adaption.

The respondents comprised 44.6% citizens, 34.5% private administration personnel, and 20.9 % public administration personnel. As Fig. 10 illustrates, awareness of blockchain was reported by 58.9% of respondents, yet a significant 61.8% perceived blockchain's utility as limited to cryptocurrency with only 16.2% recognizing its potential within government applications. The primary source of blockchain

awareness was the internet (43.7%), followed by scientific articles (32.9%), friends/colleagues (28.8%), academic studies (16.7%), and other sources (31.1%).

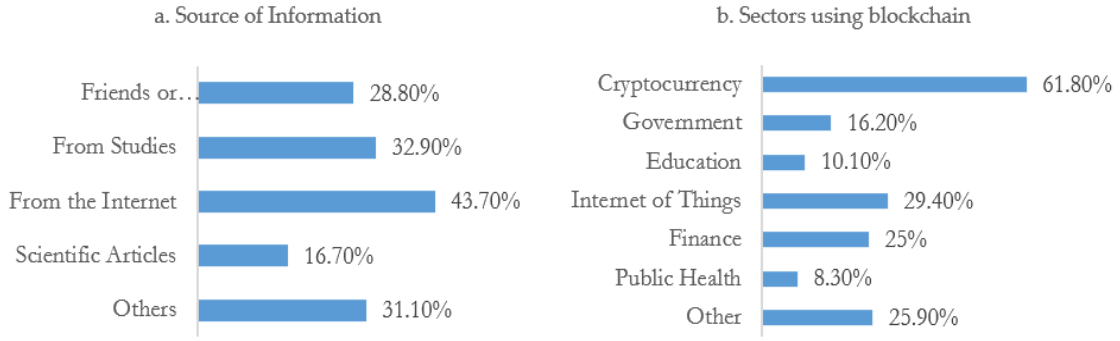

Figure 10. Questionnaire results regarding a. Source of Information about knowing blockchain technology and b. Identifying which sectors the respondents think that blockchain technology can be used

Meanwhile, as presented in Fig. 11, the result of the questionnaire shows that respondent education levels were predominantly master's degrees (62%), followed by bachelor's degrees (24.9%) and PhDs (13.2%). The age distribution leaned towards the 26-40 age group (60.9%), with 28.3% aged 18-25, and the remaining respondents falling within the 41-50 (7.7%) and over 50 (5%) years-old categories.

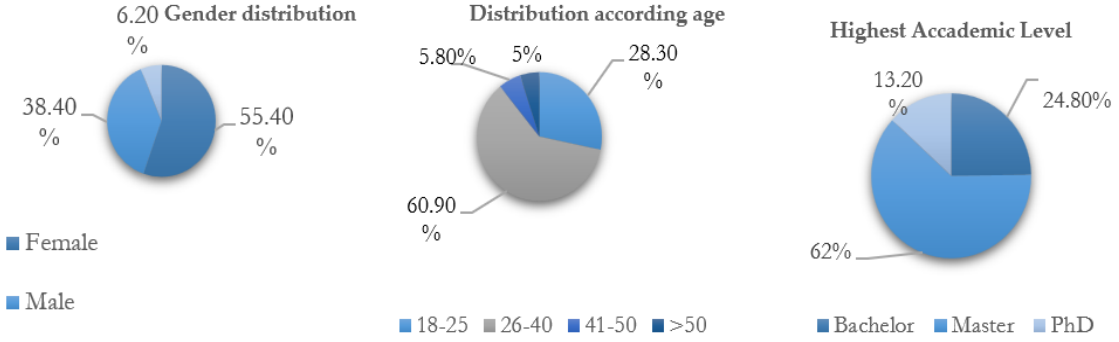

Figure 11. Responder's profile

Regarding difficulties obtaining property certificates under the existing system, 58.3% of respondents reported significant challenges (scoring 4 or 5 out of 5, where 5 represents "a lot of difficulties"). Furthermore, 58.6% reported difficulties interacting with public services, contrasting with 106 respondents (41.1%) reporting positive experiences. Despite these challenges, 71.7% of respondents rated their trust in a new decentralized system at 3 or more points (out of 5) suggesting considerable openness to change.

Based on this survey, it becomes clearer to provide recommendations for the dissemination and implementation of the project, both for the funding agency, which indirectly implies the implementation of government policies, and for the involved and interested parties. Regarding dissemination, it is planned to hold workshops and seminars with interested parties, including notaries, the cadaster agency, individuals, and researchers from the academic world and beyond. Additionally, this article will serve as a starting point for creating a scientifically based reference.

