Fund Tracking system using Blockchain

A major project report submitted in partial fulfillment of the requirement for the award of degree of

Bachelor of Technology

in

Computer Science & Engineering / Information Technology

Submitted by

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CANDIDATE'S DECLARATION

We hereby declare that the work presented in this report entitled **'Fund Tracking system using Blockchain'** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering / Information Technology** submitted in the Department of Computer Science & Engineering and Information Technology, Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from August 2023 to May 2024 under the supervision of **Mr. Praveen Modi** (Assistant professor (Grade-II), Department of Computer Science & Engineering and Information Technology).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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Arpit Kaushal
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List of Abbreviations

Acronym	Expansion
DAPP	Decentralized Application
ABE	Attribute-Based Encryption
AES	Advanced Encryption Standard
API	Application Programming Interface
NPM	Node Package Manager
UI/UX	User Interface/User Experience
DAO	Decentralized Autonomous Organization
V-ABE	Verifiable Attribute-Based Encryption
SEBDB	Secure and Efficient Blockchain-Based Database System
PoW	Proof-of-Work
DHT	Distributed Hash Table
P2P	Peer-to-Peer
SHA	Secure Hash Algorithm
GDPR	General Data Protection Regulation

ABSTRACT

Powerful Asset Tracking System is a top-notch solution, based on the best practices of blockchain technique as well as graph databases; this ensures robust and secure asset tracing platform. Transparency, security, efficiency are the major problems that plague traditional funds tracking systems. Despite all the limitations mentioned above, this system is one of a kind as it uses blockchain’s decentralization and immutability, as well as flexibility and scalability of graph databases.

The system has incorporated blockchain technology to ensure that there is transparent and unduplicated record-keeping of funds transactions. Every transaction is encrypted and saved in blocks chained together to prevent any alteration or deletion. This ensures prompt responses and cut-out the middlemen thereby minimizing costs and processing time.

Moreover, the system integrates a graphical database for tracking and analyzing the intricate connections among the font elements. This facilitates effective information query and retrieval on funds flows in real time. This modern technique of data administration enhances decision making, checks fraud and helps in quick and reliable reporting.

Keywords— Powerful Asset Tracking, System, Blockchain technology, Graph databases, Robust asset tracking platform, Traditional fund tracking systems, Transparency

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

A revolutionary solution for a powerful fund tracking system based on Blockchain and Graph In the current financial situation, transparency, security, and efficiency are the most important issues for both the investors and the fund managers. Legacy systems for gathering data, transferring funds, and allocation of resources are generally not sufficient to meet the increased workload of monitoring this global endeavor. These difficulties may include such things as data inconsistencies, inefficient procedures, and inability to avoid spoofing. The integration of blockchain technology as a transformative solution has emerged with a prime objective of noticeably improving tracking, managing, and accounting for funds, which had already been a huge issue.

Blockchain is the technology that is the basis of the cryptocurrencies like Bitcoin and Ethereum. It is a decentralized and immutable ledger that records the transactions across a network of computers. Very core characterizes of its disclosure, immutability, and cryptographic security capabilities with it become a preferred choice for the transformation of systems of monitoring and allocating public funds.

The use of blockchain technology provides such accounting systems with the outstanding attributes of transparency and ability to do internal audits. Every transaction, regardless of whether it is about fund transfers, asset purchases, or investor contributions, is documented on the blockchain in an unforgeable way. It is such transparency that causes the trust among the investors during the process since they would then have the chance to verify and confirm by themselves the originality and integrity of the fund activities.

Additionally, blockchain-based financial information systems eliminate intermediaries and centralized regulatory bodies hence making the process of tracking straightforward, effective and cost effective. Smart contracts, self-executing contracts with predefined rules written into code, are conducting a number of fund management tasks, such as the investment allocation, profit distribution and compliance requirements. These Smart Contracts provide transparency as well as accountability in the fund allocation because the system will execute the pre-defined rules automatically without requiring any manual intervention.

Besides, another incredible trait of blockchain technology in resource tracking and allocation systems is elevated security. The traditional systems are target of different kinds of cyberattacks and data breaches, and as a result investors' funds and sensitive information are at risk. Impossible to fabricate cryptographic methods and decentralized anchoring make blockchain to have high integrity and protection against illegal modifications or unauthorized access. Each transaction on the blockchain is encrypted and connected to the prior one as a result of which the unChange transaction blocks forming a chain creation process is ensured. This makes the fund managers and investors have confidence in the system's integrity and security.

Also, this technology allows greater opportunities in providing a more inclusive and participatory environment for fund management. When it comes to traditional investments, things like different countries' complicated financial environments and the inability to access these opportunities make it a tedious process. On the contrary, blockchain-based platforms enable borderless transactions which is a great thing because investors from all over the world can now participate in funds easily. The democratization of access to investment opportunities among common people created for a new option of capital formation as well as a means of economic empowerment.

1.2 PROBLEM STATEMENT

It becomes possible with blockchain to track funds and tackle various issues of fund management. One of the main issues that the system seeks to solve is opacity and accountability in financial management. The system also relies on blockchain technology, which allows for easy tracing and verification of all money transactions in the network[3]. Such may enhance public accountability, earning a high level of trust for stakeholders.

The second significant dilemma that the blockchain-based tracing tool aims to address has to do with security and fraud reduction. The current money tracking systems provide a convenient means for committing fraud and making unsanctioned access to financial transactions. Through the incorporation of block chain, the system develops an environment that is reliable and incorruptible in the process of keeping a track record in money exchange, making use of encryption technology and authorization mechanisms to forestall cheating in altering the transaction data. Moreover, the software could be tailored to resolve problems associated with efficiency and automation of revenue tracking.

Blockchain based financial tracking and management systems can incorporate smart contracts that auto approve modifications resulting in improved efficiency of operational and reducing human errors. This will enhance operational effectiveness, accelerate processing time and eventually minimize financial administration expenses.

1.3 OBJECTIVES

The concept of a money tracking system using blockchain can be summarized as follows:

- **TRANSPARENCY AND ACCOUNTABILITY**: Implement open and honest tracking mechanisms for the path of money, offering stakeholders a straight and immutable trail of transactions.
- **SECURITY AND FRAUD PREVENTION**: We use blockchain technology to strengthen our security by eliminating any possibility of fraud/unauthorized access and manipulations to ensure the validity of financial transactions.
- **EFFICIENCY AND AUTOMATION**: Use smart contracts and automate approval processes to make the financial tracking process faster, more accurate, and time saving.
- **COMPLIANCE AND REGULATION**: This is a safe and reliable environment for management of your assets, following laws about cross- border monetary operations.

1.4 SIGNIFICANCE AND MOTIVATION OF THE PROJECT WORK

The project of developing a fund tracking system using blockchain and graph database has significant significance and motivation:

SIGNIFICANCE:

- **INCREASE TRANSPARENCY**: A blockchain is a form of distributed ledger system that offers an efficient and secure methodology to maintain the records of transactions. Financial tracking systems can use blockchain to give a real time visibility of financial transactions in order to ensure transparency and accountability.
- **ENHANCED SECURITY**: The blockchain and its encryption features and algorithms are almost impossible to access or change. It guarantees the dependability and safety your accounting system should have, eliminating fraud or data manipulation.
- **AUDITABLE RECORDS**: This is because blockchain offers an auditable way to register transaction history. Irreversible blockchains are used to store all the

transactions in a safe manner making it easy to track financials.

- **EFFICIENT CROSS-BORDER TRANSACTIONS**: The blockchain technology makes it possible to cut out the middlemen and expedite processing time while transacting across the borders. It speeds up and reduces the costs of money transfers between various nations.

MOTIVATION:

- **REAL-TIME TRACKING**: A real time financial tracking system seeks to have stakeholders keep track of their finances. Keep moving. This will give you real time information on how your business is performing financially thus you get to make better decisions and manage risks appropriately.
- **ACCURACY AND RELIABILITY**: The project aims at ensuring proper representation of the data by using graph databases which are the best tools for analyzing interconnected data structures like blockchain networks. Graph databases help to carry out search and analysis of sophisticated connections in the blockchain networks.
- **LEGAL COMPLIANCE**: Organisations can also adhere to relevant regulatory requirements regarding financial transparency, anti-money laundering and intelligence laws by implementing a reliable financial monitoring system via Blockchain. - your-customer (KYC) etc.
- **POTENTIAL COST SAVINGS**: This program eliminates and automates middlemen in cross-border transactions thus minimizing the costs associated with traditional financial systems or payment providers.

