

MASTER OF INFORMATION AND COMMUNICATION STUDIES
Capstone Project



**UNIVERSITY OF THE PHILIPPINES
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MASTER OF INFORMATION AND COMMUNICATION STUDIES

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**THE USE OF NFTS AS MEMBERSHIP IDS FOR PROFESSIONAL
ORGANIZATIONS**

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14 May 2023

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THE USE OF NFTS AS MEMBERSHIP IDS FOR PROFESSIONAL ORGANIZATIONS

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This paper prepared by **RAYMOND R. HALIM** with the title: “**THE USE OF NFTS AS MEMBERSHIP IDS FOR PROFESSIONAL ORGANIZATIONS**” is hereby accepted by the Faculty of Information and Communication Studies, U.P. Open University, in partial fulfillment of the requirements for the degree Course.

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Biographical Sketch

Raymond Halim, hailing from Cavite, embarked on a versatile career journey encompassing electronics engineering and programming. He obtained his Bachelor's degree in Electronics and Communications Engineering from San Sebastian College Recoletos de Cavite in 2003 and graduated with honors as Cum Laude. He is also an active member of the Institute of Electronics Engineers of the Philippines.

Transitioning into the programming field, he evolved into a seasoned software engineer, amassing over 19 years of experience. His core strengths lie in meticulous attention to detail and a results-oriented approach, prominently displayed through his proficiency in various programming languages and technologies.

In 2007, driven by a deep commitment to his family's welfare, he pursued work opportunities in Singapore, expanding his professional horizons and international experience.

Raymond Halim's career is a testament to his unwavering commitment to excellence, seen in his academic achievements and thriving role as a software engineer.

Acknowledgement

I would like to express my sincere gratitude to Prof. Lorena Ilagan and Prof. Mariciel Teogangco who believed in me and through their recommendations, I was able to start my MIS journey.

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For the love, care and support coming from my mother and brother, thank you. To Nanay, who always believed in me and is my driving force to keep on going, thank you and I will forever miss you. Lastly, I give thanks to the Lord, our Almighty God for the knowledge, intelligence, and good health to complete this paper.

Dedication

This paper is dedicated to my mother, brother,
and especially to our Nanay in heaven.

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Abstract

Rationale: Traditional membership registration and renewals are prone to inefficiency and delay caused by the approval process and issuance of physical ID cards. The aim of this project is to digitize membership IDs of members of a professional organization into non-fungible tokens or NFTs to be stored on the blockchain. Certificates can also be issued as NFTs and, together with digital IDs, can be verified as authentic.

Problem: Both registration and renewals usually require members to fill up the same form and wait for the card to be distributed. This process is time-consuming, expensive, unsustainable, and is susceptible to replication or tampering.

Methodology: The project used the Hyperledger Fabric, an open source private and permissioned blockchain system. The strategy was to use the same programming language (JavaScript) for the client app, the backend api and the smart contract. It also explored the use of InterPlanetary File System or IPFS for the storage of NFT images while only their corresponding content identifiers or CIDs will be stored on the blockchain.

Results: Membership IDs and certificates stored as NFTs makes them tamper-proof, enhances their provenance, and are always available for verification. These NFTs are unique and do not have to contain personal identifiable information as compared to those displayed in their physical counterparts.

Application/Implication: This project opens up the possibility of having these NFT IDs issued as verifiable credentials in a self-sovereign identity system. Other related

professional organizations can join as members of the existing blockchain channel consequently contributing as peer nodes.

Chapter I

INTRODUCTION

Membership registration and renewal is a lengthy and expensive process [1]. After a member fills up the form, which is usually the same form used for renewal, submit the completed form together with the required documents and pay the required fees, the application goes through the approval process, and printing, assembling or outsourcing, and issuance of membership cards, which could take weeks and require production, postage and labor costs [1]. For many institutions, the process takes three to six weeks and can take longer due to staff shortages and postal delays leading to backlogs [2]. For instance, the *Philippine Institute of Civil Engineers* requires its members to provide a copy of their PRC ID and a 2x2 photo and email them to the organization together with the completed membership form [3]. In the case of the *Institute of Electronics Engineers of the Philippines*, it has a membership system where members can update their profile and pay for the membership fee [4]. Likewise, the *Institute of Integrated Electrical Engineers of the Philippines* has their IIEE Portal where members can renew following certain steps [5]. However, as shown in Fig. 1, some chapters like the *IECEP Singapore Chapter* require its members to upload a completed form after which the chapter facilitates the collection of membership cards from the national chapter in the Philippines and distribute them to its chapter members abroad [6]. The membership cards are available within 120 days for foreign chapters while it is 60 business days for local chapters [7]. In the Philippines, the cost of printing PVC ID cards can range from Php40 to Php120 per card [8].

Physical cards are tangible items that are made of raw materials such as paper and plastic [9]. They continue to be a source of waste as about six billion plastic

cards mostly made of unrecyclable PVC plastic are thrown away each year [10]. It is exacerbated by the fact that rebranding or redesigning the cards requires reprinting them [2]. ID cards can also be lost, damaged, forgotten or even stolen. Improving their visual security using holographic overlamine, UV ink, or microtext [11] also adds up to their production cost. Most membership cards expose the member's name, membership type, membership number, and chapter to name a few [13]. Others even include the member's address. These personal identifiable information or PII can be compromised if the card is stolen, tampered, or duplicated.



Fig. 1. IECEP-SG Membership Renewal Process

Some organizations have chapters that are located in multiple areas and even around the globe. With the onset of the pandemic, not only were people's movement

restricted but delivery of items such as ID cards was delayed. This prompted many membership organizations to move from physical membership cards to digital ones [12]. Receiving digital ID cards the same day if needed provides instant gratification to members [2]. And as we gear up for sustainability, digital cards help reduce waste associated with plastic cards and the costs of manufacturing and distributing them [2]. With digital IDs, members can never lose, damage or forget their membership cards [2].

The objective of this project is to do away with physical ID cards and streamline the renewal process by having these IDs digitized as non-fungible tokens or NFTs stored in the blockchain and letting the system auto-renew the membership. Aside from digital IDs, members can receive their certificates, also in the form of NFTs, fast wherever they are. The project provides a platform for an organization to issue membership IDs and certificates in the form of NFTs to its registered members. These NFTs are unique and can be creatively designed as standard images that can be viewed with a QR code for verification. The NFT IDs will be auto-renewed based on the points earned from issued certificates. Only members with valid (i.e. not expired) NFT IDs can view their IDs and certificates in the platform. Members with expiring NFT IDs and do not have enough points for auto-renewal will be notified via email to motivate them to actively participate so their membership will be renewed in a timely manner and increase the organization's membership renewals. As points are tied to their NFT IDs, there is no need for issuance of a certificate of good standing (CoGS) or any proof of a member's good standing.

The incorruptible, immutable, secure and decentralized nature of blockchain makes membership IDs and certificates stored as NFTs concrete and tamper-proof,

enhances their provenance, and makes them always available for verification without exposing personal information to a third party.

This project is a web application for a single organization. The means of acquiring certificates, payment of membership fee and mobile app version are out of scope.

Chapter II

REVIEW OF EXISTING ALTERNATIVES

While some organizations still go through the manual process of downloading and filling up a form and exchanging emails, others have their own membership system where members can update their profile and apply for renewal. Regular members who have a good standing with the organization for a certain number of years can apply for life membership [3]. While this option frees a member from regularly renewing his membership, the amount is usually significantly higher than the renewal fee and requires endorsement and approval by the organization's board members. In the attempt to increase renewals, some organizations offer an amnesty program to waive back dues incurred as a result of late renewals [7], [14].

Cuseum is a software platform used to streamline the membership process and generate digital membership cards for associations and societies via the mobile wallet [1]. It is a paid web application that allows digital cards to be delivered instantly and automatically via email or SMS [1]. It provides members with a unified platform to manage their information and access them at the back of the card in their mobile wallet [1]. It allows associations to deploy renewal notifications, send on-demand messages, and customize and personalize cards depending on membership levels [1].

ID123 is another paid identity solution which includes a cloud-based ID management system and ID card mobile app [15]. Using the ID management system, card administrators can customize the design of the digital ID card [15]. It allows import of cardholder data via CSV and provides In-App photo submission and moderation [15]. Digital IDs containing a scannable barcode can be issued via email with the link to download the app and install the mobile ID card [15].

Cuseum and *ID123* both offer digital solutions for membership IDs but the associations and its members are tied to their platform. This means that even if the user data is encrypted and securely stored in the cloud, users need to trust and rely on the platform. While it is convenient to update information and instantly reflect it on the card, whether the changes are audited or not, the process is tantamount to tampering the ID which the project aims to prevent. For *ID123*, renewal is managed which the project aims to automate. There is also a problem of security, in the case of *Cuseum*, should the smartphone be lost or stolen.

Chapter III

PROJECT DETAILS

A. Overview

Fig. 2 shows the high-level architecture of the system and is described as follows: (1) users interact with the system via a single-page application written in React; (2) UI sends requests together with JWT token to backend API running on Node.js; (3) images will be stored in IPFS; (4) IPFS sends back the CIDs of the images; (5) NFTs with CID as metadata are stored to and retrieved from Hyperledger Fabric; (6) PII is stored to and retrieved from MongoDB Atlas; and (7) notifications are sent through the Mailjet service.

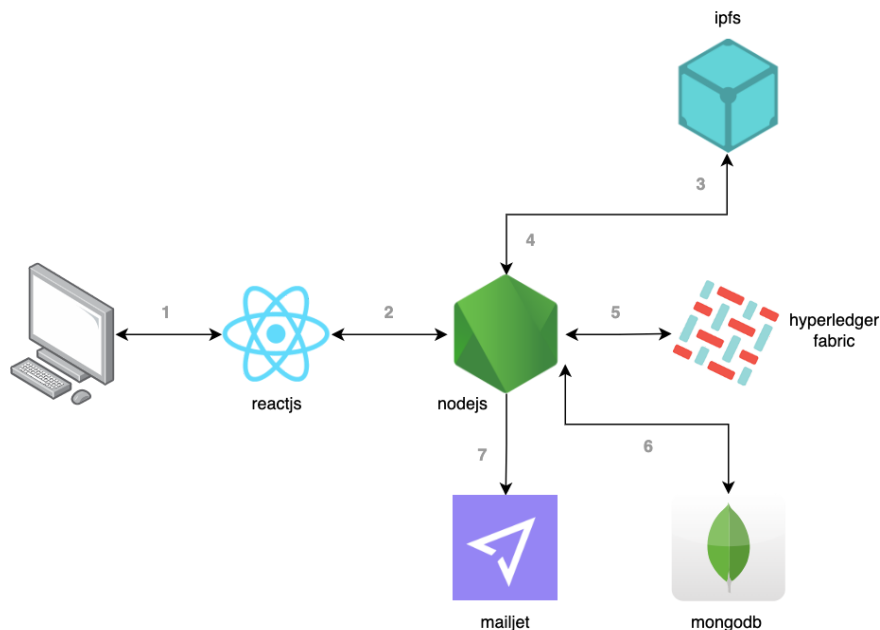


Fig. 2. System high-level architecture

The registration and approval process is described in Fig. 3. When a user registers as a member, the organization administrator receives the request which he can either approve or reject. Once approved, the member will be issued an NFT ID. The user will be notified via email of the request status.

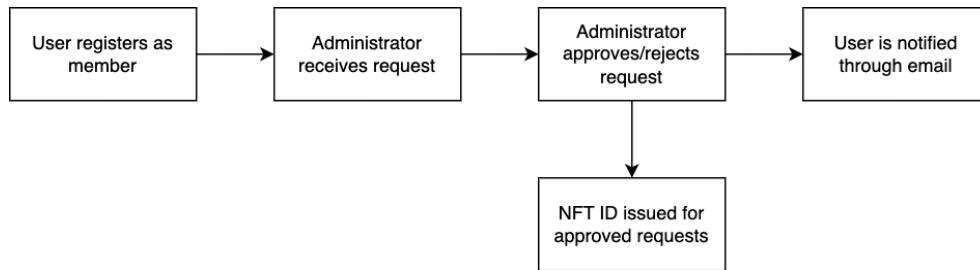


Fig. 3. Registration and approval process model

Fig. 4 shows the process of issuing and verifying NFTs. When the administrator uploads an image, the image is stored in IPFS and given a corresponding CID. When the administrator issues an NFT, an NFT metadata containing the CID will be minted or stored on the blockchain. The authenticity of the NFT can be verified by scanning its QR code.

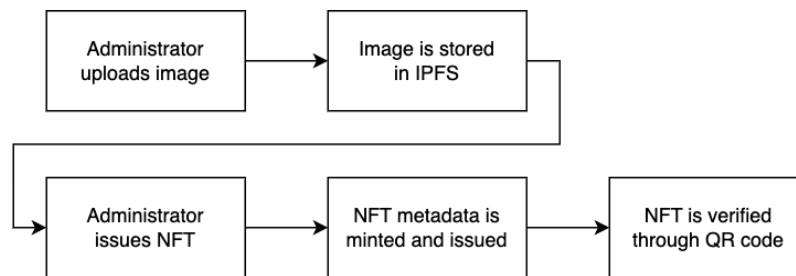


Fig. 4. NFT issuance and verification process model

The system will check for expiring IDs as shown in Fig. 5. If the owner of the ID has accumulated enough points required to renew his ID, the system will auto-renew it. Otherwise, the ID will expire. In both cases, the user will be notified via email.

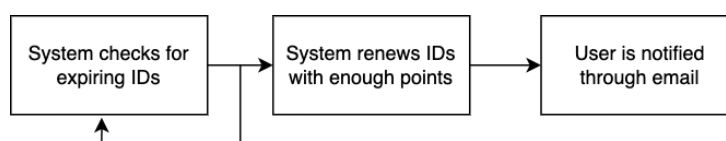


Fig. 5. Auto-renewal and notification process model

Fig. 6 shows the data model of the member object saved in mongodb. The status is pending if the user just registered into the system. Otherwise, it will either be approved or rejected. Fig. 6 also shows the data model of the token generated when a user requests to reset his password. The chapter and membership type data models are shown in Fig. 7. When the administrator creates an NFT, the system will create an item object and store it on the blockchain. This item object will be used when issuing the actual NFT. The content of this item object depends on the purpose of the image, whether it is for an ID or certificate, as shown in Fig. 8. `itemId` is a 36-character unique identifier. Fig. 9 shows the data model of the actual NFT issued to members with the `nftId` as hash of the NFT object.

