Precision Agriculture using LoRa

Sushmita Tapashetti, Dr. Shobha K.R.

Abstract—Agriculture is the broadest economic sector and plays a key role in the overall economic development of nation. There are many issues related to farmers which always hampers the course of our evolution. One of the best solution to tackle these problems is to encourage farmers to use modern techniques as they help in increasing agricultural productivity and cut down the input cost. This paper proposes, solution to measure minerals present in agricultural land such as nitrogen, phosphorous, and potassium as well as humidity, soil moisture and temperature using sensors, LoRa and Cloud technology. The data obtained from the sensors will be collected into the cloud database which will be used to give information to end user. The approach uses the combination of LoRa and cloud computing that promotes the fast development of agricultural modernization and helps to realize smart solution for agriculture and efficiently solve the issues related to farmers from a remote location.

Index Terms—Precision Agriculture, LoRa, Cloud Computing, NPK values.

1 Introduction

Agriculture Agriculture is the most important sector of Indian economy which plays a decisive role in socioeconomic development of the country. Indian agriculture sector accounts for 18% of India's gross domestic production (GDP) and provides employment to 50% of countries workforce. India is second largest producer of vegetables and fruits in the world [9]. In India 43% of geographical area is occupied by agricultural land [10]. According to prediction of FAO, one in nine people around the world lack adequate food needed to maintain a healthy and active lifestyle and says that this number is expected to increase as population continues to rise. Not only that, some researches have shown that the demand for the food is going to be doubled by 2050 due to increase in population. It will be more challenging task to meet the demands of population because of receding water level, changes in climatic changes and shrinking number of agricultural fields [8]. The age-old methods of growing crops won't help in increasing the agrarian output with all the above-mentioned issues. These facts demands for more research development in agricultural sector.

According to recent reports, about 70-80% of agricultural greenhouse gas emissions, such as nitrous oxide come from use of nitrogen fertilizer. So, one must apply the required amount of nitrogen fertilizers after knowing the requirement of the crops. Even supplying water to agriculture field should be in controlled manner so that it won't wash away the minerals added to soil as well as cause soil erosion. All these requires real time monitoring of the agricultural field as well as crop growth. Hence it requires use of modern techniques in agricultural fields which helps in improvement of crop productivity with sufficient use of resources.

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To use technology more efficiently one has to know the requirements of crop growth. There are number of elements which are essential to plant life and they must be provided in certain proportion to obtain a healthy crop. Knowing the nutrients required to grow plants is only one aspect of successful crop production. Optimum yield also requires knowing the rate to apply, the method and time of application, the source of nutrients to use, and how the elements are influenced by soil and climatic conditions. Essential nutrients are C, H, O_2 provided by atmospheric CO_2 and H_2O. Among all the nutrients that are required by crops the most important are nitrogen, phosphorous and potassium. These are used in maximum quantity by most of the crops. Hence use of sensing and cloud technology has become important as they help in providing real time requirements in the field.

The agriculture in India requires more attention to be paid to the farming activity and farmers. More research must be carried out regarding latest agriculture tools and testing the quality of various innovative ideas. So, here we study the application of Precision agriculture (PA) that aims to improve the revenue by utilizing more precise information recorded using technologies available for sensing and communicating.

1.1 Precision Agriculture(PA)

Precision agriculture is a farming management concept based on observing, measuring, and responding to inter and intra-field variability in crops. Precision agriculture uses detailed, site-specific information to manage production inputs like water, fertilizers and pesticides.

The main goal of any precision agriculture remote sensing is to detect something in time to make a correction. Examples of things that could need correction include irrigation, plant disease, drainage, soil nutrient and crop damage. Precision agriculture includes data collection from various sensor nodes placed in agricultural fields and provide solutions based on the data collected to farmers. This helps farmers to use only the required quantity of water, fertilizers and pesticides. In fact, field trials have shown that use of sensors measurement to vary water input across the farm for irrigation can increase the agricultural output by 46% while reducing water intake by 34%. Similarly, other techniques like seeds, soil nutrients have proven to be beneficiary [8]. Hence usage of modern technologies not only increases the agricultural productivity but they

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also help in saving the resources as well as keeping the environment clean and safe.

