International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9, Issue-7, May 2020

Wireless Sensor Network with Power Management System for Water Level Regulation in Paddy Fields

Rajesh Singh, Anita Gehlot, Amit Kumar Thakur, Mahendra Swain, Shaik Vaseem Akram

Abstract: ***Paddy cultivation is one of the major crops cultivated in India. Normally paddy cultivation is grown twice in a year, where the consumption of water is high during the cultivation. The monitoring of the water level continuously is a little bit tedious to the farmer. However, with the assistance of advanced technology, the burden on the farmer can be reduced. So, in this study, we are proposing the Wireless Sensor Network (WSN) architecture-based water level regulating system. WSN architecture consists of three nodes like sensor node, cluster head node, and sink node. With the assistance of the float sensor and ZigBee wireless communication module, the sensor node which is deployed in the paddy field senses the water level data and communicates to the sink node. The cluster head node monitors the sensor nodes of the cluster of paddy fields and controls the actuator concerning the water level. Sink node is generally located nearby farmer location, with the assistance of sink node the farmer observer the status of water level in their paddy fields in the LCD display. This system enhances in maintaining the optimal level of water and also reduces the burden on the farmer for continuous monitoring. Especially the sensor node follows the power management system, where the power interruption is avoided.***

Keywords: ***Wireless Sensor Network (WSN), ZigBee module, float sensor, power management, and paddy cultivation.***

I. INTRODUCTION

Rice is important grain around the planet, next to the maize. It is among India's staple foods. Rice is usually produced in paddy fields, and paddy fields require huge quantities of water for the paddy to expand. Paddy fields are ploughed using livestock and land levelling equipment, and paddy fields are supplied with vast quantities of water to maintain the soil moist. Later, the necessary nutrients are applied in a suitable proportion to the paddy field. Before the transplantation of the seedlings in the wet paddy fields, the seedlings are grown in the nursery for 20-50 days. During the growth of the crop, more amount of water and nutrients are necessary for maintaining the optimal moisture level in the paddy field. The optimal moisture level needs to be maintained for avoiding the damage to the crop, this kind of moisture level can be maintained with the assistance of precision agriculture.

Revised Manuscript Received on May 30, 2020.
***** Correspondence Author
Rajesh Singh, Lovely Professional University, Phagwara, Punjab, India. Email: srajssssece@gmail.com
Anita Gehlot, Lovely Professional University, Phagwara, Punjab, India. Email: eranita5@gmail.com
Amit Kumar Thakur*, Lovely Professional University, Phagwara, Punjab, India. Email: amitthakur3177@gmail.com
Mahendra Swain, Lovely Professional University, Phagwara, Punjab, India. Email: er.mahendraswain@gmail.com
Shaik Vaseem Akram, Lovely Professional University, Phagwara, Punjab, India. Email: vaseemakram5491@gmail.com

Precision agriculture requires the usage of technologies to maintain the optimal amount of water and nutrients for the paddy field. The various soil conditions may be calculated and analyzed with the assistance of precision agriculture. The controlling and monitoring of the paddy field is processed after observing the measured soil parameters like pH, moisture, temperature, and fertility of the soil. Precision agriculture assists the farmer to develop a strategy for selecting the crop according to their climatic conditions. Efficient water control is important to ensure the optimum amount of water in the paddy sector. Water must be drained from the water sources in the paddy field while the water level in the paddy field is small, and water must be drained out if the water level becomes higher than optimum. However, this management is a little length process during rain seasons and that to the farmer needs to continuously observe the field. To reduce manual effort, a wireless sensor network (WSN) is a suitable solution for overcoming the burden of the farmer for continuous observation in the field. Generally, the fields are located far away from the home, so with the assistance of WSN, the field can be monitored from any remote location. WSN with the power management system is the best solution for maintaining the optimum water level in the paddy fields. Although the agriculture field is witnessing rapid modernization, technology and equipment are a bit short of advanced in water-saving agricultural practices. For implementing better water utilization in the field, the technologies relevant to the crop field are required [1].

The research on WSN is gaining much attention, as the WSN is helpful for the monitoring of the various kinds of environment parameters by sensing the physical parameters. An intelligent field irrigation system is a solution proposed for overcoming the issues of water scarcity [2]. Wireless sensor networks typically consist of low-cost and low-power nodes installed in rugged conditions for irrigation applications. An effective approach for creating reliable links for irrigation sensor networks can be focused on the ZigBee specification [3]. The Wireless Sensor Network (WSN) program for tracking water irrigation control consists of multiple sensor nodes with networking capabilities that can be configured for ad hoc and continuous tracking purposes. The parameters involved in the regulation of water reservations, such as the water level and the gate movement regulating the water flow, would be determined in real-time by the sensors transmitting the data to the base station or regulation/monitoring space. Using the wireless network for monitoring purposes would not only minimize the total labor cost of the monitoring program but will also offer versatility in terms of distance or location [4].

