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Wireless Nodes Assisted Micro-Irrigation System: an IoT Approach

S. L. Deshpande, D S Chaudhari

Abstract: Irrigation systems deployed with Wireless Sensor Network (WSN) while transforming them to Micro-Irrigation systems are emerging as fruitful solution to ongoing ground water crisis. Field parameters like soil moisture, temperature and humidity can be monitored taking help of sensor array and can be fed back to decision making control system. Organized parametric results can help the optimized use of the water. By using wireless communication and environmental energy harvesting techniques, sensor network can be made totally wireless. Internet of Things (IoT) is another emerging technology that goals to extend the application of internet from complex computational machines (computer) to the stand alone devices such as consumer electronics. Integrating IoT to WSN not only can provide remote access but also allow two distinct information systems to frequently collaborate and provide common services. Also the user can be provided with flexible interface like mobile application. The miniaturization in technology and even more reliable communication are the strongest suits of such sensor network. This paper reviews for various technologies to fulfil requirement of such application and the shows some system characteristics.

Keywords: WSN, IoT, Irrigation, Moisture, Humidity, Energy Harvesting, etc.

I. INTRODUCTION

Water is one of the essential resources for the growth of the crops. The vulnerable condition of the ground water level is the prime concern of the farmers. Irrigation is the method of providing controlled amount of water supplied to plants at regular intervals for agriculture. Manual irrigations techniques are found to be inefficient in managing the water application to the crops and getting outdated. Field parameters like soil moisture, temperature, humidity, wind flow, pH level, solar radiation etc. have key importance in development of the plant and parametric measurements of them can assist irrigation process. Soil moisture measurement can be done in either ways soil moisture tension or soil moisture content. Former being measurement of efforts of plant root to extract water from the soil and later being measurement of amount of water in the soil stated in percentage. Plants growth occurs when photosynthesis is greater than respiration but increased temperature sometimes cause increase in rate of respiration even more than rate of photosynthesis, *i.e.* outcome of photosynthesis is being consumed more rapidly than being produced forming imbalance.

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***** Correspondence Author (s)
S. L. Deshpande, Department of Electronics and Telecommunication, Government College of Engineering, Amravati (Maharashtra), India. E-mail: sumitdeshpande27@gmail.com
D. S. Chaudhari, Department of Electronics and Telecommunication, Government College of Engineering, Amravati (Maharashtra), India. E-mail: ddsscc@yahoo.com

In contrast to above situation at low temperature photosynthesis slows down enough to decrease the growth and yield in turn [1]. However, this behavior changes plants to plants and effect of temperature is worth consideration. In winter the temperature drops significantly low and the frozen plant cells and tissues cause entire field to be wiped out. Relative Humidity can be defined by taking ratio of water vapor in the air to the amount of water the air could hold at a given temperature and pressure [1]. Knowledge of these parameters at particular instance would be helpful for improving the interoperability between the control system and the sensor node. This paper is structured with seven sections. The introduction is followed by system elements. The overview of work related to WSN and IoT forms the third section. Fourth section states outline of system setup. Fifth section shows initial results Conclusion forms the Sixth section.

II. SYSTEM ELEMENTS

A. Sensors

Soil profile underneath the surface of earth can be classified in areas named Surface soil, Subsoil, Substratum and Deep bed rock. Water that plant gets is mostly from the surface soil and subsoil area. The soil moisture sensor should be placed in these area. There are some physical properties of the soil like texture which need proper laboratory test. Traditional techniques such as feel method and Gravimetric method [2] of soil moisture sensing are thus prove to be precise. For purpose of irrigation, the electronic soil moisture sensors based on electric properties of soil can suffice the application, literature finds many such sensors. Soil Moisture blocks are also called as electrical resistance blocks which work on principle of electric conductivity of soil [2]. Semiconductor based temperature sensors are integrated circuit (IC) based sensors. The response of the sensor is linear but accuracy and operating temperature range is lower. Based on requirement the temperature sensor can be chosen. Humidity, simply putting, is the presence of water in the air. Many types of integrated temperature and humidity sensors are available in form integrated circuits. These sensor can be easily employed in the sensor node and consume very less area on circuit board.

