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Research Article

Real-Time Weather Data for Environment, Social, and Governance (ESG) Decision-Making

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ABSTRACT

In the 21st century, the Internet has undergone unprecedented growth in technology and accessibility, contributing to the achievement of various Sustainable Development Goals (SDGs) related to digital inclusion and technological advancement. This era witnessed the ubiquitous presence of personal computers in daily life, enabling people to access vital information online, thus promoting digital literacy and access to information (SDG 4, SDG 9, SDG 16). Moreover, the rapid expansion of mobile technology has marked a significant milestone in the development of mobile devices, aligning with SDG 9, which emphasizes innovation and infrastructure development. Android and iOS platforms currently dominate the mobile landscape, offering a range of opportunities and challenges for developers. However, the prevalent practice of developing applications exclusively for a single platform has resulted in suboptimal development efficiency, hindering progress toward SDG 9 and sustainability in technological advancements (ESG). In response, developers have begun to explore cross-platform technologies, which not only streamline development across different platforms but also contribute to cost-efficiency and resource optimization (SDG 12). This paradigm shift in development approaches presents a unique opportunity to meet the growing demand for real-time, precise, and diverse weather information. In response, this study proposes the creation of a mobile application-based weather forecast system. This system places a strong emphasis on user interface (UI) design and the successful implementation of key functionalities, promoting user-friendly access to weather data and aligning with the principles of inclusive design and technological accessibility (SDG 4). In summary, this research endeavors to harness the advancements in mobile technology and cross-platform development to deliver an innovative weather forecast system, ultimately contributing to the broader goals of digital inclusion, technological sustainability, and user-centric design in line with SDGs and ESG principles.

1. Introduction

We are now in an era where technology is changing our lives. How to better meet the needs of users has always been an important topic of mobile platform development, and the eternal theme of weather has naturally become a center. After all, weather information plays an important role in people's daily travel, agriculture, industry and other important fields. At present, synoptic methods are mainly based on weather maps, supplemented by meteorological satellite maps, radars, etc. Numerical weather prediction uses computer as a tool to obtain the information of weather prediction according to the prediction equation, and it can be released according to probability statistics. The development of the weather forecast software of the mobile platform makes the dissemination of meteorological information more convenient and expands the coverage. The majority of mobile phone users can obtain the latest weather forecast information at the first time, so that they can prevent in advance and facilitate travel. The losses caused by meteorological disasters can also be minimized, because people can easily and quickly obtain meteorological information at the first time.

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But in recent years, the development of the cell phone could not be stopped, not since the source code opened for the Android system. The development is a lot of convenient for developing the mobile platform. According to incomplete statistics, Android has taken about 70% market, and the other platform still holds its position. Your mobile phone quickly blended in life, brought the people a large change in the speed of life.

In short, three major problems on the platform grow quickly and diversify the base; The vision of the weather theme; The applications on the market for trade purposes are important issue. [1]. This paper takes the weather forecast application oriented to mobile intelligent platform as the research object, and focuses on solving two problems - how to develop a weather forecast application oriented to mobile intelligent platform, and how to design a weather forecast application to better satisfy users. Regarding the former, this paper focuses on the cross platform problem of mobile intelligent platform, and briefly introduces and analyzes the current popular cross platform development technologies in mobile development technologies. According to the principles of different kinds of cross platform development technologies, the advantages and disadvantages of each are analyzed, which can better show the characteristics of the technology selection of this topic. As for the latter, this article will give its own answers according to the user's preferences for the use of weather apps and common apps.

With respect to technical data, this paper reviews, studies, and practices various technical solutions, and gives its own opinions based on the actual situation. With regard to the content design of the weather forecast application, we downloaded and used a variety of popular weather apps such as Ink Weather, Weather Connect, and Rainy Weather. We compared and summarized the highlights and shortcomings of each software. In the design of this software, we fully considered the above factors and tried to avoid repeating the mistakes [2].

2. Literature Review

Weather forecast systems have evolved significantly over the years, with the advent of mobile technology ushering in a new era of accessibility and convenience. Mobile-based weather forecast systems have gained prominence as they empower individuals to access real-time weather information on the go. This literature review examines the key developments, technologies, and trends in mobile-based weather forecast systems, highlighting their impact on society and the challenges they face.

