WSN based Automated Irrigation Control System

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Abstract—The main aim of this work is to provide an automated irrigation system for the farmer on the basis of wireless sensor network. The challenge is to develop such an irrigation control system that makes efficient usage of water and also must be cost effective. To calculate plant's water requirement, it is important to measure different parameters. This system continuously monitors the parameters- temperature, humidity, and moisture of soil to which crops are susceptiveAn algorithm was developed with threshold values of soil moisture to be maintained continuously. System starts or stops irrigation based on moisture content of the soil. The tests were conducted on three crops- green chili, marigold and tomato. With the help of this system, water supply was reduced by 20- 30%, while crop yield was found to be slightly increased.

Keywords— *Automated Irrigation, Nodes, Sensors, WSN,*

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I. Introduction

Irrigation water requirement depends on soil properties like moisture and temperature and the type of crop which is grown in the soil. Technologies have been developed for efficient use of water for irrigation purpose. In India, agricultural area receives power supply usually in nonpeak hours; also frequent power cuts and low voltage supply creates a big problem to farmers. The off-peak hours are usually night hours after 11 pm. It is risky for a farmer to go to the field for irrigation as there is threat to his life from wild animals and snake-bites. If farmer fails to attend the irrigation, there is chance of wastage of water and electricity. Also, excess watering leads to soil damage.In order to control and monitor the irrigation process, smart and automated irrigation system is developed, implemented and tested.

II. Literature Review

SangmeshMalga et al [1] developed a small embedded system device (ESD) that takes care of overall irrigation process. The farmer sends SMS command which is received by GSM module and forward the decoded command to the microcontroller to take further actions. Farmer first verifies the status of parameters like water level of the supply, soil temperature, rainfall, three-phase supply, by sending an SMS to the ESD. ESD in return sends information regarding the status of above mentioned parameters. If farmer finds all the parameters in the limits, he sends another SMS to the ESD, then it starts the pump to initiates the irrigation process.

BenahmedKhelifa et al [2] discussed smart irrigation techniques using 'Internet of Things' (IoT). In this system sensors are placed in the agriculture field, measures the soil moisture value, water level in the tank and well-water level values. These values are sent to web service through mobile data communication network. The web servers use intelligent software to analyse the data and act according to the result obtained to perform desired action. This system which is based on 'ICT' and 'IoT' technologies ensures low cost and high accuracy in control of irrigation.

ChandankumarSahu et al [3] proposed a low cost smart irrigation control system which includes sensor nodes and control nodes. The field is divided into small squares and the moisture sensors are placed at the corners of each square. The sensors send the moisture content of the soil to ARDUINO-UNO board through WSN, where an ATMEGA-328 microcontroller processes the data and calculates the dryness level of soil. This information is sent to RASPBERRY-Pi which is control node. The control node start/stop irrigation depending on predefined values.

Ayman M. Hussain et al [4] in his paper represent irrigation management system for open canals using WSN and water pumps. Water level sensor is connected to main irrigation canals, and flow sensor is connected to water pump. These sensors are connected to wireless gateway which sends data periodically to web server. Database connected to webserver monitors irrigation water level at all main and auxiliary canals .The web based IMS analyse the data stored in database and compares with specified values. Then it (IMS) sends SMS to farmers and engineers to make aware of water requirement.

A. Kumar et al [5] proposes low cost moisture sensor and XBee based data acquisition system required for automated irrigation system. The authors have developed an impedance based moisture sensor. Sensors works on the change of impedance between two electrodes kept in soil, its moisture level changes can be measured in a relative manner. In this paper only moisture sensor was tested. More sensors can be added to record other parameters like temperature, rainfall, air humidity etc.

Y. Kim et al [6] proposes a System for production of barley over a large area along with WSN and decision making software for effective irrigation. The system consists of five sensing sites and a weather site. Every Sensing site has a processor with two soil water reflectometers, a soil temperature sensor, and Bluetooth communication. Each sensing site senses the soil moisture and soil temperature, these data is stored in the database. The decision making software start the irrigation depending on the information taken from theinformation network and location of irrigation machine.

