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Smart Farming Using Mesh Network

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Abstract

The increasing demand for food production due to the growth of the world population has led to various challenges in agriculture. Factors such as the reduction of the rural workforce and the rise in production costs have made it necessary to find innovative solutions to enhance productivity and efficiency. Smart farming, which integrates agricultural practices with the Internet of Things (IoT), has become a promising method to tackle these challenges. Smart farming leverages IoT technologies to enable the collection and analysis of data from various sources in the agricultural ecosystem. This approach, driven by data, enables farmers to make informed decisions and enhance their farming operations. The application of smart farming with IoT in agriculture has evolved over time. Initially, traditional approaches relied on reactive utilization of data, where farmers would respond to crop problems after they occurred. However, with recent technological advancements, the use of data in agriculture has shifted towards proactive and preventive approaches. Farmers can now leverage real-time data and predictive analytics to anticipate potential crop issues, optimize resource allocation, and enhance overall crop health and productivity.

Keywords: Smart farming, Internet of Things (IoT), API, Embedded system, Cloud Computing

INTRODUCTION

Internet of Things (IoT) makes a difference in daily life by upgrading the way we do things. The use of IoT devices is increasing as all industries invest heavily in IoT. The objectives of contributing to IoT are to improve durability, obtain better-quality products, and reduce production worth. The agribusiness industry seeks to gather the benefits of IoT. The use of IoT in agriculture is often referred to as smart farming or smart agriculture. It uses various IoT sensors to transmit farm data, such as humidity, temperature, soil moisture, etc., in clouds that can be monitored and controlled from anywhere in the world.

IoT utility in the agriculture quarter enables the research of data altering the farming strategies with the effects of the existing records, with advanced gadgets getting to know and facts visualization equipment, and actual-time data monitoring became possible. Consequently, they guide sizeable growth in a value-powerful manner.

Farmers' lives are changed by smart farming because their work is reduced, and they save time. Currently, we can save energy, time, and water and increase crop quality with the help of smart farming. Water is only used where it is needed and in which it is wanted; at this time, we have this kind of sensor that can improve farmers' lives. Using these sensors, farmers can easily monitor their fields and make better decisions (Figure 1).

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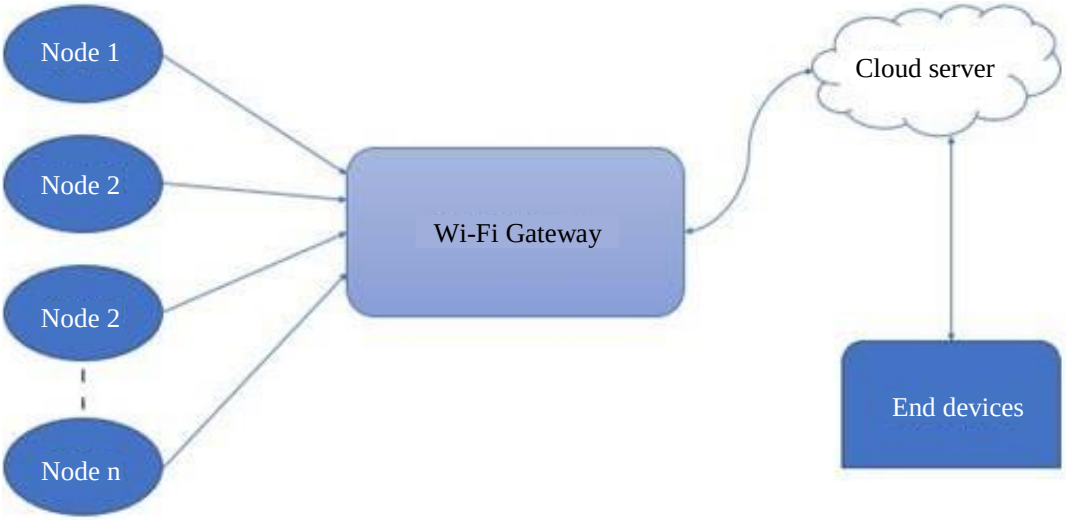

Figure 1. Block diagram of a mesh network system.

SMART FARMING

In this study, in the agricultural sector, IoT-based smart farming helps many people. This technology can save time. Our system comprises a wireless sensor node from a network for communication. Here, we develop a sensor node with an ESP microcontroller to collect data from four types of sensors: rain sensors for showing the amount of rain, soil sensors for sensing the soil moisture for appropriate watering of the plant, and a DHT sensor for humidity and temperature for irrigation [1].

