Blockchain Technology in The Education System: Certificates & Identity Management

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APPROVAL

This Thesis titled **"Blockchain Technology In The Education System (Certificates & Identity Management)"**, submitted by Niloy Chandra Shil, ID No: 213-25-076 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 17-01-2023.

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We hereby declare that, this project has been done by us under the supervision of **Professor Dr. Touhid Bhuiyan**, **Professor & Head, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Blockchain is starting to impact outside the world of digital currency. Even though most of them have a pilot nature, some applications of it also timidly make an appearance in education. Nevertheless, the piloting and some high expectations around it have prompted some inquiries about the nature of the technology, its applications, how it might be employed in education, and the opportunities, risks, and challenges it entails. Students self-identify in the present educational systems using various government-approved identity credentials. Additionally, college officials manually verify their prior degree certificates throughout the admissions process. A lot of time and labor must be put into this. A blockchain-based system has the potential to be more efficient, secure, and transparent than the current one. The suggested remedy involves combining biometrics and blockchain to access all of a student's prior degree certificates. The hash of the student's biometric information and an original phrase will be submitted. The blockchain will keep a copy of this hash. The college administration will issue the student's degree certificate. With its dependability, sturdiness, and performance, the blockchain infrastructure used by the Bitcoin application has drawn attention. The blockchain is therefore made available to reach enormous populations. Despite being the technology of the future, the blockchain has a number of drawbacks that vary depending on the application. The identity of certificates has become a big problem. I wish to employ the blockchain approach in the higher education process application was not open to students.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A person's identity is frequently checked with identification documents at many locations. If the identity documents are kept in a database, they run the risk of being stolen or misplaced. Users can access services from numerous online programs like Facebook and Amazon after having their login and password credentials verified. Databases hold these login credentials. One centralized database can be attacked by a hacker who can then engage in destructive actions. It is important to keep in mind that the use of blockchain in education is still in its early stages, which has an impact on both the availability and caliber of research on the subject[1]. Although the amount of research on the use of blockchain in education has grown over the past several years, it is still dispersed, and there hasn't yet been a systematic review on the subject, according to Alammary et al. (2019). Also according to Thayer (2018), "today's blockchain technology may not be sufficiently advanced to scale for all use cases. This is a specific issue with use cases for education platforms, including blockchain record keeping or use cases involving digital assets[3]. Many of the influential blockchain in education initiatives currently underway have not yet been well studied and documented because blockchain exploration in the context of the education industry is so young. Applying to an educational institution's academic records on behalf of somebody who didn't actually graduate or receive a credential is fraud. Sometimes, but not always, with the involvement of a member of the academic institution. Technology does not provide a simple fix if the fraud takes place on the same day as the purported graduation or certification unless the offender is in possession of the private keys required by a digital signature method[2]. Use a time mark next to each diploma's digital signature as a way to establish that someone is not a graduate from the past. Therefore, the digital signature with its timestamp must demonstrate that it was actually 10 years ago if a person claims to have gotten a university degree a decade ago. Students who apply for admission to a college must show documentation proving their identity.

To confirm the legitimacy of the student, documentation must be validated by college officials. A single point of failure exists in conventional identity management. Compared to a blockchain, it is less secure[4]. blockchain into biometric identification management for the admissions process for degrees in education. A student can sign up for this system using his or her personal information, including address, name, email address, ID number, pan card, education details number, the hash of a special phrase, and fingerprint. According to the submitted hash of the phrase and fingerprint, all of the student's information is uploaded to the college.

Should blockchain technology be used in education? should be addressed before delving into the two research questions mentioned above. This study cites the article of Tapscott and Kaplan in response to this (2018). According to the authors, blockchain technology can significantly enhance important aspects of teaching and learning processes. Blockchain allows for the ownership of identity-related data to be transferred from a central administration, such as a university, to the individual student[5]. The chance to save their information for lifelong learning, fully own it, and decide who has access to it is given to students. Blockchain is a distributed ledger that stores data and is structured as a sequence of blocks. Once information is entered into the blockchain, it is difficult to alter it. Each block in a blockchain contains transactions, a timestamp, and the hash of the block before it. The type of application determines which transactions are saved inside the block. The genesis block is the very first block on the blockchain. Transactions are signed digitally.

Enhancing security and effectiveness for businesses, students, and educational institutions the identification, confidentiality, and security of student data might be guaranteed using blockchain technology. As demonstrated in the "What Is Blockchain?" section at the beginning of this paper, Blockchain provides security and verifiability by providing immutability via its hash chain. Students cannot readily change their former academic credentials stored on the blockchain, whereas they may with conventional records[2]. Additionally, blockchain ensures anonymity by only storing hashes of the data rather than the actual data itself. The information could optionally be encrypted before being saved on the blockchain.

1.2 Motivation

In terms of education and certification, the learner gets a certificate that is printed on paper or given to them in some other way. Using paper certificates has the benefit that they are hard to fake because they have security features built in. But there are some problems, like the fact that third parties have to check the certificate mostly by hand and that certification authorities have to keep a registry or database of certificates for a long time [11]. There are many ways that schools try to stop fraud and forgery. But most of the methods take a long time because they have to be done by hand and involve people [12]. During the process, a lot of time will be spent either calling the university to confirm a certificate or waiting for a response from the university to confirm that the certificate is valid and the information is correct. This can be a very hard and expensive process, especially if a company needs to check the certificates of hundreds or even thousands of applicants. The blockchain helps protect certificates from being faked, makes it easy to check certificates even if the certification authority no longer exists, and automates monitoring processes for certificates that are only good for a certain amount of time. So, the goal of this research is to come up with a theoretical model that could be used to find a way to verify academic certificates using blockchain technology.

1.3 Research Question

- How much the Blockchain technology can find out the valid students?
- What will the efficacy of Blockchain technology in the higher education system be?
- Can we implement it to identify students?
- Does real-world use of digital certificates for verification exist?
- Should blockchain technology be used in education?

1.4 Expected Outcome

Once completed, this thesis will provide an academic credential verification model based on block chain technology. Where students, certifiers, and employers use the system. The goals of the blockchain platform for education are to aid in the prevention of forgery, the provision of secure access, and the administration of credentials based on the

requirements of students, companies, schools, and certification authorities. The framework will also ensure data integrity and security.

1.5 Report Layout

This report varied in a total of six different chapters. Which are capable of extending the understanding of “The Blockchain Technology in The Higher Education System” more briefly. In the first chapter, we’ll mention introduction, motivation, rational study, research questions and the last one is the expected outcome. In the second chapter, we’ll brief about some related works, which types of challenges that we had faced and about the research summary. In the third chapter, we’ll talk about our research subject and instrumentation, workflow of the model. In the fourth chapter, we’ll talk about the result that we got, the evaluation of our blockchain model. In the fifth chapter, we’ll describe its impact on our society, impact on our environment and sustainability. In the sixth chapter, which is our last chapter, we’ll mention the conclusion and our future works.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

The complicated field of document verification requires a number of difficult and time-consuming techniques to authenticate. In addition, different kinds of documents, such those used in banking, the government, for transactions, and educational diplomas, among others, may require special verification and authentication procedures. Each type's content differs greatly, thus it must be handled in a particular way. The most significant records that universities offer to students are educational certificates. Fake certificates can be easily produced, though, because the issuance procedure is not very clear and verifiable. A skillfully produced phony certificate is never easy to spot and can be taken as the real one. The credibility of the document holder and the issuing authority is at risk due to the rise in fake documents.