III. PROPOSED METHODOLOGY

All the systems discussed above are worked for single a crop only. In the proposed work, different crops are considered along with their water requirement at different stages. The crops are irrigated with respect to the water requirement at different stages of their growth.

The block diagram of proposed system is shown in figure It consists of three nodes sensing, controlling and processing node.

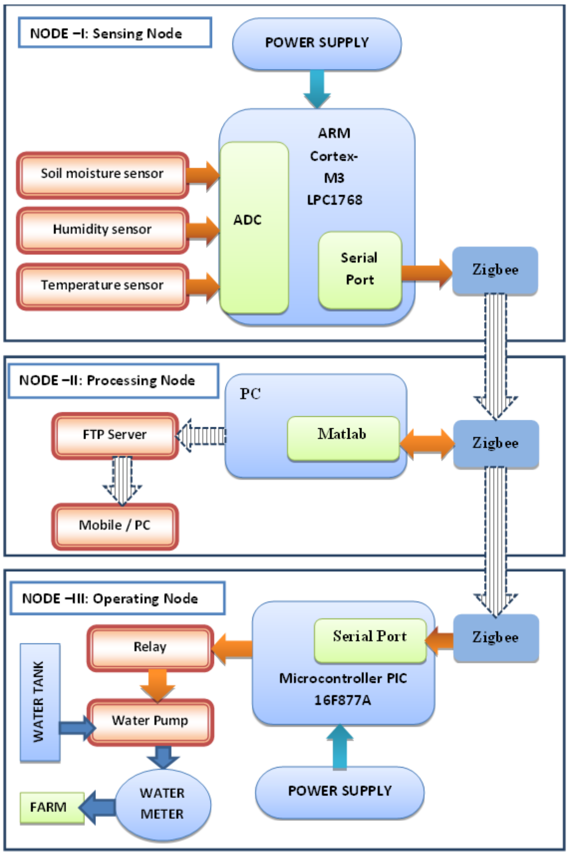


Figure 1 : Block Diagram

1. Sensing node[Node I]

a) Temperature sensor

The temperature sensors in LM35 series are precision sensors. They are integrated-circuit temperature sensors whose output voltage is directly proportional to Celsius (Centigrade) temperature.The LM35 is calibrated to operate over a temperature range of −55° to +150°C. It has Low impedance output of 0.1 Ω for 1 mA load.

b) Soil moisture sensor

This moisture sensor is simple sensor. It is used to measure moisture level of soil. It has dual output mode and its analog output is accurate. It operates in the range 3.3V-5V.

c) Humidity sensor

To measure amount of water molecules dissolved in air humidity sensor SY HS220 is used. It is precise and reliable. It work at 5 v sup land and operates at ≤ 0.3mA, operating temperature range is 0-60°C.

d) ARM Cortex M3(LPC1769)

LPC1769 is a 32bit ARM Cortex M3 microcontroller, operates at CPU frequencies of up to 120 MHz. The ARM Cortex-M3 CPU makes use of a 3-stage pipeline. It uses Harvard architecture along with separate local instruction and data buses..The advantage of the LPC1769 is that it includes up to 512 kB of flash memory with 64 kB of data memory..An 8-channel 12-bit ADC and a 10-bit DAC are used for signal conversion. It also includes up to 70 general purpose I/O pins.

1. Processing node[Node II]

This nodeconsists of Matlab code on a personal computer and a Zigbee to communicate with sensing node and operating node.

