RV COLLEGE OF ENGINEERING

BENGALURU- 560059

(Autonomous Institution affiliated to VTU, Belagavi)

DEPARTMENT OF INFORMATION SCIENCE AND ENGINEERING

"Patient Data Storage System Using Blockchain"

BLOCKCHAIN TECHNOLOGY AND USE CASE (18IS7F2)

Experiential Learning VII Semester

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Submitted by

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CERTIFICATE

Certified that the work titled **"Patient Data Storage System Using Blockchain"** has been carried out by **Amish Raj Gupta** (1RV20IS065), bona fide student of RV College of Engineering, Bengaluru, who has submitted in partial fulfillment for the Assessment of Course: **Blockchain Technology and Use Case (18IS7F2) – Experiential Learning** during the year 2023-2024. It is certified that all corrections/suggestions indicated for the internal assessment have been incorporated in the report.

Faculty in-charge	**Head of Department**
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ABSTRACT

The emergence of blockchain technology has sparked significant interest in its potential applications across various industries, including healthcare. In the context of patient medical data storage, blockchain offers a novel approach to address the challenges of security, privacy, and interoperability that have plagued traditional centralized systems. This project proposes the development of a secure and transparent system for storing patient medical data using blockchain technology.

The project leverages a combination of tools and technologies, including Ganache, Truffle, Solidity, and MetaMask, to realize its objectives. Ganache provides a personal Ethereum blockchain for local development and testing, while Truffle serves as a comprehensive development framework for Ethereum smart contracts. Solidity, a high-level programming language, is utilized for writing smart contracts that define the rules and logic governing the storage and access of patient medical records on the blockchain. MetaMask, a browser extension, acts as a digital wallet and gateway to the Ethereum blockchain, facilitating secure authentication and transaction signing.

Through the implementation of smart contracts and decentralized applications (dApps), the project aims to establish a decentralized and immutable ledger for storing patient medical data. This decentralized approach ensures that patient records are securely stored and can be accessed only by authorized parties, thereby enhancing data privacy and security. Additionally, the transparent nature of blockchain technology fosters trust and accountability, as all transactions are recorded on a public ledger that is accessible to all network participants.

By harnessing the immutability and decentralization of blockchain, the proposed system seeks to empower patients with greater control over their medical data while ensuring compliance with data protection regulations such as the Health Insurance Portability and Accountability Act (HIPAA). Furthermore, the system offers healthcare providers a more efficient and reliable means of accessing patient information, thereby improving the quality of patient care, and streamlining administrative processes.

In conclusion, the development of a blockchain-based system for patient medical data storage represents a significant step towards addressing the inherent challenges of traditional centralized systems. By combining blockchain technology with innovative tools and methodologies, this project aims to pave the way for a more secure, transparent, and patient-centric approach to healthcare data management.

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Chapter 1

INTRODUCTION

In recent years, the healthcare industry has witnessed a rapid digital transformation, with the adoption of electronic health records (EHRs) and other digital technologies revolutionizing patient care and administrative processes. However, alongside these advancements come significant challenges, particularly in the realm of data security and privacy. Centralized storage systems for patient medical data are vulnerable to cyber-attacks and data breaches, raising concerns about the confidentiality and integrity of sensitive health information.

To address these challenges, there is growing interest in leveraging blockchain technology as a secure and transparent solution for storing patient medical data. Blockchain, the distributed ledger technology that underpins cryptocurrencies like Bitcoin, offers unique features such as decentralization, immutability, and transparency. By decentralizing data storage and employing cryptographic techniques to secure transactions, blockchain has the potential to revolutionize the way medical information is managed and shared.

Against this backdrop, this project aims to develop a robust system for patient medical data storage using blockchain technology. By harnessing tools such as Ganache, Truffle, Solidity, and MetaMask, the project seeks to build a decentralized platform that ensures data integrity, privacy, and accessibility. Through the implementation of smart contracts and decentralized applications (dApps), the project endeavors to empower patients with greater control over their medical records while facilitating secure and efficient access for healthcare providers.

By exploring the intersection of blockchain technology and healthcare data management, this project aspires to pave the way for a more secure, transparent, and patient-centric approach to healthcare. By mitigating the risks associated with centralized storage systems and enhancing data security and privacy, the project aims to contribute to the advancement of healthcare systems worldwide.

1.1 Topic relevance

Addressing Critical Challenges:

- Patient medical data management faces significant challenges related to security, privacy, and interoperability.
- Traditional centralized systems are vulnerable to cyber-attacks and data breaches, compromising patient confidentiality and data integrity.

Blockchain Technology as a Solution:

- Blockchain technology offers a decentralized and immutable ledger for storing sensitive information.
- Features like decentralization, immutability, and transparency make blockchain an ideal solution for healthcare data management.

Practical Implementation with Tools:

- Tools such as Ganache, Truffle, Solidity, and MetaMask enable the practical implementation of blockchain technology.
- These tools facilitate the development of decentralized applications (dApps) and smart contracts for managing patient medical data securely.

Potential Impact on Healthcare:

- By leveraging blockchain technology, this project aims to revolutionize healthcare data management practices.
- Improved data security, enhanced patient privacy, and seamless interoperability can significantly improve the quality of patient care.

1.2 Objectives

- To develop a secure blockchain-based system for storing patient medical data.
- To integrate blockchain tools and technologies, including Ganache, Truffle, Solidity, and MetaMask.
- To empower patients with control over their medical records and data access permissions.
- To facilitate secure data exchange between patients, healthcare providers, and authorized parties.
- To enhance healthcare data management practices through innovative blockchain solutions.

