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INTERNET OF THINGS IN AGRICULTURE: A SURVEY

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Abstract - IoT has the capability to influence the world we live in; advanced industries, connected vehicles, and smarter cities are all components of the IoT equation. However, applying technology like IoT to the agriculture industry could have the greatest impact.The global population is set to touch 9.6 billion by 2050. So, to feed this much population, the farming industry must embrace IoT. Against the challenges such as extreme weather conditions and rising climate change, and environmental impact resulting from intensive farming practices, the demand for more food has to be met.Smart farming based on IoT technologies will enable growers and farmers to reduce waste and enhance productivity ranging from the quantity of fertilizer utilized to the number of journeys the farm vehicles have made.In IoT-based smart farming, a system is built for monitoring the crop field with the help of sensors (light, humidity, temperature, soil moisture, etc.) and automating the irrigation system. The farmers can monitor the field conditions from anywhere. IoT-based smart farming is highly efficient when compared with the conventional approach.The applications of IoT-based smart farming not only target conventional, large farming operations, but could also be new levers to uplift other growing or common trends in agricultural like organic farming, family farming (complex or small spaces, particular cattle and/or cultures, preservation of particular or high quality varieties etc.), and enhance highly transparent farming Greenhouse, [1], [2] being a closed structure protects the plants from extreme weather conditions namely: wind, hailstorm, ultraviolet radiations, and insect and pest attacks. The irrigation of agriculture field is carried out using automatic drip irrigation, which operates according to the soil moisture threshold set accordingly so as optimal amount of water is applied to the plants. Based on data from soil health card, proper amount of nitrogen, phosphorus, potassium and other minerals can be applied by using drip fertigation techniques. Proper water management tanks are constructed and they are filled with water after measuring the current water level using an ultrasonic sensor. Plants are also provided the requisite wavelength light during the night using growing lights. Temperature and air humidity are controlled by humidity and temperature sensors and a fogger is used to control the same. A tube well is controlled using GSM [3] module (missed call or sms). Bee-hive boxes are deployed for pollination and boxes are monitored using ultrasonic sensors to measure honey and send mails to the buyers when they are filled.

Keywords:Internet of Things (IoT),Green-house, GSM, Agriculture Monitoring, Irrigation,wireless sensor networks (WSNs),.

I. INTRODUCTION

The Internet of Things (IoT) is expected to offer promising solutions to transform the operation and role of many existing industrial systems such as transportation systems and manufacturing systems. For example, when IoT is used for creating intelligent transportation systems, the transportation authority will be able to track each vehicle's existing location, monitor its movement, and predict its future location and possible road traffic. The term IoT was initially proposed to refer to uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology [4]. Later on, researchers relate IoT with more technologies such as sensors, actuators, GPS devices, and mobile devices According to CASAGRAS project [5]: "A global network infrastructure linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object identification, sensor and connection capability as the basis for the development of independent cooperative services and applications. CERP [6], emphasizes the internetworking between heterogeneous 'smart' devices such as sensors, actuators, computers and smartphones etc., and the use of services over the internet. Any application development framework for the IoT, therefore, needs to support these heterogeneous devices.

In Indian population around 60-70 %(predicted value) is directly or indirectly depends on agriculture. That effects on food security and economic growth of India.Agriculture process can easily monitor or observe the crop growth based on collected information (soil condition and weather information) from a crop field with help of Precision,. This mechanism is called as satellite farming or site-specific crop management (SSCM) [7], manually can't able to collect environmental information because it is a difficult task. Many new farmers are emerging without any knowledge of soil types. This can be rectified by collecting Manual data; 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.

Major Problems faced in agriculture:

- Some places, which receive plenty of water through river and canal irrigation system, faces problem of soil salinity due to excess irrigation. Places with limited water supply, faces problem of acute water shortage for agriculture.
- Excessive use of fertilizers, insecticides and pesticides makes the soil dependent on them, erodes fertility, increases resistance in insects and pests, pollutes ground water and nearby water bodies whenever it rains.
- Different plants require different amount of moisture, humidity, temperature and light wavelength, and lack of awareness of this information or negligence of a person cultivating land can cause plants to die before maturing.

