Cloud based automated Irrigation System for Coconut Farms using LoRa

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***Abstract*—Today water scarcity is a worldwide problem. In India, especially in Tamil Nadu Coconut farming is one of the major parts of agriculture. There were rough times for farmers when monsoon failed in the last few years. Normal type of irrigation system followed for Coconut trees was drip and basin irrigation. But farmers were forced to save the tress by irrigating them with Tractor loads of water, since there was not sufficient water in the well and borewell. This situation could have been avoided if only the required quantity of water was fed to the Coconut trees in the past and the extra water available was saved wisely. This paper proposes a novel idea to automate the irrigation method by using the LoRa and IoT technologies. This system senses the soil moisture content in various areas of the farm and automated the irrigation. The irrigation is stopped once required moisture is observed in the field. This way it can prolong the period of irrigation and hence helps the farmers during the times of monsoon failures. Also, this system eases the work of a farmer who owns a vast farmland. The farmer is able to check the flow of water to all areas of the field from his premises.**

***Index Terms – LoRa, IoT, Coconut Farm,Automation, Irrigation*.**

I. INTRODUCTION

Tamil Nadu ranks third in India in Coconut farming with plantations spread over an area of 3.89 lakh hectares of land. Coconut trees require very less maintenance and regular irrigation to provide good yields [1]. Main methods of irrigating the coconut famers include Drip Irrigation, where the water is dripped slowly near the roots of the tree. It is necessary to water the trees daily in this method. The second method is basin irrigation where water flows from well through canals on the land to the embarkment areas around the trees. This method requires irrigating the fields once in a week. Each method has its own advantage. Recent monsoon failures led to destruction of many coconut farms all over Tamil Nadu. It is necessary for the farmers to save and store water in those times to prolong the irrigation.

II. EXISTING METHODS

There are many researches going on in the area of automating irrigation techniques. Jia Uddin ; S.M. Taslim Reza , et.al., propose a model of variable rate automatic microcontroller based irrigation system using Solar power [2]. Joaquín Gutiérrez proposes a distributed wireless network of soil-moisture and temperature sensors placed in the root zone of the plants. In addition, a gateway unit handles sensor information, triggers actuators, and transmits data to a web application [3]. Krishna S developed a controller which uses calibrated, dielectric moisture sensors, interfaced with a datalogger and solenoid valves, to measure the Volumetric Water Content of the substrate every 20 min [4]. P. Javadi, developed fuzzy logic controller which can effectively estimate amount of water uptake of plants in distinct depth using the reliable irrigation model, evapotranspiration functions, environmental conditions of greenhouse, soil type and type of plant [5]. Tahar Boutraa, evaluated the effectiveness of automated irrigation compared to manual irrigation in the case of wheat plants. Likewise, there are enormous studies and developments for automating irrigation [6]. This paper proposes an automation system using LoRa and LPWAN technologies to automate the drip and basin irrigation for coconut farms and helping the farmers to decide when to irrigate the field.

This paper deals with the design and implementation of the LoRa (Long Range) technology based irrigation system for coconut farms in detail. The LoRa network architecture is given in Section II. Section III explains the implementation of

the system. Results are discussed in Section IV and Section V gives the conclusion and future work.

III. LORA ARCHITECTURE

LoRa remains a promising technology for Wireless Sensor Networks (WSN). In today's world WSN plays a major role in industries, security, transportation and agriculture. Any WSN is comprised sensors, actuator, power source and transceivers. These networks are basically built on low power wireless technologies to conserve power and extend the life of the network. LoRa is a proprietary wireless technology developed by Semtech Corporation, which uses chirp based spread spectrum technique in the sub-gigahertz range of 433MHz, 868 MHz and 915 MHz. The LoRa physical layer was developed by Semtech and it allows for long-range and low-power communications. LoRaWAN is a low power WAN and is an open standard used for Internet of Things (IoT) which provides long range connectivity [7]. This paper selects LoRa on the basis that Coconut farms are spread across acres of land and the farmer may be located with in 1-10 km range from the farm.