1.5 ORGANIZATION OF PROJECT REPORT

The detailed organization of a project report can be outlined as follows:

CHAPTER 2 - LITERATURE SURVEY: A significant amount of research was undertaken in this chapter and combined information from different reliable sources of data like textbooks, journals, websites and technical publications. It provides a general overview concerning the pertinent literature, describes what has been done on the issue for the past five years and reveals some important blank spots in existing understanding of blockchain for fund management and following.

CHAPTER 3 - SYSTEM DEVELOPMENT: In this chapter, we will look at the technical side of things, including the requirements and analysis section, before moving on to the section about project design and architecture. It goes through data preparation and implementation phase and includes major components in the form of code snippets, algorithms, tools, and techniques employed. Moreover, the challenges encountered during the development process and their resolution are highlighted as well.

CHAPTER 4 - TESTING: This chapter provides information on the testing strategy with regard to the platform and reliability. The tools and methods used for evaluating the platform and its functionally are highlighted. It outlines the test cases and their outcomes providing strong analysis of the system.

CHAPTER 5 - RESULTS AND EVALUATION: This part comprises of results presentation and interpretation. The results are presented in a full way along with their interpretation and where necessary the comparison with the existing solutions if appropriate.

CHAPTER 6 - CONCLUSIONS AND FUTURE SCOPE: This important chapter summarizes the project and the main conclusions, limitations and contributions to the field. It concludes by outlining the scope for the future, identifying potential opportunities for further development and improvement in the field of blockchain for funds management. It provides a preview perspective on the platform and its development.

CHAPTER 2

LITERATURE SURVEY

2.1 OVERVIEW OF LITERATURE SURVEY:

Zhong et al. [4] meticulously explores the contemporary research landscape pertaining to the integration of blockchains with databases. The primary focus of their survey lies in elucidating the synergies between these two technologies, aiming to capitalize on their respective advantages, including decentralization, immutability, security, scalability, and efficiency. The authors recognize blockchains and databases as distinct yet complementary information management systems, each with its unique functionalities and tradeoffs. While blockchains offer tamper-proof and verifiable transaction records through distributed ledgers. This survey not only provides an insightful overview of the challenges and opportunities inherent in combining blockchains and databases but also references specific tools and technologies such as SQL databases, NoSQL databases, SEBDB, and ForkBase, contributing to the evolving discourse on this nascent and dynamic research topic.

Md. Mehedi Hassan Onik et al. [5] conduct a systematic literature review focused on the adoption of blockchain technology in Bangladesh, a developing nation committed to sustainable development. The authors scrutinize 70 articles published between 2016 and 2020 from prominent publishers, including IEEE Xplore, ACM, ScienceDirect, Taylor and Francis, and SpringerLink. The systematic analysis addresses key facets of blockchain adoption in Bangladesh, encompassing identified sectors, challenges, and stakeholders. Furthermore, the article sheds light on the current status, trends, and future directions of blockchain research. Notably, the study references tools and technologies integral to this exploration, specifically IPFS (InterPlanetary File System) and DPoS (Delegated Proof of Stake) consensus.

Sanskar Choubey et al. [6] concentrate on the practical implementation and scalability of blockchain technology in real-world scenarios, with a specific focus on tracking government systems and finances. The article introduces a novel system leveraging blockchain to record and monitor funds allocated to diverse government programs spanning education, health, agriculture, and infrastructure. Emphasizing the potential to enhance transparency, accountability, and efficiency in fund distribution while mitigating risks of fraud and corruption, the paper demonstrates the application of blockchain beyond theoretical frameworks. The authors employ tools and technologies such as Ganache, Geth Version, Meta Mask, and Truffle to underpin their practical implementation. Additionally, the work encompasses a comprehensive review of existing literature on blockchain technology, exploring its applications across diverse domains including finance, supply chain, healthcare, and e-government.

Z. B. Hafiz et al., 2019 [7] mainly discusses how blockchain can be used in the microcredit industry in Bangladesh. The paper brings up a blockchain based system used in Bangladesh, a country under a developing nation category, to collect and record information in relation to funds allocation for different microfinance sectors such as education, health, agriculture and infrastructures. The proposed system will be presented as an innovative solution that can increase trust, safety and credibility in microcredit distribution and management processes with subsequent effect on jobs creation and increasing tax revenues. The authors mention the fact that blockchain can increase transparency and accountability in the microfinance field. Moreover, the article reviews literature about blockchain and explores ways that blockchain can address the challenges faced by microcredit industry in Bangladesh or any other country. It shows these multifaceted approaches include the use of smart contracts and cryptocurrencies as tools/technologies.

Yang, Jinhong et al. [8] focuses on the development of a privacy-aware and GDPR compliant type of blockchain system. The article seeks answers to issues around privacy breaches and the lack of openness and accountability in present data collection practices. The system recommends use of the blockchain technology which is decentralized and more dependable for the data audit. The service allows individuals to adjust and handle their own personal details for purposes of GDPR compliance focusing on individual control. They include Multichain as a blockchain implementation device and off-the-chain data storage tools. The work makes a contribution to discussions involving blockchain technology. It proposes a systematic approach in addressing concerns surrounding sharing of personal data and its tracking.

Avinash Kaur et al. [9], focused is on establishing a secure smart grid system through the utilization of homomorphic encryption within the framework of blockchain technology. The paper addresses the perceived vulnerabilities of existing smart grid systems, emphasizing concerns related to cybersecurity and the need for enhanced transparency and accountability. The proposed solution leverages blockchain to create a decentralized and reliable data control platform, aiming to facilitate secure and efficient data sharing and management within smart grid infrastructures. Key tools and technologies integral to this proposal include homomorphic encryption for privacy preservation and digital signatures for enhanced security. The comprehensive literature review embedded in the article explores existing research on blockchain technology, shedding light on its applications not only in smart grids but also across diverse fields such as finance, supply chain, healthcare etc.

C. Iliadis et al. [10], the central focus is on the design and implementation of a secure and privacy-preserving eXplainable Artificial Intelligence (XAI)-Justice System using blockchain technology. The proposed system comprises four integral components: a web application, a smart contract, a blockchain network, and a Natural Language Processing (NLP) module. The web application serves as the user interface, facilitating interactions among stakeholders such as judges, lawyers, and citizens within the system. The smart contract encapsulates the business logic, establishing rules and conditions for monetary transactions. The blockchain network, as the underlying infrastructure, records and validates transactions through the implementation of a digital signature system. The integration of tools and technologies such as NLP, digital signatures, and ontology matching underscores the multifaceted approach taken to enhance security, privacy, and transparency within the XAI-Justice System. This paper represents a significant contribution to the discourse on leveraging blockchain in conjunction with advanced technologies for the advancement of justice systems, particularly in ensuring explainability and privacy preservation in decision-making processes.

Gary Steri et al. [11], focused on employing blockchain technology for enhancing data accountability and provenance tracking. The document outlines the design and implementation of the envisioned system, which comprises three distinct models with varying accuracy and scalability requirements. The first model involves data subjects executing contracts of each controller, while the second model entails data subjects adhering to the contracts executed by controllers. The third model introduces a scenario in which data subjects conclude contracts for each data processor. The utilization of off-the-chain data storage and smart contracts forms the technological backbone of this approach, emphasizing a multifaceted strategy to cater to diverse accuracy and scalability needs. This paper contributes to the ongoing discourse on leveraging blockchain to ensure data accountability and provenance tracking, offering insights into different models that can be adapted based on specific requirements and preferences within a given context.

Hongxia Zhao et al. [12], focused is on establishing a secure multi-party computation scheme utilizing blockchain technology. The authors employ Ethereum as the chosen blockchain platform and Solidity as the smart contract programming language. The access control mechanism is implemented using the role-based access control (RBAC) model. The paper systematically details the design and implementation of the proposed system, emphasizing the advantages it brings to the security, privacy, and fairness aspects of data sharing and processing among multiple parties. The system is positioned as a means to enhance overall efficiency by reducing administrative costs and minimizing delays. The conclusion of the paper highlights both the advantages and challenges of the proposed system, offering directions for further improvement and expansion. This work significantly contributes to the domain of secure multi-party computation, showcasing the potential of blockchain in ensuring robust security measures and streamlined processes for collaborative data sharing and processing.

