TerraByte

System Requirements Specification (SRS)

A project for EPI-USE® by GeekGurusUnion

Demo 1

3 June 2024

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Introduction

TerraByte aims to revolutionise the South African farming industry by transforming inefficiency into a well-oiled machine of data-driven precision.

In essence, TerraByte seeks to bridge the gap between the present state of farming and a future where crop yielding can be done in a risk-free manner. Here's how we will achieve this:

- Data Collection: Weather, soil quality, crop variety, and historical yield data are collected to feed the AI model.
- Machine Learning Model: This AI model analyses the data to predict future crop health and yield with exceptional accuracy.
- User-Friendly Interface & Backend: Farmers input farm data and view predictions through a user-friendly interface. A robust backend system and database manage data processing and storage.
- Continuously Learning Model: The AI model is trained on historical data and can be updated with new information for ongoing improvement.

AI Crop Prediction represents a significant leap forward in agricultural technology for South Africa. By harnessing the power of AI, Crop Prediction empowers farmers to make data-driven decisions, minimise risk, and achieve greater efficiency and profitability.

User Stories & User Characteristics

User Story 1: Farmer

As a farmer, I want to input my farm's specific data into the system so that I can receive accurate crop yield predictions.

- Description: A farmer will enter data such as soil quality, crop variety, planting dates, and other relevant information into the system.
- Acceptance Criteria:
    - The system should provide a user-friendly form for data input.
    - The system should validate the data for completeness and correctness.
    - The system should store the data securely in the backend database.
    - Upon submission, the system should acknowledge receipt of the data and initiate the prediction process.

User Story 2: Farm Manager

As a farm manager, I want to view detailed reports on predicted crop yields so that I can plan resources and operations effectively.

- Description: A farm manager will access the system to view data and reports on crop health and yield.
- Acceptance Criteria:
    - The reports should be accessible through a user-friendly dashboard.
    - The reports should include visual aids (graphs, charts) for easy interpretation.

Functional Requirements

Requirements

1. Field Management
    1.1. Manual Data Input
        1.1.1. Users should be able to manually input data related to crops, weather conditions, and other relevant factors
        1.1.2. System should be able to securely store the data while maintaining data integrity.
    1.2. CRUD Operations
        1.2.1. Users should be able to insert, update, read and delete data.
    1.3. Data Visualisation

1.3.1. Representation: Data should be represented to the user with short explanations and graphs.

1.4. View Field Data

1.4.1. The map-based interface should generate a map and show the user's current farms. Field data should be colour-coded and vectorised and shown on the map. When clicked on, it should show more details about the specific field.

1.4.1.1. A user should be able to draw and map out their field on the map.

1.4.2. View Logs: Users should be able to view past entered data and be able to correct them if necessary.

2. User Management

2.1. Map-based Interface

2.1.1. User location should be retrieved, but not stored, to be able to show their current location and let them view the fields closeby.

