HealthKard - Decentralized User Health Identity and Health Records Management with Web3, IPFs and the Ethereum Blockchain

Submitted in partial fulfillment of requirements
for the degree of

Bachelors in Technology

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Batch 2019-2023

K.J. Somaiya College of Engineering, Mumbai-77

(Autonomous College Affiliated to the University of Mumbai)

Certificate

This is to certify that this Synopsis entitled **HealthKard - Decentralized User Health Identity and Health Records Management with Web3, IPFs and the Ethereum Blockchain** submitted at the end of semester VII of LY B. Tech is a record for partial fulfillment of requirements for the degree of Bachelor of Technology in Information Technology.

Guide

Head of Department

Principal

Date:

Place: Mumbai-77

K.J. Somaiya College of Engineering, Mumbai-77

(Autonomous College Affiliated to University of Mumbai)

Certificate of Approval of Examiners

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Internal Examiner

External Examiner

Date:

Place: Mumbai-77

K.J. Somaiya College of Engineering, Mumbai-77

(Autonomous College Affiliated to University of Mumbai)

DECLARATION

We declare that this written thesis submission represents the work done based on our and / or others' ideas with adequately cited and referenced the original source. We also declare that we have adhered to all principles of intellectual property, academic honesty and integrity as we have not misinterpreted or fabricated or falsified any idea/data/fact/source/original work/matter in my submission.

We understand that any violation of the above will be cause for disciplinary action by the college and may evoke the penal action from the sources which have not been properly cited or from whom proper permission is not sought.

Signature of the Student	**Signature of the Student**
1914061	**1914058**

Date:
Place: Mumbai-77

Abstract

At the current stage, there is no unified framework in India that facilitates the storage of health records for all citizens. Although private companies/hospitals do solve this problem to some extent by providing e-health record services, they only cater to their own patients and customers. Therefore, there is a need to develop the foundations necessary for supporting digital health infrastructure to maintain health data in a decentralised and secure way. A few major advantages to this project will be ease of access, user consent for every sophisticated transaction, and portability across national borders.

In the healthcare system, a Blockchain network can be utilised to store and share patient data amongst hospitals, diagnostic labs, drug companies, and doctors. HealthKard (Blockchain applications) can precisely detect serious errors, including potentially deadly ones, in the medical industry. In the healthcare sector, it can therefore enhance the efficiency, security, and transparency of sharing medical data. Medical institutions can acquire insight and improve the analysis of patient information with the use of this application.

HealthKard supports a distinctive data storage pattern at the highest level of security, which can help eliminate the concern about data manipulation in the healthcare industry. It offers adaptability, connectivity, accountability, and authentication for access to data. Health records must be kept secure and private for a number of reasons. Blockchain helps prevent specific dangers and provides decentralised data protection for the healthcare industry.

A unique health identity will be generated via Smart Contracts, in the form of an NFT that will store the user's personal as well as health-related information, which is constant throughout to maintain the non-fungible nature of NFTs. This unique ID will help us map users' health records. Also, this will enable accessing personal health records, based on international standards, easily accessible to individuals and healthcare professionals and services providers, based on individual's informed consent.

Contents

List of Figures

Nomenclature

GUI	Graphical User Interface
API	Application Programming Interface
SDLC	Software Development Life Cycle
SRS	Software Requirements Specifications
SPMP	Software Project Management Plan
SDD	Software Design Document
UX	User Experience
UI	User Interface
JSON	JavaScript Object Notation
URI	Universal Resource Identifier
IPFS	Interplanetary File System

Chapter 1

Introduction

1.1 Product Overview

HealthKard aims to implement the following modules:

- Creation of a unique Health ID using Aadhaar Number
- Storage of Electronic Health Records (EHRs) mapped to Health Identity in the blockchain
- Integration of different sectors in the medical industry
- Encourage better administration of the health sector by utilizing health data analytics

1.1.1 Problem Definition

The purpose of this digital and decentralized health identity is to store all your health records in one place to make it convenient for users by avoiding the hassles of carrying physical reports or multiple digital reports, each from a different service.

The system is based on Blockchain and the idea of NFTs so that the unique health identity cannot tamper with and that the health records are stored in a secure manner without centralized control over your sensitive records. We will provide a comfortable User Interface to find patients, request access to health records, and ensure patients are able to grant access with his/her consent and let users store their Electronic Health Records (EHRs)

1.1.2 Motivation

Currently, there is no unified framework in India that facilitates the storage of health records of all citizens. Although private companies/hospitals do solve this problem to some extent by providing e-health record services, they only cater to their own patients/-customers. Therefore, there is a need to develop the foundations necessary for supporting digital health infrastructure to maintain health data in a decentralized and secure way. A few major advantages to this project will be ease of access, user consent for every sophisticated transaction, and portability across national borders.

Chapter 2

Literature Survey

1] The authors demonstrate the efficiency of employing blockchain technology for secure health information transfer and storage. An illustration of the health care system's decentralized architecture is provided in the article. A smart contract algorithm has been created for the healthcare industry. The study's findings demonstrate the usefulness of blocking technology for storing patient electronic medical records. According to system analysis, this technology's applications create a secure and naturally decentralized framework for efficient digital interaction.

2] The authors of this research use blockchain technology to create and assess a safe Digital Health Passport (DHP). To produce or view digital health certificates, users must first register with BigchainDB. Holders and verifiers have read-only access while the issuer has read-write access to upload test findings and ensure tamper-free. Holders can send the test results to verifiers via QR codes. This research study uses BigchainDB as the blockchain database in its execution. Then, DHP is assessed in light of the specifications for smart healthcare and the salient characteristics of blockchain technology. The evaluation and discussions present that the DHP is secured, immutable and traceable.

3] This article offers a cutting-edge solution for health identity, EHRs, and privacy using blockchain technology. This article offers a cutting-edge solution for health identity, EHRs, and privacy using blockchain technology. Individuals' identifying information and their health records are handled separately in this design of the blockchain-based health record system. An identity blockchain system houses the identity data. Through this system, healthcare providers, insurers, and governmental organizations can confirm a person's identity. The medical records are kept on a blockchain system for medical records.

4] This article describes the architecture of a Blockchain subsystem to manage access through Digital Identity to the Electronic Medical Record of patients. When a clinician has to access a patient's EHR data, the suggested solution is intended to address such a situation. The technique states that there should be two phases to the subsystem's development. The Smart Contract Part and the External Part are these two components. The first one will contain the module that controls patient data access and authorizations, as well as the policies that will direct how the subsystem functions. The external component will make it easier for users to access the application through a graphical user interface.

5] This paper describes a decentralized identity management system built on blockchain technology that enables patients and healthcare professionals to identify and authenticate themselves securely and transparently across various eHealth domains. Health identifiers allow patients and healthcare professionals to be identified in a unique way (healthIDs). A healthcare regulator certifies the identity traits, they are listed on the blockchain, and the identity owner stores them. The paper established smart contracts on a blockchain operated by the Ethereum consortium to facilitate authentication and identity processes.

6] In order to provide data privacy, data accessibility, and data interoperability for the healthcare-specific scenario, this article investigates the likelihood of portraying medical records. To access Smart Contracts supported by EHRs as information intermediaries, it created a substantial information infrastructure. Blockchain technology's decentralized structure helps make the EHR accessible across a wider network. By offering immutable, authentic, and accessible medical information, privacy, and quicker payments, the Blockchain enables the healthcare sector to undergo significant change.

7] In the proposed study, a blockchain-based architecture for the Electronic Health Record (EHR) would be framed. The suggested system consists of two steps, the first of which is block formation, and the second of which is data security utilizing the Elliptic Curve Cryptography (ECC) Algorithm. The system was developed using Ethereum. The patient, doctor, and administrator are the participants in the proposed system. Each participant has a position to perform, such as a patient, doctor, or administrator, as well as the ability to update, add, delete, and see information. Throughput, latency, and execution time are employed as the system's evaluation criteria.

8] This document proposes a comprehensive literature review to investigate recent literature on Blockchain and the healthcare domain in order to identify existing obstacles and unanswered concerns concerning EHRs in a Blockchain. The review intends to answer research concerns about EHR in a Blockchain, such as taxonomy, problems, principles, healthcare protocols and standards, and Blockchain architectural kinds, models, and techniques. The article examines the benefits and pitfalls of adopting Blockchain for EHRs in healthcare, including interoperability, privacy, access control, auditability, and scalability issues. Interoperability, privacy, and permission are among the primary problems and challenges. OpenEHR, HL7 FHIR, HIPAA, GDPR, IHE, ISO, SNOMED, DICOM, HIE, and PII are among the healthcare protocols and standards identified in the review.

9] Future study on legislation, standardisation, and cross-border health data retrieval rules, including retention and usage intention, is critically needed, according to this paper. It also addresses the potential issue of blockchain scalability and performance in storing and processing large amounts of data in a timely manner. It employs novel processes and algorithms to reduce mining latency in private and public blockchains.

10] According to this research, various methods are proposed to address some of the obstacles and constraints of adopting blockchain in health IT systems. One possibility, for example, is to keep the encrypted health data outside of the blockchain. Another option is to adhere to a stringent software development process and use all known security protections during code development to avoid the majority of security concerns.

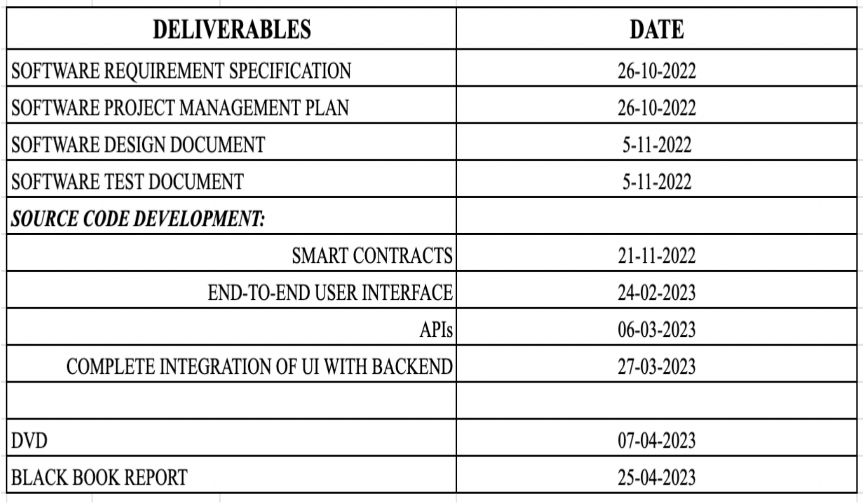
Chapter 3

Software Project Management Plan

3.1 Project Deliverables

After 12 weeks from the start of the project, the first module will be delivered. The entire product will be delivered within 7 months. The following are the project deliverables: Software Requirements Specification (SRS), Software Project Management Plan (SPMP), Software Design Document (SDD), Working Software Product with User Interface and Functions, DVD, and Black Book Report.

Figure 3.1: Deliverables



DELIVERABLES	DATE
SOFTWARE REQUIREMENT SPECIFICATION	26-10-2022
SOFTWARE PROJECT MANAGEMENT PLAN	26-10-2022
SOFTWARE DESIGN DOCUMENT	5-11-2022
SOFTWARE TEST DOCUMENT	5-11-2022
SOURCE CODE DEVELOPMENT:	
SMART CONTRACTS	21-11-2022
END-TO-END USER INTERFACE	24-02-2023
APIs	06-03-2023
COMPLETE INTEGRATION OF UI WITH BACKEND	27-03-2023
DVD	07-04-2023
BLACK BOOK REPORT	25-04-2023

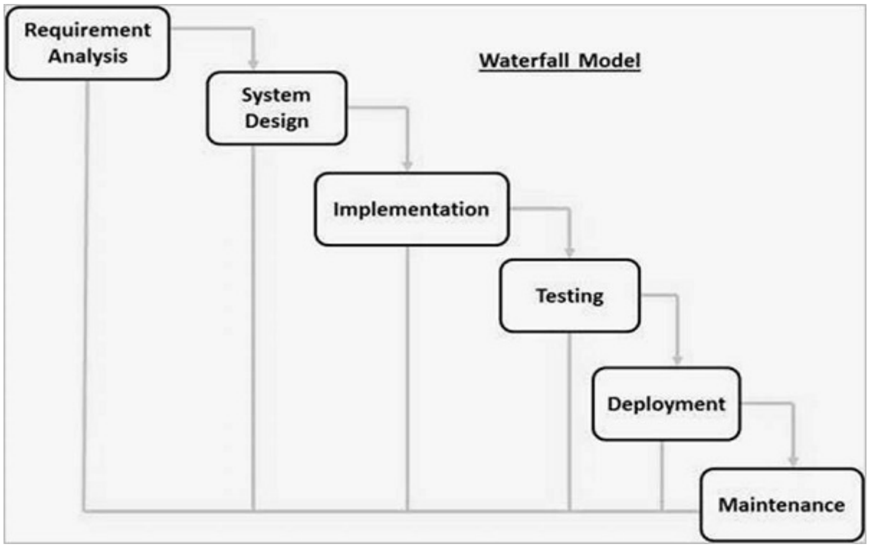
3.2 Project Organization

3.2.1 Software Process Model

The waterfall model depicts the software development process in a linear sequential flow. Due to this, it is also referred to as a linear-sequential life cycle model, which indicates that any development process steps can start after the previous one has finished. The stages are always done in this order. The model is called a waterfall because it progresses from one phase to the next logically.

