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Abstract

This thesis presents a novel IoT system designed for the collection, management, and visualization of agricultural data. The system aims to address the challenges faced by the agriculture industry, such as the need for efficient and reliable data collection, management, and visualization. The system architecture is designed to be adaptable to different agricultural applications, and it can be scaled to meet the needs of different agricultural systems. The system uses modern IoT technologies to ensure efficient and reliable data transmission from sensors to the server, where the data is processed and stored in a database for easy management and retrieval. The front-end interface of the system provides a user-friendly platform for managing and visualizing the data, enabling users to gain valuable insights into the performance of their agricultural systems. The system has been evaluated in real-world scenarios, demonstrating its effectiveness in improving decision-making and increasing productivity in the agriculture sector. The system represents a significant advancement in agricultural technology, and it has the potential to transform the way agricultural data is collected, managed, and visualized.

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Introduction

The purpose of this thesis is to develop an IoT app. The Internet of Things (IoT) is a network that allows multiple devices, as well as any object incorporating electrical methods, software, sensors, and network connectivity to connect and exchange data. Devices and objects with integrated sensors are connected to a platform (cloud) that stores data from multiple devices and incorporates details to provide the most useful information with apps tailored to individual needs. It is vital to develop such management frameworks and central control of dispersed systems. We will deal with the collection, management, and visualization of data collected through the internet of things for use in agriculture as part of this task.

The Internet of Things (IoT) is a network of physical devices, vehicles, home appliances, and other objects that are embedded with sensors, software, and connectivity, allowing them to collect and exchange data. This technology has the potential to revolutionize industries by providing unprecedented levels of insight and control over previously disconnected systems. In agriculture, IoT is proving to be a powerful tool for improving crop yields, reducing waste, and increasing efficiency.

The importance of IoT in agriculture lies in its ability to address some of the key challenges facing the industry. The world's population is growing rapidly, and with it, the demand for food is increasing. At the same time, climate change is making it more difficult to grow crops in some regions. Furthermore, traditional farming practices can be inefficient and costly, with high levels of waste and low yields. IoT has the potential to address these challenges by providing farmers with real-time data on weather patterns, soil conditions, and plant health, enabling them to make more informed decisions about planting, harvesting, and irrigation.

IoT can also help farmers to optimize their use of resources such as water, fertilizer, and pesticides. By monitoring soil moisture levels, for example, farmers can avoid over-watering, which not only wastes water but also leads to decreased yields. Similarly, by using sensors to monitor soil nutrient levels, farmers can ensure that they are applying the correct amount of fertilizer, reducing waste and improving crop health.

Furthermore, IoT can help to improve food safety and traceability. By monitoring the temperature and humidity levels of food during transportation and storage, for example, IoT can help to ensure that food is stored under the correct conditions, reducing the risk of spoilage and contamination. Furthermore, by tracking the origin and journey of food products through the supply chain, IoT can help to improve transparency and traceability, enabling consumers to make more informed choices about the food they eat.

As with any emerging technology, there are several potential issues that need to be addressed in the implementation of an IoT system for agricultural data collection, management, and visualization. One of the primary concerns is data security and privacy. With large amounts of data being collected and stored in the cloud, there is a risk of sensitive information being exposed or compromised. Mitigation strategies for this issue could include using encryption to secure data transmissions, implementing robust access controls and authentication mechanisms, and regular security audits and updates.Another emerging issue is the interoperability of different IoT devices and systems. With many different vendors and platforms in the market, it can be challenging to ensure that devices and systems can communicate with each other seamlessly. To address this issue, standardization efforts and open protocols should be encouraged to promote interoperability.

Finally, there is a need for effective training and education programs to ensure that farmers are equipped to use and interpret the data generated by IoT systems. Without proper training, the full potential of the technology may not be realized. Mitigation strategies for this issue could include providing training and support resources for farmers and agricultural professionals.

In summary, while there are several emerging issues with the implementation of an IoT system for agricultural data collection, management, and visualization, these issues can be mitigated through careful planning, implementation, and ongoing monitoring and optimization. Overall, this thesis will focus on the the benefits of IoT in agriculture which are significant, making it an exciting area of research. By harnessing the power of this technology, farmers can improve their productivity, reduce waste, and produce food more sustainably, helping to feed a growing global population while protecting the environment.

State of the Art

This section will review the available literature on the topic of general agriculture automation and cost minimization while providing a variety of options, which is the thesis's fundamental theme.

Physical items that have sensors, computer power, software, and other technologies are referred to as "Internet of Things" (IoT) objects because they can connect to and share data with other systems and devices over the Internet or other communication networks.Because devices must be connected to a network and reachable individually rather than the general internet, the phrase "internet of things" has been regarded misleading.

Precision agriculture has recently advanced thanks to the Internet of Things (IoT), allowing us to improve overall agriculture management. Because of its highly interoperable, scalable, widespread, and open nature, the Internet of Things is an ideal match for precision agriculture. There are numerous IoT- derived technologies, each of which has its own set of advantages, such as lowering the risk of vendor lock-in, implementing equipment, and improving sensing and automation systems. Due to the lack of a comprehensive, reliable, tried-and-true, and accepted standard solution, we created our model in response to the aforementioned advantages and potential of IoT in precision agriculture.