2.1.1 Blockchain Technology

Blockchain is a decentralised, unchangeable database that streamlines asset tracking and transaction recording within a business network. An asset could be tangible (like a house, car, cash, or piece of land) or intangible (intellectual property, patents, copyrights, branding). Practically anything of value can be recorded and traded on a blockchain network, reducing risk and boosting efficiency for all parties.[5]

Business requires information to function. It is ideal if it is quickly and precisely received. Because it offers real-time, shareable, and completely transparent data that is kept on an immutable ledger and only accessible to members of a permissioned network, blockchain is the best technology for delivering that information. A blockchain network can track orders, payments, accounts, and production, among other things. Additionally, you can see every facet of a transaction from beginning to end because everyone has access to the same version of the truth. This boosts your confidence and creates new opportunities. [6,7]

2.2 Features of Blockchain

The key features of blockchain technology include the following.

2.2.1 Decentralized Blockchain

A decentralized shared public ledger, or blockchain, is one in which all nodes are connected by a mesh network and where all data and decision-making are dispersed among various nodes [2].

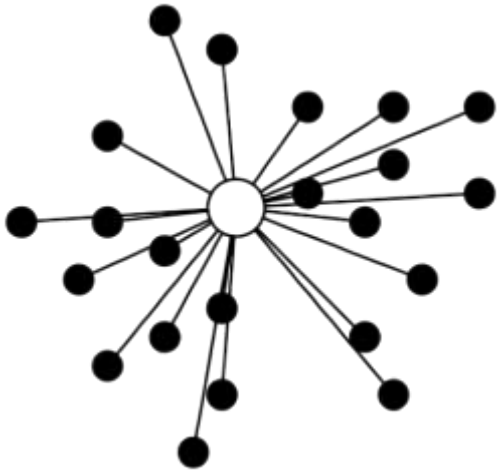

Fig.2.2 Centralized Ledger [2]

In Fig.2.2 shows the Centralized Ledger. Most e-learning platforms use centralized ledgers. All requests from different users can be handled by a single central server node. As a result, an increasing number of nodes are connecting to a single server and system scalability is limited.

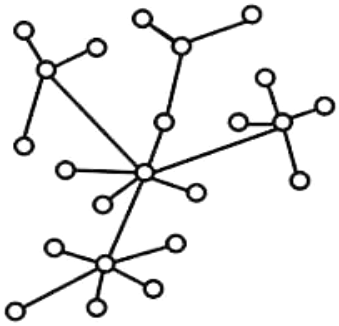

Figure.2.2.1 Decentralized Ledger [2]

In Fig.2.2.1 The central servers are distributed in the decentralized model as opposed to the centralized model. A peer-to-peer (decentralized) network is appropriate for students to feel supported by others and communicate with one another. As a result, blockchain technology provides a decentralized approach to transactions in this case.

2.2.2 Traceability: A blockchain is a decentralized shared public ledger in which all nodes are interconnected by a mesh network and where data and decision-making are distributed among numerous nodes [7].

2.2.3 Consensus Mechanism: The consensus process is the approval of all nodes connected to a blockchain network [13]. Consequently, there is no need for intermediaries. Proof-of-work (POW), proof-of-stake (POS), and delegated-proof-of-stake are some consensus mechanisms (DPOS).

2.2.4 Immutability: In blockchain, data is stored in ledger format, and if external nodes make any changes, hash key values will change because these keys are cryptographically linked to previous and previous blocks, and data changes will disrupt the consistency of the keys [14,15].

2.3 Related work

Zhimin Gao et al. (2018) researched that A person's biometric data and government identity can both be stored in a blockchain. Any time a person's identifying information is accessed, a transaction takes place. Cryptographic keys are transferred as part of every transaction to confirm the identity created by a digital certificate. Fingerprint, retinal, or face scanning can be used to investigate this solution.

According to Thayer et al. (2018), a number of blockchain-powered applications are highlighted for their efficiency. These applications include record-keeping uses for managing digital credentials and intellectual property, speeding up diploma verification, and offering quick and dependable student payments. Businesses, as well as individuals students and educational institutions, can save time and money by utilising these applications.

All transactions on a blockchain are completed without the involvement of a third party. The public can access and permanently store all of the transactions. They are planned to be a global advanced education credit stage by utilizing this technology.

According to Muhamed Turkanovic et al. (2018), Potential firms are available right now and can plainly approve the information provided by pupils. In light of blockchain innovation, it shifts the advanced education assessing framework from its current reality of physical records or conventional computerized ones to a more efficient, improved version. The distributed system framework is a factor [8].

Elena et al(2020) .'s analysis of the use of blockchain technology in education takes into account the opportunities and limitations for its use; it also seeks to determine the effects of its influence on educational advancement.

According to Jae Park (2021), after Net Neutrality and Big Data, blockchain may be the next technology-mediated socioeconomic mega movement. Blockchain technology's effects on education are examined in this theoretical essay. We cannot assume that network neutrality, widely available Internet access, and its influence on education will continue as they do today. Blockchain promises greater control over education funding

and investment, project implementation, a certification/accreditation system, and learning. The education blockchain's distributed ledgers would set new standards for crypto-learning and crypto-administration that are accepted by all organisations and countries, improving information objectivity, validity, and control without socioeconomic instability.

The blockchain system in the educational system was studied by Albérico Manuel Rosário and Ricardo Jorge Raimundo. In order to provide a Systematic Bibliometric Literature Review of studies on blockchain applications in the higher education sector, this study will do so. 37 papers were included in the review, which included the most recent data on the implications of using blockchain technology to improve higher education processes. The LRSB findings state that new interventions are being created using blockchain technology to improve the current methods of sharing, delivering, and protecting student records and knowledge data. The use of blockchain technology is furthering a conceptual advancement in the field of higher education, where it has significantly improved efficiency, effectiveness, privacy control, technological advancement, and security of data management mechanisms. Along with potential directions for future research, current research challenges are discussed.

Nursena Baygin et al. (2019), The blockchain is made available to reach a wide audience. Despite being the technology of the future, the blockchain has a number of drawbacks that vary depending on the application. This study assessed how well different blockchains performed in various applications. The pros and cons of this system, which is referred to as the technology of the future, are thoroughly studied and contrasted.

Amitkumar Dudhat et al. (2019), The Edublocs project aims to make the process of developing and putting into use a system for tracking activity results using blockchain technology simpler. This ongoing project is currently being evaluated. They can further demonstrate the viability and relevance of the use of blockchain technology in education by adhering to some design principles and experimenting with implementation in the context of higher education.

2.4 Types of Blockchain

To conduct business or send data over a secure network. On the other hand, how individuals utilize distributed ledger technology and networks varies depending on the situation. For instance, Blockchain and DLT technology are used to transact with the digital currency Bitcoin This type of blockchain network is a public network since anyone from anywhere in the globe can join, verify other nodes, and exchange bitcoins. On the other hand, suppose a bank is utilizing a private blockchain network. Only those who have been authorized by the bank will have access to the password-protected network. Bank information is therefore only available within the local network [10].

