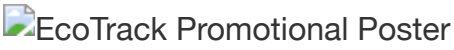
EcoTrack (NUS Orbital Project)

EcoTrack, an AI-powered waste management platform.

Proposed level of achievement: Apollo 11

Promotional Poster


EcoTrack Promotional Poster

Proof-of-Concept :

https://github.com/user-attachments/assets/7405a2f0-2817-4729-8379-8a0e70848eff

Before using the app

Limitations

🔍 1. AI Accuracy & Dependence
• Limitation: Reliance on Google Gemini AI for waste classification may lead to incorrect or biased predictions, especially for unclear images.
• Impact: Users may get inaccurate rewards or feedback, reducing trust in the system.

⚖️ 2. Verification Bottleneck
• Limitation: Waste report verifications may require human validation in some cases, especially for edge scenarios.
• Impact: Slows down the reward system and notification flow, reducing real-time effectiveness.

🔒 3. Web3Auth Adoption Barrier
• Limitation: Not all users (especially older or less tech-savvy ones) are comfortable with Web3 wallet-based authentication.
• Impact: Limits app accessibility and onboarding rate among the general population.

Milestone 1 (Ideation)

Motivation

EcoTrack aims to address these pain points by empowering both residents and municipal authorities with real-time data, actionable insights, and user-friendly tools to promote responsible waste disposal and recycling. It is designed to incentivize and streamline waste reporting and collection. Our goal is to create a community-driven approach to waste management, rewarding users for their eco-friendly actions.

Proposed core features

Features	Description
User Authentication & Role Management	Users (residents, collectors, administrators) can register and log in using web3 authentication. - Feature includes: ◦ Wallet-Based Login where users connect via a Web3 wallet (e.g., MetaMask, Web3Auth). The app verifies wallet ownership using cryptographic signatures. No traditional passwords needed.
Waste Reporting & Image Upload	Residents can report waste incidents by uploading photos, specifying waste type, and providing location details. Each report is tracked through various statuses (e.g., pending, collected, verified). - Feature includes: ◦ Users can take or upload a photo of the waste. Image is sent to the backend for storage and optional AI analysis. ◦ Users select the type of waste (e.g., plastic, paper, organic, mixed). This input can be used to help train or supplement AI classification.
AI-Powered Waste Classification	When users upload images, the system utilizes Google Gemini AI models to automatically classify the type of waste (e.g., plastic, paper, organic) and estimate its quantity, streamlining the reporting process. - Feature includes: ◦ When a user uploads an image, the AI classifies the waste as plastic, paper, organic, etc and reduces manual input and errors

Features	Description
	from users. ◦ AI estimates the amount of waste (e.g., small/medium/large, or weight approximation) and helps improve reward fairness and collection planning.
Reward Points System	Users earn points for reporting waste and for successful verifications of waste collection. Points are tracked in user profiles and can be redeemed for incentives, encouraging active participation. - Feature includes: ◦ Users earn points for submitting valid waste reports, reports that get verified as collected, participating in campaigns (e.g., clean-up events) ◦ Each user's total points are stored and updated in their profile. Their Points history (earned/redeemed) may also be viewable ◦ Users can redeem points for eco-friendly rewards (e.g., vouchers, merchandise). Backend logic ensures only eligible users can redeem. ◦ Points are automatically credited based on system triggers (e.g., verified status). Admins can manually adjust points if needed.
Real-Time Notifications	Users and authorities receive notifications for verified waste collection. - Feature includes: ◦ Users receive a notification when their reported waste has been verified as collected. Authorities/collectors also get notified when a report status changes to "verified." ◦ Users can view past notifications in a timeline or activity feed. ◦ Notification center or banner inside the dashboard to show recent updates.
Gamified Leaderboard & Achievements	A public leaderboard ranks users based on points earned, and achievements or badges are awarded for milestones, fostering friendly competition and community engagement. - Feature includes: ◦ Displays top users ranked by total points earned. Can be filtered by time (e.g., weekly, monthly, all-time).

Features	Description
	◦ Leaderboard updates in real-time or at fixed intervals after actions like report verification.

