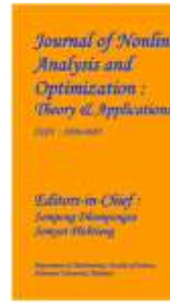

Journal of Nonlinear Analysis and Optimization
Vol. 11, Issue. 1 : 2020
ISSN : **1906-9685**

IOT AND WIRELESS SENSOR NETWORKS BASED SMART FARMING

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Abstract—
Conventional or antiquated farming practices can't keep up with increasing human populations because of how quickly our species is evolving. In light of this growing population, it is clear that more sophisticated agricultural techniques are required to sufficiently feed everyone. An increasing number of people are interested in smart farming systems that use embedded technology and the IoT to boost food output. Based on embedded systems, the Internet of Things (IoT), and wireless sensor networks, this article lays out agricultural systems for agri-farm fields and cattle farms. Circuit networks in electronic devices, the protocols employed by these networks, and smart remote monitoring systems for personal computers, smartphones, etc. are all covered in this study. An overview of the possible reach of relevant smart agricultural technology concludes the article, after which other proposals are presented.

Keyword-- Embedded system, Internet of Things, wireless sensor network, quad-copters, GSM, smart farming has never been easier.

1 INTRODUCTION

Around 9.1 billion people will call our planet home by the year 2050, according to predictions. A 70 percent increase in food supply would be required to sustain this enlarged population, according to the United Nations Food and Agriculture Organisation (FAO) [1]. U.S. Global Change Research Programme officials have warned that climate change poses serious risks to agricultural output, animal welfare, and rural economies in 2018 [2].
The agricultural sector is well-known as a lynchpin of human civilization. On a global scale, almost 60% of the population works in agriculture. Thanks to ever-improving connection and IT, farmers can now collect a deluge of data specific to each agri-field. Manual seed circulation and other antiquated methods are still used by our farmers.

unscientific farming structures, furrowing, and two harvests each year is one technique. A big problem is the inconsistent availability of water throughout the year, which is exacerbated by the unpredictable monsoons. As an added complication, farmers tend to ignore the precise state of the crop field in favour of traditional methods of watering, fertilising, and pesticide spraying. As a result, agricultural yield is low and output is inadequate. Increases in crop yields are possible as a result of the use of scientific methods into farming, which lead to more efficient methods overall [3]. For improved planting and harvesting results, it is crucial to use the right irrigation, fertiliser, and pesticides. All of these tasks can be easily automated when we construct an integrated framework. This study lays forth a set of technologies that include automated insect detection, agri-field moisture management and irrigation, and more.

and pesticide spraying, pH regulation, quad-copter fertilisation, alert systems for animals or intruders in agricultural fields, etc. The agricultural industry has seen remarkable transformations. Along with these upgrades came an integrated framework for tracking crop growth and devices using a Wireless Sensor Network (WSN). The primary role of a WSN is to accept data from a remote source and transmit it to a receiver over a wireless network so that the recipient may receive it. The primary purpose of WSN[5] technology in the agri-sector is to manage distributed data collecting from agricultural settings and, more importantly, to provide farmers with up-to-the-minute farming advice. A wide-area network (WSN) equipped with specific detecting sensors for keeping tabs on a vast agricultural setting was also part of the recommended design.

2 RELATED WORKS

M. S. Farooq et al. [6] has made significant contributions to the development of smart farming systems using the Internet of Things (IoT) in the agricultural sector.

3 SYSTEM ARCHITECTURE

Modules

The ATmega2560 microcontroller is the basis of the Arduino Super 2560 board, which is an Arduino Mega 2560 Rev3 board. A 16 MHz crystal oscillator, 16 analogue pins, 4 UARTs (serial ports), a USB communication interface, an ICSP header, a power barrel socket, a push-button reset, and 54 optical I/O pins are all part of it [7]. Figure 1 shows a schematic of an Arduino Super 2560 Rev3.

The third-generation Arduino Mega 2560 is shown in Figure 1.

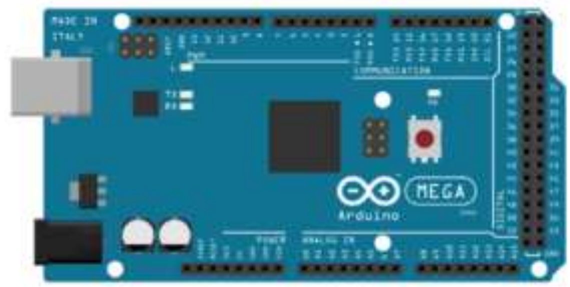

Fig 1: Arduino Mega 2560 Rev3.

A microcontroller board based on the ATmega328P, the Arduino Uno Rev3 is available here (datasheet). A 16 MHz crystal oscillator, 6 basic I/O pins, a USB communication connector, an ICSP pin, a force barrel jack, and a reset button are all part of its schematic [8]. The Arduino Uno R3 model is seen in Fig. 2.

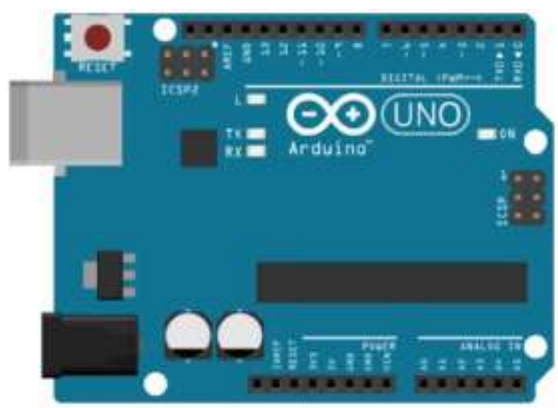

Fig. 2. Arduino Uno Rev3.

ESP8266 Module - To connect a microcontroller to a Wi-Fi network, you may use the free ESP8266 Wi-Fi Module, which is designed with TCP/IP protocol layers. Depending on the situation, the ESP8266 could encourage app development or get all Wi-Fi network features from a separate application processor [9]. Figure 3 shows the ESP8266 Wi-Fi moduleboard.

