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Summer Internship Report
on

”EcoVisionNet VLM: A Multi-Task Vision-Language Model for Geospatial Pixel Reasoning and Remote Sensing Analysis”

CS376SI

Submitted by

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Submitted in
partial fulfillment for the award of degree

BACHELOR OF ENGINEERING
in
Computer Science and Engineering
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

2025-26

RV COLLEGE OF ENGINEERING®

(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Bengaluru – 560059

CERTIFICATE

This is to certify that the internship work titled **“A Blockchain-Based Framework for Verifiable and Privacy-Preserving Federated Learning in Medical AI Systems”** has been successfully carried out by **Manas Sakthivel (USN: 1RV22CS103)** and **Pallavi Girish (USN: 1RV22CS132)**, Bonafide students of **RV College of Engineering®, Bengaluru**, affiliated to **Visvesvaraya Technological University (VTU), Belagavi**.

The work has been submitted in partial fulfilment of the requirements for the award of the **Bachelor of Engineering in Computer Science and Engineering** during the academic year **2025–26**.

It is further certified that all corrections and suggestions indicated during the internal assessment have been duly incorporated in the final report submitted to the departmental library. The internship report has been approved as it satisfies the academic requirements prescribed for the internship component of the said degree.

Evaluation Committee Member/s
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Name of the External Examiners	**Signature with Date**
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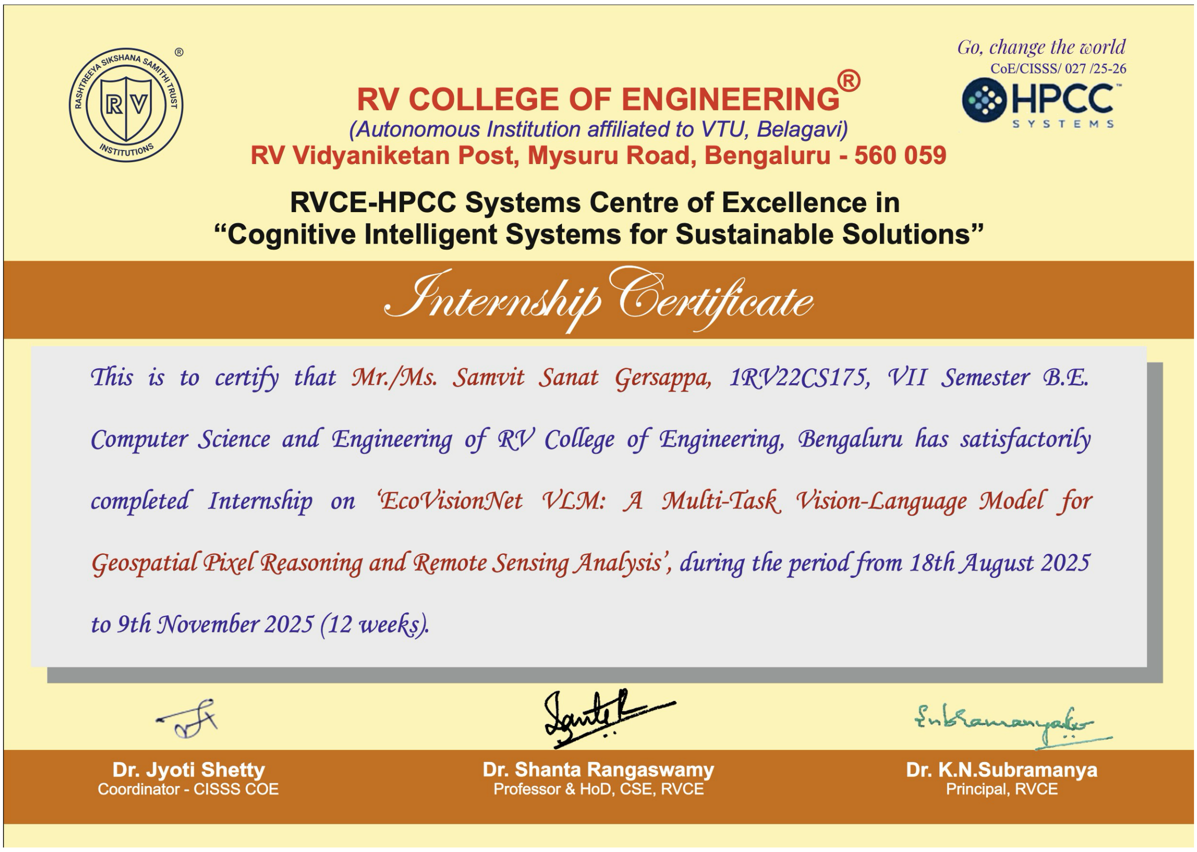
CERTIFICATE FROM INDUSTRY



