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Automated Irrigation System using WSN and Wi-Fi Module

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ABSTRACT
The objective of the developed system is to encourage the efficient water management practices that optimize the usage of water by keeping the crop health and yield intact through the implementation of automated irrigation system. The microcontroller-based solution consists of distributed wireless network (WSN), base or control station and user interface. Each sensor node will have soil-moisture, temperature and humidity sensors placed in the farmland. These WSNs are powered by battery. Base station will collect the sensor information through the use of RF transceiver. An algorithm is developed to monitor soil-moisture and temperature to control the water volume depending upon the set threshold. Base station also sends the sensor information to remote database for logging through Wi-Fi interface. Web application is developed that enables the user for remote monitoring of data and control certain parameters like soil moisture threshold, manual override of water flow, etc.

***Keywords*: Internet, J2EE, RF Transceiver, Sensor, Wi-Fi, WSN**

I. INTRODUCTION

The economy of our country India still largely depends on agriculture. Also the major portion of population is employed in agriculture field. The population of our country is increasing and so the volume of the food required. In order to meet the demand for the increased food, the more agriculture production is expected. This definitely requires more water. On other side, the factors like reduction in ground water level, climate change and uncertainty in monsoon increases the importance of saving the water while increasing food production. The solution to this is the adoption of efficient water management practices such as irrigation system.

In traditional irrigation system, farmer manually releases the water to crops either at regular interval or by monitoring the moisture of the soil. This is particular useful for small farmland. Such systems require labors and not always accurate. So there is possibility of more water is being used than required. Automated irrigation makes use of technology for measuring the soil moisture and other parameters. Based on these parameters, system on its own decides to switch on the pump.

The solution uses the distributed wireless network of sensors, data collection station and application layer. Sensor node having sensors such as soil moisture, temperature and humidity will send data wirelessly to base station. Sensor node is battery operated. Solar panels can be used to charge the battery. Base station will control the release of water based on the threshold. RF Transceiver module helps the data communication between sensor node and base station. Communication range of this RF transceiver is around 500 meters. Wi-Fi Internet module in the system allows base station to log the data in MySQL database. Web based application allows the user to monitor the data and also control few parameters.

II. LITERATURE SURVEY

Joaquin Gutiérrez et al. [1] have designed and implemented an automated irrigation System using Wireless sensor network and GPRS module which optimizes the water use for agriculture crops. It consists of distributed wireless network of soil moisture and temperature placed in the fields. WSN communicates to the base unit via Zigbee module. The base unit receives the sensor information and activates the actuators as per the algorithm developed with the threshold values of soil moisture and temperature. It also sends the data via GSM modem to web application for remote monitoring. The automated system was tested and found to save up to 90% of water saving compared with the traditional irrigation practices.

Sabrine Khriji and Dhouha El Houssaini et al. [2] have proposed a precision irrigation system composed of different types of nodes. Each node has set of sensors and communication mechanism to send data to base station. Soil node measures soil moisture and temperature. Weather node monitors the parameters like luminance level, air temperature, relative humidity and wind speed. Container node controls the irrigation process using actuator. Wireless communication is provided by Chipcon CC2420 radio module. The base station connected to a PC on a USB port logs the data in a MySQL database. Data is viewed through Java based application.

Yunseop (James) Kim et al. [3] have developed a system which makes use of Bluetooth technology for wireless communication between wireless sensor network and base station. The Bluetooth receiver wirelessly receives the data from all sensing stations and sends the data to the base computer via TCP/IP Ethernet. The base station processes the in-field sensory data through a decision making program and sends control command to the irrigation control station. The control station makes use of PLC. Microsoft .NET base graphical user interface allows the user to read the GPS data from control station and sensor data from in-field sensing stations and send control signals to the irrigation control station for individual sprinkler operation.

Orazio Mirabella and Michele Brischetto [4] have proposed a hybrid wired/wireless infrastructure solution for the management of a farm made up of several green houses in Sicily. Controlled Area Network (CAN) has been used for wired communication whereas Zigbee type network has been used for wireless communication. Supervisory Control and Data Acquisition (SCADA) system has been for moni-toring and controlling the optimal conditions of the environment in each greenhouse.

Nelson Sales, Orlando Remédios and Artur Arsenio [5] have proposed a cloud-based solution for smart irrigation system. Cloud platform receives the data from WSAN and weather information from weather station through a web service. The irrigation algorithm uses both soil moisture measurement and weather station fore-casts. Accordingly cloud platform sends the message to WSAN to activate/deactivate the irrigation.