1.2 LoRa Technology

Long range, low power wireless platform is the prevailing technology choice for building IoT networks worldwide. LoRa is the emerging technology which is making our world a smart planet. LoRa Technology offers a very compelling combination of long range, low power consumption and secure data transmission. LoRa makes use of spread spectrum modulation technique which is insusceptible for interfering signals and noise. Thus, LoRa overcomes the drawbacks of traditional direct spread spectrum modulation technique. The key features of LoRa technology which makes it efficient transceiver are scalable bandwidth, consistent envelop, high robustness, multipath/blurring resistant, Doppler resistant, Long range capability, upgraded network capacity and ranging/localization.

Public and private networks using this technology can provide coverage that is greater in range compared to that of existing cellular networks. It is easy to plug into the existing infrastructure and offers a solution to serve battery-operated IoT applications. Since LoRa provides large distance coverage with low power it gives best solution for connecting devices like sensors and gateways placed at long distances. Hence, we can make use of LoRa to collect data from sensors placed in agricultural lands with the help of gateway and store it in cloud for further analysis.

1.3 Cloud Computiong

Cloud computing is an information technology paradigm that enables ubiquitous access to shared pools of configurable system resources and higher-level services that can be rapidly provisioned with minimal management efforts, often over the internet. Cloud computing relies on sharing of resources to achieve coherence and economy of scale, like utility. In this paper we are using this cloud platform to collect data obtained by end nodes through LoRa transceiver and display the obtained data to get the required solution; the obtained information is only data which is of no help to farmers hence, it must be converted into useful information. Therefore, this data must be collected in effective storage space which can be accessed anywhere in world. The cloud database is the best place to store the data, analyse and compute the required output which can be provided to farmer or user.

2 Literature Review

In [1], a novel approach for Digital Agriculture was proposed describing Relationships between Precision Agriculture, Digital Earth, Information Agriculture, Virtual Agriculture, and Digital Agriculture. The requirement to put forward the concept of Digital Agriculture was discussed. They explained use of satellite and other on/underground instruments for information collection. And also automation and remote monitoring of agriculture is discussed.

In [2], sensor data collection and irrigation control were put forward on vegetable crop using smartphone and wireless sensor networks for smart farming. The environmental data can be collected, and the irrigation system can be controlled using smartphone was demonstrated in this work. This paper mainly concentrated on automation of irrigation by controlling the flow of water by knowing temperature, humidity and soil moisture. Thus, helping proper growth of vegetable crops. This implementation used zigbee communication to perform above functions and communication was between sensor nodes and smart phones for information collection or controlling water flow in field.

In [3], use of agricultural drone for spraying fertilizer and pesticides in agricultural lands depending on their requirement in fields was discussed. The decision about spraying of chemicals on crops was taken depending on climatic conditions, such as the intensity and direction of the wind while spraying and controlling path of UAVs to reduce the wastage of chemicals. Thus, it explains optimum use of fertilizer and pesticides in agricultural field depending on the requirement thus aiding reduction of soil pollution .

In [4], cloud computing is used to collect data related to estimation of the fields requirements, its production and quality of crops. Data collected is used effectively to increase production and reduce wastage. Thus, this paper mainly concentrates on data collection regarding growth of qualitative growth of plants. It uses zigbee technology for data collection and placing it in cloud database. They have used sensors with small memory to monitor peer nodes. App is designed for end user to get the data required for them to take further measures based on unique ID generated for each user as well as GPS location given by the user.

In [5], the idea of sensing the nutrients in soil and provide solution to farmers from the analysis done on the data collected in data collection centre was introduced. The proposed idea was implemented with WiFi or zigbee. In this paper data collection was done using zigbee or WiFi which covers smaller distance compared to LoRa.

3 Proposed Methodology

As discussed earlier, there are many issues which hinders the increase in productivity of crops as well as reduction environmental pollution.