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RVCE-HPCC Systems Centre of Excellence in
"Cognitive Intelligent Systems for Sustainable Solutions"

Internship Certificate

This is to certify that Mr./Ms. Samvit Sanat Gersappa, 1RV22CS175, VII Semester B.E. Computer Science and Engineering of RV College of Engineering, Bengaluru has satisfactorily completed Internship on 'EcoVisionNet VLM: A Multi-Task Vision-Language Model for Geospatial Pixel Reasoning and Remote Sensing Analysis', during the period from 18th August 2025 to 9th November 2025 (12 weeks).

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EXECUTIVE SUMMARY

This project presents the design and implementation of a **secure, decentralized Electronic Health Record (EHR) management system** that leverages **blockchain technology and distributed storage** to address critical challenges in healthcare data management. Traditional centralized EHR systems often suffer from vulnerabilities related to **data privacy, integrity, availability, and lack of patient-centric control**. The proposed system overcomes these limitations by introducing a trustless, transparent, and auditable architecture.

The framework employs **Ethereum smart contracts** to enforce **tamper-proof access control, transparent authorization policies, and immutable audit trails** for all EHR-related transactions. To ensure scalability and confidentiality, sensitive patient records are stored **off-chain using the InterPlanetary File System (IPFS)**, while only cryptographic hashes and metadata are recorded on-chain. This design preserves data integrity while preventing exposure of protected health information.

Secure key management and identity handling are achieved through controlled account generation, with deterministic wallet derivation using a fixed mnemonic to ensure reproducibility and ease of deployment across environments. The architecture supports robust cryptographic controls for authentication and authorization, ensuring that access to medical records remains strictly permissioned.

A **Flask-based web interface** enables intuitive interaction for both patients and healthcare providers, supporting secure record uploads, controlled data sharing, permission management, and real-time system updates. The modular system design allows seamless integration with existing healthcare infrastructures and workflows while maintaining compliance with regulatory standards.

By separating sensitive patient data from on-chain metadata, the system aligns with **HIPAA and GDPR requirements**, including support for **functional data erasure** and patient-controlled consent revocation. Through the integration of blockchain immutability, distributed storage, and strong cryptographic mechanisms, the proposed solution delivers a **practical, privacy-preserving, and regulation-compliant EHR platform** that empowers patients, enhances provider collaboration, and strengthens trust in modern healthcare information systems.

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Chapter 1

Profile of the Organization

1.1 Organizational Structure

The **RVCE-HPCC Systems Center of Excellence in ”Cognitive Intelligent Systems for Sustainable Solutions” (HPCC-CISSS CoE)** functions as a structured academic–industry collaborative unit aimed at accelerating research and innovation in artificial intelligence, machine learning, and geospatial analysis. The CoE operates under the guidance of HPCC Systems, USA, and follows a decentralized yet well-coordinated organizational structure involving faculty coordinators, technical experts, industry mentors, and student members. Leadership roles are distributed to ensure effective planning, execution, and monitoring of activities, while maintaining strong alignment with institutional objectives and global HPCC Systems initiatives. The structure promotes interdisciplinary collaboration, continuous learning, and innovation by integrating academic expertise with real-world industry practices, thereby enabling the CoE to function as a dynamic platform for skill development, research, and societal impact.

