IOT-BASED SMART AGRICULTURE WITH CLOUD COMPUTING

Abstract

IoT is a cutting-edge scientific know-how that illustrates the path of computers and correspondence. On every continent, agriculture is the primary economic activity. Therefore, intelligent IT systems must evolve alongside conventional farming techniques. Utilizing the cutting edge technologies enables the sway over expense, sustentation, and performance examination. Aerial and satellite photography are essential in contemporary agriculture. Using phones and computers, farmers can keep an eye on their crops and machinery thanks to IoT. Data pertaining to agriculture such as sultriness, dampness, greensward, soil nourishment, H_2O level, etc., are measured. precision agriculture sensor monitoring networks are frequently used. The internet of things is the newest hypothesis in the current epoch of the internet. It provides support to what appears to be all worldwide domains. Agriculture is one of these sectors that is utilizing IoT to make it smarter. There are likely to be a lot of IoT applications in the agricultural sector, which will help farmers in a variety of ways and ultimately aid in the successful development of the nation.

Keywords: Internet of Things (IoT); Cloud Computing; LiFi; GPRS; Agriculture Monitoring, Irrigation, Routing Protocol.

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I. INTRODUCTION

Agriculture is the cornerstone of the countries development. India is regarded as the son of the soil nation because of its excellent agronomic areas and natural resources. The evolution of agriculture today, including disease, productivity, and yield generation, is influenced by elements like temperature and wetness. The development of the nation has been hampered by agricultural issues. Agriculture's current traditional practices need to be modified. 60–70% (estimated value) of India's population is reliant on agriculture directly or indirectly. That has an effect on the economic growth and food security of India. Crop growth can be easily tracked or seen with the help of precision agriculture using data from a crop field (weather and soil conditions). The intricacy of the operation prevents this technique, also known as satellite farming or site-specific crop management (SSCM), from collecting environmental data manually. In states across the nation where there aren't enough fully functional soil testing facilities, new farmers are starting out in the field without knowing anything about the characteristics of the soil. The agricultural industry needs new trends in order to manage crops in a controlled setting. Have a look at greenhouses. The Internet of Things is the newest innovation in the online space. By enabling physical items with sensing, actuating, and computing capabilities to work together on a project while still being linked to the interweb, the "Internet of things" (IoT) concept connects them. The goal of producing high-quality objects is achieved with the aid of sensors, selectors, and embedded microcontrollers. These useful things gather insights from the development environment, process them, and spark appropriate behavior. As a result, the Internet of Effects can be a terrible help and aid in humankind leading an intelligent and wise life. With IoT, growers may easily obtain timely cultivation advice regarding factors like fungicide use, seasonal factory conditions, as well as regarding natural disasters and recovery methods. Eliminating trade between humans and computers and between humans and other living things is the main benefit of combining IoT with husbandry. So what does IoT mean for animal husbandry now? Homemade data collecting is the end consequence, and it poses a threat to both crop field processing and growers. So it's difficult for farmers to find settings where they can be most productive. IoT, or the Internet of Effects, is the sole solution to overcome this challenge. It is essential to information gathering. IoT has historically been expanding in new and varied ways. One of the crucial prerequisites for an IoT gadget to function well is connecting to the internet for husbandry. It is assumed that the connection is wireless, which is categorized based on energy usage, uplink and downlink data rates, packet size, the number of devices per admittance period, geography, density, and water way.

II. IOT ENABLING TECHNOLOGIES

The following technologies are part of the Internet of Things:

1. **Wireless Sensor Networks (WSN):** A WSN comprises of a collection of detectors or outgrowths attached together to trace diverse kinds of details.

2. **Cloud Computing (CC):** On-demand computing is the practice of sharing system resources and data with users when they need them. It can be portrayed in a number of ways, including IaaS, PaaS, and SaaS.

3. **Big Data Analytics:** Processing huge datasets with a variety of data types is the idea behind it.

4. **Communication Protocol:** IoT frameworks are built on correspondence conventions. They enable the organization's use of a variety of apps and information exchange.

5. **Embedded Systems (ES):** To complete a task, hardware and software are utilized in tandem. It supports the interconnection of multiple sensors in terms of IoT.

