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DIPLOMA AUTHENTICATION MADE EASY WITH BESU BLOCKCHAIN: A NOVEL PLATFORM FOR SECURE VERIFICATION

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ABSTRACT

Educational institutions, employers, and students have long struggled with the challenge of authenticating diplomas. We have identified that the absence of a dependable and secure system to verify the legitimacy of diplomas has resulted in the proliferation of counterfeit credentials and fraud. This problem is further exacerbated by the worldwide nature of education and the lack of uniformity across different regions and countries. To tackle this issue, a novel blockchain-based platform has been created for diploma authentication. The platform, built on the Besu blockchain, offers a tamper-proof and secure system for verifying the authenticity of diplomas. Advanced cryptographic techniques are employed to ensure that the data is unchangeable and can be authenticated by authorized parties in real-time. The creation of this platform comes at a critical juncture, as the need for trustworthy and secure diploma authentication has become increasingly pressing. With the rise of online education and remote work, it is crucial to have a system in place that can guarantee the authenticity of credentials.
This new platform is not only secure but also free, making it accessible to everyone. It has the potential to revolutionize the way that diplomas are authenticated and could have far-reaching implications for the future of education and employment.

Keywords: *Blockchain, Authentication of Diplomas, Hyperledger Besu, Smart Contract, Educational Certificate*

1. INTRODUCTION

In today's digital age, diploma authentication has become more critical than ever before for universities, students, and employers. The traditional paper-based diploma system is vulnerable to fraud and can be time-consuming for students and universities to verify. By using a secure blockchain-based platform for diploma authentication, universities can ensure the integrity of their academic programs while also saving time and resources. For students, having a verified digital diploma can make it easier to apply for jobs and further education opportunities, while employers can be assured that they are hiring qualified candidates who have completed the necessary educational requirements. Overall, a secure and efficient diploma authentication system benefits everyone involved and helps to create a more trustworthy and transparent education and employment ecosystem.

The current process of diploma authentication is a traditional and time-consuming practice that requires a third-party to verify the validity of the diploma. Typically, students need to contact their university or a verification agency to request authentication of their diploma, which can be a time-consuming process that takes several days or even weeks to complete. This process can also be quite costly, which can create additional barriers for students who are seeking employment or further education.

Despite the involvement of a third-party, there have been several instances of diploma fraud. Falsified diplomas have been used to deceive employers and educational institutions, which has resulted in many organizations being more cautious about accepting diplomas at face value. This has created a need for more secure and reliable

authentication methods that can guarantee the authenticity of diplomas [1].

When employers receive diplomas from job applicants, they often contact the universities or verification agencies to verify the validity of the diploma. This can be a time-consuming process that creates additional work for both the employer and the educational institution. The delays caused by this verification process can also be a barrier to employment, especially if the employer needs to fill the position quickly [2].

The aim of this study is to develop a web-based solution that simplifies and streamlines the process of diploma authentication. The platform will be based on a Hyperledger Besu blockchain, which uses smart contracts to ensure a secure and tamper-proof system for verifying diplomas [3]. This solution will significantly reduce the time and effort required to authenticate diplomas, enabling students to submit their diplomas quickly and securely to employers and educational institutions. Furthermore, this solution will be completely free, making it accessible to all stakeholders as shown in figure 1.

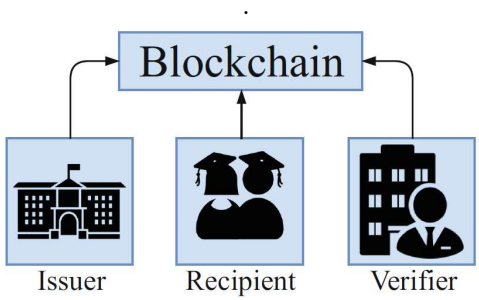

Figure 1: Stakeholders

The rest of the paper is organized as follows. Section 2 describes related work. We review the methodology in Section 3. Theoretical explanations and experimental results of the proposed TCN model are denoted in section 4. The conclusion of the proposed model is represented in Section 5.