There are different types of Blockchain:

- **Public Blockchain [11]**: It is a distributed ledger that anyone can utilize to conduct transactions. Each peer possesses a copy of this open-ended ledger format. Access to the public Blockchain is now available to anyone with an internet connection. This user has access to both old and new records and can conduct data mining operations. To validate transactions and add them to the ledger, these complex calculations must be performed. On the blockchain network, no legally binding records or transactions can be altered. Because the source code is typically available for public inspection, anyone can examine the transactions, identify issues, and provide fixes [11].

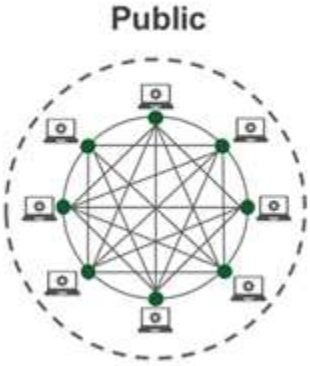

Figure 2.3: Public Blockchain [11]

❖ **Private Blockchain [12]:** A blockchain network is managed by a single identity and operates in a restricted or private environment. Despite the fact that this Blockchain is much smaller than a public blockchain network, it has a similar peer-to-peer connection and decentralization. Rather than being open to anyone who wants to donate processing power, they are frequently run on a small network within a company or organization. They are also known as enterprise blockchains and permissioned blockchains. [12].

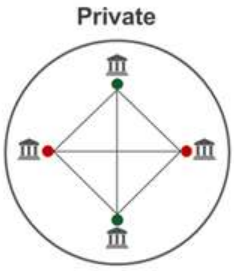

Figure 2.3.1: Private Blockchain [12]

❖ **Hybrid Blockchain [11]:** Businesses that want the best of both worlds use a hybrid blockchain, which takes the best parts of both private and public blockchains. It lets businesses create both a private, permission-based system and a public, permission-less system. This gives them control over what Blockchain data is made public and who can access it. In a hybrid blockchain, transactions and records are usually kept private. However, if verification is needed, a smart contract can be used to give access [11].

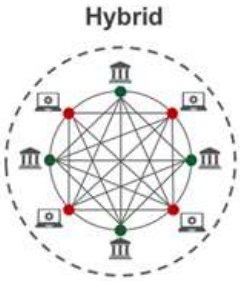

Figure 2.3.2 Hybrid Blockchain [11]

- **Consortium Blockchain [11]:** A Consortium blockchain, often referred to as a federated blockchain, has both private and public blockchain capabilities, similar to how a hybrid blockchain does. It varies, though, in that it incorporates numerous organizational members cooperating on a decentralized network. In a consortium blockchain, predetermined nodes control the consensus algorithms. It has a validator node that takes care of starting, receiving, and validating transactions. The member nodes can send and receive transactions.

2.4.1 Honey pots Work

We can understand it by a example: Jack wants to transmit 20 BTC to Phil using the Blockchain network, thus the first step is to facilitate the transaction.

Step 2: Transaction verification: All nodes on the network will get the message for transaction verification. All nodes will verify the crucial transactional characteristics, such as whether Jack has enough balance—at least 20 BTC—to complete the transaction. Jack, a node, is he registered? The node Phil is he registered? The transaction is validated when the parameters have been checked.

Formation of a new block, step three: In memory pools, a number of verified transactions accumulate and are then stored in a block. The block will also contain this verified transaction.

Because we are discussing bitcoins in this step, the Proof-of-Work consensus mechanism will be used for block verification. In proof-of-work, the system assigns a node the goal hash value, requiring it to generate a hash for the new block. The hash value for the new block that is below the intended value must be determined by the node. The block that presents the greatest challenge is chosen when two or more miners are mining the same block simultaneously. The remainder are referred to as stale blocks. Typically, mining pays out in blockchain currency. Bitcoin serves as the blockchain currency in this instance.

Fifth Step: Adding a New Block to the Blockchain Only once the freshly produced block has been added to the network and authenticated using proof-of-work will the transaction be marked as complete. Jack will give Phil 20 Bitcoin.

The blockchain's open end will connect the new block.

Step 6: The transaction has been completed: When the block is uploaded to the blockchain, the transaction will take place, and 20 BTCs will be transferred from Jack's wallet to Phil's wallet. The blockchain permanently secures the transactional facts.

Anyone connected to the network is able to retrieve the data and validate the transaction. This will make it easier to keep track of every transaction and check to see if any users are attempting to double spend. For instance, if Jack tries to execute a transaction in the future, the other nodes can look up Jack's historical transaction records to see if he has sufficient funds to execute the current transaction. The transaction will be accepted if there is enough balance.

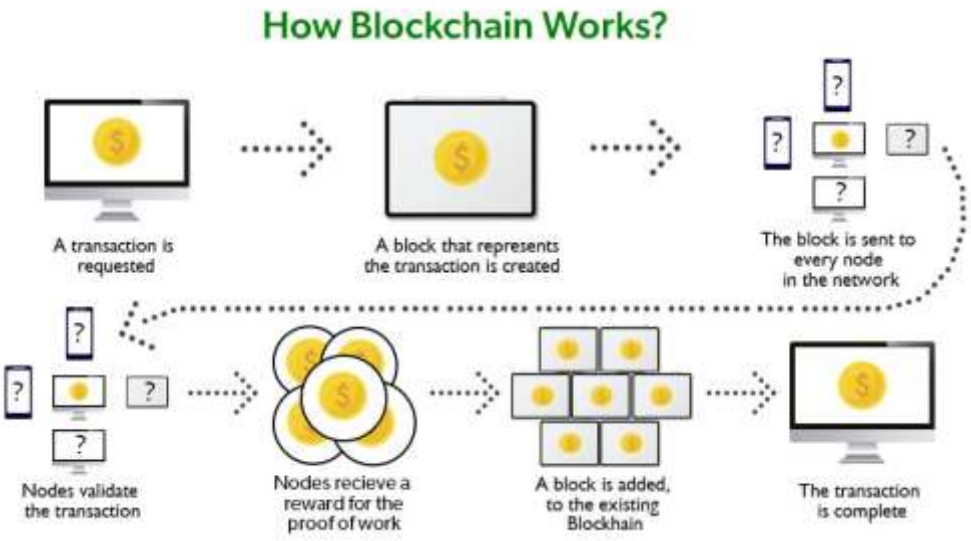

Figure 2.4 Working process of Blockchain [14]

2.4.2 Blockchain in certificate identification

The process of confirming a certificate issued by an organization is genuine and valid is known as certificate verification. Authorities responsible for providing certificates for student data protection appear to have been compromised. Data is being discarded, and dishonest persons may take advantage of this. The digital certificates are built on the Blockchain term in order to address the issue of certificate forgery. It is a relatively new technology that can have an impact on data security. We relate a blockchain hash positive method to confirm the accuracy of the facts. The prevalence of blockchain contributes to the eradication of fraudulent certifications. For certificate verification, authors have employed two different blockchain platforms: Ethereum and Bitcoin.

2.5 Research Summary

After reviewing some research paper, I got to know about the importance of Blockchain in certificate identification. The process of confirming a certificate issued by an organization is genuine and valid is known as certificate verification. Authorities responsible for providing certificates for student data protection appear to have been compromised. Data is being discarded, and dishonest persons may take advantage of this. The digital certificates are built on the Blockchain term in order to address the issue of certificate forgery.