In our project, we will first develop a unique health identity will be generated via Smart Contracts, in the form of an NFT that will store the user's personal as well as health-related information, which is constant throughout to maintain the non-fungible nature of NFTs since we cannot have a functional UI without this implementations. Then we will develop static webpages in React.js. And in final build phase we will integrate all. In our project, software requirements and technology stack is already decided, it will suitable to follow Waterfall model.

Figure 3.2: Waterfall Model



3.2.2 Tools and techniques

1. SRS, SPMP, SDD, and STD Document: Overleaf

2. Blockchain: Solidity and Metamask

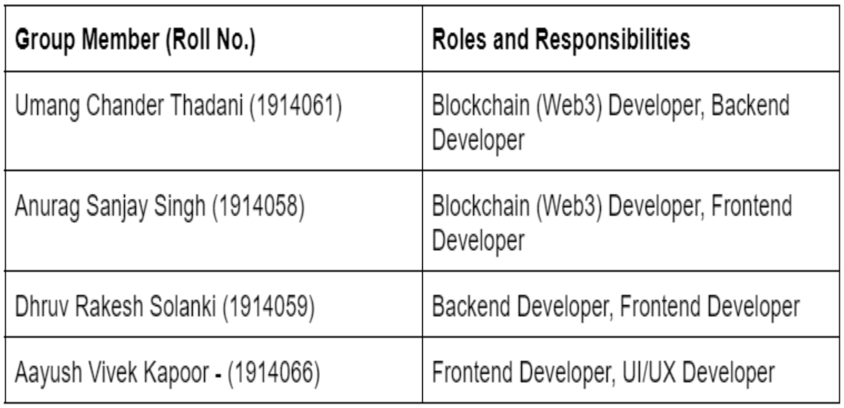
3. Back End: Django REST Framework

4. Database: PostgreSQL

5. Front End: React.js and Tailwind CSS

3.2.3 Roles and Responsibilities

Figure 3.3: Roles and Responsibilities



Group Member (Roll No.)	Roles and Responsibilities
Umang Chander Thadani (1914061)	Blockchain (Web3) Developer, Backend Developer
Anurag Sanjay Singh (1914058)	Blockchain (Web3) Developer, Frontend Developer
Dhruv Rakesh Solanki (1914059)	Backend Developer, Frontend Developer
Aayush Vivek Kapoor - (1914066)	Frontend Developer, UI/UX Developer

3.3 Project Management Plan

3.3.1 Tasks

1. Requirement Anaylsis

Description

Following elicitation, requirement analysis is an important and necessary activity. To create consistent and unambiguous requirements, we analyse, refine, and scrutinise the gathered requirements. This activity goes over all of the requirements and may show a graphical representation of the entire system. The project's understandability is expected to improve significantly following the completion of the analysis. We can also use the customer interaction to clear up any points of confusion and determine which requirements are more important than others.

Deliverables and Milestones

Completion of SRS Document and Synopsis

Resources and Dependencies

Stakeholders must be present to give inputs in order to obtain desired results, Whitepapers and websites.

Risks and Contingencies

Absence of stakeholders may lead to ambiguity in requirements.

2. Identification of Tasks and Subtasks

Description

Project management is heavily reliant on tasks. It is critical to know how to manage tasks effectively and efficiently if you want to complete your project efficiently and effectively.

Deliverables and Milestones

Tasks and subtasks identified and Risks evaluated with Task Sheet

Resources and Dependencies

SRS Document.

Risks and Contingencies

We must ensure that no tasks are left behind unidentified.

3. Schedule Preparation

Description

Another important aspect of project management is scheduling. Scheduling is important when it comes to all of the tasks and activities that make up the project as a whole. Project management can be done in a variety of ways, ranging from the more traditional to the most cutting-edge software. The goal of project management is to achieve the project's goals successfully, on time and on budget, whether internally or externally for a client.

Deliverables and Milestones

Completion of SPMP Document and Gantt chart

Resources and Dependencies

SRS and Task Sheet

Risks and Contingencies

We must ensure that schedule is foolproof.

4. Identifying Goals and Priorities

Description

We can handle a small problem at a time, but for a larger problem, divide the problems and conquer the problem means breaking the problem down into smaller pieces and capturing each piece separately.

Deliverables and Milestones

Basis for SDD is ready

Resources and Dependencies

SRS and SPMP Document

5. Constructing Designs

Description

The first step in the SDLC (Software Design Life Cycle) is software design, which shifts the focus from the problem domain to the solution domain. It tries to specify how to meet the requirements outlined in the SRS.

Deliverables and Milestones

Completion of SDD

Resources and Dependencies

SRS and SPMP Document, and Goals must be identified

Risks and Contingencies

We must ensure that all designs are constructed carefully.

6. UI Development

Description

This task involves creation of different modules for different webpages along with the styles and UX so that the UI looks clean and user friendly

Deliverables and Milestones

Complete Front End is ready

Resources and Dependencies

1. React.js
2. SRS, SPMP and SDD Document

Risks and Contingencies

There may be some instances where the UI crashes or has a loophole for unauthorized data access

7. UI Testing

Description

Testing the user interface (UI) is an important part of the software testing process. To ensure that applications have the desired functionalities and are user-friendly, they must be tested.

Deliverables and Milestones

Testing is completed on the UI part.

Resources and Dependencies

UI must be ready.

Risks and Contingencies

We must ensure that all test cases are considered.

8. Functional Development

Description

All requirements as mentioned in the SRS Document are implemented.

Deliverables and Milestones

Software Development is completed.

Resources and Dependencies

1. Django REST Framework
2. PostgreSQL
3. SRS, SPMP and SDD Document

Risks and Contingencies

There might be times when the product fails to deliver its purpose. The solution is to try and make the software fail-proof

9. Functional Testing

Description

The last step involved in wrapping up the Software is testing all of its functionality.

Deliverables and Milestones

Testing is completed on the entire product.

Resources and Dependencies

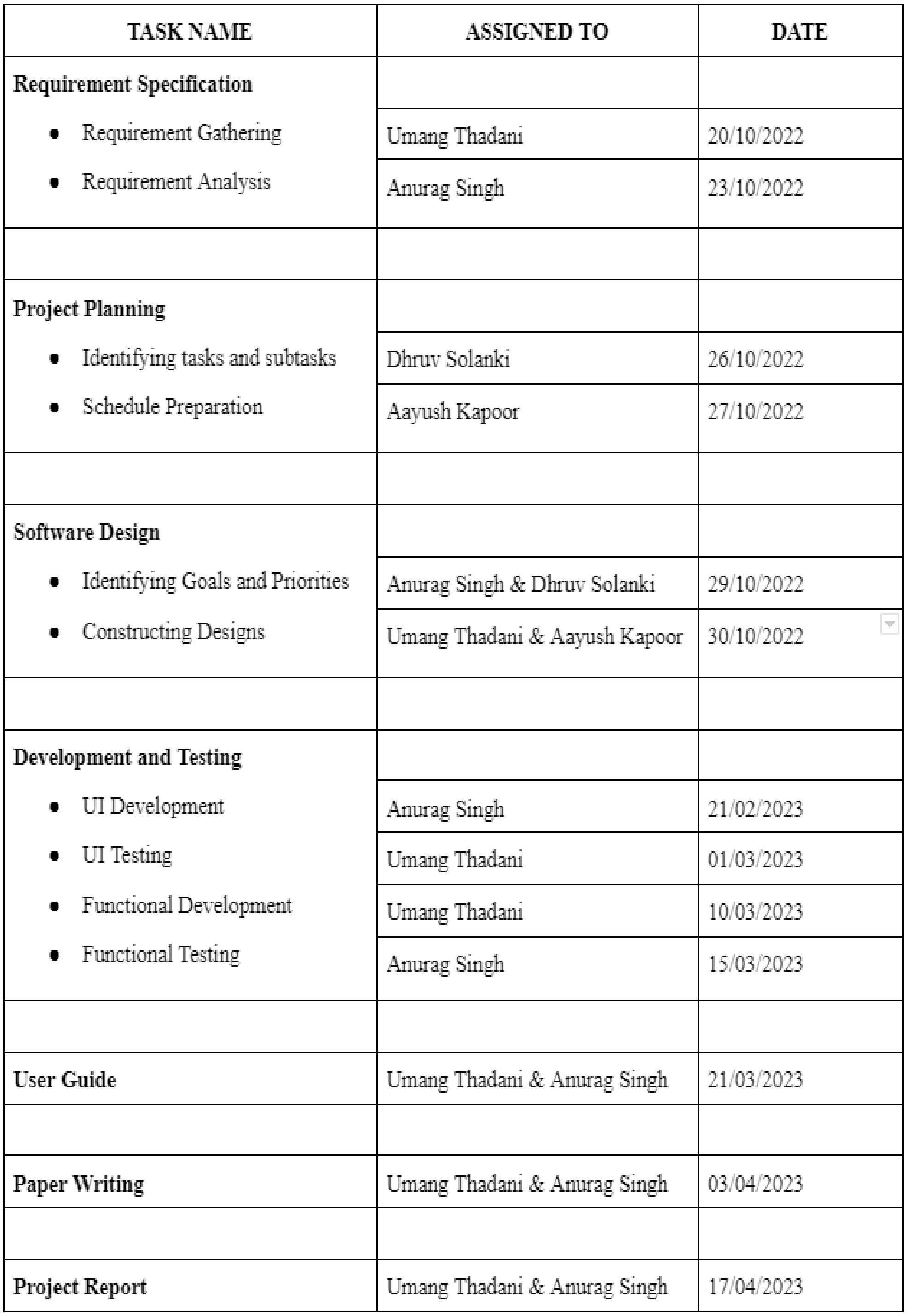
1. Software Development must be completed.
2. pytest: Testing framework

Risks and Contingencies

We must ensure that all test cases are considered.

3.3.2 Assignments

Figure 3.4: Assignments



TASK NAME	ASSIGNED TO	DATE
Requirement Specification		
• Requirement Gathering	Umang Thadani	20/10/2022
• Requirement Analysis	Anurag Singh	23/10/2022
Project Planning		
• Identifying tasks and subtasks	Dhruv Solanki	26/10/2022
• Schedule Preparation	Aayush Kapoor	27/10/2022
Software Design		
• Identifying Goals and Priorities	Anurag Singh & Dhruv Solanki	29/10/2022
• Constructing Designs	Umang Thadani & Aayush Kapoor	30/10/2022
Development and Testing		
• UI Development	Anurag Singh	21/02/2023
• UI Testing	Umang Thadani	01/03/2023
• Functional Development	Umang Thadani	10/03/2023
• Functional Testing	Anurag Singh	15/03/2023
User Guide	Umang Thadani & Anurag Singh	21/03/2023
Paper Writing	Umang Thadani & Anurag Singh	03/04/2023
Project Report	Umang Thadani & Anurag Singh	17/04/2023

Chapter 4

Software Requirements Specification

4.1 Intended Audience and Requirement Specification

This SRS is for developers, project managers, users, and testers. Further, the discussion will provide all the external, functional, and non-functional requirements of ”HealthKard - Decentralized User Health Identity and Health Records Management with Web3, IPFs and the Ethereum Blockchain”.

4.2 External Interface Requirements

4.2.1 Hardware Interfaces

The system will be lightweight and be used on any hardware with at least 1GB of RAM. No specific hardware components will be used.

4.2.2 Software Interfaces

The software will incorporate best-in-class frameworks libraries for Front-end and Back-end and software requirements are stated with respect to support for these frameworks. Following are the software interfaces that will be used in HealthKard

- MetaMask v10.20.0 for authenticating users into our application

- Ethereum blockchain to store user data and health records in a secure, tamper-proof manner.
- Multimedia documents and other relevant information will be stored on Interplanetary File System (IPFS)

4.2.3 Communications Interfaces

Communication interfaces are those that belong to communication functions. We plan to make use of the following communication interfaces:

- The software will be developed and tested for Chrome 105+, Edge 105+, Safari 15.6+, and Firefox 105+
- Web3Modal will be used to call MetaMask and authenticate users
- We will use IPFS-HTTP Client to communicate with Interplanetary File System through our web application
- HTML forms will be used to gather user data, which will be sent to the Back-end through Axios and Rest APIs and related frameworks.
- Email will be used to answer any user queries, that will make use of SMTP protocol

4.3 Functional Requirements

4.3.1 MetaMask Authentication for authenticating the user

MetaMask is an extension for accessing Ethereum-enabled distributed applications, or ”DApp” in your browser. It also lets the user create and manage their own identities, so when a DApp wants to perform a transaction and write to the blockchain, the user gets a secure interface to review the transaction, before approving or rejecting it. It also helps warn you when you navigate to sites known to have engaged in phishing or with names that are suspiciously similar to popular phishing targets. We will allow users to authenticate to our application using MetaMask.

4.3.2 Unique Health ID Generation

A unique health identity will be generated via Smart Contracts, in the form of an NFT that will store the user's personal as well as health-related information, which is constant throughout to maintain the non-fungible nature of NFTs. This unique ID will help us map users' health records. Also, this will enable accessing personal health records, based on international standards, easily accessible to individuals and healthcare professionals and services providers, based on individual's informed consent.

4.3.3 Health and Consultation History

The user's health history, previous consultation reports, doctor's remarks, and diagnoses will be saved and secured on the blockchain which makes it immutable. This will be mapped uniquely to the User's Health ID and can only be accessed through the individual's informed consent.