In this research, we propose a technique that allows for simple and inexpensive network expansion while maintaining the flexibility to install sensor nodes at a great distance from the base station, lowering the complexity and cost of the entire network. Our model architecture is very adaptable and offers a data analytics solution that enables large-scale data processing on real-time observation streams of data from many sources, such as sensor networks, weather forecasting services, and other similar sources. We employ LoRaWAN LPWAN (Low-Power Wide-Area Network) as a transmission protocol in our solution, which was developed by the LoRa Alliance to fulfill the needs of IoT services. It has a low power consumption and requires little maintenance, making it perfect for a large number of sensors. All of this makes LoRaWAN ideal for the Internet of Things (IoT) in a variety of areas, especially agriculture. Many effective IoT applications in the agriculture sector have been established all around the world.Some of the applications will be described in detail in the following sub-sections.

In the field of environmental monitoring, China has created a low-cost, low-power environment monitoring system for use in greenhouses [i]. The system's practical application demonstrates that it is dependable, lowering human costs by transmitting instructions remotely and on time. Fertilization rates were lowered by 60 percent, pesticides by 80 percent, and labor costs by 60 percent as a result of IoT adoption. Furthermore, IoTs were also used in the agro-industrial production cycle. IoTs were used in the agro-industrial production cycle by Medela (2013) [ii] . They suggested a unique architecture based on the Internet of Things (IoT) idea, combining wireless and distributed particular sensor devices with environmental simulation to follow the evolution of grapes for wineries and introduced an IoT-based agriculture in- formation system with a distributed architecture. In that suggestion, distributed IoTs servers were used to track and trace the entire agricultural production process. Protected agriculture, as opposed to open-field farming, offers a more favorable and manageable environment for crop growth through greenhouse technology. It is challenging to adjust traditional cultivation and environmental regulation to the growth of various plant kinds in various growth stages due to the considerable geographical and temporal variability of crop environmental parameters in protected agriculture. As a result, monitoring and controlling must be done with greater precision. It has been shown that it is both technically and economically feasible to utilize IoT to design and test various monitoring and control systems to change the environmental conditions in greenhouses, such as air temperature and humidity, light intensity, and CO2 concentration. [iii].

IoT solutions can now easily handle and analyze smart data in a comfortable and economical manner thanks to improvements in cloud computing, machine learning, and other areas. As a result of numerous generations of advancements in greenhouse technology, plant factories that are highly automated and mechanized have now been created. A smart farming IoT platform built on edge and cloud computing was created by Zamora-Izquierdo for soilless culture greenhouses at a reasonable price. Real-time findings and digital simulation both showed that the system can operate steadily in the presence of both internal and external disruptions [iv]. The platform was divided into local, edge, and cloud components. The local component dealt with data collection and automatic control via cyber-physical systems, while the edge component handled major management duties and could increase the stability of these systems. The cloud component handled data analytics. When compared to a standard open control, the platform saved more than 30% more water. They also developed an online system for watering hydroponic greenhouse veggies, and research revealed that it 100% increased the efficiency of water and fertilizer consumption.

Crop growth is seriously threatened by diseases and insect pests, and traditional methods of chemical prevention and management also have drawbacks.

Crop disease and pest control now have more effective and intelligent solutions because to the growth of IoT. Numerous IoT sensor types may collect information about location, greenhouse environment state, crop development, and pest situation anywhere in real-time, helping farmers to keep an eye on agricultural pests and diseases. Once in cloud processing centers, all raw data and photos are analyzed and evaluated using various models and algorithms based on various diseases and pests. The services typically offered to farmers by these cloud centers are disease or pest identification, disaster prediction and warning, and expert system-recommended governance actions [v]. Protected agriculture includes production of livestock and aquatic products, which is also a successful application area for IoT.

IoT should consider the effects of animal behaviors in addition to overcoming challenging environmental factors in order to produce good control effects in animal breeding. IoT has been used to monitor and manage the farming, animal, and environmental processes. It is possible to understand an animal's own physiological and nutritional status as well as its capacity for environmental adaptation by studying the livestock monitoring items, which contain data on body temperature, weight, behavior, exercise volume, food intake, disease information, and environmental factors.

The safety of agricultural products and food is currently a global concern, and the traceability of such products' safety is one solution that has been embraced by all parties involved in the agri-food industry. Several nations have passed laws and regulations to increase the oversight of agricultural products and food safety and to encourage the development of food traceability systems. In order to encourage consumers to feel confident about the safety of their food and to support the long-term growth of the entire food industry, the IoT-based Agri-Food Supply Chain Traceability System can ensure food safety and quality at every stage of production, from the cropland to the consumer (Figure 6).

Due to its secure and straightforward functioning, near field communication (NFC) has advanced as a revolutionary technology. The asynchronous heterogeneous data flow and distributed aspects of the Internet of Things are a common source of issues. To enable quick and specific retrieval of information about a farm product, the traceability system must develop consistent and precise identifying naming criteria. The supply chain will transition to virtualization as the IoT infrastructure deployment is finished and no longer requires physical touch. Administrators can better monitor, regulate, plan, and improve food supply chain processes by virtualizing their agri-food supply chains [vi]. Existing traceability systems may now offer automation, intelligence, and human services to organizations and consumers thanks to the development of artificial intelligence technologies. The autonomous tracing system for backward design in the food supply chain based on IoT developed by Chen et al. employed fuzzy cognitive maps and fuzzy rule technique to better trace food product issues. Traceability issues related to food safety still exist. It is important to keep in mind that the existing agricultural product safety traceability system only concentrates on a particular supply chain node or product category. We think that future study should concentrate on more intricate and systematic supply chains with the involvement of many projects or multiple sessions.

