PROJECT TITLE : *PRISM Gemonics : Decentralized AI-Powered Genomic Data Ownership & Risk Intelligence Platform*

PROJECT OVERVIEW

Team Name: Mangzing

Team Members:

1. Khumbongmayum Yaiphaba Singh – Blockchain Developer & UI/UX Designer

2. Chingkheinganba Thoudam – AI/ML Engineer

3. Thongam Gripson Singh – Backend and Frontend

Link the Concept Video: https://youtu.be/a8waELYlxZ0

THE PROBLEM LANDSCAPE

Problem Statement: Genomic data is one of the most sensitive categories of personal data. However, current healthcare systems:

- Store genetic reports in centralized databases
- Offer limited patient control over access
- Are vulnerable to breaches and data tampering
- Lack transparent audit mechanisms

Patients do not truly "own" their DNA data.

The core pain point:
No secure, patient-controlled, tamper-proof system exists for genomic data sharing with AI-driven preventive insights.

Target Audience

- Individuals who have undergone genetic testing
- Hospitals & diagnostic laboratories
- Precision medicine researchers
- Healthcare startups

"Why Now"

- Rise of precision medicine
- Increased healthcare data breaches globally
- Growing adoption of consumer genomics
- Expansion of blockchain-based digital identity systems

Current systems cannot ensure:

- Data sovereignty
- Tamper-proof storage
- Transparent access control

PROPOSED SOLUTION & USP

Solution Overview

PRISM Gemonics is a decentralized genomic intelligence platform where:

1. Files are AES-256 encrypted & BLAKE3 hashing ensures integrity
2. Encrypted files are stored on IPFS & Hash fingerprints are stored on blockchain
3. Deep Learning Artificial Neural Network (MLP) interfaces with the data to predict disease risk through the evaluation of polygenic risk patterns.
4. Doctors request access via smart contracts
5. Patients approve/reject access
6. All actions are logged immutably

Unique Selling Proposition (USP)

- True patient data ownership
- Modern cryptographic integrity
- Zero raw genome stored on-chain
- AI-powered disease Prediction and Risk
- Smart contract-based access governance
- Immutable audit trail

Unlike traditional EHR systems, **PRISM Gemonics** *combines predictive intelligence + decentralized security + patient sovereignty.*

