ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 3, Issue 8, August 2016

Design of Soil Condition Management System in Precision Agriculture Using Autonomous Wireless Sensing Nodes

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Abstract: **-- Main reasons for the global water crisis besides population growth, urbanization, and climate change are excessive water use, poor management, and inadequate irrigation. According to the United Nations World Water Development Report, 70% of freshwater worldwide is used for irrigation. The amount of applied water does usually not match the requirements of the irrigated crop, and either too much or too little water is used for irrigation. To enhance the resource utilization in a constrained manner an autonomous sensing platform is developed, where a number of wireless sensor nodesare installed in an agriculture land. Weproposed a system with three wireless sensor nodes by the exploration of "mesh network" to cover large area. Wireless sensor nodes observes the environment, samples and collects the heterogeneous data like soil moisture, temperature, from the interested field and transmits data to the server.A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. It is also a form of wireless ad hoc network. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes by using ZigBee and data of that node is transmitted to main server.**

Index Terms- **ARM7 Processor, Soil sensor, Temperature sensor, Real-Time Database, Wireless sensor Nodes, GSM, Zigbee**

I. INTRODUCTION

By 2025, as the United Nations Global Environment Outlook predicts, the water withdrawals in developing countries will increase by 50% and, if the trend continues, 1.8 billion people will be living in regions with absolute water scarcity. However, not only developing countries, which are facing severe health problems due to limited access to freshwater, but also the world's wealthiest industrial nations are increasingly suffering from water shortages. In 60% of the European cities with more than 100,000 people, for example, groundwater is being used at faster rates than it is replenished. The water scarcity severely affects the nations' socio- economic development, because industrial and manufacturing activities require adequate water supplies. As a direct consequence, increasing water, food and energy prices as well as hampered agricultural productivity has major implications on the nations' economies. For example, the water prices in the United States are growing about 10-15% every year. Main reasons for the global water crisis – besides population growth, urbanization, and climate change – are excessive water use, poor management, and inadequate irrigation. According to the United Nations World Water Development Report, 70% of freshwater worldwide is used for irrigation [1][2].

Conventional irrigation systems usually work on the principle of timer-based irrigation. Timer-based irrigation controllers, incorporated into the irrigation systems, are deployed to trigger irrigation events using mechanical or electromechanical timer. However, timer-based systems possess several disadvantages because actual soil and weather conditions are not considered. Consequently, the amount of applied water does usually not match the requirements of the irrigated crop, and either too much or too little water is used for irrigation. Recent studies have unveiled that less than 40% of applied water is used by the irrigated crop effectively. Furthermore, it is well known that poorly managed irrigation systems not only contribute to water scarcity, but can also lead to significant soil damage caused by draining (due to water shortage) or leaching (due to excessive water application) entailing a further reduction in crop yield . To overcome the problems caused by inadequate and expensive irrigation, "smart" irrigation controllers have been proposed as an alternative to conventional timer-based irrigation controllers[4][5].

Wireless sensor network is built of nodes from a few several hundreds to thousands, where each node is connected

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to one or more sensors. By using mesh technology communication between different nodes is also possible which helps for long distance monitoring. Each sensor in a node has several parts like microcontroller unit, electronic circuit for interfacing with sensors, energy source. Such tiny sensor node collects the data from the land and sends the collected information to the master controller for analysis and storage and future which can be sent to the farmer [7][8].

The proposed system is to assess or monitor the problem of agriculture management by developing a Data Acquisition & Monitoring over private Mesh network using WSN for Agricultural land management. To overcome the drawbacks of existing system like each wireless sensor node employed can be capable of collecting information to certain limited area and over watering of land area where moisture already exists; we proposed a wireless sensor network with 2 nodes by the exploration of "mesh networking". Each node in a wireless sensor network is equipped with one or more sensors in addition to a microcontroller, wireless transceiver, and energy source.When deployed inthe field, the microprocessor automatically initializes communication with every other node in range, creating an ad hoc mesh network for the transfer of information node to node.

In this study, an intelligent remote monitoring system, composed of a number of wireless sensor nodes and a computer system located on site, is proposed for irrigation control in agricultural ecosystems.Data acquisition, data analysis, data aggregation and decision making are performed directly on the sensor nodes, and real- time soil moisture measurements as well as actual weather data are used to schedule irrigation events autonomously.