2.6 Scope of the Problem

I've reviewed some papers & articles. There they mentioned & applied different approaches. Here I'll approach a model so that I can show you the certificate identification using blockchain

2.7 Challenges

I've a little amount of knowledge on blockchain. So I've to gain more knowledge on blockchain. On the other hand there was another difficulties that was the certificate identification. It was very challenging for me. The process of confirming a certificate issued by an organization is genuine and valid is known as certificate verification.

Authorities responsible for providing certificates for student data protection appear to have been compromised. Data is being discarded, and dishonest persons may take advantage of this. The digital certificates are built on the Blockchain term in order to address the issue of certificate forgery. These devices include but are not limited to synchro phasors, network switches, routers, control systems, smart meters, and other communication gateways. The most effective measures currently recommended by the industry to thwart such attacks include port security, which takes the form of hardening unused ports and setting a limit on the number of MAC addresses that can be connected to a given switch port.

CHAPTER 3

PROPOSED FRAMEWORK

3.1 Introduction

In this part, I will quickly describe the steps I took to accomplish our study project. The process of confirming a certificate issued by an organization is genuine and valid is known as certificate verification. Authorities responsible for providing certificates for student data protection appear to have been compromised. Data is being discarded, and dishonest persons may take advantage of this. The digital certificates are built on the Blockchain term in order to address the issue of certificate forgery.

3.2 Project Setup

The student's accomplishments, which are documented by a degree certificate, grade report, value-added certificate, etc., will be given significant weight when applying for jobs or advanced degrees. Only the names of the institution and the student's information may be on degree certificates and awards from educational institutions. Due to the lack of an efficient antiforge system in this situation, it happens frequently that the fake diploma is discovered. The blockchain technology would store the certificate in digital form, solving the issue of fraudulent certifications. The distributed ledger's digital certificates are very hard to alter or tamper with because of the immutability of blockchain technology. It is also quite simple to confirm the authenticity of a digital certificate.

The system's procedure for issuing digital certificates is as follows. Create the certificate's hash value using double SHA256 as a first step. As a transaction, include the fixed length hash value in the block. Members of the blockchain verify this transaction, and if they accept it as a legitimate transaction, the block is added to the already-existing blockchain.

The consensus algorithm will be used for accepting and rejecting [8]. The number of nodes and transactions may influence the selection of the consensus algorithm. The system will produce the relevant inquiry string code and QR code to add to the hardcopy certificate [11]. The solution offers the capability to scan a hardcopy certificate using a phone or authenticate certificates online [9]. Due to the distributed ledger's immutability,

3.3 Overview of System Architecture

Our system primarily serves as a resource for certification authorities, students, and employers. It increases certification authorities' efficiency and security by digitising current processes, issuing and registering certificates on the blockchain, and automating certificate monitoring. The system can support machine-readable certificates, according to the industry 4.0 approach [16]. Students can effectively manage their academic certificates and grant third-party access. As a result, the student can protect his or her privacy. Employers can obtain credible credential verification.

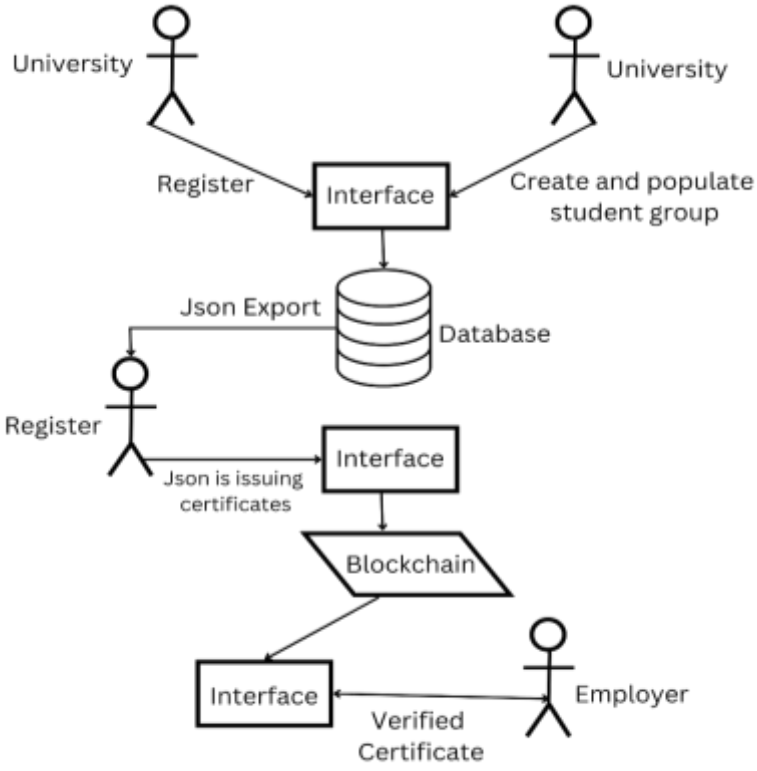

Figure.3.3: System Architecture

In Fig.3.3 Show the architecture of the credential verification system. Students, certifiers, and employers are the actors in this proposed framework. As a result, in order to achieve the minimum viable product, this study conceptualizes the characteristics of each group.

3.3.1 Characteristics for Certification Authorities

At present, certification authorities maintain their own databases or even MS Excel spreadsheets to keep track of student information, learning modules, other pertinent regulations, and exam results. Paper certificates for students are produced using this information. As a result, importing data and test results from legacy systems is a crucial first step for certification authorities. After importing the data, certificate authorities can browse the generated certificates. Additionally, based on the study plan, certification authorities demand the capability of finding learners or a summary of learners and their exam outcomes. Overview Allows certification authorities to print all certificates from a single learning course at once. The second most important function of certificate authorities is to sign certificates and store them on the blockchain. Both of the previous actions can be completed simultaneously by all students. Overview The Minimum Effective Product also includes the ability to identify the authenticity and validity of a particular certificate for all user groups. The revocation of certificates is another requirement of certification authorities. If plagiarism is found or official student misconduct is established, this might be necessary. When the necessary precautions are not taken, revocations of certificates with limited validity are frequently issued.

3.3.2 Features for Students

At present, most students receive paper certificates that already include security features. The documents are either physically mailed or emailed by the students to prospective employers. Therefore, one of the most important functions of the Minimum Viable Product is the capacity to import credentials and construct an application portfolio. Moreover, students need resources that allow them to organize and exhibit their application portfolios. After submitting an application portfolio, students are given the option of receiving notifications informing them of any action taken by potential employers on their credentials, such as reading or verification. Additional features of a minimum viable product can include time-limited certificate monitoring, which is useful for students and has a positive impact on the product's value proposition. It should be noted that certification authorities must also monitor, but the process is different. If the

renewal conditions are not met, the certification authority has the authority to remind students and revoke the certificate.

3.3.3 Features for Users

Currently, users can only obtain paper copies of student certificates, which are sometimes notarized. Users can only verify the authenticity and validity of copies in the first instance by contacting the issuing company. This is an inconvenient and costly procedure. That's why certificate reading and verification is crucial for even the most basic of products. Conceptual system architectures were created using derived attributes for certification authorities, learners, and employers. This process was aided by the engineering framework presented in the use case canvas [9] and [4] for blockchains.

