MASTER OF INFORMATION SYSTEMS

Capstone Project

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JOSH HENRY R. REGONDOLA

BLOCKCHAIN-BASED DIPLOMA VERIFICATION SYSTEM FOR HIGHER EDUCATIONAL INSTITUTIONS IN THE PHILIPPINES

Thesis Adviser:

RIA MAE H. BORROMEO, PHD
Faculty of Information and Communication Studies

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_____ 27 April 2023

RIA MAE H. BORROMEO, PHD
Adviser (Date)

_____ _____

ROBERTO B. FIGUEROA, JR., PHD
Program Chair (Date)

DIEGO S. MARANAN, PHD
Dean
Faculty of Information and Communication Studies

27 April 2023
(Date)

Biographical Sketch

Josh Henry Regondola is an experienced technical project manager and Certified Scrum Master with a proven track record in product development. He came from a technical background in software engineering before shifting to technical project management.

Josh has led several technology projects in different industries, such as education, finance, advertising, and gaming. Josh's unwavering commitment to professional development is reflected in his ongoing education and training, which keeps him current on industry trends and best practices.

Josh has held positions such as Project Management Consultant, Head of Software Development, Assistant Director in Educational Technology, Product Manager, and Software Development Technical Lead over the course of his career.

Josh graduated with a bachelor's degree from the University of Santo Tomas Legazpi. He has led several non-profit organizations, such as the Institute of Computer Engineers of the Philippines Bicol Chapter and Bicol IT Organization Incorporated, which envisions bridging the gap between academic and private IT institutions.

Dedication

This capstone project is dedicated to the people who served as my support and inspiration in finishing this endeavor.

To my wife, Michelle who remained understanding, patient and encouraging even at times when my academic aspirations are affecting our time together as a family.

To my daughter, Hera, your existence served as a reminder of my purpose and inspiration. I hope that this achievement will inspire you to value education and love learning as you traverse your own academic journey in the future.

To my mother Margarita and late father Waldo, I am grateful for the important values you instilled with me throughout the years. The principles of hard work, discipline and excellence have greatly impacted the way I view my personal, academic and professional life.

To my sister and my extended family for their unwavering support that allowed me to push through my academic aspirations.

Finally, to my mentors, professors and classmates who imparted their expertise and skills to me throughout this journey.

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Abstract

Diploma forgery is a perennial problem in the Philippines. It invalidated the time, effort, and abilities required to obtain a degree in both the higher education system and the workplace. In recent years, there have been multiple instances of academic credential fabrication. One of them was of a high-ranking Department of Foreign Affairs official who fabricated her academic credentials and worked for the government as an Assistant Secretary,[1] a position that needed not only a bachelor's degree but also extensive experience and academic achievements.

In this project, the proponent created a tamper-proof, efficient, and publicly available blockchain-based diploma verification system to expedite diploma verification for any higher educational institution in the Philippines.

The platform did not require corporations, entities, or any other public entity to create and manage a blockchain wallet in order to access and verify diplomas minted on the blockchain network.

To assess the project's success, a platform prototype was created and tested by (10) volunteers. Following the use of the system, a survey on the efficiency of the prototype in authenticating diplomas over the internet was supplied.

Overall, the project aimed to demonstrate the dependability and effectiveness of using blockchain technology to authenticate academic credentials such as diplomas in order to prevent document fraud and forgery.

Chapter I

THE PROBLEM DOMAIN

Statement of the Problem

In the Philippines, it was common for people to fake documents. Even for foreigners, the Philippines is known as a place where almost any paper could be faked easily. There were even rumors that some foreigners moved to the country and faked their deaths to get out of bills or criminal charges in their home countries [2]. Academic credentials were one of the most common things that were faked in the country. If someone went to the infamous "Recto University" in Manila, they could easily buy a fake license from any university in the country[3].

Also, because of the previous election, the problem of fake academic records has been in the news a lot during the campaign period. Some lawmakers were said to have made up their academic credentials in order to look better as candidates[3]. So far, most schools in the country do not have a regular way to check these kinds of academic records.

It was known that academic documents like the diploma needed a fast, reliable, and tamper-proof verification method. This would not only help stop forgery, but it would also speed up things like job application, employment background checks, visa application, and other things that depend on academic papers.