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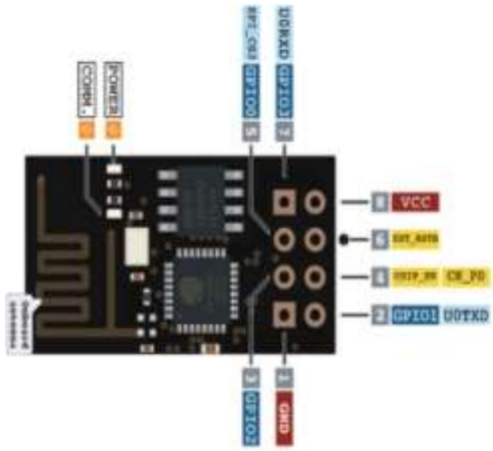

Fig. 3. ESP8266 Wi-Fi module.

GSM SIM900A Module - One communication vendor, SIMCOM, makes the SIM900A GSM module, which is dependent on their Dual-band GPRS/GSM modem. Because SIM900A is compatible with both sets of frequencies, it can operate at 90 0 and 180 0 MHz. Selecting the operational band is also possible using AT commands. Additionally, the baud rate may be adjusted from 120 0 to 11520 0 using AT commands. The GPRS/GSM modem can access the internet over GPRS since it contains built-in TCP/IP protocols [10]. You may see a GSM SIM900A module in Figure 4.

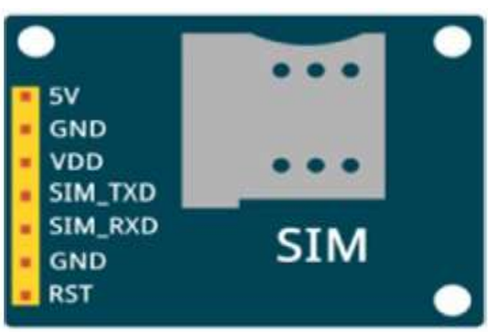

Fig. 4. GSM SIM900A module.

nRF24L01 + PA/LNA Wireless Transceiver Module -An integrated baseband convention motor (Enhanced Shock-Burst TM) is part of the nRF24L01 + PA/LNA, a 2.4GHz remote handset module based on a single chip. As far as 1100 metres it reaches.

The 2.400 - 2.4835 GHz ISM recurrence band is where the nRF24L01 + PA/LNA shine. According to [11], the nRF24L01 + PA/LNA module may be set up and operated via a Serial Peripheral Interface (SPI). You may see a nRF module in Fig. 5.

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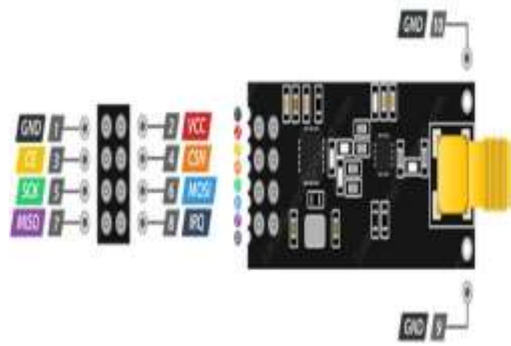

Fig. 5. nRF24L01 + PA/LNA wireless transceiver module.

A module that uses an electromagnet to operate a switch is called a relay module. In order to begin, the electromagnet requires a little amount of power, which is supplied by the microcontroller. Whenever it is driven, it will pull the contact to create the high voltage circuit. This growing system makes use of the SRD-05VDC-SL-C transfer module. Any micro regulator may limit its operation to 5V [12]. A PCB for a transfer module is shown in Figure 6.

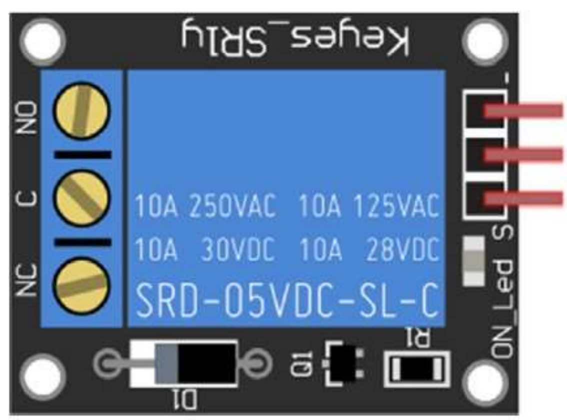

Fig 6: Relay Module.

DHT11 Temperature and Humidity Sensor - An optimised DHT11 signal is

enhanced productivity with the capacity to monitor humidity and temperature. A microcontroller would have made it operate better. This sensor is designed to work with wet

NTC temperature estimation devices and has a resistive component. It is a first-rate electrical device that is quick to respond, adaptable to different impedances, and of high quality. A DHT11 sensor chart is seen in Figure 7.

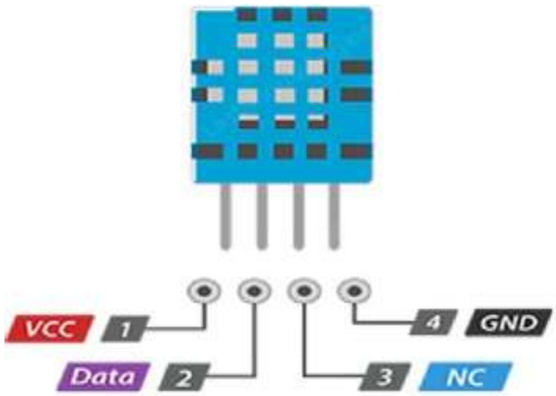

Fig. 7. DHT11 sensor.

PIR Motion Sensor - A PIR (Passive Infrared Sensor) is an electronic detecting gadget that gauges infrared signs discharge ted from objects in its scope of view. They are generally used in PIR based movement finders. The PIR sensor for the most part comprises of a pyroelectric sensor, whichcan recognize different degrees of infrared radiation. Fig. 8 will show a PIR movement sensor.

