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A SYSTEMATIC SURVEY ON THE CLOUD OF THINGS FOR SMART AGRICULTURE

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Abstract:
The development of new technologies in our day and age has led to the downsizing of sensors, and efforts to use them in a variety of applications are succeeding. They are also moving toward a concept of "smart" like smart health care systems, smart cities, smart mobility, smart grid, smart home, and smart metering, etc. as a result of the adoption of the Internet of Things (CoT) and cloud computing in all areas. The future of computers and communications may be seen in the innovative technology known as the cloud of things. The majority of people on all continents rely on agriculture. Smart IT technologies are thus required to move alongside conventional agricultural practices. Agriculture is one such field of study that has also benefited from this adoption, making it a Smart Agriculture. Utilizing contemporary technology allows for cost, maintenance, and performance monitoring management. In contemporary agriculture, satellite and aerial photography are crucial. Any nation with a big population, like China, India, etc., relies heavily on agriculture to support its economy and way of life. Through cost management, performance monitoring, and maintenance, the use of CoT and Cloud Computing in the agricultural industry will improve crop output, benefitting both farmers and the whole country. Understanding the

various technologies and developing sustainable smart agriculture are the goals of this study. A wireless network is used to address a simple CoT agricultural scenario. The introduction of a smart drone for crop management is the main emphasis of this study, and real-time drone data combined with CoT and cloud computing technologies aid in the development of a sustainable smart agriculture. Using cloud computing as the foundation, we examined several common uses of Agriculture CoT Sensor Monitoring Network technologies in this article.

Keywords: Cloud of Things (CoT), Wireless Network, Agriculture, Smart IT technologies

1. Introduction

Agricultural techniques and practices play a key role in the world's most populated countries, such as India and China, where farmland area, output value, and land yield per unit are all lower than in developed nations. The production of food is thus crucial to the fight against world hunger. Given the limited natural resources that are at our disposal, the agricultural industry has to use cutting-edge technology such as the Internet of Things (CoT) and cloud computing in addition to various machinery and other types of technology in order to overcome these challenges. It is anticipated that widespread adoption of cloud computing will result in improved cloud hosting facilities with faster internet speed. As a result, new strategies will become available to farmers and producers, allowing them to make more informed decisions, reduce expenses, improve efficiency, and boost output. The Internet of Things (CoT) will be beneficial in connecting various devices, collecting data, and spreading it throughout the internet [1].

The Internet of Things (CoT) may provide several advantages, such as the cloud-based intelligent irrigation system described in this article. However, in order to construct a tool that is as effective as it is possible to be, we need more than just sensors and a link to the internet. In point of fact, in order to support this infrastructure, a system that is capable of collecting, storing, analyzing, processing, and managing the large number of intelligent data that is generated is necessary. The structure shown in enables the automation of tasks by using protocols that are formulated on the basis of the information obtained by sensors and devices that are connected through a network. It also generates performance reports and statistics in order to deliver real-time information to the farmer on the activities of the firm and to enable the farmer to make well-informed decisions as promptly as possible. Common agricultural software is starting to go to the cloud in order to aid farmers with data access, synchronization, storage, and even pricing. This will help farmers with all of these things and more. Because of the increasing use of smart mobile and embedded devices on farms, such as Android and iOS smartphones and mobile sensors, it is possible that apps will be used to store data offline until it can be synchronized. This will allow the data to be accessed later. As a consequence of this, it is no longer necessary to link data to a specific computer or place [2].

Drones are the common name for unmanned aerial vehicles (UAVs). To put it another way, drones are considered to be examples of networked robotic technologies due to the fact that they are flying objects that can be remotely or independently programmed by a ground station or a remote control. In other words, they fall under the category of networked robotic technologies. The use of drones provides farmers with the opportunity to receive a comprehensive inspection of the area and helps them make more efficient use of their time. This eliminates the need for the farmers to be forced to travel into the field in the dark. Solutions for data extraction, analysis, and agricultural farming could potentially be provided in real time by drones that make use of CoT and cloud computing technologies. The purpose of this research is to develop a smart drone capable of performing agricultural field inspections and crop screenings via the use of remote monitoring. It is combined with other technologies, such as computing in the cloud and the Internet of Things. The data collected by drones offers various agricultural insights to farmers, such as plant health indices, plant counting, plant height measurement, field forecasting, field water and drainage mapping, and so on, and supports rapid, dependable, and affordable service for farmers [3].