The hardware of this system consists of two parts: an ESP8266 microcontroller and an NRF24l01 transceiver. Two circuits are designed: the first is the node and the second is the gateway. The gateway circuit acts as a master for all nodes connected to the wireless sensor node, and a node acts as a slave circuit. The data sent by the node are received by the gateway circuit and transferred to the IoT platform to monitor the nodes [2].

Data can easily be monitored on a ThingSpeak platform.

A sensor node is a device that can collect sensor data from the environment, process the data, and connect with other nodes [3]. A large number of inexpensive, small, low-power communication devices with limited battery and processing power are deployed in a region to monitor the environment (Figure 2).

Gateway

The gateway was based on the ESP module. The module relates to the serial link from one side and the IP network with Wi-Fi on the other side, and serial data packets are sent to IP/UDP ports and vice versa [4]. You must configure (IP, and Wi-Fi) for the first time to power the gateway. The software is designed to connect objects with homemade server software that requires frequent data transfer of short packets of data. It is easy to use a device with more than one UART [5].

Wireless Sensor Network

Given that IoT platforms are organized into more than one layer, In IoT packages, software can still be decomposed into three layers:

1. The belief layer includes devices that accumulate facts from the surroundings and procedure them.
2. The community layer—the change of facts among devices and the internet, in addition to feasible neighborhood processing, and
3. The utility layer uploads all the consumer interface capabilities into it [6].

In agriculture, an IoT platform is usually constructed around nearby networks of gadgets, which might be deployed and engaged with farm components and unfolded throughout and in extensive vicinity, including a field of wheat [7].

This IoT degree is related to the internet or an agricultural monitoring station. Local area networks that belong to the network layer and typically encompass nodes prepared with sensors or actuators are normally prepared as wireless sensor networks, normally employed to document and screen environmental situations (Figure 3).

Sensor

Smart architecture is based on the use of sensors to measure specific parameters that can be used to monitor activities. The following sensors were considered.

Temperature and humidity sensor (DHT11): DHT11 is a low-cost virtual temperature and humidity sensor [8]. This sensor is effortlessly interfaced with any microcontroller, including the Arduino, Raspberry Pi, and ESP, to degree humidity and temperature in real time [9].

Figure 2. Smart farming.

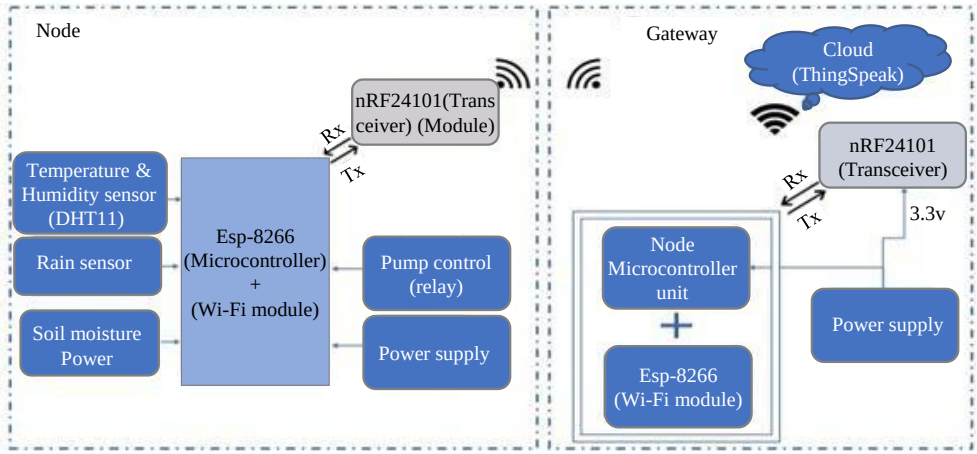

Figure 3. Block diagram of smart farming system.

The DHT11 sensor has a sensor and a module. The pull-up resistor and energy-on LED distinguished this sensor from the module. The DHT11 sensor measures the relative humidity. A thermistor and capacitive humidity sensor were used to measure the air encompassing.

Soil moisture sensor: The soil moisture sensor simply measures the amount of water present in the soil. A soil moisture sensor, which includes conducting probes that act as a probe, can be used to measure this, based on the change in resistance between the two engaging plates, which may determine the moisture content of the soil [10]. The resistance between the two plates varies in direct proportion to the quantity of moisture in the soil.