Yifan Zhang et al. [13], focused is on the development of a fund tracking system leveraging blockchain technology, specifically integrating privacy-preserving verifiable attribute-based encryption. The paper conducts a comprehensive review of existing literature on attribute-based encryption (ABE) and its various variants, including cipher-policy ABE (CP-ABE), key-policy ABE (KP-ABE), and verifiable ABE (V-ABE). These encryption schemes play a crucial role in the privacy-preserving aspects of the fund tracking system, ensuring secure and verifiable access control to sensitive information. The use of blockchain as the underlying technology enhances transparency, accountability, and the overall integrity of the fund tracking process. This paper contributes to the evolving landscape of blockchain applications by introducing a novel system that addresses privacy concerns in fund tracking through the integration of advanced encryption techniques.

2.2 KEY GAPS IN LITERATURE:

Some of the potential key gaps in the literature review include:

- Lack of comparative and benchmarking studies on the performance and scalability of different integration methods and platforms
- Lack of standardization and interoperability of blockchain and database technologies and protocols
- Lack of friendly and intuitive interfaces and tools for blockchain and database integration and management
- Legal and ethical frameworks and guidelines for blockchain and database integration and governance are lacking
- Lack of user awareness and education about the benefits and risks of blockchain and database integration
- Lack of incentives and reward mechanisms for blockchain and database integration and participation
- Lack of security and privacy enhancing technologies and solutions for blockchain and database integration
- Lack of robust and flexible failure and recovery mechanisms for blockchain and database integration
- There is a lack of empirical and practical research on the integration of blockchains and databases
- There is a lack of interdisciplinary and multidisciplinary research on the possibilities and implications of blockchain technology for sustainable development.

CHAPTER 3

SYSTEM DEVELOPMENT

3.1 REQUIREMENTS AND ANALYSIS:

3.1.1 FUNCTIONAL REQUIREMENTS

- Blockchain.js
- Development Tools
    - Visual Studio Code
    - Neo4j Bloom/Browser
    - Aura DB
- Framework Requirements
    - NodeJS ‘v20.8.0’
    - Dotenv ‘v8.2.0’
    - Nodemon ‘v2.0.7’
    - ExpressJS ‘v4.18.2’
    - BcryptJS ‘v5.1.1’
    - Neo4j ‘v5.13’
    - MorganJS
- Backend Development
    - Node JS
    - Graph DB
    - NPM

3.1.2 NON-FUNCTIONAL REQUIREMENTS

- Security
    - 256 bits Encryption for hash codes
    - Logs and monitoring

    - User authorization and authentication with different access controls
- Scalability
    - Aura DB remote instance
    - Horizontal and vertical scaling enabled by cloud resources
- Reliability
    - Backup and recovery enabled by AWS.

3.2 PROJECT DESIGN AND ARCHITECTURE:

3.2.1 DATA FLOW DIAGRAM: The Fig.. 3.1 depicts how the user allocates the data using the frontend and further the data crosses various layers such as Blockchain and Graph Database layers and then upon compiling it all in the backend services, the monitoring and logs are made. Upon passing from all the layers finally the results are compiled and visualized in the form of a graph.

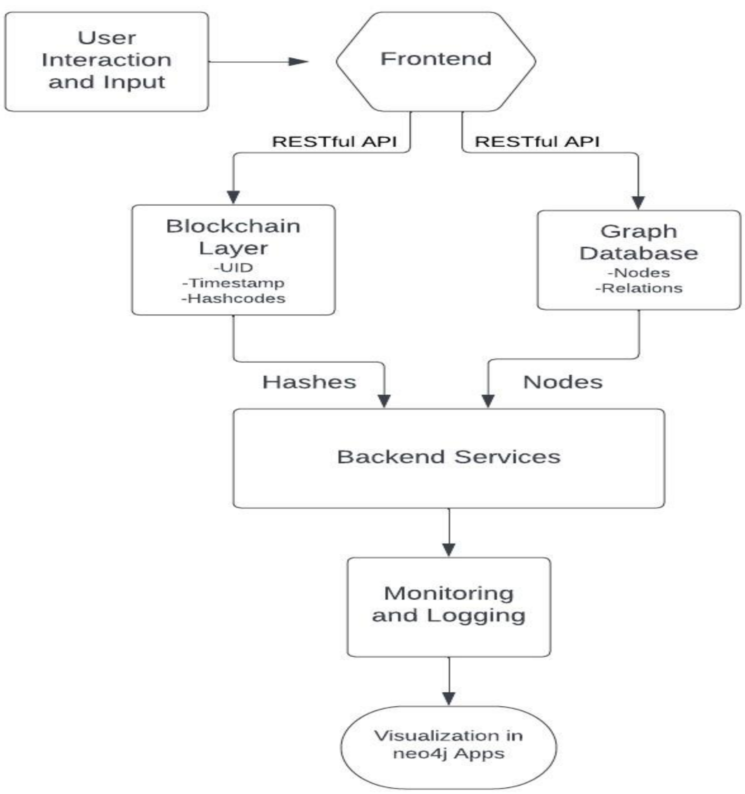


Fig. 3.1: Dataflow for Project

3.2.2 SOFTWARE ARCHITECTURE

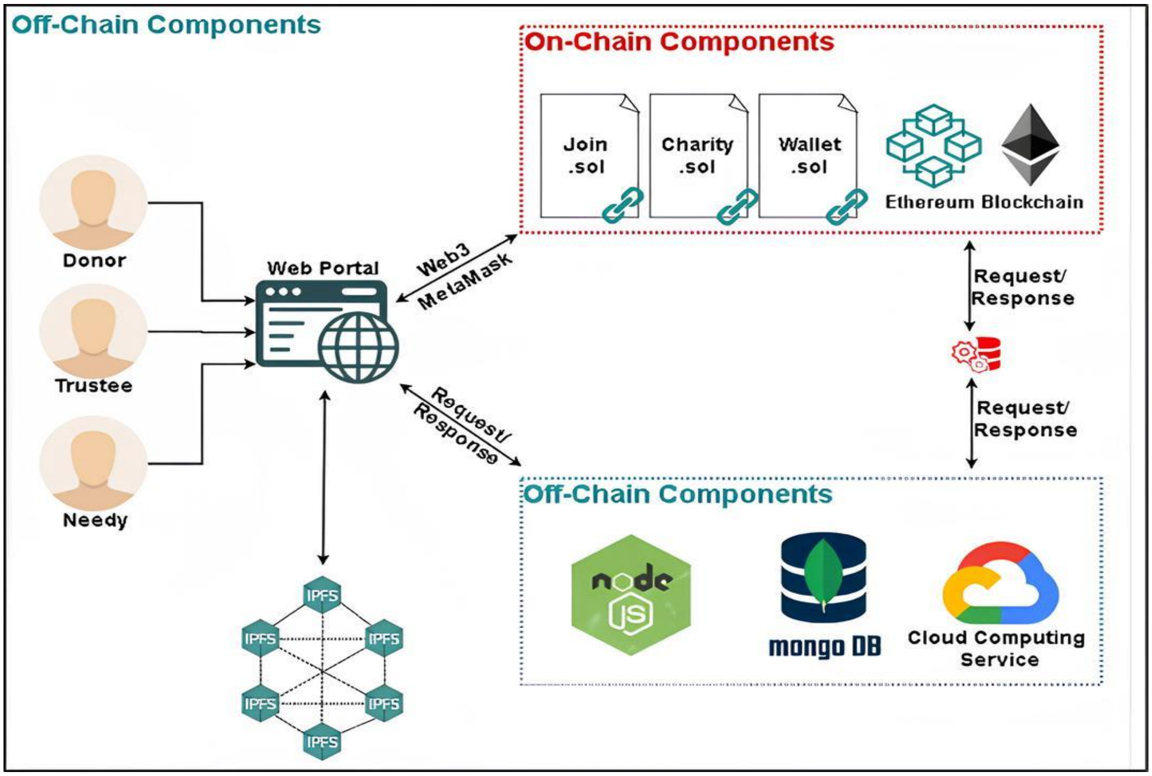


Fig. 3.2: General Architecture of Blockchain

3.3 DATA PREPARATION:

3.3.1 USER INPUTS: The data for this project mainly comprises the inputs made by the users. The data inputs are dependent on the factors of various access controls provided to the type of user logging in.
For eg: If the user is the central government, the access controls are different as compared to the local vendors. It can add the projects, manage the funds etc.