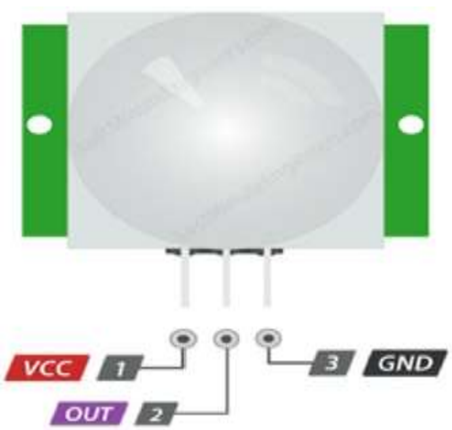

Fig. 8. PIR motion sensor.

MQ-135 Gas Sensor - For use in air control systems, the MQ-135 gas sensors can detect and evaluate a wide variety of gases, including alcohol, NH3, benzene, NOx, CO2, smoke, and more. The MQ-135 sensor module has a modern Pin that enables the sensor to function independently of a microcontroller. It is possible to utilise the basic pin due to the gas calculations in the PPM unit. Pictured in Figure 9 is the MQ-135 gas sensor.

Fig. 9. MQ-135 gas sensor.

BMP180 Barometric Pressure Sensor - One such barometric weight sensor is the BMP180 Breakout, which has an I2C ("Wire") between its faces. Barometric weight sensors determine the absolute density of the surrounding air. The environment and altitude have an effect on this weight. Weather monitoring, height measurement, and any other task requiring exact weight reading may be accomplished depending on how you interpret the data. In Figure 10, you can see a barometric weight sensor (BMP180).

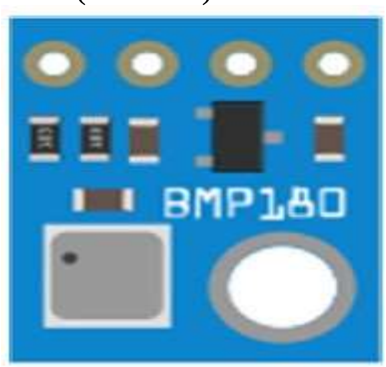

Fig. 10. BMP180 Sensor.

Rainfall Detection Sensor – A precipitation or water discovery sensor consists of a comparator that supervises knowledge and a water recognisable proof plate. The sensor can tell when there's been water loss because it connects the printed circuit tape.
The sensor functions similarly to a state-dependent variable resistor; its receptivity rises with moisture and decreases with dryness. Two yields are associated with the water or precipitation identification sensor in the comparator: a basic yield ranging from 0 to 1023 and an advanced yield of 0 or 1. Fig. 11 displays a sensor that can detect precipitation.

Fig. 11. Rainfall detection sensor.

Soil Moisture Sensor - One useful breakout module for determining the relative humidity of soil and related materials is the Soil Moisture detection sensor. An easy-to-operate device is the dirt dampness sensor. The two massive exposed identification cushions serve as both a variable resistor and a sensor test. When there is a larger concentration of water in the soil, the conductivity between the identifying cushions improves, leading to less blockage and a higher sign yield [13]. A dirt dampness sensor is shown in Figure 12.

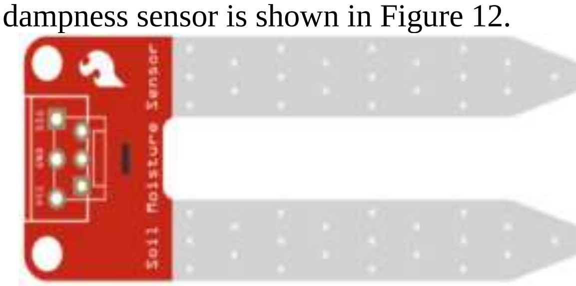

Fig. 12. Soil moisture sensor.

pH Meter - To measure the arrangement's pH and reflect its alkalinity or sharpness, a simple pH metre is specifically recommended. It finds widespread usage in several fields, including agriculture, hydroponics, and water testing, among others. The built-in integrated voltage controller chip can elegantly handle voltages ranging from 3.3 to 5.5V and is compatible with both 5V and 3.3V inputs from a microcontroller. The product library is able to automatically detect two common support configurations (4.0 and 7.0) and supports the two-point adjustment approach [14]. One way to measure how acidic or basic an arrangement is is by looking at its pH value. Additionally, it goes by the name of the hydrogen particle focus track. The standard range for pH values is 0 to 14. If the pH is 7, then the arrangement is unbiased under thermodynamic standard circumstances. If the pH is less than 7, then the arrangement is acidic. If the pH is more than 7, then the arrangement is soluble. You can see a pH metre in Figure 13.

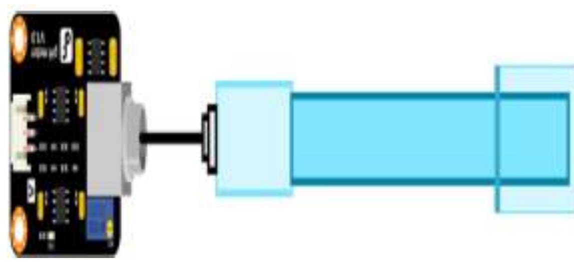

Fig. 13. pH meter.

Piezo Electric Buzzer – Depending on their construction, buzzers may be either mechanical, electromechanical, or piezoelectric. A piezoelectric sound enhancer or a tremolo electrical circuit powers a piezoelectric device. Another factor that contributes to the audible sound is acoustic hole reverberation, also known as Helmholtz reverberation. Pictured in Figure 14 is a piezoelectric ringer.

Fig. 14. Piezoelectric buzzer.

Electronic Speed Controller (ESC) An electrical circuit called an ESC (electrical Speed Controller) is primarily designed to change the speed and direction of a motor (electric engine). The ESC is responsible for deciphering control data for both brushed and brushless engines. This doesn't use mechanical motion as servo engines do, but it does change the exchange rate of a network of field effect transistors [15]. You may see an ESC in Figure 15.

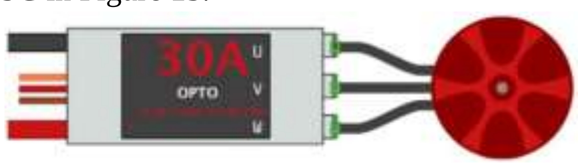

Fig. 15. ESC.