IoT applications in protected agriculture will inevitably run into difficulties from all angles. Numerous devices must contend with the harsh and complicated greenhouse environment in the perception layer.Strong vibrations, high humidity, high temperatures, and other risks can easily harm or completely destroy sensors or end devices.Furthermore, the daily activities of cattle may obstruct the work of the execution nodes or the sensor nodes, leading to subpar detection and management. The information gathering nodes generally rely on a battery with a limited amount of power to keep working because frequent battery replacement requires a lot of resources and money. Therefore, there is a pressing need to further the development of energy-efficient sink node routing protocols, low-power acquisition hardware, and energy-balanced communication algorithms [vii]. Devices spread over the world produce uncountable amounts of data, and some small servers find it extremely difficult to store this data. These agricultural IoT data's real-time, dynamic, granular, and fragmented characteristics provide major challenges for approaches employed in intermediate design, data large-scale screening, screening, mining, processing, and decision analysis. Furthermore, unstructured data like music, video, and photos cannot be stored in conventional databases. As a result, many real-time sensor data are not being used to their full potential. Additionally, certain models and algorithms don't adequately reflect objective reality, making it impossible for them to successfully direct agricultural production.

The sensors and equipment used in protected agriculture must operate continuously in a hostile and variable environment, and their placement is scarce and erratic. The wireless network has several advantages over a wired network, including low cost, superior networking flexibility, and high scalability. As a result, it has replaced the wired network as the primary application mode for the present monitoring system. The effects of temperature, humidity, and buildings or other spatial obstacles on standard wireless communication systems have been demonstrated in numerous actual deployments [viii]. Due to the low node deployment density and the aforementioned barriers in protected agriculture, it is simple to isolate a node in the original communication network. The majority of the network will become partially or even completely paralyzed if this node, which is in charge of numerous devices' communication routing functions, is damaged and cut off from the rest of the network. The most pertinent theories and studies are required on, among other things, the effects of crop development, wall thickness and material, radio signal transmission loss, and electromagnetic wave transmission at the soil-air interface. To determine the best location, height, and network configuration for sensor nodes in various environmental scenarios.

Wireless Ad-Hoc Network (WANET) is required, however, to lessen or prevent the paralysis of large-area networks. Due to its long communication distance, which eliminates the requirement for dense and expensive deployments of relays and gateways altogether, the advent of LPWAN may be able to resolve the above paralyzing concerns of WLAN. However, building LPWAN base stations is expensive. Large amounts of data are produced during the process of tracking the status of diverse agricultural goods from the field to the table, which poses significant difficulties for wireless communication with a slow transmission rate. It also caused numerous issues for network nodes in terms of energy distribution, data calculation, storage, and communication at the same time. The development of high-capacity data and real-time broadband communication standards for technologies in complex agricultural application environments is therefore urgently needed. Due to real-world examples of losses caused by vulnerabilities, network assaults, or privacy concerns, the problems of security and privacy are believed to be major hurdles in applications of protected agriculture. As a multi-network heterogeneous converged network, it not only has security issues in common with sensor networks, mobile communication networks, and the Internet, but it also has its own problems, including issues with privacy protection, authentication and access control for heterogeneous networks, and issues with information management and storage.

The WSN and RFID are the principal targets of security attacks in the perception layer. Numerous sensor nodes are used in agricultural applications, and because the wireless network is open and the farming environment is unsupervised and long-term, the wireless transmission is susceptible to interference from outside sources and unauthorized users. A single security measure is insufficient because various devices are each deployed in different locations and because of this [140]. Eavesdropping attacks, node capture, replay attacks, and information wiretapping are the key risks to WSN. As a result, several security measures such data encryption, anonymity, and identity authentication are required [ix]. There are further difficulties with security authentication across network architectures since networks with various architectures must be connected to one another. Security issues that the transport layer will face include proxy attacks, Denial-of-Service (DoS) attacks, malicious code injection, man-in-the-middle attacks, attacks across heterogeneous networks, etc. Authorization, authentication, encryption, anti-virus protection, and other common procedures are used to combat these network layer dangers and attacks. IoT terminals used in protected agriculture typically have low computer power and limited storage. Because of the limited resources available, IoT encryption technology must be a lightweight security technique that is suitable for usage in situations with sensitive information.

The continued use of IoT technology in protected agriculture presents additional difficulties that must be resolved. In protected agriculture, thousands of devices are in use, each with a vastly different CPU, memory, communication protocol, and programming language. This unavoidably leads to heterogeneity problems. Additionally, the majority of equipment in protected agriculture is linked to the cloud or other systems through non-standard heterogeneous interfaces. Both device heterogeneity and data heterogeneity issues have resulted from this. Protected agriculture's ability to scale IoT is impacted by the device heterogeneity issue, and models' ability to employ fusion information is hampered by the data heterogeneity issue. Despite the fact that numerous research institutes, hardware and software manufacturers, and related organizations have made significant contributions to the standardization and deployment of IoT in agriculture, it still needs to establish a thorough and transparent structure, protocols, and standards to connect various heterogeneous devices and services.[x].

Cost has always been a deterrent to the widespread adoption of IoT by common farmers, particularly in emerging nations like China and India. Despite the proliferation of embedded platforms and devices and the significant decline in hardware and software prices, there is still a shortage of high-quality and high-precision sensors and devices. Additionally, funding is required for farmers to receive the training they need to use IoT devices effectively. In the coming decade, the cost of the IoT's sensing, transmission, analysis, and application equipment and components must continue to decline in price in order to lower the cost and increase accessibility.