Another parameter to control the irrigation is estimating evapotranspiration. The system [6][7] is capable of predicting the evapotranspiration and irrigating considering the amount of water removed through the evapo-transpiration during the diffusion time based on the predicted evapotranspiration rate.

Systems are getting developed using advance technologies such as fuzzy logic [8], Expert system (irrigation expertise) [9], predictive control for green house process [10] and to control the irrigation.

Trifun Savic and Milutin Radonjic have implemented the irrigation solution with Libelium Waspmote open source platform, supported by GPRS communication module. System can be remotely control via SMS [11].

III. PROPOSED SYSTEM

The general block diagram of the system is shown in Fig. 1 consists of three components namely Wireless Sensor Unit (WSU), Wireless Information Unit (WIU), and Web module.

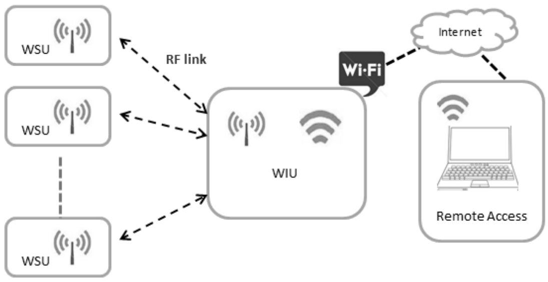

Fig. 1 General Block Diagram

WSU reads the values of sensors at specific interval and transferred these values to WIU using RF transceiver. WIU upon receiving sensor information, compare with threshold and takes the decision on starting or stopping water to crops as per programmed logic. WIU send the sensor data to server using Wi-Fi module via internet for monitoring purpose. Web application allows the user for remote monitoring and control on browser through any internet enabled devices such as PC, tablet, smartphone.

3.1 Wireless Sensor Unit

WSU consists of microcontroller, sensors, signal conditioning, RF transceiver and power supply as shown in Fig. 2. Several WSUs can be deployed in the farmland depends upon the area to be covered.

3.1.1 Microcontroller (LPC2148)

The LPC2148 microcontroller is a 32/16 bit ARM7TDMI-S CPU with real-time emulation, on-chip RTC and high speed flash memory. It has operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads. Microcontroller reads the values of sensors through 10-bit Analog to Digital Converters (ADC) ports. This in-formation is transmitted to WIU through RF transceiver RFM22B connected to microcontroller with standard 4-pin SPI bus.

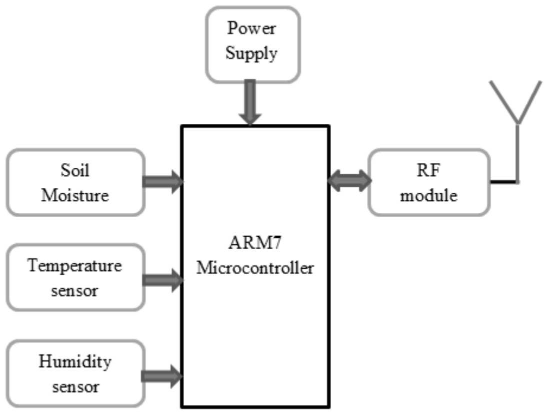

Fig. 2 Block Diagram-WSU

3.1.2 RF Transceiver (RFM22B)

The RFM22 is a wireless transceiver module with frequency range over the complete 240-930 MHz band and adjustable output power of up to +17 dBm. The proposed solution uses a low cost ISM FSK Transceiver module which operates at 433MHz. It is suitable for battery powered applications as current consumption is low and wide operating voltage range of 1.8-3.6 V.

RFM22B communicates with the microcontroller LPC2148 over 4-wire SPI interface (Fig. 3): SCLK, SDI, SDO and nSEL. A SPI transaction is a 16-bit sequence having a Read-Write (R/W) select bit, followed by a 7-bit address field (ADDR), and an 8-bit data field (DATA).