B. IoT integrated WSN

Small sensing objects called sensor nodes which communicate over wireless channel and spanned over the area under observation in distributed manner form the WSN. Sensing local parametric data, measurement of some physical phenomenon and send that to the centralized control system are the main motive of WSN. The wireless commutation when compared to wired communication offers the cheaper, faster and easier option.

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Moreover relocation of measurement point can be performed simply by moving sensor node from one point to another, provided that those points are within the range of communication with coordinator.

IoT is an emerging technology which is expected to affect human life in greater scale. Beyond doubt semiconductor giants see the IoT as the future market opportunities. Roadmap of IoT starts in early 2000s and growing since then heading towards the formation of physical world web. IoT is connecting smart devices embedded with electronics, software, sensors, and actuators with the application of internet to form a network that enables them to collect and share data among themselves. IoT sensor node has been given poor computational power for making them suitable to new type of networks, whereas the WSN relies greatly on hardware memory for storing the digital data converted from analog values measured in real world. Working through IoT integration to WSN system can provide with a way to turn these limitations of respective technologies in benefits of one another. Broadly speaking such system will have its senses rooted WSN and its brain in IoT. WSN can be the bridge that connects the real world to the digital world and responsible for passing on the sensed real world values to the Internet thus making its involvement majorly in the hardware communication. IoT further extends the systems capability to store the real world data in cloud services or in databases. It can also be used to monitor parameters of real world, make meaningful interpretations of sensed data and even help in making decisions based on the sensed data. WWW is massive network and provides a user remote access by web server application. Actuators are the essential mechanisms used for actual controlling of parameters by which a control system acts upon its environment. Actuators need to be provided with the control signals. For automated system these controlling signals must come from the centralized control block. Here comes the ongoing discussion on Micro Electro Mechanical System (MEMS) and their use in IoT.

III. OVERVIEW OF WORK RELATED TO WSN AND IoT

A number of experiments were conducted over long course of time for an efficient agriculture application. To name a few with IoT platform embedded with WSN are discussed below. Though some of these systems are applied for greenhouse, it can also be extended to suit open field.

Y Kim *et al.* [3] talk about remote sensing and controlling of irrigation system. The system proposed this paper made use of distributed wireless sensor network for a site-specific irrigation. In addition to the soil moisture the readings for air temperature, relative humidity, precipitation, wind speed, wind direction and solar radiation were also taken at the weather station. The system has base station having Bluetooth antennas which communicate to irrigation control station to operate the water application. The GPS provides navigation of the system. This proposed system offers a low power consumption with high reliability based on the result indicated. System proposed in [4][5][6] have ZigBee as the wireless protocol for information transfer between WSN. These systems perform data acquisition, transmission and reception and processing on the data. The remote intelligent monitoring gave control of greenhouse [4][5]. Cost reduced significantly due to involvement of less man power.

According to information provided in [7][8] The inspiration of the internet of things comes partly from RFID technology. RFID system has applications in tracking objects, people, and animals where the simple tags form extensive infrastructure of networked RFID readers. For IOT the smart objects autonomous in physical/digital aspect replace the simple tags.

K. Langendoen *et al.*[9], deployed a large scale sensor network with 100 nodes which monitor humidity and temperature of potato field. This paper highlighted the need for the augmentation of existing hardware/software modules having capabilities to provide a rich set of statistics, allowing for detailed 24/7 monitoring of the sensor network.

In [10] L. Li *et al.* proposed smart grid system for agriculture which makes use of wifi based WSN instead of ZigBee. With high bandwidth, fast transmission rate, long transmission distance and cost effectiveness these system can be advantageous over other systems. On the same line, M. Lee *et al.* [11] talk about IoT based agricultural production system. The system had three parts namely relation analysis, statistical prediction, and IoT service. The farmers can observe the whole production cycle from seeding to selling using IoT based agricultural production system.

IV. SYSTEM SETUP

The system is proposed by taking into consideration three purposes it should fulfil *viz.* data collection, data analysis and presentation of the data to real world.