2. Operatingnode[Node III]

a) PIC: PIC is the family of Harvard architecture microcontroller made by microchip technology derive from the PIC 164. It consists of 10-bit, up to 8-channel Analog-to-Digital Converter, Brown-out Reset (BOR), Analog Comparator module.

b) Relay

RW series relays are used on the field station to carry out switching operation. It has contact capacity of 10 A at 120 VAC or 10A at 24 VDC. It has a contact resistance of 100mΩ at 1A, 6VDC. Its operation time is very short, 10 ms to contact and 5 ms to release.

c) AC Motor

AC motor (HG410-EU) operates at 220V-240V 50 Hz voltage and has power consumption of 25W. It has a flow rate of 1200LPH (315GPH). Dry operation damages the pump.

d) Zigbee module

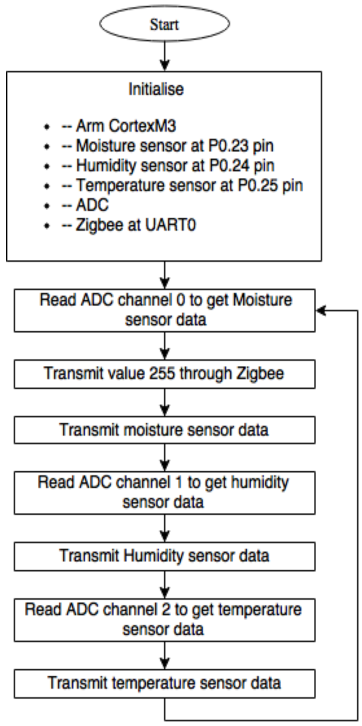
Zigbee module uses IEEE 802.15.4 protocol for fast peer to peer, point to point networking and it cover distance range for communication can be 10 m at indoor and 100 m at outdoor.

First node consists of Microcontroller along with soil moisture sensor, temperature sensor, humidity sensor, and power supply and Zigbee module. The first node is implemented in the farm area. We have used ARM LPC1768 microcontroller for all monitoring actions. It has inbuilt ADC with 12-bit resolution. Moisture sensor has analog output. Thus, we have connected it to ADC pin of microcontroller, which converts analog value to digital. Similarly, temperature sensor LM35 is used to sense temperature which has sensitivity 1 degree Celsius per mV. It is also interfaced with ADC channel. Humidity sensor is used to check humidity in the environment which is also connected to ADC channel of ARM. All sensor values are transmitted serially out through Zigbee module to second node, viz., PC.

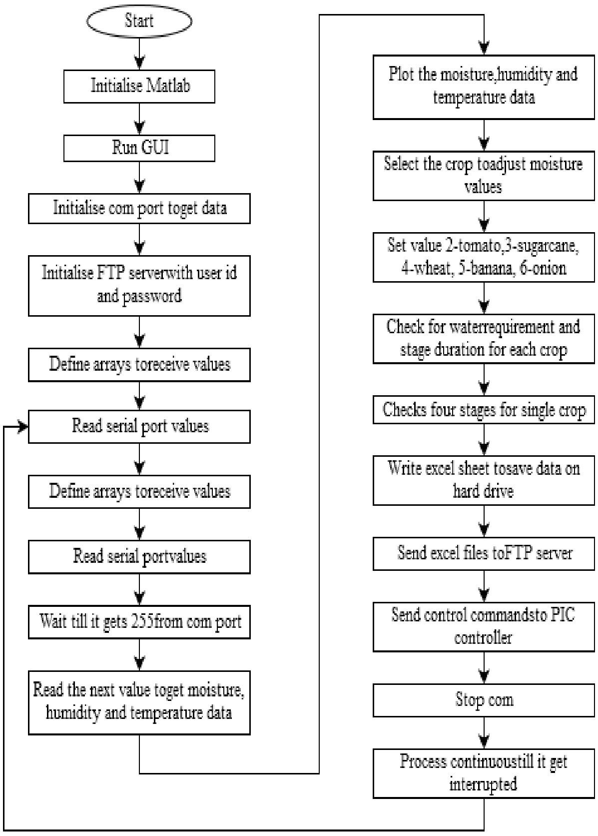
Second node consists of PC along with Zigbee module and Matlab installed on PC. On PC, MATLAB GUI is created. It runs continuously. It has start, stop, run, etc. buttons on it. It also shows plot of all sensor values. Data is received serially from ARM microcontroller and display it graphically on GUI axis. Plot also shows threshold values of every sensor. Excel sheet is created using Matlab to send data to FTP server.

Alsothis node sends command tooperating node to turn ON and OFF water motor.