Let us consider a scenario of application of fertilizer to the agricultural land. To do above procedure one has to have the knowledge of nutrient requirement by the crop as well as the know the amount of nutrient already present in the soil, so that he can have an idea of fertilizer requirement by that crop. To do this task one has to take the soil to soil testing centre, get the result and then apply the fertilizers to the field which will be tedious task and sometimes the person may just assume some amount of fertilizer and apply it in field which may be more or less. If applied nutrient is less crop production will be low and if more it may lead to leaching, soil pollution and

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account for some greenhouse gases. It's not only nutrient application, but we also need to know the amount of water required by crops so that proper quantity of water will be given to the fields during crop growth.
The field temperature and humidity also play a very important role in deciding the crops suitable for the given region.

3.1 Methodology

Smart Agricultural solutions are the evolving trend in day to day lives. Recent field trials done using advanced technology have shown increase in crop production with reduction in water consumption. It also reduces soil erosion, leaching and f greenhouse gases produced from application of nitrogen fertilizer to fields. So, in this work an attempt is made to use technology effectively to grow healthy crops by providing proper quantity of nutrients like nitrogen, phosphorous, and potassium, and water to the fields. LoRa technology, which provide long range coverage for data transmission with low power consumption and more efficient when compared to existing technologies is used in the current implementation. Sensors placed in agricultural fields are used to sense the required data from the fields and the sensed data will be collected by LoRa gateway. The collected information was uploaded to cloud for further analysis. Depending on the analysed data further measures were taken to increase the crop yield. The analysed data was converted to useful information and was given to end user using email or SMS. This information can be used in agricultural field for quantitative as well as qualitative growth of crops.
Here we have got the nutrient requirements of tomato and potato plant and we are providing requirement related to these crops through LoRa and cloud technologies by alerting end user through email notification.

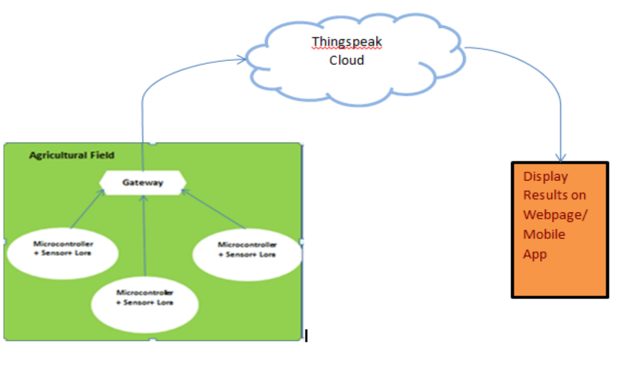

Fig. 1. Block Diagram

ously check for the availability of serial pin. If serial pin is available, collect the data from sensor and broadcast the data and then check for the gateway. If available, check for acknowledgement from gateway if acknowledgement is received successfully, then it indicates communication successful between the LoRa node and the gateway.

