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Cloud-Based Agriculture Monitoring System for Precision Farming Research

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Abstract-Cloud-based agricultural monitoring for precision agriculture. Precision farming relies on real-time data and advanced analytics to optimize farming. The system uses cloud computing to collect, process and analyse data from various sources such as weather, soil, crop health and equipment. Remotes and devices collect data from the field and then send it to the cloud for processing using machine learning algorithms and data analysis. Through a user-friendly interface, farmers can receive information and advice to help them make decisions on resource allocation, pest and disease management, water, and planting.

Keywords- Precision Irrigation, Soil Health Management, Crop Rotation and Diversity, Integrated Pest Management (IPM), Weather Data Analysis, Cover Crops, Mechanization and Automation.

I. INTRODUCTION

Precision agriculture was developed in the 1980s by analyzing soil chemical patterns in various fertilizer formulations. [1]. Since then, it has grown into a globally important agricultural sector. The purpose of precision agriculture is to: (1) Use the correct types and doses of fungicides, insecticides, and organic fertilizers in a timely manner to prevent disease; (2) Water plants only when necessary and at the appropriate time to maximize utilization Water; (3) Reduce environmental harm, as knowing when to use pesticides helps kill insects and reduce pesticide use; (4) Utilize agricultural waste to produce useful products.

Through the use of smart sensor network (SSNs) in advanced agriculture, the effectiveness, yield, and profitability of many agricultural systems are increased. Real-world environmental data can be collected from remote locations and sent to a location where it can be processed to identify problems, gather information, and/or take action.
WSN is an important component of the Internet of Things (IoT), which enables the network to access a wide range of data collected from almost anywhere in the world. Numerous applications are made possible by the coupling of wireless sensor networks with the Internet of Things, such as precision agriculture, energy and water management, smart cities, telemedicine, animal monitoring, and the monitoring of historic and structural buildings, among others.

Our work presents a cloud-based IoT infrastructure that has numerous precision agriculture applications. Three layers make up the suggested architecture: a front-end layer that collects environmental data and implements the required agricultural operations; a back-end layer; a gateway layer that links the front-end layer to the Internet layer that performs data processing and archiving. The planned architecture is developed as a prototype and tested to demonstrate how well it works.

The remainder of this paper is structured as follows. We review the relevant literature in Section 2. Section III presents the proposed IoT architecture. In Section 4, a set of preliminary findings from this design prototype is presented. This section summarizes the article.

II. RELATED WORK

1. High-Level IoT Architectures

This category includes IoT architectures that have been suggested in the literature. [2] established a taxonomy of universal IoT platforms that also generates high-level universal IoT architectures for applications related to smart cities, such as precision agriculture. The integration of facts gathering and sensible management that can be applied in agricultural infrastructure like greenhouses was also suggested by [3]. The authorsof [4] provided a well-thought-out proposal to help with the creation of a facial recognition system for residential regions. The authors of [5] recently combined a digital farm (Phen net) with an open IoT platform (ideal for various applications) to produce a semantically enhanced farm field ontology. However, not all ofthese investigations are fruitful.

2. Crop Monitoring Platforms

Numerous Internet of Things (IoT) technologies have been created for precision agricultural monitoring [6]-[8]. Crop monitoring was designed to gather crop data and adopt production strategies in order to boost crop yield. methods by analysing the correlation between crop data and agoenvironmental information [9]. Platform and control functions based on data analysis are shown in [10] and [11].

3. Platforms for Irrigation Control

Numerous IoT platforms have recently been created to manage water resources. Examples include the straightforward technique created in [12]. Users can control the water system using mobile devices thanks to sophisticated systems proposed in [13]. Similar to [14], the system uses mobile phone technology to transmit sensor details to the record systems.That framework mentioned in [15] uses HTTP for share information about cloud services.

III. PROPOSED CLOUD - BASED AGRICULTURAL IOT ARCHITECTURE

Front-end, gateway, and cloud back-end are the three layers of cloudbased agricultural IoT architecture, as shown in Figure 1. We'll go into detail about these three layers and how they are used in this section.