In view of the disadvantages of present agricultural greenhouse management, the use of information technology to make this management more efficient and intelligent is an important task in the information field. Networking technology is a new generation of information technology, it is the use of the internet or LAN technology to combine sensors, controllers and computers to connect people and 'things', thereby obtaining data, and enabling remote control and intelligent network management

II. SMART GREENHOUSE MODEL

In smart greenhouse model where the plant is provided with an environment for its optimum growth.Water received from the combination of various sources like canal, rain water harvesting and from purchase from tube well owners is stored in an underground tank. This underground tank is equipped with an ultrasonic sensor which sends an sms whenever tank is empty. Tube well pump can be switched on by sending a message to the GSM module by the farmer. This water is pumped into an overhead tank which gets filled using a pump according to the set threshold value. Overhead tank is connected to drip irrigation network via a valve, which opens when moisture level falls below threshold value. Due to the closed structure of greenhouse, insects and pests cannot enter inside, thereby eliminating the requirement of insecticides and pesticides. Growing LED lights are switched on whenever light intensity is low for photosynthesis, this ensures faster rate of growth. The humidity and temperature of air in a greenhouse are measured by sensor and whenever temperature is high or air moisture becomes too low, fogger is turned on to provide the required moisture and cool down the temperature. Pressure/Ultrasonic sensors are embedded inside the bee hive boxes to send a mail whenever the boxes are full. Storage containers (vegetables and fruits) are provided with ultrasonic sensors to estimate the volume and send a mail to an e commerce company about the volume, whenever the RFID tag is swiped. This eliminates the requirement of middleman. The various problems of the agricultural system and the solution adopted by us are explained in detail in the following sections.

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. [8] 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.

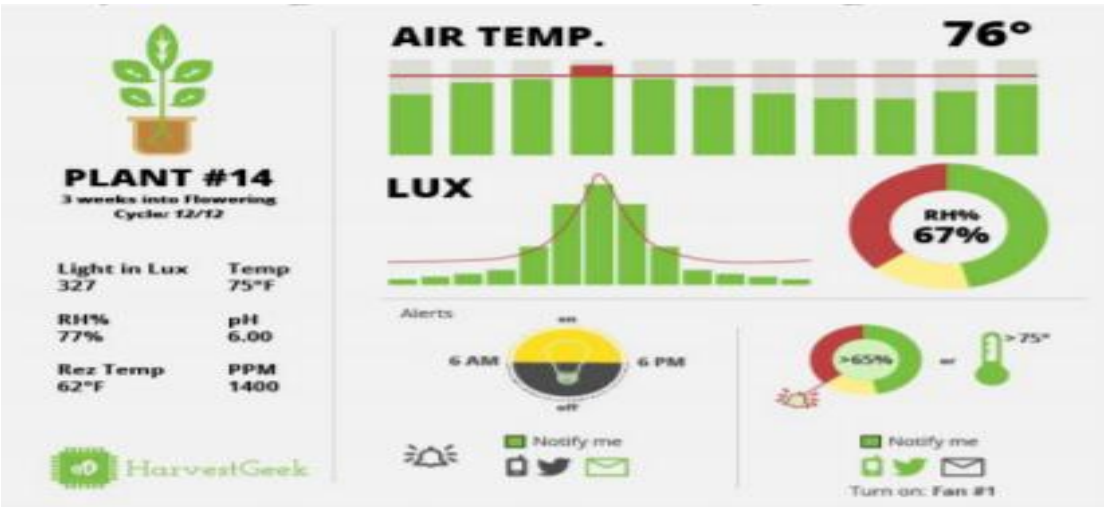

Figure 2.1 Temperature and weather sensors

III. TECHNOLOGIES

A.MICROCONTROLLER UNIT

An IoT microcontroller unit (MCU) lies at the heart of any connected greenhouse system. Depending on its capacity and computing power, a microcontroller can use firmware or a classic operating system to process sensor data and transfer it to a server. Unless you want to install a portable camera enabling real-time plant monitoring, you can opt for a simple ESP32 controller which supports multiple types of sensors, uses Bluetooth connectivity, consumes little power and can be inserted into soil or attached to stems.As a rule, one microcontroller covers up to 30 meters of arable land, so you only need five sensors to smarten up a one thousand m2 greenhouse. MCUs are then connected to your electricity grid. Since microcontrollers consume very little power (150 mA with both BLE and Wi-Fi data transmissions active and just 5 mA with the deep sleep mode on), the implementation of an IoT greenhouse solution will hardly affect your energy bill.

B.NETWORK

To enable communication between the microcontrollers which comprise the IoT system a standard Bluetooth mesh network can be used where nodes exchange data and re-transmit the messages sent by a remote MCU until it reaches the intended destination. Additionally, the network can be enhanced with a configurable server which manages other MCUs.Several Wi-Fi routers can be distributed across greenhouses, thus enabling sensors to connect to the Internet and send data directly to the server. The choice of a connectivity solution depends on the type of sensors and MCUs going to implement, the strength of Wi-Fi signal and the total area of arable land.