III. APPLICATIONS OF IOT IN SMART AGRICULTURE

Despite the fact that perceptive agribusiness isn't widely used in India, it nonetheless demonstrates a dynamic capacity for fostering horticulture. In many ways, it supports the growth and development of the plant. The following strategies are cataloged in order to enroute hedge development:

- **Monitoring of Climate Conditions:** Environment and forecast patterns turns out to be the important attributes to consider when practicing horticulture. IoT-enabled smart farming makes use of a few sensors to monitor the environmental factors' conditions. The sensor's job is to gather data from all around the groundwork and consign it to the cloud. The cloud is stacked for a few essential estimations, which will then be compared to the information that was identified. In light of the assessment, we should actually arrange the weather and choose the anticipated harvest for growth. All METEO, Brilliant Components, and Pycno are a few examples of such farming IoT devices.

- **Agriculture Drones:** Robotics are one of the most astonishing IoT applications in farming. Drones provide aerial and pictorial guides about the plants, enabling the rancher to understand what harvest is in poor condition. Additionally, drones evaluate the state of each harvest's planting, water system, and checking of progress. Drones can help you save time and effort. The robots come in two varieties: flying drones and ground-based drones. Both are owned to assess fruitage, plant, install hydration systems, and examine sand and fields. Ranchers must decide whether level or ground goal of the field will be used with the Robots. Then, at that point, the robots take pictures of the harvest and help the rancher by providing immediate assistance.

- **Livestock Monitoring:** Domesticated animals: The strategy for monitoring the state of the crowds is checking. Using an IoT device, the health of the animals is monitored and any signs of illness are looked for. The indicators attached in the direction of the critters will gather statistics regarding their locale and population levels. The sensors might actually monitor the health of dairy cow pregnancies and keep an eye on the steers that are about to give birth.

- **Smart Greenhouses:** Greenhouse farming is a methodology that bring forth's the yield of green groceries. Ecological boundaries are constrained by Nurseries in two ways; via manual mediation or a relative surveillance system. Notwithstanding, since manual intercession has inconveniences like creation misfortune, energy misfortune, and work cost, these strategies are less viable. A brilliant nursery through IoT implanted frameworks screens wisely as well as controls the environment. In this way wiping out any requirement for human mediation. Various sensors that action the ecological boundaries as per the plant necessity are utilized for controlling the climate in a savvy nursery. Then, a cloud server makes for remotely getting to the framework when it interfaces utilizing IoT.

- **Crop Water Management:** The primary resource for conducting agriculture business is water. Every agricultural activity depends on a sufficient water supply. Therefore, it is essential for the rancher to ensure that there is a sufficient supply of water for the harvests. In order to ensure an adequate water supply for the water system of the yields, this method makes use of the Internet Guide Administration (WMS) and Sensor Perception Administration (SOS). Consequently, this IoT reduces water waste. The accompanying graph illustrates how variations in temperature and soil moisture change as the frequency of long periods of precipitation increases. The investigation uses an Arduino Mega 2560. To measure the dirt's temperature, a DS18B20 sensor is used. A sensor for measuring dirt wetness is also used.

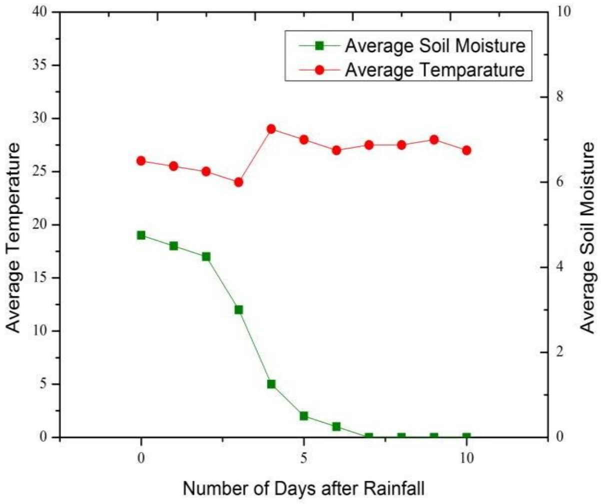

Figure 1: Temperature and soil moisture variations as the number of rainy days rises

1. Sensors Pre-Owned by Iot for Smart Agriculture

- Positioning locators employ GPS sputnik signs to determine margin, territory, and distance above the sea enclosed by lower extremity. To triangulate the position, three permanent location sensors are required.