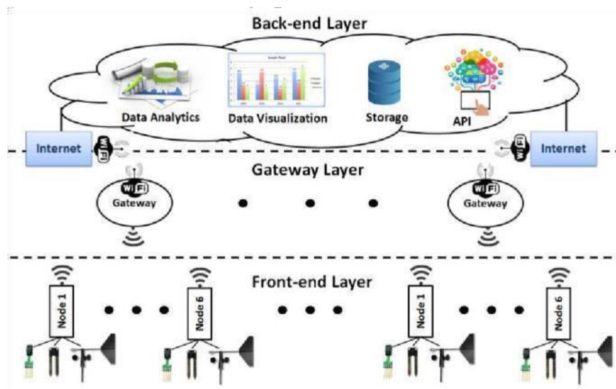

Fig. Iot proposed with cloud-based architeture for agricultural application

3.1 Front-end Layer

These four modules that comprise a sensor or physical device'sfront end layer are shown in Figure 2: the interface circuitry, wireless communication module, environmental sensors andactuators, and microprocessor.

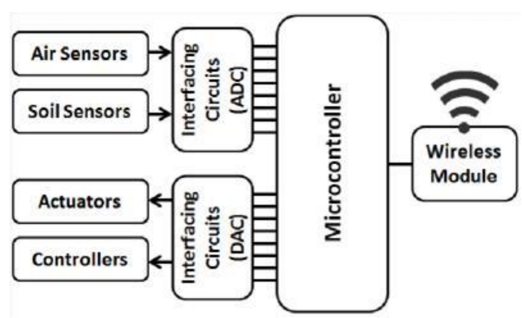

Fig. Front-end node architecture

1. Micro-controller: The microcontroller is in charge of gathering datafrom the several sensors that are attached to it and transmitting it to the architecture's subsequent layer. Depending on the application, the microcontroller may be powered by solar panels, batteries, or battery backup. We employ a Raspberry Pi 2 singleboard microcontroller, running on a 3.7 Volt Lithium ionised batteries, on the Front-end node.

2. Actuators and Sensors: Precision agriculture uses a variety of above- and below-ground sensors to measure the various environmental variables necessary for the intended use. As an illustration, consider sensors that detect the temperature, humidity, and volumetric moisture content of the air, soil, wind, and direction. Rain gauges, solar radiation (visible, UV, and infrared), and leaf moisture are a few more examples. These sensors gather and send tangible data.

Sensors	Model
AirTemperature	SHT11
Air Humidity	HTU21D
Soil Water potential	SEN0114
Leaf Moisture	FC37
Wind Speed/Direction	SEN08942
Orbrometer	SEN08942

3. Interface circuit: A variety of Sensors translate sensor data, like temperature, into corresponding voltage or water flow. States like voltage and current, however, still function in analogue form. The analogue signal from the sensor must be processed by the sensor interface circuit, transformed into the necessary digital format, and made compatible with the microcontroller. The analog-todigital converter is the central element of this communication (ADC). We employ a low-power 6-bit CMOS parallel ADC, the CA3306. Mechanical controllers and actuators receive analogue signals as inputs. As a result, the interface circuit needs to transform the microcontroller's digital output into the necessary analogue control signal. This is accomplished via digital-toanalog converter (DAC) interface circuits, like the low-power MCP4725 DAC that we employed in our system.

4. Wireless communication module: This module serves as a means of information transmission from the sensor node to the closest door. Compared to other projects employing high-power Bluetooth or mobile technologies, our system uses less power since we operate on the 2.4 GHz ISM band using the nRF24L01 ultra-low power transceiver.