Irrigation Management System (IMS) is the composition of WSN; it can be implemented in the field. The integration of this system with a photovoltaic cell and rechargeable batteries are a robust solution in rural areas for meeting the requirement of socio-economic conditions of small-scale farmers [5, 6].

In this, we are proposing a ZigBee communication module based WSN model for regulating the water level in the paddy field. For regulating water levels, the sensors are deployed in the paddy fields. This sensor senses the soil parameters according to the pre-set value which is encoded in the microcontroller unit. Visualization of soil parameters assists the farmer in controlling the water pump with the assistance of actuators. The sensors normally measure the water level at regular intervals and compare the measurements of the values of the parameter with a pre-set value.

II. COMPONENT DESCRIPTION

A. Float Sensor

A float sensor is used for sensing the water level in any premises. This float sensor is employed with a 10 turn potentiometer for measuring the readings of water of different levels like high, low, and normal. In this study float sensor is embedded in the sensor node for measuring the level of water in the paddy fields.

B. Zigbee module

Zigbee module is a low rate wireless personal area network for communicating the data from the place where there is non-availability of the internet. The frequency bands which are supported by ZigBee physical layers are 2450 MHz, 915MHz, 868MHz and data rates of this frequency bands are 250kbps, 40kbps, and 20kbps. When compared to Bluetooth and Wi-Fi, the ZigBee module consumes low energy for transmission of the data up to a range of 10-100 meters. In this study, ZigBee is implemented in the sensor node and sink node for a short-range of communication.

C. Data loggers

Data loggers signify daily observations and monitor water level details. MSC 1210 [7] is embedded as a data logger in our study it converts the analog value of the float sensor into digital form as MSC 1210 consist of analog to digital converter in it. The converted value communicates from the sensor node to the cluster node with the assistance of the Zigbee module.

III. WSN ARCHITECTURE-BASED WATER REGULATION

The water level regulations system is proposed using Wireless Sensor Network (WSN) architecture and it is shown in figure.1. Concerning WSN architecture, water regulation is designed for monitoring the water level in the paddy fields. Normally paddy field requires a large amount of water to maintain optimal moisture in the soil during growth. Fig.1 addresses the deployment of different nodes for different functioning. The sensor nodes are deployed in 'n' number clusters for sensing the water level and communicating the data of water level to the sink node via the ZigBee module. Float sensor in the sensor node measures the water level in the paddy fields. Three different levels are preset for the sensor to sense the water on a level basis like normal, high, and low. In the case of a high level and low level, the actuators need to be controlled for maintaining the optimal level of water. The sensed data communicates to the sink node, where the farmer can monitor their paddy fields.

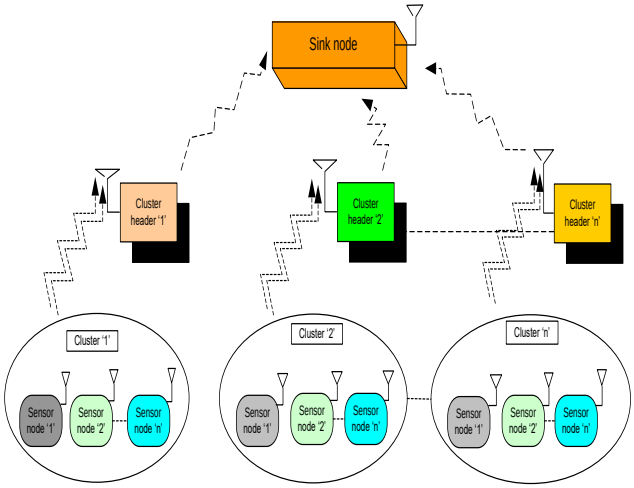

Fig.1. WSN architecture-based water level regulation

A. Sensor node with power management

The sensor node is deployed in the paddy field for measuring the water level using the float sensor is shown in Fig.2. The sensor node comprises a microcontroller unit, float sensor, ZigBee module, SD card, and power management system. Generally, sensor nodes are powered with the battery power supply and it is hectic for the farmers to check the nodes whether they are getting power supply or not. To overcome this issue, the DC power management system is including in the sensor node for continuous power supply. A solar cell is embedded at a sensor node for harvesting solar energy and the DC power management system converts the solar energy into the DC power for the sensor node. This power management system enhances the power supply facilities. SD card is additionally embedded in this system for backing up the data in case of an interruption in the sensor node.