- Ocular sensors are accustomed to gauge the soil's moisture, wholesome yard goods, and clay constituents. At regular intervals, the particular sensors are permanently attached to the drones.

- The crucial data on pH and soil nutrient levels is provided by electrochemical sensors.

- The mechanical resistances of the soil are measured using mechanical sensors.

- Dielectric soil moisture sensors use the dielectric constant to gauge the soil's moisture content.

- Parrot sensors are used to track the soil salinity, moisture, and temperature of the plant. The farmers' cell phones are sent the information.

- Spruce is a sensor gadget that regulates irrigation. The user has access to the data whenever and wherever they choose because it is saved on a cloud server.

- Koubachi is used to hydrate garden plants by misting them with water. It functions as a node that gathers information from several sensors, such as those that measure the air's temperature, the moisture of the soil, and sunlight.

S. No	Solicitations of IoT	Pre - owned Sensors	Endeavors	Benefits
1	surveillance of the climate	Sensors for sound, CO, temperature, and Light Dependent Resistor	Rainfall, wind direction and speed, temperature, relative humidity, brightness, and carbon monoxide level	lowers labor expenses, improves decision-making time convenience making use of resources
2	Agriculture Drones	Zenmuse XT2 Thermal Camera, Phantom 4 Pro V2.0 Drone, Matrice 210 Drone, NDVI Sensor, and AGRAS MG-1S Drone	issues with irrigation, the diversity of the soil, and pest and fungus infestations	Boost crop growth and productivity.
3	Crop Water Handling	sensors for warmness, moisture, and ground wateriness using ultrasonic technology,	enhance the climatic context	Knowledge of soil characteristics, the need for water supply for different plant species, minimize water waste,
4	Smart Greenhouses	Light sensor, temperature sensor, and a Mini Luminance Sensor that is compatible with Arduino	Overheating, dampness, H_2O content, light level, CO_2 level, and the contingent water in the soil	Plant development that is efficient and temperature control

5	Livestock Monitoring	Connected sensors	evaluates the livestock's vital signs, including its proportion rate, haemoglobin density, gasping ratio, temperature, metabolism, and other measurements.	conserves time and detects livestock health issues early Follow the whereabouts of animals

Table (1): Sensors used in IoT for Smart Agriculture

2. Previleges of Iot in Smart Agriculture

- IoT permits extensive data collection via sensors, enhancing control over internal processes and reducing production risks. Using IoT, the farming environment may be properly monitored.
- Farmers may remotely monitor their farms using IoT from a number of locations. Any location can make real-time decisions. IoT ensures increased crop productivity by carefully monitoring planting, watering, applying pesticides, and harvesting.

3. Four Layers Iot-Agriculture Architecture: A conceptual model for smart agriculture is suggested as a consequence of the study of the literature review. Give me a quick rundown of the general organization of the IOT. In reality, IOT is composed of multiple physical devices and has a three-layer frame. The first layer is the integrated utilization layer, which is employed in applications correlated to agriculture and is regarded as a user articulation layer. It is complimentary and monitors agricultural land using the personal devices and mobile phones of farmers. Farmers might choose to use this layer to boost food production output while keeping their crop as healthy as possible. The second layer is information management, which involves tasks like data production, classification, and monitoring in addition to other things, like decision-making. Certain tasks are kept up with and performed in this layer. Communication technologies like Bluetooth Low Energy, Zigbee, Bluetooth Low Energy, GSM, WiFi, and Gateway are represented in the network management layer, the third tier, of the OSI model. The fourth layer, which comprises various sensors, cameras, and other devices, is information gathering. In the agricultural industry, these are employed to collect crop data for more efficient and practical field monitoring.

