A Survey : Smart Agriculture IoT with Cloud Computing

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Abstract—

IoT is a revolutionary technology that represents the future of computing and communications. Most of the people over all worlds depend on agriculture. Because of this reason smart IT technologies are needed to migrate with traditional agriculture methods. Using modern technologies can control the cost, maintenance and monitoring performance. Satellite and aerial imagery play a vital role in modern agriculture. Precision agriculture sensor monitoring network is used greatly to measure agri-related information like temperature, humidity, soil PH, soil nutrition levels, water level etc. so, with IoT farmers can remotely monitor their crop and equipment by phones and computers. In this paper, we surveyed some typical applications of Agriculture IoT Sensor Monitoring Network technologies using Cloud computing as the backbone. This survey is used to understand the different technologies and to build sustainable smart agriculture. Simple IoT agriculture model is addressed with a wireless network.

Keywords— Internet of Things (IoT); Cloud Computing; Li-Fi; Gprs; Agriculture Monitoring, Irrigation, Routing Protocol.

I. INTRODUCTION

Around 60-70 %(predicted value) Indian population directly or indirectly depends on agriculture. That effects on food security and economic growth of India. With help of Precision, agriculture process can easily monitor or observe of crop growth based on collected information (soil condition and weather information) from a crop field. This mechanism also called as satellite farming or site-specific crop management (SSCM) [1], manually can't able to collect environmental information because it is a tuff task. New farmers are coming out without knowledge of soil characteristics because insufficient soil testing labs properly not available in the states of the country. So now what is the importance of IoT in agriculture? The solution is Manual data collection; absolutely it is a risk for farmers and also to processes from the crop field. So it is difficult for farmers to get optimal levels of efficiency. To solve this difficulty, IoT (Internet of Things) is only the solution. It plays vital role in collecting information. IoT has been already in raising with novel multiple techniques. In this paper, a survey on smart agriculture IoT with cloud computing is carried out to understand the recent IoT-based technical developments in smart agriculture is explained in Section II, Section III describes a conceptual model for IoT and Wireless sensor network based agriculture with cloud computing, Section IV describes a hardware analysis of architecture, Section V describes a mathematical explanation, Section VI describes a future work.

II. LITIRACHER SURVEY

In papers [2][3][4] proposed an agricultural application of wireless sensor network for crop field monitoring. These systems fully equipped with two type sensor nodes to measure humidity, temperature, and an image sensing node to compare information by taking images of crops. Parameters play an important role for taking a good decision making for healthy crop within a time. The parameters are temperature, humidity, and images. By following these methods can achieve high stability of sensors with low consumption of power. With it's a long period of monitoring the agriculture field area. Paper [5] proposed a greenhouse Monitoring System based on agriculture IoT with a cloud. In a greenhouse, management can monitor different environmental parameters effectively using sensor devices such as light sensor, temperature sensor, relative humidity sensor and soil moisture sensor. Periodically (30 seconds) the sensors are collecting information of agriculture field area and are being logged and stored online using cloud computing and Internet of Things. [6] Papers explain an IOT Based Crop-Field Monitoring and Irrigation Automation system. In their work, to monitor crop-field a system is developed by using sensors and according to the decision from a server based on sensed data, the irrigation system automated. By using wireless transmission the sensed data forwarded towards to web server database. If irrigation is automated then that means if the moisture and temperature fields fall below of the potential range. The user can monitor and control the system remotely with the help of application which provides a web interface to the user. In [7] proposed a smart drip irrigation system. In this, an Android mobile application is used to reduce the involvement of human and it used to control, monitor the crop area remotely. Water wastage can reduce with Drip Irrigation system and it works based on information from water level sensors. Some more different sensors are used to monitor the environmental

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conditions. [8][9][11] Proposed smart irrigation systems using Internet of Things. To calculate humidity and water levels of soil some wireless sensors are needed. These sensed data are sent to a smart gateway through a network, using a gateway called Generic IoT Border Router Wireless Br 1000. From the gateway, the data is then sending to a web service through a network. [12] Conducted a survey on Smart Agriculture Irrigation systems to get better understand about the IoT-based development in agriculture with cloud computing.