3.3.2 BLOCKCHAIN HASHES: If the transactions are carried out by the user for the funds. Every individual transaction would create a unique Timestamp, HashCode, nonce and transaction ID. This would serve as the input for the logs and the edges for the graph display.

3.3.3 NODES AND VERTICES: The creation and addition of the projects, stakeholders and various vendors would act as the input for the graph database and it would be visualized as the node for the graph UI or graph app.

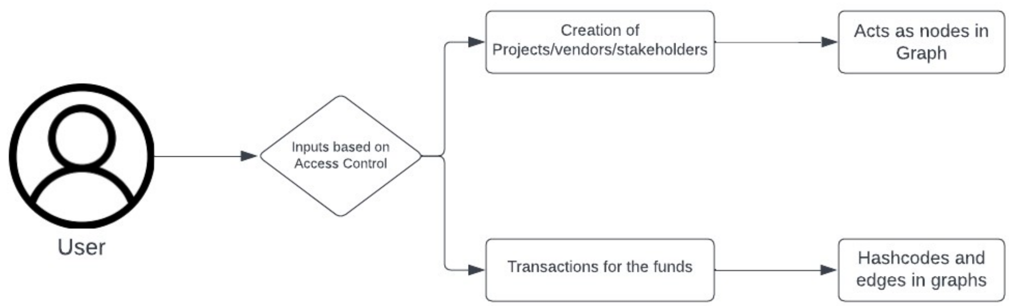
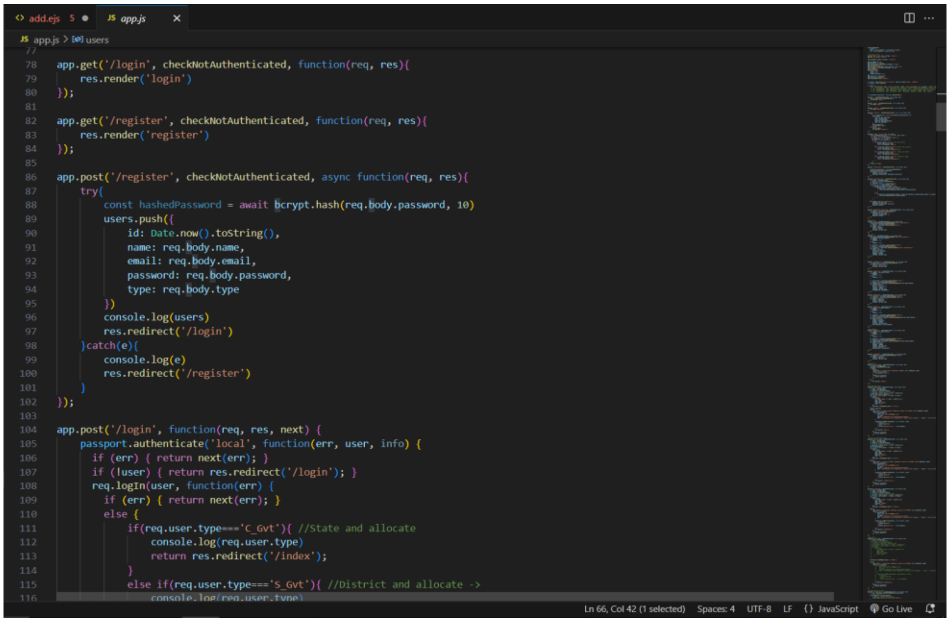


Fig. 3.3 : The Data and metadata for the project

3.4 IMPLEMENTATION:

3.4.1 FRONTEND DEVELOPMENT: The UI of Efficient Fund Tracking System is based on a dynamic combination of blockchain technology, Neo4j graphical database and web languages such as HTML, CSS and JavaScript. This web application provides fund managers, allocators and recipients with a smooth UI to effectively track funds. The user interface starts with authentication of the user's identity and managing access control rights. HTML forms are used to collect user data and JavaScript handles authentication and session control. Developed using HTML and CSS, the dashboard displays key performance data, event reports and graphical representations from the Neo4j database. JavaScript acts as a network between Neo4j and users, extracting information based on user preferences and providing real-time updates.

3.4.1.1 CODE SNIPPET:



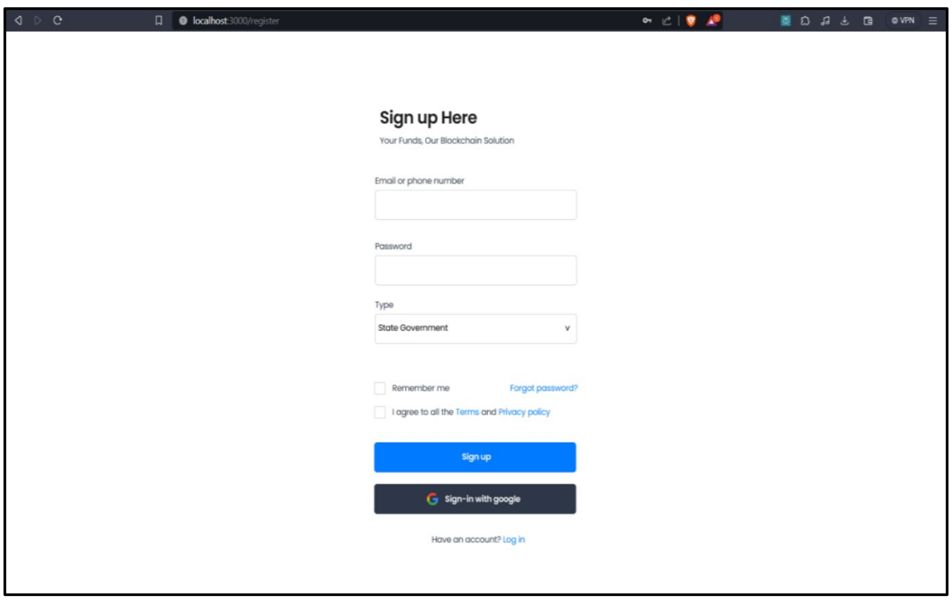


Fig. 3.4: SignUp page for the application

3.4.2 BLOCKCHAIN LAYER: This layer includes all the functioning of the blockchain and its data. This layer includes the index, timestamp, transaction id, current hash and previous hash too as displayed in Fig.3.5 . This data changes with every transaction or temperament made. The values for each variable remain unique throughout.

3.4.2.1 CODE SNIPPET:

```
add.ejs 5 ●   JS blockchain.js ×
block > JS blockchain.js > ...
const crypto = require('crypto')
const uuid = require('uuid/v1')

class Blockchain {
    constructor() {
        this.chain = [];
        this.users = [];
        this.projects = [];
        this.pendingTransactions = [];
        // this.currentNodeUrl = currentNodeUrl;
        this.networkNodes = [];
        this.createNewUser('Central Government', 10000, 'C_Gvt')
        this.createNewBlock(100, '0', '0'); // Genesis Block
    }

    createNewProject(name){
        const newProj = {
            name: name,
        };
        this.projects.push(newProj);
    }

    createNewUser(name, balance, type){
        const newUser = {
            name: name,
            balance: parseInt(balance),
            type: type
        };
        this.users.push(newUser);
    }

    getUserDataByName(name){
        for (var i = 0; i < this.users.length; i++) {
            var obj = this.users[i];
            if(obj.name == name){
                return obj;
            }
        }
        return null;
```

```
{
  index: 1,
  timestamp: 1701264188362,
  transactions: [],
  nonce: 100,
  hash: '0',
  previousBlockHash: '0'
}
```

Fig. 3.5: Initial blockchain stats. with no transaction.

3.4.3 BACKEND DEVELOPMENT: A rigid and secure background system is essential to developing an effective tracking system. This system uses a wide range of tools and techniques to ensure smooth operation. "Express", a popular Node.js web application framework forms the backbone, enabling even routing and processing of

HTTP requests.

Middleware components such as body parser, cookie parser, and morgan facilitate request parsing, cookie management, and request logging. User authentication is critical to security, as it is achieved by hashing passwords using “bcrypt” and user authentication via passthrough. Express-session is used to manage user sessions, while express-flash manages user notification flash messages.

Integration with the “Neo4j” graph database is possible using the neo4j driver. “Neovis.js” is used for interactive graphs rendering. Nodemailer enables automatic email communication for further reports. Finally, method overriding allows you to design a “RESTful API”, and bootstrap is used as a frontend-style “ejs” modeling mechanism. This panoramic stack provides a secure, efficient and user-friendly backend for an effective fund tracking system.