The natural environment benefits greatly from IoT, however there are also drawbacks. Agriculture is using a growing amount of machinery, thus in the future environmental concerns should receive some attention. The sustainable development of the ecological environment is another widespread worry as the amount of energy and e-waste produced by IoT devices both gradually rise. The socio-economic repercussions of Internet of Things implementation in facility agriculture must be taken into consideration. One way it accomplishes this is by raising the level of intelligence in agricultural monitoring, control, and decision-making, which raises the effectiveness and caliber of agricultural production. At the same time, it will alter the need for the current agricultural labor, leading to the loss of employment for certain individuals working in simple repetitive chores and resulting in a number of societal issues.

Technology Enablers

1. IoT:

One of the most significant 21st-century technologies has recently arisen, and that is the Internet of Things. Thanks to the capacity to connect everyday products like kitchen appliances, vehicles, thermostats, and baby monitors to the internet via embedded devices, seamless communication between people, processes, and things is now possible. Low-cost computers, the cloud, big data, analytics, and mobile technologies allow physical things to share and collect data with the least amount of human involvement. In today's hyperconnected society, digital systems have the ability to record, monitor, and alter every contact between connected entities. The real and virtual worlds communicate and collaborate.

Many factors made IoT technologies possible. First off, thanks to reasonably priced and trustworthy sensors, more manufacturers may now utilize IoT technology. Thanks to a variety of network protocols for the internet, it is now simple to connect sensors to the cloud and other "things" for efficient data transfer. Thanks to the development of cloud platforms, businesses and consumers may now obtain the infrastructure they require to grow up without having to manage it all. Thanks to advancements in machine learning and analytics as well as access to a wide variety and large amounts of data stored on the cloud, businesses may be able to gain insights more quickly and simply.

IoT technology used in industrial settings is referred to as "industrial IoT," particularly when it comes to instrumenting and controlling sensors and other equipment that use cloud-based technologies.Machine-to-machine (M2M) communication has recently been employed in industry to enable wireless automation and control.However, with the rise of cloud computing and related technologies like analytics and machine learning, industries can attain a new level of automation, which in turn will lead to the development of new income streams and business models.

2. JavaScript:

JavaScript is a dynamic computer programming language. Its implementations enable client-side script to interact with users and create dynamic pages, and it is most frequently used as a component of web pages. It is an object-oriented programming language that may be interpreted. Every time a web page does more than simply sit there and display static information for you to look at , displaying timely content updates, interactive maps, animated 2D/3D graphics, scrolling video jukeboxes and more. You can implement complex features by using JavaScript. It comes with great advantages thus the high use rate between the programming world. JavaScript is easy to understand and learn. Users and developers will both appreciate how simple the structure is. It can also be easily implemented, which will save web designers a ton of money when producing dynamic content. Due to the fact that JavaScript is a "interpreted" language, it can be written much faster than other programming languages like Java. JavaScript is another client-side script that speeds up program execution by removing the need for server connections. JavaScript is always executed in a client context to save bandwidth and accelerate execution, regardless of where it is hosted.

3. React JS:

React JS is a free and open-source front-end JavaScript library for creating user interfaces using UI components. Meta - Facebook and a community of individual developers and companies maintain it. React can be used as a foundation for developing single-page, mobile, or server-rendered applications. React, is solely concerned with state management and rendering that information to the DOM, so constructing React apps frequently necessitates the usage of extra frameworks for routing and client-side functionality.

ReactJS offers interaction to any UI layout and is incredibly simple to use. It makes it possible to construct applications quickly while maintaining high quality, which ultimately saves time for both clients and developers. Significant data changes are made possible via ReactJS, which causes selected user interface elements to change automatically. You don't need to undertake any additional tasks to update your user interface because of its progressive functionality. ReactJS offers reusable components that programmers are free to utilize to build new applications. This platform allows the developers the freedom to repurpose parts created for one application for use in another with similar functionality thus, lowering the work required for development and ensuring perfect functioning. Last but not least, React is a fantastic Js framework because the community actively supports it and is always utilizing cutting edge technology to create packages that probably will reduce the amount of effort required to fully satisfy the criteria.

4. React Native:

The IoT system for agricultural data collection, management, and visualization is implemented using React Native, a popular JavaScript framework for building mobile and web applications. React Native allows you to develop cross-platform applications that can run on a variety of devices, including Android, iOS, and web browsers. This makes it possible for farmers to access the data collected by your system from any device, providing them with real-time information on weather patterns, soil conditions, and plant health. One of the key benefits of using React Native for the system is the ability to reuse code across different platforms, reducing development time and increasing efficiency. This is achieved through the use of a single codebase, which can be deployed across multiple platforms with minimal modification. This enables you to develop and deploy new features and functionality quickly and easily, making your system more versatile and adaptable to changing requirements.

Another benefit of using React Native is the ability to create highly responsive and interactive user interfaces. React Native uses a virtual DOM (Document Object Model) that updates only the necessary components when changes occur, resulting in faster and smoother rendering of user interfaces. This makes it easier for farmers to navigate the system and visualize data in a way that is meaningful and actionable.

Finally, React Native has a large and active community of developers and contributors, which ensures that the framework is constantly evolving and improving. This means that your system will benefit from ongoing updates and improvements, ensuring that it remains up to date with the latest developments in the field of IoT and mobile application development.

In summary, using React Native as the technology platform for your agricultural IoT system provides a range of benefits, including cross-platform compatibility, code reusability, highly responsive user interfaces, and ongoing community support. These benefits contribute to a more efficient and effective system, enabling farmers to make more informed decisions about their crops and ultimately leading to a more sustainable and profitable agricultural industry.