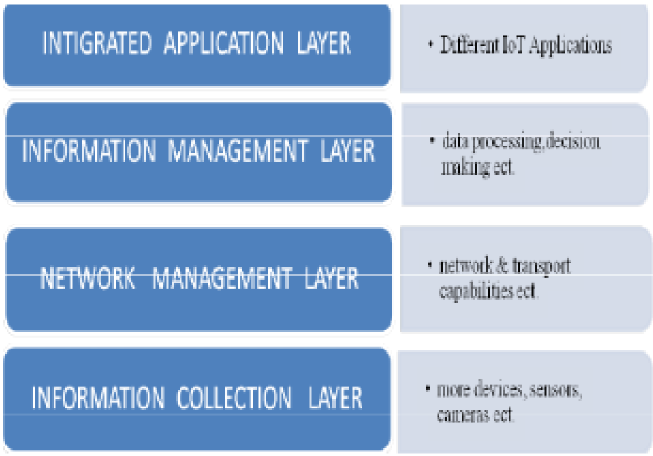

Figure 2: The four layers IoT structure

Every strategy has a set process that entails putting several sensors in the agricultural field to gather information on elements like warmness, dampness, underground PH, and magnitude of light. Every single network device will be designated with an IP address so that it can be recognized. As an illustration, the item ID T1 on the communication network will be used to identify the network's temperature sensor. Both IPv6 and IPv4 are capable of addressing IoT devices. The identification techniques provide every object in the network a unique identity. Examples of IoT sensors include smart sensors, actuators, and wearable sensing equipment. The detected information from the agricultural field is transmitted to a cloud through a gateway linked to the internet via WiFi or another communication network. Farmers' PCs or smartphones receive the data from the cloud. To assist farmers in making wise decisions, this data can be examined.

IV. ANALYSIS AND COMPARISION OF IOT HARDWARE REQURIEMENT

1. **Device:** Systems for Internet of Things (IoT) use devices to conduct sensing, actuation, control, and monitoring functions. IOT devices can exchange data with other connected devices and applications based on temporal and spatial constraints (such as memory, processing speed, communication latencies, and deadlines), or they can gather data from other devices and send it to a base station server and from there to a cloud server using a gateway, or they can perform some tasks locally and other tasks within an IOT infrastructure. IOT devices can connect to one another via a variety of wired and wireless interfaces on a single device. For example, there are interfaces for reminiscence and space, boundaries for Internet accession, and frontiers for audio and video.

2. **Communication:** The majority of IOT communication protocols are compatible with the data link layer, network layer, transport layer, and application layer. The communication block permits communication between devices and remote servers.

3. **Services:** IOT systems have the ability to carry out tasks such device modeling, device control, data publishing, data analytics, and device discovery.

4. **Management:** The management block has a range of capabilities, including controlling an IOT system and determining its underlying governance.

5. **Security:** Authentication, authorisation, privacy, message integrity, content integrity, and data security are just a few of the tasks that security blocks are capable of handling. An IOT security barrier protects the system.

6. **Application:** The application layer is the one that users need to pay the most attention to. The required modules are provided in this layer so that various IOT system components can be controlled and monitored. Applications give users the ability to watch, evaluate, and occasionally foresee the future the system status at the current stage of operation.

The following list and concise explanations include a few of the wireless sensors.

- **802.11 – Wi-Fi:** The IEEE 802.11 standard designates a set of Wireless Local Area Network (WLAN) communication protocols. For instance, 802.11a uses the 5 GHz frequency, 802.11b and 802.11g the 2.4 GHz spectrum, 802.11n the 2.4/5 GHz spectrum, 802.11ac the 5 GHz spectrum, and 802.11ad the 60 GHz range. These specifications provide data rates between 1 Mb/s and 6.75 GB/s. Between 20 meters (indoors) and 100 meters (outdoors), Wi-Fi has a communication range.

	WIRELESS TECHNOLOGIES					
PARAMETERS	**Li-Fi**	**Wi-Fi**	**WiMAX**	**LR-WPAN**	**Bluetooth**	**LoRa**
Standard	IEEE 802.15.7(out of date) (for VLC)	IEEE 802.11a/b/c	IEEE 802.16	IEEE 8205.15.4	IEEE 802.15.1	Lora WAN R1.0
Frequency band	10*1000 times frequency of radio(3KHZ-300GHZ)	5-60GHZ	2-66GHZ	2.4GHZ	2.4 GHZ	868/900MHZ
Data rate	224Gb/s	1Mb/s-6.75 Gb/s	1Mb/s-1 Gibb/s	40-250 Kb/s	1-24 Mb/s	0.3-50Kb/s
Transmission range	10 m above	20-100m	<50Km	10-20m	8-10m	<30Km
Energy consumption	Low	High	Medium	Low	Medium	Very Low
Cost	Low	High	High	Low	Low	High

Table (2): comparisons of wireless communication

- **802.16 – WiMax:** IEEE 802.16 is a group of wireless broadband standards. Data speeds ranging from 1.5 Mb/s to 1 GB/s are provided via the WiMAX (Worldwide Interoperability for Microwave Access) specifications. (802.16 m) provides a data throughput of 100 Mb/s for mobile stations and 1 GB/s for fixed stations. The provisions can be found on the IEEE 802.16 functional website (IEEE 802.16, 2014).