3.2 Enterance Layer

Different front-end nodes are in the farm to gather trigger information and send to the gate passage.Afterfirst administration, the enterance moves the logged knowledge to a backend cloud server for general data analysis and preservation. Through the gateway layer, requests are also sent from the backend to the node executors. Up to six front-endnRF24L01 transceivers (like those in a front-end node) can be connected to each gateway. The gateway may also be controlled using a Raspberry Pi 2 microcontroller. The 900MHz quad-core ARM cortex-A7 CPU, 1GB RAM, and storage of the microcontroller guarantee that every piece of recorded data is transferred to a cloud server for examination.

This gateway connects to the distant backend using a small IEEE 802.11b/g/n (Wi-Fi) module. A typical TCP/IP interface can be used to connect the module to the microcontroller. The data rate of this power module is 150 Mb's.

3.3 Back-end Layer

End users can access detection data through the backend. In addition to providing appropriate programming interfaces (APIs) and software tools for end users to collect data, a variety of services may be used to achieve this goal, involving but it is finite to warehouse, analysis, and visualization. As shown in Figure 3, we employ cloud server recovery in our proposed design..

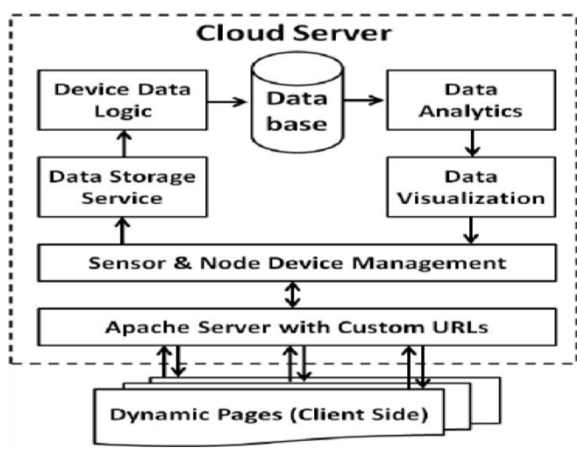

Fig. Cloud server architecture.

Big data is the main resource of the cloud server, and the gateway layer can monitor the big data sent by the front end. Many data analytics and APIs (including Google Sheets for data visualization) interact with the database. Figure 3 illustrates how to use dynamic pages to access data on the Internet.

Apache and MySQL are installed on the same virtual machine (VM) running Ubuntu 14.04 in our cloud server architecture. This virtual machine is one of several in larger Sphere applications. Virtual machines may optimise their resource allocation—such as RAM and disc space—while avoiding data loss and minimising downtime by using the vSphere Control Panel. Furthermore, virtual machines on cloud hosting services like Amazon Web Services (AWS)'s EC2 implementer may be readily moved if a server farm needs more hardware resources than are currently available.

IV. PROTOTYPE PERFORMANCE EVALUATION

An application architecture prototype for IoT precision agriculture was used to test the IoT sensor project as a proof of concept. The three front-end nodes include the sensors specified in Table 1. Frontend nodes were set up outside of the Central Michigan University (CMU) campus. Communication between nodes and gateways takes place via the nRF24L01 wireless interface. Wi-Fi technology is used by the gateway to establish a connection to the user's cloud backend over the Internet. The gateway gathers data from our front-end nodes, analyses it for instantaneous feedback (if required), and forwards the base data to the cloud for precises information text. Data from the cloud server is received by the back-end cloud server, which stores it, analyses it, and creates charts to help in decision-making.

1. Wind Velocity and Direction

Firstly, we gather information about wind velocity. For wind speed information, speed values are translated to miles per hour (MPH) speed measurements. Different values are used by the SEN08942 sensor for different directions. The sensors on the model may adjust to up to 16 distinct orientations. picture. Figure 4 displays the wind speed during the 200-minute timeframe. The graph displays minute-by-minute variations in wind speed in the inspector window. For various levels of detail, use our cloud servers. We eliminated the wind direction due to reflections in space.