2.2. User Accounts and Authentication

2.2.1. Users should be able to log in using their credentials or via OAuth.

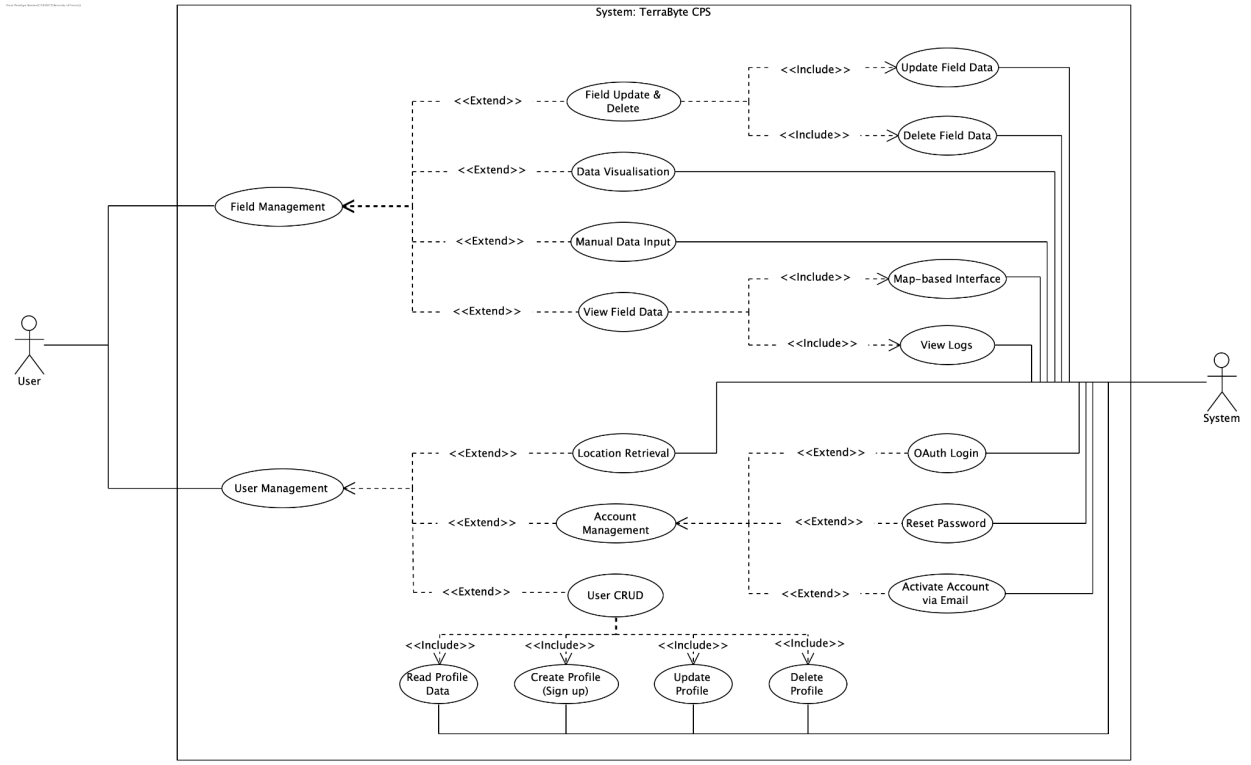
2.2.2. Users should be able to reset their password via email.

2.2.3. Users should receive an email upon account creation to activate their account.

2.3. CRUD operations

2.3.1. Users should be able to update their account details.

Use Case Diagram



View Full Image

Architectural Requirements

Quality Requirements

* denotes future implementation.

Performance

Performance is considered a crucial underlying factor for our system, highlighting the importance of processing power and all-round data analysis capabilities. On the frontend side, effective and rapid rendering is crucial for real time statistics provided to the end user, while being backed by a solid backend system with a rugged API.

Quantification

Performance is quantified by timing the amount of time it takes for our app to start up and show actionable results. Timing and performance metrics will also be gathered on ML models to ensure optimal performance. We'll keep track of the metrics while developing the model. This is defined by:

1. ML model training time*
2. App loading time
3. API response time

Targets

1. Model training time should be less than 5 minutes.*
2. App loading time should be less than 10 seconds.
3. API response time should be less than 5 seconds.

Testability

Our system's testability measures our test coverage and the ability to place a clear distinction between failing and passing units in our code. This will be required to provide a robust system that works under various circumstances.

Quantification

Automated testing and coverage reports will be used to test individual components (unit tests), interactions between units (integration tests) and system flow testing (end-to-end testing). We broke the testing into separate parts to be able to uniquely identify the layer (in our layered architecture):

1. Presentation Layer: UI component unit testing.
2. Logic Layer: function and class unit testing.
3. Data Layer: ensure consistency in the database to serve accurate and representative data.
4. Between layers: integration testing.
5. System-wide: end-to-end testing.

Targets

1. Make use of Jest to write unit tests for our frontend (60% coverage).
2. Make use of PyTest to write unit tests for our backend (60% coverage).
3. Make use of PyTest to test the database operations (60% coverage).
4. Make use of Jest and Postman to test our interactions between layers (60% coverage).
5. Make use Cypress to write end-to-end tests simulating system flow (60% coverage).

Efficiency

Because we run sophisticated services in the background on a constrained budget, having a system that avoids wasting efforts, money, and time (i.e. resources) while performing a specific task is crucial.

Quantification

Service measures will be used to identify the bottlenecks in our system. This can be reported by the SaaS (such as Digital Ocean) or defined by our code. This will be quantified by:

1. Graphs provided by our Digital Ocean droplet dashboard (budget, resource utilisation and response time)
2. Timing function calls and output for our ML model.*
3. Reporting analytics to a CSV file to analyse bottlenecks.*

Targets

1. Checking the Digital Ocean dashboard on a regular basis.
2. Setting timers in Python*

Compatibility

The app should be designed for easy installation on a variety of devices commonly used by farmers. The app should be configured for automatic updates over WiFi whenever possible.

