WEATHERSHIELD

NEXT-GEN WEATHER FORECASTING SYSTEM FOR SRI LANKA

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INTRODUCTION

The primary purpose of this document is to lay out the vision and goals of a weather prediction system designed to significantly enhance forecasting accuracy in Sri Lanka. At its core, the system aims to revolutionize weather predictions by harnessing real-time rainfall data contributed by individuals. Users will be encouraged to record detailed information about rain events, such as start and end times, GPS coordinates, and observed rain intensity.

The system's distinctive feature centers on real-time data collection, forming a dynamic dataset that serves as the foundation for an integrated Artificial Intelligence (AI) and Machine Learning (ML) product. The primary objective extends beyond enhancing weather forecasts, aiming to offer a versatile tool seamlessly adaptable to various sectors such as agriculture, construction, and event planning. Through a collaborative user environment, where contributions continuously enrich the dataset, the system fosters ongoing improvement. Employing AI and ML technologies, the system analyzes data patterns, iteratively refining weather prediction models. Ultimately, the system's purpose is to empower users with accurate, real-time weather insights, fostering informed decision-making and positively impacting diverse activities and businesses throughout Sri Lanka.

INTENDED AUDIENCE

- Local Businesses

- Agricultural Sector

- Tourism Sector

- Disaster Management Authorities

- Event Organizers

- Construction Industry

- Energy Sector

- Transport and Logistics Industry

- General Public

- Researchers

INTENDED USE

LOCAL BUSINESSES

Allows companies to plan promotions effectively, modify inventory in response to weather-related changes in predicted client demand, and decide when to hold outdoor events or specials.

AGRICULTURAL SECTOR

Leveraging data-driven insights becomes pivotal for informed decision-making in areas like crop planning, irrigation scheduling, and pest control. This holds significant value as the agricultural sector relies heavily on predictable weather conditions.

TOURISM SECTOR

To provide tourists with accurate and timely weather information

EVENT ORGANIZERS

In making decisions regarding scheduling, venue selection, and ensuring the success and safety of events.

DISASTER MANAGEMENT AUTHORITIES

Disaster management authorities can employ the system to enhance early warning systems and preparedness. Accurate weather predictions contribute to better disaster response planning, resource allocation, and timely evacuation if needed

CONSTRUCTION INDUSTRY

Planning construction activities, managing worker schedules, and mitigating weather-related risks

ENERGY SECTOR

Especially in renewable energy planning, can benefit from the system by optimizing hydropower, wind, solar electricity production based on expected rain conditions

TRANSPORT AND LOGISTICS INDUSTRY

To use the system for route planning, scheduling, and managing delays caused by adverse weather conditions

GENERAL PUBLIC

The general public can use the system for personal planning, such as deciding on outdoor activities, travel plans, or events.

RESEARCHERS

In making decisions regarding scheduling, venue selection, and ensuring the success and safety of events.

PRODUCT SCOPE

- Web Dashboard

Creation of a web dashboard that offers consumers a complete platform for interacting with and obtaining weather-related data in Sri Lanka. Users will be able to browse real-time rainfall data, stay up to date on future weather forecasts, and keep an eye on key meteorological variables like temperature and humidity thanks to this user-friendly dashboard. Users can also get access to comprehensive daily weather reports that provide historical data and patterns in the weather. Features for user authentication are included in the dashboard, guaranteeing a safe login for customized experiences. The ability for registered users to contribute to the system in real-time by reporting weather events, including the beginning and ending times of rain events, GPS positions, and observed intensity of rain, is one of its primary features. The goal of this cooperative strategy is to improve the weather forecast dataset. All things considered, the web dashboard functions as a centralized hub of contact for a wide range of users, including people, companies, and organizations. It also significantly contributes to the advancement of Sri Lankan weather forecasting models.

- Mobile Application

A smartphone app made to provide people with an easy-to-use, mobile way to obtain and contribute to Sri Lankan real-time meteorological data. With the help of this feature-rich software and its intuitive interface, people, companies, and organizations can stay up to date on the weather and make informed decisions based on facts. From their mobile devices, users can easily check rainfall data in real time, receive precise forecasts for the coming days, and keep an eye on key meteorological parameters. A daily weather report function that provides insights into past data and patterns is also included in the app. Registered users can log in using secure user authentication, gain access to customized experiences and improve the weather forecast dataset by reporting real-time weather events. The mobile app version guarantees a smooth transition into customers' everyday activities.