Rain sensor: The rain sensor detects the presence of water drops or rainfall. This type of sensor capability, in addition to transfer. This sensor consists of a sensing pad and a sensor module. During rainfall on the surface of a sensing pad, the sensor modules read the data from the sensor pad and method it to produce an analog or digital output. As the end result, the sensor's output is analog (A0), digital (DD), or (D0).

Working of IoT-based Smart Farming

In this project, we will use the NRF24L01, ESP controller, DHT11module, Soil sensor, rain sensor, and relay. The ESP microcontroller served as the processing unit and the NRF24L01 2.4 GHz wireless transceiver module served as the transceiver unit. When it comes to power, the device is operated by a 3.7V Lithium-Ion battery.

We built a Wi-Fi gateway with the ESP and NRF24L01 modules. An IoT gateway performs various critical functions, including protocol translation, encryption, data processing, management, and filtering. A gateway sits between the devices and sensors in an IoT ecosystem to communicate with the cloud. First, the sensor collects the data, and with the help of a gateway, it can be uploaded to the cloud via the Wi-Fi network. The ThingSpeak server is the cloud server used in this study. ThingSpeak is a platform where we can store and retrieve data from things over the internet using protocols such as HTTP and MQTT.

Its operation was very simple. The created nodes were placed in the farming area. Hence, the area of the farming plot is large enough, about 500 m in length and breadth, so we place each node with a difference of 100 m. Thus, all the nodes placed in the farming plot collect information about the crops; in other words, they cover the maximum area of the farming plot. As we have seen above, each node is equipped with sensors that help collect data on temperature, soil moisture, humidity, and rainfall. All collected information from each node is transferred to the gateway node through the NRF24L01 module. Each node is assigned a different node ID to identify the node that sends data to the gateway. Hence, here we have connected the NRF24L01 module, so the transmission of data is performed wirelessly.

The data collected by the gateway module is then further transferred to the ThingSpeak platform for monitoring the data, since we are using the ESP module, which has its own Wi-Fi, the transfer of the data to the cloud is done very easily without connection to the external Wi-Fi module for internet connectivity (Figures 4 and 5).

ThingSpeak Platform

ThingSpeak is a cloud-based IoT analytics tool that enables the aggregation, visualization, and analysis of live data streams. Real-time data sent to the platform by the devices are delivered by ThingSpeak. With the capability to execute MATLAB code in ThingSpeak, the data can be analyzed and managed as it arrives in real time. ThingSpeak is frequently employed for IoT system prototypes and concepts that require analytics. This platform allows live data streams to be aggregated, visualized, and analyzed in the cloud (Figure 6).