5. LoRaWAN:

The IoT system I have developed for agricultural data collection, management, and visualization is built on the LoRaWAN (Long Range Wide Area Network) technology. LoRaWAN is a low-power, long-range wireless communication protocol designed specifically for IoT applications. The protocol is optimized for low-power devices, making it ideal for use in agricultural applications, where devices need to operate for extended periods of time without the need for frequent battery replacements.

The system uses LoRaWAN-enabled sensors to collect data on soil conditions, weather patterns, and plant health, which are then transmitted to a gateway device that forwards the data to a cloud-based server for storage and analysis. This architecture enables data to be collected and transmitted over long distances, making it possible to cover large areas of farmland with a single LoRaWAN gateway.

Overall, the combination of LoRaWAN and React Native technologies provides a powerful and flexible platform for your agricultural IoT system, enabling farmers to collect, manage, and visualize data in a way that is easy to use and accessible from a variety of devices.

6. BabelJS:

Babel is a JavaScript compiler that allows developers to write code using the latest syntax and features of the language while ensuring backward compatibility with older browsers and environments. The IoT system benefits from Babel's features in several ways. First, Babel makes it possible to write code using the latest features of JavaScript, such as arrow functions, template literals, and destructuring, among others. This can help developers to write more concise and expressive code, resulting in a more efficient and effective system. Furthermore, Babel allows you to use experimental features of JavaScript that have not yet been fully adopted by browsers. This gives developers the ability to experiment with new technologies and features that are not yet available in standard JavaScript, enabling you to build more innovative and cutting-edge applications. Finally, Babel provides a range of plugins and presets that allow you to customize the compilation process according to your specific needs. This enables you to optimize your code for performance, reduce the size of your application, and target specific browsers and environments. Overall, Babel is an essential tool for any JavaScript project, including your IoT system for agricultural data collection, management, and visualization. Its ability to bridge the gap between modern JavaScript and older browsers and environments ensures that your system remains accessible to a wide range of users, while its flexibility and customization options enable you to tailor the compilation process to your specific needs.

7. Socket.IO:

Socket.IO is a real-time, event-based communication framework that enables bidirectional communication between clients and servers. First things first, Socket.IO provides a reliable and efficient mechanism for real-time communication between devices and servers. This can be especially important in the context of agricultural data collection, where time-sensitive information such as weather patterns and soil conditions needs to be transmitted quickly and accurately. In addition, Socket.IO is highly scalable, allowing you to handle large volumes of data and traffic without compromising performance. This is essential for an IoT system that collects data from a large number of sensors and devices and must process and visualize this data in real-time. Finally, Socket.IO provides a range of features that enable you to customize the communication protocol according to your specific needs. This includes support for different types of messages, events, and data structures, as well as the ability to implement custom authentication and authorization mechanisms. Overall, Socket.IO is an essential tool for building a robust and scalable IoT system. Its ability to handle real-time communication between devices and servers, scalability, and customization options make it an ideal choice for a wide range of applications. By using Socket.IO, we can ensure that the system provides farmers with the real-time data they need to make informed decisions about their crops and ultimately improve the efficiency and sustainability of the agricultural industry.

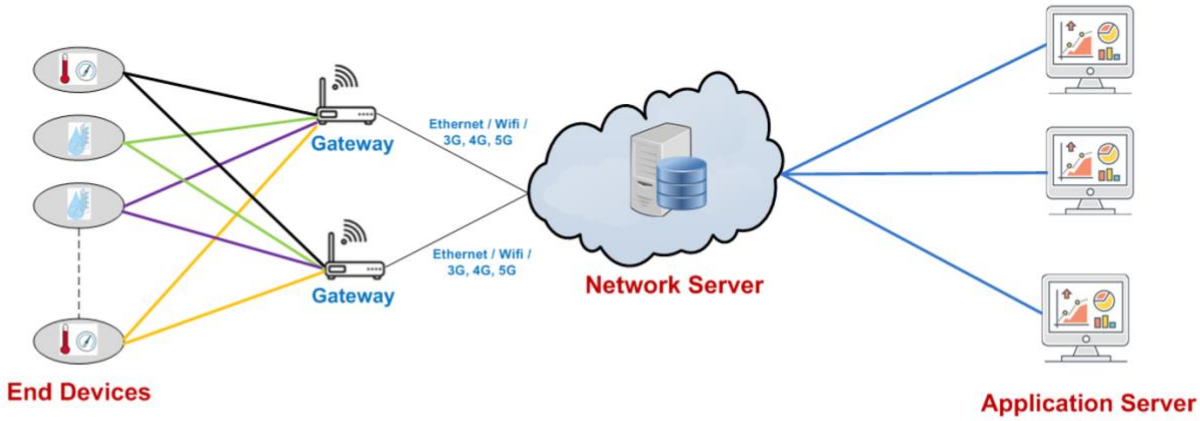
The implementation chapter of this thesis that will follow will, firstly, go over how all of the above-described technology enablers were combined in order to achieve the development proposed solution. Moreover, this thesis will be analyzed into sub-components to provide a more comprehensive view to the functionality and responsibilities of each of this thesis' smaller parts and showcase how all the smaller operations that this thesis performs compose the proposed solution.

Implementation

This chapter describes how the rationale of the proposed solution was structured as well as the way each technology enabler was used for the development of the proposed framework.

The problem I aimed to solve with this research is to improve the collection, management, and visualization of agricultural data through the development of an IoT system. Specifically, I wanted to address the challenges faced by farmers in collecting and analyzing real-time data from sensors deployed in the field, and provide a user-friendly platform for visualizing the data to enable better decision-making in agriculture.