In 2017, Fahad Idrees and his colleagues introduced an Android-based solution designed to assist farmers. This solution aims to provide farmers with timely, location-specific, and personalized weather forecasts, offering protection to the entire agricultural ecosystem and supply chain by enabling informed decision-making. Their Android mobile application, as proposed, is capable of transmitting a customized weather forecast that aligns with user preferences. The information is relayed from a cloud server to subscribing farmers via encrypted SMS messages, which contain weather-related data. To enhance accessibility and comprehension, this information is presented in a user-friendly interface, featuring visuals and icons. Furthermore, the interface includes text in the Urdu language, specifically tailored to accommodate the needs of low-literate farmers in Pakistan [3].

In 2023, the National Centre for Hydro-Meteorological Forecasting (NCHMF) and the Japan International Cooperation Agency (JICA) embarked on a collaborative effort to develop mobile services within the scope of the JICA Project. This mobile service system was created to provide users nationwide with access to data from Automatic Rain Gauge (ARG) stations, radar systems, meteorological satellites, and deliver essential extreme weather warnings. The system was meticulously designed, incorporating modern technologies to ensure exceptional stability and to align with the project's technical requirements. MongoDB, a flexible database capable of accommodating various data sizes, was chosen as the system's database. Both the website and mobile app interfaces were developed using React (including ReactJS and ReactNative). Moreover, the system was architected with two servers interconnected in a cluster, enhancing its overall stability. To promptly deliver alerts to users, push notification technology was employed, catering to personal computers as well as iOS and Android mobile devices [4].

In 2022, TP Fowdur et al. introduced an innovative real-time weather forecasting system that leverages collaborative machine learning techniques. Their approach involves utilizing data from multiple geographical locations to make predictions about the weather for a specific location. This research encompassed the use of five distinct machine-learning algorithms and conducted testing across four different locations in Mauritius. The aim was to forecast various weather parameters, including Temperature, Wind Speed, Wind Direction, Pressure, Humidity, and Cloudiness. To collect the necessary weather data, the OpenWeather API was employed, with data being gathered from both a mobile device and a desktop edge device. This data was stored as a JSON file in both the IBM Cloudant database and a local MySQL database. Analytical processes were conducted on two fronts: first, on a local server responsible for capturing incoming data from the edge device, and second, via a servlet deployed on the IBM cloud platform. The research encompassed the evaluation of five machine learning algorithms, namely Multiple

Linear Regression (MLP), Multiple Polynomial Regression (MPR), K-Nearest Neighbors (KNN), Multilayer Perceptron (MLP), and Convolutional Neural Network (CNN). These algorithms were tested using both collaborative and non-collaborative approaches. The experimental results revealed that the collaborative regression methods outperformed the non-collaborative ones, achieving a 5% lower Mean Absolute Percentage Error (MAPE). Of note, the Multiple Polynomial Regression (MLR) algorithm demonstrated the best performance, with errors ranging from 0.009% to 9% across different weather parameters. In summary, the findings indicated that collaborative weather forecasting, employing multiple predictor locations, has the potential to enhance the accuracy of machine learning predictions [5].

In 2021, Dhulipala R et al. introduced a mobile application named Meghdoot, developed through a collaborative effort involving the India Meteorological Department (IMD), Indian Institution for Tropical Meteorology (IITM), Indian Council for Agricultural Research (ICAR), and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). This application was designed with the primary goal of providing weather information and crop-specific advisories to enhance farmers' decision-making processes and mitigate production risks, especially in challenging weather conditions. Meghdoot builds upon the foundation of IMD's District Agrometeorological Advisory Service (DAAS), which issues crop-specific, weather-based agricultural advisories twice a week for all districts across India. The Meghdoot app serves as a platform where users can access observed weather data, forecasts, and warnings generated by IMD and IITM. The Meghdoot mobile application is accessible through both the Google Play Store and the Apple App Store. Since its launch over two years ago, Meghdoot has garnered a positive response, amassing over 200,000 downloads and installations, along with an average user rating of 3.3/5.0 as of July 26, 2021, on Google Play Store [6].

Based on the literature review it is evident that there is a need to develop a mobile based weather forecasting system.