User Stories

As a resident who wants to contribute to a cleaner neighborhood, I want to easily report overflowing or illegal waste via the app, so that authorities can respond quickly and efficiently.

As a resident who recycles regularly, I want to track my recycling habits and see my progress, so I can stay motivated and improve my environmental impact.

As a busy user, I want to receive timely notifications about waste collection schedules and recycling drives, so I never miss important dates or opportunities to participate.

As a waste collector, I want to view optimized collection routes and real-time bin fill levels, so I can make my rounds more efficiently and avoid unnecessary trips.

As a municipal officer, I want to access analytics and reports on waste generation and recycling rates, so I can make informed decisions about resource allocation and public outreach.

As a community leader, I want to organize local clean-up events and track participation through the app, so I can foster greater community involvement.

As a user with limited technical skills, I want the app to have an intuitive interface and clear instructions, so I can be incentivised to use the app.

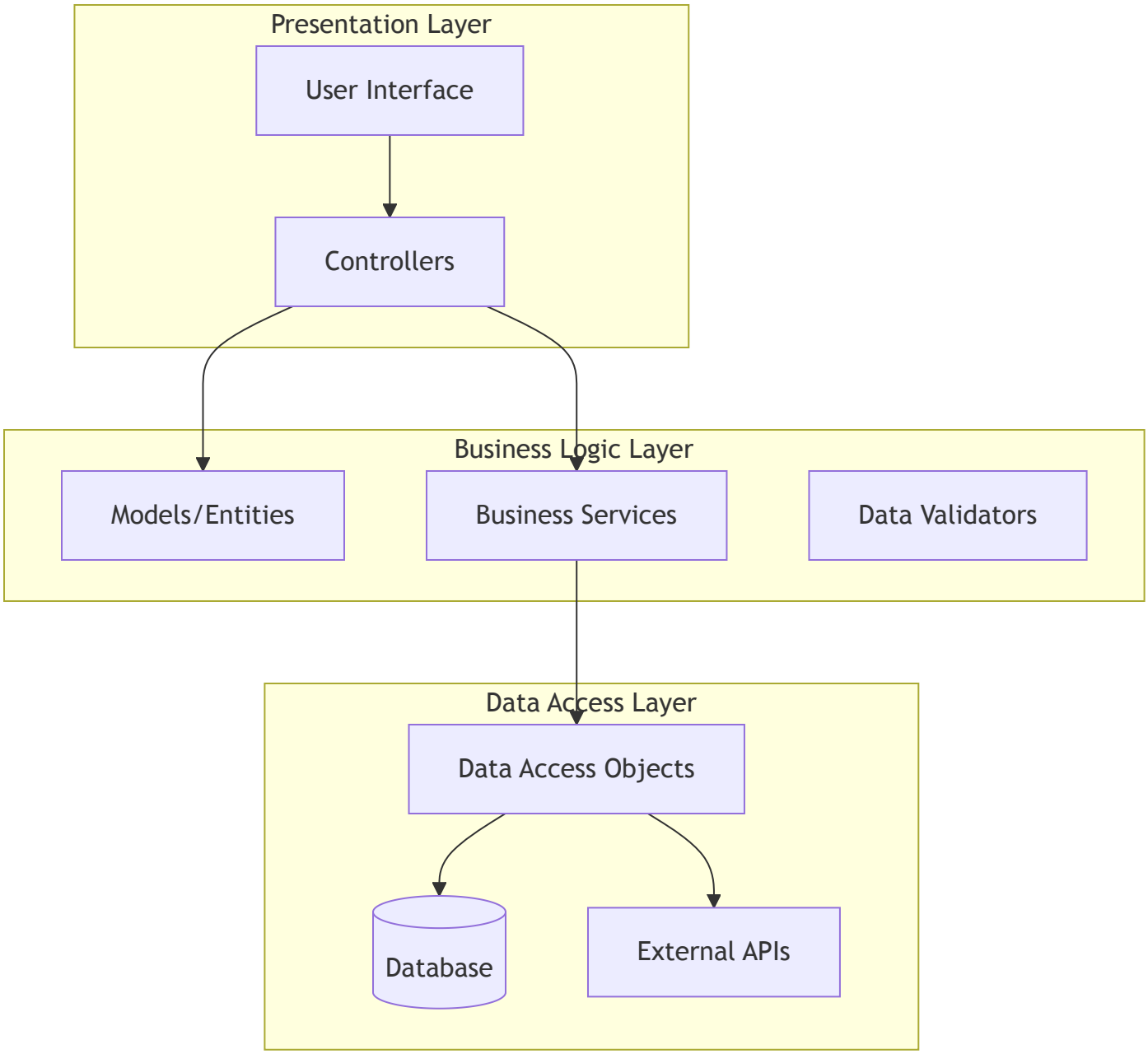
As a resident who sometimes forgets to sort waste properly, I want the app to provide educational content and AI-powered waste classification, so I can learn and improve my sorting habits.