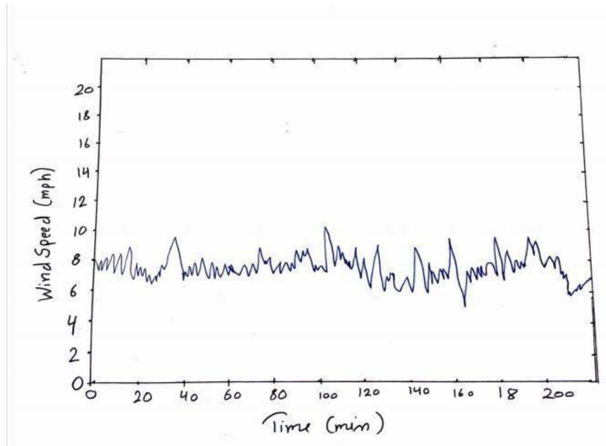

Fig. Record of wind speed over 200-minute window

2. Rain Volume

The results from the humidity sensor and rain gauge are then displayed. In Figure 5 we show such information for twenty minute window, in which it rained only for the first twentythree minutes. Figure 5 depicts therain gradually subsiding before stopping. After the rain stopped, thehumidity increased slightly. This information can be used to predicthow certain diseases will develop.

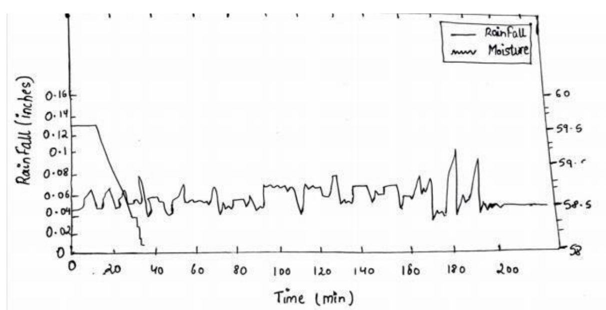

Fig. Volume of rain over a 30-minute window

3. Air Temperature and Humidity Results

Air temperature and humidity are additional important environmental variables for agricultural IoT. Figure 6 shows examples of temperature and humidity data.

The results presented in this part show how the suggested cloudbased Internet of Things system can gather, store, analyse, and display atmosphere information required for different perfection agricultural appliances..

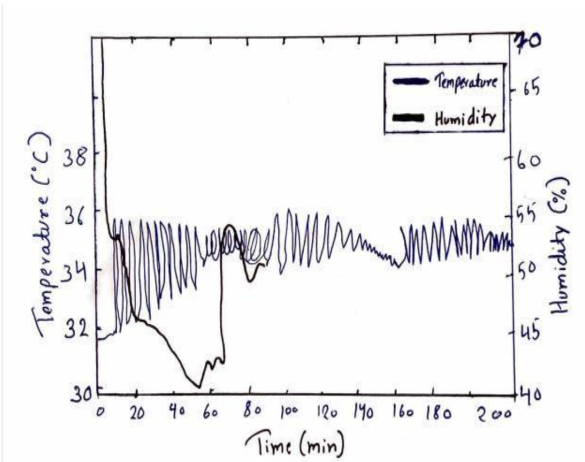

Fig. Reports for temperature and humidity

V. CONCLUSION

This article describes the creation and use of a cloud-based agricultural monitoring system for precision agriculture, a significant development in contemporary agricultural technology. This study outlines the salient features and advantages of this system and highlights its potential to revolutionize the agricultural sector. Precision agriculture and cloud computing technologies can work together to optimize resource utilization, crop yields and overall farm productivity through real-time monitoring, data analysis and informed decision-making. The conclusion of this article highlights the importance of using cloud-based solutions to address changing issues in the agricultural sector, such as climate change, resource scarcity, and growing food demand.

Farmers can use the power of the cloud to access important agricultural data anytime and anywhere, enabling proactive data-driven decisionmaking. Additionally, the adaptability and scalability of the cloud-based system enables it to adapt to a variety of farm sizes and types, ensuring broad applicability and availability. Additionally, cloud-based platforms increase the potential for collaboration and knowledge exchange within the agricultural community, supporting collaborative efforts to achieve sustainable and effective agricultural practices.

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