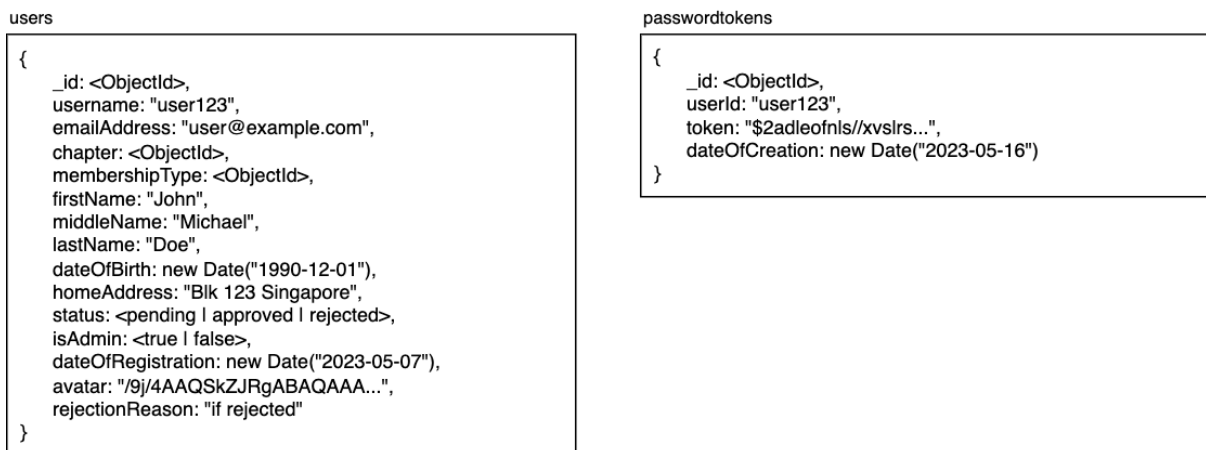


Fig. 6. Member and reset password token data model

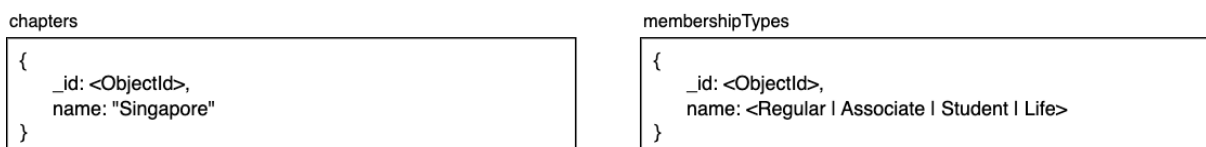


Fig. 7. Chapter and membership type data model

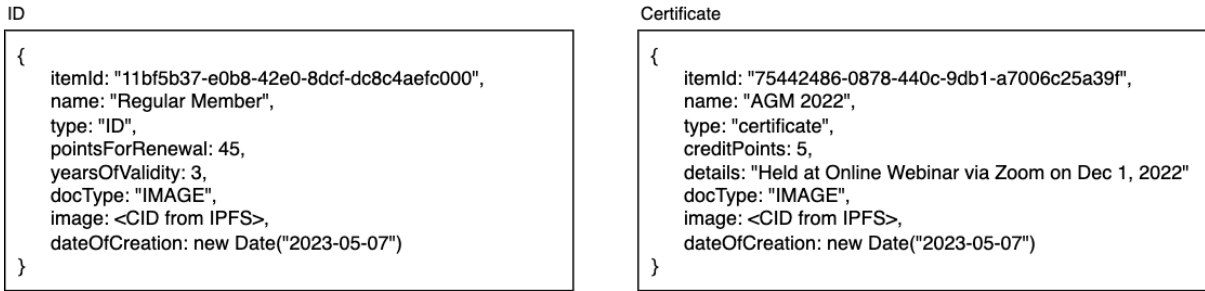


Fig. 8. NFT item data model for IDs and certificates

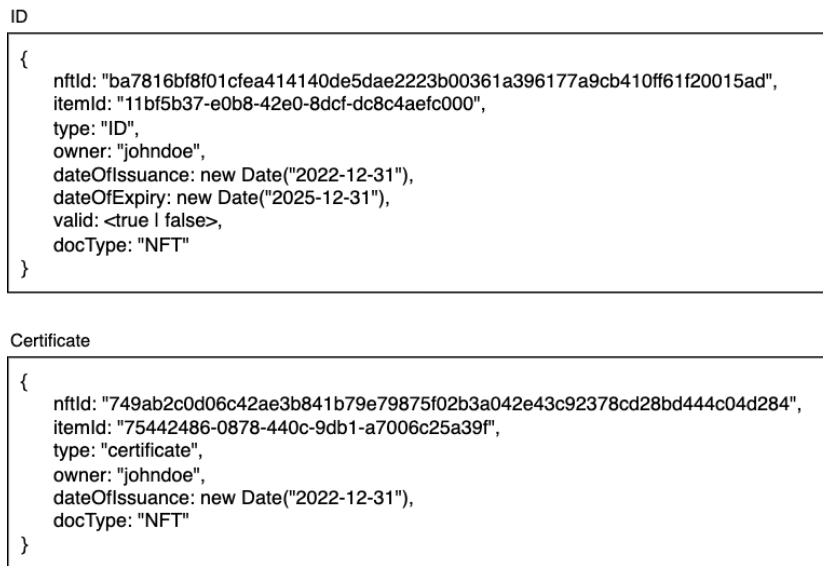


Fig. 9. Actual NFT data model for IDs and certificates

Fig. 10, Fig. 11, and Fig. 12 show the use case diagram for members, admin, and verifier and chaincode respectively.

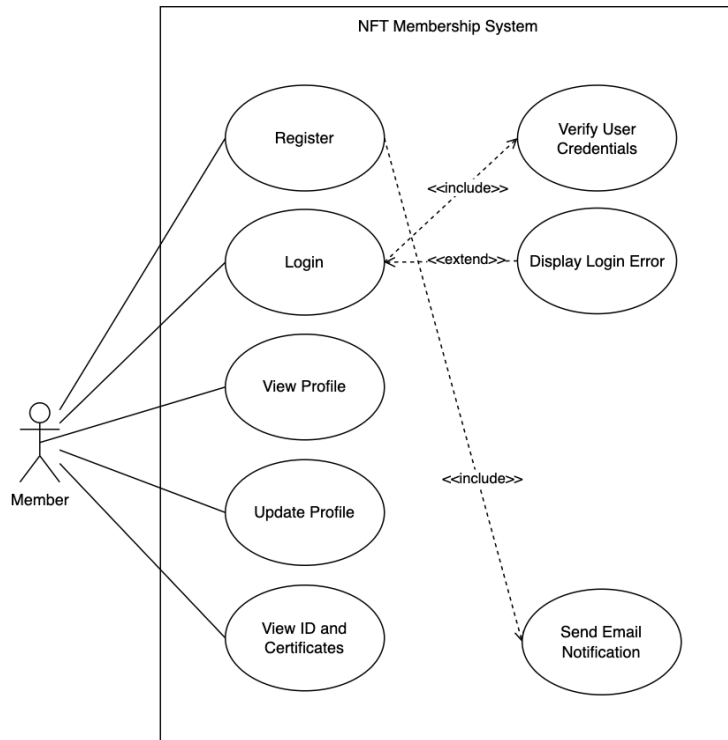


Fig. 10. Use case diagram for members

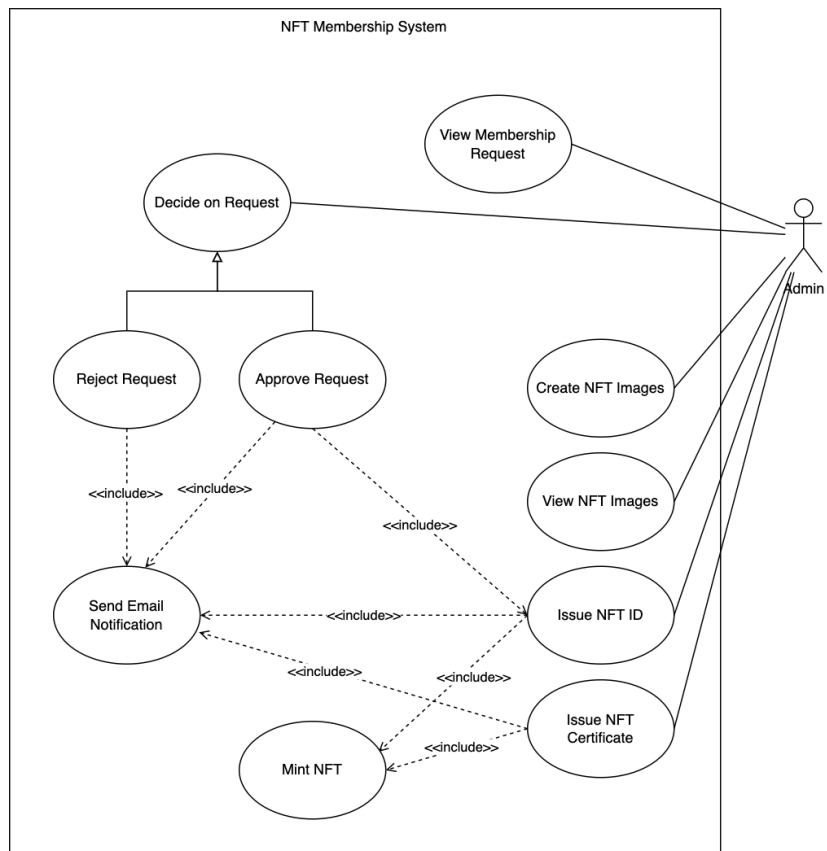


Fig. 11. Use case diagram for admin

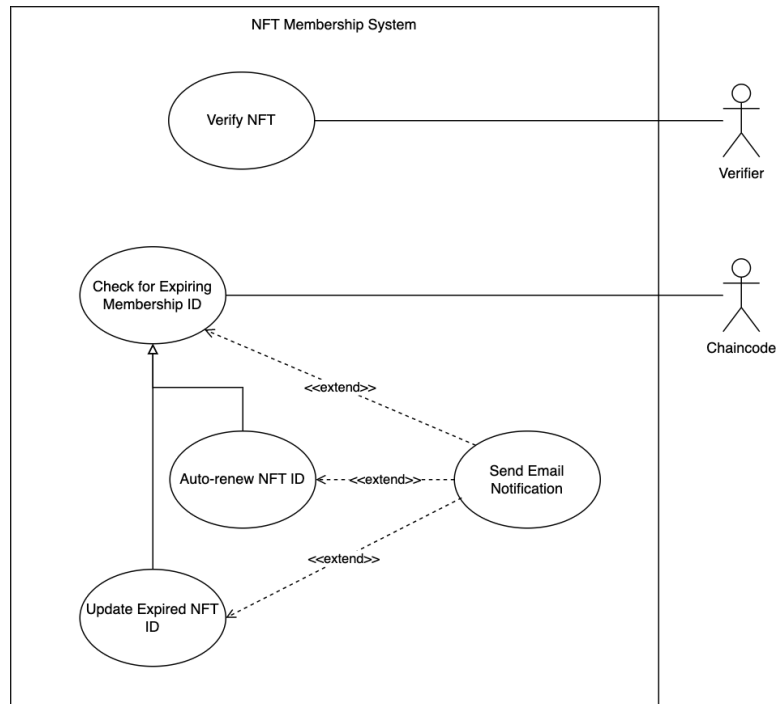


Fig. 12. Use case diagram for verifier and chaincode

B. Theoretical Framework

This project employed the use of three data storage systems - blockchain, IPFS, and a document database.

A blockchain is a digital ledger system stored across a network of computers [16]. It is a decentralized and distributed database that uses smart contracts, which are programs that run automatically after meeting some predetermined conditions [17]. Each transaction is recorded as a block of data cryptographically linked to the blocks before and after it forming an irreversible chain [16]. The blockchain is used to store the members' IDs and certificates as non-fungible tokens or NFTs together with their metadata.

Blockchains offer many benefits such as advanced security, increased efficiency and improved traceability [18]. For better security, a blockchain uses three principles: (1) cryptography - a cryptographic hash links the block of transactions together, (2) decentralization - control is transferred to a distributed network, and (3)

consensus - network members must agree on the validity of the recorded transaction [17]. This helps make our membership IDs and certificates tamper-proof. With the network members sharing a distributed ledger therefore removing time-consuming record reconciliations and a smart contract that self-executes within defined parameters without human assistance, transactions are faster and more efficient [16]. This is perfect for our auto-renewal of membership IDs. With the audit trail of every transaction, the authenticity and provenance of assets can be verified [18].

IPFS or InterPlanetary File System is a distributed system for storing and accessing data [19]. It uses content addressing in which it addresses a file not by where it is located, but by its contents [20]. When the file is added to IPFS, it is split into blocks, cryptographically hashed, and given a unique id called a content identifier or CID [20]. NFT images will be stored in IPFS while only their CIDs will be stored on the blockchain as shown in Fig. 13.

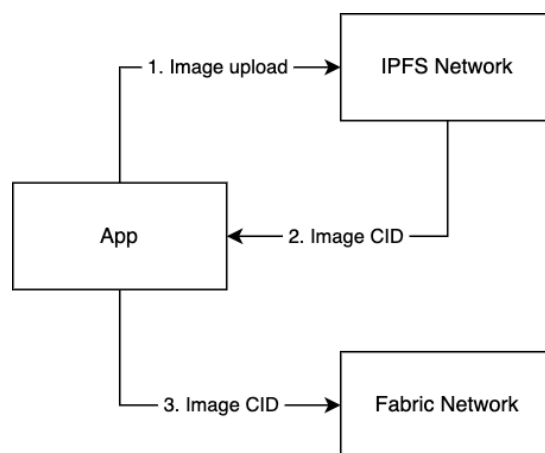


Fig. 13. Image upload to IPFS and CID stored in Fabric

It is not advisable to store large files on the blockchain [21]. Files stored in IPFS are resistant to tampering since every new version of the file has a different cryptographic hash and so a new CID [19]. Also, common chunks of the file are reusable thus minimizing storage costs [19].

A document database is a non-relational database used for storing and retrieving data as JSON-like documents [22]. Instead of storing data in fixed rows and columns, documents in a collection have a flexible schema and need not have the same fields [23]. Personal identifiable information or PII and other application data will be stored as documents.

PIIs should never be stored on the blockchain [24]. The advantage of storing PIIs as well as the application data on a document database are based on three factors: (1) as documents are mapped to objects, there is no need to decompose them across tables and run expensive joins thus providing higher performance, (2) JSON documents are lightweight and readable, and (3) the schema is flexible and self-describing [23].

This project digitizes membership IDs and certificates as non-fungible tokens or NFTs. They are created through a process called minting, which is simply publishing or storing the digital file information on a blockchain [25]. NFTs are unique and cannot be replicated so even if there are two NFTs representing the same image, their on-chain data are different [26]. NFTs represent real-world items and can serve as proof of their authenticity [27]. NFT IDs and certificates do not have to contain PIIs as compared to those displayed in their physical counterparts and ownership can be proven without exposing personal information to a third party [28].

C. Technologies Used

a. Database Layer

- **Hyperledger Fabric** - Hyperledger Fabric is an open source enterprise-grade private and permissioned blockchain [29]. “Permissioned” means that all participants in the network have known identities, therefore enabling privacy and confidentiality of transactions

[30]. Unlike public blockchains that use proof-of-work (PoW), it achieves consensus by relying on an ordering service that ensures the order of transactions submitted to the network eliminating the need for costly mining [29]. It is scalable as it allows peers to be added dynamically and programmatically [30]. The strategy of this project is to use the same programming language (i.e. JavaScript) for the client app, the backend api, and the smart contract. And with Fabric, developers do not need to learn a new language (e.g. Solidity). In Fabric, the ledger consists of two parts: a *world state* (a database that holds the current values of a set of ledger states) and a *blockchain* (a transaction log of all the changes that result in the current world state) [31]. For the world state, CouchDB is used to allow us to store the data in JSON format and issue JSON queries on the data [32].

- **Kubo** - Kubo is a Go-based implementation of IPFS. It provides an IPFS daemon server, an HTTP RPC API for controlling the node, and an HTTP Gateway for serving content to HTTP browsers [33].
- **MongoDB Atlas** - MongoDB Atlas is a cloud-hosted Database-as-a-Service (DBaaS) that allows one to set up, deploy, and scale a MongoDB database without managing servers and network infrastructure [34]. It is scalable, highly available, and offers enterprise-level security features [34].

b. Application Layer

- **Node.js** - Node.js is an asynchronous event-driven Javascript runtime designed for building scalable network applications [35]. It provides

seamless communication using JSON as the main data transfer format [36].

- **Express** - Express is a Node.js web application framework that is easy to use, efficient and provides many features such as routing and the use of middleware for request handling [37].
- **JWT** - JSON web token (JWT) is an open standard that defines a compact way of transmitting information between parties securely as JSON object [38].
- **Mailjet** - Mailjet is a real-time cloud emailing platform that provides improved deliverability of emails and allows users to track and monitor sent emails [39].

c. Client layer

- **React** - React is a declarative, component-based JavaScript library for building interactive UIs [40].
- **Material UI** - Material UI is a component library for React applications that implements Material Design [41].

D. System Design

a. System Features

The key features of the system include the following:

- **Blockchain technology** - NFTs are stored in Hyperledger Fabric, an open source private and permissioned blockchain system. It is immutable, traceable, scalable, and trusted.
- **IPFS technology** - Images are stored in a private IPFS, an open source decentralized file system. It provides content addressing, is immutable and available.

- **Mobile-first interface** - UI is built as a single-page application, therefore it is device-agnostic, responsive and fast.
- **Profile management** - Members can view and update their profiles as well as view their ID and certificates.
- **Member management** - The admin user can view, approve, or reject requests, and create and issue NFTs.
- **NFT issuance and verification** - IDs and certificates are issued as NFTs and can be verified through QR code.
- **Auto-renewal and notification** - System will auto-renew IDs based on points and will send renewal notification via email.

b. Database Design

- **Blockchain** - Fig. 14 is a simplified representation of the blockchain network which consists of two peer nodes and one ordering node. Each peer node has a copy of the chaincode and the ledger. The ledger consists of the blockchain and the world state which uses CouchDB as its database [31].

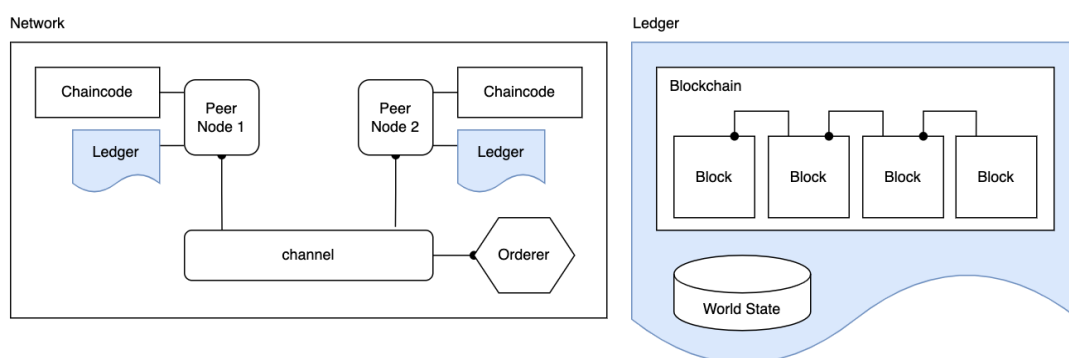


Fig. 14. Fabric network and ledger

- **IPFS** - Fig. 15 shows the private IPFS network consisting of three peer nodes.