4.4 Nonfunctional Requirements

4.4.1 Usability

Usability is a quality attribute that assesses how easy user interfaces are to use. The word ”usability” also refers to methods for improving ease of use during the design process.
Usability is defined by 5 quality components:

- Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design?
- Efficiency: Once users have learned the design, how quickly can they perform tasks?
- Memorability: When users return to the design after a period of not using it, how easily can they re-establish proficiency?
- Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
- Satisfaction: How pleasant is it to use the design?

4.4.2 Security

Security is a non-functional requirement assuring all data inside the system or its part will be protected against malware attacks or unauthorized access. Our application will only let the users authenticate to the system via their own MetaMask wallet while doctors and health experts can only view a patient's data after their consent.

4.4.3 Correctness

Our system will always display the correct and latest health records of the user since all of their data is stored on the blockchain which guarantees security, and immutability and acts as a single source of truth.

4.4.4 Maintainability

Maintainability defines the time required for a solution or its component to be fixed, changed to increase performance or other qualities, or adapted to a changing environment. Like reliability, it can be expressed as a probability of repair during some time. Since the backbone of our application uses the Ethereum blockchain, which has a 99.95% up-time, our systems will also be running 24/7 without any maintenance downtime. Also, we plan to maintain modular code so that the project can be taken forward or modified with changing requirements without any hassles.

4.4.5 Legal

Our health record storage will adopt the open standards by all national digital health stakeholders i.e. the NITI Aayog, IMHA, etc.

Chapter 5

Software Design Description

5.1 Introduction

5.1.1 Design Overview

HealthKard aims to develop the foundations necessary for supporting digital health infrastructure for maintaining health data in a decentralized and secure way. A few major advantages to this project will be ease of access, user consent for every sophisticated transaction, and portability across national borders.

HealthKard aims to implement the following modules:

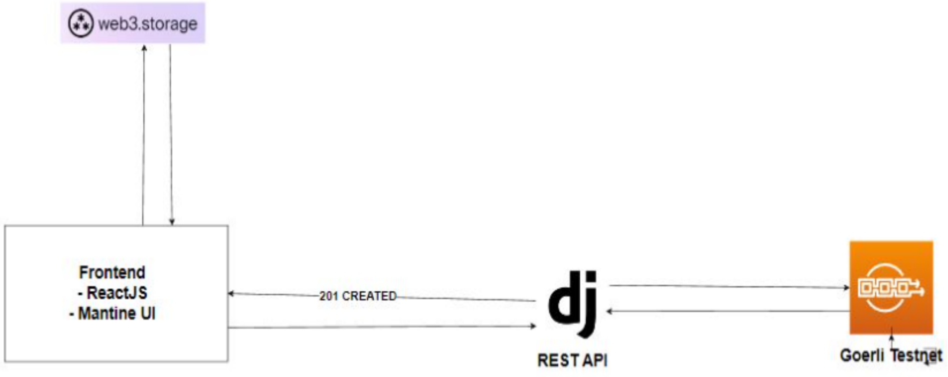
- Creation of a unique Health ID using Aadhaar Number.
- Storage of Electronic Health Records (EHRs) mapped to Health Identity in the blockchain.
- Integration of different sectors in the medical industry.
- Encourage better administration of the health sector by utilizing health data analytics.

5.2 System Architectural Design

5.2.1 Client-Server Architecture

We choose client-server architecture for our system. There are two types of clients: Normal Users and Health Experts, each having a different interface. Both of these types of users interact with the same server with a common database and blockchain. Therefore, we separate concerns for application program and data management in our system.

Figure 5.1: Architecture



5.2.2 Model-View-Controller

This is our second choice of architectural design. We chose Client-Server over MVC due to the fact that there is minimal dynamic content and need for dependency mechanism since the entire data needs to be changed, if any changes are applicable, only when the page reloads.

5.2.3 System Interface Description

Ethtreum Blockchain

We use the Ethereum Blockchain to save users' health records linked to the respective users' MetaMask account. The users' MetaMask Account is further linked to their Aadhar Card number.

File System

We use a modular file system where the Front End and Back End of the application are separated into different modules to improve maintainability.

Hardware Interfaces

1. Processor: x86 or x64
2. RAM: 512 MB (minimum), 1 GB (recommended)
3. Hard disk: up to 512 MB of available space may be required.

Software Interfaces

1. Operating System: Any OS that can support a gunicorn server.
2. Front End Stack: ReactJS, Recoil, MUI, TailwindCSS.
3. Back End Stack: Django REST Framework, PostgreSQL.
4. Browser Requirements: Any modern web browser having MetaMask extension.

Communication Protocols

1. The client side and the server endpoint will communicate using standard HTTP (Hyper Text Transfer Protocol) which is a generic stateless protocol.
2. The email system will use the SMTP protocol.

5.3 Detailed Description of Components

5.3.1 Authentication

1. Allow new users to login/register.
2. Verify their identity using the Aadhar APIs.
3. Change Password and Logout
4. Create profile for Health Expert.

5.3.2 Health Card creation

1. Link users' MetaMask to their Aadhar Card.

2. Save users' Health Records over the Blockchain.

3. Allow health experts to access users' data only after their consent.

5.3.3 Epidemic Analysis

1. Collecting anonymous health symptoms.

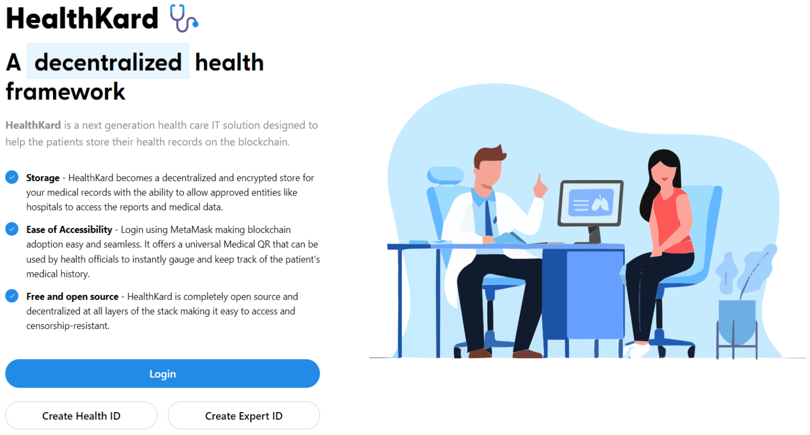
2. Analyzing anonymous health data and predicting the spread of a disease in a region.

5.4 Landing Page

A landing page is any web page that a customer can land on, but in marketing, it's usually a standalone page that serves a single and focused purpose, separate from your homepage or any other page.

5.4.1 Screen Images

Figure 5.2: Landing Page



HealthKard

A decentralized health framework

HealthKard is a next generation health care IT solution designed to help the patients store their health records on the blockchain.

- ✓ **Storage** - HealthKard becomes a decentralized and encrypted store for your medical records with the ability to allow approved entities like hospitals to access the reports and medical data.
- ✓ **Ease of Accessibility** - Login using MetaMask making blockchain adoption easy and seamless. It offers a universal Medical QR that can be used by health officials to instantly gauge and keep track of the patient's medical history.
- ✓ **Free and open source** - HealthKard is completely open source and decentralized at all layers of the stack making it easy to access and censorship-resistant.

5.4.2 Objects and Actions

Hero Image:

It is just a simple image used to beautify the Design

Description:

It showcases the features and short description of our web application

Action Buttons:

We have the following buttons here

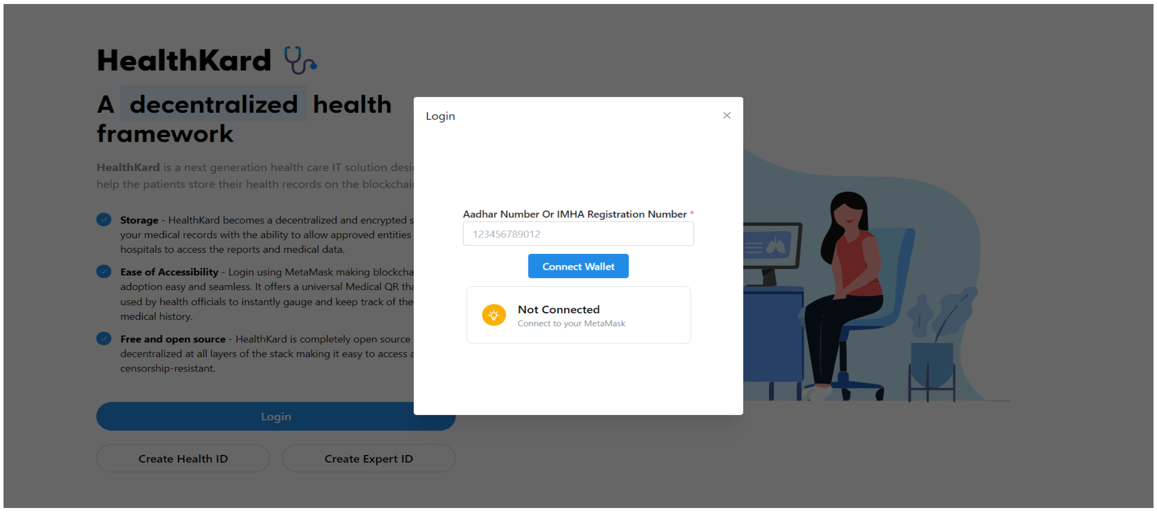
1. Login: If you already have an account, simple connect your wallet and add your Aadhar (For Patients) and IMHA (For Health Experts)
2. Create Health ID: Patients can click on this button and go ahead with creating their health identity
3. Create Expert ID: Health Experts can click on this button and go ahead with creating their expert identity

5.5 Login

The modal is for users to login using their MetaMask and Aadhar ID (For Patients) or IMHA Registration Number (For Health Experts).

5.5.1 Screen Images

Figure 5.3: Login Page



HealthKard

A decentralized health framework

HealthKard is a next generation health care IT solution desi
help the patients store their health records on the blockchai

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- **Ease of Accessibility** - Login using MetaMask making blockcha adoption easy and seamless. It offers a universal Medical QR tha used by health officials to instantly gauge and keep track of the medical history.
- **Free and open source** - HealthKard is completely open source decentralized at all layers of the stack making it easy to access a censorship-resistant.

Login

Aadhar Number Or IMHA Registration Number *

123456789012

Not Connected

Connect to your MetaMask

5.5.2 Objects and Actions

Connect Wallet

It comprises of the current connection status and asks the user to connect if not connected.

Aadhar or IMHA Input

Patients enter their Aadhar ID or IMHA mapped to their HealthKard to login

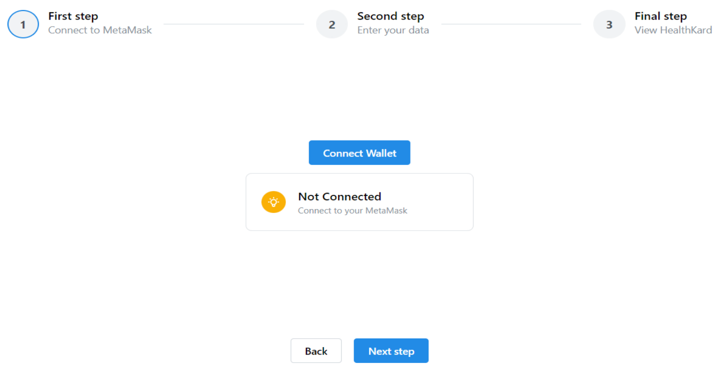
5.6 Create Patient HealthKard

This page asks the user to enter their details to be submitted on the card and create an NFT.