Software Engineering Practices and Design

Software Engineering Practices

Primary Architecture: N-tier Architecture with MVC Pattern

For EcoTrack (an environmental tracking application), we aim to implement a **3-tier layered architecture** combined with the **Model-View-Controller (MVC)** pattern:



Design Patterns

1. Model-View-Controller (MVC)

- **Models**: Represent environmental data (carbon footprint, energy usage, waste tracking)
- **Views**: User interfaces for data input/visualization
- **Controllers**: Handle user interactions and coordinate between models and views

2. Observer Pattern

- Perfect for real-time environmental data updates

- Notify users when thresholds are exceeded (e.g., high carbon footprint)
- Update dashboards automatically when new data is added

3. Command Pattern

- Implement undo/redo functionality for data entry
- Track user actions for audit purposes
- Useful for batch operations (bulk data import/export)

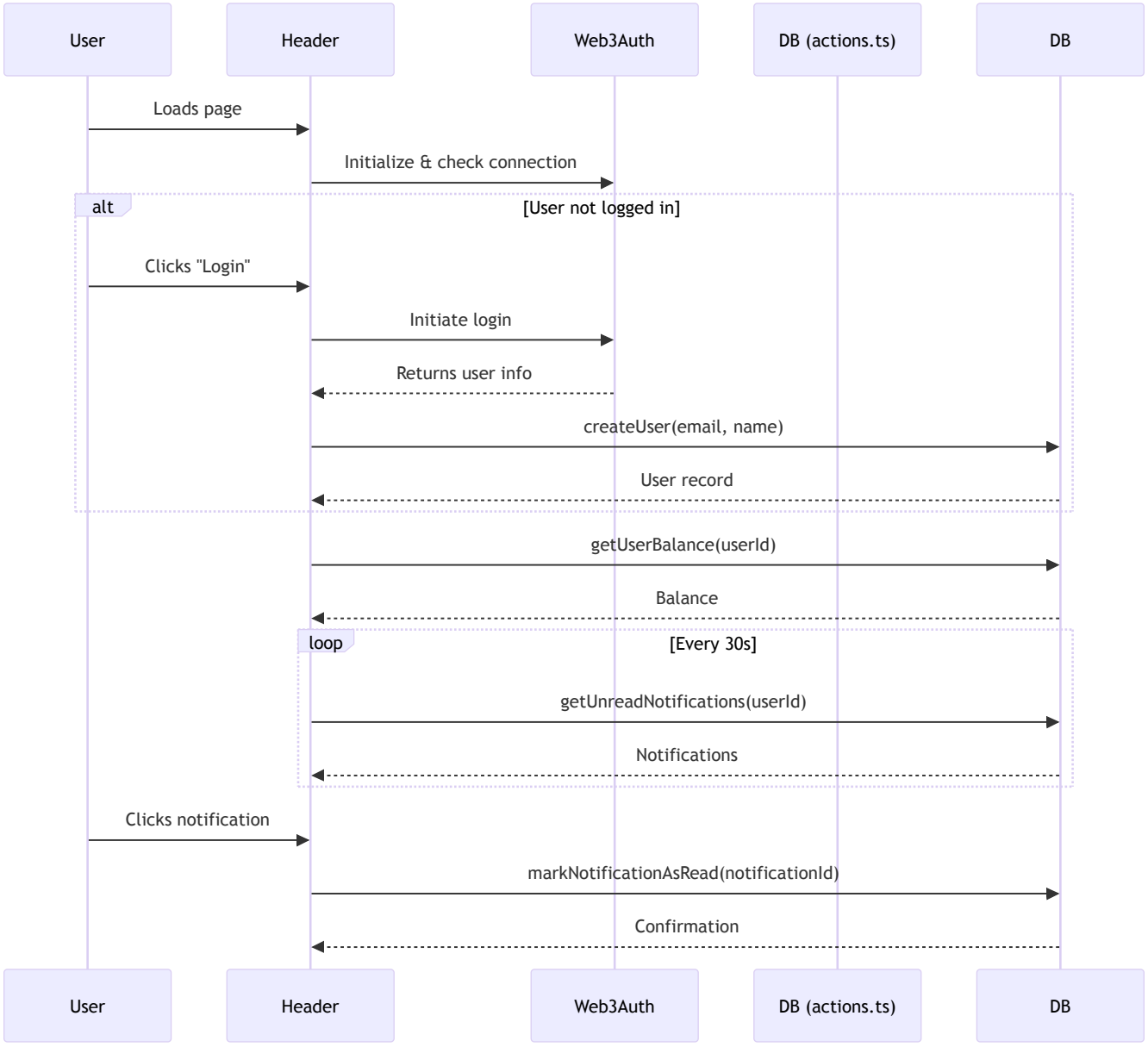
4. Factory Pattern

- Create different types of environmental trackers (energy, transportation, waste)
- Generate appropriate calculators based on data type
- Support multiple calculation methodologies