2. BACKGROUND STUDY

2.1 Blockchain

Blockchain is a decentralized and immutable digital ledger technology that enables secure and transparent transactions without the need for intermediaries [4]. In simple terms, it is a database of transactions that are verified and stored across a network of computers, making it difficult to tamper with or hack. The blockchain's principle of operation involves creating a new block of data that contains a unique code, transaction details, and a reference to the previous block. This new block is then added to the existing chain of blocks, creating an unbroken chain of data that can be audited and traced. The blockchain's use cases are vast and diverse, ranging from cryptocurrency and financial services to supply chain management, voting systems, and identity verification.

2.2 Types of Blockchain

There are three main types of blockchain: public, private, and consortium (also known as federated) [5]:

- Public Blockchain: A public blockchain is a decentralized, permissionless network that anyone can join and participate in without any restrictions. Examples include Bitcoin and Ethereum. In a public blockchain, anyone can validate transactions and add blocks to the chain.
- Private Blockchain: A private blockchain is a permissioned network where only authorized users are allowed to participate. These types of blockchains are often used by organizations to maintain privacy and control over their data. Examples of private blockchains include Hyperledger and Corda.
- Consortium (Federated) Blockchain: A consortium blockchain is a hybrid model that combines the features of both public and private blockchains. In a consortium blockchain, a group of organizations come together to form a network where they can share data and validate transactions. The consortium blockchain is controlled by a group of pre-selected nodes. Examples of consortium blockchains include Ripple and Quorum.

These three types of blockchains are designed to meet different needs and use cases, depending on the level of privacy, control, and scalability required. Figure 2 shows the architecture of consortium, private and public Blockchain [6].

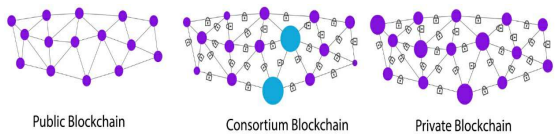

Figure 2: Architecture of consortium, private and public Blockchain

2.3 Main Pillars of Blockchain

The Blockchain platform is built on four main pillars [7]:

- Decentralization: This refers to the distribution of power and control across a network of nodes

or computers. In a decentralized system, there is no single point of control or failure, and decisions are made through a consensus mechanism that involves all participants in the network. Decentralization is a key feature of Blockchain, as it allows for greater security, transparency, and resilience.

- Immutability: This refers to the ability of the Blockchain to record transactions in a tamper-proof and irreversible way. Once a transaction is recorded on the Blockchain, it cannot be altered or deleted without the consensus of the network. This ensures the integrity and authenticity of the data recorded on the Blockchain.
- Transparency: This refers to the ability of all participants in the network to access and view the data recorded on the Blockchain. Transactions on the Blockchain are public and transparent, meaning that anyone can view the details of the transaction, including the amount, time, and parties involved. This enhances trust and accountability in the network.
- Security: This refers to the use of cryptography and other security measures to protect the data and transactions recorded on the Blockchain. The Blockchain uses advanced encryption techniques to ensure that the data recorded on the Blockchain is secure and cannot be accessed or modified without the proper authorization.

Together, these four pillars form the foundation of the Blockchain platform and enable its unique features and capabilities.

2.4 Architecture of Blockchain

The architecture of a Blockchain is composed of several key components that work together to create a decentralized and secure network. These components include nodes, blocks, hashes, and transactions [8].

- **Nodes**: A node is a computer or device that participates in the Blockchain network by maintaining a copy of the distributed ledger. Nodes are responsible for verifying transactions and adding them to the Blockchain through a consensus mechanism.
- **Blocks**: A block is a collection of transactions that are grouped together and added to the Blockchain. Each block contains a unique cryptographic code called a hash that identifies it and ensures that it cannot be altered without the consensus of the network.
- **Hashes**: A hash is a mathematical function that takes a block of data as input and produces a fixed-length string of characters as output. The hash is unique to the data it represents and can be used to verify the integrity and authenticity of the data. In the Blockchain, each block is linked to the previous block through its hash, creating an immutable chain of blocks.
- **Transactions**: A transaction is a record of the exchange of value between two parties on the Blockchain. Each transaction contains information such as the sender and receiver addresses, the amount of value exchanged, and a unique transaction ID. Transactions are verified by the nodes in the network and added to the Blockchain once they have been validated through the consensus mechanism.