5.6.1 Connect Metamask Wallet

Screen Images

Figure 5.4: Connect Wallet



1 First step
Connect to MetaMask

2 Second step
Enter your data

3 Final step
View HealthKard

Not Connected
Connect to your MetaMask

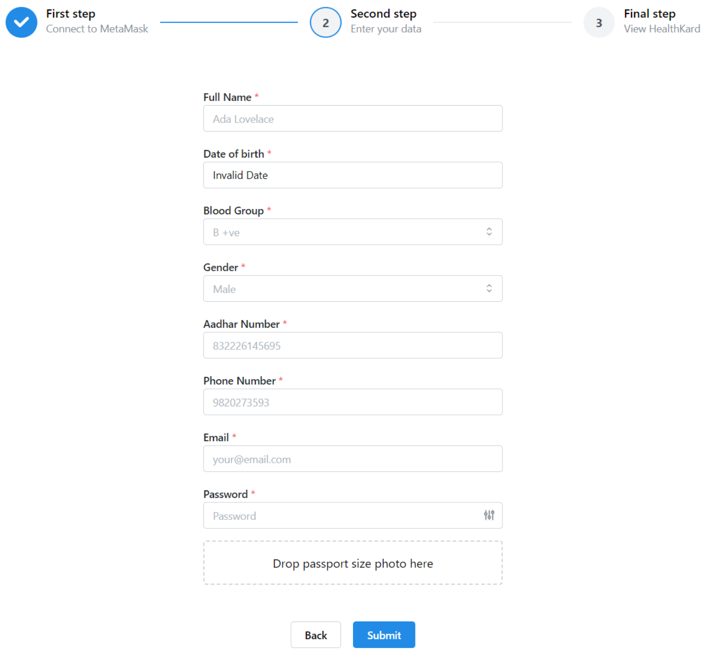
Objects and Actions

Connect Wallet: Connect your metamask wallet to the portal

5.6.2 Patient Form

Screen Images

Figure 5.5: Patient Form



Full Name * Ada Lovelace

Date of birth * Invalid Date

Blood Group * B +ve

Gender * Male

Aadhar Number * 832226145695

Phone Number * 9820273593

Email * your@email.com

Password * Password

Drop passport size photo here

Objects and Actions

Form Fields: The following form fields are required to be filled in order to create a HealthKard

1. Full Name
2. Date of Birth
3. Blood Group

4. Gender

5. Aadhar Number

6. Phone Number

7. Email

8. Password

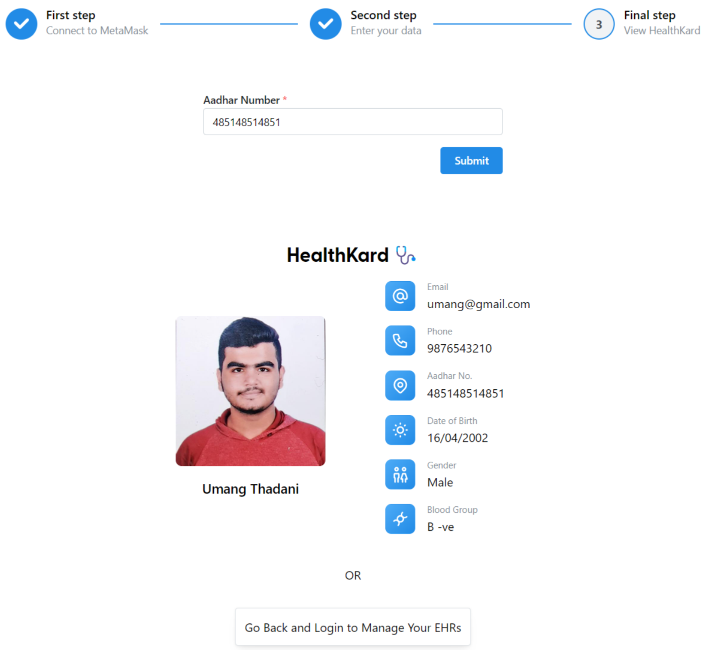
9. Passport size photo

5.6.3 Patient HealthKard

This page shows the user's HealthKard.

Screen Images

Figure 5.6: Patient Card



Aadhar Number * 485148514851

Umang Thadani

Email umang@gmail.com

Phone 9876543210

Aadhar No. 485148514851

Date of Birth 16/04/2002

Gender Male

Blood Group B -ve

Objects and Actions

View the patient's health card by fetching details from the blockchain.

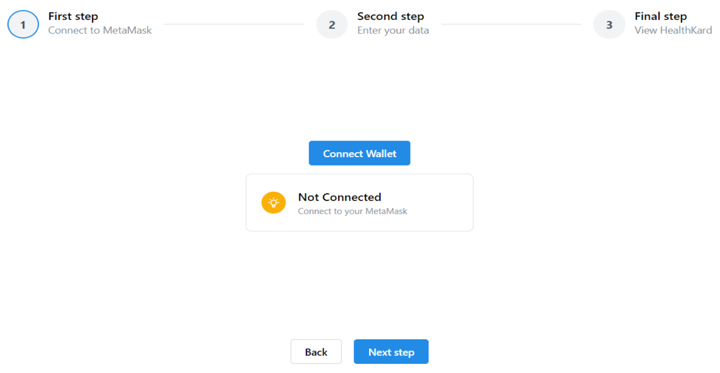
5.7 Create Expert HealthKard

This page asks the user to enter their details to be submitted on the card and create an NFT.

5.7.1 Connect Metamask Wallet

Screen Images

Figure 5.7: Connect Wallet



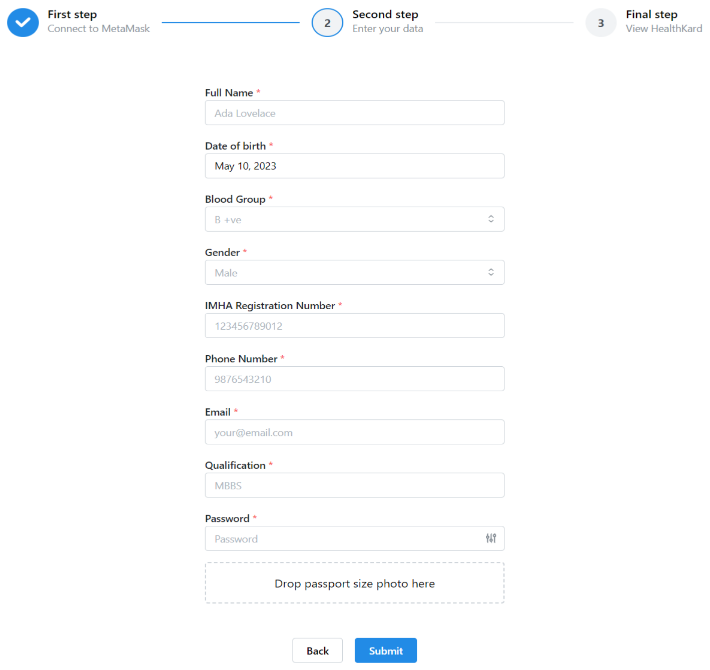
Objects and Actions

Connect Wallet: Connect your metamask wallet to the portal

5.7.2 Expert Form

Screen Images

Figure 5.8: Expert Form



Full Name *
Ada Lovelace

Date of birth *
May 10, 2023

Blood Group *
B +ve

Gender *
Male

IMHA Registration Number *
123456789012

Phone Number *
9876543210

Email *
your@email.com

Qualification *
MBBS

Password *
Password

Drop passport size photo here

Objects and Actions

Form Fields: The following form fields are required to be filled in order to create a HealthKard

1. Full Name
2. Date of Birth
3. Blood Group

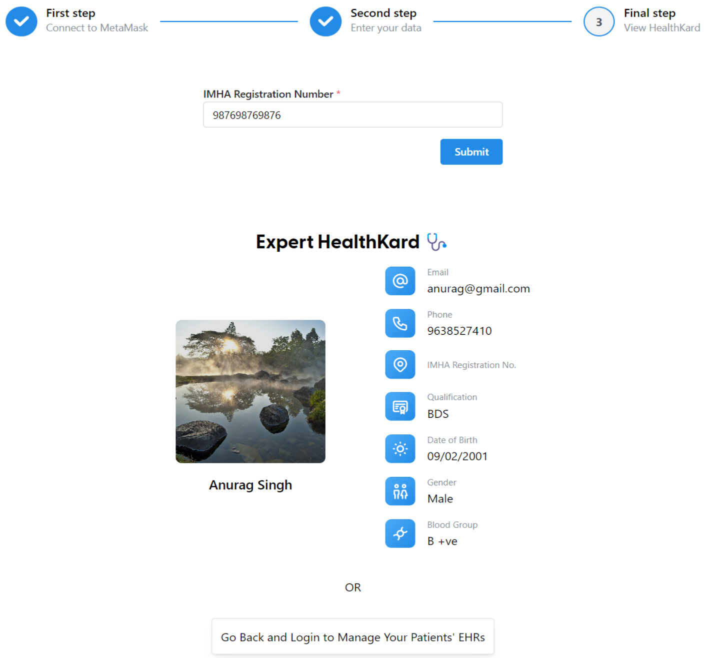
4. Gender
5. IMHA Registration Number
6. Phone Number
7. Email
8. Qualification
9. Password
10. Passport size photo

5.7.3 Expert HealthKard

This page shows the user's HealthKard.

Screen Images

Figure 5.9: Expert Card



IMHA Registration Number *
987698769876

Expert HealthKard

Anurag Singh

Email
anurag@gmail.com

Phone
9638527410

IMHA Registration No.

Qualification
BDS

Date of Birth
09/02/2001

Gender
Male

Blood Group
B +ve

Objects and Actions

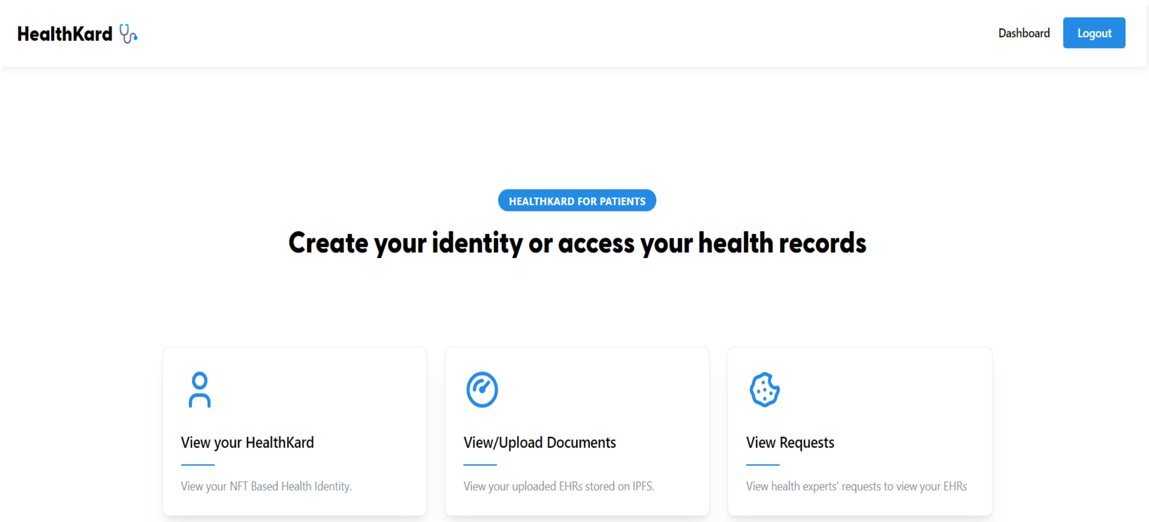
View the patient's HealthKard by fetching details from the blockchain.

5.8 Patient Dashboard

This page shows the patient's dashboard.

5.8.1 Screen Images

Figure 5.10: Patient Dashboard



Create your identity or access your health records

View your HealthKard

View your NFT Based Health Identity.

View/Upload Documents

View your uploaded EHRs stored on IPFS.

View Requests

View health experts' requests to view your EHRs

5.8.2 Objects and Actions

Patient Profile

Redirects you to your profile page

View/Upload Documents

Redirects you to a page where you can manage your Health Records

View Requests

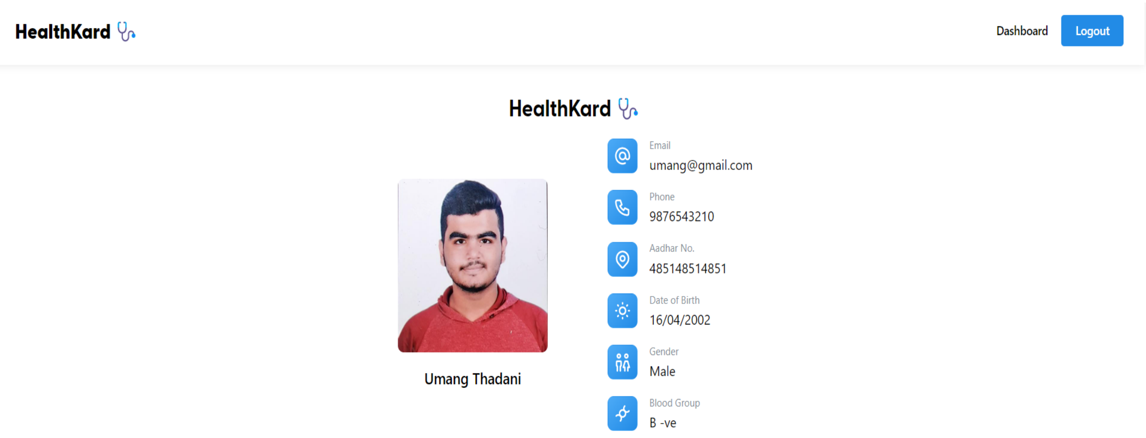
Redirects you to a page where you can manage access of your Health Records

5.9 Patient Profile

This page shows the patient's HealthKard.

5.9.1 Screen Images

Figure 5.11: Patient Profile



Umang Thadani

Email
umang@gmail.com

Phone
9876543210

Aadhar No.
485148514851

Date of Birth
16/04/2002

Gender
Male

Blood Group
B -ve

5.9.2 Objects and Actions

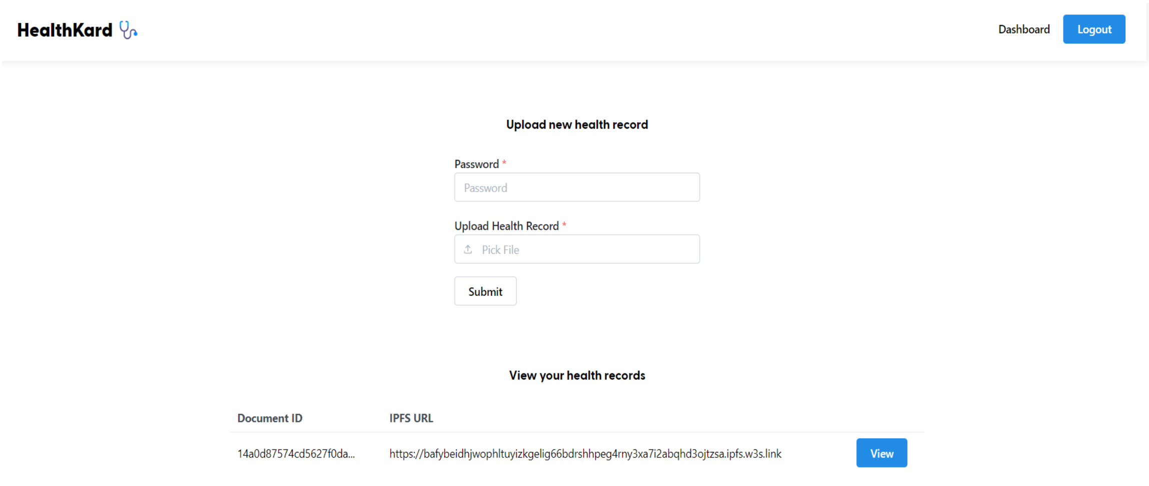
View the patient's HealthKard by fetching details from the blockchain.