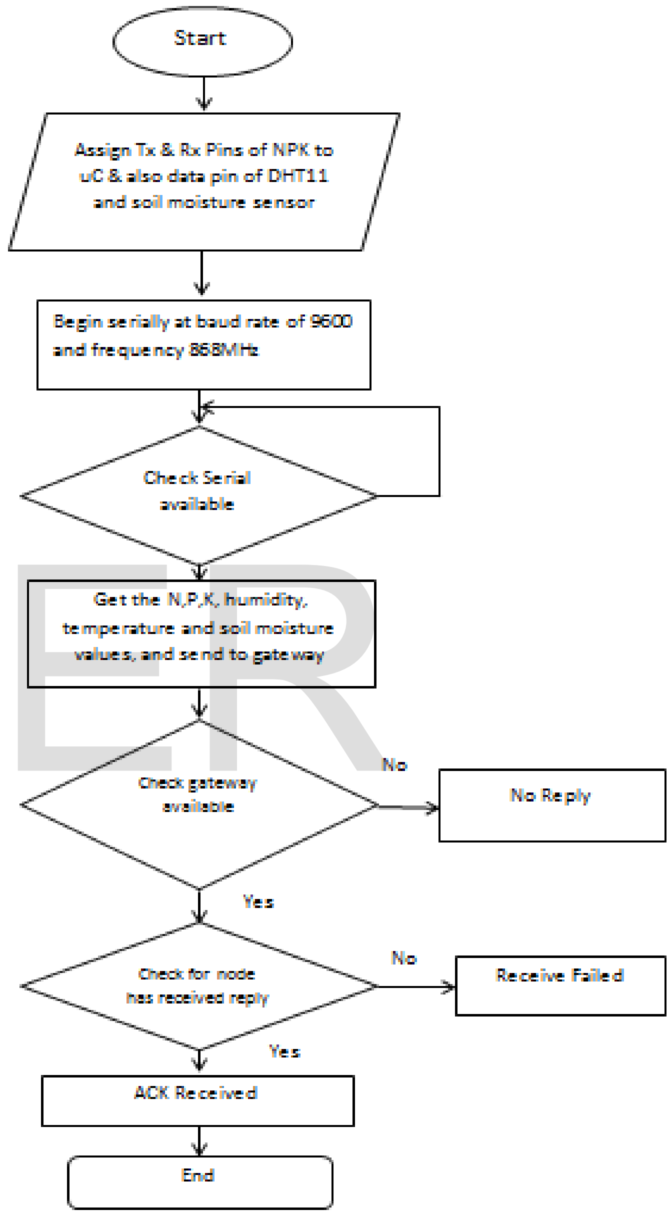

Fig. 2. Flowchart for client node

3.2 Implementation

The flow charts below explain the flow of implemented algorithm. Fig.2, elaborates the flow of algorithm at the client side. First initial settings like pin assignments must be done. Then, Baud rate and frequency must be set according to requirement. Since algorithm uses serial communication one must check for serial communication. If serial pin is available for communication one must go for next step if not, then continu-

Fig.3 elaborates in detail about flow of algorithm at the server side i.e., from receiving the broadcasted message of the LoRa node and sending out the acknowledgement to same LoRa node. Initially the baud rate and frequency have to be set with the API key obtained from the cloud account for a particular channel. Continuously check for the data at the set frequency. If available, get the data and display it on serial monitor as well as cloud.

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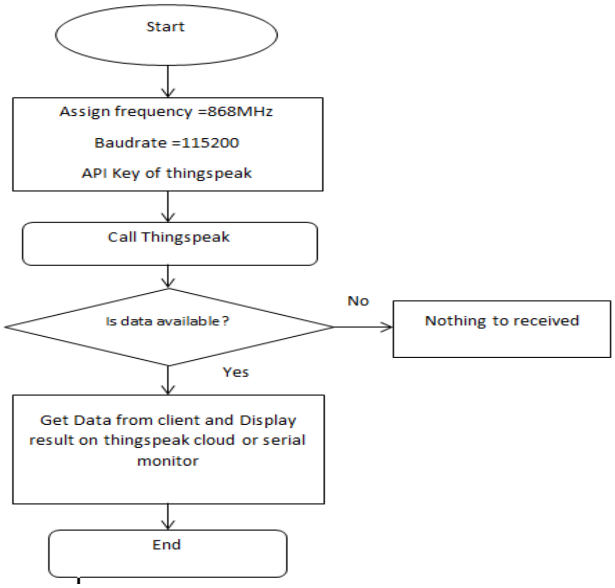

Fig.3 Flowchart of gateway

Fig.4 explains the algorithm flow for multiple nodes at the server side i.e., data transmission from multiple nodes and collecting the broadcasted data by single gateway which uploads the data collected into different channels of cloud. First, nodes must be differentiated at client side by assigning different node ID's. Once nodes are differentiated and data is transmitted from the client nodes with their ID's. The data received at gateway will be verified for their node ID. Once node ID is confirmed data will be sent to the channel assigned to it.