3.4.3.1 CODE SNIPPET

```
module.exports.genSalt = function genSalt(rounds, minor, cb) {
    var error;

    // if callback is first argument, then use defaults for others
    if (typeof arguments[0] === 'function') {
        // have to set callback first otherwise arguments are overriden
        cb = arguments[0];
        rounds = 10;
        minor = 'b';
    // callback is second argument
    } else if (typeof arguments[1] === 'function') {
        // have to set callback first otherwise arguments are overriden
        cb = arguments[1];
        minor = 'b';
    }

    if (!cb) {
        return promises.promise(genSalt, this, [rounds, minor]);
    }

    // default 10 rounds
    if (!rounds) {
        rounds = 10;
    } else if (typeof rounds !== 'number') {
        // callback error asynchronously
        error = new Error('rounds must be a number');
        return process.nextTick(function() {
            cb(error);
        });
    }

    if(!minor) {
        minor = 'b'
    } else if(minor !== 'b' && minor !== 'a') {
        error = new Error('minor must be either "a" or "b"');
        return process.nextTick(function() {
            cb(error);
        });
    }
```

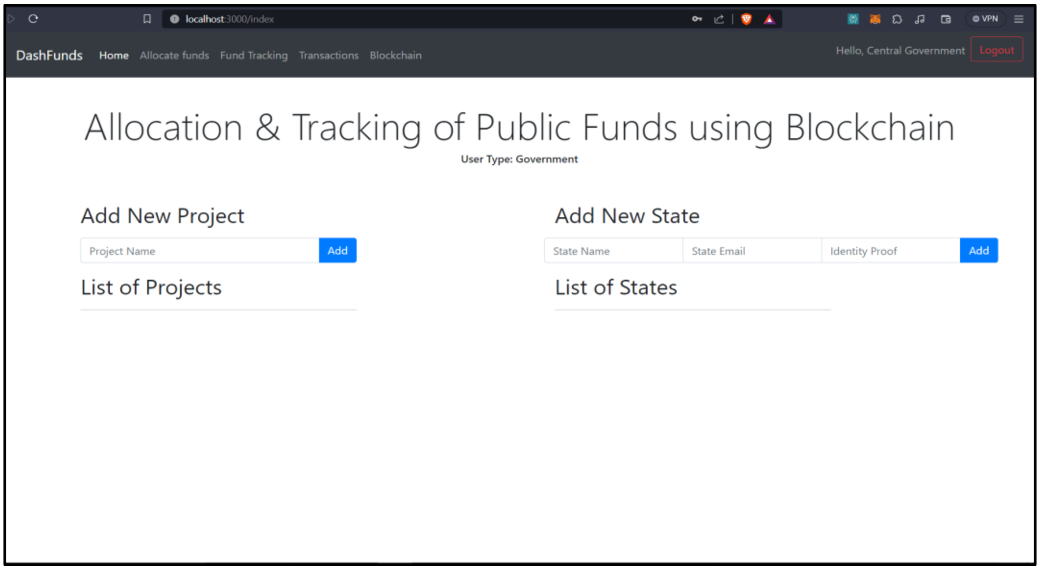


Fig. 3.6: Dashboard for user input functionality

3.4.4 GRAPH DATABASE INTEGRATION: In order to cache and manage fund-related data, the Efficient Fund Tracking System uses a graph database Neo4j. The connection between the backend service and the Neo4j database is established using the neo4j-driver library.

The utilization of the neovis.js library allows for the visualization of graph database nodes and their relationships on the frontend.

3.4.4.1 CODE SNIPPET:

```
var driver = neo4j.driver('bolt://localhost')

var streamSession = driver.session()
var streamResult = streamSession.run(query.join(' '), params)
streamResult.subscribe({
  onNext: function (record) {
    // On receipt of RECORD
    for (var i in record) {
      console.log(i)
      console.log(record[i])
    }
  },
  onCompleted: function () {
    var summary = streamResult.summarize()
    // Print number of nodes created
    console.log('')
    console.log(summary.updateStatistics.nodesCreated())
    streamSession.close()
  },
  onError: function (error) {
    console.log(error)
  }
})

var promiseSession = driver.session()
var promiseResult = promiseSession.run(query.join(' '), params)
promiseResult
  .then(function (records) {
    records.forEach(function (record) {
      for (var i in record) {
        console.log(i)
        console.log(record[i])
      }
    })
    var summary = promiseResult.summarize()
    // Print number of nodes created
    console.log('')
    console.log(summary.updateStatistics.nodesCreated())
```

3.4.5 FUND TRACKING FUNCTIONALITY: The front end interface enables the users to interact with the system through entering transactions, amount, and balance details. When you send a request through the frontend, the backend services will receive that data which they process and cache into the graph database. A graph database allows efficient queries and analysis of associations between data about funds. It is, however, an approach that helps in the discovering of important insights on this relationship and even makes the process of tracing this relationship easy.

3.4.5.1 CODE SNIPPET:

```javascript
        return null;
    }

    getTransaction(transactionId) {
        this.chain.forEach(block => {
            block.transactions.forEach(transaction => {
                if(transaction['transactionId'] === transactionId) {
                    return { transaction, block };
                }
            });
        });

        return null;
    }

    getAddressData(address) {
        const addressTransactions = [];

        this.chain.forEach(block => {
            block.transactions.forEach(transaction=> {
                if(transaction['sender'] === address || transaction['recipient'] === address) {
                    addressTransactions.push(transaction);
                }
            });
        });

        let balance = 0;

        addressTransactions.forEach(transaction => {
            if(transaction['recipient'] === address) balance += transaction['amount'];
            else if(transaction['sender'] === address) balance -= transaction['amount'];
        });

        return {
            addressTransactions,
            balance
        };
    }
}
```

Index	Timestamp	Transaction	Nonce	Previous Block Hash	Hash
1	1701264188362	100	0	0	
2	1701264924169	Amount: 1000 Sender: Central Government Recipient: Maharashtra State Government Project: Disaster Relief fund Transaction ID: 256891f08ebc11eea236d3589bd2b7d7	290508	0	00004813c2234283b4dd4c3adf4d42faf30ff9191f2fd27377c8c8acb7c963c0

Fig. 3.7: Logs and Audit for the blockchain services

3.5 KEY CHALLENGES:

- **LACK OF AWARENESS AND UNDERSTANDING**: One of Blockchain's biggest challenges is the lack of awareness of the technology and widespread misunderstanding of how it works. This can hinder the adoption and successful implementation of Blockchain-based systems.

- **TECHNICAL CHALLENGES**: Blockchain technology presents technical challenges such as performance and limited interoperability with the required systems. These technical hurdles must be overcome to ensure that a fund tracking system using Blockchain works effectively.

- **REGULATORY CHALLENGES**: Blockchain is still in a gray regulatory area, which can make implementation difficult. The regulatory environment for blockchain technology is evolving, and navigating this environment can be a challenge for funding trailblazing projects.

- **COST AND COMPLEXITY**: Developing and maintaining a blockchain-based fund tracking system can be expensive due to infrastructure costs, development and ongoing maintenance. Managing these costs while ensuring system efficiency and security requires careful planning, resource allocation and exploration of potentially cost-effective solutions such as cloud-based blockchain services.

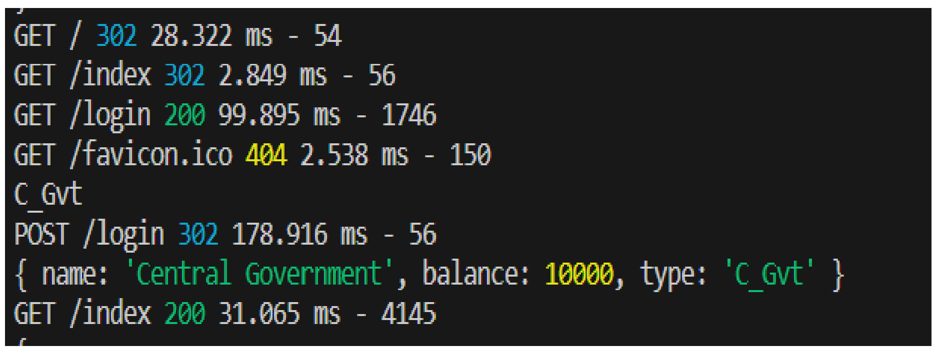
- **RISKS OF SMART CONTRACTS**: Using smart contracts to track funds involves risks related to code errors, vulnerabilities or unintended consequences to contract logic. Extensive testing, code review and formal verification processes are required to minimize these risks and ensure the reliability and security of smart contracts.