5.10 View/Upload your Documents

This page shows the documents owned by the patients with the ability to upload another EHR.

5.10.1 Screen Images

Figure 5.12: Manage Documents



Upload new health record

Password *

Upload Health Record *

View your health records

Document ID	IPFS URL	
14a0d87574cd5627f0da...	https://bafybeidhjwophltuyizkgelig66bdrshhpeg4rny3xa7i2abqhd3ojtzsa.ipfs.w3s.link	View

5.10.2 Objects and Actions

Upload EHR Form

The form consists of two fields:

1. Password: The one that the patient had used while creating their health identity.

2. Document: The EHR they want to store.

List of Documents

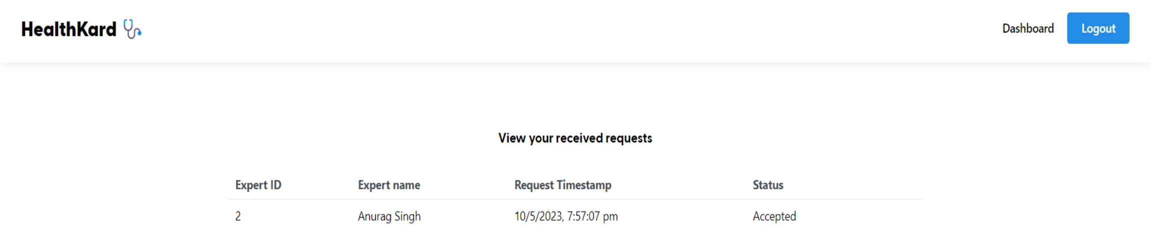
This is a list with all the documents that you have uploaded till date.

5.11 View Requests

This page shows all the requests that a patient has received with respect to EHR access

5.11.1 Screen Images

Figure 5.13: Requests List



View your received requests

Expert ID	Expert name	Request Timestamp	Status
2	Anurag Singh	10/5/2023, 7:57:07 pm	Accepted

5.11.2 Objects and Actions

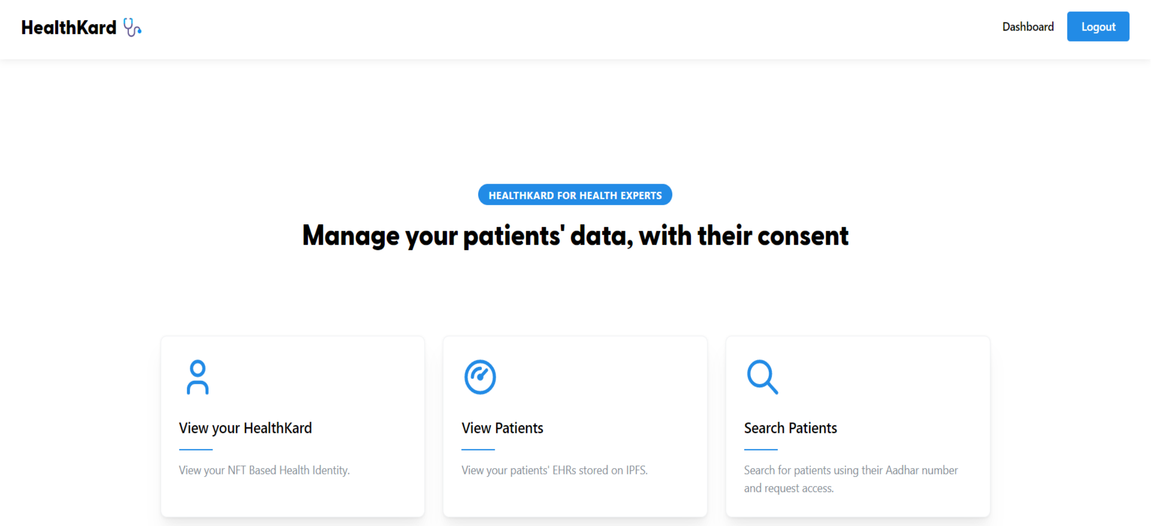
Patients can Accept or Deny a request from an Health Expert to access their EHRs

5.12 Expert Dashboard

This page shows the patient's dashboard.

5.12.1 Screen Images

Figure 5.14: Expert Dashboard



HEALTHKARD FOR HEALTH EXPERTS

Manage your patients' data, with their consent

View your HealthKard

View your NFT Based Health Identity.

View Patients

View your patients' EHRs stored on IPFS.

Search Patients

Search for patients using their Aadhar number and request access.

5.12.2 Objects and Actions

Expert Profile

Redirects you to your profile page

View Patients

Redirects you to a page where you can manage all of your Patients and their Health Records

Search Patients

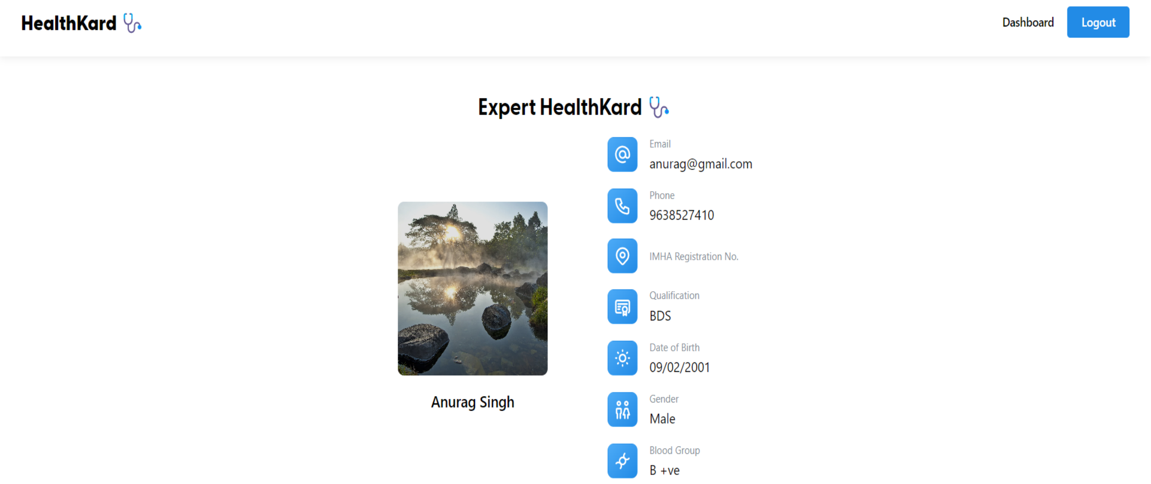
Redirects you to a page where you can search for a patient and request access of their Health Records

5.13 Expert Profile

This page shows the user's HealthKard.

5.13.1 Screen Images

Figure 5.15: Expert Profile



Expert HealthKard

Anurag Singh

Email
anurag@gmail.com

Phone
9638527410

IMHA Registration No.

Qualification
BDS

Date of Birth
09/02/2001

Gender
Male

Blood Group
B +ve

5.13.2 Objects and Actions

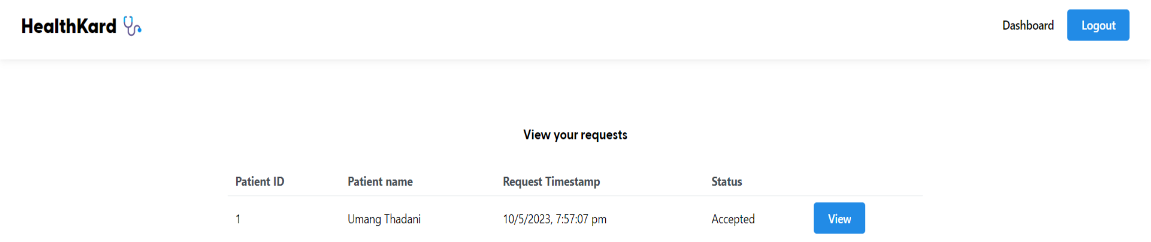
View the expert's health card by fetching details from the blockchain.

5.14 Patients List

This page shows the list of all those patients that the expert has requested access from along with the status of access (ACCEPTED, PENDING, DENIED)

5.14.1 Screen Images

Figure 5.16: Patients List



View your requests

Patient ID	Patient name	Request Timestamp	Status	
1	Umang Thadani	10/5/2023, 7:57:07 pm	Accepted	View

5.14.2 Objects and Actions

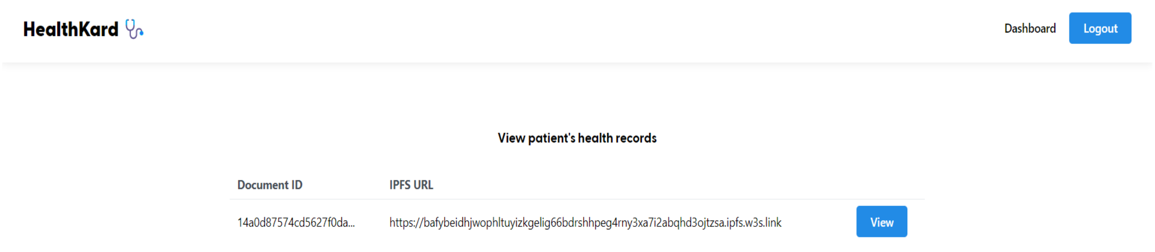
View the list of patients along with the access status. If access is granted, you will find a ”View” button in front of the Patient, which will redirect you to a page with that patient’s EHRs

5.15 Patient Documents

This page lists that patient’s documents.

5.15.1 Screen Images

Figure 5.17: Patient EHRs



View patient's health records

Document ID	IPFS URL	
14a0d87574cd5627f0da...	https://bafybeidhjwophltuyizkgelig66bdrshhpeg4rny3xa7i2abqhd3ojtzsa.ipfs.w3s.link	View

5.15.2 Objects and Actions

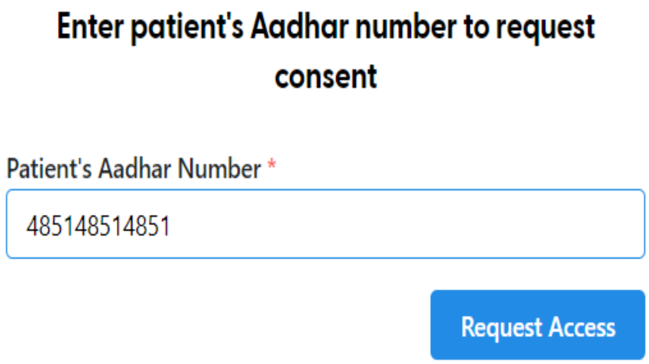
View the list of a particular patient's health records if you have been granted access by them. You will find a "View" button in front of each EHR, which will open a modal to access their records

5.16 Search Patient

This page allows searching for a particular patient and requesting access.

5.16.1 Screen Images

Figure 5.18: Search Patient



Enter patient's Aadhar number to request consent

Patient's Aadhar Number *

485148514851

5.16.2 Objects and Actions

Aadhar Input

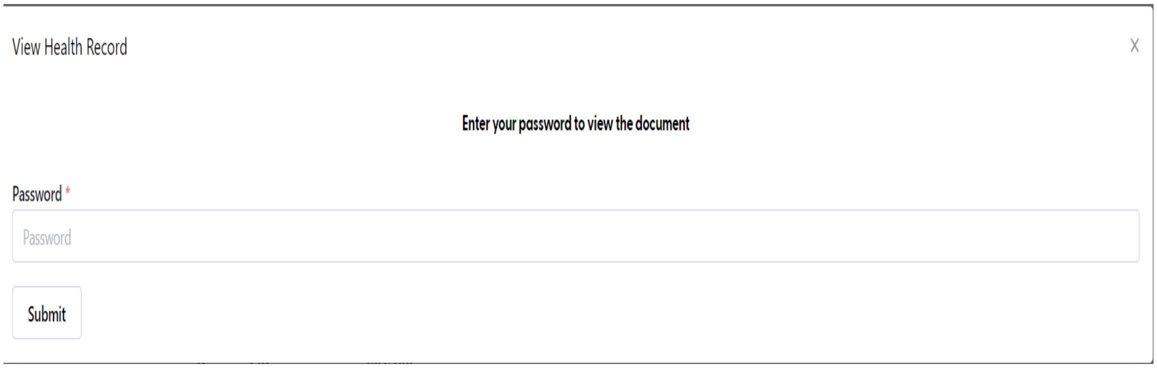
Enter Aadhar Number of the patient for whom you want access to their records.

5.17 Document Access - Enter Password

This page asks users, both Health Experts and Patients to enter their passwords in order to view an EHR.