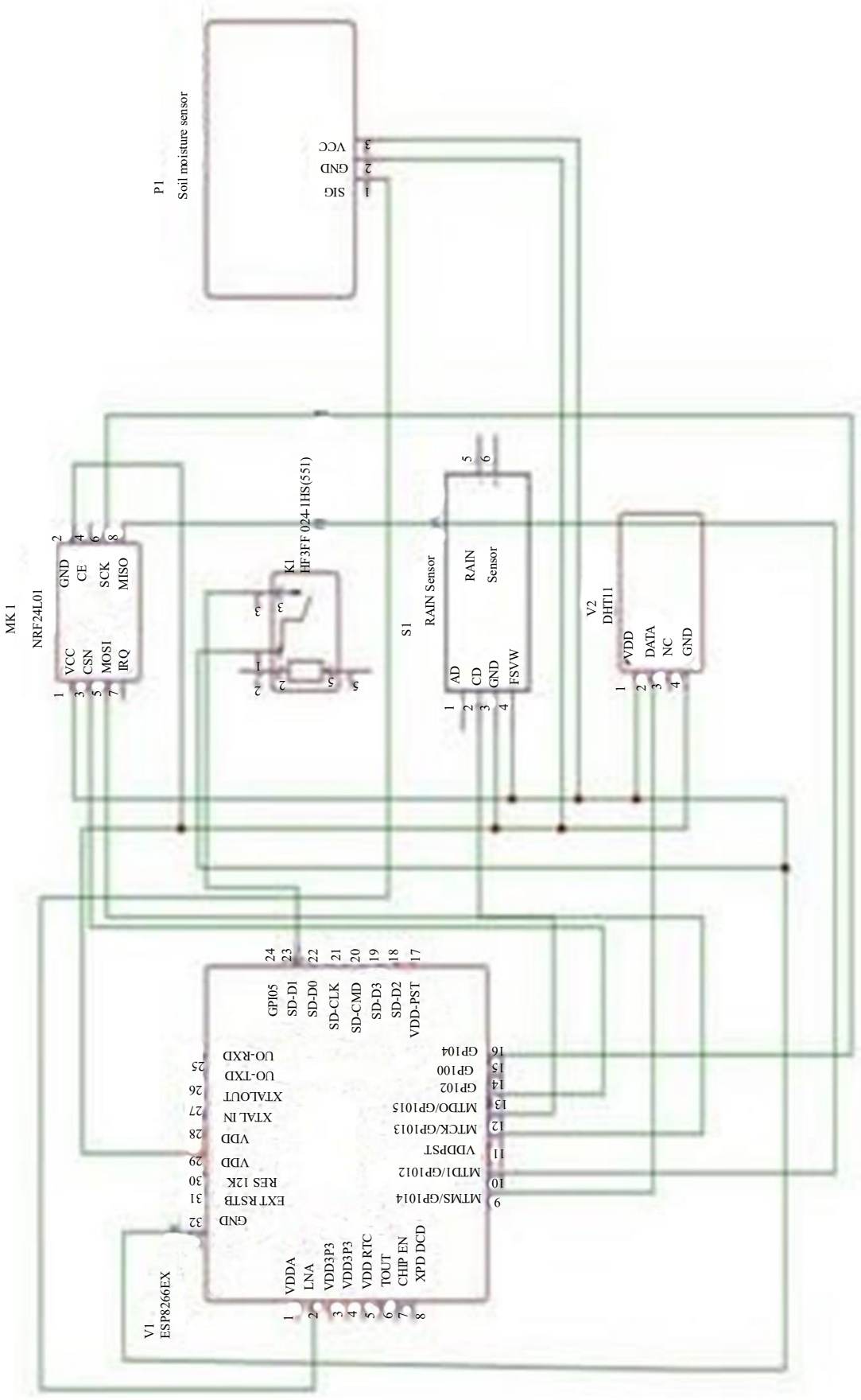

Figure 4. Circuit diagram of node.