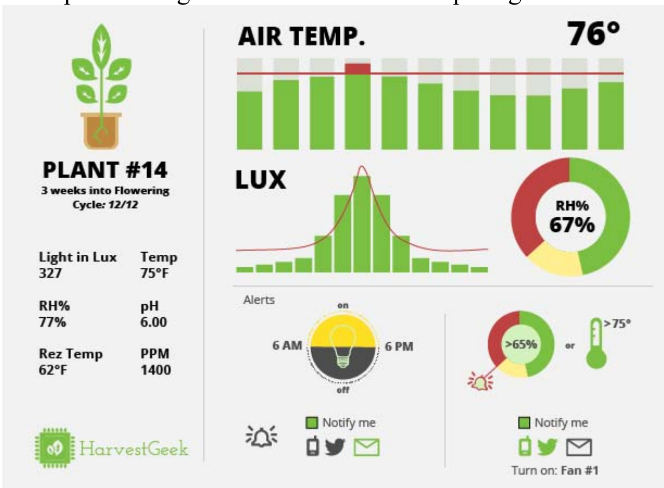


Figure (1): Tempareture and weather sensors

IoT-based smart agriculture system designed to perform various agricultural activities like weeding, spraying, moisture sensing, bird and animal scaring [13]. A GPS based robot has developed for this purpose. Here one intelligent decision making is proposed for smart control and irrigation system for monitoring agriculture area along with database management system [14]. To store the collected data here one database management is needed and it contains all soil information. Based on the temperature sensor values they have mainly focused on automatically controlling the water flow to the agricultural field. pre-prediction of rain can be done with the help of sensor to sense the weather condition, this will be intimated to farmer‘s smartphone for his references through GSM.

In wireless sensor networks automatically analyze sensed data from agriculture area field by using intelligent software application and this will take a decision, that is forwarded to the farmer for a healthy crop.[15] in this paper author Proposed a low maintenance and high gain Agriculture using novel Eco-friendly and Energy Efficient Sensor Technology. this paper clearly explains about automated farm monitoring and irrigation techniques which include wide range of sensors to remotely sense and monitor various parameters of the soil like temperature, moisture, and fertility and controls the supply of water and fertilizer to the land.

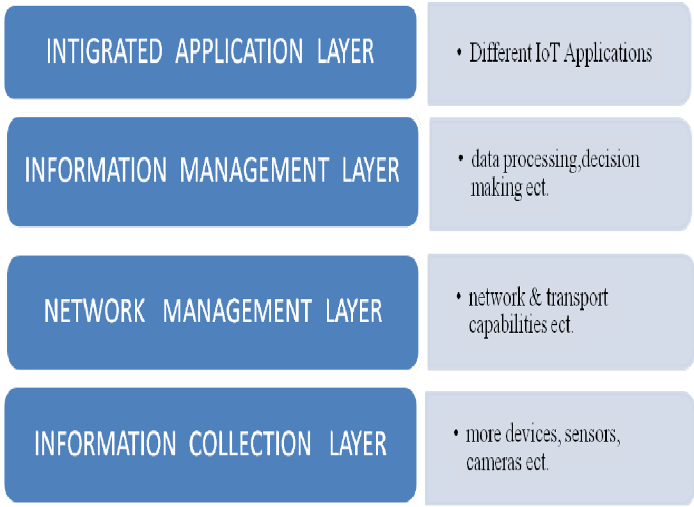
[16] GSM Proposed a system for monitoring Pest Insect Traps Using Image Sensors & Aspic. GSM used distributed imaging devices which are operated through a wireless sensor network. GSM is used to acquire and transmit images of the trapping area to a remote host station. To the farmer‘s mobile information regarding pest, accumulation is sent via call/message. This method only detects pests doesn‘t suggest any method to control the pests. For controlling the deceases of crop one spray system is needed for pesticide utilization [17]. In Paper [18] Design and Development of Automatic Weed Detection and Smart Herbicide Sprayer Robot are presented. For identification of deceases in a crop can do with the help of an image processing algorithm. In which images are captured of a crop can be easy to identify the weeds of a crop as an interval manner. In paper [19] Proposed a Smart Beehive for Environmental, Agriculture, and Honey Bee Health Monitoring. Within and outside a living beehive for monitoring the multidimensional conditions such as oxygen, carbon dioxide, pollutant levels, temperature, and humidity paper [19] deployed a wide range of sensors. From the results obtained they have developed an algorithm for automatically determining the status of the bee colony. Based on Predicted Evapotranspiration a Green Roofs Smart Irrigation Controlling System is explained in [20]. For buildings, Green roofs are beneficial in a number of ways. Crops in green roofs are exposed to direct solar radiation and strong winds. This paper contains a new system Based on Predicted Evapotranspiration a Green Roofs for Smart Irrigation Controlling System. For deciding the amount of water to be irrigated this system is capable of predicting the evapotranspiration.