- **802.15.4 – LR-WPAN:** The IEEE 802.15.4 standard, which develops advanced communication protocols like ZigBee, includes Low-Rate Wireless Personal Area Networks (LR-WPAN) requirements. Data speeds between 40 and 250 kbps are available through LR-WPAN. To power-restricted devices, LR-WPAN delivers slow, low-cost connectivity. A low frequency input ratio of 868/915 MHz and a high frequency data rate of 2.4 GHz are both available on the LR-WPAN.

- **802.15.1 – Bluetooth:** Bluetooth adheres to IEEE 802.15.1. Bluetooth permits data transmission over a short (8–10 m) distance between mobile devices. Bluetooth is a low-cost, low-power wireless communication method. The Bluetooth standard specifies how personal area networks (PANs) can communicate with one another. It utilizes the 2.4 GHz band of frequencies. The Bluetooth input range stretches from 1 Mb/s to 24 Mb/s. Bluetooth Low Energy (BLE or Bluetooth Smart) is the incredibly under sized, low cost variant of Bluetooth. BLE and Bluetooth v4.0 were combined in 2010.

- **1.5.6. Lora WAN R1.0:** Low Power Wide Area Networks (LPWAN) is a recently developed standard protocol that supports the Internet of Things (IoT) and was developed by the open and nonprofit LoraTM Alliance. This protocol's main objective is to enable interoperability between many operators under a single, open, global standard. 0.3 kbps to 50 kbps is the data rate range for LoRaWAN. The LoRa protocol operates on the ISM bands at 868 MHz and 900 MHz. Linked nodes may interact with one another up to 20 kilometers away in open areas, as stated by post capes. The progression of the linked node in general lasts up to 10 years, which is a fairly long lifespan.

IOT Platforms	**Real time data capture**	**Data Visualization**	**Cloud service type**	**Data Analytics**	**Developer cost**
Ubodots (http://ubidots.com/)	Yes	Yes	Public	Yes	Free
Thing Speak (https://thingspeak.com/)	Yes	Yes (MATLAB)	Public	Yes	Free
ThingWorx (www:thingworx.com/)	Yes	Yes	Private (IaaS)	Yes	Pay per use

Xively (https://xively.com/)	Yes	Yes	Public (IoTaaS)	No	Free
Plotly (https://plot.ly/)	Yes	Yes (MATLAB)	Public	Yes	Free
Nimbits (www.nimbits.com/)	Yes	Yes (MATLAB)	Hybrid	Yes	Free
Connecterra (www.Connecterra.io/)	Yes	Yes	Private (IaaS)	Yes	Pay per use
Axeda (www.axeda.com)	Yes	Yes	Private (IaaS)	Yes	Pay per use
Phytech (http://www.phytech.com/)	Yes	Yes	Private (IaaS)	Yes	Pay per use
Aekessa (www.arkessa.com)	Yes	Yes	Private	Yes	Pay per use
Yaler (https://yaler.net)	Yes	Yes	Private	Yes	Pay per use

Table (3): An analysis of the IOT cloud platforms that can be applied to the agricultural areas.

V. MATHEMATICAL EXPLANATION FOR HIGH YIELD PROCESS

Most of the mathematical explanations are carried out for better yield production. For instance, rice and wheat formula is

Yield = no. of plants/m2×no. of effective fillers/plants× no. of grains/plants×% of filled grains × test weight/1000× 10,000/1000.