Brushless DC Motor (BLDC Motor) - The rotor of a brushless DC (BLDC) engine is a permanent magnet, while the stator is a set of poly-stage armature windings. Because it uses an electronic drive to maintain the stator windings and eliminates the need for brushes, this dc engine stands apart from the crowd. In Figure 16, you can see a BLDC engine.

Figure 16. Inverter BLDC motor.Data Transmission Systems and Protocols Various kinds of long and short telecommunications networks and components make up the Internet of Things (IoT) network for agriculture. System and sensor development for agricultural field monitoring

makes extensive use of Internet of

Fig. 16. BLDC motor.

Things (IoT) networking advancements [16]. Systems connected to agri-networks and devices in the Internet of Things rely on contact protocols as its backbone [17].They facilitate the transfer of all agricultural data over the network.Protocols for Communication and Networking with the ESP8266 Layer of Application - A few of lightweight protocols are received on the application layer, such as MQTT, CoAP, AMQP, and HTTP, due to concerns about energy consumption and the rigorous calculations needed by IoT goods. Depending on the need, the above conventions might be either reduced or enlarged. In its application layer, the ESP8266 Wi-Fi module makes use of the HTTP standard. Using a request/response architecture, Hypertext Transfer Protocol (HTTP) stands out as a web indicating standard [18]. Uses TCP and doesn't define any quality of service; for security, it makes use of TLS and SSL. Layer of Transport—The vehicle layer, which is also known as the host-to-have transport layer, is rapidly transferred from the IP area to the IoT space. Accumulating and classifying agricultural data acquired by the sensor layer is the primary goal of this layer [19]. A pair of

protocols, such as the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP). TCP is essential for ESP8266's transport layer operations. As an association-based standard, the Transmission Control Protocol

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(TCP) ensures the constant quality of transmitted data. Transmission of agricultural data to the application layer is the responsibility of the Network layer, a fundamental specialised layer for precision cultivation [20]. The present two versions of IP, IPv4 and IPv6, are the key choice for helping the core workouts (network) of this layer. The proliferation of addressable devices has brought IPv6 to the forefront. In this case, the ESP8266 Wi-Fi module relies on IPv4 for communication at the network layer. Internet of Things (IoT) based on network engineering's physical and media access control (MAC) layer is responsible for lawfully recognising and activating a few rural borders [21]. Within this layer, IEEE 802.11 is a key concept that was developed with simplicity, low complexity, and low utilisation in mind. The unlicensed international spectrum management (ISM) bands of 2.4 GHz and 5 GHz are where IEEE 802.11 mostly operates. Use the 2.4 GHz frequency range to power your ESP8266 module. The levels and norms of communication are shown in Fig. 17.

Fig. 17. ESP8266 communication layers and protocols.

GSM SIM900A Module'sCommunication Protocols andNetworking

GSM Communication – There are three possible scenarios in which GSM communication might take place. The following are: (I) Interactions within the same BTS The connection between a GSM module and a mobile phone inside the same BTS is shown in Fig. 18. (ii) Discourse with a different BTS on the same BSC or network Figure 19 shows the relationship between a GSM module and a mobile phone from another BTS within the same BSC or company. (iii) Interactions with different groups You can see the connection between a GSM module and another organization's or circuit's mobile phone in Fig. 20.

The GSM protocol stack is a multi-tiered architecture designed to facilitate communication between two distinct frameworks in GSM network engineering. Administrations of the upper-layer conventions will be made possible by lower-layer levels. Each layer will send out the appropriate notifications to make sure the data is transmitted in the right way, conveyed effectively, and received decisively [22]. The convention stack of the GSM architecture is seen in Fig. 21.

Refer to Figure 22 for a visual representation of the SMS protocol, which shows the transmission of SMS messages from the device (in this case, the GSM module) to the SMSC. By seeing this diagram, one may learn about the standards used and the parts of the GSM network that handle the cycle of communication. To summarise the communication cycle, the GSM module sends a message to the GSM BTS (Base Transceiver Station) over radio. After there, it travels via the specialised co-op's spine transmission organisation. A variety of specialised functions are carried out by the Mobile Switching Centre (MSC), the Home Location Register (HLR), or the Visitor Location Register (VLR) to determine which Short Message Service Centre (SMSC) will store and advance messages.

The SMS is keeping tabs on the present state (availability) of the less than ideal output [23]. Fig. 22 depicts the schema and convention architecture for short message service (SMS) messages sent from a GSM module to a mobile phone within the same organisation (same BTS) and to another organisation.Horticultural mechanisation Distinctive The goal of developing agribots was to meet the demands of smart farming, which is reducing the need for ranchers to strain themselves physically by increasing the efficiency of their labour. Basic agricultural tasks like weeding, watering, planting, etc., are handled by agribots. To improve collecting profitability and strong asset utilisation, all of these robots are operated by means of the Internet of Things (IoT) [24].Principle-Based Approach

There are a number of beneficial layers that make up the approved Internet of Things (IoT) setup of the attentive growing structure. In Figure 23, you can see the layers. Figure 23 from earlier shows an Internet of Things (IoT) based utilitarian system. How ranchers might use the application layer's assistance layer to access various capabilities is discussed in the practical system. Important jobs for any Internet of Things (IoT) based cultivation are located at the implementation layer. Through Internet of Things (IoT) important protocols like HTTP, the information collecting layer establishes a connection with the meeting layer.

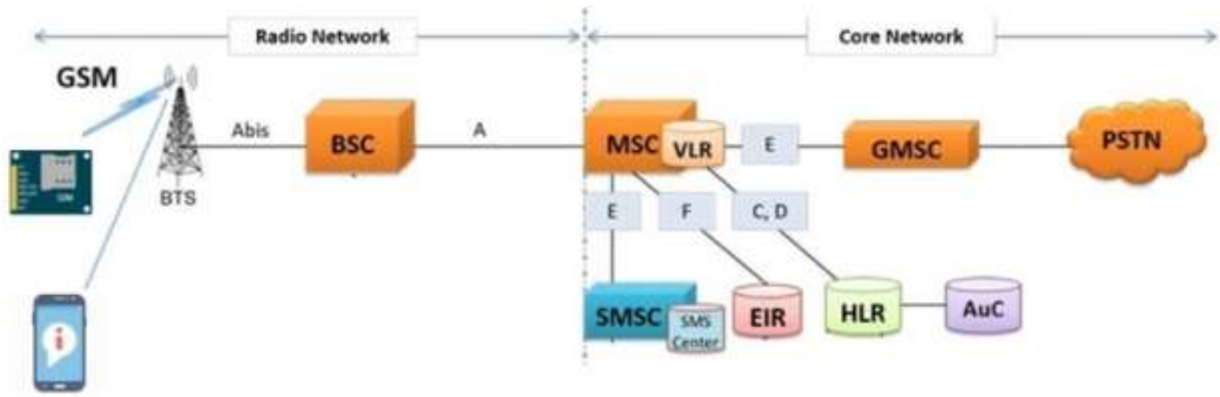

Fig. 18. Communication within same BTS.