2. Literature Review

When conducting a study of the available literature on smart agriculture, we relied on scholarly publications, articles, and research papers. One piece of study investigated the use of fuzzy control systems for irrigation and water conservation in agricultural areas, taking into account the characteristics of the crop and the location. It describes the steps that need to be taken in order to set up an irrigation system that is fully automated in the field. In a separate piece of research, the authors proposed a greenhouse monitoring system that was built on agricultural CoT and a cloud [4].

In this particular system, sensors are installed on the farm in order to collect data about the agricultural field area on a consistent basis and upload it to an internet database. In the few other articles, a wireless sensor network application for agriculture was presented. In this application, the systems are equipped with two different types of sensor nodes: one to measure various parameters, such as humidity, temperature, and so on; and the other, an image sensing node to take pictures of the crops. Both types of sensor nodes are connected wirelessly to one another. The primary focus of the bulk of these articles is on the use of irrigation techniques to agricultural land [5].

One of these works highlighted the need of accurately assessing the water needs of plants and the Neural Computing modeling of reference crop evapotranspiration in order to improve the management of the limited water resources in arid areas. Another piece of research came up with the idea of an Automatic Smart Watering Decision Support System (SIDSS). This system determines the amount of water a plantation needs to be irrigated each week based on both the measurements of the soil and the weather that are collected by a large number of autonomous nodes that are placed throughout the field. Only a few other papers have mentioned the possibility of Internet of Things–based smart irrigation systems, in which data collected by sensors is sent to a smart gateway over a network and is then delivered to a web service [6].

The Global System for Mobile Communications (GSM) also proposed a monitoring system that would make use of image sensors and Aspic to keep an eye on bug traps for unwanted pests. They did this by using distributed imaging equipment that was powered by wireless sensor networks. This method does not provide any recommendations for controlling pests; all it does is determine whether or not there are insects present. Several publications on intelligent agriculture claim that precision agriculture is already being used in a number of different countries.

Monitoring the diversity of crops within a field as well as across different fields is the primary emphasis of precision farming, also known as site-specific crop management (SSCM) [7].

A Japanese technology company, developed a blueprint for using cloud computing in agricultural settings. The model consists of the stages inputs, data storage, visualization, analysis, and instruction, but it also has potential applications in other fields, such as the medical field, the maintenance industry, and the environmental field. The majority of published works either offer the findings of exploratory investigations or discuss CoT systems that have either been created or put into action in prototypes and pilots. Sensing and monitoring are the primary topics that are discussed in the literature review. Actuation and remote control are discussed to a much lesser extent, and more advanced solutions are still in the experimental stages of research. The purpose of this article is to present a novel method for using intelligent drones to remotely operate and monitor a crop field while simultaneously keeping an eye on all of the necessary agricultural land factors to assist in field forecasting and data analysis [8].

3. Proposed Work

Intelligent Irrigation with the Use of Thermal Imaging Even while plants may be able to withstand some degree of water stress, it is essential for farmers and irrigation managers to keep a close eye on any changes in the level of water stress in order to avoid the situation from spiraling out of control. Thermal imaging is a method that does not need any physical touch or intrusion and does not require the surface temperature to be altered. In addition to that, it is capable of displaying the current temperature. When the temperature is a significant variable, this has been used in a variety of industries and/or scientific fields, including meteorology, environmental studies, medical diagnostics, and architecture, amongst others. According to the findings of a number of studies, thermal imaging is an effective approach for locating essential aspects that should be considered when planning irrigation. A few of the crucial components for irrigation include water stress, the rate of gas exchange, the rate of evapotranspiration and transpiration, stomatal conductance, and stomatal closure. When a plant is under water stress, its stomata begin to shut and it stops transpiring. At the same time, the plant itself heats up, and the temperature of the canopy rises [9].