A Sensor Network Data acquisition and Task Management for Decision Support of Smart Farming [21].In order to perform necessary tasks required for farmers using Internet of Things (IoT), this paper presents a conceptual model and system design for decision support of smart farming with network sensor applications. A Smartphone Irrigation Sensor [22] is proposed. To use in agricultural crop field they designed and implemented an automated irrigation sensor with the utilization of Smartphone we can capture and according to with that digital images can able to find out and monitor the crop area and easy to measure water levels. Smart agriculture monitoring system used for controlling and can increase the yield production value [23]. Without the involvement of human they can identify rodents, deceases of crops and send update notification analysis information and processing is focused here. Using Python scripts sensors and electronic devices are integrated. Based on attempted test cases, they were able to achieve success in 84.8% test cases. An experiment for Implementation of IoT and Image Processing has been conducted. Smart Agriculture [24] describes an approach to combine IoT and image processing in order to determine the environmental factor or man-made factor (pesticides/fertilizers) which is specifically hindering the growth of the plant. Decision-making system used to take the better analyzed process from collected information of difficult environment system and the image of the leaf lattice; it is processed by MATLAB software by the help of histogram analysis. In paper [25], it facilitates Smart Sensors Based Monitoring System for Agriculture to arrive at conclusive results. for monitoring agricultural environment a new different technology is used. That acts as the gateway (FPGA) which comprises of the wireless protocol, different types of sensors such as temperature, soil moisture, and relative humidity sensors, microcontroller, serial protocol and the field programmable gate array with the display element. With the wireless Bluetooth module, the sensed data in an agricultural environment is provided into a microcontroller and interfaced. A wireless transmitter receiver module pair helps in transmitting and receiving the data which is then fed to FPGA using a serial communication protocol UART. To monitor the level of prelatic aquifers they have presented a smart, ultra-low power, cheap and energy neutral system with Microbial Fuel Cells [26]. The Lora TM radio chip is used to transmit acquired data kilometers away also in a noisy environment keeping low the complexity of the network. By means of a terrestrial Microbial Fuel cell the device power supply is generated in an eco-friendly and zero emission manners. In paper [27] by using IoT technology the traditional methods are became Smart Agricultural Solutions to end users to get good yield. With the involvement of cloud computing and agriculture-IoT, the monitoring process became very fast and easy to maintain and helps to realize the smart solution for agriculture and efficiently solve the issues related to farmers. Agri-System is processed with input information's, may be PH value calculation, humidity prediction and temperature of apiculture area field and Multiprocessing can be achieved with cloud computing internet-of-Things (IoT), Sensors; Mobile-Computing & Big-Data Analysis [29] is used. Here, Soil and Environment properties are sensed and periodically and are sent to Agro Cloud through IoT (Beagle Black Bone). For fertilizer requirements, best crop sequences analysis, total production, and current stock and market requirements Big data analysis on Agro Cloud data is done. Proposed model is beneficial for an increase in agricultural production and for cost control of Agro-products. Automated Irrigation System is proposed with IOT sensors [30]: by using this method easy to maintain without an involvement of humans. The sensor senses the change in temperature and humidity whenever there is a change in temperature and humidity of the surroundings and gives an interrupt signal to the microcontroller. By reducing the power consumption Microcontroller in the system promises about an increase in systems life. For proper irrigation, this technique is used in Cricket stadiums or Golf stadiums and also in public garden area.

III. *FOUR LAYERS IOT-AGRICULTURE ARCHITECTURE*

A conceptual model for smart agriculture is proposed by analyzing the literature survey. Before that, let us know the overall structure of IOT. Constituting many physical devices in practice IOT basically has a three-layer structure. The first layer is the integrated application layers which in agriculture-related applications are operated because it is considered as user interface layer. It is user free and it includes farmer's cell phones and personal devices are takes place to monitor the agriculture area. According to with this layer the farmers can take a decision to protect their crop as healthy and get better food production output.

The second layer is information management layer which contains some responsibilities like formation and classification of data, creating, monitoring, decision making etc. These roles are maintained and performed in this layer. The third layer is network management layer which represents the communication technologies like Gateway, RFID, GSM, Wifi, 3G, UMTS, and Bluetooth Low Energy, Zigbee etc. The fourth layer is information collection layer which contains all types of sensors, cameras etc. These are used to collect information of crop for better and easy field monitoring of agriculture area. Figure 1 shows the four layer IoT structure.