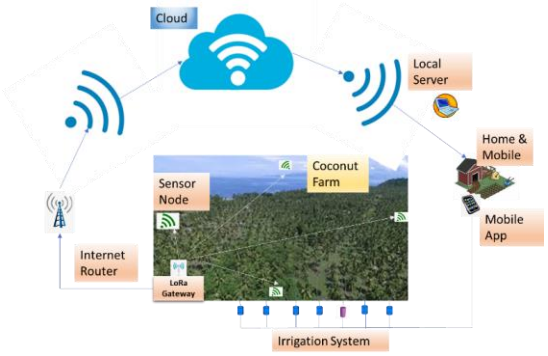

Figure 1 – LoRa Network architecture

LoRa network architecture has three types of devices namely, End Devices, Cloud and Application Front end.

The End Devices include the microcontroller, the sensors implanted in the field, transceivers and the solenoids to control the irrigation valves. They sense the required data like soil moisture and send them to server through gateway. The Gateway transfers the data to the server. The data is processed in the cloud. The cloud consists of the LoRa server and application server. These are used to process the data and forward the results to the Application. The Application front end is present in the Farmer's hand held device or a mobile. The same application is used for getting the information about the moisture content in each area of the farm and also to send control message to the irrigation system.

IV. IMPLEMENTATION

End Devices

The end device senses the soil moisture, send message to the farmer via cloud interface and also controls the solenoid of the irrigation valves based on the input given by the farmer through specially designed application.

Semtech's SX1272/73 transceiver is used for communication. It is a long range, Low power RF Transceiver which operates at 860-1000 MHz bandwidth. It is designed for multiple modulation techniques like FSK, MSK and LoRa. This transceiver comes with a built in temperature sensor and low battery indicator. It features high sensitivity and blocking immunity.

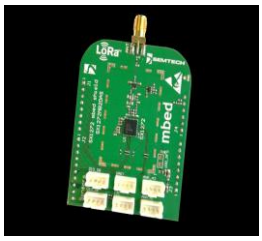

Figure 2: a) SX1272/73 b) REES52's AR605 sensor

c) Solenoid Valve

An ultra-low power, universal serial bus, ARM Cortex 32-bit RISC Core processor is used for controlling the sensors and solenoids. ToFine's solenoid valve CWX15Q CR03 (motorized ball valve) is used to open or close the irrigation system. This valve can operate at ac 220v, with an open close speed of 3 to 5 seconds and has high lifetime of about One Lakh cycles. It is rust free and made out of Brass and Stainless Steel. The irrigation system retrieves to its original state in case of sudden power cut.

The soil moisture can be measured by REES52's AR605 sensor module. Soil Moisture can be measured by inserting the sensor in the soil.

Sensors are placed at different depths like 1m, 2m, 3m and 4m to get an accurate result. Sensors are generally placed at the embarkment area of a Coconut tree. This sensor gives a 5V output for high moisture and 0V for dry soil. This sensor also comes with a potentiometer to set the threshold for moisture content. When the moisture content reaches the threshold or if there is a sudden rainfall and if the moisture increases then the sensor will send a cutoff signal and hence the irrigation pump closes.

Parameter	**Value**
Operating Voltage	3.3-5 V
Output Mode	Dual
Soil Probe Dimension	6cmX3cm
Power Indicator	Red
Digital Switching Output Indicator	Green

The end device is powered by rechargeable Lithium battery, which charges with the help of 5V hydroelectric power Micro-hydro generator F50. When the solenoid is opened, the battery gets charged automatically due to the hydrostatic pressure.

Figure 3 LoRa Gateway

Semtech's SX1301 digital baseband chip is used as the Gateway here. This chip comes with dual digital Tx and Rx front end interfaces with 10 programmable parallel demodulation paths with dynamic data rate adaptation. This gateway handles the data from the transceiver module and forward them to the server. The gateway connects to the internet router or a cellular modem to connect to internet. This gateway can handle up to 1000 sensor nodes at a time.

Intelligent Recommender System on Cloud:

The data received from the gateway through the application interface is forwarded to the specially designed automated application. This Irrigation Control Application can be maintained over Cloud for better performance. The application sends message to the farmer either to activate the irrigation valve or close it based on the inputs received from the end device.

The sequence diagram given in Figure 4 shows the events that take place in the system.

