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IoT Based Smart Farming: Applications, Technologies and Future Vision

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***Abstract*: Agriculture is our main economic occupation for ages. But agriculture is primarily limited by the migration of people from rural to urban. To solve this problem, we will use IoT to develop smart agriculture techniques. The Internet of Things (IoT) technological developments has created a revolution in every common field of life, intelligent and smart. IoT refers to a network of things that create their own network. The development of IoT-based Intelligent Smart Farming equipment turns the face of farm manufacturing every day not only into an improvement, it also makes it cost-efficient and reduces waste. The primary objective of the project is to make agriculture intelligent through automation and IoT.**

***Keywords*: IoT, Smart Agriculture, Agriculture framework**

I. INTRODUCTION

Together, the supply of industrial agriculture as well as global civilization enhanced agriculture to provide the people of the world. The agricultural domain employs new techniques and solutions [1] to provide the best solution for data collection and processing [2] while at the same time boosting aggregate profitability. Simultaneously, the unprecedented temperature change and severe soil crisis [3] demands new and improved modern industrial and agricultural technologies. To achieve this mission, automation and intelligent decision are becoming extremely essential [4]. The internet of things is becoming increasingly common in this regard [5], and all-embracing computing, mobile ad hoc sensors and networks [6], radio frequency ids [7].

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II. MOTIVATION

This paper has been influenced by various motivational factors, as noted below:

− The region of agriculture in the implementation of the IoT to improve traditional farming techniques has mostly been explored [8]. The fast development of nanotechnology in the last century has made it possible to generate tiny and inexpensive detectors.

− IoT is an intrinsically and cost-effective tool for self-organization, decision-making, and automation in agriculture cum agriculture due to its nature, along with the modularized hardware platforms and scalable technologies. There are some key applications in this respect: high-precision agriculture [9], automated irrigation schedules [54], crop development optimization [10], agricultural property monitoring [12], greenhouse monitoring [13], and crop farming system management [14].

− These restrictions present difficulties in the development of agricultural IoT apps. Most IoT applications are targeted for different applications in agriculture. In the prediction of crop health and production quality, for example, IoTs for monitoring the environmental conditions with information of soil nutrients are applied over time. IoTs are anticipated to plan irrigation, tracking soil humidity and climate.

− As it is scalable, it is possible to improve the efficiency of a current IoT implementation to track more parameters by only including other device devices for the current design.

− The problems of these apps include interoperability for the computer, heterogeneity of innovation, safety, intervals estimation, and procedures for scheduling.

− In the general situation, IoT-based agriculture alternatives must be extremely cheap for end consumers to afford. However, the supply for food grain is growing exponentially with the growing population. The latest study advises that food grain manufacturing development is less than population growth [15]. This prompted scientists to require the use of sophisticated techniques to increase manufacturing. The Food and Agriculture Organization [16] recently released report states that by 2050 the requirements for food grain worldwide will reach 3 billion tones. In many agricultural applications, therefore, new and modern technologies have been taken into account to achieve the goal.

III. IOT AGRICULTURAL FRAMEWORK

This chapter offers a comprehensive structure for IoT solutions in complete (Fig. 3.1)

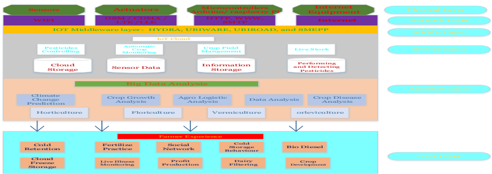

Fig: 3.1 IoT agriculture framework

The current architecture seems to be a six-stage model, which covers hardware, Network and allied communications technology, IoT middleware, IoT resources with cloud computing capabilities, large data analytics and the full experience of farmers.

− Physical layer: The system's lower layer consists of various types of detectors, actuators, microcontrollers, network equipment such as access points, switches, controllers, etc ... Here you sense the environmental parameters, work on predetermined tasks and manage the lower ground work.