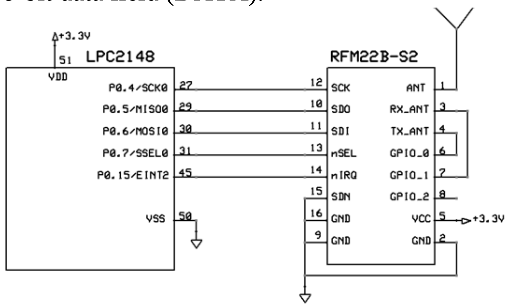

Fig. 3 Interface Microcontroller-RF Module

Since the module operates at 433 MHz, antenna length required will be 17cm (wavelength/4). 18 gauge copper wire of length 17 cm is connected to ANT pin of RFM22B.

3.1.3 Sensors

- Soil moisture sensor

It is the most critical sensor of the irrigation control system. It measures the water content in the soil. Sensor output is connected to Analog to Digital converter pin P0.10/ADC1.2 of LPC2148 via a unit gain amplifier (LM324). The sensor has two probes which can be buried into soil. The voltage of the sensor output changes with the water content in the soil. When the soil is wet, the output voltage decreases. When the soil is dry, the output voltage increases.

- Temperature

The LM35 is a precision integrated-circuit temperature sensor with an output voltage linearly proportional to the temperature in Centigrade. Output is given to Analog to Digital converter pin P0.13/AD1.4 of LPC2148 via amplifier with the gain of 3.5.

- Humidity

Humidity sensor used is an SL-HS-220 humidity sensor module which gives analog output voltage. The output is given to Analog to Digital converter pin P0.12/ADC1.3 of microcontroller LPC2148 via a unity gain amplifier. In this solution, signal conditioning is done primarily to isolate the sensor circuitry from microcontroller board. It uses M324, a low power Quad Operational Amplifier.

3.1.4 Algorithm

The WSU has been programmed with the appropriate logic shown in Fig. 4.

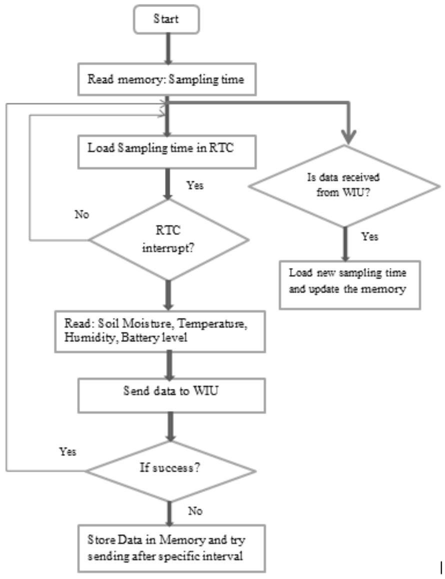

Fig. 4 Algorithm for WSU

Based on sampling interval, microcontroller reads the data from soil moisture, temperature and humidity. This sensor information is transmitted to WIU via RF transceiver. It also receives the data from WIU pertaining to sampling interval and changes its cur-rent value accordingly.

3.2 Wireless Information Unit

WIU is located at the base station. It is also called a control station. It communicates with both WIU and Web module. It consists of microcontroller, RF transceiver, Wi-Fi module and actuator (water valve) as shown in Fig. 5.

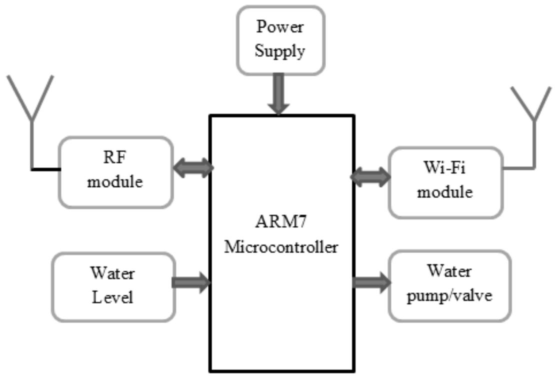

Fig. 5 Block Diagram-WIU

3.2.1 Wi-Fi Module

The Wi-Fi module used in the solution is ESP8266, a low cost wireless module with a complete AT command library. It is suitable for adding Wi-Fi functionality to a microcontroller project via a UART serial connection. It has features like 802.11 b/g/n protocol support, Built-in TCP/IP, On-board PCB Antenna, etc. ESP8266-01 module is connected to microcontroller LPC2148 using UART1 interface as shown in Fig. 6.