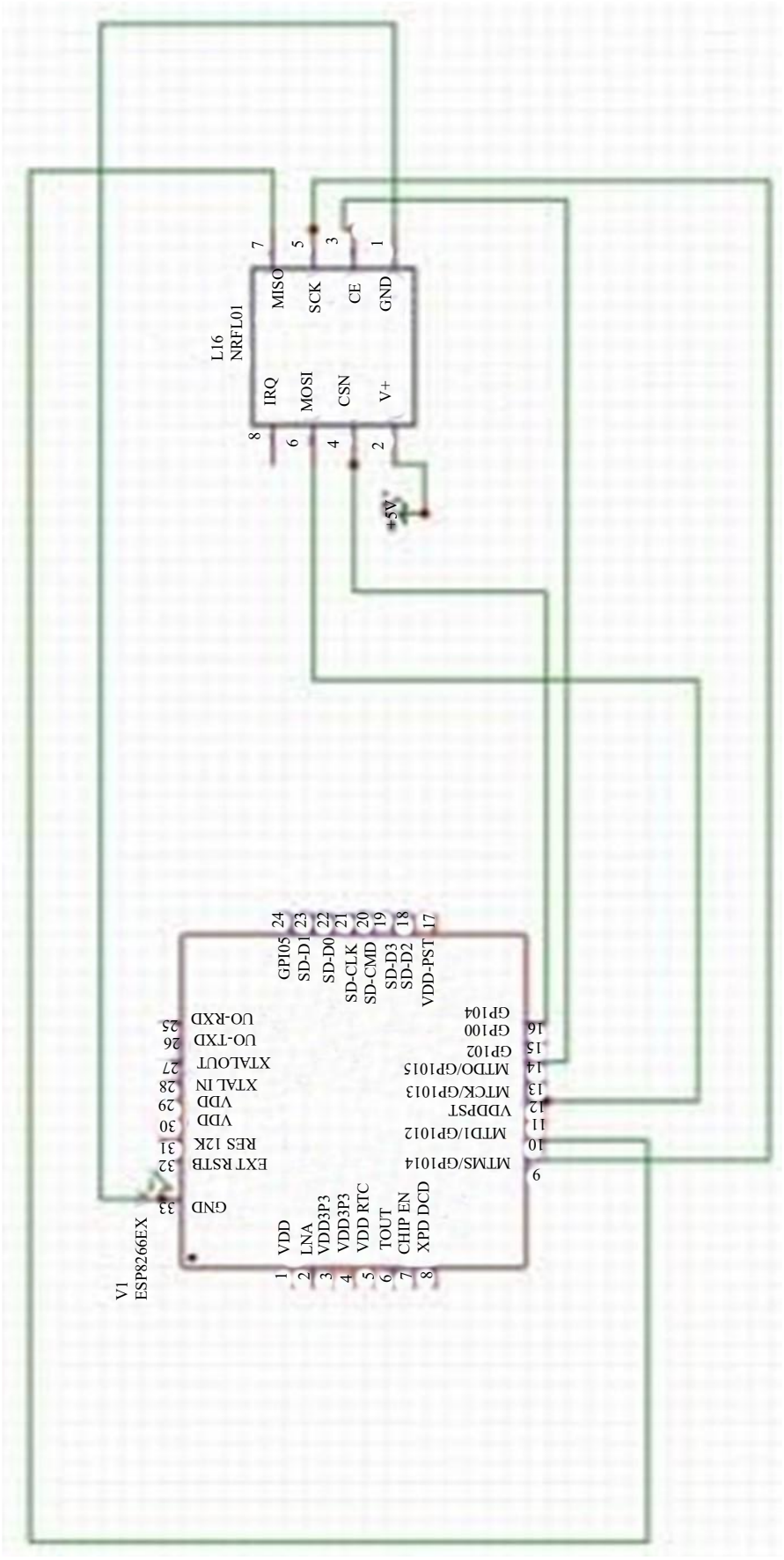

Figure 5. Circuit diagram of gateway.

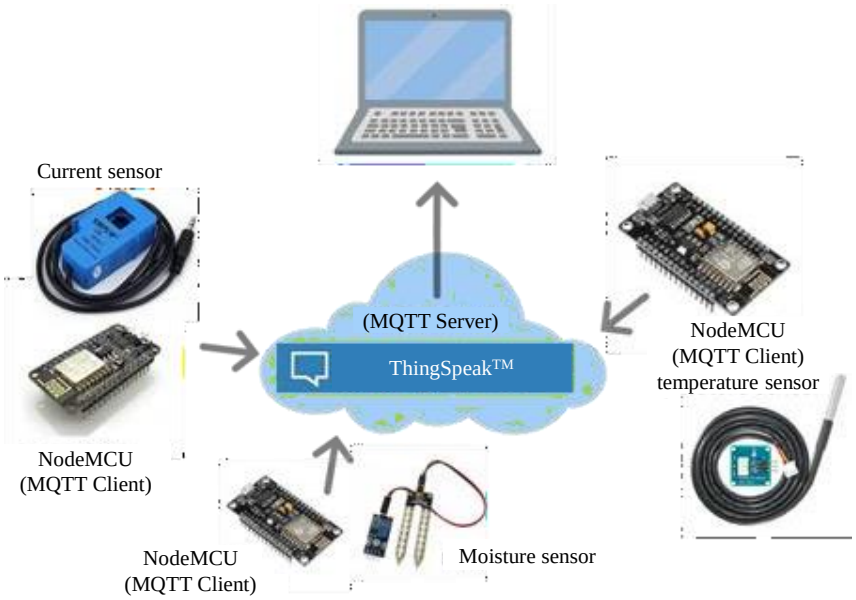

Figure 6. IoT platform.

Some of the key characteristics of ThingSpeak include the ability to:

1. Easily set up major IoT protocols for data delivery to ThingSpeak.
2. Sensor data can be visualized in real time.
3. Data can be acquired from third-party sources as needed.
4. Your IoT data can be utilized with the assistance of MATLAB.
5. IoT analytics can be automated based on schedules or events.

RESULT AND DISCUSSION

In this model, the sensor is connected to the ESP controller, and the ESP is connected to the NRF24L01 module, the NRF24L01 module helps connect one ESP to another. When the sensor gives us data, the ESP sends the data to the cloud, with the help of the data farmer, who can easily monitor their fields. The demand for smart farming systems is increasing. The implemented model helps users access their fields in real time. It is also a very tedious task for human beings to maintain that thing. The overall result of the study is to improve farmers' lives and save time, which is being used in other work. All these things can bring sweeping changes to our society, impact farmers' lives in a better manner, and save water and resources.

1. It is scalable and can accommodate any new node or gadget at any time.
2. It is miles bendy and for this reason open to physical partitions.
3. All the Wireless sensor network nodes may be accessed through centralized monitoring devices.
4. Because it is wireless, it does not require wires or cables. Refer to the distinction between the stressed-out community and the Wi-Fi network.
5. Wireless sensor networks may be applied on a large scale and in numerous domains such as mines, healthcare, surveillance, and agriculture.
6. It uses extraordinary protection algorithms, in line with underlying wireless technology, and subsequently offers a reliable community for clients and users.