Therefore, thermal remote sensing may be used to measure the temperature of the plant, the conductance of the stomata, and the rate of evapotranspiration by examining the reactions of the stomata. Thermal imaging has the advantage over thermometry, which only provides an average value, in that it can produce a temperature measurement for each and every pixel that is inside the field of view of the sensor. Thermometry can only provide an average value. As a consequence of this, it may sometimes be easier to differentiate between distinct aspects, such as sunny plant parts as opposed to covered plant sections and wet soil surfaces as opposed to dry soil surfaces. A three-tiered architecture is what we've decided to go with in order to put intelligent farming and farm safety into practice. The front-end layer consists of sensors, and it is designed in such a way that it allows wireless communication modules to make use of microcontrollers in order to send detected data to the gate passage. Microcontrollers are another component of the gateway. They provide the processing power and storage space required to ensure that all of the data that is collected is sent to the cloud server where it can be analyzed [10].

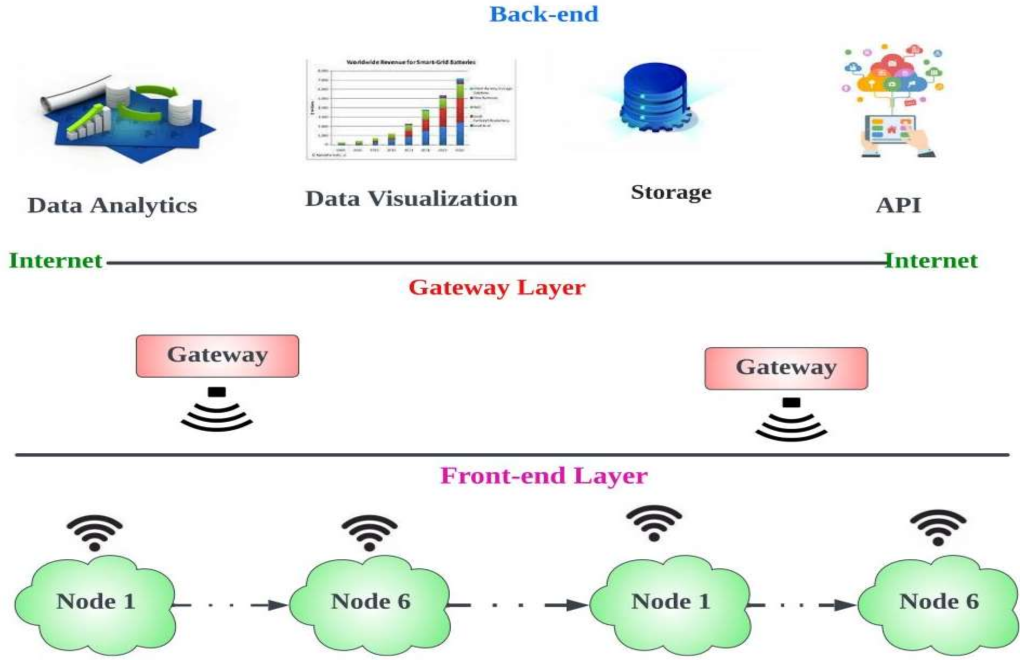


Figure 1: Basic Model of smart agriculture

4. Security and Regulatory Challenges

Systems that are based on CoT are likely going to become increasingly relevant in a number of applications that are used in the real world, such as smart agriculture. As is the case with the introduction of any new consumer or industrial technology, the implementation of CoT-based systems, including irrigation systems based on CoT, will proceed in phases before reaching widespread usage [11]. Unfortunately, in comparison to traditional, isolated irrigation systems, these systems may contain additional attack vectors (such as hardware, firmware, and applications running on CoT devices) that can be exploited by attackers in a remote capacity. These attack vectors include hardware, firmware, and applications. Because of the nature of resource-constrained devices or nodes in CoT-based systems and the interdependency of such systems, we need to rethink how we build security solutions for CoT systems. Specifically, we need to rethink how we generate security solutions for CoT systems [12]. For example, existing security solutions, which typically call for complex cryptography computations like the modular-exponentiation operation, might not be appropriate due to limitations in the computational capability of the underlying hardware. These limitations could prevent existing security solutions from being used (e.g., limited battery life and weaker computing capabilities). When developing lightweight security solutions for Internet of Things (IoT)-based systems, one of the