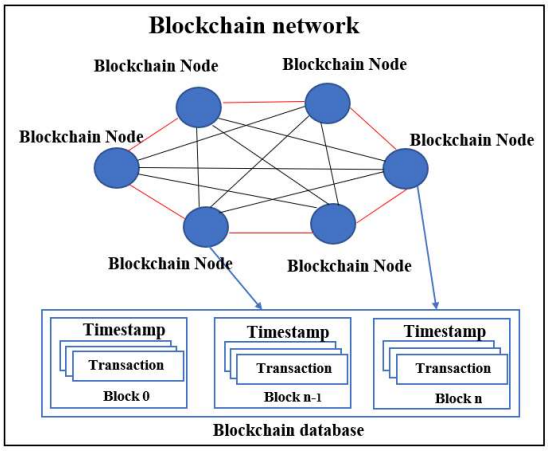

Figure 3: Architecture of Blockchain

The point-to-point distributed network architecture of Blockchain technology, along with the architectural views of block, node, key, and data, are depicted in figure 3. Blockchain is a decentralized, distributed ledger technology that allows for secure and transparent record-keeping of transactions and data. Each block in the chain contains a unique cryptographic hash, which links it to the previous block and makes it immutable. Transactions are verified by a network of nodes using consensus mechanisms, such as proof of work or proof of stake, which ensures the integrity and authenticity of the data. Once validated, the transaction is added to the block and distributed across the network. This process creates a permanent and tamper-proof record of all transactions, as any attempt to alter the data would require altering the entire chain, which is practically impossible due to the distributed nature of the network. Additionally, blockchain employs encryption techniques, such as public-key cryptography, to ensure the privacy and security of

data stored on the network. These features make blockchain an attractive technology for a wide range of applications, including financial transactions, supply chain management, and digital identity verification.

2.5 Smart Contracts

Smart contracts are self-executing digital contracts that enable automated and transparent execution of agreements without the need for intermediaries. They are written in code and stored on a blockchain network, which allows for secure and decentralized execution of the contract terms. Smart contracts can be used in a variety of applications, such as financial transactions, insurance claims, supply chain management, and digital identity verification. They offer several advantages over traditional contracts, including increased efficiency, reduced costs, and improved transparency and accountability.

From a technical standpoint, smart contracts are executed by a network of nodes on a blockchain. Once a smart contract is deployed, it becomes a part of the blockchain and can be executed automatically when certain pre-defined conditions are met. The code for the smart contract specifies the rules and conditions of the agreement, and the contract is executed automatically when those conditions are met. This allows for the automation of complex business processes and eliminates the need for intermediaries, such as lawyers or brokers. The decentralized nature of the blockchain ensures that the contract is executed transparently and securely, without the need for trust in any single party. Smart contracts can be written in a variety of programming languages, depending on the specific blockchain platform being used. Overall, smart contracts offer a powerful tool for creating efficient, secure, and transparent agreements that can revolutionize a wide range of industries.

2.6 Ethereum

Ethereum is an open-source, decentralized blockchain platform that was specifically designed for creating and executing smart contracts. It was created by Vitalik Buterin in 2013 and launched in 2015. Ethereum enables developers to create decentralized applications (dApps) that can run on the blockchain, using smart contracts to automate complex business logic. Ethereum's native cryptocurrency is called Ether (ETH) and is used to pay for transaction fees and computational services on the network. Ethereum has become one of the most popular blockchain platforms, with a large and active developer community and a wide range of applications in areas such as finance, gaming, and supply chain management.

From a technical perspective, Ethereum is a distributed, decentralized virtual machine that runs on a global network of nodes. The Ethereum Virtual Machine (EVM) executes smart contracts written in Solidity or other programming languages, using Ether as fuel to pay for computation and storage. Smart contracts on Ethereum are stored on the blockchain as bytecode and are executed when triggered by an external transaction or event. Once a smart contract is deployed on the Ethereum network, it becomes a part of the blockchain and can be accessed and executed by any node on the network. This ensures that the contract is executed transparently and securely, without the need for trust in any single party. Overall, Ethereum provides a powerful platform for creating and executing decentralized applications using smart contracts, with a wide range of potential use cases in various industries.