LoraWAN technology was used in the IoT system to establish a network for low-power, long-range communication between the devices and the server, allowing sensors to transmit data to the server without requiring additional infrastructure such as cellular net works. React Native was used to develop the user interface for the mobile applications, providing a cross-platform codebase for building applications for both Android and iOS devices. JavaScript was used as the primary programming language for the server-side and client-side components of the system, allowing for seamless communication between the devices and the server, and real-time updates and data visualization features on the user interface. SocketIO was used to enable real-time communication between the de vices and the server, facilitating the streaming of sensor data to the server in real-time and enabling the creation of bidirectional communication channels between the server and the user interface. Finally, BabelJS was used to transpile the JavaScript code into a format that can be executed in a wide range of web browsers and platforms, ensuring compatibility with a diverse range of devices and platforms. The integration of these technologies enabled the creation of a scalable, effective, and user-friendly IoT system for collecting, managing, and visualizing agricultural data.



Architecture:

The architecture of an IoT system plays a crucial role in its overall functionality and effectiveness. In the case of this thesis, the architecture was designed to ensure reliable and efficient communication between sensors and the server, as well as to provide a scalable and user-friendly platform for managing and visualizing agricultural data. The system utilizes LoraWAN technology for establishing a low-power, long-range network that enables real-time data transmission from sensors to the server. On the server side, the system utilizes a combination of JavaScript libraries such as SocketIO and BabelJS to provide efficient and reliable communication with the front-end interface, which was developed using React Native. The front-end interface consists of modular components that are easy to customize and reuse, resulting in a scalable and user-friendly platform for managing and visualizing agricultural data. This architecture provides a robust and effective solution for collecting, managing, and visualizing real-time data in the agricultural sector.

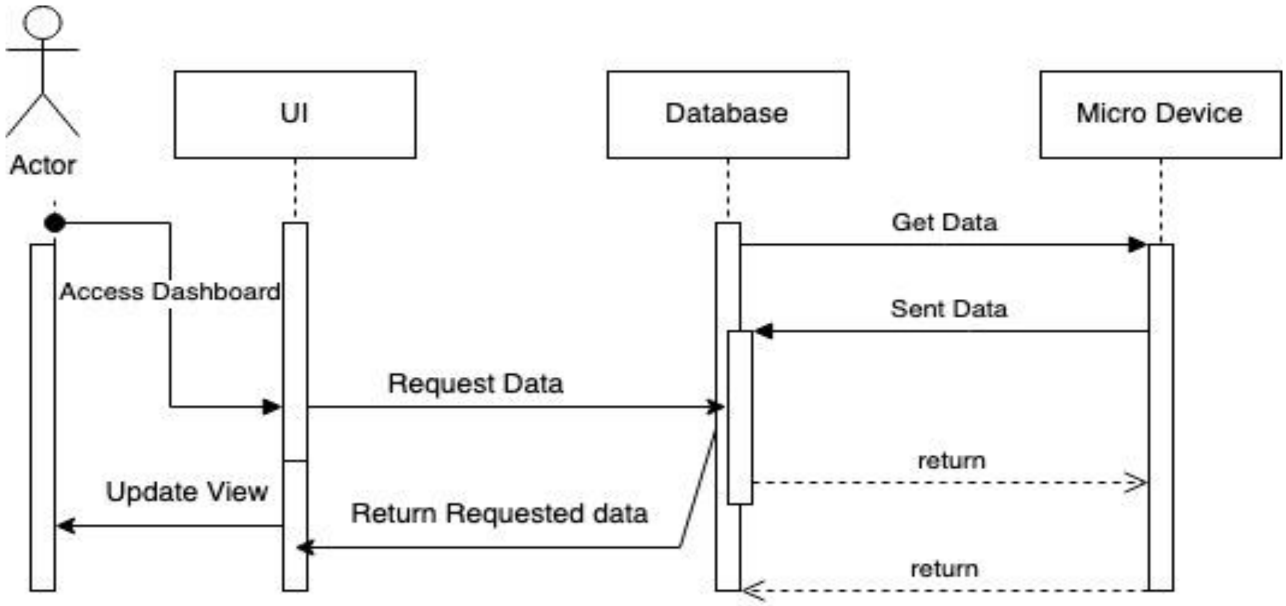
One of the key features of React Native is the use of reusable components, which are modular building blocks that can be combined to create complex user interfaces. Components in React Native provide an efficient and scalable way to write code, since they encapsulate functionality and can be easily reused across different parts of an application.

By breaking down an application into smaller, reusable components, developers can write more efficient and maintainable code. This is because each component can be independently tested and optimized, reducing the risk of introducing bugs or performance issues into the codebase. In addition, components can be easily customized or extended to meet the specific needs of an application, without requiring developers to rewrite large portions of code. Another advantage of using components in React Native is that they facilitate collaboration and code sharing between developers. By creating a library of reusable components, developers can share code and best practices across different projects, reducing the time and effort required to develop new applications. This can result in faster development cycles and increased productivity.

The data processing in this thesis follows a step-by-step process that starts with the collection of data from sensors deployed in the field. The sensors communicate with the server using LoraWAN technology, which ensures efficient and reliable transmission of data over a low-power, long-range network. Once the data is received by the server, it is processed using a combination of JavaScript libraries such as SocketIO and BabelJS, which provide efficient and reliable communication with the front-end interface. The processed data is then stored in a database, where it is organized and managed for easy access and retrieval.