most persistent challenges is to find the optimal level of security assurance while simultaneously reducing computational overhead and energy consumption. This is especially challenging on devices or nodes that have limited resources. Before releasing their software or systems to the public, creators of CoT software and systems could find it necessary to do extensive testing on their creations, which can be an expensive endeavor [13].

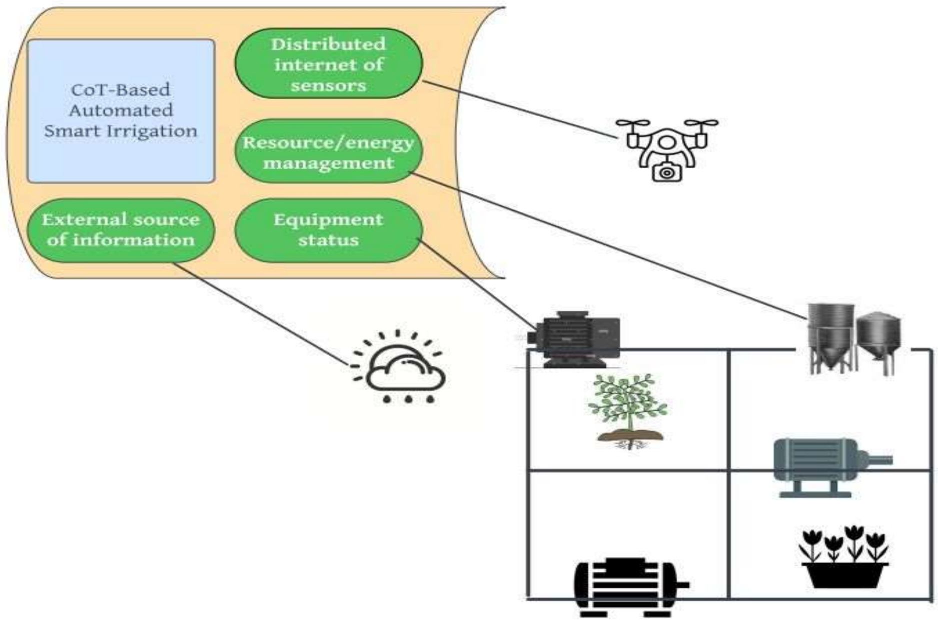
As a consequence of this, ongoing research is essential to the development of a security testbed or environment. This will enable developers of CoT software and systems to evaluate the level of security offered by the systems and the components in a setting that is both simulated and accurate. Experts in the law and privacy, in addition to politicians, are interested in the legislative framework (including data protection and Internet governance) that will surround the deployment of CoT (including Internet of Things (CoT) and Cyber Physical Systems). In spite of the fact that the vast majority of concerned individuals and consumer advocacy groups have asserted that the existing data protection framework is inadequate and that it is necessary to place a greater emphasis on privacy and data protection in the context of CoT, others have issued a warning against excessive regulation and pointless regulatory burdens in a technological landscape that is both complex and rapidly evolving. When considering how slowly governments and regulatory bodies respond to advances in technology, such concerns are not surprising. In addition, it takes a much longer amount of time to develop the systems of the next generation of CoT than it does to develop an appropriate legal and regulatory framework (or any technologies). More recently, in 2015, the Alliance for Internet of Things Innovation of the European Commission came to the conclusion that regulatory proposals aimed at the CoT should only address clearly defined market failures that cannot be addressed through existing law and self-regulatory measures, as well as the need to be mindful of regulatory error in the complex and quickly evolving technological landscape. This conclusion was reached because regulatory proposals should only address clearly defined market failures that cannot be addressed through existing law and self-regulatory measures. In addition to addressing these legal concerns (of a more general nature), it may also be necessary to address problems that are unique to a particular business or sector. One of the continuing challenges is unquestionably coming up with legal and regulatory frameworks that are sufficiently adaptable and innovative to keep up with the complicated and ever-evolving technological and risk environment. This is one of the ongoing concerns [14].