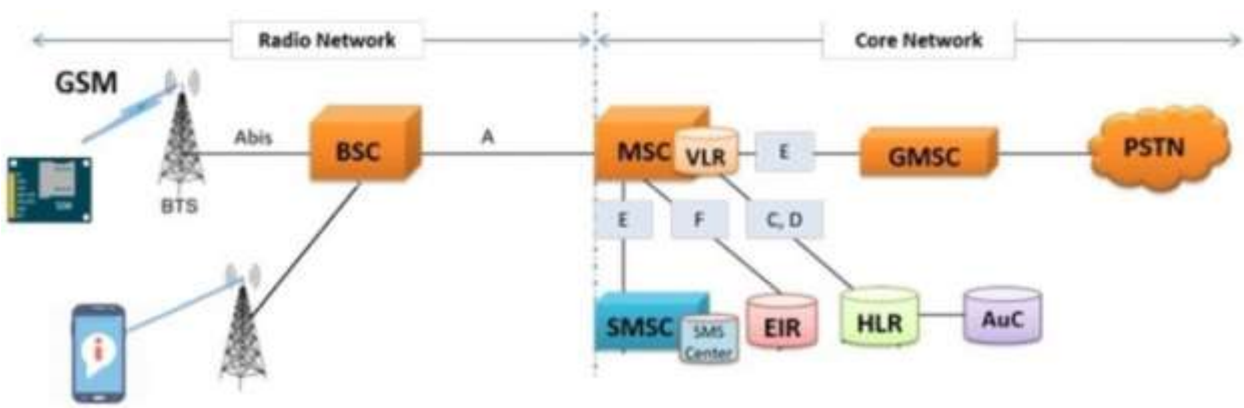

Fig. 19. Communication with another BTS within the same network.

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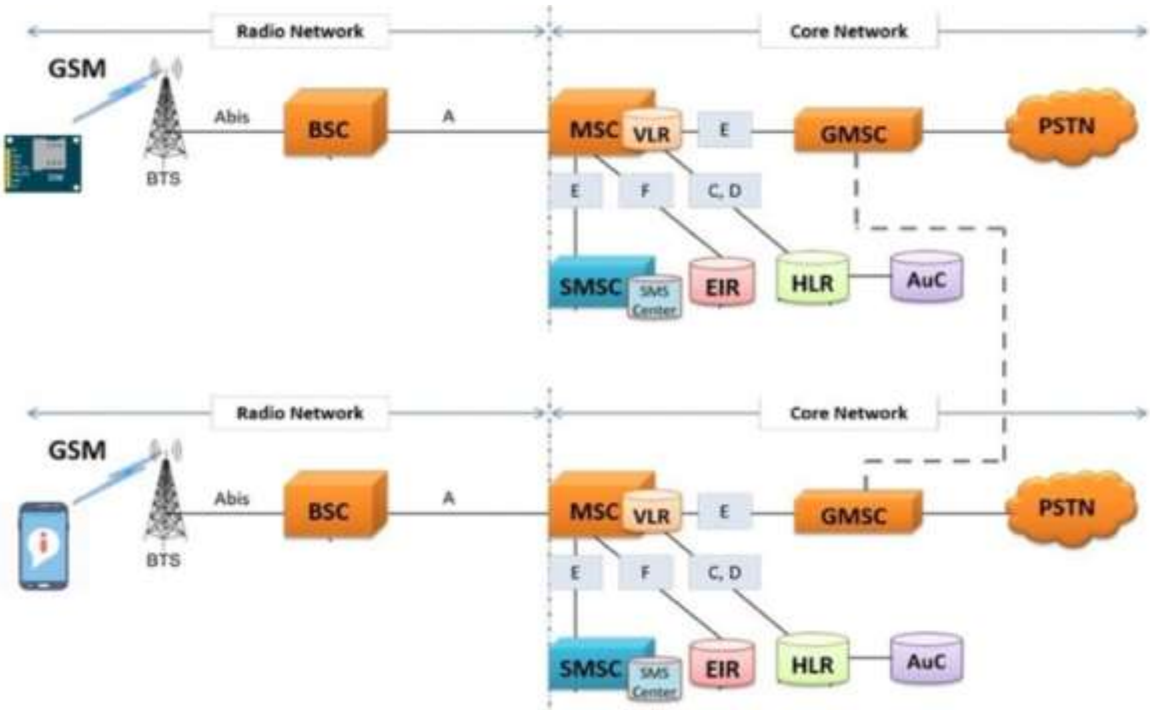

Fig. 20. Communication with another network.

Physical Implementation

4 For the purpose of screening various agri-5 social applications, a number of sensors, actuators, and microcontrollers [25] are really implemented. The physical layer was also filled out by many other pieces of organisation gear. This layer is responsible for detecting the whole natural condition of the growing field and then activating the system according to the rules that have been set. As the central regulator rabbit, the microcontroller is responsible for administrative tasks such as organising related tasks and facilitating the execution of other beneficial operations by sensors and actuators [26].

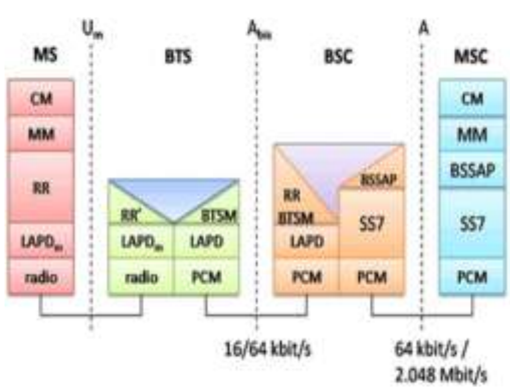

Fig. 21. GSM protocol stack.