Quantification

When a farmer wants to use the app on the go, it should be applicable to various devices, regardless of system performance. Users should be able to access the app offline, giving them the ability to view their yield data even if they are not connected. How will we achieve this?

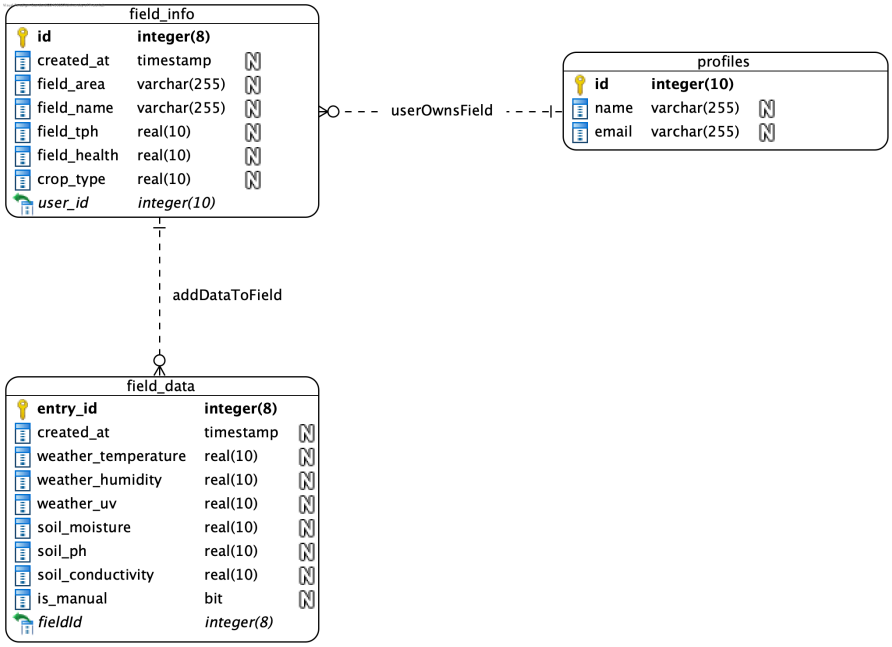
1. Making use of a PWA to ensure offline capability.*
2. User-friendly buttons.
3. Fetching new data when connected to the internet.*
4. Saving new data temporarily while the app is not connected to the internet.*

Targets

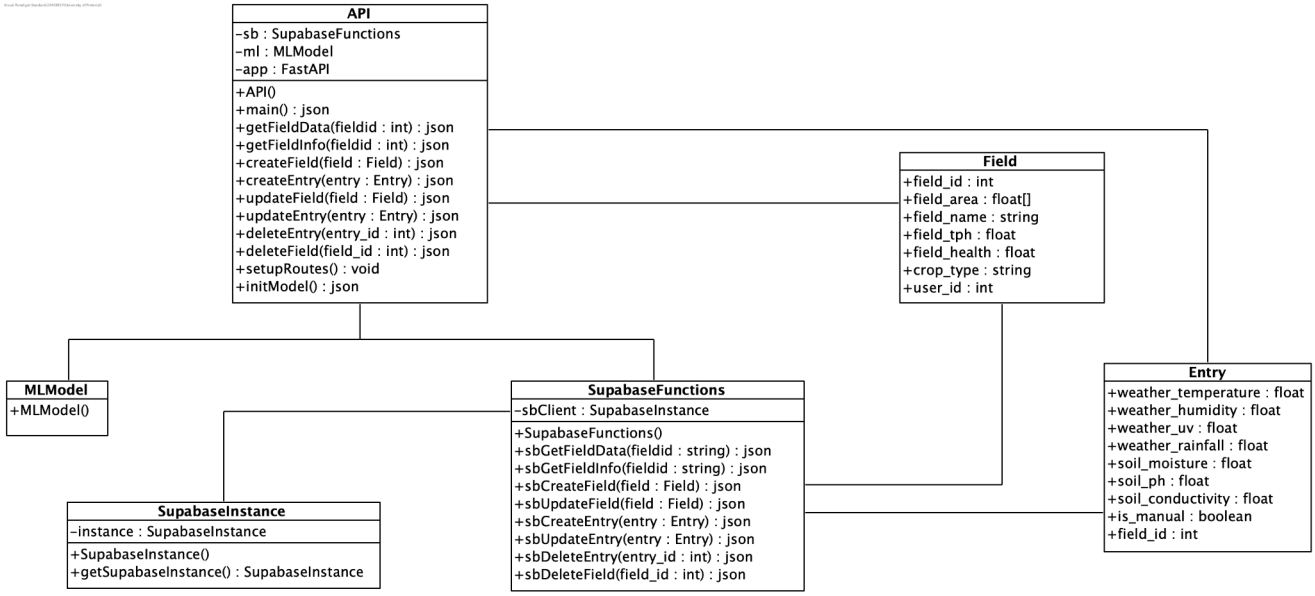
1. Have an installable PWA-app available to all users.*
2. Provide a consistent user interface using component libraries.
3. Set up runners that will periodically check for internet connection.*
4. Make use of local storage to temporarily store values while not connected to the internet.*