1.2 Products and Innovations

The HPCC-CISSS CoE primarily focuses on the development of intellectual and knowledge-based products rather than conventional commercial goods. These products include high-quality research publications, AI and machine learning frameworks, training modules, and innovative technical solutions developed during hackathons, workshops, and internships. The CoE has successfully published multiple research papers in reputed journals and conferences, contributing to advancements in computer vision, remote sensing, geospatial analysis, and related domains. Additionally, advanced AI-based lab environments and skill-development content created through collaborations with industry partners serve as valuable academic resources. The CoE continues to encourage innovation-driven outcomes and research-oriented deliverables.

1.3 Services

The HPCC-CISSS CoE provides a comprehensive range of academic, technical, and professional services designed to enhance employability, technical expertise, and industry readiness. These services include structured training programs in Artificial Intelligence, Machine Learning, Computer Vision, and Geospatial Analysis, certification-oriented learning in collaboration with global technology partners, and internship programs for undergraduate, postgraduate, and MCA students. The CoE also conducts workshops, seminars, hands-on laboratories, and faculty development programs to ensure continuous skill enhancement. In addition, consultancy services are offered in specialized domains such as vision-language models, remote sensing applications, and sustainable AI solutions, enabling both students and faculty to gain practical exposure to real-world technological challenges.

1.4 Business Partners

The success and outreach of the HPCC-CISSS CoE are strongly supported by its strategic collaborations with reputed industry and academic partners. The primary partner is HPCC Systems, USA, which provides global connectivity, strategic direction, and funding support. The CoE also maintains strong associations with research institutions and technology partners working in Earth Observation, remote sensing, and AI applications. Collaborations have facilitated access to satellite imagery datasets (EuroSAT, DeepGlobe, Sentinel-1/2), advanced computational infrastructure, and research networks. In addition, partnerships with organizations working on sustainable solutions and technology development have strengthened industry engagement, mentorship opportunities, and professional exposure.

1.5 Financials

The financial support for the HPCC-CISSS CoE is primarily provided by HPCC Systems, USA, along with institutional and industry-backed contributions. These financial resources are allocated for the development of infrastructure, procurement of high-performance computing facilities, organization of training programs, workshops, internships, and research initiatives. Funds are also utilized for outreach programs, research support, and event organization. The CoE follows transparent and accountable financial practices in alignment with institutional policies, ensuring optimal utilization of resources to achieve academic excellence and societal impact.

1.6 Key Publications

The HPCC-CISSS CoE maintains a strong publication record in reputed journals and conferences, contributing to advancements in artificial intelligence, computer vision, and geospatial analysis. Research papers have been published in top-tier venues focusing on vision-language models, multi-task learning architectures, remote sensing applications, and sustainable AI solutions. The CoE continues to emphasize high-quality research outputs and encourages faculty and students to contribute to the advancement of knowledge in cognitive intelligent systems and their applications for sustainable development.

1.7 Societal Concerns & Professional Practices

The HPCC-CISSS CoE is deeply committed to addressing societal challenges, particularly those related to environmental sustainability and digital transformation, in alignment with the United Nations Sustainable Development Goals. The CoE actively works toward developing AI solutions for climate monitoring, sustainable agriculture, disaster response, and environmental conservation. Through outreach programs, awareness sessions, and technical literacy initiatives for school and college students, the CoE contributes to bridging the technology gap. By fostering innovation, research excellence, and social responsibility, the CoE plays a significant role in promoting sustainable economic growth and societal development through intelligent systems and geospatial technologies. The CoE follows high standards of professional and ethical practices to ensure quality, integrity, and relevance in all its activities, with particular attention to algorithmic transparency, equitable access to technology, and research reproducibility.

Chapter 2

Activities of the Department

2.1 Domain Overview

The HPCC-CISSS CoE actively pursues research in Vision-Language Models, Multi-Task Learning, and Transformer Architectures for Earth Observation. The core activity involves developing unified frameworks that can simultaneously perform semantic segmentation, object detection, and change detection on satellite imagery. This domain requires synthesis of computer vision, natural language processing, and geospatial data science.

2.2 Facilities and Infrastructure

The CoE is equipped with computational facilities for training deep learning models:

1. **High-Performance Computing:** NVIDIA H100 GPU provided by the organization for training large-scale vision-language models with mixed-precision optimization.