− Network Layer: This layer contains the Internet as well as other relevant communications technology. In the agricultural fields, WIFI, GSM, CDMA, LLE (4 G) technology is commonly used. ZigBee is one of the most suitable forms of communication when no GSM / CDMA / LTE options are available. In agriculture scenarios, the HTTP, WWW, SMTP protocols adapt to Internet facilities paving.

− Middleware layer: IoT-based middleware performs device administration, context-based knowledge, ability to interact, portability of platforms and related security functions.[16] The functionality of various types of middleware like HIDRA, UBIWARE, UBI ROAD, and SMEPP is best known from the context; -

− Service Layer: The support layer of the IoT cloud services plays an essential role in providing agricultural issues with cloud storage as well as with SaaS. Software as a service. The collection of sensor data, equipment identification, storage for information on crop diseases, and statistical analysis services are designed to enable the pursuits of sense, performing and determining diseases. Furthermore, the management of livestock, management of crop fields, control of pesticides and automatic monitoring services are designed to provide value through agricultural information. Farmers could receive information via the web, message and expert services.

− Analytics Layer: This layer enables business intelligence and multi-cultural analysis to perform big data processing. Prediction is specifically designed to measure deterministic yield productivity probability in the next season. Farmers can be better acquainted with the post-apocalyptic climate of the area filed, including soil moisture, warmth, heat, the intensity of light, rainfall. This leads to precautions to save agricultural land. The ability to detect the probable situation of various crop diseases based on recent data is provided here.

The farmers can understand the motivations and trend of the disease intrusion and weed on the ground. Introduced to only the agrological unit were the highly optimized costs of further repair to vehicles like tractors and so forth and the way such vehicles have been used to increase the gross margin by sales of goods. It will have a strong impact on crop and vegetable preservation as much is lost due to a lack of timely use. Prediction can even be used to learn a gain or loss claim which may occur next season.

− Big data analysis is therefore sufficient to minimize several scientific risk factors for environmental aspects. Besides, the framework to develop, process and properly handle a few types of agriculture is added to an important level of multi-culture assessment. Big data analysis may be available for aquaculture to determine the growth rate of botanical water. Similarly, fish breeding and fish farming development can be predicted. The seasonal production, pesticide control and profit margin analyze of fruits, flowers and grapefruit, such as orange, etc. that benefit directly from horticulture, floriculture and urban plants, which can be analyzed with a wide range of data. Vermiculture will be used for

earthworms rearing or cultivation. Vermicompost is an agricultural fertilizer produced by microbial production. Because forests play an important role in human life, the development, production, structure, health and efficiency of forests can be effectively monitored to support different human desires. By using environmental analyses big data can improve the process of forestry growth. Plant cultivation is special cultivation referring to trees and bushes, vines and other transitory softwood crops.

− Big data methodology could be suggested to know how these plants are developed and how statistical modeling can respond to their environment. Olericulture is capable of forecasting the growth rate of human society's food consumption of vegetable plants. Big data analysis can assist simulate water requirements, temperature, and adequate fertilization to increase herbal plant productivity.

− User Experience Layer: this is the highest level, fully developed for farmer experience. This layer enables the farmer to interact through social network operations with representatives of the society to educate and disseminate information on different characteristics of agricultural fields from politics to economy. Cold retention serves to hold plants in several stages for consumption. Competent studies and model analyze of freeze stored could increase farmer's profit production. Farmers are authorized to determine the adequacy of the productive choice for efficient crop development. Furthermore, this coating also includes several agricultural apps. To understand the trend of resin manufacturing between the tree, resin extraction from the plants can always be linked to the IoT structure and may lead to the group exercise of scientist's use while producing elevated income. The IoT structure is to mix dairy facilities, including dairy manufacturing, dairy filtering, advertising, livestock illness monitoring, etc. to generate enormous gains in cash and wealth. Tree-and-crop power generation has become an option to standard hydropower generators, heat sources and nuclear power generators, etc.

IV. IOT BASED AGRICULTURAL APPLICATIONS

This chapter provides a catalog of potential IoT-induced agriculture, agriculture, and associated applications.

− Management of agricultural systems: modern cultivation needs an enhanced governance scheme for drainage to optimize energy use in farming and associated activities [18].