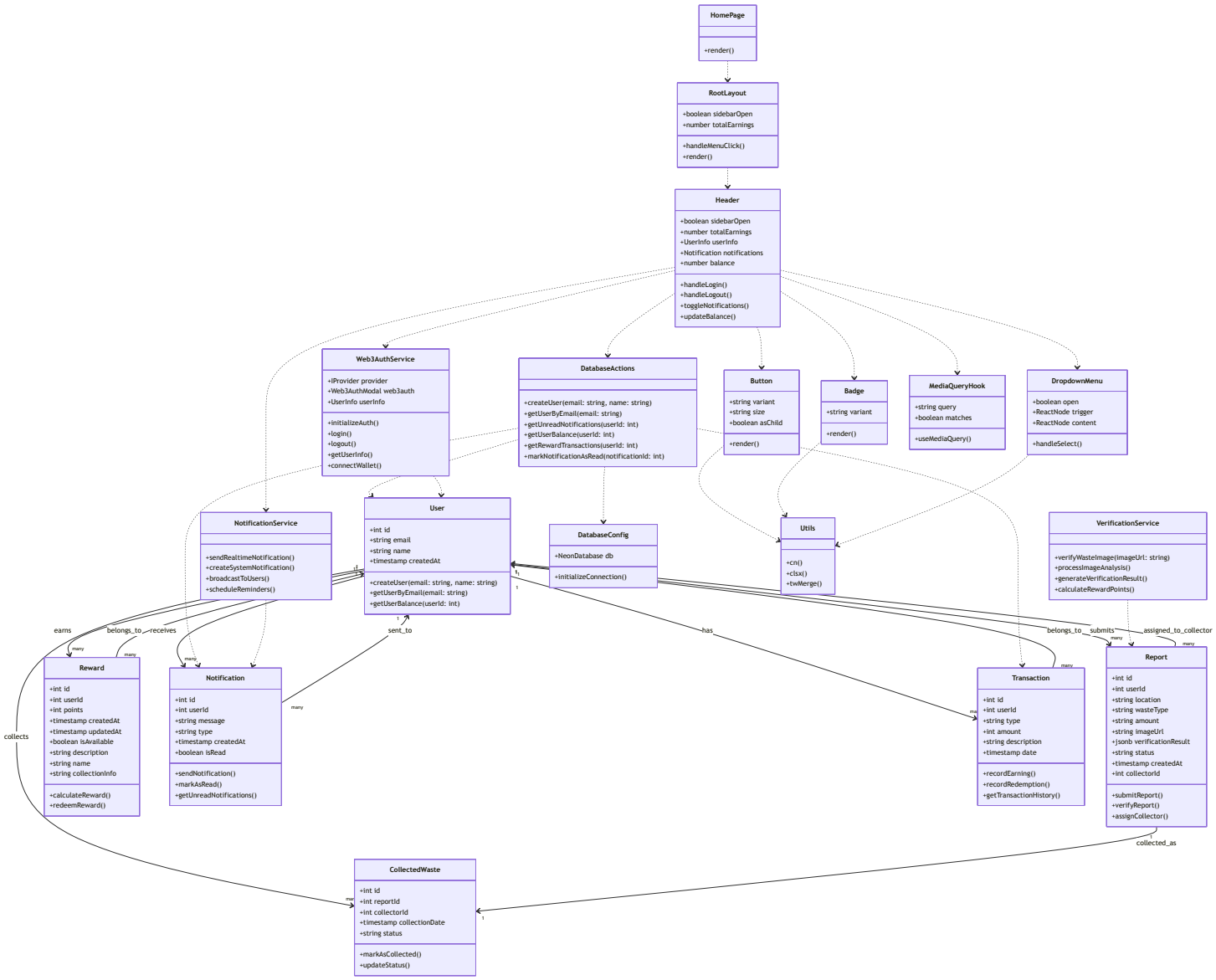
5. Strategy Pattern

- Different calculation algorithms for carbon footprint
- Multiple data export formats (PDF, CSV, JSON)
- Various visualization types (charts, graphs, reports)

Sequence Diagram



Class Diagram



Summary

Timeline and Development Plan

17 EcoTrack Development Timeline & Milestones

Milestone	Due Date	Phase	Deliverables	Status	Features
Milestone 1	**June 2,**	**Technical Proof of**	Minimal Working	**COMPLETED**	• Web3Auth user authentication

Milestone	Due Date	Phase	Deliverables	Status	Features
	2024	**Concept**	System		• Basic home page & dashboard • Waste reporting with image upload • Database integration (PostgreSQL + Drizzle) • Responsive UI components
Milestone 2	**June 30, 2024**	**Core Prototype**	Working System with Core Features	**NOT COMPLETED**	• AI-powered waste verification • Rewards points system • Real-time push notifications • User balance tracking • Report status management
Milestone 3	**July 28, 2024**	**Extended System**	Full-Featured Application	**NOT COMPLETED**	• Interactive leaderboard & achievements • Admin dashboard & analytics • System optimization & user testing • Bug fixes & UX improvements • Performance enhancements

🚀 Feature Implementation Progress

Milestone 1 - Technical Proof of Concept

- **Authentication System**: Web3Auth integration with wallet-based login
- **Frontend Foundation**: Next.js 15 with TypeScript and Tailwind CSS
- **Database Layer**: PostgreSQL with Drizzle ORM, normalized schema
- **Core UI Components**: Responsive design with shadcn/ui components
- **Image Upload**: Integrated waste reporting with photo capture

Milestone 2 - Core Prototype

- **AI Verification**: Smart waste classification and validation system
- **Rewards Engine**: Point-based incentive system with balance tracking
- **Notification System**: Real-time updates for user actions and rewards
- **Data Management**: Comprehensive reporting and tracking features
- **User Experience**: Polished interface with loading states and error handling

Milestone 3 - Extended System

- **Gamification**: Leaderboard system with user rankings and achievements
- **Analytics Dashboard**: Admin interface for system monitoring and insights
- **Optimization**: Performance improvements and user feedback integration
- **Testing & Refinement**: Bug fixes, UX enhancements, and system stability
- **Mobile Responsiveness**: Cross-device compatibility and touch optimization

Project Logging

https://docs.google.com/spreadsheets/d/1qt2mJ2I-7t5aVOVSAWLBEEHEN_XpdWWZP9iVdjLWB6Y/edit?gid=0#gid=0