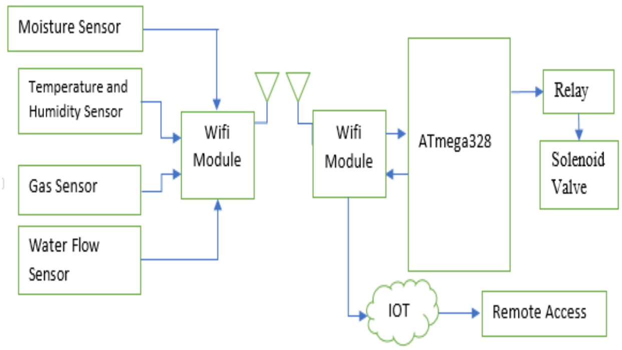

Fig. 1 Block diagram of proposed Irrigation System

Figure 1 shows the block diagram of the overall irrigation system. The wifi module used is the ESP8266−01 chip. In this project microcontrollers used are ATmega328P (Arduino uno). With a 32kb flash size, 6 analog input pins and 14 digital I/O pins this microcontroller can fulfil the basic needs. Moisture sensor is a low cost electrical block made of PCB that can inserted in the soil. For hardware optimization three moisture sensors are interfaced to one sensor node. DHT11 is the integrated temperature and humidity sensor which is used here. The gas sensor MQ-2 is a sensor that can sense the smoke. With help of relays the solenoid valves can be controlled to apply water through irrigation pipes.

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The data collected is first stored database. Then the data can be imported from the database in excel application of windows to make graphical interpretation. The analysis can be carried out on the graphs.

V. RESULTS AND DISCUSSION

The initial results are presented here. The sensor node is powered by an adapter that can give 1A current supply. Figure 2 shows the voltage and current consumption of the sensor node. For accurate current measurement the data logger with a current sensor ACS712 (5A) was used. The current is measured through a resistor of one ohm in series with sensor node. The graphs shows the maximum point with around 628 mA current and 5.56 V voltage. This point is important in solar harvesting.

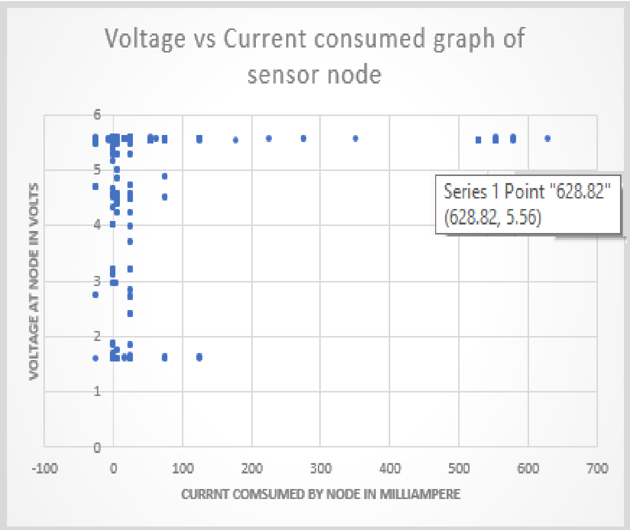

Fig. 2 Voltage vs Current consumed graph of sensor node

When the soil is wet the current flowing through the moisture sensor is at the peak. Also with the wifi module is sending the data it consumes more current. The set of lower values is because of the sleep modes of the microcontroller and wifi module introduced. The system proposed provides the real time monitoring. The sensor readings are updated for every minute. The output of the moisture sensor is in the form of ADC values. Since the ADC onboard is of 10 bit resolution, the values vary from 0 to 1024. Here the drier soil gives higher value than the wet soil. This is because moisture sensor is at ground side of the voltage divider. The application of water is at an interval (roughly one hour) as indicated on time line. The temperature is in degree Celsius and humidity is in percentages. The average value of the temperature and humidity are 27.21° Celsius and 21.28%.