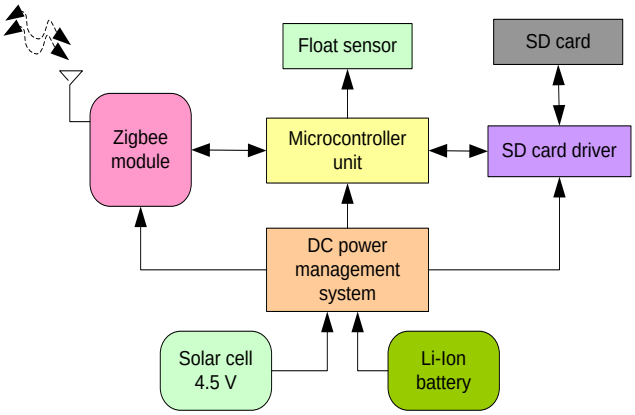

Fig.2. Sensor node with power management

The water level in the paddy fields varies according to the season, in the rainy season; the water requirement will be less when compared to the other season. In this view, the working of the sensor node should be in such a state, it should work according to the requirement of the field. To achieve this, three different modes of the sensor node are discussed in Table.1. The data stores in the SD card sends the data when the interruption is cleared.

Table 1. Modes of sensor node

Mode	Description
Off	In this mode, the node starts monitoring and no power is utilized.
Active	In this mode, the node communicates the data of the water level with high power consumption.
Sleep	Node is switched On, but it doesn't sense and transmitting the data and power consumption.

B. *Cluster head*

The paddy fields are arranged separately in cluster form. Cluster head node monitors every cluster of the paddy field and it is shown in Fig.3. Cluster head comprises of microcontroller unit, power supply unit, and actuators. Sensor nodes of every cluster are in contact with the respective cluster head for triggering the actuator depending on the sensed values of sensor nodes.

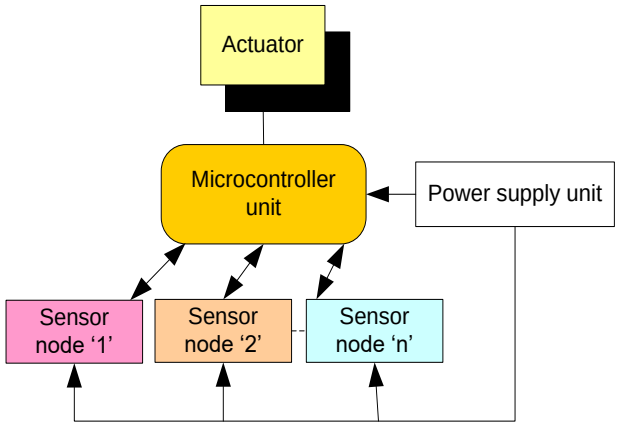

Fig.3. Cluster head mode

C. *Sink node*

Sink node is located near to the farmers' location for monitoring the paddy fields. Sink node comprises of microcontroller unit, ZigBee module, LCD, and power supply unit are shown in Fig.4. The sink node receives the sensing data of the fields with the assistance of the Zigbee communication module. An LCD (Liquid Crystal Display) is provided in the node for displaying the sensed values in digital format. With the assistance of this node, the farmer controls the actuators from their place without any communication interruption and it reduces the burden to the farmers for visiting the field.

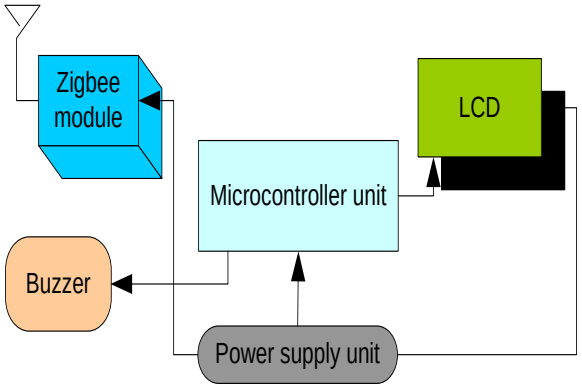

Fig.4. Sink node

IV. RESULTS

This method increases the optimum amount of water in sustaining and thus decreases the farmer's pressure of constant surveillance. The sensor node in particular implements the power management framework, where data interruptions are stopped. Thus a wireless sensor network (WSN) architecture-based water regulating system for monitoring the paddy fields wirelessly decreases the strain on the farmer in the paddy fields for constant control of the water level. The float sensor detects the water level and the ZigBee modem transmits data on the water level to the sink node. The sink node is nearby farmer location; from the sink, node farmer observes the water level data in LCD and controls the actuator for maintaining an optimal level of water. This sensor node is utilized power management for avoiding the power interruption during the transmission of data to the sink node. Our system reduces the burden on the farmer and enhances the paddy cultivation reliably.