3.3.4 Model of Conceptual Interaction:

Figure 3.3 shows an overview of the prototype's architecture. It comprises the blockchain including smart contracts, a public storage holding profile information of certification authorities, a document management system managing the actual payload of certificates tracked by the blockchain and the parties involved in the system, namely accreditation and certification authorities, certifiers, learners and employers. In the prototype implementation, only the document management system is a centralized system component.

3.3.5 Platform Bootstrapping

The accreditation authority first submits two smart contracts to the blockchain (1). The first smart contract supports management of identities in the Blockchain for Education platform and the second one manages the lifecycle of certificates issued over the blockchain. Once the contracts are deployed, it is the accreditation authority’s task to register the public keys of certification authorities as legitimate issuer of certifiers in the Identity Management contract and to submit public and non-personal profile information to the public storage. It is important to note that the profile information is read-only and publicly readable, i.e., it is not subject to the access control mechanisms of the Identity Management contract. It merely holds long-time profiles of certification authorities, such

as their name and country, but does not include any personal information of certifiers or even learners.

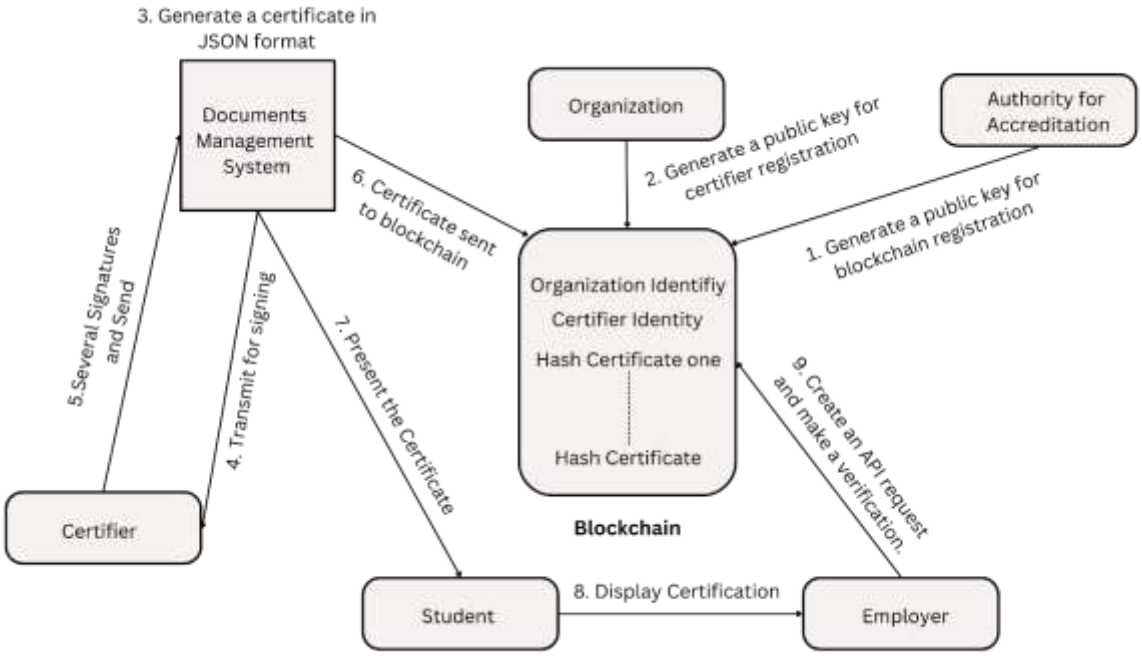

Figure.3.3.1: Blockchain-based conceptual model work for certificate verification

Following fig.3.3.1, Registered certification authorities then add the public keys of certifiers to the registry of the Identity Management contract and thereby delegate the right to issue certificates. That is, a holder of a private certifier key will typically be an employee of a certification authority who is entitled to issue certificates and signs them in the name of the certification authority. The certifier collects all information a certificate consists of. The dataset comprises qualification or title, name and address of the certification authority, name of the certifier, name of the learner, and the date. Then the certificate is signed by the certifier and stored on the document management system and its fingerprint is written to the blockchain Creation and management of application portfolios Learners are supported in the creation and management of application portfolios by a service of the document management system. Firstly, the learner has to

register with the document management system. Then, a service for the flexible creation of application portfolios supports the learner. Completed application portfolios can be shared with potential employers who can verify the validity of these certificates. A service of the minimal viable product supports employers, for example, in verifying single certificates or all certificates of an application portfolio.

3.4 Challenges in Privacy and Security

The Blockchain for Education platform solves issues with security and privacy. For instance, in contrast to the Blockchain system, the hierarchical organization of identities in the Blockchain for Education platform allows genuine certifiers to maintain their anonymity while demonstrating their affiliation with a reputable certification authority. Oyente is an extension of Osiris, which we use to security verify Blockchain for Education smart contracts based on approved templates from the Open Zeppelin collection. Oyente is a symbolic execution tool we developed to find integer over- and underflows. We have safeguards in place that prevent learning smart contracts for blockchain instances from being used when vulnerabilities are discovered. It keeps read-only access while guarding against potential record manipulation. In the upcoming iteration, we might give our smart contracts an update system. It will be able to close the gaps in our security. Furthermore, we are creating sophisticated cryptographic protocols to secretly store data in a connection-only public ledger.

CHAPTER 4

PROPOSED FRAMEWORK PROTOTYPE

We implemented a prototype of the Blockchain Technology in The Education System: Certificates & Identity Management. Two smart contracts written in Solidity4 codify access control mechanisms and manage certificate records stored in the blockchain. The Interplanetary Filesystem (IPFS) is used as a public distributed read-only storage for profile information of certification authorities. Finally, the BSCW document management system stores and validate certificates.

4.1 Proposed Framework Simulation

Components pertaining to Identity Hierarchy, certificate administration, public tamper-proof read-only file storage, and related topics are discussed here.

4.2 Identity Hierarchy and Responsibility Assignment

Blockchain for Education uses a hierarchical system to manage user identities. Accreditation bodies are at the top of the hierarchy, with the authority to grant legitimacy to certification bodies. The group of accreditation authorities for the Blockchain for Education platform, for example, could be built by participants in the European Cooperation for Accreditation. The entire collection of accreditation authorities has been combined into a single authority in Figure 2 for simplicity's sake and to reflect the current prototype setup. An accreditation organization is the owner of the smart contracts for a specific Blockchain for Education instance. It initiates the Ethereum blockchain with the first smart contracts. An accreditation body may add, modify, or remove a certification body in accordance with the Identity Management agreement. When determining the identity hierarchy, certification authorities are placed below accreditation authorities. Their unique Ethereum address is generated using a cryptographic hash of their public key. You can access a certification authority's IPFS profile if you know its address. Authorities tasked with certification cannot issue certificates. Employees can only acquire rights if they are delegated to the employee by the entity holding the right. The

certification authority does this by calling the relevant function of the Identity Management contract and passing the certifier's Ethereum address as input.