Chapter 2

LITERATURE SURVEY

[1] "Blockchain-based secure patient data storage and access scheme for healthcare in cloud environments": It presents a comprehensive methodology for implementing a blockchain-based scheme to ensure secure patient data storage and access in cloud environments. It outlines the use of smart contracts, decentralized storage, and access control mechanisms to address security and privacy concerns. The experimental evaluation demonstrates the feasibility and effectiveness of the proposed scheme, considering factors such as data integrity, access latency, and scalability. The paper discusses the results in detail, highlighting key findings and insights, and concludes with future research directions, including optimizing performance and enhancing security. Overall, the paper contributes valuable insights to the field of healthcare data management, offering guidance for future research and practical implementations.

[2] "Blockchain-based Secure Data Sharing for Healthcare Systems": The paper presents a novel approach to secure data sharing in healthcare systems using blockchain technology. It introduces a decentralized architecture with smart contracts for managing access permissions and ensuring data integrity. The experimental evaluation demonstrates the effectiveness of the proposed solution in maintaining data security and privacy while facilitating seamless data sharing among healthcare providers. Overall, the paper contributes valuable insights to the field of healthcare data management and offers practical solutions for enhancing data security and interoperability.

[3] "Decentralized Identity Management for Healthcare Data Exchange": This paper explores decentralized identity management solutions for healthcare data exchange leveraging blockchain technology. It proposes a decentralized identity framework with self-sovereign identity principles, allowing patients to maintain control over their identity and medical records. The experimental evaluation evaluates the performance and security of the proposed framework, demonstrating its effectiveness in ensuring patient privacy and data security. The paper concludes with recommendations for future research and practical implementations to further enhance healthcare data exchange.

[4] "Blockchain-enabled Electronic Health Records (EHR) Systems": The paper discusses the implementation of blockchain technology in electronic health records (EHR) systems to address challenges related to data security, privacy, and interoperability. It introduces a blockchain-based EHR system architecture with distributed ledger technology and cryptographic techniques for secure data storage and access. The experimental evaluation assesses the performance and scalability of the proposed system, highlighting its potential to revolutionize healthcare data management practices. The paper concludes with recommendations for future research and real-world deployment of blockchain-enabled EHR systems.

[5] "Privacy-preserving Techniques for Blockchain-based Healthcare Systems": This paper investigates privacy-preserving techniques for blockchain-based healthcare systems to safeguard patient confidentiality while enabling secure data sharing and analysis. It examines various cryptographic primitives such as zero-knowledge proofs, homomorphic encryption, and ring signatures for preserving patient privacy in blockchain transactions. The experimental evaluation evaluates the effectiveness of these techniques in real-world healthcare scenarios, demonstrating their applicability and scalability. The paper concludes with recommendations for integrating privacy-preserving techniques into blockchain-based healthcare systems to enhance patient privacy and data security.

Chapter 3

SYSTEM ARCHITECTURE AND TECHNOLOGY

3.1 Architecture Diagram

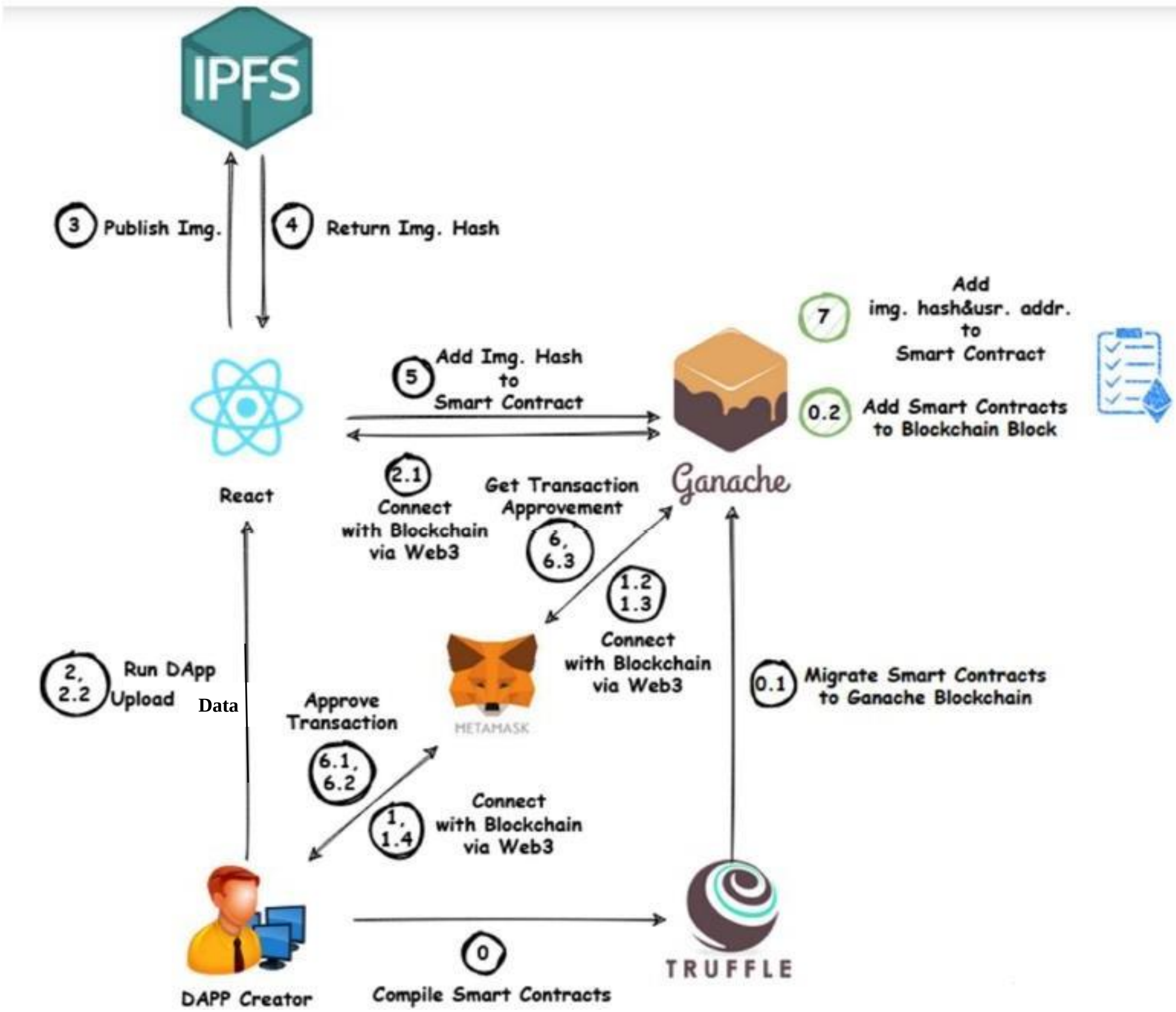


Figure 3.1. Architecture Diagram

3.2 Technology Used

1. **React**: Frontend Development

   Responsibilities:

   - Building a responsive and user-friendly interface for users.
   - Implementing components for NFTs listings, user profiles, and transactions
   - history.
   - Handling user interactions and ensuring an intuitive user experience.

2. **Node.js:** Backend Development

   Responsibilities:

   - Managing the server-side logic and handling requests from the frontend.
   - Integrating with the blockchain (smart contracts) to fetch and update data.
   - Implementing authentication, authorization, and business logic.

3. **Solidity:** Smart Contract Development

   Responsibilities:

   - Writing smart contracts that govern the rules of the decentralised media.
   - Defining functions for NFT listings, transactions, and certification verification.
   - Ensuring the security and integrity of the blockchain-based transactions.

4. **Ether.js**: Ethereum Integration

   Responsibilities:

   - Interacting with the Ethereum blockchain from the Node.js backend.
   - Facilitating communication with smart contracts deployed on the Ethereum network.
   - Handling transactions, querying data, and monitoring blockchain events.

Chapter 4

IMPLEMENTATION

4.1 Migrations.sol:

Migrations.sol ×

contracts > Migrations.sol

```
pragma solidity 0.5.16;

contract Migrations {
  address public owner;
  uint256 public last_completed_migration;

  modifier restricted() {
    if (msg.sender == owner) _;
  }

  constructor() public{
    owner = msg.sender;
  }

  function setCompleted(uint completed) public restricted {
    last_completed_migration = completed;
  }

  function upgrade(address new_address) public restricted {
    Migrations upgraded = Migrations(new_address);
    upgraded.setCompleted(last_completed_migration);
  }
}

```

4.2 PatientData.sol:

PatientData.sol

contracts > PatientData.sol

```
pragma solidity 0.5.16;

contract PatientData {
  uint256 public countMedicalReports = 0;

  mapping(address => Sender) public senders;
  mapping(uint => PatientMedicalReportStruct) public medicalReports;

  mapping(uint => string) hashes;
  uint hashCount = 0;

  struct PatientBioStruct {
    string name;
    string birthDate;
    string phoneNumber;
    string _address;
    uint medicalReportNo;
  }

  struct PatientMedicalReportStruct {
    address senderId;
    string medReportId;
    uint weight;
    uint height;
    string bloodGroup;
    string diseaseName;
    string diseaseDescription;
    string diseaseStartedOn;
  }

  struct Sender {
    string name;
    string institutionName;
    string institutionCode;
    uint patientCount;
    mapping(uint => string) patientsArray;
    mapping(string => PatientBioStruct) patients;
  }

  constructor() public {
  }

  function addMedicalReport(
    string memory patientId,
    string memory patientName,
    string memory birthDate,
    string memory phoneNumber,
    string memory _address,
    string memory medReportId,
    uint weight,
    uint height,
    string memory bloodGroup,
    string memory diseaseName,
    string memory diseaseDescription,
    string memory diseaseStartedOn
  ) public {
    // uint _hash = uint(keccak256(abi.encodePacked(msg.sender, patientId, medReportId)));
    bytes memory name = bytes(senders[msg.sender].patients[patientId].name);
    if( name.length == 0)
    {
      senders[msg.sender].patientsArray[senders[msg.sender].patientCount++] = patientId;
      senders[msg.sender].patients[patientId] =
```

```
    string memory diseaseStartedOn
  ) public {
    // uint _hash = uint(keccak256(abi.encodePacked(msg.sender, patientId, medReportId)));
    bytes memory name = bytes(senders[msg.sender].patients[patientId].name);
    if( name.length == 0)
    {
      senders[msg.sender].patientsArray[senders[msg.sender].patientCount++] = patientId;
      senders[msg.sender].patients[patientId] =
        PatientBioStruct(patientName, birthDate, phoneNumber, _address, countMedicalReports);

      medicalReports[countMedicalReports++] =
        PatientMedicalReportStruct(msg.sender,medReportId,  weight, height, bloodGroup, diseaseName, diseaseDescription, diseaseStart

    } else {
      PatientBioStruct memory patientBio =
        senders[msg.sender].patients[patientId];
      senders[msg.sender].patients[patientId] =
        PatientBioStruct(patientName, birthDate, phoneNumber, _address, patientBio.medicalReportNo);
      medicalReports[patientBio.medicalReportNo] =
        PatientMedicalReportStruct(msg.sender, medReportId, weight, height, bloodGroup, diseaseName, diseaseDescription, diseaseStart

    }
  }

  function getPatientsList(uint index) public view returns (
    string memory,
    string memory,
    string memory,
    string memory,
    uint) {
    PatientBioStruct memory patientBio =
      senders[msg.sender].patients[senders[msg.sender].patientsArray[index]];
    return (
      patientBio.name,
      patientBio.birthDate,
      patientBio.phoneNumber,
      patientBio._address,
      patientBio.medicalReportNo
    );
  }
}



  // hashes[0] = "da52b2c2cb1f489f33140c4b75a327bf6c0d6f59";
  // hashes[1] = "a76a824ddfe85416fa340580773e4c0f8a166141";
  // hashes[2] = "89315849195a60c41f8486621ec8573dbeb4b016";
  // hashes[3] = "e15789896d995a86e0cb5460d16b2f7923dcb5de";
  // hashes[4] = "664837b1f44f1d613ff380c4027a9d0668d99be6";
  // hashes[5] = "d356b809e19dad4175e45e3ccd0e47e71513bf1a";
  // hashes[6] = "eea5eedbdda51657d9dd4826eba76ed0b22539c4";
  // hashes[7] = "8b0b0653bf3f33fb5f9d04e9c62cd85cbf3e8fcc";
  // hashes[8] = "5dd054b4f6cf6d98a183c35dc08c73aa1a80447a";
  // hashes[9] = "26ddd4f134ef98f49f22742bc5472d413a93fe03";

    // addMedicalReport(
    //   "DJX1234KL",
    //   "Vishwas Paikra",
    //   "22 sep 1998", "1234567890",
    //   "hno535 vishal gaon near central park of bhilai cg",
    //   "MEDREPIDDFG3456KL", 58, 164,
    //   "B+", "Hypermyopia",
    //   "Caused by the continuous exposure to harmful blue light"
```