Class Diagrams

Database Entity Relationship Diagram



Backend Class Diagram



Architectural Patterns

Layered Architectural Pattern

Our project will leverage the use of a layered architecture. We firmly believe that a layered architecture will be the most optimal choice for this project with regards to cost efficiency, system effectiveness, and overall performance. Developing these layers independently provides us with the ability to ship a powerful project without having to compromise on hardware and software limitations related to each layer.

Our Layered Architecture Breakdown:

1. Presentation Layer
    1.1. Progressive Web App
        1.1.1. Functionality: Handles user interactions and file uploads.
        1.1.2. Technology Stack: Vue, Nuxt, Tailwind CSS (Optional: Chart.js for graphs)
        1.1.3. Deployment: Vercel (Free Tier): This provides a cost-effective and user-friendly platform for deploying and managing the frontend application as a Progressive Web App (PWA).
2. Logic Layer:
    2.1. API Gateway:
        2.1.1. Functionality: Acts as a single-entry point for the presentation layer to access the logic layer. The API gateway will be used for external API calls, and routing requests based on functionality.
        2.1.2. Technology Stack: FastAPI (Python framework) for efficient API development.
    2.2. Crop Prediction Model (Python):
        2.2.1. The Crop Prediction Model is the main model behind AI Crop Prediction, analysing vast datasets to predict crop yields. It considers weather, soil conditions, and historical data to create personalised forecasts for each farm. These predictions empower farmers to optimise resource use and boost their profitability.
3. Data Layer:
    3.1. A managed PostgreSQL database will store application data in a centralised location, accessible by the logic layer for efficient data sharing and consistency.

Design Patterns

Singleton

The Singleton pattern ensures that a class has only one instance and provides a global point of access to that instance. We utilised this pattern to manage global resources or configurations, such as a centralised connection to the database.

Benefits

- Global Access
- Centralised Management
- Resource Management
- Consistency (all components access the same instance of the singleton class)

Factors worth considering

- Alterations to the singleton object not possible (e.g. different parameters).

Facade

With our layered architecture, we ensure a single entrypoint to our (backend) system. This ensures that we connect a simple interface with a complex interface (*Facade*, n.d.) without exposing or compromising underlying functionality.

Benefits

- Simplified Interface
- Decoupling (Clients only interact with the facade and are unaware of the internal workings of the subsystems)

Factors worth considering

- Maintenance Overhead (Changes to subsystems may require corresponding changes to the facade)
- Performance Overhead (Additional layer of abstraction may incur a slight performance overhead)

Constraints

Budget Constraints

- Limited financial resources for initial development, deployment, and maintenance.
- Preference for open-source tools and free-tier services to minimise costs.

Hardware Constraints

- Compatibility with common farming hardware, including sensors and IoT devices.
- Limited processing power and memory on devices used by farmers (e.g., older smartphones and tablets).

Network Constraints

- Ensuring functionality in areas with limited or intermittent internet connectivity.
- Efficient data transfer protocols to minimise bandwidth usage.

Technology Requirements

Users are required to have at least:

- A mobile device or desktop/laptop.
- Basic internet connectivity.
- An email that can be accessed and used to log in to the dashboard.

Optional requirements include data measurement instruments to enter manual data.

Bibliography

Facade. (n.d.). Refactoring.Guru. Retrieved May 21, 2024, from

https://refactoring.guru/design-patterns/facade