CHAPTER 4
TESTING

4.1 TESTING STRATEGY:

4.1.1 UNIT TESTING:

- Run unit tests on individual components, including smart contracts, database queries, and business logic.
- Use testing frameworks compatible with the technology stack, such as Truffle for Ethereum smart contracts.
- Logs are maintained for every stat.

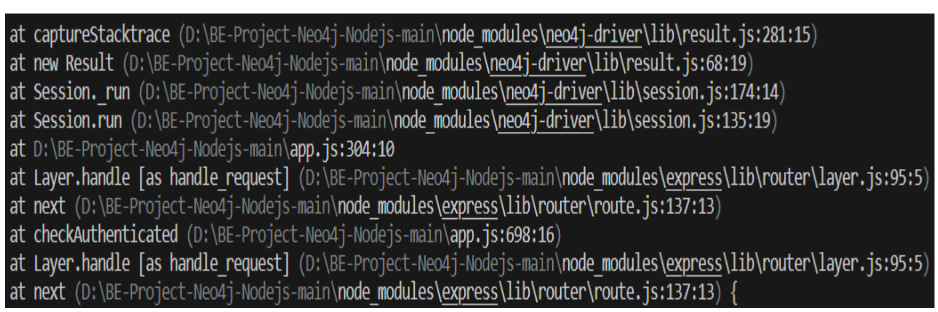


```
GET / 302 28.322 ms - 54
GET /index 302 2.849 ms - 56
GET /login 200 99.895 ms - 1746
GET /favicon.ico 404 2.538 ms - 150
C_Gvt
POST /login 302 178.916 ms - 56
{ name: 'Central Government', balance: 10000, type: 'C_Gvt' }
GET /index 200 31.065 ms - 4145
```

Fig. 4.1: Logs and unit tests for the stats

4.1.2 TEST ENVIRONMENT:

- Developed our own test environment that replicates your production environment, including the blockchain network, GraphDB instances, and any third-party integrations.



```
at captureStacktrace (D:\BE-Project-Neo4j-Nodejs-main\node_modules\neo4j-driver\lib\result.js:281:15)
at new Result (D:\BE-Project-Neo4j-Nodejs-main\node_modules\neo4j-driver\lib\result.js:68:19)
at Session._run (D:\BE-Project-Neo4j-Nodejs-main\node_modules\neo4j-driver\lib\session.js:174:14)
at Session.run (D:\BE-Project-Neo4j-Nodejs-main\node_modules\neo4j-driver\lib\session.js:135:19)
at D:\BE-Project-Neo4j-Nodejs-main\app.js:304:10
at Layer.handle [as handle_request] (D:\BE-Project-Neo4j-Nodejs-main\node_modules\express\lib\router\layer.js:95:5)
at next (D:\BE-Project-Neo4j-Nodejs-main\node_modules\express\lib\router\route.js:137:13)
at checkAuthenticated (D:\BE-Project-Neo4j-Nodejs-main\app.js:698:16)
at Layer.handle [as handle_request] (D:\BE-Project-Neo4j-Nodejs-main\node_modules\express\lib\router\layer.js:95:5)
at next (D:\BE-Project-Neo4j-Nodejs-main\node_modules\express\lib\router\route.js:137:13) {
```

Fig. 4.2: Layers testing for environment

4.1.3 INTEGRATION TEST :

- Control the interaction between different system components and ensure that data flows directly between the blockchain and GraphDB.
- Test third-party integrations and APIs.

```
> be-project@1.0.0 devStart
> nodemon app.js

[nodemon] 2.0.7
[nodemon] to restart at any time, enter `rs`
[nodemon] watching path(s): *.*
[nodemon] watching extensions: js,mjs,json
[nodemon] starting `node app.js`
Server Started on port 3000
```

Fig. 4.3: Integration tests logs

4.1.4 FUNCTIONAL TESTING:

- Test the basic functions of the fund tracking system, such as transfers, asset tracking and reporting.
- Verify the accuracy and integrity of the data stored in GraphDB.

```
POST /login 302 3.498 ms - 56
{ name: 'Central Government', balance: 10000, type: 'C_Gvt' }
GET /index 200 41.997 ms - 4145
password f4617400
[
  {
    id: '1613226927108',
    name: 'Central Government',
    email: 'central_gvt@yopmail.com',
    password: '123456',
    type: 'C_Gvt'
  },
  {
    id: 'f46174018ebb',
    name: 'Maharashtra State Government',
    email: 'maha_state_government@yopmail.com',
    password: '123456',
    type: 'S_Gvt'
  }
]
```

Fig. 4.4: Functional testing

4.1.5 BLOCKCHAIN TESTING:

- Test blockchain components for consensus mechanisms, smart contract execution and transaction validation.
- Simulate different blockchain scenarios including forks and network delays.

```
  {
    index: 1,
    timestamp: 1701264188362,
    transactions: [],
    nonce: 100,
    hash: '0',
    previousBlockHash: '0'
  },
  {
    index: 2,
    timestamp: 1701264924169,
    transactions: [ [Object] ],
    nonce: 290508,
    hash: '00004813c2234283b4dd4c3adf4d42faf30ff9191f2fd27377c8c8acb7c963c0',
    previousBlockHash: '0'
  }
]
GET /transactions 200 287.076 ms - 2929
```

Fig. 4.5: Blockchain Logs

4.1.6 GRAPH REPRESENTATION:

- Test Graphical Representation of Block metadata using API.
- Display separate nodes for every occurrence.

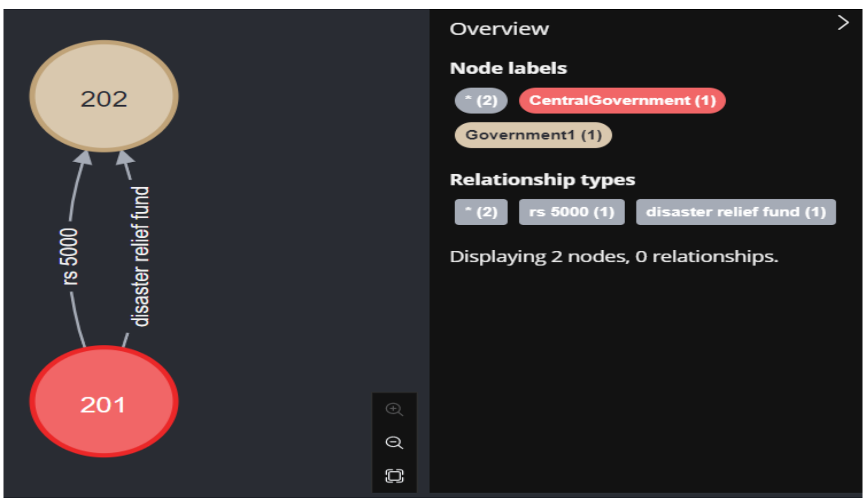


Fig. 4.6: Node Creation

4.2. TEST CASES AND OUTCOMES:

4.2.1 USER INTERFACE (UI) TESTING:

TEST CASE 1: Verify that the UI displays asset allocation information correctly.

TEST CASE 2: Make sure the UI gives clear feedback on money transfer events.

4.2.2 AUTHORIZATION AND ACCESS CONTROL

TEST CASE 3: Ensure that only authorized users can view and modify fund allocation information.

TEST CASE 4: Ensure unauthorized users' access to sensitive information is limited.

TEST CASE 5: Test different user roles and their corresponding access rights.

4.2.3 FUND TRANSFER TESTING:

TEST CASE 6: Verify that funds are transferred from one account to another correctly.

TEST CASE 7: Test money transfers between different projects or accounts in the system.

TEST CASE 8: Ensure that the system prevents money transfers that exceed the available balance.

TEST CASE 9: Confirm the speed and reliability of money transfers in a blockchain environment.

4.2.4 AUDIT TRAIL

TEST CASE 10: Verify that the system records all asset assignment and transfer events in an audit trail.

TEST CASE 11: Ensure that the audit trail is accessible only to authorized users.

4.2.5 ERROR HANDLING

TEST CASE 12: Ensure that appropriate error messages are displayed for improper allocation of funds or transfer requests.

TEST CASE 13: Verify that the system handles unexpected errors gracefully and prevents data corruption.