5. Concept Of Cloud Computing

The implementation of a Cloud of Things (CoT) network in smart agriculture, which may include Internet of Things and cyber physical system components, has the potential to improve the efficiency of energy use while simultaneously cutting expenses. For instance, data analytics gathered from the CoT network (for example, weather situation, land condition, and kind of soil) might provide useful information if combined with data from sensors monitoring heat, moisture, chemicals, water stress, pump status, level of water resources, and so on. This gives farmers the ability to increase their crop yields by applying water, fertilizer, and herbicides in more precise quantities, at more precise places, and at more precise times. Both water and electricity are put to extensive use in agricultural production, making them two of the most essential components of agricultural inputs. There is a possibility that agricultural commerce might be made or broken by the costs connected with electricity and water. More intelligent water utilization is required in order to boost irrigation efficiency and save money. This includes supervising and monitoring water capacity, location, time, and duration of flow based on data analytics. In addition, CoT might be able to provide more effective methods of utilizing energy for things like pumps, lights, and boosters, in addition to enabling remote management of the operational status, setting configurations, and performance of the equipment. Data analytics and the Internet of Things (IoT) can be used to determine the status of equipment, such as whether a gate or a valve is open or closed, whether an irrigation pump is turned on or off, as well as other indicators that signal the need for maintenance or replacement of the equipment [15].

The concept that has recently gained traction is known as the "Internet of Things," or CoT for short. It refers to a network in which all aspects of the physical world are connected to the internet through the use of a wide variety of sensors. It lessens the need for human contact while simultaneously enhancing productivity, precision, and financial benefit, and it opens up opportunities for a more direct integration of the real world into computer-based systems. Additionally, it allows things to be remotely detected or controlled using the infrastructure that already exists for networks. "Cloud computing" is a paradigm in computing that gives large groups of privately, publicly, or hybridly connected systems on-demand access to either application data or storage space. It is currently the most popular buzzword in the information technology (IT) industry. It provides a brand new method for installing, using, and exchanging information technology services that is based on the internet and includes the provision of resources that are elastic, extensible, and virtualized. The reusability of information technology skills lies at the heart of the revolutionary idea of cloud computing. This aspect is essential to achieving optimal levels of cost-effectiveness. It broadens perspectives beyond the confines of corporate boundaries by providing a feasible method to experience immediate cost savings in compute, application hosting, content distribution, and storage. Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) can all be deployed on Public, Private, or Hybrid clouds. The term "cloud" can refer to a combination of networks, hardware, storage, and interfaces to deliver a service. SaaS, PaaS, and IaaS are all abbreviations for "Software as a Service [16].

Figure 2: Overview of the Implementation of an Automated Irrigation System Based on the Cloud of Things.



6. Analysis

COT systems make use of hardware that has the capabilities of sensing, actuation, control, and monitoring respectively. due to constraints imposed by both time and space (i.e. memory, processing capabilities, communication latencies, and speeds, and deadlines CoT devices can exchange data with other connected devices and application, or collect data from other devices and that collected data sends to base station server and from it to cloud server by using gateway or perform some tasks locally and other tasks within CoT Infrastructure). A device that uses the IoT might have many interfaces, allowing it to connect to other devices through wired and wireless means. The communication block makes it easier for devices and remote servers to exchange information with one another. In general, the data connection layer, network layer, transport layer, and application layer all make use of the communication protocols that are provided by COT [17].