5.17.1 Screen Images

Figure 5.19: Enter Password



View Health Record

Enter your password to view the document

Password *

Password

5.17.2 Objects and Actions

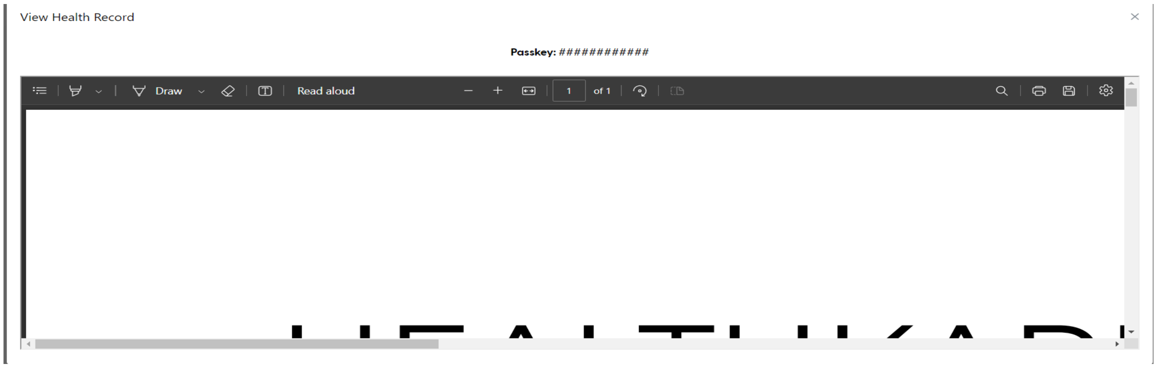
Patients can access their own EHRs and Experts can access their patients' EHR by entering their individual passwords here

5.18 Document Access - View EHR

This page shows the patient's EHR along with a passkey to decrypt the same.

5.18.1 Screen Images

Figure 5.20: Health Record



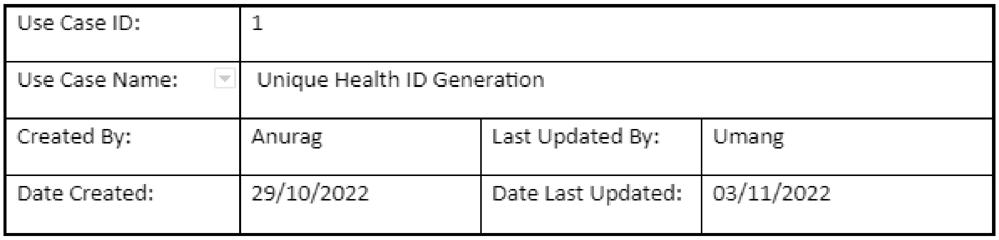
View Health Record

Passkey: ############

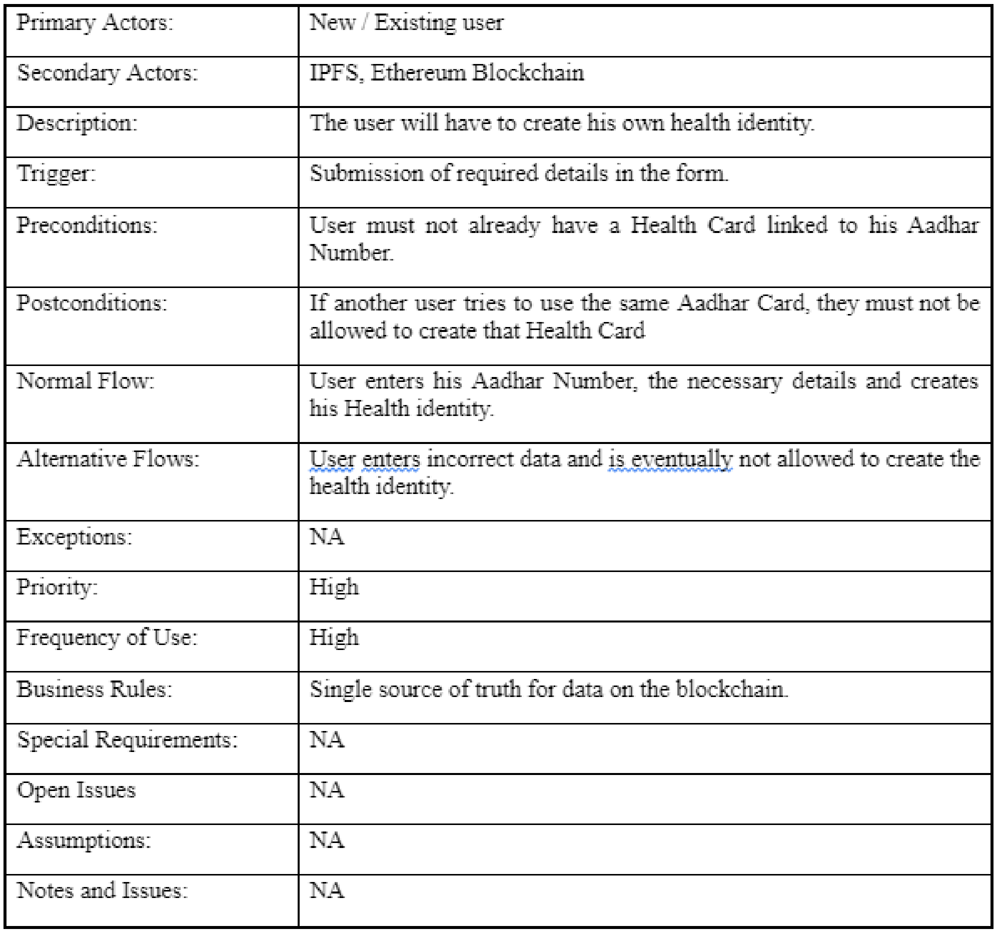
5.18.2 Objects and Actions

View the patient's health record by entering the passkey as mentioned.

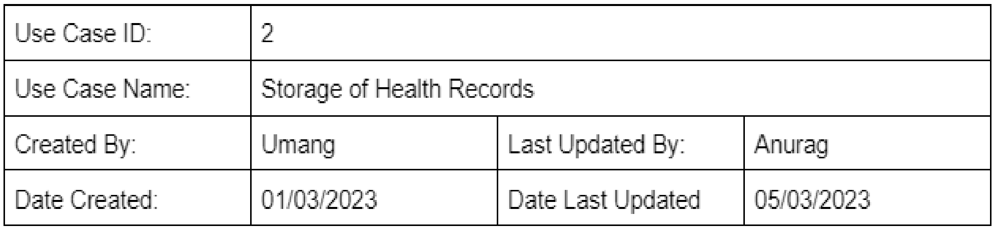
5.19 System Architecture



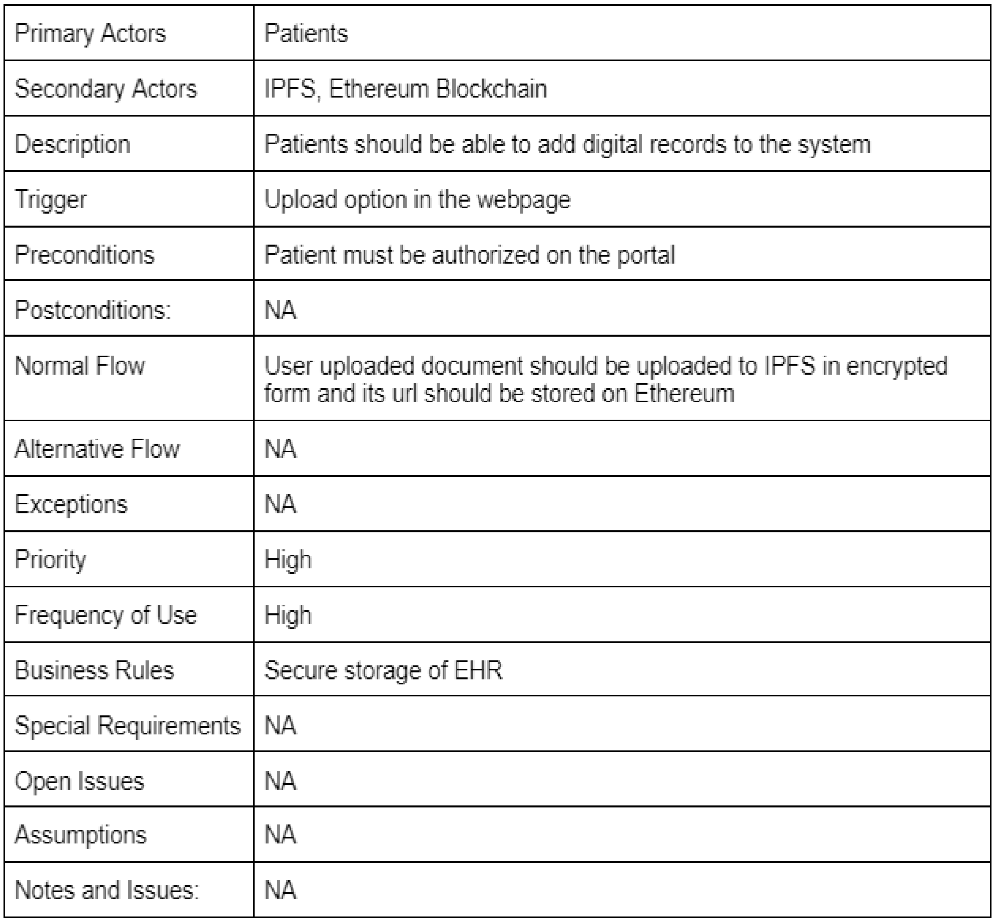
Use Case ID:	1		
Use Case Name:	Unique Health ID Generation		
Created By:	Anurag	Last Updated By:	Umang
Date Created:	29/10/2022	Date Last Updated:	03/11/2022



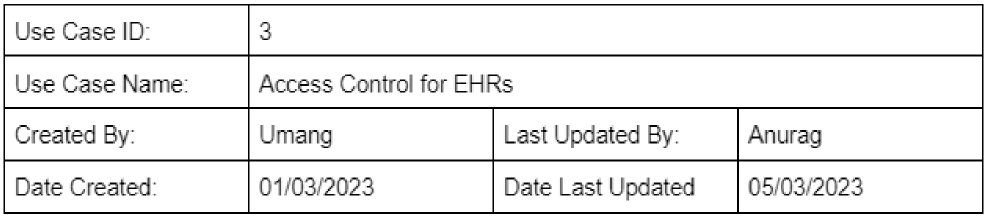
Primary Actors:	New / Existing user
Secondary Actors:	IPFS, Ethereum Blockchain
Description:	The user will have to create his own health identity.
Trigger:	Submission of required details in the form.
Preconditions:	User must not already have a Health Card linked to his Aadhar Number.
Postconditions:	If another user tries to use the same Aadhar Card, they must not be allowed to create that Health Card
Normal Flow:	User enters his Aadhar Number, the necessary details and creates his Health identity.
Alternative Flows:	User enters incorrect data and is eventually not allowed to create the health identity.
Exceptions:	NA
Priority:	High
Frequency of Use:	High
Business Rules:	Single source of truth for data on the blockchain.
Special Requirements:	NA
Open Issues	NA
Assumptions:	NA
Notes and Issues:	NA



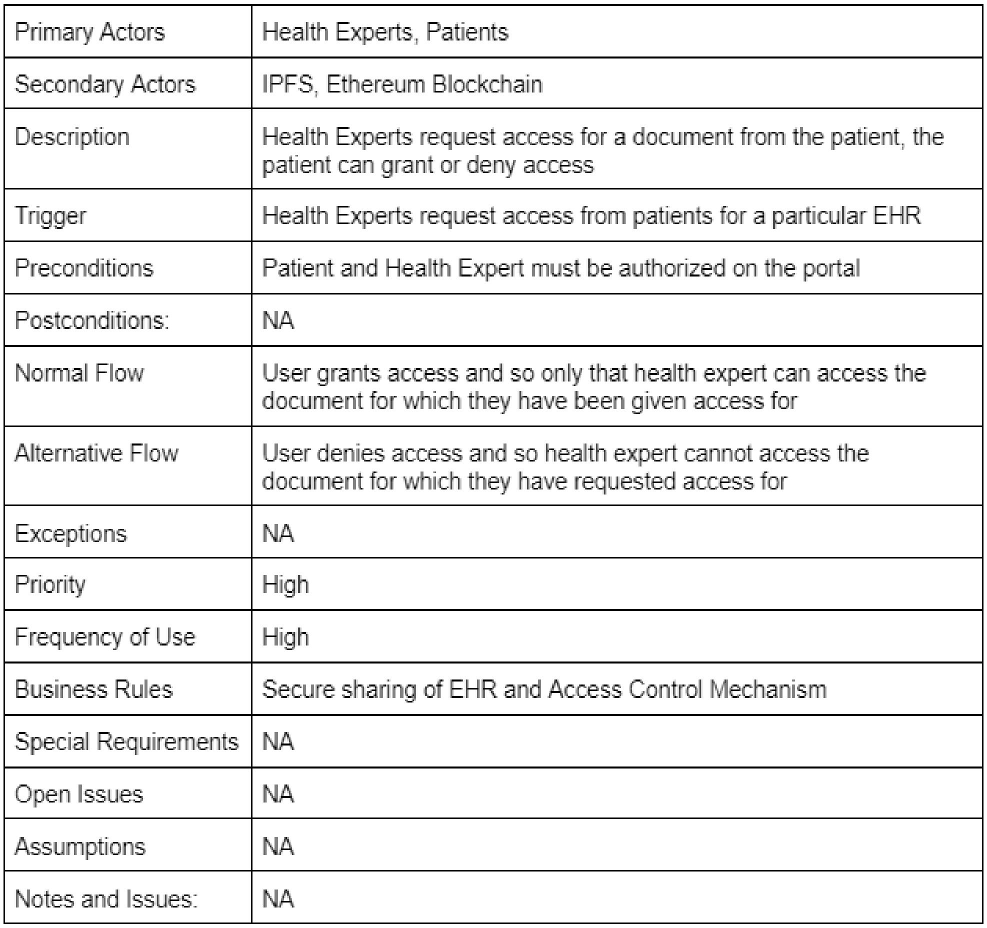
Use Case ID:	2		
Use Case Name:	Storage of Health Records		
Created By:	Umang	Last Updated By:	Anurag
Date Created:	01/03/2023	Date Last Updated	05/03/2023