Framework

There are five interdependent sub-frameworks that make up the Internet of Things (IoT) innovative agri-field system. There are many sub-frameworks involved, including detection [27], information inspection [28], information correspondence [29], representation [30], and execution. Interconnected with the detecting sub-framework is the information investigation sub-framework, which controls, handles, and examines the raw data from each sensor independently using a variety of computations made possible in the MCU for the perception and execution sub-framework [31]. In this case, the representation of the controlled sensor data is entirely dependent on the communication sub-framework. This is because, in order to visualise the data on a mobile phone or a personal computer, one must be linked to the modules of the communication sub-framework according to the perception cycle. For example, if a client, who is usually a rancher, needs to visualise the data through an internet browser, then it definitely requires the ESP8266 IoT module [32]. If "he/she" wants

"he/she" attempts to imagine information via the 'Chronic Monitor' in the Arduino 'Sketch' IDE, then relies on the nRF24L01 module [34], etc., in order to receive SMS on a mobile phone, which requires the GSM module [33]. The core objective of the supported IoT framework is the execution sub-framework, which is intelligently prepared for dynamic and execution-dependent processing of controlled sensor data. The smart agri-field framework based on the internet of things is shown in Fig. 24.

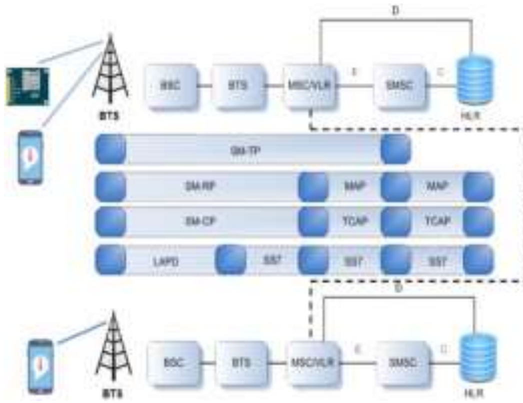

Fig. 22. SMS Network and Protocols.

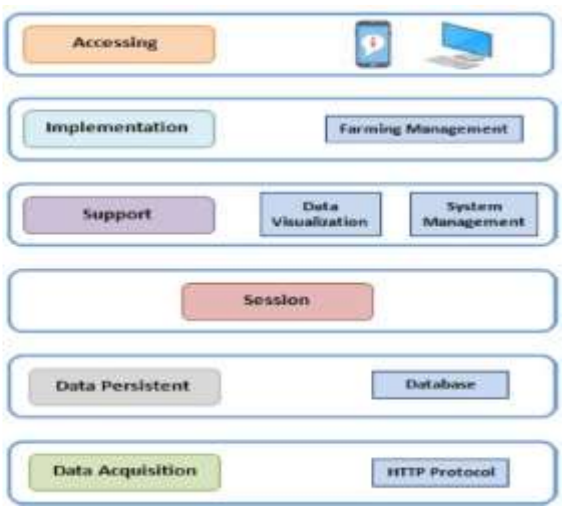

Fig. 23. Functional framework.

Circuit Design

6 There are two separate circuits that make up the astute agri-field architecture: the central node and the wireless sensor nodes. An illustration of the focus and sensor hubs may be seen in Figure 25. Nodes for Remote Sensors -

This sensor hub is made up of an Arduino Mega as the microcontroller unit, a nRF24L01 + PA/LNA remote handset module, a temperature and humidity sensor, a PIR movement sensor, a barometric weight sensor, a pH sensor, a soil moisture sensor, a bell and a MQ-135 gas sensor [35], [36] and [37] respectively. Figure 26 shows the schematic of all the remote sensor hubs that are carried out in the area of agriculture based on certain unavailable parameters of the nRF24L01 remote handset module. Central Node—An Arduino Mega serves as the microcontroller for the central hub, which also includes a GSM module, an ESP8266 Wi-Fi module, and a nRF24L01 + PA/LNA remote handset module and a syphoning framework. The contrasting hardware of the focal hub is seen in Fig. 27.

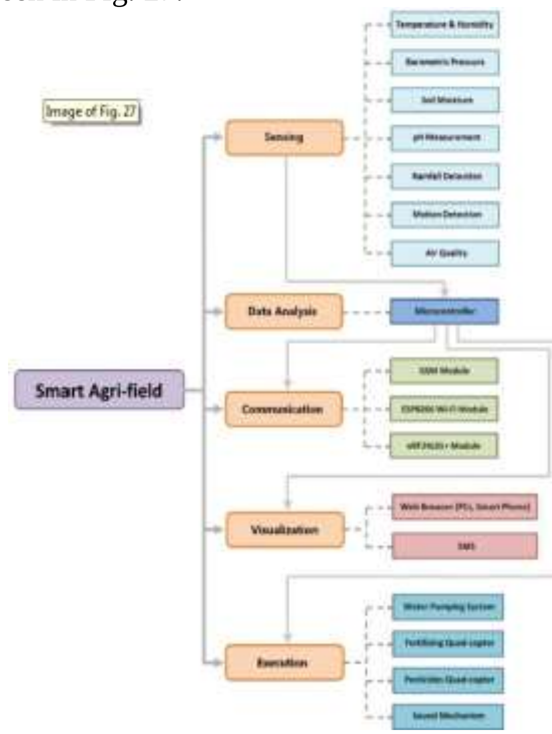

Fig. 24. IoT based smart agri-field system framework.

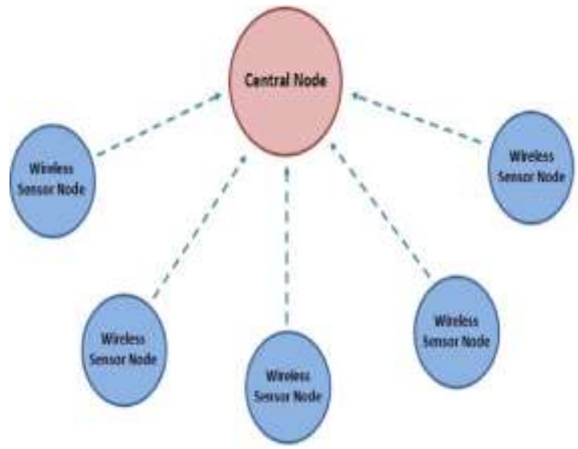

Fig. 25. Central and sensor nodes.