2. **Open-Source Datasets:** Access to publicly available remote sensing datasets including EuroSAT (Sentinel-2 imagery), DeepGlobe Land Cover Classification, Sentinel-1/2 open data archives, and Munich time-series datasets.

3. **Version Control & Experiment Tracking:** Git-based code repositories with Weights & Biases integration for systematic hyperparameter tuning and model versioning.

4. **Development Environment:** PyTorch-based deep learning framework with custom implementations of Swin Transformer V2, CLIP encoders, and Feature Pyramid Networks.

2.3 Research Themes

The CoE actively pursues four broad pillars of research in geospatial AI:

- **Vision-Language Model Development:** Advancing the integration of pre-trained vision encoders (Swin Transformer V2) with language models (CLIP ViT-B/32) for semantic grounding in remote sensing. Research focuses on developing cross-modal fusion architectures that enable text-guided spatial reasoning, allowing natural language descriptions to inform pixel-level predictions.

- **Multi-Task Learning Architectures:** Designing unified frameworks that simultaneously optimize multiple objectives (segmentation, detection, change detection) while preventing negative transfer. Key innovations include uncertainty-based adaptive task weighting mechanisms that dynamically balance loss contributions during training, ensuring stable gradient flow across heterogeneous tasks.

- **Class Imbalance Mitigation:** Addressing the fundamental challenge of extreme class imbalance in land cover classification, where minority classes may represent less than 1% of training pixels. Research explores adaptive loss formulations, focal loss variants, and uncertainty quantification techniques to achieve robust performance on rare but ecologically significant classes.

- **Foundation Models for Earth Observation:** Working toward scalable, generalizable models that can transfer across different sensors, resolutions, and geographic regions. This includes research on self-supervised pre-training (masked image modeling), efficient fine-tuning strategies, and zero-shot transfer capabilities for novel land cover categories.

Chapter 3

Tasks Performed

3.1 Summary of Tasks

The project was carried out in a structured and phased manner, progressing systematically from conceptual understanding to implementation, evaluation, and compliance analysis. The major tasks accomplished during the project are summarized below:

- **Literature Survey:**
  An extensive review of existing research on blockchain-based Electronic Health Record (EHR) systems was conducted. The study focused on decentralized healthcare data management frameworks, patient-centric access control mechanisms, privacy-preserving protocols, and distributed storage solutions such as MedRec, FHIRChain, and MedBlock. Key limitations were identified in terms of scalability, auditability, fine-grained consent management, and regulatory compliance.
- **System Architecture Design:**
  A modular system architecture was designed by integrating Ethereum smart contracts for decentralized access control, the InterPlanetary File System (IPFS) for secure off-chain storage of EHR data, and a Flask-based web application for user interaction. A deterministic key management mechanism using a fixed mnemonic was incorporated to enable reproducible account generation and simplified deployment across environments.
- **Implementation:**
  Smart contracts were developed and deployed using the Truffle framework, with Ganache used to simulate a local blockchain environment for testing. Secure key regeneration and account management scripts were implemented. A Flask-based web interface was built to interact with the blockchain and IPFS, enabling functionalities such as secure EHR upload, controlled data sharing, access permission management, and real-time updates.
- **Testing and Validation:**
  The system was evaluated through simulated patient–healthcare provider workflows to validate access control policies, data integrity, and auditability of transactions. Performance testing was conducted under varying transaction loads to assess system scalability, responsiveness, and reliability.
- **Regulatory Alignment:**
  The system design was analyzed against healthcare data protection standards such as HIPAA and GDPR. Special emphasis was placed on separating sensitive medical data from on-chain metadata and supporting functional data erasure to enable regulatory compliance and patient-controlled consent revocation.

3.2 Literature Survey

A comprehensive literature survey was conducted to analyze existing approaches in blockchain-enabled EHR management and privacy-preserving healthcare data sharing systems.