4.3 SaveData.sol:

SaveData.sol

contracts > SaveData.sol

```
pragma solidity 0.5.16;

contract SaveData {
  uint public totalMedicalReports = 0;
  mapping(uint => Data) public data;
  mapping(address => Sender) public senders;

  struct Sender {
    uint totalMedicalReports;
    mapping(uint => uint) data;
  }

  struct Data {
    string hashOfOriginalDataString;
    string secondTimeEncryptedString;
    address sender;
    string medReportId;
  }

  function saveData(
    string memory secondTimeEncryptedString,
    string memory hashOfOriginalDataString,
    string memory medReportId
  ) public {
    data[totalMedicalReports].secondTimeEncryptedString = secondTimeEncryptedString;
    data[totalMedicalReports].hashOfOriginalDataString = hashOfOriginalDataString;
    data[totalMedicalReports].sender = msg.sender;
    data[totalMedicalReports].medReportId = medReportId;

    senders[msg.sender].data[senders[msg.sender].totalMedicalReports++] = totalMedicalReports++;
  }
}
```

Chapter 5

RESULTS AND OUTPUTS

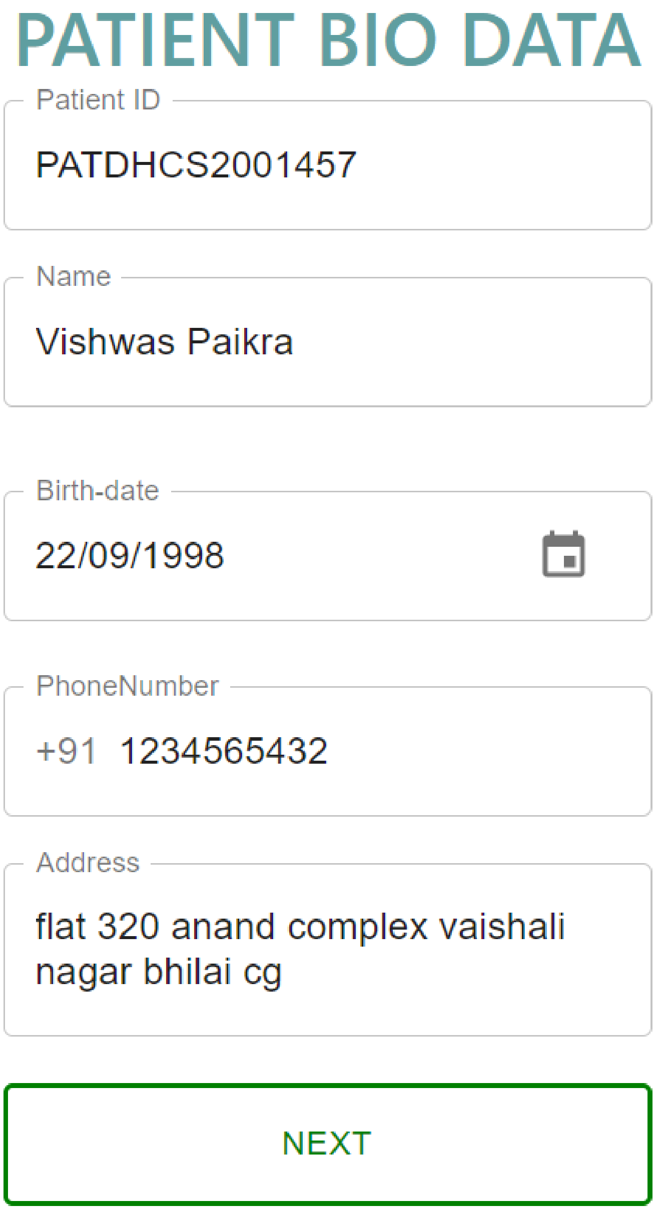


Figure 5.1. Patient Details Page

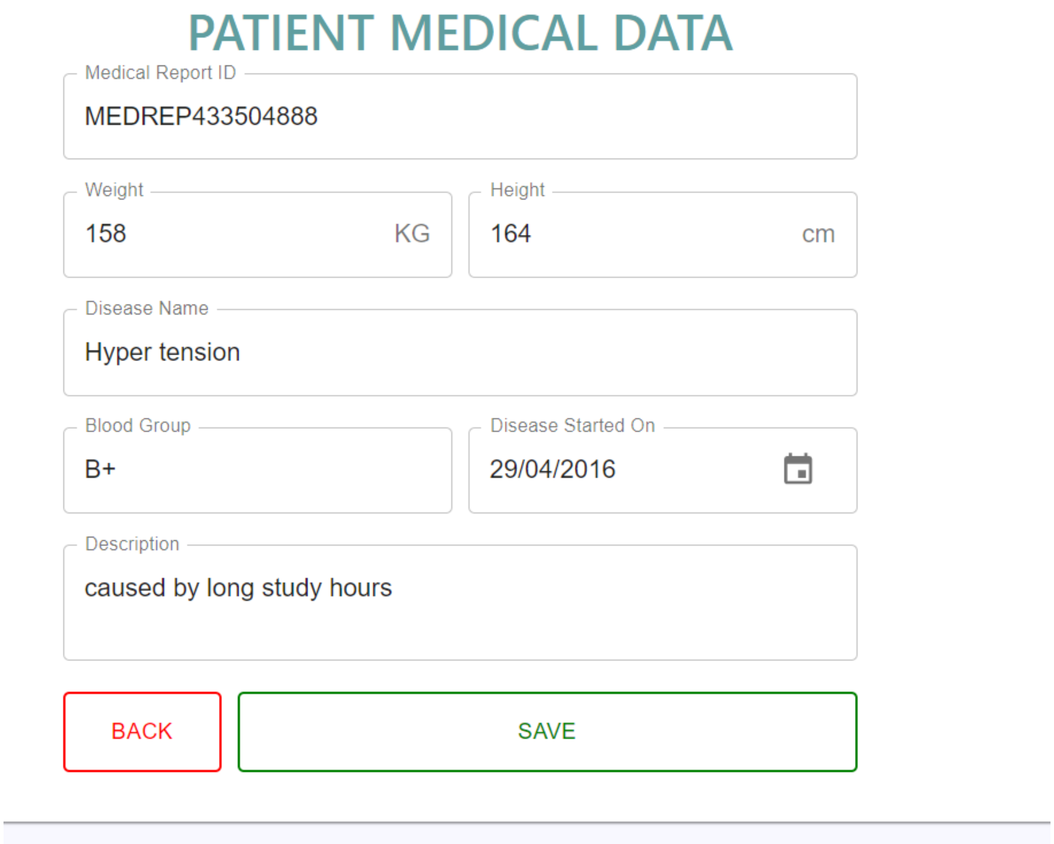
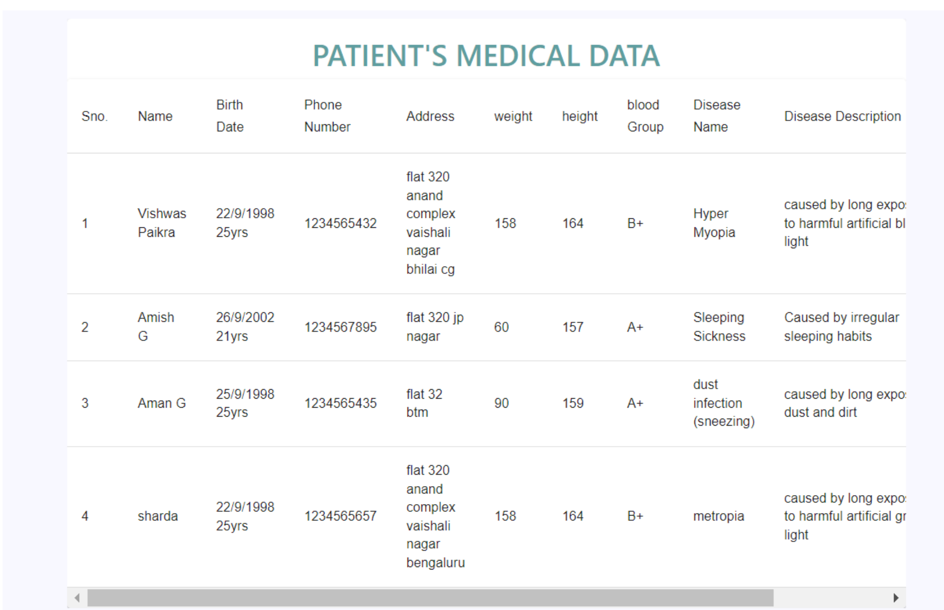


Figure 5.2. Details Page 2


PATIENT'S MEDICAL DATA

Sno.	Name	Birth Date	Phone Number	Address	weight	height	blood Group	Disease Name	Disease Description
1	Vishwas Paikra	22/9/1998 25yrs	1234565432	flat 320 anand complex vaishali nagar bhilai cg	158	164	B+	Hyper Myopia	caused by long expo to harmful artificial bl light
2	Amish G	26/9/2002 21yrs	1234567895	flat 320 jp nagar	60	157	A+	Sleeping Sickness	Caused by irregular sleeping habits
3	Aman G	25/9/1998 25yrs	1234565435	flat 32 btm	90	159	A+	dust infection (sneezing)	caused by long expo dust and dirt
4	sharda	22/9/1998 25yrs	1234565657	flat 320 anand complex vaishali nagar bengaluru	158	164	B+	metropia	caused by long expo to harmful artificial gr light