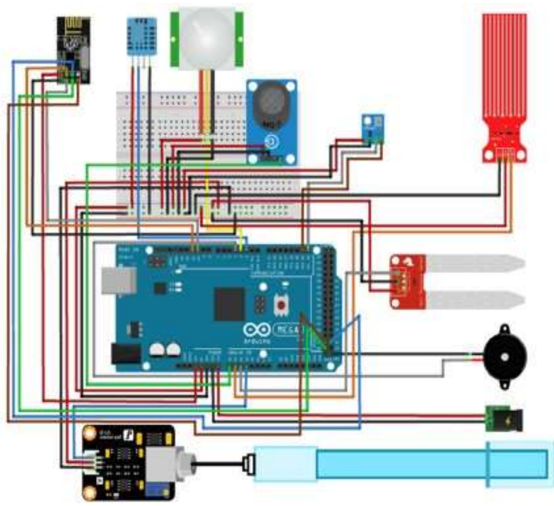

Fig. 26. Wireless sensor node.

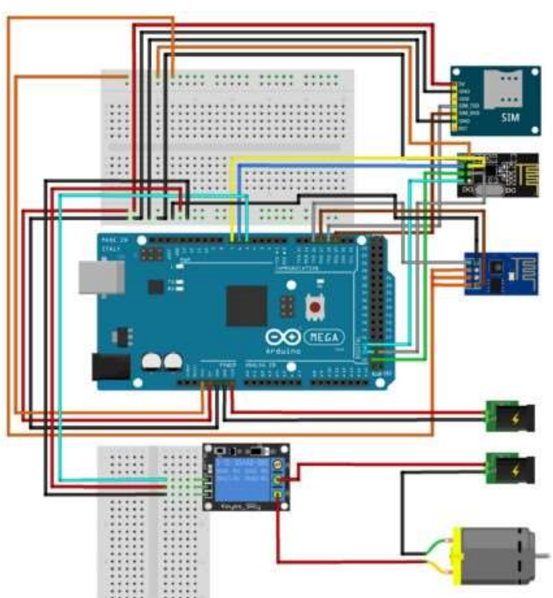

Fig. 27. Central node.

Framework Description

7 How many remote sensor hubs need to be transported depends on the area of the field that has to be farmed. The perfect sensors seen earlier are installed in every one of the remote sensor hubs. Each sensor will take readings from the weather, and the corresponding microcontroller will process the data. The DHT11 humidity and temperature sensor will determine the field's humidity and temperature, while the PIR sensor will detect motion from objects that emit infrared light, protecting the growing field from intruders like humans, animals, and birds. If anything is detected, an alarm will be sounded through the bell. [38] , The MQ-135 vehicle A gas detector can detect and measure the amount of CO 2 in the field, a barometric pressure sensor can measure how much air pressure is in the growing area, and a precipitation or water detection sensor can identify when it's raining (if the field isn't very big, then the system can trigger irrigation to protect the crops from heavy rains), a soil moisture sensor can measure how much moisture is in the soil, and a pH sensor can measure how acidic or basic the soil is. Then, the nRF24L01 remote handset module will transmit all sensor data to the central hub. With the help of the nRF24L01 module, the central hub may gather data from all of the distant sensor hubs as well as any related sensors. The central hub's microcontroller units (MCUs) assign a particular limit value to each sensor. At all times, the central hub is analysing data from all of the peripheral sensor hubs, and when the

the value exceeds or falls below the specified threshold, the central hub will send the relevant sensor data to the client's mobile phone via the GSM module. The client can also be set up to view the sensor data of each remote sensor hub through their own dedicated website page, using their mobile phone, PC, or the ESP8266 Wi-Fi module.

The central hub is programmed to do certain automated tasks; for instance, it may start the robotic water syphoning system to drain the growing field according on the data from the soil moisture sensor. In addition, it may notify the user when it's time to apply manure to the crop by providing data from pH sensors. The agri-copter, which stands for "agricultural reason quad-copter," will complete the pesticide showering and preparation. The agri-copter will be described in the next section of the article.

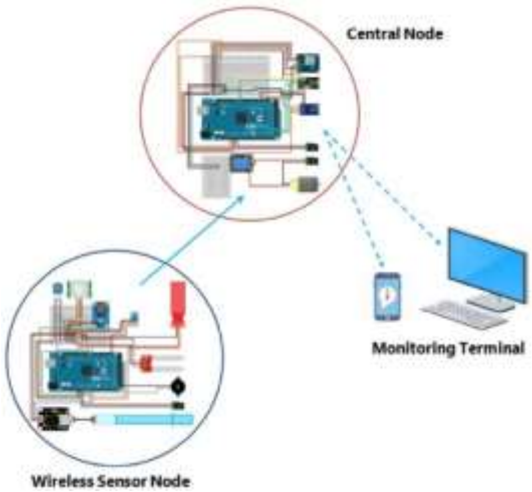

Fig. 28. Data communication.

Information Communication

Connecting a user's mobile device to the ESP8266 using Wi-Fi and inputting the designated SSID name and secret key allows users to access data stored on the module. This is after the device has been configured in AP (Access Point) mode.

pages. Fig. 28 shows the connection between centre of gravity, nodes of faraway sensors, and the way data is perceived via the centre of gravity. Connected to the internet, the ESP8266 may send comparative sensor data from far nodes to a central database, spreadsheet, or even distributed cloud. Whether on a desktop computer, a laptop, or a mobile device, anybody with access to the cloud worker may view the recorded data from anywhere. Correspondence with the cloud is seen in Figure 29.

Data exchange using cloud services (Figure 29).

