Smart Solution for Agriculture using Wireless Sensor Network and Internet of Things (IoT)

Shweta Suryawanshi[1] Neha Tiwari[2]
[1,2]Assistant Professor
[1]Department of Electronics & Telecommunications Engineering [2]Department of Computer Engineering
[1,2]Dr. D. Y. Patil Institute of Engineering Management & Research, Akurdi, Pune, India

Abstract— This paper presents the technology of Active Radio Frequency Identification (RFID) and Wireless Mesh Sensor Network (WMSN) that will be used in agriculture. In this paper, ZigBee technology platform is applied in 2.45 GHz and active RFID to sustain the WSN by developing a fully automated IoT solution in agriculture for irrigation system. The system includes a plurality of sensor nodes installed in a crop field sending an ID, which are embedded sensor and WSN that work on ZigBee 2.4 GHz platform. The ID was sent to act as a signal of soil in dry condition of a specific area to a reader at base station. The pump stations will use information from base station to sprinkling water in the specific area of the dry state automatically. The automatic control system is very practical in agriculture but most of it is based on schedule and timer regardless of soil condition and temperature. Therefore, wireless automated irrigation system for efficient water use and production is proposed.

Key words: WSN, RFID, ZigBee, Agriculture, Sensor

I. INTRODUCTION

Agriculture is an industry that uses a lot of water throughout the world. This resource should be used in an efficient way without affecting the production (Jiber et al., 2011). The obstacles in measuring and monitoring water usage and inefficient irrigation systems due to human control are the main contributors to this situation. The farmers are aware that water shortage or over watering may damage the yield. They need to understand when and the amount of water is needed for specific crops (Jiber et al., 2011).

Most farmers have little knowledge of their farm and they are unaware of the methods to improve their productivity of agricultural practices. All these conflicts make it necessary to think of resolve support systems for agriculture (Jiber et al., 2011). In order to overcome this problem, Wireless Mesh Sensor Network (WMSN) and active Radio Frequency Identification (RFID) for agriculture monitoring control are applied. In this study, we proposed an automated irrigation system with full real-time remote monitoring and control system in the farm. The system replaces human-to-human (H2H) and human-to-machine (H2M) to machine-to-machine (M2M) architecture, which is embedded with active RFID. It has moisture sensor and monitoring devices that are required for the farming data such as soil moisture and condition.

WMSN combines the reliability of hardwiring with the versatility of wireless networking in spite of having to compromise the speed. In addition, WMSN consists of cost efficient, battery-powered sensor modules and embedded networking intelligence (Zulkifli Et al., 2011). The communication that hinders optimal production output ZigBee is a growing technology that will create advantages in the agriculture industry (Zulkifli Et al., 2011).

The development WMSN application in agriculture gives it potential to increase efficiency, productivity and profitability while decreasing unintended effects on crops and the environment in agriculture production (Ruiz-Garcia et al., 2009). The real time information from the irrigation area will contribute a solid base for farmers to change consideration at any time rather of taking decisions based some assumed average condition (Ruiz-Garcia et al., 2009).

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II. METHOD AND MATERIAL

A. Radio Frequency Identification (RFID)

RFID is one of an operative automatic identification technology for different things. The ultimate function of RFID is the capability to trace the position of the tagged things. RFID Technologies composes of tags, reader and computer, which acts a host and comes in all shapes, sizes and read ranges. It is also thin, flexible and can penetrate between paper and plastic. The tag has an identification number and a memory that stores data such as manufacturer, product type and environmental data such as temperature, humidity of an object (Mustafa et al., 2013). In the RFID applications, the tags are attached into objects that are to be tracked (Mustafa et al., 2013).

RFID is the most utilized in the real-time locating system in agriculture applications. It becomes a choice for farmers due to its low cost. RFID tags come in two forms, active and passive. In this, in spite of using the same RFID technology, they are dissimilar in many forms. In this system, active RFIDs are used to send ID that works on ZigBee platform to readers at the base station. It can be seen that active tags are controlled by a battery formed into the tag, which allows data to be transmitted over long distances compared to passive RFID. The read and write distances are much longer than for passive tags. The active RFID has a small battery built–in to the tag, which works as an internal power source. The batteries can sometimes be replaceable or the unit will be replaced after certain period of time, which is normally between 1 year and 7 years.

Active tags can operate at higher frequencies such as 455MHz, 2.45 GHz, and 5.8 GHz. The active RFID

broadcasts by itself. The passive RFIDs are of low cost and low range, while relics on the reader supply the energy to power the tag. The read range is limited and it is difficult to read through metal or liquid. By comparing these two active and passive tags, in this research we provided active RFID to use in the real-time irrigation monitoring system.

B. ZigBee Technology

ZigBee, which was originated in 1998, is based on the IEEE 802.15.4 standard and pioneered by ZigBee Alliance, which was formed by several companies interested in defining low cost, low power, and wireless network standard (Lee et al., 2009). ZigBee can support large number of nodes providing a low cost global network. The IEEE defines only the PHY and MAC layers in its standard, while ZigBee defines the network and application layers, application profile and security mechanism. Due to this design, the consumption of power is minimal and the battery life span is longer.

ZigBee supports three topologies, which are star, mesh and cluster-tree, as shown in Figure 1. In star topology, each end node is connected to the coordinator and communication is carried out by the ZigBee Coordinator (ZC). In mesh topology, each device communicates with any other device within its radio range or through multi-hop. In cluster tree topology, there is a single routing path between any devices (Kalaivani et al., 2011). In the ZigBee application, it is mostly used for mesh topology. In spite of that, for the proposed system monitoring mesh topology was chosen. The various sense data from moisture sensors go to WMSN, that integrates with RFID tag and sprinkler will turn into a node. On the farm, there are plenty of nodes and each node will communicate through this ZigBee technology platform. Based on that, the reader will read the sensor data and stores the data to the server, which is used by a farmer for monitoring. In the proposed system, field monitoring uses 2.4 GHz operating frequency nodes for the purpose of study.