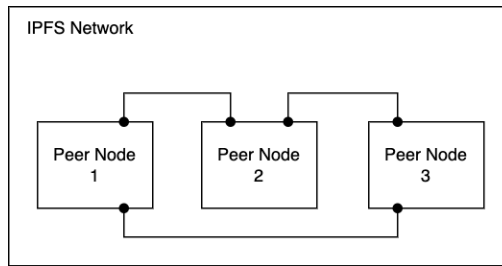


Fig. 15. IPFS private network

- **MongoDB** - To avoid duplication, normalized data models are used to describe the relationship between documents using references as shown in Fig. 16.

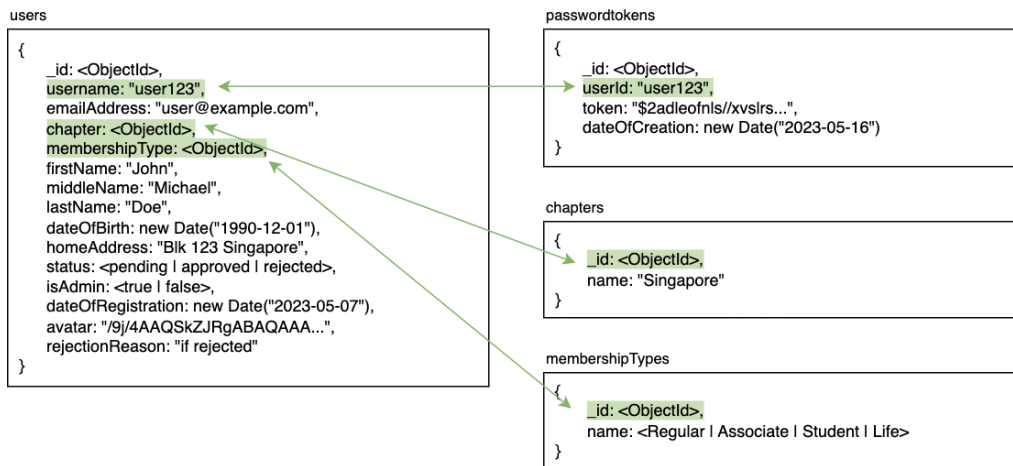


Fig. 16. MongoDB documents relationships

c. Application Screenshots

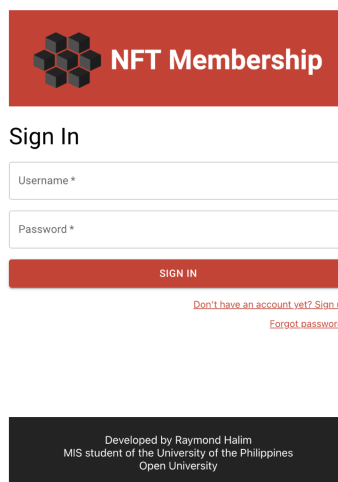


Fig. 17. Login page

NFT Membership

Registration

Username *

Password *

Email Address *

First Name *

Middle Name *

Last Name *

Date of Birth *
07/05/1982

Home Address *

Chapter *
Singapore

Membership Type *
Regular

REGISTER

[Already have an account? Sign in](#)

Developed by Raymond Halim
MIS student of the University of the Philippines
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Fig. 18. Registration page

NFT Membership

Forgot Password

Email Address *

FORGOT PASSWORD

[Don't have an account yet? Sign up](#)

[Sign in](#)

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Fig. 19. Forgot password page