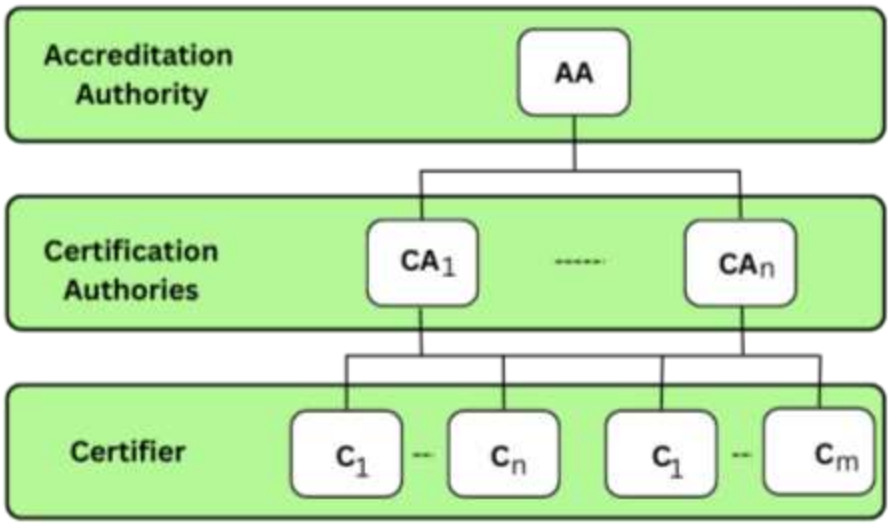

Figure.4.2 Identify Hierarchy

Figure 4.2 depicts the certificate verification system's actor hierarchy. The smart contract automatically assigns the certifier to the delegating certification authority, ensuring that only accredited certification authorities can delegate the right. Any certifier may be granted the ability to issue certificates at any time, but the certification authority may also revoke that ability at any time. This deauthorization might happen, for instance, if a certifier were to leave a certification authority or otherwise lose the right to issue certificates. As such, certifiers are unable to further delegate their authority or otherwise alter user access. Certifying entities' sole responsibility is to keep track of certificates in a distributed ledger.

4.2.1 Management of Certificates

In the Blockchain for Education system, certifiers have the ability to generate, revoke, and remove references to certificates. The Certificate Management System for Smart Contracts includes this functionality. The Certificate Management contract is created at the same time as the Identity Management contract by the accreditation authority. The

Identity Management contract's address is needed by the Certificate Management contract so that access control can be implemented. To perform any action on the Certificate Management contract, such as adding a certificate, the caller must be a certified practitioner of a recognized certification body. Given the Certificate Management contract's address and a hash of the certificate, anyone can access the corresponding certificate record.

A certificate record is a blockchain-based data structure used by the Certificate Management contract to record certificate data. Currently, this data includes the certificate's SHA256 hash, the certificate's issue and expiration dates, and a status field for indicating whether or not the certificate is currently suspended. 256-bit unsigned integers are used to store dates as a way to ensure their integrity well into the future. Dates are represented as UNIX timestamps. If a certificate is currently on hold, the on-Hold field will also contain a UNIX timestamp. By this means, one can see the precise time a certificate went into the on-Hold state.

4.2.2 IPFS as a Public Read-Only Tamper-Proof Profile Storage

Ethereum addresses, a hash of public keys, are used on the Ethereum blockchain to uniquely identify entities like accreditation bodies, certification bodies, and certifiers. This protects privacy, especially that of the certifiers, because it is difficult to tie an individual's identity to their Ethereum address. However, CAs are obligated to make their profiles easily accessible so that anyone verifying a certificate can also verify the CA. Without this context, certifications are completely anonymous and unsuitable for establishing a solid reputation for a student. For this reason, certification authorities are required to provide an IPFS address where the profile can be accessed by the public. In addition to being a requirement resulting from the European General Data Protection Regulation, which forbids any undeletable storage of personal information in a blockchain, this is crucial for certification authorities that do not wish to disclose employee personal information to rival authorities. The cost of actual blockchain storage is also relatively high. As a result, CA profiles can be found on the IPFS. Internet File System (IPFS) offers distributed, secure, and tamper-proof file storage. The Merkle tree-based hashes are how the widely dispersed block storage system locates and accesses

data. Numerous clients for various programming languages abstract away the IPFS specifics and allow client programmed to access IPFS as though it were any other block storage. When a new certification authority is added to the Identity Management registry, the accrediting body will first store the CA's profile details in IPFS before submitting the CA's public key and IPFS address. After that happened, the IPFS block containing the profile data also became replicated on all nodes in the network alongside the Ethereum transaction. The accreditation body must therefore verify the identities of certificate authorities before adding them to the distributed ledger, so as to avoid registering any fake profiles. There are two benefits to incorporating IPFS into the Blockchain for Education infrastructure. First, the immutable IPFS addresses used in the blockchain mean that no personally identifiable information is ever stored there. This paves the way for Blockchain to be used in the classroom while still complying with privacy regulations. The European Union's General Data Protection Regulation (GDPR), for instance, would likely raise objections to the immutable nature of blockchain storage of personally identifiable information. Second, there is a savings in blockchain space when certification authority profiles are stored off-chain in an immutable fashion.

4.2.3 Extended Open Badges using Certificates

To digitise certificates, we chose the JSON data format, which is compatible with Open Badges. To meet the needs of our application partners and personnel certification authority, we added six features to the baseline Open Badges schema. They include the certificate's unique identifier, the date and location of the examination, the current examination regulations, information about the certifier, information about the certificate recipient, and the address of the verified service that is available to verify the certificate.

4.2.4 Authentic Certification ID

As a result of this schema extension, our schema now also supports property assertion references of type string. For legal reasons, our staff certification agency required this special ID.

4.2.5 Examination Date and Place

Figure 4.2.1 illustrates the augmented schema. Starting today, end Today, and location are all string-type properties that have been established. ISO 8601 is used to define dates, so that's how they're formatted here. For all of our other schema extensions, this one serves as a model.

```
{
   "$schema": "http://json-schema.org/draft-06/schema#",
   "title": "Information on the examination date place",
   "description": "This extension provides additional
   information on the examination date and palce.",
    "type": "object",
   "definitions": {
       "ISO8601Date": {
       "description": "ISO 8601 date format string. For
       example, 2023-01-02T12:59:59+00:00 is a valid ISO 8601
       timestamp.",

         "type": "String",
         "Format": "date-time"
       }
   },
     "properties": {
     "startdate": {"$ref": "#/definitions/ISO8601Date"},
     "enddate": {"$ref": "#/definitions/ISO8601Date"},
     "place": {"$ref": "string"},
     },

       "required": ["Startdate"]
}
```

Figure.4.2.1: Schema Extension for Examination

In effect Examination Regulations

In particular, this schema extension provides us with the regulation's title, URL, regulation Sid, and effective date.

Certifier

We have expanded our schema to include the properties first name, last name, certification date, certification location, and blockchain address.

Holder of Certificate

Name, surname, date of birth, country of birth, and email address are all new additions to our schema thanks to this schema extension.