C. Wireless Sensor Network (WSN)

Wireless network refers to the technology to communicate and access the internet without cable connection between computers and other electronic devices. Sensor Network has contributed to several applications, and awareness has expended to implement the technology into the agriculture environment. WSN is one of the most important technologies in the 21st century (Mendez & Mukhopadhyay, 2013). WSN is an assembly of a number of low-power, low-cost, multipurpose sensor nodes communicating wireless upon a short distance (Sazak et al., 2013).

The difference between a WSN and a RFID system is that RFID devices have no cooperative capabilities, while WSN allows different network topologies and multihop communication (Ruiz-Garcia et al., 2009). WSN can cut down the effort and time needed for monitoring environment (Mendez & Mukhopadhyay, 2013). As a result, money, water and labour costs can be reduced. The technology allows for remote measurements such as temperature, humidity, soil moisture and water level (Mendez & Mukhopadhyay, 2013). There seems to be increased development towards wireless outcomes in comparison to wired-based systems. Figure 2 shows the concept of wireless monitoring that is to be applied in the agriculture environment.

III. PROPOSED SYSTEM

The remote monitoring systems are promoting IoT solution working on WSN embedded with RFID technology. The system communicates with hardware and software automatically to send data in the farm. The solution is proven and can therefore be implemented from planting to harvest as a tool for appropriate irrigation tactic to improve crop yields. Besides, the WSN nodes can effectively collect data as well. Remote monitoring for irrigation and fertilizing using WSN and RFID can ensure a good quality crop yield. In spite of the stressful environmental conditions, it increases the application efficiency of irrigation systems by 50%. The collaboration has been made with local farmer company that runs the herbaceous plants on a farm located in Ipoh, Perak. This collaboration facilitates research and development of this project, while helping the company to increase productivity and reduce operating costs.

In this system, automatic irrigation systems are developed in the farm to collect the data from moisture sensors placed in the field. The farm will be monitored through the wireless sensor network that is integrated with the active RFID at the field. WSN will sense and monitor the environment like soil moisture and temperature. The coverage area for the experiment is 10 acres, in which 20 nodes are required in this Roselle farm. The systems proposed are very intelligent where the node always sleeps in standby mode. If the sensor senses soil in dry, the node will be activated to work in the mesh network between the other nodes to send ID to the reader. The end device of active RFID shown in Figure 1 is embedded with the sensor that represents wireless network sensor ID that works on ZigBee 2.4 GHz platform. The ID sent to the reader at the base station is used to recognize and allocate which nodes are sending data to the irrigation process automatically.

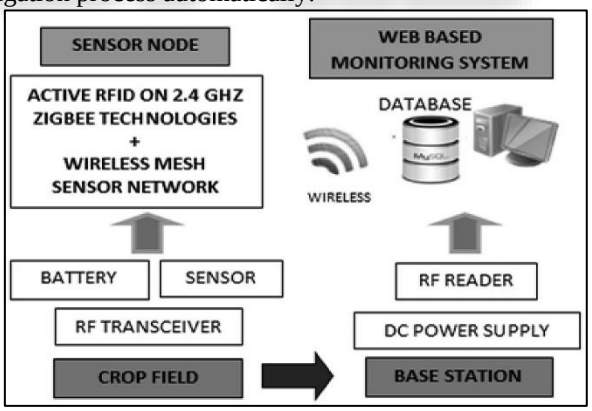

Fig. 1: The Reader at the base Station Receives ID from the Sensor Node

The full concept of the system shown in Figure 2 are active RFID on 2.4 GHz ZigBee platform and moisture sensor are embedded together to become one sensor mesh node. The moisture sensor collects data from the soil, which will be processed before sending via wireless to the controller for further action. The sprinkler will supply water based on the condition of soil. The data that are processed will be sent through the computer for monitoring by the farmers. The farmers can monitor their farm anywhere using internet connectivity by phone or computer. All the systems in the farm are connected to each other via wireless. The messy

cabling like conventional method is not used anymore because it will be disturbing an irrigation process.

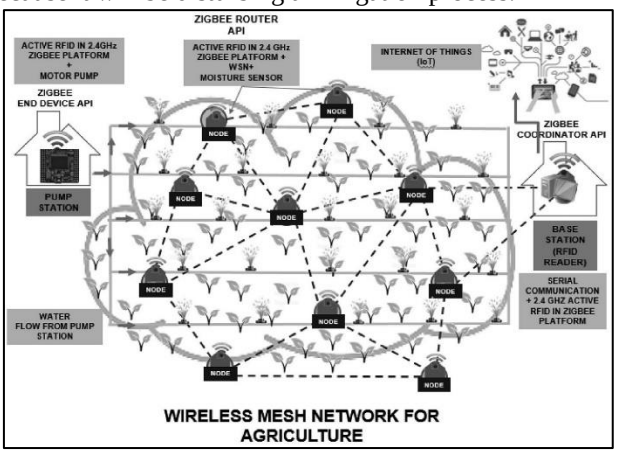

Fig. 2: The Concept of the System

IV. CONCLUSION

By introducing RFID Technology and WMSN in the farming industry, growing crops and plants can be greatly optimised. WMSN reduces the wiring and piping costs, and facilitates installation and maintenance in large areas. The use of technology in agriculture is important, particularly to increase production apart from decreasing labour cost and water requirements. Thus, the WMSN technology obviously performs the most technology to improve the current irrigation systems. Soil moisture sensors are constantly improving and becoming affordable and appropriate for massive deployment in the WMSN applications.

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