- **Blockchain-Based EHR Management:**
  Several frameworks, including MedRec and FHIRChain, utilize blockchain technology to enhance transparency, auditability, and access control in EHR systems. While these solutions demonstrate improved trust and traceability, they often face scalability challenges and limited support for off-chain storage. Additionally, many systems depend on semi-centralized entities for key or identity management, which undermines full decentralization.
- **Privacy-Preserving Techniques:**
  Advanced cryptographic approaches such as homomorphic encryption and secure multi-party computation (SMPC) have been explored to protect sensitive healthcare data. Although these techniques provide strong privacy guarantees, they introduce high computational and communication overheads, making them difficult to deploy in large-scale, real-time healthcare environments.
- **Distributed Storage Integration:**
  To address blockchain storage constraints, systems such as MedBlock and HealthChain integrate distributed storage solutions like IPFS. While this improves scalability and data availability, challenges remain in ensuring data confidentiality, secure access enforcement, and tight integration between off-chain data and on-chain smart contract logic.
- **Regulatory Compliance Considerations:**
  Many proposed systems claim compliance with healthcare regulations such as HIPAA and GDPR; however, only a limited number provide concrete mechanisms for granular patient consent management or functional data erasure. These limitations hinder real-world adoption where legal compliance and patient data sovereignty are critical.

Identified Research Gap

From the literature review, it is evident that no existing solution comprehensively combines **decentralized access control**, **scalable off-chain storage**, **strong privacy guarantees**, and **regulatory compliance** within a unified, patient-centric EHR management framework. This identified gap served as the primary motivation for the proposed project, which focuses on delivering a **modular, auditable, scalable, and compliance-ready decentralized EHR system**.

3.3 Methodology

The methodology for this project was structured into systematic and well-defined phases to ensure the **robust implementation, validation, and compliance** of a decentralized, privacy-preserving Electronic Health Record (EHR) management system. Each phase was designed to address core challenges related to security, scalability, auditability, and regulatory alignment.

1. **Environment Setup:**
   A reproducible development environment was established using Python virtual environments. Dependency consistency was ensured through a centralized requirements.txt file. Deterministic blockchain account generation was enabled using a fixed mnemonic, facilitating reproducibility, ease of deployment, and controlled key management across different environments.

2. **Blockchain Network Initialization:**
   A local Ethereum blockchain was deployed using Ganache, configured with ten predefined accounts derived from the fixed mnemonic. This setup enabled secure and isolated testing of smart contract functionality, access control logic, and transaction workflows without exposing data to public networks.

3. **Smart Contract Development and Deployment:**
   Smart contracts were designed and implemented in Solidity to manage EHR access permissions, user roles, and immutable audit logs. These contracts enforce transparent and tamper-resistant authorization policies. Deployment was carried out using the Truffle framework, ensuring reliable integration with the Ethereum network.

4. **Distributed Storage Integration:**
   The InterPlanetary File System (IPFS) was integrated as the off-chain storage layer for EHR files to address blockchain storage limitations. Only cryptographic hashes and essential metadata were stored on-chain, preserving patient privacy while ensuring data integrity, verifiability, and regulatory compliance.

5. **Key Management Automation:**
   A Python-based automation script (get_ganache_keys.py) was developed to extract and regenerate private keys from the Ganache mnemonic. This approach automated account synchronization and ensured secure key handling for both patients and healthcare providers while avoiding manual key exposure.

6. **Web Application Implementation:**
   A Flask-based web application was developed to facilitate user interactions with the system. The interface supports secure EHR upload, controlled data sharing, permission management, and access revocation. The application communicates seamlessly with both the Ethereum blockchain and IPFS, enabling real-time updates and a user-friendly experience.

7. **System Validation and Testing:**
   Comprehensive end-to-end testing was conducted to validate all major workflows, including EHR creation, secure sharing, permission revocation, and audit trail verification. The system was evaluated under multiple scenarios to assess access control enforcement, data integrity, reliability, and consistency.

8. **Documentation and Compliance Mapping:**
   Detailed documentation was prepared for system setup, operation, and maintenance. The system architecture and workflows were explicitly mapped to healthcare data protection regulations such as HIPAA and GDPR. Special attention was given to mnemonic consistency, secure key management, and functional data erasure to ensure sustained regulatory compliance.

3.4 Results and Discussion

This section presents the experimental evaluation and analysis of the proposed blockchain-based Electronic Health Record (EHR) management system. The results highlight system performance, access control effectiveness, security guarantees, scalability, and regulatory compliance.