3. RELATED WORK

Several studies have been conducted regarding the generation and upkeep of certificates, both with and without the use of blockchain technology. The following are some notable and recent research endeavors that were examined and discussed.

Blockchain is an emerging technology that is being increasingly adopted in the business processes of many companies. Its growing popularity is largely due to its security features. The various capabilities of blockchain technology could be harnessed to create a system that generates and distributes student certificates that cannot be altered, as demonstrated in [9]. The authors of [9] explore how the strengths of blockchain and smart contracts can be utilized to achieve this goal, by highlighting the features of blockchain that enable universities to produce transparent and tamper-proof student certificates.

The use of Hyperledger has led to the development of a decentralized application, as described in [10]. The author utilized chain code to communicate with the blockchain, creating certificates that were encrypted and stored on IPFS. The hash of the certificate, along with the link to its file on IPFS, was recorded in the transaction written to Hyperledger.

To prevent single point of failure, storing files on IPFS is a highly effective method, as stated in [11]. IPFS is a protocol that disseminates multimedia files across network nodes. The primary aim of [11] is to enable students to request certificates, universities to approve them, and employers to verify their authenticity.

The primary emphasis of article [12] is on automating the process of certificate generation.

Additionally, it employs a Hyperledger system to record transaction details related to certificate generation. Furthermore, it offers a means of transferring ownership of certificates to other institutions in cases where transfer is necessary.

A cost-effective and tamper-proof method of generating certificates involves using a centralized database for storage, while storing only the certificate's hash on the blockchain [13]. This simplifies the process of checking a certificate's integrity by allowing easy retrieval of its hash from the blockchain and comparison with the certificate being tested. While using a centralized database may create a single point of failure, this can be mitigated by using cloud storage that maintains multiple copies of the database on different servers. Additionally, this approach is more economical than writing directly to the blockchain, as such transactions can be costly. Table 1 summarizes literature survey.

Table 1: summarizes literature survey.

Ref.	Objective	Proposal	Drawbacks
[9]	A system for generating and distributing certificates that utilizes blockchain for verification purposes.	Employed smart contracts to record certificate information on the blockchain.	Centralised database.
[10]	Secure and tamper-resistant management of certificates.	Hyperledger was utilized for the blockchain requirements, IPFS for certificate storage, and elliptic curve encryption for certificate encryption.	The probability of certificates vanishing from IPFS is high if no nodes have pinned them.
[11]	A system for validating certificates securely.	Smart contracts, the Remix online IDE, and IPFS were employed to create and store certificates.	To use the software, client users will need to have an Ethereum account and the MetaMask extension installed.
[12]	A system that ensures security in the transfer of academic certificates between universities.	Hyperledger is utilized for the transfer and verification of certificates.	The system is unable to produce the certificate or guarantee its availability.
[13]	Generation and storage of certificates utilizing a multisignature blockchain approach.	Bitcoin transactions were employed to store the hash of the certificate in the blockchain.	A database that is centralized and does not utilize smart contracts or chaincode.
[14]	An application based on blockchain technology that facilitates the distribution and validation of certificates.	Unicoin was utilized to record the certificate hash on the blockchain for verification purposes.	Utilizes a custom/private Unicoin network; however, the availability of the certificate cannot be guaranteed.
[15]	The digitization and verification of certificates utilizing blockchain technology.	Transform the physical certificate into a digital certificate and record its hash on the blockchain.	The certificate's availability cannot be guaranteed.

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The related work in the field of diploma authentication has faced several drawbacks that our solution aims to address comprehensively. One major limitation of existing approaches is the lack of a secure and tamper-proof verification system. In contrast, our solution leverages the power of the Besu blockchain platform, which provides a robust and decentralized infrastructure for storing and verifying diploma records. By utilizing the immutability and transparency of the blockchain, our platform ensures that diploma authentication becomes highly secure, resistant to forgery, and transparent to all stakeholders. Furthermore, another drawback of previous methods is the complexity and time-consuming nature of the verification process. Our solution simplifies this process by introducing an intuitive and user-friendly interface that allows users to easily access and validate diplomas in a matter of seconds. Thus, by addressing these limitations, our innovative approach with Besu blockchain offers an efficient and reliable solution for diploma authentication, revolutionizing the way academic credentials are verified and enhancing trust in educational institutions.