In intelligent irrigation systems, four variables are often used, such as the inclusion of real-time climate predictions, the management of students ' homes systems from all around the globe, Wi-Fi and Ethernet access, the addition of moisture sensor synchronization integrated in the farmyard and the reduction in producers ' monthly charges, while assisting to preserve water resource constraints.

− Pesticide and infection management: Controlled use of pesticides increases the performance of crops and minimizes the price of agriculture. We must nevertheless monitor the likelihood and incidence of pests in plants to control the use of pesticides. We also need the use of sensor nodes, data collection, and mining to collect information on disease and insect pests using the IoT infrastructure [19]. To forecast this, we also need it. There is a three-layered IoT framework that can define the disease and act to detect the causing plague. The architecture Farmers can indicate the medication they need to save their bodies.

− Overall monitoring of movement of cattle: The IoT also enables a livestock herd, which can be farm raised in an area, to be monitored in real-time.

− Dairy surveillance: IoT-based storage applications like the connecting age are presently common for intelligent checking of milk products. It is capable of providing various conduct detections and forecasts such as animal heat and strut models, life analyses and also predict the next system begin times for the future. Additional features can be introduced to the facilities in addition to employee behavior evaluations and place.

− Monitoring air value: the place of cellular communication-enhanced detector stations helps to monitor air value. The latest paper examines air performance in actual moments using IoT.

− Monitoring the situation of greenhouse: Greenhouse and farming interconnect tightly. Greenhouse gas emissions have an immediate effect on agriculture and increase climate temperature. Greenhouse gas emissions on the other side depend on pH, temperature, carbon dioxide, etc. Harvest Geek offers an IoT cloud-based facilities which can be independently monitored by the customer or independently by himself.

− Soil surveillance: for the agrarian sector, soil ownership is essential. Soil knowledge contributes to the manufacturing of bodies a benefit. [20] 6LoWPAN with IoT technology has been integrated to directly add soil conditions while installing different sensor nodes. SNMP is used for real-time monitoring of the network.

− Agricultural accuracy by UAV: Agricultural accuracy for the successful results of a farm can be achieved with the use of sophisticated techniques such as UAV and Drone. Precision Hawk, the company's UAV, GIS, and sensor leverages allowed the IoT cloud to implement artificial intelligence on the aerial traffic calculations for weather conditions identification in the atmosphere (www.precisionhawk.com). Moreover, in-flight diagnostic tools and surveillance procedures continuously track their flight position and count on supporting operating wind/weather constraints, property surveying, and ERS.

− Management of the supply cycle in agriculture implies governance of manufacturing: farm goods must be efficiently controlled for farmers to obtain profit, and therefore operational efficiency. IoT may supervise the supply chain administration for large-products. How IoT is applied to business processes in the consumer supply chain and how IoT supply chain impacts drive the acceptance of agricultural products. It also offers the node companies of the item chain with a reference structure for the needed consequences.

V. IOT AGRICULTURAL TECHNOLOGIES

This chapter addresses IoT technique knowledge in various agriculture applications, such as hardware devices including wireless transmission systems. In forestry, IoT infrastructure applications. Many IoT based service providers specific to such applications are also investigated in the current industry.

5.1 Hardware platform

A variety of distinct hardware systems backed by IoT are available for agricultural use.

5.2 Communication Protocols

It creates the core of IoT systems and allows the network to be connected and linked with apps. Wireless communication specifications Communication procedures enable equipment to network information return. The protocols define the formats for information return, information encryption, device address systems and packet transmission from origin

to target. The protocols are also used to control sequence, control free flow and retransmit lost packets.

5.2.1. 802.11–The Wi-Fi IEEE 802.11 set is a set of interaction norms for the Wireless Local Area Network (WLAN). For instance, the 5 GHz range is operated by 802.11a, the 5 GHz range are used, the 5 GHz range is operated by 802.11b and 802.11 g and the 2.4 GHz band 802.11. In, the 5 GHz band are operated by 802,11a and the 60GHz band is operating by 802.11a. Such standards have data prices from 1 Mbps to 6.85 Gbps. The contact range of the Wi-Fi is from 20 m (internal) to 100 m (external).