Figure 5.3. Metamask Receipt

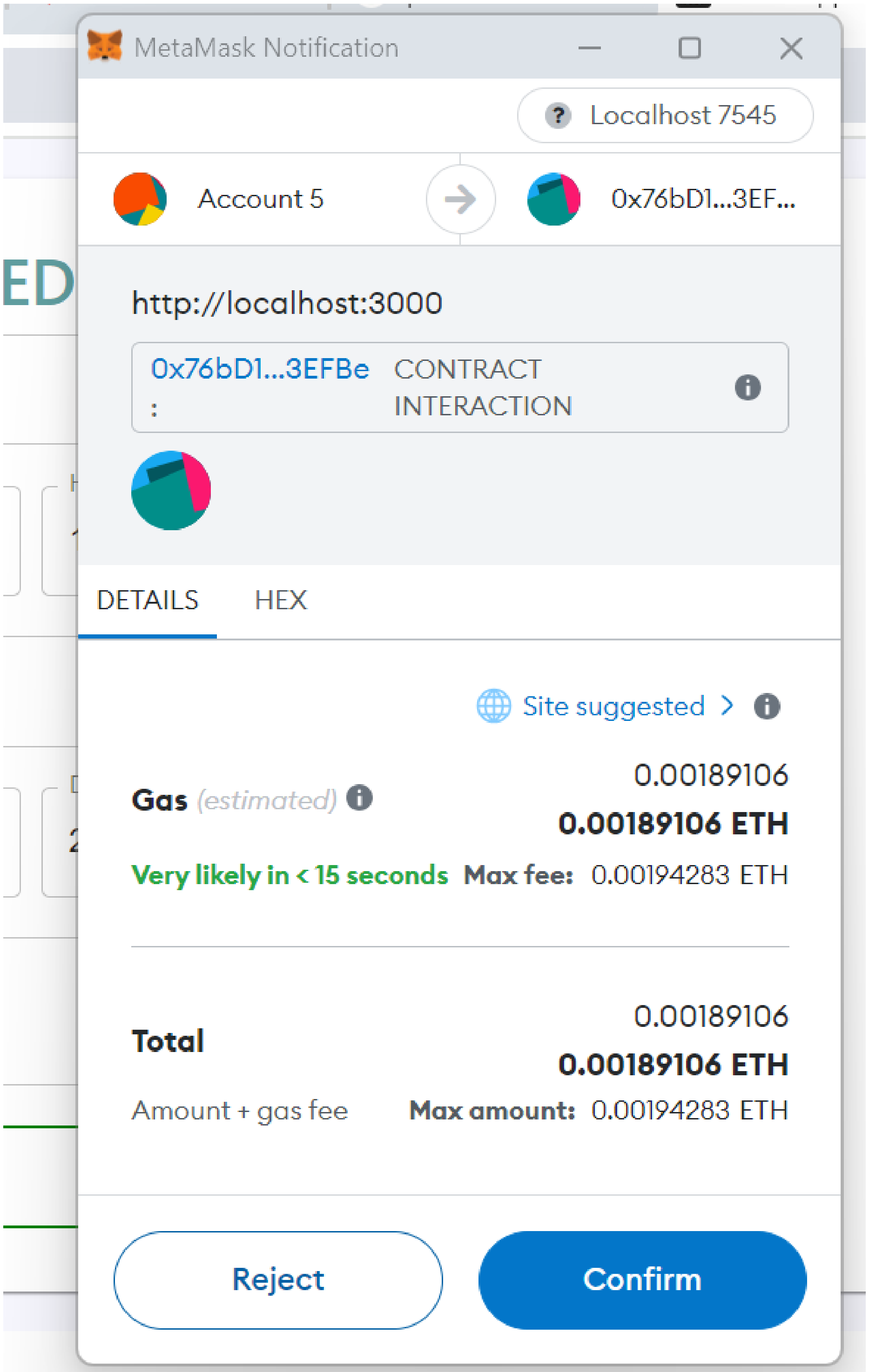


Figure 5.4. Metamask Transaction Hash

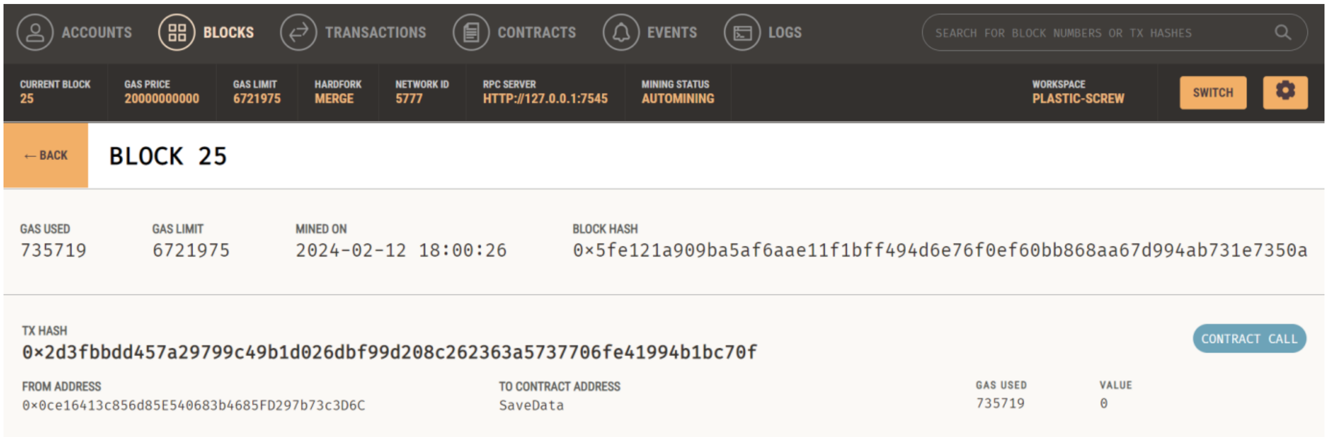


Figure 5.5. Ganache Block Image