1. The user registers with the application, on Android based app. The app is designed to be mobile friendly.
2. The sensors implanted in the farm continuously monitors the soil and sends data over the LoRa gateway and routers.
3. The real time data obtained from the field is processed by the Recommender System residing on Cloud.
4. The processing involves comparing the real time data with the already stored historic data, using intelligent techniques.
5. Based on the comparison, the system alerts the farmer and recommends the end device located in farm to open the valve for irrigation.
6. The user sends feedback and provides rating to the automated system, which is also processed and stored for future issues.

Dealing with continuous data streams and processing involves many challenges. Big data plays a major role when designing the middleware applications. So, the efficient Cassandra, a NoSQL database is used here. Processing the data requires a collaborative approach involving mathematical, statistical and optimization techniques, which in turn involves data mining, machine learning and signal processing methods.

A recommendation system can be implemented using various methods. Since it involves processing of big data, Hadoop or Apache Spark can be used for the computation. Spark computes data much faster than Hadoop and provides faster computations. Apache Spark is a data processing tool used that operates on distributed data collections.

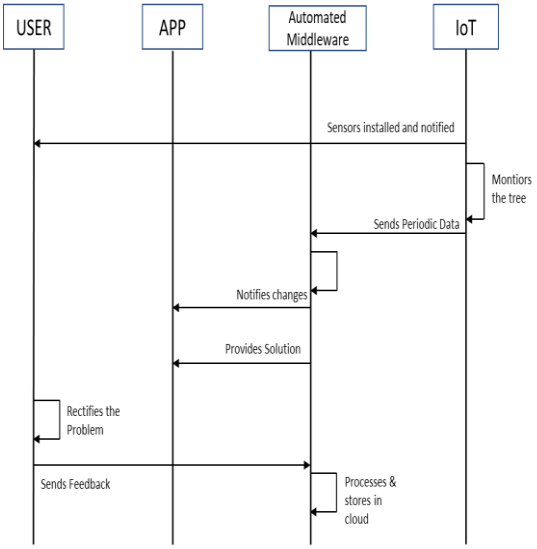

Figure 4: Sequence diagram

Collaborative filtering is the method used for processing and Alternating Least Squaring (ALS) algorithm is used to overcome the data sparsity problem in the dataset. This algorithm is used for dimensionality reduction thus increasing the computational power. Also, this is used to provide the recommendations to the user by analyzing the dataset provided. Alternating Least Squares (ALS) is an optimization technique to solve matrix factorization problems.

Initially the control will start from the dataset itself. By obtaining the data from the sensors (datasets), the control will move to its partitioning. Once partitioned, it will be converted into its RDD format. After its conversion, the best model will be determined. Until the best model is chosen, the control will be in a looping condition. This will move on to its next stage, only after finding the least RMSE value for its models. When the best model is determined, the model will be trained with the selected parameters. Then the recommendations will be provided for the trained data.

Application

The Front-end Mobile application is designed using Android. This application can receive the inputs from the end devices or Application Server. The application can also view the sensor status and control the irrigation valves. There is an option to set timer for irrigation and automatically stop the flow after certain time.