7.2. Python-Based User Adoption Analysis

Understanding user perspectives is crucial for the successful implementation of new technologies. This section analyzes survey responses (n=258) from Albanian citizens and administrative personnel to gauge their readiness to adopt a blockchain-based solution for managing property certificates. The analysis employs a novel quadrant framework to explore the interplay between perceived support and challenges, providing insights into users' motivations and potential barriers to adoption. Three key components – need for change, competence, and collaboration are examined. Fig. 12 illustrates the distribution characteristics of the data obtained from five key components.

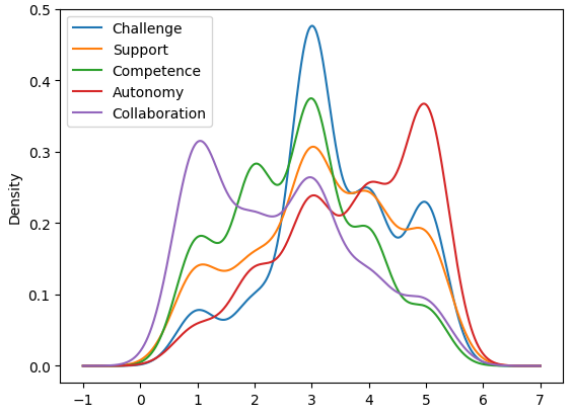

Figure 12. The distribution characteristics of the data obtained from five key components.

Two of the survey questions address the balance between challenge and support.

By placing these two values in a 2x2 matrix, we create four quadrants:

- In the first quadrant (**Support ++ / Challenge ++):** This quadrant encompasses users who perceive the technology as both challenging and achievable, finding support in its implementation;
- In the second quadrant (**Support ++ / Challenge --**): Users in this quadrant view the adoption of blockchain technology in public administration for certificate management with optimism, and they identify substantial support for utilizing this technology for that purpose;
- In the third quadrant (**Support -- / Challenge --**): This quadrant consists of disengaged users who believe that this technology can be implemented without facing significant challenges, and they do not identify any support for it;
- In the fourth quadrant (**Support -- / Challenge ++):** Users in this quadrant are categorized as stressed, as they perceive the adoption of this technology as a considerable challenge, lacking support and failing to endorse its use.

Fig. 13. compares characteristics regarding challenge, support, competence and collaboration.

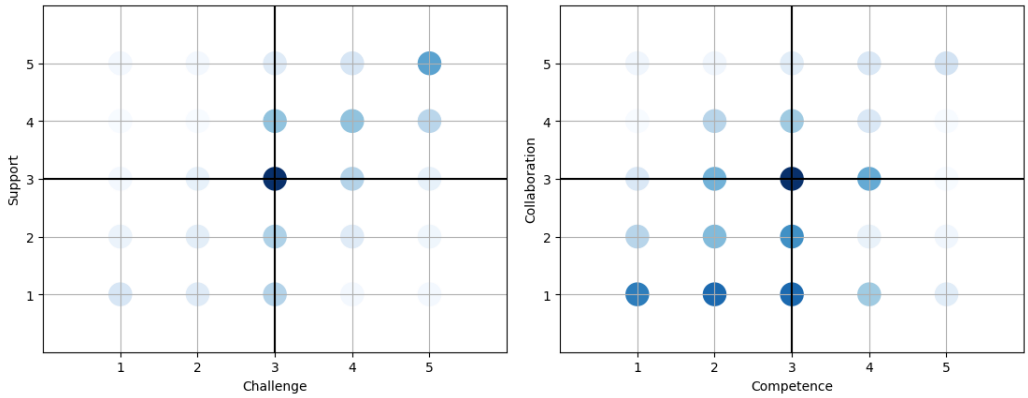

Figure 13. Challenge vs. Support and Competence vs. Collaboration; *note: the brighter the color of the dot, the more frequent the response*

Three questions were designed to examine the existence of three key components of motivation for accepting change (transitioning to the new technological system):

- *Need for Change*: This component assesses whether users are satisfied with the current state in which certificate management is conducted manually;
- *Competence*: This refers to the reliability and flexibility of the current system, as well as users' trust in the existing system and the effectiveness of problem-solving based on past experiences;
- *Collaboration*: This component evaluates how the current system functions through human collaboration, including the potential influence of corruption;

Fig. 14 provides autonomy boxplot. According to the analysis, individuals who possess all three characteristics are considered "autonomous" and exhibit high levels of motivation to change.