Fake academic certificates have been a problem in the Philippines for a long time[4]. It is a common problem that isn't being fixed because there are no platforms that are built to solve this particular issue.

Due to the lack of a reliable and tamper-proof diploma verification system in the country, the proponent developed a prototype of a system that would use blockchain technology and Non-Fungible Tokens (NFTs) for diploma verification.

Background and Objectives of the Project

Forging diplomas is still a problem in Philippine education and the workforce. This malpractice puts organizations at risk and reduces the value of true academic accomplishments by undermining the legitimacy of professional credentials and academic institutions. Notably, there have been instances of public servants holding posts based on fabricated qualifications, and these occurrences necessitate immediate changes to the authentication process for academic records.

This project suggests a tamper-proof, effective, and publicly accessible blockchain-based diploma verification system. The objectives of the study are as follows:

1. To develop a decentralized application that enables institutions of higher learning to mint verifiable academic credentials using blockchain technology,
2. To enable verifiers, like employers and agencies, to authenticate diplomas without the need for a blockchain wallet or technical know-how; and
3. To evaluate the platform's usability and efficacy through user feedback and prototype testing.

Significance and Scope of the Project

The significance of this project lies in its potential to safeguard the integrity of academic records in the Philippines. Blockchain is ideal for storing tamper-resistant credentials because it is designed to guarantee data transparency and immutability. This gives educational institutions a low-maintenance, scalable method of issuing and confirming academic records. It streamlines the credential validation procedure for companies and outside organizations, saving money and time.

The project includes the development of a prototype platform specifically for diploma verification. With this version, users no longer need to create a blockchain wallet which makes access easier and improves usage. To assess the system's practical functionality, ten (10) volunteers tried and evaluated the system. The results are intended to show how blockchain can be implemented in a Philippine higher education setting.

Documentation of Existence and Seriousness of the Problem

While academic fraud is a global concern, it has gained significant attention in the Philippines because of prominent cases of falsifying academic records in both public and private sectors. A 2015 incident concerning an Assistant Secretary in the Department of Foreign Affairs who altered her academic qualifications illustrates the fragility of existing verification processes.

These dishonest practices undermine years of scholarly work and damage institutional trust. Manual checks with registrars and administrative staff are common in traditional verification procedures, which are laborious and prone to errors. These inefficiencies highlight the necessity of automatic, unchangeable verification systems

that lessen the need for manual documentation handoffs and validation.

Significance of the Study

This study supports Philippine efforts to combat fraud, innovate digitally, and reform education. It provides a road map for academic institutions looking to incorporate blockchain technology into their records management systems. This will provide a platform for transparent, real-time diploma validation for both public and private sector organizations. The platform guarantees that the credentials of graduates are safe, easily verifiable, and impermeable to fraud.

The project also supports the Philippine's larger ambitions for digital transformation and is in line with its initiatives to use emerging technology to modernize governance.

Scope and Limitation of the Study

The study is limited to the design, development, and evaluation of a working prototype of the blockchain-based diploma verification platform. National adoption at scale and institutional policy reforms are not included. The prototype testing was restricted to ten (10) users, which yielded preliminary findings but did not fully represent the range of stakeholders in the employment and higher education sectors.

Another limitation is that no legal or regulatory compliance analysis has been done on the use of blockchain in official records. The scope of this study did not include interoperability with international verification systems or integration with

legacy school systems.

Operational Definition of Terminologies

- **Blockchain** – Blockchain is a decentralized, cryptographically secured ledger that is used to store data in an unchangeable and transparent way[5].
- **Credential Forgery** – The act of creating fake academic records to misrepresent one's educational history.
- **Minted Diploma** – A blockchain-stored digital credential that functions as a verifiable academic record.
- **Prototype** – An early iteration of a product designed to test and improve features before widespread use.
- **Tamper-Proof** – A feature of a system that prevents data from being changed or removed covertly once it has been recorded.
- **Verification Platform** – An online tool created to enable businesses and the general public to verify academic qualifications.