Verify

The schema extension is illustrated in full in Figure 4.2.1. Assertion Hash and Verify Address are now defined properties. Because of these characteristics, outside parties can create their own verification system. To validate our augmented Open Badges credentials, we turned to the IMS Global Learning Consortium's validator service. The BSCW 2.0 Open Badges Manage Certificates specification has been met by our certificates.

```
{
   "$schema": "http://json-schema.org/draft-06/schema#",
   "title": "Verify Certificate in BlockchainForEducation",
   "description": "This extension provides the URL to the
   BlockChainForeducation Verify smartcontract to verify a
   certificate.",
    "type": "object",
   "definitions": {
       "HashString": {
         "type":  "string",
           "description": "Open Badges SHA-256 Hash",
            "Pattern": "sha256\\$[a-fA-F0-9]{64}$"
       }
   },
     "properties": {
    "verifyaddress":{
      "type": "string",
       "format": "url"
    },
      "assertionhash": {"$ref": "#/definitions/HashString"}
     },

       "required": ["Verifyaddress", "assertionhash"]
}
```

Figure.4.2.2 Schema Extension for Verification

The Blockchain for Education project utilizes BSCW, a Web-based groupware system [9], to record student information, course information, and exam results. In order to facilitate the transfer of information from older systems, a service was developed specifically for the blockchain in education project. When a certification body uploads its information for a given training module, a certificate bundle for that module's completion is created in a separate folder. Figure 4.2.2 depicts a screen capture.

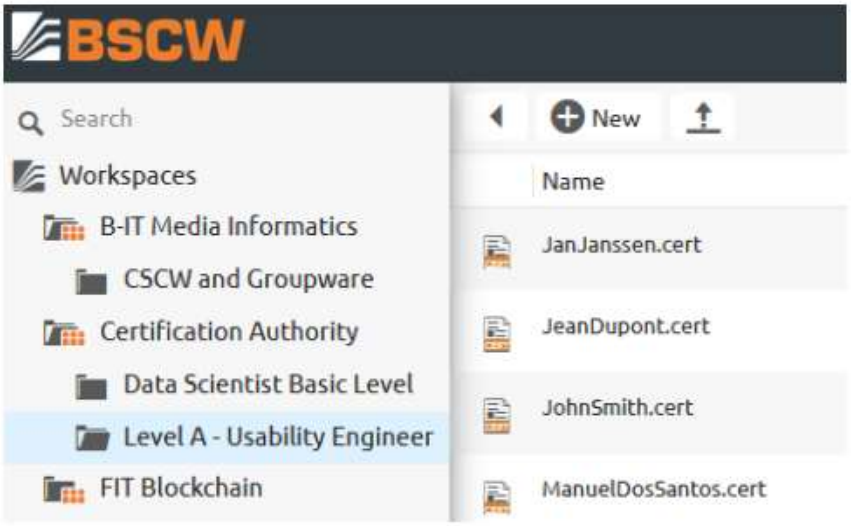

Figure.4.2.3 Personnel Certification Authority and List of

Figure 4.2.3's left side shows a folder hierarchy. The extended Open Badge certificate and each exam-passing student's course folder are both located in the Certification Authority folder. It has been decided to use the Level A - Usability Engineer folder. As a result, Figure 5's right side shows the pertinent certificates. By clicking on a certificate, certifiers can view a preview of it. Increase the Distributed Ledger. After reviewing the certificates during the preview phase, the certifier can then sign them and add them to the blockchain. The send to blockchain operation performs this task. This procedure is depicted in Figure 6 for the JanJanssen.cert certificate. If the operation succeeded, a pop-up message alerting the certifier that the certificate has been added to the blockchain will appear. It's important to remember that the blockchain only stores the certificate's fingerprint and a few other attributes.

The status attribute's default value is "valid," but it can also be "on hold" or "invalid." You can find information about the certificate's issuing authority in an attribute called issuer. The date it was issued is yet another distinguishing feature. Certificates have no default expiration date. Attribute expiration dates are updated if the certificate has a time limit.

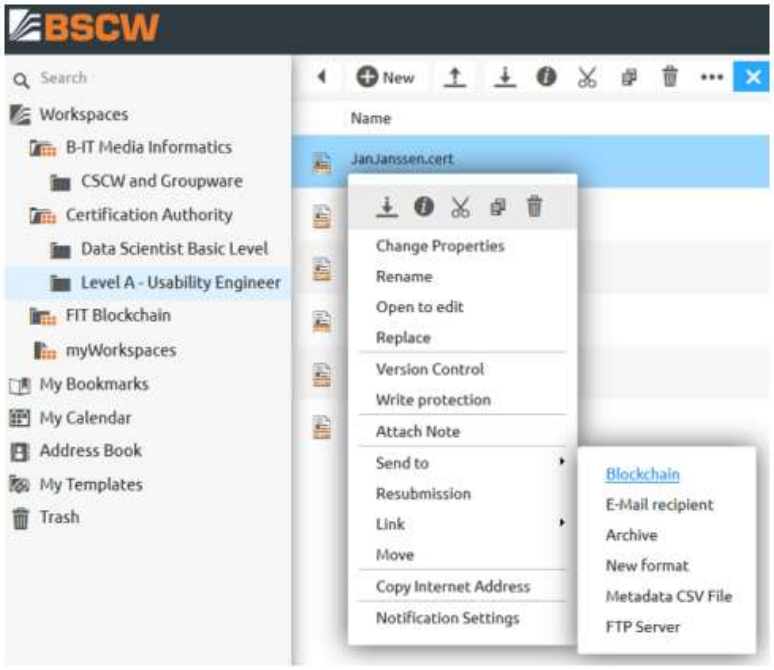

Figure.4.2.4 Write Fingerprint of Certificate to Blockchain

Figure 9 depicts the certificate's fingerprint in the blockchain. Communicating Accomplishment to Students After certificates have been uploaded to the blockchain, they are sent to students in two different file types: a PDF and an encoded JSON file. After students have finished with their work, they should back up the files somewhere secure. Keep in mind that the certificate's serialized JSON string is stored as meta data in the PDF file.

4.2.4 Application Portfolios in BSCW

The ability to self-register with BSCW, import certificates into personal folders, and create a variety of application portfolios tailored to the distinct employers one is interested in working for are all available to learners. With two levels and a folder assigned to each, the application portfolios in BSCW are arranged hierarchically. The individual folders each contain the certificates' PDF versions. The learner can give the application folder to a potential employer, who can then check the certificates to verify the learner's credentials.

4.2.5 Certificate Verification

To provide a trusted way to verify certificates when they are presented to us, we have developed our very own verification service. A free service that you can use is available on the landing page of the Blockchain for Education platform. The service accepts JSON or PDF documents, and users only need to drag and drop certificates onto it. Following that, the service will look to see if the fingerprint of the certificate has already been recorded in the blockchain. As a result, in addition to the true or false value, information about the registered issuer (if it is a registered certification authority) and the attributes status, issuer, issue date, and if set, validity for the certificate are also displayed. The user interface of the verification service is depicted in figure 4.2.8 below.