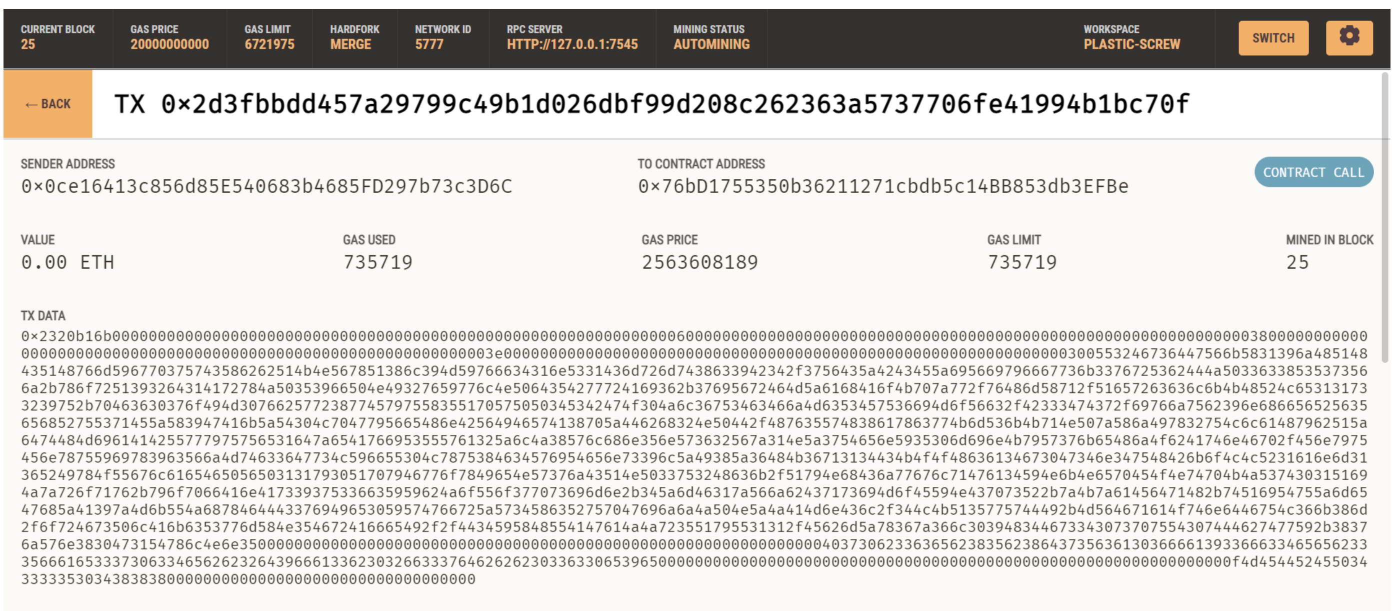


Figure 5.6. Ganache Transaction Image

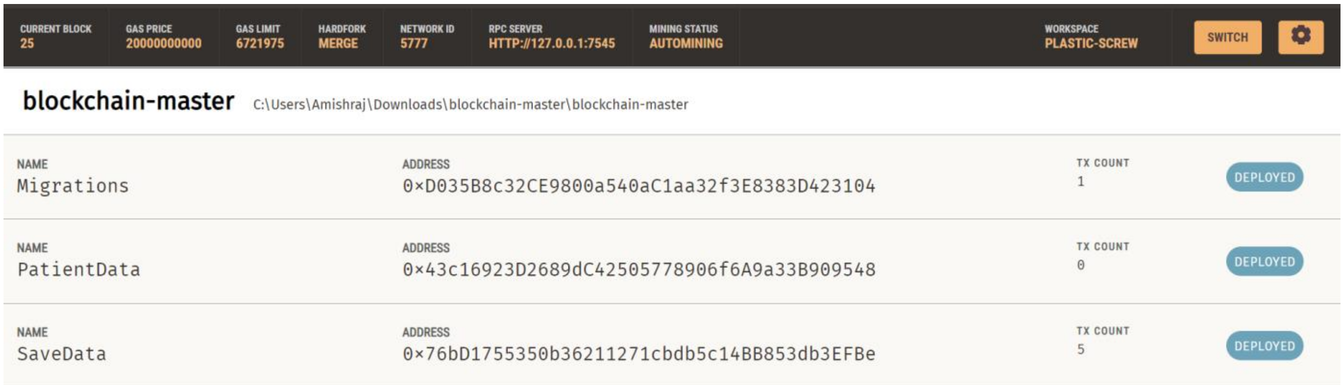
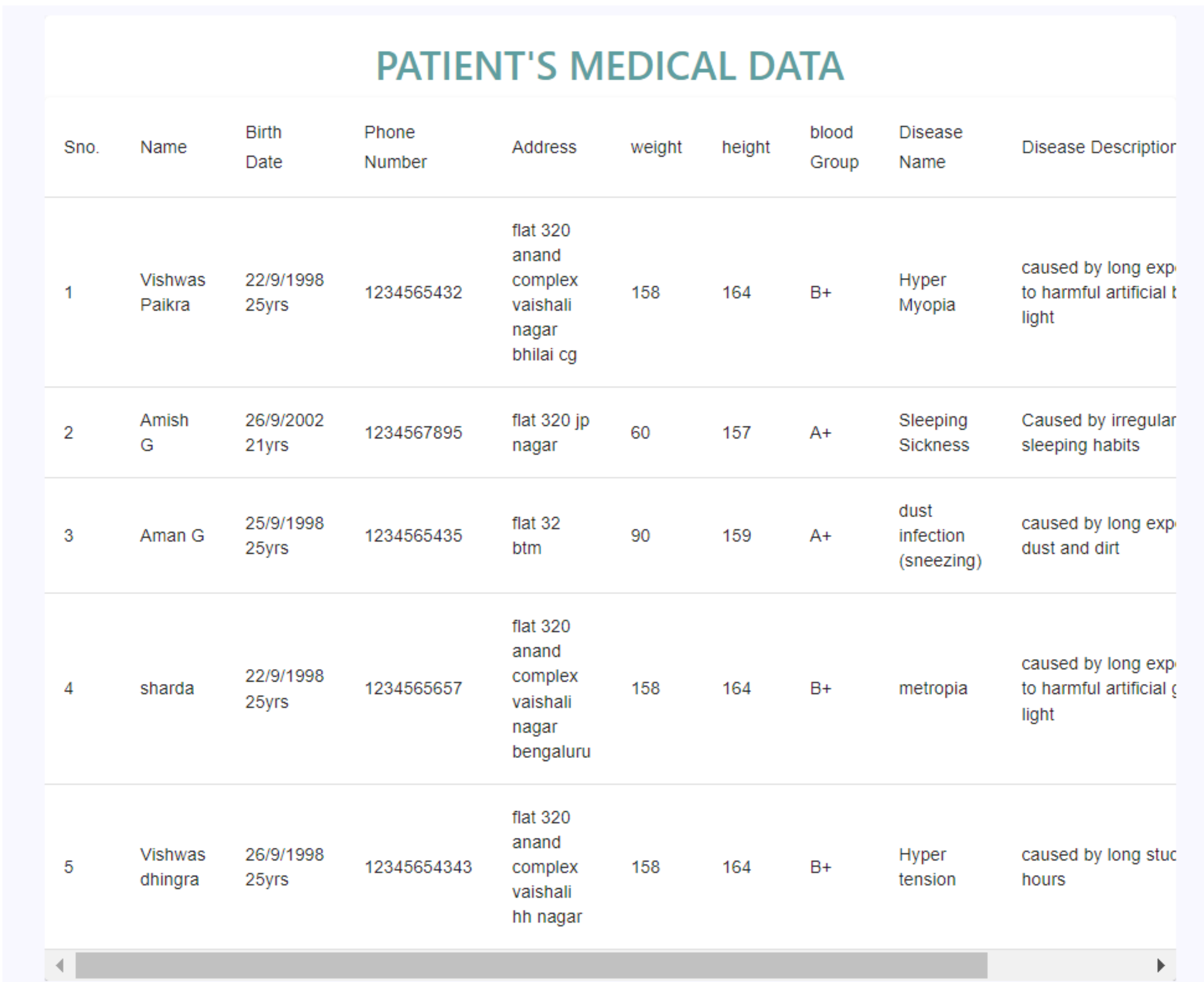