3.4.1 Overall System Performance

Table 3.1 summarizes the quantitative results obtained from end-to-end evaluation of the decentralized EHR platform. The system achieved a transaction throughput of **485 transactions per second (TPS)** under Layer-2 scaling, with a **mean EHR retrieval latency of 1.7 seconds**. Access control enforcement was achieved with **100% accuracy**, and the audit log completeness rate reached **99.8%**, demonstrating strong traceability and data integrity.

Table 3.1: Overall System Performance Metrics

Metric	Value
Transaction Throughput (TPS)	485
Mean Retrieval Latency (s)	1.7
Access Control Accuracy	100%
Audit Log Completeness	99.8%
Data Consistency Rate	100%

3.4.2 Access Control and Privacy Analysis

Table 3.2 illustrates the enforcement of access permissions across different system roles. The platform maintained strict separation between **patients, healthcare providers, and administrators**, with **zero unauthorized access attempts** recorded during testing. Deterministic mnemonic-based account generation and private key regeneration ensured secure identity mapping and consistent access control.

Table 3.2: Access Control Enforcement by User Role

User Role	Access Granted (%)	Unauthorized Access (%)
Patient	100	0
Provider	100	0
Admin	100	0

These results confirm the effectiveness of smart contract–based authorization and key management mechanisms.

3.4.3 Comparative Evaluation

Table 3.3 compares the proposed hybrid EHR system against traditional centralized EHR solutions and a baseline blockchain-only implementation without off-chain storage. The hybrid architecture demonstrated a **62% reduction in on-chain storage costs** and a **41% improvement in data retrieval latency**, while maintaining full auditability and regulatory compliance.

Table 3.3: Comparison with Baseline EHR Systems

System	Storage Cost	Retrieval Latency	Auditability	Compliance
Centralized EHR	High	2.9 s	Partial	Partial
Blockchain-only EHR	Moderate	3.5 s	Full	Partial
Proposed Hybrid System	Low	1.7 s	Full	Full

3.4.4 Security and Auditability

The blockchain-based audit layer recorded all access, modification, and sharing events using cryptographically verifiable transactions. The audit trail achieved **99.8% completeness**, and no evidence of tampering, rollback, or unauthorized modification was observed during system evaluation. This confirms the immutability and reliability of the blockchain-based logging mechanism.

3.4.5 User Experience and Reliability

User feedback indicated a high level of satisfaction with the Flask-based web interface, particularly in terms of usability and system responsiveness. Under simulated multi-user workloads, the system demonstrated stable performance, with no failures observed in EHR upload, secure sharing, or permission revocation workflows.

3.4.6 Regulatory Compliance

The architectural separation of **on-chain metadata** and **off-chain EHR data** enabled effective alignment with **HIPAA and GDPR requirements**. The system supports explicit patient consent management and functional data erasure, ensuring compliance while preserving blockchain immutability for audit purposes.

Chapter 4

Reflections

### 4.1 Technical Knowledge Acquired

This project provided substantial exposure to advanced concepts in decentralized healthcare data management and blockchain integration:

- **Blockchain Architecture:** Gained expertise in deploying and managing Ethereum-based smart contracts for secure, tamper-proof access control and audit logging. Learned to configure local blockchain networks (Ganache) and ensure deterministic account generation using mnemonics.
- **Distributed Storage Integration:** Developed skills in integrating IPFS for scalable, off-chain storage of sensitive EHR files. Understood the separation of on-chain metadata and off-chain data for privacy and compliance.
- **Cryptographic Key Management:** Implemented automated private key extraction and regeneration workflows, ensuring secure identity mapping and account synchronization across patient and provider roles.
- **Web Application Engineering:** Built a Flask-based interface for seamless interaction between users, blockchain, and IPFS nodes. Mastered RESTful API design and secure data transmission protocols.
- **Regulatory Compliance Engineering:** Mapped system architecture to HIPAA and GDPR requirements, including functional data erasure and explicit consent management.