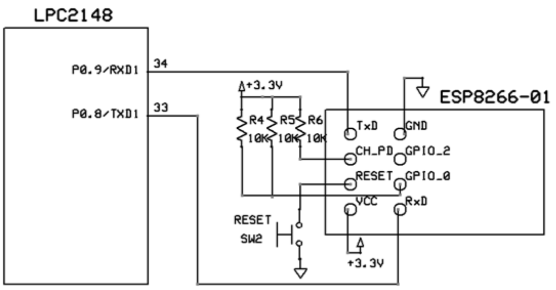

Fig. 6 Interface Microcontroller-Wi-Fi Module

3.2.2 Water Control Valve

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current flowing through a solenoid. In proposed solution, plastic water solenoid valve is used which is suitable for irrigation system. Port P0.12 is connected (Fig. 7) to Signal pin of relay module.

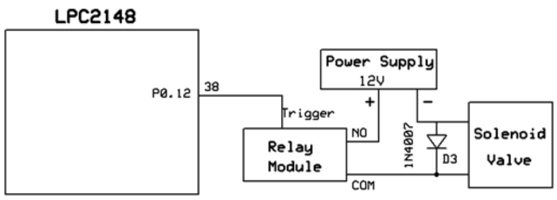

Fig. 7 Interface Microcontroller-Control valve

When P0.12 is high, relay gets energized and in turn opens the valve allowing water to flow. When P0.12 is low, relay gets de-energized and valve closes stopping the water flow.

3.2.3 Algorithm

WIU has been programmed with the logic shown in Fig. 8. It receives sensor in-formation from WSU; compare soil moisture reading with set threshold & as per programmed logic start or stop the water valve. Water flow remains for the set duration (control parameter). It also sends the sensor information to remote database using Wi-Fi module via internet. It receives the control parameters such as sampling frequency, soil moisture threshold, water flow duration and manual on/off of valve from remote application and action accordingly. It sends sampling interval data to WSU to change the sensor reading intervals.

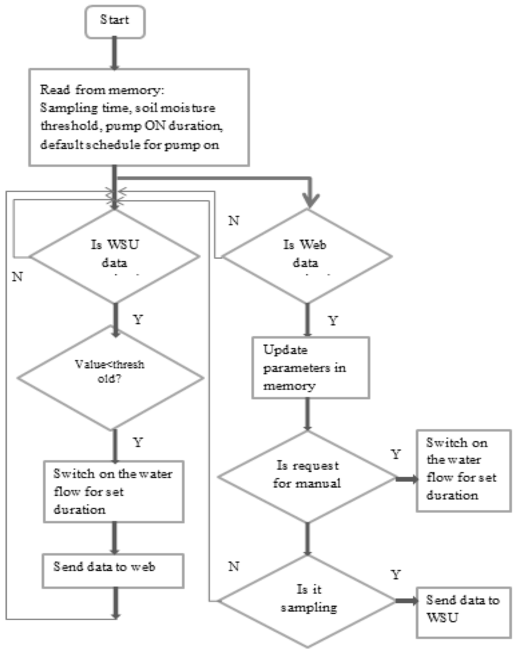

Fig. 8 Algorithm for WIU

3.3 Web Module

Web module architecture is shown in Fig. 9. A service utility parse the data send by WIU and store in MySQL database. Application has been developed in MVC struts2 architecture and deployed on Apache server. Web application helps the user remote monitoring and control of various parameters of the irrigation system. This module provides easy to use graphical interface for displaying the parameters on browser. Application can be seen on any device with internet enabled.

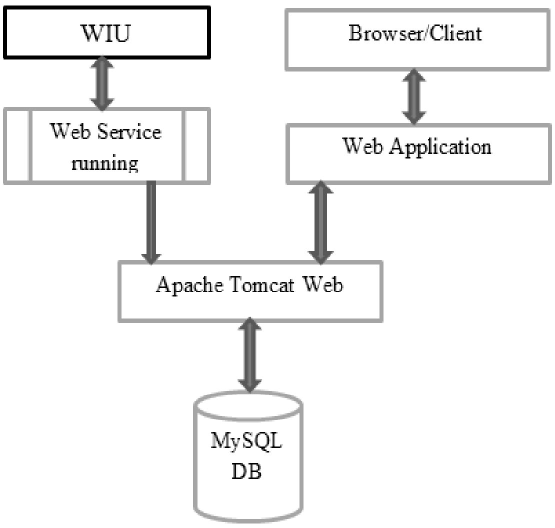

Fig. 9 Web Architecture

Application Interface as shown in Fig. 10 has following sections.