C.SENSORS

Moisture Sensors:The moisture sensors are deployed in the field which measures the soil moisture and opens the valve whenever moisture is below threshold and closes it when moisture has reached optimum value[9].

Temperature and humidity sensor: Temperature and humidity sensor are placed inside the smart greenhouse to measure humidity and temperature. When temperature rises above a certain level, micro-controller will trigger relay attached to the fogger, which will sprinkle tiny water droplets of size of micron which will remain suspended in the air and bring the temperature down. In case the air moisture falls below the set value, similar mechanism will be triggered and the small water droplets will maintain the relative humidity (RH). In case the relative humidity is at threshold and further cooling is required, Peltier module is used which can be powered by solar panels and can regulate the temperature by cooling or heating as per the requirements. Glass greenhouse structure can hold the heat during night time, that prevents the leaves from frost bite in cold winter night in some cold and dry areas[10]

Figure 3.1 Greenhouse

Soil Moisture Sensor:Soil moisture sensor is a sensor which senses the moisture content of the soil. The sensor has both the analog and the digital output. The digital output is fixed and the analog output threshold can be varied. It works on the principle of open and short circuit. The output is high or low indicated by the LED. When the soil is dry, the current will not pass through it and so it will act as open circuit. Hence the output is said to be maximum. When the soil is wet, the current will pass from one terminal to the other and the circuit is said to be short and the output will be zero[11].

IV RELATED WORK

Researchers provides different technologies used in the field of agriculture which would increase the production as well as in reducing the extra man power effort without causing pollution. Some of the researches carried out in field of agriculture are summarized here.

Yue Shaobo et al. developed a Bluetooth based system for monitoring agriculture parameter like temperature with the use of microcontroller which works as a smart weather station. The system provides low cost wireless solution. This system is used for real time monitoring agriculture field data. The drawback of the system were its communication range limited and connectivity configuration must be required Bluetooth with android mobile for continuous monitoring [12].

M. Haefke et al. developed a ZigBee based smart sensing platform for monitoring environmental parameter such as temperature, relative humidity, pressure and sunlight with the use of microcontroller which work as a smart weather station. The research was based on characteristics such as use of low cost equipment, accurate sensor and high data rate. The XBee module have the ability to provides wide range of data rate, low operated voltage and also reduces the current consumption of the circuit. This system working on mesh network so each and every node can communicate each other and also send data to main station. The platform is working for 24 Hrs and real time data observed on GUI based application in PC [13].

A remote sensing and control irrigation system using wireless sensor network aiming for variable rate irrigation, real time in field sensing, controlling of sites, this is only possible to develop a system based on feedback system. Pavithra D. S. et al. developed a GSM based system for automatic irrigation system. This system uses android application for measuring environmental parameter such as temperature, humidity and dew point and also controlling the water level in agriculture field. The objective of the system is to develop a low cost wireless technology. The drawback of the system is to know the command for getting the agriculture parameters and actuate the field motor [14].

A ZigBee and GSM based smart sensor network for agriculture was developed by G. V. Satynarayana et al. used for measuring environmental parameter such as temperature, humidity and moisture of the soil. This is ARM processor based technology which is work as a base station, which can collects data from sensors node and transmitted to monitoring system in wireless. In this technology uses internet protocol for data storage and monitoring. It is low cost and low power based technology having advantages such as minimizing excessive use of water and ensuring rapid growth of crop system may be more effective by considering other environmental parameter [15].

W. Medny developed a system based on FPGA and GSM used for measuring greenhouse environment such as temperature and humidity. This technology is providing real time monitoring, timely provided information of crop and soil status due to this it is easily possible to take decision for crop production improvement. The system is low cost, user friendly. The system can be made effective by considering other environmental parameter [16].

A smart wireless sensor network for agriculture parameter based on Wi-Fi developed by G. Mendez et al. considering measuring parameter such as temperature, humidity, pressure, light intensity, soil moisture and water level. The objectives of the system were developing a smart wireless sensor network for agriculture, implementing to acquire data to PC which is connected to network from various sensor nodes. Wireless, to reduce the cost and effort of incorporating wiring, to enhance the flexibility and mobility for the system. This system provides transmitting and logging data into the cloud. It reduces the setup difficulty. The system completed when interchangeability of nodes and power taking from renewable sources [17].