Primary Actors	Patients
Secondary Actors	IPFS, Ethereum Blockchain
Description	Patients should be able to add digital records to the system
Trigger	Upload option in the webpage
Preconditions	Patient must be authorized on the portal
Postconditions:	NA
Normal Flow	User uploaded document should be uploaded to IPFS in encrypted form and its url should be stored on Ethereum
Alternative Flow	NA
Exceptions	NA
Priority	High
Frequency of Use	High
Business Rules	Secure storage of EHR
Special Requirements	NA
Open Issues	NA
Assumptions	NA
Notes and Issues:	NA



Use Case ID:	3		
Use Case Name:	Access Control for EHRs		
Created By:	Umang	Last Updated By:	Anurag
Date Created:	01/03/2023	Date Last Updated	05/03/2023



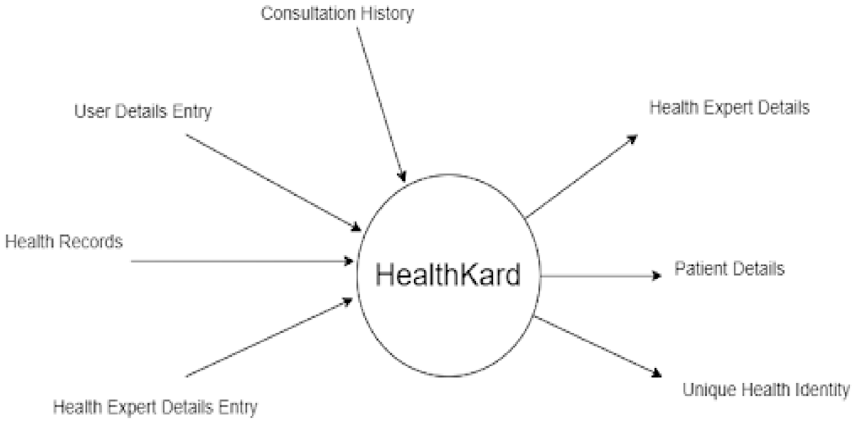
Primary Actors	Health Experts, Patients
Secondary Actors	IPFS, Ethereum Blockchain
Description	Health Experts request access for a document from the patient, the patient can grant or deny access
Trigger	Health Experts request access from patients for a particular EHR
Preconditions	Patient and Health Expert must be authorized on the portal
Postconditions:	NA
Normal Flow	User grants access and so only that health expert can access the document for which they have been given access for
Alternative Flow	User denies access and so health expert cannot access the document for which they have requested access for
Exceptions	NA
Priority	High
Frequency of Use	High
Business Rules	Secure sharing of EHR and Access Control Mechanism
Special Requirements	NA
Open Issues	NA
Assumptions	NA
Notes and Issues:	NA

5.20 Data Flow Designs

DFD is created from the SRS document provided.

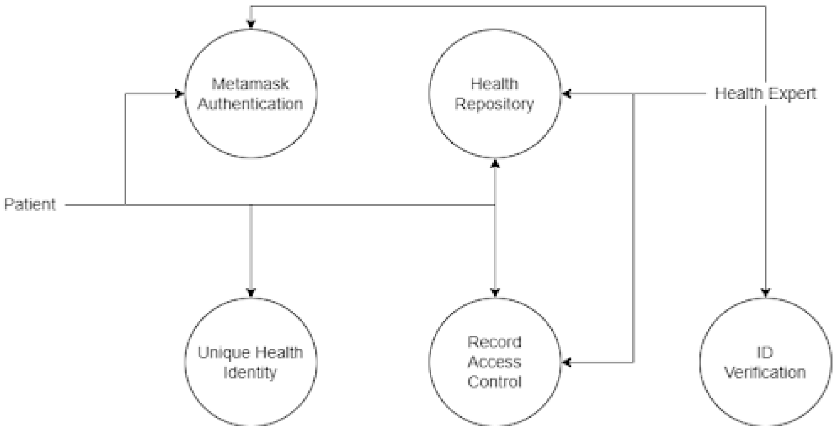
5.20.1 Level 0 DFD with description

Figure 5.21: Level 0 DFD



5.20.2 Level 1 DFD with description

Figure 5.22: Level 1 DFD



Chapter 6

Software Test Document

6.1 Test Approach

Test will be conducted to test the efficiency of the software. The reason for this test is to check for any errors and limitations. A list of various planned tests is as follows:

6.1.1 Unit Testing

Unit testing, is a testing technique using which individual modules are tested to determine if there are any issues by the developer himself. It is concerned with the functional correctness of the standalone modules. Unit Testing is done during the development (coding phase) of an application by the developers. Unit Tests isolate a section of code and verify its correctness. A unit may be an individual function, method, procedure, module, or object.

6.1.2 White Box Testing

White Box Testing is a software testing technique in which the internal structure, design, and coding of software are tested to verify the flow of input-output and to improve design, usability, and security. In white box testing, code is visible to testers so it is also called Clear box testing, Open box testing, Transparent box testing, Code-based testing, and Glass box testing. White box testing techniques analyze the internal structures, the used data structures, internal design, code structure and the working of the software rather than just the functionality as in black box testing. It is also called glass box testing or clear box testing or structural testing.

6.1.3 Black Box Testing

Black box testing is a method of software testing that tests the functionality of an application as opposed to its internal structures of working. Specific knowledge of the application's code/internal structure and programming knowledge, in general, is not required. The tester is only aware of what the software is supposed to do, but not how i.e. When he/she enters a certain input, he/she gets a certain output; without being aware of how the output was produced in the first place. Test cases are built around specifications and requirements i.e. what the application is supposed to do. It uses external descriptions of the software, including specifications, requirements, and design to derive test cases.

6.2 Test Plan

The objectives supported by the Test Plan are:

1. To test the project such that it meets the business and user requirements.
2. The Test Plan should find defects that may get created by the programmer while developing the software.
3. To make sure that the end result is correct.
4. Testing can be helpful in gaining confidence in and providing information about the level of quality.

The scope of the Test Plan are: The major functions that would be tested are:

1. Metamask Authentication
2. Unique Health ID Generation
3. Health and Consultation History

The following points are to be considered while testing:

1. Perform unit testing on individual modules
2. Integrate the modules to perform the integration testing after the successful completion of unit testing.
3. Then, the system as a whole will be tested and we will perform the system testing.
4. Different scenarios that can occur once the project will be deployed have been considered for ensuring effective testing of the software.

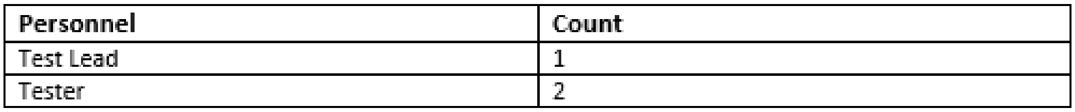
6.2.1 Features to be tested

Features	Scenarios
Metamask Authentication	• Login when the user mapped with the same address exists. • Create a new user in case a user with the same address does not exist. Verification through Aadhar has to be done in such a case.
Health ID Generation	• NFT must be generated when the user creates his/her profile • The details are not editable and NFT must be tamper-proof
Health Card Dashboard	• Show details relevant to only that particular user • Authorization is taken care of in this step

Features	Scenarios
Patient Request	• Medical Experts should be able to request patients for access to patient's health records and the same should be reflected on the Patient's account • Patient's health records should not be visible to healthcare professionals without consent.
Manage Approval	• Patients should be able to grant/revoke access to medical practitioners to access health records. • The same should be reflected on the Practitioner's Dashboard.
Adding Medical Records	• Users should be able to add medical health records linked to their Unique Health ID. • Medical experts with access should also be able to add to patients' health records.
Editing Medical Records	• Users should be able to edit medical health records linked to their Unique Health ID.

6.2.2 Testing Tools and Environment

Testing Staff



Personnel	Count
Test Lead	1
Tester	2

Testing Environment

Operating System

1. MAC Operating system
2. Microsoft Windows (Windows 8, 10, 11)
3. Linux Ubuntu

Devices

1. Laptop/Desktop
2. Mobile/Tablet

Browser requirement

1. Google Chrome
2. Microsoft Edge
3. Mozilla Firefox
4. Safari

Development

1. Network: Ethereum
2. Authentication: Metamask
3. File System: IPFS
4. Editor: Visual Studio Code
5. Documentation: Overleaf

6.3 Test Cases

Test Case ID	Module Name	Input	Expected Output	Actual Output	Status (Pass/-Fail)
1	Metamask Authentication	User Wallet Address	• Ensure that Metamask is connected without any issues	Metamask is successfully connected	Pass
2	Health ID Generation	• Name • Date of Birth • Blood Group • Gender • Aadhar Number • Phone Number • E-Mail • Photo	• NFT must be generated when the user creates his/her profile • The details are not editable and NFT must be tamper-proof	NFT is generated and cannot be tampered	Pass

Test Case ID	Module Name	Input	Expected Output	Actual Output	Status (Pass/-Fail)
3	Health Card Dashboard	User Wallet Address	• Show details relevant to only that particular user • Authorization is taken care of in this step	Relevant details are shown to the user	Pass
4	Patient Request	Document ID, Patient Address and Health Expert Address	• Medical Experts should be able to request patients for access to patient's health records and the same should be reflected on the Patient's account • Patient's health records should not be visible to healthcare professionals without consent.	The request flow for patient's documents works fine	Pass

Test Case ID	Module Name	Input	Expected Output	Actual Output	Status (Pass/-Fail)
5	Manage Approval	Document ID, Patient Address and Health Expert Address	• Patients should be able to grant/revoke access to medical practitioners to access health records. • The same should be reflected on the Practitioner's Dashboard.	The patients are able to grant and revoke access of EHRs	Pass
6	Adding Medical Records	Document, Wallet Address	• Users should be able to add medical health records linked to their Unique Health ID. • Medical experts with access should also be able to add to patients' health records.	Users are able to add documents to the blockchain	Pass
7	Editing Medical Records	Document ID, Patient Wallet Address	• Users should be able to edit medical health records linked to their Unique Health ID.	Users are able to edit/delete documents	Pass

Chapter 7

Conclusion

7.1 Conclusion & Future scope

The outcomes of the experiments suggest that our proposed strategy is capable of achieving good results. Interplanetary File System does help in saving important user data securely and makes it immutable for other users. More effort should be put into improving the verification process which have been restricted from the Aadhar APIs. Our future efforts will be focused on improving the system's performance and developing the health consultation logic for doctors as well as patients.

7.1.1 Future Scope

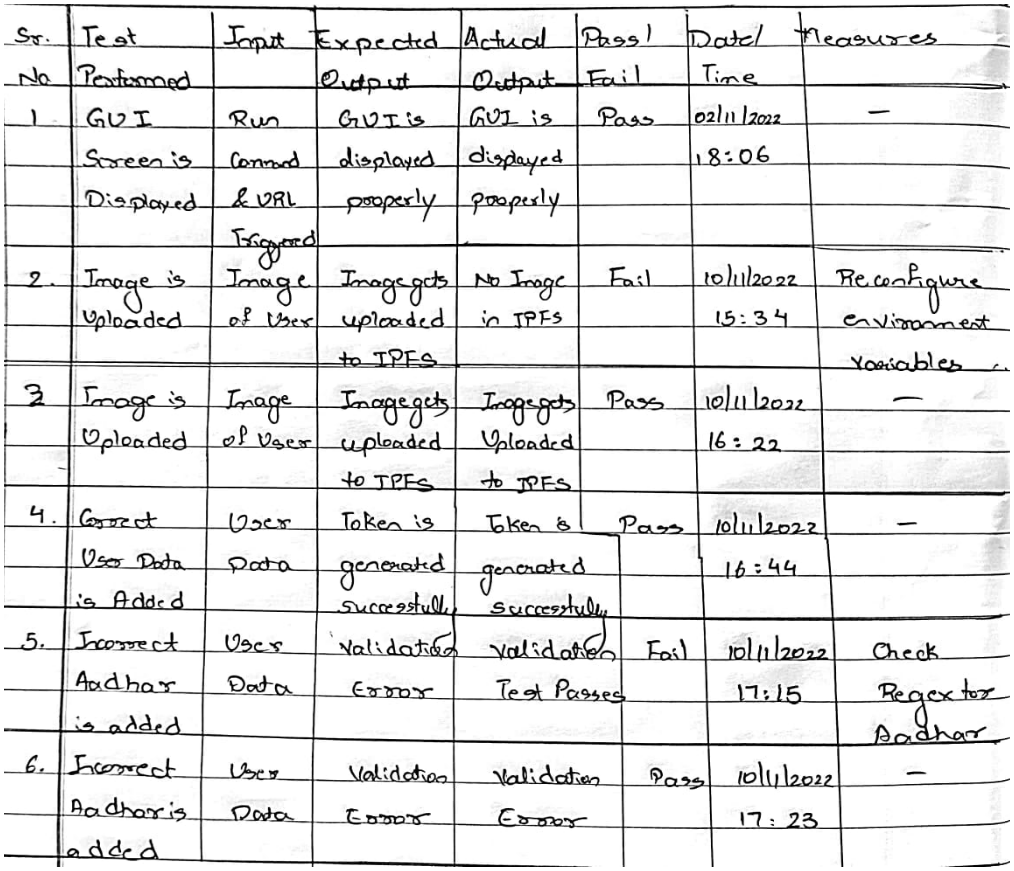
1. Health Consultations/Prescriptions
2. Epidemic Analysis
3. End-to-End Deployment