6.1 Applications of CoT in Agriculture

CoT is putting the power back where it belongs, which is causing a transformation in the agricultural business. This transformation includes disease control methods as well as

technologies for monitoring livestock and fields. Right into the hands of the farmers. Agriculture, livestock management, and aquaculture are just few of the major industries that have benefited significantly from the use of this technology.

6.2 Robotics

Since the beginning of the third industrial revolution, there has been a significant advancement in robotic technology, which has been helped along by the growth of the internet. Agricultural robots, also known as agribots, might provide a workaround solution to the issue of labor shortages in the food and beverage industry, despite the fact that they are unlikely to fundamentally transform the sector. Unmanned Aerial Vehicles, sometimes known as UAVs, may be used to survey a field and eradicate any weeds that they find there. By accurately responding to the demand, they might save farmers time, human resources, and the amount of spray that was needed. Because of these savings, the soil will be healthier, as it will be exposed to a lower level of pesticides and weedicides and will have an increased number of beneficial microorganisms [18].

Table 1: Global market for agricultural robots from 2020 to 2025

Year	Average
2020	7.5
2021	8.9
2022	11
2023	13.8
2024	15.8
2025	21.6

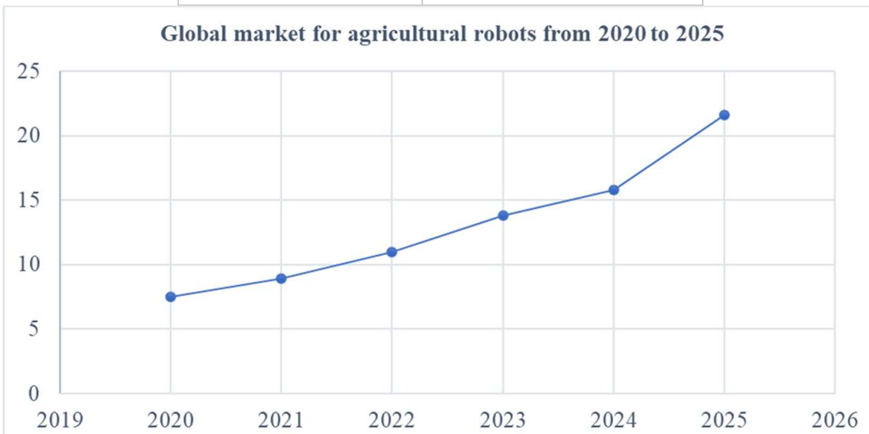
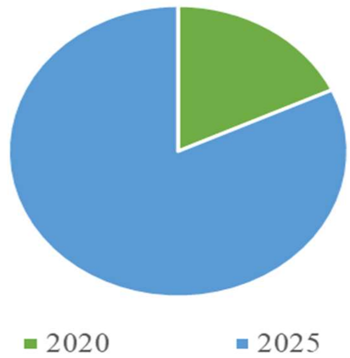


Figure 3: Global market for agricultural robots from 2020 to 2025

6.3 On-field Navigation

The use of humans to navigate manned machines is becoming increasingly obsolete as technologies such as machine learning, GPS, and the internet of things become more widespread. Smartphones allow farmers to exercise remote control over a wide variety of farm machines, including tractors, rotavators, and other implements. As the program memorizes the rough spots, it will learn how to adjust the gears and smoothen the navigation in order to safeguard the crops as well as the machinery.

Figure 4: Attractive Opportunities in The Agricultural Robots Market



6.4 Automated Crop Harvesting

The harvesting of crops frequently proves to be a difficult task for farmers, frequently as a result of late harvests. It's possible that the weather, inexperienced workers, or other aspects of farm management played a role in causing these incidents. With the wealth of information that we currently have at our disposal, harvesting robots could be programmed to pick the appropriate fruit at the appropriate time. Farmers would be better off hedging their bets with varieties that are supported by minimum support prices if they had access to the technology that is provided by the Internet of Things to grow high-value crops at scale [19].