V. CONCLUSION AND FUTURE SCOPE

Rice is one of the staple foods which are produced in large quantity in India. Normally paddy fields are utilized for growing this crop, where a large amount of water is consumed and that to nowadays many labours are not showing interest in paddy cultivation. However, this problem can be overcome by the integration of technology for the growth of the paddy field.

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AUTHORS PROFILE

Dr. Rajesh Singh is currently associated with Lovely Professional University as a Professor with more than fifteen years of experience in academics. He has been awarded as a gold medalist in M.Tech and honors in his B.E. His area of expertise includes embedded systems, robotics, wireless sensor networks, and the Internet of Things. He has organized and conducted several workshops, summer internships, and expert lectures for students as well as faculty. He has twenty-three patents in his account. He has published around hundred research papers in refereed journals/conferences. Under his mentorship students have participated in national/international competitions including Texas competition in Delhi and Laureate award of excellence in robotics engineering in Spain. Twice in the last four years, he has been awarded a "certificate of appreciation" and "Best Researcher award- 2017" from the University of Petroleum and Energy Studies for exemplary work. He got a "certificate of appreciation" for mentoring the projects submitted to Texas Instruments Innovation challenge India design contest, from Texas Instruments, in 2015. He has been honored with the young investigator award at the International Conference on Science and Information in 2012. He has published ten books in the area of Embedded Systems and Internet of Things with reputed publishers like CRC/Taylor & Francis, Narosa, GBS, IRP, NIPA, and RI publication. He is an editor of a special issue published by the AISC book series, Springer with the title "Intelligent Communication, Control, and Devices"-2017 & 2018.

Dr. Anita Gehlot is associated with Lovely Professional University as an Associate Professor with more than ten years of experience in academics. She has twenty patents in her account. She has published more than fifty research papers in refereed journals and conferences. She has organized several workshops, summer internships, and expert lectures for students. She has been awarded a "certificate of appreciation" from the University of Petroleum and Energy Studies for exemplary work. She has published ten books in the area of Embedded Systems and Internet of Things with reputed publishers like CRC/Taylor & Francis, Narosa, GBS, IRP, NIPA, and RI publication. She is an editor of a special issue published by the AISC book series, Springer with the title "Intelligent Communication, Control, and Devices-2018".

Dr. Amit Thakur is currently associated with Lovely Professional University Associate Professor with more than seventeen years of experience in academics and research. His area of expertise includes renewable energy resources and Robotics. He has organized and conducted several workshops, summer internships, and expert lectures for students as well as faculty. He has published around eighteen research papers in refereed journals/conferences. He is the Life Member of The Indian Society for Technical Education (ISTE), a faculty member of the Society of Automotive Engineers (SAE), life member of The Aeronautical Society of India (AMAeSI). He is the editorial board member and reviewer of various reputed journals. He completed a three week summer school program on Environment at Tsinghua University, Beijing, China. Topper of NPTEl online course. University topper in M.Tech, RGPV, Bhopal. Faculty Advisor of SAE collegiate club, Organizing head of IC engine and robotics workshop. Organized and conducted many workshops and national level working model competitions. Research sub-coordinator for ADRDE, DRDO in the project of design and development of the deceleration system for Space capsule recovery experiment (SRE).

Mahendra Swain a PhD Scholar at Lovely Professional University, Jalandhar, Punjab. He has completed his B.Tech in ECE from Centurion University of Technology and management, Bhubaneswar. M.Tech from Lovely professional University. He has published various research article and attended National and international conferences in the field of Embedded System and Internet of Things. He has chosen Electrical& Communication engineering with an intense urge to delve into the challenging field like embedded systems, wireless communication, Electronics products development and IoT.

Shaik Vaseem Akram is pursuing a Ph.D. in embedded systems from Lovely Professional University, Punjab, India. His area of research is on waste management using the internet of things and blockchain.