II. OVERVIEW OF SYSTEM

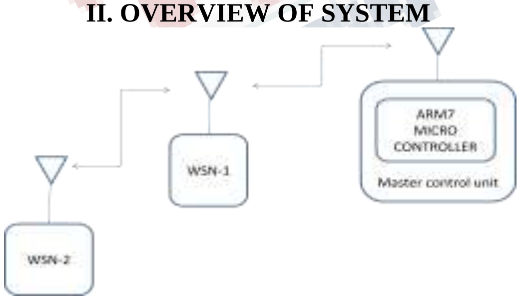

Fig 2.1 Overview of the system

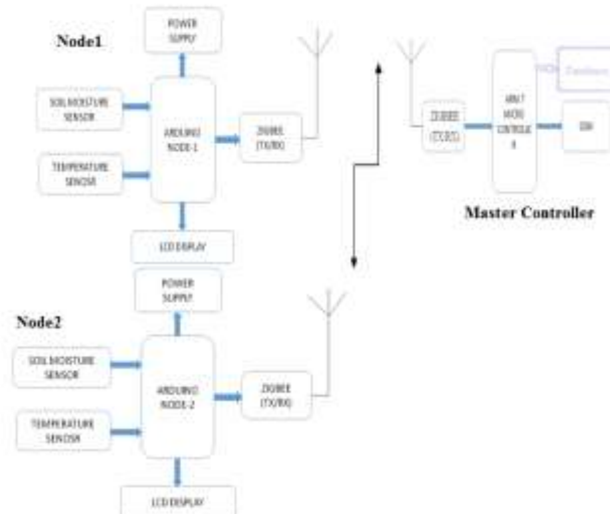

Fig 2.2: Proposed system Blockdiagram

The overview of the proposed system contains two nodes with soil moisture sensor and temperature sensor. These sensors will exhibit analog output. The normal microcontroller will be having digital input pins, so we can't connect these analog sensor's output to microcontroller directly. We need to get analog to digital converter(ADC) in order to interface with these sensors. To overcome this problem, Arduino board is taken which is having analog and digital pins. Here node -1 is nearer to the master control unit, thus it receives data from node-1 directly but node-2 will be far from this master.

A mesh network is employed in between the nodes so that both the nodes communicate with each other and node-2 data is transfeerred to master through the mesh networking. The ARM7 microcontroller is used at the master control unit. Later the received data is sent to authorized number by using GSM/GPRS. Then the required action is taken place by user.

III. SOFTWARE DESIGN

a. Wireless Sensor Node-1 Flow Chart

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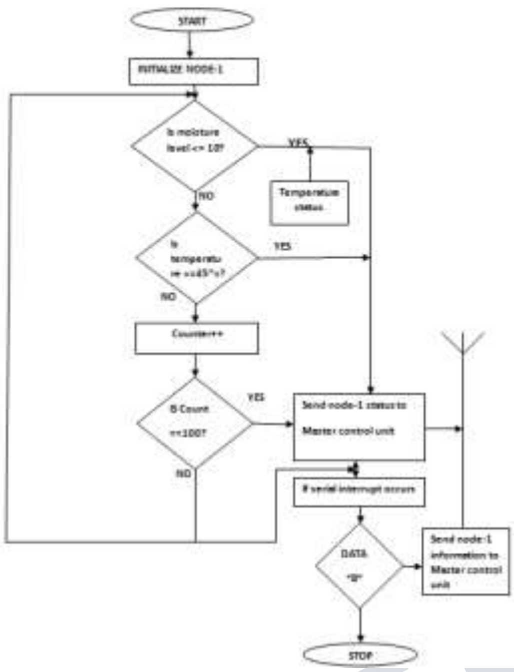

Fig 3.1 Node-1 flow chart

In node-1, the ARDUINO is the key device to control whole system, so the main program runs in ATmega328. The main program starts primarily by initializing the node-1, LCD & Event Counter=0. After initializing LCD, it checks for soil moisture level whether it is less than threshold that is set before.

If moisture level is low, then it reads the temperature status and displays on LCD and then sends these node-1 details to Master Control Unit. If moisture level is medium or high then also it checks for temperature status and sends those details to Master Control Unit. If both moisture and temperature levels are low then event counter will get incremented and loop repeats againIf any serial interrupt occurs then data that is stored with code “B” will be sent to Master Control Unit.

b. Wireless sensor node-2 flow chart:

In node-2, the main program starts primarily by initializing the node-2, LCD & Event Counter=0. After initializing LCD, it checks for soil moisture level whether it is less than threshold that is set before. If moisture level is low, then it reads the temperature status and displays on LCD and then sends these node-2 details to node-1. If moisture level is medium or high then also it reads temperature status and sends those details to node-1. If any serialinterrupt occurs then data that is stored with code “Z” will be sent to Master Control Unit.

At node -1, the details of the node-2 sensors are received when the master control unit requests for the information. Then first node-1 requests for node -2 details, the node-2 sends the acknowledgement to node-1 and then node-1 receives the node-2 information. As node -1 acts as intermediate node, it sends node -2 information to Master Control Unit.

If moisture level is low, then it reads the temperature status and then sends these node-2 details to node-1and displays on LCD. If moisture level is mediumor high then also it checks for temperature status& sends those details to Node-1.

If both moisture and temperature levels are low then event counter will get incremented and loop repeats again. If any serial interrupt occurs then data that is stored with code “Z” will be sent to Master Control Unit through node-1.