3. Methods

Agile is a widely used process framework for software development that addresses the evolving nature of requirements and solutions. It is based on the Agile Manifesto, which emphasizes values and principles such as iterative development, collaboration, and individual skills could come [7]. As highlighted by Salza et al. in [7], Agile methodologies, including Scrum and eXtreme Programming, have been developed to implement these values and principles effectively. Agile promotes a team-based approach, reducing resource waste and development time. It focuses on people factors, encouraging excellent communication, interaction, and individual talent utilization within teams to achieve common goals efficiently [8]. Karrenbauer et al. (2019) mentioned that Agile methodologies offer numerous advantages in software development, such as addressing complexity, reducing effort, improving usability, and promoting collaboration. Firstly, Agile methodologies provide an iterative approach that enables teams to adapt to evolving requirements and master the project's intricacies [9]. Additionally, they facilitate efficient development by minimizing effort and ensuring the delivery of a minimum viable product at an early stage. Additionally, they enhance the usability of software development processes through employee innovation, continuous process improvement, collaboration, and streamlined documentation. By encouraging employee involvement, fostering a culture of innovation, and providing opportunities for continuous improvement, agile methodologies empower teams to create high-quality software solutions. The collaborative nature of agile methods fosters teamwork, shared responsibility, and a greater appreciation for the expertise of developers. However, Džanić et al. (2022) highlighted that Agile methodologies also have drawbacks. One of the main drawbacks of Agile methodologies is that it is unsuitable for larger projects due to their iterative and flexible nature. Additionally, their emphasis on working software over comprehensive documentation raises concerns about the adequacy of documentation for larger projects. The lack of documentation poses a challenge for future maintenance and knowledge transfer, as documentation plays an integral role in capturing the knowledge and details of a project [10].

In our project, we use the Agile methodology to divide the tasks into 6 phases: requirements analysis, planning, design, development, testing, and deployment as shown in Fig. 1.

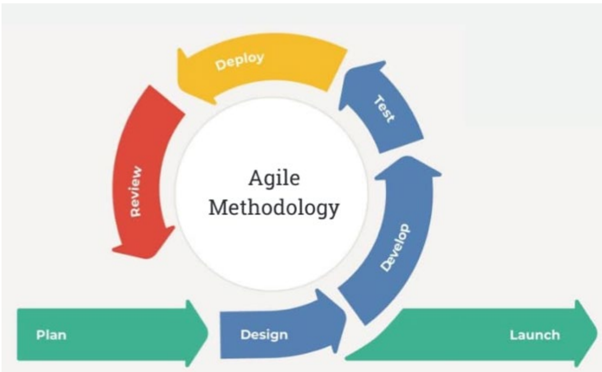

Fig.1 Agile Methodology

In the requirements analysis phase, the project's scope and requirements are identified. Surveys and interviews are necessary to gather the users' opinions and understand their needs. Additionally, a feasibility study is conducted to assess the project's viability and identify any potential challenges that may arise.
A project timeline is established and divided into several deliverables and milestones in the planning phase, making creating a project roadmap easier. Additionally, project risks are analyzed and identified, and risk management plans are developed to reduce or eliminate their effects. During this phase, a project budget is also developed, considering financial resources and estimated costs for specific tasks. Besides, necessary project resources are identified, including personnel, hardware, and software requirements. The design phase includes planning the app's visual components and layout as we aim to produce a user-friendly interface that adheres to UI/UX design guidelines. A database schema and data model are also specified to organize and structure the application's data efficiently. Besides, UML diagrams, such as class and sequence diagrams, are created to visualize the system's design and behavior, which serve as development roadmaps. The development phase involves implementing the application's front end, including developing the user interface and ensuring it is responsive and usable. At the same time, developing back-end functions is also involved in this phase, such as focusing on data processing, business logic, and database integration. Following coding best practices and maintaining clean code while documenting the development process for future reference and collaboration is crucial. In the testing phase, test cases are created and executed. The test cases include functional and non-functional testing to ensure the application meets specified requirements. Debug and resolve any identified defects or issues, ensuring a high-quality final product. Finally, in the deployment phase, the application is deployed to production. The deployment process involves configuring the necessary setup and ensuring compatibility with the target platform.