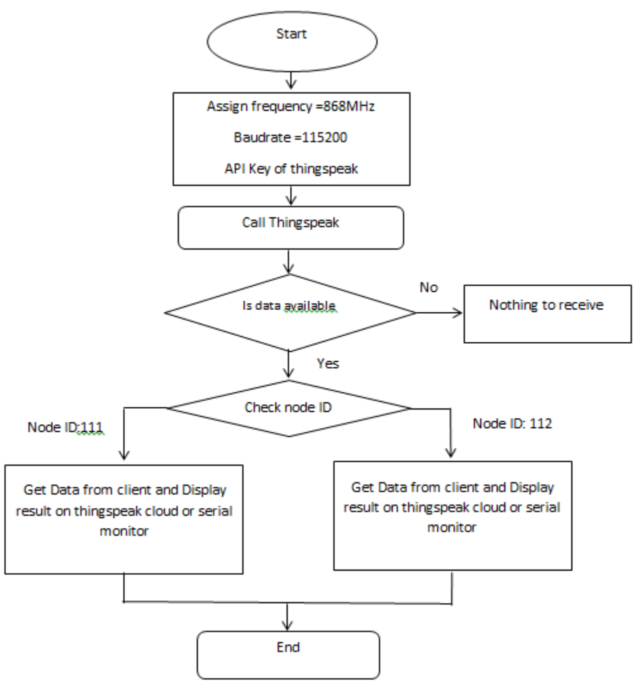

Fig.4. Flowchart of the gateway for multiple nodes

4 System Design

The comple system is divided into three modules as shown in following diagram

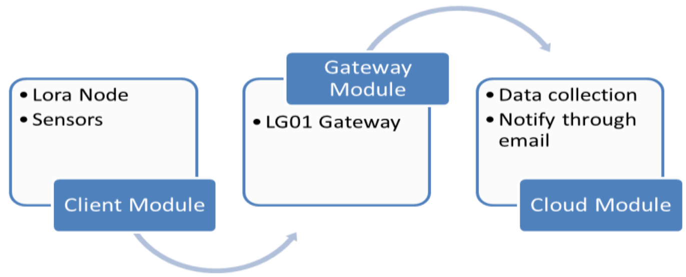

Fig.5 System Design

4.1 Client Module

Client module consists of LoRa node along with atmega128 controller and is connected with sensors which are used to collect condition of soil such as its moisture and also nutrients present in soil like nitrogen(N), phosphorous(P) and potassium(K). Humidity and temperature of the field is collected at regular interval to provide information regarding water requirement in the field. NPK sensor is used to collect the information regarding amount of N,P,K present in the soil and suggest the crop that can be grown in such soil and also suggest if extra quantity of fertilizers is required in soil for the suggested crop. Soil moisture sensor is used to calculate the moisture of soil. DHT11 sensor is used to collect humidity and temperature of field. This data collected, was analyzed to provide information regarding water requirement in the field.
The same setup as explained above is done with another LoRa node and experimented to get data from multiple nodes to gateway.

4.2 Gateway Module

Gateway module acts as a link between the LoRa nodes and cloud. Gateway collects the data from the LoRa nodes and gives it to cloud to analyze the data. LoRa gateway can communicate with the LoRa nodes placed at almost 1-3kms distance in open field as their range is higher than the any present technologies.
Basically, gateway uses two technologies to communicate one is Lora technology to collect information from LoRa nodes placed in fields and second one is WiFi, which is used to upload the data collected into the cloud. It uses HTTP protocol to communicate between gateway and cloud.
Thus gateway has to be placed as per the requirements. receive data from LoRa nodes through LoRa communication and upload data to cloud through HTTP protocol.

4.3 Cloud Module

To store the data collected in gateway to cloud, one has to create an account in cloud with specific user name and password. Once account is created one must give the API keys of specific channel of the account to make the HTTP communication

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from gateway to cloud. Once the connection is established between cloud and gateway, the data from gateway will be stored in the cloud. Data collected in the cloud is analyzed in MATLAB to notify user through email (shown in Fig.12) about water and fertilizer requirement in field. Even the data collected in cloud can be displayed in mobile through mobile widget as shown in fig.8 and 11.