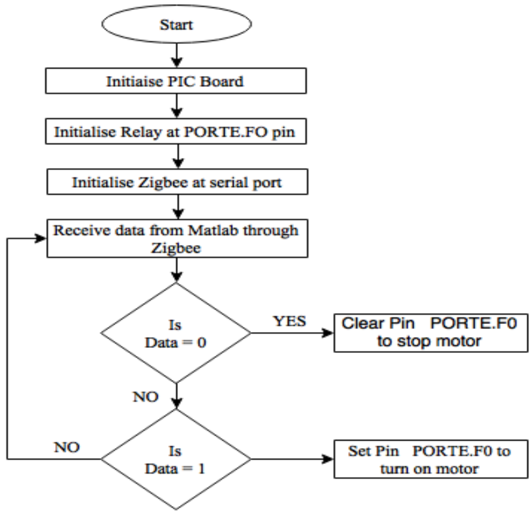
Flow chart for NODE – I



Flow chart for Node – II



Flow chart for Node-III



Third node consists of microcontroller PIC 16F877A along with Zigbee module, relay and AC motor. Command sent by controlling node is received by PIC microcontroller. As per command received, it will turn ON and OFF the motors in farm area.

IV. PROCEDURE

The tests were conducted on three different crops viz. marigold, tomato and green chili. The development period of all those crops is around 10- 12 weeks. The yield starts after 7^{th} or 8^{th} week. The moisture required for those crops were finalized after consultation with expert farmers and the values are presented in the table 1. The system started irrigation automatically whenever moisture value drops below threshold values. The results of the experiment are presented in table 2 (in terms of water saving) and table 3 (crop yield).

Table 1: Moisture Requirement for different stages

	Moisture Requirement (%)		
Stage	**Green Chilly**	**Marigold**	**Tomato**
Stage I	15	14	18
Stage II	18	16	20
Stage III	22	20	24
Stage IV	26	24	30

Table 2: Water saving comparison

	Water supply (liters)		
Crop	**Normal Drip Irrigation**	**Moisture Based Drip Irrigation**	**Saving in Water (%)**
Green Chilly	3467.80	2298.60	33.71
Marigold	1866.90	1351.40	27.61
Tomato	2665.60	2032.70	23.74

Table 3: Yield comparison per plant

	Crop Yield per plant (kg)	
Crop	**Normal Drip Irrigation**	**Moisture Based Drip Irrigation**
Green Chilly	2.5	2.8
Marigold	1.8	1.95
Tomato	2.7	3.1