4. Results

This section describes the weather forecast mobile application interface and the findings obtained from the user acceptance test. When the weather forecast app is opened for the first time, the user is required to grant the location access permission as shown in Fig. 2. The app will show an error message as shown in Fig. 3 if the location is disabled in the mobile. However, the app allows the user to search for the specified city. There is an animation effect when loading, which enhances the smoothness of software use, as shown in Fig. 4.

Fig.2 Permission for location access

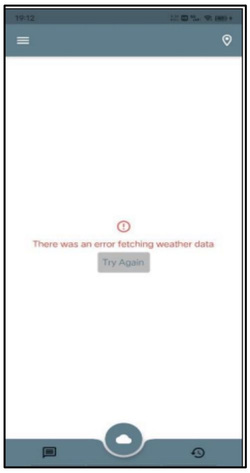

Fig.3 Error message when the location is disabled

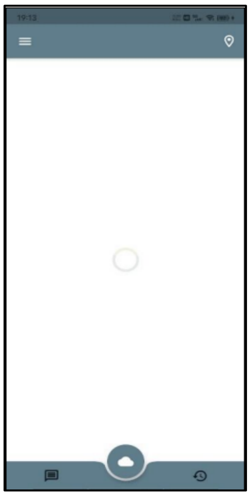

Fig.4 Loading page

Once the location has been enabled, the user needs to go back to the app. The name of the city, weather conditions, real-time temperature, maximum and minimum temperatures of the day, hourly weather in the next 24 hours, body temperature and other indexes are displayed on the home page of the app as shown in Fig. 5. The weather line chart for the next 7 days can be viewed on the app when the upper middle area is scrolled. Moreover, the app could also show the 24-hours weather module which can be viewed horizontally, as shown in Fig. 6.

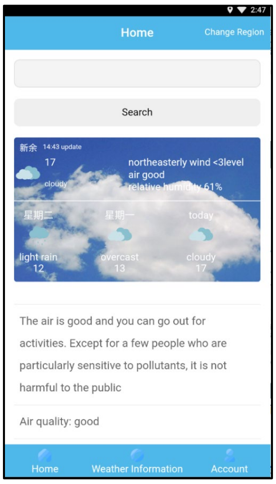

Fig.5 Main page

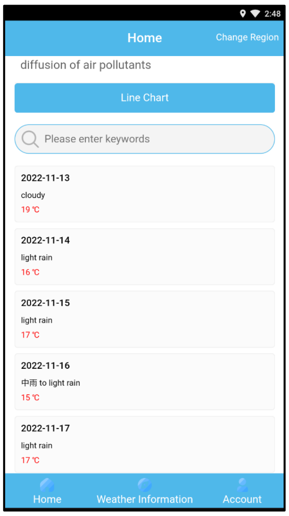

Fig.6 24 hours weather module

The city can be changed by clicking the button on the top right. The app not only allows the user to change the city but it also allows the user to perform city positioning. The city modification process involves performing a fuzzy search based on the input city name, automatically identifying the city that closely matches the search query.

You can observe the user interface for this process in Fig. 7, and the outcomes of the selection are presented in Fig. 8. We have conducted testing to assess the accuracy of the positioning functionality during software input.

Fig.7 Change of city

Fig.8. Weather information of the city

To access the city management interface, click the button located at the top right corner. This interface displays a list of cities that have been visited. To switch between cities, you can simply click on the desired city. Alternatively, a long press on a specific city allows you to delete the corresponding city information. Once multiple cities have been visited, you can open the city management interface, depicted in Fig. 9. Upon selecting "Beijing City" from the list, the interface will show the weather information for Beijing as demonstrated in Fig. 10. To streamline the interface and accommodate specific needs, it is possible to remove cities that are no longer in regular use. By long-pressing on three cities, you can initiate the removal process, and the results are illustrated in Fig. 11.