Figure(2):layers of IoT architechture

In every method by default, a process is, several sensors are deployed in the crop field for measuring various parameters like temperature, humidity, soil PH, light intensity. Each device in the network will be assigned with an IP address for identification purpose. For example, the temperature sensor in the network will be addressed with object ID T1 within the communication Network. Addressing methods of IoT objects include IPV6 and IPv4.Identification methods are used to provide a clear identity for each object within the network., IoT sensors can be smart sensors, actuators or wearable sensing devices. The sensed data's from crop field are sent to a cloud through a gateway which is connected to the internet via Wifi or any other communication network. From the cloud, the data's are sent to farmer's smartphones or computers. By analyzing this data farmers can take appropriate decision.

IV. *ANALYSIS AND COMPARISION OF IOT HARDWARE REQURIEMENT*

Device: An IOT system uses devices which provide sensing, actuation, control, and monitoring activities. Based on temporal and space constraints (i.e. memory, processing capabilities, communication latencies, and speeds, and deadlines IOT 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 IOT Infrastructure). An IOT device may consist of several interfaces for communications to other devices, both wired and wireless. These include (i) I/O

interfaces for sensors, (ii) interfaces for Internet connectivity, (iii) memory and storage interfaces, and (iv) audio/video interface.
Communication: communication between devices and remote servers is done by the communication block. Data link layer, network layer, transport layer, and application layers generally work with IOT communication protocols.

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

Table (1): comparisons of wireless communications

Services: Functions such as device modeling, device control, data publishing, data analytics, and device discovery can be done by IOT system.
Management: Different functions like to govern an IOT system& to seek the underlying governance of IOT system can be done by management block.
Security: providing functions such as authentication, authorization, privacy, message integrity, content integrity, and data security can be done by security block. Security block also secures IOT system.
Application: For users, the Application layer is the most important layer. This layer provides necessary modules to control, and monitor various aspects of the IOT system. Applications allow users to visualize and analyze the system status at present stage of action, sometimes prediction of futuristic prospects.
Some of the wireless sensors are listed out below and explained briefly

i. 802.11 – Wi-Fi

IEEE 802.11 is a collection of Wireless Local Area Network (WLAN) communication standards. For example, 802.11a operates in the 5 GHz band, 802.11b and 802.11 g operate in the 2.4 GHz band, 802.11n operates in the 2.4/5 GHz bands, 802.11ac operates in the 5 GHz band and 802.11ad operates in the 60 GHz band. These standards provide data rates from 1 Mb/s to 6.75 GB/s. the communication range of Wi-Fi is in the order of 20 m (indoor) to 100 m (outdoor).

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 (2): Comparison of the IOT cloud platforms may be used for agricultural domains: a case study.

i. 802.16 – WiMax

IEEE 802.16 is a collection of wireless broadband standards. Data rates from 1.5 Mb/s to 1 GB/s provided by WiMAX (Worldwide Interoperability for Microwave Access) standards. Data rate of 100 Mb/s for mobile stations and 1 GB/s for fixed stations is provided by (802.16 m). On the IEEE 802.16 working group website (IEEE 802.16, 2014) specifications are readily available.

iii. 802.15.4 – LR-WPAN

IEEE 802.15.4 is a collection of Low-Rate Wireless Personal Area Networks (LR-WPAN) standards. High level communications protocols such as ZigBee are formed by

802.15.4. Data rates from 40 Kb/s to 250 Kb/s are provided by LR-WPAN. Low cost and low-speed communication to power constrained devices is provided by LR-WPAN. The low frequency data rate of LR-WPAN is 868/915 MHz and the high data rate frequency of LR-WPAN is 2.4 GHz.

iv. 802.15.1 – Bluetooth

IEEE 802.15.1 is the Bluetooth standard. For a short range (8-10 m) data transmission between mobile devices is provided by Bluetooth. Bluetooth is a low power, low cost wireless communication technology. The Bluetooth standard defines a personal area network (PAN) communication. It operates in 2.4 GHz band. Bluetooth data rate ranges from 1 Mb/s to 24 Mb/s. Bluetooth Low Energy (BLE or Bluetooth Smart) is the ultra low power, low cost version of Bluetooth. BLE was merged with Bluetooth standard v4.0 in 2010.

v. 1.5.6. Lora WAN R1.0

The LoraTM Alliance which is an open and non-profit association recently developed long range communication protocol called Low Power Wide Area Networks (LPWAN) standard protocol to enable IOT. The main aim of this protocol is interoperability between various operators in one open global standard. LoRaWAN data rates range from 0.3 kb/s to 50 kb/s. LoRa operates in 868 and 900 MHz ISM bands. LoRa communicates between the connected nodes within 20 miles range, in unobstructed environments according to post capes. Battery life for the attached node is normally very long, up to 10 years.