Chapter II

REVIEW OF EXISTING ALTERNATIVES

Verification of academic records is currently handled differently in every institution. The standard process would be visiting the respective registrar's office and requesting for a document verifying if a certain person is a graduate of the said institution. This could take weeks or months depending on the issuing institution. Additionally, these requests for verification may be declined depending on the purpose of the requesting entity.

For example, if a company would like to verify the authenticity of a diploma provided by their applicant or employee. They would usually need to send someone physically to the institution and request a verification. This manual and stringent measure of verification is often the reason why most companies and entities wouldn't want to bother anymore about the authenticity of the documents that were provided to them by an individual.

Moreover, these records are stored in a centralized management information system for some modern institutions in the Philippines but records are typically not properly archived for the majority of the higher educational institutions.

In terms of a general service for document signature verification, recently a startup called twalasign.io developed a service for business organizations that leveraged blockchain technology to digitally sign documents[9]. This is a similar concept to what the proponent developed but instead of signed documents, the proponent focused on diploma verification.

Chapter III

APPROACH TO BE TAKEN IN THIS PROJECT

Overview

The Blockchain-based Diploma Verification System supports two user types with distinct access levels:

1. Guest User

   This user role is intended for employers, agencies or individuals who need to verify graduate information without login credentials. Guest Users have open access to the platform's verification features and can search and view lists of graduates.

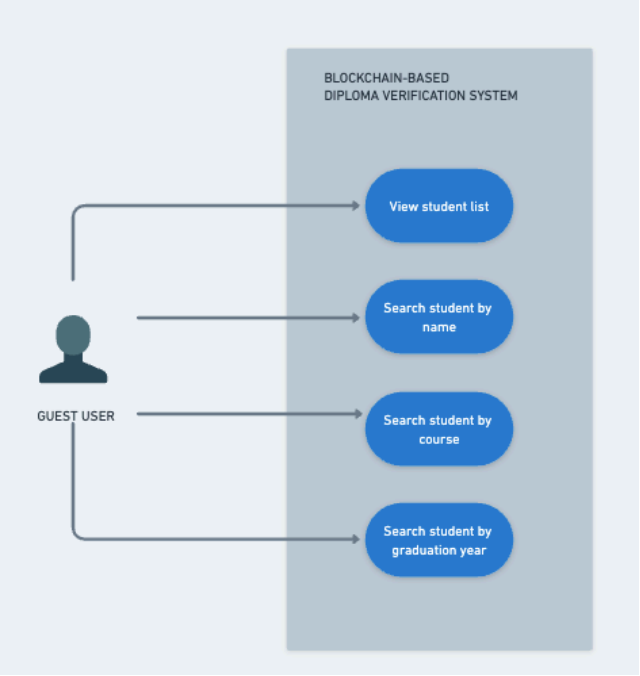

Figure 1. Guest user type use case diagram

2. Administrator

The Administrator is a registered and authorized personnel for managing student records on the platform. This role has the capabilities to view, create, update and delete student records.