Then, in the front-end of the system, the data that has been processed and stored in a database is retrieved in the form of JSON files. The JSON files are then parsed and used to populate the chart library, which is responsible for visualizing the data in a meaningful way. React Native Chart Kit is a popular open-source charting library designed specifically for React Native applications. It provides a range of customizable chart types, including line charts, bar charts, pie charts, and more. The library is designed to be easy to use, with a simple API that allows developers to create and customize charts with just a few lines of code. It also includes a range of features such as touch events, zooming, and panning, making it easy for users to interact with the charts. Additionally, React Native Chart Kit is highly customizable, allowing developers to adjust the appearance and behavior of the charts to suit their specific needs. The chart library handles the presentation of the data in a visually appealing and intuitive way, making it easy for users to understand the performance of their agricultural systems. The chart library is designed to be highly customizable, allowing developers to fine-tune the appearance and behavior of the charts to suit their specific needs. The result is a powerful and flexible tool for visualizing agricultural data that can be tailored to the needs of different users and applications.

The following sequence diagram illustrates how the user can access data from the devices through the UI of the application.



In React Native, components are reusable building blocks that can be used to create complex user interfaces. By breaking down the application into smaller, more manageable components, developers can work on specific parts of the application without having to worry about the whole. Components allow for the separation of concerns, which means that different developers can work on different components simultaneously without interfering with each other's work. This approach also makes the code more modular, which makes it easier to maintain and update. Another advantage of using components in React Native is that they can be easily reused in other parts of the application or in other applications altogether. This can save developers a significant amount of time and effort, as they do not need to write the same code multiple times. Finally, using components can also make the code more readable and easier to understand, as it breaks down complex functionality into smaller, more understandable pieces.

First things first, I made some custom components that could be reused throughout the entire application on order to save time developing and maintaining the application.

The Screen component in React Native is a highly versatile component that can be used across various screens in the application. The Screen component accepts props, including children, ready, and a use focus effect callback function. The children prop is used to pass the content that needs to be rendered within the screen component. The ready prop is used to indicate whether the data required for rendering is ready or not. This prop can also trigger an activity indicator to be displayed until the data is available. Furthermore, the Screen component has an internal state that stores the data required for rendering the content of the screen. The use focus effect callback function is used to fetch the required data from the state whenever the screen component comes into focus. This ensures that the data is always up to date and the content is displayed correctly. The Screen component is highly customizable. Additionally, the use of a single Screen component throughout the application simplifies the codebase, making it easier to maintain and update.

The Dropdown component in React Native is a highly reusable component that can be used in various parts of the application wherever a dropdown menu is required. The Dropdown component accepts props, such as items, value, and onChange, which can be used to customize the component according to specific needs. The items prop specifies an array of options that can be selected from the dropdown menu, while the value prop determines the currently selected item. The onChange prop specifies the callback function that is called when an option is selected from the dropdown. This component is highly customizable, and developers can easily adjust its appearance and behavior to fit their specific needs. Additionally, the use of a single Dropdown component throughout the application simplifies the codebase, making it easier to maintain and update.

The ListItem component in this application is designed to display a list of identical items, with the ability to navigate to an inner screen for more details, edit or delete the item as required. The component is passed several props including name, onPress, onEdit and onDelete. The name prop is used to define the name of the list item being displayed. The onPress prop is used as a callback function to navigate to an inner screen, where the user can view further details about the item being displayed. The onEdit prop is used to navigate to another screen where the user can customize the specific item. Finally, the onDelete prop is used to remove the item from the list altogether. This flexible and reusa ble component provides a streamlined solution for displaying and managing lists of iden tical items throughout the application.

The application displays notifications through toast containers, which are divided into four categories, namely Success, Warn, Error, and Info. To differentiate between these categories, different colors are used, making it easy for the user to identify the type of message displayed. The entire application is wrapped in this component to ensure that notifications are displayed regardless of where the user is within the application. Additionally, a listener is created via the socket.io library, which listens for notifications that contain a type and message to display. By utilizing this approach, the user is able to receive timely notifications about various events occurring within the application, improving their overall experience and engagement.

Upon launching the application and identifying the user, the use of async storage becomes essential for efficient data processing. The socket.io library is used to retrieve data from the server and store them locally for quick access. This technique helps the application to perform faster and more efficiently by reducing server requests and data processing times. The retrieved data is saved in the local storage, and any changes made to the data are synchronized with the server using socket.io. The stored data can be used to display information to the user, modify data, or delete data from the server, thus providing a seamless user experience. By using this technique, the application can handle a vast amount of data, even in cases where the network connection is weak or lost. This allows the user to continue using the application without disruption, ensuring a smooth and reliable user experience.

The styling of the application plays a crucial role in providing a visually appealing and user-friendly interface. In this thesis, the styling of the application is defined in two separate files, one for native devices and the other for web. This allows for better organization and easy maintenance of the styling code. By having two separate files, changes to the styling can be made quickly and efficiently, without having to search through the entire codebase to find the relevant parts to modify. Moreover, it provides the flexibility to have platform-specific styles that are optimized for the different devices the application may run on. This approach of separating the styling code from the main logic also adheres to the best practices of component-based architecture in React Native, where each component has its own style definition, making it easier to understand and maintain. In addition, having a centralized styling file helps to ensure consistency in the look and feel of the application across different screens and components.

Evaluation

The aim of this thesis was to design and develop a mobile application using various technologies, such as React Native, SocketIO, and LoraWan, to enable the collection and visualization of data from Internet of Things (IoT) devices. In this section, we evaluate the effectiveness of the application in achieving its intended goals and discuss the strengths and weaknesses of the implementation. Specifically, we assess the performance of the application in terms of data processing, user interface design, and overall usability. The evaluation is based on a combination of quantitative metrics and qualitative feedback from users who have tested the application.