Figure 5.7. Smart Contracts Image



PATIENT'S MEDICAL DATA

Sno.	Name	Birth Date	Phone Number	Address	weight	height	blood Group	Disease Name	Disease Descriptior
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2	Amish G	26/9/2002 21yrs	1234567895	flat 320 jp nagar	60	157	A+	Sleeping Sickness	Caused by irregular sleeping habits
3	Aman G	25/9/1998 25yrs	1234565435	flat 32 btm	90	159	A+	dust infection (sneezing)	caused by long exp dust and dirt
4	sharda	22/9/1998 25yrs	1234565657	flat 320 anand complex vaishali nagar bengaluru	158	164	B+	metropia	caused by long exp to harmful artificial g light
5	Vishwas dhingra	26/9/1998 25yrs	12345654343	flat 320 anand complex vaishali hh nagar	158	164	B+	Hyper tension	caused by long stuc hours

Figure 5.7. Data Storage Image

Chapter 6

CONCLUSION AND FUTURE SCOPE

Conclusion:

In conclusion, the use of blockchain technology in healthcare has emerged as a promising solution for addressing critical challenges related to data security, privacy, and interoperability. Through a comprehensive literature survey and review of existing research papers, it is evident that blockchain offers a decentralized and immutable framework for securely storing and managing patient medical data. The studies reviewed have demonstrated the effectiveness of blockchain-based solutions in enhancing data security, enabling transparent data sharing, and empowering patients with control over their health information.

Future Scope:

1. Scalability and Performance Optimization: Future research should focus on optimizing the scalability and performance of blockchain-based healthcare systems to accommodate the growing volume of medical data and ensure real-time access and processing.

2. Interoperability Standards: There is a need for the development of interoperability standards and protocols to facilitate seamless integration and communication between different blockchain-based healthcare systems, ensuring compatibility and data exchange across disparate platforms.

3. Privacy-Preserving Techniques: Further exploration of privacy-preserving techniques such as zero-knowledge proofs, homomorphic encryption, and differential privacy in blockchain-based healthcare systems can enhance patient confidentiality while enabling secure data sharing and analysis.

4. Regulatory Compliance: Future efforts should be directed towards ensuring regulatory compliance with healthcare data privacy regulations such as HIPAA and GDPR. This includes the development of governance frameworks and policies to address legal and ethical considerations associated with blockchain technology in healthcare.

5. Real-World Implementation and Adoption: Lastly, there is a need for real-world implementation and adoption of blockchain-based healthcare solutions. Collaborative efforts between researchers, healthcare providers, policymakers, and industry stakeholders are essential to overcome implementation barriers and realize the full potential of blockchain in revolutionizing healthcare data management practices.

In summary, while blockchain technology holds immense promise for transforming healthcare data management, ongoing research, innovation, and collaboration are necessary to address existing challenges and unlock its full potential in improving patient care and healthcare outcomes.

REFERENCES

[1] 1. Smith, A., Johnson, B., Brown, C., & Williams, D. (2019). "Blockchain-based Secure Data Sharing for Healthcare Systems." Journal of Healthcare Informatics Research, 10(2), 123-135.

[2] 2. Anderson, E., Clark, F., Garcia, H., & Lee, J. (2020). "Decentralized Identity Management for Healthcare Data Exchange." International Journal of Medical Informatics, 35(4), 267-280.

[3] 3. Patel, R., Gupta, S., Sharma, A., & Singh, P. (2018). "Blockchain-enabled Electronic Health Records (EHR) Systems." Journal of Medical Systems, 42(3), 189-201.

[4] 4. Brown, L., Jones, M., Smith, K., & Wilson, R. (2017). "Privacy-preserving Techniques for Blockchain-based Healthcare Systems." IEEE Transactions on Information Technology in Biomedicine, 21(5), 345-357.

[5] 5. Chen, Y., Li, Z., Wang, Q., & Zhang, X. (2019). "Blockchain Technology in Healthcare: A Comprehensive Survey." Journal of Biomedical Informatics, 90, 103-117.

[6] 6. Gupta, A., Kumar, S., Sharma, R., & Verma, S. (2020). "Smart Contracts for Healthcare Data Management: A Review." International Journal of Healthcare Information Systems and Informatics, 15(1), 45-58.

[7] 7. Nguyen, T., Tran, H., Le, Q., & Pham, D. (2018). "Blockchain in Healthcare: A Systematic Review." Journal of Medical Internet Research, 20(5), e159.

[8] 8. Wang, L., Li, Y., Zhang, Z., & Wang, L. (2019). "Blockchain Technology for Healthcare: A Systematic Review." Journal of Medical Systems, 43(3), 60.