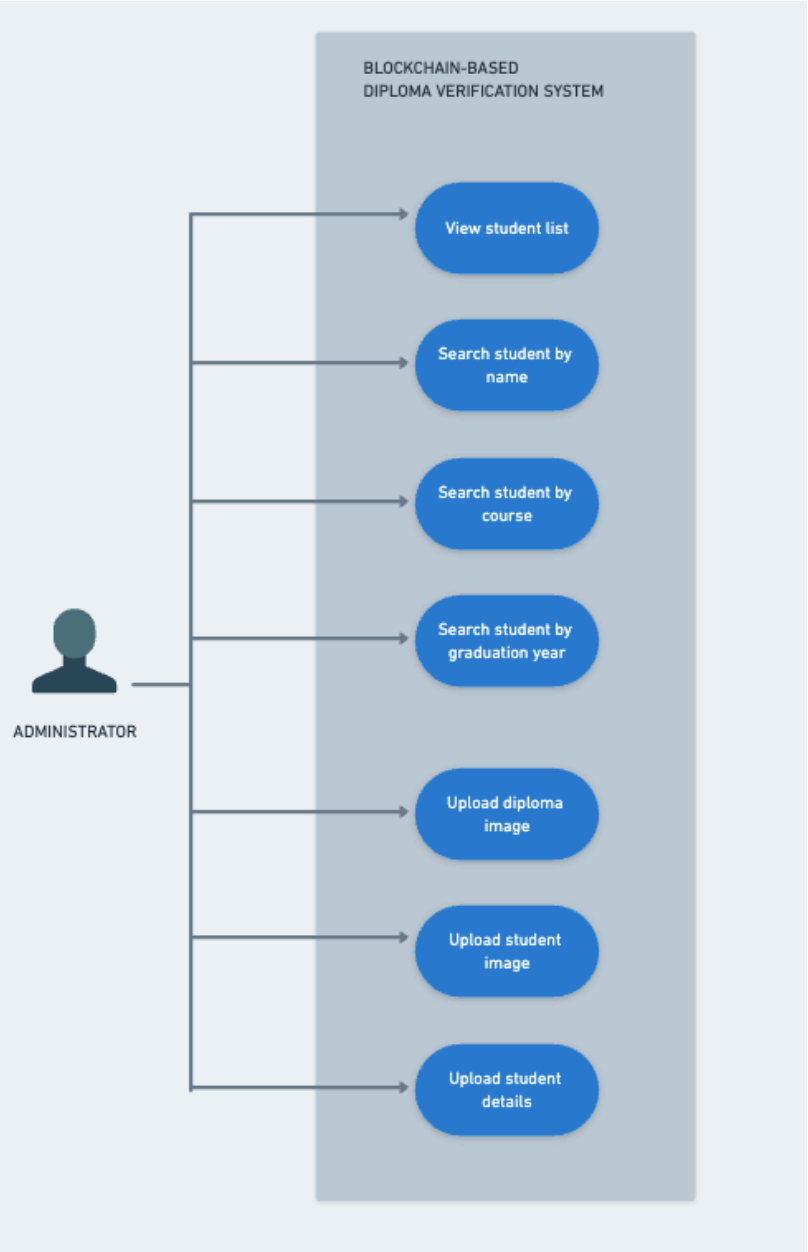

Figure 2. Administrator user type use case diagram

Theoretical Framework

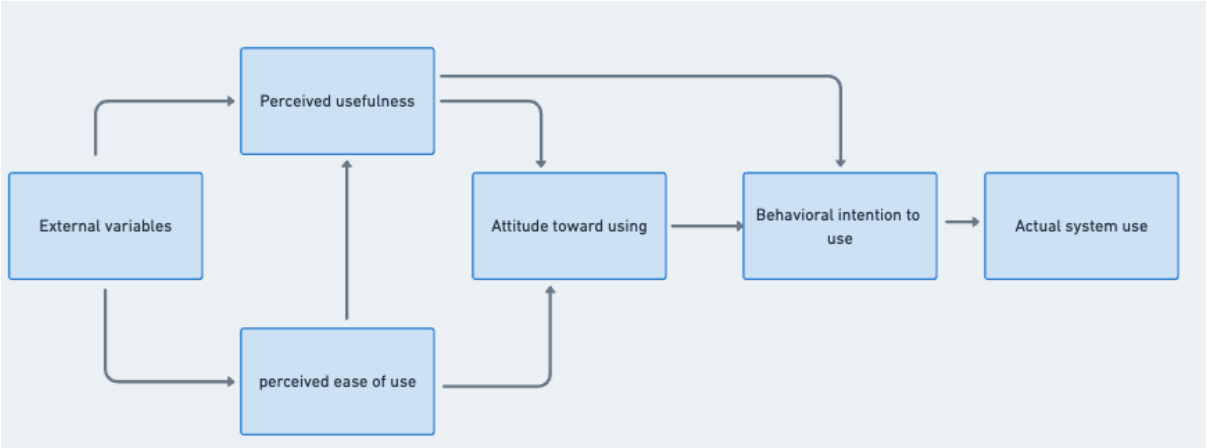

Figure 3. Technology Acceptance Model Theory

The study is anchored on the Technology Acceptance Model Theory[6]. This theory models how users accept and use a certain technology. According to this theory developed by Fred Davis when users are presented with a new technology, the notable factors that will affect their decision are the following. First, Perceived Usefulness which is defined by Davis as “the degree to which a person believes that using a particular system would enhance their job performance”. Lastly, Perceived ease-of-use which is defined by Davis as “the degree to which a person believes that using a particular system would be free from effort”.