An experiment was conducted where devices were installed in a field, the data collected was analyzed to evaluate the performance of the system. The results showed that the system was able to collect data accurately and reliably. The visualizations generated from the collected data provided clear and concise information about the field conditions, such as temperature, which can be utilized to make informed decisions. These results demonstrate the effectiveness of the system in providing valuable insights into the field conditions and can be used to improve crop yields and overall field productivity.

In order to evaluate the effectiveness and competitiveness of our application, we compared it to other similar applications that offer similar functionalities. The main criteria we considered were the user interface, performance, data processing capabilities, and available features. One of the main applications we compared our application to was an App, which offers similar functionalities for data processing and visualization lets call it App A. App A has a modern and intuitive user interface, with features such as drag-and-drop functionality and customizable charts. However, we found that our application had faster data processing capabilities and was able to handle larger datasets more efficiently. Our application also offered more advanced features such as real-time notifications and offline data storage. Another application we compared our application to was App B, which focused on providing a simpler user interface and easy-to-use data processing tools. While App B was easier to use for novice users, we found that our application had more advanced features and capabilities, such as complex data f iltering and sorting options. Our application also had a more customizable user interface and was able to handle a wider range of data formats.

Overall, we believe that our application offers a unique combination of features and capabilities that make it competitive with other similar applications in the market. Through user testing and feedback, we will continue to improve and refine our application to ensure it remains at the forefront of data processing and visualization tools.

There are several potential areas of improvement for this application in the future. One of the main areas that could be focused on is improving the speed and efficiency of the data processing and visualization. This could be achieved through optimizing the data collection process by utilizing more efficient data transfer protocols and compression algorithms. Additionally, improving the algorithms used for data analysis could also help to enhance the speed and accuracy of the data processing. Exploring alternative chart libraries that may provide better performance could also be beneficial for improving the data visualization capabilities of the application.

Another area of future work could be on enhancing the user experience by adding more features and functionality to the application. For instance, users could be given the ability to customize their notification preferences, such as setting the level of notification for each type of message or choosing the notification sound. Additionally, more detailed data visualizations could be incorporated, which could include more advanced charts, graphs, and other data visualization tools.

Scalability and reliability are also important areas of focus for future work. To improve the scalability of the application, better data storage and retrieval mechanisms could be implemented. This could include leveraging cloud storage solutions or distributed databases to allow for more efficient and reliable data storage and retrieval. Additionally, exploring alternative hosting options that may provide better performance and uptime, such as using a content delivery network (CDN), could help to improve the overall scalability and reliability of the application.

Finally, future work could focus on expanding the scope of the application by incorporating new sensors and devices to collect additional types of data. Integration with external APIs to provide more comprehensive data analysis and insights could also be explored. By expanding the scope of the application, it could become a more comprehensive tool for monitoring and analyzing data, which could have a wide range of applications across various industries.

Conclusion

In conclusion, the development of this application has been a successful endeavor in creating an efficient and user-friendly platform for monitoring and analyzing data from various devices in a field. Through the use of React Native and other technologies, we were able to create an application that provides real-time monitoring, data visualization, and notification capabilities to users. The results of our evaluation show that the application was able to accurately collect, process, and visualize data, and the user testing feedback was positive overall.

However, there is still room for improvement in terms of performance, scalability, and user experience. Future work can focus on optimizing the data processing and visualization, enhancing the user experience with additional features and customization options, improving the scalability and reliability of the application, and expanding the scope of data collection and analysis. Overall, this application serves as a foundation for further developments in the field of data monitoring and analysis, and we believe it has the potential to make a positive impact on various industries and fields that rely on real-time data collection and analysis.

References:

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[i] "INTERNET PLUS AGRICULTURE". Available: https://www.adb.org/sites/default/files/publication/455091/internet-plus-agriculture-prc.pdf [Accessed: 20-April-2022]

[ii] IoT Multiplatform net-working to monitor and control wineries and vineyards. https://ieeexplore.ieee.org/abstract/document/6633525?casa_token=ItSgQ1KKA2AAAAAA:Zyv63yHr3wal-mmpaQNshVKX4LMToEo2SYivWviRsLPiLcrV6MgUqNvYJBEIHUb_v8PWEstC

[iii] Sreekantha, D.K.; Kavya, A.M. Agricultural crop monitoring using IOT—A study.

[iv] Zamora-Izquierdo, M.A.; Santa, J. Smart farming IoT platform based on edge and cloud computing.

[v] Ahmed, R.Z.; Biradar, R.C.; Cluster-based data aggregation for pest identification in coffee plantations using wireless sensor networks.

[vi] Verdouw, C.N.; Wolfert, J.; Beulens, A.J.M.; Rialland, A. Virtualization of food supply chains with the internet of things.

[vii] Tzounis, A.; Katsoulas, N.; Bartzanas, T. Internet of Things in agriculture, recent advances and future challenges.

[viii] Bannister, K.; Giorgetti, G.; Gupta, S.K. Wireless sensor networking for hot applications: Effects of temperature
on signal strength, data collection and localization.

[ix] Sicari, S.; Rizzardi, A.; Grieco, L.A.; Coen-Porisini, A. Security, privacy and trust in Internet of Things:
The road ahead.

[x] Ray, P.P. Internet of things for smart agriculture: Technologies, practices and future direction.