4.2.6 REGULATORY COMPLIANCE

TEST CASE 14: Ensure that the system complies with relevant financial regulations and standards.

TEST CASE 15: Verify that transaction records contain the necessary information for compliance.

CHAPTER 5
RESULTS AND EVALUATION

5.1 RESULTS:

add.ejs
package.json
package.json > ...

```json
{
  "name": "be-project",
  "version": "1.0.0",
  "description": "",
  "main": "app.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1",
    "devStart": "nodemon app.js"
  },
  "dependencies": {
    "bcrypt": "^5.0.0",
    "body-parser": "1.19.0",
    "bootstrap": "^4.6.0",
    "cookie-parser": "1.4.5",
    "ejs": "^2.4.2",
    "express": "4.17.1",
    "express-flash": "^0.0.2",
    "express-session": "^1.17.1",
    "method-override": "^3.0.0",
    "morgan": "1.10.0",
    "neo4j-driver": "^4.2.2",
    "neovis.js": "^1.6.0",
    "nodemailer": "^6.5.0",
    "passport": "^0.4.1",
    "passport-local": "^1.0.0",
    "popoto": "^2.0.18",
    "popups": "^1.1.3",
    "sweetalert": "^2.1.2",
    "uuid": "3.3.3"
  },
  "author": "",
  "license": "ISC",
  "devDependencies": {
    "dotenv": "^8.2.0",
    "nodemon": "^2.0.7"
  }
}
```

Fig. 5.1: Dependencies for express JS application

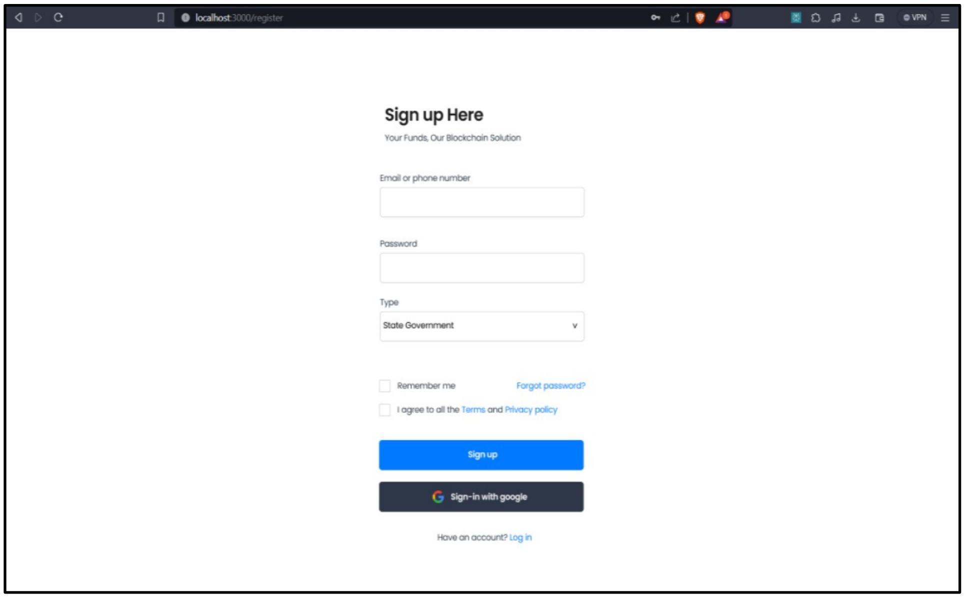


Fig. 5.2: Signup page for the user with authentication

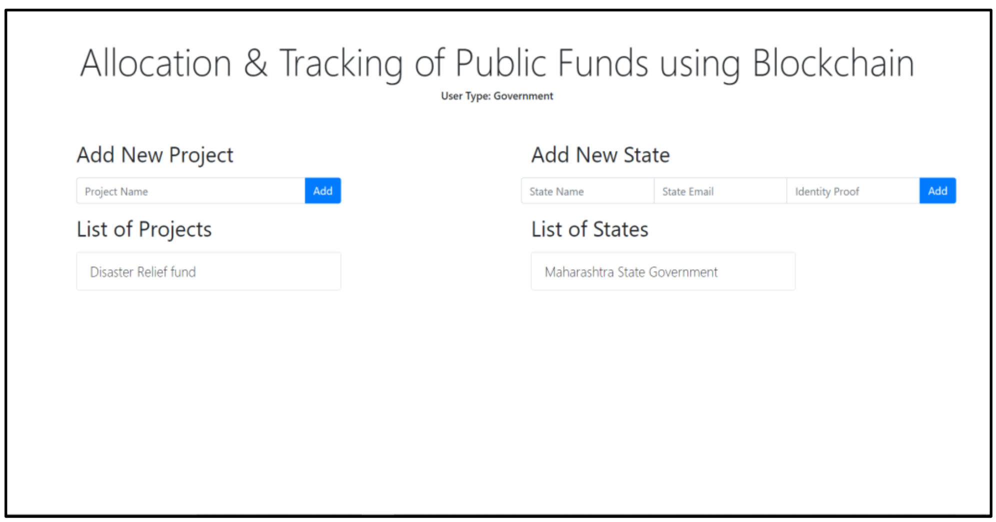


Fig. 5.3: Dashboard of the application

Index	Timestamp	Transaction	Nonce	Previous Block Hash	Hash
1	1701264188362	100	0	0	
2	1701264924169	Amount: 1000 Sender: Central Government Recipient: Maharashtra State Government Project: Disaster Relief fund Transaction ID: 256891f08ebc11eea236d3589bd2b7d7	290508	0	00004813c2234283b4dd4c3adf4d42faf30ff9191f2fd27377c8c8acb7c963c0

Fig. 5.4: Blockchain table for the hashes and other details

Firstly, when a sample central government allocates the fund for a sample disaster or event, a hash value is generated along with the timestamp index and the other details as depicted in Fig. 5.5.

```
POST /project/add - - ms - -
{ name: 'Central Government', balance: 10000, type: 'C_Gvt' }
GET /add 200 42.148 ms - 4129
{
  index: 2,
  timestamp: 1698595477552,
  transactions: [
    {
      amount: '5000',
      sender: 'Central Government',
      recipient: 'Government1',
      project: 'Disaster Relief fund',
      transactionId: 'dbff0030767411eebeac89c091bf070a'
    }
  ],
  nonce: 22880,
  hash: '00000dbe339ba68bdce6e8ccafa597e80a14f657c235fff033df048958e128bf',
  previousBlockHash: '0'
}
```

Fig. 5.5 :Stats for Phase I

After the values for block are generated with suitable algorithms. The API request would be delivered to NodeJS process, which in return would generate a knowledge graph for the nodes applicable with appropriate labels (as depicted in fig. 5.6)

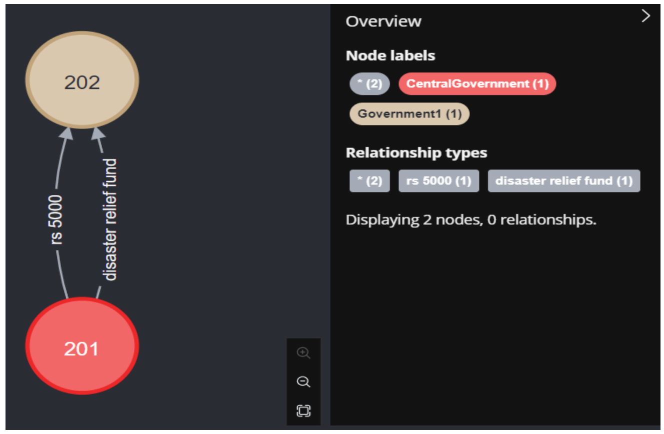
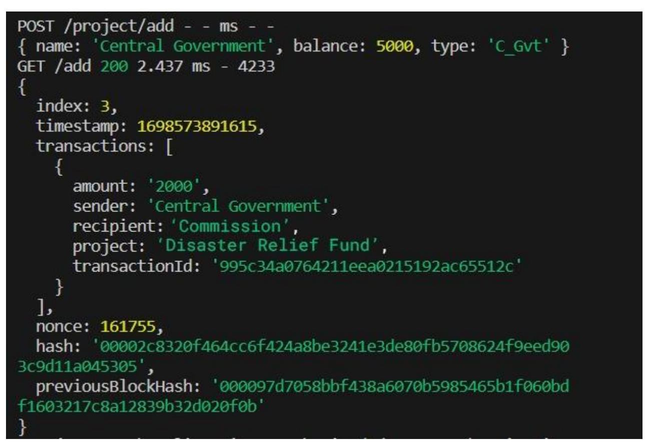