V. MATMATICAL EXPLANETION FOR HIGH YIELD PROCESS

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

$$\text{Yield} = \text{no. of plants/m2} \times \text{no. of effective fillers/plants} \times \text{ no. of grains/plants} \times \text{\% of filled grains} \times \text{test weight}/1000 \times 10{,}000/1000.$$

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

$$\text{Biological yield} \times K = \text{economic yield}$$

A crop which produced a dry matter is called Biological yield and a fraction of biological yield which is used by man is called economic yield.

In order to get high production yield, two important parameters are involved. Temperature and soil moisture. The temperature and soil moisture must within 18-25̊ c and 15-60% respectively.

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

T = temperature optimal range 18-25̊ c
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 production yield. It seems must be within optimal range only.

VI. FUTURE WORK

A large research effort is still required although the architectures described in earlier section make IOT concept practically feasible. Technical problems associated with current IOT architectures are reviewed in this section. To meet all necessary parts that are missing in existing architecture, later on, a novel concept of IOT architecture was developed. Before the IOT will be widely accepted and deployed in all the domains, a sufficient understanding of industrial characteristics and requirements on factors such as cost, security, privacy, and risk has to be discussed. Let us discuss a few problems in this regard:

a) Maintaining cost- is a more important parameter in case of farmers. So on order to reach this point, researcher concentrate on developing new smart agriculture IoT architecture with added advantages.

b) Current database management system may not handle in a real-time manner because the originated data may be too much large in size. Proper solutions need to be idealized. In a rapid speed, IOT based data would be generated. Current RAID technology is incapable of handling the collected data at receivers end. To handle this problem IOT based data service-centric architecture need to be revised.

c) Data is a raw fact that generally does not conform to non-relevant handouts. Data play the massive role in decision making in IOT. The value of data is the pool of data. By orientation of mining, analysis, and understanding meaningful information of data can only be obtained. For handling similar regression Big data problem is sufficient. Data mining, analytics, and hence decision-making services can be done by a relevant architectural framework. With data mining analytics Big Data approach could be aggregated.

d) The design of Service-oriented Architecture (SOA) for IOT is a big challenge where service-based objects may face problems from performance and cost related issues. To handle a large number of devices connected to the system which phrases scalability issues, SOA needed. Challenges like: data transfer, processing, and management become a matter of burden over headed by service provisioning.

e) The quality of service is also a big issue. To achieve an optimal range of QoS, a developer needs to concentrate on parameters of QoS.

f) An incredibly high number of nodes are envisaged with IOT. All the attached devices and data shall be retrievable. For efficient point-to-point network configuration, unique identity is the must. IPv4 protocol identifies each node through a 4-byte address. The availability of IPv4 numbered addresses is decreasing rapidly by reaching zero in next few years, so new addressing policy named IPv6 is developed. to pursue device naming and identification capability IPv6 area is the area where utmost care is needed and appropriateness of architectural proficiency is a must..

VII. CONCLUSION

precision agriculture can be made more accurate and efficient with IOT enabled technologies. IOT can be applied in different domains of agriculture First one is the Water and Energy: for Agriculture, Water and energy are the most important inputs and their costs can improve or break the agricultural business. Due to leaky irrigation systems, inefficient field application methods and the planting of water-intensive crops in the wrong growing location water wastage is done. For its operation Pumps, boosters, lighting etc need electrical energy. water use can be made smarter for agriculture by monitoring and change water volume, location timing and duration of flow can be done with IOT. With the help of IOT, use of effective energy for pumps, boosters, lighting and other purposes also done the second one is the crop monitoring: the major concerns in this area are an application of fertilizers, pesticides based on crop and soil health, pest control. By deploying sensors and image capturing devices in the crop field which is connected to the internet for an appropriate decision can be taken with IOT. Efficient use of fertilizers and pesticides can be made with IOT. Finally conclude that need to develop on optimal Agri-IoT architecture which is enclosed with low cost, low power consumption of devices, better decision making process, QoS service, optimal performance and it is easy to understand the farmer without knowledge.

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