- SMS Service

SMS service is a simple way for people in Sri Lanka to get weather updates through text messages. It's easy to use and doesn't need a smartphone or internet. You can get info about rain, future weather, and important weather details straight to your phone.

SYSTEM REQUIREMENTS ANALYSIS

The proposed system aims to provide a comprehensive weather forecasting service, incorporating features such as user registration and authentication, secure login, data input for rain events, data collection and transmission, data storage with proper indexing, integration with machine learning models for accurate forecasting, and a user-friendly UI/UX. To ensure performance, the system must implement caching technologies, limit real-time update requests, optimize database queries, and optimize ML models for near real-time outputs. Accuracy is crucial, demanding precise location details and timely notifications for incomplete rain event inputs. Timeliness is emphasized for up-to-date weather information, while reliability ensures continuous system operation. Security measures include safeguarding data and granting access only to authorized users. Scalability is essential for handling increasing users and data, and usability requires an intuitive interface. Availability, compatibility across devices and browsers, compliance with regulations, performance efficiency, maintainability, disaster recovery, and interoperability are additional requirements to create a robust, user-friendly, and reliable weather forecasting system.

SYSTEM REQUIREMENTS SPECIFICATION

- Functional Requirement

1. User Registration

Users should be able to register for an account with the system through their personal mobile number or email under a unique username and register to the system.

2. User Authentication

The user authentication system ensures the secure verification of registered users accessing the weather forecast system. Employing robust methods such as email verification, the system guarantees the legitimacy of user identities. Since the data from users will go through the process of forecasting, to ensure the reliability of sources, users will need to authenticate themselves securely to gain access, fostering a protected and reliable user experience.

3. User Login

With their unique username and password, authenticated users will have safer access to the system, guaranteeing a reliable login procedure. Multiple device logins will be supported by the system, giving users the freedom to easily access their accounts from various platforms. This functionality maintains security standards while improving user ease.

4. Data Input

This covers details like the location and the beginning and ending times of rain. With the use of this input, the system analyses historical trends, meteorological data, and other variables to produce precise forecasts. Users should receive a notification from the system if they haven't entered the end periods of the rain within a reasonable amount of time. This guarantees the completion of important input data, improving the precision of the weather forecast predictions produced by the AI system.

5. Data Collection and Transmission

The system shall allow users to record their current GPS location, starting time, ending time, and intensity (should include categories such as Heavy rain, Upper high intensity, Lower high intensity, Higher low intensity, Upper low intensity, and Light rain) of rainfall events and facilitate the secure transmission of collected rainfall data to a centralized database server.

6. Data Storage

Every rain event that is captured should be safely stored in a database by the system. Proper indexing of data (according to the timestamp and GPS coordinates) is necessary for effective data retrieval and analysis.

7. ML / AI Integration

For weather forecasting, the system is integrated with algorithmic or machine learning models. Machine learning models should be trained and tested using the processed dataset as input.

8. UI / UX Integration

The system needs a user interface (UI) that is easy to use and visually appealing, with a smooth user experience (UX) that facilitates data input, navigation that is straightforward, and a responsive design that works on different devices.

• Non-Functional Requirement

1. Performance

The system must implement caching technologies, rate limit the real-time update requests per user per hour, optimize database queries for minimal execution times, and optimize the ML model for near real-time outputs.

2. Accuracy

The system must maintain a high degree of accuracy in collecting, processing, and presenting rainfall data to ensure reliable weather predictions and analysis. When recording real-time rain incidents, the starting location and end location must be within a 1km range. The software system will notify users within a 1 km range when someone records the start of a rainfall event, prompting them to confirm whether the event has ended. The notification includes event details, and users can respond with "Event Ended" or "Not Ended." If confirmed, both users' records are updated. This feature enhances collaboration and ensures accurate rainfall event documentation.