Fig.9. City management

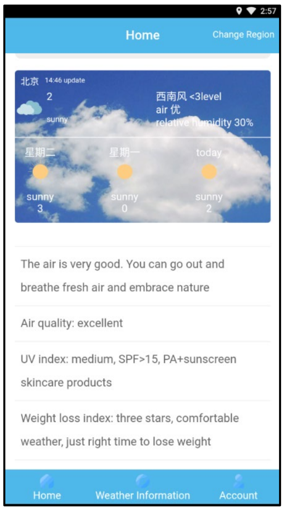

Fig.10. Weather information for Beijing

Fig.11. Removing a city

To access the historical weather page, click the button located at the bottom right corner of the software interface This page presents historical weather information for the currently selected city, visualized using both line charts and tables, as exemplified in Fig. 12. Given the constraints of mobile device screen sizes, certain sections may not be fully visible at once. To facilitate complete data access, users can navigate through the data by swiping the screen, as illustrated in Fig. 13, or opt for a horizontal orientation to visually scroll through the data along the horizontal axis.

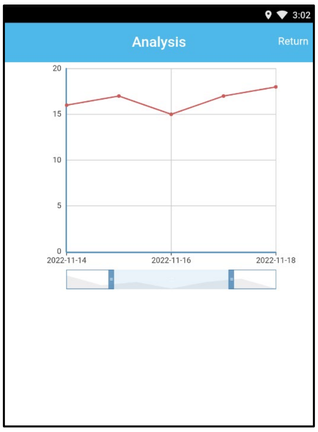

Fig.12. Weather line chart

Fig.13. Weather information in table

To access the weather news page, click the button positioned at the bottom left of the software interface. On this page, an overview of weather news is presented in a strip format, as depicted in Fig. 14. To access additional information, users can swipe upwards. The user can also view news articles related to "popular science knowledge of weather information," by selecting the relevant news item and click on it. This action will redirect the user to the details page within the browser, containing the news links, as demonstrated in Fig. 15.

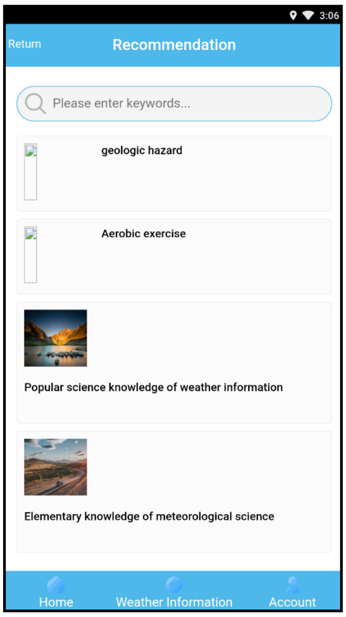

Fig.14. News page

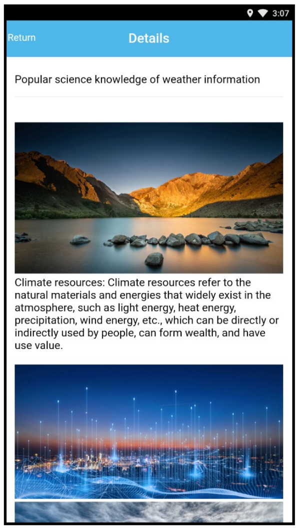

Fig.15. Detail of News (Browser)

5. Conclusion

This paper harnesses cross-platform technology to construct a mobile weather forecasting application, aligning with Sustainable Development Goal (SDG) 9, which emphasizes innovation and infrastructure development. The application leverages the Vue+Spring Boot front-end and back-end separation framework, contributing to efficient technology use and resource optimization in line with ESG principles. The research delves into the advantages of the Vue+Spring Boot framework, demonstrating its potential to streamline development processes across multiple platforms, thus promoting SDG 9 objectives related to technological advancement. The framework is currently experiencing increased adoption, with developers actively embracing this innovative front-end and back-end separation paradigm, facilitating skill development and contributing to a more robust technology ecosystem (SDG 4). Despite the study's limited scope, it offers a concise evaluation of the Vue+Spring Boot framework, providing a practical demonstration of its capabilities. Throughout the development process, the framework exhibits notable efficiency in code composition and program debugging speed, aligning with SDG 12's focus on responsible consumption and production through resource-efficient development practices. It is anticipated that as technology continues to evolve, the Vue+Spring Boot framework will contribute to the development of more extensive and resilient technology ecosystems. However, it's essential to acknowledge that adopting new technologies often entails a steeper learning curve. Developers well-versed in these technologies are aware of the additional learning efforts required to integrate them into their skill set, emphasizing the importance of ongoing skill development and education (SDG 4).

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