The researchers found out the way for agriculture parameter control and acquisition is most important for future calculation for crop production for this SCADA based system developed by P. Silva et al., which is work on hierarchical three layer model that is filed layer, control layer and supervision and management layer. The field layer related with sensor node, control layer concern on actuator network and supervision and management layer concern on heavy calculation. The main objective of this system can be built using the plug and work model, there in no need to install device driver and software application whenever the changes network. This system is a low cost wireless technology with the use of microcontroller and CAN protocol for measuring agriculture parameter. There is a one common problem some of the system do not support an embedded JVM. The work can be done if it is implementing of Java based Bluetooth stack.

IV. FOUR LAYERS IOT-AGRICULTURE ARCHITECTURE

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 5.1 shows the four layer IoT structure.

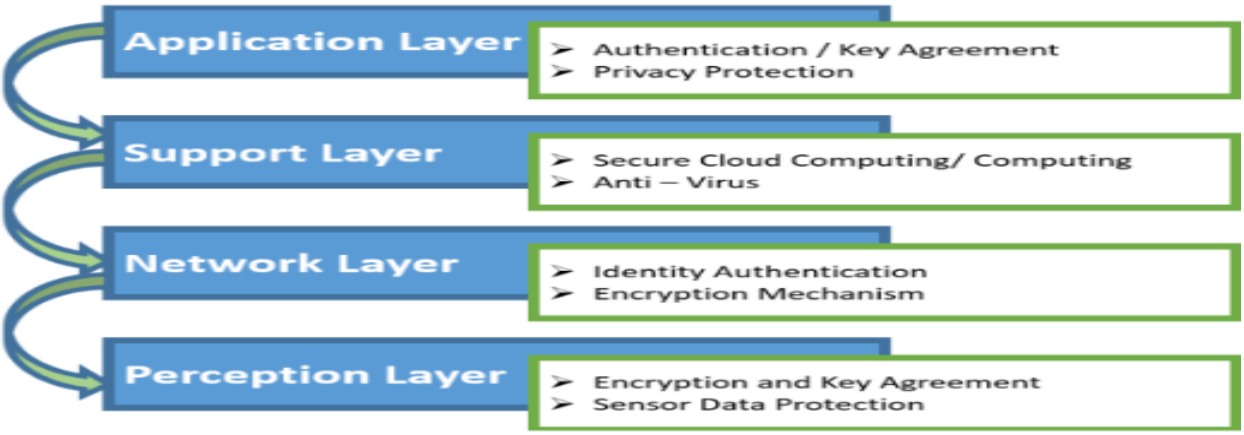

Figure 5.1 Layers of IoT

V. IoT HARDWARE REQUIREMENTS

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.

Five main components of IoT are as follows

Power source and power management- Every IoT device needs to be supplied some sort of power in order for it to operate. This can include battery, energy harvesters, or line. Understand the customer usage habits and product intent of IoT device. Power can be saved by only transmitting data at certain intervals while the rest of the time it is in "sleep" or low power mode. what type of power will device have access to. Will IoT device be stationary and have access to the line ? Or does device need to be portable and need to have on board energy storage should be considered. Remote applications that might need to use energy harvesters such as solar cells and fault protection because IoT devices commonly are under varying environmental conditions should also be considered.

Sensors/actuators-Most IoT devices either gather information of the physical world through sensors or manipulate the physical world through actuators. They can be as simple as flex sensors to as complicated as MEMS airflow sensors. Sensor should be interfaced with MCU this will require amplifiers or analog to digital converters.

Processor and memory storage-The Processor is the heart where it process data and run software. Depending on node application it might have to run RF stack and algorithms. Memory is also necessary to store local data such as, session data, user settings etc. SoC or system on chips integrate many functionalities such as power management, memory, wireless transceiver and processor.

Wireless communication- There are lot of choices when it comes to wireless communication. There are modules that integrate your RF communication which include rf shield,amplifier,oscillators and antennas. what type of wireless transceiver is used should be determined on the board.These transceivers will send and receive data wirelessly. Determine what range your IoT device needs to communicate over as well as data rates. For example, will the user be controlling the device through their cell phone or will you have nodes part of a larger meshed network. Again determine the use case because different communication protocols require more power,cost, and board space . Some examples include wifi,bluetooth and zigbee protocols.

UI/UX- A lot of IoT devices can be controlled by smartphone or web app. However, it might be necessary to have user interfaces on the product. So for example for nest the device needs to have a screen to display and control the settings. Consider physical knobs or buttons as well.

VI.CONCLUSION

IoT based monitoring system for agriculture has been used to maximize the yield of crop by monitoring the environmental parameters and thus providing the necessary information to the farmer remotely. The use of IoT over the other technology one helps for deploying it in any type of environment for monitoring, making it flexible and robust.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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