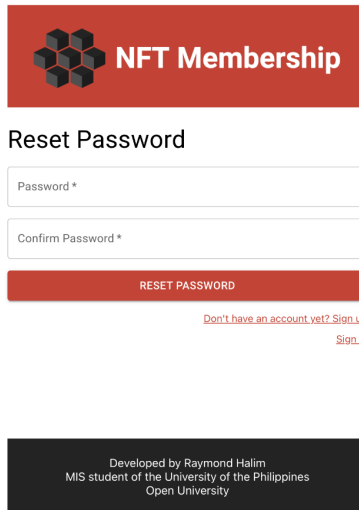


Fig. 20. Reset password page

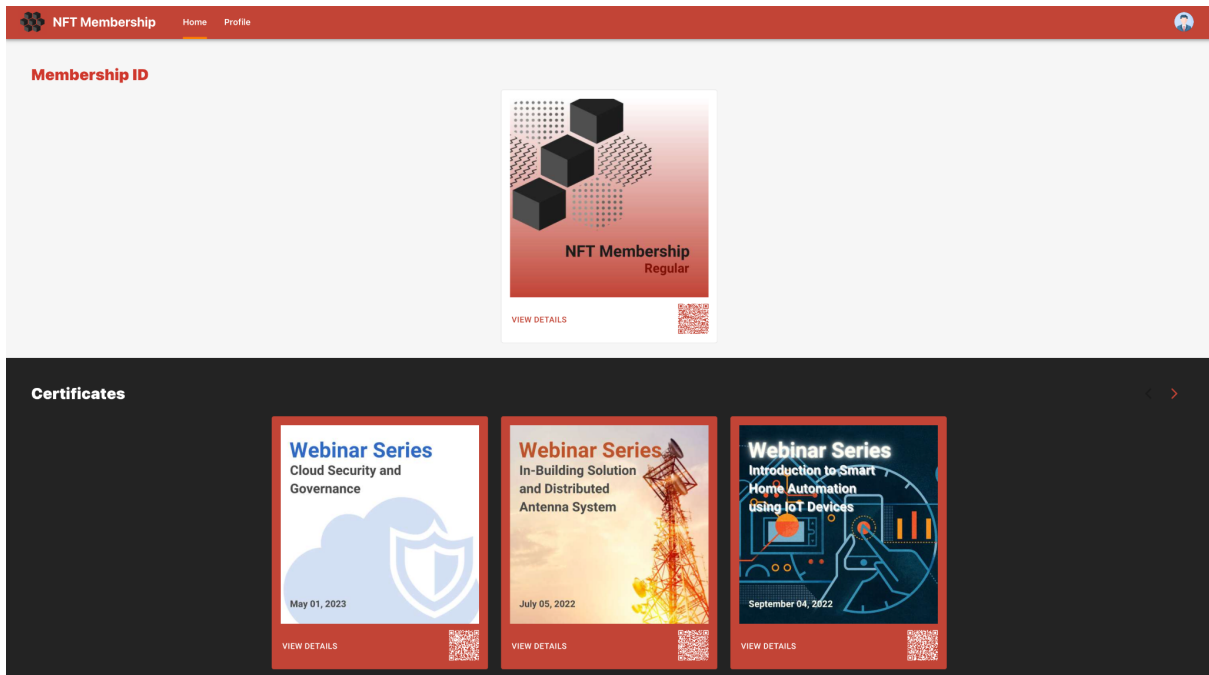


Fig. 21. Home page

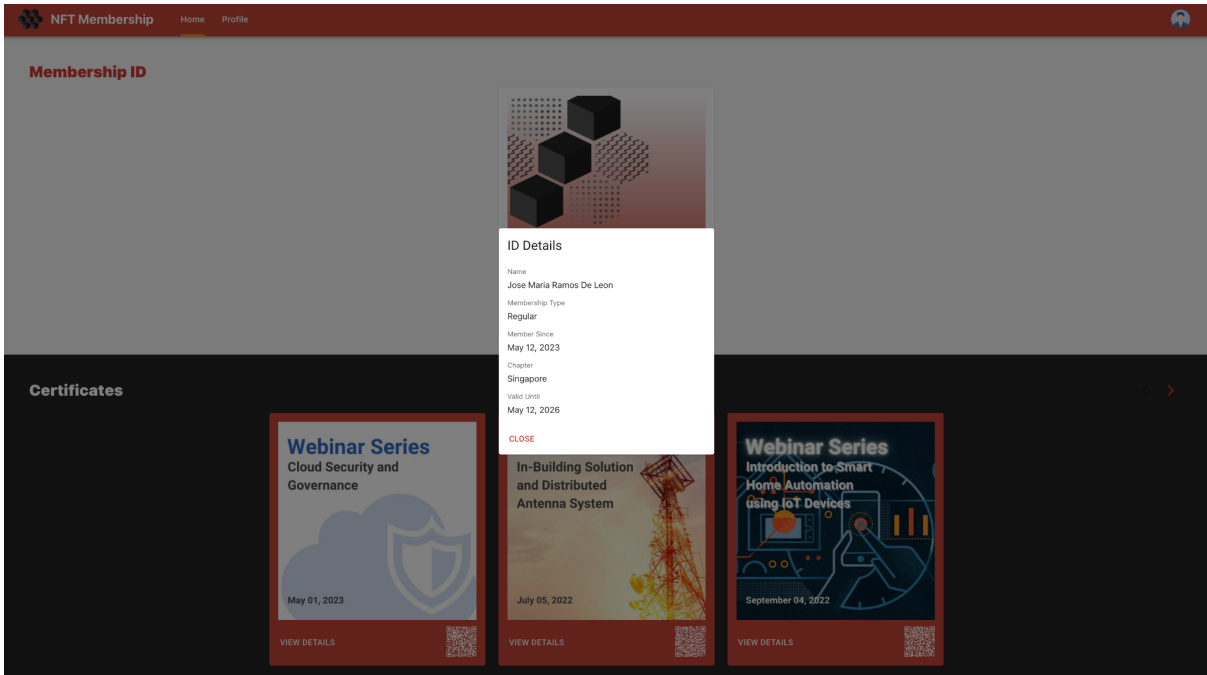


Fig. 22. Membership ID details

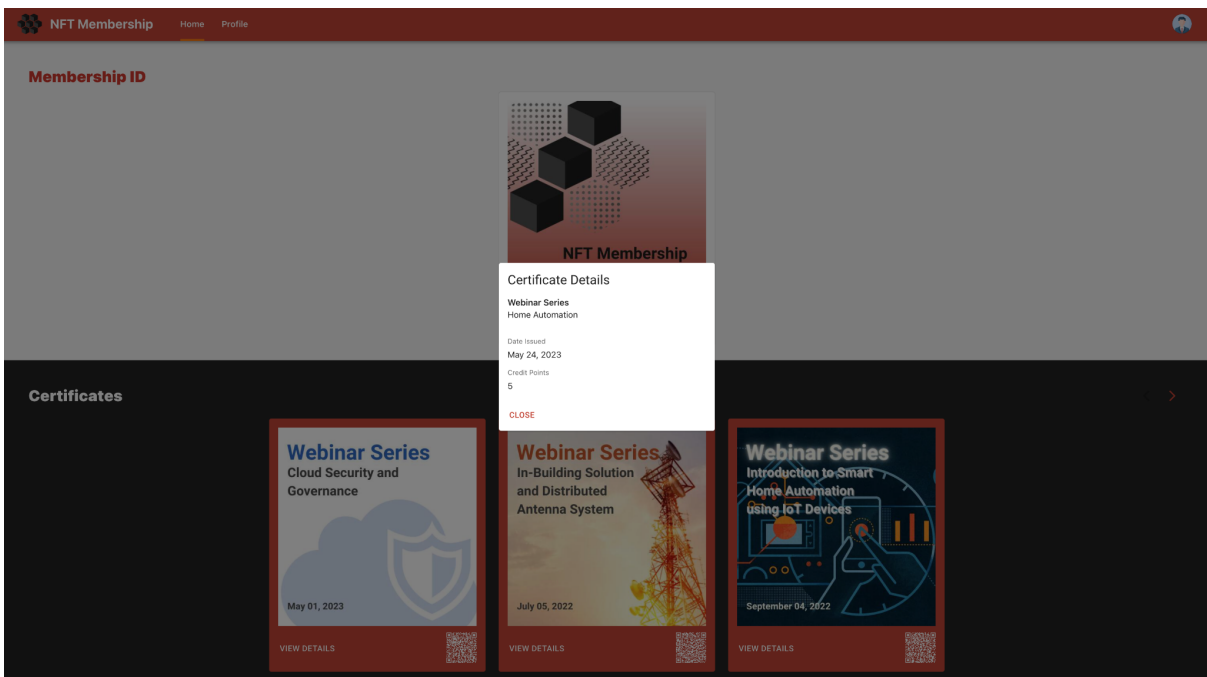


Fig. 23. Certificate details

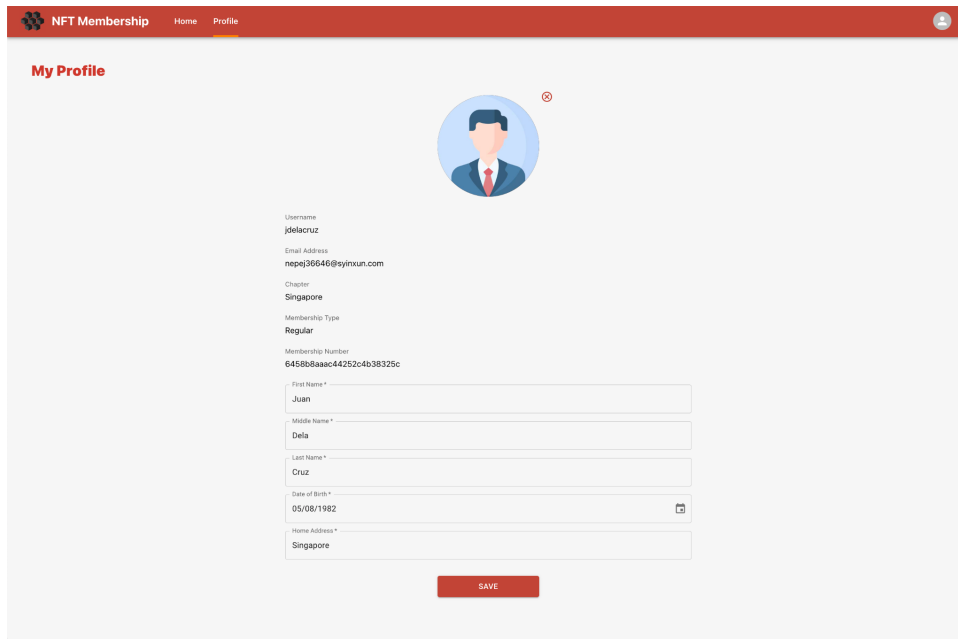


Fig. 24. Profile page

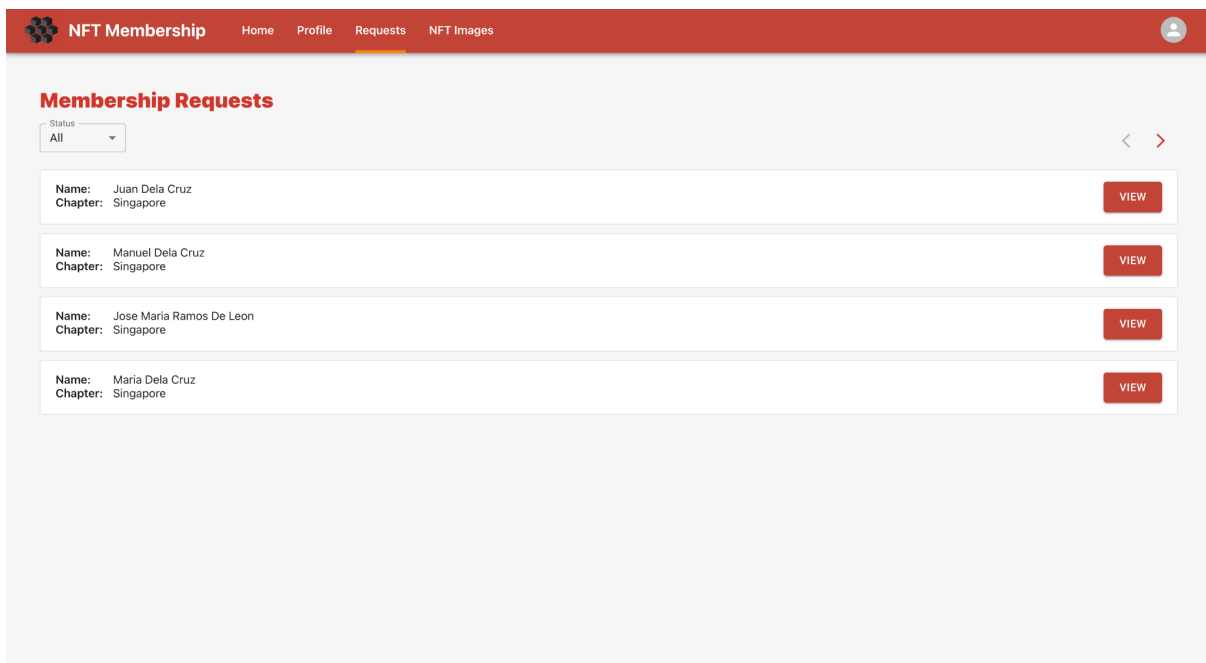


Fig. 25. Requests page

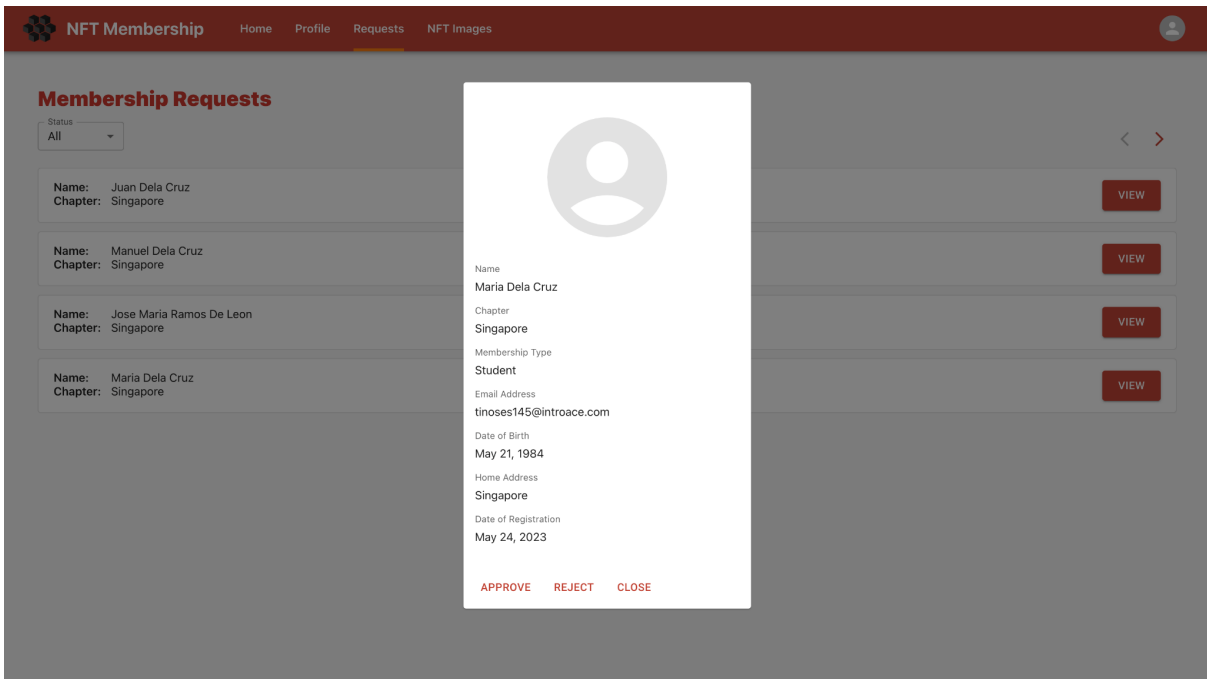


Fig. 26. Request details

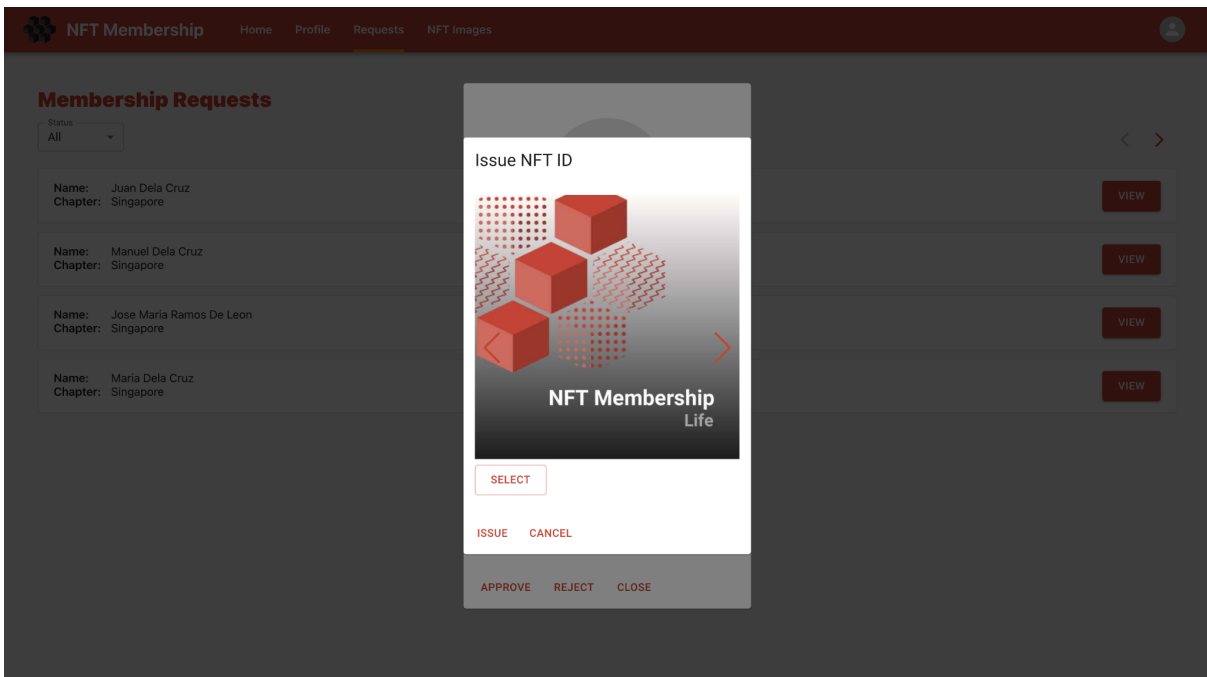


Fig. 27. NFT ID issuance on request approval

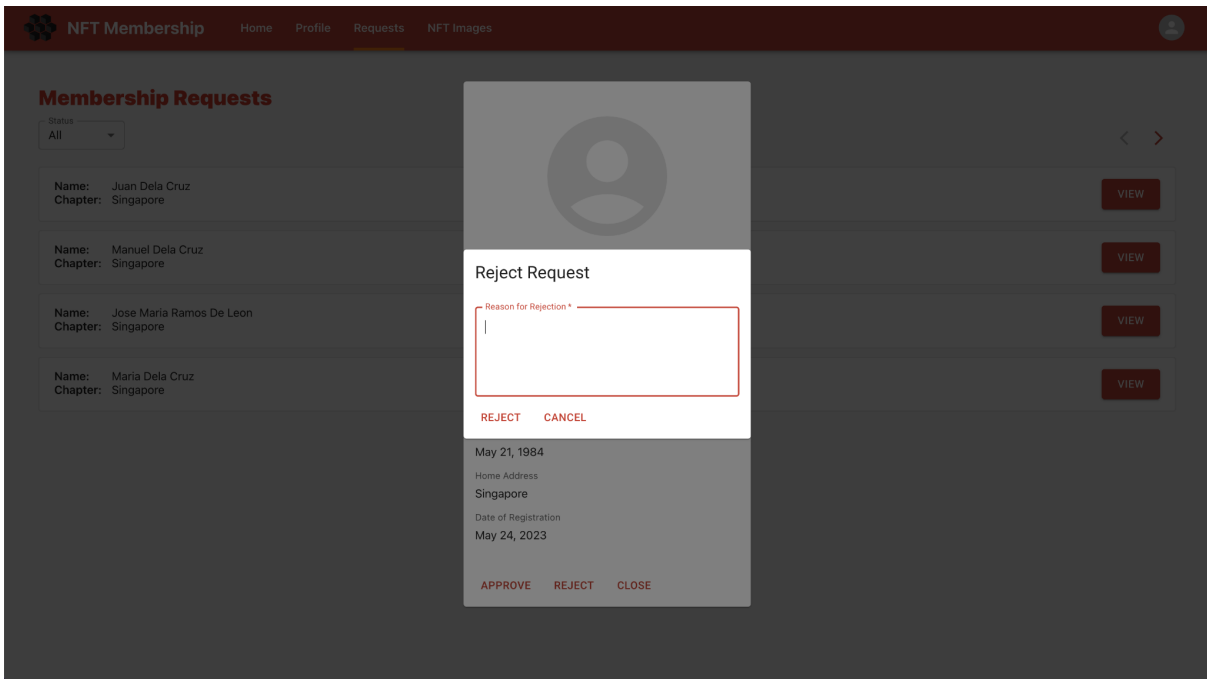


Fig. 28. Request rejection

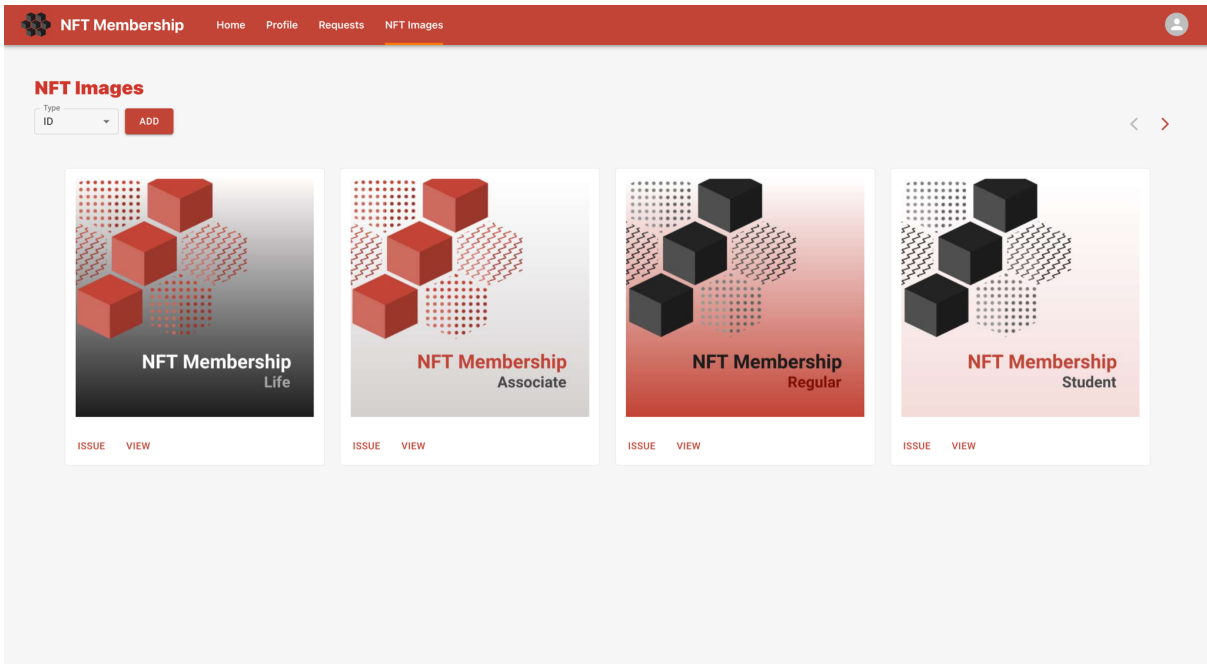


Fig. 29. NFT images page (ID)

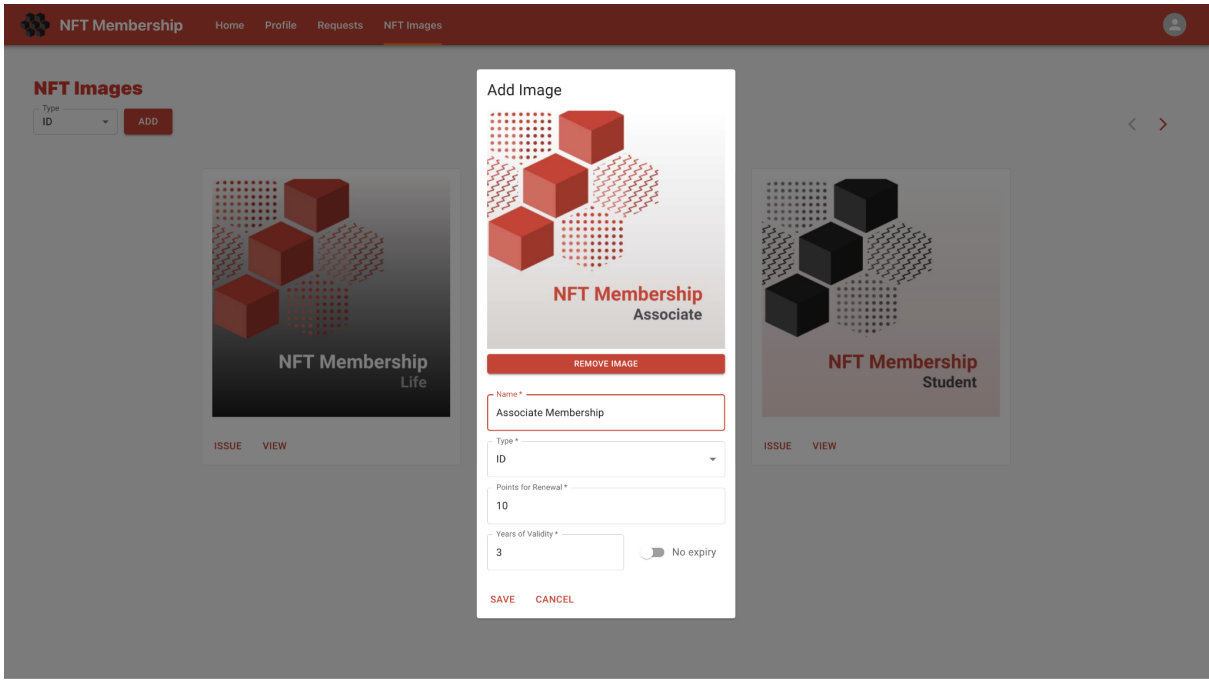


Fig. 30. Add NFT ID image

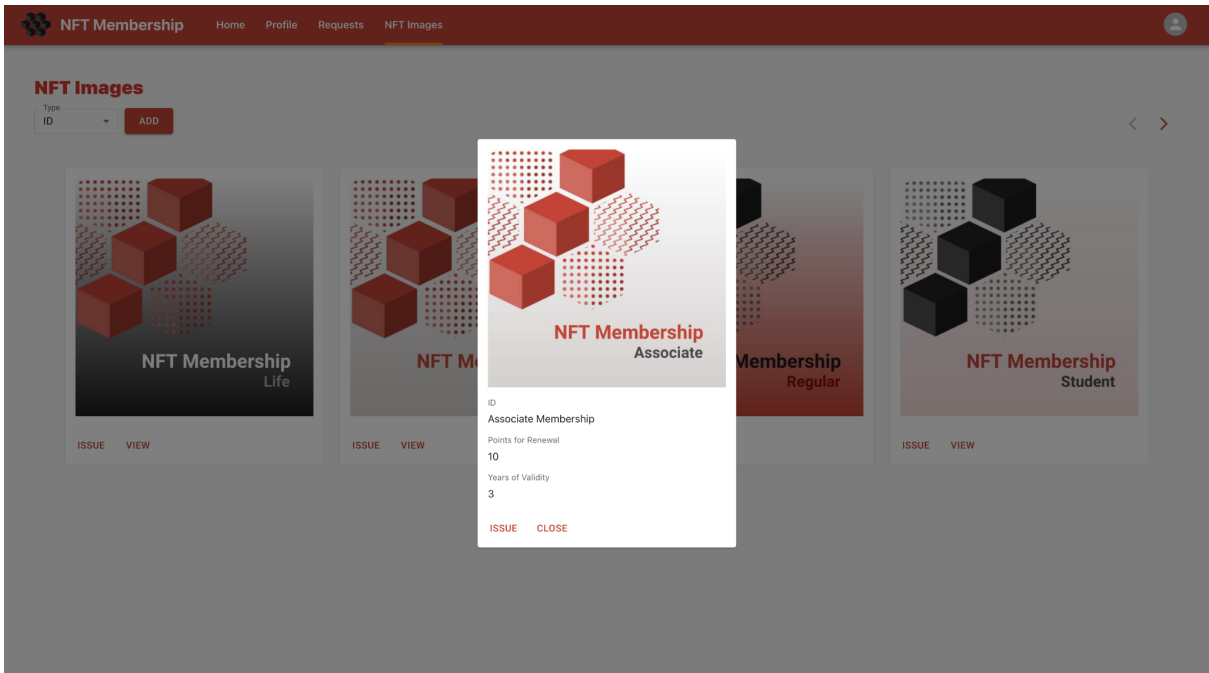


Fig. 31. View NFT ID image details

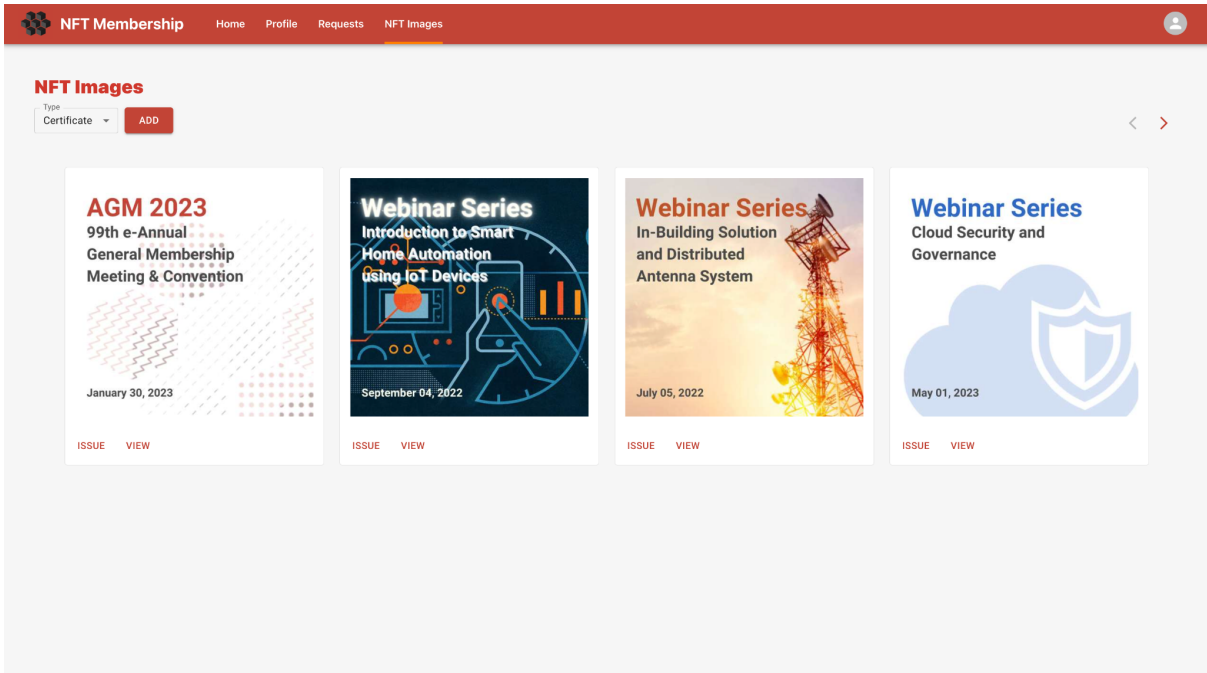


Fig. 32. NFT images page (certificate)