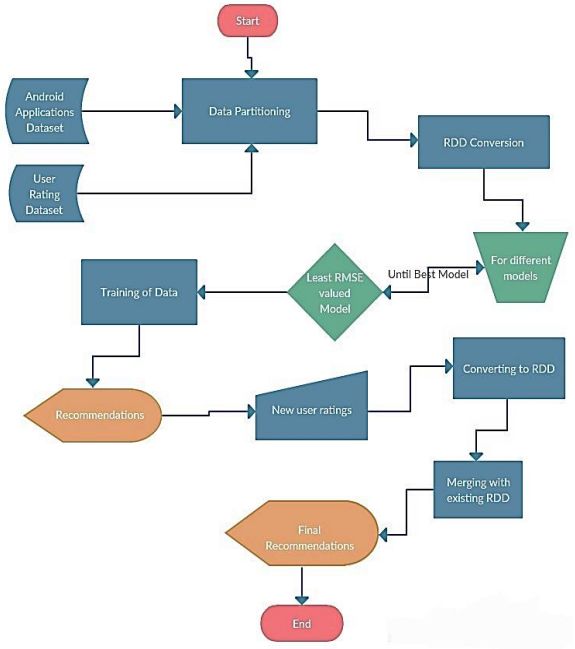

Figure 5 Control Flow Diagram for Recommendation System

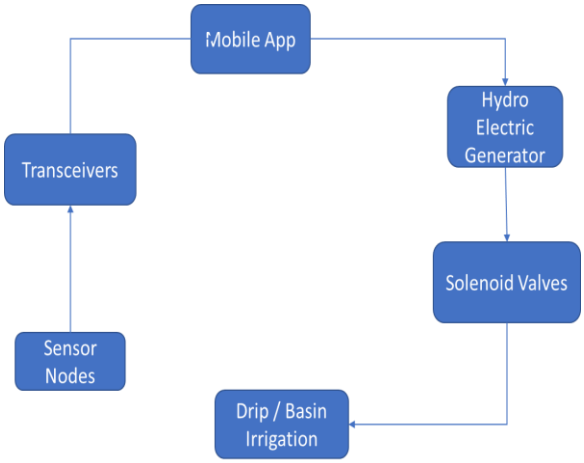

Figure 6 Irrigation System for Coconut Farms

V. RESULTS

LoRa based Irrigation System can be implemented as shown below. The assembled system served a radius of 3kms. Some of the parameters used in the end device are given in the table below:

Parameter	**Value**
Modulation Scheme	LoRa
Frequency	433 MHZ, 915 MHz
Transmit Power	20dbm
Coding Rate	4
Spread Factor	12
Distance	0.5 Km – 6 km

Battery Voltage	3-5V
Area	200 – 300 Hectares
Type of Farm	Coconut trees

The assembled system is studied in a coconut farm of 3 acres with 300 trees. The mobile of the farmer is located 2 kms away and the nearest Internet Tower is situated 1 km away from the farm. Readings noted during three different days is presented in the graph shown in figure 7. The graph clearly shows that the irrigation system is turned ON (Valves Opened) once the moisture content goes below 40 % and is turned OFF (Valves Closed) once the moisture content reaches above 90%. During rainy days, sometimes the valves remain closed, since the moisture level is always above threshold.

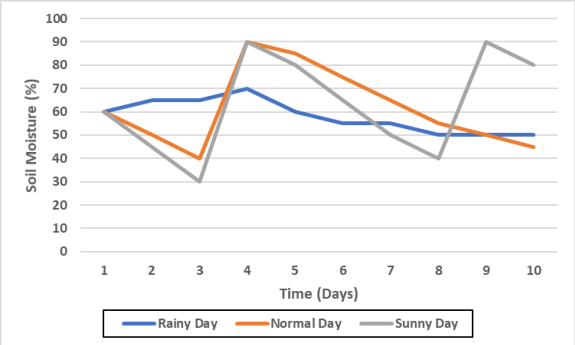

Figure 7 Study of Soil Moisture

Type	Water Consumed	Frequency of Irrigation
Basin Irrigation Method	410 lit / 7 days	Once in a 6-7 days
LoRa based Irrigation	280 – 320 lit / 7 days	Once in 10 days

The Table shows the frequency of watering required for a normal basin irrigation method and LoRa based irrigation method. LoRa based irrigation system gives about 20% - 30 % savings in water usage. This system will send a message to the farmers' application once the moisture level goes low. But it is left to the farmers to decide whether to keep the valves open or closed based on the availability of water.

By using LoRa technology, in the real case scenario, it is noted that, the range covered by this system is considerably high when compared to Wi-Fi based technologies. It is clearly seen that this system provides a considerable improvement than the existing technologies.

VI. CONCLUSION

This LoRa based irrigation system plays an important role in the life of farmers. It reduces human power requirement and gives accurate results. All the components required are available readily in the market. It is easy to build this secure, highly capable and low-cost unit easily. The simple front end designed makes it easier for a layman (Farmer) to operate the automated system with ease. LoRa can handle up to thousands of messages in a day and hence can handle hundreds of sensor nodes. This can cover a large area of Coconut farm. There is significant amount of water savings by using this method. Also intelligent cloud based software provides cost effectiveness and scalability.

In future, it is possible to commercialize this project and make it reach every farmer in India. The system can also be improved by adding sensors to test the fertility of the soil, study different diseases affecting the coconut trees, insects spoiling the trees, etc.

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