Mesh Network

Before delving into the specific benefits provided by mesh networks, it is crucial to understand why mesh networks, as a concept, are an ideal fit for smart agriculture networks.

1. *Self-sustaining network:* A standout characteristic of mesh networks is that each device acts as an access point, forming an interconnected web that facilitates efficient data transmission. This decentralization eliminates the need for cellular connectivity and numerous static access points scattered across agricultural fields.

2. *Strength and persistence:* In an industry characterized by diverse and unpredictable conditions, mesh networks offer a level of flexibility and resilience that is unmatched by traditional connectivity solutions. For instance, the mesh network seamlessly functions with moving machinery and dynamically adapts to equipment movements. This adaptability is especially advantageous in smart agriculture, where machinery traverses vast areas of land. The multipath routing protocol ensures that even if a device goes offline or moves out of range, data are automatically rerouted through alternative nodes, minimizing disruptions, and maintaining a stable and dependable connection, allowing seamless entry and exit of devices from the network.
3. *Plug-and-play functionality:* Another compelling aspect is that the network requires no setup. Once the devices are powered on, the network auto-configures, saving significant time and effort that would otherwise be spent on manual setup and maintenance. This feature is particularly beneficial in the constantly evolving landscape of agricultural technology, where equipment configurations are often changed, or new additions are made.
4. *Safe communication:* Finally, because mesh networks do not rely on a central hub or cellular connectivity, they offer an additional layer of security. Data remains within the local network, reducing the risk of security breaches and making the network less susceptible to single points of failure (Figure 7).

Now that we have established why mesh networks align well with the requirements of modern agriculture, let us discuss how mesh addresses the pressing challenges faced by the agricultural sector.

Figure 7. Mesh network.

CONCLUSION AND FUTURE SCOPE

The environmental condition has successfully been amassed using numerous sensors and ships that provide information wirelessly through the RF transceiver to the sink, which receives the data through the RF receiver. The connection is set up between the gateway circuit and node circuit using the NRF24L01 module and an ESP8266 microcontroller. The statistics received via the gateway are then transferred to the server, which is a platform unbiased framework, as it is a web-primary-based framework. This framework is likewise scalable while deployed in real-time surroundings resulting in

high performance, while all the realistic layout constraints are nicely maintained; based on the selection, the respective actuators are powered up to meet the crop requirements. The personal interface for this machine has been built, which allows the consumer to sign up for themselves and the crop they desire to grow of their subject in conjunction where with the agriculturist well timed receives a message.

This challenge offered a prototype mesh community set of rules for agriculture farming using IoT gadgets in a clever farm, and the existing case looks at employing low-cost sensors and microcontrollers rather than using long-range modules and excessive value mini pcs, which may make the procedure unfeasible, relying on the insurance place to be carried out.

By producing the crop without infection and with the right soil moisture content, the smart farm assists the farmer in making a high profit. Because of the automated procedure, less human labor is required, and crop progress can be monitored using a smartphone. Wireless communication lowers implementation costs. This will be performed for a large area of land in the future. Internet connectivity is always essential for sending data to farmers.

Smart cities: Wi-Fi mesh networking is extremely good for extending radio signals through parking garages, colleges, university grounds, business parks, etc. Parking garages that utilize space availability checkers as an instance benefit substantially from mesh networks, as they can extend the sign at some stage in the entire area, allowing them to speak, while a gap has been taken by way of a motive force or emerge as to be had.

Smart domestic: Wireless mesh networks let you track and manipulate across your house. Set up one powered gateway and use a temperature sensor and mesh-enabled nodes in each room to seize live information and modify the settings mechanically.

Agriculture: Wireless mesh networking is also suitable for monitoring public health and water ranges across vegetation. You can scale at a low-cost with mesh-enabled nodes throughout the entire farmland.

Interface to any sensor/actuator: This provides a smooth interface universally for most sensors/actuators. This interface, collectively with air capabilities, allows one to connect with the maximum present and future sensors/controllers at once. Splendid range and coverage, with excellent range insurance, may reach quite a number of 700 m in an urban environment and hop 29 times.

We are currently implementing audio-signal processing in this module. This enhances the operation of this module by taking the voice signals of different animals or insects that affect the crop and then sending them to the server. On the server side, an alert is generated that detects the animal, and accordingly, action will be taken from the farmer side.

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