Fig: Wi-Fi IEEE 802.11

5.2.2. **WiMAX IEEE 802.16** – The standard set is a WiMAX IEEE 802.16. The standard WiMAX provides information speeds between 1.5Mb / s and 1Gb / s. Worldwide Interoperability for Microwave Access. In the recent update (802.16 m), information rates for portable devices are 100Mb / s and fixed devices are 1Gb / s. The specifications can be found easily on the page of IEEE 802.16.

Fig: WiMAX IEEE 802.16

5.2.3. LR-WPAN IEEE-802.15.4- These laws are the basis for high levels of communication protocols such as ZigBee. Standards from the LR-WPAN have 40 Kbps and 250 Kbps for data rates.

The LR-WPAN IEEE 802.15.4 standards for LR-WPAN are a low-level set of specifications for the WLAN network. These rules ensure that computers with reduced energy consumption have low cost and low-speed communication. It works with 868/915 MHz and 2.4 GHz, both at high and low price for data. The 802,15.4 standards are guidelines on the IEEE 802.15.15 workstation Website.

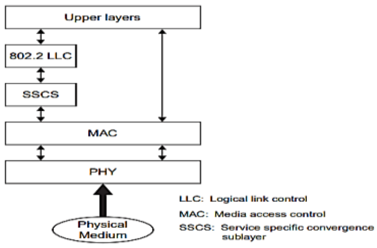

Fig:LR-WPAN IEEE-802.15.4

5.2.4. **2G/3G/4 G**– Changing connectivity Wireless standards for 2 G, like GSM and CDMA were available for various generations; 3 G, (even CDMA2000 ad UMTS), 4 G and 2G/3G/4 G are available. In compliance with these standards, IoT systems can transmit through cellular networks. The data rates for these standards sha ll be 9.6 Kbps (2 G).

Fig: 2G/3G/4 G

5.2.5. 802.15.1-The specification is used for Bluetooth (http:/www.bluetooth.org). This is a small-power, cheap cellular communications technique appropriate for short-range (8-10 m) information transfer between mobile devices. The Bluetooth protocol defines the communication of the PAN. It works at 2.4 GHz. In different Bluetooth range variants, the Bluetooth rang of1Mb / sto24Mb / s. Bluetooth Low Energy (BLE or Bluetooth Smart) is the ultra-low-power, low-cost variant of this norm. In 2010, BLE had previously been combined into Bluetooth v4.0.

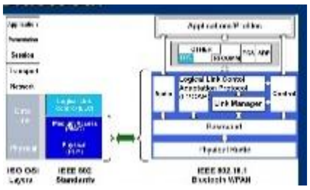

Fig: IEEE 802.15.1

5.2.6. LoRa WAN R1.0 – LoRa WAN (https:/www.lora-alliance.org) is a long-range messaging system lately established by the accessible, non-profit LoRaTM Alliance. It sets the norm of Low Power Wide Area Networks to allow IoT. Its main objective is to ensure interoperability between different carriers in an accessible worldwide norm. Lora WAN data rates vary from 0,3 to 50 kbps. Lora operates in 868 and 900 MHz ISM channels. In unimpeded environments, as per links capes (HTTP:/postscapes, com / lengthy-range, mobile-IoT-protocol-Lora), Lora can interact with the connected devices at the range of 20 kilometers. For the linked node, battery life is normal.

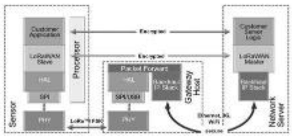

Fig: LoRa WAN R1.0

VI. FACTORS REQUIRED FOR AGRICULTURAL

The following list shows the IoT-related factors that need extra attention in the upcoming years.

− Autonomy: potential apps must be completely independent to meet the specific requirements.

Cost: The development and use of IoT-based alternatives are acceptable with low-cost alternatives.

− User monitoring board: In general, non-technical individuals in the workplace use approaches focused on IoT-agri. Thus, user-friendly application information for reliable applications will be a superior design.