Where yield analysis is done with two parameters. The relation between Biological yield and economic yield is

Biological yield× K = economic yield

The biological yield of a crop is the amount of dry matter it generated, and the fiscal return is the portion of the biological production that is consumed by humans. There are two key factors that must be considered in order to achieve high manufacturing yield:
(i) Soil moisture
(ii) Temperature.
Both the temperature and the soil's moisture content must be between 18 and 25 °C and 15

and 60%, respectively.

$$Y = T \times M \times A \times 100$$

T = temperature optimal range 18^0-25c M = soil moisture optimal range 15-60%
A = area of crop field

This equation is used to finalize the yield of the crop field. When these values are increased or decreased (violating the optimal range) means, there is a chance of minimal productionyield. It seems must be within optimal range only.

However, the concepts shown in the previous section make the IOT concept essentially practicable, despite the fact that a significant amount of research effort is still needed. In this section, specialized challenges regarding existing IOT models are discussed. Later, a novel concept of IOT engineering was developed to satisfy all of the key components that the old design was missing. Earlier the IOT is predominently adopted and manipulated in all areas, it is necessary to have a sufficient understanding of contemporary requirements on factors like cost, security, protection, and risk. Permit us to look at a few topics in this way:

1. For farmers, staying within budget is a more important limit. As a result, the examiner's current efforts are focused on creating new intelligent IoT designs for the agribusiness that have added advantages.

2. The existing database management system might not be able to handle the original data's size in real time. There must be idealized solutions. IOT-based data would be produced swiftly. The receiver end's RAID technology is unable to manage the obtained data. To crack this hindrance, IOT-premised data endeavour-centric design must be changed.

3. Data are undone truths that, for the most part, do not adhere to pointless handouts. Decision-making in the IOT is heavily influenced by data. Data value comes from the data set as a whole. Significant data-based information can only be examined and understood with the right application of mining. To solve regression issues of a similar sort, big data is adequate. Data mining, interpretation, and ultimately administrative undertakings are all capable of being performed by the right architecture framework. Data mining could pool Big Data analytics.

4. Service-based objects may encounter performance and budgetary issues, making it challenging to design a Service-Oriented Architecture (SOA) for the Internet of Things. The system's high device density, which leads to scaling issues, needs SOA in order to be supported. Problems with data administration, processing, and transfer are now taken care of as a burden by the service provider.

5. The standard of service is still another important concern. To achieve the best QoS bounds, a developer must concentrate on QoS elements. A mind-bogglingly enormous number of nodes are envisaged with IOT. All attached hardware and data must be able to be retrieved. Unique identification is a crucial component of an efficient point-to-point network design. The IPv4 protocol uses 4-byte addresses to identify each node. A new

addressing system named IPv6 has been developed since IPv4 addresses would run out in a few years. In order to pursue device naming and identifying capacity, IPv6 is the area where the most prudence is necessary and adequate architectural expertise is a must.

VI. CONCLUSION

Various IoT-supported technologies and IoT applications for smart agriculture are investigated in this study. In this paper, the benefits of IoT in agriculture are highlighted. Understanding the concepts behind the Internet of Things is more crucial than ever because it is a relatively new idea. Farmers now have access to a straightforward manual that might help them work more productively and take good care of their crops. The accuracy and efficiency of agricultural procedures can be increased by IOT-enabled devices. Water and energy are the initial aspects of agriculture where IOT can be used. The most important inputs for agriculture are water and electricity, and the price of these resources may make or break the sector. Water wastage is a result of ineffective irrigation systems, poor field application techniques, and the planting of crops that require a lot of water in the wrong place. Lighting, pumps, boosters, and other devices all depend on electricity to function. By employing IOT to monitor and modify water amount, location, timing, and flow duration, agriculture may use water more wisely. The application of fertilizers, pesticides based on crop and soil health, and insect management are the primary challenges in the second category, which is crop monitoring. Effective energy consumption for pumps, boosters, lighting, and other uses is also accomplished with the help of IOT. So that the right choice may be taken, IOT enables the deployment of internet-connected sensors and image-capture equipment in agricultural fields. IOT makes it feasible to utilize pesticides and fertilizers more effectively. Lastly, it should be mentioned that the best Agri-IoT architecture needs to be developed, one that is affordable, uses less device power, has superior decision-making skills, QoS service, achieves optimal performance, and is easy enough for farmers without technical expertise to understand. All the applications covered above have 98% accuracy rates. The farmer can improve crop productivity this way, which will benefit the country's welfare.

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