- Monitoring Data

Monitoring data includes the latest information of parameters such as Soil moisture, Temperature, Humidity, Battery level, Water level and status of Water flow.

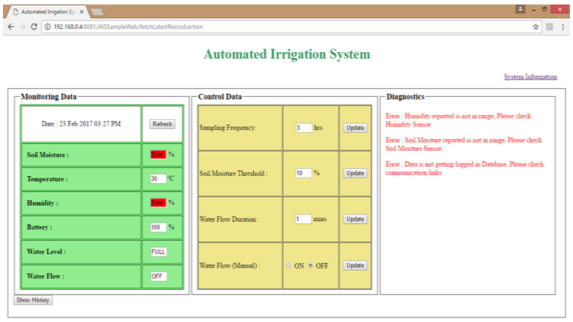

Fig. 10 Web Application

- Control Data

The four parameters can be change in order to control the proposed irrigation sys-tem to suit the particular requirement. Changing value of any of the above parameters and pressing button 'Update' will send the respective change data to WIU.

- Diagnostics

Diagnostics form helps the user to keep track of health of the system by providing warnings or errors occurring in operation. The message includes 'Temperature reported is very Low, Please check Temperature Sensor', 'Soil Moisture reported is not in range, Please check Soil Moisture Sensor', 'Data is not getting logged in Database, Please check communication links', etc.

- System Information

A link is provided giving information about the system in brief. This will be useful for the user to understand the system interaction. This can be updated as and when there are any changes.

Tool tip information is visible on taking mouse over a particular parameter text such as mouse over text 'Sampling Frequency' shows the information as 'Sets the time interval for reading Sensors values'.

IV. RESULTS

The humidity and temperature sensors are placed at the field station. Soil moisture sensor is buried into the soil near roots of the plant as shown in Fig. 11. WIU is connected to internet via Wi-Fi module.

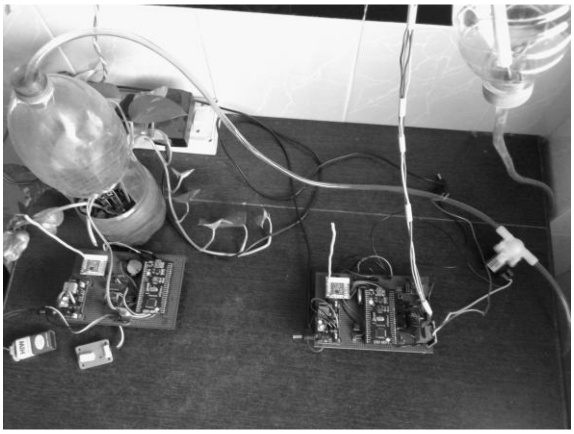

Fig. 11 Actual Setup

Fig. 12 shows the values received from sensors and transmitted to WIU via RF Transceiver the received values are compared with the set threshold. Whenever the soil moisture value is less than the set threshold, the water valve is opened and water is applied to the plants. Wi-Fi module in WIU uploads the sensor information in web. Application displays the data onto the screen to the user. Manually turning on the water flow action from application starts the water flow for set duration.

Record No.	Record Time	Soil Moisture %	Temperature °C	Humidity %	Water Level	Pump Status	Battery %
87	16 Mar 06:31 PM	82	31	56	HIGH	OFF	80
86	16 Mar 06:01 PM	81	32	44	HIGH	OFF	80
85	16 Mar 05:31 PM	74	33	37	HIGH	ON	80
84	16 Mar 05:01 PM	74	32	43	HIGH	OFF	80
83	16 Mar 04:31 PM	74	32	39	HIGH	OFF	80
82	16 Mar 04:01 PM	74	32	21	HIGH	OFF	80

Fig. 12 Test Results

V. CONCLUSION

Considering the scarcity of water at the global level and the importance of agriculture for the existence of life on earth, managing water resources for agriculture is becoming a challenge.

The automated irrigation system based on WSN has been designed. The wireless data communication among WSN, base station and user application requires less maintenance. A simple application allows the user the monitor and control of the system without any technical knowledge.

The developed system is cost effective and proves the saving of water. The system can be adjusted for different crops. System can be used for farms at remote place where human presence is not feasible or monitoring is difficult. System can be extended to greenhouse monitoring.

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