− Energy: the current IoT farm needs green computational methods to be disseminated with IoT systems consuming very much less electricity, which may boost their lives expectancy pattern and render them less defective, hence extremely efficient.

− Interoperability: Interoperability problems in IoT systems are also the most prevalent. Devices should interact sufficiently with others of distinct genres so that the scheme generally works as a permanent environmentally friendly installation.

Artificial Intelligence: Applied by sophisticated policy supporting scheme and real-time assessments, machine learning and machine learning techniques must together be applied to meet predictive and behavioral analysis functionalities.

− Maintenance: IoT devices are intended to reduce all maintenance and costs, to an approval decline for the inexperienced customers.

− System portability: To be sufficiently requested with various environmental elements, the probability of current structure architectures should be enhanced.

− Robustness: To ensure that devices function sustainable manner, the IoT's design must be solid and fault-tolerant.

− Weather, soil and water: variations in temperature, ground and air across the globe tend to become the most challenging aspect to establish an Internet of things-based cultivation scheme. Farmers should be fitted with local climate sensors to connect with national climate centers in order to raise awareness before the unexpected scenario. This could increase plant production and precisely resist agri-product destruction.

− The segmented soil framework: divided soil agriculture in many nations across the world generates an issue. To address this specific issue, the appropriate IoT architecture will be created. This issue needs to be addressed in advance by adequate strategy and adequate scheduling.

− Low servicing: Maintenance involvement generates great difficulty at a moment. Therefore, a low maintenance scheme must be designed that can automatically execute the duties optimized by natural interference.

− Portability: Portability is an important factor that would make it harder to control the system. So, mobile device types like SoC (system-on-chip), SiP (system-in-package), etc.

VII. EXPERIMENT AND RESULTS:

Drone centered IoT controlled precision agriculture is takes place throughout different places around the world (http:/droneapps.co/case-study-drone-precision-farming/). Drone has been used to investigate the possibility in using airborne imagery to offer farmers data on request, about their fields. Presently, Agribotix will use its Hornet drone fixed wing or Enduro drone depending on RV Jet air frequency from Range Video and fitted out of high-grade completely non-distorting camera lenses and nearly-infrared (NIR) (Canon's) S100 etc and GoPro video cameras. A snap probably taken and collected and analyzed mostly by the predator drone while flying over all the target field is shown in Figure 7.

Fig. 7. Agribotix Imaginary analysis done by drone.

Table describes all the parameters associated with this system.

Parameter	Value
Transmitter	RC
Drones	Hornet-fixed wing, Enduro
Hornet	long range Cruising Speed 33 mph, Linear Flight Distance 40 Miles, Flight Endurance 80 min, Maximum Wind Tolerance 20 mph, Batteries 2
Enduro	drone Cruising Speed 30 mph, Linear Flight Distance 13 Miles, Maximum Wind Tolerance 25 mph, Acres Covered/Flight 160 acres, Telemetry Range 1 mile
Imaging	hardware IR: GP Hero4 Silver RGB camera with non-distortion lens, GoPro Hero4 Silver with non-distortion lens and red-notch filter,
Data access	Smart phone, PC and tablets

Pros of drone:

1. Infra-red imagery analysis algorithm is used.
2. Better data quality
3. Flexible analysis
4. Easier to deploy
5. Crop spraying

Cons of drone:

I. Cost and energy efficient need to be optimized
II. Subject to weather conditions
III. Requires a high level of skill
IV. High Initial Investment

VIII. CONCLUSION

The introduction of IoT is intended to be helpful by presenting different features for the promotion of agriculture. In this document, I propose to leverage the full-blown mix between agriculture and IoT depending on the IoT agricultural structure. First, I present the idea, definition, and features of IoT. Then I emphasize the numerous main agricultural IoT apps. The following chapter of this article discusses the hardware systems in the industry accessible in the field of agriculture. Different wireless communication techniques have also been provided which are suitable for agricultural applications and various levels of layers useful in the IoT framework. In the future, IoT has a great extension feature and the various development technologies are generated in the forthcoming future.

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