4. METHODOLOGY

In order to address existing drawbacks and create additional opportunities, we propose a Besu Blockchain Platform for Diploma Authentication. Our proposed system leverages cutting-edge technologies to provide a secure and efficient solution for diploma verification. Figure 4 shows the workflow of the proposed model.

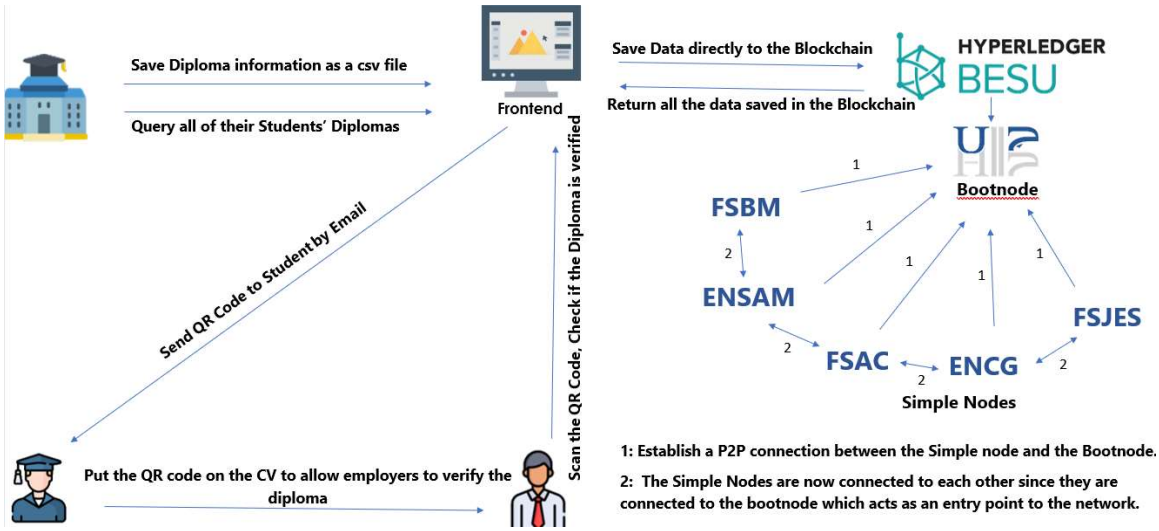

Figure 4: The workflow for issuing and verifying diplomas

This framework model is implemented in the Solidity programming language, which is specifically designed for developing smart contracts on Ethereum-based blockchain networks. Solidity is known for its security, reliability, and transparency, making it an ideal choice for creating smart contracts to manage and verify diploma information on the blockchain. In addition, we use React.js, Node.js, and Ether.js to create an intuitive user interface that enables academic administrators to upload, read, and update diploma information, and send email notifications to students.

We create a private blockchain network for storing and managing diploma information using Besu blockchain, an open-source blockchain developed under the Hyperledger umbrella, known for its scalability, interoperability, and support for the Solidity programming language, making it ideal for our proposed solution.

To make the platform user-friendly and responsive, we integrate TailwindCSS, a utility-first CSS framework that provides a customizable and responsive user interface design.

We use Remix, a web-based Integrated Development Environment (IDE) for Solidity, to develop and test our smart contracts before deploying them to the blockchain network.

Remix's user-friendly interface for writing, testing, and debugging smart contracts makes it a valuable tool for our development process. Figure 5 depicts the implemented smart contract of this research paper on the web3 environment supported remix IDE.

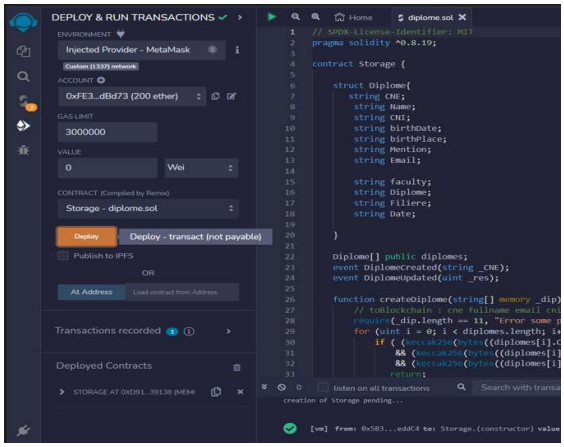

Figure 5: Smart Contracts deployment in Remix IDE

We evaluated and tested several other technologies, including IPFS, Thirdweb, Hyperledger Fabric, and Ganache, but ultimately decided not to use them due to their complexity, compatibility issues, and lack of support for our specific requirements.