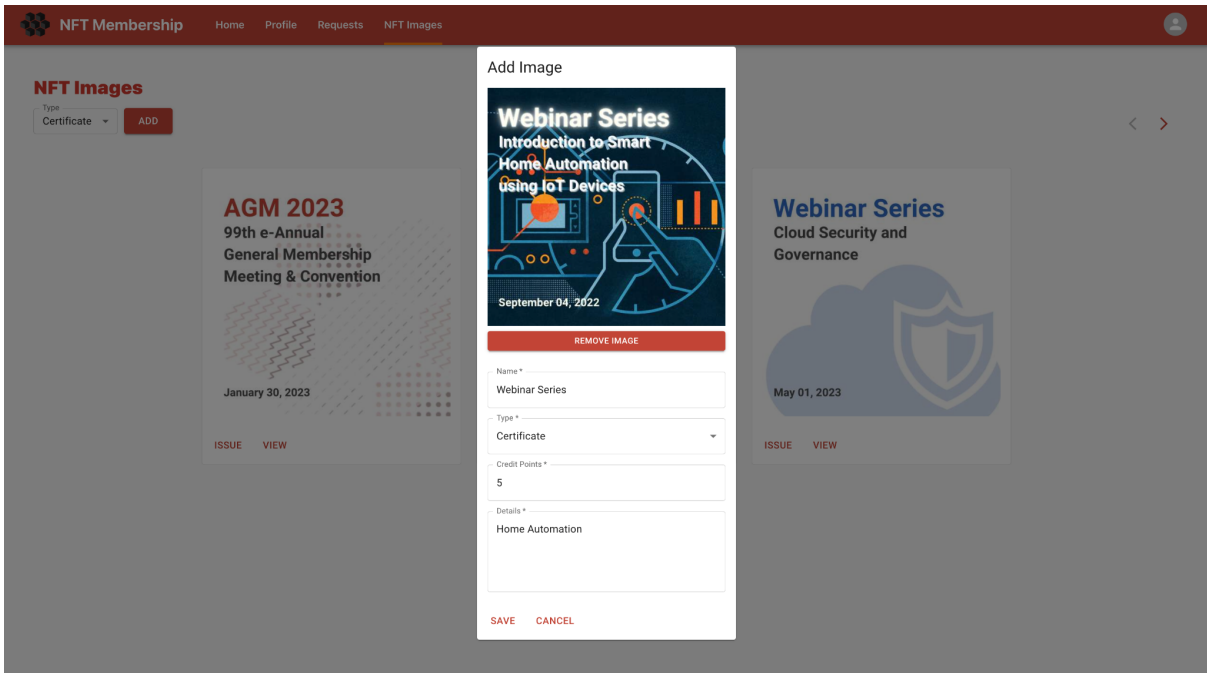


Fig. 33. Add NFT certificate image

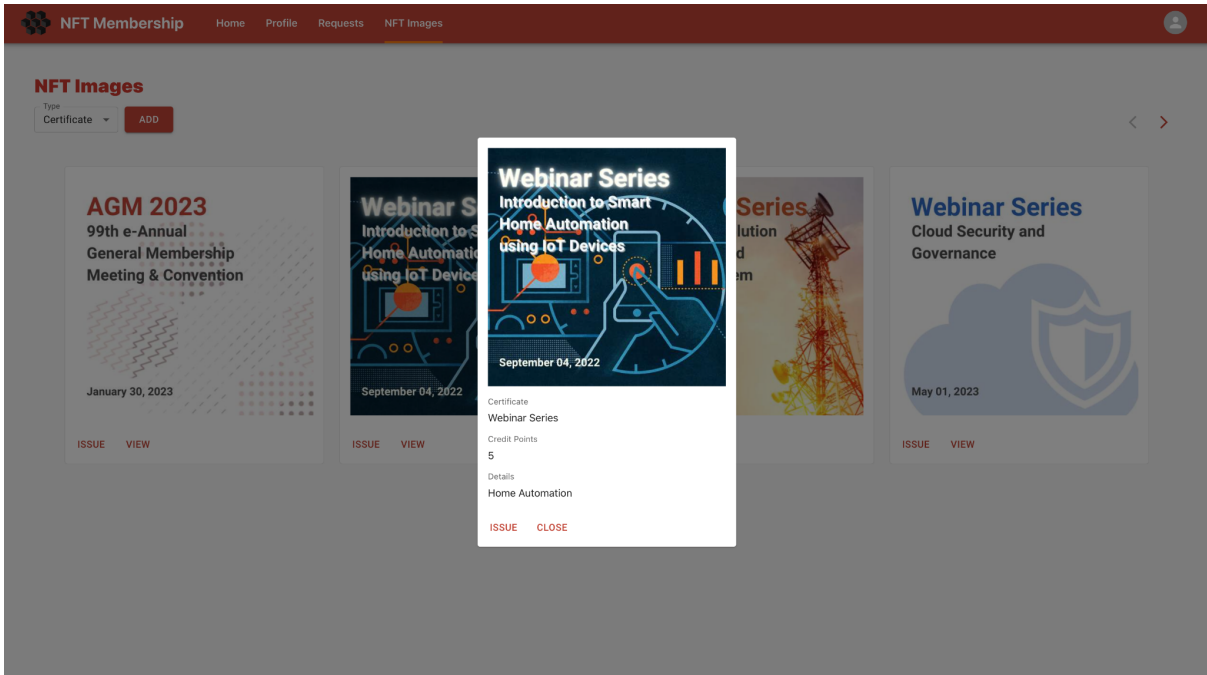


Fig. 34. View NFT certificate image details

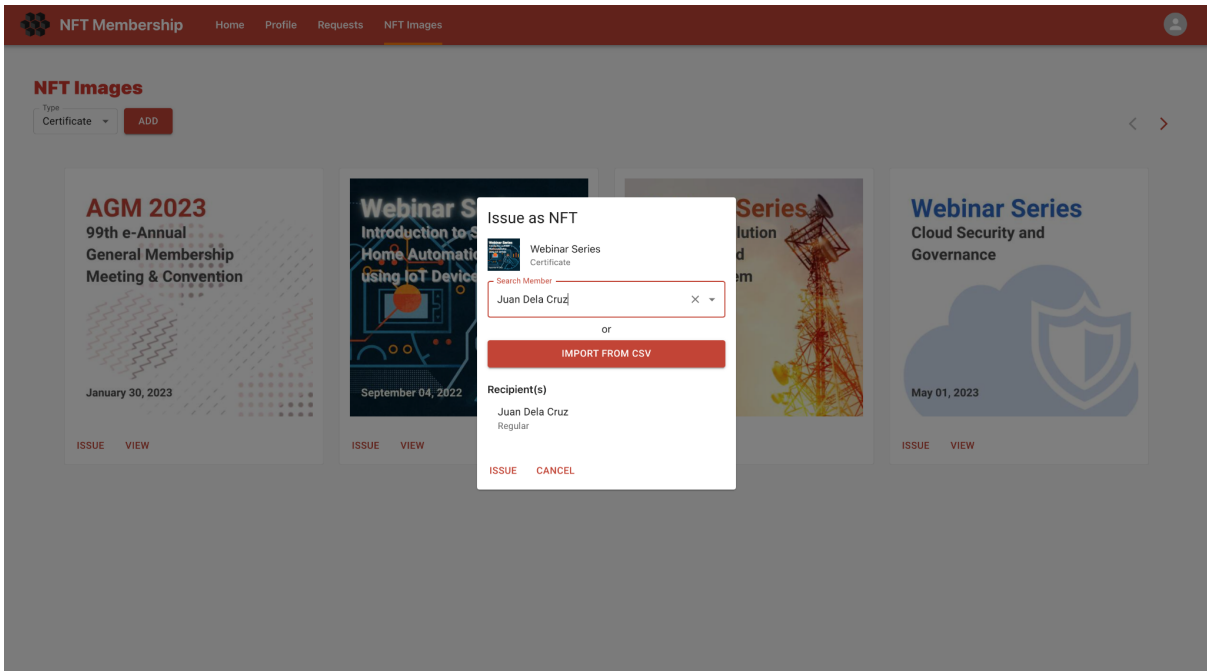


Fig. 35. NFT certificate issuance



This is to certify that **Juan Dela Cruz** is a regular member of **NFT Membership Singapore Chapter** valid until May 8, 2026.

Fig. 36. NFT ID verification page



This is to certify that **Juan Dela Cruz** has participated in the seminar on **Webinar Series** credited with **5 points**.

Fig. 37. NFT certificate verification page

E. Implementation

- Blockchain** - The Hyperledger Fabric test network is used to build the blockchain network which consists of two peer nodes and one ordering node. Each node runs as a docker container. The network is deployed in a DigitalOcean droplet with the configuration as shown in [Table 1](#). The table also shows the versions of the Fabric and the Fabric CA used. Fabric CA is a built-in certificate authority that issues digital identities to users participating in the network.

Server Hardware	
VM	DigitalOcean droplet
Operating System	Ubuntu 20.04 (LTS) x64
CPU	1 vCPU
Memory	2 GB
Disk Size	50 GB
Server Software	
Product	Version

Docker	23.0.4
Fabric	2.2.11
Fabric CA	1.5.6
CouchDB	3.1.1
Network	
nft-membership-network	based on release-2.2
Chaincode	
nft-membership-chaincode	v1.0.0

Table 1. Blockchain server setup

- **IPFS** - The private IPFS network consists of three peer nodes. Each node is deployed in a DigitalOcean droplet with the configuration as shown in [Table 2](#). Go is used for the deployment process.

Server Hardware Node 1, Node 2, Node 3	
VM	DigitalOcean droplet
Operating System	Ubuntu 20.04 (LTS) x64
CPU	1 vCPU
Memory	2 GB
Disk Size	50 GB
Server Software	
Product	Version
Go	1.20.3
kubo (go-ipfs)	0.19.1

Table 2. IPFS servers setup

- **MongoDB** - The MongoDB database is hosted in MongoDB Atlas shared cluster with the configuration as shown in [Table 3](#).

Server Hardware	
Tier	M0 Sandbox
CPU	Shared
Memory	Shared
Disk Size	512 MB
Server Software	
Product	Version
MongoDB	6.0.5

Table 3. MongoDB server setup

- **API** - The backend API server is deployed in a DigitalOcean droplet with the configuration as shown in [Table 4](#).

Server Hardware	
VM	DigitalOcean droplet
Operating System	Ubuntu 20.04 (LTS) x64
CPU	1 vCPU
Memory	1 GB
Disk Size	10 GB
Server Software	
Product	Version
NodeJS	18.7.0
NGINX	1.17.10
PM2	4.4.0
API	
nft-membership-api	v1.0.0

Table 4. API server setup

- **UI** - The UI is deployed in a DigitalOcean droplet with the configuration as shown in [Table 5](#).

Server Hardware	
VM	DigitalOcean droplet
Operating System	Ubuntu 20.04 (LTS) x64
CPU	1 vCPU
Memory	1 GB
Disk Size	10 GB
Server Software	
Product	Version
NodeJS	18.7.0
NGINX	1.17.10
UI	
nft-membership-ui	v0.1.0

Table 5. UI server setup

Chapter IV

PROJECT ASSESSMENT

A. User Testing

Unit testing was performed manually during the development phase. After the system was deployed in production, a system integration testing was conducted.

The testing centered on the following items:

- Functional testing - the functionality of each feature was tested using the functional requirements provided in the SRS as a guide. This ensures that:
 - All links are working properly.
 - Form validation is enforced, mandatory fields are checked, dropdown lists are populated, and default values are set.
 - JWT token is saved in the local storage and cleared when the user logs out.
 - Data is saved to the database and can be retrieved.
 - Email notifications are sent as expected.
 - Negative scenarios are tested and appropriate error messages are shown.
- Usability testing - ensures that:
 - Menus, buttons, dropdowns, and links are clearly visible and consistent throughout the application.
 - Drag and drop component for image uploading is working.
 - Content is legible and free from spelling and grammatical errors.
- Interface testing - using a REST client such as Postman, ensures that:
 - API requests are handled by the server and acted upon.
 - Only authorized requests (i.e. having a valid JWT token) are permitted.

- Compatibility testing - ensures that the application can be viewed correctly across different devices such as desktop, mobile and tablet.

Test scenarios were determined and test cases per scenario were listed and executed. Refer to the [appendices](#) for the test case documentation. Note that some bugs were already found and fixed during the development phase and manual unit testing so the integration system testing focused more on the end-to-end workflow.

IECEP Singapore Chapter has been identified as a target organization. A total of 7 respondents (officers and members of *IECEP SG*) were determined and the following profiles were recorded: name, occupation, chapter, and membership type. Respondents were asked to test the system and provide their feedback through an online form. The form used a System Usability Scale or SUS which is composed of ten questions each having a five-point scale that ranges from Strongly Disagree (1) to Strongly Agree (5) [42]. The SUS scores were added and averaged. Refer to the [appendices](#) for the report.

B. Security Testing

Using OWASP ZAP, an automated scan was performed on the site <https://nft-membership.raymondhalim.live/> and outputs the results as shown in [Fig.](#)

38. The result of the scan shows one high risk and two medium risks:

- The two medium risks can be resolved by enabling CSP in the React application. However, after applying the fix, the UI was not rendered correctly. More research is needed to properly enable CSP on a React application.
- The one high risk is related to the NGINX configuration file which was created by default when the NodeJS image was used in creating a DigitalOcean droplet. The vulnerability points to the overly permissive proxy configuration

such as `proxy_pass http://$host`. This has already been commented and any proxy settings were commented as well. However, the scan still highlighted the described risk. Further research is needed to fix this vulnerability.

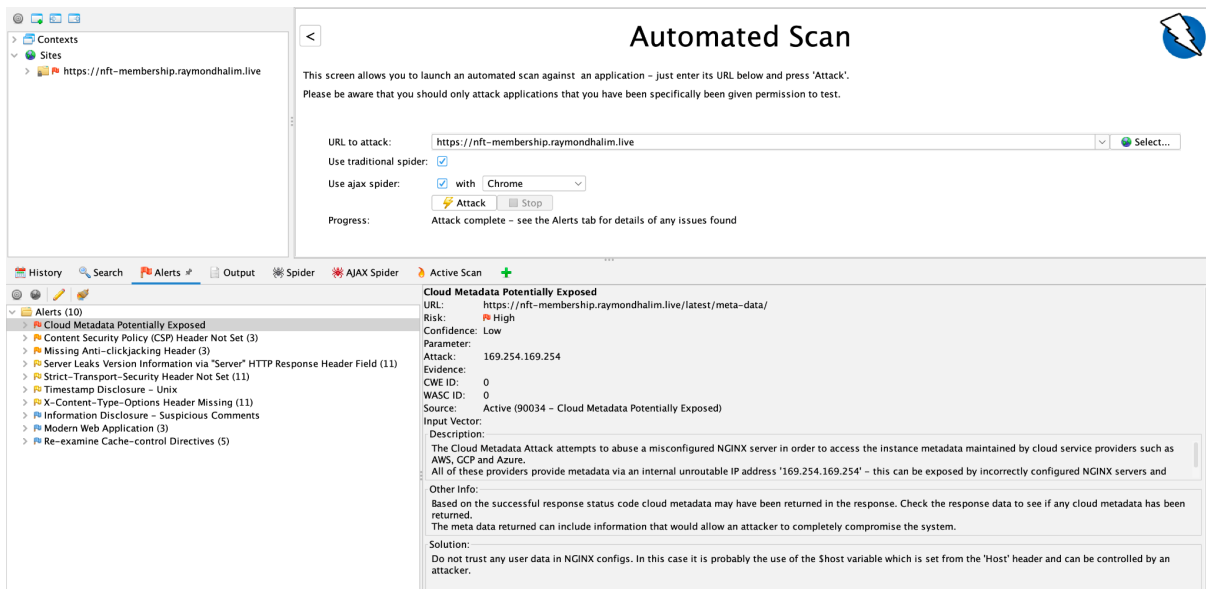


Fig. 38. OWASP ZAP scan results

Chapter V

DISCUSSIONS

This project provided the opportunity to learn how a private blockchain network works, how to set up one using Hyperledger Fabric's test network, and how to develop a smart contract or chaincode. Since the chaincode is installed after the network is initialized, any change on the transactions or additional transactions handled by the chaincode during the development phase will require for the chaincode to be reinstalled. This initially worked by recreating the network and installing the latest chaincode. However, recreating the network produces new certificates for the peer nodes rendering the existing connection profiles useless. Fortunately, Fabric allows us to upgrade the chaincode without the need to recreate the network by incrementing its version and sequence number. Also, since the test network is deployed in docker containers, we can simply stop and start them if needed. It is also possible to view the activities in the network by using Fabric's blockchain explorer.