The prototype developed was able to prove to be a more efficient alternative to the current verification processes and additionally, it was easy to use for regular users.

The proponent adhered to the User Experience design principles such as design simplicity, accessibility and user centric design.

Rationale for the Framework

The education sector being the pillar of innovation in any country should be the first to adopt new technologies and leverage it. However, due to several factors like bureaucracy and outdated processes, the education sector in the country has been usually late to adopt useful technologies especially in the areas of information technology. The rationale for this project is to prove that adopting a new emerging technology like blockchain can be beneficial in the academic sector. The use of blockchain to counter fraud in terms of diploma verification can be easily adopted using principles like perceived usefulness and perceived ease-of-use.

Technologies Used

The proponent used blockchain technology specifically ethereum smart contracts for the verification process. The use of smart contracts ensured that the system is tamperproof and publicly available. For the frontend of the decentralized application the proponent developed the web application using the Reactjs framework. This framework is a modern javascript framework. For storing the assets the proponent integrated a third party cloud provider called digital ocean spaces. The backend server was built using NestJS framework, the database of choice is MongoDB for better flexibility of the records because of its schema-less feature and was hosted in a digital ocean cloud service. For the minted diplomas to be available publicly, the proponent will be integrating to Opensea.io and other popular third party marketplaces. Lastly, our frontend was hosted in vercel.com for faster deployment and built in continuous integration.

Chapter IV

CHARTER PLAN

Concepts

a. Roles

The platform will have two user types namely, the admin and guests. The Admin will have access to all functionalities including, viewing and managing the list of alumni and minting the diploma in the blockchain. The guest user can view public profiles of any graduates that are available in the system.

b. System Design

The platform is separated into three parts. The first part is the Smart Contract hosted in the ethereum testnet. Second is the web app which was built using the reactjs framework and hosted in vercel. The third is the backend server hosting the REST APIs allowing the frontend to update records before minting it to the blockchain. This backend server is hosted in Digital Ocean cloud service.

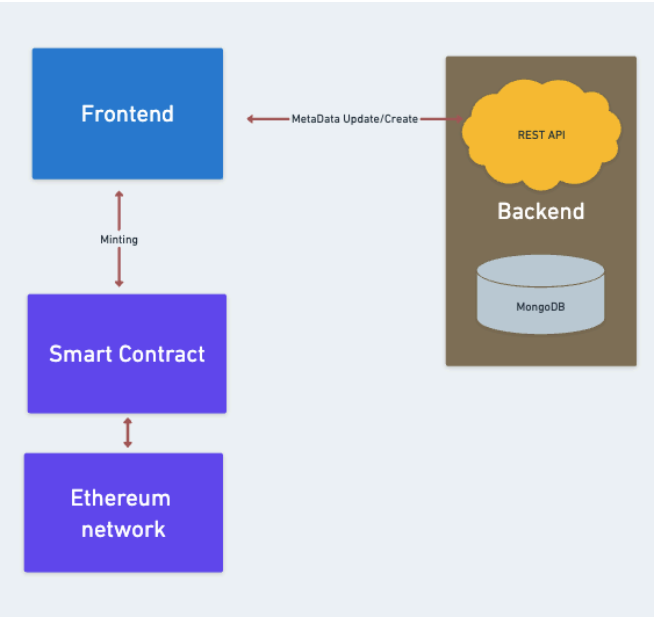

Figure 4. Blockchain-based Diploma Verification System Architecture

c. System Features

a. Frontend Site

i. Administrator

1. Authentication via crypto wallet
2. Student list viewer
3. Student search
    a. Search by name
    b. Filter by course
    c. Filter by graduation year
4. Assets Uploader
    a. Upload diploma image
    b. Upload student image
    c. Upload student details
        i. First Name
        ii. Middle Name
        iii. Surname
        iv. Date of Graduation
        v. Course

ii. Guest

1. Student list viewer
2. Student search
    a. Search by name
    b. Filter by course
    c. Filter by graduation year

b. Smart Contract[8]