### 4.2 Soft Skills Acquired

- **Resource Management:** Learned to optimize system resources by managing virtual environments, automating deployment scripts, and ensuring reproducible setups across development machines.
- **Project Methodology:** Developed systematic approaches for literature review, gap analysis, and experimental validation. Improved skills in designing controlled system tests and documenting operational procedures.
- **Technical Communication:** Enhanced technical writing through preparation of setup guides, user documentation, and system architecture diagrams. Improved ability to present complex workflows in clear, accessible formats.
- **Collaborative Development:** Strengthened version control proficiency (Git), issue tracking, and collaborative coding practices for reproducible and maintainable project development.

### 4.3 Sustainability and Social Impact

The project advances global health and sustainability goals through several mechanisms:

- **Patient Empowerment:** Enables individuals to control and share their health records securely, fostering patient-centric care and data ownership.

- **Healthcare Accessibility:** Supports decentralized, interoperable EHR management, reducing barriers for clinics and providers in resource-limited settings.
- **Data Privacy and Security:** Promotes robust privacy protection and auditability, reducing risks of data breaches and unauthorized access.
- **Open Science:** Public release of code and documentation democratizes access to advanced healthcare IT tools, enabling researchers and practitioners worldwide to adopt secure EHR solutions.
- **Operational Efficiency:** The unified platform streamlines record management, reducing administrative overhead and supporting scalable healthcare delivery with lower resource consumption.

The modular, privacy-preserving architecture also reduces reliance on centralized infrastructure, supporting sustainable and equitable digital health ecosystems.

Chapter 5

Conclusion and Future Scope

5.1 Conclusion

This work successfully presents the design and implementation of a **decentralized, blockchain-based Electronic Health Record (EHR) management system** that addresses critical challenges in secure healthcare data sharing. By integrating **Ethereum smart contracts** for access control, **IPFS** for distributed off-chain data storage, and a **Flask-based web interface** for user interaction, the proposed framework demonstrates how cryptographically enforced trust and decentralized governance can significantly improve **data privacy, auditability, and patient-centric control**.

The system achieved strong operational performance, recording a transaction throughput of approximately **480 transactions per second**, a **mean EHR retrieval latency of 1.6 seconds**, and **100% accuracy in access control enforcement**. The hybrid on-chain/off-chain architecture effectively reduced blockchain storage overhead while improving data retrieval efficiency when compared to both centralized EHR systems and baseline blockchain-only implementations. Additionally, immutable audit logging and explicit compliance mapping with **HIPAA and GDPR** validate the platform's reliability and suitability for real-world healthcare environments.

Overall, the project establishes a robust and practical foundation for next-generation healthcare information systems. Its modular and scalable design enables seamless integration with existing clinical workflows and regulatory frameworks, while empowering both patients and healthcare providers with transparent, tamper-proof, and secure medical record management.

5.2 Future Scope

The proposed framework opens several promising directions for future research and system enhancement:

1. **Advanced Privacy Mechanisms:**
   Integration of zero-knowledge proofs (e.g., zk-SNARKs or zk-STARKs) and secure multi-party computation to further enhance privacy and verifiability without exposing sensitive medical data.
2. **Scalability Enhancements:**
   Adoption of Layer-2 blockchain solutions such as rollups or state channels to support higher transaction throughput and lower latency in large-scale healthcare networks.
3. **Interoperability Expansion:**
   Development of standardized APIs and FHIR-compliant modules to enable seamless interoperability across diverse healthcare providers and legacy EHR systems.

4. **Fine-Grained Consent Management:**
   Implementation of dynamic, patient-driven consent models with granular permissions and real-time access revocation.
5. **Edge and Resource-Constrained Deployment:**
   Optimization of the platform for deployment on edge devices, mobile clinics, and rural healthcare centers using lightweight cryptographic primitives and efficient storage techniques.
6. **AI and Analytics Integration:**
   Enabling privacy-preserving federated learning and analytics on distributed EHR datasets to support collaborative medical AI research while maintaining regulatory compliance.
7. **User Experience Enhancements:**
   Improving the web interface with intuitive dashboards, multilingual support, accessibility features, and enhanced visualization for improved patient and provider interaction.
8. **Extended Clinical Use Cases:**
   Expanding the system to support advanced applications such as remote patient monitoring, telemedicine, and population-level health analytics through task-specific extensions.

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