During development, kubo was installed as a docker container to provide the local node to interact with the public IPFS network. IPFS provides a web-ui interface to check the uploaded images. However, accessing the web-ui interface from a private network set up in production did not work [43]. So in order to validate that the image was indeed uploaded to the node, we need to execute `ipfs cat CID` inside the node server. Setting up three separate servers as peer nodes and having them communicate with one another required quite a number of configurations but was achievable.

The project allows GIF files to be uploaded as NFT images. Images are resized to smaller size before uploading them to IPFS and this causes the GIF file to

be saved as a JPEG file. An enhancement can be made in the future to enable resizing a GIF file and still save it as GIF.

To test the expiring or expired NFT ID, we cannot simply change the system date as it can cause havoc on the fabric network. Instead, the NFT IDs were updated by running a script to modify their blockchain states.

Maintenance plan for the system includes the following:

- Security - Security audits shall be performed on a quarterly basis to scan the site for vulnerabilities. High and medium risks such as those found during the [security testing](#) shall be addressed with high priority.
- Backup - As MongoDB Atlas M0 cluster does not provide backup, an upgrade to a higher cluster will be needed to provide daily snapshots.
- Site performance - The site will be continuously monitored for speed issues. Reliability relies on the SLA provided by DigitalOcean, MongoDB Atlas, and Mailjet which is at 99.99% uptime.
- User experience - The design of the website shall be regularly reviewed and accessibility shall be enhanced.
- Change requests - Requests for new functionalities shall be reviewed and properly scheduled for development and releases.
- Updates - Upgrades, patches, and fixes to the system will be deployed during non-peak hours to minimize service disruption and downtime.

Chapter VI

CONCLUSION

As more and more organizations are moving towards digitalization, the conversion of physical IDs to their digital forms solves a lot of issues associated with traditional membership registration and renewal such as time-consuming approval process, delayed issuance of ID cards, high manufacturing and logistics costs, use of unsustainable materials, and instances of lost, damaged or stolen cards. This project moves a step forward by digitizing these IDs, as well as certificates, into non-fungible tokens or NFTs.

The use of a private and permissioned blockchain network such as Hyperledger Fabric not only ensures privacy and confidentiality but also makes the NFT IDs and certificates resistant to replication and tampering, ensures their authenticity, enhances their provenance, and makes them verifiable without exposing personal identifiable information or PII.

Storing large files such as NFT images in a private IPFS network makes them tamper-proof and helps minimize the overall storage cost as common chunks of the files can be reused. PII is stored in a document database such as MongoDB to take advantage of its flexible schema and high performance. This ensures the right of a member to be forgotten which is not possible if these PII were stored on the blockchain.

The project also provides notification for expiring NFT IDs and auto-renewal. As the NFT ID renewal is based on points earned from issued certificates, this helps increase membership renewals by encouraging the members to have active participation. The NFT IDs may also serve as a proof of a member's good standing as points are tied to them.

Chapter VII

FUTURE WORK

Setting up a Hyperledger Fabric blockchain network is a complicated task and a real world production network is usually a collaborative effort of several organizations [44]. Instead of using a test network provided by Fabric, switching to a managed service such as that of Amazon's [Managed Blockchain](#) or the [Blockchain-as-a-Service](#) provided by Kaleido shall be considered.

Creation of an IPFS cluster on top of the private IPFS network for data replication shall be implemented. Enabling the IPFS dashboard for the private network shall be looked into.

As any change in the images can affect the issued NFTs, allowing an administrator to update or delete existing NFT images shall be further studied.

The possibility of issuing the NFT IDs and certificates as verifiable credentials in a self-sovereign identity system shall be further researched.

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APPENDICES

A. Deliverables and Milestones

- Refer to [SRS.pdf](#) for the project schedule and milestones. The actual implementation schedule can be found in [Gantt.pdf](#).
- The prototype can be accessed at <https://nft-membership.raymondhalim.live>.
- The user testing plan included the following activities:
 - Identify the features of the system to test.
 - Define the scope of the test.
 - Define test cases. Identify the inputs and expected outputs.
 - Execute the test cases and evaluate the results.
 - Analyze the test results.
- Test cases and results can be found in [NFT Membership Test Cases.pdf](#).
- The System Usability Scale report can be found in [SUS Report.pdf](#).
- The success of the project was assessed through the following activities:
 - The times spent in development, deployment, and testing were recorded.
 - Test cases which are based on the functional requirements and interface requirements specified in the SRS were executed successfully.
 - Deployment setup documentation is provided so the system can be recreated if needed.
 - A feedback form using a System Usability Scale (SUS) was provided to 7 respondents from *IECEP Singapore Chapter*. The average SUS score is 59.6 which is considered good based on adjective ratings [45].

- The actual time spent has exceeded the estimated effort. This can be attributed to the fact that more time is needed to familiarize oneself on Hyperledger Fabric, IPFS, and the development of smart contracts.

B. Budget

Refer to  SRS.pdf for the proposed budget.

C. Qualifications

The required skills for the development of this project are as follows:

- knowledge of JavaScript programming
- experience in linux systems and commands
- knowledge of MongoDB query language
- UI/UX design skills

Knowledge and skills gained while developing the project are as follows:

- knowledge of setting up a private IPFS network
- knowledge of setting up a private blockchain network
- knowledge of developing a smart contract

D. Resources

Refer to  SRS.pdf for the list of required resources.

E. Complete Program Listing

The source codes can be found in <https://github.com/rrhalim/nft-membership>.

F. Technical References

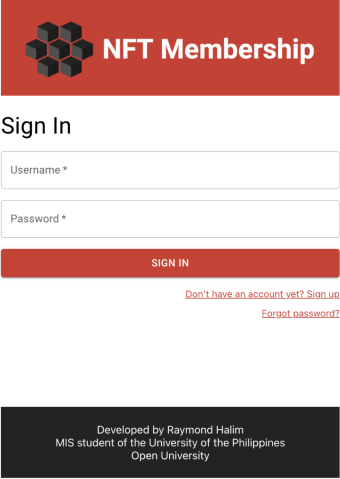
The final system specifications are described in the [implementation](#) section.

The deployment setup is detailed in  NFT Membership Deployment Setup.pdf .

G. User Manual

a. Registration

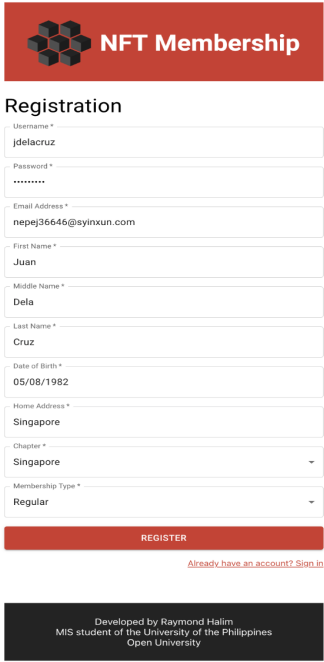
- The login page is shown in Fig. A-1. To register, click the “Don’t have an account yet? Sign up” link.



The screenshot shows the 'Sign In' page for 'NFT Membership'. At the top is a red header with a hexagonal logo and the text 'NFT Membership'. Below the header is the title 'Sign In'. There are two input fields: 'Username*' and 'Password*'. A red 'SIGN IN' button is positioned below the password field. Underneath the button are two links: 'Don't have an account yet? Sign up' and 'Forgot password?'. At the bottom of the page is a black footer with white text: 'Developed by Raymond Halim, MIS student of the University of the Philippines, Open University'.

Fig. A-1. Login page

- Fill up the registration form shown in Fig. A-2 and click the “Register” button.



The screenshot shows the 'Registration' page for 'NFT Membership'. At the top is a red header with a hexagonal logo and the text 'NFT Membership'. Below the header is the title 'Registration'. The form contains several fields: 'Username*' (filled with 'jdelacruz'), 'Password*' (filled with dots), 'Email Address*' (filled with 'nepej36646@syinxun.com'), 'First Name*' (filled with 'Juan'), 'Middle Name*' (filled with 'Dela'), 'Last Name*' (filled with 'Cruz'), 'Date of Birth*' (filled with '05/08/1982'), 'Home Address*' (filled with 'Singapore'), 'Chapter*' (filled with 'Singapore'), and 'Membership Type*' (filled with 'Regular'). A red 'REGISTER' button is located below the form. Underneath the button is a link: 'Already have an account? Sign in'. At the bottom of the page is a black footer with white text: 'Developed by Raymond Halim, MIS student of the University of the Philippines, Open University'.

Fig. A-2. Registration page

- Once registered, you will receive a welcome email as shown in Fig. A-3.

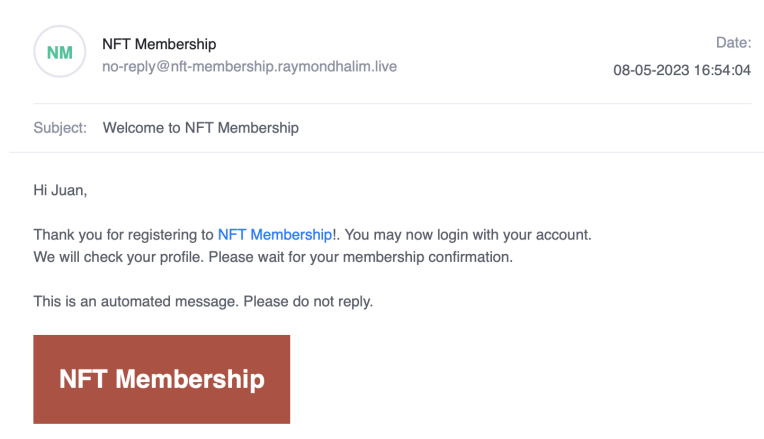


Fig. A-3. Welcome email

b. Home Page

- Login to your account in the login page shown in Fig. A-1. Once logged in, you will be directed to the home page as shown in Fig. A-4. Only members whose registration requests were approved and whose IDs are not yet expired can view their IDs and certificates in the home page.

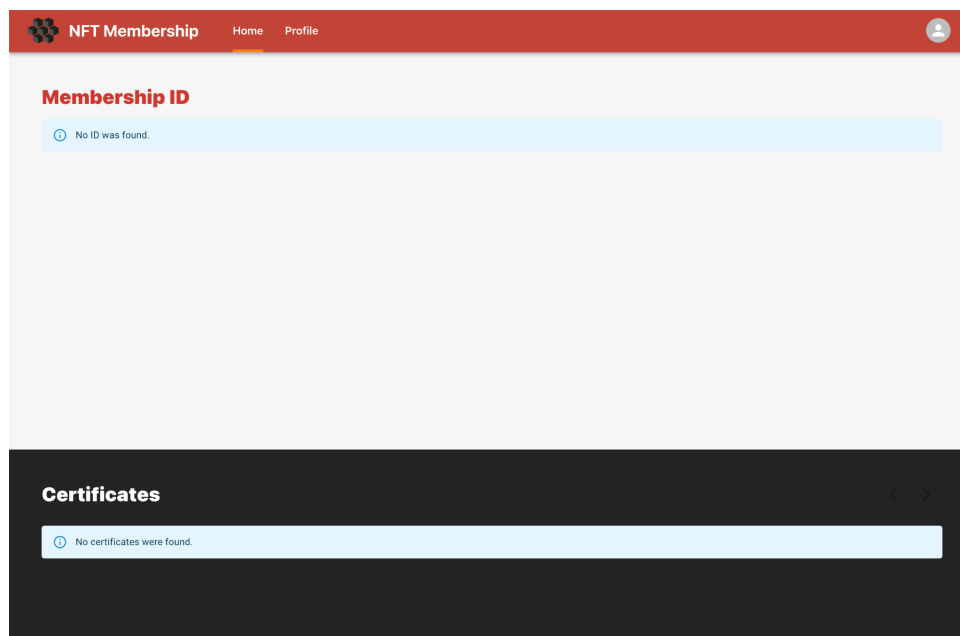


Fig. A-4. Home page

c. User Profile

- Click the “Profile” menu in the header or click the avatar on the upper right corner and select the “Profile” menu to view your profile as shown in [Fig. A-5](#).

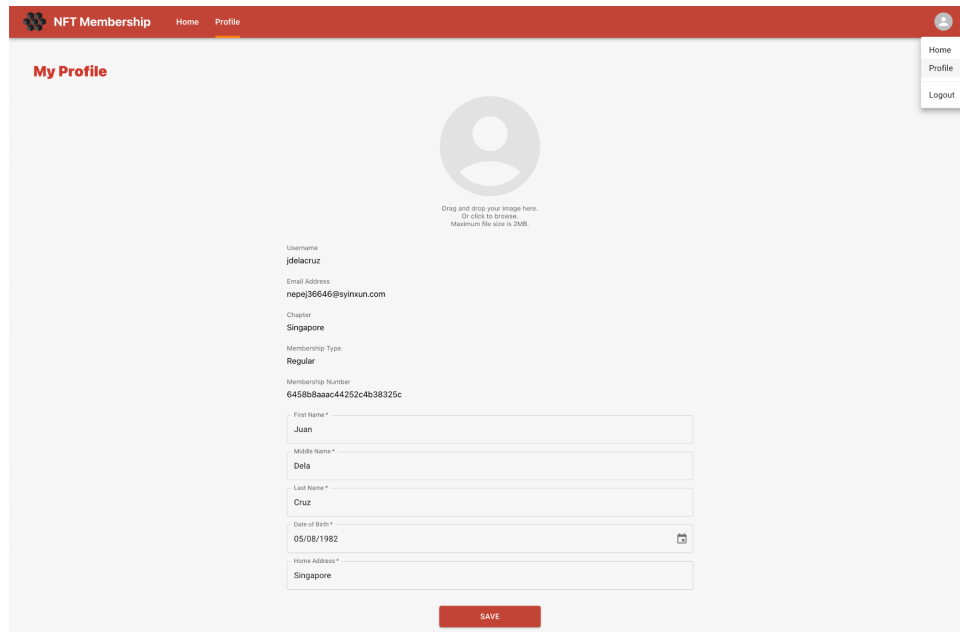


Fig. A-5. Profile page

- You can update your name, date of birth, home address and upload your profile picture by clicking on image on the center or by dragging your photo in the image as shown in [Fig. A-6](#). Click the “Save” button to update your profile.

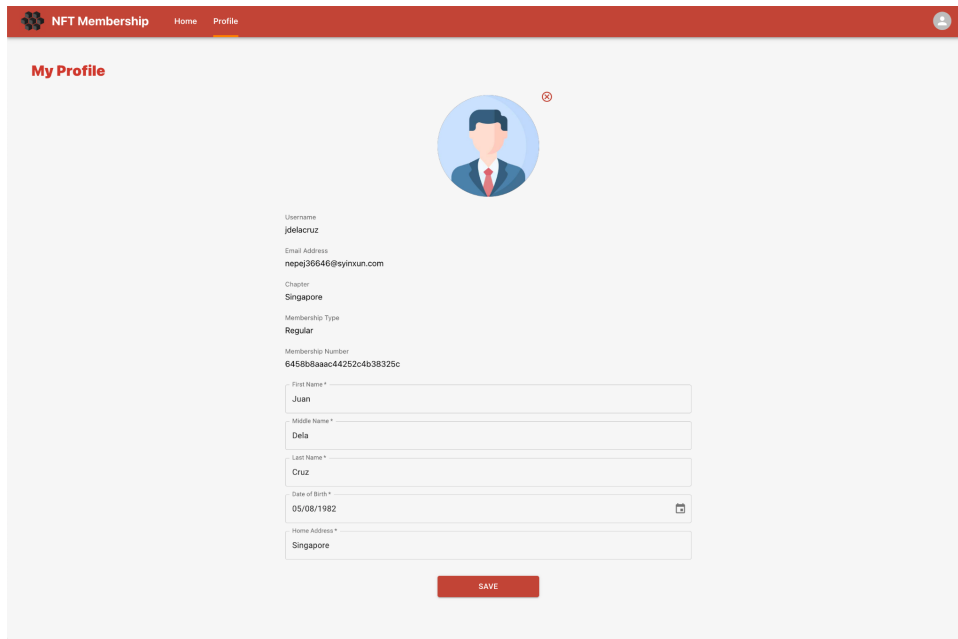


Fig. A-6. Update profile

d. Change password

- To change the password or request to reset a forgotten password, click the “Forgot password?” link in the login page as shown in [Fig. A-1](#). Enter your registered email address as shown in [Fig. A-7](#).