Core Logic
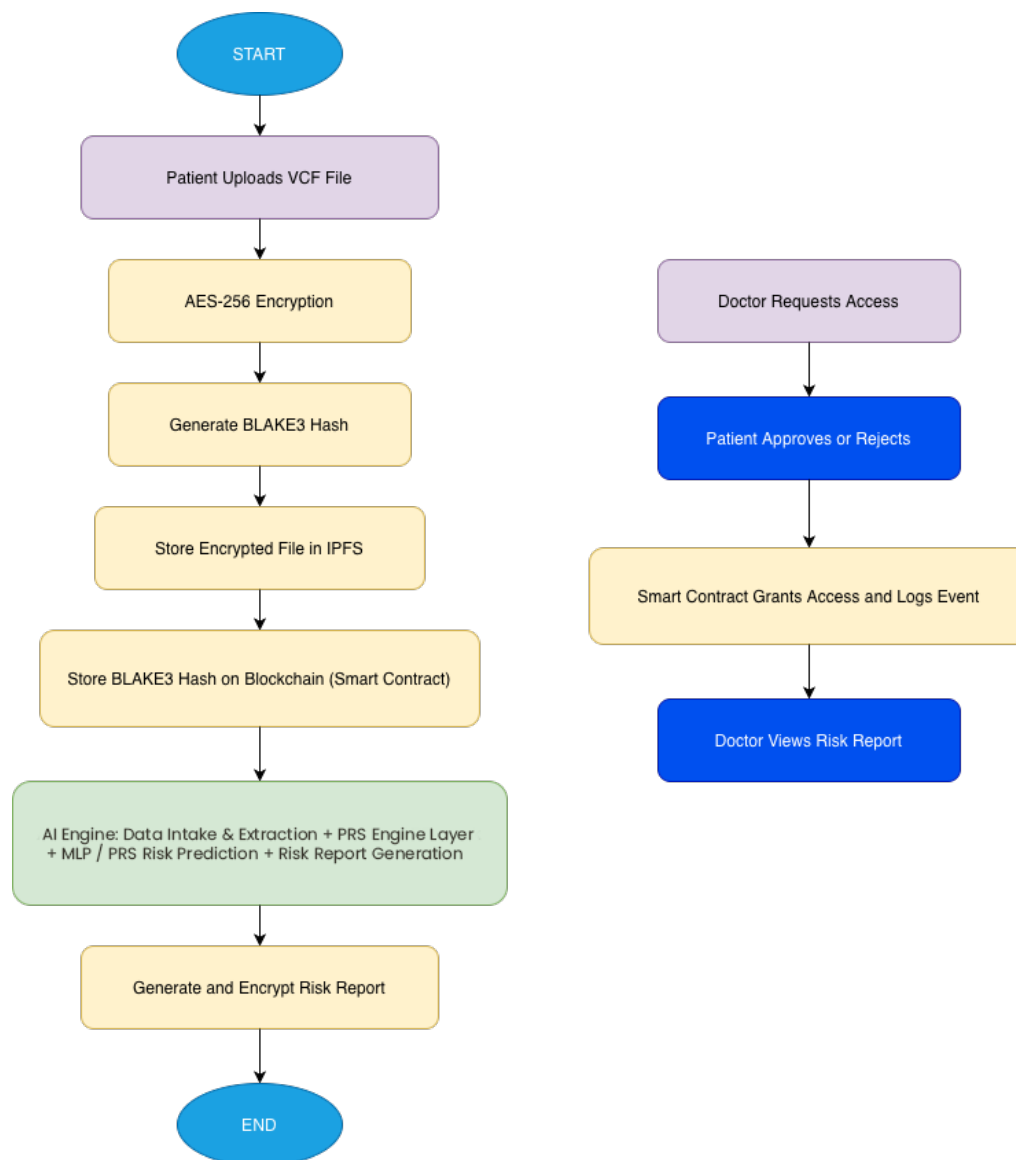
The system integrates:

- AI models for disease risk prediction
- AES-256 symmetric encryption for file protection & BLAKE3 hashing for fast, tamper-proof integrity & IPFS for decentralized storage
- Solidity smart contracts for access control

Biological Logic:

- Extract disease-associated SNPs from VCF
- Encode genotypes (0,1,2)
- Apply weighted risk scoring
- Generate probability output

TECHNICAL ARCHITECTURE & STACK

System Workflow

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                    ┌─────────────┐
                    │    START    │
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              ┌──────────────────────────┐
              │  Patient Uploads VCF File │
              └──────────────────────────┘
                           │
                           ▼
              ┌──────────────────────────┐           ┌──────────────────────────┐
              │     AES-256 Encryption    │           │   Doctor Requests Access  │
              └──────────────────────────┘           └──────────────────────────┘
                           │                                      │
                           ▼                                      ▼
              ┌──────────────────────────┐           ┌──────────────────────────┐
              │    Generate BLAKE3 Hash   │           │ Patient Approves or Rejects│
              └──────────────────────────┘           └──────────────────────────┘
                           │                                      │
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              ┌──────────────────────────┐           ┌──────────────────────────────┐
              │ Store Encrypted File in IPFS│         │ Smart Contract Grants Access │
              └──────────────────────────┘           │         and Logs Event        │
                           │                          └──────────────────────────────┘
                           ▼                                      │
      ┌──────────────────────────────────┐                       ▼
      │ Store BLAKE3 Hash on Blockchain   │           ┌──────────────────────────┐
      │        (Smart Contract)           │           │  Doctor Views Risk Report │
      └──────────────────────────────────┘           └──────────────────────────┘
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      ┌──────────────────────────────────┐
      │ AI Engine: Data Intake & Extraction + PRS Engine Layer │
      │ + MLP / PRS Risk Prediction + Risk Report Generation   │
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              ┌──────────────────────────┐
              │ Generate and Encrypt Risk Report│
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                    ┌─────────────┐
                    │     END     │
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Tech Stack