There are different types of users on our platform, including academic administrators, students, and employers. Academic administrators have the privilege to upload, read, and update diploma information, as well as send email notifications to students. The step-by-step process of our Besu Blockchain Platform for Diploma Authentication begins with academic administrators uploading a CSV file containing the necessary diploma information for students. This information includes the student's name, date of graduation, degree earned, and any other relevant information as shown in figure 6.

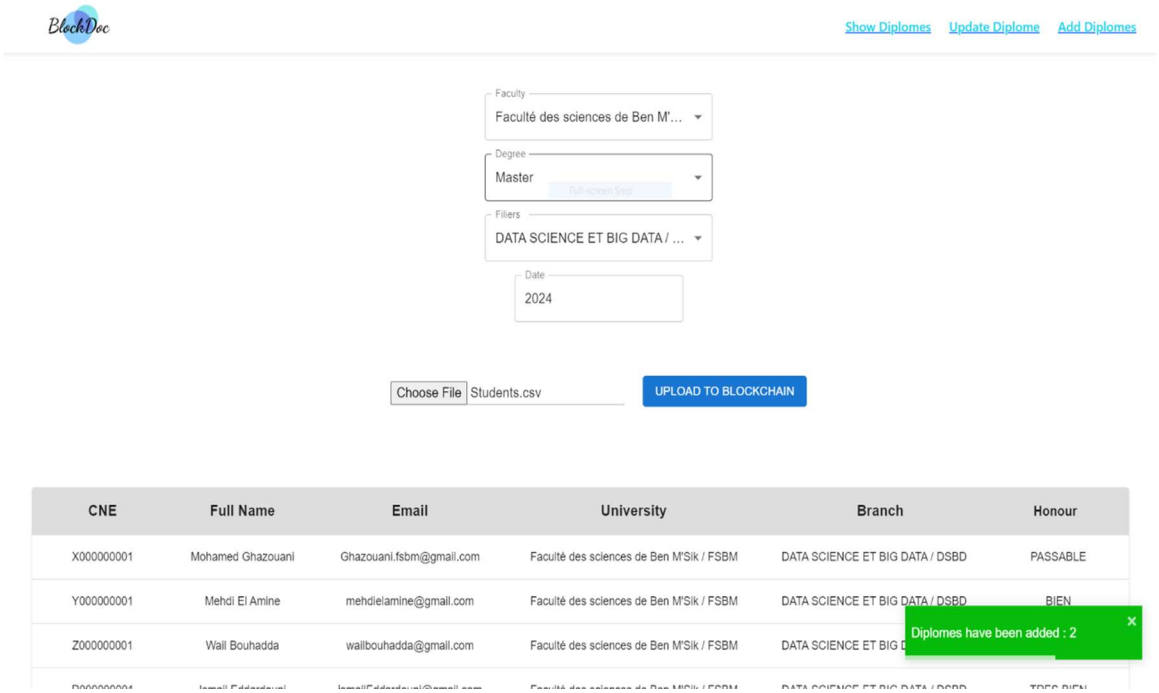

Figure 6: Institute management

Once the diploma information has been uploaded, the system generates a unique QR code for each student. This QR code is generated using the diploma information and is unique to each student. Students receive their unique QR code as an image file via email as shown in figure 7, which they can use to verify their diploma at any time and they can put it in their CV. The email will include instructions on how to use the QR code to access their diploma information. On the flip side, employers can scan the QR code to access the diploma information and verify its authenticity.

Figure 7: An example of an email with QR Code

Once the student receives the email with the QR code, they can use it to access their diploma information at any time. They simply need to scan the QR code using a smartphone or other mobile device, and it will route them to a web page containing their diploma information.