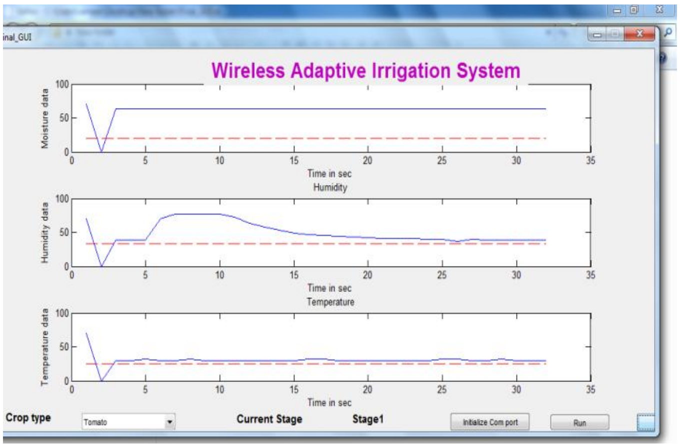


Figure 2: Snapshot of system in operation

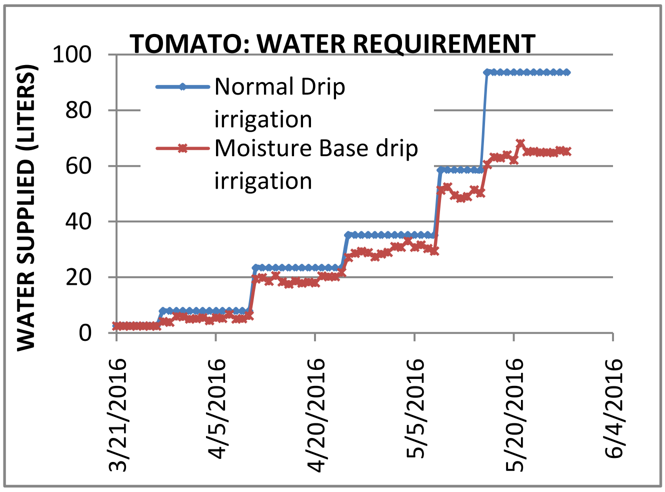


Figure 3: Water requirement of tomato for normal and moisture based irrigation

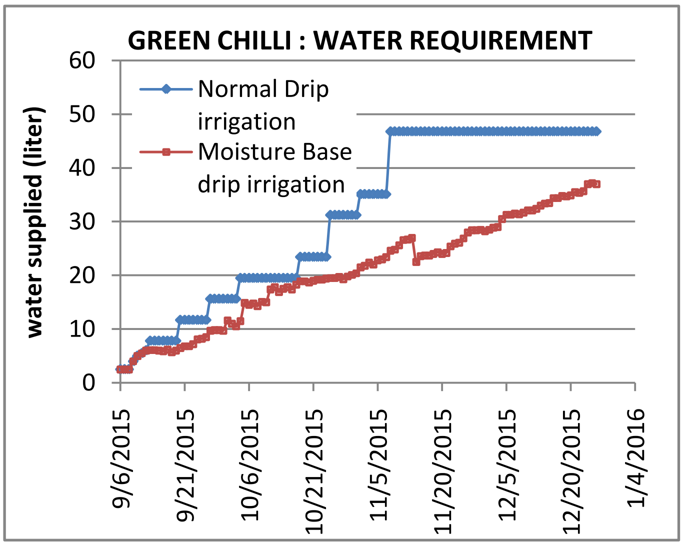
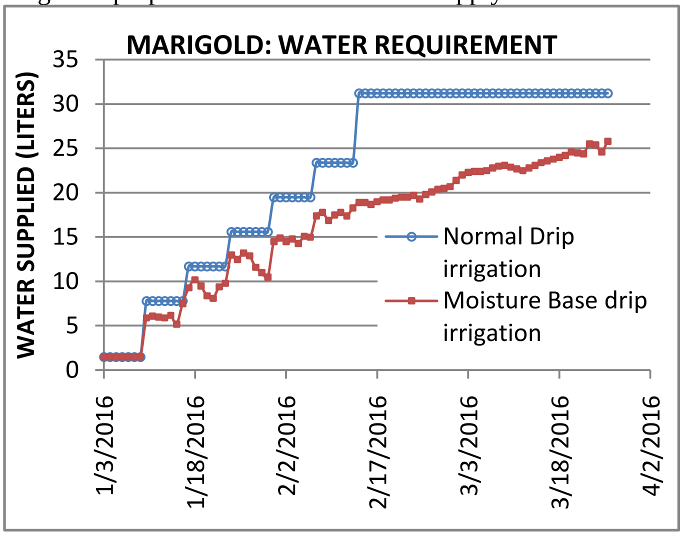


Figure 4: Water requirement of green chilly for normal and moisture based irrigation

V. CONCLUSION

The automated irrigation system presented in this work was found more viable, and can manage irrigation water supply more effectively. It helps to optimize the use of water for irrigation purpose. It shows that water supply can be reduced



with the help of soil-moisture based automated irrigation system. Water saving was amounted to 23.74% for tomato crop,27.61% for marigold and 33.71% for green chilli. At the same time, the crop yield difference in the two methods is negligible. This also reduces the electricity consumption to the extent of reduced water supply. The automated irrigation system can be adopted for different crops using multiple sensors at a time, which reduces the farmer's efforts to monitor different crops being cultivated simultaneously. With the help of such a system, each crop will receive water as per the demand only. The use of internet link will further reduce the efforts by remotely controlling the system using 'TeamViewer' or a similar software

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