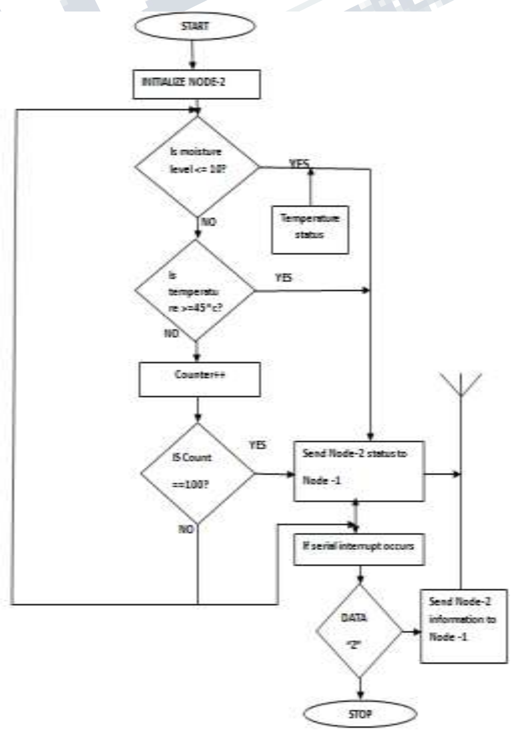

Fig 3.2 Node – 2 flow chart

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ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
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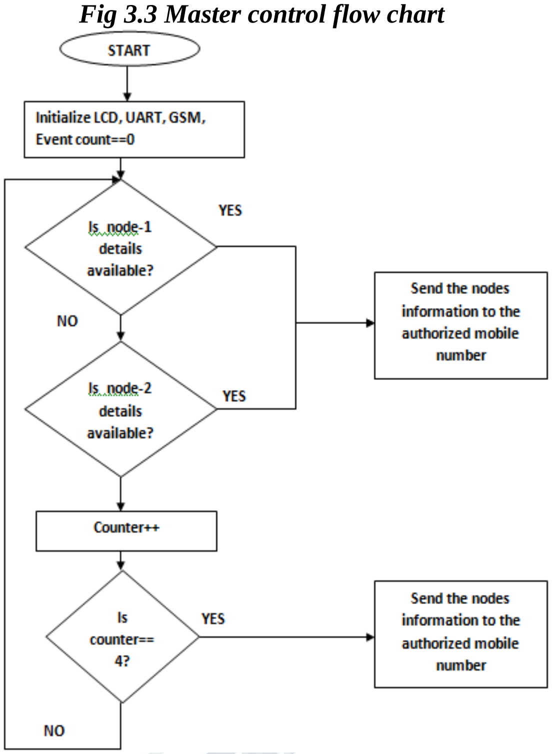
The ARM7 is the key device to control whole system, so the main program runs in ARM. The mainprogram starts primarily by initializing the LCD, UART and GSMModem,& Event Counter=0. In this master requests the node- 1 details and node -2 details through node-1 then the node-2 details after acknowledgement are received at node -1 and then node -1 sends node -2 details to the master.

Master as connected to GSM, the total information will be sent as SMS to the authorized mobile number.

c. Master Control Unit Flow Chart

Fig 3.3 Master control flow chart



IV. RESULTS AND DISCUSSION

The system continuously senses soil moisture and atmospheric temperature which are very much useful for irrigation purposes and alerts the authorized person through GSM modem to take certain measures.

If any moisture level gets lowered then those details are displayed on LCD display and SMS is sent to authorized person.

The details of the node-1 and Node-2 are displayed on LCD; it shows that the soil moisture level is low or high. When the soil moisture level is dry or wet, the details are sent to real-time database every second .Fig 4.1 to fig 4.4 shows soil condition for Node-1 &2.

Fig 4.1: node-1 details when soil is in dry condition

Fig 4.2 : Node-1 details when soil is in wet condition

Fig 4.3: Node-2 details when soil in dry state

Fig 4.4: Node-2 details when soil in wet state

When both the nodedetails are acquired at the master control unit, then that information has been sent to authorized number through SMS by using GSM shown in fig 4.5.

Fig 4.5: SMS notification from the nodes

The Node details are updated in the real-time database for future processing and interpretation. As shown in fig. 4.6.

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fig. 4.6: Real-Time database & server uploading

V. CONCLUSION AND FUTURE SCOPE

This paper describes about the design and implementation of an autonomous sensing platform to sense the soil condition and temperature at the large acres of land areas. The system incorporates the low power, cost effective autonomous sensing nodes to acquire the different conditions of soil and atmosphere. The nodes are installed at different areas in a land and communicate each other in the private mesh networks to overcome the limited range coverage. The system shows the satisfactory results to monitor the agricultural land parameters.

The sensed parameters are processed by the master controller for interpretation to transfer into farmer friendly system. The condition of land parameters are often sent to the farmers for manual operation. At the same time the sensed data from various nodes are uploaded into real-time database for future analysis and crop management.

The system can be further innovated by monitoring nutrients levels of a soil for season crop management. By incorporating Internet of Things (IoT) technology agriculture land management becomes very user friendly.

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