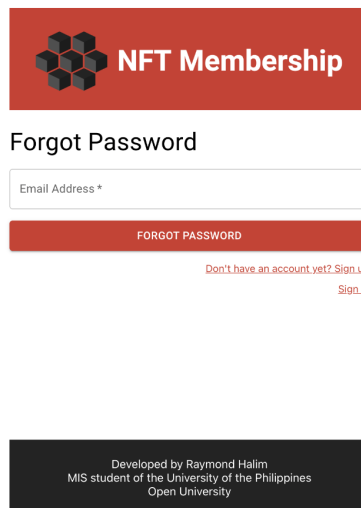


Fig. A-7. Request to reset password

- You will receive a reset password email as shown in [Fig. A-8](#). Click the link provided in the email.



NFT Membership
no-reply@nft-membership.raymondhalim.live

Date:
24-05-2023 15:01:14

Subject: Reset your password

Hi Maria,

You requested to reset your password.
You may click this [link](#) to reset your password.

This is an automated message. Please do not reply.



Fig. A-8. Reset password email

- Enter your new password and click the “Reset Password” button as shown in [Fig. A-9](#).

NFT Membership

Reset Password

Password *

Confirm Password *

RESET PASSWORD

[Don't have an account yet? Sign up](#)

[Sign in](#)

Developed by Raymond Halim
MIS student of the University of the Philippines
Open University

Fig. A-9. Reset password

e. Add an NFT ID Image

- Login as admin, go to the “NFT Images” page and click the “Add” button.
The “Add Image” modal window will appear as shown in [Fig. A-10](#).

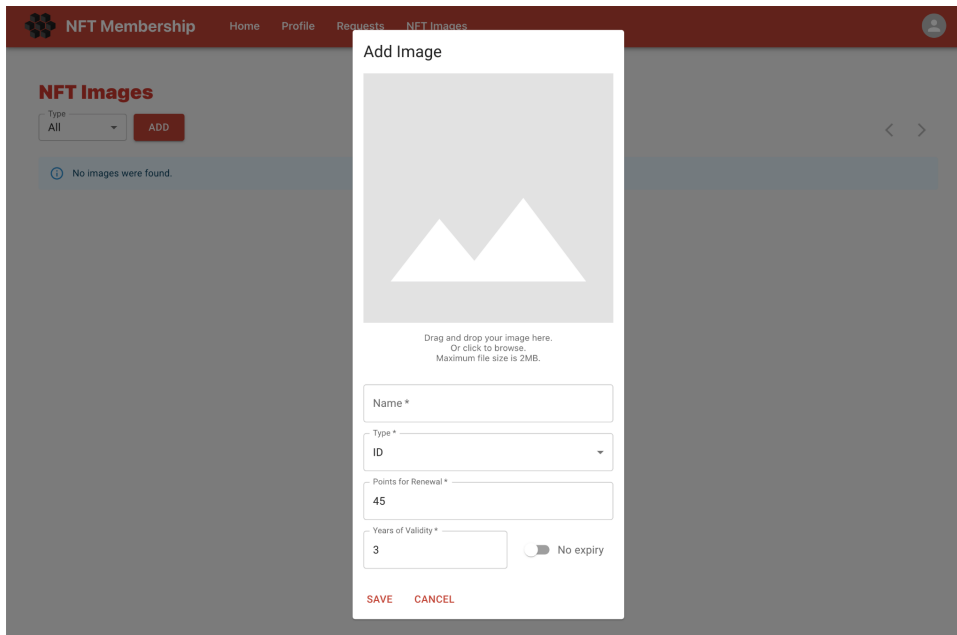


Fig. A-10. Add NFT ID image

- Upload an image and input the name of the ID image, points for renewal and years of validity as shown in [Fig. A-11](#). You have an option to toggle the “No expiry” switch to on for non-expiring IDs. Click the “Save” button to add the image.

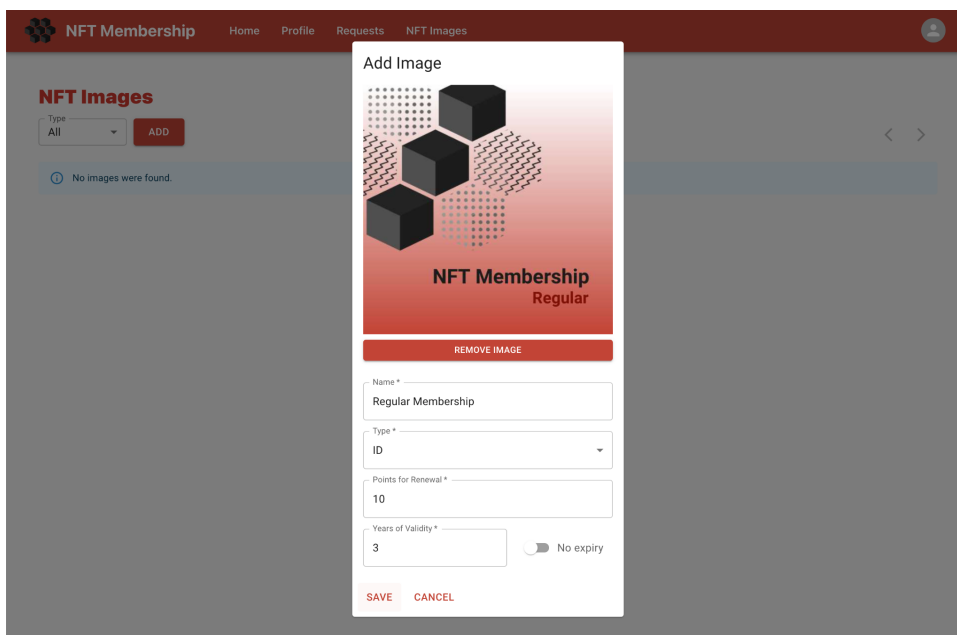


Fig. A-11. Save NFT ID image

- The ID image is added to the NFT Images page as shown in Fig. A-12. To view the NFT ID image, click the “View” button and a modal window will appear showing the details of the image as shown in Fig. A-13.

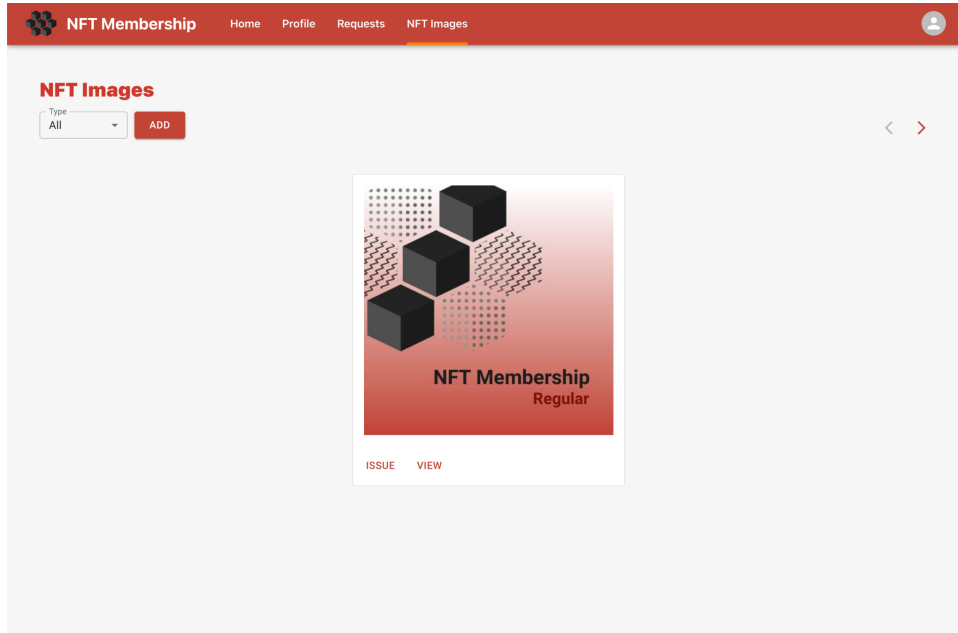


Fig. A-12. NFT ID image listed in NFT Images page

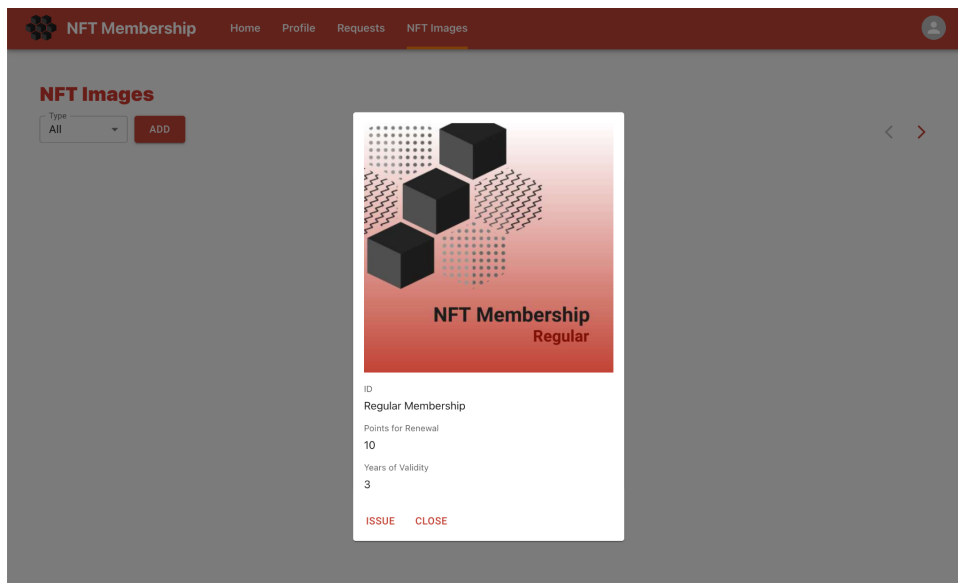


Fig. A-13. NFT ID image details

f. Add an NFT Certificate Image

- Login as admin, go to the “NFT Images” page and click the “Add” button. The “Add Image” modal window will appear as shown in [Fig. A-10](#).
- Upload an image, select “Certificate” as the image “Type”, and input the name of the certificate image, credit points, and details as shown in [Fig. A-14](#). Click the “Save” button to add the image.

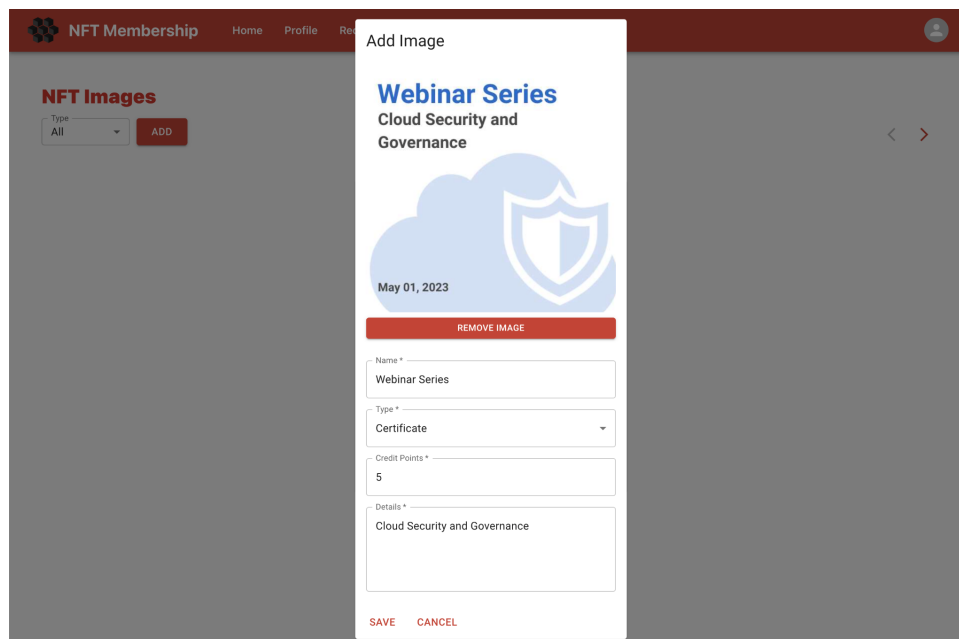


Fig. A-14. Save NFT certificate image

- The certificate image is added to the NFT Images page as shown in [Fig. A-15](#). To view the NFT image, click the “View” button and a modal window will appear showing the details of the image as shown in [Fig. A-16](#).

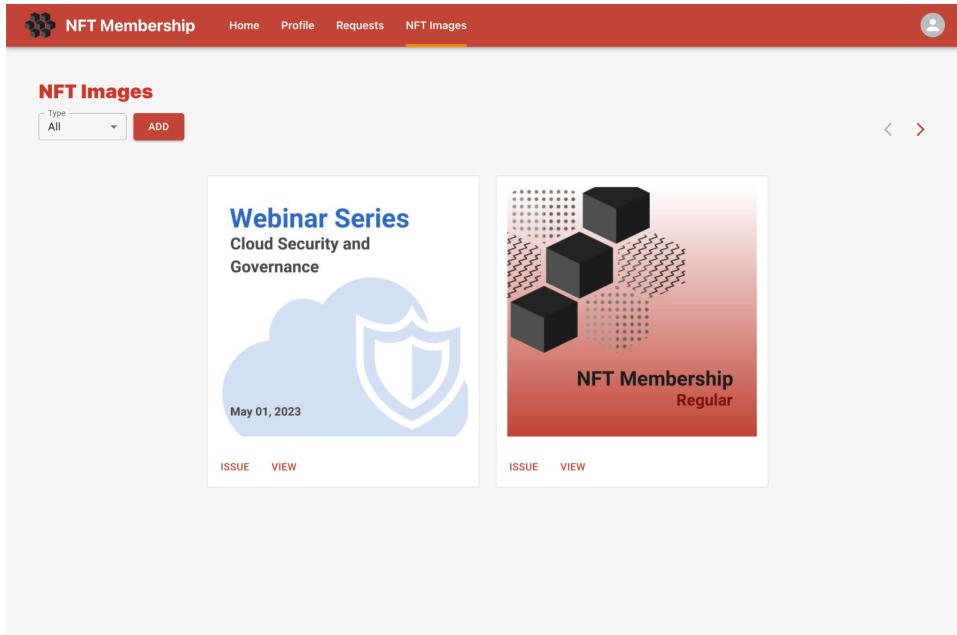


Fig. A-15. NFT certificate image listed in NFT Images page

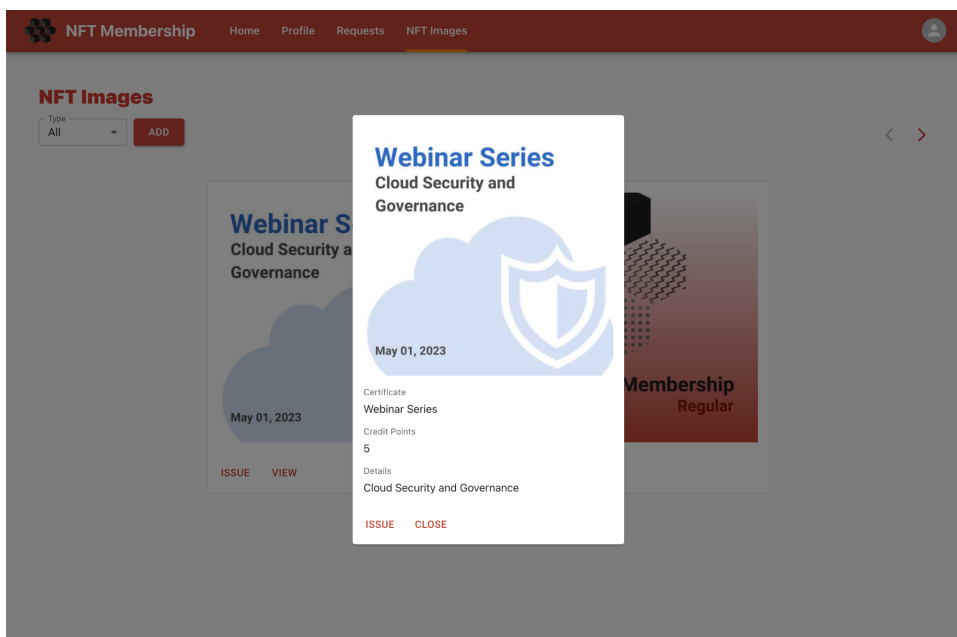


Fig. A-16. NFT certificate image details

g. Approve Registration Request

- Login as admin, go to the “Requests” page and click the “View” button on a request. The details of the registration request is displayed in a modal window as shown in Fig. A-17.