Frontend : *Next.js, Tailwind CSS, Recharts, Web3 Wallet Integration*

Backend / Database: *FastAPI, Uvicron, Prisma ORM, Web3,py, PostgreSQL (Superbase)*
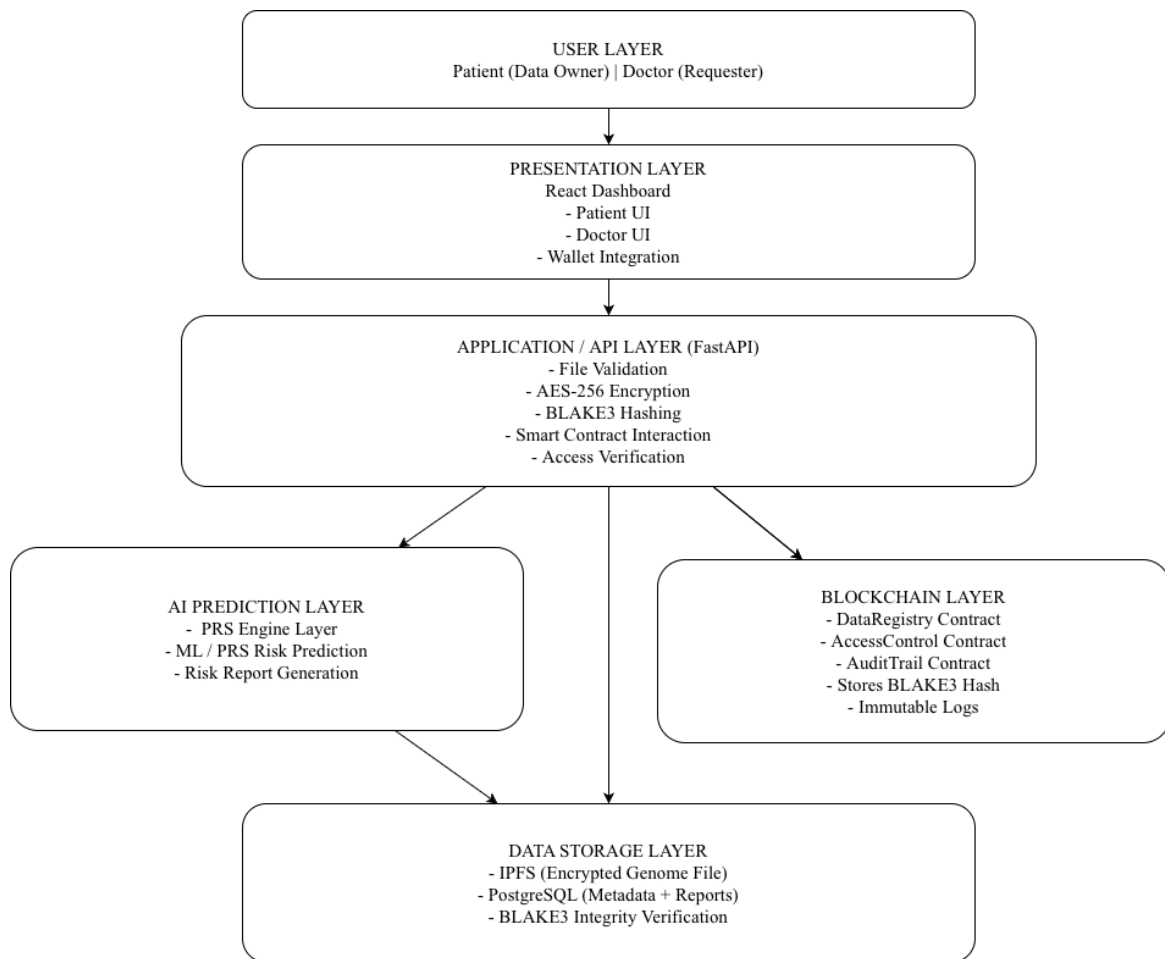
AI / Specialized Tools: *Python, gzip, MLP, pytorch, pandas, numpy*