3. Timeliness

The system must ensure timely collection, processing, and presentation of rainfall data to provide up-to-date and actionable weather information for effective decision-making.

4. Reliability

The system should work all the time and not break down often. System stability is crucial because it offers a safety net against data loss through regular backups and a thorough recovery strategy.

5. Security

Security must be the system's priority. Encryption and secure authentication methods must be used to protect data from unwanted access. To guarantee continuous defense against any vulnerabilities and inspire user confidence in the system's security measures, regular audits and updates will be carried out.

6. Scalability

The Weather Forecasting System is built to handle more users and data effectively, focusing on making the database grow as needed. The design includes strong mechanisms so that the system can handle a lot of data while keeping good performance. By using smart database technologies and scalable infrastructure, the system can easily grow its storage space and handle the increasing need for

storing and getting data. This careful approach to scalability shows our commitment to giving a weather service that's reliable, fast, and easy for users. We've made sure the system can adjust its database resources as more people start using it. This way, the system stays strong and can provide accurate weather forecasts to a bigger audience.

7. Usability

The Weather Forecasting System keeps things simple for users, making it easy to use without needing lots of training. The design is straightforward, with clear instructions and helpful tips. This makes it easy for everyone to understand and use the system, making weather forecasts simple and stress-free for everyone.

8. Availability

Availability is about making information accessible to people whenever they need it, no matter where they are, what time it is, or how they're trying to access it. The goal is to ensure that information is always there for users, making it convenient and accessible at all times, regardless of their location or the device they're using. But we have to maintain the security standards so as not to fall.

9. Compatibility

The weather forecast system must work smoothly on various devices and browsers. Additionally, a backend API will be developed for easy integration with other systems, ensuring compatibility and enhancing overall functionality.

10. Compliance

Making certain that industrial, legal, and moral standards are followed. This includes protecting user data and adhering to cybersecurity and meteorological regulations.

11. Performance Efficiency

It should use resources like CPU and memory efficiently. Not only computer resources but also power need to be used efficiently in this case.

12. Maintainability

Focusing on simple troubleshooting and enhancement. This guarantees prompt and effective repairs, encourages continuous improvements, and adds to the system's long-term resilience and adaptability.

13. Disaster Recovery

To protect data and functioning, the system should have dependable backup mechanisms. This entails consistent data backups, offsite storage, and a clear recovery strategy. To reduce downtime and data loss and enable a quick and efficient system restoration in the event of unplanned disruptions, disaster recovery preparation is essential.

SOFTWARE REQUIREMENTS ANALYSIS

The system outlines a comprehensive strategy for weather forecasting through machine learning, involving model training and daily updates. Dedicated servers execute the models, populating a central database, while an Insights Generator Program provides personalized insights and notifications. The central database is crucial for storing various data types, with optimizations for performance. The client software, a React-based web application, emphasizes a unified development approach for all devices and efficient functionality.
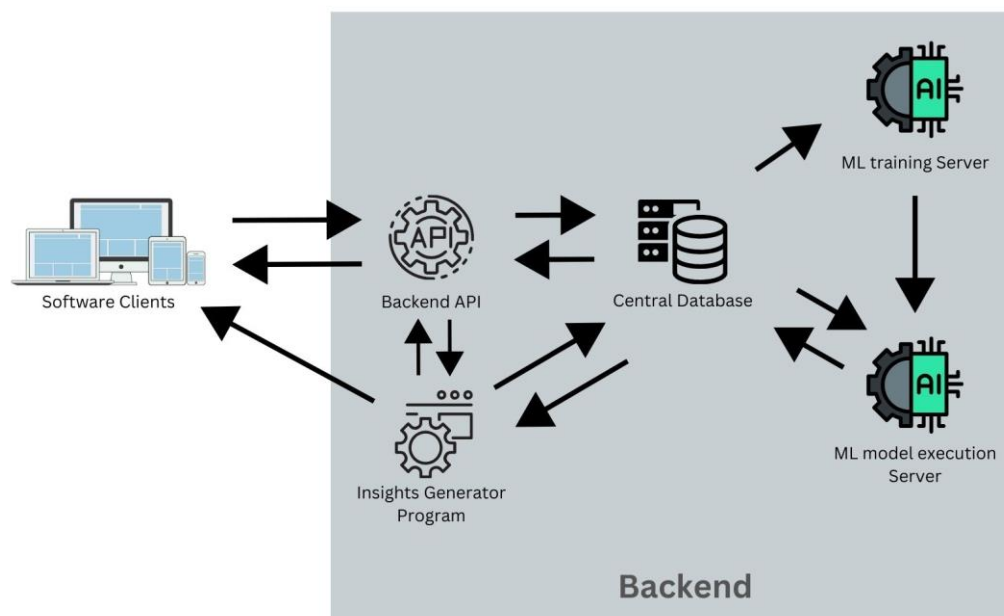
SOFTWARE REQUIREMENTS SPECIFICATION