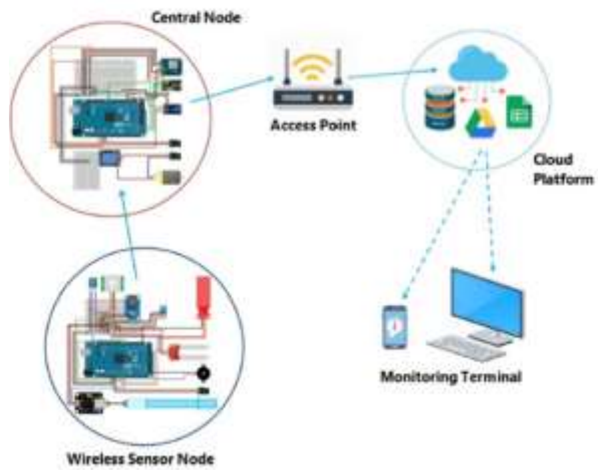

Fig. 29. Data communication with the cloud.

4. Result.

Implementing the framework in a specific environment pertinent to the homestead field yielded the desired outcomes, rather than applying it straight to the ranch field. The calculated outcomes were quite similar in this context. The actual results are obtained by physically applying the framework to the ranch field, but this is an enormous endeavour that demands a great deal of energy. Nevertheless, the results of the hypothetical testing indicate that the framework performs as anticipated and will provide more accurate outcomes when implemented in the actual field. The accompanying diagrams will show the potential results of the trial run of the attentive cultivation system framework that was constructed using the internet of things. The data collected by sensors at WSN-1, the first remote sensor hub, are shown in Figure 30. The results from WSN-2 are shown in Fig. 31. A distributed storage worker, the framework has just announced that it is suitable for recording data into the "Google Sheet" of the "Google Drive" platform. The system is successfully uploading and storing data to "Google Drive" within a "Google Sheet" (as seen in Fig. 32). The specific details of WSN-1 may be seen in Fig. 33. The data from WSN-2 will be discussed in Fig. 34. Also, for certain pre-defined scenarios, the framework may send the client (the rancher) brief messages (SMS) (depicted earlier). The marvels will be shown in Fig. 35.

Fig 30. Sensor readings from WSN-1.

Fig. 31. Readings from WSN-2.

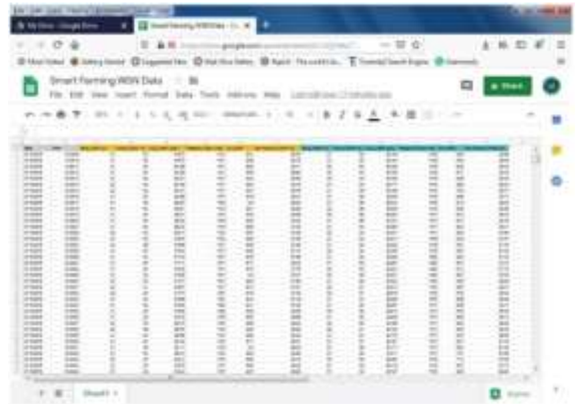

Fig. 32. Stored data in Google Sheet of Google Drive.

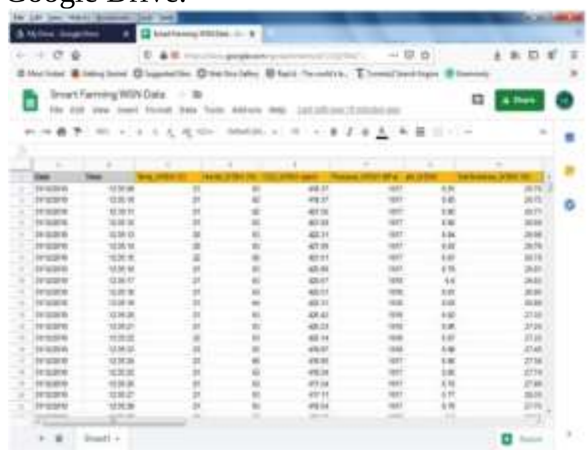

Fig 33. Sensed data of WSN-1.

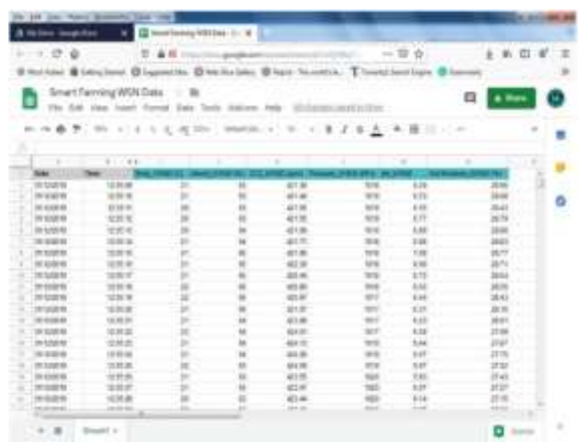

Fig. 34. Sensed data of WSN-2.

http://doi.org/10.36893/JNAO.2020.V11I01.457-472

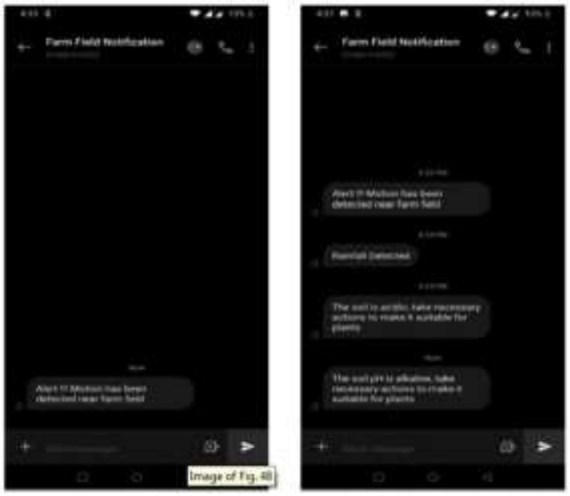

Fig. 35. SMS to the farmers.

4. Conclusion

Improved agricultural offices are very needed to gently provide the growing global population with food as the world's population continues to grow at an exponential rate. Because of this, researchers may put more focus on the development and improvement of the smart cultivation framework. With the aforementioned focuses covered, this paper should be useful to analysts in their pursuit of better information on IoT based keen cultivating.

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