Blockchain: *Solidity, Hardhat, Viem, OpenZeppelin, Ethereum-compatible network*

Storage & Security: *IPFS, AES-256 Encryption, BLAKE3 Hashing*

Deployment & Infrastructure: *AWS EC2(t3. Micro), Docker*

Architecture Visualization

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│                    USER LAYER                         │
│       Patient (Data Owner) | Doctor (Requester)       │
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┌─────────────────────────────────────────────────────┐
│                 PRESENTATION LAYER                    │
│                   React Dashboard                     │
│                    - Patient UI                       │
│                    - Doctor UI                        │
│                  - Wallet Integration                 │
└─────────────────────────────────────────────────────┘
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│            APPLICATION / API LAYER (FastAPI)          │
│                  - File Validation                    │
│                  - AES-256 Encryption                 │
│                  - BLAKE3 Hashing                      │
│                - Smart Contract Interaction           │
│                  - Access Verification                │
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          │                              │
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┌──────────────────────┐      ┌──────────────────────────┐
│  AI PREDICTION LAYER │      │     BLOCKCHAIN LAYER      │
│   - PRS Engine Layer │      │  - DataRegistry Contract  │
│ - ML / PRS Risk      │      │  - AccessControl Contract │
│   Prediction         │      │  - AuditTrail Contract    │
│ - Risk Report        │      │  - Stores BLAKE3 Hash     │
│   Generation         │      │  - Immutable Logs         │
└──────────────────────┘      └──────────────────────────┘
          │                              │
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┌─────────────────────────────────────────────────────┐
│                 DATA STORAGE LAYER                    │
│            - IPFS (Encrypted Genome File)             │
│          - PostgreSQL (Metadata + Reports)            │
│           - BLAKE3 Integrity Verification             │
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KEY FEATURES & FUNCTIONALITIES

Feature 1 (Primary): AI-based genomic disease risk prediction.

Feature 2 (UX): 1. Web3 Wallet-based authentication
2. Patient dashboard with risk visualization

Feature 3 (Reliability & Security): 1. AES-256 encrypted genomic storage &BLAKE3
2. Immutable blockchain logs
3. Temporary permission-based decryption keys

IMPLEMENTATION ROADMAP

Phase 1:

Focus: 1. Problem validation
      2. Architectural design
      3. Smart contract drafting
      4. AI prototype (basic model)

Deliverables: 1. Concept video
         2. Documentation
         3. Initial Prototype

Phase 2:

Focus: 1. Full encryption integration
      2. BLAKE3 hashing implementation & IPFS deployment
      3. AI Model Optimization (hyperparameter) & UI/UX refinement
      4. Final demo video

Deliverables: 1. Working prototype
         2. 2-minute demo video

IMPACT & SUSTAINABILITY

Social & Economic Impact

- Empowers individuals with genomic ownership & Promotes preventive healthcare
- Reduces fraud and tampering & Encourages transparent research collaboration

Scalability: The architecture can expand to:

- Electronic Health Records (EHR)
- Medical imaging storage
- Clinical trial management
- Insurance claim validation
- Biomedical research datasets

Designed for distributed large-scale genomic storage.

Risk & Mitigation

Identified Risk: AI predictive bias resulting from localized or homogenous genomic training datasets

Mitigation:

  • Utilize highly diverse, global genomic datasets (e.g., 1000 Genomes Project).
  • Implement continuous model retraining protocols. & algorithmic transparency explainable risk score •
  • Mandate human-in-the-loop (HITL) clinical review for diagnostic assertions.

Genomics & Genetic Databases & AI/ ML Technology Documentation

1. NCBI SNP Database (dbSNP) – https://www.ncbi.nlm.nih.gov/snp/
2. GWAS Catalog – https://www.ebi.ac.uk/gwas/
3. 1000 Genomes Project – https://www.internationalgenome.org/
4. XGBoost - https://arxiv.org/abs/1603.02754
5. VCF Processing - https://academic.oup.com/bioinformatics/article/27/15/2156/402296
6. Python Software Foundation - https://www.python.org/

Blockchain & Cryptography Documentation

5. Ethereum Solidity Documentation – https://docs.soliditylang.org/
6. IPFS Documentation – https://docs.ipfs.io/
7. BLAKE3 Official Specification – https://github.com/BLAKE3/BLAKE3

Research Papers on Polygenic Risk Scores

8. Polygenic Risk Scores: Genomes to Risk
   Prediction – https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10681370/
9. Genome-wide association studies, Polygenic Risk Scores and Mendelian
   Randomisation – https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12013552/
10. Polygenic Risk Score Knowledge Base
    (PRSKB) – https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9438378/