The decision control system takes the decision of when apply water to the crops through micro irrigation pipes which are controlled by solenoid valves. From the graphical interpretation, it can be visible that the decision control should be able to take care of the points shown in red circles where sensor readings don't vary much (in case of the moisture sensor) or false sensor readings (in case of temperature or humidity sensor *i.e.* DHT11). Along with moisture level, temperature and humidity reading, the knowledge of the water flow, which is included in future work, through pipes can give more reliable decision making.

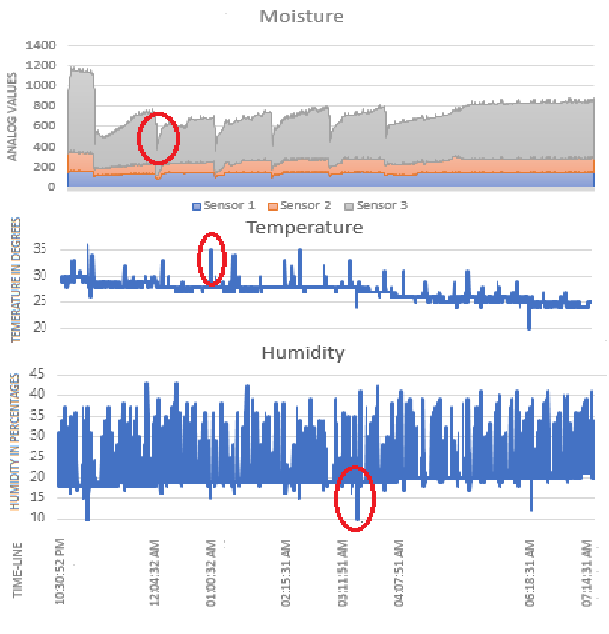

Fig. 3 Graph generated in excel indicating sensor values obtained over time

VI. CONCLUSION

To sustain the crop yield, optimization of water like resources is important. Monitoring the field parameters can assist the irrigation system. Wireless sensor network integrated with internet of things (IoT) can help in managing the resources. The WSN provides remote access to the field data and IoT provides monitoring of the data and controlling of water outlets over the internet.

The proposed system is capable of real time monitoring of the soil moisture, temperature and humidity values. The extensive work is to collect and analyze data to predict the right amount of water for the crops.

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AUTHOR PROFILE

Dr. Devendra S. Chaudhari obtained BE, ME, from Marathwada University, Aurangabad and PhD from Indian Institute of Technology, Bombay, Mumbai. He has been engaged in teaching, research for period of about 25 years and worked on DST-SERC sponsored Fast Track Project for Young Scientists. He has worked as Head Electronics and Telecommunication, Instrumentation, Electrical, Research and in-charge Principal at Government Engineering Colleges. Presently he is working as Head, Department of Electronics and Telecommunication Engineering at Government College of Engineering, Amravati. Dr. Chaudhari published research papers and presented papers in international conferences abroad at Seattle, USA and Austria, Europe. He worked as Chairman / Expert Member on different committees of All India Council for Technical Education, Directorate of Technical Education for Approval, Graduation, Inspection, Variation of Intake of diploma and degree Engineering Institutions. As a university recognized PhD research supervisor in Electronics and Computer Science Engineering he has been supervising research work since 2001. One research scholar received PhD under his supervision. He has worked as Chairman / Member on different university and college level committees like Examination, Academic, Senate, Board of Studies, etc. he chaired one of the Technical sessions of International Conference held at Nagpur. He is a fellow of IE, IETE and life member of ISTE, BMESI and member of IEEE (2007). He is recipient of Best Engineering College Teacher Award of ISTE, New Delhi, Gold Medal Award of IETE, New Delhi, Engineering Achievement Award of IE (I), Nashik. He has organized various Continuing Education Programme and delivered Expert Lectures on research at different places. He has also worked as ISTE Visiting Professor and visiting faculty member at Asian Institute of Technology, Bangkok, Thailand. His present research and teaching interests are in the field of Biomedical Engineering, Digital Signal Processing and Analogue Integrated Circuits.

Sumitkumar L. Deshpande, received the B. Tech. degree in Electronics and Telecommunication from Vishwakarma Institute of Technology, Pune in 2014 and currently pursuing the M. Tech. degree in Electronic System and Communication from Government College of Engineering, Amravati.

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