If an employer needs to verify a student's diploma information, they can scan the QR code using a smartphone or other mobile device. The QR code will route them to a web page containing the student's diploma information, which is retrieved from the blockchain and displayed in a template provided by the academic administration as shown in figure 8.

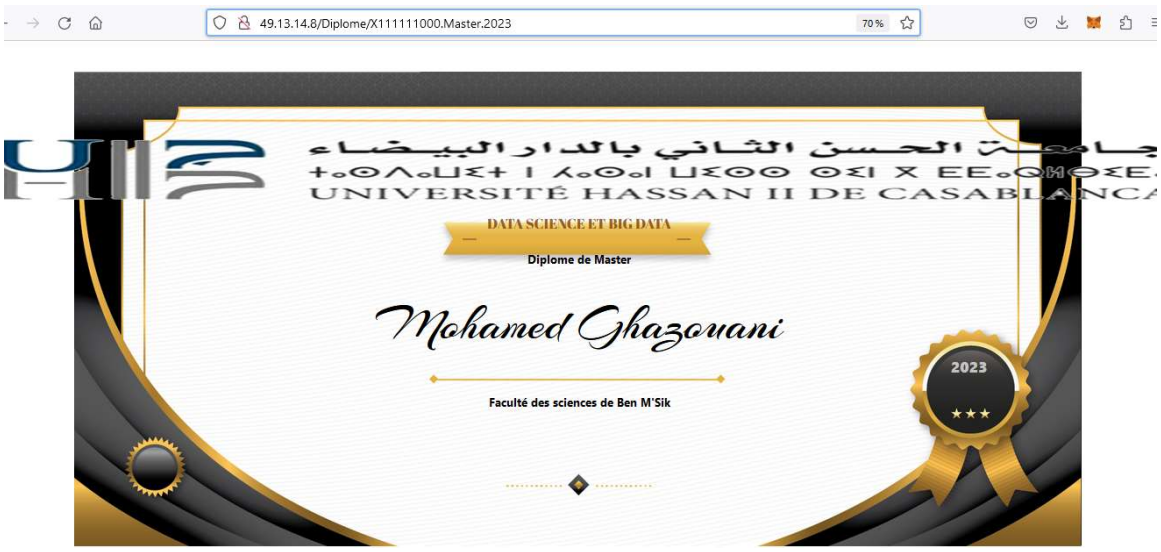

Figure 8: Generated diploma from Blockchain

5. CONCLUSION

In this article, A decentralized application for verifying educational diplomas was created on the Ethereum Blockchain platform. The application utilizes Blockchain technology to provide secure and reliable verification of diplomas. The initial goal of this research project was successfully accomplished through the gradual and efficient implementation of the proposed model, as well as the development of the platform. To assess its functionality, the platform was evaluated and tested on a Hyperledger Besu blockchain. The outcomes of the execution of the platform were presented in this paper.

This paper is introduced to avoid the middleman or any third party in the diploma verification process. One of our goals is to diminish the cost and time of the verification process. Surprisingly, this paper evaluates the cost of the proposed decentralized app,

and it costs nothing. However, the main challenge of this paper is to eradicate fake educational diplomas and our system almost met all the conditions to fight against this fraud and scam channel. In conclusion, from this work, this article promotes the idea that Ethereum Blockchain platform should be a top choice for developers who are interested in building decentralized applications on the Blockchain. It is expected to become an exciting and promising sector for the next generation. In the proposed smart contract example, step by step is explained, and also an application development environment is described. We have also represented a way that how Ethereum, react.js and web3 can be a powerful combination to build a Decentralized Application. As more and more companies recognize the benefits of blockchain technology, it is expected to become even more widespread in the coming years, revolutionizing the way we conduct business and exchange value.

In a promising outlook, we envision extending our diploma verification solution to all institutions under our university. By expanding the implementation of our innovative platform across our network of establishments, we aim to truly validate our solution in comparison to existing challenges. This approach will solidify trust in our academic institutions by providing a uniform and secure method for verifying the authenticity of issued diplomas. Through widespread adoption of our secure diploma solution based on the Besu blockchain, we will create a harmonized ecosystem that promotes transparency, integrity, and trust in the field of academic certification. This will help reduce diploma fraud, streamline the verification process, and enhance the reputation of our university and its affiliated institutions.

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