i. Read functions

1. balanceOf: This function takes an Ethereum address as input and returns the number of tokens owned by that address.
2. getApproved: This function takes a token ID as input and returns the address of the account that has been approved to transfer the token.
3. isApprovedForAll: This function takes two Ethereum addresses as input and returns a Boolean indicating whether the first address has approved the second address to manage all of its tokens.
4. name: This function returns the name of the token as a string.
5. owner: This function returns the address of the contract owner.
6. ownerOf: This function takes a token ID as input and returns the address of the account that currently owns the token.
7. supportsInterface: This function takes an interface ID as input and returns a Boolean indicating whether the contract implements the given interface.
8. symbol: This function returns the symbol of the token as a string.

9. tokenURI: This function takes a token ID as input and returns the URI (Uniform Resource Identifier) for the metadata associated with the token.

ii. Write functions

1. approve: This function approves a designated address to transfer the ownership of a given token. The designated address can then call safeTransferFrom or transferFrom to complete the transfer.
2. mint: This function creates a new token and assigns ownership to a specified address. This can only be invoked by the smart contract owner.
3. renounceOwnership: This function renounces the contract ownership. It can only be called by the current owner of the contract.
4. safeTransferFrom: This function takes three arguments: the address of the current token owner, the address of the new token owner, and the token ID to transfer. This function transfers ownership of a token to a new owner, but only if the new owner has implemented the ERC721Receiver interface to ensure that they can receive the token.
5. transferFrom: This function takes three arguments: the address of the current token owner, the address of the new token owner, and the token ID to transfer. This function transfers ownership of a token to a new owner.

6. transferOwnership: transfers ownership of the contract to a new address. It can only be called by the current owner of the contract.

c. REST API

i. Student

1. POST
2. GET
3. PATCH
4. DELETE

ii. Metadata

1. GET

iii. Upload files

iv. Course

1. POST
2. GET
3. PATCH
4. DELETE

d. Database Design

The database used in the prototype is mongoDB which is schema-less. This allowed flexibility and better scalability of the records in the future. The following collection was created for this prototype.

Student	
_id	ObjectId
firstName	String
middleName	String
course	String
yearGraduated	String
diplomaImageUrl	String
studentImageUrl	String
tokenId	String
minted	Boolean
transactionUrl	String
openSeaURL	String
createdAt	Date
updatedAt	Date

Courses	
_id	ObjectId
courseName	String
updatedAt	Date

Figure 5. Database collections

e. Implementation

For this project we will be adopting the Agile Scrum Methodology[7] in terms of project delivery. The whole project will be done in three sprints and each sprint will have the duration of four weeks.

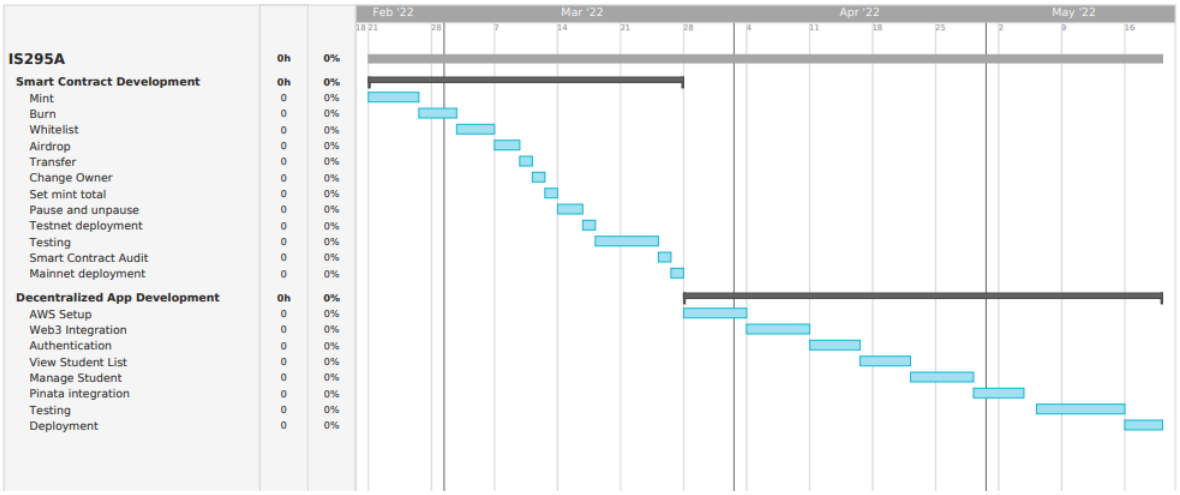

Figure 6. Project development timeline

Methods

Following the Scrum framework, to develop the project the following steps were taken towards developing the prototype:

1. Product Backlog Creation - In this step, the functional requirements are converted to epics and user stories.
2. Sprint planning and Sprint Backlog Creation - In this step, the proponent prioritized the user stories from the product backlog and moved them to the sprint backlog. Also, story points were added for every user story to determine the complexity.
3. Sprint and Development - This is the actual development process wherein the user stories that are part of the sprint backlog were worked on and moved to in progress status.
4. Testing and deployment - This is the step where the initial version of the app is deployed and submitted for testing. For every sprint a deployment was done iteratively updating the platform with new features. Process one to four were repeated for three sprints until the final version of the platform was ready for the demonstration and usability testing.
5. Final Demonstration and Usability testing - The last phase where the platform was demonstrated to 10 interested individuals and usability testing was done for the volunteer users.

User Testing and Project Assessment

To assess project success, the proponent conducted a customer satisfaction survey to a minimum of ten (10) volunteers. The questions focused on the usability of the prototype and its efficiency on verifying academic records, specifically the diploma.

During the Usability Testing the participants completed specific tasks in the platform to determine the ease-of-use of the prototype, usefulness, speed and security.

A. User Testing

The system was tested using the following testing methods and practices:

1. Unit testing / Test Driven development

   Unit tests are written in the backend code to cover for vulnerabilities since the majority of the transactions are done in the backend.

2. Functional testing

   The system was tested per functionality to ensure the features are working as intended. This involves manually checking the design, user experience and the platform's overall functionality.

3. Integration Testing

   The system integration testing was conducted to ensure the interaction between the different components of the platform. The purpose of this is to identify any issues that might arise when the components interact with each other.

4. Regression testing

   When the system was fully completed a regression testing was conducted to make sure that there were no regression issues or issues that

were introduced during the software modification process. This ensures the whole system's integrity when updates are made.

5. Usability Testing

To assess project success, the proponent conducted a customer satisfaction survey to a minimum of ten (10) volunteers. The questions focused on the usability of the prototype and its efficiency on verifying academic records, specifically the diploma.

During the Usability Testing the participants completed specific tasks in the platform to determine the ease-of-use of the prototype, usefulness, speed and security.

Table 1. Usability testing and Customer satisfaction survey results

Respondent	**Ease of use**	**Usefulness**	**Performance & Speed**	**Security**
Respondent 1	10	10	10	10
Respondent 2	9	9	9	9
Respondent 3	9	9	9	9
Respondent 4	8	8	8	9
Respondent 5	10	10	10	10
Respondent 6	10	10	10	8
Respondent 7	10	10	10	10
Respondent 8	9	9	9	8
Respondent 9	10	10	9	10
Respondent 10	9	9	9	7
Mean Score	**9.4**	**9.4**	**9.3**	**9.0**

The prototype blockchain-based diploma verification system received mostly positive responses from the volunteer respondents. The survey was conducted with 10 participants, ages ranging from 20 years old to 50 years old. The survey involved asking the participants to rate the system on a scale of 1 to 10, where 10 is the highest and 1 is the lowest, for different categories such as ease of use, usefulness, performance and speed, and security.

In the area of ease of use or usability, the prototype scored an average of 9.4 out of 10, indicating that the system was user-friendly. For perceived usefulness, the participants gave the system an average of 9.4, validating that the prototype is useful enough for validating diplomas. Speed and performance also received an outstanding score of 9.4, indicating how fast and well built the system is. Lastly, in the area of security, the system scored an average of 9.0 based on the fact that the authentication was strict, especially for the administrator role.

Overall, the survey's findings show that the blockchain-based system for verifying diplomas is a useful tool. With future feature additions, it might be even more advantageous for students and educational institutions.