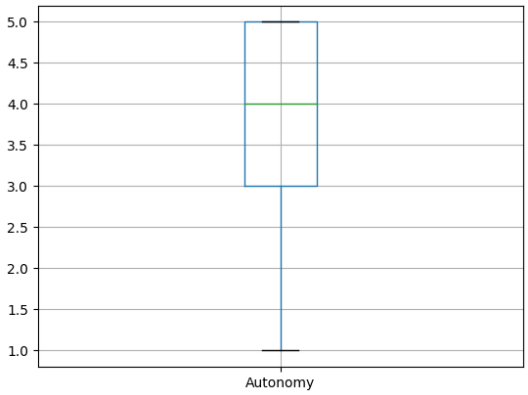

Figure 14. Autonomy boxplot

If they have competence and collaboration but lack autonomy, they are categorized as "under control" - capable of performing tasks but believing that outcomes are influenced by corruption. If they lack both competence and collaboration, it is stated that their current perception is indeterminate.

To address the challenge and ensure a smooth transition, it is necessary to implement a series of dissemination policies, including the development of workshops and seminars. Additionally, it is essential to interact with users to provide support through a well-trained staff.

7.3. Future works

In future work, we plan to integrate the system with notary services and land registries to streamline property transactions. For notaries, the system will allow the digital validation of contracts directly on the blockchain, ensuring faster, automated workflows with smart contracts triggering payments and land registry updates after notary approval. Integration with land registries will enable real-time, automatic updates to ownership records, reducing delays and errors. These integrations will enhance transparency, reduce manual intervention, and ensure the seamless transfer of property ownership.

8. Conclusion

This proposal outlines a comprehensive and innovative approach to digitalizing the Albanian process of certifying and transacting real estate property. By utilizing decentralized technologies, including blockchain and IPFS, it aims to eliminate inefficiencies and weaknesses in the current manual and paper-based system. The proposed system streamlines the process of transferring ownership and ensures end-to-end transparency, accountability, and security.

The integration of smart contracts enforces ownership rules, and transfers in accordance with Albanian property law, establishing a reliable and tamper-proof foundation. The system architecture incorporates a combination of Ethereum blockchain, IPFS document storage, encryption keys, QR codes, NFC paper tags, PDF certificates, and customized user interfaces tailored for all stakeholders.

By prioritizing the verification process and utilizing advanced encryption algorithms, the proposed system enhances the security of ownership certificates, eliminates the need for intermediaries, reduces costs and increases transparency. Benchmarks conducted on the blockchain and IPFS servers demonstrate their stability and efficiency when idle periods, further confirming the feasibility and robustness of the proposed solution.

In conclusion, this proposal represents a well-designed strategy to modernize Albania's real estate transaction landscape, by providing a secure, decentralized, and transparent solution. The successful implementation of this system has the potential to revolutionize real estate transactions, significantly reduce fraud, improve efficiency, and foster a more reliable and trustworthy real estate ecosystem in Albania.

While the proposed system represents a significant step forward in digitizing real estate transactions in Albania, several opportunities for future work can improve its effectiveness and sustainability.

Implementation of existing documents: Convert documents from the current system into a suitable dynamic format and embedding data related to the certificates.

Long-term performance monitoring: The benchmarks provide valuable insights into the server infrastructure's initial behavior. However, to achieve a comprehensive understanding of stability and

performance over time, it is essential to conduct additional benchmarks over a more extended period under different usage scenarios. This ongoing monitoring will help identify potential problems, ensure scalability, and fine-tune the system for optimal performance.

User feedback and interface optimization: The success of any technological solution depends on user acceptance and satisfaction. Obtaining feedback from property owners, buyers, notaries, and other stakeholders will be essential to refining and optimizing the user interface. Improving usability and accessibility is vital for system's success and adoption.

Updates on legal and regulatory provisions: The legal framework for real estate transactions can change over time. It is essential to stay informed about any changes to regulations and compliance requirements. Regular updates and adjustments to the system will ensure that it complies with the legal framework and providing a reliable and compliant platform for real estate transactions.

Integration with external systems: While the proposed system focuses on the core aspects of property certification and transactions, exploring opportunities to integrate with external systems, such as tax authorities and financial institutions, can further streamline the property transaction process and facilitate seamless coordination with existing external processes.

Education and training initiatives: Successful implementation of the proposed system requires widespread acceptance and understanding among stakeholders. Education and training programs for property stakeholders will ensure a smooth transition to new digital methods.

In summary, the future work for this project encompasses continuous performance monitoring, refinement based on user feedback, compliance with legal updates, and integration with external systems and educational initiatives. These elements will contribute to the sustained success and relevance of the proposed system in Albania's dynamic property transaction landscape.

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