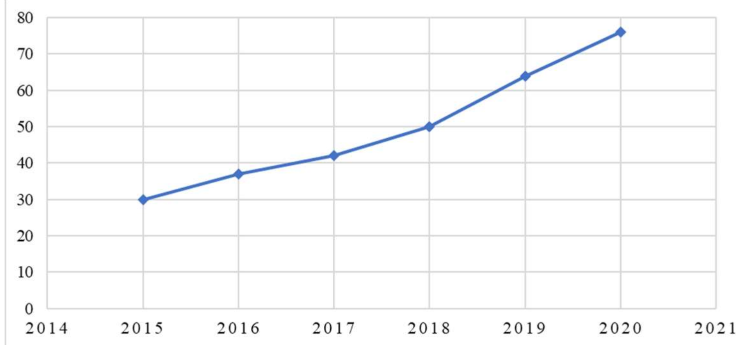
6.5 Remote Sensing

Installation of on-field sensors is just another method by which the food sector is increasing its thirst for the Internet of Things. Sensors are built with the purpose of identifying anomalies in a variety of factors, including the weather, crop nutrition, the pH of the soil, and more. Farmers benefit from this kind of crop monitoring system since it provides them with information in advance and alerts them to be ready for any contingencies [20].

Table 2: Estimate Agricultural CoT Device Shipments Global

Year	CoT Devices Shipments (Millions)
2015	30
2016	37
2017	42
2018	50
2019	64
2020	76

Figure 5: Estimate Agricultural CoT Device Shipments Global



7. Conclusion

With the advent of the Cloud of Things (IoT), the purpose of smart agriculture is to provide the most recent technology in agriculture and farming in order to improve crop production. This will be accomplished by gathering the current real-time status of the crop and helping farmers understand the advancements that have been made in agriculture, which will include a large number of additional features and benefits that will help improve farming practices. In the study, we examined a concept for a Smart Drone that has been offered. This Smart Drone would act as an eye in the sky for agricultural land and would be more effective than satellite technology in the construction of a Smart Agriculture. The public cloud is considered in relation to its significance in agriculture due to the fact that it may facilitate the sharing of resources, the reduction of costs, and the storing of data. There are a number of different characteristics that might be added to Smart Drones in order to increase their usefulness. Additional advantages include expanding the capabilities of the drone by including a pluggable scheduler and an intelligent analyzer into the drone itself. These features assist in reducing the amount of human involvement that is required whenever an unusual discovery is made in the crop. There will be additional safeguards and hazards implemented. It is necessary for drones to have reprogrammable software that can assist the drone change its flight path, return to its home base, and land safely.

The cloud application that is used to provide agriculture with a service for all of the users of this resource and the data center of CoT that is based on cloud computing have a responsibility to provide more dependable virtualized platforms that will assist in the construction of a more sustainable smart agriculture. With the help of CoT -enabled technology, precision agriculture may achieve greater levels of accuracy and productivity. CoT has a number of potential applications within the agricultural industry. The first of these applications is in the field of water and energy management. In the agricultural industry, water and energy are two of the most important inputs, and the costs associated with them can make or break an agricultural business. Water is wasted as a result of irrigation systems that are prone to leaking, ineffective field application techniques, and the placement of water-intensive crops in locations that are not optimal for their growth. Energy from an electrical source is required for the functioning of various pumps, boosters, and lighting systems. Monitoring and adjusting the amount of water, as well as its position, timing, and duration of flow, may be done using CoT, allowing for more efficient water usage in agricultural settings.

With CoT, the right choice may be made via the deployment of sensors and image-capturing equipment in the crop field, all of which are linked to the internet. With the help of CoT, one may make more effective use of fertilizers and insecticides. The conclusion that there is a need to develop on optimal Agri-CoT architecture, which must be enclosed with low cost, low power consumption of devices, better decision making process, QoS service, optimal performance, and it must be easy to understand for farmers who have no prior knowledge.

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