Appendix A

Appendix

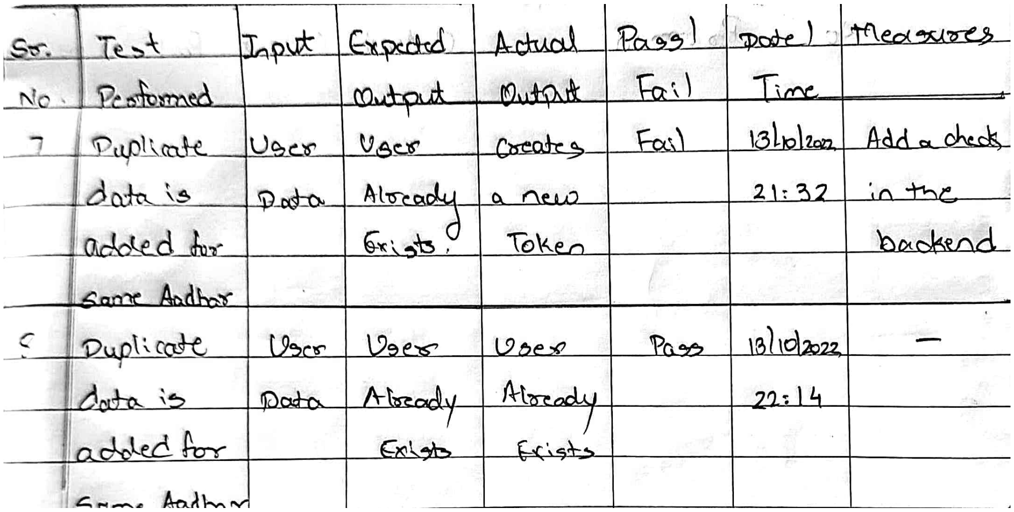
A.1 Test Logs

Figure A.1: Test Logs - 1



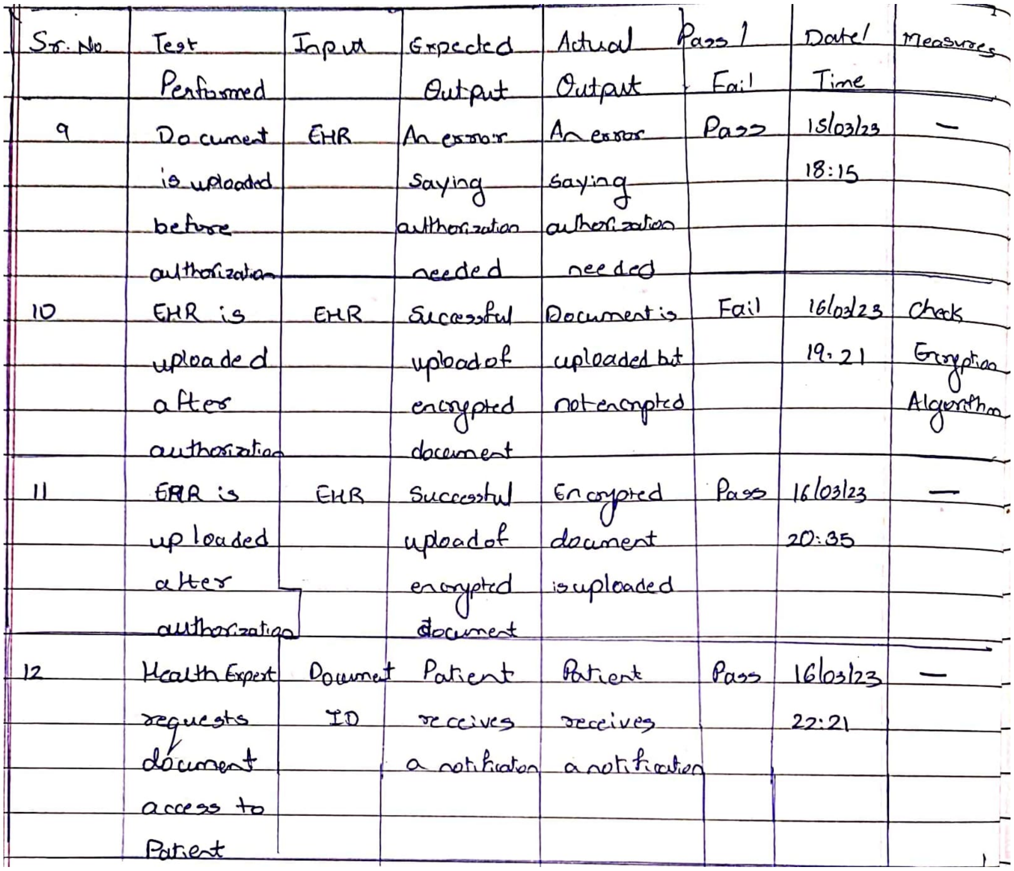
Sr. No	Test Performed	Input	Expected Output	Actual Output	Pass/ Fail	Date/ Time	Measures
1.	GUI Screen is Displayed	Run Command & URL Triggered	GUI is displayed properly	GUI is displayed properly	Pass	02/11/2022 18:06	—
2.	Image is Uploaded	Image of User	Image gets uploaded to IPFS	No Image in IPFS	Fail	10/11/2022 15:34	Reconfigure environment variables
3	Image is Uploaded	Image of User	Image gets uploaded to IPFS	Image gets Uploaded to IPFS	Pass	10/11/2022 16:22	—
4.	Correct User Data is Added	User Data	Token is generated successfully	Token is generated successfully	Pass	10/11/2022 16:44	—
5.	Incorrect Aadhar is added	User Data	Validation Error	Validation Test Passes	Fail	10/11/2022 17:15	Check Regex for Aadhar
6.	Incorrect Aadhar is added	User Data	Validation Error	Validation Error	Pass	10/11/2022 17:23	—

Figure A.2: Test Logs - 2



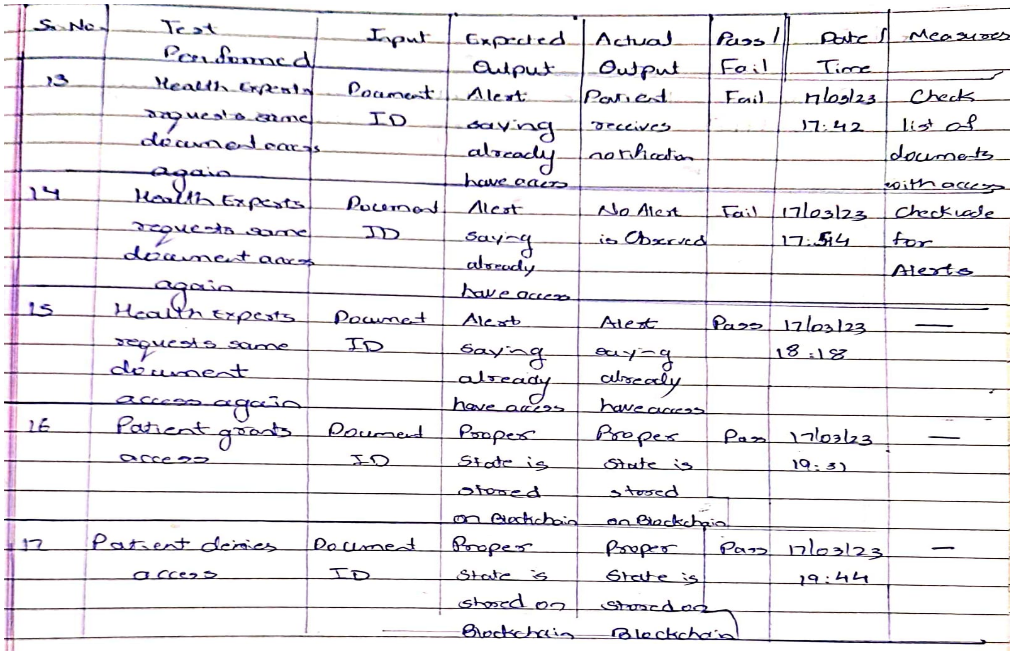
Sr. No.	Test Performed	Input	Expected Output	Actual Output	Pass/ Fail	Date/ Time	Measures
7	Duplicate data is added for same Aadhar	User Data	User Already Exists.	Creates a new Token	Fail	13/10/2022 21:32	Add a check in the backend
8	Duplicate data is added for Same Aadhar	User Data	User Already Exists	User Already Exists	Pass	13/10/2022 22:14	—

Figure A.3: Test Logs - 3



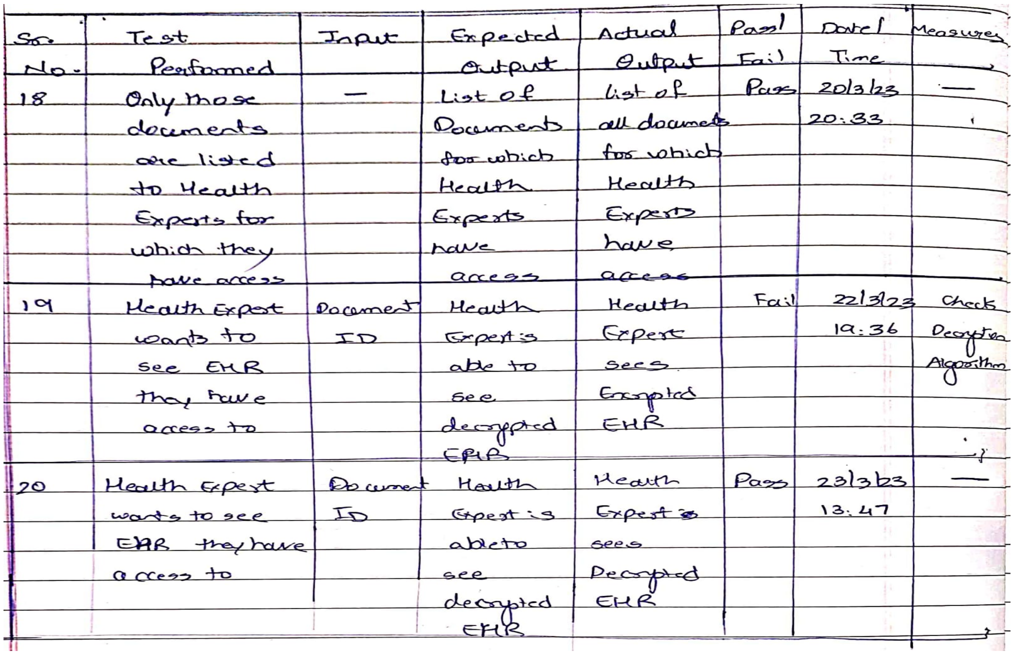
Sr. No.	Test Performed	Input	Expected Output	Actual Output	Pass/ Fail	Date/ Time	Measures
9	Document is uploaded before authorization	EHR	An error saying authorization needed	An error saying authorization needed	Pass	15/03/23 18:15	—
10	EHR is uploaded after authorization	EHR	Successful upload of encrypted document	Document is uploaded but not encrypted	Fail	16/03/23 19:21	Check Encryption Algorithm
11	EHR is uploaded after authorization	EHR	Successful upload of encrypted document	Encrypted document is uploaded	Pass	16/03/23 20:35	—
12	Health Expert requests document access to Patient	Document ID	Patient receives a notification	Patient receives a notification	Pass	16/03/23 22:21	—

Figure A.4: Test Logs - 4



S.No.	Test Performed	Input	Expected Output	Actual Output	Pass / Fail	Date / Time	Measures
13	Health Experts requests same document access again	Document ID	Alert saying already have access	Patient receives notification	Fail	17/03/23 17:42	Check list of documents with access
14	Health Experts requests same document access again	Document ID	Alert saying already have access	No Alert is Observed	Fail	17/03/23 17:54	Check code for Alerts
15	Health experts requests same document access again	Document ID	Alert saying already have access	Alert saying already have access	Pass	17/03/23 18:18	—
16	Patient grants access	Document ID	Proper State is stored on Blockchain	Proper State is stored on Blockchain	Pass	17/03/23 19:31	—
17	Patient denies access	Document ID	Proper State is stored on Blockchain	Proper State is stored on Blockchain	Pass	17/03/23 19:44	—

Figure A.5: Test Logs - 5



Sr. No.	Test Performed	Input	Expected Output	Actual Output	Pass / Fail	Date / Time	Measures
18	Only those documents are listed to Health Experts for which they have access	—	List of Documents for which Health Experts have access	list of all documents for which Health Experts have access	Pass	20/3/23 20:33	—
19	Health Expert wants to see EHR they have access to	Document ID	Health Expert is able to see decrypted EHR	Health Expert sees Encrypted EHR	Fail	22/3/23 19:36	Check Decryption Algorithm
20	Health Expert wants to see EHR they have access to	Document ID	Health Expert is able to see decrypted EHR	Health Expert sees Decrypted EHR	Pass	23/3/23 13:47	—

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