B. Security Testing

The system primarily authenticates using a web3 wallet like metamask. All administrator functions rely solely on checking if the current user is also the smart contract owner. This assures a high level of security.

Security testing was also conducted using OWASP ZAP and showed a total of 10 risk:

Table 2. OWASP ZAP Scanning Reports and Solution

Alert type	Risk	Solution
Cloud Metadata Potentially Exposed	High	Ensure that the cloud infrastructure is properly configured to restrict access to metadata.
Content Security Policy Header Not Set	Medium	Implement a Content Security Policy (CSP) header to restrict the types of content that can be loaded on the website.
Cross Domain Misconfiguration	Medium	Implement appropriate cross-origin resource sharing (CORS) settings.
Missing Anti-clickjacking header	Medium	Add an anti-clickjacking header, such as X-Frame-Options, to prevent clickjacking attacks.
Timestamp Disclosure-Unix	Low	Avoid displaying or leaking UNIX timestamps in error messages or responses.
X-Content-Type-Options Header missing	Low	Set the X-Content-Type-Options header to "nosniff" to prevent browsers from MIME-sniffing the response content type.
Information Disclosure - Suspicious comments	Informational	Review the website's source code and remove any suspicious comments that may provide sensitive information.
Modern Web Application	Informational	Regularly update and patch the website's underlying technologies, frameworks, and libraries to mitigate known vulnerabilities.
Re-examine Cache-control Directives	Informational	Determine appropriate caching policies for different types of resources.
Retrieved from cache	Informational	Configure the cache-control headers to prevent caching of sensitive data.

Chapter V

RESULTS AND DISCUSSION

As the proponent who built the system prototype, I learned a lot regarding several areas of development. I learned about the different possible applications of blockchain technology.

I gained more insights about the educational system and the different areas where we can apply existing technologies to improve it further. I also gained a deeper understanding of the integration between traditional cloud servers and blockchain networks.

One of the main challenges I encountered was testing. Being of a software development background, it was always a challenge to test your own work because of certain biases. It's easy to miss issues, especially in the functional area, when you are both the developer and the tester. However, I was able to overcome this challenge by properly writing test cases and documenting edge cases.

Overall, building the prototype requires technical expertise in all areas of the software development lifecycle. It also requires an understanding of how educational institutions operate and the main pain points of implementing the system in an actual functioning organization.

Through this project, I was able to gain valuable insights into how we can leverage blockchain technology to transform our educational institutions, specifically in the area of credential verification.

Chapter VI

CONCLUSIONS

In conclusion, the development of the diploma verification system prototype has demonstrated high potential for combating diploma-specific document fraud. By using blockchain technology in the development of the prototype, the proponent was able to secure the system and at the same time made the documents publicly available. Additionally, because the system has a user-friendly interface making it easy for users to navigate and verify the document easily, it was able to validate its usefulness and efficiency in validating the diplomas.

The proponent believes that the development of the system can improve the integrity of educational systems by safeguarding academic qualifications.

Chapter VII

RECOMMENDATIONS

The current prototype of the system is enough to perform the needed requirements for a basic diploma verification system. However, there are still a lot of significant improvements needed based on the feedback of the respondents of the survey and from the proponent's observation:

1. Probability of adding more fields in the student view.
2. Additional customization of the platform.
3. Tooltips and help section to improve user experience.
4. Adding support for additional academic documents such as Transcript of records or TOR.
5. Adding the feature of verified students to own their diploma NFT.

Additionally, there might be additional work needed for the viability of the system as a business of service. The proponent identified a viable business value in the system by making it a Software as a Service type of platform. However, this needs further market research and validation.

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Website

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APPENDICES

A. Complete Program Listing

1. Frontend Website - https://diploma.bosshenry.com/
2. Frontend Code - LINK
3. Backend Code - LINK

B. Technical Reference

1. Smart Contract - https://goerli.etherscan.io/address/0x6d1166d9cefaa6ba7cc6d05d1039ada337b2cc87#code
2. REST API Documentation - https://api.bosshenry.com/swagger

C. User Manual

1. Blockchain-based Diploma Verification System V1.0 User Manual