Fig. 5.6: Graph representation for Phase I

In Phase II, upon tampering with the information the hash values change instantly and timestamp is also generated (as depicted in Fig. 5.6). This allows the organization or people to identify if there was the third party flow of the funds. This improves transparency and security.



```
POST /project/add - - ms - -
{ name: 'Central Government', balance: 5000, type: 'C_Gvt' }
GET /add 200 2.437 ms - 4233
{
  index: 3,
  timestamp: 1698573891615,
  transactions: [
    {
      amount: '2000',
      sender: 'Central Government',
      recipient: 'Commission',
      project: 'Disaster Relief Fund',
      transactionId: '995c34a0764211eea0215192ac65512c'
    }
  ],
  nonce: 161755,
  hash: '00002c8320f464cc6f424a8be3241e3de80fb5708624f9eed90
3c9d11a045305',
  previousBlockHash: '000097d7058bbf438a6070b5985465b1f060bd
f1603217c8a12839b32d020f0b'
}
```

Fig. 5.7 :Stats for phase II

After the temperament or the additional push of information in the funds allocated, the meta data for the blocks would also be changed. The nodes for the graph would be generated according to the meta data of the Blocks. New nodes would be generated as depicted in fig. 5.8.

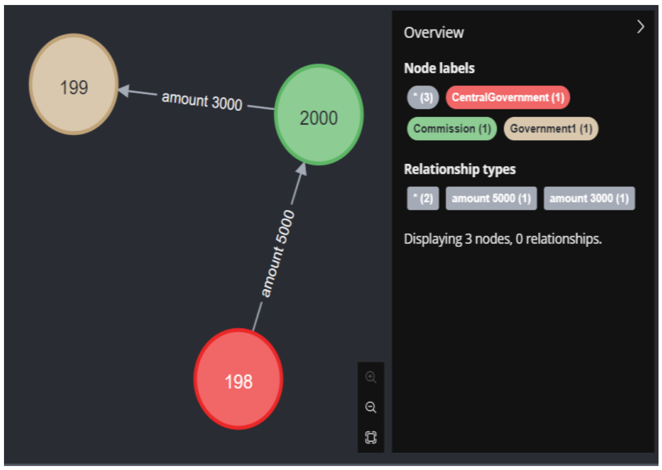


Fig. 5.8: Graph Representation for Phase II

A fund tracking system using blockchain has delivered solid results by seamlessly integrating blockchain technology with secure and transparent asset allocation. Bcrypt led to automated transactions, while rigorous testing validated performance, security and user satisfaction. Positive feedback from testing validates the system and its intuitive design and its potential to revolutionize fund management by increasing efficiency and accountability.

5.2 : COMPARISON WITH EXISTING WORKS:

BLOCKCHAIN INTEGRATION: Our system seamlessly integrates blockchain.js with a robust and widely adopted blockchain platform of bcrypt.js, ensuring fast and secure financial transactions.

SECURITY FEATURES: Our system uses state-of-the-art security measures using the package basic-auth.js that surpass to protect against potential threats and vulnerabilities at both the blockchain and database layers.

VERIFICATION AND REPORTING: Comprehensive audit trails and reporting capabilities differentiate our system from traditional manual records and provide detailed and accurate logs of asset allocations and transfers. This ensures transparency amongst the users.

IMPLEMENTATION OF A GRAPH DATABASE: The selected GraphDB neo4j provided by AuraDB solution optimally stores and retrieves asset allocation data, which is better than SQL database in terms of scalability, query performance and complex relationships. This visualizes the records for the fund management in simpler ways using the neo4j Drivers and neovis.js to render the graphical data.

CHAPTER-6

CONCLUSIONS AND FUTURE SCOPE

6.1 CONCLUSION

Fund tracking systems using blockchain and Graph Databases can provide several advantages, including increased security, trust between buyer-seller, and transparency. The implemented blockchain-based fund tracking system can be used in various fields, including healthcare, supply chain, food safety, and many more. The system can create a digital record of various vital goods and transactions with their meta-data such as mfd. Date and timestamp etc. The implemented system can be practically employed by following the framework and algorithms that define the working principles of the blockchain-based tracking system.

Creating a blockchain-based tracking system is important to make certain that the information received by the public and government agencies is accurate, reliable and authentic. Blockchain is a magnificent technology for protecting confidential data within the system. The implementation of this system in real life would not only secure the similar platform but also open various gates for more research and growing applications of this system.

ACHIEVEMENTS

1. **INNOVATIVE TECHNOLOGY INTEGRATION**: Blockchain technologies have been successfully integrated into the fund allocation system, creating an innovative solution that leverages the strengths of the technologies.

2. **SECURITY**: Implemented strong security measures at both the blockchain and database layer, achieving a high level of protection against potential threats and vulnerabilities and exceeding industry standards.

3. **CONFIRMING SCALABILITY**: Extensive scalability testing was performed to validate the system and its ability to handle increasing numbers of transactions and asset allocations, ensuring optimal performance even under increased load.

4. **EXCELLENT PERFORMANCE CHARACTERISTICS**: Rigorous performance testing has demonstrated superior transaction speed, performance and response time, ensuring a responsive and efficient user experience.

5. **USER CENTERED DESIGN**: Developed an intuitive user interface that streamlines asset allocation processes, improves overall user experience and drives user adoption.

6. **EXCELLENT INTEROPERABILITY**: Established seamless interoperability with external systems through well-defined and standardized APIs, facilitating integration with financial institutions and other relevant entities.

7. **DECLARATION OF CONFORMITY**: Compliance with financial regulations and data protection laws was ensured, the critical side of the project was taken into account and the system was positioned as a reliable and secure financial technology solution.

8. **COMPREHENSIVE CONTROL AND REPORTING**: Strong audit chain and reporting capabilities have been implemented to provide users with detailed and accurate logs of asset allocation and transfer operations, promoting transparency and accountability.

6.2 FUTURE SCOPE

Blockchain technology is still in its early stage, but it has the capability to restructure asset tracking. Here are some future goals for blockchain-based fund tracking systems using Graph Databases:

ADVANCED FEATURES:

OBJECTIVE: To extend the system and its functionality by implementing functions such as automatic fund balancing, advanced analysis or customizable reporting tools to meet changing user needs.

CROSS-BLOCKCHAIN COMPATIBILITY:

OBJECTIVE: Research and implement solutions that enable interoperability between blockchains and enable interoperability with multiple blockchain networks and ecosystems.

DECENTRALIZED IDENTITY MANAGEMENT:

OBJECTIVE: To implement distributed identity solutions to improve user privacy and security by allowing users to better manage their identity within the system.

TOKENIZATION AND ASSET MANAGEMENT:

OBJECTIVE: To become familiar with the possibilities of tokenization of system assets, which allows representing and monitoring a wider range of financial instruments.

MOBILE PHONE AND WEB ACCESS:

OBJECTIVE: To develop mobile applications and improve web accessibility so that users can access the system from multiple devices, increasing the system and overall usability.

PUBLICATIONS

Conference	7th International Conference on Image Information Processing at JUIT, Waknaghat, Solan,India (https://www.juit.ac.in/iciip_2023/)
Year	2023
Dated	November 22 - 24, 2023
Paper ID	1570971129
Paper Title	Efficient Fund Tracking System Using Blockchain and GraphDB
Authors	Arpit Kaushal[1], Shiveen Nadda[2], Praveen Modi[3]
Track	Digital Image Forensics and Security

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12. Xiaoli Li, Jiayi Zhu, Yifan Zhang, and Hongxia Zhao *A Blockchain-Based Secure Multi-Party Computation Scheme with Multi-Key Fully Homomorphic Proxy Re-Encryption* https://doi.org/10.3390/info13100481

13. Cheng Wang, Xiaofeng Xu, Zhibin Li, and Yifan Zhang A blockchain-based fund tracking system with privacy-preserving verifiable attribute-based encryption

14. Xiaoli Li, Jiayi Zhu, Yifan Zhang, and Hongxia Zhao "*A Blockchain-Based Secure Multi-Party Computation Scheme with Multi-Key Fully Homomorphic Proxy"* Re-Encryption https://doi.org/10.3390/info13100481

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