5 Results and Discussions

The figures below show the graph of information collected by gateway in cloud at real time

Fig.6 shows the results obtained from node 1 It shows humidity, temperature, soil moisture and nitrogen, phosphorous and potassium content in soil of node ID 111 and Fig.8 shows the data collected in cloud through mobile widget.

Fig.6 Data obtained from sensors connected to node ID:111

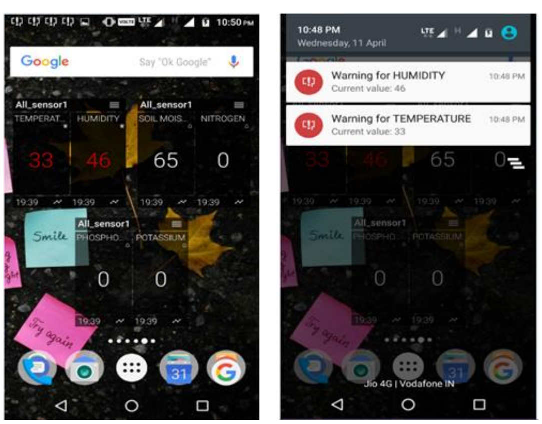

Fig.7 Data obtained on mobile widget for node ID: 111

Fig.8 shows the results obtained from node 2. It shows humidity, temperature, soil moisture and nitrogen, phosphorous and potassium content in soil by node ID 112 and Fig.9 shows the data collected in cloud through mobile widget.

Fig.8 Data obtained from sensors connected to node ID:112

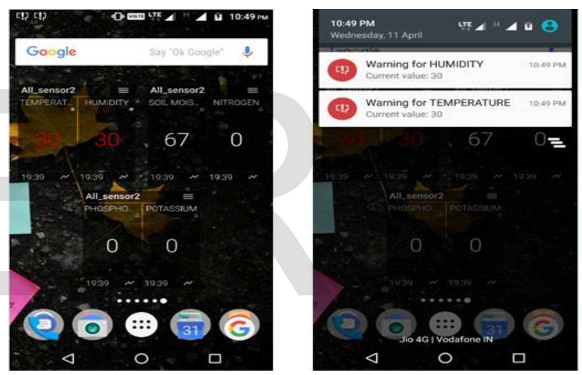

Fig.9 Data obtained on mobile widget for node ID: 112

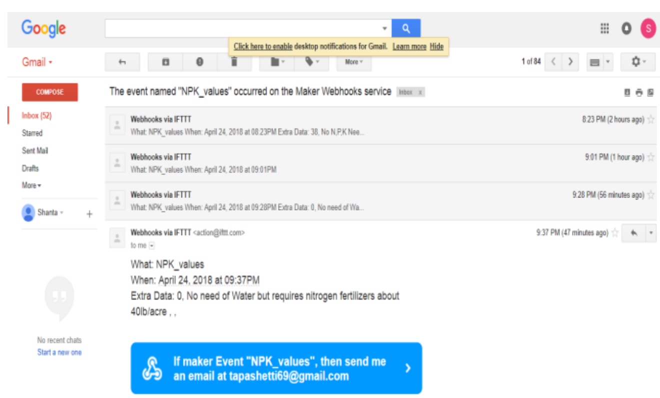

Fig.10 Email notification sent to end user

Fig.10 shows the email notification got by the end user which tells end user about water and fertilizer requirement.

6 Conclusion

Agriculture plays a very important role in growth of Indian

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economy, hence methods for improving crop yield plays a significant role. The above work helps one to monitor the amount of NPK present in the soil and its moisture content. Thus, above work provides a solution to increase the yield of crops using current technology of sensors and LoRa. The information obtained from sensors is analysed and information regarding amount of nutrients and water required by crops is given to end user using email and mobile. The use of LoRa Techonolgy helps to cover large geographical land with low power consumption. Thus, increasing the efficiency of operation. This work aids remote monitoring of fields to farmers as well as assists increase in yield.

As part of future work drones can be used to cover larger geographical area and collect data from substantial number of nodes and upload it to cloud for remote monitoring

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