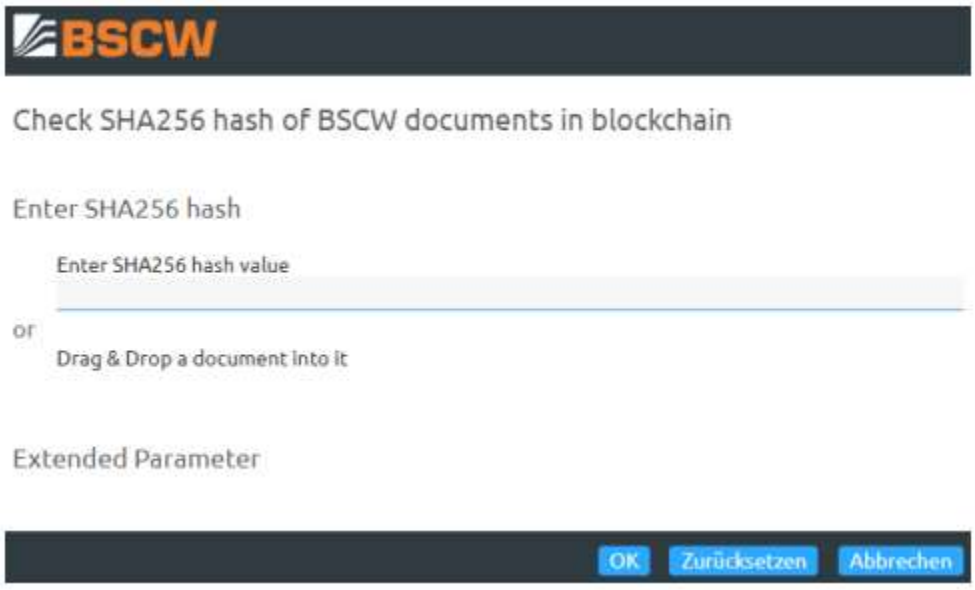

Figure.4.2.5 User Interface of Verification Service

4.3 Use Case of the proposed system

The blockchain for Education platform makes it possible to verify and authenticate certificates, as well as archive them in a way that prevents tampering and ensures they are correctly and permanently assigned to students. In addition, the majority of the support is provided for three distinct scenarios. In the first possible scenario, a learner has expressed interest in putting together a certificate portfolio using a selection of available

certificates. The creation of application portfolios is made possible by the underlying groupware known as BSCW. The learner will assemble all necessary application materials into the proper portfolio and then present it to a potential employer. The employer can then verify the certificates using the platform's verification service or another verification service that is able to call the specified smart contract and is compatible with our extended Open Badges.

A second scenario involves a student who has demonstrated proficiency in the fundamentals of usability engineering by passing an associated exam. After that, the student continued their education by completing additional training in information and interaction design. The learner is awarded the qualification of senior usability engineer once they have completed this course and demonstrated that they are qualified to do so. This new qualification will be determined through the use of a smart contract The third conceivable scenario involves an independent contractor who promotes themselves online as a master craftsman in the industry of high-quality fitting. Prospective customers can check the validity of the qualification in question and the reliability of the certification authority issuing the qualification by using a verification service. With the help of potential end users, the Blockchain for Education platform was developed iteratively. A first draught of the minimum viable product was presented to our personnel certification authority, and a thorough discussion followed. The issuance and management of certificates were already included in this version. On the other hand, the revocation of certificates was not anticipated, so it was added as an extra feature of the minimal viable product to account for it. In addition, the discussions that we had with the personnel certification authority resulted in additional, less significant revisions and redesigns. In the third conceivable case, a freelancer lists their professional credentials as being a master craftsman in the discipline of high-quality fitting on the internet. The validity of the qualification in question can be checked, as well as the reliability of the certification authority issuing it, using a verification service, which prospective clients can use. The Blockchain for Education platform was developed iteratively with the help of prospective customers. A first draught of the minimum viable product was shown to our personnel certification authority, and a thorough discussion followed. The functions for issuing and managing certificates were already present in this version. On the other

hand, certificate revocation was not anticipated and was therefore added as an extra feature to the minimal viable product to account for it. The procedures for issuing, validating, and sharing certificates have not changed significantly.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

5.1 Impact on Society

Every human feeling may be linked to the words we view on a daily basis on various online platforms in the digital world. In this case, it is critical for these platforms to have a mechanism in place to discern which are genuine emotions and which are pre-programmed aggressiveness. This is why I've decided to focus on one of the most fascinating genres of all time. By doing so, we can expect to create a more definitive and diverse digital era.

With the growth of Industry 4.0, the scope of the technological revolution has beyond many conventional boundaries. The world is currently getting ready to become accustomed to the usage of autonomous and intelligent systems that are based on machine learning and data. Digital identity, however, is one of the key components in the realm of digital services.

Digital identity is essentially the digital representation of data relating to a specific person, business, or group. Is the blockchain technology equation for digital identity practical? With all the features to make digital identity management more engaging, safe, and versatile, blockchain is like the new kid on the block.

5.2 Impact on Environment

In the market for digital identity technologies, it is new at the same time. Therefore, it's critical to understand how blockchain technology affects digital identity and its potential for transformation. The following article provides a thorough overview of how blockchain affects digital identification and enables you to determine whether blockchain is a safe bet in terms of digital identity. Everybody thinks it is a normal issue. But it is not. So that’s why I decided to work on it.

5.3 Ethical Aspects

The internet's media outlets have now become accessible to people of all ages. As a result, the conditions of the user limitations are no longer valid. Because there are insufficient security measures to distinguish between moral and social perspectives. One must be able to comprehend the overall context of a notion conveyed through platforms. In many circumstances, this has been shown to be harmful to people's moral ideals.

5.4 Sustainability

- There are over 2.3 billion active internet-based life clients worldwide.
- At least two internet-based life cycles are present in 91 percent of large business brands.
- When they can't access their online life profiles, 65 percent of individuals feel uneasy and uncomfortable.
- It will be a helping hand for researcher.
- Able to gain more knowledge about blockchain.
- It’ll be easy to the validation of a student

CHAPTER 6
DISCUSSION AND CONCLUSION

6.1 Summary of the Study

At this recent pandemic time, a digital certificate is required despite the fact that certificates are still issued as paper documents. This thesis presents the conceptual framework that will be used to issue a certificate in a digital format by utilizing blockchain technology. To begin, the framework that has been proposed offers a decentralized and immutable method to store digital certificates. Second, the system verification service makes it possible for third parties to check the validity of certificates in an efficient manner. Finally, there is an identification process that is stored in the blockchain in an immutable manner. This process involves certification authorities and certifiers. A blockchain-based platform would need to provide the appropriate services in order to successfully achieve counterfeit protection for certificates. [20].

As part of its education platform, Mozilla offers the Open Badges specification, which can be used to record information about certificates on blockchains. Open Badges is widely utilized, and because of this, its advantage schema has the potential to be expanded. There are a number of application programming interfaces (API) and tools that can be used to verify or manage Open Badges. An analysis of the differences and similarities between the Blockchain-based proposed model for the education platform and Blockcerts. Due to the fact that it is based on the Bitcoin platform, Blockcerts cannot mark with a complex smart contract. The proposed model makes use of the integration of smart contracts into the lifecycle of certificates as well as the management of identities of management, including certification institutions and certifiers. The model put forth in this thesis, in contrast to Blockcerts, aims to eliminate fake certificates.

6.2 Conclusion

With the volume of data that was gathered over the available time period. Because there wasn't really enough variation to get a top-notch result, some of the conclusions may not be totally true or lack clarity or definition. Having said that, the comprehension of the data has much improved, and if more data were collected over a longer period of time, the results would be much better and could even reach a high level.

In the market for digital identity technologies, it is new at the same time. Therefore, it's critical to understand how blockchain technology affects digital identity and its potential for transformation. The following article provides a thorough overview of how blockchain affects digital identification and enables you to determine whether blockchain is a safe bet in terms of digital identity.

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Blockchain Technology in The Education System Certificates & Identity Management

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