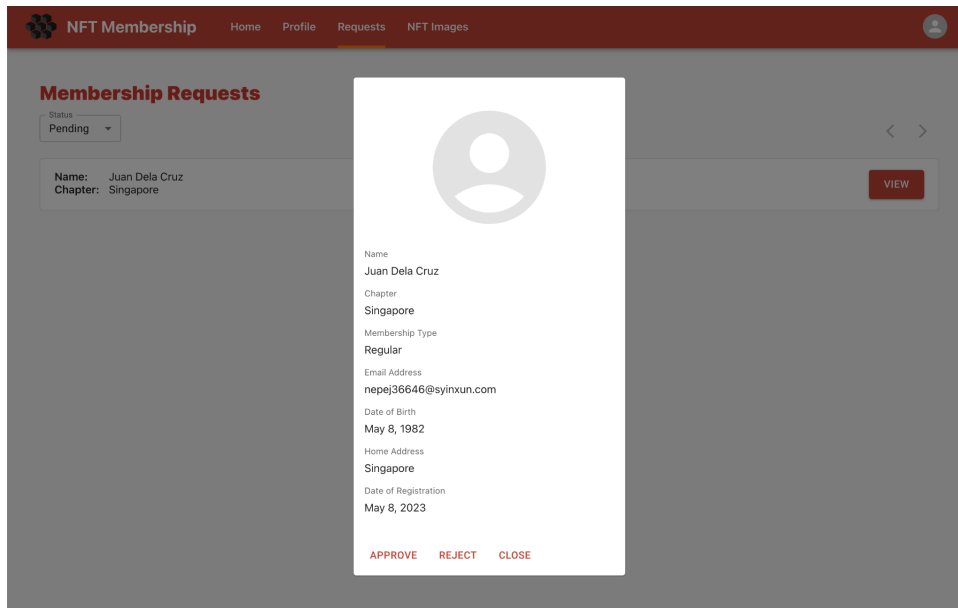


Fig. A-17. Registration request details

- Click the “Approve” button. The “Issue NFT ID” modal window will appear as shown in [Fig. A-18](#). Select the NFT ID image to issue and click the “Issue” button.

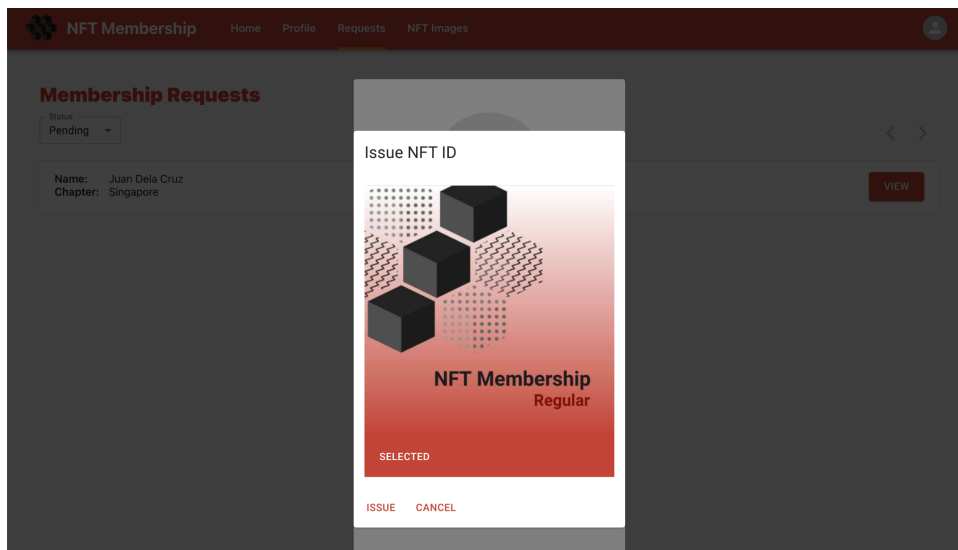


Fig. A-18. Issue NFT ID

- The approved member will receive a confirmation email as shown in [Fig. A-19](#).

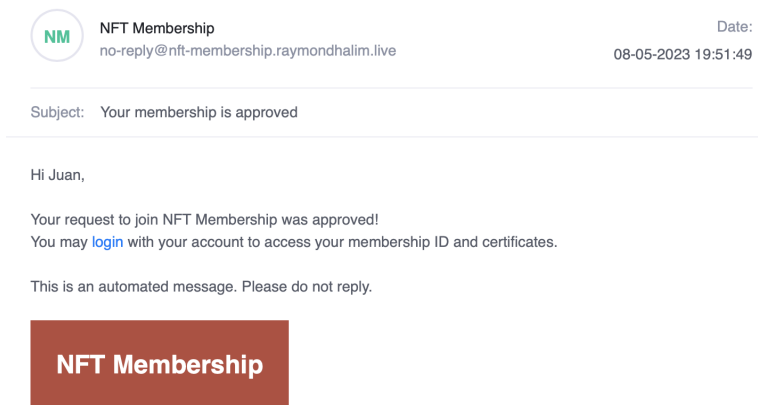


Fig. A-19. Registration approval confirmation email

h. Issue an NFT Certificate

- Login as admin, go to the “NFT Images” page and click the “Issue” button on a certificate image. The “Issue as NFT” modal window appears as shown in Fig. A-20.

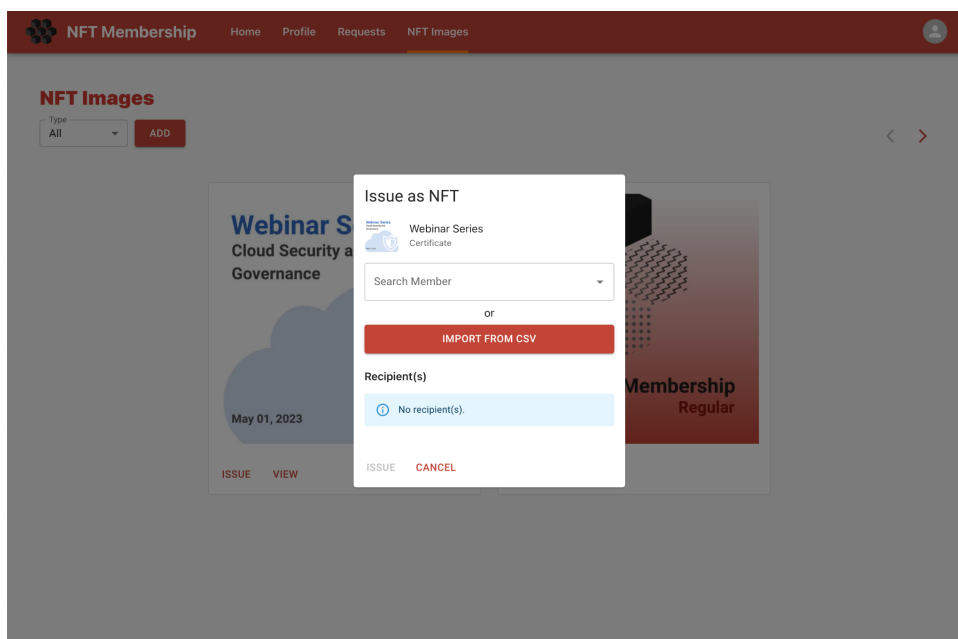


Fig. A-20. Issue certificate image as NFT

- To identify the recipient of the NFT, you can search for the member’s first name, middle name, last name, or membership number from the “Search

Member” box as shown in Fig. A-21. Alternatively, you can import multiple recipients from a CSV file. The format of the CSV file is shown in Fig. A-22. Click the “Issue” button.

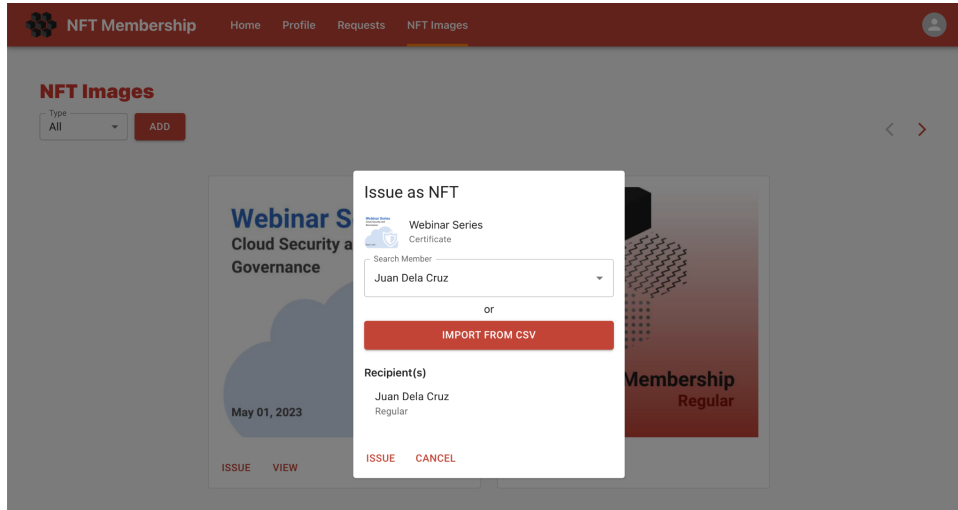


Fig. A-21. Identify NFT recipient(s)

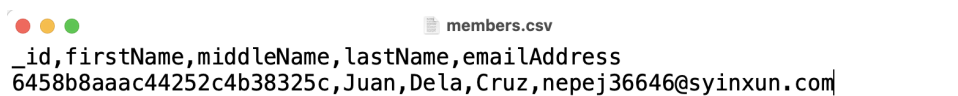


Fig. A-22. List of recipients

- The recipient(s) will receive a confirmation email as shown in Fig. A-23.

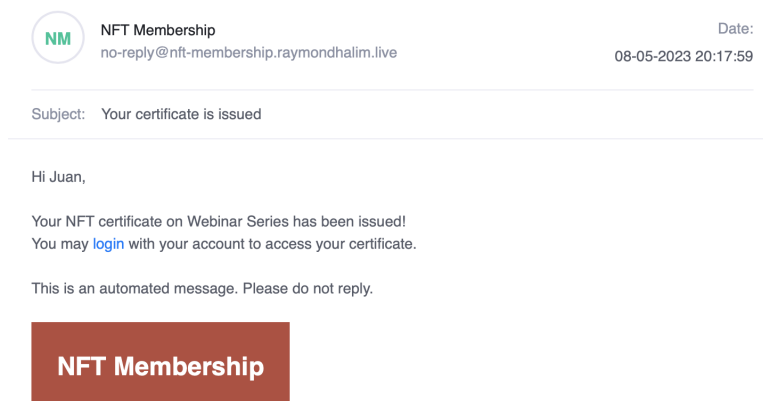


Fig. A-23. Confirmation email for issued certificate

i. View NFTs

- Login as a registered member. The home page should display the member's "Membership ID" and "Certificates" as shown in [Fig. A-24](#).

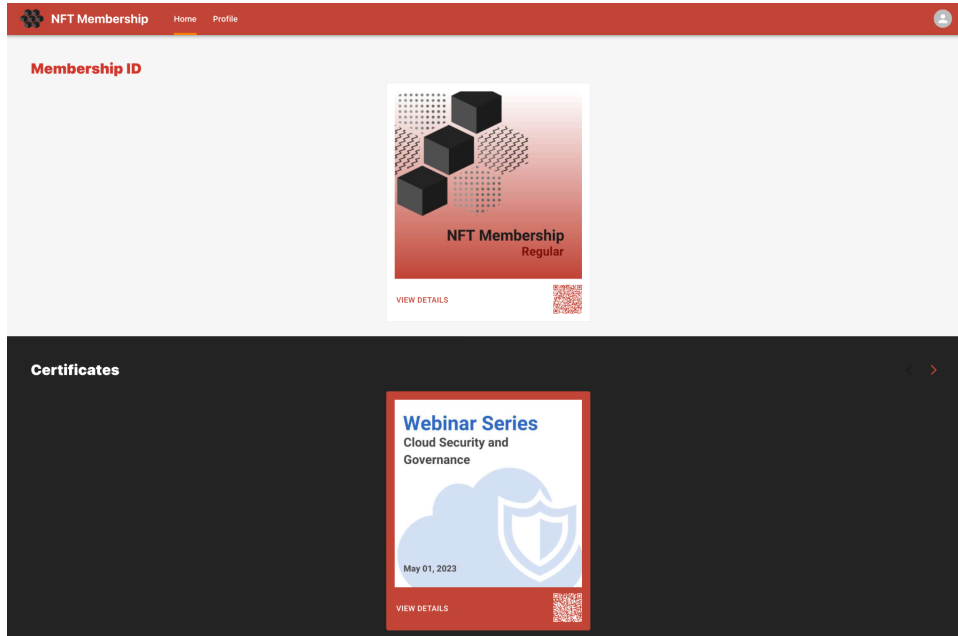


Fig. A-24. Membership ID and certificates

- Click the "View Details" of the membership ID. The "ID Details" modal window appears with the details of the ID as shown in [Fig. A-25](#).

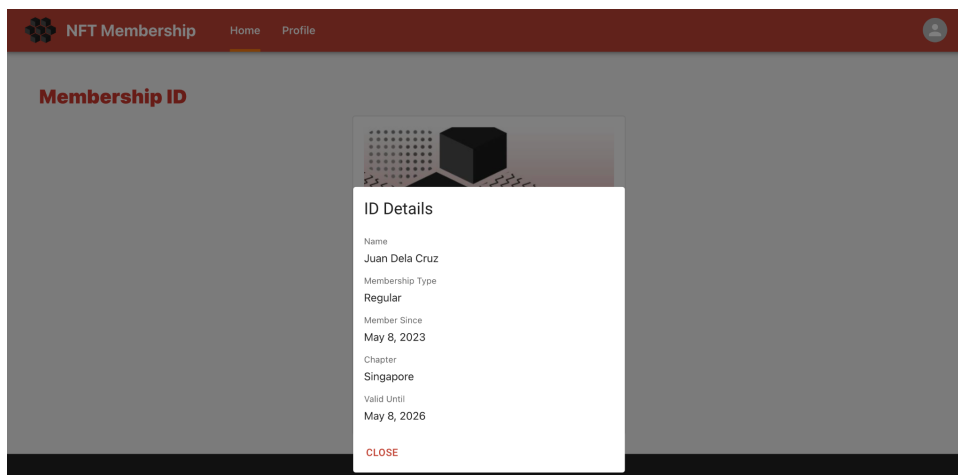


Fig. A-25. Membership ID details

- Click the "View Details" of a certificate. The "Certificate Details" modal window appears with the details of the certificate as shown in [Fig. A-26](#).

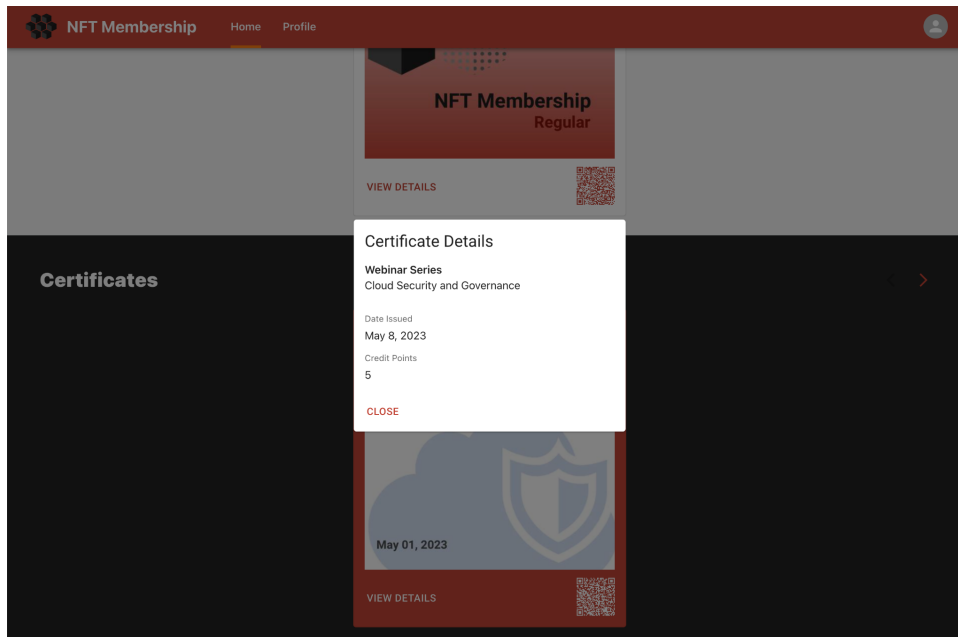


Fig. A-26. Certificate details

j. Verify NFTs

- Scan the QR code of the NFT ID as shown in [Fig. A-27](#).

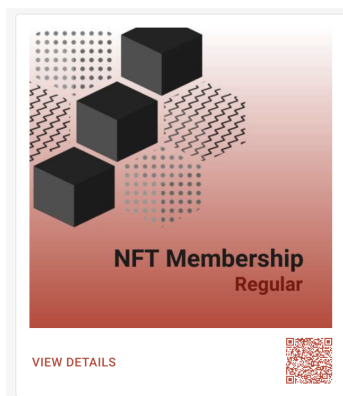


Fig. A-27. NFT ID with QR code

- A browser window will appear showing the verification results as shown in [Fig. A-28](#).



This is to certify that **Juan Dela Cruz** is a regular member of **NFT Membership Singapore Chapter** valid until May 8, 2026.

Fig. A-28. NFT ID verification

- Scan the QR code of an NFT certificate as shown in [Fig. A-29](#).



Fig. A-29. NFT certificate with QR code

- A browser window will appear showing the verification results as shown in [Fig. A-30](#).



This is to certify that **Juan Dela Cruz** has participated in the seminar on **Webinar Series** credited with **5 points**.

Fig. A-30. NFT certificate verification