- <u>Machine Learning Model Training</u>

  To initiate the process, the initial model must undergo training. We can use training data from historical data sourced from the Meteorological Department of Sri Lanka, the Visual Crossing Historical Weather API and other candidates. Subsequently, daily training sessions are imperative to update the machine learning models with newly collected data.

- <u>Machine Learning Model Execution</u>

  Dedicated machine learning model execution servers will be employed to execute the model using the latest training outcomes. This execution process will then populate the central database with the resultant output, ensuring a daily operational cycle.

- <u>Insights Generator</u>

  An Insights Generator Program is designed to derive personalized insights for users, leveraging new and updated data within the central database. This program is equipped to dispatch notifications for special weather events and changes. Additionally, users retain the flexibility to incorporate personal insight rules into the system.

- <u>Central Database</u>

  Serving as the primary data repository, the central database is pivotal for storing model predictions, weather insights, and user data. To enhance performance and reliability, the database incorporates both big file storage and cache storage functionalities.

- <u>Client Software</u>

A web application, developed using the React framework, serves as the client software. This application visually presents weather forecasts for various locations on a Sri Lankan map. Notably, a "Report an event" button facilitates the receipt of real-time rain updates from users. The decision to utilize the React framework ensures a unified development environment for both web and mobile applications, contributing to streamlined and efficient development processes.

HARDWARE REQUIREMENTS

- <u>User Side</u>

Device: Users need a device to access the weather prediction system, such as a smartphone, tablet, or computer. Any device with internet access and a web browser can be used to interact with the system.

Location Services: Users must enable location services on their devices. Enabling location services allows the system to gather accurate GPS coordinates for more precise weather data.

- <u>Developer Side</u>

Computer or Laptop: Developers need a high-performance computer or laptop to write, test, and deploy the software.

Sufficient RAM (Random Access Memory): A good amount of RAM ensures smooth software development processes and testing.

Processor (CPU): A decent processor helps in faster compilation and running of the software.

Storage Space: Adequate storage is necessary for storing code, databases, and other development-related files.

Internet Connectivity: Developers need internet access for research, accessing libraries, and collaborating with team members.

Mobile Device for Testing (Optional): Having a smartphone or tablet for testing ensures that the developed software functions correctly on various devices.

Database Server: Developers need access to a database server to store and manage the collected rainfall data efficiently.

Sufficient Storage for Database: The database server should have enough storage space to handle the growing dataset of real-time rainfall information.

Backup System: A backup system is crucial to prevent data loss, ensuring that valuable rainfall data is not compromised.

NETWORK REQUIREMENTS

- **User Side**

Stable Internet Connection: Users should have a consistent and reliable internet connection to access the weather prediction system without interruptions.

Data Connection for Location Services: Users need an active data connection to enable location services, allowing the system to accurately capture GPS coordinates.

- **Developer Side**

High-Speed Internet: Developers require a fast and stable Internet connection for seamless collaboration, accessing development tools, and updating the software.

Database Connectivity: The development team needs a reliable network connection to interact with the database server, storing and retrieving rainfall data.

Secure Connection for Data Transfer: A secure network connection is essential to protect user data during transmission between the user's device and the system.

Version Control System Access: Developers use version control systems that require network access for efficient collaboration, code management, and tracking of changes.

Backup System Connectivity: A network connection is necessary for maintaining a backup system, ensuring that valuable data is securely duplicated for recovery purposes.

USER INTERFACE SKETCHES